Fig. 1.—View of Butler Falls, one mile south of Hanover, Indiana. This exposure shows the Saluda beds. The conspicuous layer *x*, about half way up the overhanging ledge is the hard limestone that caps the "shale bed." (See page 673.)

INDIANA.

DEPARTMENT

OF

Geology and Natural Resources.

THIRTY-SECOND ANNUAL REPORT

W. S. BLATCHLEY,

STATE GEOLOGIST.

1907

INDIANAPOLIS:
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1908.

THE STATE OF INDIANA,
EXECUTIVE DEPARTMENT,
March 10, 1908.

Received by the Governor, examined and referred to the Auditor of State for verification of the financial statement.

OFFICE OF AUDITOR OF STATE,
INDIANAPOLIS, April 17, 1908.

The within report, so far as the same relates to moneys drawn from the State Treasury, has been examined and found correct.

J. C. BILLHEIMER,
Auditor of State.

April 17, 1908.

Returned by the Auditor of State, with above certificate, and transmitted to Secretary of State for publication, upon the order of the Board of Commissioners of Public Printing and Binding.

FRED L. GEMMER,
Secretary to the Governor.

Filed in the office of the Secretary of State of the State of Indiana, April 17, 1908.

FRED A. SIMS,
Secretary of State.

Received the within report and delivered to the printer April 17, 1908.

HARRY SLOUGH,
Clerk Printing Bureau.

State of Indiana,
Department of Geology and Natural Resources.
INDIANAPOLIS, IND., March 2, 1908.

HON. J. FRANK HANLY, *Governor of Indiana:*

MY DEAR SIR—In accordance with law I submit to you herewith the manuscript of the Thirty-second Annual Report of the Department of Geology. It comprises, in the main, papers relating to the soils, mineral resources and paleontology of Southern Indiana. In addition it also contains the reports of the State Mine Inspector and the State Supervisor of Natural Gas for the calendar year 1907.

Yours very truly,

W. S. BLATCHLEY,
State Geologist.

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Isadore Kessler	Clerk.
Millard Gilliam	Messenger and Janitor.

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DEPARTMENT OF GEOLOGY AND NATURAL RESOURCES.

INDIANAPOLIS, IND.

W. S. BLATCHLEY, State Geologist.

PLEASE ACKNOWLEDGE RECEIPT OF THIS VOLUME.

In return, Scientific Books, Fossils, etc., and Implements of the "Stone Age" are acceptable

State Museum, Room 126, Third Floor, State House.

Open to the public from 8 A. M. to 5 P. M., except on Sundays and legal holidays.

Admission free.

Office of State Geologist, Room 89, Third Floor, State House.

INTRODUCTORY.

A fourth of a century ago Indiana was noted mainly for her agricultural products—her crops of corn and wheat, her droves of fine cattle and hogs, her blue grass pastures and her large areas of native timber land. Then came the discovery of natural gas and petroleum, the development of her enormous coal deposits, the opening up of many new quarries of unexcelled building limestone, the realization of the value of her great clay deposits—until from a truly agricultural State she merged gradually into one of high rank as a manufacturing and mineral producing center. The increase in value of her mineral resources grew year by year from $17,125,000 in 1895 to $41,781,678 in 1905. A backward tendency then began. Her gas for manufacturing purposes was gone, the value of the output having decreased from $7,254,539 in 1900 to $1,750,715 in 1906. Her petroleum output began to dwindle and in the last three years has fallen off more than one-half, or from 11,338,538 barrels, valued at $12,177,098 in 1904 to 5,103,297 barrels, valued at $4,489,213 in 1907. The combined loss in value of these two great natural fuels alone in Indiana in 1906 was $3,888,262. The output of coal, of building stone, of clay products has grown in value year by year, but it will probably be a long time before the total value of the State's mineral resources will again reach the high tide of 1905.

But whatever the fate of such mineral resources as those above mentioned, there still remains to Indiana the most valuable of all —her soils. More people are dependent upon them than upon all the rest of her resources and manufacturing establishments combined. The study of the origin, distribution and constituents of soils falls naturally to the Department of Geology, though many essays and valuable papers relating to their culture and fertilization appear in the reports of the State Board of Agriculture.

The soils of Indiana may be roughly classified into three great groups, viz.: Drift soils, residual soils and alluvial soils. The drift soils are found in the northern three-fourths of the State, are extremely varied in depth and character, and are formed of a mass of heterogeneous material which was brought to its present resting place by a great glacier or slowly moving sheet of ice which, thousands of years ago, covered the area mentioned.

The residual soils are found in the counties south of the southern limit of the glacier. They were formed for the most part in the place where they are now found by the decay of the underlying limestone, sandstone or shale rocks. The variety of materials entering into their composition is, therefore, limited, and they are for that reason among the poorer soils of the State.

The alluvial soils are those of the river and creek bottoms throughout the State. Gentle rains and earth-born torrents, little trickling rills and strong streams are ever at work tearing down the soils and underlying clays from every slope and bearing them away to lower levels. The small water-formed trench of today next year becomes a chasm and ages hence a hollow, and the transported material is gradually deposited as alluvial soil over the so-called bottom lands, which are annually overflowed.

In the production of any cereal nothing new is created, but forms of matter, already existing in the earth, air and water are utilized by the growing plant. Taking wheat for example, besides the carbon, hydrogen and oxygen, which make up the greater bulk of the straw and grain, and which are abundant enough in the air and water, potash, nitrogen, phosphoric acid, magnesia, lime, sulphur, chlorine and silicon are absolutely essential constituents. If any *one* of these is lacking in the soil, or is present in a form not available by the wheat roots, the plants will not flourish and the soil will be worthless for wheat production. Such a soil may, in most cases, be made to produce a crop of grain by adding to it the constituent which is lacking, but if this cannot be done except at a prohibitory cost, or one at which more fertile ground can be procured, the soil may be regarded as "worn out" or "barren."

On account of the small appropriation allotted the Department of Geology for field work and expenses, no attempt has heretofore been made to classify and map the soils of any section of the State. The great increase in value of improved farm lands in the northern and central portions of the State during recent years has caused many inquiries to come into the office regarding the character and possibilities of the poorer residual soils of southern Indiana. The older reports, treating of the geology in that portion of the State, being wholly out of print, no literature was available by which these inquiries could be answered in detail. A soil survey of a portion of the southern third of the State was, therefore, planned for the field season of 1907, and Mr. Chas. W. Shannon, of Bloomington, was placed in charge of the work. Assisting him were two of the former field men of the Department, Messrs. L. C. Ward and R. W. Ellis. For a few months Mr. L. C. Snider was also employed as an aid to Mr. Shannon. The reports of these assistants, each of whom was assigned certain territory, comprises the first portion of the present volume.

In these reports the soils of 17 counties of the State are classified, and the area covered by each of the soil types mapped. Complete analyses of 20 examples of the typical soils were made by Dr. R. E. Lyons. From these analyses the assistants have been able to show the food constituents lacking for each of the leading cereals and other crops in the area covered. By aid of the analyses and other data gathered in the field they have also shown the use to which each type of soil is best adapted, the kind of fertilizer most needed and much other information which will undoubtedly prove of great value to the land owners, both present and prospective, of the area covered. The soil survey thus begun will be continued from time to time, as the means of the Department will allow, until the southern portion of the State is wholly covered.

No detailed report upon the Oolitic Stone Industry of the central southern portion of the State has been made since 1896. During the eleven years which have elapsed this industry has grown until it has become the leading one among the mineral resources of southern Indiana. The supply of the old report of Messrs. Hopkins and Siebenthal, in which the area producing the stone was first accurately mapped, has been exhausted. A new one was therefore planned which, while retaining the more important information regarding the location and physical and chemical properties of the stone shown in the old report, would also show the improved methods used in quarrying and the present status of the industry. The data for this report was gathered and compiled by Raymond S. Blatchley, and under the title "The Indiana Oolitic Limestone Industry in 1907"; it forms an important feature of the present volume.

Following the paper on Oolitic limestone is one entitled "The Petroleum Industry in Indiana in 1907," in which will be found the principal facts and statistics relating to that industry for the year.

The report of the State Mine Inspector, James Epperson, of Linton, Indiana, for the year 1907 is the next paper in the volume. Mr. Epperson and his four deputies have given careful attention to the duties which they are empowered to perform and have tried to enforce impartially all laws relating to the mining industry. In his report the statistics of the coal industry for the year are given, the tables being very full and complete in detail.

Since the year 1898, no survey of the coal area of Indiana has been made, as the report for that year—a volume of 1740 pages with seven large maps—was devoted wholly to the coal interests of the State. Since then, hundreds of bores have been sunk to test the thickness and character of the coal in different parts of the area, and scores of new mines have been opened in the development of the industry, the output having almost trebled in quantity during the past ten years. Much new data has therefore become available and a new coal survey, to be made in co-operation with the U. S. Department of Geology, has been planned for the year 1908. Dr. Geo. H. Ashley, the efficient chief in charge of the coal survey from 1896 to 1898, will again be in charge, thus insuring the accuracy and value of the results. It is hoped that the data thus gathered can be put in shape to form a part of the annual report for 1908.

From the report of Mr. Epperson the following table, showing the relative rank of the 14 coal producing counties of the State for the year, with the output of each in tons, has been prepared.

Tons of Coal Produced and Wages Paid to Miners in 1907, by Counties.

Counties.	Tons Produced.	Wages Paid.
Greene	2,704,408	$2,189,153 98
Sullivan	2,660,333	2,263,994 54
Vigo	2,581,379	2,246,366 78
Vermillion	1,485,091	1,267,531 80
Clay	1,230,872	1,338,727 88
Parke	654,808	729,493 89
Warrick	454,831	326,033 45
Pike	427,932	398,443 05
Knox	375,082	314,819 71
Vanderburgh	311,240	300,288 45
Gibson	227,688	209,599 17
Daviess	87,385	83,109 70
Fountain	40,099	39,733 97
Perry	9,567	10,527 17
Totals	13,250,715	$11,717,822 54

Of the coal produced, 875,233 tons were block coal, and the remainder bituminous. The total production for the year shows an increase of 1,828,888 tons, the increase in block coal being 128,563 tons and that of bituminous 1,700,125 tons.

The report of the State Supervisor of Natural Gas, Mr. B. A. Kinney, of Marion, Indiana, follows that of Mr. Epperson. Mr. Kinney has been active in suppressing the waste of gas wherever he could find violations of the law or have them reported to him. With regard to the future supply of natural gas in the State, we believe his report more optimistic than the facts will justify. The total amount produced in Indiana in 1906, according to careful figures gathered by the U. S. Geological Survey*, was valued at only $1,750,715, as against a value of $3,094,134 in 1905, a loss of 43 per cent. Although a number of light producing wells were drilled in various portions of the gas bearing area in 1907, we believe that when the value for that year is computed the loss will be at least one-half as great.

With the exception of a few fair wells in Sullivan County, southwestern Indiana has yielded no gas of consequence during the past year. The eight producing oil wells in the Riley field near Terre Haute are operated with coal, and no gas wells of any size were completed in the Princeton field during the year. The larger towns in northeastern Indiana are gradually abandoning the use of gas for domestic purposes, the amount available not being sufficient to justify its continuance, and we believe that in a year or two the supply, except in a few localities in that field, will be wholly exhausted. Jay and Delaware Counties may yield enough to supply by metre measurement a portion of the residences in Portland, Muncie and some of the other towns in those two counties for five years, but aside from that we have little hope for the future.

Following the custom adopted in recent years of ending the reports with one or more papers on the Natural History or Paleontology of the State, we present this year two which we believe will be of especial interest to high school students and others interested in those subjects. The first is entitled "The Stratigraphy and Paleontology of the Ordovician Rocks of Indiana," and is based upon a number of seasons' field work by Mr. E. R. Cumings, Associate Professor of Geology in Indiana University. The Ordovician Rocks comprise the oldest existing land formation of the State, being part of an island which was raised above the surface of the ocean when all the remainder of the area now forming Indiana was yet covered by the sea. All known species from Indiana of the

*Mineral Resources of the United States, 1905, p. 45; 1906, p. 50.

remains of the animals inhabiting the waters of that age are described, many of them being new to science. The paper is fully illustrated by a series of excellent plates.*

The final paper in the volume is one entitled "A Preliminary List of the Mushrooms of Indiana," by Donald Reddick, graduate student of botany in Wabash University. This paper is accompanied by excellent plates showing all the more common edible and poisonous forms occurring in the State, and it will be welcomed by all persons who desire to make use of a valuable and much neglected food supply.

*Other papers on the paleontology of the principal rock formations of Indiana which have appeared in the Reports of this Department during the last few years are: "The Devonian Fossils and Stratigraphy of Indiana," by E. M. Kindle in the Twenty-fifth (1900) Report.

"The Stratigraphy and Paleontology of the Niagara Rocks of Northern Indiana," by E. M. Kindle, in the Twenty-eighth (1903) Report, and "The Fauna of the Salem Limestone of Indiana," by Messrs. J. W. Beede and E. R. Cumings, in the Thirtieth (1905) Report.

A SOIL SURVEY OF SEVENTEEN COUNTIES OF SOUTHERN INDIANA.

BY

CHAS. W. SHANNON,
R. E. LYONS,
L. C. WARD,
R. W. ELLIS.

The Indiana Soil Survey.

By Chas. W. Shannon.

Indiana in area of square miles ranks but thirty-fifth among the States of the Union, but in its great natural resources it stands among the first; yet not including any of the precious metals its resources are varied in character and are very valuable, and the state is rapidly growing as a mineral producing and manufacturing center. The finding of natural gas and oil, the abundance of coal, the inexhaustible supply of limestone, good cement shales, excellent fire-clays, together with the splendid transportation facilities, have all added to the building up of great enterprises which have brought into the State millions of dollars to be invested in economic interests which are paying handsome dividends on the money spent. Yet among the most valuable of the natural resources of Indiana are the productive soils. All the great business enterprises are dependent to a large extent on the productiveness of the soil,

"For, nevertheless, whate'er befall,
The farmer he must feed them all."

Indiana ranks high as an agricultural State, with her great crops of corn and wheat, her thousands of fine cattle, hogs and sheep, her blue grass pastures and meadow land and an increasing acreage of fruit. There are about 17,448,000 acres of tillable land in the State. The six chief agricultural products of the State are in the order of importance, corn, oats, wheat, timothy meadow, clover meadow and potatoes.

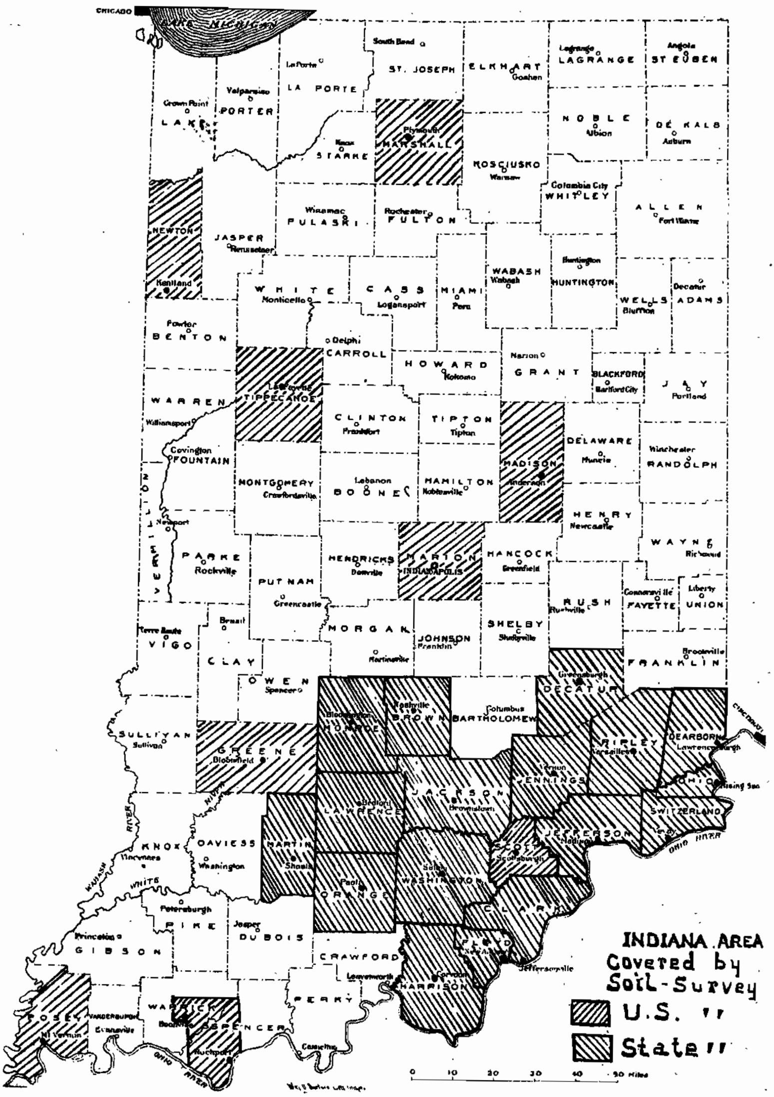
Many of the wealthy citizens of the State can today point back to the pioneer history of Indiana when their capital consisted of a few acres, a little log cabin, and an ax and some provisions and a large supply of persistent energy. Every one, as soon as possible, prepared a field for corn, started a garden, procured a few hogs, one or two horses, or a yoke of oxen and a few cows. It was rather easy in those days to keep live stock. The wild grass, nutritious roots, and several kinds of nuts and acorns were so abundant that neither horses, cattle nor hogs required much grain, and often large numbers of farm animals were maintained. A surplus of corn, beef, pork, etc., was produced and low prices created a market, and profitable business began to grow. Demand led to a greater diversity of crops and an increase in commerce. The soil, though rich, requires and is well adapted to a great variety of crops. Thus step by step, year by year Indiana has grown to be a great agricultural State, with farms of the highest value, and her crop production and value of her live stock worth about $250,000,000 in the year 1907.

In view of the greatly increased price of land, the important question confronting the farmer is how to secure from his farm returns in proportion to the increased money value of the land. It is becoming more and more difficult to secure adequate farm labor, and thus the successful cultivation of large farms is becoming a problem. Future farming is to be intensive rather than extensive. The man who produces the same amount of grain on one-half the acreage does it at a great saving and at the end of the year will be much in advance of his neighbor who has expended the same energy in twice the acreage.

During past years farming in Indiana has been carried on with profit, but agriculture has not yet reached its highest possibilities with the great variety of soils of the State and the intelligence and industry of the farming population. Indiana soils have been made to produce 150 bushels of corn per acre, but now with the average production of corn per acre less than 40 bushels, something must be wrong under the present ordinary conditions of cultivation.

Many farmers are using some kind of commercial fertilizer as a means of restoring to the soil the elements needed, but too frequently the fertilizer has not been selected with any reference to soil conditions or composition, and the result would seem to show a further depletion of the soil rather than an improved condition. Many others sow clover to restore the native fertility to the soil, but fall short of their object by cutting off the first crop of clover for hay and the second crop for seed, and thus robbing the soil of the elements they wished to restore to it. The farmer who studies carefully the existing soil conditions and who uses care in selecting his fertilizers to restore deficient elements has done much to make agriculture an interesting and profitable occupation.

Soil Survey.—The future of our agriculture depends to a great degree upon a proper knowledge of the nature of our soils and how they can be best preserved and cultivated. While it is not necessary for the farmer to trouble himself with technical geology, chemistry, botany, etc., it is one of the absolute requirements of successful, economic agriculture that he have an intelligent com-



prehension of the habits and demands of the plants he cultivates and a fair knowledge of the nature and requirements of the soil he tills.

Until within the past few years little attention has been given to Indiana soils either by the geologist, scientific agriculturist or the farmer.

The State Department of Geology has made some investigation previous to the present survey, the Indiana Experiment Station has done a great deal in reference to a cropping system and the manurial requirements of certain types of soil. The Bureau of Soils of the United States Department of Agriculture has carried on some work on the soil survey in the past few years and has to the present time made a survey and published reports on ten counties, as follows: Marshall, Tippecanoe, Newton, Madison, Marion, Green, Scott, Posey and a part of Warrick and Spencer Counties. The State Department of Geology in 1907 made a survey of the following counties in Southern Indiana: Monroe, Brown, Lawrence, Jackson, Washington, Orange, Martin, Decatur, Jennings, Ripley, Dearborn, Ohio, Switzerland, Jefferson, Clark, Floyd and Harrison.

Maps were constructed showing the boundaries of the various soil types and numerous samples were collected and mechanical analysis made of these by the field men and a complete chemical analysis of typical samples were made by Dr. R. E. Lyons, Bloomington, Ind. His method of work and the results of the analysis are given under an included article written by himself. The analyses are repeated under the discussion of the various types from which analyses were made. These are compared also with other analyses that have been made and those of the residual soils are given in connection with analysis showing the average composition of the parent rock.

Throughout the survey the field men had the hearty co-operation of the farmers and by this many things of special interest and importance were developed that otherwise would have been unobserved. The following list of questions was sent out to farmers who might be interested in soil investigation and improvement; while many of the lists were never returned, many were returned, giving a full report of valuable information:

SOIL SURVEY OF .... COUNTY, INDIANA.

The State Department of Geology is beginning a Soil Survey of this County. The following is a list of questions relating to the soils. The conditions covering crop production are so complex that even with the fullest information, and the most careful work, cases are found in which as yet the best experts will be at fault. Your assistance in the work through the information to be gained from answers to the following questions will be greatly appreciated, and we trust the report may prove beneficial to you. Your set of answers is important in compiling information in your neighborhood. If you can not answer all the questions, please answer those you can. The favor of a prompt reply, even though incomplete, will be highly appreciated.

QUESTIONS.

1. Name ....
2. Location of land.............Sec........Twp........Range........
3. Color of soil ....
4. Character of soil ....
5. What crops are grown most successfully?.........................
6. What is the average crop per acre of wheat? ......, of corn? ......, of oats? ......, of rye? ......, other grains ...... of vegetables? ......
7. What fertilizer, if any, do you use?
8. What is the average sized farm in your part of the county? ....
9. Note any peculiarities of the soil and subsoil ....
10. Their behavior under tillage and cultivation of various crops ....
11. Their behavior in wet and dry seasons ....
12. Difference in the behavior of different portions of the same field or soil area ....
13. Give any and every circumstance that can throw any light on the agricultural qualities or peculiarities of the soil ....
14. Suggest any questions or suggestion for our consideration ....

Soil Maps.—It is impossible in some cases to obtain a base map of proper accuracy. In such cases it is necessary to use a plane table outfit and construct a traverse base map in the field. This traverse work can, however, be reduced to a minimum by making careful use of all data at hand and by continually checking up all minor errors which are encountered.

Most counties are provided with fairly accurate base maps showing township and section lines, towns, churches and schools. But often the roads and streams, especially the minor drainage, are much in error if shown at all.

In places where a topographical survey has been made, the mapping of the line between the upland and lowland is much facilitated. In parts where no topographic and but little geological work has been done, some plane table work is usually required where there is much valley or bottom land, with somewhat abrupt valley sides.

In a soil survey it is not necessary to attempt to construct a general topographic map, but areas rising to considerable distance above surrounding country, and distinct bluffs, or the occurrence of a hill in a generally level tract such as cut off hills and lost ridges, or terraces should be indicated by some special markings.

All mapping should be on a scale of not less than one inch to a mile and a two-inch scale is preferable, as the field mapping can be done more accurately and then the original may be reduced to any size for publication, but in no case should be smaller than one-half inch to the mile and if soil types are numerous and of small area, the printed map should be one inch to the mile. On a scale of one inch to the mile a square one-eighth of an inch on each side represents ten acres, and smaller areas can not be well represented, but if smaller areas are found of a distinct type they should be discussed in the notes. In many cases terraces can be mapped with the valley, but where of considerable area or of a distinct type should be so indicated.

If maps are to be published in colors the soil boundaries may be indicated by dotted lines and the area marked in with the color chosen for that special ytpe. If to be printed in black and white as zinc etching, some system must be established for indicating the various types, which will make it distinct and so that when reduced will not appear too black, such a system may be made somewhat general but in some counties change will necessarily be made because of the diversified character of the soils. The boundaries may be indicated either by a solid or a broken line, and the boundary mark should be as light as possible to show distinctly, since a mark one-hundredth of an inch wide on the paper will represent a width of nearly fifty-three feet on the ground.

The Geological maps of the State which have been prepared and are being constructed at the present time, showing the outcrop of underlying rocks, the glacial and alluvial deposits of recent time, become the basis of a soil map or in a general way may serve as such a map. After such maps have been prepared it greatly facilitates all kinds of soil investigation.

In the case of hillsides or along slopes the formation outcropping high up in the hill influences to some extent the soils belonging properly to the lower formation. Otherwise a knowledge of the character and value of the soil derived from any given formation will apply to the residual soils of that formation whenever found. The geological and soil maps will show at once where such soils occur. It is then important that soil maps be made to correlate as far as possible with geological maps. Particular modification of the general type will occur and require mapping, and such mapping should be on a basis that will make the most profitable and intelligent application to the farmer of that area. While the line between the soils of different formations and soil types cannot be defined to a space of a few feet and the same general farming principles may seem to apply, the soils upon investigation may be entirely different and require a different treatment and are adapted to special crops in order to secure the best results.

AGRICULTURE.

History of Agriculture.—Agriculture as a science is based upon a group of sciences which in their growth have revolutionized it. The most important of these are chemistry, botany, zoology and geology. There are many divisions of agriculture referred to under various terms, as tillage, husbandry, grazing, dairying, feeding, breeding, horticulture and arboriculture, and care of all vegetables and animal life supported by the earth for the benefit of mankind.

Agriculture is one of the oldest of human employments, dating from long before the dawn of history. The inhabitants of the lake dwellings of Switzerland were perhaps the earliest tillers of the soil and stock keepers about whom we know. Among their dwellings we find the bones of cows, pigs, sheep and goats as well as of wild animals. Grain crushers were in every dwelling. Wheat, barley, millet and flax seem to have been cultivated. The Aryan peoples are believed to derive their name from a word which indicated that they were users of the plow, and were thus distinguished from other people. Most of our knowledge of the earliest agriculture clusters about the river valleys—that of the Nile in Egypt, and that of the Tigris and Euphrates. In Oriental agriculture the great need is water. In Egypt once a year the Nile comes to the relief of man, gives him the water for a crop and prepares the bed for the seed. Sir Isaac Newton claimed that agriculture began in the Nile Valley, and that the river taught men the art. Its teeming population that anciently existed in that narrow valley, the large army maintained, and the great engineering and architectural works constructed indicate a successful cultivation of the soil. Seeds were sometimes sown upon the mud and trodden in and when the soil needed stirring a pick was used constructed of two sticks tied together. Then came the rude plow formed by fastening together a pointed share, two handles and a pole. Sowing was always broadcast and the heads of grain were cut from the stalks and carried to the threshing floor.

Of Babylonian agriculture there are few records, but as in Egypt, a dense population was supported. The Euphrates overflowed but did not do the work of the Nile. In all the region irrigation turns desert lands into fruitful fields.

The Scriptures are full of allusions to the operations of husbandmen in Palestine as well as in Egypt. The laws were those of an agricultural people. Extensive plains of fertile soil yielded the finest wheat. The hillsides were covered with vines' and olives often planted in terraces formed with much labor to afford a large mass of soil in which the plants might flourish in the dry season. The valleys were well watered and afforded pasture for numerous flocks. Little is known of early Grecian agriculture. It has been said they knew the value of the scarecrows and when these failed had a sure charm produced by carrying a toad about the field by night, and then burying him in the middle of it. They used a plow similar to the Egyptians, and plowed their ground several times. Manures were used and soils were combined for fertilizing purposes.

Roman agriculture has received special attention since so much was written about it by the Romans themselves, and since they carried it into other countries where it modified or dominated agricultural customs when Rome was only a colony on the Tiber, land was divided among the citizens in small allotments. The common conditions were that the occupants paid one-tenth of the produce of the corn lands, one-fifth of the product of the vines and fruit trees and a moderate rate per head for cattle pastured. Later the place of the small farmer was taken by the planter, who cultivated a large territory with slave labor. The chief grain cultivated by the Romans was wheat, with barley second, and meadows were also highly valued. They believed in and understood crop rotation. After the overthrow of the Roman Empire the conquering people began to study the works of Roman agriculture and all western Europe agriculture was benefited. In England at the same period the agriculture showed alterations of indolence and bustle. In August, 1317, wheat was twelve times as high as in the following September. Rye was the breadstuff of the peasantry. Little manure was used and the soils became less productive.

The discovery of the New World showed two grades of agriculture carried on by those who had even used a plow similar to the Egyptians, and plowed their ground several times. Manures were used and soils were combined. The great contribution of America to the world's agriculture was the three plants, the potato, tobacco and Indian corn or maize. In the region north of Mexico the labor of planting and caring for the scanty crops was performed by the women, who broke the ground with the rudest possible implements. The leading agricultural writer of the sixteenth century was Sir Anthony Fitzherbert, who published his "Book of Husbandry" in 1523. In this century agriculture became moré profitable. Gardening greatly neglected in the first part of the 17th century, received much attention in the latter part. Deep drainage was much talked about and crop rotation was carried on successfully. And thus the beginning of the 18th century saw a great revolution in English farming.

English agriculture of the first part of the nineteenth century was marked by the influence of Arthur Young, who traveled much, carefully observed, experimented somewhat, and wrote industriously. He was one of the first to make experiments in regard to nitrogen and in regard to ammonia, previously supposed to be injurious to vegetation. Of his works one has recently been republished. As secretary of the Board of Agriculture, established in 1793, he was concerned in the discussion of all the agricultural questions of the period. Jethro Tull, whose book on Horse-hoeing Husbandry appeared in 1731, was almost in touch with the methods of the nineteenth century. His theory was that seeds should be sown in drills and the spaces between the drills kept thoroughly cultivated. He asserted that the plant lives upon minute particles of soil and obtains food from the air when the soil is brought to dust. He invented a drill and a horse-hoe. He did not succeed in obtaining a large crop; but modifications of the method have since been made. Considering that Tull did not have the aid of agricultural chemistry, he could not more nearly have touched hands with the scientific observers of today. In one respect there is an approach to his position. The supposed proof that plants cannot take nitrogen from the air has been questioned since 1880. At present it is generally accepted that certain (if not all) plants do require the plant food nitrogen from the air. The theories of Tull may acquire fresh interest through the present discussion of the relations of the physical properties of the soil to the cultivation of plants.

The white colonists of North America had much to discourage them as agriculturists, and in New England the additional drawbacks of long winters and a rocky soil. The colonists in Virginia found both Indian corn and tobacco, the latter fitted to become an article of export. The New England settlers brought with them English modes of farming. From the Indians they learned how to raise corn, breaking the soil with a hoe and manuring with fish. Corn was the great product to be depended upon, although other grains were cultivated and cattle and sheep increased slowly, fed first upon the native grass, then upon the herd grass specially fitted for New England soil.

Potatoes began to be raised in the first part of the eighteenth century. The Southern colonists, more favored by nature, made less actual progress than those of the North. An important part of the little written upon agriculture was the volume of essays published by Jared Eliot, 1735. Even as late as 1790, as we learn from McMaster's History of the American People, little progress was made. Throughout the South it was the common practice to grow crops without rotation, and in general manure was thrown away.

Marked changes have taken place in the agriculture of the past fifty years, in a great part due to the development of agricultural chemistry. Among the results of the study of agricultural chemistry have been an extensive use of chemical fertilizers, selected with reference to soils and crops and a comparative independence of the fixed rotations. Researches, however, are not confined to agricultural chemistry. The work as carried on in more than three hundred experiment stations of the world is planned to attack one after another the pests and the problems that confront the farmer. Other features of the great progress are, the extensive introduction of machinery, careful cultivation, thorough drainage and deep plowing. Market gardening or "truck farming" has been made a branch of agriculture.

Agricultural Education.—It is only within recent years that adequate attention has been paid to agricultural education. The first agricultural school was founded by Fellenberg, at Hofwyl, in Switzerland, in 1806. His pupils were taken from the poorest class of peasantry, of whom he truly observed, that "having no other property than their physical and mental faculties they should be taught how to use this capital to the best advantage," by a combination of "discipline, study and manual labor." No fewer than 3,000 pupils were trained in this school, which flourished for about thirty years. Since then various schools of like character have sprung up in Europe. The French Government makes large appropriations to support agricultural education and one school at Grigron has an old royal palace with its domain of 1,185 acres. In Prussia there is scarcely a province that does not boast of its agricultural school and model farm; and throughout Germany, as well as in Russia, we find educational institutions supported by the state, in all of which agriculture is practically as well as theoretically taught. Finland possesses in all ten agricultural schools and seventeen small dairy schools. Denmark spends about $55,000 annually. Japan has an agricultural college on the island of Yeso, and an experimental farm in the province of Shimosa, near Tokio. In Great Britain a large number of colleges and secondary schools teach agriculture, and in some of the best schools a full course of agricultural education is given, as at the Royal Agricultural College and the College of Agriculture, near Salisbury. At the University of Edinburgh, practical agriculture is acquired by residence on a farm near Edinburgh, and by Saturday excursions to selected farms near at hand. The most important experimental station in England is a private one at Rothamsted. Woburn Station is next in importance and was started in 1876 by the Royal Agricultural Society.

In 1847 the United States made the first step toward agricultural education, when John P. Norton, agricultural chemist, just returned from Europe, agitated the question of agricultural schools and one school was begun. In 1860 it was liberally endowed by Joseph E. Sheffield and is now attached to Yale College as the "Sheffield Scientific School." In 1852 a similar school was started at Dartmouth College.

Congress was repeatedly asked to set apart lands for the support of agricultural colleges, and a bill was passed in 1858 for that purpose, but the president failed to sign it. In 1862 the effort was successful, and a bill became a law appropriating about ten million of acres to all the states, to be divided according to the number of representatives from each state in Congress. Meantime, New York and other states kept the question alive and Michigan opened her Agricultural College in 1857; and now, under one or another name, nearly all the states have colleges or parts of colleges in which agriculture is taught.

The Department of Agriculture was established in 1862, though the first distribution of seeds, etc., was made by the commissioner of patents in 1836. The first garden was established in 1858. The object of the department is to acquire and disseminate among the people of the United States the latest and best information on the subject, and to introduce into the country new and desirable seeds, plants, etc. The divisions of the department are seeds, propagating garden, pomology, ornithology, forestry, and library, chemistry and the Weather Bureau. Monthly reports on the state of crops and kindred subjects are issued and farmers' bulletins are printed and distributed throughout the country. Year books are also published, giving the progress of the work of the department for the past year, and includes many valuable papers upon subjects relating to the various divisions of agriculture.

Agricultural Experiment Stations are now in operation in every state and territory and are carrying on a large amount of scientific and practical work, giving results of great value to American agriculture. These stations are departments of the agricultural colleges and were first established under act of Congress of 1887, and intended "to promote scientific investigations and experiments respecting the principles and applications of agricultural science." They conduct researches with regard to the physiology of plants and animals, the advantages of rotative cropping, the analysis of soils and waters, and the chemistry of manures, foods, etc. The act of 1887 appropriates $15,000 annually for each state for the purposes of such stations. The officers of the stations report to the Department of Agriculture, and publish bulletins giving results of experiments. They enjoy now more than ever the support of farmers, horticulturists, etc. A number of the states have liberally supplemented the funds appropriated by Congress for the maintenance of the stations. So great has been the success of the stations, and so urgent have been the demands for the information which they are able to give, the calls for the preparation of popular bulletins and the delivery of addresses at farmers' meetings, that it has in some cases been almost impossible to meet the demand without endangering the success of the original investigations which it was their first business to conduct. While the farmers of the country may well congratulate themselves on having such numerous and important agencies for the discovery of new truths and the dissemination of useful information, they should not relax their efforts to aid the stations in advancing their work and securing the greatest benefits to agriculture which can be obtained with the resources at their command. Fitness and ability to carry on successful investigations should be the fundamental qualifications for station officers, and when competent men are once obtained they should be held in their positions and supported in their efforts to plan and carry out thorough experiments.

Agricultural societies for the purpose of promoting the interests of agriculture have sprung up in great number, farmers' congresses, farmers' institutes, boards of agriculture, state and county fairs, horticultural societies, experiment clubs, are all means of education for the farmer. In Oklahoma farmers are forming "acre clubs," each member taking one acre for an experimental crop, doing his best with it, and when the season is over, reporting his experience, including mistakes, and describing his methods. This is a practical form of agricultural education and the plan might well be tried in other places.

In the secondary schools of our rural communities agricultural instruction is growing in importance. The effort to introduce nature study largely on subjects relating to agriculture is being actively undertaken in several states. The result of pushing this educational motive into the rural communities has caused a most decided waking up of those communities. For many years schemes for the teaching of agriculture in the common schools have from time to time been put forward and have attracted more or less public attention, but none of these have been found practicable. This is largely because they have ignored the conditions existing in our common schools, as well as the nature of the subjects with which the theory and practice of agriculture deal. The art of agriculture is best learned on the farm. That is the place where the boy learns how to plow, plant and reap, and how to feed and care for stock. It is true that at an agricultural college or other school where the farmer boy may reside for a considerable time, he may learn new and better ways of doing these things than on his father's farm, but the chances are against him in the rural school, since most of the time must be taken up with the rudiments of a general education. In his school he must be taught the principles underlying agriculture; that is, he must be taught why he plants and plows and reaps in one way rather than another, and what laws of nature he violates in his bad management that his crops do not yield and his stock do not grow and fatten. This education must also be carried into the high school, where large numbers of farmer boys and girls complete their education. These schools are located near their homes and they are unable to attend the longer and more expensive college courses. Any school so far distant from the farmer's home as to require the boys and girls to be away from home two years or more is too expensive for most of the farmers' children after they have reached the age when they will be of service on the farm. What then is needed is courses in agriculture in the common schools and in numerous high schools to which farmers' children resort, near their homes, to "finish" their education after they have completed the common schools. The more practice the boy has had on the farm the better able he will be to appreciate a systematic course in agriculture. Such instruction in the secondary schools will open the mind of the pupils to the wonderful progress which is being made in agricultural science and practice. It will enable him to take a more thorough advantage of the information furnished through books, bulletins of experiment stations, farmers' institutes, home reading clubs, etc. The farmer must be taught to think in the lines where science has shed light upon his art if his practice is to be most thoroughly successful. Fortunately, science has already much to tell the farmer which is most useful to him, and every year sees an increase from which the agricultural student can safely draw.

SOILS IN GENERAL.

Soil.—Soil is the loose mantle of material covering the surface of the earth. It consists of the disintegrated materials of the earth's crust mixed with varying amounts of decayed vegetable matter. The earth's crust is composed of more than seventy elements, most of which are present in very small proportions. Of the numerous elements known, only eighteen are of importance either in soil formation or plant growth, and of this list, three or four have no active part in normal plant growth. They are as follows: Metallic elements—potassium, sodium, calcium, magnesium, iron, manganese, aluminum, and titanium; non-metallic elements—carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur, chlorin, fluorin, iodin and silicon. Iodin and titanium perform no important function in soils and plant growth. The value of fluorin is little known, but it is found as an ingredient of animal bones and its presence is often found in plant ashes. Aluminum in the form of its compounds with oxygen and silicon is a very prominent soil ingredient and has an important place in the physical properties of the soil, but does not perform any direct function in plant nutrition, and is absent in the ash except in a few low forms. The remaining fourteen are always present in plants, carbon, hydrogen, oxygen and nitrogen forming the volatile part, while the rest occur in the ashes. Thus these various elements supply singly, or in combination, all the constituents necessary to plant growth, each of them having its own portion of the plant to sustain—the silica producing strength and rigidity to the stem; aluminum giving tenacity to the soil, and thus rendering it a stable support; magnesia perfecting the seeds; iron absorbing oxygen and ammonia from the atmosphere, and giving it up as required, and so on. Of these ingredients, silica, aluminum, lime, along with the organic matter, constitute the bulk of the soil, the others existing only in small quantity, and hence is derived the common division of soils—siliceous or sandy, argillaceous or clayey, calcareous and humus.

The relative abundance of the elements found in the crust of the earth shows that one-half of the total consists of oxygen, and thus we find that most of the other elements exist in combination with it as "oxids." The oxid of silicon predominates over all other substances, while quartz occurs alone in large masses, the greater proportion is found in combination with other oxids—those of aluminum, calcium, iron magnesium and the alkali metals, potassium and sodium.

Subsoil.—Immediately beneath the soil or stratum of earth which affords nourishment to plants, is a mass of earth or rock, unmixed with decayed matter, to which the term subsoil is applied. The subsoil may or may not be similar in its geological constitution to the soil. The term "surface soil" is generally applied to that part of the soil turned over in cultivation, and the subsoil is all that part of the soil mass extending down from the surface soil. This is a distinction of practical importance, but the real distinction is due to the action of organic matter and certain physical and chemical causes. In the latter case the surface soil may be only a few inches in depth, or may extend downward several feet. The subsoil is usually of lighter color, due to the absence of organic matter, except where there is deep coloration caused by the presence of iron. Another striking difference between soil and subsoil is the degree of compactness of the material in two layers and also the extent to which the earth is mixed with fragments of the parent rock. The agencies acting upon the surface tending to give it a loose, open structure, do not act in the subsoil, and it therefore remains in a more solid form.

Soil Formation—Rock Weathering.—Rocks are simple mineral aggregates; and a few only, limestone, quartzite, etc., expand or contract alike throughout; with each change of temperature there is a tendency to form fissures, which will gradually lead to the disruption of the rock surface. Temperature changes, therefore, is an important agency in the breaking down of rocks. Disintegration is effected partly by the chemical action of oxygen, carbonic acid and the other acid or alkaline substances brought by the atmosphere to bear upon rocks and partly by the wearing action of water in a fluid state or in the form of glaciers, or by its expending force when broken. Almost any locality will afford opportunities for observing the nature of the process by which soils are made. We may examine the exposed rock of some old quarry where the soil covering has been removed and the rock is again left to recover its coat of loose material. Even where quarries do not exist, an old pavement will often show the soil-making process. Water and the atmosphere and the heat of the sun coming upon the earth's surface are the important agencies by which the rocks are pulverized. The drops of rain water as they fall upon the rock surfaces tend to loosen small particles from the partly decayed rock. The water soaks into the minute fissures of the rock and dissolves the cementing material so that the grains of sand, mud, etc., are more easily broken loose by the blows of other rain drops. In freezing, the water that has been absorbed by the rock surface expands, and masses of rocks are broken into fragments by the agency. Cracks and crevices are made larger and a large amount of new surface is exposed, and the smaller particles are torn loose and added to the mass of accumulating soil.

After the rock surface begins to decay, low forms of plants become attached and absorb certain portions of mineral matter by the broad adhesions which bind them to the surface. As soon as the surface has secured a coating of these lichens the process of soil-making goes on with increased rapidity. These plants are active only when they can obtain sufficient water from the moisture of the air and the surface on which they rest. The decay of the lichens supplies the water with a certain amount of carbonic acid gas, by which the solvent power of the water is increased in its effect of disintegrating the rock.

"Among siliceous rocks, chemical action proceeds but slowly, and the amount of material actually removed in solution is rarely over 60%, and may be so small that the residue in extreme cases occupies some 80% more space than the rock from whence it was derived. Carbonate of lime, the essential constituent of ordinary limestone, is, however, as has been observed, soluble, in the carbonated water of rainfalls, and in time, may undergo complete removal, leaving but the insoluble impurities behind. This is, indeed, the universal history of limestone soils. They are, however, infrequently so siliceous or ferruginous as to be quite barren and of a nature to be benefited by the application of lime as a manure.

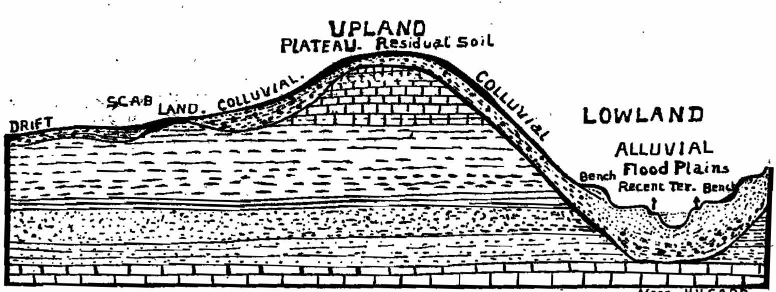
"Throughout the areas occupied by the Trenton limestones, in Maryland, nearly every farm has, in past years, had its quarry and limekiln where the stone was fitted for supplying lime once more to soils from which it had been so thoroughly leached as to render them lean and poor. It is to this solvent action that is due the formation of the multitudinous caverns, large and small, of the lime-

Illustrating manner in which the roots of trees break up rock masses in the Harrodsburg limestone, one and a half miles north of Bloomington, Monroe County, Ind.

Illustrating same as above; also shows low forms of plant life attacking the surface. Notice the large root after passing through the crevice again widen out. Near Oliver Quarry, southwest of Bloomington.

stone regions. Even where caverns are not present, the corrosive action is evident to the practised eye. In the quarry regions of Tennessee surface blocks of limestone are often grooved to a depth of an inch or more with the acids absorbed from the atmosphere and surface soils, while in the quarry bed the stone is found no longer in continuous layers, but in disconnected boulder-like masses. In such cases casual examinations give very little clew to the rapidity of the destruction going steadily on, since all is removed in solution excepting the comparatively small amount of insoluble matter (usually clay or silica) existing as an impurity."*

Classification of Soils.—The determination of the true relationship of the soils of different areas is a difficult problem, since, being derived from rocks of all kinds and under varying conditions, no fixed lines for soil classification can be laid down. But for the purposes of discussion and definition we have the primary divisions of sedentary and transported soils, and each of these is again subdivided according to the agencies involved in its transportation or original formation.



RELATION OF SOIL CLASSES

1. *Sedentary or Residual Soils*—(a) *Residuary*, (b) *Cumulose.*—These are known as soils in place and have not been removed from the parent rock. The rock underlies the soil or subsoil at a greater or less depth, and the soil bears some characteristics of the original rock. The upper part of the rock surface is generally somewhat broken and decayed, with fragments scattered through the subsoil. The prevailing charactertistic of an old residual deposit, from whatever rock it may be derived, is a ferruginous clay. With the exception of quartz, the various mineral constituents are often in advanced stage of decay, and the more soluble constituents are wholly or partially lacking, having been leached out. In the case of limestone the soils consist mainly of aluminum and fer-

*Geo. P. Merrill, "Rocks, Rock Weathering and Soils," pp. 245–46.

ruginous matter, grains of sand, and nodular masses of chert which existed as admixed impurities. At first one would believe the residual soils derived from limestone to differ greatly from soils orig inated from sandstones or shales, yet the difference is not so great. There usually overlies the sandstone strata a loamy earth, not very different in character from that overlying the limestone. It is somewhat more sandy, and thus less cohesive, and becomes less so farther from the surface, while in the limestone region the toughest clay lies next to the surface rock. The limestone clay shows a tendency to cleave, breaking up into little pieces which are roughly cubical. The residual soils occur principally on plateaus and gentle slopes, where the velocity of the surface water from rainfall is not sufficient to dislodge the rock debris.

Another group of soils to be classed as sedentary are in cumulose deposits, as peat, muck and swamp, since they result from the gradual accumulation of material "in situ" through differing in both composition and origin from those just described.

2. *Transported.*—Because of the transporting power of water, wind and ice, few residual materials are left undisturbed for any length of time but become more or less intermixed with materials from near or distant sources. It is through the influence of running streams, both in the past and present, and moving ice in times past that has been brought about the great mass of material known as drift. According to the agencies involved, we have a variety of transported materials.

(a) *Colluvial Soils.*—These colluvial soils form a large part of rolling and hilly uplands, and are of varying degrees of productiveness. They owe their origin to soils removed from the original site to such a degree as to become intermingled with the soils of other rocks, or by the rolling or sliding down the slopes the particles become more finely divided, and the soil masses are subject to landslides from penetrating waters underneath and from complete saturation and from hard freezing and rapid thawing, but ordinarily the movement down the slopes is slow, yet perceptible in a short time. Sedentary soils are dependent almost entirely on the parent rock for their specific character, and nearly the same is true in the case of colluvial soils.

(b) *Alluvial Soils.*—The alluvial soils are those of the valleys, flood plains, sea and lake borders. The materials of which these soils are composed have been gathered from all along the course of the stream and may consist of a great variety of components. and although they may vary greatly in their character, they are usually fertile. They are usually of fine texture, but the relative proportion of sand and clay are dependent upon the velocity of the water current. In the upper part of the valleys and where the slope is relatively steep and the velocity great, there is a large proportion of coarse stones and gravel, and as the slope and velocity decrease, coarse and then fine sand will be the prominent component of the soil, while farther down the stream the finest sand, silt and clay are the principal constituents. The alluvial soils differ from those thus far described in that they are always more or less stratified.

(c) *Aeolian Soils.*—These deposits owe their origin and present structural features mainly to wind action, but sharp lines cannot always be drawn between them and those of alluvial types. The principal occurrence of such soils are in the Loess deposits and in the sand hills or dunes, and to a small degree the volcanic dusts.

(d) *Glacial or Drift Soils.*—Ice in the form of glaciers has great eroding and transporting powers. The moving of the ice, with its embedded stones, cuts, scores and grinds even the hardest rocks, and the product is largely very fine and easily transported by the glacial streams. The fineness of this material renders it very suitable for the making of soil, and such soils are usually very productive and lasting. The rotten and mechanically mixed detritus of many rocks from many sources forms a soil which is abundant in all the necessary plant foods, and hence does not require a large outlay for commercial fertilizer as do other soils.

The material of the glacial drift is spread out over the land in a manner far from uniform and under varying conditions, and may be separated into two classes: (a) stratified or assorted drift, laid down under the influence of water, (b) unstratified or unassorted, deposited directly from the ice and consisting of a heterogeneous mass of coarse and fine material. A large part of the drift is composed of this unassorted material, consisting of clay, sand, gravel and bowlders, to which the name till or bowlder clay is applied, or, from its mode of deposition, the ground moraine. The accumulation of rocks and debris of all sizes in the moraines form glacial-made lands which cover extensive and important agricultural areas; such areas are undulating and the soil usually has imbedded in it stones of great variety and size.

Varietal Names.—In a general way, "rock powder," "clay" and "humus" are the chief constituents of soil. According to the predominance of one of these over the others, soils are classed as "heavy" or "light." Clay soils are usually heavy, while sandy and humus soils are spoken of as light. As regards the degree of fineness of the rock particles, together with the physical and chemical properties, soils are known as gravelly, sandy, silty, loamy, calcareous, siliceous, magnesian, ferruginous and others of local importance.

Soils of sedentary origin are usually spoken of in regard to the rock from which they were derived, as granite soil, limestone soil, etc. Transported soils are designated by the names given in above description with such local variations as indicate their production and adaptability. A loam is usually defined as an admixture of sand and clay with more or less organic matter, a clayey loam being one in which clay predominates and a sandy loam one which has sand prevailing. Peat and muck are known as humus soil. Silt, loess and adobe are terms applied to fine soils of varying origin. Swamp, marsh and meadow designate low-lying, wet tracts. In addition to these, many local names are used which in general have no special significance.

Soil samples are separated by mechanical means into various sizes, and the various percentage relationships determine the soil type, as coarse, medium or fine sand, sandy loam, silt loam, clay and clay loam.

It has been found through soil investigation in the United States that a given set of soils are so evidently related through source of material, method of formation, topographic position and coloration that the different types constitute merely a gradation in the texture of an otherwise uniform material. Soils of different classes thus related constitute a series. A complete series of soils consists of material similar in many other characteristics, but grading in texture from stone and gravel on the one hand through the sands and loams to a heavy clay on the other. Soils may, however, be very similar in origin and texture but may occupy so entirely different topographic position that their relation to crops is entirely changed and the use of another serial name should be applied.

Soil Coloration.—Another division of soils is that on the basis of natural colorations. Farmers use soil colors as a basis in determining the quality of land.

A black soil is considered a rich soil. The black or brown-black color is with few exceptions due to the presence of much humus. The shade of the black deserves close consideration. If tending toward brown, acid humus or "sour" land is indicated. The jet black tint is an indication of calcareous land, and these are almost always highly productive.

Red soils take second place except in such cases where the red soil has been derived from ferruginous sandstones, that furnish little else but quartz and ferric hydrate. It is not the iron content that renders the land productive, but its presence is a sign of other favorable conditions: that a red soil is a well-drained soil, that ferric hydrate absorbs moisture and gasses, and, like humus, it renders heavy clay soils more easily tillable.

Yellow lands owe their color to smaller amounts of ferric hydrate, and share somewhat in the advantages of the red.

White soils or those of very light color are not usually considered of much value. The light color means the absence of both humus and ferric hydrate, and usually implies that the soil has been subject to reductive maceration through the influence of stagnant water; the ferric hydrate having been reduced to ferrous salts, the humus oxidized away, and most or all of the lime, iron and phosphoric acid of the soil mass accumulated in the form of inert concretions. The term "craw-fishy" is commonly applied to such soils, since they are usually inhabited by cray-fish, whose holes reach water a few feet below ground, and are surrounded on the outside by piles of white subsoil mixed with black gravel or concretions of bog iron ore. Such lands require careful drainage, and even then produce poorly, and are in immediate need of fertilization by green manuring and the use of phosphates.

Chemical Elements Important to Agriculture.—As stated above, eighteen elements require mention in connection with either soil formation or plant growth. The most important of these will here be discussed more fully in reference to plant growth and the use of natural and artificial plant foods.

Potash, phosphoric acid and nitrogen are three substances needed by all plants and crops for their food. These are taken up from the soil by the roots of plants and are contained in the crop which is harvested and removed from the farm. Hence, by continued cropping a soil becomes depleted of its plant foods, or "worn out" and unproductive. These three plant foods can be given back to the soil either in the form of natural or artificial manures, all of which contain one or more of these plant foods. Potash, phosphoric acid and nitrogen are equally important as plant food and one cannot take the place of another. Potash is necessary for the formation of starch, sugar and woody fiber in plants. Phosphoric acid is needed for the formation of seed, and nitrogen is necessary for the production of leaves and stalks. But when nitrogen is in excess it will cause a rapid and excessive but watery and unnatural growth of wood at the expense of fruitfulness.

Until within the last century, stable manure, composts, etc., were practically the only fertilizers known and used, and the use of these might have continued indefinitely but for the attention of chemists, such as Liebig, who discovered the use of mineral fertilizers.

"The chemical composition of stable manure does not, alone, suffice to explain its efficacy and the difficulty of replacing it by any other material. The composition of manure, of course, differs not only with different animals but also with the different feeds consumed by them; but the average composition of farmyard manure is approximately given thus by Wolff and others:

ANALYSES OF VARIOUS FARMYARD MANURES

	1.	2.	3.	4.	5.
Water	71.00	75.00	79.00	79.95	72.33
Dry matter	29.00	25.00	21.00	20.05	27.67
Ash ingredients	4.40	5.80	6.50	....	5.87
Potash	0.52	0.63	0.50	*0.84	0.69
Lime	0.57	0.70	0.88	....	0.85
Magnesia	0.14	0.18	0.18	....	0.14
Phosphoric acid	0.21	0.26	0.30	0.40	0.30
Ammonia	....	....	....	....	0.02
Total nitrogen	0.45	0.50	0.58	0.78	0.46

1. Average composition of fresh farm manure (Wolff).
2. Average composition of moderately rotted farm manure (Wolff).
3. Average composition of very thoroughly rotted farm manure (Wolff).
4. Mixed cow and horse manure from a bed two feet thick, accumulated during the winter in a large covered yard, and packed solid by the tramping of cattle (the analysis by F. E. Furry).
5. "Box manure," consisting of mixed manure of bullocks, horses and pigs (Way, Royal Agric. Soc. Journ. 1850, II., 769).

*And Soda.

"It is thus seen that the percentage of the important plant foods in stable manure are minute when compared with those commonly found in "commercial" fertilizers. Nor are they so much more available for plant absorption than the latter; a very large proportion is not utilized at all the first year, and unless the amount applied is very large it hardly carries the supply needed for the usual crops.

"It is now well understood that its efficacy is largely due to the important physical effects it produces in the soil. It helps directly to render heavy clay soils more loose and readily tillable. If well "rotted" or cured it also serves to render sandy, leachy soils more retentive of moisture, and the humus formed in its progressive decay imparts to all soils the highly important qualities discussed later. More than this, the later researches have shown that stable manure acts perhaps most immediately upon bacterial activity in the soil, greatly increasing it not only directly by the vast numbers of these organisms it brings with it but also in supplying appropriate food for those normally existing in the soil. In so doing it serves to render the soil ingredients more available and to impart to the soil the loose condition required in a good seed bed—a "tilth" which cannot be brought about by the operations of tillage alone.

"The only possible substitute for the use of stable manure is found in green-manuring with leguminous crops conjointly with the use of commercial or mineral fertilizers. Unless this is done, the use of the latter alone ultimately leads to a depletion of humus substances, which render the acquisition of proper tilth by seed-bed impossible, and causes a compacting of the surface soil which no tillage can remedy."*

All stable manures contain potash, phosphoric acid and nitrogen, but nearly always too much nitrogen in proportion to the mineral fertilizers, that is, potash and phosphoric acid. Therefore, when using stable manure, it is best always to add potash and phosphoric acid to it, so that the manure may have its full effect. It is not necessary to apply plant food in the form of stable manure. Potash, phosphoric acid and nitrogen can be bought and used in the form of commercial fertilizers usually at a less expense than in the form of a manure.

The principal sources of potash are the potash salts from Germany, and the most important of the potash salts are sulphate of potash and muriate of potash and kainit; the former two contain about 50 per cent pure potash, and kainit contains about 12½ per cent. Sulphate of potash is best for tobacco and some other specialties, while muriate of potash is somewhat cheaper and is useful for most crops. Kainit, in addition to its effect as a potash fertilizer, is useful for killing grub worms and other insects living in the soil, and is a remedy against cotton blight. Wood ashes are also a source of potash, containing from 2 to 7 per cent pure potash. Their composition is varied and uncertain.

The main sources of phosphoric acid are the large deposits of phosphate rock in South Carolina, Florida and Tennessee. The phosphoric acid in these rocks is insoluble and must be made soluble by chemical treatment before it can be used to advantage.

*Soils, E. W. Hilgard, pp. 73-74.

The phosphoric acid in the rock becomes then "available." Other sources of phosphoric acid are bone-meal, bone-black and thomas slag.

The most important nitrogen fertilizers are nitrate of soda, sulphate of ammonia, cottonseed meal and animal refuse, such as dried blood, dried fish, etc.

For the permanent improvement of soils it should not be overlooked that lime and organic matter (humus) are also frequently needed. Lime is especially useful on sour soils and makes them sweet. Humus is the product of decaying plants and is useful to make soils more loose and retentive of water. It may be furnished either by using stable manures or by green-manuring, especially with leguminous crops, such as peas or clovers. In the case of green-manuring, humus is produced directly through the decay of plants plowed into the soil, and in the case of stable manure indirectly after the plants have passed through the digestive organs of the anmials.

Fertilizers or fertilizing materials, that is, chemicals containing potash, phosphoric acid and nitrogen, are applied either broadcast or in the hill or with the drill. Each method has its preference in certain cases. Broadcasting of fertilizers is best where intensive culture is practised and large quantities of fertilizers are used. Applying in the hill or with the drill has been found more effective in case only moderate quantities of fertilizers are given. Top dressing is practised usually only in case of fertilizers containing nitrogen, such as nitrate of soda, because these nitrogen materials quickly wash into the soils through the rains.

When unmixed fertilizing materials are used it is best to apply the mineral fertilizers, that is, those containing potash and phosphoric acid, some time previous to planting, in which case there will be sufficient time for them to disseminate in the soil and get well mixed. The materials containing nitrogen are then used at the time of planting or immediately afterwards as top dressing. When mixed fertilizers are used, it is usually best to apply immediately before planting.

The quantities of fertilizers to be used per acre are dependent on the soil and the crop to be grown. Usually to a soil which is in good condition larger quantities of fertilizers can be given to advantage than to a soil which is in poor physical condition, that is, either too hard, void of organic matter or poorly drained. The amounts of complete fertilizer applied usually vary from about 400 pounds to 3 tons per acre.

Plants differ in their requirements of the three essential plant foods. For example, all plants producing sugar and much starchy matter, such as potatoes and fruit crops, need much potash, while leguminous crops, which have the power of absorbing nitrogen from the air, can get along with a small supply of nitrogen in the soil. Fertilizers, therefore, must differ in the proportionate amounts of potash, phosphoric acid and nitrogen, so as to suit the particular crop to be grown.

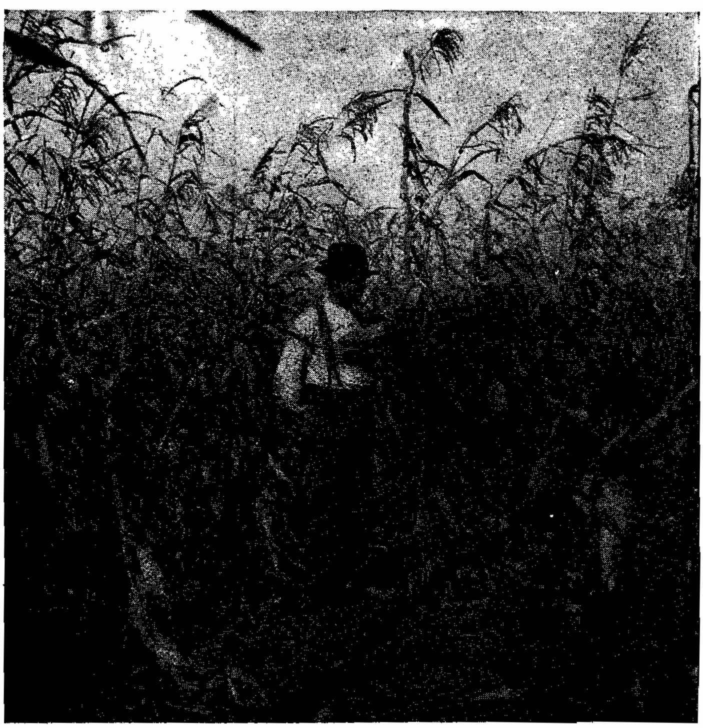
Soils likewise differ in the amount of available plant food already present in them; therefore, a proper fertilizer must suit the soil as well as the crop.

A very large amount of commercial fertilizer is used within the State of Indiana, but largely without any understanding as to the needs of the soil or the requirements of the plants. Numerous experiments have been made with fertilizers on the various soil types, and very good results obtained. The following description, together with the accompanying photographs, will show the results of some of the experiments. These are in reference to the corn experiments on the farm of W. A. Hart, near Portland, Jay County.

The land is a moderately heavy clay loam which had become very badly worn through bad cropping by tenant. For the past six years which Mr. Hart has owned it the land has received heavy applications of highly steamed bone meal, which provided an abundant supply of phosphoric acid and at first gave good wheat yields and good stands of clover. The land, however, would not produce good corn, the stalks being very short and the ears small and light. Mr. Hart believed, in common with a great many other farmers, that potash was not "necessary" on this land because the soil already contained in the neighborhood of one and one-half per cent of potash. But he did not realize that this was practically all in the form of feldspar or related compounds, and about as soluble as window glass.

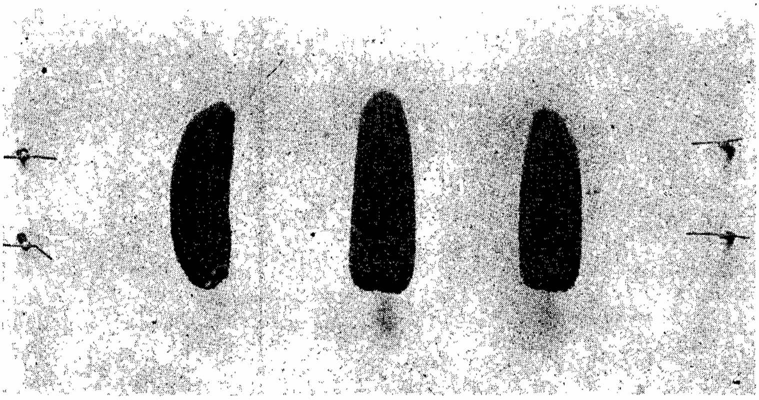
According to some of the theories now current in agricultural literature, his repeated turning under of clover crops and manures should have rendered enough of this insoluble potash available to produce a good corn crop. But, in fact, nothing of the kind happened, and he has never been able to produce good sound corn without the addition of soluble potash compounds. The yield on Mr. Hart's farm was increased from 40 bushels to about 70 bushels per acre.

Corn grown with clover and manure as fertilizer upon the farm of W. A. Hart, near Portland, Jay County.

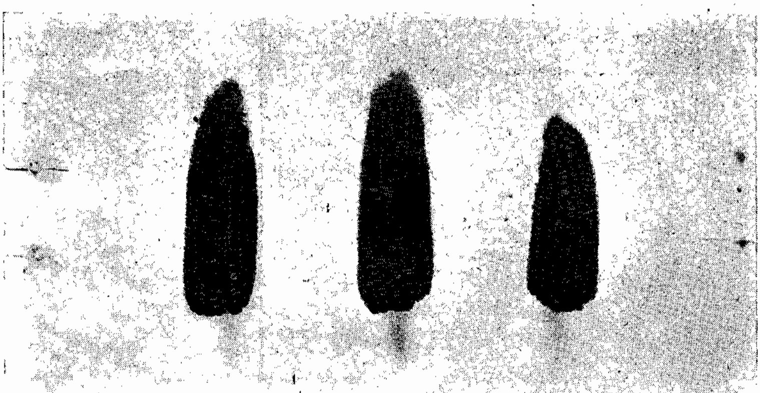


Corn grown with clover, manure and 35 lbs. sulphate potash per acre. Increase from 40 to 70 bushels per acre.

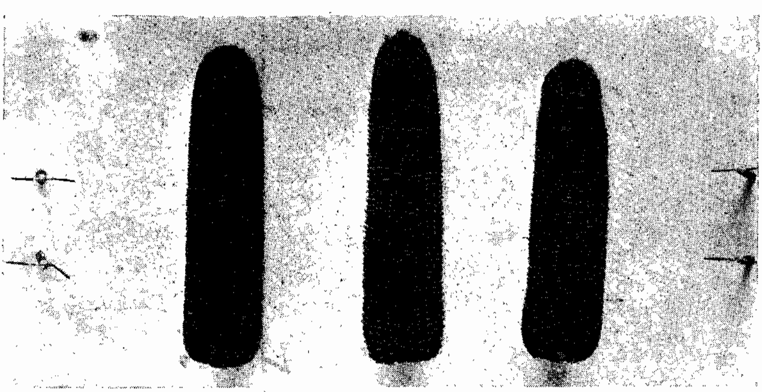
1. Corn grown with clover alone as fertilizer. 3. With clover and manure.
5. With clover, manure and 35 lbs. sulphate potash per acre.



Corn grown with clover alone as fertilizer.



Corn grown with clover and manure. The three stalks were badly broken and not used in photo as shown in lot numbered 1, 3, 5.



Corn grown with clover, manure and 35 lbs. sulphate potash per acre.

Such experimental work has been tried upon hundreds of farms with great success. Upon the reclaimed swamp lands, of which there are millions of acres in Indiana, the results are even more striking than the example given. In the case of muck lands, however, there is not even a lot of insoluble potash present. On the swamp lands it is not unusual to send the yields from nothing up to 65 or 75 bushels per acre by the application of 100 pounds of muriate of potash per acre.

The cheapening of potash as a fertilizer has rendered possible the profitable cultivation of large areas of land which were naturally too poor in that substance for ordinary productions, and has likewise rendered possible the restoration of lands that had become worn out by long-continued cropping. It also served to intensify agricultural production wherever desired, and between this supply and that of phosphoric acid and the discovery of the nitrogen absorbing power of leguminous plants, which can be used for green manuring, farmers have been enabled to dispense largely with the production and use of stable manure, which until then had been considered indispensable to agriculture everywhere.

The Chemical Composition of Indiana Soils and Methods for Soil Analysis.

ROBERT E. LYONS.

The data presented herein concerning the composition of Indiana soils was desired by the department for the study of soil origin. It includes the results of the chemical analysis of twenty different samples of surface and subsoils collected by the departmental assistants, Messrs. Shannon, Ward and Ellis.

Description of Soil Samples.

Laboratory Number.			Collector.
1.	No. 94,	first foot, Oolitic, light soil	C. W. Shannon
2.	No. 94,	second foot, Oolitic, light soil	C. W. Shannon
3.	No. 94,	third foot, Oölitic, light soil	C. W. Shannon
4.	No. 95,	first foot, Harrodsburg, light soil	C. W. Shannon
5.	No. 95,	second foot, Harrodsburg, light soil	C. W. Shannon
6.	No. 95,	third foot, Harrodsburg, light soil	C. W. Shannon
7.	No. 208,	surface, Huron, light soil	C. W. Shannon
8.	No. 208,	subsoil, Huron, light soil	C. W. Shannon
9.	No. 1,	volusia silt loam	L. C. Ward
10.	No. 2,	Miami silt loam	L. C. Ward
11.	No. 3,	Waverly silt loam	L. C. Ward
12.	No. 4,	Waverly silt loam	L. C. Ward
13.	Nos. 2-5,	Upland limestone soil	L. C. Ward
14.	No. 6,	Upland limestone soil	L. C. Ward
15.	No. 7,	limestone and shale soil	L. C. Ward
16.	No. 26,	second foot, silt loam	R. W. Ellis
17.	No. 26,	first foot, silt loam	R. W. Ellis
18.	No. 10,	first foot, limestone	R. W. Ellis
19.	No. 16,	Ohio valley	R. W. Ellis
20.	No. 10,	second and third foot, limestone	R. W. Ellis

The chemical examination to which the samples were subjected includes the determination of the total soil nitrogen, soil acidity. moisture, volatile and organic matter, matter insoluble in hydrochloric acid of 1.115 specific gravity, and the silica, iron, alumina, lime, magnesia, soda, potash, sulphate and phosphate in the portion of the soil soluble in hydrochloric acid.

METHODS OF ANALYSIS.

The determination of the soil constituents was made by the Official Method for Soil Analysis* modified as follows:

Preparation of the Sample.—Reduce the material to a fairly fine state of division by gently crushing on a clean hard wood board with a wooden roller and allow to dry for several days in the air at room temperature. The air dry soil is further reduced by gently rubbing in a mortar with a wooden pestle and the fine earth removed through a 20 mesh sieve.

(1) *Reaction of the Soil.*—Mix 10-20 grm. of soil with water to make a thin paste, allow to settle and introduce a piece of sensitive litmus paper into the supernatant fluid. (This test may be satisfactorily made by dividing a lump of moist soil with a clean knife, placing the test paper between the freshly exposed surfaces and pressing firmly together. Avoid touching the paper with moist fingers. Perspiration shows acid reaction with litmus.

(2) *Moisture.*—Weigh out accurately 5 grm. of air-dried soil, which has passed through a 20 mesh sieve, in a weighed porcelain crucible and dry to constant weight in an air bath at 105°Cent. From the percentage of moisture calculate the moisture factor. [See (6) p. 53.]

(3) *Volatile and Organic Matter.*—Heat the crucible and soil from determination (2) to full redness until all organic matter is burned off. If appreciable quantities of carbonates are present in the soil, moisten the contents of the crucible, after cooling, with a few drops of ammonium carbonate solution. Then dry, heat carefully only to dull redness and expel ammonium salts, cool and weigh. The loss represents water of combination, salts of ammonium, organic matter, etc.

(4) *Hydrochloric Acid Digestion.*—Place 20 grm. of air-dried soil and 200 cc. of hydrochloric acid of sp. gr. 1.115 in a flask fitted with a ground-glass stopper, carrying a condenser. Place in a water bath so that the level of the water comes above the level of the soil, and boil for ten hours continuously, shaking the flask once an hour. Pour contents of flask into a 400 cc. beaker and thoroughly rinse out the flask. Then filter the solution, using two 12.5 cm. filters if necessary, and employing suction with a platinum cone in the tip of the funnel if advisable. Wash thoroughly with hot water until free from chlorides. Dry the residue, ignite thoroughly and weigh. (*Insoluble matter.*)—Evaporate the clear filtrate in an

*Bull. 46, U. S. Department of Agriculture, Division of Chemistry.

evaporating dish, not more than 100 cc. at a time, until the total bulk is about 500 cc. then add 10 cc. of concentrated nitric acid, cover until spattering ceases and evaporate to dryness. Take up with aqua regia (1 part conc. nitric acid and 3 parts conc. hydrochloric acid), cover until spattering ceases and evaporate again to dryness. Repeat until organic matter is oxidized. Then take up with conc. hydrochloric acid and evaporate to dryness. Repeat once. When dry place in air bath and heat at 120° until there is no odor of hydrochloric acid. Take up with conc. hydrochloric acid, mix thoroughly and add water; warm until everything but the silica is dissolved. Filter and wash with hot water. Dry the residue, ignite and weigh (*Soluble Silica*).

Make the filtrate to 1000 cc. and label it Solution (A).

(*a*) *Fe_2O_3, Al_2O_3 and P_2O_5 collectively.*—To 100 cc. of solution A add 4-5 cc. of conc. hydrochloric acid and bring almost to a boil. Then carefully pour in a slight excess of ammonium hydroxide and boil for about one minute. Allow the precipitate to settle for a few minutes, filter and wash with hot water a few times. Dissolve the precipitate in dilute nitric acid. Heat until the solution becomes perfectly clear and reprecipitate with a slight excess of ammonium hydroxide. Filter, wash thoroughly with hot water, dry the precipitate and ignite in a weighed platinum crucible, cool, moisten with a few drops of nitric acid, ignite again and finally heat with the blast. Cool in a desiccator and weigh. The increase in weight represents Fe_2O_3, Al_2O_3 and P_2O_5.

(*b*) *Calcium Oxide.*—Have the combined filtrates from (a) slightly alkaline with ammon. hydroxide. Bring to a boil and add 20-25 cc. saturated solution of ammon. oxalate. Boil for a few minutes, then let stand until the precipitate settles. Filter and wash a few times with water. Dissolve the calcium oxalate through the paper with warm dilute nitric acid (1-5), add a few drops of ammon, oxalate to the solution, render alkaline with ammon. hydroxide and boil. Let stand as before and filter through the same paper. Wash the precipitate thoroughly with 1% ammon. oxalate solution. Dry and ignite the precipitate gently at first, then finish with the blast to constant weight so that the calcium oxalate may be entirely converted into calcium oxide.

(*c*) *Magnesium Oxide.*—Have the combined filtrates from (b) concentrated to about 200 cc., cool and slightly alkaline, and add slowly with constant stirring about 30 cc. of 10% sodium phosphate solution. Let stand one hour and add 30 cc. conc. ammon.

hydroxide; then let stand 12 hours. Filter and wash with water containing 1/4 its volume of ammon. hydroxide. Dry the precipitate and ignite*. Moisten with a few drops of nitric acid and ignite again. Finish with the blast and weigh as magnesium pyrophosphate. Calculate to magnesium oxide. The factor for MgO in $Mg_2P_2O_7$ is 0,36036.

(*d*) *Ferric Oxide.*—(1) Evaporate 100 cc. of solution A in an evaporation dish with 10 cc. of dilute sulphuric acid to fumes of SO_3. Dilute carefully with water and transfer to a 600 cc. Erlenmeyer flask. Have an excess of sulphuric acid present. Add zinc and keep on water bath till iron is all reduced. Test this by removing a drop and adding hydrochloric acid and ammon. sulphocyanide. When no red color is produced by this treatment, showing that no ferric iron is present, cool rapidly with ice, decant from any undissolved zinc that may be present and titrate with N/10 K MnO_4. If more convenient the iron may be reduced in a sulphuric acid solution by passing it through a column of shot zinc, known as a "reductor." Calculate to F_2O_3.

(2) The iron may be determined in 100 cc. of solution A by the Zimmerman-Richards method, as follows: Drive off the excess of hydrochloric acid, reduce the hot solution with a solution of stannous chloride, using one drop in excess after the color disappears, and add ice to cool rapidly. Then add 20 cc. of saturated mercuric chloride solution (the separation should have a silky appearance), 10 cc. of titrating solution (manganese sulphate and phosphoric acid) and titrate quickly with standard potassium permanganate.

(e) *Phosphoric Acid Anhydride.*—Evaporate 100 cc. of solution A to about 25-30 cc. Neutralize with ammon. hydroxide and add enough nitric acid to dissolve the precipitate. Add 10 grm. solid ammon. nitrate and warm to about 60°. Then pour in 50 cc. of molybdic solution, shake well and let stand in a warm place

*Caution is necessary if the operation is conducted in a platinum crucible. Carbon reduces magnesium pyrophosphate at 950°. The phosphorous, resulting from this reduction, attacks and seriously damages platinum through the formation of crystalline platinum phosphide. This filter paper with the precipitate should be completely ashed over a Bunsen burner. Do not ignite strongly nor heat to the fusing point of the residue until the material in the crucible is white (carbon free). If the ashing of the paper has been imperfect (mass not white), allow the crucible to cool, moisten the residue with a few drops of nitric acid, carefully evaporate the acid and heat again in the Bunsen flame. This treatment must be repeated until the residue becomes white, then ignite strongly with the blast until the residue ceases to decrease in weight.

over night. Filter off the yellow precipitate* and wash thoroughly with a solution containing 1% nitric acid and 10% ammon. nitrate. Dissolve in dilute ammon. hydroxide, wash the filter thoroughly with hot water, neutralize the solution with hydrochloric acid, then make very slightly alkaline with ammon. hydroxide. (The volume of the solution should, if necessary, be reduced to about 200 cc.) Add 15-20 cc. of magnesia mixture slowly with constant stirring. Let stand an hour and add 30 cc. conc. ammon. hydroxide. Allow to stand 12 hours, filter, wash with water containing one-fourth its volume of ammon. hydroxide, dry, ignite** and weigh as magnesium pyrophosphate as under (c). Calculate to P_2O_5. The factor for P_2O_5 in $Mg_2P_2O_7$ is 0.63758.

(*f*) *Aluminum Oxide.*—Add together the weights of Fe_2O_3 and P_2O_5. Subtract the sum from the combined weight of the oxides determined in (a). The result is the weight of Al_2O_3.

(*g*) *Sulphuric Acid Anhydride.*—Evaporate 100 cc. of Solution A to dryness. Take up with 2 cc. of concentrated hydrochloric acid and 150 cc. of water. Heat to boiling and add drop by drop 5 cc. of a 10-per cent solution of barium chloride. Continue boiling for 5 minutes and let settle. If the precipitate does not settle quickly, boil again, or keep at a temperature just below boiling until it does settle. Filter and wash with hot water until the washings show no trace of chlorides. Ignite, let cool, moisten with a few drops of concentrated sulphuric acid and ignite again, gently at first. Weigh $BaSO_4$ and calculate SO_3. The factor for SO_3 in $BaSO_4$ is 0.34296.

(*h*) *Potassium and Sodium Oxides.*—Treat 100 cc. of solution A., or the filtrate from (g), except that the precipitate of iron should be dissolved in hydrochloric instead of nitric acid, as in (a). Evaporate filtrate and washings to dryness, heat below redness until ammonium salts are expelled, dissolve in about 25 cc. of hot water, add 5 cc. of barium hydroxide solution, and heat to boiling. Let settle a few minutes and test a little of the clear liquid with more barium hydroxide solution to be sure than enough has been added. When no further precipitation is produced, fil-

*This residue may be washed with 1 per cent nitric acid, then with 1.5 per cent potassium nitrate solution, the filter and contents placed in the precipitation flask, or beaker, a known amount of standard sodium hydroxide solution added to dissolve the precipitate and the excess of sodium hydroxide determined by titrating with standard nitric acid, using phenolphtalein as indicator, 46 parts of sodium correspond to 1 part phosphorus pentoxide.

**See foot note, page 50.

ter and wash with hot water. Add ammonium hydroxide and carbonate to complete precipitation of barium, let stand a short time on the water bath, filter and wash the precipitate thoroughly with water. Evaporate filtrate and washings to dryness in a porcelain dish, expel ammonium salts by heat below redness, take up with a little hot water, add a few drops of ammonium hydroxide and a drop or two of ammonium carbonate, let stand a few minutes on the water bath and filter when cool into a weighed platinum dish. Evaporate to dryness on the water bath and heat to dull redness, until all ammonium salts are expelled and the residue is nearly or quite white. The heat must not be sufficient to fuse the residue. Cool in a dessicator and weigh KCl and NaCl. Dissolve the mixed chlorides in a *little* water. If there is an insoluble residue, filter, evaporate filtrate to dryness in a weighed platinum dish, heat to dull redness, cool and weigh the chlorides again. If all the residue dissolves place in a small porcelain evaporating dish, add a drop of HCl and 3-5 cc. of platinic chloride solution, and evaporate on a water bath *almost* to dryness. *Remove the dish before the mass is entirely dry.* Let cool and add 80% alcohol. Allow to soak for about 15 minutes, then filter** through a weighed Gooch filter, wash with alcohol, dry in air bath and finally heat up to 120° to constant weight. From weight of K_2PCl_6 calculate KCl and subtract from weight of combined chlorides. The difference is NaCl. Calculate to Na_2O. From K_2PtCl_6 calculate K_2O.

(5) *Nitrogen.*—Place 10 grm. of soil in a long-necked Kjeldahl flask, together with 10 grm. of potassium bi-sulphate and 30 cc. pure conc. sulphuric acid. Support the flask at an angle of 45° on a wire gauze and heat cautiously with a small flame. After the first violent action ceases add about 1 grm. of C. P. copper sulphate and continue boiling until oxidation is complete.

When cool transfer the digested mixture to a 700 cc. Erlenmeyer flask, equipped with a three-hole rubber stopper bearing a separatory funnel, a glass tube of sufficient length to almost touch the bottom of the flask and a potash safety bulb, connected with a long Liebig's condenser. Tie down the rubber stopper and place 25 cc. of normal hydrochloric acid in a receiving flask

**This double salt may be decomposed by gently heating in a weighed platinum dish with a few crystals of oxalic acid, the platinum residue washed with water, dried, ignited and weighed. The weight of metallic platinum multiplied by 0.48125 gives the weight of potassium oxide; the weight of platinum multiplied by 0.76142 gives the weight of potassium chloride. The weight of sodium chloride multiplied by 0.53078 gives the weight of sodium oxide.

(cap. 500 cc.) at the end of the cooler. Run in a strong solution of caustic soda through the separating funnel to alkaline reaction and distill with steam until the distillate attains a volume of almost 400 cc. Titrate the distillate in the presence of methyl-orange with normal sodium hydroxide. One cc. of normal hydrochloric acid corresponds to .014 grams of nitrogen.

(6) Calculate the results of the analysis of the air-dried soil to a moisture free basis by multiplying the percentage of each constituent by the moisture factor. The factor is found as follows: If moisture in the air dry sample is 3.19%, then 100—3.19=96.81; 100÷96.81=1.032 moisture factor.

TABLE SHOWING THE RESULTS OF THE ANALYSES.

COLLECTOR, SOIL SAMPLE, DESCRIPTION.	Shannon, No. 94. First Ft.	Shannon, No. 94. Second Ft.	Shannon, No. 94. Third Ft.	Shannon, No. 95. First Ft.	Shannon, No. 95. Second Ft.	Shannon, No. 95. Third Ft.	Shannon, No. 208. Surface.	Shannon, No. 208. Subsoil.	Ward, No. 1. Volusia Silt Loam.	Ward, No. 2. Miami Silt Loam.
LABORATORY NUMBER	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Reaction to litmus	Acid.	Acid.	Acid.	Acid.	Acid.	Acid.	Acid.	Acid.	Acid.	Acid.
Moisture from air dry at 105°C.	3.19	5.24	6.77	2.87	5.81	9.20	3.95	5.56	3.87	3.66
Total soil nitrogen	.222	.074	.121	.201	.103	.120	.138	.140	.115	.058

ANALYSIS OF FINE EARTH DRIED AT 105°C.

COLLECTOR, SOIL SAMPLE, DESCRIPTION.	Shannon, No. 94. First Ft.	Shannon, No. 94. Second Ft.	Shannon, No. 94. Third Ft.	Shannon, No. 95. First Ft.	Shannon, No. 95. Second Ft.	Shannon, No. 95. Third Ft.	Shannon, No. 208. Surface.	Shannon, No. 208. Subsoil.	Ward, No. 1. Volusia Silt Loam.	Ward, No. 2. Miami Silt Loam.
Volatile and organic	4.860	3.976	5.252	4.188	5.620	9.380	3.737	2.147	3.910	3.359
Insoluble in 1.115 HCl	85.230	80.939	74.847	86.078	75.110	61.083	84.268	79.200	83.272	84.567
Soluble Silica	.044	.066	.014	.045	.190	.085	.065	.050	.034	.086
Ferric oxide (Fe_2O_3)	3.560	5.201	6.646	3.517	6.216	8.716	4.061	5.230	3.993	4.345
Alumina (Al_2O_3)	4.668	8.191	10.363	4.432	10.376	15.775	6.034	9.870	7.860	6.167
Phosphoric acid anhydride (P_2O_5)	.159	.182	.137	.131	.213	.248	.184	.150	.137	.153
Calcium oxide (CaO)	.509	.541	1.278	.692	.732	2.695	.523	1.277	.169	.428
Magnesium Oxide (MgO)	.543	.520	.568	.519	.769	1.139	.709	.889	.378	.639
Sulphuric acid anhydride (SO_3)	.072	.066	.045	.067	.066	.068	.033	.044	.046	.021
Potassium Oxide (K_2O)	.367	.482	.535	.336	.505	.704	.415	.677	.359	.383
Sodium oxide (Na_2O)	.200	.197	.222	.214	.206	.385	.234	.373	.098	.164
Total	100.212	100.361	100.007	100.219	100.003	100.278	100.263	99.907	100.256	100.372

TABLE SHOWING THE RESULTS OF THE ANALYSES—Continued.

COLLECTOR, SOIL SAMPLE, DESCRIPTION.	Ward, No. 3. Waverly Silt Loam.	Ward, No. 4. Waverly Silt Loam.	Ward, No. 5. Upland Limestone S.	Ward, No. 6. Upland Limestone S.	Ward, No. 7. Limestone and Shale Soil.	Ellis, No. 26. Second Ft.	Ellis, No. 26. First Ft.	Ellis, No. 10. First Ft.	Ellis, No. 16. Ohio Valley.	Ellis, No. 10. Second and Third Ft.
LABORATORY NUMBER	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
Reaction to litmus	Neutral.	Neutral.	Acid.	V. F. Acid.	V. F. Acid.	Acid.	Neutral.	Neutral.	Neutral.	Acid.
Moisture from air dry at 105°C.	2.63	2.20	1.23	4.73	3.74	1.95	1.50	2.87	2.29	4.08
Total soil nitrogen	.165	.280	.101	.116	.183	.133	.099	.108	.092	.085

ANALYSIS OF FINE EARTH DRIED AT 105°C.

COLLECTOR, SOIL SAMPLE, DESCRIPTION.	Ward, No. 3. Waverly Silt Loam.	Ward, No. 4. Waverly Silt Loam.	Ward, No. 5. Upland Limestone S.	Ward, No. 6. Upland Limestone S.	Ward, No. 7. Limestone and Shale Soil.	Ellis, No. 26. Second Ft.	Ellis, No. 26. First Ft.	Ellis, No. 10. First Ft.	Ellis, No. 16. Ohio Valley.	Ellis, No. 10. Second and Third Ft.
LABORATORY NUMBER	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
Volatile and organic	5.940	6.428	3.268	4.353	6.342	2.170	2.628	4.002	5.207	3.501
Insoluble in 1.115 HCl	85.270	80.029	93.033	78.695	74.985	90.835	92.902	85.808	83.691	83.445
Soluble silica	.071	.044	.124	.076	.075	.043	.074	.085	.074	.096
Ferric oxide (Fe_2O_3)	3.047	5.290	1.094	5.370	6.508	2.313	1.715	3.488	4.053	4.359
Alumina (Al_2O_3)	3.253	5.536	1.673	8.588	7.195	3.205	2.037	5.350	4.357	7.214
Phosphoric acid anhydride (P_2O_5)	.275	.220	.111	.210	.571	.177	.119	.176	.278	.244
Calcium oxide (CaO)	1.162	1.444	.306	.764	1.300	.597	.266	.229	.852	.190
Magnesium oxide (MgO)	.437	.932	.201	.859	.380	.621	.267	.572	1.003	.627
Sulphuric acid anhydride (SO_3)	.050	.056	.042	.036	.039	.024	.018	.032	.057	.033
Potassium oxide (K_2O)	.321	.148	.347	.726	.855	.226	.131	.371	.491	.346
Sodium oxide (Na_2O)	.171	.132	.233	.252	.644	.138	.111	.120	.206	.148
Total	99.997	100.260	100.432	99.929	99.914	100.349	100.268	100.233	100.269	100.203

Indiana Soil Types.

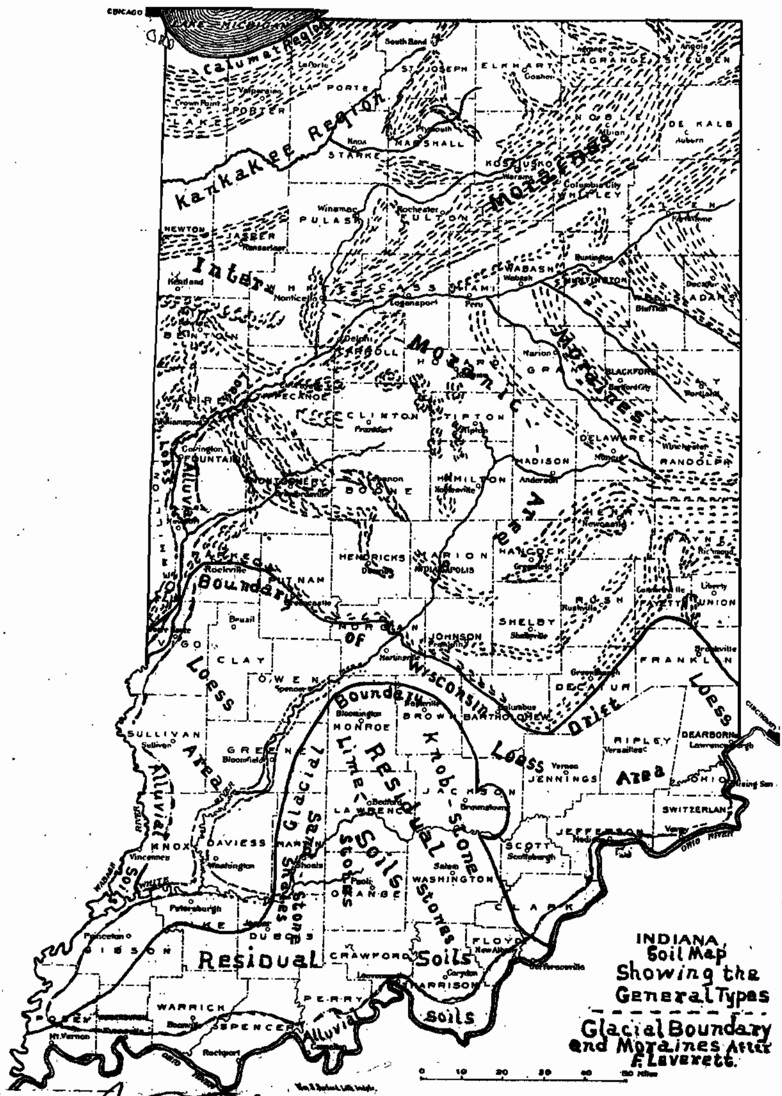
CHAS. W. SHANNON.

The excellent showing which Indiana makes among the States of the Union, in the production of wheat, corn, hay, oats, etc., and in the value of her live stock, is due chiefly to three things: First, the great variety of soil types adapted to the growing of numerous crops; second, the high average fertility of the soils; third, the degree of intelligence manifested by the farming population in the care and cultivation of the soils.

As a basis of classification the soils of Indiana may be divided into three great groups, viz., drift soils, residual soils, and alluvial soils.

The fundamental unit in mapping and classifying soils is the type. The most important things to be considered in the determination of a type are the texture, which deals with the size of the particles; the structure, which deals with the arrangement; the organic matter content, origin, color, depth, drainage, topography, native vegetation, and natural productiveness—all factors that influence the relation of soil to crops must be taken into consideration.

The grouping known as the soil class is based on texture. All soils are made up of particles of different sizes and by means of mechanical analysis the particles are separated into different grades and the various percentage relationships determine the class of soil, as sand, sandy loam, clay, etc.; and if in addition to the fine earth the soil contains particles of larger size it is called gravel, and if larger are called stones, so that it is possible to have gravelly or stony members of the various classes—as a gravelly loam or a stony clay. A set of soil classes may be so related through source of material, method of formation, topographical position, and coloration that the different types constitute merely a gradation in the texture of an otherwise uniform material. Soils, of different classes thus related constitute a series. Soils may, however, be very similar in origin and texture but may occupy so entirely different topographic positions that their relation to crop production is entirely changed, and this fact would be recognized by another serial name. Many of the soil types in any area have



been formed by the same general processes, and necessarily grade into one another in respect to all characteristics.

The names given to the various soil types in the description and on the maps which accompany this report will be correlated so far as possible with established names in Indiana Geology, in relation to the different geological formations and agencies to which they are due, and to their topographic position; and with the common terms of agriculture, in relation to crop production, native vegetation and general characteristics of texture, structure, color, drainage, etc. There will be found in nearly all areas soils of local origin and of exceptional characteristics which will necessarily be given local names, but such soils encountered will be placed as much as possible under the general types, but described as to their importance, peculiar qualities, and their behavior under cultivation.

(a) DRIFT SOILS.

The drift soils of Indiana cover approximately three-fourths of the State. Extending from the north boundary to the southern limit of the Wisconsin drift, the glacial material is on an average more than 100 feet in thickness, with a maximum thickness of about 500 feet. South of this limit about one-half of the area has a comparatively thin covering of drift due to earlier ice invasions.

"In Indiana, the glacial deposits and scorings have been recognized from the earliest days of settlement; indeed, it is in this State that we find about the first recognitions in America of the boulders as erratics and of striae as products of ice action. So long ago as 1828, granite and other rocks of distant derivation were observed by geologists near New Harmony, in the southwestern part of the State. At nearly as early a date (1842), striae were noted near Richmond, in the eastern part of the State.

"Notwithstanding the early date at which observations of glacial action began, very little attention was given to the drift, here or elsewhere, until within the past twenty years. It was commonly passed over in geological reports, much as the soil is even today, with some casual remark concerning its presence in great or small amount. Within the past twenty years interest in these deposits, because of the varied history which they reveal, has been so aroused, that many geologists, both in America and Europe, are making a systematic study of them.

"In Indiana these deposits are engaging the attention of both the State and the United States Survey. The study of general features and a comparative study of the drift of Indiana and neighboring states has been undertaken by the United States Survey, while the detailed examination of deposits has been entered upon by the State Survey.

"*First Ice Invasion.*—This State was invaded by ice which had as its center of dispersion the elevated districts to the east and south of Hudson Bay. There was a movement from the region north of Lake Huron in a course west of south over the Lake Michigan basin, Illinois and Western Indiana. There was also a southward movement from the same region across Lakes Huron and Erie, Western Ohio and Eastern Indiana. It is not known whether these movements were independent and of different dates, or whether there was simply a radiation in movement of a single ice accumulation. It should not be taken for granted that even within the State of Indiana the ice-sheet was occupying the glacial boundry completely at any one time.

"The ice deposited but little drift near its extreme limits, either in Indiana or the states to the west. There is not, as a rule, a well-defined ridge or thick belt of drift along the glacial boundary, such as characterizes the southern limit of some of the later drift-sheets, though occasional ridging of drift is to be seen, as in the Chestnut Ridge in Jackson County, and a similar ridge in Southern Morgan County. The boundary of the drift in Indiana is usually so vague and ill-defined that it is only approximately known.

"If we may judge of the deposit over the State from the outlying portions, south of deposits made by later invasions, the deposits of the first are of much less volume than those of the later invasions. They appear to include not more than 30 to the 130 feet which the writer estimates the State to carry. In the portion of the State which was glaciated but once the thickness is usually less than the 25 feet. but filled valleys will probably give it an average of somewhat above that amount. What is true of the drift of the earliest invasion in Southern Indiana is also true of the same drift of Southern Illinois and Southern Ohio. This invasion seems, therefore, to be quite widely characterized by a lighter deposition than that of the later invasion.

"*First Interglacial Interval.*—After reaching the line marked by the glacial boundary, the ice melted away and left the drift exposed to atmospheric agencies. How far to the north the land became uncovered is not known. At this time a black soil was formed, which is now concealed beneath deposits of silt, termed loess, in Southern Indiana, and beneath later deposits of till in the northern portion of the State. This soil is found at the base of the loess at various points over the southern portions of the State, but is best developed on flat tracts. It may be seen beneath the loess in the flat districts east and south of Terre Haute at a depth of from six to eight feet. The vegetable matter appears to have accumulated there just as it does on the present surface of poorly drained tracts in northern latitudes, where decay is slower than accumulation. In Western Indiana, from Parke to Vermillion counties northward, the soil is found below a later sheet of till at depths varing from twenty feet up to one hundred feet or more. Numerous references to the soil below till in this portion of the State are to be found in the 'Indiana Geological Reports.' It has not been observed in Eastern Indiana, so far as the writer is aware, but it may be present, for few valleys there reach low enough to expose it. It seems not to be so conspicuous, however, as in Western Indiana, otherwise it would have been brought to notice in well-borings.

"No conclusions have been reached concerning the length of time involved in the formation of this soil. The land at that time seems to have been so low or so flat in Indiana, that drainage lines were not so well developed in the drift surface, and we are thus deprived of one important means of estimating the work accomplished."

"*Main Loess Depositing Stage.*—For explanation and description of this period see 'Loess Covered Areas.'

"*Interglacial Stage Following the Loess Deposition.*—Between the main deposition of loess and the invasion of Northern Indiana by a later ice-sheet, considerable time elapsed; for we find that the drainage lines have reached a much more advanced stage on the loess-covered districts south of the deposit of the later ice-sheets than they have upon those deposits. It is found that large valleys had been opened in the loess and the underlying drift before the streams from the later ice-sheet brought their deposits into the valleys. This interval of valley-erosion is thought by several who have had opportunity to study it, including the present writer, to be longer than the time which has elapsed since the ice-sheet last occupied Northern Indiana.

"The question has been raised, whether the greater amount of erosion outside the later drift may not have been due to streams of large volume which accompanied the later ice invasion. That this is only a minor influence, is shown by the fact that valleys in Southern Illinois which lie entirely outside the reach of such waters are much larger than valleys of similar drainage areas within the limits of the later drift-sheet.

"It can not be urged that the region with the smaller valleys is less favored by slopes or stream gradients than the region with well-developed valleys, for the reverse is the case. There are large areas within the loess-covered districts which do not possess the reliefs and other conditions favorable for the rapid development of drainage lines which appear in much of the newer drift. In short, there appears no escape from the view that the interval between the loess deposition and the later ice invasion was a long one.

"*The Wisconsin Stage of Glaciation.*—After the interglacial interval just mentioned, there occurred one of the most important stages of glaciation in the entire glacial period. It is marked by heavier deposits of drift than those made at any other invasion. Throughout much of its southern boundary in the United States, a prominent ridge of drift is to be seen rising in places to a height of 100 feet or more above the outlying districts on the south, and merging into plains of drift on the north, which are nearly as elevated as its crest.

"The southern border of this drift sheet is less conspicuous in Indiana than in the states on the east and west. The ridge on its southern border in Western Indiana rises scarcely twenty feet above the outer border tract, and it is no more conspicuous in Central Indiana. Indeed, from near Greencastle to the vicinity of Columbus there is not a well-defined ridging of drift along the border; the limits there being determined by the concealment of the loess beneath a thin sheet of bouldering drift. From the east border of East White River a few miles below Columbus, northeastward to Whitewater Valley at Alpine in Southern Fayette County, there is a sharply defined ridge of drift standing twenty feet to forty feet above outer border tracts. Upon crossing Whitewater, where the border leads southeastward, it is not so well defined as west of the river, though there is usually a ridge about twenty feet in height.

"Although not conspicuous in Indiana by its relief, this border is about as clearly defined as anywhere in the United States. Within the space of a half dozen steps one will pass from loess-covered tracts of earlier drift to the bouldary drift of this later invasion. Accompanying the change from loess to bouldary drift, there is a change in the color of the soil, from a pale yellowish or ashy color to a rich black. This line is one of great agricultural importance. The distinct lying to the north is finely adapted to corn and timothy, while that to the south seems poorly adapted to these crops. The southern district when uncultivated, soon becomes thickly covered with briers, a feature which is not common to the black soil of the bouldary drift. In this connection we would remark, that while the loess has great fertility, the compact loess of Southeastern Indiana is adapted only to certain products. It seems as well adapted to wheat, orchards and small fruits as the black soil, and there appears to be an appreciation on the part of the residents of this restricted adaptability.''—Frank Leverett, United States Geological Survey. See Studies in Ind. Geography, Dryer, pp. 29-40.

The glacial drift is for the most part a very productive and permanent soil. The drift deposits of the State are varied in the arrangement of clay, gravel and sand, so that what is true in one area may be entirely different in another. But in general it consists of a confused mass of material from various primary and igneous rock, and is usually rich in all the necessary constituents of plant food.

The various types of the drift soils of the State are described under the following divisions:

1. The Calumet Region.

The Calumet River rises in Laporte County, near the Porter County line. It is a meandering stream, with sluggish waters, and without definite banks, except in places where they rise a little above the water level, but seldom more than 10 feet. Near its source it flows in an almost straight course and has the appearance of an artificial ditch rather than a natural stream. After flowing across the counties of Porter and Lake, it crosses the State line but three miles south of the line of its entry into Porter County, and almost due west of its source. From the State line it flows in a northwesterly direction for about seven miles, and then at Blue Island, Illinois, it makes a sharp curve, then flows northeast, then southeast and again crosses into Lake County about three miles north of its first line; then continuing eastward for 14 miles it empties into Lake Michigan, but two and one-half miles northwest of where it first entered Lake County. The area included in this great meander consists of slightly elevated morainic belt, sandy beaches and marshes.

The principal part of the Calumet area occupies that part of Indiana included in the glacial lake known in geological literature as "Lake Chicago." The area extends from the present shore line of Lake Michigan as far as Dyer, 15 miles south of Chicago, and reaching to the east to a point of crossing Deep River 2½ miles south of Hobart, thence to the northeast in a rather regular line, with arms including the present stream of Salt Creek and the head waters of the Calumet, and then at a point opposite the mouth of Salt Creek continues to the northeast in a strip two to three miles wide to the Indiana-Michigan line.

The general physiography of the area under consideration, will show the presence of a variety of soil types and on our basis of classification it will be seen that we have there an area of beaches, sand dunes, marshes and morainic ridges. A large part of this region is physically unfavorable from an agricultural standpoint, but we find a dense population, due to the influence of Chicago.

1. *Area of Beaches.*—This area includes three distinct lines of beaches. The first known as the Glenwood Beach, enters Indiana at Dyer. It extends east for four miles as a ridge and then for a distance of two miles and one-half is broken and finally lost. Then rising again, stretches out to the northeast and into the second beach. The crest of the ridge rises 20.45 feet above the marshes to the north and from 80 to 95 feet above the present level of Lake Michigan. The crest is practically level and from 40 to 70 feet wide, the base is from 40 to 60 rods wide, and with the south slope much more gradual than the north. This beach represents the first stage of Lake Chicago.

The second or Calumet Beach lies between Glenwood Beach and the Calumet River. It extends eastward about a mile and a half south of the river and along the north edge of Cady Marsh, until it joins the Glenwood Beach northeast of Ross. In general it is about the same in width and elevation as the first beach.

The third or Tolleston Beach, lies between the Little Calumet and the Grand Calumet River. Through Lake County the beach is composed of a broken ridge of sand dunes, varying in height from 20 to 30 feet. In Porter County it is largely covered with the sands from the present lake, and the original beach can not be easily distinguished.

In many places these beaches are spread out over considerable distance and are composed of several small ridges with intervening depressions. The beaches consist of a fine sand with a mixture of rather coarse gravel some distance below the surface. The vegetation consists of small, scrubby, black oak, thickets of crab-apple and other trees, and shrubs and grasses peculiar to a sandy soil. The wooded crests stand out in sharp contrast to the treeless swamp intervening. When vegetation is plentiful the ridges are less broken, since the vegetation protects from the wind. On the crest and slopes of many of the higher ridges wild grapes grow abundantly, and the fruit is large and well developed. Wild berries also grow luxuriantly. The huckleberry appears to be especially adapted to the sandy ridges, and is one of the most prolific and highly esteemed of the wild summer fruits. Wherever wild berries and wild grapes thrive tame ones can be successfully cultivated. Within recent years the growing of strawberries has been carried on quite successfully, especially in the vicinity of Furnessville. This fruit is adapted to sandy soil and hundreds of acres in the Calumet region which now produce nothing but weeds and shrubs, would be suited to strawberry culture. The sand contains sufficient calcareous and organic matter to furnish a plentiful food supply. To produce a good yield of berries there should not be an excess of vegetable matter in the soil. The raising of raspberries has also been successful in the vicinity of Furnessville, as well as on the sandy land farther south. Tame grapes are grown successfully, peach and cherry trees thrive and give a fair yield. Plum trees would doubtless grow well, since many wild plums grow on the sand ridges. The more level tracts of the sand areas, when first cultivated, produce excellent sweet potatoes, watermelons and pumpkins. But in order to obtain a good yield, year after year, a careful system of fertilization is required. Even as a result of such a system abundant yields of vegetables have been obtained from land thought to be barren. The raising of small fruit and vegetables should be encouraged, since all produce will find a ready market in Chicago.

2. *The Sand Dune Area.*—All the area lying between Tolleston Beach and the present shore line of Lake Michigan, is covered with sand. It is a series of low beaches, sand ridges and high isolated sand dunes, due partly to a former extension of the lake and partly to present wind action. The highest of these hills reach a height of 150-200 feet above the level of the lake. In some places the ridges are for long distances without vegetation. In many places the drifting sands have wholly or partly covered tall trees, and when the dead tops are projecting a few feet above the crest of the ridge they have the appearance of dwarfed trees and shrubbery, and one may rest in the top limbs of a tree whose trunk and main branches are buried in the sands. Back some distance from the lake the dunes are often covered with black oak, northern scrub pine, stunted white pine and many shrubs, grasses and other plants peculiar to a sandy soil. The sand is held in place by the network of roots from the vegetation, but if this network is

destroyed the wind storms begin to carry the sand about and entire dunes are swept away and the sands are built up into new ridges or hills farther inland. But very few forms of animal life are found among these dunes; even insect life is rare and the sound of a bird is seldom heard. The entire area is of very little agricultural value, but in places where the sand ridges may be protected and in the lower areas, fruit growing may be carried on to some extent. The chief value of the dunes is in the sale of the sand for elevating the beds of railways, filling lots, brick manufactories, etc. Thousands of trainloads of sand are annually shipped from the dunes, but the supply is continually increased by the waves and wind.

3. *Marshes.*—Throughout the greater part of its course in Indiana, the Calumet River in the summer season has a very slight current. In places the waters spread out a mile or more and the channel is so obstructed with the water-lily and other aquatic plants, that it is almost impossible to even pass down the stream in a boat. "But in the late winter or early spring time, when the melting snow and heavy rainfalls fill to the brim the low banks, the overflow covers a large amount of the surface, justifying the expression of the early geographers that 'the country around the extreme south bay of Lake Michigan has the appearance of the sea marshes of Louisiana.' It is then that the marshes of the Calumet become the temporary home of thousands of water fowl and the paradise of sportsmen."*

A very large part of the land adjacent to the Calumet River is marsh, but the largest and most important of these areas are known as Cady Marsh, lying between Glenwood and Calumet Beach; the Grand Calumet Marsh, between Tolleston Beach and the low beaches and sand dunes; the Furnessville Marsh, and McDonald's Marsh, southeast of Furnessville.

The marshes are covered with a growth of grasses, bulrushes, reeds, wild rice and other moisture-loving plants. Much of the area is too wet to even allow passing over it. Other parts have been sufficiently drained to allow the cutting of marsh hay. In the marshes wild cranberries grow and excellent crops are produced. With a little care and cultivation, the largest, best flavored and highest-priced berries can be grown on much of the marsh land now uncultivated. Large areas now uncultivated will also produce paying crops of peppermint and celery, both of which require rich, moist soil to be successfully grown.

*22d Annual Report Department of Geology, p. 42.

The soil of the marshes is a dark sandy loam, rich in organic matter. It is porous and retains large quantities of water; below the surface is a darker colored sand and below this is gravel and blue clay of the older glacial till. A noticeable feature of this area is the treeless marsh, bordered by the wooded crests of the beaches.

These marshes contain some peat, valuable as fuel. Several beds are found in the Cady Marsh and several years ago some of these were worked with profit. That of the Grand Calumet area is shallow and loose, and of a poor quality, but may be burned in its crude condition. In the marsh north of Furnessville, peat of a fine quality is found in abundance. Beneath the peat in these marshes is usually found quantities of limonite or bog ore.

Public roads are built through these marshes with difficulty, and the railways which cross over them have trouble in keeping the roadbed in suitable condition.

4. *Morainic Area.*—This includes the slightly elevated area now mostly covered with the lake sand. West of Hobart is a strip of moraine rising out of the southern limit of [illegible] Chicago, and also between Furnessville and the eastern part of the Little Calumet a practically level area rises above the arm of the ancient lake and the low beaches of the present lake. These higher areas are covered with glacial till, which is also found in a strip one-fourth of a mile to three miles wide, bordering a very large part of the outer margin of the old glacial lake. These tracts will be included in the description of the great morainic belt lying between the Calumet River region and the Kankakee River area.

The Calumet River region is traversed by a dozen lines of the great railway systems, and five great belt railways connecting these roads for transferring freight from one great trunk line to another, cross and intersect the Calumet region, giving to that area the most excellent shipping facilities. In the past few years promoters and capitalists have availed themselves of the opportunity offered by their facilities and about Hammond, East Chicago, Whiting, Hobart, Porter, Chesterton and Gary, have been located some of the largest and most flourishing factories in Indiana. Hammond at present ranks next to Indianapolis as a manufacturing center. The union of cheap coal and iron has attracted to the shores of Lake Michigan, at the new industrial city of Gary, Ind., what will eventually be the largest and most complete iron and steel manufacturing plant in the world. In fact, the Calumet region, with its many railways, its waterways, afford shipping facilities unrivalled in the world; its close proximity to Chicago, the cheap price at which factory sites can be secured within its bounds, now mark this once little valued region as one of the future great manufacturing districts of the world.

2. The Kankakee Region.

The Kankakee River rises in a large marsh about three miles southwest of South Bend in St. Joseph County. It flows in a southwesterly direction to the Laporte County line, from which point it forms the boundary between the counties of Laporte, Porter and Lake on the north, and Starke, Jasper and Newton on the south. It crosses the State line almost thirty miles south of the point where the Little Calumet crosses. From the State line it flows southwest until it joins with the Iroquois River and then turns to the northwest, where it unites with the Des Plaines, the two forming the Illinois River. The Kankakee is noted for its low banks, the sluggish motion of its waters and the peculiar direction of its course. From its source to the State line is about 75 miles. Within this distance the stream is said to make 2,000 bends and to flow over a total length of 240 miles, and according to the survey of Dr. J. L. Campbell, in 1882, the difference in level of the two points is but 97.3 feet, showing a fall of but 1.3 feet to the mile. The bed of the river is composed mainly of sand and fine gravel, but in a few places contains rather coarse gravel and large boulders.

The Kankakee marshes comprise the most extensive body of swamp land in Indiana. In the seven counties drained by the Kankakee, the original area of the marsh was almost a half million acres. In many places wild rice, rushes, water-lilies and grasses grow so abundantly in the channel as to cause the flooding of the marshes even during a summer freshet. In former years the river could scarcely be approached, but now more than a dozen railways cross the stream and numerous public highways bridge its waters. In 1872 Rev. T. H. Bell of Crown Point wrote of that portion of the Kankakee bordering on Lake County: "A river is known to be there. The blue line of trees marking its course can be discerned from the prairie heights; but only occasionally in midwinter or in a time of great drought can one come near its water channel. So far as any ordinary access to it from this county is concerned, it is like a fabulous river, or one the existence of which we 'take on trust.' Now within Lake County five north and south roads reach its borders through the marshes, while three wagon and two railway bridges span its waters. In Porter County six roads lead to it, and one railway and three wagon bridges cross it.

"The surface of this marsh land is for the most part a great treeless plain, with an average slope of about 1.2 feet to the mile in a westerly direction. On the immediate border of the river there is a strip ranging in width from a fourth to one and one-half miles, which is heavily timbered. In the southeastern corner of Lake and on adjacent territory in Porter County this timbered area widens and comprises about ten square miles. The only other timber is found on the so-called 'islands' or 'groves,' whose surfaces rise 10 to 20 feet above the general level of the marsh. All were once covered with a heavy growth of oak, hickory, black gum and other timber, the best of which was long ago removed by the early settlers along the northern border of the marsh. The surface of these islands, when cleared, becomes fair grazing lands, but the soil is in general too sandy for cultivation. On the majority of the 'islands' are houses, in which dwell the owners or renters of the surrounding marsh lands.

"*Vegetation of the Marshes.*—The open marsh is covered with a rank growth of wild grasses, bullrushes, sedges, reeds, wild rice and semi-aquatic vegetation. Over a large area which has been sufficiently drained much of this growth is annually cut, either for bedding or marsh hay. In other places the surface is either too rough, being cut up with sloughs and bogs, or never dries sufficiently to allow teams to pass over it. Oftentimes, after a long drouth, thousands of acres are burned over by a fire which sweeps along with great rapidity, consuming everything in its path.

"Between the woodland bordering the river bank and the marsh, as well as around the margin of most of the islands, there are dense thickets of elbow brush, willows, swamp dogwoods, soft and red maples and other swamp-loving shrubs. These grow so densely that a person has no little difficulty in forcing his way among them. In some places * * * large areas of land, whose soil is a rich, sandy loam, rise above the surrounding swamps. These areas were less heavily timbered than the islands above mentioned, and comprise valuable farming lands.

"*Soil of the Marshes.*—In general the soil of the marsh is a dark, sandy loam, very rich in organic matter. For century upon century a thick mass of vegetation has fallen and decayed, and mingled with its remains have been the particles of sand and clay brought down as sediment by the overflowing waters. No richer soil occurs in the State, and its depth in many places is from three to five, and even six feet. Like all soils composed of similar materials, it is very porous and has the power of taking up and retaining large quantities of water. Beneath the soil is a sand, darker colored and containing a greater mixture of calcareous and earthy matter than that found near the shores of Lake Michigan. When thrown up by the dredge it packs and becomes hard, forming excellent roadbeds wherever it has been put to that use. Below the sand are layers of fine gravel and below that the omnipresent blue clay of the older glacial tills next above the surface rock.

"*Origin of Kankakee Valley.*—All of the materials lying between the blue clay and the soil are the sedimentary deposits of a post-glacial river, for the valley itself doubtless owes its origin to the flow of waters which followed the melting of one of the later retreating ice sheets. This flow was at first sufficient in volume and velocity to erode the present valley to quite a depth through the underlying clay. Later, on account of a diminution in the supply of water, as well as the gentleness of the slope, the current became too sluggish to erode much deeper or to carry coarse material, and only the finer sediment was brought down. From a still farther diminution in the water supply, as well as by the building up of a sedimentary dam near the western end of the valley, the water for a long period ceased to flow, and a lake of shallow depth resulted. Where the waves or currents of this lake washed against the higher portions of its bed, or its shores, accumulations of sand and mud were thrown up from its bottom. These increased in size, and, rising above the water, became covered with trees. The surface of the 'sand islands' has ever since remained above the flow of waters and, as a consequence, their soil lacks those rich organic constituents formed by the decay of aquatic plants, which are possessed by the soils of the surrounding marsh.

"Again, by a new accession of water from the northwest, the barrier at the foot of the valley was washed away and the river of the present had its beginning. At first the waters flowed the full width of the valley, but in time their volume decreased and a portion of the river's bed became bare in summer. Over this a vegetation sprang up and decayed. A soil was started above the sands and was added to each year by the decay of the summer's vegetation and the sediment brought down by the overflow in the spring. The main current of the stream was thus gradually narrowed until it reached its present size. The annual overflow is yet sufficient to cover the porous soil and fill its every interstice with water, which, on account of the gentle slope, can not flow rapidly away after the subsidence of the flood. Thus the valley remains a marsh, and will so remain until a complete system of drainage furnishes a more rapid outlet for the waters which are absorbed during the annual overflow."*

The entire region of the Kankakee is commonly known over the State as the "Swamp" or "Marshes." But within this region there are several distinct soil types, grading from the richest to that which is at present absolutely worthless. Yet it is the general opinion that the area is such a worthless tract that at its best nothing more can be gained than the cutting of some marsh hay, or the use to some extent for pasture. It is necessary to make a distinction between the swamps and the marshes, which have a much wider area. We then have the following types in the region: swamp, marsh, island, peat and muck.

1. *Swamp.*—The classification of swamp is based upon topographic position and drainage conditions rather than upon the physical character of the materials of which it is composed. The term designates areas too wet for any crop and covered with standing water for the greater part or all the time. Variation in texture and in organic matter may occur even in small areas. Much swamp land is capable of drainage, and when this is accomplished they constitute lands of high agricultural value.

The swamp area of the Kankakee comprises a strip along the river from one-eighth to two miles in width. It is low-lying and generally level, though more or less broken by old stream channels and lagoons and is under water most of the year. During dry weather some areas become dry enough to allow the cutting of hay and for pasturage. The soil varies from a light sandy soil to a heavy clay loam. The color is very dark on account of the large amount of organic matter that has been added through the growth of a heavy vegetation. The area is practically covered with a heavy growth of water-lilies, wild grasses, sedges, rushes, reeds, wild rice and other water loving plants. On the immediate border of the river is a dense growth of brush, oak, poplar and willow, elbow brush, swamp dogwood, and soft and red maples. A very few acres of the swamp area has been drained sufficiently to admit of cultivation, but under present conditions it can not be drained economically.

2. *Marsh.*—This term designates low, wet, treeless areas, cov-

*W. S. Blatchley *in* 22d Annual Report State Geologist, 1897, 56-59.

ered with water much or all of the time, and supporting a growth of wild grasses, rushes, etc. The marsh area of the Kankakee occupies a broad valley between the borders of the moraines—the Valparaiso moraine on the north and the Iroquois on the south—and the swamp area adjacent to the channel of the river. For at least four months of the year hundreds of thousands of acres are covered with water and during half the remainder of the year much of this area is an immense bog or quagmire. In general, the soil of the marsh is a dark sandy loam, rich in organic matter. For hundreds of years a heavy growth of vegetation has fallen and decayed and become mixed with the sand and clay. The soils may be divided into two distinct classes which gradually merge into each other. The first, a dark gray to black, medium to fine sand is the prevailing type; at varying depths from 6 to 24 inches, the soil grades into a subsoil having about the same texture as the surface soil, but containing much less organic matter. The color ranges from a gray and yellow mottled to a reddish yellow or brown in areas where considerable iron is found. In other areas the subsoil consists of a coarse, fibrous peat, which is underlain by a dark-colored sand containing a high percentage of organic matter. On the average the surface soil of the fine sand areas contains about 60 per cent fine sand, 12 per cent silt and about 6 per cent clay. The subsoil contains about 70 per cent fine sand, 6 per cent silt and about 6 per cent clay.

The second type is a heavy clay loam, of a black color, due to a large amount of organic matter. The subsoil contains more sand but constitutes a sort of "semi-muck," due to the high clay content, which is rather impervious. It checks into cubical blocks upon exposure. In some areas this subsoil is underlaid by a layer of peat, which is underlaid by an impure marl of varying thickness. Usually the soil of this second type grades gradually into the sandy soil and in other areas the line is well defined.

Both of these soils are low lying, wet, practically level, with only a slight fall toward the stream, and hence the first and important question concerning these lands is that of drainage. Can they be drained economically?

A large acreage of the marshes has been partially reclaimed by large ditches, either dredged by private enterprise or by assessment against the adjacent land. The main ditches are cut 20 feet or more across the top and usually with considerable slope toward the bottom, the depth being on the average from 5 to 8 feet. The work is done chiefly by the use of a steam dredge. Leading into these main channels, laterals are cut, and branching off from these are minor, secondary channels or ditches. Where the banks are left too straight, freezing causes the sides to slough off and partially fill the ditch; the sand and material washed in by subordinate ditches also accumulates in the ditches, so that it is necessary to have them redredged.

Dr. J. L. Campbell in 1881-1882, by authority of an act of the Legislature, prepared a report on the drainage of the Kankakee Marsh. In part he says: "The drainage and recovery of the Kankakee marshes will include: First, the construction of a better main channel than now exists, for the flow of the river; second, the straightening and deepening of the beds of the streams which empty into the main stream; and third, the digging of a large number of lateral ditches through the swamps to the improved channels.

"The Kankakee River below the mouth of Mill Creek (in Laporte County) has a belt of timber along its banks which would make the cost of straightening the river very great.

"The great deflection of the river from the general direction of the valley makes it important to shorten the distance by a new channel.

"The line proposed for the improvement lies in a remarkable part of the valley. The line will be clear from timber obstruction, except about one and one-half miles at the lower end, where it passes through the belt of river bank timber into the old channel. The line lies for the most part in a series of deep marshes, now impassable, and well known in the neighborhood as a deep slough, sand channel, etc."

(For line of proposed channel see map in State Geologist's Report 1897.)

"At Grand Junction, the new channel or the Upper Kankakee, the old channel or the Yellow River section, and Crooked Creek, unite their waters and form the enlarged lower river.

"From Grand Junction to the State line, and to Momence, Illinois, there is plenty of water for the purpose of navigation and it is desirable that the improvement below Grand Junction should be made with reference both to drainage and navigation.

"In addition to the cost of construction, the question of maintenance of the new channel requires consideration. The same causes which produced the present crooked river will in a less degree afflict the straightened stream, and continued care will be required to preserve an unobstructed flow.

"If we assume that the river has an approximately stable bed, the result mainly of the free action of mutual forces on the sandy soil, it is evident that any increase of velocity will affect this stability and introduce a disturbing element which will require special attention.

"The banks of the new channel will likewise deliver quantities of sand into the current until they assume their proper angle of rest and are protected by grass or other vegetable growth.

"The lateral ditches will also bring down masses of sand, which will, if left uncared for, form bars where these ditches empty into the river.

"To meet these difficulties it will be necessary to keep at work one or two dredging machines until the new channel has assumed a partially stable condition.

"Grasses grow most luxuriantly in all parts of the Kankakee Valley, and from this cause we may expect that the banks will be covered very rapidly. After the drainage has been once accomplished and the lands brought under cultivation, there will be a great diminution of the volume of water to be carried off.

"The absorbent power of the reclaimed lands and the evaporating surface will be increased, and the quantity of surplus water will be proportionately diminished.

"The diminished volume will give a relative increased capacity, with less depth, and thus by degrees the new channel will become stable, while at the same time it fulfils all requirements for complete drainage."

The cost of constructing a comprehensive drainage system will be necessarily large; but the land if properly managed, should yield a profitable return on the investment. According to Dr. Campbell, the cost of the improvements for the drainage system west of Mill Creek would be not less than $294,015, and the maximum $390,450. But when we take into consideration the large area to be benefited the cost would be small when estimated by the acre.

The agricultural and crop value of the fine sand areas varies in different areas, depending largely upon the amount of organic matter contained. Areas in which the organic content is small are used chiefly for pasture when sufficiently drained. This type in some places forms dunes, the higher parts of which are either without vegetation or only a sparse growth of bunch grass. In the areas containing a greater percentage of organic matter the staple crops grow and produce fairly well, but as the organic matter is consumed the average yield decreases from year to year. The average yield of corn which a few years ago was as high as 50 bushels, is now estimated much lower. Oats average about 25 bushels. Timothy makes a fair growth but is usually coarse. The soil is not suited for clover and very little is sown. Some rye is grown, and on well drained areas blue grass grows well. The soil is very suitable for truck farming and for the growing of small fruit. The successful growing of potatoes, however, in this region, depends much upon the season and the drainage conditions, as the crop is often water-killed or rots before coming up. Some stable manure is used as fertilizer, but very rarely has any commercial fertilizer been used. This is a very fairly good grass land and on account of its decrease in organic content when cultivation begins, its value as a grain soil depends very much upon the organic matter added through the application of stable manure or changes to grass.

The U. S. Department of Agriculture, Bureau of Soils, have made examination of a sample of soil from this type, in order to obtain an idea of the manurial requirements, the result of which "by the wire-basket method indicate that stable manure has a moderate effect in increasing the growth of crops; that nitrate of soda and sulphate of potash give a small increase, and that nitrate of soda, sulphate of potash, acid phosphate, or lime used alone or in combination (except as above), have little or no effect. These results were obtained under favorable climatic conditions for the crop and by having the soil in the best possible physical condition, and, while held to be strictly applicable only to the field from which the sample was taken, they substantiate the general farm practice on this type of soil in Newton County, where considerable barnyard manure is applied to the fields with beneficial results and practically no mineral fertilizers are used."

In the heavy clay loam areas a large percentage has already been partially reclaimed and most of such areas can be successfully and economically drained. This soil is very productive and is well adapted to corn, the yield averaging from 40-50 bushels; oats, with a yield of about 35-40 bushels; rye, timothy, clover and blue grass.

In the sandy area sugar beets were formerly raised in a limited way, and produced fairly well, but at present very little attention is given to their production. The soil seems well adapted to their growth and, since they must be rotated with other crops, the beet sugar industry would certainly prove a paying industry for this area. The beet tops, and refuse beets, are also of value for feeding farm animals, and the improved condition in which land is put by beet cultivation, for better and larger yields to the crops which follow beets, is an advantage to be considered as additional money value.

"Taking into consideration their proximity to Chicago and the excellence of their soil, there is little doubt but that these lands, if permanently drained, would command from $40 to $60 per acre. It would seem, therefore, that private enterprise would have long since provided for their drainage. But in this instance private enterprise has been waiting for State aid, which has been granted only to the extent of partially removing the barrier of rock at Momence. If the State would appropriate $300,000 for straightening the river and reclaiming the lands, it would be only a loan of money soon to be repaid, for the increase in the taxable value of those lands would soon bring back to her coffers far more than the amount expended. The principal reason why such an appropriation is not made doubtless lies in the fact that the lands are, for the most part, owned in tracts of from one to ten thousand acres, instead of by many individuals. The people of the State do not believe in increasing the wealth of these speculative owners by temporarily taxing themselves. Still, as a business enterprise, the State would in time be largely the gainer, and a portion of her area now practically valueless would soon be known as the garden spot of northern Indiana."—W. S. Blatchley in State Geologist's Report for 1897, 64.

3. *Island.*—The "islands" or "groves" rise on an average 10 to 20 feet above the general level of the marsh. They vary in area from a few acres to about four square miles in extent. The surface is very irregular, consisting of slight elevations, rounded hills, and ridges, in a few cases rising to considerable height. The soil consists of a loose, medium to fine sand, varying in color from light brown to yellow, according to the amount of organic material. On the more elevated areas the organic content is very low, the sand loose and drifting, and vegetation often suffers from lack of moisture. The native growth of timber is chiefly a heavy growth of scrub, white and black oaks, hickory, black gum, hazel, sumac and a few quaking aspens. The best of this timber has been removed by the early settlers along the borders of the marshes. The surface of these islands when cleared becomes fair grazing land, but on account of the loose, open character of the soil, and the drifting nature of the sand, it has little agricultural value. Blue

grass grows well on the lower areas. Sorghum is grown to some extent for home use, and melons and early potatoes do fairly well. The growing of fruit has been tried to a limited extent and from results it seems that these areas would be well adapted to fruit. In some places this soil grades into a rich sandy loam, which is less heavily timbered and a more valuable farming land.

4. *Peat.*—The peat areas of Indiana may be divided into two groups: The deposits found within the marsh regions along the Calumet and Kankakee rivers, and the marsh areas in the region of morainic lakes. But wherever found the general characteristics are the same, and their soils may be described as one type. Peat consists of vegetable matter in various stages of decomposition occurring as turf or bog, in low situations, always more or less saturated with water, and representing an advanced stage of swamp, with drainage partially established. Within the region of the Kankakee some extensive peat deposits are found. The soil varies from a coarse, fibrous peat through all stages of decomposition to that of muck. The subsoil varies from a medium to fine sand, in which there is but a small percentage of organic matter, to a light blue clay and in some areas to an impure marl.

As has been the experience in most peaty soils, the farmers have found that the soils of this area produce fairly well for a few years after having been reclaimed, when the productiveness has begun to decline, which shows that the productions of the peat is correlated in some way with the state of the organic matter present, and that as soon as the marsh sod, leaves, trash, etc., plowed under, become thoroughly decayed or consumed the yield of the crops cease to be profitable. The results obtained on an experimental plot of peat soil in McClellan Township, Newton County, under the direction of the Indiana experiment station, show that "two plots upon which muriate of potash and sulphate of potash were applied, respectively, produced at the rate of 48.9 bushels and 40.5 bushels of corn per acre. Where no fertilizer was added the yield was 36.4 bushels. Another plot, where one ton of coarse straw was applied, produced at the rate of 58.5 bushels per acre, or about ten bushels more than the plot fertilized with murate of potash.

"It would seem from these results, together with the generally observed fact that these soils produce well until the marsh sod, etc., is destroyed, that the peat of the area is not lacking in plant food, and that the low yields are due to some unfavorable condition, which was alleviated by the addition of the coarse straw. While potash improves these soils it seems quite probable that the beneficial results are not due to the plant food thus added, but to some other effect it has upon the soil."

Corn is grown more extensively upon these soils than any other crop, but the corn is usually of poor quality. Timothy and blue grass may be grown where drainage conditions are good. The soil is adapted to special crops and considerable experimental work is being carried on in these areas. For further description and importance of peat soils, see under "Peat" in Morainic Areas.

5. *Muck.*—This type of soil is less extensive in the area under consideration than any other type discussed. The muck occurs around the outer margin of the peat deposits. It may be considered an advanced stage of peat, in which the vegetable decomposition is more complete, and in addition varying amounts of mineral matter have been added. The muck soil does not extend to as great depth as the peat, and is of a finer texture and closer structure.

In accordance with experiments as to manurial requirements of muck soils in this area, it has been found that stable manure and green manure are both very beneficial. Sulphate of potash gave a large increase in growth, but lime, nitrate of soda and acid phosphate had little or no effect. For further discussion of muck soils see under "Muck" in Morainic Areas.

3. Morainic Areas.

A study of the form and arrangement of the moraines of Indiana will show a somewhat regular series of crescentric ridges, parallel, in the main, with each other, but in places curved, twisted and crowded together so that there seems to be no general arrangement, and in some cases so inconspicuous that they cannot be traced accurately.

"When the glacier covered most of Indiana the ice was at least 500 or 600 feet deep over the present site of Terre Haute, and nearly as deep over that of Indianapolis, and it thickened gradually northward. If an observer could have stood on one of the hills in Brown County at that time he would have seen to the east of him the great wall of the ice front extending south towards Kentucky, while to the west it would have been seen in the distance stretching away towards the southwest. For hundreds of miles to the east and west, and for 2,000 miles or more to the north, the glaring white desert of snow-covered ice like that seen in the interior of Greenland by Nansen and Peary, would have appeared, stretching away out of sight with not a thing under the sun to relieve the cold monotony. It is hard to think of Indiana and her neighboring sister states as being clothed in such a shroud-like mantle as this. But it was in large part this same ice sheet, coming four or five times in succession, that covered the State with the inexhaustible soil of the drift, and made Indiana the fertile agricultural State that she is today.

"Three glacier lobes, corresponding to as many basins toward the north, entered Indiana; the Erie (with which was combined the lobe from Lake Huron) covered the eastern part of the State, and the Saginaw and Michigan lobes combined to cover the northern and western parts. The combined effect of the extent, relative strength, oscillations, conflicts and the relative positions of these lobes was the prime factor in shaping the topography of the northern half of the State. With the probable exception of the Wabash below Attica, every stream in this area had its course determined or largely modified by the features of the drift, and especially by the moraines. If the lake basins had been absent or differently located, or if the ice had advanced from a different direction, the drainage systems and the general arrangement of the physical features of this part of Indiana would have been entirely different." *

"Whenever a glacier has reached the limit of its advance and there halted a sufficient length of time to deposit a large amount of debris, such an accumulation is called a terminal moraine. This moraine does not consist, as is often supposed, of numerous large bowlders, which have been dropped on the surface in more or less regular concentric lines. Such bowlders are only an accompaniment, and constitute but a very small fraction of the moraine proper. The main portion usually consists of a thick bed of compacted tough clay, in which are many pebbles and bowlders of small size, and often pockets of gravel and sand. Such a moraine may be a number of miles in width and consist of many small parallel ridges, or it may have been a number of subordinate ridges branching off in every direction from the main one. These 'unite, interlock, separate, appear and disappear in an intricate manner. Several of these subordinate ridges are often plainly discernible. It is usually between them and occupying depressions caused by their divergence that most of the larger lakes embraced in the moraine are found. * * * The component ridges are them-

*B. F. Taylor, Studies in Indiana Geography, 1897, 97, 102.

selves exceedingly irregular in height and breadth, being often much broken and interrupted.' When very complex, the term 'morainic system' is often given to a terminal moraine."*

The great rugged and massive morainic belts are "hills of accumulation" formed by the excessive dumping and heaping up of drift along the margins and between the lobes of the melting ice-sheet. The more rugged part consist of dome shaped hills as steep as the material will lie, and in many cases reaching to a considerable height. The best examples of this type are found in Steuben, Lagrange, Noble and Kosciusko counties. There are many morainic ridges of slight elevation and gentle slopes, which are scarcely noticeable except for their influence upon streams. In addition to these are the long, narrow, curving strips thickly covered with large bowlders—known as "bowlder belts."

The principal morainic belts are, (a) *Valparaiso Moraine,* separating the basins of the Kankakee and Calumet rivers. It is about fifteen miles in width and is due to the last advance of the great Michigan lobe. The surface of this moraine to the north and northeast is more broken and irregular than farther to the south. The soil overlies a thick bed of clay, in which are imbedded many pebbles and small bowlders, and becomes quite gravely to the east.

The crest is a wooded ridge intersected toward the north by numerous other ridges composed mainly of stiff, yellowish white clay containing many pebbles and fragments of limestone.

Extending across from Illinois on either side of the main crest a high rolling prairie sets in and extends to Cedar Lake, where a wooded table land begins stretching eastward for six or seven miles, when the rich prairie again comes in on the south of the crest and extends to the vicinity of Hebron, where it is again interrupted with the timbered areas; then, again, north of Hebron, a prairie again rises until it reaches the region of high ridges and morainic lakes.

The soil of the prairie is a rich black loam, from one to three feet in thickness, overlying the clay till of the moraine. This clay varies in thickness from 40 to 65 feet, beneath which is a layer of sand of varying thickness, which furnishes a good supply of water. The soil of the wooded tract and the broken ridges to the northeast is of a yellowish white clay, far less rich and productive than that of the prairie. In the more broken parts, bowlders of large size are very plentiful. With the exception of the Calumet and Kankakee rivers, all the principal streams which drain this area have their

*W. S. Blatchley, State Geologist's Report, 1897, 31.

sources on or near the crest of the moraine, except a few tributaries which flow through breaks in the crest.

(b) *Moraines of Erie-Wabash Region.*—This region extends from the west end of Lake Erie southwestward across Ohio to Central Indiana. There are in northeastern Indiana massive moraines twenty-five miles in width, extending from Steuben County to Cass, with arms making broad, sweeping curves to the southeast, to the south of the Wabash River. This massive morainic belt consists of a part of four or five great moraines. The part covering Steuben, Lagrange, Noble, Kosciusco, Whitley, and on to the southwest through Cass, is a typical terminal moraine in all its phases. The surface is a confused series of irregular valleys and narrow, winding ridges, consisting of clay, sand and gravel and bowlders piled together, and in many places rising 200 feet or more with the slopes as steep as the material will lie. But in general the greater part of the area the slopes are more gentle and the tops of the ridges are broad, yet there is very little level ground. Throughout this morainic region the depressions are occupied by marshes or lakes ranging in area from the fraction of an acre to several square miles and numbering more than a thousand within the State. Within this region is a great variety of soils. Underlying all is the stiff, gravelly clay, similar to the great mass of drift, and forming the surface soil over the greater part of the area, but containing in places great heaps of sand, gravel and bowlders. Many shallow lakes have been entirely or partly filled with heavy growth of vegetation and converted into marshes or muck lands, much fine material has been washed into the old valleys, producing a fertile soil of fine texture.

"The whole region was originally covered with a heavy growth of hardwood forest, except the marshes, or so-called 'wet prairies,' and a few small tracts of genuine dry prairie in the northwest. No equal area has furnished more valuable timber, oak, walnut, beech, maple, ash, elm, sycamore, poplar, hickory, locust, cherry and others. For unknown centuries before the advent of the white man, the Indian hunted in the forests and fished in the lakes. The Maumee-Wabash was an important route of canoe travel between the Great Lakes and the Ohio. The carry or portage from the head of the Maumee over to the little stream which now occupies the Erie-Wabash channel was short and easy, and in 1680 LaSalle found there an Indian village and fur-trading post. Here was a favorite congregating place for men, savage and civilized, at the forks of four water-ways, and the spot was naturally predestined to be the site of an important town. It has passed through all the regular stages characteristic of so many American towns, Indian village and portage, trading post, military fort, modern city. It was as easy a route for the canal boat as for the canoe, and as early as 1834 the Wabash and Erie canal was constructed through it, having its summit level in the abandoned glacial drainage channel, and fed with water from the St. Joseph. Towns sprang up all along its course and Defiance, Fort Wayne, Huntington, Wabash and Peru owe their early start and substantial growth to their situation upon this line of communication.

"Twenty years after the canal, the Wabash Railroad followed the same route and now three east and west trunk lines avail themselves of the Fort Wayne gap to pass through the highlands. At the same time the Maumee Lake bottom, known as 'the black swamp,' with its tenacious soil, poor drainage, and absence of road-making materials, offered a serious obstacle to immigration by wagon from the east, delaying the settlement of the country until long after that of Southern Indiana. The tide of immigration did not come in until the decade 1840-50. The heavy forest was but an indication of the fertility of the soil. The pioneers had the strength and courage to attack, and with incredible labor to clear it away. Their reward was the rich farms which now form the greater part of the wealth of the region. Many of the marshes have been drained, among the rest the Erie-Wabash channel itself, thus adding to the health and productiveness of the country. The hills and lakes remain, and render the region of the higher moraines among the most picturesque and beautiful under the sun. The Maumee Lake bottom has been last to come under the hand of man, and within the last year many square miles of virgin soil have been cleared, drained and brought under profitable cultivation. Every feature of the Erie-Wabash region, natural or artificial, marsh, lake and hill, forest and farm, lonely cabin and prosperous city—is, in a real sense, the gift to man from the Erie lobe of the North American ice-sheet."*

Other Moraines.—Numerous arms of the chief moraines branch in every direction, and the remnants of other moraines are found scattered over the entire area as far south as the boundary of the Wisconsin drift. Some of these are several miles in width and rise to a considerable elevation above the surrounding country, and are decidedly undulatory and rolling; others are almost inconspicuous except their presence is shown by their influence upon drainage.

*Charles R. Dryer, in Studies in Indiana Geography, 1897, pp. 51, 52.

In general the texture of the soils is a yellow clay, mixed with sand and gravel, and frequently grading into a fine sandy loam.

In the morainic region the various kinds of soil may be included under the following types: fine sand, sandy loam, black clay loam, silt loam, peat, muck and meadow. Of these general types many divisions might be made by one type grading into another, giving a difference in fineness, color, etc.

1. *Fine Sand.*—This soil is found chiefly in the low hills and ridges and probably represent deposits of glacial outwash made during the recession of the ice-sheets, and has since been modified to some extent by the wind action. The soil consists of a medium fine sand, grading from light to dark brown, due to the amount of organic matter contained. The subsoil is about the same texture as the surface, except in places it becomes more gravelly. Drainage conditions are well developed and crops often suffer from the effects of drought, hence the wet seasons are more favorable for this type. Corn, oats, rye and timothy are the principal crops, and the yields are only fair. The soil is well adapted to vegetables and melons, but very little attention has been given to such crops.

2. *Sandy Loam.*—The surface of the area covered by this type is for the most part undulating and rolling. The soil is a medium to fine sandy loam, and contains a high percentage of organic matter, giving to the soil a very dark color. The subsoil underlying this type varies greatly in different areas. It consists of clay sand and gravel in varying proportions, usually becoming more gravelly with depth. In some small areas the surface soil becomes quite gravelly and some large bowlders are found scattered over the surface. Natural drainage is good, but artificial drainage increases the productiveness of the soil. This type in general is a productive soil and is adapted to a great variety of crops; corn and oats are the chief crops. Timothy and clover are grown, but it is usually difficult to obtain a good stand of clover on account of the dry summer weather. Blue grass is grown for pasture and wheat is grown to some extent, but its yield is uncertain. Some fruit is grown and the soil seems fairly well adapted to the growing of fruit.

3. *Black Clay Loam.*—This is a heavy clay loam, carrying about equal proportions of clay and silt and a considerable percentage of fine sand. The color is due to the organic content and this type varies in color from black to yellow. The soil when wet is often of a mucky nature, and if worked when in this condition large clods are formed, which become very hard and can scarcely be pulverized until moistened again by rain. The subsoil is a mucky, yel-

low colored clay, almost impervious, and causes the natural drainage to be very poor. This type occupies the basin-like depressions between the hills and ridges and the surface is generally level. The fine texture of this soil has been increased by the washings of fine particles from higher elevations. Corn is the principal crop of this soil, and yields on an average about 45 bushels per acre. Oats yield from 30-40 bushels per acre, but often lodge badly and the crop is uncertain. Timothy yields well and the better drained areas are well adapted to the production of clover.

4. *Silt Loam.*—This type is found chiefly occupying the upland along the Wabash River, and belongs both to the morainic and intermorainic region. It is due to the deposition of loess over glacial drift. The greater part of the surface is level, but in places is somewhat broken. On the level areas the soil is much deeper than on the rolling tracts. It grades in color from a brown to black loam, and contains a very high percentage of silt. Large amounts of organic matter have been added to the level areas and shallow depressions, while in the more elevated parts organic matter is almost lacking and the soil is of a very light color and far less productive. The principal part of the area comprises the typical prairie lands of this section with the heavy nature growth of grasses and other prairie vegetation. Along the streams and in the more hilly parts are found forest growths of oak, ash, walnut, maple and hickory. In general the natural drainage is good, but artificial drainage is necessary in the lower areas. Corn, oats, wheat and clover are the chief crops produced. The average yield of corn is about 45 bushels, oats about 50 bushels, wheat about 20 bushels per acre, and clover about two tons per acre. Wheat does better on the lighter areas, and corn produces better on the heavy, dark areas. The hilly tracts are used principally for pasture and fruit. The subsoil grades from a sandy silt or clay to a medium gravel, and contains a considerable number of iron concretions, which impart a rusty yellow color to the soil. From experiment as to the manurial requirements of this soil, the Indiana Experiment Station has found that an excellent increase in production may be obtained by the use of stable manure; that nitrate of soda, with either sulphate of potash or acid phosphate, will give a large increase, and that cowpeas and lime, acid phosphate alone, or nitrate of soda alone, will give a fair increase. Sulphate of potash or lime gave only a small increase. The samples were taken from a field that had been planted to corn most of the time for 20 years, and no fertilizer of any kind had been used, and the average yield was about 30 to 35

bushels per acre. In the tests wheat plants were used as an indicator, and the results were not held to be applicable to other and unrelated crops, or to fields which have received treatments essentially different from that from which the sample was taken.

5. *Peat.*—Peat is found to some extent in all parts of the areas covered by the Wisconsin drift, but the large areas found in the three northern tiers of counties. These areas are the site of old glacial lakes, bayous and sand-dune lake basins. The soil is of a brownish color and varies from a coarse, raw fibrous peat, in which the percentage of combustible matter is extremely high, through all stages of decomposition to that of muck. The peat is usually much deeper than the muck, generally extending to a depth of 8 to 12 feet. The subsoil varies from a medium to fine sand, containing a very low percentage of organic matter. In some places the subsoil is a light blue or gray sandy clay, and in some small areas the subsoil is a marl. The peat deposits have been found by the gradual accumulation of organic remains in low situations, with a very slight fall toward the drainage. These areas are always more or less saturated with water, representing an advanced stage of swamp with drainage partly established. In the spring of the year large amounts of water accumulate, both from melting snow and spring rains, so that practically the whole areas are under water. The drainage of these areas is of very great importance to the State and especially to the land owners of these sections. Large areas have been fairly well drained by a system of dredged ditches, but these have not proven satisfactory; the cost has been great and the desired results have not been obtained. The ditches are difficult to keep open on account of the slight fall. The tile drains become choked with fiber and sand. An economic drainage would mean millions to this part of the State. In most cases the peat land produces fairly well for two or three years after it has been drained, and then begins to decline, but it is believed that the soil will gradually improve with careful cultivation, and may be especially adapted for special crops. Considerable corn is grown upon this soil, giving for the first few years a fair yield, but of a rather poor, chaffy quality. Grasses may be grown on reasonably well drained areas, but with little profit. Some areas are adapted to truck farming, but to the present time but little has been undertaken. When the peat is reclaimed it should be well adapted to corn, rape, grasses, potatoes, onions, celery, cranberries and similar crops in small fruit and truck. From investigations of the experiment stations of Illinois, Wisconsin and Indiana, on these and similar soils, it has been

found that they are in need of potash, and in some cases potash, phosphoric acid and stable manure should be applied to make them productive. But in many cases it has been found that where coarse straw was applied the yield was greater than where muriate of potash was used. In the areas under these conditions it would appear that the peat is not lacking in plant food, and that the low yields were due to some unfavorable condition which was overcome by the addition of coarse straw. Both stable manure and green manure are beneficial on these soils. These soils contain a high percentage of nitrogen, which would make it peculiarly adapted to corn, rape, grasses, etc., mentioned above. Aside from the condition already given, the chief difficulties in farming peat soil are great amounts of water in spring, danger of frost and the accumulation of nitrates. Even under the best condition, the soils are often too wet to admit early spring sowing, and crops are often planted two or three times before a successful stand is secured. This shortens the growing season and frost often comes before the crops mature. The presence of nitrates stimulate stalk and leaf growth, and being in excess, the grain crops fall badly.

Peaty soils and all those containing large amounts of humus are liable to visible shrinkage. When passing from the wet to dry conditions, but in their texture being loose and porous, such shrinkage does not usually cause cracks in the soil or injure the roots, as is the case in heavy clay lands. The entire mass of the soil shrinks downward, but rarely cracks on the surface. From these observations it shows that the introduction of ''humus'' into heavy clay soils is among the best means of improving their tilling qualities.

6. *Muck.*—The ''muck'' areas of Indiana occur most extensively in the four northern tiers of counties and especially in the localities where the peat deposits are largest and most numerous. This type is composed of a more or less thoroughly decomposed vegetable mould occupying low, wet places, with little or no natural drainage, and are locally known as ''marshes.'' The surface soil is usually of a very black color, grading into a reddish brown down from the surface as the depth increases. The muck varies in depth from 1 to 3 feet or more. The muck is an advanced stage of peat decomposition, with the addition of mineral matter, brought in by water and wind. A white sand or sandy clay usually underlies the muck. This type is found in areas of a few acres up to 2 and 3 miles in extent. The muck areas are almost level and are supposed at one time to have been shallow lakes or ponds. In some cases muck is

found entirely surrounding a lake; it is also found in streams in narrow strips. The vegetation consists of swamp grasses, coarse sedges, mosses, golden-rod, willow, huckleberry bushes, cottonwood, alder and birch, with a very few larger trees around the edges.

Artificial drainage is necessary before the areas can be used, except for pasture and for marsh and timothy hay, which are generally of a poor quality, but yielding from 1 to 3 tons per acre. When drained, muck is very productive and well adapted to corn, potatoes, cabbage, onions, celery, peppermint, etc.

Much has been accomplished in drainage by the large open ditches which are made by the steam dredge; the tile drains empty into the larger ditches. But at the present time more than three-fourths of the area remains undrained.

In recent years the muck lands, which were formerly considered of very little value, are becoming valuable and some of them, where truck farming is carried on, sell as high as $150 per acre. Without fertilizer, the yield is less. The improvement of the muck is brought about by mixing it with clay, sand, manure, or straw, by adding fertilizer and by bringing several inches off the surface in the thicker beds. The plowing under of the fertilizer, such as straw and manure, not only enrich the muck by supplying potash, but also interferes with the capillary rising of the water level, and thus permits the soil to dry out. In general the clayey subsoil is preferred to that of underlying sand.

"Chemical analysis of the muck by the Agricultural Station of Indiana, shows a typical muck soil of Indiana, when dry, to contain about three-tenths per cent of potash, the same amount of phosphoric acid, and from three and one-half to four per cent of nitrogen; while a clay subsoil of the State has about two per cent of potash and one-tenth per cent each of phosphoric acid and nitrogen. This indicates that the muck runs very low in potash and high in nitrogen, while the clay has a fair amount of potash, but becomes in a few years deficient in nitrogen. Sand runs much higher in potash and lower in nitrogen than the muck; and straw and barn-yard manure contain considerable amounts of potash.

"When muck is added to clay or sand, the improvement of the soil may result from the power of the muck to absorb and retain water, thus, to some extent, replacing the dry condition by a moist one and influencing the temperature of the soil. The various organic acids attack the complex silicates, breaking them down through solution into the more simple forms. Solution and weath ering brings on disintegration, which produces a more comminuted form of the material. Ammonia is added, which gives nitrogen to the soil.

"The effect of mixing muck, clay and sand is very well illustrated in Allen County, on the farm of Thomas Elliston, in the southeast quarter of section 26, the southwest of 25, the northwest of 36, and northern half of 35 (30 N. 11 E.). Here, where Lost Creek empties into Little River, 200 acres are composed of a mixture of muck, clay and sand. This association resulted from the fact that Lost Creek has a fall of 7½ feet to the mile, while Little River has only 1½ feet. At times of flood the steeper grade developed a strong current in Lost Creek, which, upon meeting the more quiet waters of Little River, slackened its rate and deposited sand and silt upon the muck beds that fill the river valley. Corn crops raised on this mixed soil are reputed to average at least 70 bushels to the acre, while the adjacent land, composed of either muck or sand, will scarcely yield 47 bushels to the acre. This seems to indicate that none of these soils alone contain all of the constituents necessary for plant growth, but the combination furnishes the necessary food. Numerous other cases were brought to the writer's notice, where the farmers would haul sand or clay onto the muck, or vice versa. In all of these instances, the results are said to have been very good.

"Although the burning of the surface in order that the inorganic material contained by the muck may be concentrated, is frequently resorted to with good results, yet the waste of fuel is enormous, and the improvement in the soil will not begin to recompense for the loss of peat. Mr. H. Fancher, whose farm is located five miles west and one mile north of Hamlet, Starke County, experimented by turning 1½ acres to a depth of 6 inches. Afterward he put on 300 pounds of Armour's High Grade Potato Grower Fertilizer, which is said to contain 8 per cent of potash. The yield on this 1½ acres was 1,030 bushels of onions, while on ground adjacent to it that was not burned, but was treated with the same amount of fertilizer, the crop was less than 400 bushels to the acre.

"In section 30 (33 N. 13 E.) of Dekalb County, about 4 inches of muck was added to a clay soil that was very cloggy. During the first season the muck dried out and did not mix with the clay, the clogs remained and the production was lower than previously. But when the fall rains came on, followed by the freezing and thawing of the winter, and then the spring rains, the muck and clay became well mixed. The clogs disappeared and the annual yield was decidedly increased. The kernel of the potato, instead of being mealy and thick shelled, like that raised on the pure muck in this vicinity, was firm and large like that produced on a clay soil.

"Farmers who have both sand and clay underlying their muck, say, in general, that they prefer the clayey subsoil. Where the land has been drained the muck overlying the clay requires less fertilizer to keep it in a good condition, and seems to improve with age. The writer will suggest two possibilities that may account in part for this improvement. It is to be noted, where the muck beds do not exceed 2½ or 3 feet, that the crayfish carry up the clay to the surface much more than they do the sand. This permits a more thorough mixing of the muck and clay than of the muck and sand, and consequently a greater addition of potash to the former than to the latter.

"Charles Fairfield, whose farm lies several miles northwest of Ft. Wayne, experimented by putting the muck on a sandy soil, which previously had grown twelve bushels to the acre. The same soil, after manuring, yielded 35 bushels to the acre. The first year after putting on several inches of muck and plowing it in, the production was less than 12 bushels. The muck did not seem to dry out and become well mixed with the sand. The next year there was a great improvement in the soil and a yield of 35 bushels to the acre, and for several succeeding years the crops were no smaller."*

Undrained muck land sells at an average of about $25 per acre, and when drained the value is more than double, often selling for $75 and upwards. Corn in the drained areas yields from 40-75 bushels per acre. At present the greater part of this type is used for pasture and hay.

7. "*Meadow.*"—The term meadow is used to designate low-lying, flat, poorly drained land, in areas adjacent to water courses, or subjected to overflow or seepage, such as may occur in any soil type. The term represents a condition, irrespective of soil texture or vegetation. Soils of this type are used chiefly for pasture or forestry, and can in most cases, when cleared and drained, be made tillable land, of high value for the production of various general farm crops. The soils of this type frequently vary in texture, even in very small areas, and being subject to overflow, the character of the soil at any point may be changed, and does not permit of detailed mapping as distinct types.

*A. E. Taylor, State Geologist's Report, 1906, p. 286.

4. Intermorainic Area.

Lying between the morainic belts are large areas comprising the most fertile agricultural tracts within the State. This area extends as far south as the limit of the Wisconsin drift. While the limit is not marked by a well-defined ridging of drift along the border, the limit is determined by the concealment of the loess beneath a thin sheet of bowldery drift. Within a very short distance one will pass from loess covered tracts of earlier drift to the bowldery drift of the latter invasion. The change is also marked by color of the soil from a pale yellowish or ashy color, to a rich black. It is this rich black soil which is the prevailing type within the intermorainic area, and that which gives to it its great agricultural importance. It is this soil, especially, that places Indiana in the front rank as a great corn producing State. It is not to be understood that this is the only type within this area, but there are numerous types—sandy loam, silt loam, gravel areas, peat, muck, meadow and various kinds of clay loam grading through all colors, containing varying proportions of organic matter, and variously adapted from an agricultural standpoint. The silt loam, peat, muck and meadow areas of other areas have been described in the foregoing pages, and need here only be mentioned as occurring within the area under consideration, since these types, wherever found, are of the same general characteristics and crop values.

1. *Sandy Loam.*—The soil of the sandy loam type generally occurs on a rolling topography. The soil or the higher elevations being a light-brown sandy loam, underlain by a yellow sandy clay or gravelly clay. The depressions have a black sandy loam of greater depth and containing less gravel than the higher elevations, and the subsoil in general is a heavy, bluish gray, sandy loam. Near the streams both the soil and subsoil contain considerable gravel. Several bowlders are found scattered over the surface. Small areas of this type are found scattered through the other types of this region. The sandy loam is especially adapted to truck farming and the growing of small fruits. Corn yields from 25 to 60 bushels, wheat from 10 to 20 bushels. Clover and timothy give fair yields.

2. *Gravel Areas.*—Small areas of gravelly soil occur within the other types. These grade from a coarse sand containing large pebbles to a coarse gravel in which are found numerous large bowlders. These gravelly areas frequently occur as the subsoil of other types. In the sandy loam areas on the higher tracts are spots

which are quite gravelly. These spots of coarse sand and gravel are clearly defined during the growing season, as the crops upon them frequently suffer from lack of moisture. Corn, clover, oats and wheat are the principal crops. The yields are best when the rainfall is quite evenly distributed throughout the growing season.

3. *White Clay Loam.*—This type is found in small areas usually bordering muck areas. The soil is somewhat silty in character and contains a large proportion of fine sand. It is of little agricultural value, yet in the better parts it produces a fair yield of corn and wheat, and is well suited for pasture land.

4. *Yellow Clay Loam.*—This soil is of a brown color when wet or newly plowed, but becomes light yellow when dry. It contains considerable coarse sand, and a relatively high percentage of silt. Many small pebbles are found in the surface of this soil and a few small bowlders, but not in sufficeint quantity to interfere with cultivation. When dry the soil is light and easily tilled, but when wet becomes quite sticky; in general it contains a small amount of organic matter. The subsoil is a heavy, tenacious clay of mottled yellow color, grading into a gravelly, sandy loam. The natural drainage conditions are only fair and artificial drainage is necessary for the best results. Corn is the principal crop and yields on the average from 35 to 45 bushels; wheat will, in favorable seasons, yield 20 bushels, and oats yield about 40 bushels.

4. *Black Clay Loam.*—The soils under this heading consist of two or three distinct types. The chief divisions are the timbered areas of central and eastern Indiana, and the prairie tracts of the central western part of the State.

The native forest growth of the first division consists chiefly of red and white oak, walnut, beech, ash, wild cherry, hickory, elm, etc. The soil consists of a dark brown or black loam of fine texture, and very rich in organic matter. The areas are practically level, but are low lying in reference to surrounding types. In some places where the drainage is bad the soil is of a heavy nature and is apt to form large, hard clods when plowed. The entire area of this type must be well drained by artificial ditches in order to be in proper condition for successful tillage. The depth of the soil varies from 6 to 24 inches. The subsoil varies from a heavy loam to a medium to fine gravel, mixed with some clay. All the grain crops are grown successfully on this type, but corn gives the best yield, often producing as high as 75 bushels per acre, but averaging about 40 bushels. When the season is not too wet oats grow well and give a good yield, as in former years; it now averages about 12-15 bushels per acre. Much of the wheat in the past few years has been winter-killed, and the acreage grown to wheat is becoming less each year, and more oats are sown. The oats are used largely as a nurse crop for clover and timothy, both of which yield well in this area.

The soil of the second division, the black loam of the prairie tracts, is designated by the United States Bureau of Soils as the Marshall loam, which, by the mechanical analysis, shows about 24 per cent clay, 37 per cent silt and 21 per cent fine sand. The area covered by this type is mainly a level plain sloping gently toward the drainage channels. The surface is sometimes broken by small, shallow depressions and slight knolls and ridges. The surface soil is a black or dark brown loam, varying in depth from 8 to 24 inches. In places this soil has the characteristics of a silt loam. On the low knolls and ridges the soil is more sandy than the typical loam. Below the surface the soil becomes lighter colored, and at an average depth of 12-18 inches the subsoil grades into a yellow clay loam, which, as depth increases, becomes more sandy and in some areas becomes coarse gravel. Some gravel and a large number of bowlders occur on the surface. Most of these have been picked from the fields and piled along the fences, and in some places have been constructed of these large bowlders. They are also used for foundation stone for buildings. The dark color of the soil is due to the large amount of organic matter which has been added by the decay of a heavy growth of prairie vegetation, and as the organic content decreases on the more elevated tracts and in the subsoil the color becomes lighter. The clay subsoil is often a mottled yellow, due to the presence of irony concretions.

In the more rolling parts natural drainage conditions are well developed, but in the level areas tile drainage is necessary to insure productions of good crops. A large proportion has been tiled, but there yet remains much to be done before the largest yields can be expected.

The soil of this type is especially adapted to the production of corn and oats and has been used almost exclusively for these crops. This continual cropping system has caused the productiveness of the soil to decline, so that the average yield is considerably lower than 15 or 20 years ago. The average for corn is about 35-40 bushels per acre. Some wheat is grown, but does not give a good yield. Clover and timothy are grown to some extent, but it is often difficult to get a stand of these crops. Blue grass and white clover are sown together for pasture. Fruit and vegetables are grown for home use. They produce well on this soil, but as yet very little attention has been given to their cultivation.

"There are a number of unproductive spots in the Marshall loam that are locally called 'alkali spots.' Their unproductiveness, however, is not due to the presence of alkali salts. Before this part of the county was drained these areas, which occupy depressions too small to be shown on the map, were known as 'sink holes' or 'quicksand' areas, and the soil is now generally somewhat more sandy than the neighboring productive lands, while the subsoil is largely composed of sand. Liberal applications of stable manure increase the productiveness, and large quantities of straw have been burned on them with good results.

"A test was made to determine the manurial requirements of this type, using a large sample collected about 1½ miles west of Goodland. The soil here consists of a dark brown to black, heavy silt loam, and the sample was taken to a depth of six inches. The land has been in cultivation for from twenty to thirty years, the chief crops being corn and oats, with some grass. Moderate applications of stable manure are used, but no other fertilizers. Yields of both corn and oats average about 40 bushels per acre, while hay averages about 1½ tons per acre.

"The results of the examination of this sample by the wire-basket method indicate that stable manure has a large effect in increasing the growth of the crop. Results obtained with nitrate of soda, sulphate of potash, acid phosphate, and lime, used separately and in various combinations with each other, were small, and were no greater when two or more of these substances were used in combination than when one is used by itself.

"These results are held to be applicable only to the field from which the sample was taken, but it may be stated that they agree well with the experience of farmers upon this type of soil."*

5. Loess Covered Areas.

The line between the loess covered areas and the bowldery drift is one of great agricultural importance. There is a notable difference of topography, soil, vegetation and general improvement. The soil changes from the rich black, so well adapted to corn and oats and hay, and many special crops, to that of the loess covered area, with its pale yellow color, and producing only fair yields of the

*Field Operation, Bureau of Soils, 1905, pages 16-18.

staple crops, with the exception of wheat, which is usually above the average; but the soil is somewhat well suited to the growing of fruit, and special crops, when care and intelligence are manifested in cultivation. The loess of Indiana is more compact, and less uniform in texture and of less fertility than soils usually described as typical loess. These soils contain about 75 per cent silt and 18 per cent clay, and a small percentage of medium and fine sand.

"Loess is a term applied to a fine-grained, yellowish silt or loam, which overspreads the southern portion of the glacial drift in North America and extends thence southward on the borders of the Mississippi Valley to the shores of the Gulf of Mexico. The term was originally applied to deposits of this character on the Rhine, which have extensive development in the German lowlands and bordering districts in Northern Europe. Microscopical analysis shows it to consist principally of quartz grains, but it usually has a variety of other minerals such as occur in the glacial drift. It is apparently derived from the drift, either by the action of the water or wind. In many places, especially the borders of the large valleys, the loess is charged with calcareous matter which partially cements it. When excavations are made in it the banks will stand for years and will retain inscriptions nearly as well as the more solid rock formations. It has a strong tendency to vertical cleavage, and usually presents nearly perpendicular banks on the borders of streams which erode it. It often contains concretions of irregular nodules of lime and of iron and manganese oxides. It is also often highly fossileferous. The fossils are usually land and fresh-water mollusks, but occasionally insects and bones of mammals are found.

"There is in Western Indiana along the Wabash, a loess of more recent date than the main deposit, but it is confined to low altitudes, seldom appearing more than one hundred feet above the river level. In Western Illinois, a loess has been found which is older than the main deposits, but it has been seen in only a few places and is apparently a thin and patchy deposit. It is thought by Professor Salisbury that the loess of the lower Mississippi was deposited at two distinct stages. Loess is, therefore, a deposit which, like sand or gravel, may be laid down whenever conditions are favorable, but the great bulk of it having been deposited at a definite stage of the glacial period, it seems proper to refer to that stage as the loess stage.

"In Southern Indiana, and in bordering portions of Southern Ohio and Southern Illinois, there is a continuous sheet of pale silt, locally termed 'white clay,' which is thought to be a phase of the loess. It covers the interfluvial tracts as far north as the limits of a later sheet of drift and has been discovered at a few places below that later drift. It probably extended much farther north than its present exposed limits, for the ice-sheet appears to have receded far to the north at the main loess depositing stage, thus leaving the surface free to receive these deposits. The northern limit of the exposed portion in Indiana is marked by the 'Wisconsin boundary.' This deposit is usually but a few feet in thickness, seldom exceeding eight feet. Along the Wabash, however, where it becomes a typical loess, it often reaches a thickness of twenty to twenty-five feet It may be readily distinguished from the underlying till by texture and color. It contains only very minute rock fragments, while the till is thickly set with stones of all sizes. In color it is a paler yellow than the till. There is usually also a weathered zone at the top of the till and sometimes a black soil, making still more clear the line of contact.

"The loess and its associated silts is found at all altitudes in Southern Indiana; from the low tracts near the Wabash, scarcely 400 feet A. T., up to the most elevated tracts in Southeastern Indiana, which in places exceed 1,000 feet A. T. The great range in altitude is one of the most puzzling features of the loess. The same perplexing distribution is found in Europe as in America. As yet no satisfactory solution for the problem of its deposition at such widely different altitudes has been found."*

Large areas within the limits of the region here described belong to the alluvial soils, and will be presented under that heading. The silty loess material has contributed considerable material to some of the alluvial types. Some areas of peat are also found and large marshes are numerous, especially in the southwestern part of the State. In Knox County about 4,000 acres have been reclaimed in the vicinity of Decker by the completion of the Plass ditch. The ditch runs through six miles of what has been the least valuable land in Knox County. About 25,000 acres near the swamp will also be increased in value by this ditch. The ditch will cost the owners of the land affected about $60,000. The improvement will result in the value of Knox County real estate being raised at least $200,000. In addition to the draining of the large tract of land the ditch robbed the Wabash River of one of its tributaries, the Du-Chien River. Before the ditch was constructed this river emptied into Wabash River a few miles above Mt. Carmel, Illinois. Now

*Frank Leverett. United States Geological Survey. See Dryer's Studies in Indiana Geography, pp. 35–36.

the stream empties into White River, using the ditch as its channel for six miles of its course. Before the completion of the ditch the Du Chien River was the only outlet for these swamp lands; but the river never did its work and the swamp spread out over a wide area.

The loess soils are easily cultivated. Much of the surface of a well tilled field is frequently a loose floury dust and the small clods are easily broken. It may be plowed when rather wet and yet easily be worked to a loose, pliable condition. There is a marked deficiency of organic matter in the virgin soil and as this amount becomes less the soils get in a poor physical condition and are sometimes difficult to manage. A large amount of commercial fertilizer is used, but a systematic rotation of crops and good application of stable manure and straw are necessary to keep the soils in a good state of cultivation.

The average yield of corn is about 40 bushels, but the yield varies greatly, even on adjoining farms. Oats average less than 30 bushels and the yield is very dependent on the season. Wheat averages about 15 bushels. Timothy and clover yield about one and a quarter tons per acre. A large acreage has been sown in alfalfa during the past few years. Potatoes average from 50-80 bushels. In some of the counties melons are grown extensively, and much small fruit is raised for the market. Much of the land is used for pasture, but when left uncultivated for a few years the ground becomes covered with a growth of wild briers.

Considerable tracts in Indiana which have been included in various writings as loess covered, will be found to represent soils in places, and their origin can be clearly traced to the underlying formations.

(b) Residual Soils.

The great mass of soils has been produced by the weathering and disintegration of rock under atmospheric influence; and it is generally found in the place where formed. Every species of rock has produced its soil; but the older formations, from their greater hardness and power of resistance to atmospheric action, produce in proportion to their exposed surface, less soil than do the secondary and tertiary groups. Any weathering rock surface shows us the process of soil making and the mosses and lichens that grow on the rock surface and aid in the deepening and enriching the soil. In some places the soil is thick and in others it is thin. In the level regions or those of gentle slope the soils have considerable depth; on the steeper slopes the soil is thin; and on the steepest slopes the rocks are laid bare and we have a region of waste, in which but little vegetation can find a foothold. To be valuable soils must have depth and must contain more or less organic matter. Residual soils usually have a rusty red color, varying from a reddish yellow to a deep dark red. A vertical section of a soil in place from the surface to the decomposing rock will show a series of soil characteristics. The surface for a few inches is usually of a dark yellow to black soil of fine texture and containing a high percentage of organic remains; immediately beneath this layer is a mass of earth in which very little trace of vegetable matter is found, the color assumes more of the rusty red color which increases with depth, the particles are less finely divided and small fragments of the parent rock are found, and at a depth of a few feet we find the weathered surface of the rock mass and a little farther below we come to the solid rock. The line between soil and subsoil is usually well dfined.

The residual soils of Indiana cover a part of 20 counties of the central southern part of the State lying south of the glacial boundary, and in several other counties of southern Indiana the geological formations are responsible to a considerable degree for the character and fertility of various soil types. These soils have less fertility than the drift and alluvial soils because of the limited variety of materials entering into their composition.

The various limestones, sandstones and shales with their resulting soils are of special interest and importance, both from a geological and an agricultural standpoint, and many questions arise as to origin, composition, requirements, adaptability, and general value.

It is an old saying that "a lime country is a rich country," and the limestone soils, such as are found in Kentucky and Tennessee, are famous for their fertility and richness. In the soils of Indiana derived from the limestone formations, while they have a marked degree of fertility, the lime content is low. In most cases these soils are "acid" or "sour." At first thought it would appear that soils produced from formations containing about 98 per cent lime carbonate would be strongly calcareous. But since this lime carbonate is highly soluble, the penetrating roots and heavy rainfall have leached these soils of the lime, and one of the things necessary for high productions is the application of lime on the surface. In the presence of high lime content relatively low percentages of phosphoric acid and potash prove adequate; while the same or even higher amounts, in the absence of satisfactory lime percentage, prove insufficient for good production. It has been found by observation and numerous analysis that the higher the clay content of a soil, the more lime carbonate it must contain to have the value of a lime soil; and that while in sandy lands lime growth may follow the presence of only .10 per cent lime, in heavy clay soils not less than about .6 per cent should be present to bring about the same result. The dark tinted humus characteristics of calcareous lands do not appear in clay soils until the lime percentages rise to nearly 1 per cent, while in sandy lands a much smaller amount, or about .2 per cent, will produce this effect. In heavy clay soils where the lime content falls below .5 per cent, lime vegetation is lacking and a growth of black jack and post oaks is found, which indicate soils too poor for profitable cultivation, while phosphoric acid, potash and nitrogen are the leading plant foods; lime is an important factor in soil fertility and exerts a wide influence upon plant distribution.

The analyses of limestone soils of Indiana show in the surface soil about .50 per cent calcium oxide, and .35 per cent potassium oxide and .15 per cent phosphoric acid anhyd. The first foot below the surface soil shows an average of about .55 per cent calcium oxide, .45 per cent potassium oxide and .18 per cent phosphoric acid anhyd. The third foot down to the rock mass shows an average of about 1.5 per cent calcium oxide, .60 per cent potassium oxide and .17 per cent phosphoric acid anhyd. We see from the above that the lime content is lower than that of true calcareous soil, the amounts of total phosphoric acid and potassium oxide are low and that the amount contained within these percentages of readily obtainable material would be very small, and these soils are likely to call for early fertilization. By careful investigations less than one-fourth of one per cent of potash is likely to constitute a deficiency. One-fourth of one per cent is usually high for phosphoric acid content. One-tenth of 1 per cent of P^2O^5 may prove adequate, but soils showing between .1 per cent and .05 per cent are weak and are liable to need phosphate fertilization very early. In soils with a weak phosphoric acid content a high percentage of lime carbonate or the presence of a large supply of humus often produce good results by bringing about greater availability of the phosphates. In the absence of lime carbonate, ferric hydrates may render phosphoric acid inert by the formation of insoluble ferric phosphate. The nitrogen content in soils is variable, and the amount necessary for plant growth depends largely upon other soil conditions, as moisture, etc., and upon the nitrification of the organic matter of the soil.

The soil types in the residual soils are varied and numerous. The limestone soils grade from a reddish yellow to a dark red; the ferruginous sandstones and shales produce a variety of colors in their soils; the purer sandstones and shales break down into yellow soils. In passing from east to west over the residual soils, the topography is varied, on account of the succession of hard and soft strata, with their different rates of disintegration. The shales weather faster than the limestones, and the limestones more rapidly than the massive sandstones.

1. Knobstone Group.*

General Description.—The Knobstone Group, consisting of a series of shales, sandstones, and patchy, thin-bedded limestones, is so called because "these siliceous strata weather into peculiar conical knobs or hills." The Knobstone Group is the surface formation of a strip extending from the south of New Albany to near Crawfordsville. This strip reaches its maximum width in Jackson, Monroe, Brown and Bartholomew, where the belt is from 25 to 35 miles in width. To the north of Monroe and Brown the formation is more or less covered with glacial material, and has but very little relation to the soil, and the same is also true to the east of an irregular line extending from the northwest corner of Bartholomew County to the outlying knobs of the Guiena Hills at the south side of Scott County, along which line the glacial debris laps up against the foot-hills of the "Knobs"; within these limits there are considerable areas over which some glacial material is scattered, but in such small amounts that the soils will be classed as residual soils of the knobstones. In addition to the counties named, this group comprises large areas in Lawrence, Washington, Clark and Floyd Counties.

The thin, rather persistent bed of limestone at the base of the formation is known as the Rockford Goniatite limestone. It varies in thickness from a few inches to about two feet, and usually contains a large number of crinoid stems. The other limestone mentioned is near the top of the formation and is not so persistent as

*The discussion of the soils of the Ordovician, Silurian, and Devonian formations, the oldest rocks exposed in Indiana, has been omitted from the general discussion of the soil types; but in so far as these formations have produced soils of their own or influenced other soils they will be taken up by Messrs. Ward and Ellis in their description of soils of Southeastern Indiana in which area they have made special investigations.

the first. It is very thin bedded, and on weathered edge is shown to be an impure, porous limestone.

Overlying the basal limestone is a thick bed of greenish-colored shale known as the "New Providence Shale." This shale has a maximum thickness of about 120 feet. Imbedded with this are several thin layers of iron carbonate, fragments of which may be seen very plentiful along the streams and sides of ravines, but not in sufficient quantity to be of any economic value, although in 1835-40 preparations were made to erect a furnace near Henryville to smelt this ore.

The Knobstone Group is capped with the Knob Sandstone. It is not a single, massive sandstone, but is a series of rather pure, soft sandstones separated by layers of sand shales. The upper layers of the sandstone are somewhat ferruginous. The total maximum thickness of the Knobstone Group is over 500 feet.

Topography.—The hills resulting from the erosion of the Knobstones present the most important topographic feature of southern Indiana. These hills or knobs rise from 150 to 500 feet above the drainage level of the surrounding country. The sandstones predominate in the greater part of the region. These sandstones and alternating shales have not been affected by erosion as early as have the areas farther south, where the shale predominates and where the sandstones are found only at the top of the group, and the soft shales are thus worn away as rapidly as they are exposed by the removal of the overlying sandstones. A topographical map of the knobstone area would show lines with somewhat regular curves along the broken ridges, others would show knobs almost isolated, and in every case the lines would be very close together.

The scenery is very attractive, varied by the undulating uplands and round topped hills, among which many streams wind their way, through valleys now wide and again so narrow that scarcely a roadway can be made at the side of the stream. From the higher points magnificent birds-eye views of the surrounding country may be seen in all their beauty. The local names that have been given to various ridges and hills in Brown, Scott, Clark and Floyd Counties will give an idea of the diversified forms and types resulting from the erosion and weathering of the knobstone.

"Weed Patch Hill," in Brown County, is a high ridge forming the divide between two of the main branches of Salt Creek. At its highest point it is more than 1,000 feet in elevation. One of the illustrations gives a view looking northeast from the ridge and gives an idea of the knob topography. "Bear Wallow Hill" is another high ridge forming part of the divide between the Bean Blossom and Salt Creek. "Guinea Hills" and "Silver Hills" are names given to parts of a continuous line of knobs extending from the Ohio through Floyd and Clark Counties into southeastern Washington and southwestern Scott and forming the divide between the tributaries of the Muscatatuck River and the head waters of Silver Creek; and south of this the waters of Mutton Fork of Blue River and Indian Creek on the west are separated from those of Silver Creek to the east. The early settlers gave the name of "Silver Hills" to the southern part of this ridge and the name "Guinea Hills" has been given to that part extending through northern Clark into Washington and Scott Counties. Some of the names given to other hills within this area are "Pigeon Roost," "Buzzard Roost Point," "Piney Point," "Round Top," "Hay Stack Knobs," "Horse Shoe Range," "Hound's Leap," "Huckleberry Knob," and "Pike's Peak." When we view the landscape from these various points and see the succession of hills and valleys, woodland and cultivated fields, streams and rocks, or look across on the broad valley with its meandering streams, the Ohio is certainly entitled to the name given to it by the French, "La Belle Riviere."

The western dip of the knobstone strata has controlled the initial drainage of this area, and the main drainage lies, with the exception of the lower course of the Muscatatuck and middle course of East Fork of White River. The intricate system of narrow V-shaped valleys running in every direction form the most important topographic characteristic of the knobstone area.

Economic Value.—Until within the past few years the knobstone formations have contributed very little to the economic interest of the State. Considering the formation, the amount of material of commercial value is very low. The sandstones are used to some extent in buildings and for bridge abutments. When first quarried the stone is very soft, but hardens on exposure. Two things especially are against these sandstones for structural purposes: being thin-bedded and irregular, much time and waste is necessary in quarrying; because of their power to absorb water they are easily disintegrated by frost action. But in some places the stone has been found massive for several feet and has proved a durable stone.

From a few localities considerable of the shale is being used in the manufacture of cement, brick and drain tile. It is probable that the knobstone shale in many places will be found suitable for

Portland cement manufacture. Much of the shale is too high in silica to make a good cement. The best deposit contains a large number of iron stone concretions, but these can readily be removed in the quarrying. The limestones are used some for the improvement of the public roads. Some sandstone is also used for this purpose, but stream gravel is the principal road metal through the section. A number of mineral springs rise from the New Providence Shale, and their waters have been used for medicinal purposes, and in the future some developments may be made along this line.

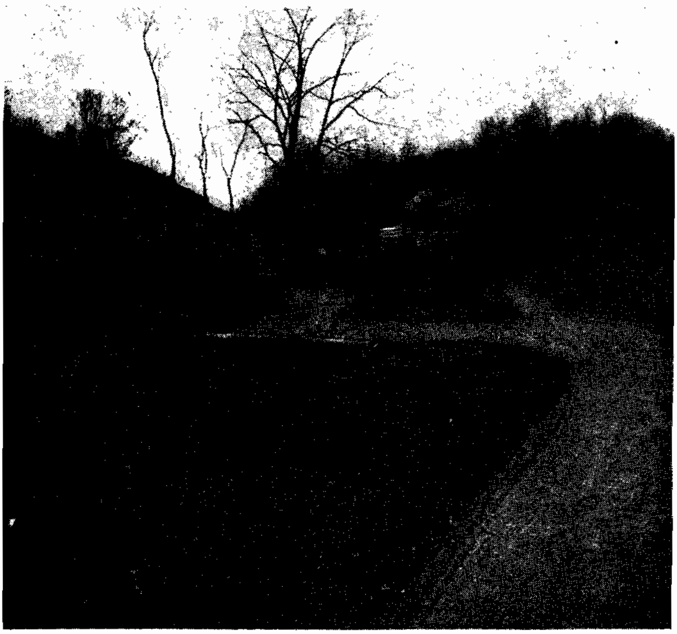
Weathering.—The strata of the Knobstone Group disintegrate very rapidly. The soft sandstones and shales absorb water easily, although they are practically impervious as far as circulating waters are concerned, and they are thus readily disintegrated by frost action. The power of erosion in these soft formations has been shown in the discussion of the topographic features. The knobstone where exposed in bluffs weather largely by exfoliation, and large pieces are often broken loose by frost action. While running water has had a great influence upon the topography, temperature changes are the agencies of greatest importance in the disintegration of these formations, as is evidenced by the broken strata along the bluffs and streams, and in the differential weathering of the hill slopes.

"It is a noticeable fact that throughout the whole Knobstone area where unaffected by glacial material, and where the valley systems are well developed, the south hillsides have gentler slopes than those facing northward, i. e., that erosion is farther advanced on the south-sloping hills that those sloping northward.

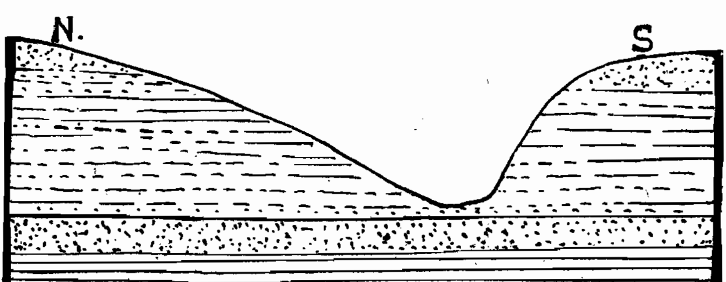
"This feature is most noticeable along the east-west valleys. In north-south valleys the gentler slope, when one is gentler than the other, is usually on the east side of the valley, i. e., on the westward sloping hillside. The difference in the angle of slope between east and west hillsides is not so noticeable as that between north and south slopes.

"This differential weathering of the slopes is attributed to the effect of temperature changes, especially of freezing and thawing, upon the rocks. Changes in temperature probably have a more potent effect in breaking up these rocks than has any other agent.

"The south hillsides are exposed to many more changes of temperature in the course of a year, and especially in the winter time, than are the hillsides facing northward. During the winter months in this region the nights are cold, often for weeks at a time, freezing a crust over the ground, which next day is thawed out on the south-sloping hillsides. The north slopes, however, being sheltered from the sun's rays, are frozen, or covered with snow,



View along Hinkle Creek, Monroe County, in Knobstone area, showing south slopes and manner of weathering.



TYPICAL NORTH-SOUTH VALLEY in the KNOBSTONE.

and remain so almost the whole winter long. Thus, while the rocks of the south slopes will be successively frozen and thawed out many times during the winter, the corresponding north slopes may be frozen and thawed only two or three times.

"One has only to cross this country on a warm winter's day after a cold freezing night, and to see the muddy streams flowing down from the south hill slopes while the north slopes remain solidly frozen, to realize the importance of this process of wearing away of these rocks. Both the climate and the structure of the rocks are peculiarly favorable for this class of erosion.

"There is considerable difference, also, in the quantity of heat that reaches east and west slopes, the westward slopes receiving more heat than those facing eastward, owing to the fact that the afternoon is the warmest part of the day. Because of this the westward slopes are not so noticeably different, however, as are the north and south hillsides.

"These differences can not be due to the gentle south-westward dip of the beds, because if they were so controlled, the westward slopes would certainly be the most gentle of all, as the prevailing dip is westward."*

Soils.—The soils of the Knobstone area are composed of sand and clay in varying proportions, and present several closely related soil types. Clay, sandy and silt loam, sand areas, clay tracts and rough, stony land containing many broken pieces of sandstone are often so plentiful as to prohibit successful cultivation. These knobstone soils are usually of little value, but within the past few years they have begun to attract the attention of fruit and vegetable growers. While as a class these soils do not produce large yields of the staple crops, they are capable of yielding much greater returns than in the past.

Corn yields on an average from 25 to 30 bushels to the acre, wheat averages 10 to 15 bushels, oats average 25 to 40 bushels, clover and timothy yield from one to two tons per acre. Alfalfa has been successfully grown on small areas, and a fair grade of tobacco is also produced on the silt and sandy loam. Tomatoes yield well on the various types and a number of canning factories are being built up within the area, with apparent opportunity for many more to do a successful business. Large yields of peaches and apples are realized from the orchards located on these soils, and from present indications grapes might well be grown with profit for the market.

There is no marked line between the various soil types given above, and several or all of them frequently occur even in the same field. The natural fertility and productiveness is about the same for the various types for general farming, but with some variation

*J. F. Newsom, in Report of State Geologist for 1901-02, 270.

for special cropping. Potatoes yield about 40 bushels to the acre, but experiments have demonstrated that as high as 80 bushels or even more can be grown.

The surface soil is from 10-14 inches in depth, and usually grades from a gray to light brown color and becomes a dark yellow or light red at greater depth. In places small fragments of chert, limestone and sandstone are found, which represent the remains of the upper strata of the Knobstone. Thin layers of hard brown ferruginous shale, such as form the outer layers of the imbedded geodes and iron concretions, frequently occur with the softer shales, or are found scattered over the surface. The characteristic red or yellow or brown color of the soil is due to the oxidation of the large amount of iron contained in the original material.

The soils wash badly on the hill slopes, and the texture of the soil on the slopes varies according to the steepness of the slopes and the amount of erosion that has taken place. Careful management is necessary to keep these soils in a productive state and some system of crop rotation is very important. The turning under once in every two or three years of clover, cowpeas or some other crop that adds a large amount of humus to the soil is very important.

The alluvial soils of this area are composed chiefly of the upland wash, and the material is not far removed from its original location, and shares the same properties of the upland soil except for poor drainage conditions, which in some cases has caused a depleted condition of the soil-reductive masceration.

The general improvement on these soils ranges from poor to fair, but some marked changes for better have been made even in the past few years. Railroad facilities are bringing about improved farm conditions, and this region yet promises to become an important agricultural district, and large tracts are being bought by wide-awake, energetic men who see great possibilities in the knobstone soils. The average price of land at present is from $25 to $50 per acre. The rougher portions of the area offer splendid opportunties for grazing and fruit growing.

Taken as a whole, the area is of value, and with improved methods of agriculture, railroads, improved public roads, rural routes, etc., this area will add much to the wealth of the State. Places which now yield hooppoles, ties and hickory bark will produce grain, fruit and vegetables in abundance, and the sites of one and two-room log cabins will be marked with up-to-date farm homes.

2. The Harrodsburg Limestone Area.

General Description.—The Harrodsburg Limestone lies above the Knobstone, and with it are included the transitional beds of chert, geodes and limestones that lie directly above the knobstones. The masses of chert fragments are very plentiful, and the geodes or "mutton heads," ranging from the size of a pea up to 24 inches in diameter, are found in great quantities. A few geodes are found scattered through the knobstone, but they are confined principally to the lower part of the Harrodsburg. Above the geode layer there is a crystalline, fossiliferous limestone, containing small crystals of pyrites, which give it a greenish tint. In many places the bedding planes are marked by stylolites or crowfeet, and masses of chert are very common. The upper strata of this limestone becomes more massive, and consists chiefly of bryozoa with its lacework effect.

The Harrodsburg limestone is the surface rock over an irregular belt from one to six miles wide, lying between the Knobstone Group and the Oolitic belt. It is from 60 to 90 feet in thickness.

Topography.—The Harrodsburg Limestone is the cap rock protecting the softer knobstone below, and to its influence are due the bold, unbroken escarpment of the knobstone strata. The limestone at its eastern contact outcrops at the tops of steep-sided hills and ridges, whose lower portions are composed of the knobstone. The top of these hills form a more or less even plateau sloping gently to the west. In areas where the Harrodsburg has not cut through to the knobstone the slopes are more gentle, and on the table lands broad rolling tracts stretch out in contrast to the knobs. But upon a map the greater part of the Harrodsburg appears in fringe-like strips branching off from a main continuous belt. It will be seen by noting the drainage that this main belt caps the high ridges and that the sinuous line passes around the heads of the streams.

Economic Value.—The Harrodsburg Limestone is of medium hardness and in places coarsely crystalline, is rather impure from chert, etc., and has but little economic value except as a road metal and for ballast. As such it is second best in this section of the State. Being of medium hardness, it readily wears a smooth surface. The cementing value and the lasting qualities are good except on roads of the heaviest traffic. The stream gravel derived from the chert, geodes and fragments of limestone is a very suitable road metal. The massive bryozoan strata have been quarried to a small degree as marble. On a polished surface the bryozoan lace work gives a beautiful effect, but on account of the porous nature the stone will not retain a high polish. This stone has little use as a building stone, but is sometimes used in foundations and in bridge construction. It has been used some for the burning of lime, but on account of the high proportions of clay it is less suited for this than other limestone. The purer beds give an analysis which shows this stone to be of value in the making of Portland cement, and especially may it prove of such value when it can be used in connection with the overlying Salem and Mitchell Limestones.

Weathering and Soils.—One of the chief economic values of the Harrodsburg Limestone is the fine, deep, rich soil formed by its decomposition. The soil varies in depth from about three feet to about twenty feet in a few places, with an average depth of five or six feet, except on the steeper slopes, where it is very shallow. The soil in general is stiff, fine-textured clay of a deep red to chocolate brown color. The lower members of the limestones with the geode and chert beds form a soil of a much darker red than that from the upper strata. The line between the surface soil and the subsoil from the lower members contain many chert fragments and geodes, increasing in number until the remnants of the solid rock are reached. In places these are so plentiful that the subsoil may be classed as coarse gravelly. Large areas of soil containing these insoluble rock constituents are found in the transition planes, with no remaining limestone other than fragments at the base. Thus on the soil maps showing the contact between knobstone and Harrodsburg soils, the line will in most cases be farther to the east than the line of contact of the rock outcrop shown on geological maps.

The surface soils from the different strata of the limestone are similar, being a loamy clay of fine texture, and varying in color from a light brown to a dark reddish brown. The various colors are due to the different proportions of organic matter present and to the leaching action of roots. These soils owe their red color chiefly to the large amount of ferric hydrate contained, and where the roots of plants and trees have penetrated these soils, that part of the soil in immediate contact with the roots has lost part of its iron content and the color becomes a dull brown. The surface soil is from 6 to 18 inches in depth. The subsoil derived from the massive strata is a fine clay of uniform texture extending down to the parent rock. In some places, however, it departs from the usual red color and becomes somewhat mottled with white, yellow and red. This is due partly to the thin-bedded shales and to poor drainage conditions. The clay of the subsoil, when exposed, breaks and crumbles in cubical forms. These little blocks continue to crumble until the clay becomes very finely divided. In general, the natural drainage conditions are good. It may be cultivated when rather wet, without injury since upon drying it readily goes to pieces and does not have the strong adhesive properties of such heavy clays as the Flatwoods and like soils. But upon a roadway, even after a summer shower, this clay works up into the toughest kind of mud.

The native timber growth of the Harrodsburg is such as denotes a good, rich soil—maple, walnut, ash, poplar, hickory, cherry, beech, oak, etc. This soil ranks as second best among the residual soils of the State. The area for the most part is inhabited by a thrifty set of farmers, who have their farms fairly well improved with buildings, fences, etc., so that in appearance the area shows agricultural progress.

Corn, wheat, hay and oats are the principal crops. The soil contains a considerable percentage of humus, and an adequate amount of the essential plant food. But it appears that this plant food is not highly available for some crops. Large amounts of stable manure are used, and in addition commercial fertilizer is used in the wheat and corn. Clover, alfalfa and cowpeas are grown for the crop, and aid greatly in the nitrification of the soils. Corn gives an average yield of 45-50 bushels, and is usually af a fair quality. Wheat grows well and yields from 15-30 bushels per acre. Oats yield about 40 bushels. They usually grow rank but rust badly. Timothy makes a good, heavy growth and yields from one and a half to three tons of hay per acre. Much of the corn is cut into fodder and shredded for feed. Considerable fruit is grown, and the soil seems well adapted to fruit. Vegetables grow well and give good yields. The soil is excellent for blue grass, and large tracts on slopes and rougher portions should be sown to grass, and a greater number of live stock should be kept. In this way all waste places may be utilized.

3. Oolitic Belt.

General Description.—The Indiana or Bedford Oolitic Limestone outcrops in a sinuous belt ranging from a few feet to more than a mile in width and lying between the Harrodsburg and Mitchell Limestones. It lies conformably upon the Harrodsburg Limestone and varies in thickness from 25 to 100 feet. It is a massive limestone, generally free from lamination, and shows very few bedding planes. It is soft and easily worked when quarried, but hardens upon exposure. It varies in color from a white to a blue or buff. The Oolitic Limestone is a granular limestone in which both the grains and the cementing materials are carbonate of lime. The texture varies from a very even, fine-grained limestone, made of rounded grains mostly of foraminfera and bryozoa and other forms, to a coarse fossiliferous stone in which large forms of gasteropods, brachiopods, bryozoa and other fossils are very abundant and are commonly clustered together. The fine-grained stone is of value from a commercial standpoint. There are slight variations in the hardness of the stone, but only in a few places is it too soft to be of any value, and in no place is it too hard to work.

Topography.—The thickness and width of the Oolitic Limestone is not sufficient to develop a strong topography of its own, but in the broader areas where the topography has been controlled by the limestone the slopes are gentle and the surface slightly rolling. The long, gentle slopes toward the drainage levels and the rolling uplands present the most picturesque farming region in southern Indiana. The topographic features are such that almost any point of the area can be reached by railways at a moderate expense for grading.

Economic Value.—Next to the coal beds of Indiana, the Oolitic Limestone is the most important geological formation in the State from a commercial standpoint. Its chief value is as a building stone. Considerable is used for monuments and bases. Large quantities are used as ballast on railroads. It is used as a road metal, but is not durable for that purpose, yet makes a good, smooth roadway when traffic is light, and is the best material that can be had for roadmaking with the exception of the stream gravel, which is derived principally from the limestone. A large amount is burned for lime, and produces a very white lime of excellent quality. In the past few years this limestone has been used to a considerable extent in the manufacture of Portland cement, and the large amounts of waste about the quarries and the areas unsuited for commercial stone should encourage an extensive use of this limestone. "The tests show the cement to be of the highest quality, and at least equal to any Portland cement manufactured in this country or Europe."

Weathering.—Chemical analysis shows no sufficient percentages of elements that should cause weakness in the stone itself. The stone is about 98 per cent carbonate of lime, one of the most durable substances under ordinary conditions. In contact with acids, however, it is one of the least stable, and is readily dissolved by any of the acids. On the open outcrops and where the surface soil has been removed from the limestone in quarry stripping it is found to be weathering into numerous fissures, caves, seams and corrugated surfaces. This is caused by the solubility in acids. The rainwater absorbs some acid from the air and more from the soil through which it passes, and acting for long periods of time it leaches away great quantities of stone. This stone is more porous than the average limestone, and great quantities of water are absorbed. The joint planes furnish openings for the ground water, and the effect of solution is very great.

Some of the old quarries of the Oolitic Limestone furnish excellent examples of the weathering process. Large blocks are scarred and furrowed by the action of the rainwater, and in many places the surfaces are honeycombed or pocketed, due o the unequal solubility of the limestone.

Soils.—When the lime carbonate has been dissolved out and carried away there remains a small percentage of unsoluble matter which forms the basis of the deep red soil of the Oolitic belt. In many places the gradation from surface soil to solid rock can be readily observed. Although these soils contains so little lime that it is necessary to apply lime to secure the best results in crop production, the lime percentage increases with depth, but even very near the rock the lime content is very low. The soil finally grades into an earthy limestone which crumbles easily, and this passes gradually into the solid stone.

In color, depth, texture, structure, native vegetation and crop production the soil of the Oolitic limestone is very similiar to that of the Harrodsburg Limestone.

The rolling blue grass pastures, wheat and hay fields afford a most picturesque scenery. Considerable dairying is carried on in this section. The staple crops all produce well, but the chief attention is given to corn, wheat and hay. Corn is of good quality and yields an average of about 45 bushels. Wheat averages about 18 bushels, and in some places the yield has been about 30 bushels. Timothy is grown rather extensively, and yields from 1½ to 3 tons per acre. Clover is grown principally for the hay. Some seed is threshed, but the average yield is low. A large proportion of the hay, both timothy and clover, is sold from the farm. Some fruit is grown, and truck farming is receiving considerable attention.

4. The Mitchell Limestone Area.

General Description.—The Mitchell Limestone is a series of impure limestone, calcareous shales, and fossiliferous limestone, overlying the Oolitic Limestone. This limestone is the surface rock over a large area. In eastern Owen and northwestern Monroe, extending through central Monroe to the southern boundary, the strip of Mitchell Limestone is from one to six miles wide, and in Lawrence County it widens until it is about ten miles from east to west, and continues to widen until in Orange County and Washington County the belt is more than 25 miles in width, and continues in a wide strip to the valley of the Ohio. The eastern outcrop runs in an irregular curving line about the outcrop of the Oolitic. To the western side large areas are made irregular and patchy by the overlying Huron. In general, the limestone has a very white appearance. The lower members are unfossiliferous and of a dirty yellow or gray color. Above this stone comes the thin-bedded shales and heavy dark blue flaggy limestone and the massive gray lithographic limestone.

Topography.—The Mitchell area is in general a fairly level plateau, dotted with a great number of sinkholes. These sinkholes are basin-like or funnel-shaped depressions from a few feet to more than 50 feet deep, and ranging in diameter from a few feet to five hundred feet, with an opening at the bottom which leads to underground water channels which form the true drainage lines of the country. When the underground drainage is well developed there is scarcely any surface drainage. These underground streams produce a great variety of sinkhole caves and Lost River. If the openings in the sinkholes have been closed, the basin is filled with water. These are very common over the area and are utilized by the farmers as source of stock water because of their convenience and since it is difficult to obtain good wells in the formation. In many places streams flow into the sinks and are lost for some distance, and rise again. The best example of this is Lost River in Orange County, which enters the ground two miles southeast of Orleans and again emerges at Orangeville after flowing underground by a winding course for about fifteen miles. In wet weather this stream also occupies a surface channel in a very narrow valley. The stream throughout its course has a very meandering direction and very little valley except as occurs in the meander curves. When the underground channels have been abandoned by the stream, they may be explored great distances, as in Wyandotte Cave and the numerous smaller caves. Many narrow amphitheaterlike valleys have been formed by the falling in of the roof of subterranean caverns. Numerous springs are found along this outcrop of the limestone. This topography in the main has been developed by the solution and erosion of the underground waters.

Economic Value.—The Mitchell Limestone has little value as a building stone. Its chief value in former years was for the manufacture of lime; but recently a large amount has been used as the limestone ingredient in the manufacture of Portland cement. Near the top of the formation is a fine-textured, even-grained, gray lithographic stone, but on account of the many little veins of calcite the stone cannot be secured in pieces large enough to be of value. Large quantities are used as railroad ballast, and as a road metal it stands at the head of the list.

Weathering and Soils.—Surface weathering is less noticeable in the Mitchell Limestone than in either of the above-described limestones. Joint and bedding planes are very plentiful and solution is concentrated along these lines, and being fine-grained, the stone absorbs very little water and the ground water is forced to follow the joints.

As a formation the Mitchell contains a much larger per cent of impurities than the Oolitic. The soil resulting from its decay is a stiff red clay, similar in general appearance to the limestone soils described above, but lacking in the general fertility and agricultural advantages. Throughout the soil, and especially in the subsoil, are found many fragments of chert and fossils.

The soil is of a light yellow to brick-red color, the two colors showing very prominently in patchy areas in the same field when fresh plowed. The red patches occur principally on the more elevated parts and are due to the surface soil being carried to lower levels and leaving the unleached soil exposed. The yellow soils are of a more loamy texture on account of the mechanical action of the roots of plants, and owe their lighter color also to the leaching action of the plant roots. In places the soils become of a darker color, due to the greater amount of organic matter. When in a good state of tilth the surface soil is very fine and contains much flour-like material and also a large amount of fine grit derived from impurities in the limestone and from the sandstone formations which formerly extended over much of the area. The soil varies in depth from 6-18 inches.

The subsoil is a stiff clay of a dark brown or red color, and contains much chert and other impurities and fragments of stone.

The chert beds of the area may in the future prove of some value as rock fertilizers. No analyses have yet been made.

The growths of sassafras and briars are very noticeable on these soils, and fields left for a year or two without cultivation are rapidly covered with these plants. The soils are in need of available potash and phosphoric acid. It has been noticed that when fire has burned the briars over a given area that the amount of potash made available in the ash causes a very thrifty growth of the briar, often becoming much higher than a man's head and more than a half inch in diameter. A large amount of commercial fertilizer is used on these soils. The yield of corn when fertilized is from 40 to 70 bushels. Unfertilized, it is often almost a failure, except in seasons of great rainfall. Because of the system of underground drainage and sink holes, the soil soon dries out and crops often suffer from drought. In some places, especially on the more level uplands, series of shallow sink holes have become clogged, and the standing water gives the appearance of a marsh area and the vegetation is that of a typical marsh.

The Mitchell soils generally produce wheat well, with an average of 12 to 15 bushels per acre, and in many cases it will yield 25 bushels or more. Oats grow fairly well, but seem to rust considerably. It is a good soil for fruit, and does fairly well for vegetables. In the rough parts the soils wash badly, and should be kept in grass as much as possible and used for pasturage. Timothy yields from one and a half to three tons per acre.

The improvements over the area are good, especially in the large, level tracts of the uplands, where there are many large farms of great value. The roads are for the most part in a fair condition, and much has been done in the last three or four years to improve their condition. Some dairying is carried on and sheep raising is becoming an important occupation.

5. The Huron Formation.

General Description, Topography, Etc.—The Huron consists of a series of limestones, sandstones and shales. There are three limestones and two sandstones, and the total thickness of the formation is more than 100 feet. The sandstones of the formation are of fine texture and are usually a buff or gray color. The lower limestone resembles very closely the Mitchell, and all the limestone contains considerable chert and other impurities.

The topography of the Huron is more rugged than that of the

Mitchell. Most of the drainage is subterranean, although well defined drainage lines can be traced through the confused system of hills and valleys.

The limestones are used for the burning of lime, for road metal and for bridge abutments and foundation stone. The sandstones are also used in bridge construction and for foundations, and in Orange County they are quarried to some extent for whetstones.

Soils.—The soils of the Huron vary from sandy areas to stiff, mucky clay. The sandy types are of a reddish-yellow color and are not very productive since they consist of little but quartz and ferric hydrate. A small percentage of these lands are under cultivation. The soils, derived principally from the shales, are tenacious clays with a variety of colors, but chiefly of a white or light yellow color. They retain a large amount of water, but are fairly productive, corn, wheat, oats, clover and timothy being grown successfully. White daisies, briars, sassafras, persimmons and pawpaws are the principal products from uncultivated areas. The soils wash badly, and most careful cultivation is required on the slopes to prevent destruction.

The areas which have for their soil a mixture of the sand, shales and clays of the limestone are the most productive and present the greatest opportunity for agricultural development. Improvements are poor, railroads few, but the public roads are being rapidly improved, and the Huron limestone, which is an excellent road metal, is used principally on this improvement.

6. The Mansfield Sandstone.

General Description, Topography, Etc.—The Mansfield Sandstone lies to the west of the Huron formation. It was formerly designated as the "Millstone grit" and "Conglomerate sandstone." The sandstone has a thickness of about 150 feet, and even more is shown along the bluffs of White River north of Shoals. It varies in texture from a fine-grained stone to a coarse, pebbly conglomerate. It varies from light yellow to dark brown in color. At the base of the sandstone beds of shale with thin veins of coal are rather persistent, varying in thickness from a few inches to fifteen or twenty feet.

The topography of the Mansfield area is very rugged. It is a thoroughly dissected plateau. Steep hills, abrupt cliffs and long, narrow, winding valleys are characteristic of the area. The hill tops are protected by a layer of heavy, hard sandstone, and the streams have cut down rapidly through the softer beds. The eastern part of the area is far more rugged than the west.

The Mansfield has been used to a small degree as a building stone. Some of the fine-grained parts have been used for whetstones and grindstones, and the conglomerate beds are a source of road material.

Soils.—The soils of the Mansfield sandstone are of a light yellow color and vary from sandy loams to sandy clay loam. The average depth of the soil is from 10-15 inches. At greater depth the soil usually becomes more tenacious and of a reddish color, due to the large amount of iron contained within the original stone. Large areas of these soils are uncultivated, being grown up with second-growth timber and underbrush. The improvements are, as a rule, very poor, and the necessary thrift is lacking to accomplish much in an agricultural line.

Oats grow well, wheat produces from 8 to 20 bushels. Timothy and clover are grown, but the hay is of rather poor quality. Farmers are beginning to use considerable fertilizer and are well repaid.

In some parts the soils have a stiff, clayey texture due chiefly to the overlying shales of the coal measures. Within the Mansfield area is much rough, stony land. It includes the rock outcrop along the streams, the steep, stony hillsides and the land which is intersected with deep ravines so close together that the land is worthless for farming purposes.

The principal timber growth consists of oaks, beech, mulberry and some maple and walnut. Some fruit is grown and the soils seem well adapted for the same. Very few stock are raised for the market; sheep raising and dairying might be engaged in with profit.

There are few railroads through this area, and the public roads are yet in a poor condition. The agricultural products are not much in excess of the local demand.

7. Coal Measures.

General Description.—The coal measures lie unconformably upon the Mansfield and consist of a series of shales, sandstones, coal, fire clay, concretionary iron ores and thin-bedded limestone. The coal measures are of varying thickness and cover a wide strip of country. The topography is usually gently rolling or flat. In the eastern part of the area, where the coal measures occur as remnants on the higher ridges, the ridges are flat topped and present some of the most level and productive soils of that part of the area. The coal measures are the chief sources of Indiana coal, fire clays and shales.

Soils.—The soils of the area grade from sandy and silt loam to clay, and usually contain large numbers of iron concretions and fragments of sandstone. The soils are of a light color and as a rule are fairly productive. The staple crops are all grown, and considerable vegetable farming is carried on. In the rougher parts to the east the greatest drawback to development is the high elevations above the surrounding country, and the difficulty thus experienced in marketing produce. In some parts of the level area mining is the chief concern of the people and the soils are neglected.

The chief and most extensive soil type is the silt loam, locally known as "yellow clay." It is high in silt and contains but very little sand. The soil is easily cultivated. If plowed when slightly moist, the surface material crumbles easily into a loose, floury dust. Oats produce well, corn averages about 40 bushels, wheat about 15 bushels in the best season. Considerable fertilizer is used, especially on the wheat. The soil grows good grass, and water is abundant, and dairying and stock raising could be made paying enterprises. Fruit growing should also be encouraged.

Several railroads traverse this area, public roads are being well improved in the level parts and the general improvements are advancing.

8. Alluvial Soils.

Alluvial soils are those deposited along streams, the materials having been gathered along the course of the streams from various sources and carried to some distance before being deposited. The characteristics of the alluvial soils are largely dependent upon the nature of the formation and soils found within the drainage area of the stream, and the relative proportions of the various components is dependent upon the steepness of the slope and the velocity of the current.

The principal alluvial soils in Indiana are those of the White River, Wabash and Ohio valleys. The valleys of Indiana streams are the result of stream erosion, most of them by the streams which now occupy them. During the glacial period they were largely choked with drift, only a small part of which has been removed. Gorges and ravines exist in great numbers along the Whitewater, White and Ohio rivers and all their tributaries. The eastern tributaries of the Wabash in Fountain and Parke counties flow through beautiful canyons cut in massive sandstones, often with overhanging walls. The streams flowing from the glacial area had their valleys flooded with glacial waters and choked with glacial debris. The effects of this are shown by the extensive terraces of sand and gravel which border their present channels and mark the heights at which they were once able to deposit sediment. Between these terraces are the bottom lands or flood plains, large areas of which contain some of the most productive soils to be found anywhere.

The Wabash River valley in the upper two-thirds of its course presents a variety of fine, sandy loams, gravelly, sandy loams, silt loams and clay loams. The lower part of the valley consists chiefly of clay underlain by sand or sandy clay. The clay is of two special types—a brown clay loam containing a small amount of sand, mingled together with a large amount of organic material, and is in a good state of cultivation; the second is a whitish silty loam about six inches in depth, underlain by a stiff clay mottled with yellow and white. Varying amounts of coarse sand and iron concretions are found through the soil. At present a small percentage of this type is under cultivation because of the poor drainage conditions. All along the lower Wabash there are numerous depressions, bayous, sloughs and narrow ponds lying parallel with the course of the river.

The greater part of the soils of the lower Ohio are of the same general types as those of the lower Wabash. Farther up the Ohio the valley becomes much wider, and the soils are usually of a very productive type.

The soils of the lower White River consist of varying proportions of clay, sand and silt, the prevailing type being a silty clay similar to that of the lower Wabash. The soils of the West Fork through its lower and middle course consist of a yellowish-brown silt loam containing considerable fine sand. The remaining timber along the streams consists of walnut, ash, elm, sycamore and poplar. The soil is excellent for corn but the soils are poorly cared for and no cropping system is attempted. The upper course is of clay and sandy loam with considerable coarse gravel.

The soils of the East Fork in its lower course consist of sandy loams of fine texture. This part of the valley is very narrow, in some places being less than a quarter of a mile in width. The upper part of the valley is very wide and affords large areas of the best farming land within the State. The soils are sand, sandy loam and brown clay loam. Along the Muscatatuck, the principal tributary, are a series of clay mucks, white clays, clay loams and silt loams.

The alluvial area of the State is subject to frequent overflows; each flood leaves a sediment or washes away a part of that already deposited, and thus the surface soil is constantly renewed and altered. Thus a strong, fertile soil is formed, capable of producing good yields of various crops. On account of danger of overflow, however, it is planted almost exclusively to corn.

During the past two years the amount of overflow has exceeded that of former periods, and much change in soil has taken place and great injury been done to growing crops. In the spring of 1907 much bottom land corn was not planted until late in June, but, however, was well matured before killing frost came. In the spring of 1908 the rainfall was very great, and during the month of May was far in excess of that of former years, consequently much bottom land was too wet for plowing, and large areas had not even been plowed up to the first of June, yet it is reported that a much larger acreage will be planted to corn than in 1907.

Soil Survey of Monroe, Brown, Lawrence, Martin, Orange, Washington, and Jackson Counties.

By C. W. Shannon and L. C. Snider.

The counties in this group occupy an area in central southern Indiana of about 3,000 square miles. The north line of this area is about 30 miles south of Indianapolis, and the southern boundary is about 15 miles from the Ohio. Transportation facilities are good, and the cities of Chicago, Indianapolis, Louisville, St. Louis and Cincinnati are easily reached, and several cities within the area are in a very prosperous condition and are the center of great industrial activity.

Geology of the Area.—The seven counties here treated lie for the most part in the driftless part of the State, and the surface rocks of the area belong to the Subcarboniferous or Mississippian Period, hence in the discussion of the soils of this section we are dealing principally with residual types. The Knobstone formation covers the whole of Brown and the eastern portions of Monroe, Lawrence and Washington and the greater part of Jackson County. This formation consists of shales and sandstones, and its general characteristics have been discussed under the subject of "Indiana Soil Types." The Harrodsburg, Salem and Mitchell limestones lie on the order named above the knobstone, or to the west of the knobstone area. Each of these comprise large areas in the counties of Monroe, Lawrence, Washington, and about 15 square miles of Harrodsburg are found in western Jackson, and the Mitchell covers more than a third of Orange County. The Huron group, a series of limestones, sandstones and shales, extend over western Monroe, Lawrence and eastern Martin and about one-half of Orange.

The Mansfield sandstone occurs to some extent in Lawrence, and covers large areas in Martin and Orange. The coal measures proper are confined to isolated patches and ridges in Martin County.

Very small amounts of glacial material occur in northern Monroe and Brown and is thinly distributed over the eastern half of Jackson, except in a few places, such as Chestnut Ridge, where the material is ridged in a conspicuous manner. Also in eastern Jackson, a few square miles have their soils derived chiefly from the Devonian formation. About 250 square miles of alluvial soils are found in these seven counties.

Topography.—This area is a great plain of disintegration and degradation, the original rock surface having been removed by the processes of weather and stream erosion, and now present even, flat-topped ridges, divides and isolated knobs with a complex network of valleys, ranging in width from a few feet to several miles. That portion covered by the first ice invasion has been but little changed in its topographic features. This area thus presents the most rugged and picturesque of the State. The upland plateaus of the Mitchell form the most level portion within the area, and this limestone has its own topographic features, due to the presence of caves, sinkholes and underground channels. Taken as a whole, this block of counties may be considered a good agricultural section, with its great variety of soil types and the great range of adaptability. The cereals are grown to more or less advantage on all the types. The limestone soils give abundant yields of timothy, clover and the most beautiful blue grass pastures of the State. Fruit growing and truck farming are also carried on successfully on the various soil types. However, in the growing of crops, a large amount of commercial fertilizer is used to produce good results. The agricultural advantages and improvements are, on the whole, progressing very rapidly.

Drainage.—The drainage of this section is chiefly through the east and west forks of White River. The Patoka River carries the waters of southern Orange west to the Wabash. Southern Washington drains south through Blue River into the Ohio. The Bean Blossom carries the waters of northern Brown and Monroe into the west fork of White River; and Salt Creek, with its many tributaries, and Lost River carry the principal part of the southern drainage into the east fork. Most of the streams throughout the area are well supplied with gravel suitable for road metal and ballast.

MONROE COUNTY.

History of Settlement and Agricultural Development.

Monroe County, named in honor of James Monroe, the fifth President of the United States, was organized in 1818. An old historical account of 1850 says: "There are in the county eleven grist mills, twelve saw mills, four oil mills, nine carding machines, one foundry, one spinning, weaving and fulling machine, three printing offices, about twenty general stores and groceries, nine lawyers, ten physicians, and preachers too tedious to mention."

The population in 1830 was 6,578; in 1850, 13,000, and at the present time is about 22,000. The county contains 420 square miles. The civil townships are Bean Blossom, Washington, Marion, Benton, Bloomington, Richland, Van Buren, Perry, Salt Creek, Polk, Clear Creek and Indian Creek.

The principal towns are: Bloomington, Ellettsville, Stinesville, Clear Creek, Smithville, Harrodsburg. Other small villages and trading centers are Sanders, Kirksville, Buena Vista, Victor, Ketchem, Stanford, Hinsonburg, Mt. Tabor, Dolan, Hindostan, Unionville, Payne and Fairfax. Of these Sanders is a quarry town on the old line of the Monon, and Ketchem is a station on the new line. The villages of Stanford, in the western part of the county, and Unionville, in the eastern part, are both more than a mile from the line of the Indianapolis Southern Railroad, but each has a station by the same name. Victor and Hinsonburg are quarry districts; the others named are little more than country stores, and in few places postoffices are still kept.

Bloomington, the county seat, has a population of 10,000. It is growing very rapidly. A new court house of Oolitic stone is just nearing completion, and many other improvements are being constructed. The State University situated here has an enrollment of 2,000, and adds greatly to the business, thrift and general welfare of the city. Two railroads pass through the town. The C., I. & L. (Monon) in a north and south direction and the Indianapolis Southern in an east and west direction. An interurban line making Bloomington a junction point promises to be built during the coming year. The principal industries within the city are: quarrying interests, furniture factory, spoke factory, mitten factory, basket factory, milling and feed establishments, lumber and coal yards and various other industries which give employment to a large number of people. The town should continue to grow rapidly and improve in the most modern way, because of its varied interests and permanent population.

Ellettsville is a town of 800 inhabitants situated on the Monon Railway seven miles north of Bloomington. Its chief interests are in the stone quarry district, and it also serves as an agricultural trading center.

Stinesville has a population of three hundred, and was built up in the early days of the stone industry in that region, and new developments in that section look favorable for a continued growth. A large stone mill operates within the village.

Smithville, eight miles south of Bloomington, has a population of 150, and is chiefly a trading center for an agricultural and quarry district.

Harrodsburg, twelve miles south of Bloomington, has a population of about 400, and is a thriving little village dependent on the surrounding country for its trade and business. The railway station is about one mile east of the town.

Clear Creek is a beautiful little village four miles south of Bloomington, and has a population of 100. It is also the center of some stone interests.

At present the county produces about 600,000 bushels of corn, an average yield of 40 bushels per acre; about 8,000 acres of oats, average 25 bushels; about 7,000 to 8,000 acres of wheat, average 16 to 20 bushels. The county usually ranks fourth or fifth in the State in acreage of timothy meadow, and is among the leaders in average yield. In 1905 the county produced 53,800 tons. In 1906 the acreage dropped to 20,000, and the average yield 1.1 tons. From 2,000 to 3,000 acres are given to clover, which yields about 1½ to 1¾ tons of hay per acre, and about 500 bushels of seed. Among other crops the average acreage and yield are as follows: Potatoes 300 acres, average 50 to 60 bushels; tomatoes, a rapidly increasing acreage, 40 acres being grown in 1906, yielding over 5,000 bushels; peas, 5 to 10; watermelons, 10 to 15 acres; tobacco, 5 to 10 acres. The yield of apples in 1906 was about 60,000 bushels. A large yield of peaches is also produced. While Monroe produces large quantities of live stock, it is not a leading industry in the county.

SOILS.

Monroe has a greater variety of soils than any other county within the area touched by this survey. There are eight general types with various subdivisions of these which will be treated under the following description: Six of these soils are due directly to the weathering and disintegration of the underlying geological formations. The glacial area belongs chiefly to the part of an old glacial lake extending into the northwest part of the county; the other glacial soils are found along the Bean Blossom. The alluvial soils belong principally to the valleys of Bean Blossom and Salt Creek, and present a variety of types. The following table will show the extent of each of the general types:

Knobstone	130 square miles
Harrodsburg	77 square miles
Oolitic	26 square miles
Mitchell	89 square miles
Huron	59 square miles
Glacial	8 square miles
Alluvial	26 square miles
Clay	5 square miles

1. The Knobstone Area.

The Knobstone soil of Monroe County covers a much larger area than any other type. It comprises a wide, irregular strip along the entire eastern side of the county and widens to the north, until all of Marion township is covered, and continues across the northern part with patchy areas reaching to the White River. In the southern part principally all of Polk township is covered with this type, and it continues with wide strips extending along the Salt Creek valley until the uplands of the Harrodsburg limestone are reached. Irregular patches of this soil occur throughout the eastern-central area and the stone outcrops several miles up the ravines of the stream. In many places the hills rise 150 feet or more above the drainage level and the slopes are very steep and the knob topography in general is well developed.

The characteristics of the soils are the same as given in the discussion of the Knobstone under the "Indiana Soil Types," and under Brown County in particular, in the following pages.

The public roads are in fair condition and several miles through the part of the area nearest the Harrodsburg contact have been improved with crushed stone and others with stream gravel. In the rougher parts the steepness of the slopes preclude economic hauling, and being distant from railroads thus prove a great drawback to the development of the area. Since the building of the Indianapolis Southern Railroad the lands in the northeast part of the county have about doubled in price and some developments are being made.

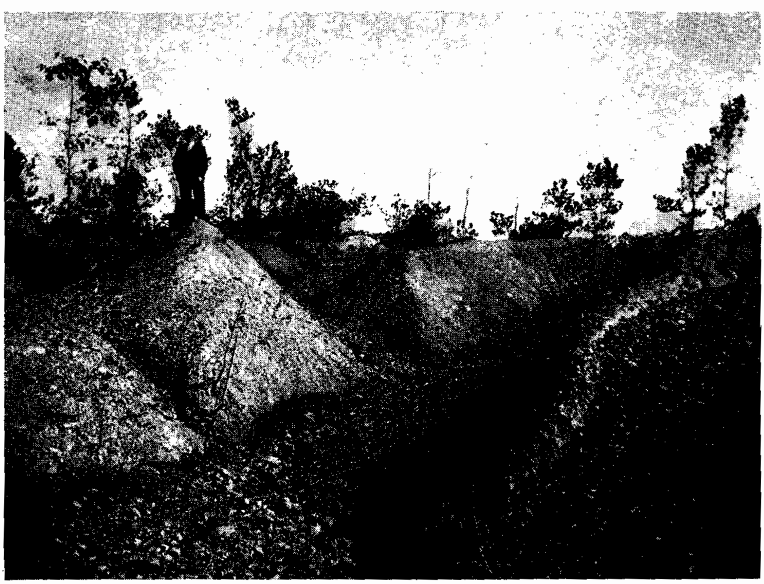
A small percentage of the lands are under cultivation, the greater part being grown up with second growth timber. Some good timber also remains; about $10,000 worth of hooppoles and hickory bark was hauled into Bloomington during the spring of 1907, and thousands of railroad ties are also cut from this area. The average yield of corn is from 10 to 30 bushels. Little wheat is grown. Timothy and clover grow fairly well, but it is usually difficult to obtain a good stand. The rapid and excessive growth of "white top" often renders the hay of poor quality. Very few vegetables are raised, scarcely sufficient to supply the local demand. Although few live stock are raised the people are often seen buying feed before the winter is over. The soil is capable of producing much greater returns than are now realized. Some fertilizer is used, but without any reference to the soil conditions. Bone meal and phosphates are the principal fertilizers used.

Fruits grow well on these soils, but very little has been grown. The best example of what can be done with fruit growing and vegetable farming in the rough part of this area has been demonstrated by Frank Morris, gardener and fruit grower, in Bloomington. Five years ago Mr. Morris bought twenty acres of this land, five miles east of Bloomington, paying only $5 an acre. The surface is very rough and broken and was covered with a dense growth of second growth timber and shrubbery, and much hard work was required to prepare the ground for cultivation. Enough wood was, however, secured from the land to about pay for the land and the clearing. Over 25,000 strawberry plants have been set out on the hillsides and almost a thousand dollars have been realized from this investment. Several hundred young peach trees have been set out, also about 6,000 raspberry bushes, 700 dewberry bushes and a quantity of small fruit of all varieties. He expects to increase these numbers from year to year. A large quantity of vegetables are also raised on this tract.

This is only an example of the worth of the apparently worthless hill land of the eastern part of the county. Here are opportunities for many people in various lines of agriculture and truck farming, and extensive developments can here be made that will greatly repay the promoter and add much to the welfare of the county.

Arbutus Hill is the name given to a part of the same ridge on which Mr. Morris's fruit farm is located. Here, over a limited area, the trailing arbutus grows abundantly, and this is one of the few places within the State where it is found growing. It is a rare plant, known only in a few localities, principally Indiana, Michigan and New England. The soil of the Arbutus Hill is of a fine sandy loam of a yellow color. The arbutus has its roots imbedded very shallowly in the soil and appears to depend very largely on the leaf mold for its support.

Gullies in the clay and shales of the Knobstone, eastern Monroe County, near Stobo.



Gullies in clay and shales of Knobstone in eastern Monroe County, west of Arbutus Hill.

2. Harrodsburg Limestone.

The residual soils of the Harrodsburg rank third in area and probably second in general productiveness in the county. The soil has the general characteristics of the type, grading from light yellow to dark, with a deep dark red subsoil. The soil of this type, found within the immediate vicinity of Bloomington, and also in the vicinity of Harrodsburg, is of rolling topography and affords excellent agricultural land. In the northeast and south edges of the area the streams have cut back through the limestone and into the soft Knobstone below, and this part of the county is of much rougher topography. The soil is easily cultivated, natural drainage is good and a fair yield of most crops produced. A large amount of fertilizer is used. Corn yields about 50 bushels, wheat 15 to 30 bushels, timothy one and one-half to three tons per acre, and the hay is of a good quality. Oats grow very rank, but usually rust badly. Some alfalfa is grown and makes a good growth. It is an excellent soil for vegetable farming and the growing of small fruit. The native timbers are sugar, walnut, poplar, ash, beech, hickory and wild cherry.

The following table shows the results of mechanical analysis of the residual soils, and the sample of Harrodsburg soil, of which complete chemical analysis was made, given in the table under number 95, is a typical sample from the formation within the county:

MECHANICAL ANALYSIS OF HARRODSBURG RESIDUAL.

Number.	Locality.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
1	1½ miles north of Bloomington	Surface	.0	.3	.5	2.0	8.0	89.4
1		Subsoil	.8	.2	.5	3.0	4.0	92
2	Near Harrodsburg	Surface	.0	.2	.8	4.0	9.0	86
2	Near Harrodsburg	Subsoil	2.0	.5	.5	3.0	3.0	92

The general farm improvements throughout the area are good. All the principal roads are well improved with crushed stone and stream gravel. Two railroads pass through the area. Excellent advantages are offered for truck farming and a number of persons are engaging in it to some extent. Potatoes will produce from 75 to 200 bushels per acre, sweet potatoes average 175 bushels; tomatoes, cabbage, beans, etc., give abundant yields. Small fruit gives

Strawberry Culture on the Harrodsburg soil. One mile east of Bloomington, Tenth Street Pike. Fruit farm of W. S. Pinkerton.

Side of new cistern in Harrodsburg formation showing changes from surface soil to solid stone with fragments of stone in compact subsoil. The line marked by the trowel is depth to which soil has been affected by roots of plants. One and one-half miles east of Bloomington.

large returns and considerable areas are being planted in larger fruits. The eastern border of the area, although somewhat rougher than the rest, is a good location for apple and peach orchards and for the growing of grapes, and the deep red subsoil will no doubt add to the flavor and richness in appearance of the grapes. The land can be bought at prices ranging from $25 to $150.

3. The Oolitic Area.

The residual soils of the Indiana Oolitic limestone rank fifth in area within the county and hold first place in its agricultural advantages. The topography of the area is gently rolling, the slopes are long and fall gradually to the streams. The area extends in a north and south direction and the Monon Railway extends the full length of the area, and thus all parts are brought to within a short distance of the railroad facilities and towns of considerable importance. The principal part of the area lies within the immediate vicinity of Bloomington, and both town and country are greatly benefited by the advantages of the other. The improvements are good and up to date methods are used in the agricultural pursuits. The blue grass pastures afford excellent pasture. Clover and timothy grow well and yield from 1½ to 3 tons of excellent hay per acre; wheat yields from 12 to 30 bushels; oats average about 45 bushels; some alfalfa is grown; also small areas of cow peas and soy beans. Dairying is carried on with profit; market gardening and the growing of small fruit is engaged in to a considerable extent, and the soils are well adapted to this kind of intensive farming. Potatoes will yield from 75 to 200 bushels per acre. Sweet potatoes, 100 to 300 bushels per acre. Small fruits make the best yields possible, and tomatoes will produce 5 or 6 tons per acre.

Large amounts of stable manure and commercial fertilizer are used. On account of its nearness to Bloomington and the great number of live stock raised, far more manure is secured than on other types, some farmers and gardeners keeping a team busy most of the year hauling manure from the city. There have been comparatively few fruit trees planted in the area, the chief reason being that greater and quicker returns are obtained from quicker growing crops.

The general characteristics of the soils are the same as those described under the general discussion of the soil types. The natural drainage within the area is good. Great advantages are offered for intensive farming. The city population, the large student population and the hundreds of families whose interests are in the factories and stone quarries, must buy, and the home-grown products are in greater demand than those shipped in from other places. But at present the demand is far greater than the production. Land sells at $50 to $150 per acre, but will yield good returns even at higher prices.

The following table will show the results of mechanical analysis of typical samples of the soils of this area, and the sample No. 94, in table of complete chemical analysis, is typical from this area:

MECHANICAL ANALYSIS OF OOLITIC RESIDUAL.

Number.	Locality.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
1	Near Ketchams	1st foot (surface)	1.8	.9	1.1	.8	2.6	91.4
1	Near Ketchams	2nd foot (subsoil)	.0	.0	5.0	2.6	14.2	83.0
1	Near Ketchams	3rd foot (subsoil)	.0	.5	2.1	1.2	7.2	88.6
2	One mile S. Bloomington	1st foot	.8	1.0	.8	.9	2.5	93+
2	One mile S. Bloomington	2nd foot	.5	.0	5.0	.9	5.0	89.0
2	One mile S. Bloomington	3rd foot	1.0	.2	4.0	2.0	5.0	92.0

Some of the old quarry districts in the area present some of the most excellent examples of soil formation. In the Big Creek quarries near Stinesville, and in the old Cleveland quarry near Harrodsburg, all gradations may be seen from the solid rock to the finest soil. Some of these are shown in the illustrations.

All the principal roads of the area are improved with crushed stone, chiefly from the Harrodsburg and Mitchell formation; these afford more durable stone for road purposes than the Oolitic. Very little timber remains, but the original timber was such as to indicate a very fertile soil—maple, walnut, beech, poplar, etc.

4. The Mitchell Limestone Area.

The residual soils of the Mitchell limestone rank second in area and about fourth in value. The topography of the region is rolling and covered by numerous sinkholes of all sizes; along the western border the region becomes somewhat abrupt and the general value of the soil declines considerably.

The surface soil is from six to eighteen inches in depth and consists of clay loam, grading from a light yellow to red. The subsoil is a somewhat darker color than that of the Harrodsburg

View in the old Cleveland Quarry, north of Harrodsburg, showing processes of weathering and soil formation. The small tree and some weeds are taking hold in the talus heap of new made soil.

View in same quarry showing low forms of plant life attacking surface of old stone giving spotted appearance.

and Oolitic areas, and it usually contains a large amount of chert. The soil becomes more shallow and the amount of chert and other impurities increase as the drainage line of sinkholes are reached. The soils are well drained by the underground channels and crops sometimes suffer from drought. Springs are abundant and furnish an excellent water supply. Clogged sinkholes are plentiful and offer good water for stock; wells are difficult to obtain.

Places where the soils are worn out and washed and become partially covered with sassafras and blackberry briars, are known as "the barrens" and cannot be made of much value for agriculture. The soils in general are fairly productive, but great care must be taken in their cultivation to keep them up to the standard. Large applications of stable manure render the soil very fertile, and this is due probably to two things: by adding a large amount of humus to the soil, and by rendering available larger amounts of the potash and phosphates contained in the cherty soils. Large amounts of commercial fertilizer are also used.

This soil is excellent for the growing of timothy and large acreages are raised; corn, except when well fertilized, is short, but can be made to produce 50-75 bushels. It is difficult to obtain good crops of clover. Some cow peas are grown on limited areas; wheat yields from 12-20 bushels, and in some cases 30 bushels have been reported.

Some dairying is engaged in and the soils produce good pasture, and sheep raising might be made a thriving industry. Several farmers are beginning to raise fine bred hogs and cattle, and the general improvement in live stock has made a marked change in the past five years.

In the more fertile parts of the area the farms are in a good condition. The public roads are being rapidly improved. The Mitchell limestone furnishes the best road metal within the southern part of the State.

The following table shows the results of the mechanical analysis of three samples of Mitchell soils:

MECHANICAL ANALYSIS OF MITCHELL RESIDUAL.

Number.	Locality.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
1	S. E. of Campbellsburg, Vernon Tp., Wash. Co.	Surface light clay	.2	.1	1.3	1.3	11.2	86.5
1		Subsoil	.0	.1	1.2	.5	18.6	77.2
2	N. E. part Van Buren Tp., Monroe Co.	Surface yellow clay	.0	.0	.0	1.2	2.1	96.5
2			.0	.0	.0	.4	22.0	75.6
3	Four miles southwest of Bloomington	Surface, 1st foot	.2	.0	3.0	2.0	10.0	85.5
3		Subsoil, 2nd foot	2.0	.0	2.0	1.5	4.0	93.4
3		Subsoil, 3rd foot	5.0	.3	1.0	.0	2.0	91.6

5. Huron Soils.

The soil derived from the Huron group covers about sixty square miles in the west and southwest part of the county, principally in Indian Creek Township. The Huron group, being composed of extremely varied rocks, limestone, shale, sandstone, and conglomerate, weathers into very steep slopes, so that this portion of the county has a much rougher topography than the limestone areas. The difference in level of the hills and valleys is from 150 to 250 feet.

Owing to the varied nature of the rocks from which it is derived, the soil is not very uniform. Usually the surface soil is a yellowish sandy loam, underlain by a stiff white to yellow subsoil more clayey than the surface, but still containing a large per cent of sand. At a depth of 8 to 10 feet this subsoil grades into a soft white mucky shale, which has a very sour taste. In the valleys the subsoil is a coarse gravel composed principally of sandstone fragments.

Vegetation and Improvements.—The line between the limestone areas and the Huron group is sharply marked by a change in vegetation. The varied forests on the limestone soils give place to forests which are almost altogether red and black oak. The uncultivated fields grow up very quickly in wild daisies and sassafras. Persimmon trees are very plentiful in this area, although seldom found over limestone.

The soil is rather unproductive, easily exhausted, and washes badly. Much of the area is uncultivated and is overrun with second growth oak, the forests, which originally covered the slopes having been removed. The improvements are poor and the roads very bad, some of them almost impassable. The water supply is poor, except along the outcrop of the Huron limestone, where several fine springs occur. This limestone is one of the best road metals in the State and is easily obtained. Its use on the roads of the area would bring about a wonderful improvement.

The following table shows the results of analysis of samples of the residual soils of the Huron area:

MECHANICAL ANALYSIS OF HURON RESIDUAL.

Number.	Locality.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
1	Three miles S. W. of Harrodsburg, Monroe Co.	Surface sandy loam	.2	.8	2.1	2.4	16.9	77.0
1		Subsoil	.0	.3	3.1	1.7	10.3	84.6
2	S. W. Corner Indian Creek Tp., Monroe Co.	Yellow sandy loam	.1	.0	.2	.3	25.6	74.0
2		Subsoil	.0	.0	1.2	1.2	21.0	75.4

6. Glacial.

The glacial drift within the county is found principally in the northeast corner of the county and along the northern edge, with traces in a few places extending as far south as the Bean Blossom. Extending from Hubbard's Gap, in Marion Township, across the northern side of the county, the action of the glaciers is seen by the gravel covered places and the bowlders scattered along the streams and the heaps of sand, gravel and till which lie against the northern hill slopes; however, over most of the glaciated area the drift covering is very thin and the influence on the soils is small.

Below Mt. Tabor and Gosport, and in some of the hills south and east of Mt. Tabor, are heavy deposits of sand and a similar sand is also found along the south side of Bean Blossom, about two miles east of Stinesville.

"That it was of glacial origin is attested by the fact that it is banded with erratic gravel. The sand here is cross-bedded, stratified, and, in several instances, finely laminated. The lamination and stratification, however, are not constant. Towards the top of this sand the stratification ceases. This top seems to have been of eolian origin. This sand was deposited as an outwash in front of the advancing glacier after it had filled the channel of Bean Blossom. That it was deposited in front of the ice-sheet is clearly shown by evidence that after its deposition the glacier passed over it, crushing it under its weight until now the sand is almost as compact as the Knobstone formation beneath it. Still further evidence that the sand was deposited just in front of the ice-sheet is the fact that the Bean Blossom was filled at that point with ice. Had it been filled with sand instead of ice to the level of the present deposits, some remnants of the sand would still remain on the south side of the inner valley of Bean Blossom Creek, which is not the case. The sand in the vicinity of Mt. Tabor and Gosport is very fine and flourlike. It usually forms a loose or slightly compact, massive bed twenty or more feet in thickness. Occasionally it shows indications of stratification, but at no place is the stratification constant. In speaking of this sand Mr. Siebenthal says that it seems to have been deposited from high water resulting from a melting ice-sheet. It is, therefore, outwash material. How it came to be deposited as it is, however, is quite a mystery. The deposit is V-shaped, with the apex to the west. A limestone ridge separates its legs. On this ridge the sand is thin and suggests by its distribution that it might be eolian in origin. It seems clear, then, that the sand on the south side of the ridge must have come around the west end of the ridge instead of over it, and that the whole deposit was laid down in the slack water that accompanied the melting of the ice-sheet between Bean Blossom Creek and White River at the time of the high water that accompanied the melting of the ice-sheet. This opinion is strengthened by the fact that the sand plain gets lower and lower toward the east instead of higher, as it would had the sand come over the ridge. This conclusion is farther strengthened by the fact that this sand does not occur on the current, or south of Bean Blossom, as it probably would had it not been deposited in slack water. The sand, on the whole, seems to have been an eddy deposit."*

The Flatwoods.—The land known as the Flatwoods occupies a level tract of about 2½ square miles northwest of Elletsville. It is a part of an old glacial lake which extends for some distance over into Owen County. The area is surrounded by a ridge of higher land which terminates rather abruptly. This higher ridge shows evidence of glaciation, chiefly on the southern side, where many bowlders lie against the slopes. The surrounding ridge is broken by gaps at Ellison Branch, McCormack Creek and at three or four other places where streams head up against this area and at the same level with them.

The soil consists of a variety of black mucks, white and yellow clays. The surface appears somewhat uneven, because of the areas

*Albert B. Reagen. Proceedings of Indiana Academy of Science, 1903.

of the limestone formation which rise above the level of the Flatlands.

The white or light yellow soils are the prevailing type and are locally known as the "White Turkey Gravel." These soils are a mixture of glacial material, residual wash and organic matter. Some glacial sand and gravel are intermixed and small iron concretions are numerous, due to the action of stagnant water leaching out the soils. The black muck soil occurs in some areas as the surface soil, but principally is the subsoil.

The drainage conditions are poor and in wet seasons corn crops are a failure. The average yield is about 40 bushels. Timothy grows well and gives large yields of hay. Oats in favorable seasons yield about 30 bushels. The soils become very hard and crack in dry weather. The soils are sour and sad and are in need of lime and potash. The average sized farm is about 80 acres. The improvements are fair and land sells for about $40 to $65 per acre.

A section of a well in the N. W. part of Section 31, Township 10 North, Range 2 West, shows the following nature of the soils and underlying materials:

Soil and clay	17 to 18 feet
Imbedded logs	1 foot
Clay	8 feet
Water-worn gravel	1 foot
Blue, sticky clay	8 feet
Limestone	

Also section of well in S. E. part Section 26, Township 10, R. 3 West:

Black mucky soil	8 feet
Sand and fine gravel	6 feet
Blue, sticky quick sand with logs, sticks and leaves	8 feet

"Prof. Collett suggests that the Flatwoods formed a portion of the preglacial channel of White River, the valleys of McCormack and Raccoon Creeks furnishing the portions connecting with the present valley of that river. A close examination of the region in question, however, shows this to be impossible.

"The Pleistocene terraces of Bean Blossom Creek clearly prove the preglacial valley of that creek to have been practically as it is at present. It is impossible to imagine how it could be cut down to its present depth, while White River, into which it emptied, was running at a level approximately 150 feet higher than now, as it is alleged to have done. Moreover, the gorge of McCormack's Creek is clearly post glacial. And further, it empties into White River at least a mile below the upper end of the 'narrows,' whose existence it was brought forward to explain.

"A more reasonable explanation of the Flatwoods is that it is the site of a shallow glacial lake. This area in preglacial times must have been a region of sink holes, with drainage largely, if not wholly, subterranean, similar to the country which surrounds it, and to the region of caves and sinkholes west of Bloomington—in short, a region characteristic of the Mitchell limestone. When the glacier pushed down across these sinks, the excess of silt and sand choked up the underground outlets, and on the retreat of the ice-sheet the area was left covered by a thin sheet of water, probably from 20 to 30 feet in depth near the middle. Subsequently the drainage by way of McCormack's Creek was begun, resulting in the cutting of the gorge through which that creek finds its way to the river. The size of the drainage area and a fall of nearly 150 feet distributed over about two miles explain the steepness and narrowness of the gorge."*

7. Alluvial Soils.

The alluvial soils of Monroe County consist of about two and a half square miles of the White River valley, in the northwest corner of the county, the bottom lands and terraces of the Bean Blossom and Salt Creek and their tributaries and small areas in the south and western parts along the course of Richland and Indian Creeks.

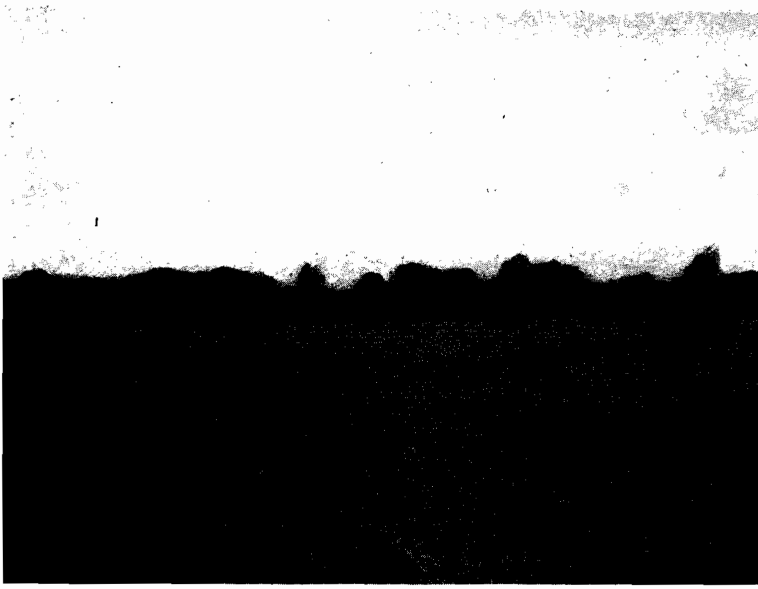
The soil of the White River valley consists chiefly of a fine sandy loam of a dark color. It extends to from eighteen inches to several feet in depth, before any marked change occurs. It is a very productive soil, but on account of frequent overflows almost the entire area is planted in corn. Cut-off hills and lost ridges of the Subcarboniferous rise above the valley floor in a few places. The second bottoms to the east consist principally of glacial sand, together with some residual soils. Gosport is the trading center for this part of the county. The Vandalia and Monon Railroads furnish transportation facilities.

Bean Blossom is a meandering stream with an alluvial plain

*Hopkins and Siebenthel, 21st Annual Report, Department of Geology, 1896, 301-2.

which will average about one mile in width through the county. Numerous terraces rise along the valley slopes. The terraces range from five to fifty feet in height, those further up the creek being the higher. They range in size from small areas to a mile wide and three or four miles long; delta-like accumulations rim the edge of the terraces next the valley floor. The lower parts consist of sand and erratic gravel, with sand and fine gravel above, and sand, clay and loam overlying all. The benches proper seem to be due to the weathering of the soft shales and sandstones of the region. The stream clings closely to the southern side of its valley, as is also the case with all its tributaries. Numerous streams of small size enter the Bean Blossom from the north; and three or four streams of considerable size flow in from the south, the largest of which are Sheuffle Creek, Griffy Creek and Jack's Defeat; all of these have comparatively wide valleys. The soils are for the most part poorly drained and not fitted for a great variety of crops. Corn is the principal crop grown. Timothy grows well, and yields much hay, which is rather coarse in quality. Much of the valley is in grass and a large number of live stock are raised. In places the soil has lost its loamy texture and become very clayey and loses its best physical properties because of the large amount of water retained. The average price of land is about $50. Very little tile draining has been done, but a thorough tiling would greatly increase the value of the land, and the soils could be made to produce from 75 to 100 bushels of corn per acre. In the spring of 1907, during the overflows, the Bean Blossom valley received a deposit of sediment about three inches in thickness over almost the entire area and thus its value for cultivation was much increased for that year, while in the Salt Creek valley at the same time practically all the surface soil to the depth of cultivation was swept away as far down as the junction of Clear Creek and Salt Creek. Farmers were much discouraged and crops were in a poor condition for that year.

The Salt Creek alluvial plain will average about a half mile in width. The soils are sandy clays, owing their origin to the upland formation. The subsoil contains numerous fragments of sandstone, and in the lower course geodes and fragments of limestone. Well defined low and high terraces occur along the valley of Salt Creek to a point below the Fairfax bridge. The Salt Creek has a large drainage area—three forks entering from Brown County and three principal streams from Monroe—Stephens Creek, Brummets Creek, and Clear Creek in the south.



Recent terraces in Salt Creek Valley, southeast Stobo, Monroe County.

Salt Creek Valley, showing high terraces in background. Southeast Stobo, Monroe County.

Land can be bought at prices from $20 up, according to locality and improvement. The upper part of the valley and the surrounding country are in a backward condition because of their great distance from towns and railroads.

Small barren spots are found, both in the Bean Blossom and Salt Creek valleys, due probably to the presence of saline shales. Swamps and bayous are also found along the course of both streams.

Richland Creek and Indian Creek have very narrow valley floors, but the second bottoms comprise considerable areas and the long, gentle slopes from the north and west add much to the agricultural value of the south and west part of the county. The Richland area is better improved than the Indian Creek valley. The soils of the former are derived principally from the slopes of the limestone area, those of the latter chiefly from sandstones and shales.

8. Clays.

The type here designated as clay and having an area of about five square miles includes those scattered areas of small extent in parts of the Knobstone and Harrodsburg regions where the surface soil has practically all been removed and the stiff clayey subsoil exposed. Such areas are of no agricultural value, except as for some deep-rooted fruits. The principal areas of this type are located in southern Marion Township, along the north side of the Bean Blossom, along Sheuffle Creek and in the vicinity of Dolan, Unionville and Stobo.

The clay of the Harrodsburg limestone is the typical stiff red clay. That from the Knobstone shales is usually of a bluish color, except on much weathered surfaces, where it becomes light yellow. Much of this clay would burn well for tile and in this way supply a great need of much adjacent land.

In addition to the clays mentioned above, considerable of the delta and bench formations in the lower Bean Blossom valley are composed entirely of stiff yellow clay and might be included in this type.

General Summary.

The great variety of soils in Monroe County, with wide adaptation, make possible the successful carrying on of many branches of agriculture.

Canning factories should be established, and lands which are

Field of corn not planted until late in June, 1907, near Harrodsburg in the Clear Creek Valley. Well matured before frost and yielding above the average.

Salt Creek Valley, east of Harrodsburg, Monroe County.

now scarcely paying expenses would be valuable feeders for such factories. Factories could well be maintained at several points and run all the year.

Several large groves of maple trees remain on the Harrodsburg, Oolitic and Mitchell areas and hundreds of gallons of molasses are made every spring.

There is great opportunity for extensive truck farming and fruit growing. Last year forty-five carloads of potatoes were shipped into Bloomington. The average yield in the county is low and only small areas are planted. There is enough extra space for the forty-five carloads. Practically all the fruit for market purposes, except strawberries, raspberries and blackberries, is brought in from distant points.

The Knobstone clays are well adapted to the growing of tomatoes and small fruits, and interested persons, with small capital, should be attracted to these cheap soils.

Large areas are in need of drainage and the large deposits of clay afford good material for the making of drain tile. At present the only kiln in the county is at Dolan, and it cannot nearly supply the demand, nor can they be hauled enconomically to the most needed places. For example, the writer, when working along the Salt Creek valley, saw a farmer hauling tile from Dolan's, a distance of twenty miles. He could haul but few for a load and about a fourth of these were broken when he reached home.

Wells are difficult to obtain throughout the entire county, except in the bottom lands, where water can be found at a depth of a few feet. For domestic purposes people are dependent chiefly on cisterns and springs. The best spring waters are found in the Mitchell formation; sinkholes and artificial ponds and streams furnish most of the water for live stock.

School advantages are good and the school enumeration is high. Rural routes serve about 7,500 people in the county. Good telephone systems lead to all points. There are in the county 875 miles of public road, with almost 200 miles improved with crushed stone or stream gravel. The stone industry is just now being fully developed and everything presents an encouraging outlook for the county, and the agricultural growth must necessarily be great to meet the demand.

BROWN COUNTY.

History of Settlement and Agricultural Development.

Brown County was organized in 1836, and named after Gen. Jacob Brown, one of the heroes of the War of 1812.

In the early days there were several tanneries in the county doing an annual business of about $50,000. The articles exported were principally leather, wheat, stock, hoop-poles, etc., to the value of $100,000 annually.

In 1850, with a population of 4,000, there were about eight schools in the county, with 160 scholars, but at the present time the school enrollment is about 2,500 and the school facilities rank among the best in the State.

Brown County is twenty miles in length from north to south, and sixteen miles in breadth, and contains 320 square miles.

There are five civil townships: Hamblin, Jackson, Van Buren, Johnson and Washington. The population in 1900 was 9,727.

The principal towns are Nashville, Georgetown, Helmsburg, Trevlac and Elkinsville. Numerous other villages and country stores and postoffices over the county are: Christiansburg, Buffalo, Pike's Peak, Mt. Moriah, Needmore and Belmont.

Nashville, the county seat, is a small village with a population of about 400. Its progress has been hampered by the lack of railroad facilities. An excellent artesian well, drilled in 1899, furnishes a good supply of saline-sulphur water. The well is 530 feet deep, and when first drilled yielded a flow of about ten gallons of water per minute. It now, however, does not flow, but stands within a few inches of the surface and must be pumped. It has a temperature of 56 degrees F. The water is clear and sparkling, with hydrogen sulphide and carbonic acid gases. The "Nashville Sanitarium," a frame hotel and bath house, containing 24 rooms, was erected in 1900, and under the present management is open to guests the entire year. Since the completion of the Indianapolis Southern Railroad through the northern part of the county many visitors come to the sanitarium during the year. The accommodations are good and the rates low, and the quietness of the place makes this an excellent place for those desiring rest. Numerous places of interest are easily reached by drives or walks. Other mineral waters are found within the county. With better means of transportation, Nashville as a center, with the mineral waters and beautiful surrounding scenery, is in a position to receive many guests who may come for the benefit of health and recreation, and also become a noted resort for picnic and pleasure parties. Helmsburg, the nearest railroad station, is five miles distant. A hack from Nashville meets all the trains.

Georgetown, or Bean Blossom, is a little village in the northern part of the county. It has a population of 260. Helmsburg is the railroad point.

Helmsburg and Trevlac are new towns on the Indianapolis Southern Railroad. Helmsburg is the station for Nashville. Formerly all merchandise for the county seat was brought in either by way of Columbus or Bloomington. Trevlac promises to be a thriving little village, and a number of summer cottages have been erected and a park is being arranged, and, with the picturesque scenery surrounding, it is expected that many guests will frequent this place to spend their summer vacations.

Elkinsville is a little village in the southern part of the county on the main branch of Salt Creek, and has a population of about 75. It is a trading center for southern Brown, and receives its merchandise by wagons from the line of the Southern Indiana Railroad through northern Jackson County.

General Improvements.—There are in the county 350 miles of public roads, with thirty miles improved with gravel. Many of the roads have been partially covered with creek gravel, and if they had been properly graded and drained, this improvement would have been permanent, but in the majority of cases the cost of improvement will be as much as on a new road. Excellent creek gravel occurs everywhere along the streams and in sufficient abundance to easily and cheaply improve every public road in the county.

Until 1906 the county was without a railroad. The nearest railroad stations were in Columbus on the east, Bloomington on the west, Morgantown on the north and stations of the Southern Indiana to the south. With the completion of the Indianapolis Southern, the business interests were revived and increased trade gave a brighter outlook for the county. A few rural routes go out from Nashville and others serve part of the county, coming from adjoining counties.

Agricultural conditions have not reached the highest standard. While the soil is not a rich soil, taken as a whole, there are large areas that are valuable farming tracts and could be made to produce well. The principal occupation has been to remove the timber from the thickly wooded hills, and sell for lumber, wood, hoop-poles, railroad ties, tanbark and hickory bark, and to cultivate sufficient land to yield grain and vegetables for home use, with perhaps a few bushels to sell. Very little stock is raised. Under these conditions agriculture for many years made but little progress. With careful cultivation and fertilization the soils of this county may be made to yield abundantly. While few special experiments have been tried, careful investigation has shown that the "Knob Soils" are of value and not to be regarded as too poor to grow anything but briers and sassafras. An important thing in the cultivation of these soils is to prevent washing. The staple crops can all be made to give paying returns and the region is specially adapted to the growing of fruit.

The county now produces, according to latest statistics, about 400,500 bushels of corn, an average yield of about 30 bushels to the acre; wheat, 91,838 bushels, an average yield of about 15 bushels per acre; oats, 190,091 bushels, an average per acre of 38 bushels; timothy, 9,249 acres, with an average yield of about one and one-third tons; clover, 1,500, with a yield per acre about one and one-third tons, and also giving a fair yield of seed; alfalfa, 25 acres, has only been tried a few years. About 500 acres are planted in potatoes, with an average yield of 40 bushels. Very few tomatoes are grown. Peas, watermelons, cantaloupes, etc., would not total a good sized garden. A little tobacco is grown for individual use. For results on fruit growing, see paragraph on vegetables and fruits.

Physiography and Geology.

Brown County, in its geological formation, is confined to the members of the Knobstone group, with slight modifications in places from stream action and glacial invasion, and on a few of the higher ridges in the western part there remain a few fragments of the reddish crinoidal Harrodsburg limestone. The soft sandstones, with the alternating shales, are easily eroded and a very rough topography has been developed, except in the southeast corner, where there is a large area of level table land. High level topped ridges, remnants of the old plateaus, stretch out for great distances. The slopes are high and steep, and numerous streams have cut "V"-shaped valleys down the slopes. Thus the knobstone plateau has been very perfectly dissected by the streams, which, with their small tributaries, form an intricate dendritic system of valleys. These valleys are unproductive, except where bottoms have been formed in them by the silting-up process.

The Knobstone strata absorbs water easily, but are practically impervious to circulating waters, and for this reason springs are rarely found. Drinking water is mostly obtained from wells and is usually of a very poor quality. At the top of these impervious strata, however, is a natural spring horizon, and along this line springs are abundant.

The southern slopes, exposed to the action of the sun, and during the winter to constant freezing and thawing, are long and gentle, while those to the north are more abrupt, in many cases being steep bluffs. The Knobs attain their highest elevation, 1,147 feet, above sea level, in "Weed Patch Hill," southeast of Nashville. Several years ago a triangulation tower was erected on the hill; a government stone now marks this point. "Bear Wallow" hill, northeast of Nashville, is also another point of highest elevation. "As one ascends these higher elevations on some of the winding roads, knob after knob and ridge after ridge are unfolded to view, disclosing the knobstone topography in all its pristine beauty. The narrow valleys trend mainly east and west, making the slopes of the ridges north and south. The latter are everywhere eroded into many gulches and ravines. Here and there on some distant ridge can be seen a roadway, winding in and out in great spiral convolutions, like a great snake, stretched out in lazy, graceful curves. It is one of the most picturesque and rugged portions of the State, well worth the name of the "Switzerland of Indiana."

The part of the county north of the Bean Blossom Ridge is within the glacial limits. Some drift accumulations are found over this area, and extending over the slope of Bean Blossom Ridge to a height of almost 200 feet above the water in the streams. In general the topography and the soil have been but little modified by the drift. North of the boundary of Brown the knobstone area is practically all covered by glacial debris, and the strata are exposed only in the stream valleys and along the larger streams high bluffs are found.

In the western part of the county on some of the higher elevations, the soil is of a red, clayey texture, intermingled with chert geodes and crinoidal limestone fragments, due to the weathering of the lower impure members of the Harrodsburg limestone. Some geodes are also found in the upper knobstone.

The drainage of the county is chiefly by the Bean Blossom and Salt Creeks. The former, with its tributaries, drains the northern one-third of the county. The stream has a meandering course and with considerable areas of bottom land and low terraces. The principal tributaries are from the north and fall rapidly to the

Knobstone topography as viewed from east side of Weed-Patch Hill, Brown County.

Looking north across Salt Creek Valley at Nashville, Brown County.

main stream. For further description see Bean Blossom under Monroe County.

Salt Creek, the principal stream of the county, consists of three main branches—the "North," the "Middle" and the "South" forks, which unite near the southwest corner of the county and flow through Monroe and Lawrence counties into the East Fork of White River. The entire stream is meandering in its course and there is but little valley except across the meander curves. The valley soils are usually wet, but with artificial drainage produce well. The narrow valleys, with their steep sides and winding streams, are subject to great overflows three or four times each year, and crops are often badly ruined. The main tributaries of the North Fork are: Jackson Creek, Lick Creek, Clay Lick Creek, from the north, and Henderson Creek and Schooner's Creek from the southeast. All these streams contain considerable quantities of red stream gravel. The branches of the middle fork are: Crooked Creek, Little Blue Creek and Grave Creek, from the north, and Hamilton Creek and South Fork Salt Creek from the southeast.

SOILS.

The soils of Brown County are derived chiefly from the decay of the Knobstone strata, and consist of sands and clays. For this reason the soils of this area have become considered the poorest and most unimportant of any in the entire State. But as stated in a foregoing paragraph, these soils are not wholly bad and will admit of much profitable cultivation and improvement. The low price at which land may be bought offers abundant opportunity for the enterprising farmer who has not the means to secure land in a more fertile area. The net income from these cheap lands should be greater than in places where more money must be expended. However, special cropping systems are advisable and a large amount of experimental work should be carried on here by our agricultural schools and experiment stations.

Although the soils owe their origin chiefly to the same source, we find within the county a number of types which may be given as follows:

Knobstone residuals—	
Clay	150 square miles
Sand and sandy loam	100 square miles
Harrodsburg limestone, clay	10 square miles
Glacial	50 square miles
Alluvial	20 square miles

THE KNOBSTONE RESIDUALS.

The clay is derived from the shaly members of the formation, and are usually of a light yellow color and grade in the subsoil into a stiff, mucky clay, usually of a brown color, or may be mottled yellow and brown.

A mechanical analysis of the soils show the following proportions:

MECHANICAL ANALYSES OF KNOBSTONE RESIDUAL.

No.	LOCALITY.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
1	Top of Weed Patch Hill.....	Sandy clay loam.	11.1	2.7	7.2	17.2	14.0	47.2
1	Top of Weed Patch Hill.....	Subsoil.........	7.6	2.2	8.7	12.0	9.6	58.8
2	3 mi. N.E. of Georgetown...	Brown loam.....	1.7	1.3	6.0	2.4	12.7	74.5
2	3 mi. N.E. of Georgetown...	Subsoil.........	2.5	.4	3.9	2.2	10.1	79.0
3	1½ mi. S.E. of Georgetown...	Clay loam	0.0	.7	5.3	9.1	18.8	65.2
3	1½ mi. S.E. of Georgetown...	Subsoil.........	25.0	2.8	5.4	4.0	19.2	40.2

Chemical Analyses of Two Samples of Knobstone Shales.

Silica (SiO_2)	59.64	64.59
Titanium oxide (TrO_2)	1.05	.30
Alumina (Al_2O_3)	19.14	16.37
Combined water (H_2O)	14.36	3.71
Ferric oxide (Fe_2O_3)	3.39	5.37
Ferrous oxide (FeO)	4.20	1.59
Lime (CaO)	0.26	.16
Magnesia (MgO)	2.31	1.56
Potash (K_2O)	3.53	4.24
Soda (Na_2O)	.80	.97

Many concretions of considerable size are found in the knob shales, but not of sufficient quantity to be of any value in the manufacture of iron, but when worn into creek gravel they make an excellent road metal. The reddish brown color of the soil in many places is also due to the oxidation of the iron received from the weathering of these concretions.

The Sand and Sandy Loam.—The sand areas are due to the sandstone found chiefly on the top of the series which in their disintegration yield an unproductive medium sand. The soil has a red color, due to the presence of iron and the subsoil grades into a coarse, gravelly sand, and in depth to a rather porous rotten sandstone. The true sand areas are small, but grade into the sand loam, usually at a lower level and due to the mixing of the disintegrating material of the thin bedded sandstone and alternating shaly portions. These sandy loams are usually of a brown color and contain a higher percent of organic matter than is found in the sand areas. The sandy loam occupies numerous but rather small areas and grades into the clay, which is also of a somewhat loamy nature. The lines of demarkation between these soils are not well defined and the character of the soil, its natural vegetation and productions, justify the mapping as a single type under the knobstone group. All three types may occur on one farm or even in a single field, and accurate delimitation would not be practical.

The greater part of the original growth of timber has been removed and the knobs and slopes of the ridges are now thickly covered with second growth timber and underbrush. It consists chiefly of chestnut, black, white, scarlet, jack, post and red oak, beech, elm, walnut, hickory, sassafras and sumac, dogwood and redbud, with an occasional maple, poplar, etc.

Corn yields on the average about 30 bushels; wheat produces 10 to 20 bushels; oats are only fair. Timothy and clover usually yield a fair tonnage, but are soon largely taken by red top and wire grass.

Special Farm Products.

The possibilities of Brown County have been but little developed in this line. About 500 acres of potatoes are raised annually, but the average yield is only 32 bushels per acre. Until very recently no tomatoes have been grown, although the soil is very similar to that which gives excellent crops in other counties. Some tobacco is raised, the acreage running from 5 to 10 yearly.

The soil will not produce these crops without fertilization, but with proper care there is no reason why much larger yields of all these products should not be produced. On soil which has not been built up by clover from 800 to 1,500 pounds of fertilizer are required per acre. For tomatoes, the fertilizer should have the following constituents: Nitrogen, 4%; active potash, 6%; available phosphoric acid, 7%. For potatoes the amounts should be: Nitrogen, 3%; potash, 9%; available phosphoric acid, 6%.

Fruit.

While Brown County does not lead in fruit production, it is well located and has a good soil for all sorts of fruits. At present the number of fruit trees in the county is about as follows: Apple, 75,000; pear, 5,000; plum, 3,000; peach, 15,000; cherry, 4,000. All these do well and yield good returns. While the fruit crop of 1907 was a total failure, in 1906 about 70,000 bushels of apples were produced, and the peach crop was correspondingly large.

Two of the largest orchards of the county are the Freeman and Waltman orchards, about one mile south of Georgetown. The Freeman orchard consists of about 75 acres and contains 700 bearing apple trees and 8,000 bearing peach trees. The orchard is well kept up and is sprayed four times each year. The apples are just beginning to bear well, producing about 600 bushels per year at present. An average yield of peaches is about 2,000 bushels. Over 4,000 peach trees were recently destroyed by forest fire. The Waltman orchard consists of 6,000 apple trees, 100 pear trees and 500 young peach trees. The average age of this orchard is about twelve years. Of an ordinary season the yield of apples averages about seven bushels per tree, the older trees producing as high as 12 or 15 bushels. The orchard is still increasing in yield. Both of these orchards have been successful from a financial standpoint, in spite of their distance from a good market. Helmsburg, on the new railroad, is about two and one-half miles from the orchards, and the returns will probably be larger in the future than they have been in the past.

Very little small fruit is grown for market, but many of the hill slopes are covered with wild blackberries and raspberries, and the cultivated fruit would certainly do well in these localities. One of the principal areas of strawberry culture in the State is located on the Knobstone soil near New Albany, where the crop yields the grower annually about $300,000.

The principal factor in retarding the production of the varied farm products and of fruit, was the distance from good markets. The building of the Indianapolis Southern has removed this disadvantage from the north portion of the county and great development should be made. There seems to be an excellent opportunity for the location of a canning factory at one of the stations along the railroad or at Nashville. A factory which could can the different fruits, beans, corn, pumpkins, tomatoes, etc., could be kept running through the summer, and if hominy and sauerkraut were added to the list of products, almost the whole year. While one of the stations along the new road would be the better location as regards transportation, the factory could be located at Nashville and the finished product hauled to the railroad. The roads, although rather hilly, are in fair condition and would not prohibit this arrangement.

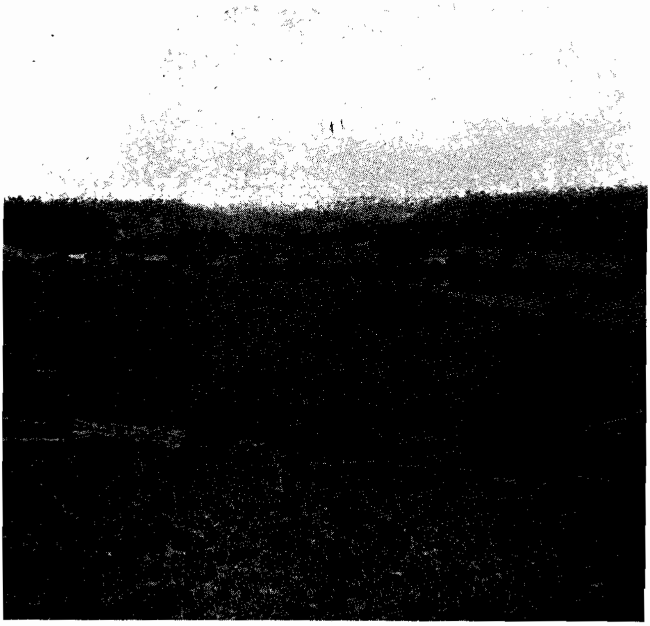
Alluvial Soils.

The alluvial soils of Brown County are found along the Bean Blossom and the various forks of Salt Creek. The total area is about 20 square miles. The greater part of the bottom land is in the meander curves. The alluvial soils in both areas are fairly productive but are difficult to drain.

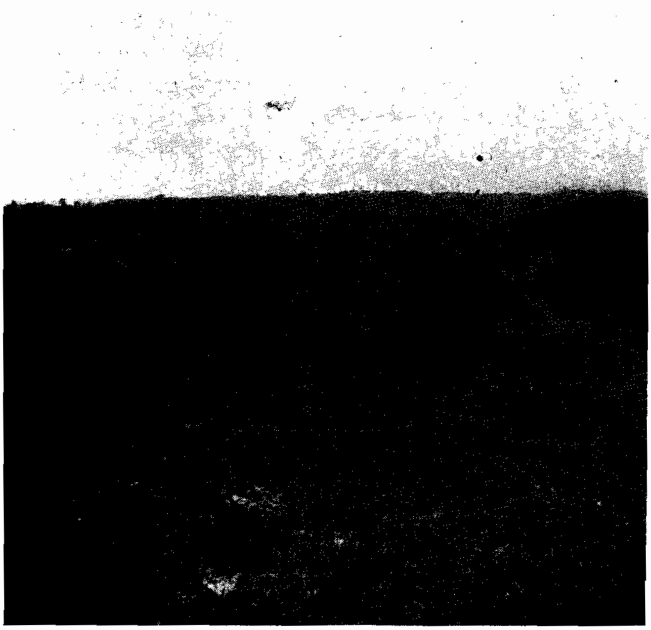
The Bean Blossom soil contains considerable glacial material, and numerous geodes in the subsoil. The surface soil is a heavy brown clay loam. Along the stream are two sets of terraces. The first is the flat top of the old plateau, and stands high above the stream; the other is a more recent terrace, and rises 5-10 feet above the valley floor. These low terraces have in most cases been mapped with the valley. They consist of a very stiff white clay, which is wet and unproductive. Corn will sometimes yield 35 bushels per acre on this. It is too wet for timothy, wheat, or oats to produce well. Buckwheat and flax grow well on these terraces. These soils owe their color to the absence of both humus and ferric hydrate. The soil has been subjected to reductive maceration through the influence of stagnant water; reducing the ferric hydrate to ferrous salts, oxidizing away the humus and accumulating the form of inert concretions the lime, iron and phosphoric acid of the soil mass. This land is called "crawfish" land, and it is very common to see crawfish mounds thickly studded over such soils. This soil may be improved with green manure and the use of phosphate. The best land in the valley sells for $50 and upward. The improvements are fair. Water for domestic use is obtained from wells dug in the valley flow, and water is usually found at about 8 to 10 feet. The water is not first-class, on account of surface seepage.

The Salt Creek valleys are low lying and wet. The clay soil, when wet, is very tenaceous and is of a dark brown color, but when it is plowed and becomes dry it is of a white color. If plowed when wet it is very hard to pulverize. Corn yields from 35 to 40 bushels per acre. In the upper valley, wheat will produce 10 to 12 bushels. During 1907 there were four floods that did great damage to the Salt Creek valleys, by carrying away almost the entire surface soil. The land sells from $25 to $55 per acre.

Along the foot hills is a strip of land a few rods in width which is very wet and mucky from the numerous springs and seepage water from the hills.



Looking east up the valley of the Middle Fork of Salt Creek, from a point two and one-half miles west of Pikes Peak



Looking south from same point as above. The creek here makes a curve to the south.

The timber growth of the alluvial soils consist of water and white beech, white walnut, sycamore, elm, ash, wild cherry, pawpaw, willow and locust.

Glacial.

About 60 square miles of northern Brown County lies within the drift covered region of the "first glacial invasion." The principal part of the glacial material lies against the northern hill slope, and only in a few places has any considerable amount been found south of the Bean Blossom Ridge. Over the greater part of the area the material has been carried down to the stream valleys and underlies the more recent stream wash material. It is from these stream deposits that are the source of the gold found in Brown County. As regards the upland soil, there are but slight modifications due to glacial material, except in small areas.

General Summary.

In general the farmers of the county are satisfied with the returns from their land. The average price of land is from $25 to $35 per acre. The improvements range from poor to good. A small percentage of the uplands are under cultivation, and yield only fruit trees, hickory bark and railroad ties. In the greater part of the county the necessary thrift and energy is lacking to get the best results from the soil. Yet new machinery and farming tools are being brought into use and progress is being made; however, some corn is still planted by hand dropping and some wheat harvested with the cradle, and occasionally a yoke of oxen may be seen slowly wending their way into the county seat.

Red-top, wire grass, hog or steel weed, and plantin are very troublesome.

A good cropping system, with an abundant supply of manuring and a liberal supply of potash, together with the best care in cultivation to prevent washing the knobstone soils of this county, may soon be a paying investment. And with the introduction of the up-to-date methods of agriculture and husbandry, grazing, etc., Brown County may readily in twenty-five years more than double her agricultural wealth.

LAWRENCE COUNTY.

History of Settlement and Agricultural Development.

Lawrence County was organized in 1818 and named in honor of Capt. Lawrence of the Frigate Chesapeake, who was killed in the battle with the frigate Shannon. In 1830 the county had a population of 9,237; 1850, 13,000; and at the present time has a population of 26,000.

The county contains 454 square miles, being 22 miles from east to west and 21 miles in length. The civil townships are Shawswick, Pleasant Run, Perry, Indian Creek, Spice Valley, Marion, Bono and Flinn.

The principal towns are Bedford, Mitchell, Oolitic, Heltonsville, Huron, Avoca, Williams, Springsville, Tunnelton and Fort Ritter.

Bedford, the county seat, was laid out in 1826. It now has a population of 7,000. It is the center of trade for a large agricultural district, and is also the leading city in the quarrying, sawing and cutting of the Oolitic limestone.

Mitchell, in the south central part of the county, at the crossing of the B. & O. S. W. and the Monon Railroads, has a population of 1,772. It has a large country trade, being located on the level land of the Mitchell soil. The Lehigh Portland Cement Company has two large mills at this place.

Heltonsville, with 525 inhabitants, is in the northeast part of the county, on the S. I. Railroad. It is principally a trading center for this section of the county.

Tunnelton, Huron and Ft. Ritner are stations along the B. & O. S. W. They are trade centers for the farming population around them. All three have sawmills.

Springville has a population of 270. It is in the northwest part of the county, on the B. B. branch of the Monon; is a trading center.

Williams is on the S. I. Railroad, near the Martin County line, and has 200 inhabitants. A large road metal and ballast quarry in the Mitchell limestone is just west of the village.

Oolitic, Peerless, and Dark Hollow, are villages in the vicinity of Bedford, which owe their existence to the stone quarries. Other stations and postoffices are Guthrie, Georgia, Yocky, Reeds, Shawswick and Rivervale.

There are in the county 600 miles of public roads, with almost 400 miles improved with gravel and crushed stone.

The first improved roads were built in 1895. The stream gravel his been used far more extensively than the crushed stone, and gives good satisfaction. On many of the roads the gravel is used as a top dressing for the stone. Most of the roads south of the river are built of Mitchell limestone. Those west of Bedford largely of limestone, and practically all in the eastern part are of stream gravel. There is also much gravel along White River, but it is inferior to the creek gravel for road purposes.

The county now produces about 900,000 bushels of corn, with an average yield of 35 bushels per acre; 250,000 to 300,000 bushels of oats, average about 20 to 25 bushels per acre; 130,000 bushels of wheat, average 16 bushels; 15,000 acres of timothy are grown annually, which yields 1¼ to 1½ tons per acre. About 3,000 to 3,500 acres of clover produce an average of 1 to 2 tons per acre and a total of from 450 to 600 bushels of seed. The acreage of potatoes is usually about 300 acres, and 40 to 45 bushels is an average crop. Of other crops about 10 acres of peas are produced; 100 of watermelons, and 2 to 5 each of tomatoes and cantaloupes. Between 30,000 and 40,000 bushels of apples are produced in fair seasons. More attention is being given to tobacco raising, about 30 acres being reported in 1905, and nearly 75 in 1906. Lawrence is an excellent fruit county and ranks fifth among the counties of the State in the number of plum trees, having about 16,000 trees. While not especially a live stock county, it ranks tenth in number of mules sold, about 700 annually. It also ranks among the leaders in its poultry production, which is about 35,000 dozens annually.

PHYSIOGRAPHY AND GEOLOGY.

Lawrence County.—"The rocks forming the surface of the county represent six geological epochs. The Knobstone covers the northern half of the northeastern fourth and a narrow strip along the eastern border. The Harrodsburg limestone forms the greater part of the eastern half, and where eroded through by the streams, has exposed the underlying Knobstone in a number of the valleys. The famous Indiana Oolitic limestone covers a narrow, irregular strip just to the west of the Harrodsburg. The Mitchell limestone occurs over the surface of a strip three to nine miles in width extending from northwest to southeast, just west of the center, the wider portion being in the area south of White River. The Huron Group covers large areas in the northwestern and southwestern portions, while the Mansfield sandstone forms the surface of some of the higher elevations in the extreme southwestern corner.

"On account of the presence of so many rock formations, the surface of the county is exceedingly diversified. The eastern and northeastern parts are undulating or gently rolling plateaus drained by deep, narrow valleys, the central region north of White River is hilly, and the western and southwestern is rough and broken. Each of these divisions is covered with a soil almost wholly formed from the decomposition of underlying rocks. We consequently find the soil in the first, tenacious clay and sand; of the second, a calcareous clay, and of the third, principally siliceous material, with an intermixture from both of the others. In that part of the county underlain by the oolitic and the Mitchell limestone, comprising a broad belt about 12 miles wide, passing centrally from northwest to southeast, sink holes are so numerous as to form a striking feature in the configuration of the surface.

"The East Fork of the White River, which, with its tributaries, drains the entire county, crosses the county from east to west in a very meandering course a little south of the center. It is a broad, clear stream, as large as the Wabash at Lafayette, and flowing with a rapid, strong current. From the north it receives Indian, Salt, Leatherwood and Guthrie creeks, while from the south enter Sugar, Fishing and Beaver creeks."*

SOILS.

Lawrence County has a great variety of soils, ranking next to Monroe in number. There are seven general types, with many local variations. Six of these general types owe their origin directly to underlying geological formations and the others to stream action. The following table will show the extent of each type:

Knobstone	75 square miles
Harrodsburg	90 square miles
Oolitic	15 square miles
Mitchell	175 square miles
Huron	65 square miles
Mansfield	10 square miles
Alluvial	25 square miles

1. Knobstone Area.

The Knobstone soils lie principally in the northwestern part of the county and along the streams of the eastern side. The general characteristics are the same as described under preceding

*W. S. Blatchley, Report 1905, 913.

counties. The close proximity of the Southern Indiana Railroad has brought about some advancement, but a large part of the area yet remains covered with a growth of shrubbery and second growth timber. Most of the large timber is gone, but large numbers of railroad ties are cut and hauled to Heltonsville and Norman. Land is valued at prices ranging from $5 to $50.

2. Harrodsburg Area.

The residual soils of the Harrodsburg limestone rank second in area in the county. The soils contain large numbers of geodes and chert fragments. In the central part of the area the surface is gently rolling, while around the edges the streams have cut down through into the Knobstone and etched their way back into the formation for several miles, in some cases leaving long, narrow ridges capped with the limestone. The soils are considered among the most productive in the county, and although the improvements are not good as in some other localities, great advancement is being made and the price of land is steadily advancing. The principal roads are improved with crushed stone and stream gravel of a most durable sort. Large amounts of commercial fertilizer are used. Corn produces about 50 bushels per acre, wheat 10 to 20 bushels, oats 30 to 40, and timothy and clover yield well. Little attention is paid to stock raising and only a small amount of fruit has been planted.

3. Oolitic Belt.

The residual soils of the Oolitic belt of limestone do not cover as large an area as might be expected from the map, since, especially along the streams, the Oolitic forms little more than rock outcrops winding in narrow sinuous strips but producing very little soil. In the larger areas the surface is gently rolling and presents a most picturesque appearance. Generally the soils are productive and are cultivated in the best manner possible, and good improvements have been made in other localities. Where quarrying is the chief occupation, large areas have become practically worthless from an agricultural standpoint. Railroad facilities for the area are good and most of the public roads are well improved.

The following table shows the mechanical analysis of two typical samples of the soils of this area:

HANICAL ANALYSIS OF OOLITIC RESIDUAL SOILS.

Number.	Locality.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay
1	Near Oolitic	Surface	.0	2.2	.6	5.0	.5	92.4
1	Lawrence Co.	Subsoil	2.0	3.0	.5	.5	.5	93.5
2	S. E. Bedford	Surface	.5	1.5	.3	3.0	1.0	94
2	S. E. Bedford	Subsoil	3.5	2.0	.2	.2	3.0	90.5

4. The Mitchell Area.

The residual soils of the Mitchell limestone occupy the largest area of any type in the county. The typical topographic features are best developed in the vicinity of the town of Mitchell. The area is that of an upland plateau, generally level, except for the presence of sinks. The sinkhole depressions are very numerous, and lying just north of the town of Mitchell is an area in which the sinks have been clogged and are filled with water and give the appearance of large marshes. Willows, cat-tails, water lilies and other water-loving plants grow in abundance, and bordering these sinks is the typical growth of sassafras and briars. Over most of the area the soil has greater depth than in Monroe County and the subsoil is more nearly free from chert and other impurities.

Large amounts of commercial fertilizer are used, also a great deal of stable manure. Corn yields about 50 bushels on the average, wheat 10 to 15 bushels, timothy and clover 1 to 2½ tons, and some clover seed is threshed. Small areas are devoted to truck farming. A great deal of fruit has been planted during the past five years, and the Indiana Experimental Fruit Farm is also located in this area, south of Mitchell, near the county line, and just east of the Monon Railroad. Here thousands of trees are planted, including several hundred seedling apple trees for experimental purposes. The greatest care is manifested in the care of the orchard, in pruning and spraying, and methods of handling the fruit. In 1907, when the fruit crop for Indiana was so near a failure, a large quantity of apples of the very best quality were raised in this orchard. Meetings of the State Horticultural Society are held here and the interest manifested and the results of the experiments should mean much for the county and the whole of Southern Indiana, as to the value of fruit growing.

The following table shows the results of mechanical analysis of the residual soils:

MECHANICAL ANALYSIS OF MITCHELL SOILS.

Number.	Locality.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
1	N. E. of Springville.......	Surface......................	.8	1.5	1.5	.5	4.0	92.5
		Subsoil......................	4.0	2.5	1.5	.3	5.0	89.4
2	S. E. of Mitchell..........	Surface......................	.2	.5	.8	.3	5.0	93.0
		Subsoil......................	.5	.5	1.5	.5	3.0	94.5

5. The Huron Area.

The Huron group, composed of limestones, shales and sandstones, weathers into a varied topography and gives a soil of varied texture and quality. The sandstones and shales predominate, so that the topography is as a rule much more broken than in the limestone belt to the east. The ridges extend principally from the northeast to the southwest and have long, moderate slopes to the southeast and very steep slopes to the northwest.

The soil is a yellow loam, usually very sandy from the disintegration of the sandstone layers. At a few feet in depth it usually grades into a white shale muck of strong acid reaction. Some iron ore concretions are often found in the subsoil. The soil is poor and much of it is untilled. Practically all the slopes are overgrown with second growth timber, in which oaks predominate.

Commercial fertilizer is necessary to produce good crops of the common cereals. Some fruit is raised and there is good opportunity for development along this line.

The improvements are poor and the roads in such bad condition that even if good crops could be raised it would be almost an impossibility to market them rapidly and economically. This condition is unnecessary, as the limestones of the group are excellent road materials and are easily accessible. The water supply is rather poor, although there are some good springs along the outcrop of the limestones.

Corn produces from 20 to 50 bushels, wheat 8 to 15 bushels, oats 25 to 30 bushels; clover grows well on the tops of the ridges and timothy thrives better on the slopes and lowlands. Three railroads pass through this area and there are chances for great developments along special lines in this area. Land sells at prices ranging from $10 to $50 per acre.

The accompanying photograph will show something of the topography of this area.

View in Huron topography. Overlooking Indian Creek from the west near the Lawrence and Martin County line.

6. Mansfield Sandstone.

The residual soils of the Mansfield sandstone comprise an area of about ten square miles in the southeast part of the county. These soils occur in irregular patches capping the highest hills. The typical soil is a yellow sandy loam, underlain by a more tenacious subsoil of a reddish yellow color, mottled with white.

These soils have always been considered of a poor quality for general farming purposes, but their value has been somewhat increased by some experimental work and the liberal application of fertilizers. Corn yields on the average about 30 bushels, wheat 10 to 12 bushels. The land is well adapted for grazing purposes, except in the driest seasons, when the ground becomes parched and water becomes very scarce. The Mansfield soils are described more fully under Martin County, where the formation is the prevailing type.

7. Alluvial Soils.

The alluvial soils of Lawrence County consist of the bottom land along Salt, Leatherwood, Guthrie and Indian Creeks and the east fork of White River; also a part of an old abandoned river valley just east of Williams.

The Salt Creek bottoms are on the average from three-fourths to a mile in width, generally low lying and wet, and considerable areas do not permit of successful cultivation. The parts of the area which are drained produce excellent crops. The soil is a sandy clay loam, with the clay predominating in the poorly drained areas, and such areas are termed "crawfishy."

Leatherwood and Guthrie Creek have bottoms with an average width of a half mile in their lower course. The soil is a sandy clay containing considerable gravel, consisting of geodes, limestone and sandstone fragments. The soil is productive. Corn and timothy are the principal crops.

Indian Creek has little bottom land except that occurring in the meander curves. The soil is quite sandy and is planted in patches of corn, potatoes, sugar cane, etc.

The valley of the east fork of White River is very narrow through Lawrence County, averaging less than a quarter of a mile in width. The soil is of a sandy clay with a loamy texture and is very productive. On the hills bordering the river valley are deposits of sand occurring up to a height of 75 or 100 feet, and always on the side away from the current of the stream. Second bottoms of small areas also occur along the streams. The sandy areas are favorable for the growing of melons, vegetables and some general crops. At Sandpit hundreds of carloads of this sand are shipped away for ballast, etc.

The improvements through the alluvial area are good, most of the roads are improved with crushed stone or stream gravel, and the lands usually demand a good price; the question of economic drainage and the fear of damage from overflows are the greatest drawbacks to this area.

General Summary.

Lawrence County affords excellent opportunities in many lines of agriculture. The greatly diversified characters of the soil make them adapted to all sorts of crops.

Canning factories for the using of tomatoes, pumpkins and corn would prove paying investments and would make of value much land now of little worth.

Large amounts of planer dust from the stone mills are being used as a lime application on the various soils with good results. The most noted of these experiments are in cases where from 1,000 to 2,000 pounds per acre of the dust was applied to fields of alfalfa and clover, and as a result much better stands were secured than in parts without the lime. This is a cheap source of lime for those who have access to the mills. It is not necessary that all of the lime be in the form of dust, but small fragments of the limestone included will also improve the physical condition of the soils.

The county ranks tenth in the State in the growing of watermelons and there are in the county 52,500 apple trees, 27,000 peach trees and 27,000 of all other fruit trees.

There are in the county 75 factories which represent great amounts of capital and employ thousands of men. The supplies for these people must be furnished by the products of agriculture, and with this in view much more attention can safely be paid to vegetable raising and the growing of small fruits. The demand is great, but is now largely furnished from outside the county.

The railroad facilities are good; school advantages rank among the best; roads are well improved; the natural resources, including the soils, are unlimited; rural routes and telephones reach all parts of the county; and everything seems to be in the best condition to promote the welfare of the rural communities.

MARTIN COUNTY.

History of Settlement and Agricultural Development.

Martin County, named in honor of Major Martin, a hospitable and patriotic citizen of Newport, Kentucky, was organized in 1820. It is about twenty-six miles in length by thirteen in width, and contains 340 square miles. Its civil townships are: Baker, McCameron, Brown, Mitchelltree, Halbert, Perry, Rutherford and Lost River. The population in 1830 was 2,010, and in 1850 about 5,000, and at the present time 14,800. In 1850 there were in this county nine grist mills, nine saw mills, two lawyers, nine doctors, six preachers, and 126 mechanics. The surplus articles for exportation are corn, hay, flaxseed, pork and beef, and those, with staves, hoop-poles, etc., were shipped down the river to the value of about $50,000 annually.

Martin County produces about 600,000 bushels of corn annually, but the average yield is not over 30 bushels. About 7,000 to 8,000 acres are sown to oats, but the average yield is again very low, being from 20 to 25 bushels per acre. The wheat acreage is usually 8,000 to 9,000, and the average crop is 12 to 13 bushels. Timothy hay is grown on about 13,000 acres and gives an average production of 1 to 1-14 tons per acre. Less than 2,000 acres of clover is grown and 1¼ to 1½ tons is the ordinary yield. Of the minor crops the acreage and yields are as follows: Potatoes, 300 acres, average yield 40 bushels; tomatoes 30 acres, total yield 900 bushels; peas, 10 to 15 acres; watermelons, 20 to 40 acres; cantaloupes, about 5 acres; tobacco, 5 to 15 acres.

Considerable live stock is raised, but Martin is not an important county in this respect.

The principal towns are Shoals, Loogootee, Willow Valley, Indian Springs, Mt. Olive, Buris City, Blankenship, Windom, Lacy, Natchez.

Shoals, the county seat, has 1,013 inhabitants, and is situated about the center of the county on White River, and on the B & O. S. W. Railroad. It is the trading center for a large portion of the county. It has two sawmills, two grist mills, a novelty works and other small manufacturing establishments.

Loogootee, with 1,382 inhabitants, is in the west central part of the county, on the B. & O. S. W. R. R. It is principally a manufacturing town. It has a carriage factory, three glass factories, a canning factory, grist mills and several other small concerns. The volume of business has decreased since the failure of natural gas.

Indian Springs, Burns City, Blankenship and Mt. Olive are stations and trading points along the Southern Indiana R. R. The first two named have sawmills.

Windom, Lacy and Natchez are country stores and trading points in the south part of the county.

Trinity Springs has several boarding houses and several guests stay there each summer. It is in the central eastern part of the county, eight miles northeast from Shoals.

Physiography and Geology.

The surface rocks of Martin County belong to three epochs, the Huron of the Lower Carboniferous or Mississippian period, and the Mansfield sandstone and coal measures of the Carboniferous or Pennsylvanian period. The Huron group of limestone, shale, sandstone and conglomerates, cover most of the eastern third of the county, the Mansfield sandstone the major part of the remainder, while the coal measures occur in the southwest part and on top of the ridges and hills of the Mansfield.

The streams, in cutting through the hard Mansfield and into the softer Huron, have produced extremely steep slopes, and in many places there are almost perpendicular bluffs reaching a height of 80 to 100 feet. Some of the highest and most famous of these are along White River near Shoals. Altogether the topography of the Mansfield area, where the streams have cut down into the

White River Valley looking north from Pinnacle, Shoals, Martin County.

Huron, is probably the roughest in the State, the tops of the ridges being 100 to 250 feet above the valleys.

Drainage.—With the exception of a small portion of the northwest part of the county, which is drained by Furse Creek into the west fork, the whole county is drained by the East Fork of White River and its tributaries. The East Fork enters the county north of the middle of the east line and takes a meandering course to the south and west, forms a part of the southern boundary and leaves the county at the southwest corner. Indian Creek, Boggs Creek, and Haw Creek are the principal tributaries from the north and west, and Beaver Creek and Lost River from the south and east.

Economic Geology.—Over most of the county the water supply is poor, but along Indian Creek and Sulphur Creek, at Indian Springs and Trinity Springs, are mineral springs whose waters are very similar to that of the famous springs at French Lick and West Baden. Other important mineral products are coal (which, however, seldom appears in workable deposits), and iron ore, which occurs as concretions and veins in the surface rock. The sandstone of the Huron group and some of the Mansfield, is used in the manufacture of grindstones and whetstones.

Natural Scenery.—Among the bluffs along White River which have already been mentioned, one of the highest is the "Pinnacle," near Shoals, the county seat. Here a high ridge of Mansfield sandstone one hundred ninety-six feet above the level of the stream terminates abruptly within a few yards of White River. Large masses of rock that have broken off lie around the foot of the ridge in every position. From this point one obtains a good view of the character of the topography of this region. To the northwest of this ridge the formations have been cut through by disintegrating forces and there has been left standing at some distance from the head of the ravine a tall mass of sandstone, which has received the name of "Jug Rock," from the fancied resemblance to an old-fashioned jug. On the upper side it is 45 feet high, and on the down hill side is 75 feet high; it is capped with a hard projected layer of harder sandstone. At the south of the deep-wooded ravine is "the Glen," an under-cut sandstone cliff with an intermittent cascade. Across a valley to the north is "House Rock," a large sandstone cave, the entrance to which is about 35 feet high, and the main room with an opening in the top is very much higher. It is formed principally by the tilting of large rock masses. The sandstone in front of the cave is weathered into an elaborate fretwork. Other points of interest as one goes down the river are the "Acoustic Rock," "Buzzards' Roost," "Hanging Rock," "Kitchen-middings," "Shell Bank," and the Hindustan Falls.

SOILS.

Four soil types occur in Martin County. Three of these owe their origin directly to the geological formations, and the alluvial type, which has an area of 25 square miles, consists of three or four types. The following table shows the extent of each general type:

Huron	40 square miles
Mansfield	200 square miles
Coal measures	75 square miles
Alluvial	25 square miles

1. Huron Area.

The Huron formation covers an area of about forty square miles in this county, comprising three principal areas in the eastern side of the county—first, along the White River valley and extending northward along Indian and Sulphur Creeks; second, from Shoals in a northeastern direction in a narrow strip along Beaver Creek; third, occupying a strip along either side of Lost River for a distance of several miles, with small patchy areas coming in along the streams from the east. The greater part of the area consists of long, rather steep slopes toward the drainage level. These slopes for the most part can be cultivated rather successfully. The soil is a sandy clay, having a loamy texture. The improvements are better than over most of the area in the counties to the east.

Corn produces from 25 to 50 bushels, wheat 10 to 15 bushels, oats about 25 bushels. Taken together, the slopes and lowlands comprise good grazing lands, but only a limited number of live stock are raised. Some fruit is grown and the soil seems well adapted to it. These soils, while somewhat productive and easily tilled, must be handled with care to prevent washing and depletion by continual cropping.

2. Mansfield Area.

About two-thirds of the area of Martin County is included in the Mansfield sandstone area. This sandstone is a rather coarse-grained, hard stone of considerable thickness. The topography is very broken, as the sandstone weathers into very steep slopes and in many places the streams have precipitous banks. The ridges between the streams are broad and flat-topped, and it is here that most of the tillable land lies. The slopes are too steep and the valleys of the small streams are too narrow to be of much importance.

The surface soil is usually a sandy yellow loam from one foot to two feet in depth. This is underlain by a subsoil, which is about the same color, but more clayey and tenacious. With increasing depth the soil grades into a stiff, white clay, mottled with yellow; at the base of the Mansfield the subsoil grades into a soft, mucky shale at 6 to 10 feet. Sometimes considerable quantities of iron ore concretions are found in the subsoil.

This Mansfield soil is not very productive. Corn is often injured by dry weather and even in good seasons seldom produces more than 30 bushels per acre. Heavy dressings of commercial fertilizer are used to produce good crops and this soon exhausts the land, so that after a few years it is abandoned and grows up in briars, sumach, persimmons and sassafras. The chief cause for this wearing out of the soils is due to the removal of all crops from the field and thus entirely doing away with the supply of humus. Some of the farms on top of the flat ridges are kept up by clovering, but the use of commercial fertilizer is also extensive. The permanent improvement of these soils might be brought about by a careful cropping system.

The improvements as a rule are poor. Very few roads are improved, and owing to the topography and sandstone outcrops, they are very hilly and rough.

Most of the timber has been removed, and the greater portion of the slopes and much of the table land is covered with a second growth, consisting of different varieties of oaks. Very little ditching has been done, but the sandy soil and steep slopes make the natural drainage very good, and little of the land suffers from being too wet.

Much fruit, principally apples and cherries, is grown in the county, and there are splendid opportunities for development along this line. The principal hindrance is the distance which most of the produce must be hauled over the extremely rough roads. In the south part of the county much of the fruit finds a good market, at French Lick and West Baden. About 50,000 bushels of apples are produced in the county, of which the greater portion is grown on the Mansfield area.

Prices of improved land run from $20 to $35 per acre, while the unimproved and run-down farms are valued at from $5 to $25.

The following table will show the result of the mechanical analysis of the Mansfield residual soil:

MECHANICAL ANALYSIS OF MANSFIELD RESIDUAL SOILS.

Number.	Locality.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
1	Three miles N. of Blankenship, Martin Co.	Sandy loam	.0	.0	.0	.6	13.5	85.5
1		Subsoil	.0	.3	1.2	1.4	25.6	70.5
*2	North part of Baker Tp., Martin Co.	Sandy loam	11.3	1.1	1.4	.5	18.7	64.5
*2		Subsoil	13.5	.4	1.0	1.4	18.0	63.8

*Sample No. 2 contained some small fragments of sandstone which is classed as gravel.

3. Coal Measures.

The residual soils of the coal measures occupy about 75 square miles in Martin County. A large part of the area consists of isolated patches and ridges of the higher elevations, while in the southwestern part the area of several square miles becomes of much more even topography and of much greater agricultural value. The ridges are flat-topped and produce much better farming tracts than the Mansfield area. A typical section of the soil taken from center section 17, Baker Township, is as follows: First foot, sandy loam, few fragments sandstone; second foot, stiff, sandy clay, with sandstone fragments and iron ore concretions; third foot, stiff, sandy clay, with increasing amounts of broken sandstone and iron ore concretions to eighth foot, where occurs a layer of shaly iron ore underlain by a thin bed of coal, underlain by alternations of shale and sandstone and coal. The surface soil in general is a sandy clay loam, and of a productive type.

The farmers are using considerable fertilizer on wheat and some are beginning to use it on corn. Wheat yields 12 to 25 bushels, corn 30 to 45 bushels per acre; oats, timothy and clover yield well. Rye makes a strong growth. It is planted for spring pasture and then plowed under as fertilizer.

The principal water supply for stock is from artificial ponds, and cisterns are used for water for domestic purposes. The native timber growth consists of walnut, beech, white oak, gum, ash, wild cherry, hickory, locust, mulberry, maple and persimmon. Fruit trees grow and produce good crops. A large number of peach trees have been planted during the past few years. The greatest drawback to the development of these soils is the difficulty with which markets can be reached. Land can be bought at prices from $5 to $50.

The following table shows the result of mechanical analysis of coal measure soils:

MECHANICAL ANALYSIS OF COAL MEASURE RESIDUAL SOILS.

Number.	Locality.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
1	North central part Baker Tp., Martin Co.	Sandy red soil	6.5	1.2	2.0	5.0	16.2	68.0
1		Subsoil	*80.0	1.6	1.0	1.9	6.7	10.6
2	N. W. corner McCameron Tp., Martin Co.	Sandy red soil	.5	.4	6.2	28.5	18.9	46.4
2		Subsoil	*8.2	1.4	4.0	36.8	21.4	28.4

*Sandstone fragments.

4. Alluvial Soils.

The alluvial soils consist of sandy loams along the White River and Lost River valleys, with small areas along First, Indian, Sulphur, Boggs, Beaver Creek and other small streams. The White River valley through Martin County is very narrow, varying from a half mile to less than an eighth of a mile in width. The valley is subject to frequent overflow, and for this reason the entire valley is planted chiefly in corn. Some clover, timothy and alfalfa are grown, but it is usually difficult to obtain good crops because of the wet condition. Wheat is grown successfully on the long slopes coming down into the meander curves of the river. The improvements along the valley are good. The valley of Lost River is very narrow and the soils are only fairly productive. Along the creeks named the soil areas are small, but adapted to a greater variety of crops.

Some excellent farms are found in the alluvial area, and good prices are secured for the land. The most progressive farmers have part of their land in the bottoms and part on the uplands, with the house, barn, orchards and pastures on the uplands and all the bottoms devoted to grain crops. The soils do not require a great outlay for fertilizers, although some is used—both commercial and stable manure.

General Summary.

Martin County is commonly classed among the poor counties of the State. As a county the agricultural development is in a backward condition, and the farming population is hampered for lack of proper facilities and improvements to meet its needs. More railroads, improved public roads, increased telephone service will add much to the prosperity of the county. In parts the county is in a prosperous condition and improved methods of farming are finding a place.

Much profit could be made from the cheap lands in devoting them to special crops, as tomatoes, pumpkins, sweet corn, etc., for canning factories; vegetable raising and growing of small fruits for the market at distant points, as St. Louis, Cincinnati, Louisville and Indianapolis. The building of a north and south line of railroad through the county would open up great advantages in this line. Each year Indiana pays other states over a million dollars for apples and large sums for other fruits. Such apples as can be raised in Southern Indiana are worth from $1 to $3 per box and from 100 to 200 boxes can be grown to the acre.

There are in the county at the present time 53,500 apple trees, 25,050 peach trees and 66,696 of all other fruit trees. Many cherries are grown in the south and central part, and beside the local use, are marketed for good prices at French Lick and West Baden.

Some parties in Shoals buy the "sulphur balls" from the various coal mines of the county, and after removing the small pieces of coal, ship the material to certain fertilizer companies, to be used as an ingredient in fertilizers.

The White River valley presents the most picturesque scenery to be found within the State, which, in fact, is probably not excelled in the Ohio valley. The natural scenery, with advantages for drives, boating, etc., and the development of mineral waters, offer a most attractive location for summer resorts or sanitariums, which will not only add to the wealth of the county, but will materially aid the agricultural pursuits.

ORANGE COUNTY.

History of Settlement and Agricultural Development.

Orange County was organized in 1816, and was named after a county of North Carolina in which many of the early settlers had previously resided.

The county contains 400 square miles, being 20 miles square. It is divided into nine civil townships, viz.: North East, Stampers Creek, South East, Orleans, Greenfield, Paoli, French Lick, Jackson and North West.

The population in 1830 was 7,909, and in 1850 about 12,000, and at the present time about 18,000. In 1850 the surplus articles of export were 30,000 bushels of corn, 20,000 bushels of wheat, 20,000 bushels of oats, 6,000 hogs, 1,000 cattle, 1,200 horses, and 300 mules. There were in the county at that time thirteen grist and saw mills, propelled by water and three by steam; three carding machines, eight tanneries, eighteen general stores, five groceries, one printing office, two lawyers, thirteen physicians, twenty-five preachers, 125 mechanics, one county seminary and seventy district schools, in which 4,200 children were instructed about three months in the year. Paoli then had a population of 400, and French Lick and West Baden were not on the map.

The county now produces about 800,000 bushels of corn, with an average yield of less than 35 bushels; oats, 250,000 bushels, average about 20 bushels; wheat, over 200,000 bushels, average 15 bushels. About 10,000 acres are in timothy meadow, which yield about 1½ tons per acre; about 3,000 acres in clover meadow, yielding about 1½ tons of hay per acre, and a total of 800 bushels of seed. Only about 70 acres are planted in potatoes, but they yield an average of over 60 bushels per acre. The average of tomatoes is usually about 60, and these yield about 13,000 bushels. From 20 to 40 acres of watermelons are raised; about five acres of cantaloupes and five to ten acres of tobacco. An ordinary yield of apples is about 40,000 bushels. Orange County ranks fourth in the State in number of peach trees, about 45,000 being planted.

The principal towns are Paoli, Orleans, West Baden, French Lick, Orangeville and Stampers Creek, Youngs Creek and Leipsic.

Paoli, the county seat, is situated on the Monon Railway near the center of the county. It has a population of 1,200 and is pleasantly located—fifteen factories, mills and shops are established here, including flouring mills, lumber yards and a spoke factory. It has connection with New Albany by stage line, which passes over the New Albany and Paoli turnpike, which was owned by a private corporation and operated as a toll road until 1899.

Orleans, eight miles north of Paoli, is on the main line of the Monon, C., I. & L. division, and is a thriving town of 1,250 inhabitants. It has a dozen factories and shops. The French Lick line of the Monon makes connection at this point with the main line of the Monon, and trains between the two places are run every hour of the day.

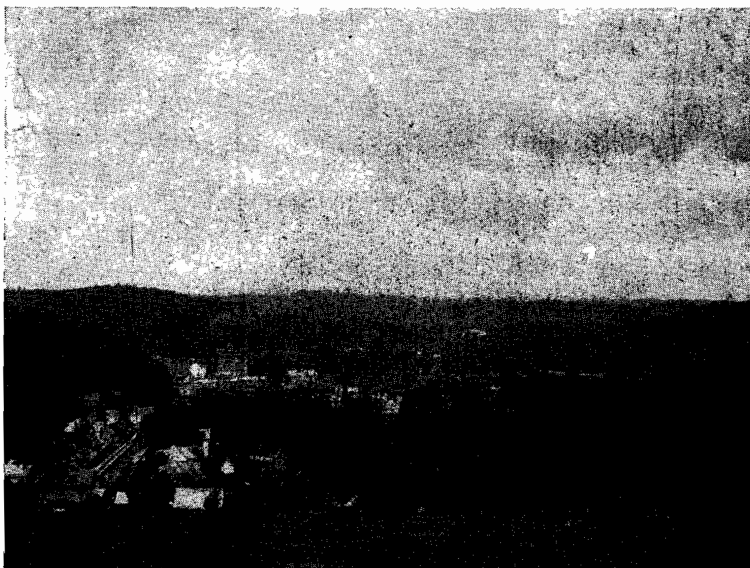
West Baden, with a population of 225, and French Lick, with a population of 275, are located in the French Lick valley, and both have been built up since the mineral waters of that region have been so well known. Their importance are as summer resorts and each has large, beautiful hotels for the accommodation of hundreds of guests and thousands of people visit these places each year. The livery business is a prosperous business at these resorts, and excellent drives are arranged in every direction, and the scenery is most picturesque. Other business enterprises are bottling works, flouring mills and lumber yards. The new line of the Southern Railroad now connects these places with Jasper and points south.

Orangeville, in the northwest part of the county at the rise of Lost River, has a population of about 100. Its chief industry is a flour and feed mill, and it is a good country trading center.

Stampers Creek and Young's Creek each have a population of about 100. Each has a flouring mill and the former has an establishment for distilling liquors and fruits.

Leipsic is a little village in the northeast corner of the county, on the main line of the Monon.

There are in the county 700 miles of public roads, with 192 miles of improved roads of crushed stone and stream gravel. The first improved road in the county was the old New Albany and Paoli turnpike, completed as far as Paoli by the State in 1839 and later turned over to a private corporation, which operated it as a toll road until 1899, when Orange County purchased the eleven miles



French Lick Valley viewed from ridge southwest of French Lick.

within her bounds for $11,000, and made it a free road. The first road improved under the present law was the Orleans and Paoli Pike, built in 1897. Rapid progress has been made in the road improvement of the county and with the abundant supply of stream gravel and the modern methods of construction, the county will soon have a large percentage of its roads in excellent condition.

There are within the county three lines of railway. The Chicago & Louisville line of the Monon passes through the northeast corner, and the French Lick & West Baden branch of the Monon passes through Paoli, the county seat, and has its termination at French Lick. During the early part of 1907 the Southern Railway completed a line from Jasper, in Dubois County, to French Lick, and making connections with the Monon at the latter place. The nearest railroad for the southeastern part of the county is along the Southern at the towns of English and Marengo, in Crawford County.

Physiography and Geology.

In Orange County three geological formations make up the surface rock. The Mitchell limestone covers the eastern two-thirds of the northern part. The Huron limestones and sandstones form the surface rock over the southern third, and a large area in the northwestern part. The Mitchell area is comparatively level, but somewhat varied by numerous sink holes and irregular depressions. The remainder of the county, especially in the south and western parts, is very rugged. High, steep ridges and narrow winding valleys are the prevailing surface features. Mt. Arie, near West Baden, and Burtin Hill, southwest of French Lick, are two of the highest points within this area. The drainage of the county is by two streams and their tributaries, Lost River, across the northern part, and the Patoka River, across the southern part. Both streams have very meandering courses and extremely narrow valleys. The general course of the drainage is from east to west. Lost River sinks southeast of Orleans and flows by an underground channel with a winding course for a distance of 12 or 15 miles, and again rises at Orangeville. The Patoka, after leaving Orange County, widens its valley very rapidly until just before joining the Wabash valley it is fully two miles in width.

The French Lick and West Baden and other mineral springs have an important place in the history and geology of Orange County. The water issues from joints and fractures in the lower carboniferous limestone at its junction with the Mansfield sandstone. These springs break out in a number of places along the streams and wells have also been drilled and strong flows of mineral water obtained.

Soils.

There are in Orange four general types of soil, all having been derived from the three geological formations discussed above. The fourth type, the alluvial, comprises a small area and the materials of which it is composed are not far removed from the point of original formation. The general types have local variations which will be discussed.

The following table shows the proportion of each general type:

Mitchell	150 square miles
Huron	190 square miles
Mansfield	55 square miles
Alluvial	5 square miles

1. Mitchell Area.

The residual soils of the Mitchell limestone cover about one-third of the entire county. The area is for the most part level, except along the western and southern edges, where the surface becomes somewhat rougher, due principally to the increased number of sinkholes. The soils of the level areas are the most valuable soils found in the Mitchell formation. They are deep, easily tilled, and productive. The rougher parts are not so uniform in character and contain large amounts of chert and other impurities. In these places the soils wash badly and become grown up with sassafras, sumac and briars.

The typical soil is a clay loam of a yellow color with an average depth of 8 to 14 inches. Near the Huron contact the soil contains considerable percentages of sand from the sandstone of the formation; in the cherty areas the soil in some places becomes very gravelly.

Corn yields from 40 to 60 bushels, wheat 12-20 bushels; clover and timothy produce good hay, but in many places it is difficult to obtain good stands. Some experiments are now being made as to the needs of the soil and some helpful suggestions may be given out at a later time. The special need seems to be lime and potash; the amount of organic matter is also very low and good systems of green manuring would be very beneficial.

A great many live stock are raised and the chief source of water is from the clogged sinkholes. Poultry raising is carried on to some extent. The direct communication of the area with Louisville and West Baden and French Lick gives good outlets for a surplus of farm, garden and live stock products. Several farmers are engaged in dairying and this also adds to the value of their farms by feeding all crops raised on the land and thus returning to the soil a large part of the material used in the production of the crop.

The following table shows the result of mechanical analysis:

MECHANICAL ANALYSIS OF MITCHELL RESIDUAL SOILS.

Number.	Locality.	Description.	Gravel.	Coarse Sand.	Medium Sand	Fine Sand.	Very Fine Sand.	Silt and Clay.
1	Two miles east of Orleans.....	Surface.....................	.0	2.0	.5	.5	5.0	93
1	Two miles east of Orleans.....	Subsoil.....................	.8	2.0	.5	.8	10.0	87
2	Near Orangeville............	Surface.....................	2.0	2.0	.8	.5	5.0	90.3
2	Near Orangeville............	Subsoil.....................	6.0	3.0	1.0	.7	12.0	79

2. Huron Area.

The Huron formation covers almost one-half of the county. The ruggedness of this area stands out in contrast to the level Mitchell area to the east. The greater part of the area is very rough, but the flat tops of the ridges afford some good tillable land and the slopes are well adapted to grass and fruits. The soil is a sandy clay loam, grading from a fine light yellow to dark brown color. Corn, wheat and clover grow well on the tops of the ridges. Millet and alfalfa are also grown. The soil of this area has the general characteristics of this type of soil as discussed on preceding pages. The following table shows the result of mechanical analysis of Huron residual soil:

MECHANICAL ANALYSIS OF HURON RESIDUAL SOILS.

Number.	Locality.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
1	N. W. of Orangeville.........	Surface.....................	.3	.7	1.0	10	12	75+
1	N. W. of Orangeville.........	Subsoil.....................	4.0	.5	2.5	8	10	74
2	East of West Baden.........	Surface.....................	1.0	.5	2.0	12	12	73
2	East of West Baden.........	Subsoil.....................	3.0	1.0	1.5	10	10	78.4

3. Mansfield Area.

The Mansfield occupies an irregular patchy area of over 25 square miles, on the tops of the higher ridges in the western part of the county. There are no special developments or advantages to mention from this area in addition to the discussion already given for the type.

4. Alluvial.

The alluvial soils in the county are of small extent and of little importance. The only bottom soils to be considered are along Lost River, small areas in the meander curves, extending from Orangeville west to the county line. The most of these patchy areas do not exceed an acre or so, and are planted to various crops, as garden spots, melon patches, pumpkins, corn, etc.

The Patoka River also has a very narrow valley through the county, but widens rapidly farther west.

General Summary.

Orange County is large in area, but has few general soil types, yet with great variation in topography, productions, and natural vegetation.

Until within the past few years the railroad facilities were poor, and only few public road improvements were made until recently. The completion of the new line of the Southern Railroad from French Lick to Jasper in 1907, gives the county an outlet to the south and may have a decided influence on the southern part of the county.

The following table, showing the average climatic conditions for a period of fifteen years, as compiled at Marengo, Crawford County, will serve as a basis for Orange County:

Mean temperature	56° Far.
Highest temperature	106° Far.
Lowest temperature	—28° Far.
Mean precipitation	57.6 inches
Average depth of snow	20 inches
Average number of rainy days	97

The corn crop of the county in 1907 was greatly damaged by hail and wind.

The marked improvements which have taken place during the past ten years give an encouraging outlook for far greater developments in the next decade. Many farmers from northern counties have come into this county in the past few years and bought farms in the rougher parts of the county, and an interest is being aroused in these low-priced lands.

WASHINGTON COUNTY.

History of Settlement and Agricultural Development.

Washington County was organized in 1813. This county is one of the largest in the State, being 25 miles in extreme width from north to south and 25 miles in greatest length from west to east, with a total area of 523 square miles. The civil townships are Monroe and Gibson in the north, Franklin in the east, Washington, Central, Jackson in the south and Posey, Vernon and Brown in the west.

The population in 1830 was 13,072, in 1850 about 18,000 and at the present time about 20,000. The surplus products of the county in the early days consisted of corn, wheat, flour, beef, pork, hay, oats, tobacco, timber, live hogs, cattle, horses, mules, etc., estimated to be worth $300,000 annually. These products were conveyed to market either by flatboat or wagon, and the stock were driven to southern markets until the new railroad was completed from New Albany to Salem, about 1850, and a few years later was extended on northward. There were at that time in the county 25 saw mills, 20 grist mills, ten carding machines and two cotton factories, two printing offices, which issued weekly papers, 40 general stores, 22 groceries, six lawyers, 30 physicians, 18 ministers and about 300 mechanics. Carriage and wagon making and the construction of carding machines were carried on extensively. There were 120 schools and 44 churches in the county. Salem at that time had a population of about 1,200.

The county now produces about 1,000,000 bushels of corn, but the average yield is less than 40 bushels. Oats, 500,000 bushels, average per acre about 25 bushels; wheat, 400,000 bushels, with an average of 18 bushels per acre, and in 1905 the county ranked fifth in the State for average yield of wheat, with 21.60 bushels per acre. The average of timothy meadow is 15,000, yielding on the average 1¼ tons. Clover meadow, 3,500 acres, yeilding from one to one and a half tons, and producing annually about 500 bushels of seed. About 350 acres are planted in potatoes each year, and the average yield is about 50 bushels. The county ranks fifth in the growing of tomatoes, with an average of about 800 to 1,000 acres annually during the past three or four years. Four canning factories in the county take care of the crop. A few acres each year are planted in watermelons and tobacco.

Washington County ranks among the first in the growing of apples, pears, peaches and plums. In has about 90,000 apple trees and in 1907 the yield was good, considering the year, and in 1906 the yield was 90,500 bushels. Pear trees, 16,000; peach, 40,000, and a considerable acreage of plums and a large number of young cherries.

In the southern part of the county, berry culture is beginning to gain some prominence.

Dairying is carried on to some extent and a large number of cattle are sold each year. Many horses are marketed and the county stands among the first in the raising of mules. Several sheep and a large number of hogs are raised, and the raising of poultry is on the increase. There are in the county more than 50 factories and mills of various sorts.

The principal towns are Salem, Campbellsburg, Saltillo, Canton, Little York, Pekin and Fredericksburg. A number of small villages are Hardinsburg, Fayetteville, Martinsburg, New Philadelphia, South Boston, Livonia, and Lesterville.

Salem, the county seat, is situated near the center of the county and is on the C., I. & L. division of the Monon Railroad. The town has a population of 2,000. It has a beautiful court house built of oolitic stone, and the school facilities are good. There are 20 or more factories, shops and mills in the town. The growth in the past few years has been slow but substantial. The location and surroundings are such that with increased agricultural wealth of the county the town should grow to considerable size.

Campbellsburg, situated on the C., I. & L. ten miles northwest of Salem, has a population of 700. It is a thriving agricultural town and has a half dozen or more shops and factories, including a canning factory for tomatoes.

Saltillo is a railway station one and a half miles northwest of Campbellsburg, and has a population of 200. It is chiefly a trading center for the surrounding country.

Canton, with a population of 275, is situated northeast of Salem. A canning factory is also located at this place.

Little York, in the northeastern part of the county, has a population of 225. The principal business is a lumber yard and a canning factory.

Pekin, in the southeastern part of the county, is on the Monon Railroad, and has a population of 175. It has a lumber yard, flouring and feed mill and a canning factory for canning tomatoes. It is a successful little trading center and shipping point for small fruits, berries, etc., which grow well in that section.

Fredericksburg, in the southwest corner of the county, has a population of 275. It has a flour and grist mill, harness shop, and has an establishment which publishes newspapers and does job printing.

Hardinsburg, in the southwest corner of the county, has a population of 210. It is a country trading center, but has no mills except a sawmill.

Martinsburg has a population of about 90, and has an exchange for flour, meal and feed. It also has a lumber and shingle mill. It is located in the southeast corner of the county.

Livonia, in the western part of the county, has a population of 200. It has a good country trade and also does some lumber business.

The transportation facilities of the county are very poor, the C., I. & L. (Monon) being the only railway within its bounds. This crosses the county in a northwest-southeast direction, passing through Salem, the county seat.

The county has about 1,500 miles of public roads, but until the last few years but little has been done in the way of road improvement, there now being but 120 miles of improved roadway, not including eight miles of the old New Albany and Vincennes turnpike, owned by private corporation and operated as toll road. Most of the roads have been improved with crushed stone and after up-to-date methods. Stream gravel has been used on about 11 or 12 miles of the road, but is not as satisfactory as the stone. There is an abundant supply of good road material, both gravel and stone.

The county offers great advantages in agricultural pursuits, especially in the growing of fruits and tomatoes and in dairying and stock raising. Good land can now be bought at very reasonable prices and will yield good returns. With the increase in taxation from improved lands will come more improved roads and added railroad facilities.

CLIMATE.

The following table, compiled from Weather Bureau records, shows the normal monthly and annual temperature and precipitation taken at Salem and at Scottsburg, just east of the area of this survey:

NORMAL MONTHLY AND ANNUAL TEMPERATURE AND PRECIPITATION.

MONTH.	Salem.		Scottsburg.	
	Temperature of	Precipitation. Inches.	Temperature of	Precipitation. Inches.
January	29.2	3.35	32.9	3.28
February	30.6	3.57	31.0	2.60
March	41.9	3.83	43.2	4.44
April	52.4	3.05	52.3	2.31
May	63.5	3.22	65.0	3.70
June	71.2	4.52	74.4	4.30
July	77.2	2.89	78.0	3.02
August	74.6	3.50	76.4	2.90
September	68.1	2.58	69.1	2.38
October	56.4	2.66	57.5	2.13
November	44.5	3.94	44.5	3.43
December	32.4	3.32	36.3	3.25
Year	53.5	40.43	55.1	37.74

Physiography and Geology.

The rocks of five geological epochs form the surface of Washington County. First, the Knobstone, covering a large area in the northern part and about one-third of the eastern part; the Harrodsburg limestone covers considerable areas in the southeastern and central parts, and extends to the northeast, principally on the higher hills and ridges. The Indiana oolitic occupies a narrow winding strip in the central part, forming a belt between the Harrodsburg and Mitchell; the Mitchell limestone covers the northwestern part of the county and the western third, except about 8 or 10 square miles in the southeastern part, which is capped with remnants of the Huron.

That part of the county lying within the Mitchell area is generally level and comprises an important agricultural area. The remainder of the county, with the exception of the regions of the Muscatatuck, is very rough and broken. In the knobstone region is a series of deep, narrow valleys, from 150 to 300 feet deep, from one to five miles long and separated by flat-topped, narrow divides. Cuts in the crests and abrupt ridges give rise to the knob topography.

The drainage is through the East Fork of White River and the Muscatatuck. The main tributaries leading into these streams are Clifty, Twin, Rush, Buffalo, Delaney and Elk Creek. The eastern and south parts of the county are drained by the three branches of Blue River. These branches unite near Fredericksburg, in the southern part of the county. Blue River, in all its forks, is a meandering stream, with sharp curves, and has practically no valley.

A part of the central western part of the county is drained by the head water of Lost River.

SOILS.

Six principal soil types are found in Washington County. Of these, five are derived from the weathering of the underlying geological formations. The sixth or alluvial type, which consists of two or three varieties, occurs in the low, flat bottom lands and is derived from material deposited by the streams and the wash from the surrounding uplands. The following table shows the extent of each of the types:

Knobstone	150 square miles
Harrodsburg	75 square miles
Oolitic	20 square miles
Mitchell	230 square miles
Huron	10 square miles
Alluvial, clay muck, white clay, clay loam and silt loam	40 square miles

The Knobstone Soils.

These soils consist of two main types, a silty clay loam and a sandy loam. The silty loam is of a light gray color and the more sandy areas grade from a light yellow to brown color. In their topographic features and productions and general characteristics the soils are the same and will be treated under one description.

The soil is from 8-12 inches in depth and numerous iron concretions are scattered over the surface; below 12 inches the soil grades into a light yellow or mottled silt loam, and at greater depth into a compact sandy clay, containing larger concretions and fragments of sandstone.

The topography of the area is very rough and broken, especially in the southeastern part, where the hills attain a height of 200-300 feet above the streams. The numerous small streams that traverse the area are adequate to carry off the surface water in times of heavy rain, and very little tile draining has been done; however, tile drains improve the conditions for most crops. If cultivated in a wet condition, the soil dries out rapidly and bakes into clods which are difficult to pulverize.

Careful management and cultivation are necessary to keep these soils in a productive state and some system of crop rotation is very important, as the continual cultivation of one crop causes depletion of the soil. Green manuring is the best means of fertilization, but commercial fertilizer should be freely applied.

These soils are adapted to corn, wheat, oats, clover, timothy and tomatoes, and abundant yields are often produced. Corn yields on the average about 30 bushels, wheat 12 to 15 bushels, oats 20 to 30 bushels. Clover and timothy produce from one to two tons per acre, and clover seed yields from one to three bushels.

The soil is especially adapted to tomatoes, small fruits, vegetables and all early maturing crops. The rough, hilly portions are well suited to larger fruits. Large yields of apples and peaches have been secured from the orchards now bearing. Grapes grow well and could be profitably grown for the markets.

MECHANICAL ANALYSIS OF KNOBSTONE, SILTY CLAY-LOAM AND SANDY LOAM.

No.	LOCALITY.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Silt.	Clay.
600	Washington County........	Knob. silt loam..	0.9	3.3	4.1	16.3	63.8	12.
600	Washington County........	Subsoil.........	0.8	0.9	1.0	10.6	65.0	25.
615	Washington County........	Knob.sandy l'm.	1.0	3.0	5.0	13.0	60.5	20.
615	Washington County........	Subsoil.........	1.5	3.8	4.8	20.	43.	26.5

The Harrodsburg Area.

The Harrodsburg residual clay covers about 75 square miles and are covered in the northern part to the tops of the hills and winding ridges. Larger areas are found in the central and southeastern parts and occupy more level and lower tracts, and are of more agricultural value. In general the improvements are good. The general characteristics and productions of these soils are the same as described under the Harrodsburg soil of preceding counties.

MECHANICAL ANALYSIS OF HARRODSBURG RESIDUAL SOILS.

Number.	Locality.	Description.	Gravel.	Coarse Sand.	Medium Sand.	Fine Sand.	Very Fine Sand.	Silt and Clay.
1	Six miles N. of Salem........	Red clay loam..............	.1	.2	.7	1.2	10.9	85.4
1	Six miles N. of Salem........	Subsoil.....................	.0	.4	4.5	12.3	22.4	59.2

The Indiana—Oolitic.

The Oolitic belt in Washington County occupies about 20 square miles and extends in a narrow, winding strip through the central part of the county. Although small in extent the Oolitic belt presents the best improved area within the county. Along the north fork of Blue River the long gentle slopes to the streams yield excellent crops and the farms are well improved, good farm houses, large barns, dairy herds, good horses, mules and numbers of hogs add to the interest as compared with the poor regions to the east. The roads are being rapidly improved and the latest machinery and farm tools are being used. Good apple orchards are planted and a large number of Winesap and White Pippin apples are planted, and in 1907, when the apple crop was so near a failure through this section, these varieties gave good yields. The best part of this region lies near the county seat and has every advantage to become well developed and gradually increase the agricultural value of the county. Corn yields on the average 50 bushels; wheat from 18-25 bushels; oats about 35-40 bushels, and timothy hay produces from one and one-half to three tons. The blue grass pastures are typical of the formation.

The Mitchell Soils.

The residual Mitchell soils comprise the largest area within the county. The surface is generally level or slightly rolling. The area is the original table-land of the Mitchell formation. The soil is a clay loam of a yellow color and has an average depth of 10-14 inches. The subsoil is a compact clay of a darker color and usually contains cherty fragments in some places of sufficient quantity to be termed gravelly. The area is of great agricultural importance in this county. Drainage is an essential thing to secure good crops, although both the surface and underground drainage are well developed. Corn yields as high as 60 bushels in favorable seasons; wheat 10 to 20 bushels, oats are only fair. Within the past few years a large acreage of tomatoes has been successfully grown. Some fruit is grown on this type and there are no reasons why this should not be a great fruit producing region. Stock raising is on the increase, and some farmers are beginning to make a specialty of pure breeds. The improvements are good and the farms are good, and usually of larger size than in other types. Land sells at from $50 to $100, and can be made to pay well on the investment.

The Huron Soil.

The remains of the Huron formation within the county includes about ten square miles in the southwest part of the county, on the points of highest elevation. These soils are derived principally from the sandstone members of the Huron and are of a yellowish red medium sand, containing sufficient clay and silt to be somewhat loamy. The region is rough, but mostly admits of cultivation.

ALLUVIAL SOILS.

Clay Muck.—Along the narrow portion of the Muscatatuck valley, where the knobstone hills come down near the stream, the soil which has been derived from the wash from these hills is a stiff gray clay muck. It is very wet and of little value from an agricultural standpoint.

White Clay.—The white clay area forms a narrow, winding strip along the foot hills of knobstone along the Muscatatuck valley. This clay is cold and wet and in the subsoil contains numerous small irony concretions and gravelly fragments. It is poor in humus and is continually receiving a coat of lifeless soil from the hill slopes above. Topographically, this soil may be considered a low bench terrace.

Clay Loam.—The clay loam type occurs along the forks of Blue River. The streams have a very meandering course, and long slopes and steep bluffs come down to the streams and the valley is very narrow and occupies only a part of the meander curves. The soil is a rich clay loam and is used principally for the growing of potatoes and other garden vegetables and tobacco. Along Blue River are some of the most beautiful landscapes in the county. The bordering slopes and uplands are well improved and the whole represents progressive farming on a hilly and rolling surface.

Silt Loam.—The silt loam occupies an area of about 40 square miles bordering the Muscatatuck River, and is locally known as "the flats." The same type extends up the valleys of the principal tributaries and gradually grades into the white clay strip as the hill line is approached. The silt loam area is low lying and has a very gently rolling or level topography. In some places a narrow ridge of slight elevation extends along the immediate bank of the stream, and occasionally small, sandy areas are found along the streams; numerous ponds, bayous and old stream beds and swampy depressions are scattered over the area. The soil of these wet places is somewhat heavier than the typical silt loam. The silt loam has been formed from material deposited by streams at times of overflow, mingled with the wash material from the upland. The sand of the part of the area near the upland has been brought down from the adjoining hills. The soil has an average depth of 8-10 inches and consists of a gray to light brown silty loam, which becomes heavier with depth. It contains varying amounts of medium to fine sand and a large quantity of small iron concretions mixed with the soil and strewn over the surface. These are due to the poor drainage condition, and the action of stagnant water has reduced the ferric hydrate to ferrous salts, and the lime, phosphoric acid, etc., which the soil has given up are formed into concretions. These concretions increase in size and number with depth, and the subsoil becomes a heavy mottled silty or clay loam somewhat gravelly from the large number of concretions. Local variations occur over the area, but are not of sufficient extent and importance to be discussed separately.

The natural drainage conditions of this type are very poor. The small streams have but slight fall, and during heavy rains they spread out over the adjoining bottoms, yet there is sufficient grade to admit of successful tile draining, and the land would soon be drained sufficiently after the floods had passed to admit of cultivation. The agricultural value of these lands depends largely on the successful drainage. The soil when drained is sufficiently fertile to yield excellent crops, while the poorly drained areas can be devoted to but little use except the growing of grass.

In the well-drained area corn will yield 45 bushels per acre, and in a favorable season will yield as much as 60 bushels. Wheat yields 18-20 bushels per acre, but little is sown on account of loss by heavy rain. Oats will yield 25 bushels, but the soil is not adapted to oats. Tomatoes yield 5-6 tons per acre, and timothy produces 2-3 tons per acre, and clover does fairly well. Thus we see the soil is best adapted to corn and timothy.

The native timber growth principally is oak, hickory, beech, sycamore, elm and ash.

The following table gives results of mechanical analyisis of the soil and subsoil of the silt loam of the Muscatatuck area:

MECHANICAL ANALYSIS OF SILT-LOAMS.

No.	LOCALITY.	Description.	Gravel.	Coarse Sand.	Medium Sand	Fine Sand.	Silt.	Clay.
610	Wash. Co. (Muscatatuck V.)	Silt loam........	1.2	3.0	1.5	8.4	65.5	20.5
610	Wash. Co. (Muscatatuck V.)	Subsoil.........	1.5	2.5	1.5	7.5	63.4	24.2
612	Wash. Co. (Muscatatuck V.)	Silt loam........	.4	1.5	1.0	8.2	55.3	34.5
612	Wash. Co. (Muscatatuck V.)	Subsoil.........	.6	1.4	1.0	8.4	57.3	31.2

General Summary.

Washington County on the whole may be said to be a good agricultural county. With its diversified soil types it admits of all branches of agriculture.

The Harrodsburg, Oolitic and Mitchell area are well improved and are inviting to the most enterprising farmers and fruit growers. The soils of these types are very permanent soils, and when proper care is used do not lessen in value by continual cultivation.

In the Knobstone area many of the hillsides, where the topography is most broken, are too steep to be successfully cultivated, and, as a whole, less of this type of soil has been developed agriculturally than any other soil in the area; but the greater part of these soils cultivated give fair yields of corn, oats, wheat, rye, timothy, clover and tomatoes, and the value of fruit growing cannot be overestimated. The constant cultivation of the land in the growing of tomatoes seems to benefit these lands.

Alfalfa has been successfully grown on small areas, and it has been shown that a very good grade of tobacco can be grown on the soil. Sorghum has also been raised with profit.

Timothy is extensively grown on the poorly-drained areas of the silt loam, and produces a greater tonnage than on the uplands.

The corn crop on the silt loam is planted late, after danger of heavy rains, and usually matures before killing frost comes.

The county is favorably located for reaching good city markets, but the great drawback in this region is the lack of railroad facilities. It is probable that within a short time other railway or interurban lines will traverse the county and add much to the value and progress of the county.

JACKSON COUNTY.

History of Settlement and Agricultural Development.

This county was first settled in 1809, by parties from the falls of the Ohio and from Kentucky. When they first came to the county they met with a few French traders, who complained that the trade with the Indians had been ruined by the war. These Frenchmen left the county and probably went to Vincennes. Among the first Americans who settled in the county and whose names are still prominent were H. and A. Rogers, Abram Miller, J. B. Durham, James Hutchinson, Thomas Ewing, John Ketcham, William Graham, Abram Huff, Thomas Carr, and Alexander Craig.

"In 1812, the Indians became troublesome, and some of the settlers removed to escape their wrath; others sent their families, but remained themselves. They built a little fort for their defense, which alone saved them from the 'Pigeon Roost' massacre, where in 1812 twenty families perished beneath the tomahawk. This little fort was frequently besieged, but always held out. The Indians, however, drove off all the horses and cattle and otherwise impoverished the settlers.

"During the War of 1812-14 several persons were shot and killed or wounded in this county. The Indians were very hostile, and kept a close watch for an opportunity to pick off the settlers. However, the only battle fought in the county during the war was at Tipton Island in 1814. There were about 50 Indians opposed to thirty whites, but they were quickly dispersed, leaving one or two killed upon the field. This encounter was conducted by General Tipton, the Commander."*

The county was organized in 1815 and named in honor of General Andrew Jackson. In the following spring the county seat was located at Brownstown, which received its name in honor of General Jacob Brown, who distinguished himself in the War of 1812. Brownstown was laid out in the woods, and in consequence the county seat was temporarily located at Vallonia.

Very soon after the organization of the county the population increased greatly, and general improvement was pushed forward. In 1830 a number of Germans settled in the eastern part of the county. They were a very enterprising class of people and have done much to promote the general welfare of the county, and today many of the wealthy and well-to-do people of the county are descendants of these early German settlers.

The surplus produce of the early settlers was shipped down the East Fork of Driftwood River in flatboats or taken to different points on the Ohio in wagons and then on flatboats to the southern and eastern markets, but after the completion of the Ohio and Mississippi Railroad, now the B. & O. S. W., the trade of the county was carried to Cincinnati.

The agricultural advantages of the county rank it among the best in the State. The soil is of various types, well adapted to the production of grains of all kinds, fruits and melons. The constant increase in population and the continued increase of the surplus products of the county show that its agriculture is in an improving condition.

There are in the county 650 miles of public roads, with 500 miles well improved with crushed stone and gravel. The red creek gravel and the gravel deposits of White River are the gen-

*Goodrich and Tuttle's History of Indiana, 1876.

eral sources of road material. Only about ten miles of the improved roads have been built of limestone.

Jackson County contains about 520 square miles, and has a population of 27,000. It is divided into eleven civil townships, viz.: Driftwood, Grassy Fork, Brownstown, Washington, Jackson, Reddington, Vernon, Hamilton, Carr, Owen and Salt Creek.

The principal towns are Brownstown, Seymour, Vallonia, Medora and Crothersville.

Brownstown, the county seat, is located on the B. & O. S. W. Railroad and has a population of 2,200. It has a fair court house and good school facilities.

Seymour is the largest town in the county and has a population of 6,500. It is a good railroad center, and has every appearance of thrift, and is pressing forward in all valuable industries and improvements.

Vallonia has a population of 400, and is located on the B. & O. S. W. Railroad. It is the shipping point for the agricultural produce of the surrounding country. Hundreds of carloads are loaded here every year.

Medora is also situated on the B. & O. S. W., five miles west of Vallonia; has a population of 625, and is also chiefly an agricultural village of some importance.

Sparksville, with a population of 150, is also located on the B. & O. S. W.

Situated along the line of the Southern Indiana Railroad are the little villages of Norman, Kurtz, Freetown, Surprise, Cortland and Reddington. Of these Freetown is the largest, having a population of about 250. Surprise is a little station with about 30 inhabitants. The others range from 100 to 200 in population. These places afford trading points for northern Jackson County, and give the nearest railroad facilities for southern Brown.

Houston is a little village in the northwest part of the county with a population of 120. It receives a considerable amount of country produce, which is hauled to the railroad stations.

Crothersville, in the southeast part of the county, is situated on the Pennsylvania Railroad. The town has a population of 750. It is a good country trading center. Two canning factories afford a ready market for all tomatoes grown in this section. About 500 acres of tomatoes are annually grown in the county.

Rockford, with a population of 150, three miles north of Seymour, and Chestnut and Retreat, to the south, with a population of a few families each, are other stations along the Pennsylvania line.

Tampico, with a population of 150, is located in the central southern part of the county, and receives the general trade from that section and the valley of the Muscatatuck.

The county is traversed by three railroads. The B. & O. S. W. Railroad crosses from the southwest corner to near the northeast corner; the Southern Indiana crosses through the northern half to Seymour, and has a branch line north and east, making connections with various other lines; the Pennsylvania line runs north and south through the eastern edge of the county. All these roads center in Seymour. All have good passenger service and heavy freight traffic. An interurban line, just completed, gives good connection between Louisville, Seymour, Columbus and Indianapolis.

The greater part of the county was formerly covered with valuable timber, very little of which now remains. The productive and easily cultivated soils of the valley areas rendered this part of the county better adapted to general farming purposes than the more broken areas of the northwestern part. The agricultural wealth of the county has probably increased 50 per cent during the past 12 or 15 years. Corn, oats, wheat, clover, timothy and vegetables are grown on almost every type of soil, and the rougher parts are well adapted to fruit growing, and the sand areas are especially suited to the growing of melons.

In 1907 the county produced 1,620,164 bushels of corn, 554,540 bushels of wheat, 453,848 bushels of oats, 6,396 tons of clover, 13,744 tons of timothy, 29,140 bushels of tomatoes, 27,100 bushels of potatoes and 471 acres of watermelons and 226 acres of muskmelons.

Considerable interest is manifested in county and state agricultural and historical organizations. Telephones and rural routes cover the county. Improvement is shown on every hand, and rapid progress is sure to continue.

Physiography and Geology.

The western two-thirds of Jackson County is the southern extension of the knobstone plateau which includes all of Brown County, and the physiographic features of this section are much the same as in the former county. The small streams have carved deep "V" shaped valleys into easily-eroded shales and sandstones. The general trend of these valleys and the ridges is from northeast to southwest.

In the northern part of the county the valley of the East Fork of White River forms the eastern boundary of the hill region. White River enters the county at the northeast corner and flows southeast until joined by the Muscatatuck at a point six miles east of the Lawrence County line. After its junction with the Muscatatuck the river flows almost directly west, forming six miles of the southern boundary.

The valley varies in width from eight to ten miles at Seymour to about four miles at Vallonia. The principal tributaries are the Muscatatuck, which forms most of the southern boundary; White Creek from the west, and Rough's Creek from the southeast. The Muscatatuck has a very narrow valley on the Jackson County side. Its principal tributaries are Vernon Fork and Grassy Fork, which enter from the northeast.

In the south half of the county the knobs extend east of the valley. The foothills to the south and east of these knobs spread out into a broad table-land covered with white clay, which reaches almost to the eastern border. A belt about six miles wide along the eastern border is thinly covered with glacial material, which is in too small quantities to affect the topography except in the case of Chestnut Ridge, a long ridge of drift which starts in Jackson Township and extends southwest through Washington Township into Grassy Fork Township. Its width is from one-fourth mile to one and a half miles.

As has been said, most of the surface rocks of the county are those of the knobstone group. Along the western side some of the hills and ridges are capped with remnants of the Harrodsburg limestone, and the deep red color of the soil and the presence of crinoid stems show that the same limestone once covered a much larger area than it does now. Along the eastern border a belt of from one to three miles in width is underlain by the New Albany black shales of the Devonian Period, but there are few outcrops and there is no marked change in the soil or topography.

SOILS.

There are five general soil types now within the county. Each of these have local variations which will be described under the various types. Three of the general types are derived ~~from the~~

weathering of the geological formations; a fourth is due to the glacial invasion and presents same marked characteristics within this area; the fifth, the alluvial types, are due to three agencies: stream action, glacial invasion, together with the mingling of the residual material. The following table gives the area of each type:

Devonian	25 square miles
Knobstone	290 square miles
Harrodsburg	15 square miles
Glacial	10 square miles
Alluvial	160 square miles

Devonian Soil.

The Devonian soil lies in a narrow belt along the east edge of the county. The surface is level and usually shows traces of glacial material, but not in sufficient quantity to affect the character of the soil to any great extent. The soil resembles the knobstone soil but is of less sandy texture and of a lighter yellow color than the knobstone of the ridges.

Knobstone Soil.

In general characteristics the knobstone soils of Jackson County resemble the same soils in the counties previously discussed (see especially Brown and Monroe counties). There is a larger proportion of the white clay of the low hills and terraces. This white soil is predominant in the southeastern part of the county and is used extensively in tomato growing. The soils are generally more productive than the knobstone of the other counties, and consequently the farms are as a rule better improved. Much better use is made of the creek gravel, which is common in all the streams of the area, than in the other counties, and the roads are above the average for so hilly a region.

Harrodsburg Soil.

Only a small part of the county is covered by the Harrodsburg soil although on the western border much of the soil is slightly affected by the presence of soil from the Harrodsburg which has been altogether eroded from the hilltops. As in the other counties, the soil is a stiff, red, somewhat sandy clay, which usually produces good crops of hay and wheat. A full description of this type of soil may be found in the general discussion of Indiana Soil Types.

Glacial Soil.

A large area in this county has been affected more or less by the invasion of the ice sheet, but the soils have been but little influenced by the glacial material except in an area of about ten square miles, where there has been a ridging or piling up of the drift. This is a long, irregular ridge from 5-20 feet in height extending in a north and south direction throughout the eastern part of the county south of the river and extending into the northern edge of Washington County. It is called Chestnut Ridge, and is composed of clay, sand and gravel. Some drift material is found sparsely scattered over the eastern third of the county. The upper course of the East Fork of White River has been changed by glacial action.

Alluvial Soils.

White Clay.—Just east of the hill line is a belt of white clay land from one-half mile to one and one-half miles in width. The north part of this belt is drained by White Creek and is known locally as "the White Creek Slashes." White Creek is a meandering stream almost in the valley floor, and has little fall, so that much of this soil is subject to overflow during the spring.

The soil is a white clay, very stiff when wet, and extremely hard when dry. The subsoil is still more compact and is mottled with yellow and brown. Owing to its extreme hardness when dry, the land must be worked while wet. The most valuable crops are clover and grass. Corn does well in moderately wet seasons, but in dry the soil becomes so hard that it can not be well cultivated. However, the summer of 1907 was too wet and the corn was badly damaged. Ditching would greatly improve the soil, especially the clay soil along the hills, which is very wet since it receives the water from the hills to the west. Ditching is hardly practicable on account of the high level of White Creek. Through part of Hamilton Township a dike of five to six feet in height has been constructed along the east bank as protection against freshets.

Brown Sandy Loam.—Between the white clay and the true bottom soil is a strip of brown, sandy loam from one to two miles in width. This is a very loose sandy soil of a few feet in depth, grading along the west side into a more compact dark subsoil, but into glacial drift along the east side. It is very productive; corn, the principal crop, usually yields fifty to eighty bushels per acre. Clover is grown extensively and does well. In the south part of the county several acres are devoted to the growing of muskmelons and nutmegs. They are reported as giving a return of about one hundred and fifty dollars per acre of an ordinary season. The farms in the loam belt are much better improved than those on the knobstone and clay lands. The sandy soil also produces better in moderately wet seasons, as it is so loose that it dries out rapidly.

Valley Soil.—The sandy soil grades into the true valley soil, which is a black, sandy loam, although the percentage of sand is less than in brown soil. Glacial gravel underlies much of this soil, especially along stream courses. The crops are much the same as on the brown soil; corn does better in dry seasons but is more injured by wet. Clover is used for hay and for enriching the land. Wheat produces twelve to eighteen bushels per acre, and corn some better than on the sandy soil. Little commercial fertilizer is used on any of these soils.

Most of the timber has been removed, but some woods remain, which are composed principally of white, black, red and burr oak, swamp and gray ash, paper birch, yellow and tulip poplar, water elm, scarlet maple, cottonwood, sycamore, black and sweet gum, hickory and black and white walnut.

The price of the clay lands runs from $20 to $50 per acre according to location and improvements; the brown sandy loam from $50 to $100 per acre, and the valley soil somewhat higher.

Fine Sand Areas.

On the east side of the river is a belt of the true valley soil somewhat narrower than on the west side. Back of this is a belt of a peculiar sand land. This belt is one to three miles wide in Reddington Township, widens to about four miles in Jackson, narrows to about a mile in Brownstown and again widens to three or four miles in Driftwood.

This soil is of a lighter color and more sandy texture than the brown loam on the west side. Its surface is somewhat irregular, being thrown into rounded knolls. The regular crops are raised with fair success, although the soil is not so productive as the true valley soil or the brown loam.

This area is especially famous on account of its production of melons. Over five hundred acres of watermelons and one hundred acres of canteloupes were planted last year. They yield well, and while the expense and labor of raising them are heavy, they are usually a very paying crop. Vallonia is the center of the melon industry and is the principal shipping point, although heavy shipments are made from Medora, Brownstown, Seymour and Rockford. Several hundred carloads are shipped from these points, principally to the Cincinnati and Chicago markets. An accompanying photograph shows the method of handling and loading melons at Vallonia.

General Summary.

Jackson County ranks as one of the best agricultural counties in the State. The knobstone soils which cover most of the county

Delivering watermelons for shipment at Vallonia, Jackson County.

do better and are better improved than is usual with this type of soil. The alluvial soils, especially the sandy soils and the loam, are unexcelled for corn, wheat and clover. The improvements on these soils will compare favorably with those of any portion of the State.

The prices of land are from $5 to $30 for the knobstone ridge soil, $20 to $30 for the white alluvial clay and terrace clay and $80 to $120 for the valley soils.

The roads are, as a rule, well improved; some of the ridge roads have been laid out by professional engineers and go over or around the ridges with the least possible grade.

By Wm. Tuell, Brownstown.

Watermelons ready for shipment, Vallonia. Jackson County. Twenty-five loaded cars were on switch in addition to 40,000 melons on ground.

Stock raising is an important industry, about 600 horses and the same number of mules being sold annually. The number of horses in the county is about 5,000 and of mules about 2,500. About 3,000 cattle and 20,000 hogs are sold annually.

There are over 100 factories, shops and mills in the county, including two canning factories, numerous grist and flouring mills, one meal and hominy factory and one commercial fertilizer factory.

A Soil Survey of Decatur, Jennings, Jefferson, Ripley, Dearborn, Ohio and Switzerland Counties, Indiana.

By L. C. Ward.

THE TERRITORY.

The territory embraced in this report consists of the seven counties above mentioned, lying in the southeastern corner of Indiana. The area is bounded on the south by the Ohio River, on the east by the State of Ohio, and on the north and west by the limiting lines of the counties named above. With the exception of Decatur County, a common bond of geology justifies the consideration of this territory in a single report.

The work done is an attempt to classify the soils of the territory on the basis, first, of their origin, and, secondly, their physical and chemical composition. The methods, in the main, are those used by the Soil Survey of the United States Department of Agriculture; and wherever possible the system of nomenclature used by that survey has been followed.

Geology and Physiography.

No discussion of the soils of a region can be intelligently begun without some discussion of its geological history, and the subsequent effects of weathering, stream action and other agencies which have operated to make it what it is. These will be considered in detail in connection with the descriptions of the soils by counties. But it seems desirable here to consider these subjects in their general relations with the area as a whole. This general description must be understood as applying to all the region except Decatur County, which, in two-thirds of its area, is entirely different from the remainder of the territory.

Geologically, the region under discussion forms part of the western side of the Cincinnati dome, a name given by geologists to an island which arose from the ancient interior sea, and has probably been land ever since. This dome is elliptical, with its long axis nearly north and south, with the present city of Cincinnati not far from its focus. On this western side the rocks dip to the west at an inclination of from 10 to 60 feet per mile. The surface, however, rises toward the west, perhaps because of the increasing resistance of the rocks, in an ever greater degree; hence, in traveling from Cincinnati to Batesville, in Ripley County, a distance of fifty miles, one rises gradually from a height of about 475 feet above tide to about 1,050 feet. As a whole, the area is a plateau, with an average elevation of about 900 feet above sea-level—a plateau with its highest levels in the northern part of the area, sloping off to the south and east, gradually, until within a mile or two of the Ohio River, and then abruptly sloping down into the valley of that stream, 300 feet or more in a distance of four or five miles. This plateau is underlain with limestones and shales, beveled to a small degree where they outcrop. These, in order, beginning with the lowest and oldest, are as follows:

(1) The Trenton formation, which has been mapped as a narrow ribbon in the extreme southeastern corner;

(2) The Utica shales, exposed in the deepest valleys near the Ohio;

(3) The Lorraine limestone, which is the principal outcropping formation for 10 to 20 miles back from the Ohio;

(4) The Hudson River group, the upland limestones and shales between the last-mentioned group and the Niagara;

(5) The Niagara, a hard limestone which extends in a belt averaging 15 miles in width from the river to the northern limits of the territory;

(6) The Corniferous limestone, a narrow strip just above the Niagara, and,

(7) The New Albany shales, which are the surface strata on the western border of the region.

The first four groups are commonly known to geologists as members of the Ordovician or Lower Silurian series, and the last three as parts of the Upper Silurian strata. The arrangment of these strata can best be understood by reference to a good geological map of the State. The influence of each formation will be considered in detail in connection with the counties in which it occurs. Suffice it to say here, that the Niagara limestone is the backbone of the entire area, a resistant stratum furnishing a pronounced divide between the softer rocks on each side.

Mention must be made here, also, of the glaciation of this region. Any map of the United States, representing its condition during the great Ice Age, shows the terminal line of the glacier as just touching the Ohio Valley near the southern border of our area. If the reader will understand by this line, a boundary, not of the ice itself but of certain *results* of glaciation, it is, no doubt, nearly correct. But of the actual presence of the ice within the limits of these counties there is very little evidence, except in the extreme northern portion. Probably the greatest influence of the glacier upon this area lay in the deposition, from the waters escaping from it, of enormous quantities of silt, sand and gravel, partly in terraces along the Ohio River, but mainly as a great sheet of yellow "loess" over the greater portion of the plateau.

Physiographically, the region is a dissected plateau, with the master stream, the Ohio, just approaching maturity. The Ohio, in its course along the southern border, flows in a rather deep gorge, averaging perhaps 300 feet in depth. The stream fills practically the entire gorge floor, flood plains being found only at intervals on the inner sides of the bends. Of course, with the principal river not yet possessed of flood plains, one should not expect very extensive valley floors along the tributary creeks. As a matter of fact, these smaller streams all flow in narrow, deep valleys, in some places near the river veritable canyons. Very few of them have bottoms at all commensurate with the size of the current. It is probable, also, that where bottoms are found they are due mainly to the influence of glaciation. Very nearly all of the Ohio valley floor is made up of gravel and sand terraces, of which the composing material is entirely glacial. Along Laughery, Muscatatuck and numerous smaller tributaries the soil of the bottoms is found to contain many glacial pebbles, and sand and loess from the neighboring hills. It is certain that in the extreme southern border of the area, where one would naturally expect the streams to show their greatest development of valley floor, no bottom ground occurs. In this portion of their courses, however, the creeks have little material to carry, since the valley sides are largely stone. Farther up, the hill tops are mainly loose clay, sand and loam—material easily eroded by the active rills of the uplands, but carried in flood times into the more gently-sloping larger valleys in such quantity that much of the suspended material must be laid down as alluvium.

Climate.

From the agricultural standpoint, the climate of this region is very favorable. The average date of killing frost is nearly a week later than in northern Indiana, and late spring frosts are not so likely. The Ohio valley has its beginning of spring at least two weeks earlier than Huntington or Ft. Wayne, as I have determined by the collection of data as to the times of blossoming and "leafing out" of common trees and wild flowers. The total annual rainfall averages not far from 40 inches—an amount sufficient for all crops likely to be attempted in this region, without irrigation. Few seasons are too wet for the majority of crops, but once in every five or six years an extraordinarily dry August injures late maturing crops, as corn or late potatoes.

In the collection of samples for chemical analysis, no account has been taken of county boundaries. The aim has been to obtain a fair average specimen of each soil type. Thus, for the Miami silt loam, eight samples were taken from widely different points in its occurrence, and these thoroughly mixed. From this mixture a sample was chosen which presents the average characters of this soil. For the mechanical analysis, on the other hand, the samples were tested by counties. If a soil thus tested differed in no great particulars from a previous test of the same type, the test refers back to the previous test. When there is a divergence, a second table is included in the report.

JEFFERSON COUNTY.

The extreme length of this county is 26 miles, east to west; its breadth 23 miles, north to south. Its approximate area is 360 square miles. Madison, the county seat, is in the southern end of the county on the Ohio River, and on a branch of the Pennsylvania Railway lines—the old J., M. & I., the first railroad in the State. The extreme western side of the county is crossed by the Louisville branch of the B. & O. S. W. Railway.

Climate.

The records of the Weather Bureau, compiled at Madison, show the average annual temperature at that point to be 55.7° Fahr., with a range of from 31.5° F. in February to 77.9° F. in July. The average annual precipitation at the same place is 40.96 inches, with a range of from 2.06 inches in October to 4.86 inches in March. On the uplands in the north of the county, the temperature is perhaps 2° lower. These conditions of temperature and precipitation are sufficient for any ordinary farming; and taken in connection with the early spring and late fall of this section of the State, this county is, from the climatic standpoint, one of the most favorably situated in the State.

Geology and Physiography.

Within the borders of this county are represented all the strata mentioned in the opening section except the Trenton. The eastern third of the county is underlain by the Utica shales, Lorraine limestone, and Hudson River group of mixed limestone and shales. All three of these formations are more or less shaly with intercalated beds of thin, hard limestone. On the whole, however, all are soft and easily worn. A belt averaging about 8 miles in width, extending north and south across the county, has for its underlying rock the Niagara limestone, a hard resistant stratum, whose wearing qualities are responsible for the great upland region in this county. Above the Niagara comes the Corniferous limestone, almost as hard, with the New Albany shales, a much softer formation, for the cap-rock on the western border. On all of the uplands there are traces of glacial action, very faint in most of the county. These traces consist for the most part of occasional fragments of glacially-transported pebbles, and the presence of certain soils whose origin is hard to explain as a result of mere rock decay.

Physiographically, the Ohio River has been the greatest factor in the bringing about of the present appearance of the land. This great stream, in cutting its gorge down through the rocks, has carried the minor tributary streams with it. These, therefore, are now found occupying deep, narrow valleys, incised often 300 feet beneath the surface of the uplands. The other factor of importance has been the resistance of the Niagara limestone. This rock has so well protected the uplands that the streams have been able to do relatively little sidewise cutting. The topography, then, of the greater part of this county may be described as the resultant of these two factors—a gently-rolling interstream upland, cut deeply by narrow, steep-sided gorges—essentially a youthful topography.

SOILS.

Five types of soil have been mapped in Jefferson County. Four of these have been derived from the decomposition of the underlying formations, with perhaps some glacial action. One of the four, the Miami silt loam, is perhaps entirely glacial, and another, that mapped as limestone upland, has been only slightly influenced by glaciation. The fifth soil consists entirely of material deposited by the Ohio River in its flood plain, or, in the smaller streams, of deposited material plus some wash from the neighboring hillsides. These soils, arranged in order of amount of territory occupied, are:

Volusia silt loam	161 square miles
Limestone, upland	126 square miles
Miami silt loam	41 square miles
Waverley silt and gravelly loam.......	13 square miles
Scottsburg silt loam	19 square miles

THE SCOTTSBURG SILT LOAM.

This type of soil occurs very sparingly in Jefferson County, forming oval or nearly circular patches of from 10 acres to 1,200 acres in extent on the highest points of land in the western part of the county. It is a light-colored soil, in the summer when dry being almost white. When wet it is gray or drab in color. At depths of 8 to 15 inches this color gives place to a slightly yellow subsoil, sometimes mottled with drab and darker yellow. In places there is considerable sand; but for the most part sand is absent, and the soil in such places is very much like a stiff clay. This soil type is easily recognized by its nearly white color, by its stiffness and by its flatness. The tracts of this soil are in many places so flat as to be swampy. Where the patches are small, indicating advanced erosion, little streams have worked their way into the swamps and drained them; but in the larger tracts, say 100 acres and up, even in June swampy, marshy places are common. The native forest in such places consists of the water loving trees of southern Indiana—elm, black gum, sweet gum, beech and black hickory.

This soil is called by the farmers "thin." It undoubtedly is poor farm soil, so poor that much of it is still uncleared. This stiff, tenacious soil is slow to part with its water, and consequently is too wet for the plow until late in the season. On the other hand, only 15 inches down is a bed of clay, almost impervious; and in July or August, if drought should come, plant roots could find no moisture in the subsoil. Therefore this is a bad soil for dry summers. If it is to be cultivated at all, probably the best scheme is to tile thoroughly, thereby securing early summer plowing; and then to plant to such crops as mature early.

When this soil is first cleared, a few good crops can be obtained, until the meager supply of humus is exhausted. After that stage is reached, careful rotations of clover must be made to obtain anything like fair yields. Thus, on one such area, corn yielded 30 bushels per acre for three years, and then dropped to 10 bushels. Wheat and grasses do better than corn, if enough commercial fertilizer be used, since these crops are harvested before dry weather begins. Clover does fairly well, and should be sown every third year to keep this soil in even fair condition. The most profitable crops, however, seem to be tomatoes, garden vegetables, and small fruit, but this is due probably to the fact that gardens are usually kept in better condition than the larger fields.

Taken all in all, this soil is poor, and Jefferson County is fortunate in possessing so little of it.

Volusia Silt Loam.

This soil is one of the most important of the county, being surpassed in general agricultural virtues only by the limestone upland to the east. This soil lies almost altogether to the west of a line passing through Bright's, a village on the J., M. & I. Railway. It is recognized as a fair farming soil, adapted to most of the crops usually attempted in this region. It forms the surface soil of the western part of the county, except where the Scottsburg caps the higher hills. It is formed by the decay of the New Albany shales, and thus lies well east of the present outcrops of that formation, over ground where it formerly existed. The evidence that this soil resulted from the decay of the shales is the presence in both of great numbers of peculiarly-shaped brown iron concretions. These, in the beds of the smaller streams, are so numerous as to form small gravel banks; and they have been used to a limited extent in road repair work.

The Volusia is a brown soil, sometimes, however, yellowish when dry. At depths of two or three inches it is invariably brown, and the color increases in depth with the depth of the soil. In the surface, sand is present in noticeable quantities, very fine in texture. At depths of 8 to 12 inches the soil gives place to the subsoil, light red or yellow in color, stiffer than the surface and with less sand. With increasing depth practically all of the sand disappears, leaving a heavy, tenacious clay which grades into shale at depths of four to five feet. Throughout the entire depth iron concretions are met, more numerous at the top. The shale beneath contains these concretions also, but not nearly so numerously as the weathered clay. This fact points to the theory that many feet of the shale must have been decomposed to yield one foot of the soil and subsoil.

The topography of the Volusia area is rather broken. The underlying Corniferous and Niagara formations have served to protect the uplands from great erosion. Consequently, to a depth of about 30 to 40 feet below the general surface, the hills are rounded and the valleys rather open. When once the streams get through the harder rock upon the softer shales below, they cut almost straight down with steep-walled, deep valleys. The effect upon the drainage is good. Practically all the area covered by this soil is well drained naturally, and the deep gorges rapidly carry off surface waters. Where the underlying shale is close to the surface, along the steeper upland slopes, crops suffer from drought, but on the majority of this soil body there is little danger in average seasons. Corn averages here 32 bushels, wheat 18 bushels, oats 27 bushels and clover 1.5 tons per acre. Tomatoes thrive, and garden truck generally. Careful cultivation and systematic rotation pays well here, as upon most clay lands; and the figures given above are often exceeded by those farmers who mix brains with their fertilizer and care with their crop rotations.

Since this soil and the Scottsburg silt loam occur in the same district, it has seemed well to place together tables showing the mechanical composition of the two soils, side by side, for comparative purposes:

Volusia Silt Loam.

	1mm+ Gravel.	.16mm+ Sand.	.08mm+ Very fine sand.	.04mm+ Silt.	.0017mm+ Clay.
Soil	2.4%	16.2%	5.4%	66.2%	10.7%
Subsoil	.7%	9.9%	8.2%	56.3%	26.2%

Scottsburg Silt Loam.

Soil	1.1	12.6	11.7	60.4	15.6
Subsoil	.5	5.7	6.6	70.4	18.7

The principal differences are in the content of gravel, (which is practically all iron concretions), and in the colors of the two soils. There is yet another physical difference, which does not come out in the table, namely, the tenacity. The Volusia, probably because of its higher sand and concretion content, is a rather loose, crumbly soil. The Scottsburg loam, on the contrary, has a tendency to pack into hard lumps. Probably the great difference in the farming value of the lands is traceable to this physical difference in the soils.

The Limestone Upland Soil.

This somewhat awkward name has been applied locally for years to a certain class of soil in this and neighboring counties, and adopted in this report, although it is not recognized in the Soil Primer of the U. S. Department of Agriculture. It is used here because no other designation could be found which could be made to apply. In Jefferson County this soil is second in extent and a very close second in farming value to the Volusia, if, indeed, it does not surpass that soil. The name is used to designate those soils which have been formed from the decay of limestones, without much admixture of shale products. On the western border no hard and fast line can be drawn between this region and the Volusia. Indeed, there is a belt, some half-mile in width, which is a mixture of the two. The criterion of separation of the two is the presence or absence of chert or flint pebbles. The Niagara, in its upper layers, is rather thickly studded with chert concretions, while these are almost entirely absent in the overlying rocks. It is obvious, then, that if a soil is found containing many flint pebbles, it must have resulted largely from the decay of the flint-bearing rock; and all soils containing these in quantity have been called Limestone Upland. In the eastern portion of this area the flint pebbles are absent, but the soil contains many rock fragments and fossils exactly like those still in place in the stream beds of the vicinity.

Soil Characters.

In attempting to describe this soil one must recognize two regions in the area covered by it. The difference is partly topographical and partly due to the difference in the composition of the rocks whose decay produced the soil. The western half of this belt, comprising those soils produced by the decay of the upper members of the Niagara, is a gently-rolling upland, with none of the hillsides too steep for cultivation. Back from the river six or eight miles the streams occupy open valleys, and the ground may be plowed almost to the creek banks. Near the river the creeks have cut through the Niagara, and below that formation have steep-sided gorges, whose walls can not usually be cultivated. On this portion (the western half) of the Limestone Upland the soil is red. It is distinctly redder than the brown Volusia, and somewhat more compact. At depths of 10 to 20 inches this red soil gives place to an orange-colored or yellow subsoil, the difference in color between soil and subsoil depending upon the extent of oxidation of the iron so plentifully contained in the soil. Pebbles of flint occur abundantly, forming a sort of gravel, which tends to keep the soil open and porous. These pebbles are angular, and vary in size from a hickory nut to a large egg. This soil is strong, capable of raising great crops of the usual farm products of this region. In average seasons corn runs here 45 to 55 bushels, wheat 18 to 20 bushels, clover 2 tons or more and timothy 1.5 tons per acre. Drought has little effect upon this soil, since moisture penetrates the entire depth of soil and subsoil. The rolling character of the land renders tiling unnecessary in 99 per cent of the area. This is a limestone soil at its best.

The eastern portion of the Limestone Upland, to a distance of five miles, approximately, from Indian Kentuck, is occupied by a soil of a different character. The resistant Niagara is absent here, and the streams have had only soft shales and limestones to work upon. Consequently the gorges are deep, and the sides of the valleys in most places too steep for cultivation. This is a hillside soil, made up of the products of the decay of the rock. It might well be called a stony loam, since flakes and slabs of limestone are plentifully mixed with sand and clay. It is a very open, porous soil, usually less than 24 inches in depth, with the ledge rock immediately below. In wet periods, in the spring and autumn, great bodies of it slide down the hills, exposing scars very noticeable among the heavy underbrush. As to fertility, it is doubtful whether any soil in the State equals this for the first two years after being cleared. When new it is black, loose, porous and, of course, well drained. Where the hillsides are gently sloping enough for cultivation this soil yields tobacco, corn and anything else planted in Indiana. In the alluvial fans which occur along the foot of the hills, potatoes and garden truck grow luxuriantly. Unfortunately, however, these soils are transitory. Erosion is proceeding at such a rate in this area, and the streams are so active, that within five years after clearing most of the soil is gone. It is a common practice on these steep slopes to get as much profit out of the soil as possible in the shortest time, and then clear a new tract. Thus, tobacco is planted the first two years and then corn as long as there is soil enough. This wasteful method has resulted in the abandoning of many farms as worn out. It is an actual fact that much of this region is not worth as much as it was forty years ago. The salvation of the soil rests in finding some crop that will perform the function of tree roots in holding the soil between years of plowed crops, and alfalfa seems destined to that use. Little of it is sown in Jefferson County, but in Switzerland County it is coming into use and will be considered there as a crop for such soils as these. The following table gives the mechanical analyses of samples of both Limestone Upland soils, one being designated as Limestone silt loam, the other Limestone stony loam:

Limestone Silt Loam.

	1mm+ Gravel.	.16mm+ Sand.	.08mm+ Very fine sand.	.04mm+ Silt.	.0017mm+ Clay.
Soil	4.2%	6.7%	8.3%	59.2%	22.0%
Subsoil	2.3%	5.7%	7.8%	63.3%	21.7%

Limestone Stony Loam.

	Gravel.	Sand.	Very fine sand.	Silt.	Clay.
Soil	16.3%	14.2%	17.7%	50.1%	2.3%

It will be noticed that the latter soil is much more composed of coarse elements than the former; the greater per cent of gravel is explained by the fact that this rock is much less weathered than the former. The higher sand content is due to the admixture of shale products, as well as the fact that the finer clay particles have to a great extent been removed by stream action.

Glaciation and the Volusia, Scottsburg and Limestone Upland Soils.

These three soils have been mapped as drift soils. There is very little evidence for such placing, in the soils themselves. Each is exactly what one would expect to result from the decay of the underlying rock. Not a dozen pebbles of igneous rock were seen in the area covered by these soils, nor any sign of till or boulder clay. There is not a glacial striation on the Niagara limestone at any of its exposures. The soils themselves do not seem to have been disturbed. The iron concretions in the Volusia and the flint fragments in the Limestone Upland increase gradually in relative numbers as the surface is approached; and the soils grade downward from true soil, through fine waste, coarse waste, rock fragments into the solid rock below. It may be true that these soils have been affected by glaciation, but there is now no sign of such action. Quoting from Mangum and Neill, in their Report on the Soils of Scott County* in this connection:

U. S. Dept. of Agriculture, Soil Survey of Scott County, Ind., page 10.

"The surface material of the area is, in the main, so similiar to that formed by the disintegration of the underlying geological formations that it is difficult to determine what proportion of the soils is derived from material reworked by glacial agencies and what proportion has been derived directly from the decomposition of the rocks."

THE MIAMI SILT LOAM.

This soil, the third in extent of the soils of Jefferson County, occurs here as two tongues extending south from a larger body of the same soil in Ripley County. Since its chief occurrence in the seven counties is in Ripley, it will be taken up in more detail there. At this place it will be sufficient to say that it is a clay soil, usually yellow, but often bleached to white, with a subsoil of a deeper yellow hue, mottled with drab and containing lumps of bog iron ore. It is invariably flat and poorly drained, and supports a group of plants more or less swamp-like in character. There is evidence that this soil was formely more extensive in Jefferson County, forming the cap of the interstream ridges of the eastern half of the county. When it finally had been removed from those points it left behind a few small glacial pebbles, with here and there a trace of blue till. This soil requires tiling and careful cultivation to render it dry enough for good farming. It is a grass soil primarily, yielding as well in timothy and wheat as the better Limestone Upland soil, but not so well in corn or potatoes. It responds fairly well to commercial fertilizer, but experience shows that barnyard manure and clover are the better soil dressings. This soil is undoubtedly glacial. The evidence will be given later, in connection with the work upon Ripley County.

A mechanical analysis of this soil, taken from near the center of its area, shows:

Mechanical Analysis Miami Silt Loam.

	1mm+ Gravel.	.16mm+ Sand.	.08mm+ Very fine sand.	.04mm+ Silt.	.0017mm+ Clay.
Soil	.56%	12.0%	8.2%	60.3%	21.4%
Subsoil	.5%	14.0%	9.6%	51.2%	25.5%

WAVERLEY SILT LOAM.

This soil-type, which occurs only sparingly in Jefferson County, is defined as soil deposited by streams upon their valley floors, or flood-plain soils. Of this type there is little along the Ohio within this county. In the northwest portion of the county on Big Creek there is a narrow bottom occurring principally in small tracts on the inside of the bends. This bottom soil is derived from the hillsides, and is much like the soils of the uplands. The sand content is a little greater, and the clay somewhat less. There is a greater amount of organic material, shown by the darker color of the soil, but its relation to the uplands is clear. This soil is well drained and porous. It raises corn, wheat, potatoes and garden truck, and is the best tomato soil in the county. The canning factory at Deputy relies upon the bottom lands in the vicinity for most of its pack.

A glance at the map shows that the greater part of Jefferson County is on the outer side of the bend in the Ohio. This means, of course, that there will be little river bottom in this county. Only in the extreme southwest portion, in Saluda Township, is there any considerable river bottom. These deposits are partly glacial, as shown by the glacial pebbles contained in them, and partly due to local deposition, as shown by the iron concretions and flint pebbles so similiar to those in the uplands. Besides these sources, the bottoms contain much silt brought down by the river. These river bottom soils will be taken up in detail in connection with Ohio and Switzerland counties, where they form the most valuable soils of those counties.

Agricultural Conditions.

There is as much variation in farming conditions in different parts of Jefferson County as one can well imagine. In some portions the farms are as well and as carefully cultivated as any in the State. In other localities there is a general air of shiftlessness and poor farming that can hardly be excused. The soils of this county are such that only the most careful husbandry can keep them at their highest state of productivity. Experience shows that for such soils as these no fertilizer is equal to barnyard manure; and yet in many places this valuable material is found piled close to the edge of a brook that soon carries away the best part of it. Care must constantly be exercised on the steep hills to prevent their washing away. That this can be prevented in many places is shown by a number of fine hillside farms. That it is not always prevented is shown by the number of worn-out farms. The great need of this county is a wise rotation of crops, conservation of all manure elements, and a return to the soil, from year to year, of a little more plant food than is taken off. Such a policy has produced some of the finest farms in southern Indiana—farms that have brought their owner at least moderate wealth, and which are today more valuable than ever they were.

The principal drawback to farming in perhaps half this county is a lack of transportation facilities. True, the river flows along one edge of the county, but there is difficulty in descending the steep river bluffs with any fair sized load; and the best farming land in the county is at a great hauling distance from a shipping point. The railways, also, are far removed from at least one-third of the county, and some of that the equal of any land in the county for farming purposes. This points to concentration of weight in sale products, which is reached probably in the hog and cattle. At any rate, two thousand pounds of hog, worth $120, are no harder to haul twelve miles to market than two thousand pounds of corn, worth $20; and the farmers in this county whose farms indicate careful work, are those who have most hogs and cattle to sell.

Erratum.—In the soil map of Jefferson, the portion of the legend reading "Miami Clay Loam" should read "Miami Silt Loam."

Chemical Analysis of the Volusia Silt Loam Occurrence—Jefferson and Jennings Counties.

Moisture at 105° C	3.87
Total soil nitrogen	.115
Reaction of soil to litmus	Acid
Volatile and organic matter	3.910
Insoluble in Hcl (1.115 sp. gr.)	83.272
Soluble silica	.034
Ferric oxide (Fe_2O_3)	3.993
Alumina (Al_2O_3)	7.860
Phosphoric acid (Anhyd) (P_2O_5)	.137
Calcium oxide (CaO)	.169
Magnesium oxide (MgO)	.378
Sulphuric acid (Anhyd) (So_3)	.046
Potassium oxide (K_2O)	.359
Sodium oxide (Na_2O)	.098
Total	100.256

RIPLEY COUNTY.

LOCATION.

This county is in the southeast corner of Indiana, one county removed from the State of Ohio on the east, and also from the Ohio River on the south. Its greatest length is about 27 miles, its greatest width 18 miles, with an area of approximately 450 square miles.

Climate.

The average temperature of the county, obtained from averaging temperatures furnished by the Weather Bureau at points east, west, north and south, is about 54°, with a minimum for February of 30°, and a maximum for July of 77°. The precipitation averages about 40 inches. From the climatic standpoint this county is as favorably situated as can be expected in this latitude.

Geology and Physiography.

Laughery Creek forms the dividing line for its entire length in this county between the soft limestones (impure) and shales of the Cincinnati epoch on the east, and the Niagara formation of the Upper Silurian on the west. The outcrops of the Niagara form an escarpment on the western bank of this stream easily recognizable throughout the county. The topography of the county is directly a result of the geological structure. East of Laughery the rocks are soft and easily eroded. Even the smaller streams in that half of the county flow in narrow, steep-walled gorges, especially as they approach the master stream. On the western side of the county, however, the resistant Niagara furnishes a solid base for the streams, and only the larger are able to cut through it into the softer rocks beneath. These are Big and Little Graham, Otter Creek and Tanglewood Creek. Generally speaking, the area east of Laughery is a very much dissected plateau, the area to the west much smoother. Toward the east border of the county, however, where the streams head, the surface is quite level; and on the western plateau the surface is very broken in the southwest corner of the county near the larger streams named above.

As a consequence of the dip of the rock to the west in this county, Laughery has been forced always toward the western bank with greater pressure than toward the eastern. This fact, in connection with the presence of a resistant rock on the west, and soft rock on the east, has resulted in a peculiar valley form. The western valley side is practically everywhere steep—so steep that cultivation is entirely out of the question. It is an ideal cliff-and-talus slope for much of its course, averaging something more than 125 feet in height throughout the county. The eastern valley-side is much less precipitous, in some places arable from top to bottom, and nearly everywhere of gentle slope enough to allow of an accumulation of soil over the rocks. The entire expression of this valley is youth, or early maturity. There are bottoms, or alluvial deposits along the stream, but these are comparatively small, and found only on the inner sides of the bends of the stream. There are few true meanders, and the valley sides are entirely too steep to admit placing the stream in any other stage than youth. Such alluvial lands as occur are of great farming value, and are the most valuable agricultural asset of the county in point of fertility and productiveness.

The underlying rocks of this county have not exerted a profound influence upon the chemical composition of the soils except in very limited areas. Glacial debris was carried out by the escaping waters from the old ice front and laid down over practically all of this county, in a sheet varying from 30 feet in thickness on the north boundary, to 3 or 5 feet toward the south. Perhaps some of the debris was derived from rocks now buried beneath later accumulations, but there is little positive evidence for such belief. But if the underlying strata have contributed little to the composition of the soils, they have influenced to a very great degree the present condition and value of lands. On the western side of the county the resistant Niagara limestone has protected the glacial clays from erosion, by preventing stream action. Hence in this area the soils lie in great flats, which are unprofitable unless drained. On the eastern side of the county, where the rocks are softer, the streams soon recovered their former channels, and have since then been carrying off great quantities of glacial clays and sands, leaving the eastern side much better drained than the western.

THE SOILS IN DETAIL.

Miami Series.

The principal soils of this county, both from the point of view of extent and value, belong to the series called by the U. S. Government Soil Survey, Miami. These soils are described in the Soil Primer as "light colored surface soils," as "derived from glaciation," and as "having been timbered either now or originally." This last characteristic is necessary to separate the Miami soils from the poorer members of the prairie-making soils. These Miami soils are often called "Loess," a name applied to certain fine-grained, light-colored soils which occur in many places on the earth. With regard to the derivation of Loess in general there is at present a great conflict of opinion, some geologists holding it to be due to wind deposit, others to water. In Indiana there can be little doubt that water was the agent, for our so-called loessal soils, at least in southeastern Indiana, are not true Loess. In the six counties which contain much of this material, it is invariably found to contain a considerable percentage (1 to 6) of very small pebbles, none larger than buckshot, evenly scattered throughout the entire mass of soil. Small as they are, these pebbles are too heavy for any ordinary wind to move about; and if we imagine their being carried by storm-winds, there is little chance of their being evenly distributed. Further than that, such storm-winds would have to exceed in violence any of the last five years, for repeatedly within that time I have seen great winds blow the dust from our roads, leaving behind the pebbles. But there is other evidence. Quite often, in digging wells and cellars, one cuts through beds of gravel, with pebbles as large as a hickory nut, which are clearly too large for wind-carrying, and yet which bear evidence, by their arrangement, of deposition. It seems better, on the whole, not to call these deposits, in the area described here, Loess, but to use the term Miami, which at any rate is accurately defined.

Reference to the map of Ripley County accompanying this report, shows that about eight-tenths of the area is mapped as Miami soil, either Miami clay or Miami silt. The reasons for making the distinction between these soils east of Laughery and west, rests upon internal differences in part, and partly upon diverse conditions of drainage, including till, and farming value. It is probable that a long while ago, shortly after the glacial waters had subsided, both sides of the county were covered with a layer of waste substantially alike in its composition, and that it was all more like the soil mapped as Miami silt than Miami clay. But, as we have shown, erosion was much more rapid on the east than the west side, and valleys were carved through the waste very soon. Thus it happened that in this region the early glacial surface was soon cut to pieces and the soil dragged down into the valleys. At the present, on the highest lands of this area, in the vicinity of Milan, and Clinton in Adams township, there are tracts of soil which bear a very close resemblance to the Miami silt; but for the most part the soils in this area are a mixture of glacial waste and the clay resulting from the decay of the shale and impure limestone below. This, then, is the first characteristic of the Miami clay loam. We keep the name Miami to indicate the fact that the soil is partly glacial, and use the word clay to indicate that part of the soil substance results from the decay of native rock. The addition of "loam" implies that this mixture is in a tillable state. The soil is yellow at the surface, grading downward into a brown subsoil, somewhat mottled and stained in places with darker brown spots. These mottled places, when examined, are often found to contain nodules of limonite or bog iron. Furthermore, on this eastern area, the soil is frequently found to contain siliceous fossils and bits of limestone identical with the fossils and rock below. Over most of the area covered by this soil drainage is good, due to the rolling nature of the surface, and the abundance of small streams. Tiling is necessary on the higher lands about the head waters, and in some of the flat valleys. In the northern part of this area the blue till, an impervious stratum, is found, at depths of from 6 to 30 feet, about 12 feet being a fair average.

When we compare the Miami silt loam with the Miami clay loam, the chief difference at first noticeable is compactness in the latter. In the clay, the admixture of limestone residuum left the soil somewhat porous; but in the silt, where rock fragments are few, the soil is exceedingly close and compact. The color of the Miami silt loam is light yellow to drab when damp, but when dry it is often almost white. At depths of six inches to one foot the soil grades into a subsoil of lemon-yellow, with brown mottlings; and from top to bottom there occur numerous very fine pebbles of granite, quartz, slate and other glacially transported fragments. At depths seldom exceeding ten feet, and usually about four, the blue till is found, a dense, impervious blue clay containing many bowlders, from the size of a cocoanut to the size of a flour barrel. Where a stream cuts into this bowlder-clay, its floor is studded with hundreds of these stones. The presence of the blue till exerts a marked influence upon the soil, if it is within five feet of the surface. Water cannot penetrate it except very slowly; hence the silt lying above becomes heavily waterlogged, all the more because these lands are flat. Such soils are hard to cultivate, being too wet for the plow until a month after hillside ground has dried out. They are readily recognized by the timber growing upon them, which is chiefly swamp-growth—beech, sweet gum, black gum, swamp maple, etc. Another mark is "crawfish chimneys." These creatures, in excavating their holes, find an ideal condition of permanent water in the upper portion of the blue till; and this material, when heaped up in their peculiar style, dries into a white chimney. Of these, I counted in a space three paces (9 feet) square, 53; and there were at least five acres as badly infested. The early settlers were careful of buying "crawfish" land, and a farm containing much of such soil is considered even yet poor.

Another peculiarity of these lands is the white or drab-colored mud of early spring, from which they are known locally as "Buttermilk flats," or "slashes." Trivial as such marks may seem, they yet have value because based upon real characters in the soils. Where the till is still closer to the surface, say 2 or 3 feet, another important effect of its presence is noticed in dry years. For the same reason that moisture does not pass downward in wet times, it cannot pass upward in dry, nor can plant roots penetrate such formations. In droughts, then, the plants which first die are those in the soil which was wettest in the spring.

Methods of Cultivation.

When the first settlements were made along the Ohio, the slashes and swamps of Ripley County were a "hissing and a byword" among the settlers on the hills near the river. They were esteemed of little value except for hunting grounds; and to a great extent the prejudices of those days yet live. When Ohio and Switzerland and Dearborn counties were famous throughout the Ohio Valley for hay, and potatoes, and corn from the bottoms, Ripley was a wilderness, except along the streams, where the country was broken enough to suit the pioneer. After awhile, however, it was discovered that these wet lands would grow crops if they were properly plowed, in narrow "lands," with ditches running down the faint slopes to the creeks. Plowed in this manner, wheat and grasses grew pretty well, and yielded fairly, but the waste of land was great, since only the higher portions would grow crops. Then came the tile-makers, who made not only their tiles, but the fortunes of wet counties as well. The flat lands, drained thoroughly with tile, prove as good as any in the district. They are not as fertile or productive as the bottoms along the creeks; neither are crops drowned or uprooted by freshet. They will not raise corn or tobacco, as the hillside soils further south, but neither are they gone in five years' time. They do not raise such enormous crops as the black lands of northern Indiana, but neither do they bankrupt the poor man who tries to work out a home for his family. Considering the crops which these lands raise, they are the cheapest in the State; and it is easily enough shown that they furnish at least twice as good an investment as the prairie lands of Illinois.

The other soils of importance in Ripley County are represented in the map as Waverley loam and limestone clay. The

Soil Map of Ripley County.

former name is used by the U. S. Soil Survey to denote any river or stream deposited soil, commonly known as bottom ground. Of this soil, there is comparatively little in Ripley County, a mere strip averaging perhaps half a mile in width along Laughery, and smaller belts along the smaller streams. In places the Laughery bottoms are more than a mile wide; and whether wide or narrow, they are the finest soil in the county. In the upper part of the valley, down as far as the B. & O. S. W. Railway, the bottom soils are principally the wash from the hillsides, and are much like the hillside soils in color, being somewhat darker because of the greater organic content. They are sandier, too, much of the finer clay having been carried away by the streams. Thus these valley soils are more "mellow" or "light" than the uplands, and are thus more desirable. From the B. & O. S. W. Railway south, the bottom soils are chiefly made up of the residuum from the decay of the limestones and shales in the valley sides. The soil is dark, mellow and rich, and no better can be found in the State for general farming.

The other soil mentioned above is the limestone-clay soil. This is the product of disintegration of the shales and limestones underlying the county. Where this decay has progressed far with little removal of the waste an excellent soil is left, loose, fertile and producing abundant crops. It is, however, a hillside soil, often on very steep slopes. It is therefore temporary, unless carefully conserved. In the areas of limestone-clay on the west side of the county there is very little of the shale products, and the soil is a reddish clay. It is not nearly so fertile as the limestone-clay along Laughery Creek; but it lies better, in that it does not slope so much, and is permanent. This limestone-clay soil is very important in Ohio and Switzerland counties, and will be more fully considered there. It is enough here to call attention merely to the extent of territory covered.

Agricultural Conditions.

This county has had a very slow agricultural development. When the counties to the east and south were among the best in the Ohio Valley from the farming standpoint, Ripley was scarcely touched by the plow. This was in part due to its exceedingly heavy forests; in part to the swampy nature of the soil over two-thirds of the county, and the malaria that lurked in the swamps; and in part to remoteness from the river, at that time the sole outlet for surplus farm produce. The last difficulty was partially overcome by the building of the Big Four and the old O. & M. Railways, at least for the northern half of the county. But only in the last ten years, when the increasing price of lumber has resulted in the cutting of practically all the woods, has the county become fairly cleared. The lumbering industry, until the last decade, has been of too much ready-money value in this county to allow of superior farming. Any able-bodied man could make good wages in the woods, or buy a saw mill rigging and go into business during the winter. As a result, a large proportion of the rural population farmed in the summer and lumbered in the winter. With the passing of the woods, however, it became necessary for the farmer to farm better than before, and he had more time for his real work. When the forests were once in large measure gone the soil dried considerably, and moderate sums spent for tiling brought results. We thus find a remarkable change in the farms of Ripley County within the last ten years. New buildings and better are being built every year; an excellent system of free macadamized roads, with substantial bridges, connects all places of importance in the county. Telephone lines are strung everywhere, and rural mail service is nearly complete. No better illustration of the change in conditions can be given than the increase in land values There are farms which ten years ago were for sale at $25 per acre, and now are held at $75. In Shelby Township there are farms which have sold within the last year for $40, and which ten years ago were worth not more than $5. Real estate men estimate the average increase in values at 100 per cent; and in localities especially favored with good drainage facilities and good roads, as high as 200 per cent.

The greatest difficulty in the way of farming in a large part of this county is remoteness from railroads. There are settlements in the southern part of the county where the soil is good and conditions favorable to successful farming, which are 17 or 18 miles from a shipping point. A north and south railroad, even a trolley line, equipped to carry freight, would be a godsend to this county and would advance it fifty years.

Mechanical Analysis of Soils of Ripley County.

Table No. 1. Miami Clay Loam.

	1mm+ Gravel.	.16mm+ Sand.	.08mm+ Very fine sand.	.04mm+ Silt.	.0017mm+ Clay.
Soil	.87%	6.01%	12.2%	61.2%	19.5%
Subsoil	.6%	3.64%	9.18%	54.4%	32.3%

Table No. 2. Miami Silt Loam.

	1mm+ Gravel.	.16mm+ Sand.	.08mm+ Very fine sand.	.04mm+ Silt.	.0017mm+ Clay.
Soil	.18%	2.8%	5.2%	86.0%	6.0%
Subsoil	.00%	1.6%	4.4%	81:0%	12.7%

Table No. 3. Waverley Sandy Loam.

	1mm+ Gravel.	.16mm+ Sand.	.08mm+ Very fine sand.	.04mm+ Silt.	.0017mm+ Clay.
Soil	.25	12.2	40.2	31.8	16.2
Subsoil	.28	10.6	36.6	33.3	19.7

Chemical Analysis of the Miami Clay Loam. Occurrence—Ripley, Dearborn and in Smaller Bodies in the Other Counties.

Moisture at 105° C.	.366
Total soil nitrogen	.115
Reaction of soil to litmus	Acid
Volatile and organic matter	3.910
Insoluble in Hcl (1.115 sp. gr.)	84.567
Soluble silica	.086
Ferric oxide (Fe_2O_3)	4.345
Alumina (Al_2O_3)	6.167
Phosphoric acid (Anhyd) (P_2O_5)	.153
Calcium oxide (CaO)	.428
Magnesium oxide (MgO)	.639
Sulphuric ac. anhyd (SO_3)	.021
Potassium oxide (K_2O)	.383
Sodium oxide (Na_2O)	.164
Total	100.372

Chemical Analysis of Miami Silt Loam. Occurrence—Ripley County, with Tongues Extending Into Jefferson and Jennings.

Moisture at 105° C.	1.23
Total soil nitrogen	.101
Reaction of soil to litmus	Acid
Volatile and organic matter	3.268
Insoluble in Hcl (1.115 sp. gr.)	93.033
Soluble silica	.124
Ferric oxide (Fe_2O_3)	1.094
Alumina (Al_2O_3)	1.673
Phosphoric ac. anhyd. (P_2O_5)	.111
Calcium oxide (CaO)	.306
Magnesium oxide (MgO)	.201
Sulphuric ac. anhyd. (SO_3)	.042
Potassium oxide (K_2O)	.347
Sodium oxide (Na_2O)	.233
Total	100.432

JENNINGS COUNTY.

Location and Boundaries.

Jennings County lies just west of Ripley and northwest of Jefferson, being bounded on its eastern side by these counties, on the south by Scott, west by Jackson, and north by Decatur. Its extreme length is 25 miles, extreme width 19 miles, with an approximate area of 400 square miles. In climate it is very much like Ripley and Jefferson.

Geology and Topography.

This county is underlain by the New Albany shales for more than half its area; just east of that formation is the Corniferous limestone forming a belt from two to eight miles wide, extending north and south through the county; and a narrow strip averaging from four miles wide along the eastern border is Niagara limestone. The Corniferous formation is thin in most of its outcrops in this county, and has had little influence upon the topography or the soils.

From the standpoint of drainage, this county is well supplied with water courses. The Muscatatuck and the Big Graham Creek are considerable streams here, with well opened valleys and numerous small tributaries. Besides these larger streams there are a dozen or more smaller creeks, five to twenty miles in length, which all aid in giving the most of this county plenty of outlet for rainfall.

The general expression of the topography in Jennings is rolling to rough. On the uplands, far from the streams, there is some flat country, and some gently rolling. There are, however, too many streams to permit of much of this smooth surface; and over most of the county, notably in the southeast corner, there is much very rough land. The surface, as a whole, seems to be merely the product of local conditions. On the shales the valleys are usually well-opened, with fair-sized bottoms. The valley walls are often gently sloping enough for cultivation, and nearly everywhere for trees or shrubs. Where the limestones form the surface rock the valleys are commonly narrower, with more or less cliff-like walls.

THE SOILS IN DETAIL.

Of the six types of soil recognized in Jennings County, the Volusia is by far the most extensive. Then follow, in the order named, Miami silt loam, Limestone upland, Miami Clay loam, Waverley silt loam and Scottsburg silt loam.

It is scarcely necessary to enter into a lengthy discussion of the Volusia soil here, since that has already been done in the soil descriptions for Jefferson County. It is a soil derived from the weathering, with perhaps some glacial modifications, of shales. In Jennings County there is no trace of any glacial modifications save in the northwest corner of the county, where this type merges into the Miami soils. In this area the Volusia silt loam is a light brown to light yellow soil, often ashy or drab when dry, but with its characteristic shades of brown when damp, or an inch or two below the surface. It has a depth of 8 to 12 inches, with a subsoil of from 6 inches to 6 feet. This subsoil, in its lower layers, contains many fragments of the parent shale; and the fact that these fragments grow progressively smaller, as well as less numerous, toward the top, is pretty good evidence that glaciation had little influence upon this soil. The soil proper contains some sand, and occasional iron concretions. These, however, are not so numerous as in the same soil in Jefferson County. The sand is not sufficient in amount to exert much influence upon the soils, and, indeed, is scarcely noticeable in some localities.

This soil lies, in Jennings County, mainly in a flat to gently rolling upland, rough only near the larger streams. By far the greater part of it is tillable, and a fair farming soil. It cannot rank with the limestone soil of Jefferson County, nor the sandy loam of Decatur; but where it is intelligently farmed fair crops can be raised in favorable seasons. By reason of the nearness of the impermeable underlying shale, it is not a dry-weather soil; and droughty seasons prevent the ripening of corn. This points to the cultivation of crops which mature early in the summer, and the small grains and grasses prove to be the best farming crop year after year. Berries do well in this soil, if the ground is properly prepared and fertilized. This soil is deficient in some of the necessary plant foods, especially nitrates and nitrites; and the sowing of clover every third or fourth year is recommended by many of the most skilful farmers. This is not a corn soil, although good crops are raised in good years. The chances, however, are so much against corn success here that a surer crop ought to be tried.

The second soil in extent in this county is the Miami silt loam, of which there are two bodies, one along the eastern side, and one on the northern. The eastern body is an extension of the great body of Miami soil in Ripley County, and is described there. The northern body is a southward tongue from the Decatur County Miami. It is distinctly sandy, and loose, with enough sand in its composition to furnish valuable sand bars in the creeks. It is a yellow to brown soil, 8 to 15 inches in depth, resting upon a brown subsoil 12 to 40 inches deep. The soil consists of about 20 per cent sand, 70 per cent clay, 10 per cent silt and pebbles. It lies in gently rolling uplands, somewhat broken near the larger streams. It is practically all cultivable, and is the best corn soil in the county, away from the bottoms. It does very well in wheat, oats and grass. Fruit trees thrive, and ought to be more numerous. The only objection to this soil in Jennings County is that there isn't enough of it. It requires fertilizer, preferably barnyard or clover, and well repays careful cultivation.

The soils mapped as Limestone upland (for want of a better name in this county) are those found on the valley sides, and interstream spaces where the Miami soils have been removed by erosion. The northeast corner of the county contains the largest body of this soil, derived probably from the Niagara limestone with some admixture of Miami clay. It is a yellow to red soil, mostly clay, with a good many chert fragments from the limestone. Once in a while iron concretions occur in abundance, derived probably by the decay of some outlying mass of shale. In this body of soil there is no hard and fast line of separation from the Miami soils north and south. These grade insensibly into the Limestone soil, by outwash and stream transportation. Usually the Limestone upland soil in this area is 10-12 inches deep, with a subsoil extending down to the rock at depths of 2 to 8 feet. It is an excellent grass and fruit soil, fair for wheat, oats and potatoes, and not very good for corn.

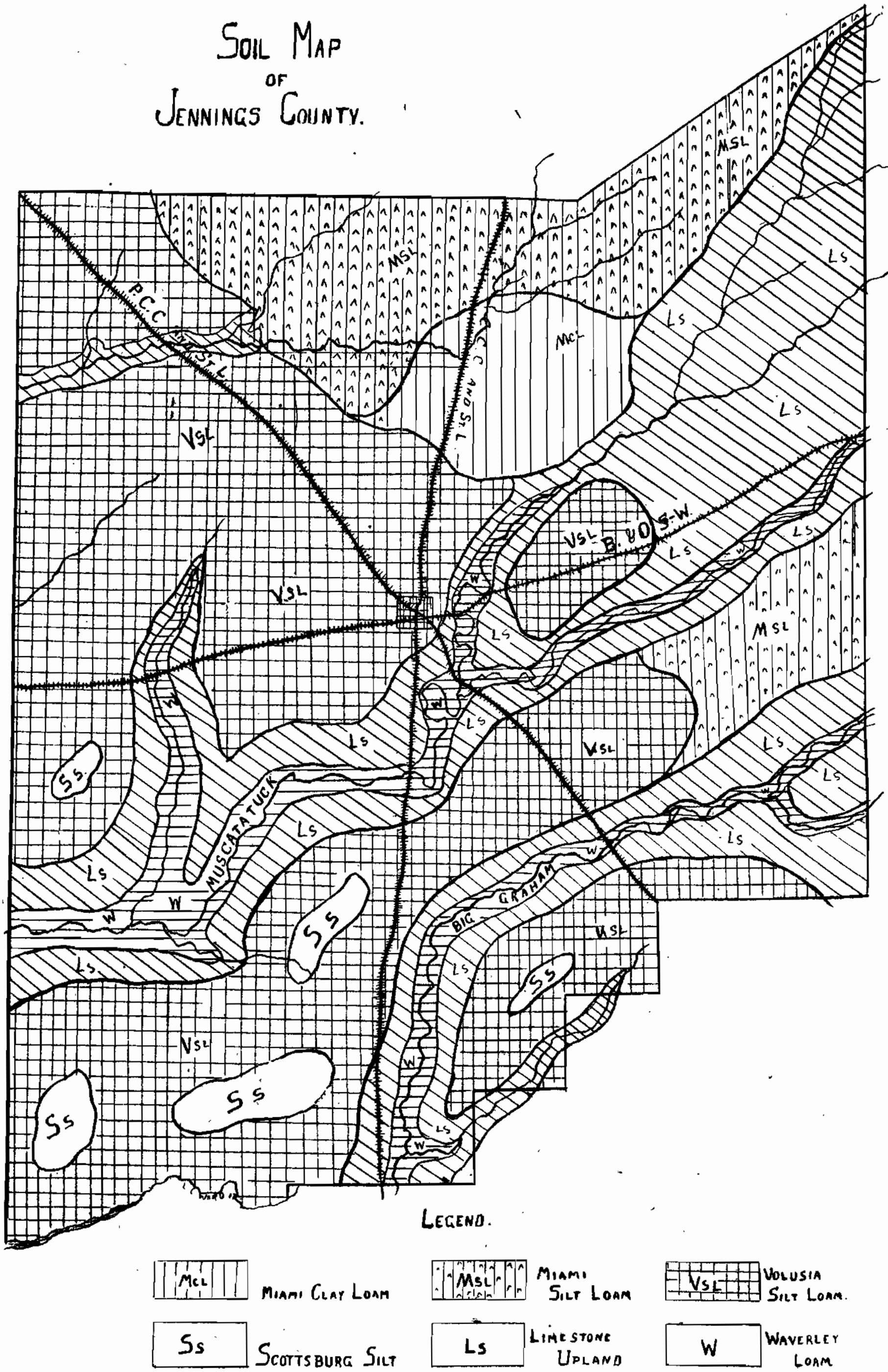
Along the valley sides the name "Limestone Uplands" does not strictly apply throughout the county. In the western portion the principal source of soil material is in the shales; but even here there is enough limestone to give the soil much the same appearance wherever it occurs. This valley-side limestone soil is for the most part useless, on account of the steepness of the hillsides, and the thinness of the soil. In many places, too, it consists mainly of flat plates of shale, too rough for plowing. It is not a true soil in such places and is of little worth.

Just south of the main belt of Miami silt in this county there occurs an area of about 40 square miles of Miami clay loam. This differs from the Miami in being almost white in color with faint yellow mottlings; in having a yellow subsoil of heavy clay, grading into blue till at 4 to 6 feet. It lies flat, with no hills or hollows except close to the streams. It is poor soil, covered with a growth of marsh timber, and hard to drain, except within half a mile of the valleys. Water stands in the lower portions practically all of the year; and there are numerous little ponds where the blue till forms an impervious bottom for some of the hollows. Where cultivated, this soil is used for grass and wheat, requiring fertilizer and drainage. For some reason clover does not grow well, and that valuable fertilizer can not be used.

Along the larger streams there are narrow bottoms (exaggerated in the map) of good soil, where it lies so it can be farmed. On the shale areas in the western part of the county where the valleys are open and the streams have come nearer to their base level, these bottom lands are often more than half a mile in width. In this area, also, the creeks do not rise so high, and destructive freshets are not so likely. On the limestone belts, however, the valleys are narrow, with little bottom ground, and that subject to flood. Since the streams with their headwaters reach practically all of the soils of the county, the bottom ground is made up of an aggregation of all. It is sandier than most uplands, with enough clay for stability. Often the valleys are so low-lying that tiling is necessary. On the whole, they furnish about as fertile a soil as any in the county, when properly cultivated.

In the southwest corner the highest uplands are composed of the Scottsburg silt loam, described in Jefferson County soils. It may be known by its whiteness, by its almost invariable flatness and wetness, and by being higher than any area near it. It differs from the Miami clay (the only soil in this county which it resembles in the least), by not having mottled spots in its make-up, and principally by the absence of the blue till. Here, as in Jefferson County, the Scottsburg silt has poor drainage and is on that account scarcely used for farming. It is yet timbered, with the swamp-tree forms—elms, black hickory, burr oak, sweet gum, etc. Fortunately there is little of it in this county.

Soil Map of Jennings County.



Farming Methods.

Generally speaking, this is a county of poor farms. There are places, of course, where excellent farming is being done, particularly in the vicinity of Scipio and Queenstown. But, taking the county as a whole, there is much slip-shod work. The soils here are naturally poor, and require careful management to keep them in fair shape. It is the exception to find farms in this county which are growing better from year to year. It seems probable that stock raising would help in this matter. Many hillsides which plow down in five years would last indefinitely as pasture. There are abundant springs of fine water, and grass grows naturally here. It looks like a horse and cattle country over most of the county. At any rate, the present method of selling off everything that can be sold can, in the end, only result in degeneration of farms.

From the point of view of transportation facilities, no county in southeastern Indiana is so well situated as Jennings. There is scarcely a farm in the county more than six miles from a railroad; and there are shipping stations conveniently near almost all farms. With markets so near as they are, three large cities being within 75 miles, it would seem that only a proper selection of crops is needed to insure success. The quality of fruit and garden truck is excellent where any attempt has been made in that direction; and it seems that on the better soils of the county horticulture and truck farming will be more profitable than general farming.

Mechanical Analysis of Jennings County Soils.

Table No. 1. Miami Clay Loam.

	1mm+ Gravel.	.16mm+ Sand.	.08mm+ Very fine sand.	.04mm+ Silt.	.0017mm+ Clay.
Soil	.90	11.6	9.7	58.6	19.7
Subsoil	.60	14.3	8.8	60.6	17.0

Table No. 2. Limestone Upland.

	1mm+ Gravel.	.16mm+ Sand.	.08mm+ Very fine sand.	.04mm+ Silt.	.0017mm+ Clay.
Soil	12.2	14.8	8.7	29.4	34.5
Subsoil	11.7	12.9	8.9	31.2	35.8

DEARBORN AND OHIO COUNTIES.

Location and Size.

Dearborn County is the extreme southeastern corner of Indiana, being bounded on the east by Ohio and the Ohio River, and on the south by Ohio County. This latter small county is so closely related in surface features and geological structure to Dearborn that it seems well to consider their soil make-up together.

The extreme length of Dearborn County is about 26 miles and breadth about 16 miles, with an area of approximately 315 square miles. Ohio County has an extreme length from east to west of 16 miles, and a breadth of 9 miles, with an approximate area of 87 square miles.

Geology and Topography.

These two counties are very near the center of the Cincinnati dome. The Ohio River has cut a deep gorge through the comparatively soft rocks of this dome—a gorge which in these counties averages some 350 feet in depth. The smaller streams in this area, then, are compelled to maintain a pretty rapid course by the steepness of their slopes. At the very edge of the river, where the river channel is deepest, the lowest rocks exposed are the Utica shales. These are soft, blue shales, often soft enough to cut readily with a knife, at other places, where freshly exposed, still somewhat hard. These shales contain many thin beds of limestone (mostly impure) interbedded with the shale. This shale formation forms the bottom layer in nearly every creek bottom as one passes back into the hills away from the river. Thus on Tanner's Creek, these shales can be traced in the creek bottom beyond Guilford, or about 8 miles, in direct line from the river. On Hogan Creek these shales are found at about the same distance from the Ohio; and on Laughery, a larger stream, the shales extend back at least 16 miles. Down near the river the lower 40 feet of the bluffs are made up of this shale; and further down the river, in Ohio County, the lower 60 feet.

Next above the Utica shales in these counties comes the Lorraine limestone. In Ohio County at least 9-10 of the surface is underlain with this formation. In Dearborn County about half the surface is underlain with this rock. In this part of the county it is merely a matter of courtesy to call this formation a limestone. A typical section of it shows a good deal more shale than limestone; and what there is of the latter is usually so impure that it is of no practical use, either for building stone or lime. There are occasional thin layers of hard, crystalline limestone which are put to use as road metal, but they do not form one per cent of this entire formation. This rock extends up the creeks to a distance of 16 to 18 miles on Tanner's and Hogan, and on Laughery beyond these counties and 12 miles into Ripley. Between the latter creek and Hogan this rock is the capping layer of all the hills; but between Hogan and Tanner's Creek the divide is capped with the limestones of the Hudson River group. These, like the Lorraine group, are mostly shale and impure limestone, soft, easily weathered and of little practical use. In the northwest corner of Dearborn County, and in one or two patches of Ohio, the surface formation is glacial in origin, and conceals the rocks.

The topography of these counties is entirely a product of the softness of the rock and the proximity of the river. The latter has a deep gorge, and the creeks from the back country have had to maintain steep courses in cutting down to the river level. Thus Tanner's Creek in sixteen miles falls 400 feet; Hogan Creek in the same distance falls 425 feet, or falls of about 25 feet per mile. Even a small stream, with such a fall is capable of carrying large loads and of digging out a deep gorge. Then the smaller streams which flow into the creeks named above have even steeper slopes, and of course are able to work with amazing power. It comes as a surprise to see for the first time what enormous blocks of stone one of these hill torrents can carry; but after seeing that, one is not surprised that the country should be so rough.

The general expression of the topography here is of long, high ridges, with deep gorges between. Only the upper third of the ridges, in most places, is gently sloping enough for cultivation, and even that, in many places, is too steep for plowed soil to stick. Near the Ohio, and on the lower courses of the larger creeks, the hills are steeper than in the back country, at least for the lower half of the ridges; and in most places no attempt is made to cultivate these slopes.

THE SOILS IN DETAIL.

In these two counties there are not many distinct types of soil. In the first place, there is little variety in the underlying rocks and could therefore be little variety in the soils resulting from their decay. In order of area covered these soils can be classified as follows:

(1) Limestone upland, which occupies at least two-thirds of the area of these counties;

(2) The Miami clay loam, which occupies nearly one-third the area;

(3) Waverley clay loam, the bottom soil along the Ohio River and creeks;

(4) Waverley gravel, the terrace soils.

The Limestone Upland Soil.

This soil may be divided into two general groups, depending upon whether the rocks from which it was derived were limestone chiefly or shale. In the first class comes most of the soil mapped as limestone upland. It is the great upland soil in this county, formed by the decay of the Hudson River and Lorraine limestones and shales. It is yellow to brown in color, markedly darker than the Miami soils to the west. It is principally a slope soil, and in nearly every locality is much mixed with flat fragments and plates of limestone. In many places these fragments are so numerous and large as seriously to interfere with plowing. Often they are gathered together and built into fences. Near the Miami areas there is often a mixture of that soil and the limestone soil. Where pure, this soil is fertile and loamy. On the steeper slopes it is usually sown to grass, wheat or rye, since these crops assist in holding the soil on the hills. Where the slopes are gentle, or in small bottoms, corn is grown successfully. This soil is excellent for small fruits, berries, etc., and for orchards. It is an excellent soil for most farming purposes. Being shallow, it is, however, subject to drouth with late maturing crops. There is a strong tendency to wash, and every community contains abandoned fields where the forces of erosion overcame the rate of decay of the rock. The small bottoms along the creeks in this region are peculiar in their formation. At least 50 per cent of the bottom material consists of flat plates of rock tilted at an angle of about 30°, with soil between the plates. As a result, the plowing of these small bottoms is almost as difficult as hillside plowing.

The most fertile soils in these counties is undoubtedly the shale soils, or the limestone upland soils on the lower portions of the slopes. In Ohio County, and near the river in Dearborn County, this division of the Limestone upland soil reaches within 60 feet of the hill tops. When freshly cleared these soils resulting from the decay of the shales have no superior in fertility in the State

They are dark brown or black, from the high percentage of humus which they contain, but after being cropped for three or four years they become somewhat lighter in color. It is often mixed with fragments of limestone from the slopes above. It is a loose soil, from 1 to 4 feet in depth, deeper at the foot of the slopes. It is in this soil that the tobacco of Dearborn and Ohio counties is raised—the most profitable crop that can be raised in Indiana soil, but exhausting to the ground. This soil raises excellent corn, or anything else that requires a strong soil. Wherever it is possible to retain this soil, it does not seem to diminish in fertility, but its situation is bad, being subject to erosion, soil creep and freezing and thawing. Unless exceptionally well cared for, within five or six years after clearing, practically all of the soil is gone, washed into the creeks and carried down into the river.

The Miami Clay Loam.

This soil, the second in extent in these counties, is similar to the Miami clay loam of Ripley County, of which it is merely an extension. In Ohio County the two bodies of Miami are outliers from the main body, separated by the action of Laughery Creek from the original plateau surface. In these counties, as in Ripley, this soil lies flat, with poor drainage. It is a compact, yellow clay soil, nearly white when dry. In the subsoil there are mottles, and sometimes a blue till at the base. This soil bears a marsh vegetation, sweet gum, beech, etc. It is a good grass soil here as elsewhere, and fairly good for wheat when fertilized. It invariably requires tiling and careful rotation of crops to yield profitable results. The town of Dillsboro, in Dearborn County, is on the line separating the Miami clay from the Limestone upland. It is a matter of common remark that east of Dillsboro corn is better than west, while the soils on the west produce better wheat and grass.

The Waverley or Bottom Soils.

The principal development of Waverley soils in these counties is in the "Bottoms" of the Ohio and the creeks just as they leave the hills for the river plain. In Dearborn County the principal area of Waverley soils has been known for a hundred years as the "Big Bottoms." This comprises a body of about 7,200 acres of land, lying between the Miami River and the Ohio, crossed by Hogan and Tanner's Creek. It is likely that this great alluvial plain is due to deposition of silt from the waters of the Miami, the

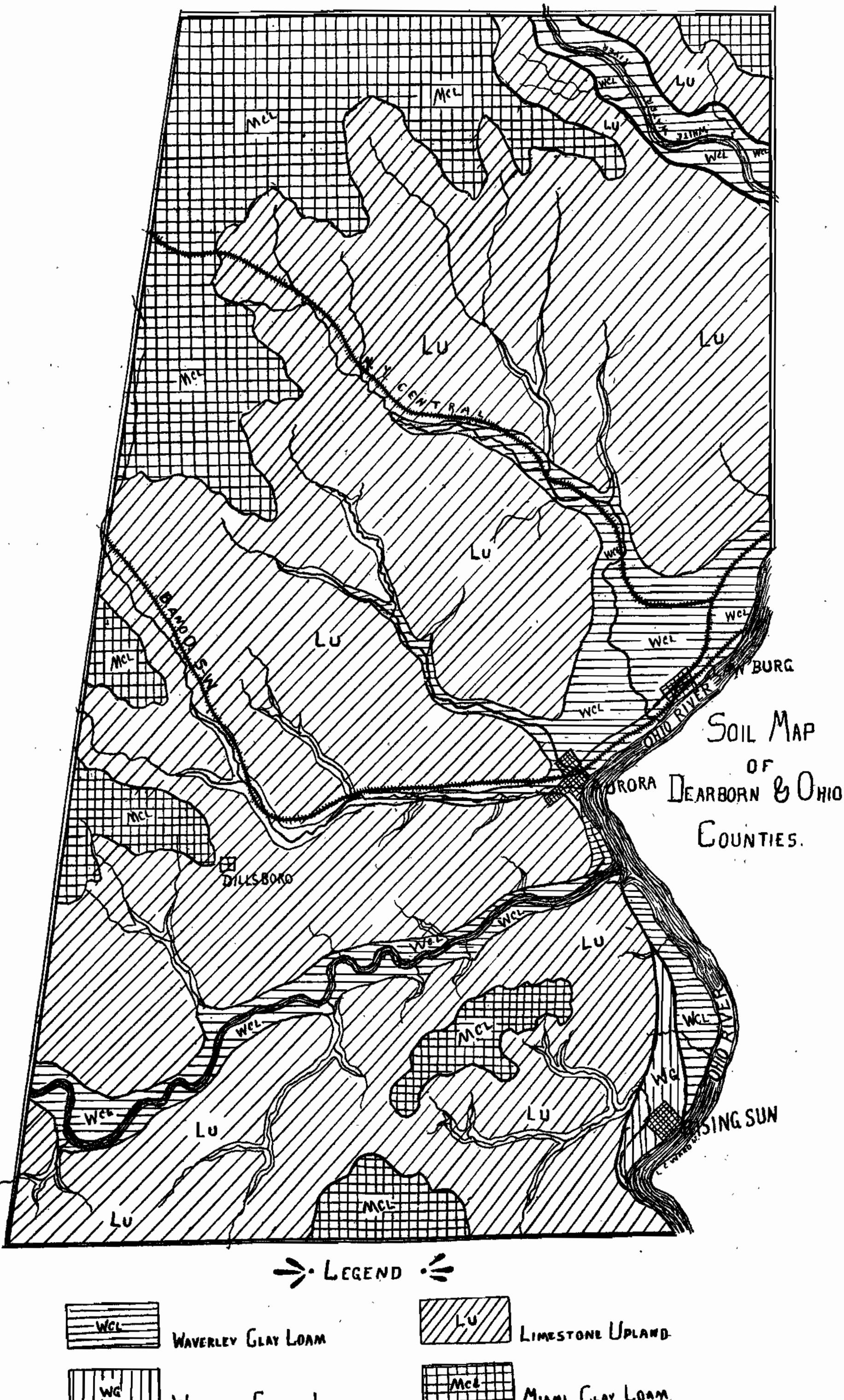
Ohio and the two creeks in times of high water, when the smaller streams had their currents checked by the back-waters of the Ohio. At any rate, this result follows during every flood, when a thin layer of silt is deposited over the entire plain. From the fact that the lower parts of this soil contain much sand and pebbles foreign to the uplands, it seems certain that a large part of this bottom land was laid down in the period of the ice invasion, and that these Waverley soils are in part due to glacial floods, in part to the annual flood of the Ohio.

This flat-floored valley, with its hills conveniently near, offered an attractive place for settlement to the early emigrants from the East. The first clearing was made in the "Big Bottoms" in 1794, and it has been permanently occupied since then. For a hundred years this land was planted in corn, some portions of the valley having certainly been planted to that crop every year of the century. In late years the bottoms have not been so fertile, or, at any rate, the corn crops have not been so large. This is probably due to lack of rotation and can be mended by some attention to that phase of good farming. In the summer of 1907, while there was a great deal of corn in this valley, probably one-third of the bottoms were in grass, wheat or oats. Physically, no soil could be better. It is fine, loamy, easily plowed and cultivated, deep enough to withstand drought, and fertile beyond most soil. It is close to a good market, and, indeed, has but one danger, that of overflow. This, however, is in part counterbalanced by the increase in fertility due to the silt left behind, and is the original source of the bottom.

In Ohio County there is a narrow belt of bottom ground, usually less than one-quarter mile in width, but widening near Rising Sun to a width of nearly a mile. In this bottom the soil is light colored, almost yellow, of fine silt. Like the "Big Bottoms," it is an excellent corn soil, and is said to be even better than that soil for grass, wheat and oats. Much tobacco is also grown in this soil, and garden truck. These bottoms resemble closely those of Switzerland County and will be dealt with then more fully. In the vicinity of Rising Sun the terraces of glacial times are conspicuous. Traces of these appear near Lawrenceburg, but they are too small to be of importance until near Rising Sun. The city itself is built on the first terrace above the bottoms—a terrace averaging perhaps 30 feet above the river in June. Back of this yet another terrace can be traced in remnants of gravel and sand. There can be no question of the glacial origin of these terraces, for practically all of the pebbles are of rocks foreign to this region—granite, diorite, slate, sandstone, etc. They mark a time when the river was much higher and more heavily burdened than it is now. These terraces are extensively developed in Switzerland County and will be treated there.

Farming Methods.

Agriculture is difficult in such a country as that of Dearborn and Ohio counties in the rough portions. The soil when freshly cleared is usually fertile enough, but incessant care is required to keep it from washing away. In many places this can only be prevented by growing such crops as require little plowing and loosening of the soil. These slopes have, in the past, been famous for their hay and their small grain, but hay is exhaustive to soil, and the best hay crops are things of the past in this area. Corn is not a good crop, for the looseness of soil necessary for that grain offers too great a chance for the washing of the earth into the valleys. The fact that these hillsides sooner or later become bare has led to a very destructive method of farming in some localities. A typical case is the following, which occurred in Ohio County. A woods was partly cleared and burnt over for a space of six acres. This was planted to tobacco for two successive years, and the receipts from the two crops were nearly sufficient to pay the original cost of the farm. The ground, however, was about exhausted for tobacco, and the owner sold the farm to another person for about two-thirds of what it cost him. He cleared about $700 from his two crops of tobacco. Then the second owner planted to corn, and obtained a good crop the first year, a poorer crop the second year, and not enough to pay the third year. The fourth year of his occupancy, and the sixth after clearing, this ground lay vacant, and by the middle of the summer following the hillside was practically bare rock. In the meantime, the second owner had cleared some five acres and the same process began anew on this tract. There is little wonder that the hill country in these counties is growing constantly poorer. The worst feature of the case is that there seems to be no remedy, unless the growing of alfalfa will improve matters. To some extent this valuable grass is grown in Switzerland County, where it seems to have a real value in holding the soil, and at the same time producing a crop with a market value. In the summer of 1907, however, alfalfa on these hillsides was apparently dying, and if it should turn out impossible to grow suc-



SOIL MAP OF DEARBORN & OHIO COUNTIES.
McL
Lu
WcL
Wg
N.Y. CENTRAL
B.&O. S.W.
OHIO RIVER
BURG
URORA
DILLSBORO
RISING SUN
LEGEND
WcL Waverley Clay Loam
Wg Waverley Gravel Loam.
Lu Limestone Upland
McL Miami Clay Loam

cessfully here, the case will be desperate. Unless some remedy is found, it is only a question of time until these farms will have to be abandoned. Residents are free enough in saying that their farms are losing in value year by year. Perhaps the intensive farming methods of Switzerland and mountainous Germany, with their terracing and stone walls, might be of service here; but such methods are not to be expected in a country of cheap lands.

In the river bottoms, where the soil is, or was, the equal of any in the country, a near-sighted policy of farming very nearly ruined much of the soil. Corn was profitable in this easily tilled soil, and much of it was practically tilled to death in corn. Only when much of it was practically exhausted did the farmers awake to a necessity of fertilization. Now one sees a reasonable rotation of clover with the more exhausting crops, and in course of time these bottoms can be brought to their ancient fertility.

Transportation facilities are poor for a great part of these two counties, hauls of eight to ten miles to market being not uncommon. Ten miles through these hills are equal to fifteen miles in smoother country. For this reason and for the further reason that such crops need little stirring of the soil, it has been suggested that an attempt be made to grow fruit extensively in this region. Even with the little care now given to fruit trees, exceptionally fine peaches and apples grow here; and it is possible that the fruit crop will one day be the salvation of these hillsides.

Mechanical Analysis of Soils of Dearborn and Ohio Counties.

Table No. 1. Limestone Upland.

	1mm+ Gravel.	.16mm+ Sand.	.08mm+ Very fine sand.	.04mm+ Silt.	.0017mm+ Clay.
Soil	8.2%	16.6%	10.7%	34.1%	30.3%
Subsoil	10.1%	18.3%	12.2%	30.3%	29.3%

Table No. 2. Waverley Clay Loam.

	1mm+ Gravel.	.16mm+ Sand.	.08mm+ Very fine sand.	.04mm+ Silt.	.0017mm+ Clay.
Soil	.4%	6.6%	9.2%	59.2%	25.1%
Subsoil	.5%	7.7%	9.0%	54.7%	27.9%

Table No. 3. Waverley Gravel Loam.

	1mm+ Gravel.	.16mm+ Sand.	.08mm+ Very fine sand.	.04mm+ Silt.	.0017mm+ Clay.
Soil	8.6%	12.9%	16.6%	36.6%	25.1%
Subsoil	9.1%	13.1%	18.4%	34.2%	26.1%

Chemical Analysis of Waverley Sandy Loam. Occurrence—Bottom Lands of Laughery Creek in Ripley, Ohio and Dearborn Counties.

Moisture at 105° C.	2.63
Total soil nitrogen	.160
Reaction of soil to litmus	Acid
Volatile and organic matter	5.940
Insoluble in Hcl (1.115 sp. gr.)	85.270
Soluble silica	.071
Ferric oxide (Fe_2O_3)	3.047
Alumina (Al_2O_3)	3.253
Phosphoric acid anhyd. (P_2O_5)	.275
Calcium oxide (CaO)	1.162
Magnesium oxide (MgO)	.437
Sulphuric acid anhyd. (SO_3)	.050
Potassium oxide (K_2O)	.321
Sodium oxide (Na_2O)	.171
Total	99.997

Chemical Analysis of the Upland Soils of Northern Dearborn County—A Mixture of Miami Clay and Decayed Shales.

Moisture at 105° C.	4.73
Total soil nitrogen	.116
Reaction of soil to litmus	Very faintly acid
Volatile and organic matter	4.353
Insoluble in Hcl (1.115 sp. gr.)	78.695
Soluble silica	.076
Ferric oxide (Fe_2O_3)	5.370
Alumina (Al_2O_3)	8.588
Phosphoric acid anhyd. (P_2O_5)	.210
Calcium oxide (CaO)	.764
Magnesium oxide (MgO)	.859
Sulphuric acid anhyd. (SO_3)	.036
Potassium oxide (K_2O)	.726
Sodium oxide (Na_2O)	.252
Total	99.929

SWITZERLAND COUNTY.

This little county is in the extreme southeast corner of the State, having the Ohio River for its eastern and southern boundaries. It has a maximum length of 23 miles and a breadth of 18 miles, with an approximate area of 210 square miles. In climate it is little different from the other counties of this district.

Geology and Physiography.

In geology this county is exactly like its northern neighbors, Ohio and Dearborn. Along the Ohio and in the lowest portions of the creek beds, the outcropping rock is the Utica shale. In 8-10 of the county the rock exposed is the Lorraine limestone. In the northwest corner of the county the Hudson River group caps the highest land in the county, with a small outlier of Niagara limestone at the extreme summit.

There are no large streams in Switzerland County, but the proximity of the Ohio River gives to these minor streams a tremendous fall and cutting power. They have therefore excavated deep gorges through the soft rocks—gorges which, near the debouching of the streams onto the river plain, are often 350 feet in depth, and too steep walled in many places even for trees to stick. Along the river these little streams come down from the hills at intervals of two to five miles, and the deep notches which they have sawn into the escarpment are very striking. The closeness of these streams, and the depth of their valleys, result in a region of great roughness, with little level land. In this county there is a small body of comparatively level ground near Allensville and East Enterprise, and a smaller body of similar surface in the northwest corner. Along the Ohio there are some level bottom lands, and a little valley floor along the lower courses of some of the smaller streams. All the remainder of the county is hilly, varying from merely strongly rolling to mountainous.

The Soils in Detail.

There is not a great deal of difference between the soils of this county and those of Jefferson on the west, or Ohio on the north. In the north central portion there is an irregular oval of level land, perhaps three miles across, which is Miami clay loam, so often described before. It is somewhat startling to see, in this upland fringed about with great hills, a marsh vegetation; and yet the Miami clay here, as elsewhere, retains its moisture-bearing characters. In comparison with the limestone upland soils surrounding it, this soil is poor, and is commonly spoken of as "thin." It raises grass, wheat or rye, but not much corn. At the edges this soil grades imperceptibly into the Limestone Upland, a soil which has been described in detail in Dearborn and Ohio counties. It bears exactly the same characters here as in those counties. It is everywhere a fertile soil where it can be persuaded to stay on the hillside. Along some of the streams this soil is retained as a little bottom, and is of exceptional fertility. This is the great tobacco soil of these counties, and is said to have no superior for that crop anywhere in the United States. The principal other crops which it produces are corn, grass and anything that grows in this latitude. Of late, an effort has been made to grow alfalfa upon these hillsides. It has done fairly well, and may in time be a profitable crop here.

The principal discussion of Switzerland County soils will be of the bottom soils or river terraces, because, in the first place, this soil is more extensively developed in this county than elsewhere in the district, and is also the most valuable soil in the county. This county is geographically well situated for the development of flood plains of the meander type. Two excellent meanders are developed on the eastern side of the county, and a less noticeable one on the southwestern border. There is more or less flood plain along the entire course of the river in this county except at Patriot and Florence, where the sweep of the river is almost under the hills. In the bends, however, above and below Patriot, there are excellent developments of alluvium, in the region famous in old days from one end of the Ohio to the other as the "Egypt bottoms." On examination it is readily seen that the bottom ground consists really of two terraces. The first, or lower terrace, in July of 1907 was scarcely more than 10 feet above the river level. It is composed entirely of fine, silty material, which is a slippery, clayey mud when wet. It is dark brown in color when damp, contains no pebbles or gravel particles, and little sand. It is evidently recent river deposit, and is being added to at every flood. Spring after spring this bottom is overflowed, scarcely ever missing a four-weeks' submergence. If this flooding occurs in February or early March, the soil may dry sufficiently to get a crop of corn planted, and if the river continues favorable a great crop will be gathered. Some years, however, the river stays high until too late for corn, and then the soil becomes a rank waste of horseweeds. In eight years out of ten, however, this bottom raises corn, and is accounted among the most desirable land in this part of the State. The second terrace, or "Egypt bottoms" proper, is somewhat higher than the first bottom, sloping gradually or abruptly back from the latter toward the back hills. This terrace is the "bottom" of the river when it was larger than now, probably in glacial times. At any rate, much of this terrace contains glacial pebbles. In structure this terrace differs from the lower one in having a gravel subsoil, and considerable sand in the surface. It is not flat, but rolling, and in some places pretty badly cut up by creeks. It is overflowed only in the higher floods, averaging perhaps twice in five years. This has been sufficient to yield a layer of silt from two to ten inches deep over the surface. This is an excellent farming soil, which can not be excelled anywhere in the State. It has been marked, too, by excellent farmers, who have loved their soil enough to keep it getting better year after year. There is no better looking farm country anywhere. The crops here are an indication of the care of the farms. After almost a hundred years of cultivation this ground raises as good crops now as ever, which of course a well-farmed soil ought.

Mechanical Analysis of Switzerland County Soils.

Table No. 1. Limestone Upland.

	1mm+ Gravel.	.16mm+ Sand.	.08mm+ Very fine sand.	.04mm+ Silt.	.0017mm+ Clay.
Soil	7.9%	14.4%	12.6%	36.3%	28.3%
Subsoil	10.6%	17.6%	13.3%	32.4%	25.8%

Table No. 2. Waverley Silt Loam (First Bottom).

	1mm+ Gravel.	.16mm+ Sand.	.08mm+ Very fine sand.	.04mm+ Silt.	.0017mm+ Clay.
Soil	.3%	7.1%	12.4%	61.3%	19.0%
Subsoil	.5%	7.7%	11.8%	58.8%	21.3%

Table No. 3. Waverley Sandy Loam (Second Bottom).

	1mm+ Gravel.	.16mm+ Sand.	.08mm+ Very fine sand.	.04mm+ Silt.	.0017mm+ Clay.
Soil	6.3%	21.4%	18.8%	30.3%	33.4%
Subsoil	8.6%	25.4%	22.2%	26.2%	17.9%

Chemical Analysis of Waverley Loam. Occurrence—Bottom Lands of the Ohio River in the Counties of Switzerland, Ohio, Dearborn and Jefferson.

Moisture at 105° C	2.20
Total soil nitrogen	.280
Reaction of soil to litmus	Acid
Volatile and organic matter	6.428
Insoluble in Hcl (1.115 sp. gr.)	80.029
Soluble silica	.044
Ferric oxide (Fe_2O_3)	5.290
Alumina (Al_2O_3)	5.536
Phosphoric acid anhyd (P_2O_5)	.220
Calcium oxide (CaO)	1.444
Magnesium oxide (MgO)	.932

Sulphuric acid anhyd (SO_3)	.056
Potassium oxide (K_2O)	.148
Sodium oxide (Na_2O)	.132
Total	100.26

Chemical Analysis of Limestone Upland Soil of Dearborn, Switzerland, Ohio and Jefferson Counties—The Tobacco Soil of Southeast Indiana.

Moisture at 105° C.	3.74
Total soil nitrogen	.183
Reaction of soil to litmus	Very faintly acid
Volatile and organic matter	6.342
Insoluble in Hcl (1.115 sp. gr.)	74.985
Soluble silica	.075
Ferric oxide (Fe_2O_3)	6.508
Alumina (Al_2O_3)	7.195
Phosphoric acid (anhyd) (P_2O_5)	.571
Calcium oxide (CaO)	1.300
Magnesium oxde (MgO)	1.380
Sulphuric acid anhyd (SO_3)	.039
Potassium oxide (K_2O)	.855
Sodium oxide (Na_2O)	.644
Total	99.914

DECATUR COUNTY.

Location and Size.

This county is likewise in the southeastern part of the State, one county removed from the Ohio boundary, and two removed from the Ohio River. Its greatest length is 21 miles, greatest breadth the same. Its area is approximately 375 square miles.

Geology and Physiography.

Geologically, there is very little difference between this county and Jennings. In the deepest stream beds in the southern part of the county the soft limestones of the Hudson River formation appear. These outcrops are small and of no practicable importance, since they contribute nothing to the soils and are in themselves of no value. The southeastern third of this county is underlain by the Niagara limestone, perhaps the most valuable stone in the State, after the Oolitic. In Decatur County it lies as a rule close to the surface, usually at depths of 4 to 12 feet on the level, outcropping on stream banks, and occasionally being found only at depths of 30 feet. It is a very valuable rock commercially in this county, being quarried extensively at Newpoint, Westpoint, St. Paul and in many small local quarries. The product is used for building stone, especially for trimming, for abutments, for flagging in sidewalks, and in a crushed state for macadam and for concrete construction. From the standpoint of soils, it is of importance chiefly from the fact of its resistance to weathering, which has resulted in very flat uplands. The northwestern half of the county is underlain at depths of 5 to 40 feet by the Corniferous limestone, a softer rock as a rule than the Niagara. Finally, the entire surface of the county, except near the streams, is covered with a mantle of glacial waste, which effectively covers the underlying rocks over practically all the county.

The topography of the county is a product of two great factors —the Niagara limestone and the arrangement of the drift. The latter is disposed in belts of one to five miles in width crossing the county from southwest to northeast. In the northwest corner there occurs a till-plain where the surface is nearly level, rolling in gentle waves and only a little broken by streams. Then comes a belt about 4 miles in width of upland—a glacial moraine. This is followed by another till-plain, from 6 to 10 miles in width, gently rolling, with occasional knolls and swales, somewhat cut by streams. This is followed by a second ridge averaging five miles in width, with the remaining southeastern corner occupied by a flat plain of loess. Under the last feature lies the Niagara limestone, at an average depth of 7 feet. The streams are comparatively of little importance in this county as agents in bringing about the present surface, since this surface would be practically the same if the streams had not come into being. Their courses have been largely determined by the belts of drift.

The Soils in Detail.

In describing the soils of this county, one can do no better than take them in their order from one side of the county to the other. At the outset, it is evident that one factor which has been of the first importance heretofore will have little to do with the soils here, namely, the character of the underlying rock. It is probable that not an acre of tillable soil in this county has resulted from the disintegration of the underlying rock, but has, on the contrary, been carried here through the agency of the ice from some region to the north. We shall begin our discussion of the soils in this county with a soil which we have described several times before, the Miami Clay Loam.

This soil occurs in a small area in the extreme southeastern corner of the county. It is part of the great area of this soil which occurs in Ripley County. It is there described as a yellow clay, sometimes almost white where it is dry, with mottles of darker yellow in its deeper portions. This soil is underlain with blue till, and in most places grades into that form of glacial waste imperceptibly. It consists almost entirely of clay, with a small admixture (usually less than 5 per cent) of sand. There are practically no gravel pebbles in it. It is a pretty good material for tile and brickmaking, and has been used considerably for that in the past. From the farming standpoint it is poor. Grasses do fairly well, and wheat. Fertilizing must be constantly done, and, away from the streams, tiling.

THE MIAMI SILT LOAM.

This soil is mapped as occupying almost one-third the area of the county. It forms a belt in the southeastern part of the county, almost the full width of the territory on the south, and narrowing to about five miles on the north. It must be understood that this soil is not uniform throughout its occurrence. An average sample would show about 60 per cent clay, 20 per cent silt, 15-18 per cent fine sand, and some little gravel in spots. As one approaches the Miami clay loam, however, this composition changes until the sand is reduced to 5 per cent or less, and the clay correspondingly larger in amount. It was impossible to use any hard and fast rule in separating these areas, but the presence or absence of gravel pebbles gives about the line as mapped. Going to the northwest, as one approaches the ridge, this soil becomes sandier on account of the outwash from the moraine, and is to be distinguished from the Miami Sandy Loam because the latter has no clay subsoil, while the Silt Loam has.

The Miami Silt Loam is a yellow to brown soil with a subsoil usually darker in color, and much streaked and mottled with iron oxide. A few concretions of bog iron ore occur in this soil, and a good many glacial pebbles. Rarely bowlders are found, sometimes of large size. The subsoil grows heavier and more tenacious as one digs deeper, and at four to eight feet is a very stiff clay. It is not, however, blue till; and this character serves to distinguish the Miami Silt Loam from the Miami Clay Loam. The farming value of this soil varies considerably with reference to the place of observation. Down near the Miami clay this soil is very much like its neighbor—poor, ill-drained and not valued very highly. It is flat and swampy by nature, due to the closeness to the surface of the Niagara. Tiling must be resorted to constantly; and the soil is so poor that often a field will not repay the expense of drainage. Practically the only good crops are grasses, and sometimes wheat, if fertilizer enough be used. As one approaches the ridge, however, the increasing percentage of sand results in a looser soil, permitting much of the rainfall to soak into the soil; tiling helps here, also. Then the Niagara is here somewhat deeper, and the surface therefore more rolling. In this sandier region corn can be grown with success, as well as wheat and grass. Some of the best farms in Decatur County are in this region, close to the foot of the ridge. They owe their superior fertility solely to the outwash from this ridge, for at distances of two to four miles out from it corn makes only half a crop. It is said that one can tell within five rows where one soil begins and the other ends.

Upland Clay Loam.

A belt some four miles in width succeeds the Miami Silt Loam, which has been called here the Upland Clay Loam. It has been so called for two reasons. First, much of it is really upland, standing visibly higher than the till plains on either side. Secondly, the knolls appear to be principally clay, and very often are entirely of that material. It must not be understood that this belt is a continuous ridge, extending as a well-marked divide from one corner of the county to the other. It is, on the contrary, a belt of hill and hollow. It is made up of a great number, possibly five hundred, low rounded knolls with swales or sags between. The knolls average, perhaps, 30 feet higher than the plains, and the swales are probably about at the plain level. The soil of the typical knoll is yellow in color at the surface, grading into a darker yellow at depths of two to four feet. It is made up principally of clay, with a good deal (about 10 per cent) of fine sand in its composition. Besides these it contains here and there small pockets of gravel, and often at depths of 16 to 30 feet a gravel base; and huge boulders are often found in these gravel bases. In the swales, the soil is sandy, with little clay in evidence. It is black or brown in color, due to the presence of much humus.

Usually at depths of 6 to 10 feet sheets of clay are found, which dip upward in every direction, forming a little saucer-shaped depression, in the middle of which lies the lowland. Many of these little hollows were undoubtedly in a former age lakes. Some of them are still marshy, and practically all require tiling. The soil here is remarkably fertile, ranking with any in the State. It is great corn soil, and is rarely planted to anything else, unless it be clover. The knolls, on the other hand, are better for wheat and grass. A farm in this belt is a joy forever, with its capacity for varied crops, with its excellent drainage, and the abundance of pure water which can be had by driving wells into the gravel at the base of the hills. Very little fertilizer is used here aside from the barnyard products and clover. There are many fine farms in this belt, and some fine cattle.

MIAMI SAND LOAM.

This soil occupies a belt averaging five miles in width lying west of the ridge soil. It is, as the name implies, a "light-colored glacial soil." It is, however, light-colored only on the knolls and knobs which occur plentifully in its surface, interrupted by extensive lower grounds. It is a typical till-plain, uninfluenced by anything except glacial action. In general, it would be called level, varying throughout the county probably less than 50 feet between its highest and lowest points. Yet there is not a flat farm in the area, and not many single fields so flat that cultivation is difficult. A good deal of tile is used in the lower grounds, and is said to yield a high income on the investment. The knolls, which make up perhaps 10 per cent of the total area, are far less fertile than the lowlands. They contain considerable sand, and give up their water content easily, either by evaporation into the air or by conduction into the nearby lowlands. In a dry summer, even of average dryness, they therefore usually yield far less than the swales. They make up so little of the total surface, however, that one forgets their shortcomings on account of the superior excellence of the lowlands. These areas, which often are 200 acres in extent, are the banner corn soils of Decatur County. They are carefully farmed also, being put in clover every fourth or fifth year. Oats are good here also, and, somewhat uncommonly, wheat yields well enough to be a very important crop, especially on farms where the knoll land is much in evidence. Occasionally throughout this area occur drumlins, whose graceful swells have tempted every farmer owning one to build his house upon it. Some of the famous farms of this county have as no little part of their claim to honor the beautiful situation of the homestead on one of these hills, commanding a view of every field of the estate. A particularly large and beautiful one of these drumlins can be seen from the cars of the Big Four Railway and the interurban about one-half mile east of Adams.

The remainder of the soils in this county belong to one or the other of the soils already described. In the extreme northwest corner is a little triangle of Miami Sandy Loam, and just east of this there is a small belt of Upland Clay Loam. Along the larger streams there occur little strips of bottom ground (mapped as Waverley), which differ little from the surrounding slopes, and are of such little extent as to need no extended description. These bottoms are usually not more than one-fourth mile in width, and are composed of material washed from the neighboring uplands. As a rule they are pretty wet and require tiling, but when drained they are valuable little fields.

There are few counties in the State which are any better farmed than Decatur, especially on the sandier portions. In the southeast corner the heavy clay soil limits farming practically to the grasses and small grain, but in at least eight-tenths of the county any crop suitable to the latitude can be grown successfully. On the typical corn lands corn yields as well, year by year, as anywhere in the State, and the same farm which yields a "bumper" corn crop may, the same year, yield a good wheat crop on the more clayey knolls. Grasses thrive in the wet bottom grounds, and good water is easily obtained. All conditions are favorable to stock raising, and much of the corn of this county goes to market as fat hogs and cattle. Such a method, of course, can not be otherwise than good farming, since practically everything is returned to the soil, and in Decatur County most of the farm lands are continually increasing in value. The excellence of transportation has a great deal to do with farm values here. There is scarcely a farm in the county farther than six miles from a railway, and the vast majority are within three miles. An excellent system of macadamized and gravelled roads connects almost every community with the railway.

Mechanical Analysis of Decatur County Soils.

Table No. 1. Miami Clay Loam.

	1mm+ Gravel.	.16mm+ Sand.	.08mm+ Very fine sand.	.04mm+ Silt.	.0017mm+ Clay.
Soil	0.7%	11.8%	6.3%	61.3%	20.2%
Subsoil	.6%	16.3%	8.8%	56.6%	17.6%

Table No. 2. Miami Sandy Loam.

	1mm+ Gravel.	.16mm+ Sand.	.08mm+ Very fine sand.	.04mm+ Silt.	.0017mm+ Clay.
Soil	4.6%	18.3%	18.8%	32.5%	26.1%
Subsoil	5.8%	19.8%	16.6%	33.8%	24.2%

A Soil Survey of Clark, Floyd and Harrison Counties.

By Robert W. Ellis.

DESCRIPTION OF THE AREA.

The territory under consideration in this report embraces the counties of Clark, Floyd and Harrison. These counties all border on the Ohio River. They are bounded on the north by the counties of Jefferson, Scott and Washington. Washington County also forms the western boundary of Clark County, while Crawford County lies west of Harrison. The area comprises about 1,000 square miles, being approximately 50 miles in length and 20 in breadth, lying with its greater extension in a northeast-southwest direction. The Ohio River courses along its southeastern boundary, a distance of 30 miles above the Falls and 55 miles below the Falls, and its central portion is nearly opposite Louisville, Ky. A brief statement of facts concerning the surface features, the settlement, the industrial facilities, etc., is given for each county, as follows:

Clark County.—The population of Clark County in 1900 was about 32,000, being an average of 85 people to the square mile. The population is largely white, but a considerable percentage of colored population exists in the larger towns. The county embraces most of the tract known as "Clark's Grant," this being the portion of land assigned to Capt. George Rogers Clark in recognition of his services against the British in the Revolutionary War.*

The first settlements were made in 1787, and the settlers came from Pennsylvania, from Virginia, from North Carolina, from Maryland and from New York. Development was slow till after the Civil War, when its progress became very rapid.

*Clark's Grant comprises an area about 15 miles square and it is laid off in 500-acre tracts numbered successively from 1 to 298. The lines of these tracts do not run in north-south and east-west directions but approximately parallel or at right angles to the Ohio river a few miles above the Falls. One line runs about north 30° west, the other, north 60° east. Most of the roads follow the directions of these lines, but some of them follow irregular courses between towns, without reference to section lines or points of the compass.

Jeffersonville, the county seat, has a population of 11,000, and is situated on the Ohio River in the extreme southern portion of the county. It is a prosperous manufacturing town and railroad center. The State Industrial and Reform School for Boys is located here. The city is closely connected with Louisville, Ky., and New Albany by river, railroad and electric lines. Three railroad lines and one interurban system traverse the county and furnish ready means of communication with the county seat, and its river traffic is large.

Charlestown and Sellersburg are next in size, each having a population of about 1,000. They are easily accessible by railroad and electric lines. Charlestown was formerly the county seat, while Sellersburg is the center of extensive cement manufactories.

Shipment of produce is done mostly by rail, but to some parts the Ohio River furnishes an ample and more convenient means of shipment. The principal ports aside from Jeffersonville are Bethlehem and Utica. Many small "landings," also, are points where much freight is taken aboard the steamers. The country roads in many places have been macadamized, and these furnish good communication between towns, giving the farmer easy access to market. While the county has, in the past, been a little backward in extending its "free gravel roads," there is awaking a more general interest in the matter. The antiquated toll system of pikes has been done away with altogether in this county.

Many northern farmers, seeing the opportunities for future development of the country, are coming in, and these add new life and wealth to the county.

The surface of the county presents a variety of types. The eastern and larger portion is moderately level but slopes in general toward Silver Creek. This surface is cut by many small valleys leading either to Silver Creek Valley or the Ohio River Valley. There are extensive areas, uncut by drainage systems, which present a surface about as level as a floor, upon which rainwater will stand for many days—until it is evaporated or is slowly absorbed by the almost impervious soil. The main topographic features of the area are resultant from the nature and position of the underlying geological formations. These formations, from the Niagara of the Silurian to the Knobstone shales of the Carboniferous, are not folded but have a gentle westward dip, the massive limestone beds of the Niagara forming the high escarpment along the eastern edge of the county, while the channel of Silver Creek lies at the foot of a somewhat similar escarpment of the Knobstone formation in the western part. The stream valleys, where they cut a limestone formation, are narrow and deep, but where the streams traverse a formation of softer material—as the New Albany black shale—the valleys widen out. Such a variation of conditions occurs along the course of Silver Creek. Streams emerging from the southeastern border approach the Ohio Valley between limestone walls 200 to 300 feet high.

As viewed from the Knobstone hills at the west, the surface of the county to the east appears quite level and nearly forest-covered. The area covered with trees is, however, comparatively small, being probably not more than 10 per cent. This timber, the remnants of the once universal forest in this region, comprises, mainly, beech and oak, with some poplar, some gum and some sugar maple. As a rule, the maple occurs on the limestone slopes; the beech on the flat, wet areas; the oak, sometimes interspersed with the beech, on the more broken areas. The Knobstone hills are nearly covered with timber, the lower slopes with oak and hickory, the higher parts with chestnut, oak and jack pine.

The region known as the "Knobs" embraces most of the county west of Silver Creek. It is a region formed from the dissection of the soft shales of the Knobstone group, whose firm upper layers have resisted erosion and so have tended to preserve the original height of the surface while it was being deeply trenched by weathering processes. The surface is almost wholly broken, and many portions exist as outlying knobs. The western arm of the county includes the valley of Muddy Fork, with the accompanying broken country lying adjacent.

Floyd County.—The Knobstone range of hills continuing south extends through the central part of Floyd County, giving that county as a whole a rather hilly surface. Floyd County occupies a position between Clark and Harrison counties. It is bordered for 10 miles on the southeast by the Ohio River, and it touches Washington County at the north. Being a small county with a large town within its borders, its population per square mile is over 200.

The county was settled about 1800. A few scattering settlers had come in before that time. Among the pioneers who took an active part in the early development of the county were David Lewis, Leonard Leach, Joseph Smith, Howell Wells, Louis Mann, John Barnett, Martin Very, Israel Moore, John Baumann, August Genung and Jacob Korb. These settlers occupied lands in the vicinity of New Albany. The county at that time was an almost unbroken forest, consisting of oak, beech, hickory, chestnut, walnut, ash, poplar, gum and sugar maple.

The largest city and the county seat is New Albany. It has a population of 21,000, and extends two miles along the Ohio River. It is situated mainly on the upper terrace of the river, some 60 feet above ordinary low water, but a portion of the business section is on a second terrace 15 or 20 feet lower, lying along the river front. High water in the Ohio sometimes floods the lower part of town, but does not extend to the upper terrace. The city has a fine court house and government building. It has also a creditable city library and many commodious churches. Steel works and other important industries make this one of the most important commercial cities in the southern part of the State. The city is connected with Louisville, Kentucky, by several lines of railroad and an electric line. The Southern, the Chicago, Indianapolis & Louisville, the Baltimore & Ohio Southwestern, and the Pennsylvania Lines give ample facilities for freight and passenger traffic, in addition to which is electric road connection with Indianapolis. The river traffic is very large. New Albany is one of the leading markets of the region for a farming and truck-raising area 20 miles in radius.

Georgetown, on the Southern Railway, and Greenville, on the Paoli pike, are two of the larger inland towns of the county, each with a population of about 350.

Practically the whole county is hilly. To the east of the main divide the surface descends rather abruptly to the level of the Ohio River bottom. Most of the streams are short and are dry much of the time. The western slope is more gentle and the headwaters of Indian Creek have broad valleys. The stream channels are frequently shallow and have rock or gravel beds, which are often traveled as roads. The larger of these streams are seldom without water, which, when not in flood, flows clear and fresh over pebbly bottoms or percolates slowly through beds of sand. While the valleys are broad the amount of bottom land along the streams is limited, since the gradient of the streams is steep and the downward erosion is rapid. There is, however, a greater relative amount of alluvial deposits from the town of Crandall up stream than from there down stream. In the eastern part of the county there is a large area of comparatively low land lying between the Knobs and Silver Creek, from St. Joseph to New Albany. This was formerly base leveled, part of it being made up largely of the original shales.

but there also being extensive tracts of loess-like deposit. The general surface is that of a plain, partly trenched by young valleys, lying 100 feet or so above the Ohio River. The Ohio River, from New Albany south, has a bottom land averaging probably half a mile wide till in the vicinity of Bridgeport. This is low enough to be covered with water when the river is at its highest stage.

Owing to the irregularity of surface the roads do not closely follow the section lines. Floyd County roads are, however, well improved, many of them being graveled with the soft gravel that comes from the Knobstone formation. The Paoli-New Albany pike is here a toll road and is one of the chief channels of trade between New Albany and a wide territory untapped by any railroad.

Harrison County.—The early settlement of Harrison County, like that of Clark and Floyd, began about the first of the nineteenth century. Ephraim Fleshman came to Harrison County in 1807 and settled in Heth Township, on what is known as the John Frank land. John Ripperdan and wife, from Danville, Kentucky, settled in 1807, in the valley that has since borne his name. Daniel Boone's brother, Squire Boone, with his sons, in 1802 settled in "Grassy Valley," about six miles back from the Ohio River. John Hudson came from the Shenandoah Valley, Virginia, in 1798, and settled in Harrison County. There was at that time only one house on the site of New Albany. The county was organized in 1809, having been named after General William Henry Harrison, who had entered government land known as the Wilson Mills property, in 1806. General Harrison built a grist mill on Blue River in the southern part of Spencer Township, the foundation of which is still in use.

The population of Harrison County is about 22,000, being only 47 to the square mile. There are no large towns, but many villages. Corydon, the county seat, has a population of 1,700, and is the metropolis. Corydon has many features of historical interest, which can barely be mentioned. It received its name from General W. H. Harrison. The State government was constructed here and the original State house still stands, in the center of the town. Morgan's raid reached to Corydon, and the Battle of Corydon is one in the official list of battles of the Civil War. The town is a prosperous one in the center of the county, without saloons. Extensive canning factories are established here, and the Corydon wagon works have more than local renown. The town is provided with electric light and ice plants. It is the southern terminus of the Louisville, New Albany & Corydon Railway. This road provides an outlet for a large part of the county's produce. The Southern

Railway runs through the northern half of the county and gives a good market for farmers of that region, with Louisville, Kentucky, less than 30 miles away. The southern part of the county depends largely on river traffic. New Amsterdam, Mauckport, Evans' Landing, Rosewood and many other landings, make convenient points for shipping. The Paoli pike cuts the extreme northern end of the county and provides a good communication with New Albany by team.

The character of the population is unusually high. Harrison County is one of two in the State that in 1907 had no inmate in the State penitentiary. The strict enforcement of the county option law against saloons is suggestive of the prevailing sentiment of the people, as well as being conducive to the further betterment of the communities. A large part of the population is descendant from the early settlers, although in the towns the change has been greater.

The topography of the surface of the county embraces a number of types. The prevailing type is that of a moderately undulating plain cut by few streams, but pitted with sinkholes. This type embraces mainly the central portion, north and south. The peculiar character of the underlying formations has caused the drainage to be carried on underground, largely. The relation of this structure to surface features and to soils is discussed in another chapter.

The western part of the county, in addition to the sink-hole topography, is much roughened by isolated or somewhat connected elevations forming steep ridges and giving a picturesque aspect to the landscape.

The eastern portion lies near the outcropping edge of several geological formations, from the Knobstone to the Mitchell. The southern half of this section is a strip about three miles wide lying along the Ohio River bottom from Bridgeport to the southern part of Boone Township. It is deeply cut by valleys and embraces a very hilly country. The northern half of the eastern area is traversed by an elaborate system of surface drainage, comprising many of the headwaters of the two Indian Creeks.

Of the once widely extensive forest covering the county the principal remnants are along the streams and on the untillable slopes of the high ridges. Some good farm land is still devoted to timber, but the carriage and furniture factories are eagerly buying up all available tracts, which the unsuspecting farmer readily yields to the uncommonly good offers of the "cruisers," though those offers be only one-half of what the lumber company could easily afford to pay. But it is so much in advance of the old prices at which the farmer used to sell his timber that he thinks he is the one who is getting the bargain rather than is the buyer.

CLIMATE.

The temperature and rainfall of this region is shown in a general way by the following table. It should be noted, also, that the high per cent of humidity of the atmosphere renders the summer heat quite oppressive and the cold of the winter more biting than would be the case with corresponding temperatures in a more arid region. In spring the precipitation is frequently too great to permit a proper cultivation of crops. The winters are not so cold but that rains and muddy roads are as frequent as in any part of the year. The months of September and October are usually dry and delightful.

SUMMARY OF CLIMATIC CONDITIONS THAT PREVAIL IN OR NEAR THE COUNTIES OF CLARK, FLOYD AND HARRISON, INDIANA. RECORD FOR 21 YEARS.

STATIONS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
MEAN TEMPERATURE.													
Vevay, Ind.	32	34	43	56	66	74	77	75	69	57	45	36	55
Marengo, Ind.	33	35	44	56	65	74	77	75	69	57	45	36	56
Louisville, Ky.	35	37	45	56	67	75	79	77	70	59	46	38	57
HIGHEST TEMPERATURE FOR PERIOD.													
Vevay, Ind.	70	75	85	91	95	99	105	101	99	91	79	72	105
Marengo, Ind.	69	73	81	91	94	98	106	103	100	96	80	71	106
Louisville, Ky.	72	78	86	91	94	100	107	105	102	91	79	74	107
LOWEST TEMPERATURE FOR PERIOD.													
Vevay, Ind.	—23	—22	2	24	32	43	50	44	32	18	5	—5	—23
Marengo, Ind.	—18	—28	0	19	29	37	47	49	26	17	5	—19	—28
Louisville, Ky.	—20	—14	3	21	33	44	54	50	36	26	4	—7	—20
MEAN PRECIPITATION.													
Vevay, Ind.	3.9	4.1	3.8	3.6	4.5	4.8	3.5	3.3	3.0	2.0	3.7	2.9	43.1
Marengo, Ind.	4.9	6.5	5.3	5.4	5.2	5.4	4.0	4.2	4.0	3.1	5.4	4.2	57.6
Louisville, Ky.	3.9	3.9	4.3	4.0	3.8	4.3	3.8	3.5	2.7	2.6	4.0	3.7	44.5
AVERAGE NUMBER OF RAINY DAYS.													
Vevay, Ind.	9	9	11	9	10	9	7	7	6	5	8	7	97
Marengo, Ind.	9	9	10	8	10	9	7	7	6	6	8	8	97
Louisville, Ky.	13	11	13	12	12	12	10	8	8	8	10	11	128

SUMMARY OF CLIMATIC CONDITIONS—Continued.

AVERAGE DEPTH OF SNOW.

STATIONS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual.
Vevay, Ind.	7.5	6.1	4.0	3.8	0.1	0	0	0	T	T	1.1	4.1	26.7
Marengo, Ind.	5.3	5.6	4.6	0.3	T	0	0	0	0	T	0.8	3.4	20.0
Louisville, Ky.	3.7	4.5	3.2	0.2	T	0	0	0	0	T	0.4	2.4	14.4

T Indicates trace.

AGRICULTURE.

The farmer of the early days was satisfied with a small farm and small crops. When he first landed on the lonely banks of the Ohio River he was face to face with innumerable obstacles. The lurking Redman still prowled in the region. Lowland and upland alike were covered with a dense forest, almost unbroken by any prairie land. The soil, protected from the sun by the impenetrable shade. was cold and water-soaked—even covered by standing water in many places. Mosquitoes and malaria made life anything but pleasant at times. There were no roads, and when a trail had finally been cleared the springy, undrained land was almost impassable during a large part of the year. Markets were few and far-distant. Trade was done mainly with the few boats that plied up and down the Ohio River, but most of the household necessities were produced at home. Machinery and tools were scarce and primitive, yet the pioneer farmer had the most arduous task of the century to perform, and he labored well. By toilsome effort the trees were felled, the little log cabin, in all its primitive simplicity, was soon erected and the work of clearing the land went on. Giant oaks, poplars, maples and walnuts all fell a prey to the flames in order to give room for the encroaching grain fields. One who now rides through this same county can hardly realize what was the original condition of the present stretches of open country, dotted with farm houses and covered with crops of corn and wheat and oats.

Much of the early-day farming was done with ox teams. The principal crops were corn, oats, potatoes and hay. Grass was cut by scythes and was raked by hand rakes. Grain was threshed by flails or by being trodden out under the feet of horses. Corn was shocked and later in the season was husked on the barn floor. Plowing was done with a wooden moldboard plow, and grain was cut with a sickle or a cradle. Flour was made at a water mill, and these in time became quite numerous. At one time there were 42 mills on the creeks of Harrison County alone. Money was scarce and resort was had to barter in most of the commercial transactions. Stock was unimproved and received little care. Hogs ran wild and fed on grass, roots and mast from the beech and oak. It was customary to mark the ears of the hogs to prevent them being killed by anyone as wild game. These marks were recorded at the county seat. Wild game was abundant. Turkeys, pigeons, deer and bear were common, and hunting was a profession.

Careful cultivation of the soil did not receive much attention at first. The soil was naturally very productive just after the timber had been taken off, and with the added benefit of the ashes from the burned logs. But in time careless methods began to reduce the fertility and to allow the soil to wash away. Commercial fertilizers were not used and the barnyard manure available was not sufficient for all the land. Now the depleted condition of the soil is being improved upon by many means, such as rotation of crops, rest, clovering and commercial fertilizers. Grain was sown broadcast and corn was dropped by hand. Crops grown under such primitive methods were small and inferior, compared with those grown by modern methods. About the close of the Civil War mowing machines, reapers, horse rakes, better plows and many kinds of labor-saving machinery began to come into use, and farming interests developed rapidly. Gardening and fruit-raising received a good deal of attention and became sources of wealth in many places.

Education has kept pace with other elements of civilization in the region. The first school houses were rudely built of logs, the equipment being simple and meagre, while the teachers were poorly prepared and poorly paid. The school term lasted only two or three months of the year and the chances for an education were small. At present the educational facilities of these counties are unexcelled in the State; yet, sad to state, they are not always taken advantage of to the fullest extent. Good country schools are maintained six or seven months of the year, while many of the towns have high schools, which places a high school education within the grasp of every ambitious youth.

The average-sized farm in Clark County is about 100 acres; in Floyd, about 60 acres, and in Harrison, about 85 acres. A large per cent of the farms of the area are operated by their owners. In Harrison County the average is 90 per cent. The price for ordinary farm labor is 75 cents a day, with board, but in the summer season help is frequently scarce and larger wages are offered. The tendency is for the young men to migrate to the cities for work, they preferring a little lower wage and the companionship of society, to good wages with isolation on the farm. The price of farm land in Harrison County is generally about $30 an acre. The larger farms are on the bottom lands of the Ohio River. There, also, the larger proportion of renters exist.

The area contains much land of little fertility, and this unproductiveness is shown in the appearance of the dwellings and farm buildings thereon. Other parts are naturally fertile, and this condition is expressed in commodious and well-built houses and barns. In nearly every part the use of commercial fertilizer is considered necessary. On the fertile valleys fertilizers are little used. Once in a while a farmer is found who has discarded their use altogether, he having been convinced that by proper tillage and rotation of crops the productivity of his land is relatively greater than is that of his neighbors who use fertilizers. A great variety of brands of fertilizer are used and some attention is given to the selection of that kind that experience has shown to be best adapted to a given soil. Some of the more common are brands made by the Bash Packing Company, the Chicago Fertilizer Company, the Cincinnati Phosphate Company, the Globe Fertilizer Company, the National Fertilizer Company, and the Northwestern Fertilizing Company. From 200 pounds to 300 pounds per acre are used and the cost of fertilizer varies from $18 to $25 per ton. This is said to increase the productivity of land sometimes to the extent of 15 bushels of wheat per acre. "The better the land the more gain in the use of fertilizers," is the experience of many. Others feel that the purchase of fertilizers barely pays—that the increase in yield is hardly commensurate with the great outlay for fertilizers.

The value of clover as a fertilizer is generally recognized. Some farmers assert that it is equal to the ordinary benefit derived from commercial fertilizers. And clover is thus used to some extent, but not so extensively as it would be were it not for the fact that it is extremely difficult to secure a stand on much of the land. It is held by some that the use of commercial fertilizers has impaired the land for the growth of clover—that before these fertilizers were used it was not difficult to secure a stand of clover. It has been observed that the parts of a field most difficult to seed down are places where the soil is in need of drainage. It is probable that as tile drainage comes more into use that less difficulty will be had in seeding land to clover. Of late years it has been difficult to obtain clover seed free from foul seeds. One of the worst enemies of this kind is a variety of plantain. This plant has a seed much like the clover seed in size and weight, thus being not easily separated by machinery. The plantain spreads rapidly and crowds out the clover as it goes. Notwithstanding the difficulties attending the raising of clover, it seems reasonable to suppose that by some means or another clovering must supersede the use of commercial fertilizers to a great extent as a permanent means of soil enrichment. It is the farmer's own means and is a less expensive method. It is depending more on natural resources and not so much on the manipulation of the manufacturer or of middle man. The farmer should seek relief from the oppressive drain upon his profits by the substitution of intelligent and attentive practice of "clovering" and rotation of crops for the customary dependence upon commercial fertilizers exclusively.

Wheat is the leading crop of the area. The yield in recent years is a third greater than in former times, on the same land. This is due to better tillage, to the conservation of the fertility of the soil, to the prevention of waste by erosion of the surface and to the use of fertilizers and "clovering." The wheat is put in in the fall. The land is first plowed, as early in the fall as possible. It is then well cut up with the disc, is rolled and harrowed in turn. The seed is then drilled in, the fertilizer being run into the ground with the wheat. The wheat is harvested usually from June 15 to July 1, and there is seldom a failure of crop. The yield varies from 15 to 30 bushels per acre, according to the land and the season. Some years ago wheat was generally stacked before threshing; now the common way is to thresh from the shock. The liability of prolonged wet spells makes this method rather precarious, however. Some farmers store the grain in barns till threshing time, and the straw is usually carefully taken care of. A very good quality of wheat is raised here. The principal varieties are the Pool, the Fultz, the Harvest King, and the Silver Chaff. The Kentucky Wonder is a rather new variety, that has been found to be very productive.

Corn is the next staple product. The average yield per acre is about 35 bushels. As high as 75 or 80 bushels per acre is common on the rich bottom lands of the Ohio. Next to the Ohio bottom lands the best corn land is the loamy creek bottoms or the rolling "limestone" land. Corn is planted in drills or is "checked." The fertilizer is applied in the row with the corn drills, at the rate of 150 pounds to 250 pounds to the acre. Cultivation is continued until the corn is in tassel and is done largely by single-horse cultivators with several small shovels. The use of much fertilizer on corn land has been found to work disastrously in a season when a moderately wet spring has been followed suddenly by drouth. The roots of the corn in this case would be clustered around the base of the stalk and near the surface. On the other hand, in fields in which no fertilizer had been used in seeding, the corn would send its roots deeper into the earth at once or extend them farther into the surrounding soil, thus affording better resistance to drouth. One of the worst weeds to contend with in the corn field is what is known as horse sorrel. It is practically impossible to kill it out. As good a way as any to keep it in check is by careful cultivation. One spring crop, such as potatoes, followed by late corn, well cultivated, seems to be as good a way as can be found to manage it. The larger part of the corn crop is cut for fodder, though when left shocked in the field it is frequently injured by the fall rains. Many farmers use the shredder and run the fodder into their barns.

The average yield per acre of oats is about 30 bushels. The acreage is generally not so large as that of corn or wheat. The grain is usually threshed from the shock and the straw is fed or baled and sold. In the city market it will bring $10 a ton.

Potatoes are a profitable crop in many parts of the area, a yield of 140 bushels to the acre being about the average. There are two times of the year when potato planting is done. The early crop is planted in the spring and is dug early in the summer. At about the first of August the late crop is planted, following millet or some other early-harvested crop. The late crop will easily mature before frost and is a better crop than the one planted in the spring. The acreage of potatoes is not usually large, many farmers having less than one acre. The care of the crop after planting is often simplified by using a heavy mulch on the newly-planted field, thus at the same time preventing growth of weeds and conserving the moisture of the soil.

One of the most profitable crops is the tomato. It is especially valuable, since it produces well on land that is not well suited to grain production. The foot hills of the Knobs and other hilly tracts are notable areas where this is true. This vegetable, with proper planting and proper care, will produce 300 bushels per acre, and the price ranges from 25 cents to 50 cents a bushel at the canning factory. In the region where tomatoes are largely grown, nearly every railroad station has a canning factory, the output of which is mainly tomatoes.

The hay crop is important. Timothy and clover do well when once started. Timothy yields from one to one and a half tons to the acre, and always brings a good price in the market—$18 to $25 a ton. The favorite crop for meadow and pasture is orchard grass. Clark County is especially noted as being a good place for this forage crop. The grass grows in tufts or clumps and to about three feet in height. It is vigorous and prolific and gives a good pasturage after the hay crop is removed. It is not easily affected by dry weather nor does it winter-kill. The seed brings a good price and the yield is 7 to 15 bushels of seed per acre. Alfalfa is beginning to be raised to some extent and it has been found to produce well and to be well suited to the soils and climate. It is raised mainly on the Ohio bottom lands and will yield three crops a year, with one and a half to two tons per acre at each cutting. With the more general introduction of this crop the dairying interests in the region will no doubt be enlarged. Millet is raised to some extent as a hay crop. It will yield two to three tons to the acre.

Tobacco is raised to a limited extent in Clark County. It is quite frequently the main crop among the hills overlooking the Ohio River. It is also raised on the Ohio bottom land. The best quality comes from the hillside land. In many places in the vicinity of Bethlehem the hillsides, too steep for a horse to work on, are covered with little patches of tobacco, and the crop when gathered is pulled down the hill on sleds. The tobacco plant is started in a bed early in spring and these beds are covered with cheese cloth to prevent injury from frost or from insects. When two to three inches high the young plant is transferred to the field, being set out in rows about three feet apart. The tobacco grown on the rich bottom lands is heavier and of good color, but inferior in quality to that grown on the limestone hills.

In Clark County, notably in the vicinity of Bethlehem. a very profitable business is the raising of sunflowers. The seed is sold to buyers in Madison and elsewhere. The use to which such great quantities of sunflower seed are put is a mystery to the producer, but it is thought to be used in the manufacture of oil. Buyers are very reticent about telling what the seed is used for. The crop is planted and tended much after the manner of corn culture. The soil of the Ohio Valley is especially adapted to this crop.

Besides the regular farm crops, an immense amount of garden truck is produced for the local markets of Louisville, New Albany and Jeffersonville. Butter-making is not prominent, but eggs and poultry are very abundant. Large stock raisers are not numerous, although every farmer has a small herd of cattle and of hogs, and this industry seems to be increasing. Many farmers keep a few sheep.

Much fruit is produced throughout the area. Apples do well on the soil of the Knobstone shale. Peaches are grown on almost every soil type. Pears, mainly of the Keifer variety, are most abundant along the taller slope of the limestone hills bordering the Ohio River. Blackberries grow wild in great abundance along every road or patch of timber land, and native blue berries are still found on the Knobs. Some of these are shipped to Indianapolis markets.

For the western part of Clark County and the northern part of Floyd, berry-raising has lately come to be the leading industry. The wealth being thus derived from this hitherto rather unprofitable soil of the Knobstone hills is simply marvelous. Farmers who once barely eked out an existence on their little, unprofitable farms, now reap a harvest of $1,000 to $1,500 a year from their berry crop. Strawberries and raspberries were shipped from one station —Borden—in 1907, at the rate of four or five carloads a day for the season of about four weeks. One firm alone cashed checks in the amount of $123,000, all of which was from the sale of berries.

In some parts of Clark County the land is so nearly level and the subsoil is so impervious that crops are frequently drowned out. Tiling has been employed to some extent and with good results. It is probable that much of the lack of fertility attributed to portions of the land is due to insufficient drainage. Much of the heavy, wet land is in need of something to give coarseness and friability to the soil. It lacks humus. It would seem that with the use of much barnyard manure and the turning under of clover these heavy soils might be made far more productive than they are at present. It would seem that the use of the roller and the excessive pulverizing of the surface for winter wheat would better be omitted in the case of soils that thus easily become packed. A comparatively rough surface would hold the snow over the crop in winter and would facilitate evaporation in the spring. But the enterprising farmer is trying every feasible way to accomplish the best results. Care, attention and experiment will tell, and the farmer who does not keep abreast of the times in knowledge of improved methods will go to the wall. The agricultural schools should see a large attendance of young men and the "short courses" for farmers, during winter, should be attended by men from every township. Local meetings for the discussion of immediate and important farm problems should command the support and interest of every farmer in the neighborhood. Where interest in improvement fails, that farmer is liable to be supplanted by others, who will buy his farm at a moderate figure and build up one of the most productive estates in the county. It is being done now. Farmers must have more faith in the ultimate worth of their own lands. It will not do for anyone to drop out of the game and idly bemoan the "worthlessness" of the land. He must be looking for the redemption of the good name of his property, not so much by the fulfilment of some ancient Indian legend of hidden mineral wealth therein, as by the application of hard, intelligent labor, coupled with the latest knowledge of scientific farming. Probably the legendary silver cave of the old "tunnel mill" will never be found, but a wealth none the less valuable remains to be drawn from the surface, which hitherto has been only partially realized.

SOILS.

As the variety and the distribution of soil types depend on the geological structure and certain geological processes, these types can best be understood by a consideration of the latter. By reference to the geological map of Indiana it will be seen that the uppermost rocks of this region are, successively from east to west, those of the Silurian, the Devonian and the Mississippian (Lower Carb.) periods. It should also be understood that each formation of rocks extends underneath the formation next to it on the west, so that a deep well in western Harrison County might, at a depth, reach the same formation that comes to the surface in eastern Clark County. These ancient rock beds consist of limestones, shales and sandstones. Besides being a determining agency in the process of topography formation, they are, in whole or in part, the source of the local soils. Through long ages since their formation as beds of sediment in the sea bottom, subsequently upheaved, they have been subject to the erosive and the disintegrating agencies of weather. These modifying agencies have left at the surface a layer of residual material varying in depth and in the relative proportions of the original rock elements. In the case of limestones the residual part is generally less than five per cent of the original rock. That is, 100 feet depth of limestone after being acted upon by the weather, would leave only five feet of residual matter. In the case of disintegrated sandstones and shales, the residual matter comprises probably 95 to 100 per cent of the original rock. Not all of the disintegrated material has remained in position, but some has been removed by running water and has been redeposited in stream valleys or has been carried out of the region and deposited farther away. In parts of the area the soils are of the general class just mentioned as having originated from disintegrated rock without having been modified by running water. These naturally accord with the nature of the rock over which they lie and vary as the successive geological formations vary. In such regions the soil overlying the same formation does not show much variation from one part of the area to another. This class of soils lies generally in the western part of the area, notably in Harrison and Floyd counties and the western part of Clark County. In other portions of the area the soils are made up of material that has been brought to its present position by moving waters or is the worked-over surface soil that existed in those localities previous to the glacial epoch. Much of the remaining area of Clark County is covered with this kind of soil. It is a loess-like mantle covering the upper level portions of country and reaching well up over the foot hills of the Knobs. It is more fully described in this report under "Description of Individual Soil Types." Underlying this mantle in the northeastern part of Clark County lie discontinuous patches of unsorted drift—remnants of ancient terminal moraines that formerly marked the extent of the ice sheet in this locality. This drift is frequently exposed in the bottom of deep ravines or on hillsides, while large isolated bowlders are sometimes found at the surface of loess-covered areas, as if dropped from floating ice moving off from the glacial front. The approximate limit of the ice sheet, as judged from the occurrence of bowlders, is shown on the soil map. It is thus clear that the underlying rocks of this region have less to do in determining the character of the soils that lie above them then is the case in Floyd and Harrison counties, which are unglaciated.

DESCRIPTION OF INDIVIDUAL SOIL TYPES.

The soils may be divided into two groups, according to their origin: (1) Residual, those resulting from the disintegration of rock beds of the same locality; and (2) transported, those that have been formed from material deposited from water or that has been modified by moving water. The first of these includes the upland soils of Harrison and Floyd counties and part of the upland of Clark County. The second comprises most of the soils of Clark County and the bottom lands of Harrison and Floyd counties. Many local variations occur, and a single farm may contain half a dozen distinct grades. It is impracticable to note these local phases, and only the more general types are described in this report.

Miami Silt Loam.

The Miami silt loam is generally a light gray color at the surface, grading at a depth of six inches or a foot into a yellowish buff color. It usually contains some fine sand and often fine quartz gravel. It rarely contains gravel of local origin, other than iron oxid gravel. This occurs in considerable amount in the subsoil and gives a rusty spot on a fresh surface of the lighter colored loam in which it is imbedded. This soil is usually compact, the sand element in it being too small in amount to assist very materially in giving porosity to the mass. The surface soil is quite uniform in appearance, but the subsoil varies more or less in color from a light buff to a brownish yellow. There is also considerable variation in the amount of iron concretionary gravel that the subsoil contains. The soil is moderately plastic, growing more so with depth. It is easily settled by the rain into a heavy, closely-compacted surface that does not readily loosen up to the plow. This soil, being a deposit from glacial waters, probably was once quite continuous over hill and valley, but erosion has removed much from the hill slopes, leaving the greater depth on the level areas more remote from streams. It has a depth of 15 to 20 feet and its lower portion frequently grades at that depth into coarse gravel. In some places it overlies glacial drift, while in other places there seems to be no glacial till between the silt and the surface of the rock below. This soil is of unmistakable glacial origin, having probably been laid down as a fluvio-lacustrine deposit in front of the receding ice sheet. When first tilled after the timber has been removed, the upper three or four inchs contains considerable vegetable matter and usually has a darker color.

The land was originally heavily forested with beech, oak, poplar, gum, etc. The timber growth has retarded erosion on the level areas remote from the preglacial valleys, and those level tracts are easily flooded with water in a rainy time. The impermeability of the subsoil and the underlying rock bed prevent proper drainage below, and the water is thus retained on the surface until evaporation has had time to assist in its removal. These level undrained tracts are locally called "white slash," and are notoriously poor land until they are drained. Since the timber has been removed and the land has been brought under cultivation the moisture is more readily evaporated. But tile drainage is necessary to put them in condition to realize the full possibilities of their fertility. Some tile draining has been done and the amount is increasing, as it is found to be a paying investment. The humus content is small and if this could be increased it would no doubt produce marked results in crop production. Tillage of the slash land is attended with some difficulties on account of the heavy nature of the soil and the superabundance of moisture during the spring and early summer. Farmers are tempted to work the land when it is too wet and with the consequence that the soil on drying out is lumpy and unsuitable for plant growth. Many farmers, profiting by their experience in this matter, are very careful not to till the land before it is dried sufficiently. The results are easily seen in the growth of the crop. While there is some difference of opinion as to the proper depth for plowing, the prevailing sentiment seems to be in favor of deep plowing. Some of the most successful in producing large crops plow their land about eight inches deep. Deep plowing not only aids in retaining moisture during a dry spell, but facilitates the drying up of the excess of moisture after a rain.

The boundaries of this soil—the Miami silt loam—are not very closely marked, as it grades easily into other types. The principal difficulty in determining the boundaries of the type is at its contact with the De Kalb silt loam.

The principal crop of the Miami silt loam is wheat. Wheat is said to do better on the "white slash" than on "limestone" land. The yield is 15 to 20 bushels per acre. Commercial fertilizers are used extensively. The average yield of corn is about 33 bushels per acre; of oats, is 25 bushels per acre. Hay is a good crop, yielding, of timothy, about one and a half tons per acre. Potatoes yield about 70 bushels per acre, and rye about 10 bushels per acre. These last are not raised to any great extent. Tomatoes are raised extensively on this soil.

The following tables give the results of mechanical and chemical analyses of this soil:

MECHANICAL ANALYSES OF MIAMI SILT LOAM.

Number.	LOCALITY.	DESCRIPTION.	Color (dry).	Friability.	Nature of coarse gravel.	Coarse gravel, larger than 2 mm., per cent.	Gravel, 2 to 1 mm., per cent.	Coarse sand, 1 to 0.5 mm., per cent.	Medium sand, 0.5 to 0.25 mm., per cent.	Fine sand, 0.25 to 0.1 mm., per cent.	Very fine sand, silt and clay, 0.1 to 0.0001 mm., per cent.
1	Half mile east of Nabb	Silt loam, 0 to 6 inches	Gray buff	Medium	Chert	3.8	.8	5.6	9.6	10.4	67.4
2	Half mile east of Nabb	Silt loam, 6 to 18 inches	Buff	Medium	Chert and iron conc.	8.2	2.2	5.4	8.6	9.5	62.4
3	Half mile east of Nabb	Silt loam, 18 to 36 inches	Light buff	Medium	Iron conc.	17.4	.8	8	5.9	10.2	52.6
7	N. E. cor. N. W. ¼ N. E. ¼ Sec. 24 T. 2 N., R. 8 E.	Silt loam, 0 to 12 inches	Gray brown	Easy	Iron conc.	1	.8	9.3	12.8	19.2	51.4
8	N. E. cor. N. W. ¼ N. E. ¼ Sec. 24 T. 2 N., R. 8 E.	Sandy silt loam, 12 to 24 inches	Pink buff	Medium	Chert	1.2	1	6.2	20.6	27	45
9	N. E. cor. N. W. ¼ N. E. ¼ Sec. 24 T. 2 N., R. 8 E.	Silt and sand loam, 24 to 36 inches	Light buff	Easy	Chert and iron conc.	4.2	1.2	6.6	16.6	22	47.2
10	N. E. cor. Sec. 22 T. 2 N., R. 9 E.	Silt loam, 0 to 18 inches	Light gray	Medium	Iron conc.	1.8	2.6	5.2	11.4	21	55.2
11	N. E. cor. Sec. 22 T. 2 N., R. 9 E.	Silt loam 18 to 36 inches	Light buff	Medium	Quartz and iron conc.	18.6	2.2	7	9.6	15.2	46
23	S. E. cor. Grant 247	Silt loam, 0 to 18 inches	Gray buff	Medium	Quartz, chert and iron conc.	2	.6	10.2	18.8	18.8	48.4
24	S. E. cor. Grant 247	Clayey silt loam, 18 to 36 inches	Light buff	Medium	Chert and iron conc.	2	.8	8.2	12.7	18.9	56.8
28	Watson, near interurban station	Silt loam, 0 to 6 inches	Light gray	Easy	Iron conc.	6.4	1.2	6.2	2.4	3	80.4
29	Watson, near interurban station	Compact silt loam, 6 to 18 inches	Light buff	Medium	Iron conc.	1	.6	3.4	.5	1.2	90.2
30	Watson, near interurban station	Clayey silt loam, tenacious, 18 to 36 inches	Mottled, blue-gray and yellow	Medium	Iron conc.	.2	.2	2.4	.7	4.2	89.2

Chemical Analysis of Miami Silt Loam.

Soil sample No.	23	24
Laboratory No.	17	16
Reaction to litmus	Neutral	Acid
Moisture at 105° C.	1.5	1.95
Total soil nitrogen	.099	.133

Analysis of Fine Earth Dried at 105° C.

Volatile and organic matter	2.628	2.170
Insoluble in HCl (1.115 sp. gr.)	92.902	90.835
Soluble silica	.074	.043
Ferric oxide (Fe_2O_3)	1.715	2.313
Alumina (Al_2O_3)	2.037	3.205
Phosphoric acid, anhydrid (P_2O_5)	.119	.177
Calcium oxide (CaO)	.266	.597
Magnesium oxide (MgO)	.267	.621
Sulphuric acid, anhydrid (SO_3)	.018	.024
Potassium oxide (K_2O)	.131	.226
Sodium oxide (Na_2O)	.111	.138
Total	100.268	100.349

New Washington Clay Loam.

This is a type of soil occurring mainly on hill slopes in central and eastern Clark County. It is commonly known there as "limestone" land, and is essentially the residual soil of the disintegrated limestone of the Jeffersonville and the Niagara formations. The surface soil is a light buff, grading downward into reddish yellow, then to a dark red. It frequently contains fragments of chert and has a considerable proportion of clay, the subsoil being very plastic. There are intermediary stages between this and the Miami silt loam, where the limestone residual seems to have been slightly worked over by the waters of the fore-glacial lake. The soil usually overlies limestone, which is at no great depth, often cropping out at the surface. The surface soil is a moderately loose loam, easily tilled and fertile. This is well known as being one of the most productive soils in the area. Originally timbered with sugar maple, walnut, etc., it now produces large crops of corn, wheat and vegetables. In fertility it resembles the Bedford limestone land of Harrison County.

The following tables give the results of mechanical and chemical analyses of this soil:

MECHANICAL ANALYSES OF NEW WASHINGTON CLAY LOAM.

Number.	LOCALITY.	DESCRIPTION.	Color (dry).	Friability.	Nature of coarse gravel.	Coarse gravel, larger than 2 mm., per cent.	Gravel, 2 to 1 mm., per cent.	Coarse sand, 1 to 0.5 mm., per cent.	Medium sand, 0.5 to 0.25 mm., per cent.	Fine sand, 0.25 to 0.1 mm., per cent.	Very fine sand, silt and clay, 0.1 to 0.0001 mm., per cent.
12	N. W. ¼ Sec. 28 T. 2 N., R. 9 E.	Loose loam, 0 to 6 inches	Brown	Easy	Iron conc.	0	1	12.2	3.6	10.6	67.6
13	N. W. ¼ Sec. 28 T. 2 N., R. 9 E.	Silty clay loam, 6 to 18 inches	Reddish brown	Difficult	Iron conc.	1.4	6.4	30.7	22.7	14.5	24
14	N. W. ¼ Sec. 28 T. 2 N., R. 9 E.	Silty clay loam, 18 to 36 inches	Dark reddish brown	Medium	Iron conc.	2.8	4.6	20.2	7.4	10	52

Chemical Analyses of New Washington Clay Loam.

Soil sample No.	12	13–14
Laboratory No.	18	20
Reaction to litmus	Neutral	Acid
Moisture at 105° C...............	2.87	4.08
Total soil nitrogen	.108	.085

Analysis of Fine Earth Dried at 105° C.

Volatile and organic matter.......	4.002	3.501
Insoluble in Hcl (1.115 sp. gr.)....	85.808	83.445
Soluble silica	.085	.096
Ferric oxid (Fe_2O_3)..............	3.488	4.359
Alumina (Al_2O_3)	5.350	7.214
Phosphoric acid, anhydrid (P_2O_5)..	.176	.244
Calcium oxid (CaO)	.229	.190
Magnesium oxid (MgO)	.592	.627
Sulphuric acid anhydrid (SO_3)....	.032	.033
Potassium oxid (K_2O)	.371	.346
Sodium oxid (Na_2O)	.120	.148
Total	100.233	100.203

Dekalb Silt Loam.

The soil that forms this type is partly a residuum and partly a deposit from glacial waters. It covers mainly what may be called the foot hills of the Knobs, but it also overlies certain areas of the New Albany black shale. In either case it contains much of the material of the underlying rock. The color is generally a light buff near the surface, grading into yellowish or bluish gray below. It occurs generally on the upper part of the undulating surface lying along Silver Creek and its branches. It is, as a whole, the least productive of all the soils of Clark County.

The most productive crop is that of tomatoes, which, accordingly, are extensively raised here. The yield may be as great as 300 bushels per acre. Wheat yields 15 to 20 bushels per acre; corn, 20 to 30; oats, 20 to 25; potatoes, 150. Melons also do well here.

The soil is a stiff clay, except about six inches on top, which is moderately loose. Where the soil is closely underlain with New Albany black shale (slate) there is a marked difference in the productivity between wet and dry seasons. When wet seasons prevail the "slate" land is at its best, but in dry seasons such land is not able to retain enough moisture for productive growth of crops. Then it is that the land underlain by the comparatively barren, but more porous, Knobstone shale, exceeds the slate land in crops. The Dekalb silt loam is very susceptible to poor treatment, and if plowed when it is wet it becomes hard and cloddy.

The following table gives the results of mechanical analyses of this soil:

MECHANICAL ANALYSES OF DEKALB SILT LOAM.

Number.	LOCALITY.	DESCRIPTION.	Color (dry).	Friability.	Nature of coarse gravel.	Coarse gravel, larger than 2 mm., per cent.	Gravel, 2 to 1 mm., per cent.	Coarse sand, 1 to 0.5 mm., per cent.	Medium sand, 0.5 to 0.25 mm., per cent.	Fine sand, 0.25 to 0.1 mm., per cent.	Very fine sand, silt and clay, 0.1 to 0.0001 mm., per cent.
31	Near the road, about on the line between Grants 204 and 187.........	Granular loam, 0 to 12 inches.......	Gray-brown............	Easy..........	Iron conc..............	2.2	1.2	.9	1.8	3	86.5
32	Near the road, about on the line between Grants 204 and 187.........	Tenacious clay loam, 12 to 24 inches.	Light brown...........	Medium........	Iron conc and shale......	1.6	3	9.2	3.2	8	71.2
33	Near the road, about on the line between Grants 204 and 187.........	Tenacious clay loam, 24 to 36 inches.	Brown.................	Medium.......	Shale...................	7.2	8.3	8.8	2.9	3.2	65.8
58	S. E. part of Grant 44.............	Loose silt loam, 0 to 12 inches......	Buff..................	Easy..........	Quartz.................	.4	2	2.6	3.2	3	85
59	S. E part of Grant 44.............	Granular clay, 12 to 24 inches.......	Buff to gray mottled.....	Difficult........	Quartz.................	.4	1.4	1.6	9.2	11	72.6
60	S. E. part of Grant 44.............	Tenacious clay, 24 to 36 inches......	Gray..................	Very difficult....	Iron conc and black shale.	5.6	1.8	6	2.8	6	74.2
61	Near west side of Grant 106 near the road..........................	Loose loam, 0 to 12 inches..........	Buff..................	Difficult........	Iron conc and Knobstone shale.................	5.6	2.2	1.8	7	8	75.7
62	Near west side of Grant 106 near the road..........................	Tenacious clay, 12 to 24 inches......	Yellow................	Difficult........	Iron conc..............	.4	1.4	6.4	9	15	65
63	Near west side of Grant 106 near the road..........................	Clay, 24 to 36 inches...............	Yellowish buff..........	Difficult........	Iron conc, chert and Knobstone shale.......	41.8	2.8	3.4	4	10.8	37.8

KNOBSTONE SANDY LOAM.

The Knobstone type embraces the soils of the Knobstone formation as it occurs in a prominent system of hills formed by the eastern outcrop of the formation in western Clark County and in Floyd County. It is mainly the residuum of the upper members of this formation and its sand content is derived from the uppermost beds. It usually appears in a buff color as surface soil, with a subsoil brownish yellow. It is comparatively fertile, considered with the soil occurring on the foot hills of these Knobs. Owing to the very broken surface that it occupies, there is much of the tract that is too steep for cultivation. Excellent wheat can be raised on top of the Knobs. The main crop is tomatoes. All kinds of fruit do well here. Apples and peaches are especially suited to this soil and this situation. When other parts of the country fail, here can be found a fair crop, while in good seasons the production is greater than the farmer can handle. Berries of all kinds are naturally adapted to conditions found on these hills. While some attention is already given to fruit raising, the acreage is continually increasing. The price of land here now is not commensurate with the wealth-producing capacity of the soil. The farmer here is gradually learning to divert his efforts from general farming to fruit-raising. The chief drawback seems to be the rather inaccessibility of the region, owing to the altitude, poor roads, and the comparative remoteness from market of some portions. To see what is now being done in the fruit business here is an eye-opener to the future possibilities in that line. A farm of 15 acres can be bought for $400, and which in two years after clearing of timber will have yielded a net income of $500 a year.

The following table gives the results of mechanical analyses of this soil:

MECHANICAL ANALYSES OF KNOBSTONE SANDY LOAM.

Number.	LOCALITY.	DESCRIPTION.	Color (dry).	Friability.	Nature of coarse gravel.	Coarse gravel, larger than 2 mm., per cent.	Gravel, 2 to 1 mm., per cent.	Coarse sand, 1 to 0.5 mm., per cent.	Medium sand, 0.5 to 0.25 mm., per cent.	Fine sand, 0.25 to 0.1 mm., per cent.	Very fine sand, silt and clay, 0.1 to 0.0001 mm., per cent.
25	N. E¼ Sec. 3 T. 1 N. R. 6 E.	Loose sandy loam, 0 to 6 inches	Light gray	Easy	Sandstone and iron conc.	18.6	3	5.8	1.9	7.2	68.6
26	N. E. ¼ Sec. 3 T. 1 N., R. 6 E.	Sandy loam, 6 to 18 inches	Brownish yellow	Easy	Sandstone	56.8	2.8	10.8	8.8	3.4	15.6
27	N. E. ¼ Sec. 3 T. 1 N., R. 6 E.	Sandy loam, moderately tenacious, 18 to 30 inches	Grayish yellow	Medium	Sandstone	70.6	4.2	11	2.8	3.8	3.6

Yazoo Clay.

Probably the most fertile soil of any in the area occurs in the narrow strips of bottom lying along the Ohio River and that are usually annually covered by high water of the river. The prevailing color is a dark chocolate brown. It varies in texture from that made up largely of clay and silt to a variety containing considerable fine sand. Having been made up of sediment from the river floods the texture does not vary greatly with depth, while in plant growing properties the subsoil to a depth of 10 feet is as rich as the surface foot. This soil produces abundantly. Corn is the principal crop and this produces 50 to 80 bushels per acre. Alfalfa is beginning to be raised and it does well, as many as four crops per season being produced, with a yield of one to two tons to a crop. In the vicinity of Bethlehem large acreages of sunflowers are raised on this land, while tobacco is found to do remarkably well, although the quality is not so fine as when grown on limestone land. This soil needs no fertilizer, since it has naturally an abundance of the elements necessary for plant growth. This land is not subject to drouth, nor does its low-lying position materially affect the culture and growth of crops by being too wet. It is true that the liability to periodic overflow renders this less suitable for small grain, yet even on some of the higher portions 20 bushels of wheat per acre may be reasonably expected.

The farm buildings of this area have been situated on the highest parts of the bottom land, but in more recent years the dwellings are being moved to the edge of the hills, where all danger from floods is removed.

The results of mechanical and chemical analyses of this soil are shown in the following tables:

MECHANICAL ANALYSIS OF YAZOO CLAY.

Number.	LOCALITY.	DESCRIPTION.	Color (dry).	Friability.	Nature of coarse gravel.	Coarse gravel, larger than 2 mm., per cent.	Gravel, 2 to 1 mm., per cent.	Coarse sand, 1 to 0.5 mm., per cent.	Medium sand, 0.5 to 0.25 mm., per cent.	Fine sand, 0.25 to 0.1 mm., per cent.	Very fine sand, silt and clay, 0.1 to 0.0001 mm., per cent.
54a	S. E. part of Grant 5	Silty clay loam, 0 to 12 inches	Brown								
54	S. E. part of Grant 5	Silty clay loam, 12 to 36 inches	Dark brown	Difficult		0	0	0	.1	.8	97.4

Chemical Analysis of Yazoo Clay.

Soil sample No.	54a
Laboratory No.	19
Reaction to litmus	Neutral
Moisture at 105° C.	2.29
Total soil nitrogen	.092

Analysis of Fine Earth Dried at 105° C.

Volatile and organic matter	5.207
Insoluble in HCl (1.115 sp. gr.)	83.691
Soluble silica	.074
Ferric oxid (Fe_2O_3)	4.053
Alumina (Al_2O_3)	4.357
Phosphoric acid, anhydrid (P_2O_5)	.278
Calcium oxid (CaO)	.852
Magnesium oxid (MgO)	1.003
Sulphuric acid, anhydrid (SO_3)	.057
Potassium oxid (K_2O)	.491
Sodium oxid (Na_2O)	.206
Total	100.269

Jeffersonville Fine Sandy Loam.

The greater part of the Ohio River bottom land is seldom or never covered by high water. This higher portion exists as a high terrace skirting the upland, running far back up the creek valleys and bordering the low bottom (of the Yazoo clay) or, where that is wanting, in some instances coming close to the Ohio River. The soil varies much on this higher terrace. In some places it is mainly sand, and, before vegetation had ever become abundant upon it, was blown into low dunes and ridges, which now cause slight irregularities in the surface. Other parts show a quality and texture not much different from the Miami silt loam. It is a terrace that was probably built up by the river at the time when the melting glacial floods were spreading fine silt in a blanket-like deposit over the upland of eastern Clark County. As a rule the higher parts of this terrace are the most sandy. Such areas are found in the vicinity of Jeffersonville and of New Amsterdam. The various grades of soil occurring on this upper terrace are put together to form one general group, the boundaries of which generally coincide with the extent of the terrace. Also there can be no sharp distinction made between the limits of the river terrace and the corresponding terrace of the tributary streams, and the line of separation shown on the soil map is very arbitrary, the general quality of soil of the high river terrace and that of the high creek terrace, however, being after some miles quite distinct.

The crop-producing capacity of the soils of this area is quite variable, but on the whole it is inferior to that of the New Washington clay loam. The sandy areas north of New Amsterdam are best adapted to melons and berries. Much of the land just north and northwest of Jeffersonville comprises largely the light colored silt that on the upland grades into Miami silt loam. This part is slightly lower than the sandy portions that occur irregularly on the same terrace and the land is more nearly a "white slash." Much of this land in the vicinity of Jeffersonville is devoted to hay. The looser and sandier parts form good general farming land. Many fine estates are seen along the highway leading from Jeffersonville to Utica. Most of this wealth has probably been produced by the intensive farming of the not-unusually-fertile land of the high terrace. Corn yields from 35 to 40 bushels per acre. Potatoes are a good crop, and all kinds of fruit do well here, if proper care is taken of the soil.

The following table shows the results of mechanical analyses of this soil:

MECHANICAL ANALYSES OF JEFFERSONVILLE FINE SANDY LOAM.

Number.	LOCALITY.	DESCRIPTION.	Color (dry).	Friability.	Nature of coarse gravel.	Coarse gravel, larger than 2 mm., per cent.	Gravel, 2 to 1 mm., per cent.	Coarse sand, 1 to 0.5 mm., per cent.	Medium sand, 0.5 to 0.25 mm., per cent.	Fine sand, 0.25 to 0.1 mm., per cent.	Very fine sand, silt and clay, 0.1 to 0.0001 mm., per cent.
46	Just east of the interurban bridge over Silver creek, opposite Glenwood Park	Loose loam, 0 to 6 inches	Buff	Medium	Quartz and iron conc.	2.6	4.7	7.5	21.3	21.3	42.7
47	Just east of the interurban bridge over Silver creek, opposite Glenwood Park	Compact loam, 6 to 18 inches	Buff	Difficult	Iron conc.	1.2	6.8	16.6	3	6	64.8
48	Just east of the interurban bridge over Silver creek, opposite Glenwood Park	Tenacious clay	Brownish buff, mottled	Difficult	Iron conc.	.1	.2	2	.8	5	87.8
49	1½ miles N. W. of Jeffersonville, Grant 19	Sandy loam, 0 to 6 inches	Gray buff	Easy	Iron conc.	.4	.7	4.4	5	5.4	82.6
50	1½ miles N. W. of Jeffersonville, Grant 19	Clayey silt, 6 to 18 inches	Brown buff	Medium	Iron conc.	.4	.15	4.	4.6	5.2	81.6
51	1½ miles N. W. of Jeffersonville, Grant 19	Sandy clay, 18 to 36 inches	Brown buff	Difficult	Quartz	.2	.2	.9	4	7.4	85.6
52	About 1½ miles N. E. of Jeffersonville on "upper Utica" road, Grant 3	Sand, 0 to 12 inches	Dark brown	Very easy		0	0	.4	29	45.2	23.8
53	About 1½ miles N. E. of Jeffersonville on "upper Utica" road, Grant 3	Sand, 12 to 36 inches	Brown	Very easy		0	0	.1	38.8	47.6	14.2

MECHANICAL ANALYSES OF JEFFERSONVILLE FINE SANDY LOAM—Continued.

Number.	LOCALITY.	DESCRIPTION.	Color (dry).	Friability.	Nature of course gravel.	Coarse gravel, larger than 2 mm., per cent.	Gravel, 2 to 1 mm., per cent.	Coarse sand, 1 to 0.5 mm., per cent.	Medium sand, 0.5 to 0.25 mm., per cent.	Fine sand, 0.25 to 0.1 mm., per cent.	Very fine sand, silt and clay, 0.1 to 0.0001 mm., per cent.
55	Near Utica-Jeffersonville pike, in E. part of Grant 3	Silt loam, 0 to 12 inches	Gray buff	Easy	Quartz and limestone	5.2	.2	1.2	5.4	20	66.8
56	Near Utica-Jeffersonville pike, in E. part of Grant 3	Crumbly silt loam, 12 to 24 inches	Light brown	Medium	Quartz	1.1	.3	.6	2.4	23.6	70
57	Near Utica-Jeffersonville pike, in E part of Grant 3	Silt loam, 24 to 36 inches	Brown	Medium		0	.2	.2	2.4	25.4	70
86	North side of Sec. 7, T. 6 S., R. 5 E.	Silty loam, 0 to 18 inches	Buff	Easy	Iron conc	.4	1	5.8	3.6	7.4	79.6
87	North side of Sec. 7, T. 6 S., R. 5 E.	Tenacious silty clay, 18 to 40 inches	Reddish brown	Difficult		0	0	.2	6.8	17.2	75.8
95	S. side Frac. Sec. 2, T. 5 S., R. 2 E., just N. of New Amsterdam	Sandy loam, 0 to 6 inches	Gray	Easy	Chert	1	0	1	14.8	49.3	34.4
96	S. side Frac. Sec. 2, T. 5 S., R. 2 E., just N. of New Amsterdam	Sand, 6 to 40 inches	Brown	Easy		0	0	2.4	31	54.4	12.6

WAVERLY SILT LOAM.

This type occurs along the valleys of the streams within the area. In general it includes both the low, flood plain and a "second bottom" or terrace from three to ten feet above. As a rule the bottom lands of these streams consist of a series of terraces—two or three in number—each one being three to ten feet higher than the next lower one. In some places the distinction between the terraces can not be noticed. These terraces follow the natural order of formation that arises when an area is uplifted after having been trenched by a drainage system. The lower end of the stream valley is first cut below the former level, a new flood plain soon appearing there, while the upper reaches of the stream retain the same old flood plain for some time longer. Thus anyone in following along the flood plain of the headwaters of some stream will find himself almost imperceptibly elevated to a "second bottom," or terrace, by the time he has gone a few miles down the valley. This arrangement of terraces renders an exact delineation of their boundaries almost an impossibility. In this report no distinction is generally made between the high and the low creek bottoms.

There is considerable variety in the soils occurring as alluvial deposits along these valleys. As a rule the lower levels—the present flood plains—are the most fertile, but even these bottoms are frequently made up of material that is very poor in productivity. The quality of the alluvial deposits of small streams is largely affected by the nature of the geological formations composing the adjacent highlands. The low-bottom type varies in color from a grayish buff to a brownish buff at the surface, and the subsoil varies from a light buff to a dark brown. The texture varies from that in which there are considerable amounts of medium to fine sand to that having a content mainly of silt and clay. Fourteen-mile Creek and other small streams in the eastern part of Clark County have so little bottom land that it is scarcely worth mentioning.

Silver Creek and its tributaries have for the most part wide valleys. The low-bottom type here is generally a light buff colored clay loam. The upper bottom type here is lighter in color than the low-bottom type. In some places the low bottom is of the "white slash" order. The upper branches of Silver Creek have the most fertile bottom land of any part of that system. From Memphis to its mouth the main stream has little very fertile bottom. Along Muddy Fork, below Bridgeport, the bottom land also is poor, compared with that farther up the valley.

Indian Creek has a narrow valley from Crandall to its mouth, while the upper portions have considerable bottom land for so small streams—from 20 to 40 rods much of the way. The upper parts of the branches of Indian Creek and Buck Creek have rather wide sloping valleys.

The valley of Blue River is very narrow and crooked. Its meandering course was determined ages ago when the stream was flowing at a level some 200 feet above the present one. As the stream has sunk its way through the limestone walls of its present canyon-like valley, it has in some degree accentuated its meanders, but the downward cutting has always exceeded the lateral erosion. This type of valley is found with other streams of this area in certain portions of their courses, but in none other is it so emphatically displayed as in Blue River valley. There are narrow strips of low bottom lying within the bends of the stream. These are seldom over 40 rods wide in the widest part and usually do not extend farther than half a mile along the stream.

The soil of the bottom lands of Harrison County is generally a light loam, often somewhat sandy, having a grayish-brown color. It is fertile, as a rule, when so situated as to receive additional deposits of sediment from high water.

The principal crop of these alluvial soils is that of corn. Some of the best will produce as high as 80 bushels per acre, while 100 bushels per acre have been reported. Grass, also, is a paying crop. Other crops are raised to a greater or lesser degree, though usually other parts of the farm are devoted to crops that cannot so well be raised on the bottom land.

The following table shows the results of mechanical analyses of creek-bottom soils:

MECHANICAL ANALYSES OF WAVERLY SILT LOAM.

Number.	LOCALITY.	DESCRIPTION.	Color (dry).	Friability.	Nature of coarse gravel.	Coarse gravel, larger than 2 mm., per cent.	Gravel, 2 to 1 mm., per cent.	Coarse sand, 1 to 0.5 mm., per cent.	Medium sand, 0.5 to 0.25 mm., per cent.	Fine sand, 0.25 to 0.1 mm., per cent.	Very fine sand, silt and clay, 0.1 to 0.0001 mm., per cent.
4	14-mile creek, N. E. ¼ Sec. 23, T. 2 N., R. 8 E.	Sandy loam, 0 to 12 inches	Brown	Difficult	Chert	.6	.6	2.4	6.4	29	62
5	14-mile creek, N. E. ¼ Sec. 23, T. 2 N., R. 8 E.	Sandy clay, 12 to 36 inches	Dark brown	Difficult	Chert	1.4	.6	2	5.8	17.4	68
6	14-mile creek, N. E. ¼ Sec. 23, T. 2 N., R. 8 E.	Sandy clay, 36 to 60 inches	Gray-brown	Very difficult	Chert and iron conc.	3.	1.2	6.4	17.2	28	44
15	N. W. ¼ Sec. 25 T. 2 N., R. 8 E.	Silt loam, 0 to 18 inches	Brown buff	Medium	Limestone and iron conc.	0	3	4.6	6.6	20.8	65.6
16	N. W. ¼ Sec. 25 T. 2 N., R. 8 E.	Silt loam, 18 to 36 inches	Dark brown	Difficult	Chert and iron conc.	7.2	1	5.4	8.6	16	59.2
40	Middle of W. side of Grant 68	Silt loam, 0 to 12 inches	Gray-buff	Easy	Iron conc.	1.2	1.4	5	4.4	8.4	76.4
41	Middle of W. side of Grant 68	Compact silt loam, 12 to 24 inches	Buff	Medium	Iron conc.	1.2	1.2	19.8	4	6	63.6
42	Middle of W. side of Grant 68	Compact silt loam, 24 to 36 inches	Light buff	Medium	Iron conc.	18.4	2.2	7.2	3.4	6.6	60.6
88	S. E. Cor. Sec. 1 T. 6 S., R. 4 E.	Loose silt loam, 0 to 36 inches	Gray-buff	Medium		0	.2	1	2.3	13.4	78.3
89	½ mi. E. of Sharp's Mills, Sec. 13, T. 3 S., R. 2 E.	Loose sandy loam, 0 to 12 inches	Buff-gray	Easy	Chert	.2	.1	.1	.6	20	74
90	½ mi. E. of Sharp's Mills, Sec. 13, T. 3 S., R. 2 E.	Sandy loam, 12 to 36 inches	Buff	Medium		.1	0	0	1	14	80.4
101	S. W. ¼ Sec. 18, T. 4 S., R. 2 E.	Loose silt loam, 0 to 12 inches	Gray-buff	Medium		.1	.2	5.	1.8	7.6	83.3
102	S. W. ¼ Sec. 18, T. 4 S., R. 2 E.	Clayey silt loam, tenacious below 12 to 36 inches	Yellow-buff	Difficult	Chert	.2	.3	.9	2.4	10.6	81.6

MECHANICAL ANALYSES OF WAVERLY SILT LOAM—Continued.

Number.	LOCALITY.	DESCRIPTION.	Color (dry).	Friability.	Nature of coarse gravel.	Coarse gravel, larger than 2 mm., per cent.	Gravel, 2 to 1 mm., per cent.	Coarse sand, 1 to 0.5 mm., per cent.	Medium sand, 0.5 to 0.25 mm., per cent.	Fine sand, 0.25 to 0.1 mm., per cent.	Very fine sand, silt and clay, 0.1 to 0.0001 mm., per cent.
103	W. side Sec. 36, T. 3 S., R. 3 E......	Sandy loam, 0 to 12 inches..........	Gray-buff..............	Easy..........	....	0	0	.2	.2	6.6	91
104	W. side Sec. 36, T. 3 S., R. 3 E......	Sandy loam, 12 to 24 inches........	Light brown............	Medium........	....	0	0	0	.4	7.2	90.2
105	Sec. 25, T. 2 S., R. 4 E.............	Sandy loam, 0 to 12 inches.........	Buff-gray..............	Easy..........	....	0	0	.3	.5	2.5	92.4
106	Sec. 25, T. 2 S., R. 4 E.............	Sandy loam, 12 to 36 inches........	Brown-buff.............	Easy..........	....	0	0	.2	18	30	53.8
114	S. W. Cor. Sec. 9, T. 2 S., R. 5 E....	Loose silt loam, 0 to 18 inches......	Gray-buff..............	Easy..........	....	.1	.1	1	1	2	95
115	S. W. Cor. Sec. 9, T. 2 S., R. 5 E....	Silt loam, 18 to 36 inches..........	Gray-brown.............	Easy..........	....	.2	.2	.3	.1	.8	95.6
120	S. W. ¼ Sec. 18, T. 4 S., R. 5 E.....	Sandy loam, 0 to 12 inches.........	Brown-gray.............	Medium........	Chert..................	1.6	.1	1.4	2.2	8.4	84

Muck.

This is a dark-colored soil—almost black, its color forming a striking contrast with the usual buff-colored soils of the region. At a depth of three to four feet the color changes gradually to a yellowish gray. It is of very fine texture, being made up almost wholly of silt, clay and organic matter. When wet, the soil becomes very plastic and owing to this plasticity it is rather difficult of tillage. In such condition it compresses into large, heavy masses before the plow, and these, on drying, are like lumps of brick. In extreme drouth the surface hardens and cracks open to a foot or two in depth. This soil much resembles the "gumbo" of the Missouri River bottoms in western Iowa. A wagon driven over it when the surface is slightly wet, will have its wheels completely clogged by the adhesive mud. Cultivated fields in drying out become baked, with a coarsely granular covering on top. The best results are obtained when the land is plowed in the fall, thus allowing the frost to pulverize the surface and to prepare it for seed growth in the spring. This type occurs in only limited areas, and in Clark County alone is it noticeable to any great extent. The larger of these is found two and a half miles northwest of Jeffersonville, on the upper terrace. Other isolated patches occur in the northern part of the county, near Nabb. Its occurrence is usually on level or poorly drained tracts remote from streams. Its origin seems to have been from the slow accumulation from forests that originally covered the land, with the possible addition of sediment deposited from the still waters that may have frequently flooded the tract.

Notwithstanding the difficulty of culture under certain conditions, it is one of the most fertile soils. Corn, oats and timothy are the principal crops and no fertilizer is needed. Corn yields on an average 35 bushels per acre; oats, 35 bushels; timothy, one and a half to two tons per acre. With proper drainage and the addition of humus this soil could be made much more productive. The areas near Nabb, having a less depth of the soil and having been carefully farmed for many years, as well as being better drained, are less difficult of cultivation.

The following table gives the results of mechanical analyses of this soil:

MECHANICAL ANALYSES OF MUCK.

Number.	LOCALITY.	DESCRIPTION.	Color (dry).	Friability.	Nature of coarse gravel.	Coarse gravel, larger than 2 mm., per cent.	Gravel, 2 to 1 mm., per cent.	Coarse sand, 1 to 0.5 mm., per cent.	Medium sand, 0.5 to 0.25 mm., per cent.	Fine sand, 0.25 to 0.1 mm., per cent.	Very fine sand, silt and clay, 0.1 to 0.0001 mm., per cent.
21	Farm of Martin Mace, ½ mile S. E. of Nabb. Grant 249	Sandy loam 0 to 12 inches	Dark gray	Easy	Chert and iron conc	4.6	1	4.2	6.4	11.6	73.4
22	Farm of Martin Mace, ½ mile S. E. of Nabb. Grant 249	Tenacious sandy loam 12 to 30 inchs.	Light buff	Difficult	Iron, conc., chert	2	1.3	8	6.4	10.4	70.1
43	N. W. side of Grant 33	Loam 0 to 12 inches	Gray-black	Very difficult		0	0	.7	.7	.1	92.2
44	N. W. side of Grant 33	Clay 12 to 24 inches	Gray-black	Very difficult		0	0	.6	.3	.4	93
45	N. W. side of Grant 33	Clay 24 to 36 inches	Gray-buff	Very difficult		0	0	0	.1	.4	94.8

New Washington Sandy Clay Loam.

A limited and local variety of soil occurs on a low ridge running southeast from the vicinity of Nabb, almost parallel to, and near, the northeast line of Grants 249, 232, 215 and 198. This ridge is 30 or 40 feet above the country to the east or to the west. It resembles a terminal moraine, but its structure would suggest an esker formation. It is composed largely of sand, apparently stratified at some depth. In making wells on this ridge, sand is encountered to a depth of 30 or 40 feet, then gravel or sand to a depth of 57 feet. No shale or limestone has been struck in wells nearly 70 feet deep—a depth much below the level of the outcrop of New Albany black shale about half a mile to the west. On the southeast flank of this ridge a partial section could be obtained. The lower part of this exposure is about 10 rods from Fourteen-Mile Creek, Grant 198, and about 40 feet above it. The lower portion contains pebbles and bowlders of quartzite, granite, greenstone, limestone, etc., some of which are distinctly glacially polished and grooved. Above this bed of bowlders the material is more largely gravel and sand, somewhat arranged by water. The lower matrix is a drab-colored clay; the upper 12 feet of the section shows the effects of oxidation, it being of a yellowish color. Some bowlders occur over the surface of this ridge. A similiar arrangement of structure in this ridge was shown in making a well on top of the ridge about half a mile northwest of the outcrop just described.

Other similar deposits were noticed on Grants 248 to 231, about half a mile southeast of Marysville, and on the southeast quarter of Grant 90.

The soil is a dark red, sandy clay, very fertile, with the upper six inches of a grayish buff color. It resembles a limestone soil in color, but its origin, of course, is different from residual limestone soils. The drainage is accomplished by means of the gentle slope of the surface and by the underground filtration through the porous subsoil. In this respect it has the advantage over a limestone soil underlain by a comparatively impervious layer of rock.

The fertility of this tract is shown in the large growth of corn that it produces, excelling any other in the neighborhood, growing on Miami silt loam. This ridge is especially productive at its junction with the level land to the west, where the colluvial soil has gathered. The usual farm crops and many varieties of fruit are produced on this soil in abundance.

The following table shows the results of mechanical analyses of this soil:

MECHANICAL ANALYSES OF NEW WASHINGTON SANDY CLAY LOAM.

Number.	LOCALITY.	DESCRIPTION.	Color (dry).	Friability.	Nature of coarse gravel.	Coarse gravel, larger than 2 mm., per cent.	Gravel, 2 to 1 mm., per cent.	Coarse sand, 1 to 0.5 mm., per cent.	Medium sand, 0.5 to 0.25 mm., per cent.	Fine sand, 0.25 to 0.1 mm., per cent.	Very fine sand, silt and clay, 0.1 to 0.0001 mm., per cent.
17	Farm of C. F. Graves, S. E. side of Grant 215	Sandy loam, 0 to 12 inches	Red-brown	Easy		0	.1	2	6.6	10.5	75.4
18	Farm of C. F. Graves, S. E. side of Grant 215	Sandy loam, more compact than 17, 12 to 24 inches	Red-brown	Medium		0	.1	1.6	15.2	8.4	71.6
19	Farm of C. F. Graves, S. E. side of Grant 215	Compact sandy loam, 24 to 36 inches	Red-buff	Medium	Iron conc	1	2	26.2	18.1	20.2	31.4
20	Farm of C. F. Graves, S. E. side of Grant 215	Sandy clay, 36 to 60 inches	Red-brown	Medium	Iron conc and chert	0	1.6	19.2	21.8	25.5	31
37	S. E. ¼ Grant 90	Loose silt loam, 0 to 12 inches	Gray-brown	Medium	Chert	.2	.15	3.8	4	3.6	85.2
38	S. E. ¼ Grant 90	Clay silt loam, 12 to 24 inches	Yellow-brown	Medium	Quartz and iron conc	.1	.4	4.6	3.2	4.7	84.8
39	S. E. ¼ Grant 90	Tenacious sandy clay, 24 to 36 inch.	Red-brown	Medium	Iron conc	1.6	1.6	18.8	13.6	10.2	52.4
40	S. E. ¼ Grant 90	Gravelly loam, 36 to 48 inches	Dark red-brown	Medium	Iron conc and chert	22	8	16.6	15.4	9.2	27.4

Harrodsburg Clay Loam.

This type of residual limestone soil overlies the Harrodsburg formation. It is found capping the Knobstone ridges in the northern part of Floyd County and the adjacent parts of Clark County. It is a grayish, rather loose loam in the surface foot, while the subsoil is a yellowish tenacious clay, more compact than the surface layer. Both the surface and the subsoil contain some flint gravel.

It is a fair, general farming land, but berries and other fruit make the most paying crop. Corn yields about 25 bushels per acre; oats, about 20; wheat, about 15. Timothy yields one and a half tons per acre.

The following table shows the results of mechanical analyses of this soil:

MECHANICAL ANALYSES OF HARRODSBURG CLAY LOAM.

Number.	LOCALITY.	DESCRIPTION.	Color (dry).	Friability.	Nature of coarse gravel.	Coarse gravel, larger than 2 mm., per cent.	Gravel, 2 to 1 mm., per cent.	Coarse sand, 1 to 0.5 mm., per cent.	Medium sand, 0.5 to 0.25 mm., per cent.	Fine sand, 0.25 to 0.1 mm., per cent.	Very fine sand, silt and clay, 0.1 to 0.0001 mm., per cent.
34	½ mile N. of Co. line S. W. Cor. Sec. 16, T. 1 S., R. 5 E.	Loose loam 0 to 6 inches	Brown-yellow	Med.	Iron, conc. and chert	.3	.8	1.6	2.3	8.4	83.8
35	½ mile N. of Co. line S. W. Cor. Sec. 16, T. 1 S., R. 5, E.	Tenacious Clay, 6 to 18 inches	Yellow-brown	Med.	Iron, conc. and chert	10.4	1	3.2	2.4	31.2	49.7
36	½ mile N. of Co. line, S. W. Cor. Sec. 16 T. 1 S., R. 5 E.	Tenacious clay, 18 to 36 inches	Yellow-brown	Med.	Chert	2	.5	2.2	6.	43.8	44.2
64	S.E. ¼ of S.W. ¼ Sec. 24, T. 1 S., R. 5 E.	Loose loam, 0 to 12 inches	Brown-gray	Med.	Chert	1.6	.6	7.6	2.4	3.2	83.2
65	S.E. ¼ of S.W. ¼ Sec. 24, T. 1 S., R. 5 E.	Tenacious clay, 12 to 36 inches	Red-buff	Med.	Chert	1.7	2.4	7.8	3.3	6	79.6

Bedford Clay Loam.

One of the best limestone soils in the area is found overlying the outcrops of the Bedford limestone, being residual from that formation. It occurs mostly in Floyd County. The upper foot consists of a brownish-gray, loose loam. The subsoil consists mainly of a dark red, tenacious clay. This is a rich farming land. Corn will produce 40 bushels per acre; wheat, 20; timothy, 1½ to 2 tons. The soil is adapted to general farming and fruit raising. The price of such land is $75 to $100 an acre.

The following table shows the results of mechanical analyses of this soil:

MECHANICAL ANALYSES OF BEDFORD CLAY LOAM.

Number.	LOCALITY.	DESCRIPTION.	Color (dry).	Friability.	Nature of coarse gravel.	Coarse gravel, larger than 2 mm., per cent.	Gravel, 2 to 1 mm., per cent.	Coarse sand, 1 to 0.5 mm., per cent.	Medium sand, 0.5 to 0.25 mm., per cent.	Fine sand, 0.25 to 0.1 mm., per cent.	Very fine sand, silt and clay, 0.1 to 0.0001 mm., per cent.
112	Center of Sec. 8, T. 2 S., R. 5 E.	Loose loam 0 to 12 inches	Red-brown	Medium		0	.3	1.8	1.4	2.4	92.6
113	Center of Sec. 8, T. 2 S., R. 5 E.	Clay, 12 to 36 inches	Dark red	Difficult	Chert and iron conc	2	.8	2.8	3.6	6	78

Mitchell Clay Loam.

A greater part of the territory of the area is covered with soil of the Mitchell clay loam type. It is the soil of most of Harrison County. It is found overlying the Mitchell limestone and may be considered as the residuum of the upper part of that formation. The surface soil is a loose grayish loam. This is underlain by one to two feet of brownish-yellow clay loam. Below this is a six-inch layer of mottled yellowish and grayish sandy clay loam, with considerable flint gravel. Underneath the gravelly layer is found a bed of dark red clay, very tenacious, of a thickness varying from one to several feet. In some places the surface has been removed by erosion, so that the depth to the red clay varies from nothing to three or more feet.

The topography of the surface of the most of Harrison County is peculiar in having no system of surface drainage. The underlying rocks are much eroded, having many caverns and underground passages for water. The roofs of many of these cavities having fallen in, the surface is left much broken with deep pit-like depressions called sink-holes. The water that falls in rain is gathered into these sink-holes instead of running off on the surface through a system of valleys and streams. As there is usually an opening at the bottom, these sink-holes are generally dry. By artificial or natural means the opening may be closed, and a small pond of water will cover the bottom, while inwash of soil from the surrounding plowed fields tends to fill them up. Their diameters vary from five to twenty rods, and they are from 15 to 30 feet deep.

Frequently, instead of the circular sink-hole, the depression extends in a broad valley-like surface for two or three miles, with the drainage above ground, a small stream possibly occupying the lowest part and draining at last into a hole in the ground, becoming from there on an underground stream. All of these disappearing streams connect with the main drainage channels of the region—such as Buck Creek, Indian Creek and Blue River—or there may be complete underground connection with the Ohio River. Often one of these underground streams appears suddenly at the surface, forming a "spring." Wilson's spring, in the southern part of Spencer Township, is a notable example. Here the water bursts forth from the ground in volume enough to form a good sized creek, which furnishes 30 to 50 horsepower for a mill, throughout the summer. In Indian Creek, about two miles southwest of Corydon, there is a place where the stream at low water entirely disappears through the bottom of its channel, leaving the channel a bare rock surface for half a mile or more, when the water again begins to follow the creek bed.

Around the edges of these sink-holes the soil has become thin and stony through the erosion of the surface layer. The roughness of surface and the stoniness of the land increase as one approaches the creek valleys. At a distance of a mile or so from the streams the surface is quite gently rolling, Boone Township comprising many of the most level and most fertile tracts. Other notably fertile areas are certain broad basin-shaped valleys lying among the hills of the Huron formation in the southwestern part of the county, such as "Ripperdan Valley," in the vicinity of Valley City, and "Grassy Valley," a mile or so northeast of Valley City. The soil of these valleys is somewhat different in appearance from the soil of the same geological horizon in other parts of the county, but it is grouped with the other as a type.

Corn, wheat and oats are the crops grown most successfully. The yield of wheat is 15 to 25 bushels per acre; of corn, 20 to 50; of oats, 20 to 30; potatoes, 100 to 250 bushels per acre. Tomatoes are extensively raised in the northern part, where railroad facilities are obtainable. Fruit of all kinds is raised, but no large orchards occur. The productivity of the Mitchell clay loam varies greatly in different parts of the area, being dependent upon the relative amount of erosion that has removed the surface soil. When the surface has been washed away till the flinty layer is nearly at the surface, the fields are stony and comparatively unproductive. It has been found that deep plowing, which would reach to the red clay lying below the flinty layer, will result in adding to the fertility of the soil.

The amount of stock raised in regions of this soil is comparatively small, this being due partly, probably, to the difficulty of securing water supply. A few farmers are raising fine stock to some extent.

The following table shows the results of mechanical analyses of this soil:

MECHANICAL ANALYSES OF MITCHELL CLAY LOAM.

Number.	LOCALITY.	DESCRIPTION.	Color (dry).	Friability.	Nature of coarse gravel.	Coarse gravel, larger than 2 mm., per cent.	Gravel, 2 to 1 mm., per cent.	Coarse sand, 1 to 0.5 mm., per cent.	Medium sand, 0.5 to 0.25 mm., per cent.	Fine sand, 0.25 to 0.1 mm., per cent.	Very fine sand, silt and clay, 0.1 to 0.0001 mm., per cent.
69a	Farm of W. E. Yeager, Sec. 1, T. 6 S., R. 3 E.	Loose loam 0 to 12 inches	Gray-brown	....	....	....	....	....	....	....	....
69	Farm of W. E. Yeager, Sec. 1, T. 6 S., R. 3 E.	Clay loam, 12 to 24 inches	Yellow-brown	Medium	....	0	0	.4	1.4	.4	95
70	Farm of W. E. Yeager, Sec. 1, T. 6 S., R. 3 E.	Silty clay loam, 24 to 48 inches	Yellow and gray mottled	Medium	....	.4	.2	3	1.6	4.2	87
70a	Farm of W. E. Yeager, Sec. 1, T. 6 S., R. 3 E.	Tenacious clay, 48 to 60 inches	Dark red	Difficult	....	....	....	....	....	....	....
74	N. W. Cor. Sec. 20, T. 4 S., R. 4 E.	Loose loam, 0 to 6 inches	Gray-buff	Easy	Iron conc	1	1.2	4.8	3.4	4	87.6
75	N. W. Cor. Sec. 20, T. 4 S., R. 4 E.	Sandy clay loam, 6 to 24 inches	Yellow-brown	Difficult	Iron conc.	1.8	2.8	9.2	4	7.8	73.2
76	N. W. Cor. Sec. 20, T. 4 S., R. 4 E.	Sandy clay loam, 24 to 30 inches	Yellow and gray mottled	Medium	Chert and iron conc.	64.3	1	12	.2	2.4	16.8
77	N. W. Cor. Sec. 20, T. 4 S., R. 4 E.	Tenacious clay, 32 to 42 or more in's.	Dark red	Difficult	Iron conc.	5.2	.8	.8	.2	2.8	86.2
78	Sec. 7, T. 5 S., R. 3 E, ½ mile west of Valley City	Loose loam, 0 to 18 inches	Gray-buff	Easy	Chert, etc.	0	1.4	3	5.6	11.9	87.2
79	Sec. 7, T. 5 S., R. 3 E., ½ mile west of Valley City	Clayey loam, 18 to 36 inches	Red-buff	Medium	Chert	6.8	2.2	4.6	9.6	.94	70.8
80	Sec. 7, T. 5 S., R. 3 E., ½ mile west of Valley City	Clay	Red-buff	Easy	Chert	31	2.4	2.8	3	10	52.8
91	N. W. ¼ Sec. 18, T. 3 S., R. 3 E.	Loose loam, 0 to 12 inches	Brown-buff	Easy	....	.1	.1	.8	1.3	1.4	94.2
92	N. W. ¼ Sec. 18, T. 3 S., R. 3 E.	Tenacious clay, 12 to 48 inches	Red-brown	Medium	....	0	0	1.5	6.4	19	74.6
107	N. W. ¼ Sec. 30, T. 1 S., R. 5 E.	Sandy loam, 0 to 6 inches	Gray-buff	Easy	....	.1	.1	1	2.8	6	89.5
108	N. W. ¼ Sec. 30, T. 1 S., R. 5 E.	Sandy clay loam, 6 to 24 inches	Light-buff	Medium	....	0	.1	.3	2.6	11	85.6
109	N. W. ¼ Sec. 30, T. 1 S., R. 5 E.	Sandy clay loam, 24 to 40 inches	Buff mottled	Medium	Iron conc	.2	.2	2.6	4.6	22.2	65.4

HURON SANDY LOAM.

The outcrop of the Huron formation occurs in irregular and isolated patches in the western part of Harrison County, forming round-topped hills or flat-topped ridges rising a hundred feet or so above the surrounding country. It is made up of limestone, with several intervening beds of shale and is capped with a layer of moderately tough brownish-gray sandstone. It is this sandstone layer that has protected the top while erosion has cut away the slopes, causing the rough topography of the region. Certain layers of the underlying limestone contain much chert.

The soil is a brown sandy loam, where the sandstone comes near the surface and on the slopes below. Where these ridges are of sufficient extent to have an area of level land on top, the surface soil is a very fine light gray sand or silt, in some places forming a heavy impermeable layer of "slash." Such areas are poor for crops. The soil of the Huron is in general only fairly fertile. Fruit does well on this soil, apples and peaches, especially, make a paying crop. Much of the surface of the Huron area is too stony for proper cultivation. These hills are most commonly forest-covered—poplar, oak, hickory and chestnut. But the more level parts and the gentler slopes are being reduced to farming land.

The following table gives the results of mechanical analyses of this soil:

MECHANICAL ANALYSES OF HURON SANDY LOAM.

Number.	LOCALITY.	DESCRIPTION.	Color (dry).	Friability.	Nature of coarse gravel.	Coarse gravel, larger than 2 mm., per cent.	Gravel, 2 to 1 mm., per cent.	Coarse sand, 1 to 0.5 mm., per cent.	Medium sand, 0.5 to 0.25 mm., per cent.	Fine sand, 0.25 to 0.1 mm., per cent.	Very fine sand, silt and clay, 0.1 to 0.0001 mm., per cent.
81	Near top of hill, S. side Sec. 5, T. 5 S., R. 3 E.	Sandy loam, 0 to 18 inches	Buff	Medium		0	0	.7	.4	19.8	72.3
82	Near top of hill, S. side Sec. 5, T. 5 S., R. 3 E.	Sandy loam, 18 to 36 inches	Yellow-buff	Medium	Iron, conc.	4	.4	1.6	2	40.4	50.4
83	⅔ the way down from top of same hill	Loose loam, 0 to 18 inches	Brown-buff	Medium		0	0	.6	.2	3.4	90.2
84	⅔ the way down from top of same hill	Sandy loam, 18 to 36 inches	Red-brown	Medium		0	.8	1.4	2.8	6.8	86
85	⅔ the way down from top of same hill	Sandy clay loam, 36 to 48 inches	Brown-red	Medium	Iron conc.	1.2	0	3.4	1.2	15	76.1
97	Farm of S. S. Brandenburg, S. E. ¼ Sec. 36, T. 4 S., R. 2 E.	Sandy loam, 0 to 6 inches	Brown-buff	Medium	Iron conc.	.2	.1	.1	.4	2	95
98	Farm of S. S. Brandenburg, S. E. ¼ Sec. 36, T. 4 S., R. 2 E.	Sandy loam, 6 to 24 inches	Brown-yellow	Difficult		0	0	.3	.6	.6	96.6

Huron Sandy Loam—Sub-Type.

Along the eastern edge of the Mitchell formation and on the upper parts of the drainage divide running along the eastern side of Harrison County and into Floyd County, there are numerous deposits of sand. These deposits are very noticeable where the wagon road has cut into the hillsides in the central part of Taylor township, Harrison County. The sand is usually colored a brownish yellow by iron oxid, but in some places it is nearly white. These sand deposits occur at a certain level, but do not at the surface appear as a continuous stratum.

As to the origin of these sand beds, the aeolian theory has been advanced. It has also been suggested that they are of a sea deposit, but one of much more recent formation than the Huron beds lying above the Mitchell group a little farther to the west. Many evidences seem to point to water deposition as the origin, while some of the facts connected with the arrangement of the beds would lead one to class them as correlative with the lower part of the Huron formation. As the soil type is very similar to that found on the Huron formation farther west, the location of this soil area also is indicated on the soil map as Huron sandy loam.

In many instances the red clay, customarily associated with the residuum of limestone beds, occurs just above the sand, frequently merging gradually into it. Coarse chert gravel is nearly always found overlying the sand. In several places the sand at the top is consolidated into a firm gray or brown sandstone. At one place near the south part of the N. E. 1/4, Sec. 28, T. 5 S., R. 5 E., a layer of sandy limestone, or sandstone, with fossil shells, occurs just above the sand. Near the south line of Sec. 28, T. 5. S., R. 5 E., the road cuts through the sand formation exposing a section about 10 feet thick. The top is a grayish loam grading at a depth of one to two feet into a yellowish sandy clay, which in turn grades below into red, sandy, tenacious clay. The appearance is as if a limestone stratum had disintegrated just above a layer of sandstone.

The soil of this area is a grayish buff, moderately friable loam at the surface, growing coarser as it merges into the subsoil, which is often of a mottled red and buff color and may contain coarse gravel of chert, sandstone or iron concretion. The surface soil is not always affected by the underlying sand, the sandier areas being on the slopes where erosion has brought the surface of the ground to the level of the sand.

Similar deposits of sand occur in the southwestern corner of Clark County and the northwestern part of Floyd County. In this neighborhood large quantities of white sand were removed some years ago for the New Albany glass works. The deposit here is about 30 feet thick, the upper part being colored by iron oxid.

The soil of this area is especially adapted to fruit. Many acres of strawberries are grown, and apple and peach trees do well. Corn yields about 40 bushels per acre; wheat about 20 bushels.

The following table shows the mechanical analyses of this soil:

MECHANICAL ANALYSES OF HURON SANDY LOAM—SUB-TYPE.

Number.	LOCALITY.	DESCRIPTION.	Color (dry).	Friability.	Nature of coarse gravel.	Coarse gravel, larger than 2 mm., per cent.	Gravel, 2 to 1 mm., per cent.	Coarse sand, 1 to 0.5 mm., per cent.	Medium sand, 0.5 to 0.25 mm., per cent.	Fine sand, 0.25 to 0.1 mm., per cent.	Very fine sand, silt and clay, 0.1 to 0.0001 mm., per cent.
66	Middle of W. side Sec. 8, T. 1 S., R.5E.	Loose loam, 0 to 12 inches	Buff	Easy		0	0	1.2	4	15	78.4
67	Middle of W. side Sec. 8, T.1 S., R.5E.	Sandy loam, 12 to 36 inches	Yellow buff	Medium		0	0	.3	7.4	23.4	64.5
68	Middle of W. side Sec. 8, T. 1 S., R.5E.	Sand 36 to 48 inches or more	Buff	Medium	Iron conc.	.4	.4	1	20.8	38	40
110	S. E. Cor. Sec. 19, T. 1 S., R. 5 E., about 40 rods N. of the corner	Sandy loam, 0 to 12 inches	Gray-buff	Medium		0	.4	.7	8.8	34.2	51
111	S. E. Cor. Sec. 19, T. 1 S., R. 5 E., about 40 rods N. of the corner	Sandy loam, 12 to 36 inches or more	Mottled buff	Medium	Sandstone	1.2	.3	.4	14.1	41.2	37
118	½ mile west of N. E. Cor. Sec. 14, T. 4 S., R. 5 E.	Sandy loam, 0 to 18 inches	Buff	Medium		0	0	.6	2.4	33.6	61
119	½ mile west of N. E. Cor. Sec. 14, T. 4. S., R. 5 E.	Sandy loam, grading below into a red sandy clay, under which is a reddish sand	Red-buff, mottled	Medium	Chert and soft sandstone	4	0	3.4	3.2	52.6	36.8

SUMMARY.

In the above discussion we have attempted to show the present conditions as dependent upon the past and as suggestive of what may be expected of the future. We have seen that former methods of farming, with new land, were less effective in producing wealth than are modern methods on old, worn-out soil. We have seen that, whereas the former generations allowed the land to decrease in fertility, modern enterprise is seizing the legacy of depleted natural wealth and is endeavoring to redeem, to conserve and to accentuate its value. We have observed that thoughtless and unscientific labor must be superseded by efforts directed by experience, by experiment and by enlarged apprehension of conditions and possibilities. To some extent we have gone over the relations existing between natural processes, with their results, and the manipulation of the soil to produce crops. From the facts set forth here, it should be easier for the farmer to arrive at results in his efforts to solve the problems of production. He should study the tables of mechanical and chemical analyses of the main types of soil and should deduce conclusions as to the particular need of his own land. He must experiment. After all is said and done in the way of a soil survey, it rests with the farmer to work out his own solution for the proper adjustment of conditions for the ideal operation and utilization of refractory soils. This report should be of service also to those farmers in other parts of the State, and in other States, who wish to gain some idea of agricultural conditions in this region preparatory to investment in these lands.

It has been seen that there is a great variety of soil and that there is a marked disparity in their fertilities. The cause for this difference, it has been observed, is attributable to certain chemical and physical properties of the soil, to insufficient drainage, to excessive erosion, etc. While much may be attained through the soil survey, it would seem that the most effective way for the State to secure intelligent, concise and conclusive information as to the needs of particular soils would be by having a small area of each type operated for a term of years experimentally. The State could well afford to rent or buy these experimental tracts and to have a thorough and systematic course of experiments applied, with a view to ascertaining all possible facts connected with crop production on those areas. In no other way can experimental farming be so effective, for in no other way can every condition of climate, of surface, of geological structure and of soil be realized. Many parts of this area have a confessedly poor soil, for some reason. It is a matter of supreme importance to the farmers of these regions that something be done, by State aid, that will show actual results in increasing the productivity of these soils, if the results of the soil survey be not sufficient.

THE INDIANA OOLITIC LIMESTONE INDUSTRY IN 1907.

BY

RAYMOND S. BLATCHLEY.

The Indiana Oolitic Limestone Industry in 1907.

BY RAYMOND S. BLATCHLEY.

INTRODUCTORY.

BY W. S. BLATCHLEY.

The Indiana oolitic limestone is the best known and most valuable limestone in the United States for building and ornamental purposes. It has a wider sale and more extended use than any other building stone in North America, its wide reputation being due to its general usefulness in masonry, ornamentation and monuments; its abundance; the ease with which it can be quarried and dressed, and its pleasing color and durability. During the past seven years the industry has more than doubled in extent, the value of the annual output increasing from $1,699,649 in 1900 to $3,673,965 in 1907. In that time many new quarries have been opened up and much of the area mapped in the last extended report on the stone, that of Messrs. Hopkins and Siebenthal in the 21st (1896) Report of this Department, has been developed. That report is now out of print, and the Department of Geology has no recent literature to furnish the many stone dealers, architects, scientists and others who each year ask for detailed and specific information regarding the quality of the stone, the extent of its area and the present status of its development. For that reason the present paper was planned and is herewith presented.

Since the general geographical, stratigraphical, structural and economic features of the stone are practically the same as in 1896, when the report of Messrs. Hopkins and Siebenthal was prepared, the three chapters treating of those features in their paper have been included practically without changes, except such minor condensation, eliminations and additions as would bring the paper up to date. The two lithographic maps of the area embracing the oolitic limestone region are the same as prepared by Mr. Siebenthal for the report mentioned, with the exception that the new railways and switches since built and the location of the new quarries since opened are shown thereon.

The remaining chapters of the paper treating of the local features of the oolitic limestone and descriptions of the quarries in operation in 1907, together with the 15 etching maps of the individual quarries or quarry districts, have been written and prepared by Raymond S. Blatchley from data gathered by him personally during the summer months of 1907. In many places in treating of the older quarries in operation in 1896 he has incorporated a portion of the matter written by Messrs. Hopkins and Siebenthal, adding such new details as were necessary to show the present status of the operations. All quarries opened since 1896 he has treated from his own viewpoint.

The paper as presented deals only with the oolitic stone industry in Owen, Monroe and Lawrence counties, as it is only in those three counties that active quarries are at present in operation. It must not be understood, however, that the area covered by the stone is limited to those counties, for its outcrops extend from a point north of Parkersburg in the southern part of Montgomery County south across the Ohio River, a distance of 142 miles in the State of Indiana. The rock, however, loses its massive structure just north of Romona, on the White River, and in its northern extension becomes thin bedded or even shaly on some of its exposures. While it thus loses its massive structure and hence its value as a building stone, it retains its characteristic granular texture and fossils. At many points in the southern and southeastern parts of Putnam County the rock is exposed and at several places has been quarried for local use as road metal. There are a number of similiar exposures in northeastern Owen and northwestern Morgan counties in T. 11, 12 and 13 N., R. 2 and 3 W.

South of Lawrence County the oolitic stone has been quarried extensively only at Salem. In recent years, however, the quarry at that point has been operated solely for lime making. There are many localities in Washington, Floyd and Harrison counties where the oolitic stone industry could doubtless be profitably developed were transportation facilities present. Detailed descriptions and large scale maps of the stone area in these southern counties are given in the paper entitled "The Lower Carboniferous Area of Southern Indiana," by Dr. George H. Ashley, in the 27th (1902) Report of this Department, to which persons interested are referred.

CHAPTER I.

GENERAL GEOGRAPHICAL AND STRATIGRAPHICAL FEATURES OF THE INDIANA OOLITIC LIMESTONE.

C. E. S.

Location.—The area mapped and covered by this report includes the Indiana oolitic limestone as it occurs in Owen, Monroe and Lawrence counties. This limestone, in the region under consideration, is exposed in a labyrinthine outcrop winding in and out the valleys and around the hills over a distance of more than 60 miles, and varying in breadth from outlier to inlier, from two to 14 miles; on the average, perhaps, five miles. As noted in the introductory, it is not to be inferred that this area includes the whole of the oolitic limestone within the State, nor even all of commercial value. It is simply the ground covered within the limits of time and means at the disposal of the survey, and is inclusive for all the area north of the south boundary of Lawrence County.

The oolitic belt practically begins on the north at Gosport. The limestone is traceable north of there as far as Parkersburg, Montgomery County, but at no place does it occur in commercial quantities. Southwest of Gosport it shows in bluffs of White River to within about a mile of Spencer. Southeast of Gosport the oolitic crops out in a belt about three miles wide, embracing the quarry districts of Big Creek, Stinesville, Ellettsville and Hunter Valley and extending to Bloomington. Four miles south of Bloomington, in the vicinity of Clear Creek Station, the oolitic belt rapidly widens to six miles, due to the fact that the lower course of Clear Creek makes a broad circle to the west, cutting down through the Mitchell and oolitic limestone, thus adding the oolitic outcrop on each side of the creek to the original outcrop of that limestone.

The great width of the outcrop in Lawrence County is due to similar causes. The lower course of Salt Creek and that portion of White River from Tunnelton to the mouth of Salt Creek both lie several miles west of the eastern outcrop of the oolitic limestone, but have cut their valleys down through both the Mitchell limestone and the oolitic limestone. The various creeks from the east—Little Salt, Pleasant Run, Leatherwood and Guthrie creeks—also cut down through the oolitic, and what would otherwise be a plateau is divided into a number of flat ridges capped with Mitchell limestone, but fringed with a band of outcropping oolitic limestone.

The oolitic belt, after passing out at the southeast corner of Lawrence County, swings eastward to Salem, Washington County, taking in the Salem quarries and Spergen Hill. Thence it swings southward, its westward limit following the lower course of Blue River to the Ohio, and its eastern limit taking in the quarries at Georgetown and Corydon.

Topography.—The dip of the Subcarboniferous rocks over the region herein described is from 50 to 60 feet to the mile in a direction south of west. This dip does not seem to have left any impress on the topography of the region *other than the initial direction of the drainage.* The topographic features of the area owe their existence to the inherent qualities of the different formations. Thus the incoherent, loosely cemented, easily eroded knobstone has been cut up into a confused tangle of crooked ridges and deep hollows which trend in all directions. The topography of that part of the Harrodsburg limestone area which borders the knobstone partakes more or less of the character of the knobstone topography, though the ridges are larger as a rule. As for the remainder of the Harrodsburg limestone area, whether or not it is deeply eroded and broken depends on its distance from White River, and the height of its drainage level above the base level, which is the level of White River. This may readily be seen in the vicinity of Bloomington, at a point two miles east of that city on the divide between Bean Blossom and Salt creeks. The distance north to Bean Blossom Creek is five miles; the distance east to Salt Creek by way of Jackson and Clear creeks is sixteen miles. The result is manifest in the topography. Northward and eastward from the divide the hills are rugged, the hollows crooked and deep. Southward, down Jackson Creek, the surface is but gently rolling.

The oolitic limestone, being the thinnest of the Subcarboniferous formation, has no particular type of topography. It usually occurs as a narrow outcrop from 100 to 400 yards in width, fringing the flanks of the hills. Where it forms the surface rock over any extent of territory, as it sometimes does, when it makes the cap rock of a wide ridge, the topography is gently undulating.

The Mitchell limestone, where it has superficial drainage and especially where it has a capping of the Huron sandstone, forms high, bold hills with wide, well-rounded valleys between. Where the drainage is subterranean the result, of course, is an irregular, undulating plateau.

The valley of White River at Gosport is 570 feet above sea level. The river hills rise 100 to 150 feet above the valley, and the crests gradually rise southward, until in the vicinity of Bloomington, along the divide between the two branches of White River, the hills reach 900 to 950 feet in elevation. The highest points in Monroe County range themselves between these elevations. The valley of the east fork of White River, south of Bedford, is 500 feet above sea level. The highlands about Bedford range from 700 to 750 feet in elevation, and those about Mitchell something near the same. The crest of the ridge, which marks the eastern escarpment of the Huron group, approximates 800 feet in height.

Nomenclature.—The Indiana oolitic limestone is one of the six great geological horizons or formations which in this State comprise the Lower Carboniferous or Mississippian Period. Named in the order of their age or area of outcrop from east to west, they comprise the Rockford Goniatite limestone; the Knobstone shale; the Harrodsburg limestone; the Indiana Oolitic limestone; the Mitchell limestone, and the Huron limestones and sandstones.

The *Rockford Goniatite Limestone* outcrops in Clark, Scott, Jackson and Bartholomew counties in southern Indiana. It is a thin bed of limestone and calcareous shale of limited areal extent, coming between the Devonian black shale and the Knobstone and furnishing the famous fossils which led, after much controversy, to its recognition as the base of the Lower Carboniferous.

The Knobstone comprises a series of alternating friable arenaceous shales and sandstones, ranging in the region under consideration from 500 to 600 feet in thickness. The outcrop reaches its maximum development in Hendricks, Morgan, Brown and Jackson counties, in which region it ranges from 30 to 50 miles in width. The outcrop narrows rapidly both north and south of this area. It is in the main unfossiliferous, but at intervals there are intercalated lenticular beds of limestone and calcareous septaria with faunas, and in several places the Knobstone itself is fossiliferous. The name is derived from the peculiar topography which it superinduces in regions where fully developed, as in the "knobs" of Floyd and Clark counties.

The Harrodsburg Limestone lies above the Knobstone and between that formation and the Indiana oolitic limestone. At first known as the Encrinital limestone, it was afterwards correlated with the Burlington and Keokuk limestone of the Mississippi section. It has in Indiana been designated the *Harrodsburg* limestone, taking the name from the village of that name on the C. I. & L. (Monon) Railway in the southern part of Monroe County, where this limestone is typically developed. The village itself is mainly built upon the oolitic limestone, but near its contact with the Harrodsburg limestone, and descending the hill from the village either north, east or south, one passes over the whole outcrop of the latter from its contact with the oolitic to its contact with the Knobstone.

The Harrodsburg limestone varies from 60 to 90 feet in thickness. It forms a belt four or five miles in width lying along the eastern outcrop of the oolitic, rising gradually toward the east at the rate of 50 or 60 feet to the mile, and bordered by the broken hills of the Knobstone region.

The "beds of passage" from the Knobstone to the Harrodsburg limestone contain great numbers of geodes, or, as they are more familiarly termed, "mutton heads," ranging from the size of a pea up to 18 or 24 inches in diameter. These geodes are confined to the lower members of the Harrodsburg limestone, though a few are scattered through the Knobstone.

Above the geode layers there is a bright gray or blue highly crystalline and quite fossiliferous limestone with small crystals of pyrites, giving it in places a greenish tint. Many of the bedding planes are marked by "crowfeet" (stylolites), and intercalated lenticular masses of chert are very plentiful. The residual clay is very stiff and of a deep red color.

Toward the top of the limestone the strata become more massive and at the top the upper four to eight feet usually have lost the molluscan character of their fauna and consist almost wholly of comminuted bryozoa. In places these more massive strata are quarried in a small way as "marbles." On a polished bedway face the delicate tracery of the bryozoa comes out with a very pretty lacework effect, but the porosity of the stone prevents its taking a high polish, so that it could not justly be classed as a true marble. The value of some of the more crystalline strata which would take a good polish is lessened by the disseminations of crystals of pyrite, siliceous fossils and nodules of chert.

The contact of the Harrodsburg and oolitic limestones is almost always marked by a bad crowfoot (stylolite), with which are associated masses of silicified oolitic fossils and black siliceous masses.

The Indiana Oolitic Limestone.—The term "oolitic" was first applied in Indiana by D. D. Owen to the whole series of limestones from the Knobstone to the Coal Measures.[1] The name had been previously applied by G. Troost to limestones in Tennessee, to which those of Indiana were supposed to be analogous. In the revised reprint of Owen's report[2] the name is retained; but its application is restricted to a subordinate member of the Subcarboniferous limestone—in reality to the present quarry bed, the Indiana Oolitic limestone—and its age is carefully distinguished from the oolite of Europe, which is a well marked group in the Mesozoic.

The name "Bedford rock" first appears in Richard Owen's report.[3] By other writers it has been variously called Bedford stone, Bedford oolitic stone, Indiana oolitic stone, Spergen Hill limestone, White River stone, St. Louis limestone, Warsaw limestone, etc. It is probably best known to the trade as the Bedford stone; but as Bedford itself is situated on an overlying stone, the word oolitic has been included to specify more particularly the bed of quarry limestone. Bedford oolitic limestone is thus a definite geological term and a well-known commercial one.[4]

The economic character of the present report has precluded anything of a paleontologic nature, but the fauna of the Indiana oolitic limestone will be found fully treated by James Hall[5] and R. P. Whitfield in their various papers on the famous Spergen Hill fossils, and by Messrs. Cumings and Beede under the title "The Fauna of the Salem Limestone of Indiana" in the 30th (1905) Report of the Department of Geology and Natural Resources.

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[1] D. D. Owen, Geological Reconnaissance of Indiana, 1839, 12, 13.

[2] D. D. Owen, Geological Reconnaissance of Indiana, 1837; reprinted 1859, 21.

[3] R. Owen, Report of Geological Reconnaissance of Indiana made in 1859 and 1860; published in 1862, 137.

[4] Since the above was written it has been shown that the name Bedford as applied to a geological formation was preoccupied. Messrs. Cumings and Beede, in the 30th (1905) report of this Department, gave the name "Salem limestone" to the formation now under discussion, but the deposits about Salem are very little known and are not typical of the better grades of the stone to the northward. Since the stone is quarried and shipped from so many localities in southern Indiana, it is thought best to adopt the name proposed in 1900—viz. "The Indiana Oolitic Limestone," and by that name it will be called in the present paper, and in the reports of the Department hereafter issued by me. By thus conferring upon it the broader name "Indiana," no one locality in the State will be advertised as against another; the stone in Monroe County being as typically oolitic and as excellent in quality as that about Bedford.—W. S. B.

[5] James Hall, Transactions Albany Institute, Vol. IV, 1856, pp. 4-34. James Hall, Geology and Natural History of Indiana, 12th Rep., 1882, 319-375. R. P. Whitfield, Amer. Museum Natural History, Bull. 3, 1882, 42-94.

The Mitchell Limestone.—Overlying the oolitic limestone is a series of impure limestones, calcareous shales and fossiliferous limestones aggregating from 150 to 250 feet in thickness. This formation is known as the Mitchell limestone, taking the name from the town of that name in Lawrence County at the crossing of the C. I. & L. (Monon) and the B. & O. S. W. railways. This limestone is well developed about Mitchell, which is situated upon it, but especially is its peculiar topography typically shown in that locality. The topographic tendency of the Mitchell limestone expresses itself in plateaus perforated at short intervals by sink holes. For this reason it has been called the cavernous limestone by early writers, and by others the barren limestone, because of tracts which were largely covered with residual chert fragments which have weathered out of the limestone. The lower members of this formation, lying just above the oolitic, constitute the so-called "bastard limestone" stripping of the quarrymen. They are unfossiliferous and of a dirty yellow or gray color. Above these come shales with interbedded, dark blue, heavy, flaggy limestone and gray lithographic beds. Specimens of the lithographic stone have been found which worked almost, of not equally, as well as the Bavarian stone, but as yet no locality has been discovered where they can be obtained in commercial quantities. The stone is usually so intersected at short intervals by calcite seams that no stones of size can be obtained. What search may discover can not, of course, be foretold.

At different horizons in the Mitchell limestone the stone is fossiliferous. In some places it is as truly oolitic as the Bedford stone. Such oolitic limestones may be distinguished from the true Indiana or Bedford oolitic by the fossils, and usually by a peculiar weathering under atmospheric agencies, in which a coating of between one-eighth and one-fourth of an inch scales off or exfoliates with a peeling effect. The following section in Sec. 13, 7 N., 2 W., is typical of the Mitchell limestone and is herewith given, in order that persons boring through a portion of the Mitchell formation in search of the oolitic may know something of the character of the strata they will encounter:

Detailed Section of the Mitchell Limestone, 7 N., 2 W., Sec. 13.

	Feet.
Drab lithographic limestone, *L. proliferum*, in top layer	20
Chert breccia, rotten lithographic groundmass	8
Bluish-drab, fine grained, fetid limestone	10
Lithographic limestone	4

	Feet.
Drab calcareous clay shale	9
Drab, rotten, magnesian limestone with chert inclusions	29
Bluish vermicular, shaly limestone	2
Drab calcareous shale	4
Rotten and shaly lithographic limestone	5
Lithographic limestone	2
Rotten lithographic limestone	5
Drab calcareous shale	7
Fine-grained, bluish-gray limestone with conchoidal fracture	5
Calcareous clay shale	2
Gray limestone in eight-inch beds	5
Fossiliferous shaly limestone	14
Concealed	6
Fossiliferous coarse-grained limestone	2
Oolitic limestone	..

The Huron Group, as recognized by Messrs. E. M. Kindle and Geo. H. Ashley, in Orange and Martin counties consists of the Upper, Middle and Lower Huron limestones, separated from each other by the Upper and Lower Huron sandstones.* Overlying the Huron is the Mansfield sandstone, the basal member of the Coal Measures.

*Department of Geology and Natural Resources of Indiana, 20th Annual Report, 1895, 331; Twenty-seventh Annual Report, 1902, 71.

CHAPTER II.

GENERAL STRUCTURAL AND ECONOMIC FEATURES OF THE INDIANA OOLITIC LIMESTONE.

T. C. H.

Structural Features of the Indiana Oolitic Limestone.—This limestone occurs in a massive bed varying in thickness in different localities from 25 to nearly 100 feet. The bulk of the stone is free from lamination and shows very few bedding planes. On weathered surfaces of the natural outcrop the lines of sedimentation are brought out more or less conspicuously at many points. Sometimes even a shaly structure may be developed on the top of the bed. In several places lines of cross-bedding are brought out quite conspicuously on the weathered surface, noticeably on the bluffs of Big Creek a mile west of Stinesville and on the face of the old Terre Haute quarry, half a mile west of Stinesville. The same thing is shown less conspicuously in places in a great many quarry openings throughout the region, and is known among the quarrymen as cross-grain. There is abundant evidence of this nature both of the false bedding and the true bedding to show the sedimentary character of the stone. Yet, as before stated, the great bulk of the stone is massive, and in all the better class of stone shows little or no evidence of lamination or bedding except at the outcrop.

In all the outcrops and in many of the quarries there is at least one system of vertical or nearly vertical joint seams, and in most places two systems, one having a general east and west direction, the other north and south. The joint seams are rarely abundant, generally 20 to 40 feet apart. Where there is a solid rock covering the oolitic stone the seams are generally inconspicuous features, seldom more than regular cracks in the rock mass. In a number of places, in fact in nearly all places where the oolitic stone has no solid rock covering, the weathering agencies have penetrated along the joint planes, forming irregular, cave-like openings sometimes two or three feet across. These cavities are mostly filled with clay and debris from the top, causing a great deal of waste and annoyance in quarrying, as the waste is not limited simply to the cavity, but the irregular walls cause much waste in squaring the blocks, and where the cavities are close together the irregular blocks between them can not always be divided to advantage. There is a further waste where the stone happens to be blue stone, from the fact that along the joint planes the stone is oxidized irregularly, forming a band of buff of varying width on each side of the cavity. It is hard on the channeling machine to cut across one of these cavities.

Stylolites ("crow-feet," "toe-nails").—While ordinary bedding or lamination planes are exceedingly rare in the interior of the oolitic limestone bed at any considerable distance from the outcrop, there are what might be called extraordinary bedding planes, resembling suture joints, which, unfortunately, occur in many places, appearing on the face of the quarry as jagged dark to black lines. On each side of this line, generally more pronounced on the lower side, are jagged points extending sometimes a fraction of an inch, sometimes several inches into the limestone. The longer points, and sometimes the smaller ones, have an apparent columnar structure, with the sides nearly parallel, and frequently striated. Frequently the shorter points have a more serrated or tooth-like projection. In all cases observed, with one exception, the planes have a nearly horizontal position, as nearly horizontal and about as regular as any other bedding planes, and the teeth or "toe-nails" are generally vertical. While this is true in the oolitic limestone quarries, it is not true in all localities, as in the magnesian limestone quarries in the city of Chicago they follow quite irregular lines, in some places apparently running over little hillocks or sharp prominences. The stylolite seams are of great interest and annoyance to the quarrymen, as they probably cause more waste than any other structural feature of the rock. Because of their economic importance they deserve more than a passing notice.

The stylolites have been variously designated. Among the names which have been proposed are, *suture joints, crystallites, lignillites* and *epsomites*. The quarrymen designate them as *crow-feet* or *toe-nails* quite frequently with a harsh adjective prefixed. The most commonly accepted term among scientists is stylolite, from the Greek stylus for pen, referring to the fancied resemblance to a pen. The terms crystallite, lignillites and epsomites are objectionable, as they imply an origin which is not proven. Suture joint is a very good term. Crow-feet and toe-nails will continue to be used among the quarrymen, and are very expressive and not wholly inappropriate terms.

There is a difference of opinion as to the origin or cause of the stylolites. Both Dana[1] and Geikie[2] accept Marsh's explanation that they are caused by "the slipping, through vertical pressure, of a part capped by a fossil shell against an adjoining part not so capped."

It is quite probable that as the stylolites differ in appearance in different localities that they may not all be produced in the same manner. The writer is convinced from his observations in the field that at least in all places where they occur in the oolitic limestone of Indiana that they mark bedding or stratification planes in the rock. The reasons for so thinking are, (1) That they correspond with the grain or bedding of the rock, occasionally running on the false bedding, but never across the grain; (2) they are in places traceable, with no break or sharp line of division into the common bedding planes, having no evidence of stylolites; (3) there is in nearly every instance a layer of carbonaceous material, sometimes a mere film, sometimes nearly half an inch thick; (4) they are always of considerable, though not unlimited, extent; (5) a view from above shown in a few places on (the Cleveland quarry, near Harrodsburg, is one of the best illustrations) quarry floors shows water action not unlike the common bedding plane; (6) they frequently occur between the oolitic stone and the underlying and overlying beds which are not at all oolitic; (7) the cross bedding always terminates at the stylolite seam; in no instance was it observed to cross it.

The explanation of the stylolitic or tooth-like markings along this seam is not so satisfactory as the evidence of its being a bedding seam. It is quite probable that all are not due to the same cause. Some look as though they were formed by cracks in the drying of the limestone mud, and others look like a rain or spray-washed surface. In fact, there is probably about such variety in the markings as one might expect to find on the surface of indurated calcareous mud, some of which dried in the sun, some of which was rain-washed or spray-washed in the drying. The layer of carbonaceous matter is probably due to the organisms left to die on the beach, either algae or animal forms, or both. It is in some instances associated with considerable iron pyrites. A microscopic examination of this material from two localities shows black bituminous matter, with no organic structure or markings perceptible.

There appears to be little or no evidence in this locality in sup-

[1] Manual of Geology, 4th Ed., by J. D. Dana, 543.

[2] Text Book of Geology, 2d Ed., by A. Geikie, 290.

port of Marsh's theory, as in only one locality was any noticeable proportion of the stylolites capped with fossils, and where such was the case many of the fossils were delicate gastropod shells that would quickly show any pressure, had such been brought to bear. Not only were they not crushed in the least, but 90 per cent or more of the stylolites have no fossil on either the top or the bottom, while there are shells in abundance both above and below the stylolite seam, with no stylolites near them. Furthermore, sometimes the stylolites show just the opposite of compression by forming or occurring in an open seam. The amount of waste caused by the stylolite or crow-foot seam is frequently more than the width of the seam plus the length of the stylolite points, especially so where they occur in the buff stone, as the carbonaceous material in the seam prevents oxidation and there is an irregular blue band along the seam extending several inches to a foot or more from the seam into the buff stone, and the seams are not always the right distance apart to get either one or more cuts of standard size without considerable waste.

Textural Features.—The Indiana oolitic limestone is a granular limestone, a calcareous sandrock, in which both the grains and the cement are carbonate of lime. The greater part of it is properly freestone in character, although that term is commonly limited to the siliceous sandstones.

The texture varies in coarseness in different parts of the area, and generally in different parts of the same bed. The finest-grained varieties appear to be the most in demand in the markets and hence are the most sought after and the most valuable. In all of the oolitic limestone throughout the area the grains are made up of fossils, mostly foraminifera and bryozoa, mingled with which are other forms, some of which were not identified. The foraminifera are mostly intact, showing little or no evidence of wear. The other forms appear more or less imperfect in places, but apparently more from a leaching action than from wear. The finer-grained forms differ from the coarse in having smaller shells. The great mass of the stone is made up of these minute, almost microscopic, shells which are generally pretty uniform in size, but in some localities the larger forms predominate, in others the smaller forms prevail, hence coarser and finer-grained stones occur. In some places, as at Romona and Heltonville, bryozoa are very abundant. In other places gastropods and brachiopods abound, often of considerable size—half an inch to an inch in diameter, in a few instances two or three inches. The large forms are commonly clustered, forming a large part of the rock where they occur, and not scattered indiscriminately throughout the rock, and as all of the coarsely fossiliferous stone goes into the waste or into a low grade stone, none of it being sold for first-class dimension stone, the separation is readily made, and if the bed proves to be wholly or largely of coarse stone it is not worked at all. Hence, from a commercial standpoint, the absence of large fossils is desirable.

The fossils, which are composed of finely crystallized calcite, are imbedded in a cement of calcite. On the relative amount, purity and coarseness of this cement depends the hardness and compactness of the stone. To the happy combination of soft grains in the firm cement in the right proportions depends the value of the oolitic stone for building purposes. With any considerable decrease in the amount of the cement the stone would be too soft, crumbling and disintegrating too readily, as is the case in several localities. With an increase in the proportion of the cement the stone would become more difficult to work, losing its freestone character and becoming plucky. There are slight variations in the relative hardness of the stone in different localities, but only in a few places is it too soft to be of any value, and in no place is it too hard to work.

The effect of growing organisms on stone is highly detrimental. A vine or plants clinging to stone find footing in the outer pores. Lichens and algae cause a disintegration. Ivy finds incipient joints which have been set up by abrasion in mechanical dressing and has a tendency to open these joints or invisible fissures. Plants have a tendency to keep stone moist and so cause probable discoloration as well as disintegration from freezing. However, in the case of flowing water the algae give a protective covering to stone that would be desired in canal blocking, etc.*

Colors of the Indiana Oolitic Limestone.—All the stone of the region is classed as "blue," "buff" or "mixed." The blue is evidently the original color of at least the greater part of the stone, and is thought to be caused by iron in the protoxide form and organic matter, the buff being largely, if not entirely, derived from the blue by oxidation of the iron to the peroxide, and of the organic matter to some volatile form, or some stable form, in which it unites with mineral matter in colorless stable form. The oxidation is a continuous process, not yet complete, carried on mainly by the oxygen in solution in the meteoric water, the circulation of which is accelerated or retarded by a variety of causes, and hence does

*R. S. B.

not take place along parallel or regular lines, so that there is always considerable stone along the contact of the two colors that can not be obtained in suitable dimensions of either color alone, but contains a combination of the two colors, and is classed as mixed stone. In most of the quarries it goes into the dump pile as waste. Occasionally some of it is sold for bridges or foundations at a greatly reduced price, often less than the cost of quarrying it. The price of the good stone is so low, and the freight rates so high, that none but first-class stone is shipped to any considerable distance.

Some analyses, made with a view of determining the cause of this coloration, gave the following result:

PARTIAL ANALYSES OF BLUE AND BUFF OOLITIC LIMESTONE.*

Color.	Quarry.	Inorganic Insoluble Matter. Per Cent.	Organic. Per Cent.	Ferrous Oxide, FeO. Per Cent.	Ferric Oxide, Fe_2O_3. Per Cent.
Blue......	Thornton's........	2.16	0.24	0.067	0.196
Buff.......	Thornton's........	.86	.12	.050	.126
Blue......	Hunter's..........	1.25	.22	.063	.044
Buff.......	Hunter's..........	1.10	.11	.055	.150
Blue......	Perry's...........	1.14	.21	.055	.089
Buff.......	Perry's...........	1.24	.13	.050	.119

*Made for the survey by W. A. Noyes, Rose Polytechnic, Terre Haute, Ind.

The results are not as satisfactory as might be desired. The samples were taken from three different quarries, in each case from each side of the line of contact at the same place in the quarry, hoping thus to get specimens as nearly identical as possible in everything but color. Each sample was then tested for ferrous and ferric iron and organic matter. The organic matter was determined by drying the residue insoluble in boiling dilute hydrochloric acid at 135° to 140° C. and determining the loss of weight on ignition. While the results are only approximate, they ought to be relatively correct. The percentages are so small that it is doubtful whether the differences are due to more than the possible errors incident to manipulation. Yet it is probably more than a coincidence that the organic material in each case is only half as much in the buff as in the blue. It indicates a loss of organic material, as might be expected. It is more marked than the difference in the iron which is indicated only in the second or third decimal place. There is in each instance a slight decrease in the percentage of the ferrous iron in the buff from that in the blue, and in two examples out of the three an increase in the proportion of the peroxide, which is what was expected. Yet the differences are so slight that, considering the possible errors in manipulation, we do not feel like emphasizing the import of them without further evidence.

It should be borne in mind that the difference in color is not great, sometimes scarcely perceptible in a hand specimen, but quite distinct on a large block or quarry face, and is brought out more distinctly by exposure than on a perfectly fresh surface. Thus, on the channeled face that has been exposed for a few years, the contrast between the buff and the blue is much stronger than it is on a fresh fracture beneath the surface.

The percentage of bituminous matter is sufficient, in some instances, to discolor the stone to some extent on exposure by the heat of the sun drawing this material to the surface, where it collects the dust and disfigures the stone for a time. Objection has been raised to the stone in some places on this account, but it must be remembered that this occurs with but a small part of the stone. and with that part the disfiguring is only temporary, and in nowise affects the durability of the stone, acting rather as a preservative.*

With the exception of the bituminous varieties, the general tendency of the stone is to become lighter colored on exposure. Much of the buff stone has a dull yellow color when first quarried, that becomes much lighter on exposure.

A few years ago the blue stone was the highest priced and most sought after. Now, while there is good demand for both colors, the buff is most sought after and most quarried, the proportion being about three to one. The prices are about the same for each.

Physical tests of various kinds have been tried on the oolitic stone, the results of which are given below. Not only those made directly for the present report, but those made elsewhere, so far as could be obtained, are brought together and classified.

Specific Gravity.—The specific gravity tests on the accompanying tables were made for the present survey at Rose Polytechnic Institute, except those marked (1), which were made in duplicate at State College, Pennsylvania, to show the different results by different methods. At Rose Polytechnic Institute the stone was weighed in air, and as quickly as possible in water, the specific

*The uniformity of color is to some extent dependent upon the fineness of the grain, for the finer the grain the more intense the shade of buff or blue.—R. S. B.

gravity being the weight in air divided by the difference in weight of the two. At State College it was determined by a specific gravity bottle, weighing first the bottle, second, the bottle filled with water, third, the bottle with the powdered rock, and fourth, the bottle with the powdered rock filled with water. The weight of 3 subtracted from 4, and that result from 2, gives the weight of the water displaced by the stone, and that divided into the weight of the stone, obtained by subtracting 1 from 3, equals the specific gravity. The latter method attempts to give the specific gravity of the particles of the stone independent of the interstitial air, and the former process to give the relative weight of the stone as it is, including the air. As it is impossible to weigh so quickly that some of the water is not absorbed, the actual weight of the stone is less than that shown by the first process. As it is impossible to exhaust all the inclosed air, the absolute weight of the material of the stone, excluding the pores, is a little more than that shown by the second process.

The figures given are for seasoned stone, the green stone being heavier. The weight per cubic foot, as given in the table, is obtained by multiplying the specific gravity by 62½, the weight in pounds of a cubic foot of water. The quarrymen generally count the weight of the stone in the rough for shipping purposes at from 175 to 180 pounds per cubic foot.

Ratio of Absorption.—In the absorption tests made at the Rose Polytechnic Institute the specimens were approximately one-inch cubes, weighed and placed in water, where they were left for 24 hours, and then removed and the faces dried with blotting paper and reweighed. The ratio of absorption is the weight minus the weight dried divided by the weight dry. This 1-31 means that 31 pounds of the stone would absorb one pound of water, about five pounds to the cubic foot.

In the recorded tests made by General Gilmore the experiments were made in about the same way.

The stone showing the highest absorption is the most porous, the lightest, the softest, and generally, other things being equal, the least able to withstand the weather.

**Porosity.*—The interspaces between grains of stone are called pores. They differ greatly in size according to the class of stone, but in the oolitic limestone the sizes are divided into capillary and subcapillary. Pores of .00002 of an inch are called capillary pores, while those smaller than this are designated as subcapillary spaces.

*The matter under this head was inserted by R. S. B.

These pores are of considerable importance in the stone industry, for their number and size control, to a certain extent, the length of the quarry season. This is due to absorption of water and its subsequent freezing, so limiting the output.

The water which thus collects within the pore space of a block of stone is divided into two classes:

(1) "Water of saturation," or the water of green stone. This eventually dries away.

(2) "Water of imbibition," or that which collects in the fine subcapillary spaces. This does not dry out unless the stone is raised for some time to 100° or higher temperature.

The water of the stone is retained by capillary attraction, the finer the spaces the higher the retention of water. This retention of water is dependent upon the inverse relation to capillary attraction or, in other words, the size of the spaces. A rock with three per cent of fine pore space is more dangerous than that having ten or even fifteen per cent of the coarser space, as it is readily seen that the water is ejected more quickly from the latter.

It has been found that pores not more than nine-tenths full of water will not injure the stone. If it is confined, the natural event will be that it must sooner or later break out. So it follows that the rock injured most is that of the finest pore space. Oolitic limestone generally remains free and solid because, as a rule, the pore space is large. The Mitchell limestone has three to four per cent pore space, and so cracks and breaks up in the ground, due to the expansion of freezing. The manufacture of cement blocks is dependent directly upon pore space. Stone material required for water lining in foundations, for piers, abutments, canal locks, etc., requires a high pore space.

In practical work the quarrying operations in the oolitic area usually cease November 1st, and remain idle until the rigor of winter has subsided. This gives an opportunity to save stone which otherwise would freeze and eventually crumble down. As it is, the least loss is sustained by a light freezing on the surface of a quarry face, which is readily removed in the spring by a shallow channel cut.

The pore space of a stone is approximately determined by placing a weighed cube of stone in a jar of hot water, where it is kept immersed twelve hours almost at the boiling point, and later 24 hours in cool water. The cube is then taken out, the surface wiped off quickly and the material weighed. The stone is then heated to 110° C. and left at that temperature for 24 hours. The difference in weights is then multiplied by the specific gravity of the stone. Adding to this result the dry weight and dividing that sum into the former computation gives the pore space. Concentrated into a formula, it reads:

$$\frac{\text{Wet wt.} - \text{dry wt.} \times \text{sp. gr.}}{\text{Sp. gr. (wet wt.} - \text{dry wt.)} + \text{dry wt.}} = \text{P. S.}$$

In seasoning, all organic matter in the stone has a tendency to follow the water to the surface. The water is removed by evaporation but the organic material remains in the stone close to the surface, and as the stone dries out forms a hard crust. This often brings about the injury of good stone by seasoning at the quarries and sending it to destination to be dressed. The seasoned stone, when dressed, loses its organic crust, which is impervious to water. The block is then free to take in water, freeze in building, crumble down, and so render it comparatively worthless. If such stone were dressed in the green or wet state at the quarry and then allowed to season and dry out, the possible loss through this crumbling is eliminated by the formation of a hard crust on the stone, which would tend to greatly prolong its durability.

Compression Tests.—The compression tests made for the survey at Rose Polytechnic Institute were upon specimens of about two-inch cubes. Each specimen was measured to the nearest 1-100 of a square inch and tested upon a Riehlé testing machine having a capacity of 100,000 pounds.

The specimens were tested between two pieces of tarboard 2¼ x 2¼ inches. The rate of application of the load was slow and the same for all.

It will be noticed that most all of the specimens range between 4,000 and 10,000.

The first two tables show the details of the tests made by Professor Howe at Rose Polytechnic Institute.

Table III gives a summary of these, along with tests made by General Gilmore for comparison. It is worthy of note that in four sets of samples the strength on edge is greater than that on the bed, in one instance the first being twice as great. The reason for this is not apparent. One might think that it was due to an imperfect specimen, but the tests on the bed were made on three specimens which averaged nearly the same, and two of them broke with two perfect pyramids. A possible explanation is that the stonecutter marked them wrong.

The samples from Ellettsville were from G. K. Perry's quarry, a half mile north of the Ellettsville Station.

The Twin Creek specimens were from a newly-opened quarry on the bluff of Twin Creek, about six miles north of west from Salem in Washington County; Nos. 7 to 9 were specimens quarried in November, 1895, about six feet below the surface, in township 8 north, range 1 west, section 20, on land of John B. Crafton.

Nos. 10 to 12 were from second and third floors seven to 20 feet deep in the quarry of Hunter Valley Stone Co., Hunter Valley.

Nos. 25 to 27, quarried Nov. 7, 1896, near the top of ledge, township 7 north, range 2 west, section 24, lot 8. No quarry opened.

Nos. 31 to 33, from quarries on Big Creek, North Bedford Station, on Gosport branch of I. & V. R. R., part 20 feet and part 30 feet below the surface; quarried Nov. 26, 1896, hence not properly seasoned.

Nos. 34 to 36, broken off near the top of the ledge, Nov. 7, 1896, on lot 15, township 7 north, range 2 west, section 12. Buff and Blue Oolitic Stone Co. Quarries not developed.

TABLE I.—COMPRESSION TESTS ON INDIANA OOLITIC LIMESTONE. SPECIMENS ON NATURAL BED.

Number.	COMPANY.	Locality.	Area in Square Inches.	Strength in Pounds Per Square Inch.	Remarks.
1	G. K. Perry	Ellettsville	4.35	6,700	Faces crowned; top pyramid long.
2	G. K. Perry	Ellettsville	4.22	5,900	Failed on two sides; signs of pyramids.
3	G. K. Perry	Ellettsville	4.33	6,900	Two perfect pyramids.
4	Twin Creek Oolitic Stone & Land Co	Salem	4.08	11,700	Two perfect pyramids.
5	Twin Creek Oolitic Stone & Land Co	Salem	3.92	6,900	One side split off.
6	Twin Creek Oolitic Stone & Land Co	Salem	4.24	11,000	Two pyramids.
*7	John B. Crafton	Bloomington	3.82	11,400	Two good pyramids.
*8	John B. Crafton	Bloomington	3.72	9,100	Two poor pyramids.
*9	John B. Crafton	Bloomington	4.08	8,400	Split off one side; probably tested on edge.
10	Hunter Valley Stone Co	Bloomington	4.00	3,400	Two fairly good pyramids.
11	Hunter Valley Stone Co	Bloomington	4.20	4,200	Split off on one side.
12	Hunter Valley Stone Co	Bloomington	4.08	4,600	Failed on three sides.
13	Romona Oolitic Stone Co	Romona	4.20	6,800	Two good pyramids.
14	Romona Oolitic Stone Co	Romona	4.24	6,400	Two good pyramids.
15	Romona Oolitic Stone Co	Romona	4.20	7,800	Top pyramid good; bottom one-sided.
16	Bedford-Indiana Stone Co	Bedford	4.28	6,800	Two fair pyramids.
17	Bedford-Indiana Stone Co	Bedford	4.00	3,400	Faces not parallel; failed on one side only.
18	Bedford-Indiana Stone Co	Bedford	4.04	6,700	Two fair pyramids.
19	Hunter Bros.' Stone Co	Bloomington	4.14	5,900	Two good pyramids.
20	Hunter Bros.' Stone Co	Bloomington	4.00	6,900	Two good pyramids.
21	Hunter Bros.' Stone Co	Bloomington	4.08	4,400	One side split off.
22	Chicago Bedford Stone Co	Bedford	4.04	9,600	Two fine pyramids.
23	Chicago Bedford Stone Co	Bedford	4.12	6,400	Failed on one side; indications that specimen was tested on edge.
24	Chicago Bedford Stone Co	Bedford	4.12	9,700	Two fair pyramids.
25	John B. Crafton	Bloomington	4.49	6,400	Two poor pyramids.
26	John B. Crafton	Bloomington	4.41	4,700	Split top to bottom around vertical axis of specimen.
27	John B. Crafton	Bloomington	4.54	8,200	Two good pyramids.
28	Crescent Stone Co	Bloomington	4.10	4,500	One poor pyramid and wedges.
29	Crescent Stone Co	Bloomington	4.16	7,500	Two fine pyramids.
30	Crescent Stone Co	Bloomington	4.20	5,000	Two fair pyramids.
*31	Indiana Steam Stone Works	Stinesville	4.08	6,600	Two fair pyramids.
*32	Indiana Steam Stone Works	Stinesville	4.16	4,100	Faces not parallel; failed vertically around axis of specimen.
*33	Indiana Steam Stone Works	Stinesville	4.08	6,200	Faces not parallel; failed vertically around axis of specimen.
34	Buff and Blue Stone Co	Bloomington	3.79	6,100	Two very poor pyramids; faces not parallel.
35	Buff and Blue Stone Co	Bloomington	4.33	5,800	Top pyramid good; faces not parallel; bottom pyramid wedge-shaped.
36	Buff and Blue Stone Co	Bloomington	4.28	6,200	Two good pyramids.
37	Bedford Quarries Co	Bedford	4.00	3,300	Top pyramid fair; bottom one very poor.
38	Bedford Quarries Co	Bedford	4.00	4,300	Two fair pyramids.
39	Bedford Quarries Co	Bedford	4.12	4,800	Failed on two sides; signs of pyramids.

* The natural "bed" of these specimens was not marked.

TABLE II.—COMPRESSION TESTS ON INDIANA OOLITIC LIMESTONE SPECIMENS ON EDGE.

Number.	COMPANY.	Locality.	Area in Square Inches.	Strength in Pounds Per Square Inch.	Remarks.
1	G. K. Perry	Ellettsville	4.08	13,500	Failed in two pyramids.
2	Twin Creek Oolitic Stone & Land Co.	Salem	4.02	8,900	Failed in two pyramids.
3	Jno. B. Crafton	Bloomington	3.94	8,000	Faces crowning badly cut; failed like specimen tested on natural bed.
4	Hunter Valley Stone Co.	Bloomington	3.98	4,200	Split off on sides; for most part parallel to the natural bed.
5	Romona Oolitic Stone Co.	Romona	4.20	11,200	Failed in two pyramids; fine specimen.
6	Bedford Indiana Stone Co.	Bedford	4.18	4,600	Faces not parallel; one side split off. Signs of pyramids.
7	Hunter Bros. Stone Co.	Bloomington	4.12	4,200	Failed in two pyramids like specimens tested on natural bed.
8	Chicago Bedford Stone Co.	Bedford	4.02	6,600	Faces badly out of parallel; split off on high sides.
9	Jno. B. Crafton	Bloomington	4.45	3,900	Faces not parallel; split off on one side and corner.
10	Crescent Stone Co.	Bloomington	4.04	5,700	Faces not quite parallel; split off on one side.
11	Indiana Steam Stone Works	Stinesville	4.12	2,800	Faces not parallel; one face showed tool marks; split off on one side.
12	Buff & Blue Stone Co.	Bloomington	4.10	4,100	Split off on one side.
13	Bedford Quarries Co.	Bedford	4.12	4,800	Two fair pyramids.

TABLE III.—SHOWING CRUSHING STRENGTH, SPECIFIC GRAVITY AND RATIO OF ABSORPTION OF INDIANA OOLITIC LIMESTONE.

Number.	QUARRY.	Location.	Crushing Strength Per Square Inch.	Number of Specimens Tested.	Specific Gravity.	Weight Per Cubic Foot.	Ratio of Absorption.	Where Tested or Authority
1	G. K. Perry	Ellettsville, Ind.	6,500 13,500	3 1			1-31	Rose Polytechnic Institute, Terre Haute, 1896.
2	G. K. Perry	Ellettsville, Ind.	12,625			152.4	1-41	Gen. Gilmore, Rep. No. 6, Board State House Commissioners, 1879.
3	Matthews Bros.	Ellettsville, Ind.	13,500			142.2	1-28	Gen. Gilmore, Rep. No. 6, Board State House Commissioners, 1879.
4	Indiana Steam Stone Works	Stinesville, Ind.	5,600 2,800	3 1			1-17	Rose Polytechnic Institute.
5	Simpson & Archer	Four miles east of Spencer, Ind.	7,500			142.2	1-30	Gen. Gilmore, Rep. No. 6, Board State House Commissioners.
6	Simpson & Archer	Four miles east of Spencer, Ind.	8,750			156.9	1-95	Gen. Gilmore, Rep. No. 6, Board State House Commissioners.
7	Hunter Valley Stone Co.	Bloomington, Ind.	4,100 4,200	3 1			1-14	Rose Polytechnic Institute, 1896.
8	Hunter Bros. Stone Co.	Bloomington, Ind.	5,700 4,200	3 1	2.46	153.7	1-19	Rose Polytechnic Institute, 1896.
9	Crescent Stone Co.	Bloomington, Ind.	5,700 5,700	3 1			1-15	Rose Polytechnic Institute, 1896.
10	Buff & Blue Stone Co.	Bloomington, Ind.	6,000 4,100	3 1			1-22	Rose Polytechnic Institute, 1896.
11	Crafton	Bloomington, Ind.	6,200 3,900	3 1			1-16	Rose Polytechnic Institute, 1896.
12	Crafton	Bloomington, Ind.	9,600 8,000	3 1			1-3300	Rose Polytechnic Institute, 1896.
13	Dunn & Co.	Bloomington, Ind.	13,750			146.6	1-43	Gen. Gilmore.
14	Romona Oolitic Stone Co.	Romona, Ind.	7,000 11,200	3 1	2.48	155.0	1-39	Rose Polytechnic Institute.
15	Bedford, Indiana, Stone Co.	Bedford, Ind.	5,600 4,600	3 1	2.47	154.4	1-23	Rose Polytechnic Institute.
16	The Chicago & Bedford Stone Co	Bedford, Ind.	8,600 6,600	3 1			1-31	Rose Polytechnic Institute.
17	Bedford Quarries Co.	Bedford, Ind.	4,100 4,800	3 1			1-15	Rose Polytechnic Institute.
18	Bedford Quarries Co.	Bedford, Ind.	14,000					Bedford Quarries Co. Circular.
19	Chicago & Bedford Co.	Bedford, Ind.	11,750			147.6	1-28	Gen. Gilmore, Indiana Geological Report, 1878.
20	Dark Hollow Stone Co.	Bedford, Ind.	6,625			142.9	1-19	Gen. Gilmore, Rep. No. 6, State House Com.
21	Dunn & Co.	Bedford, Ind.	6,500			147.0	1-24	Gen. Gilmore, Rep. No. 6, State House Com.
22	Twin Creek Stone Co.	Salem, Ind.	9,900 8,900	3 1	2.51	156.9	1-31	Rose Polytechnic Institute.
23	E. Zink & Son	Salem, Ind.	8,625			144.3	1-22	Gen. Gilmore, Rep. No. 6, State House Com.
24	S. M. Stockslager	Corydon, Ind.	10,250			149.6	1-27	Gen. Gilmore, Rep. No. 6, State House Com.
25		Bowling Green, Ky.	3,000					Min. Res. U. S. 1889-90, p. 396.

One is liable to error in making comparison of the crushing strength of building stones made by different persons, or even by the same person, as the maximum strength of the stone depends upon a number of conditions: 1. On the size of the specimen; a large specimen will give a higher result per square inch than a small one. 2. The shape of the specimen, as shown below. 3. The rate of speed of the machine. 4. The accuracy with which the specimen has been dressed; the more nearly absolutely parallel the higher the results. 5. The method of dressing the specimen. The tests showing difference in transverse strength of tool-dressed and sawed samples made by Mr. Johnson apply as well to crushing tests, as shown experimentally by Gilmore. 6. The seasoning of the specimen. 7. The method of bedding the specimen. 8. The care of the operator in watching all the details of the test; and 9. The accuracy of the machinery. The machines are not all calibrated alike. The above points are not all theoretical, but largely based on experience. Hence comparisons on the basis of crushing strength alone should be made with caution.

The following results by Mr. Hatt will illustrate several of the above points:

*The Relative Crushing Strength of Indiana Limestone in Prisms and Cubes.**—From an examination of the results of J. Bauschinger's investigation of the effect which the shape of a specimen of stone has on its crushing strength, a writer in the "Digest of Physical Tests" for July, 1896, has stated that the strength of a stone prism, whose height is one and one-half times its least lateral dimension, is only 92% that of a cube of the same material. If the normal shearing angle for stone is 60°, this conclusion seems reasonable.

There are here communicated tests on a number of specimens of Indiana oolitic limestone, sawn to cubes (4″x4″x4″) and the prisms (4″x4″x6″). They were tested partly directly after being taken from the paper wrappers and rubbed down by hand with emery to a smooth bed, and partly after having been exposed to the air of the laboratory for one month. Part of the series was tested directly in contact with the beds of the machine, which was a Riehlé machine of 300,000 pounds capacity, run at a speed of one-tenth inch per minute. It is to be noted that the specimens were not well seasoned, and so the results are not given as evidencing the full strength of the stone.

*Presented to the Indiana Academy of Science, December, 1896, by W. K. Hatt.

The average crushing strength of the 17 cubic specimens was.....	4326.7
The average crushing strength of the 14 prisms was	4436.4
Omitting 3 cubical specimens, the strength of the remaining 14 is..	4191
Omitting 3 of the prisms, the strength of the remaining 11 is......	4305
For those tested with plaster bed the average is..................	4239
For those tested without plaster bed the average is...............	4359
For those tested December 17th the average is..................	4385
For those tested before November 18th the average is.............	4274
The average of all specimens is................................	4381.5
The average with six omissions is..............................	4248

In these tests of 31 specimens the six-inch prisms had, under all conditions, a greater strength than the cubes of the same sectional area, and the difference does not amount to three per cent.

The average angle of pyramid of fracture is 64.5 degrees. The results do not sustain the conclusion mentioned above as having been stated in "Digest of Physical Tests."

Fire Tests.—There seemed to be some doubt in regard to the heat-enduring properties of the oolitic limestone, and a series of tests were made for the survey at Rose Polytechnic Institute, with the following results: A sufficient number of specimens from different localities were taken, we think, to fairly represent the whole district. The results appear to be about the same in each test, so that it is not necessary to enumerate the different localities under each test.

It will be seen that the results are all that could possibly be desired or expected, since the samples retained their form uninjured up to and beyond the point of calcination.

The specimens were approximately one-inch cubes, all supported in the same manner on wires placed ¾-inch apart, and all heated under similar conditions in a furnace composed of an iron box surrounded by an iron jacket, leaving a two-inch space on all sides but the front and bottom.

Specimens were taken from the following quarries: G. K. Perry's, Ellettsville; Hunter Valley Stone Co. and Crescent Co., Hunter Valley, Bloomington; Romona Oolitic Stone Co.'s Quarry, Romona; The Chicago and Bedford Stone Co., Reed's Station; The Bedford Indiana Stone Co., Peerless; The Bedford Quarries Co., in the vicinity of Bedford; The Twin Creek Co., Twin Creek, northwest of Salem; The Buff and Blue Oolitic Stone Co., and two localities on the property of the Crafton Stone Co., south of Bloomington, and the quarry of the Indiana Steam Stone Works, on Big Creek, West of Stinesville.

The specimens were first heated until lead melted on their top surface, about 619° F., and cooled slowly in air—all specimens uninjured. Other specimens heated to the same temperature were sprinkled with water and then quenched in cold water—all uninjured.

The same experiment was tried with melting zinc, temperature about 777° F., with the same result—specimens all uninjured.

The specimens were heated until cupric chloride ($CuCl_2$) melted, temperature about 928° F., and some were cooled in air and some sprinkled and quenched in water. The specimens retained their form and were uninjured except a discoloration very slight in some and pronounced in others, due to the oxidation of the iron. Three specimens showed indications of lamination.

They were then heated until aluminum melted on the upper surface, temperature about 1157° F. They were sprinkled and quenched in water. The lower edges crumbled when sprinkled. The upper edges and faces were uninjured.

Some were heated to "cherry red," about 1500° F., and cooled in air, calcination was pronounced, but the specimens retained their cubical form and sharp edges.

Other specimens were heated to the temperature of melting potassium chloride, K Cl, sprinkled and quenched in water. The lower edges went into fine powder (quicklime). The upper edges were uninjured.

These results show pretty conclusively that the oolitic stone is fire-proof up to the point of calcination or turning to quicklime, in which respect it is superior to the average building stone, so far as shown by the published tests. While a few building stones will withstand a temperature above the calcination point of lime uninjured, the greater number will be destroyed at a temperature below that point.

Transverse Strength and Elasticity.—Mr. Johnson made a series of tests on the transverse strength and elasticity of the oolitic limestone, a few of the results of which are given below,* as the original source is not accessible to all.

He tested specimens having approximately one inch cross-section and 14 inches long, by resting them on supports at the ends and applying the load to them on a knife edge in the center. They were all measured accurately in cross-section, most of them varying from a square inch by a small fraction.

AVERAGE RESULTS FROM EXPERIMENTS ON SAWED AND TOOL-DRESSED SAMPLES OF OOLITIC LIMESTONE.

	Load Causing Rupture, in Pounds.	Modulus of		
		Rupture.	Compression.	Elasticity.
Sawed	130	2,338	12,675	4,889,480
Tool-dressed	81	1,477	7,857	2,679,475
Ratio of tool-dressed to sawed	62 per cent.	63 per cent.	62 per cent.	55 per cent.

*Experiments upon the Strength and Elasticity of Building Stones, by Thomas H. Johnson, in the 11th Ann. Rep. Dept. Geol. and Nat. Hist. of Ind., 1881, pp. 34–42.

For the tool-dressed specimens the breaking loads varied between 40 and 110 pounds; for the sawed specimens, from 120 to 150. The modulus of rupture for the tool-dressed specimens varied between 950 and 1,928; for the sawed specimens between 2,187 and 2,593. These results show quite conclusively not only the great elasticity of the stone, but the injurious effects of hammering it in tool-dressing. Mr. Johnson also noted that the strongest stones were the most resonant. All the tool-dressed specimens had a dull sound, while the sawed specimens had a clear, ringing sound. It should be noted that the sawed specimens were taken from different quarries from the tool-dressed ones and part of the difference in the results may be due to inherent qualities in the stone.

Chemical Composition.—The accompanying table gives a record of all the analyses obtainable of the oolitic limestone from different localities. The similarity is remarkable. Thus the percentage of carbonate of lime varies between 95 per cent. and 98.27 per cent., a variation of but little more than three per cent. in 16 different samples from widely separated localities, varying from Romona on the north to near the Ohio River on the south.

The percentage of magnesium carbonate is less than one per cent. in all the specimens except two from Big Creek, and there is a possibility in that case that the greater quantity may be due to error in analysis.

The insoluble residue which includes the silica, insoluble silicates, and organic matter, averages less than one per cent., never as high as two per cent., and only four running over one per cent.

The iron and alumina combined average less than one per cent. The alkalies form a mere trifle.

The last column, headed water, in the two analyses, where it shows more than half of one per cent., includes water and loss on ignition. Probably the greater part in each is due to the unavoidable errors of analysis.

The analyses show the stone to be a lime carbonate of remarkable uniformity and purity. Possibly no other stone in the country would show such a remarkable uniformity of composition over such a wide area.

Thus, from the standpoint of purity, the stone is all that could be desired, only the purest marbles giving a higher percentage of lime carbonate.

CHEMICAL ANALYSIS OF INDIANA OOLITIC LIMESTONE.

Number.	LOCALITY.	Quarry.	Date.	Lime Carbonate, Ca CO_3.	Magnesia Carbonate, Mg CO_3.	Insoluble.	Iron Oxide, Fe_2O_3.	Alumina, Al_2O_3.	Alkalies, K_2O_5. Na_2O.	Water, H_2O.	Total.	Authority.
1	Bedford	Bedford, Indiana Stone Co.	1896	98.27	.84	.64	.15	...	...	...	99.90	W. A. Noyes, Rose Polytechnic Inst.
2	Hunter Valley	Hunter Bros' quarry	1896	98.11	.92	.86	.16	...	...	...	100.05	W. A. Noyes, Rose Polytechnic Inst.
3	Romona	Romona Oolitic Stone Co.	1896	97.90	.65	1.26	.18	...	...	...	99.99	W. A. Noyes, Rose Polytechnic Inst.
4	Twin Creek	Twin Creek Stone & Land Co.	1896	98.16	.97	.76	.15	...	...	...	100.04	W. A. Noyes, Rose Polytechnic Inst.
5	Big Creek	Indiana Steam Stone Works	...	93.80	4.01	.15	.64	...	...	1.09	100.00	L. H. Streaker, State University.
6	Big Creek	Indiana Steam Stone Works	...	93.07	4.22	.50	.71	...	...	1.19	100.00	L. H. Streaker, State University.
7	Bedford	Chicago and Bed. Stone Co.	1878	96.60	.27	.50	.98	...	.40	.61	100.00	Indiana Geological Rep., 1878, p. 95.
8	Bedford	Hoosier Quarry, buff	...	98.20	.39	.63	.39	...	...	...	99.61	Bedford Quarries' Co. Circular.
9	Bedford	Hoosier Quarry, blue	...	97.26	.37	1.69	.49	...	...	...	99.81	Bedford Quarries' Co. Circular.
10	Four miles E. of Spencer	Simpson & Archer	1878	96.79	.23	.70	.91	...	.32	.41	99.90	Indiana Geological Rep., 1878, p. 94.
11	Bloomington	Dunn & Dunn Quarry, white	1881	95.62	.89	1.74	.23	.06	...	.59	99.45	Indiana Geological Rep., 1881, p. 32.
12	Bloomington	Dunn & Dunn Quarry, blue	1881	95.55	.93	1.60	.09	.09	...	.42	99.37	
13	Bloomington	Dunn & Co.	1878	95.54	.40	.65	1.00	...	.55	.25	...	Indiana Geological Rep., 1878, p. 95.
14	Stinesville	Monroe Marble Co.	1862	95.00	.22	.90	3.00	...	.83	.05	100.00	Ind. Geol. Rep., 1862, Owens, p. 137.
15	Salem	...	1886	96.04	.72	1.13	1.06	...	.15	.10	...	Indiana Geological Rep., 1886, p. 144.
16	Harrison Co.	Stockslager's Quarry	1878	98.09	...	.31	.18	.14	.40	.12	...	Indiana Geological Rep., 1878, p. 96.
	Average	...	...	96.50	1.00	.88	.75	...	.17	.29	...	
17	Hardin County, Ill.	Rosiclare Oolitic limestone	1882	90.16	3.18	2.72	1.06	...	...	.15	...	Econ. Geol. of Ill., Vol. I, p. 318.
18	Bowling Green, Ky.	...	1889	95.31	1.12	1.42	.39	...	...	1.76	100.00	Min. Resources U. S., 1889-90, p. 395.
19	Portland, Eng.	...	...	95.16	1.20	1.20	.50	...	...	1.94	100.00	Min. Resources U. S., 1889-90, p. 395.

Durability of Oolitic Limestone.—The Indiana oolitic limestone ranks among the most durable building stones in the market, the proof of its durability being found (1) in the appearance of the stone in the outcrops; (2) in old buildings and monuments; and (3) the chemical and physical tests.

The outcrops of the oolitic limestone are in some places rounded prominences projecting through the soil, in other places bold cliffs along the water courses. These cliffs sometimes show a large face of stone, remarkably regular and even, denoting a stone of great uniformity. As the weathering agencies attack the rock always at the weakest spots, if there are any, the outcrop is frequently irregular from the deeper weathering along seams, joints or lines of weakness. Where the water-course has its channel in the oolitic limestone, it frequently cuts a deep, narrow gorge in which it runs, and sometimes undercuts the rock on one side or the other, forming overhanging bluffs. The number and prominence of the bluffs, the most conspicuous topographic features of the region, indicate its greater durability in comparison with the overlying and underlying rocks.

As the oolitic stone field is a comparatively new one in its larger development, there are not many old structures in which the stone has been exposed for a long period, as is the case with stone in the Eastern States. However, such as have been erected are, without exception, so far as known, in a good state of preservation. The Winthrop Foote vault on the east side of Bedford, constructed in 1840, and the stone chimney on the old homestead of Dr. Foote, built before that date, are the oldest pieces of work in the Bedford stone known to the writer. They are apparently as sound as when first erected, more than fifty years ago. Of the many buildings constructed wholly, or in part, since that time, and of the numerous monuments in the cemeteries, none that are injured in any way, except sometimes by discoloration, have been observed. The same can be said in part of the rock in the old quarry openings south and east of Bedford that were made 40 or 50 years ago. The stone in the dump and on the old quarry face is, as a rule, as sound and firm, and harder than when just quarried. Where the stone lies under the trees, or in well-shaded places, it is covered by a vegetable growth, like all other building stones in similar positions; and in a few of the more recent quarry openings the stone is shelly and exfoliating for a few feet above the water that stands in the quarry, caused, presumably, by the freezing of the wet stone, but in nearly every instance of this kind it is a band of very coarse texture, of coarsely fossiliferous stone, that is shelly, while the fine-grained stone, both above and below it, remains firm. It is said that some of the ground courses in bridge abutments have been known to scale and exfoliate. None such have been seen by the writer, but his opportunity for observation in this line has not been extensive.

The chemical analyses show no marked percentage of elements of weakness in the stone any less stable than lime carbonate, the percentage of alumina and alkali being too minute to affect the strength in any way. The stone is practically a carbonate of lime, one of the most durable substances under ordinary conditions. In contact with acids, however, it is one of the least stable, as it is readily dissolved by any of the acids. For this reason it is liable to tarnish in a city atmosphere where there is much sulphurous coal smoke. However, unless it is in the immediate vicinity of a large furnace or factory, the injury from this cause is little to be dreaded beyond the roughening and sometimes discoloration of the surface.

The numerous fissures, caves, open seams and corrugated surfaces found in the quarries and outcrops are caused by its solubility in acids, as the rainwater absorbs some acid from the air and more from the soil through which it passes, and, acting continuously for ages, it leaches away great quantities of the stone. This action, which is so marked in the stone in its natural position, ceases almost entirely when the stone is placed in the wall, as the circulation of the sap or interstitial water ceases, its load is deposited and many of the pores are closed. The little water that falls on the surface during a rain storm contains but little acid and that under such slight pressure as not to be very active, and of the little that is dissolved by carbonic and sulphuric acids part is redeposited in the pores, tending to make the surface more impervious. It might readily be inferred, then, that i should not be used where it will be exposed to the action of acids. For that reason it is not suitable for the base of bridge-piers in regions where the water is very acidic, as in coal-mining regions.

The physical tests show the stone to be more porous than the average limestone, but in crushing and transverse strength up to or beyond the average; much more flexible and elastic than the average building stone, by means of which it is able to withstand sudden changes of heat and cold without injury, that would cause less elastic stones to crack or crumble. This is shown by the heat tests described above, in which the stone remains intact, uninjured, under heat up to the point of calcination, even standing sudden cooling in cold water from a nearly red heat, that is, a sudden change of nearly a thousand degrees, which is probably as severe a test as any to which a stone could be subjected.

This happy combination of properties, by means of which this oolitic stone, while so soft as to be so easily cut and carved into desired shape, is at the same time so firm and elastic as to withstand the strains put upon it either by its position in the structure or the strain of rapid changes in temperature, makes the stone so valuable for building purposes. This is due probably to its unique texture, as already stated, in which it differs from other sandstones in having the grains cellular and porous in a fine cement. It differs from other limestones in its granular character, consisting of the yielding grains in the finer cement. And furthermore, calcite itself is highly elastic, as shown in the action of many of our marbles.

The Indiana oolitic limestone can unhesitatingly be recommended as one of the most durable building stones in the market, where not exposed to the action of acids. It is fire-proof up to the point of calcination, in which property it can be surpassed by no other limestone and but few other building stones, as very few are absolutely fire-proof.

We cannot refrain at this point from calling attention to the extravagant, boastful and misleading statements made by some previous writers on this subject, statements that are injurious because false. Such statements as the following, by their very extravagance, defeat their object: "This purity insures absolute integrity on exposure to the fumes of coal, while the perfect elasticity and flexibility of the mass render it invulnerable to the forces of cold and heat, air and moisture. Cliffs of this limestone, exposed to our variable climate for unknown centuries, show no sign of disintegration, the finest angles standing out as sharp now as when first the mass was fractured." And from another writer: "At the numerous exposures along the various watercourses, where it has been subjected to the action of the elements for hundreds and thousands of years, it does *not display* in *a single instance* a *tendency* to *disintegrate* or *break down* under prolonged exposure."

To say nothing about the above statements, one only need to visit any of the outcrops to see the absurdity of such statements. Again, the following awe-inspiring statement has been quoted and requoted with an apparent confidence that seemed to settle all doubts: "When we consider to what awful and prolonged frigidity of temperature this rock was exposed during the Glacial age, without in the least affecting its integrity, we may safely trust it in our buildings. Other limestones were cracked, shivered, crushed under the compressions and expansions of the arctic period, while this massive deposit was scarcely changed in any part of its great body." The "awful and prolonged frigidity" of the Glacial age presumably never reached the main body of the oolitic limestone; at least the glacier itself did not. It stopped near the north end of the oolitic region, probably because of the very opposite condition to frigidity, as the best barrier against ice is heat, and likely the warm climate of this part of Indiana stopped the glacier in the extreme north part of Monroe County or beyond by melting its southern end. Furthermore, the part of the oolitic belt that the glacier passed over is not the part that contains the best stone, and again the "other limestones" in the glacial areas are no more "cracked, shivered and crushed under the compressions and expansions of the arctic period" than similar stones are many miles south of the glacial area. The truth in regard to the durability of the oolitic stone is sufficient, and needs no embellishing.

Workability.—The Indiana oolitic limestone probably works as easily and freely as any other building stone in the market, almost rivaling the French Cæn limestone in this respect. While the French stone is a little softer and more easily cut, it is said to be much less durable in a northern climate. Like all freestones, the Indiana stone is much softer when first quarried, hardening on exposure; hence it is more easily sawed or cut to the desired form when fresh than it is after seasoning. Yet while it becomes firm and compact, resonant almost as a metallic substance, calcite in itself being a soft mineral, it never becomes as hard or as difficult to cut as siliceous rocks of equal strength; nor does it become as hard as marble. The lack of grit or siliceous material thus renders the channeling of the stone from the quarry, the sawing of the stone and the cutting and carving of it not only possible, but enables it to be so worked much more economically than almost any other building stone, a saving of both time and wear on the tools when compared with sandstones of equal strength, or granite, or even marble or more compact limestone. Besides being easy to channel, cut or saw, it also splits as readily as almost any other rock, where not locally cross-grained, splitting or breaking readily in any direction, excelling the average building stone in this respect, thus adding to its value for ornamental work. These properties enable it to be removed profitably from a massive bed containing few seams, where a harder stone or one more difficult to work could not be quarried with any profit.

Accessibility.—The Indiana oolitic limestone area is near the center of population of the United States, in the very midst of the Mississippi Valley, which is not only the largest, but destined to be the most productive and populous valley of the world. The area is traversed by one north and south railroad, and four running east and west, besides several branch roads. The topographic features are such that almost every point of the area can be reached by railways at a moderate expense for grading. In evidence of the easy grades, the Monon Railway, running north and south on the entire length of the productive area, was built before the great value of the stone was known. The structural position of the stone, lying, as it does, with a gentle dip to the southwest, makes a larger area of the stone accessible than if it were inclined at a high angle or even perfectly horizontal.

A stone may be inaccessible because of its remoteness from markets, such as large cities or populous districts, or its distance from railroads or other means of transportation, or because of its structural and stratigraphical position. Thus, an intrinsically good building stone in many of the Western States would not be accessible to Eastern markets, even though it were on a railway, because of the excessive freight rates. Throughout North Arkansas are valuable beds of marble, but they are inaccessible, because they are many miles from a railroad. A bed of stone, inclined at an angle of 40 to 60 degrees to the horizon, has but a small part accessible; likewise a bed in a horizontal position, overlain by a very durable rock, is liable to be accessible in very limited areas. The Indiana oolitic limestone, as noted, is not subject to any of these difficulties.

*Stone Observation.**—The observation of stone already used in buildings to determine the ability of stone at hand to withstand time and weathering agencies should include an examination of masonry for effect in bedding planes; abrasion by effect on steps; the water line for effect of water; effect of dust, which always adheres to limestone because of bitumen present; coloration, and if fossils are shown. With regard to the latter, dressed stone rarely shows fossils, but disintegration brings them forth. In the case of abutments, the condition of the stone above and below the water line should be noted. Railroad abutments should also be carefully examined to determine whether or not the masonry has worked

*R. S. B.

loose on account of the continual pounding of passing trains. To prevent this effect a tough, elastic stone should be used. A brittle stone in such abutments often works loose and takes on incipient cracks, eventually causing decay.

Carelessness in laying stone has caused considerable loss in building in this country, and, moreover, has often resulted in a bad effect. Stone has been laid without regard to natural bedding planes. It should be laid in a building as it lies in the ground, otherwise the pressure above will increase its tendency to foliation or splitting. However, if a slant is given to the blocks, the pressure does not cause new bedding because of the force being balanced. The brown stone fronts of New York City were set on edge. The stone split easily and a small amount of it often went a long way in construction work. The pressure from above split the slabs in bedding planes and this, aided by the disintegration of water, has caused an unsightly front, if not an insecure one. The same principle would apply to the oolitic limestone, and care should be exercised by architects in the way the stone is laid.

THE PETROLEUM INDUSTRY IN INDIANA IN 1907.

BY

W. S. BLATCHLEY.

The Petroleum Industry in Indiana in 1907.

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During the year 1907 Indiana took a long step backward in its once leading industry, the production of petroleum. The output for the year was less than for any one since 1900, while the number of wells abandoned was more than three times the number drilled. This great decline was not due to the lack of productive territory, for large areas which undoubtedly contain oil in commercial quantities lie along the border and in the midst of the previous producing Trenton rock field. Rather was it due to the migration of the principal operators to Illinois and other fields where the output per well is much greater than in Indiana. The average oil operator is ever on the lookout for a "gusher" or big producer, and quickly abandons a territory where the wells are light, even though they are lasting and the profits fair, for one which promises a bigger yield per well, though the final profits are less. For that reason and for the further one that there was no material rise in the price of Trenton rock oil during the year, Indiana owes her big slump in oil output. As a very full report,* accompanied by detailed maps, was made on the industry in the State for the year 1906, but brief mention of the more important developments in 1907 will be given in connection with the statistics for the year.

The Trenton Rock Oil Fields of Indiana for the Year 1907.

Grant County.—In this county, which in 1902 and 1903 was the principal seat of operations in the Indiana field, but little new work was done during the year. All the producing bores sunk were light in output, the average initial production of the 103 bores drilled being but 7.5 barrels per well. Much of the productive area in the county yields heavy salt or "blue lick" water, and the gas supply has become so meager that most of the oil must be pumped with steam engines using coal for fuel. Small producing wells can not, therefore, be pumped with profit, and as a

*"The Petroleum Industry in Indiana in 1906," by W. S. Blatchley, *in* Thirty-first Annual Report Indiana Department Geology and Natural Resources, pp. 429-558.

result 418 of them were abandoned, the iron in many of them being pulled and taken to Illinois, where the majority of the former Grant County operators are now located. Should the price of Trenton rock oil materially increase, many of these operators will doubtless return and start new work in the undrilled intervals between the older wells of Grant County. However, the county will never be what it was in the halcyon days of 1903, when the cough of the gas engine and the churn of the drill were heard on every side, and 1,383 bores, or nearly three times as many as were sunk in the entire State in 1907, were put down within its bounds.

Huntington County.—Inside of known productive limits in this county a bore is as sure a venture as one can make anywhere in the United States in the oil business, since of the 976 sunk within the county during the past five years, but 24, or 2.4 per cent, were dry. There was, however, little doing here, as elsewhere, in the extension of new territory in 1907. The number of new bores sunk was but 48, as against 121 in 1906, while 70 old ones were abandoned. The average initial output of the new wells fell from 13.6 to 10.6 barrels, showing that the stored supply is gradually being exhausted.

Wabash County.—This county lies outside the main producing Trenton rock area, and has as yet produced but little oil. In the old Rich Valley pool in Noble Township but two small producers were drilled during the year, while two of the old wells were abandoned. There are but about 25 producing wells left, all of which are very light in yield.

Liberty Township, in the southeastern part of the county and near productive territory in Grant and Huntington counties, also yielded two producers which started at only five barrels each. This area may in the future produce quite a quantity of oil, as the wells just to the east in Huntington have many of them been above the average.

Blackford County.—But 22 new bores were sunk in this county during the year, and no one of them opened up any new territory. Of the 22, three, or 13.6 per cent, were dry, while the initial production of the others averaged but 7.4 barrels each. The number of abandoned wells in the county was 156, or more than seven times as many as were drilled. Montpelier, in the northeastern part of the county, and once the leading oil town in the State, has during recent years lost much of its prestige, the most of the oil well supply stores and part of the offices of the Ohio (Standard) Oil Company having been removed to more promising territory.

Wells County.—This county ranks among the best in the Indiana field. While most of its productive area has been drilled over, there are hundreds of untested locations among the older wells, as well as considerable outlying territory that has had no drilling done on it since the first tests made during the early development of the field. The percentage of dry holes is as low as anywhere in the State, unless it be in Huntington County, and in 1907 it outranked that county in this respect. During the year 122 bores were sunk, of which only two, or 1.6 per cent, were dry. The average initial output of the 120 producing bores was 8.9 barrels, as against 9.4 in 1906, the loss being less than in any other of the larger producing counties. While the number of abandoned wells in the county was 224, this was below the average as compared with the number drilled.

Three or four of the largest producers finished in the State during 1907 were put down in the old developed territory of Jackson Township, one on the Risinger farm, in section 33, starting at 250 barrels, while a second and third on the Younce and Kilander leases, in section 28, made 175 and 150 barrels respectively during the first 24 hours. Such wells as these, in the midst of numerous small ones starting at five to 15 barrels, put new hope in the heart of the operator and go to prove that each new bore, even though surrounded by well drilled territory, is almost as much of a gamble as the rankest wildcat, far outside of productive limits. It is this element of chance, ever present, which adds to the excitement and pleasure of the oil industry, and so tends to keep the beginning operator a life-long devotee before its shrine.

Adams County.—This county has produced Trenton rock oil only in its southern third, but here, as elsewhere, developments were at a minimum during 1907. But 30 bores were sunk, while 125 old wells were abandoned. Of the new ones, four, or 9.1 per cent, were dry, while the average initial output of the others was 5.7 barrels, or four barrels below the average of the Trenton rock field.

Jay County.—This county was the most active in the older Indiana oil district during the year, 152 bores, or more than one-fourth of the total in the Trenton rock area, having been sunk within its bounds. Of these 30, or 19.7 per cent, were dry. This large percentage was due to a number of wildcat bores put down in search of new territory, the majority of which came in barren.

One of the most important of these tests was on the Strong farm, east half of the northwest quarter of section 29, Richland

Township, about three miles southwest of Redkey and the same distance south of Dunkirk. This well is accredited with producing 100 barrels in the first 24 hours. Another test on the Smith lease in the northeast quarter of the same section, finished in October, was even better, starting at the rate of 150 barrels. These two wells are but a few miles northeast of the productive Albany pool in Delaware Township, Delaware County, and denote an extension of that pool in that direction. That the territory is spotted here as elsewhere was shown by a bore on the Murphy farm in the southwest quarter of the same section, which came in dry.

Some new territory was also opened up in the southeastern part of Bear Creek Township, in the northeastern part of the county, where a test bore on the Pape lease started at 75 barrels. No less than 105 of the 152 bores sunk in the county were drilled in Bear Creek Township. Of these 16 were dry, while the average initial output of the others ran about 12.5 barrels. To the prospective operator Jay County offers as good undrilled territory as can be found anywhere in the State. In a number of isolated test bores put down at wide intervals in the county, oil in commercial quantities has been found. The most of these bores were sunk by companies with small capital which could not develop their leases after they had made a fair strike. A list, with localities, of these test bores was published in the 1906 report above cited. There is little doubt but that Jay will continue to produce large quantities of oil as long as the price justifies the sinking of a number of new bores each year.

Randolph County.—The effect of the slump in the Indiana oil industry during the past five years is nowhere more effectively shown than in the record of Randolph and its neighboring county, Delaware, in the once famous Muncie-Selma-Parker field. In the small portion of that field lying in Randolph County there were drilled in 1903, 128; in 1904, 113; in 1905, 80; in 1906, 26, and in 1907, five bores. Of the five sunk in 1907 two were dry, while 71 of the old wells were abandoned.

On the E. and Z. Cecil leases just northeast of Parker, the site of the greatest producing oil pool in the deep pay sand of Indiana, no less than 33 wells were abandoned during the year. This territory was, however, always very spotted, the per cent of dry holes averaging about 40 for the years mentioned. Judging from its past record, Randolph offers little to induce the prospective oil operators to locate within its bounds.

Delaware County.—Nowhere in the State has the petroleum industry shown greater retrogression during the past three years than in Delaware County. The original home of the deep pay bores, it enjoyed a boom during 1904 and 1905 which resulted in a big producing but short lived pool. Backing up an abundance of oil was an inexhaustible flow of salt water which drowned out many of the best wells while yet in their prime. The early operators who were fortunate enough to hold big leases and sell them before the water made its appearance made some money, but the purchasers lost hundreds of thousands of dollars by the quick flooding of the field.

The rise and fall of the industry in the county is graphically shown by the number of producing wells and dry holes sunk during the years 1903 to 1907 inclusive, as follows:

Year.	Producing Wells.	Dry Holes.	Average Initial Output, Bbls
1903	74	48	20.7
1904	831	121	44.4
1905	570	83	32.6
1906	141	39	33.2
1907	49	16	14.6

The best producing well put down in the county in 1907 was a test bore on the Hitchcock lease, in the southwest quarter of section 23, Delaware Township, which is said to have started at 200 barrels. Several other good ones were drilled on the Michaels farm, in section 15 of the same township, where the first deep pay bore was sunk in 1903. During the year 330 of the old producing wells were abandoned, while the number abandoned in 1906 was 208.

If the new producing wells drilled south of Dunkirk, in Richland Township, Jay County, are any criterion, quite an area of productive territory may yet be opened up in the northeast corner of Delaware County, but aside from this there is little hope of locating a new area of any importance within its limits.

The following table gives the output of the Muncie-Selma-Parker field by months for the years 1904 to 1907, inclusive:

Number of Barrels of Oil Piped or Shipped from the Muncie-Selma-Parker Oil Field in 1904 to 1907, Inclusive, by Months.

	1904.	1905.	1906.	1907.
January	42,835	358,483	182,927	74,970
February	33,081	282,773	143,410	70,681
March	40,869	321,650	145,442	72,206
April	46,504	305,129	143,823	72,139

	1904.	1905.	1906.	1907.
May	73,162	320,287	151,860	76,545
June	115,048	311,030	143,309	65,516
July	176,624	277,177	134,479	68,111
August	240,050	255,854	132,482	59,618
September	311,098	230,970	107,129	54,434
October	384,380	218,052	113,151	53,985
November	356,173	210,724	90,742	49,603
December	382,302	200,163	85,905	50,340
Totals	2,202,126	3,292,292	1,574,659	768,148

Madison County.—But little can now be said of the oil industry in this county, though the record for 1907 was better than that for 1906. Only five bores were sunk within its limits during the year, and two of these were barren; the average initial output of the others being 16.6 barrels. Of the old producing wells 25 were abandoned, as against 32 in 1906. The new producers are on the Gray lease in Monroe Township, east of Alexandria. The total output of the Alexandria field during the year was but 64,141 barrels.

Miami County.—In this county there was not a bore sunk in 1907 and but one in 1906. The number of wells abandoned in 1907 was 13, and in 1906, 16, thus showing progression backward at a rapid rate.

Hamilton County.—The isolated pools about Olio and Horton, which were fully described last year, and which at one time created quite an excitement among the oil fraternity, had only three dry holes to their credit during the year 1907. Four of the old producing wells were abandoned. There was produced in the Olio pool and shipped from Noblesville during the year 3,234 barrels, while the Horton pool yielded for the same time 2,961 barrels.

Marion County.—No new bores were sunk or old ones abandoned in this county during the year. Six or seven wells are yet being pumped at intervals on the Wiggins and Lee tracts near Broad Ripple. Their total output for the year was only 556 barrels. There is doubtless quite a quantity of oil yet stored in the Trenton in the immediate vicinity of the old Broad Ripple pool, the limits of which were never clearly defined. The proximity to Indianapolis and the fact that no big wells or "gushers" were struck prevented the rapid growth and greater extension of the pool at the time it was most productive.

STATISTICS OF THE INDIANA TRENTON ROCK PETROLEUM INDUSTRY FOR 1907.

The past year was the third in succession that the output of Trenton rock petroleum fell below what it was the previous year. The loss in 1905 was 388,592 barrels, or 3.4 per cent; in 1906 it was 3,129,613 barrels, or 28.8 per cent, while in 1907 the loss was 2,803,717 barrels, or 36.1 per cent. As already noted, this loss of more than one-third of the production of the previous year was due almost wholly to the small number of new bores sunk, the operators seeking other fields where the prospective outlook was more promising.

The fluctuation in price was less during 1907 than in any other year in the history of the field, there being but four cents difference between the minimum and maximum prices paid. Starting the year at 85 cents per barrel, it held this figure until February 11, when it rose to 87 cents, and again on March 9 to 89 cents, the maximum, which price it held to the end of the year. The average price for the year, taking both days of time and amount received into consideration, was 88 2/5 cents, as against 88 3/5 cents in 1906 and 84 4/5 cents in 1905.

The total production of Trenton rock oil in Indiana in 1907 was 4,959,108 barrels, which, at the average price of 88 2/5 cents, had a value of $4,383,851, this sum being $2,494,006, or 36.2 per cent, less than was received by the producers in 1906.

The first of the following tables gives a complete record of the monthly production of petroleum from the Trenton limestone fields of Indiana for the 17 years beginning January 1, 1891, and ending December 31, 1907. This does not include the amount used in the field for fuel and other purposes, or that wasted by the burning of tanks or the leaking of pipes, but only that shipped or piped by the companies who purchase the oil from the operators. The second table shows the annual production, the average yearly price and the total value by years for the same period:

I. TOTAL PRODUCTION OF TRENTON LIMESTONE PETROLEUM IN INDIANA FROM 1891 TO 1908 BY MONTHS.

(Barrels.)

MONTH.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.
January	6,171	15,841	111,824	259,000	300,568	365,582	290,746	317,014
February	5,981	18,946	96,025	232,107	230,559	241,743	309,922	272,780
March	5,159	24,794	134,549	282,376	310,303	386,586	341,961	325,301
April	4,973	26,184	146,493	287,330	352,077	395,032	328,779	310,034
May	5,757	31,033	186,939	321,502	397,001	417,963	340,023	311,208
June	8,136	40,888	209,616	333,479	403,569	434,167	369,803	320,477
July	10,809	49,203	241,666	327,349	434,376	422,968	375,249	314,861
August	11,603	56,109	248,353	345,031	420,132	407,238	371,921	322,777
September	16,500	66,034	245,615	319,588	409,169	415,675	362,528	326,264
October	19,029	95,699	252,568	339,424	393,153	394,283	408,179	319,490
November	20,801	129,270	245,607	304,030	373,789	337,331	430,958	300,644
December	21,715	144,067	236,038	337,450	361,436	362,164	423,069	300,457
Totals	136,634	698,068	2,335,293	3,688,666	4,386,132	4,680,732	4,353,138	3,751,307

MONTH.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.
January	297,291	353,451	425,140	554,038	651,355	714,594	1,038,324	759,518	471,926
February	220,440	302,493	384,735	460,073	568,789	664,058	804,100	657,201	438,332
March	290,257	364,590	432,922	573,412	724,969	797,133	1,037,320	678,788	447,174
April	325,774	381,804	447,261	579,711	680,921	804,121	964,242	684,810	457,286
May	344,831	426,363	482,118	635,752	751,348	851,071	1,011,859	701,766	466,270
June	334,282	446,492	481,807	633,452	809,438	940,391	1,011,965	692,390	423,333
July	329,086	437,087	506,065	696,911	831,005	998,229	937,960	684,056	446,740
August	347,621	466,127	523,106	697,040	838,615	1,084,560	916,803	673,721	410,881
September	332,283	418,716	519,087	672,611	857,117	1,104,771	840,804	563,100	366,752
October	326,781	467,521	532,960	725,973	873,160	1,139,000	791,881	607,178	369,255
November	326,802	406,684	510,788	656,457	778,323	1,098,832	765,078	547,134	334,146
December	332,266	441,347	479,485	650,131	796,291	1,084,270	772,102	513,163	327,013
Totals	3,807,714	4,912,675	5,725,474	7,535,561	9,161,331	11,281,030	10,892,438	7,762,825	4,959,108

II. PRODUCTION OF TRENTON ROCK PETROLEUM IN INDIANA FROM 1891 TO 1908, WITH VALUE.

	1891.	1892.	1893.	1894.	1895.	1896.
Total production (barrels of 42 gal.)	136,634	698,068	2,335,292	3,688,666	4,386,132	4,680,732
Total value at wells of all oils produced, excluding pipeage	$54,787	$260,620	$1,050,882	$1,774,260	$2,807,124	$2,954,411
Value per bbl	$0 40	$0 37	$0 45	$0 48	$0 64	$0 63

	1897.	1898.	1899.	1900.	1901.	1902.
Total production (barrels of 42 gal.)	4,353,138	3,751,307	3,807,714	4,912,675	5,725,474	7,535,561
Total value at wells of all oils produced, excluding pipeage	$1,871,849	$2,228,276	$3,331,750	$4,740,731	$4,775,045	$6,450,440
Value per bbl	$0 43	$0 59 2/5	$0 87½	$0 96½	$0 83 2/5	$0 85 3/5

PRODUCTION OF TRENTON ROCK PETROLEUM IN INDIANA—Continued.

	1903.	1904.	1905.	1906.	1907.
Total production (barrels of 42 gal.)	9,161,331	11,281,030	10,892,438	7,762,825	4,959,108
Total value at wells of all oils produced, excluding pipeage	$10,457,659	$12,127,107	$9,236,788	$6,877,863	$4,383,851
Value per bbl.	$1 14$\frac{3}{20}$	$1 07$\frac{1}{2}$	$0 84$\frac{4}{5}$	$0 88$\frac{3}{5}$	$0 88$\frac{2}{5}$

From the first of the above tables it will be found by addition that the total production of Indiana Trenton rock oil for the 17 years reached the enormous sum of 90,068,156 barrels, which sold for $75,383,443, or an average of $4,434,320 per year.

In the third table there is shown the number of wells completed in the Indiana Trenton limestone fields by months from June, 1891, to January, 1908:

III. NUMBER OF WELLS COMPLETED IN THE INDIANA TRENTON LIMESTONE OIL FIELDS FROM 1891 TO 1908 BY MONTHS.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
1891	......	......	......	......	......	......	6	6	15	15	15	8	65
1892	11	13	18	13	17	19	17	30	25	52	33	47	295
1893	20	30	31	36	45	47	47	55	27	72	56	76	542
1894	90	103	103	80	110	107	84	123	100	107	97	85	1,189
1895	61	45	81	111	122	153	132	140	129	106	102	85	1,267
1896	76	90	86	136	148	150	113	121	70	58	66	66	1,180
1897	41	35	40	47	49	52	60	45	55	89	119	54	686
1898	41	23	29	43	38	55	53	80	72	82	92	86	694
1899	75	48	68	64	87	99	77	104	106	118	106	105	1,057
1900	113	67	98	148	165	163	158	155	135	152	118	108	1,580
1901	111	72	81	121	167	171	167	169	184	207	220	132	1,802
1902	176	113	169	182	247	297	288	279	323	295	320	243	2,932
1903	168	178	233	236	331	408	377	387	337	366	375	290	3,686
1904	235	157	234	202	296	393	394	383	378	388	320	344	3,724
1905	194	130	149	185	196	157	159	145	130	108	163	166	1,882
1906	135	90	84	68	106	142	120	100	93	69	66	59	1,132
1907	46	40	63	44	49	63	56	52	40	52	38	41	584
Total	......	......	......	......	......	......	......	......	......	......	......	......	24,297

From this table we learn by subtraction that 548 fewer bores were sunk for oil in the Trenton rock fields of Indiana in 1907 than in 1906. This was a loss of 48.4 per cent, as against a loss in 1906 of 39.8 per cent over the previous year.

From the table it may also be learned that up to January 1, 1908, 24,297 bores had been drilled in the Trenton rock fields of Indiana for oil alone. On that date there were 15,210 producing wells in the Trenton rock fields, as against 16,221 on January 1, 1907, a loss of 1,011 for the year.

By subtraction it will be noted that of the total number of bores sunk for oil in the Trenton rock fields of the State, 9,087 have proven dry, or have been abandoned as nonproductive. The number abandoned in 1907 was 1,510, or 472 more than in 1906, while the number of dry holes drilled during the year was 85, or 39 less than in 1906. Of the total number of bores sunk in 1907 14.5 per cent were dry, as against 10.9 per cent of those drilled in 1906 and 12.6 per cent of those sunk in 1905.

The following table shows the number of producing wells, number of dry holes, total bores, average initial production of wells drilled, and number of wells abandoned in each of the Trenton rock oil producing counties of Indiana in 1906 and 1907:

COUNTIES.	Producing Wells, 1906.	Producing Wells, 1907.	Dry Holes, 1906.	Dry Holes, 1907.	Total Bores, 1906.	Total Bores, 1907.	Percentage of Dry Holes, 1906.	Percentage of Dry Holes, 1907.	Av. Initial Output of Productive Wells, Bbls., 1906.	Av. Initial Output Productive Wells, Bbls., 1907.	Abandoned Wells, 1906.	Abandoned Wells, 1907.
Adams	44	30	4	3	48	33	8.3	9.1	10.	5.7	120	125
Blackford	55	19	9	3	64	22	14.0	13.6	12.6	7.4	152	156
Delaware	141	49	39	16	180	65	21.7	24.6	33.2	14.6	208	350
Grant	216	103	20	12	236	115	8.5	10.4	8.1	7.5	307	418
Hamilton	6	0	3	3	9	3	33.3	100.0	26.6	0	2	4
Huntington	121	46	2	2	123	48	1 6	4.1	13.6	10.6	6	76
Jay	178	122	27	30	205	152	13.1	19.7	15.4	11.2	65	72
Madison	2	3	1	2	3	5	33.3	40.0	15.0	16.6	32	25
Miami	1	0	0	0	1	0	0	0	10.0	0.0	16	13
Randolph	18	3	8	2	26	5	30.7	40.0	33.7	18.3	5	71
Wabash	2	4	0	0	2	4	0	0	10.0	5.0	0	2
Wells	224	120	11	2	235	122	4.6	1.6	9.4	8.9	125	224
Henry	0	0	0	10	0	10	0	100.	0	0	0	0
Totals	1,008	499	124	85	1,132	584	*10.9	*14.5	*14.6	*9.7	1,038	1,510

*Denotes average.

From the table it will be seen that in all of the counties the number of productive wells drilled fell off very greatly. For the first time Jay County took the lead in new work, having ranked third in both 1905 and 1906. The average initial output of the new wells fell off 4.9 barrels per well, which was less than the loss in 1906, when it was six barrels per well. The greatest loss was in the initial output of the productive deep pay wells in Delaware County, where it was 18.6 barrels per well. The percentage of dry holes in this county was also much above the average.

Wells still maintains its good record among the older producing counties, there being but two dry holes among the 122 bores sunk within its bounds. This was a percentage of but 1.6, against the average of 14.6 for the field. From a careful study of the table one can learn many other facts of interest regarding the relative importance of each county in the field.

The record of the year as above stated shows that the petroleum industry in the Trenton rock area of Indiana has passed its zenith point in development and output, and the future must reveal a constant decline unless the unexpected happens in the way of discovery of new territory.

Corniferous Rock Petroleum.

The "Coruiferous rock" or Corniferous limestone is the oldest and lowest division of the Devonian system of rocks in Indiana. It ranges up to 65 feet in thickness and is immediately overlain by a thick bed of blackish or brownish shale, known as the New Albany or Genesee shale. This ranges up to 195 feet in known thickness and forms the necessary impervious cover which has retained the oil of the Corniferous in the limestone in which it is found.

Petroleum in commercial quantities is being produced from the Corniferous rocks in Indiana at present only in or near Terre Haute, Vigo County, and northwest of Medaryville, Jasper County. The production from the latter place was never large, and has dwindled in recent years so that it is no longer worthy of record.

Vigo County.—A full and detailed history of the production of oil in this county up to January 1, 1907, was given in the last (Thirty-first) Report of this Department. Only a brief record of the new developments and output for the year 1907 will therefore be given.

The Phoenix well, operated by Prox & Brinkman, and located near the center of the city of Terre Haute, still continues to yield a good supply of oil. This well was finished in May, 1889, and is the oldest and best paying oil well ever sunk in Indiana. For 12 or more years it yielded an average of 1,000 barrels per month. In the last few years this has gradually lessened, and in 1907 it averaged about 425 barrels per month. Two other wells, located but a short distance from the Phoenix, are producing oil from the same stratum at a depth of about 1,660 feet. One of these, known as the McWhinney well, has been a small producer since it was finished in 1899, but was shut down during the greater part of the year. The other was completed by Geo. C. Foulkes in May, 1907, and is located on a lot just across the street from the Phoenix. It started at about 25 barrels, and when pumped yielded about eight barrels per day during the last five months of the year.

The total amount of oil produced from the three wells during the year was 7,098 barrels. This was sold to local consumers at an average price of 94 cents per barrel, the whole amount received being $6,672.

In the so-called Riley field, 10 to 15 miles southeast of Terre Haute, there was much drilling during the year, but the great majority of the bores produced nothing but salt water. The first well in this field was completed by the Vi-Clay Oil Company in November, 1906. It was located on the Joslin tract in the southeast quarter of the northeast quarter of section 23 (11 N., 8 W.), Riley Township, and yielded 132 barrels the first day. On January 1, 1907, the output was about 50 barrels per day. The oil was found about 16 feet below the top of the Corniferous, at a depth of 1,614 feet.

The usual excitement fostered by a new strike in wildcat territory followed the successful shooting of the well. Oil men from everywhere flocked to the vicinity, and leases were taken on hundreds of farms within a radius of 20 miles. The Vi-Clay Company was offered $100,000 for their holdings, but refused that price and let the contract for a second well. During the year 1907 16 bores were completed in Riley Township, only seven of which yielded oil in paying quantities. These started at 20 to 30 barrels each per day and were all located within one mile of the original Joslin well. Five of the seven producers were drilled by the Vi-Clay Company, which sunk the first well.

Mr. E. D. Fagin, of Riley, who was the leading promoter of the first well sunk in the field, has kindly furnished me the data for the following table of information regarding the bores sunk in Riley Township during the year:

RECORD OF BORES SUNK IN RILEY TOWNSHIP (11 N., 8 W.), VIGO COUNTY, IN 1907.

LEASE.	Top of Sand, Feet	Total Depth, Feet.	Character of Well.	Location by Section.
D. Close	1,598	1,614	Producing	W. ½ of S. E. ¼ of N. E. ¼ of 23
Nancy Jeffries No. 1	1,615	1,629	Producing	S. E. of N. E. of 23.
Nancy Jeffries No. 2	1,628	1,641	Producing	S. E. of N. E. of 23.
A. Hixon	1,618	1,639	Producing	N. E. of S. W. of 24.
C. Fox	1,622	1,637	Producing	E. ½ of N. W. of 24.
John Reece	1,644	1,659	Producing	E. ½ of N. W. of 23.
Alma Donham	1,619	1,631	Producing	E. ½ of S. E. of 24.
Z. Stewart	....	....	Dry	E. ½ of N. W. of 22.
E. D. Fagin	1,647	1,709	Dry	W. ½ of S. E. of 13.
H. C. Jeffries	....	1,670	Dry	W. ½ of S. E. of 23.
Emma Coble	....	....	Dry	N. W. ¼ of S. E. ¼ of 24.
D. Swank	....	....	Dry	S. E. of S. E. of 24.
C. Dailey No. 1	....	....	Dry	S. W. of S. E. of 14.
C. Dailey No. 2	....	....	Dry	S. W. of S. E. of 14.
M. E. Hensley	....	....	Dry	N. ½ of S. E. of 9.
E. Shaw	....	....	Dry	N. E. ¼ of 26.

The drive pipe in the Riley Township wells runs from 15 to 40 feet in length, and the $6\frac{5}{8}$-inch casing averages about 1,440 feet. The "pay streak" of the limestone is thin, running only four to seven feet in thickness. The elevation of the surface of the wells is about 622 feet above tide, or 130 feet higher than that of the Phoenix well at Terre Haute. Coal mined in the immediate vicinity is used for fuel, though many of the producing wells would yield sufficient gas for pumping. From January until September 1st the oil was classed with that of the Illinois field and sold at 68 cents per barrel. It is, however, of much higher grade, a fact finally acknowledged by the present purchasers, the Indiana Pipe Line Company, and on September 1st they began paying 89 cents, or the same as paid for the Trenton limestone oil of eastern Indiana. The total amount of oil shipped during the year from the station of Riley, where a loading rack was built, was 20,112 barrels, valued at $15,195.

Besides the nine dry holes drilled in Riley Township during the year, one was sunk just to the south on the Pierson lease in the northwest quarter of section 1, Pierson Township, and another on the Reed tract in Prairie Creek Township, to the southwest. Five dry holes were also drilled in Perry Township, Clay County, in a vain endeavor to extend the Riley pool to the eastward. The cost of each of these completed wells was about $6,000, or $144,000 for the twenty-four bores so far sunk in the Riley field. Besides this amount spent in legitimate drilling, as much or more was paid out for bonuses and for leases on tracts which were never tested. The developments to date show the Riley pool to be extremely spotted territory, and one which only an operator with "money to burn" should tackle.

Clay County.—Besides the dry holes above mentioned as having been sunk in the vicinity of Corey, Perry Township, there were drilled in Clay County during the year the following: One bore to a depth of 2,200 feet on the land of the Excelsior Clay Company, just northeast of the city of Brazil; a second near Center Point, in Center Township, to a depth of 1,300 feet; a third on the Scherbe lease near Clay City, and a fourth near Poland, in Cass Township, in which the top of the Corniferous was found at 1,186 feet. All of these came in dry. The well at Brazil developed a large amount of a very salty mineral water, which a chemical analysis shows to possess excellent medicinal properties.

Sullivan and Knox Counties.—On account of their proximity to the large productive area just across the Wabash River in Illinois, these two counties were the center of much oil excitement during the year. As most of the wells drilled in Sullivan County were sunk for gas, B. A. Kinney, the State Gas Supervisor, has given the principal data available concerning them in his report in another part of this volume. Of those drilled for oil in that county, only three came in as small producers, starting at 10 to 15 barrels each. Two of these were on the Jamison lease in Fairbanks Township, the other on the Coulson tract, section 31, Hamilton Township. Six or seven dry holes were drilled in the immediate vicinity of these producers. The oil is found in a sandstone at a depth of about 750 feet.

In Knox County six test bores were completed during the year, five of which came in wholly barren, while the only producer, one near Little Rock, started at only ten barrels. As far as the results of the year show, the counties of Knox and Sullivan hold out little hope for the prospective oil operator.

Huron Sandstone Petroleum.

Petroleum from the Huron sandstone, one of the upper formations of the Subcarboniferous or Mississippian period, has been produced for a number of years near Princeton, Gibson County, and was formerly produced near Loogootee, Martin County. A full account of the Princeton field to January 1, 1907, with accurate detailed map, was prepared by R. S. Blatchley and published in the 1906 report of this department. Up to the beginning of the year 1907, 176 bores had been sunk in the Princeton field. Of these 44 were wholly dry and 11 were abandoned after producing a short time, leaving 122 producers on January 1, 1907. During the year 1907 only 19 bores were drilled in the field, three of which were dry. The average initial output of the 16 producers was 17 barrels. No one of the new wells increased the limits of the known productive area to any great extent.

The output of the Princeton field by months for the years 1904 to 1907, inclusive, is shown in the following table:

Number of Barrels of Huron Sandstone Oil Piped or Shipped from the Princeton Field in the Years 1904 to 1907, Inclusive, by Months.

	1904.	1905.	1906.	1907.
January	1,412	4,043	8,026	9,163
February	1,399	3,037	6,127	9,875
March	2,920	5,400	7,322	9,534
April	1,319	5,262	9,033	7,713
May	2,047	5,559	8,463	10,894

	1904.	1905.	1906.	1907.
June	2,315	4,523	10,201	10.209
July	2,971	5,569	9,498	9,693
August	2,991	6,296	9,429	11,029
September	3,345	6,141	9,469	8,484
October	3,093	6,865	9,312	11.372
November	4,554	6,116	8,294	10.056
December	3,841	5,395	8,382	8,957
Totals	32,207	64,806	103,843	116,979

By subtraction the gain in the field for the year was 13,136 barrels, or 12.6 per cent, as against a gain of 39,037 barrels, or 60.2 per cent, in 1906. Of the amount produced in 1907, 74,520 barrels were sold to the Indiana Pipe Line Company at an average price of 67.4 cents per barrel, the price being 21 cents lower than that paid for Trenton rock oil during the entire year. The remainder, amounting to 42,459 barrels, was sold to independent purchasers at an average price of 78.3 cents per barrel, the total value of the oil produced in the Princeton field being $83,495 for the year.

Other Counties in Southwestern Indiana.—A number of test bores were sunk in other counties in southwestern Indiana during the year, almost all of which came in barren. One of these was on the Houchins lease in the southwestern part of Patoka Township, Pike County, and about two and a half miles east of Oakland City. It was finished on November 15 to a depth of 1,444 feet.

A bore completed about three miles farther east, near the town of Arthur, produced about ten barrels per day from a formation about 25 feet thick and 1,165 feet deep. Another bore on an adjoining farm and about 400 feet south was barren.

Near Rutherford, Martin County, a small producer was finished in September, but two other bores in the same vicinity were dry. This was not far from the former productive Huron rock wells at Loogootee.

Dry holes or very small producers were also drilled in Vigo, Linton and Washington Townships, Greene County; near Montgomery, Daviess County, and in Fulton Township, Fountain County.

No one of the wells drilled in southwestern Indiana during the year was productive enough to cause much excitement among the leading operators. Hundreds of thousands of dollars were spent in wildcatting in that section of the State, but the results may be classed as wholly negative.

Adding to the output of the Trenton rock petroleum fields that produced by the Corniferous limestone at Terre Haute and Riley, and by the Huron sandstone at Princeton, we find the total production and value of petroleum in Indiana for the last four years to be as follows:

TOTAL PRODUCTION AND VALUE OF CRUDE PETROLEUM PRODUCED IN INDIANA IN THE YEARS 1904 TO 1907 INCLUSIVE.

	1904.		1905.		1906.		1907.	
	Barrels.	Value.	Barrels.	Value.	Barrels.	Value.	Barrels.	Value.
Trenton Rock Petroleum..	11,281,030	$12,127,107	10,892,438	$9,236,788	7,762,825	$6,877,863	4,959,108	$4,383,851
Corniferous Rock Petroleum.......	18,103	21,040	12,064	13,270	7,269	8,456	27,210	21,867
Huron Rock Petroleum..	32,405	28,951	64,806	55,413	103,843	81,770	116,979	83,495
Total....	11,331,538	$12,177,098	10,969,308	$9,305,473	7,873,937	$6,968,089	5,103,297	$4,489,213

REPORT OF THE STATE INSPECTOR OF MINES FOR THE YEAR 1907.

BY

JAMES EPPERSON.

OFFICE OF INSPECTOR OF MINES,
INDIANAPOLIS, IND., February 29, 1908.

Prof. W. S. Blatchley, State Geologist:

Dear Sir—I have the honor to submit to you herewith my ninth annual report as Inspector of Mines, covering the calendar year of 1907, and being the Twenty-ninth Annual Report of this department and the seventeenth made to the Department of Geology and Natural Resources.

I trust it will receive your approval and be found worthy of consideration by the public.

JAMES EPPERSON,
Inspector of Mines.

CONTENTS.

Twenty-ninth Annual Report of the Inspector of Mines for the State of Indiana.

COAL AND LABOR STATISTICS AND GENERAL INFORMATION RELATING TO THE MINING INDUSTRY OF INDIANA FOR THE YEAR ENDING DECEMBER 31, 1907.

The following general subjects have been included or covered in this report, arranged and treated in the following order:

Coal Trade in 1907.
Coal and Labor Statistics.
Mine Casualties.
Legislation Enacted and Recommended Legislation.

Under the head of Coal Trade a general résumé of the coal business for the year is given. Under Coal and Labor Statistics we exhibit tables showing by counties and mines the total production of coal, the different grades of coal, the block and bituminous coal shown separately and the distribution of the product, number of employes, wages, number of mules, number of kegs of powder, average and comparative tables of wages and kegs of powder used, geological tables of new and abandoned mines and strikes. Under Mine Casualties tables are given showing the number of fatal, permanent, serious and minor accidents, causes of accidents, the number of dependents left at each death, the age and occupation of persons killed, the time lost by persons sustaining permanent or serious accidents, a comparative table by years of fatal accidents and accidents to mine property. Under Legislation Enacted we enumerate the different laws enacted in 1907, with comments as to the effect obtained by their passage and enforcement and the attitude of miners toward same. Under Recommended Legislation we advise such new laws as we think should be enacted and certain changes in those now on the statute books. The legislature of 1907 increased the force in this department two additional assistants. This much-needed increase in our force has enabled us to make inspections more complete and more frequent, to more thoroughly investigate accidents, to enforce the mining laws more rigidly, and has been of great help in the general performance of the duties required of the department. Wellington O'Connor, of Terre Haute, Vigo County, and Albert A. Sams, of Chandler, Warrick County, were appointed April 11th, and their work of inspections, reports and enforcement of the mining laws has been entirely satisfactory to this office, and has met the approbation of the miners and operators and other persons concerned.

SUMMARY.

Number of coal seams operated in the State	6
Number of coal producing counties	18
Number of counties having shipping mines	14
Number of new coal companies organized	6
Number of block coal mines	34
Number of bituminous mines	170
Number of new block coal mines opened	4
Number of new bituminous mines opened	9
Number of mines changing ownership	8
Number of bituminous mines abandoned	14
Number of block coal mines abandoned	2
Number of electric chain machine mines	51
Number of compressed air punching machine mines	12
Total number of machine mines	63
Number of hand mines	141
Total number of mines employing more than ten men	204
Number of pick miners	8934
Number of machine runners and helpers	881
Number of loaders	3632
Number of inside day and monthly men employed	3907
Number of outside day and monthly men employed	1655
Total number of mine employes	19,009
Number of mules used	1506
Number of kegs of powder used	476,692
Total number of days the mines have been operated	34,074
Tons hand mined block coal	730,426
Tons machine mined block coal	144,807
Total tons block coal	875,233
Number of tons hand mined bituminous coal	6,200,408
Number of tons machine mined bituminous coal	6,175,074
Total tons of bituminous coal	12,375,482
Total tons of all kinds of coal produced	13,250,715
Tons of coal shipped outside the State	6,138,339
Tons of coal consumed in Indiana	7,112,376
Total wages paid to block mine employes	$1,230,199 23
Total wages paid to bituminous mine employes	$10,487,623 31
Grand total wages paid to mine employes	$11,717,822 54
Total amount of money expended on improvements	$112,982 54
Number of fatal accidents	53

Number of permanent accidents	9
Number of serious accidents	271
Number of minor accidents	171
Total number of accidents to mine employes	504
Number of accidents to mine property	8

GENERAL REVIEW OF COAL TRADE FOR 1907.

Conditions of mining and coal trade during the past year were exceptionally good. The production for the year was 12,375,482 tons of bituminous coal, an increase of 1,700,125 tons, or a fraction over 15.9 per cent over 1906, and 875,233 tons of block coal, an increase of 128,563 tons, or a fraction over 17 per cent in block coal over 1906. The total production for the State was 13,250,715 tons, a gain of 1,828,688 tons over 1906. Of this tonnage 7,112,376 tons was consumed in Indiana and 6,138,339 tons were shipped outside the State. The total wages reported from the bituminous mines was $10,487,623.31, a cost of 84.7+ cents per ton of coal produced.

The total wages reported from the block coal field was $1,230,-199.23, or a cost in wages for production of $1.40 per ton. Selling prices during a greater portion of the year were fair, ranging from a minimum of 88 cents to $1.54 per ton f. o. b. cars at the mine for bituminous mine run coal. A fair average for the year would probably be $1.20 per ton. The prices of block coal ranged from $2.25 to $3.00 per ton for screened coal f. o. b. cars at the mine, $2.60 being a probable average for the year.

There are two important factors which, in addition to a strong demand for coal during a greater portion of the year, played an important part in the large increase in the output, viz., the car service on all the railroads was much better than in former years, and strikes and labor troubles of consequence were comparatively few. These conditions enabled the mines to be operated more days than in former years, resulting not only in an increase in production but a large increase in the total wages earned by mine employes. This report shows a total of 19,009 employes in 1907, a decrease of 453, or a fraction over 2.3 per cent under 1906, and an aggregate of $11,717,822.54 in wages, or $616.43 per mine employe, an increase of $107.05, or a fraction over 24 per cent over the average wages in 1906, showing a higher average earning per employe than ever before in the history of the State.

Considering all of the above conditions and figures, i. e., the strong demand for coal, the large increase in tonnage, the cost per ton for wages, the average selling price and the extraordinary high average earnings per mine employe, both miners and operators evidently enjoyed a more prosperous year in 1907 than they have experienced for several preceding years.

LEGISLATION ENACTED IN 1907.

The legislature adjourning March 8, 1907, enacted the following new mining laws and amendments, all of which were signed by the Governor and went into effect April 11:

Section 1. A statute regulating the use of high explosives, dynamite, dynamite caps, etc., in coal mines.

Section 2. A statute regulating the preparation of shots, drilling holes, charging shots, opening powder kegs, preparing drill bits and prohibiting the use of high explosives in conjunction with black powder.

Section 3. Prohibiting drilling past the cutting or loose end, except in the block coal field.

Section 4. Establishing prima facie evidence in case of violations.

Section 5. Regulating the manner of lighting shots.

Section 6. Pertaining to stairways in escape shafts.

Section 7. Regulating the number of persons permitted to ride on cages.

Section 8. Prohibiting the use of inflammable materials in tamping shots.

Section 9. Relating to employment of shot-firers.

Section 10. Relating to Inspector of Mines assistants, duties, pay, etc.

Section 11. Police power conferred on Inspector of Mines and assistants.

Section 12. Relating to sprinkling roads.

Section 13. Abolishing the issuance of certificates of service.

Section 14. Relating to penalties for violation of statute.

Section 15. Relating to Inspector's failure to perform duties, penalty, number of inspections to be made each year, etc.

Sections 16, 17, 18, 20. Relating to examinations for eligibles and appointment as Inspector of Mines or assistants.

Section 19. Relating to Assistant Inspector of Mines.

Section 21. Defining provisions of laws on coal mining.

Several of the above laws were most strenuously opposed by the miners, chief among which was the statute prohibiting shots from being drilled past the cutting or loose end and limiting the size of drill bits to two and one-half inches in diameter. Notwithstanding the fact that these laws were enacted for the protection and safety of miners, and that under former conditions fatal and serious accidents resulting from smoke explosions and windy or blown out shots were of daily occurrence, the feeling against their enforcement was extremely bitter. It may be said on behalf of the miners that the changes made in mining conditions under the new laws were so radical as compared with former conditions they could hardly be expected to accept the changes without opposition until they had become accustomed to them. There are a large per cent of the miners in Indiana who are non-English speaking people, who with many of the English speaking did not understand or appreciate the full importance of the changed laws nor that they were the beneficiaries. For these reasons I instructed each of my assistants on their first round of inspections after the new laws went into effect not to file prosecutions but to instruct miners as to the new laws and to warn them that the same would be strictly enforced in the future. I regret to say in this connection that the officials of the miners' organization in District No. 11, from the District President down to the members of the executive board and a few mine superintendents and mine operators (the latter were but few), men who were in position to know and appreciate the full importance attached to the new laws enacted, and who should have aided us in securing a peaceful conformance to the statute on the part of the mine employes, used their efforts in the opposite direction and encouraged the opposition in every way possible. This action, coming from such sources, naturally served to increase the bitter feeling.

A special convention was called in District No. 11 on the 8th of July (which was attended by a delegation from District No. 8) and a committee selected to wait on Governor Hanly with a view to secure his aid in the abrogation of the objectionable mining laws. This committee met the Governor on July 15th, President Van Horn acting as spokesman for the miners of District No. 11. Among the many allegations made in explaining their reasons for wishing the annulment of these laws was the fact that more blown-out and windy shots, smoke explosions and accidents to mine employes had occurred since the enforcement of the new laws than before the changes were made; that more powder was required to blast the coal, and that the earning capacity of the miners had been reduced at least one dollar per day. These statements were made without foundation or evidence of any kind tending to show their truthfulness, and were made in some instances by persons who, to say the least, were in position to know the true conditions existing, and who also knew they were not true. A reference to our tables of accidents, tables of powder and the average wage table included in this report discloses the fact that since the enforcement of these laws, beginning in April, not a single accident from windy and blown-out shots or smoke explosions occurred; also that more tons of coal per keg of powder were mined in 1907 than in 1906, and that the total average earnings per pick miner in District No. 11 in 1907 was $627.55, as against $495.92 in 1906, which shows a difference of $131.63, or a fraction over 26 per cent gain per each pick miner in 1907 over 1906. The total average earnings of the block coal pick miners for 1907 was $606.64, as against $484.85 in 1906, a difference of $121.79, or a fraction over 25 per cent gain per each miner in 1907 over 1906. The Governor took no action in the matter other than to inform the committee he had no authority to change the laws, and that the same must be conformed to. Our efforts to secure a conformance to law on the part of the miners, mine bosses, mine superintendents and mine operators without resorting to the courts met with such poor results we were compelled to begin making prosecutions during the month of May.

The following exhibits the number of prosecutions made by this department during the year, and the different causes thereof:

Companies for failure to provide sign boards pointing to manway	1
Engineers for serving without certificate	1
Mine bosses for failure to have break-throughs made	19
Mine bosses for failure to report accidents	25
Mine bosses for failure to provide trappers at mine door	1
Mine bosses for failure to conform to orders given by Inspector of Mines	5
Mine bosses for failure to split air currents	3
Companies for failure to provide fire bosses	10
Companies for failure to provide lamps on shaft bottom	4
Superintendents for failure to provide places of refuge on haulage roads	1
Mine bosses for failure to visit working places as required by law	4
Companies for failure to provide hospital supplies	2
Blacksmiths for violating statute relating to size of drill bitts	8
Miners for opening powder kegs with picks	37
Miners for preparing shots over the maximum thickness provided by law	6
Miners for tamping shots with drill dust	11
Miners for drilling past cutting or loose end	115
Total prosecutions made	253

In each of the above cases, with one exception, a decision was rendered in favor of the State, fines and costs assessed and collected. The exception referred to was the prosecution of the Lower Vein Coal Company for failure to provide a fire boss. The company stood trial, and Mr. Clement Richards, general manager, while admitting the fact that he had operated his mine for about three months without a fire boss, claimed he had tried to employ one (three miners were burned by fire damp during this time), yet he was able to procure one within a few hours after charges were filed against him. Justice of the Peace Brown, before whom the cause was tried, decided in favor of the company.

RECOMMENDED LEGISLATION.

On the matter of future mine legislation we recommend the enactment of the following laws and amendments:

1. Making provision for the better protection of drivers. Providing that each driver shall be furnished with a portable seat which can be attached to either end of a mine car, and prohibiting drivers, miners or other persons from riding on loaded mine cars in any other manner than that which shall be provided by law.

2. Amending the present statute relating to the use of explosives. Providing that all powder kegs, cans or packages containing powder or other explosives shall be stored in boxes, which shall be kept securely closed at all times except when miners are preparing cartridges or charging blasts, and such powder boxes shall not be kept closer than within one hundred feet of any working face.

3. Providing that the statute relating to break-throughs shall be amended to read as follows, to wit: "Break-throughs or air ways shall be made in each pillar between rooms and entries. Such break-throughs must be made not less than six feet wide, unless the conditions of roof, etc., are such as will not permit this width. It shall be the duty of the mine boss to see that at all times the last break-through between rooms or entries is clear of powder boxes, kegs, timbers, slate or other debris."

4. Amending the present statute relating to the examination of mines for fire damp. Providing that the time elapsing from the time a fire boss has examined a working place and the regular hour for the mine to commence work shall not be more than four hours. The fire boss shall keep a record of all the working places examined by him, which shall be entered in a book kept for that purpose, the

said book to be open for the inspection of the Inspector of Mines and the miners working in such mine.

5. Amending the present statute relating to oils used for illuminating purposes in coal mines. Providing a smoke test and equipping the office of supervisors of oils with appliances for making such tests.

LABOR CONDITIONS.

Labor conditions in 1907, taking the State as a whole, were generally satisfactory to all concerned. No strikes of serious consequence occurred, and notwithstanding the fact the year was prolific of many local disputes between operators and miners, resulting in miners being idle, they usually involved only the employes at individual mines and covered periods ranging from but two to ten days, and even these short stoppages of work by reason of strikes were of less frequent occurrence than in former years. It might be well before discussing this subject at length to call attention to a certain factor which has had much to do with the elimination of strikes in coal mines, as well as curtailing the time of their duration. The factor referred to is a clause in the Terre Haute agreement jointly entered into by and between the United Mine Workers of America, District 11, and the Indiana Bituminous Coal Operators' Association and signed by the officials of both organizations. This clause or contract reads as follows: "It is agreed that when miners come out or stay out of the mine for the purpose of redressing a grievance, real or supposed, thus entirely or partially shutting down mine or mines contrary to agreement, each employe so ceasing or refraining from work shall be fined in the sum of one dollar per day during such shut down. The fine thus assessed shall be deducted from each person so offending through the payroll, and this agreement is the company's authority for making such deduction. All money collected as fines shall be divided equally between District 11 U. M. W. of A. and the Indiana Bituminous Coal Operators' Association." Prior to 1906 mines were shut down by employes with impunity, whether their cause was just or not, and the result was a large loss in tonnage produced, days worked and wages earned by employes.

This fact probably renders the above contract one of the most effective ever entered into between the two associations, and the results obtained by a strict enforcement of the same have undoubtedly been gratifying to the conservative miners as well as the operators. This opinion is confirmed by an increase in tonnage produced, an increase in the number of days worked and a large increase in the average yearly earnings of mine employes as indicated by this report.

The following are some of the strikes occurring and a brief statement as to their cause and the manner in which each was adjusted.

During the month of February a strike of three days occurred at the Shirley Hill No. 2 mine, Sullivan County, over the discharge of an employe. The strike was in violation of contract and was settled in favor of the company, and each employe fined one dollar per day for the time the mine was idle.

The employes of the Queen mine, Greene County, were called on strike in February by the state president over the refusal of the company to blow the mine whistle at night as provided by contract. After six days' idleness the matter was adjusted in favor of the miners.

About March 1 the employes at the Fauvre No. 2 mine, Vigo County, went on strike over the company's refusal to make provisions for lowering or hoisting the shot firers into or out of the mine. The matter was adjusted after about eight weeks' idleness, the company and W. D. Van Horn, state president of the U. M. W. of A., District 11, agreeing to permit the night watchman to hoist the shot firers.

During the month of April the drivers at the Forrest Mine, Vigo County, brought on a strike of two days over a division of work on idle days. The strike was in violation of contract, and the matter was settled in favor of the company. The drivers were fined two dollars each.

During the month of June a dispute arose between Vandalia No. 316 employes and the company over the payment for the blackjack which underlies the coal seam. A strike of about one month resulted, and the matter was finally adjusted in favor of the company.

During the same month a dispute over the employment of a driver and a blacksmith came up between the employes of the Citizens Mine, Sullivan County, and the mine management, which resulted in a strike of about seven weeks. The matter was amicably settled.

The employes in the Muren Mine, Pike County, in July, demanded the discharge of the mine boss, and on the company's refusal to conform to the request went on strike. After being idle four months the matter was settled in favor of the miners by the company acceding to the demand.

During the month of July the miners at the Victor Mine went on strike, refusing to handle a certain amount of falling slate without pay. The strike lasted five weeks and was finally settled in favor of the company.

August 5th the miners at the Vandalia No. 67 Mine, Vigo County, went on strike "ostensibly" on account of the poor condition of the ventilation in the mine. A request was made of this department to inspect the mine and the same was made on the 6th by Assistant Inspector O'Connor, and the mine was found in conformance to statute in all respects, the ventilation especially good. This strike was in violation of the contract and the mine resumed operation after an idleness of two days. The miners were fined two dollars each. This money was deducted from the payroll as per contract and twenty-nine of the miners refused to accept payment on pay day and sued the company for payment in full. The matter was referred to P. H. Penna, Secretary of the Indiana Bituminous Coal Operators' Association, and W. D. Van Horn, President of District No. 11, U. M. W. of A., and the executive committees of the two associations, the operators contending for an enforcement of contract and the miners' officials contending for an abrogation of the fine. After much controversy and failure on part of the two committees to agree, the matter was finally referred to National President Mitchell, who confirmed the contract and sustained the position of the company in collecting the fine, and informed the Vandalia Coal Company that they would be reimbursed from the funds in the treasury organization of District 11, U. M. W. of A., for any expense caused by the lawsuits, and that District 11 would collect such expense from the members who brought the suits. Notwithstanding this decision the members bringing suits refused to recede from the position they had taken and persisted in pushing their cause. Last account arrangements were on foot to expel them from the organization.

About the middle of September the miners of the Lattas Creek Mine, Greene County, went on strike refusing to handle a certain amount of falling draw slate without pay. This strike was also in violation of contract and lasted about thirty days. The cause was finally settled in favor of the company and the miners were fined one dollar each.

In October the miners at the Chandler Mine, in Warrick County, went on strike against the fire boss for holding two positions, i. e., he was mining coal during the day and serving as fire boss in the morning before the miners entered the mine. After twenty days' idleness the matter was settled by the company employing a fire boss.

On October 10th (pay day), on account of the stringency in money matters, the Vandalia Coal Company proffered to pay their employes partially in currency and partially in clearing-house checks. The employes refused to accept the checks and went on strike, demanding payment in full in United States currency. Some of the miners were idle six days before the company could meet their demands. On the 25th, following, the same conditions obtained at all of the Dering Mines, a greater portion of the Vandalia Mines and all of the Consolidated Indiana Mines, the miners refusing to accept part of their pay in checks, and a majority of the mines of each company were idle about five or six days.

In the latter part of November the miners of the Summit No. 2 Mine, in Greene County, went on strike and demanded the discharge of the mine superintendent. The company refused to grant the demand and work was resumed after an idleness of eight days, the miners each being fined eight dollars for violation of contract, some of whom sued the company for payment in full.

TABLE SHOWING BY MONTHS AND BY COUNTIES THE NUMBER OF TONS MINED AND WAGES PAID TO EMPLOYES FOR THE YEAR 1907 AT MINES EMPLOYING MORE THAN TEN MEN.

MONTHS.	Clay County.		Daviess County.		Fountain County.	
	Tonnage.	Wages.	Tonnage.	Wages.	Tonnage.	Wages.
January	109,435	$125,716 06	7,505	$7,743 10	7,174	$4,897 39
February	114,272	125,929 01	6,367	10,114 40	4,010	3,433 60
March	96,176	14,664 62	5,929	7,063 72	1,908	2,234 40
April	81,501	96,849 65	6,662	8,268 23	2,740	3,122 01
May	91,094	94,787 48	4,855	5,588 95	2,498	2,442 32
June	87,500	112,447 64	2,209	2,968 47	2,488	2,682 05
July	100,607	119,007 38	1,556	2,348 07	2,469	3,518 17
August	112,308	125,495 95	5,848	2,061 20	3,455	2,825 23
September	113,744	142,747 58	10,610	8,787 18	2,940	3,077 52
October	124,594	136,668 60	11,250	9,629 40	3,277	4,192 75
November	106,841	129,744 42	17,334	10,131 63	3,503	3,597 48
December	92,800	114,669 49	7,260	8,405 35	3,637	3,710 96
Total	1,230,872	$1,338,727 88	87,385	$83,109 70	40,099	$39,733 97

TABLE SHOWING THE NUMBER OF TONS MINED—Continued.

MONTH.	Gibson County.		Greene County.		Knox County.	
	Tonnage.	Wages.	Tonnage.	Wages.	Tonnage.	Wages.
January	14,162	$12,478 08	257,555	$218,452 02	35,776	$34,002 12
February	19,501	18,049 39	210,278	203,778 13	32,368	31,128 01
March	17,928	15,897 00	203,271	174,367 89	35,153	26,871 36
April	18,898	15,512 65	295,810	163,531 19	17,671	27,631 90
May	19,107	17,315 56	204,681	158,758 15	21,948	25,644 95
June	17,035	14,908 77	199,334	144,833 88	33,155	22,047 63
July	19,416	18,493 33	179,115	142,038 28	28,043	20,467 71
August	20,690	19,873 94	208,130	170,052 00	21,994	22,987 39
September	16,788	16,299 45	195,097	172,014 89	30,000	21,576 35
October	24,605	22,110 06	263,938	219,049 53	42,819	29,035 20
November	21,647	21,736 79	247,650	212,429 72	39,684	24,505 20
December	17,911	16,924 15	239,549	209,848 20	26,471	28,921 89
Total	227,688	$209,599 17	2,704,408	$2,189,153 98	375,082	$314,819 71

MONTH.	Parke County.		Perry County.		Pike County.	
January	64,817	$70,897 93	643	$699 15	53,703	$43,631 04
February	49,835	59,180 69	706	766 01	48,333	35,125 65
March	48,483	48,020 22	834	780 04	36,647	32,843 07
April	33,812	49,033 62	825	902 96	32,756	22,791 01
May	54,986	47,726 32	1,035	1,140 48	36,750	30,688 17
June	28,496	36,570 47	1,440	1,625 00	28,010	29,171 97
July	35,228	50,685 43	1,221	1,100 09	26,264	32,362 54
August	69,813	63,801 45	926	1,117 03	26,361	40,440 66
September	65,750	72,048 79	574	627 35	37,106	42,830 41
October	77,874	83,559 17	578	694 71	37,480	34,250 17
November	69,389	83,336 79	284	401 28	33,971	34,007 36
December	56,325	64,633 01	511	673 07	30,551	20,300 00
Total	654,808	$729,493 89	9,567	$10,527 17	427,932	$398,442 05

MONTH.	Sullivan County.		Vanderburgh County.		Vermillion County.	
January	281,863	$243,310 07	31,899	$29,858 15	123,887	$128,538 25
February	219,787	198,788 28	32,256	24,478 85	151,164	122,000 43
March	173,159	149,465 19	20,923	24,768 10	150,657	102,962 43
April	211,854	171,343 25	23,451	21,603 36	102,862	91,823 33
May	201,808	164,775 12	18,791	11,916 72	102,516	95,128 34
June	172,491	146,064 81	16,422	18,263 23	122,359	93,842 57
July	182,215	146,800 52	16,811	17,517 19	114,761	96,194 81
August	193,368	181,459 94	22,139	20,458 84	120 200	101,356 56
September	224,457	210,286 25	26,542	25,288 32	127,933	105,203 30
October	290,643	241,570 80	35,952	45,302 97	145,736	127,132 73
November	290,139	234,818 67	36,064	27,246 63	104,442	95,222 58
December	218,549	175,311 64	29,990	33,586 09	118,574	108,126 47
Total	2,660,333	$2,263,994 54	311,240	$300,288 45	1,485,091	$1,267,531 80

TABLE SHOWING THE NUMBER OF TONS MINED—Continued.

MONTH.	Vigo County.		Warrick County.	
	Tonnage.	Wages.	Tonnage.	Wages.
January	324,384	$288,384 95	39,238	$23,794 76
February	183,325	264,424 98	31,906	31,465 19
March	161,720	138,683 29	37,461	18,722 47
April	264,362	138,702 62	36,218	23,568 14
May	167,428	144,929 45	31,222	26,209 43
June	163,724	140,075 57	30,496	23,475 54
July	157,582	142,098 76	35,839	26,167 31
August	185,824	160,146 50	33,671	24,702 23
September	188,566	165,267 13	40,349	29,978 22
October	223,659	263,865 51	51,188	29,801 93
November	354,155	206,441 32	36,868	30,801 35
December	207,150	193,346 70	50,375	37,346 88
Total	2,581,379	$2,246,366 78	454,831	$326,033 45

NEW DEVELOPMENT.

The amount of capital invested in the development of new mining properties in 1907, as compared with the six preceding years, was exceedingly small. The total development for the year consists of eight shipping mines and five local mines, distributed in the different localities as follows: Clay County, four block and hand mines, two of which are shipping and two local mines. Daviess County, one bituminous hand mine (local). Greene County, one bituminous hand mine. Knox County, one bituminous, compressed air, punching machine mine (shipping). Parke County, two (local) block coal, hand mines. Pike County, one (shipping) bituminous electric machine mine. Sullivan County, one (shipping) bituminous electric machine mine. Vermillion, one (shipping) bituminous, compressed air punching machine mine and Vigo County, one (shipping) bituminous, hand mine. The following table exhibits the names of the companies owning these mines, the names of the mines, the geological number of coal seam mined, thickness of seam in feet and inches, depth and size of hoisting shaft, character of coal, i. e., block or bituminous, whether hand or machine mine, location of mine as to nearest town or city, the railroads on which the shipping mines are located and the date of the first shipment of coal:

TABLE OF NEW MINES.

CLAY COUNTY.

NAME OF COMPANY.	Name of Mine.	Geolog. No. of Seam.	Thickness of Seam.	Character of Coal.	Depth of Shaft.	Size of Shaft	Pick or Machine.	Date of First Shipment.	Location of Mine.	Railroad.
Nick Schefferman	Schefferman	III	4′6″	Block	60	7x14	Pick	Sept. 1, 1907	1½ miles So. Knightsville	Wagon mine.
Hall & Zimmerman	Wizard	III	3′6″	Block	42	8x18	Pick	Jan. 1, 1907	3 miles N. E. Brazil	C. & I.
Crawford Coal Co.	Crawford No. 10	IV	4′6″	Block	128	8x20	Pick	June 3, 1907	4 miles N. W. Brazil	C. & E. I.
Sam Pyria	Pyria	IV	4′	Block	40	8x16	Pick	Jan. 1, 1907	2 miles S. Brazil	Local.

DAVIESS COUNTY.

NAME OF COMPANY.	Name of Mine.	Geolog. No. of Seam.	Thickness of Seam.	Character of Coal.	Depth of Shaft.	Size of Shaft	Pick or Machine.	Date of First Shipment.	Location of Mine.	Railroad.
Wm. Winterbottom	Winterbottom	IV	4′	Bitum.	40	8x12	Pick		2½ miles S. Washington	Local.

GREENE COUNTY.

NAME OF COMPANY.	Name of Mine.	Geolog. No. of Seam.	Thickness of Seam.	Character of Coal.	Depth of Shaft.	Size of Shaft	Pick or Machine.	Date of First Shipment.	Location of Mine.	Railroad.
Mooney, Donnelly & Keers	Mooney	IV	5′	Bitum.	50	8x16	Pick	Nov. 1, 1907	3 miles So. Linton	I. & V.

KNOX COUNTY.

NAME OF COMPANY.	Name of Mine.	Geolog. No. of Seam.	Thickness of Seam.	Character of Coal.	Depth of Shaft.	Size of Shaft	Pick or Machine.	Date of First Shipment.	Location of Mine.	Railroad.
Tecumseh Coal Co.	Tecumseh	V	6′6″	Bitum.	156	9x16	Comp. air. Machine.	July 1, 1907	1 mile E. Bicknell	I. & V.

PARKE COUNTY.

NAME OF COMPANY.	Name of Mine.	Geolog. No. of Seam.	Thickness of Seam.	Character of Coal.	Depth of Shaft.	Size of Shaft	Pick or Machine.	Date of First Shipment.	Location of Mine.	Railroad.
James Moore	Moore	IV	4′	Block	24		Pick		3 miles N. E. Tangier	Local.
William Moore	Moore	IV	5′	Block	Drift.		Pick		4 miles N. E. Tangier	Local.

PIKE COUNTY.

W. S. Little Coal Co.............	Blackburn No. 2...	V	7′	Bitum..	80	9x16	Electric Machine.	Jan. 9, 1907	Rogers........................	E. & I.

SULLIVAN COUNTY.

Shirley Hill Coal Co.............	Shirley Hill No. 3..	VI	5′6″	Bitum..	100	8x16	Machine..	Aug. —, 1907	2 miles W. Dugger...............	C. & E. I.

VERMILLION COUNTY.

Clinton Coal Co..................	Crown Hill No. 3..	VI	6′	Bitum..	340	19x9-6″	Comp. air machine.	Jan. 1, 1907	2 miles S. W. Clinton............	C. & E. I.

VIGO COUNTY.

Coal Bluff Mining Co............	Minshall..........	III	5′	Bitum..	180	9x20	Pick.....	Oct. 4, 1907	½ mile E. Fontanet..............	Big Four.

Note 1. The Dering Coal Company, in March, abandoned the Workings in the No. VII coal seam, which they had exhausted in their No. 8 Mine, Vermillion County. The hoisting shaft was sunk during the summer months to a lower seam, claimed to be No. IV, and shipment of coal resumed in September. This seam lies at a depth of .... feet below No. VII and carries from 4½ to 6 feet in thickness and has all the characteristics of No. IV. The coal is of excellent quality.

Note 2. On April 1st the Oak Hill Coal Company abandoned the workings in the No. VII coal seam, which they had worked out at their Prince Mine, Vermillion County. The hoisting shaft was sunk during the fall months to the No. VI and shipment of coal resumed in December. This seam has an average of 6 feet in thickness and lies at a depth of 330 feet from the surface.

Note 3. The Carlisle Coal and Clay Company (early in the year) abandoned the No. VI coal seam at their Viola Mine, located at Carlisle, Sullivan County, and sunk the hoisting shaft down to No. V. Shipment of coal was resumed in the latter part of December. No. V carries 5 feet in thickness and lies 84 feet below No. VI, which was so badly broken with faults and horsebacks as to render it unprofitable to mine.

CHANGES IN OWNERSHIP.

Changes in the ownership and operation of mining properties were made during the year 1907 as follows:

The Clover Leaf Mine, Sullivan County, formerly owned by the Clover Leaf Coal Company, was purchased by the Shirley Hill Coal Company, who assumed control and operation of the property April 16th.

The Hartwell Mines, Nos. 1 and 2, formerly owned by the Patoka Valley Coal Company, Pike County, were transferred to the Binghampton Trust Company, who assumed control of the properties in August.

The Keystone Mine, formerly owned by the A. H. Whitset Coal Company, Sullivan County, went into the hands of a receiver in July and has not been in operation since that time.

The Chicago No. 7 Mine, owned by the Raccoon Coal and Mining Company, went into the hands of a receiver in August and was idle the remainder of the year.

The Cummins Mine, Sullivan County, owned by the Indiana Southern Coal Company, changed hands in January, being transferred to Ralph Sharp, who operated the mine during the entire year.

The Massey Coal Company was reorganized during the year and the property is now operated under the name of the Peacock Coal and Mining Company.

The Fort Branch Mine, Gibson County, was purchased by William Jackson, who assumed control and operation of the mine in June.

ABANDONED MINES.

Sixteen mines were abandoned during the year, one of which was block and fifteen were bituminous mines. The block coal mine was located in Clay County and the fifteen bituminous mines were located in the different counties as follows: Clay County, two, both hand mines. Greene County, one machine and one hand mine. Knox County, one machine and one hand mine. Parke County, one hand mine. Sullivan County, two machine mines. Vermillion County, four hand mines. Vigo County, one hand mine and Warrick County, one machine mine. The following table shows the names of the mines abandoned, the names of the different companies owning them, the date of abandonment, the county and railroad on which the mines are located.

TABLE.

NAME OF COMPANY.	Name of Mine.	Date of Abandonment.	County.	Railroad.
Vandalia Coal Co	Vandalia No. 63	Jan. 15, 1907	Clay	Vandalia.
Deering Coal Co	Deering No. 15	Jan. 30, 1907	Vermillion	C. & E. I.
Vandalia Coal Co	Vandalia No. 68	Feb. 15, 1907	Vigo	Vandalia.
Consolidated Indiana Coal Co	Consolidated No. 34	Feb. —, 1907	Sullivan	E. & T. H.
J. Wooley Coal Co	Big Vein No. 3	Feb. —, 1907	Warrick	Southern.
J. S. Tiley	Sturm	Feb. —, 1907	Fountain	Clover Leaf.
Vandalia Coal Co	Vandalia No. 40	March 3, 1907	Knox	I. & V.
Vandalia Coal Co	Vandalia No. 316	March 15, 1907	Parke	Vandalia.
Southern Indiana Coal Co	Midland	March 15, 1907	Greene	So. Indiana.
Deering Coal Co	Deering No. 8	March 15, 1907	Vermillion	C. & E. I.
Oak Hill Coal Co	Prince	April 1, 1907	Vermillion	C. & E. I.
Stunkard Coal Co	Stunkard	April 1, 1907	Clay	Local.
Shirley Hill Coal Co	Victoria	April —, 1907	Greene	Monon.
Dan Davis Coal Co	World's Fair No. 2	May 29, 1907	Clay	Vandalia.
Prospect Hill Coal Co	Prospect Hill	July —, 1907	Knox	I. & V.
Shirley Hill Coal Co	Shirley Hill No. 2	Nov. 8, 1907	Sullivan	I. & V.

TABLE

Showing by Counties the Name of Mine, Number of Screened, Slack, Nut and Mine Run Coal, Total Tons of All Grades of Coal Produced, and the Distribution Thereof, the Production of Block and Bituminous Coal, Each Being Shown Separately, as is the Machine and Pick or Hand Mined Coal.

BLOCK COAL MACHINE MINES.

CLAY COUNTY.

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside day men.	To outside day men.	Total wages.
Monarch	....	....	2,534	2,534	....	....	4,922	4,922	7,456	....	$9,031 68	$6,681 37	$2,082 01	$17,795 06
Total	....	....	2,534	2,534	....	....	4,922	4,922	7,456	....	$9,031 68	$6,681 37	$2,082 01	$17,795 06

PARKE COUNTY.

NAME OF MINE.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside day men.	To outside day men.	Total wages.
Mary	60,630	9,356	....	69,986	3,982	959	....	4,941	5,011	69,916	$53,461 85	$25,707 14	$9,411 86	$88,583 85
Total	60,630	9,356	....	69,986	3,982	959	....	4,911	5,011	69,916	$53,461 85	$25,707 11	$9,411 86	$88,583 85

VIGO COUNTY.

NAME OF MINE.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside day men.	To outside day men.	Total wages.
Domestic Block	46,016	6,073	....	52,089	6,303	4,032	....	10,335	19,536	42,888	$55,110 98	$21,599 16	$7,517 68	$84,127 82
Total	46,016	6,073	....	52.089	6,303	4,032	....	10,335	19,536	42,888	$55,010 98	$21,599 16	$7,517 68	$84,127 82

BLOCK HAND OR PICK MINES.

CLAY COUNTY.

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Tons of screened coal.	Tons of slack and	Tons of mine run.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside day men.	To outside day men.	Total wages.
Stunkard							1,489	1,489	1,489		$1,237 01	$480 24	$220 00	$1,937 25
Brazil No. 1					10,796	2,155		12,951	8,815	4,136	12,337 03	5,744 33	5,644 13	23,725 49
Brazil No. 4					42,340	8,650		50,990	8,516	42,474	48,491 46	14,312 04	8,488 14	71,291 64
Brazil No. 8					2,140	425		2,565	352	2,213	2,297 41	1,043 22	936 96	4,277 59
Brazil No. 7					20,974	4,195		25,169	12,436	12,733	24,862 66	6,683 97	5,900 74	37,447 37
Continental No. 1							12,552	12,552	12,552		11,780 79	4,001 78	2,070 47	17,853 04
Rebstock					32,691	9,020		41,711	21,144	20,567	34,611 01	13,461 12	5,267 18	53,339 31
Superior No. 4					38,018	9,250	602	47,870	47,870		44,118 78	14,870 75	7,435 70	66,425 23
Crawford No. 8					10,970	3,080		14,050	5,410	8,640	11,913 65	4,583 99	3,199 80	19,697 44
Crawford No. 9					36,910	9,000		45,910	25,818	20,092	39,577 95	17,939 12	7,073 61	64,590 68
Glenn No. 1					21,593	4,940		26,533	5,706	20,827	22,856 35	6,510 30	2,976 65	32,343 30
Plymouth No. 2					19,832	4,255		24,087	530	23,557	22,351 95	5,740 50	2,814 20	30,906 65
Wizard					17,325	1,805	264	19,394	10,830	8,564	21,203 90	3,714 10	3,763 04	28,681 04
Indiana Block					7,092	767	3,456	11,315	3,858	7,457	9,474 95	3,571 59	2,934 82	15,981 36
Worlds Fair No. 2					1,604	220		1,824	1,824		1,824 54	467 60	902 64	3,194 78
Crawford No. 2					25,747	5,910	33	31,690	12,432	19,258	31,168 68	12,834 03	5,645 15	49,647 86
Harrison No. 4					11,754	3,510		15,264	12,569	2,695	13,281 20	2,440 00	1,440 10	17,161 30
Vandalia No. 50					17,332	6,086		23,418	22,616	802	20,908 51	7,548 66	3,698 32	32,155 49
Eureka No. 5					36,291	7,880	86	44,257	28,334	15,923	37,986 55	10,188 20	7,070 35	55,245 10
Crawford No. 6					40,234	10,500		50,734	15,220	35,514	46,212 41	16,617 70	6,079 76	68,909 87
Treager					8,910	1,459	205	10,574	2,984	7,590	8,776 64	1,270 54	662 50	10,709 68
Progressive					11,647	817	1,742	14,206	12,548	1,658	14,573 07	4,540 43	4,943 00	24,056 50
Crawford No. 4	Idle													
Total					414,200	93,924	20,429	528,553	273,853	254,700	$481,846 50	$158,564 21	$89,167 26	$729,577 97

BLOCK HAND OR PICK MINES—Continued.

PARKE COUNTY.

NAME OF MINE.	Machine Mine.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of screened coal.	Ton of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside day men.	To outside day men.	Total wages.
Brazil No. 9	....	....	....	....	33,735	6,855	....	40,590	16,820	23,770	$39,030 86	$14,390 54	$7,295 91	$60,717 31
Brazil No. 12	....	....	....	....	6,075	1,215	....	7,290	1,184	6,106	7,504 66	4,378 84	2,473 39	14,356 89
Superior No. 1	....	....	....	....	16,557	3,850	85	20,492	....	20,492	16,833 64	6,912 39	3,665 93	27,411 96
Superior No. 2	....	....	....	....	25,267	6,140	123	31,530	....	31,530	30,740 53	12,617 69	6,568 83	49,927 05
Superior No. 3	....	....	....	....	33,837	8,340	....	42,177	....	42,177	37,987 01	12,559 78	6,371 02	56,917 81
Superior No. 5	....	....	....	....	38,294	9,320	....	47,614	....	47,614	51,309 41	15,718 82	7,593 28	74,621 51
Total	....	....	....	....	153,765	35,720	208	189,693	18,004	171,689	$183,406 11	$66,578 06	$33,968 36	$283,952 53

VIGO COUNTY.

NAME OF MINE.	Tons of screened coal.	Ton of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside day men.	To outside day men.	Total wages.
Plymouth No. 1	....	....	....	....	9,487	2,693	....	12,180	8,732	3,448	$12,547 05	$8,874 50	$4,740 45	$26,162 00
Total	....	....	....	....	9,487	2,693	....	12,180	8,732	3,448	$12,547 05	$8,874 50	$4,740 45	$26,162 00

RECAPITULATION.

NAME OF MINE.	Tons of screened coal.	Ton of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside day men.	To outside day men.	Total wages.
Total pick mined block coal	....	....	....	....	577,452	132,337	20,637	730,426	300,589	429,837	$677,799 66	$234,016 77	$127,876 07	$1,039,692 50
Total machine mined block coal	106,646	15,429	2,534	124,609	10,285	4,991	4,922	20,198	32,003	112,804	117,507 51	53,987 67	19,011 55	190,506 73
Total block coal	106,646	15,429	2,534	124,609	587,737	137,328	25,559	750,624	332,592	542,641	$795,307 17	$288,004 44	$146,887 62	$1,230,199 23

BITUMINOUS MACHINE MINES.

CLAY COUNTY

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of screened coal.	Tons of slack and nut.	Tons of mine run	Total tons of all kinds of coal produced.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside day men.	To outside day men.	Total wages.
Gifford No. 1	13,775	1,216	....	14,991	13,168	5,215	....	18,383	11,121	22,243	$25,579 63	$14,912 88	$6,135 51	$46,628 02
Gifford No. 2	18,073	2,947	....	21,020	9,225	5,696	....	14,921	11,980	23,961	21,818 58	12,612 01	5,377 06	39,807 65
Lewis	17,081	25,391	18,321	60,793	....	....	....	....	49,695	11,098	24,344 46	11,664 60	10,560 64	46,569 70
Vivian No. 2	20,568	10,384	48,003	78,955	3,466	1,517	5,640	10,623	64,250	25,308	40,992 47	18,489 19	9,106 15	68,587 81
Gold Knob	21,719	11,984	2,488	36,191	5,749	3,119	527	9,395	38,437	7,179	19,437 18	14,320 01	8,499 09	42,256 28
Total	91,216	51,922	68,812	211,950	31,608	15,547	6,167	53,322	175,483	89,789	$132,172 32	$71,998 69	$39,678 45	$243,849 46

GREENE COUNTY.

NAME OF MINE.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run	Total tons of all kinds of coal produced.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside day men.	To outside day men.	Total wages.
Island Valley No. 4	42,210	22,397	50,086	114,693	122	66	94	282	74,788	40,187	$53,392 46	$16,115 68	$8,198 75	$77,706 89
Black Creek	47,972	24,603	7,067	79,642	48,489	26,099	6,622	81,210	100,224	60,628	90,483 89	28,855 68	10,383 11	129,722 68
Glenburn	3,574	2,040	1,683	7,297	12,171	6,446	4,016	22,633	18,920	11,010	17,527 00	6,236 38	3,194 25	26,957 63
Vandalia No. 2	....	....	80,541	80,541	....	....	118,420	118,420	192,440	6,521	113,518 38	41,167 33	11,013 30	165,699 01
Vandalia No. 5	55,654	29,222	12,914	97,790	47,806	25,337	11,010	84,153	150,274	31,669	108,453 13	35,826 50	15,865 74	160,145 37
Vandalia No. 8	62,361	35,180	70,265	167,806	8,030	4,465	9,338	21,833	180,960	8,679	99,745 61	36,602 47	11,374 63	147,722 71
Vandalia No. 9	45,245	21,779	54,907	121,931	10,998	5,255	12,629	28,882	144,650	6,163	84,895 51	25,783 04	9,479 60	120,158 15
Vandalia No. 21	46,062	27,663	44,019	117,744	....	....	....	....	116,807	937	58,912 48	12,573 41	10,328 07	81,813 96
Gilmour	....	....	101,497	101,497	....	....	....	....	....	101,497	63,528 00	24,611 00	7,752 00	95,891 00
Hoosier No. 1	1,292	644	7,174	9,110	209	....	2,182	2,391	11,501	....	6,150 08	2,730 95	2,118 66	10,999 69
Lattas Creek	101,298	116,642	73,938	291,878	46,179	....	25,165	71,344	....	363,222	201,249 33	62,523 89	20,167 38	283,940 60
Summitt No. 2	75,426	35,886	82,891	194,203	....	....	....	....	177,456	16,747	89,178 08	42,917 10	13,307 01	145,402 19
Green Valley	31,461	18,975	44,723	95,159	....	....	....	....	70,696	24,463	48,004 94	14,108 05	8,091 85	70,204 84
North West	45,498	27,151	20,694	93,343	5,602	3,360	1,550	10,512	79,670	24,185	52,761 09	21,124 22	7,406 68	81,291 99
Twin No. 4	21,030	10 560	14,642	46,232	1,187	555	1,167	2,909	42,639	6,502	24,649 20	11,470 85	3,555 70	39,675 75
Twin No. 5	57,143	22,311	37,977	117,431	6,168	2,779	4,129	13,076	113,155	17,352	64,510 00	17,218 05	9,197 85	90,925 90
Black Hawk	50	18	57	125	1,849	912	3,437	6,198	4,308	2,015	4,279 89	1,482 08	805 03	6,567 00
Total	636,276	395,071	705,075	1,736,422	188,810	75,274	199,759	463,843	1,478,488	721,777	$1,181,239 07	$401,346 68	$152,239 61	$1,734,825 36

BITUMINOUS MACHINE MINES—Continued.

KNOX COUNTY.

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside day men.	To outside day men.	Total wages.
Knox	8,813	5,729	30,248	44,790	....	....	....	....	17,404	27,386	$20,478 31	$9,909 44	$8,747 37	$39,135 12
Lynn	15,170	9,506	27,133	51,809	1,305	684	1,781	3,770	52,946	2,633	25,506 34	10,285 81	7,143 47	42,935 62
Freeman	16,481	6,139	81,759	104,379	....	....	....	....	93,413	10,966	52,192 59	14,288 59	11,823 85	78,305 03
Tecumseh	4,125	1,436	25,170	30,731	....	....	....	....	10,751	19,980	16,109 24	3,458 89	4,393 85	23,961 98
Total	44,589	22,810	164,310	231,709	1,305	684	1,781	3,770	174,514	60,965	$114,286 48	$37,942 63	$32,108 54	$184,337 65

PARKE COUNTY.

NAME OF MINE.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside day men.	To outside day men.	Total wages.
Mecca No. 3	5,352	2,613	4,584	12,549	32,894	16,522	24,256	73,672	62,113	24,108	$54,970 87	$23,121 54	$6,356 42	$84,448 83
Parke No 11	....	....	106,595	106,595	....	....	24,555	24,555	107,276	23,874	66,882 68	25,086 66	9,057 54	101,026 88
Lyford No. 1	7,341	4,335	26,376	38,052	1,931	1,340	31,224	34,495	....	72,547	42,906 32	12,751 22	9,033 78	64,691 32
Total	12,693	6,948	137,555	157,196	34,825	17,862	80,035	132,722	169,389	120,529	$164,759 87	$60,959 42	$24,447 74	$250,167 03

PIKE COUNTY.

NAME OF MINE.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside day men.	To outside day men.	Total wages.
Ayrshire No. 5	4,771	3,319	4,117	12,207	2,922	2,588	10,105	15,615	19,551	8,271	$15,685 25	$6,996 11	$4,381 94	$27,063 30
Total	4,771	3,319	4,117	12,207	2,922	2,588	10,105	15,615	19,551	8,271	$15,685 25	$6,996 11	$4,381 94	$27,063 30

SULLIVAN COUNTY.

Rainbow			66,190	66,190					32,923	33,267	$44,009 00	$12,362 00	$6,132 00	$62,503 00
Phoenix No. 4			97,182	97,182					22,050	75,132	60,965 00	23,667 00	8,728 00	93,360 00
Hocking			46,688	46,688					12,150	34,538	27,665 73	11,931 56	5,825 72	45,423 01
Citizens			13,318	13,318			4,135	4,135	10,453	7,000	12,085 00	4,829 80	2,692 80	19,607 60
Sun Flower	56,325	21,034	4,515	81,874					4,824	77,050	45,127 52	9,607 32	11,251 92	65,986 76
Consolidated No. 25	35,566	17,125	21,045	73,736					22,852	50,884	43,600 79	17,891 74	8,101 32	69,593 85
Consolidated No. 26	10,096	5,021		15,117					3,952	11,165	8,538 43	4,950 02	2,573 40	16,061 85
Consolidated No. 28	2,296		5,848	8,144	27			27	674	7,497	4,543 66	2,794 08	1,123 78	8,461 52
Consolidated No. 30	37,915	25,268	10,907	74,090					21,542	52,548	39,183 44	14,542 34	9,127 54	62,853 32
Consolidated No. 33	115,161	22,652	37,744	175,557	8,774	913	2,018	11,705	31,541	155,721	103,812 06	39,512 73	11,923 75	155,248 54
Consolidated No. 34	1,004		16.815	17,819	117		2,010	2,127	14,365	5,581	8,808 06	4,209 58	1,751 02	14,768 66
Jackson Hill, No. 2	84,746	30,858	87,450	203,054						203,054	100,195 00	34,023 80	12,814 13	147,032 93
Jackson Hill, No. 4	91,380	49,164		140,544						140,544	72,843 04	26,781 22	6,588 84	106,213 10
Dering No. 13	43,768	20,404	50,802	114,974						114,974	52,232 65	32,336 40	8,499 37	93,068 42
Dering No. 14	93,976	72,073	174	166,223						166,223	84,738 68	47,106 29	13,745 98	145,590 95
Mammoth Vein	88,986	58,668	33,712	181,366	279		502	781		182,147	100,364 21	36,706 73	16,292 60	153,363 54
Shirley Hill No. 1	60,720	23,469	22,210	106,399	26,473	10,139	11,282	47,894	154,293		97,915 49	28,550 93	10,917 22	137,383 64
Shirley Hill No. 2	12,054	10,809	10,628	33,491	1,050	956	775	2,781	36,272		25,378 19	12,387 38	5,468 88	43,234 45
Shirley Hill No. 3	1,159	718	2,929	4,806					4,806		3,599 20	2,251 84	2,325 18	8,176 22
Little Giant	9,059	4,044	131,065	144,168	5,628	2,690	89,544	97,862	242,038		135,077 28	46,851 15	14,897 24	196,825 67
Kettle Creek	45,303	23,642	20,198	89,143					73,479	15,664	43,338 86	21,179 61	9,743 45	74,261 92
Reliance	40,722	27,642	2,545	70,909	1,596		12	1,608		72,517	42,648 34	18,225 50	9,582 23	70,456 07
Hamilton	4,624	3,602	9,784	18,010	17,043	13,402	40,298	70,743	3,743	85,010	49,770 07	15,452 11	9,578 22	74,800 40
Clover Leaf	45,772	25,149	17,723	88,644	2,375	677	828	3,880	71,096	21,428	53,352 99	19,804 94	10,204 42	83,362 35
Washington			1,200	1,200					600	600	891 00	294 00	215 00	1,400 00
Vandalia No. 10	75,561	30,846	133,615	240,022	6,739	3,334	16,570	26,643	257,081	9,584	135,564 06	46,739 62	12,997 60	195,301 28
Consolidated No. 32	Idle													
Total	956,193	472,188	844,287	2,272,688	70,101	32,111	167,974	270,186	1,020,734	1,522,120	$1,396,247 75	$534,989 69	$213,101 61	$2,144,339 05

VERMILLION COUNTY.

Crown Hill No. 3	8,999	2,971	4,033	16,003					4,095	11,908	$10,160 87	$3,864 31	$2,627 49	$16,652 67
Total	8,999	2,971	4,033	16,003					4,095	11,908	$10,160 87	$3,864 31	$2,627 49	$16,652 67

BITUMINOUS MACHINE MINES—Continued.

VIGO COUNTY.

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside day men.	To outside day men.	Total wages.
Atherton	31,313	16,432	10,317	58,062	3,563	1,874	1,808	7,245	4,451	60,856	$34,118 39	$20,800 35	$7,022 89	$61,941 63
Parke No. 10	....	....	19,344	19,344	....	....	106,692	106,692	108,698	17,338	72,201 26	28,108 20	11,106 52	111,415 98
Forrest	....	....	91,910	91,910	....	....	....	....	45,760	46,150	59,017 00	17,389 00	8,303 00	84,709 00
Total	31,313	16,432	121,571	169,316	3,563	1,874	108,500	113,937	158,909	124,344	$165,336 65	$66,297 55	$26,432 41	$258,066 61

WARRICK COUNTY.

NAME OF MINE.	Machine Mined.				Pick Mined.				Distribution.		Wages Paid.			
	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Tons of screened coal.	Tons of slack and nut.	Tons of mine run.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside day men.	To outside day men.	Total wages.
Big Four	7,820	5,971	76,544	90,335	....	....	....	....	73,566	16,769	$42,364 34	$11,253 28	$7,449 88	$61,067 50
Electric	....	....	113,461	113,461	....	....	2,856	2,856	57,297	59,020	48,108 39	21,098 37	7,031 33	76,238 09
Dawson	....	....	9,064	9,064	....	....	....	....	3,786	5,278	3,524 23	2,489 22	1,003 22	7,016 67
Chandler	....	....	19,759	19,759	....	....	12,181	12,181	9,511	22,429	15,512 45	4,769 45	2,565 94	22,847 84
Erie Canal	....	....	50,412	50,412	....	....	....	....	35,560	14,862	21,710 86	8,263 34	4,341 28	34,315 48
Menden	4,720	2,531	8,889	16,140	....	....	....	....	16,140	....	7,749 02	2,188 09	1,321 93	11,259 04
Total	12,540	8,502	278,129	299,171	....	....	15,037	15,037	195,850	118,358	$138,969 29	$50,061 75	$23,713 58	$212,744 62

BITUMINOUS HAND OR PICK MINES.

CLAY COUNTY.

NAME OF MINE.	Pick Mined.				Distribution.		Wages Paid.			
	Tons of screened coal.	Tons of slack and nut coal.	Tons of mine run coal.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside Day men.	To outside Day men.	Total Wages paid.
Vandalia No. 60	76,643	46,023	1,991	124,657	124,100	557	$76,220 83	$20,497 95	$8,092 24	$104,811 02
Vandalia No. 65	150,695	76,145	3,569	230,409	194,772	35,637	145,143 69	27,335 56	9,210 34	181,680 59
Fortner	Idle									
Vivian No. 1	375	171	22	568	446	122	348 48	369 60	447 21	1,165 29
Klondyke No. 2	40,979	27,604	5,374	73,957	70,690	3,267	43,385 06	11,724 44	4,738 99	59,848 49
Raccoon	Idle									
Total	268,692	149,943	10,956	429,591	390,008	39,583	$265,098 06	$59,927 55	$22,479 78	$347,505 39

DAVIESS COUNTY.

NAME OF MINE.	Tons of screened coal.	Tons of slack and nut coal.	Tons of mine run coal.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside Day men.	To outside Day men.	Total Wages paid.
Horney	3,442	890	10,619	14,951	14,951		$6,642 76	$1,692 76	$2,545 95	$10,881 47
Montgomery No. 3			38,520	38,520	38,520		13,982 96	6,660 60	4,703 92	25,347 48
Mutual	10,587	2,500	20,827	33,914	23,168	10,746	33,710 00	8,373 25	4,797 50	46,880 75
Mandabach	Idle									
Total	14,029	3,390	69,966	87,385	76,639	10,746	$54,335 72	$16,726 61	$12,047 37	$83,109 70

FOUNTAIN COUNTY.

NAME OF MINE.	Tons of screened coal.	Tons of slack and nut coal.	Tons of mine run coal.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside Day men.	To outside Day men.	Total Wages paid.
Indio	22,223	8,839	4,471	35,533	35,533		$24,014 37	$6,734 90	$5,100 29	$35,849 56
Silverwood		30	4,536	4,566	4,566		2,660 24	688 90	535 27	3,884 41
Total	22,223	8,869	9,007	40,099	40,099		$26,674 61	$7,423 80	$5,635 56	$39,733 97

BITUMINOUS HAND OR PICK MINES—Continued.

GIBSON COUNTY.

NAME OF MINE.	Pick Mined.				Distribution.		Wages Paid.			
	Tons of screened coal.	Tons of slack and nut coal.	Tons of mine run coal.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside Day men.	To outside Day men.	Total Wages paid.
Oswald	49,509	54,380	55,926	159,815	159,815	....	$98,081 02	$37,896 19	$10,823 55	$146,800 76
Fort Branch	3,950	2,684	340	6,974	6,974	....	4,094 58	1,043 82	958 20	6,096 60
Massey	22,928	11,092	26,879	60,899	60,899	....	37,966 26	10,864 98	7,870 57	56,701 81
Total	76,387	68,156	83,145	227,688	227,688	....	$140,141 86	$49,804 99	$19,652 32	$209,599 17

GREENE COUNTY.

NAME OF MINE.	Tons of screened coal.	Tons of slack and nut coal.	Tons of mine run coal.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside Day men.	To outside Day men.	Total Wages paid.
Antioch	12,765	6,605	43,375	62,745	40,597	22,148	$42,079 53	$16,342 14	$7,733 20	$66,154 87
North Linton	9,037	4,947	983	14,967	9,332	5,635	9,941 39	3,218 89	1,694 41	14,854 69
Vandalia No. 3	27,362	14,084	26,527	67,973	66,925	1,048	42,608 95	13,617 03	4,318 98	60,544 96
Vandalia No. 4	33,741	17,640	43,147	94,528	90,217	4,311	58,572 55	12,155 63	4,290 44	75,018 62
Vandalia No. 6	23,801	13,128	25,250	62,179	60,604	1,575	40,393 58	10,481 75	4,067 88	54,943 21
Tower Hill	21,252	12,064	16,661	49,977	....	49,977	31,385 72	8,832 86	4,167 97	44,386 55
Vulcan	1,380	700	11,100	13,180	13,180	....	8,420 30	1,815 41	2,277 56	12,513 27
Victoria	7,110	5,343	1,935	14,388	14,388	....	8,562 83	1,824 04	1,603 73	11,990 60
Queen	5,212	5,105	19,707	30,024	29,349	675	20,133 26	5,346 15	3,809 04	29,288 45
Letsinger	7,091	3,331	16,981	27,403	18,075	9,328	17,221 37	4,271 53	5,087 86	26,580 76
Midvale	6,109	3,092	7,838	17,039	6,104	10,935	11,058 99	2,378 06	1,608 17	15,045 22
Sponsler	8,815	5,479	34,346	48,640	31,477	17,163	30,311 90	7,260 71	4,234 31	41,806 92
Mooney	....	....	1,100	1,100	1,100	....	875 50	129 50	195 50	1,200 50
Total	163,675	91,518	248,950	504,143	381,348	122,795	$321,565 87	$87,673 70	$45,089 05	$454,328 62

KNOX COUNTY.

Pine Knot	4,467	11,668	1,500	17,635	8,634	9,001	$14,654 55	$5,364 00	$2,145 05	$22,163 60
Bicknell	8,732	6,861	24,449	40,042	25,159	14,883	25,190 67	6,809 09	4,676 36	36,676 12
Prospect Hill	....	....	5,760	5,760	5,760	....	3,564 36	2,324 74	888 49	6,777 59
Vandalia No. 40	3,507	2,880	999	7,386	7,386	....	4,834 23	1,396 95	790 84	7,022 02
Wheatland	....	....	68,780	68,780	68,780	....	43,053 73	9,792 10	4,996 90	57,842 73
William Moore	Not reported	....	....	....	....	....	....	....	....	....
James Moore	Not reported	....	....	....	....	....	....	....	....	....
Total	16,706	21,409	101,488	139,603	115,719	23,884	$91,297 54	$25,686 88	$13,497 64	$130,482 06

PARKE COUNTY.

Vandalia No. 316	38,900	21,883	25,439	86,222	81,027	5,195	$64,225 58	$20,760 69	$7,252 20	$92,238 47
Vandalia No. 317	4,893	2,202	43	7,138	4,794	2,344	5,088 49	2,232 78	952 09	8,273 36
Harrison	....	....	6,910	6,910	6,910	....	4,538 75	1,064 90	675 00	6,278 65
Total	43,793	24,085	32,392	100,270	92,731	7,539	$73,852 82	$24,058 37	$8,879 29	$106,790 48

PERRY COUNTY.

Troy	....	....	9,567	9,567	9,567	....	$6,740 51	$2,223 95	$1,562 71	$10,527 17
Total	....	....	9,567	9,567	9,567	....	$6,740 51	$2,223 95	$1,562 71	$10,527 17

PIKE COUNTY.

Muren	100	151	16,634	16,885	....	16,885	$9,687 19	$4,744 59	$2,624 20	$17,055 98
Ayrshire No. 3	32,145	19,298	10,775	62,218	33,153	29,065	34,295 40	11,296 54	6,466 41	52,058 35
Ayrshire No. 4	78,253	55,964	11,889	146,106	73,053	73,053	85,462 63	32,257 53	14,562 24	132,282 40
Rogers	....	....	515	515	515	....	174 25	109 00	52 68	335 93
Blackburn No. 1	....	....	8,739	8,739	7,743	996	5,186 90	1,575 00	1,486 49	8,248 39
Littles	52,531	74,254	12,782	139,567	77,622	61,945	80,329 72	23,568 32	7,197 48	111,095 52
Hartwell No. 1	6,538	2,754	11,382	20,674	15,376	5,298	15,712 76	9,095 33	2,063 00	26,871 09
Hartwell No. 2	....	....	5,406	5,406	5,406	....	17,058 81	4,940 81	1,431 47	23,431 09
Petersburg	Idle	....	....	....	....	....	....	....	....	....
Winslow No. 4	Idle	....	....	....	....	....	....	....	....	....
Winslow No. 5	Idle	....	....	....	....	....	....	....	....	....
Total	169,567	152,421	78,122	400,110	212,868	187,242	$247,907 66	$87,587 12	$35,883 97	$371,378 75

BITUMINOUS HAND OR PICK MINES—Continued.

SULLIVAN COUNTY.

NAME OF MINE.	Pick Mined.				Distribution.		Wages Paid.			
	Tons of screened coal.	Tons of slack and nut coal.	Tons of mine run coal.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside Day men.	To outside Day men.	Total Wages paid.
Semi Block	Idle.									
Cummins			18,664	18,664	5,226	13,438	$12,815 00	$5,054 00	$2,120 00	$19,989 00
Dering No. 12	6,334	5,540	509	12,383		12,383	6,814 25	4,234 97	1,301 43	12,350 65
Superior	9,132	7,154	10,260	26,546		26,546	15,739 55	6,140 33	2,746 27	24,626 15
Keeley	19,743	9,669	2,505	31,917	19,150	12,767	22,514 60	8,228 66	4,987 74	35,731 00
Keystone	17,342	9,365	1,262	27,969	7,392	20,577	17,213 27	5,406 29	4,339 13	26,958 69
Total	52,551	31,728	33,200	117,479	31,768	85,711	$75,096 67	$29,064 25	$15,494 57	$119,655 49

VANDERBURGH COUNTY.

NAME OF MINE.	Tons of screened coal.	Tons of slack and nut coal.	Tons of mine run coal.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside Day men.	To outside Day men.	Total Wages paid.
First Avenue	20,092	12,392	7,141	39,625	39,510	115	$26,548 45	$7,352 41	$6,922 65	$40,823 51
Ingleside	6,398		40,949	47,347	47,347		33,773 15	9,959 20	7,713 68	51,446 03
Sunnyside	23,942	18,909	7,179	50,030	41,616	8,414	29,717 59	9,028 14	9,029 82	47,775 55
Crescent	30,269	24,936	75,150	130,355	130,355		81,367 75	23,768 40	10,738 85	115,875 00
Diamond	22,996	14,207	6,680	43,883	43,883		29,167 27	8,320 55	6,880 54	44,368 36
Total	103,697	70,444	137,099	311,240	302,711	8,529	$200,574 21	$58,428 70	$41,285 54	$300,288 45

VERMILLION COUNTY.

Dering No. 5	56,531	34,405	120,758	211,694	....	211,694	$117,095 04	$46,756 18	$7,701 23	$171,552 45
Dering No. 7	....	....	212,500	212,500	....	212,500	118,147 85	42,358 70	6,941 12	167,447 67
Dering No. 8	11,817	8,146	34,261	54,224	....	54,224	36,682 81	15,795 61	4,197 78	50,676 20
Dering No. 15	....	....	5,709	5,709	....	5,709	3,061 59	1,692 27	601 19	5,355 05
Eureka	....	....	17,558	17,558	....	17,558	11,774 83	3,435 61	1,733 01	16,943 45
Crown Hill No. 1	51,636	16,877	88,077	156,590	31,486	125,104	127,048 87	27,748 50	4,423 87	159,221 24
Crown Hill No. 2	69,056	22,552	95,594	187,202	45,664	141,538	162,378 94	28,801 54	3,626 55	194,807 03
Oak Hill	24,304	14,400	99,858	138,562	....	138,562	79,322 53	23,909 72	8,609 92	111,842 17
Maple Valley	17,010	10,980	139,739	167,729	....	167,729	99,428 94	25,279 06	9,521 35	134,229 35
Buckeye	30,494	19,150	236,823	286,467	....	286,467	166,471 16	33,852 05	9,593 70	209,916 91
Prince No. 1	15,265	8,720	5,848	29,833	....	29,833	18,195 80	6,116 05	2,518 55	26,830 40
Prince No. 2	....	....	1,020	1,020	....	1,020	807 56	769 65	480 00	2,057 21
Total	276,113	135,230	1,057,745	1,469,088	77,150	1,391,938	$934,415 92	$256,514 94	$59,948 27	$1,250,879 13

VIGO COUNTY.

Lower Vein	37,620	19,307	28,530	85,457	85,457	....	$55,200 74	$15,249 60	$7,042 48	$77,492 82
Dering No. 6	59,705	23,850	207,056	290,611	....	290,611	165,496 78	50,477 38	8,216 82	224,184 98
Ray No. 2	37,149	19,036	61,852	118,037	118,037	....	77,591 64	23,951 15	7,669 30	109,212 09
Lawton	122,019	67,677	529	190,225	189,696	529	119,663 25	34,679 35	11,355 75	165,698 35
Grant No. 2	4,696	3,361	90,153	98,210	37,466	60,744	61,305 60	28,945 80	10,423 18	100,674 58
Vandalia No. 66	94,063	67,223	1,499	162,785	157,785	5,000	95,790 36	27,925 42	8,204 73	131,920 51
Vandalia No. 67	136,185	71,298	6,770	214,253	197,485	16,768	138,821 61	30,437 67	9,596 19	178,855 47
Vandalia No. 68	753	593	12	1,358	1,358	....	671 75	484 99	567 21	1,723 95
Vandalia No. 69	74,188	50,519	532	125,239	123,746	1,493	77,901 92	22,787 60	7,372 40	108,061 92
Vandalia No. 81	34,513	27,304	8,885	70,702	45,464	25,238	41,056 54	12,305 27	7,466 18	60,827 99
Chicago No. 6	301	175	1,948	2,424	....	2,424	961 68	283 00	400 00	1,644 68
Miami No. 1	88,580	87,728	24,237	200,545	....	200,545	103,621 89	34,652 83	8,290 24	146,564 96
Miami No. 2	51,964	46,707	14,533	113,204	....	113,204	69,649 43	22,804 52	7,388 80	99,842 75
Miami No. 3	102,562	48,944	43,684	195,190	....	195,190	120,873 20	30,522 91	7,275 59	158,671 70
Fauvre No. 1	26,426	18,728	8,027	53,181	53,181	....	26,425 17	14,771 91	5,913 19	47,110 27
Fauvre No. 2	17,254	10,513	7,059	34,826	34,826	....	17,426 30	7,269 32	5,585 93	30,281 55
Deep Vein	36,522	22,356	31,694	90,572	67,584	22,988	61,030 43	13,646 59	8,710 45	83,387 47
Sugar Valley	4,161	1,433	2,911	8,505	8,505	....	5,407 90	2,273 58	2,369 63	10,051 11
Victor	62,719	39,115	1,306	103,140	103,140	....	56,982 25	10,988 65	6,405 05	74,375 95
Wabash	11,662	7,381	39,161	58,204	54,003	4,201	37,964 00	13,432 80	6,795 75	58,192 55
Minshall	3,549	1,749	1,556	6,854	6,119	735	6,742 60	1,010 45	1,481 65	9,234 70
Total	1,006,591	634,997	581,934	2,223,522	1,283,852	939,670	$1,340,579 04	$398,900 79	$138,530 52	$1,878,010 35

BITUMINOUS HAND OR PICK MINES—Continued.

WARRICK COUNTY.

NAME OF MINE.	Pick Mined.				Distribution.		Wages Paid.			
	Tons of screened coal.	Tons of slack and nut coal.	Tons of mine run coal.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside Day men.	To outside Day men.	Total Wages paid.
Big Vein No. 3	....	....	9,104	9,104	9,104	....	$5,633 45	$1,604 90	$996 65	$8,235 00
Castle Garden	....	....	93,039	93,039	93,039	....	59,476 35	7,556 80	5,186 90	72,220 05
Burke	12,660	6,251	5,180	24,091	24,091	....	14,656 88	2,634 87	1,682 75	18,974 50
Elberfield	....	....	14,389	14,389	14,389	....	9,089 85	2,224 38	2,545 05	13,859 28
Star No. 1	Idle	....	....	....	....	....	....	....	....	....
Total	12,660	6,251	121,712	140,623	140,623	....	$88,856 53	$14,020 95	$10,411 35	$113,288 83

RECAPITULATION.

Showing Total Production and Wages of Indiana Mines for 1907.

TOTAL PRODUCTION OF BLOCK COAL.

	Machine Mined.				Pick Mined.				Distribution.		Wages.			
	Tons of screened coal.	Tons of slack and nut coal.	Tons of mine run coal.	Total tons of all kinds of coal produced.	Tons of screened coal.	Tons of slack and nut coal.	Tons of mine run coal.	Total tons of all kinds of coal produced.	Indiana.	Other states.	To miners.	To inside day men.	To outside day men	Total wages paid.
Total machine mined block coal...........	106,646	15,429	2,534	124,609	10,285	4,991	4,922	20,198	32,003	112,804	$117,507 51	$53,987 67	$19,011 55	$190,506 73
Total pick mined block coal......	....	....	....	....	577,452	132,337	20,637	730,426	300,589	429,837	677,799 66	234,016 77	127,876 07	1,039,692 50
Total block coal	106,646	15,429	2,534	124,609	587,737	137,328	25,559	750,624	332,592	542,641	$795,307 17	$288,004 44	$146,887 62	$1,230,199 23

TOTAL PRODUCTION OF BITUMINOUS COAL.

Total bituminous machine mined coal...........	1,798,590	980,163	2,327,889	5,106,642	333,134	145,940	589,358	1,068,432	3,397,013	2,778,061	$3,318,857 55	$1,234,456 83	$518,731 37	$5,072,045 75
Total bituminous pick mined coal	....	....	....	....	2,226,684	1,398,441	2,575,283	6,200,408	3,382,771	2,817,637	3,867,137 02	1,118,042 60	430,397 94	5,415,577 56
Total bituminous coal	1,798,590	980,163	2,327,889	5,106,642	2,559,818	1,544,381	3,164,641	7,268,840	6,779,784	5,595,698	7,185,994 57	2,352,499 43	949,129 31	10,487,623 31
Total machine mined coal.....	1,905,236	995,592	2,330,423	5,231,251	343,419	150,931	594,280	1,088,630	3,429,016	2,890,865	3,436,365 06	1,288,444 50	537,742 92	5,262,552 48
Total pick mined coal..........	....	....	....	....	2,804,136	1,530,778	2,595,920	6,930,834	3,683,360	3,247,474	4,544,936 68	1,352,059 37	558,274 01	6,455,270 06
Grand Total..	5,052,791	2,677,301	5,520,623	13,250,715	....	....	....	....	7,112,376	6,138,339	$7,981,301 74	$2,640,503 87	$1,096,016 93	$11,717,822 54

TABLE

Showing Number of Miners, Machine Runners and Helpers, Loaders, Inside Day and Monthly Men, Persons Employed Outside; Total Number of Employes at Each Mine, Number of Days Worked and Number of Mules Used; Totals by Counties.

CLAY COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Gifford No. 1	25	4	17	13	9	68	234	5	1,507
Gifford No. 2	25	8	36	22	9	100	115	9	1,051
Lewis	3	16	54	12	8	93	132	5	675
Vivian No. 2	12	12	54	16	5	99	248	8	1,498
Gold Knob	8	10	29	14	9	70	161	4	867
Vandalia No. 60	89			29	12	130	281	7	3,728
Vandalia No. 65	208			47	16	271	260	16	8,271
Fortner (Idle)									
Vivian No. 1	6			5	1	12	49	1	39
Stunkard	11			4	2	17	41	2	119
Klondyke No. 2	61			15	5	81	275	5	3,095
Brazil Block No. 1	20			6	4	30	304	3	910
Lower Vein No. 1 (Idle)									
Brazil Block No. 4	85			23	12	120	201	8	3,426
Brazil Block No. 8	14			5	3	22	46	2	115
Gart No. 7	40			7	6	53	249	3	1,108
Continental No. 1	14			5	5	24	183	2	229
Rebstock	49			23	7	79	269	7	2,151
Superior No. 4	70			19	6	95	253	5	3,146
Crawford No. 8	26			5	4	35	235	2	1,062
Crawford No. 9	65			16	5	86	277	6	3,327
Glen No. 1	35			8	5	48	221	4	1,519
Plymouth No. 2	36			6	4	46	258	2	2,274
Monarch	20			2	2	24	295	1	704
Indiana Block	24			4	4	32	197	2	679
Worlds Fair No. 2	21			3	3	27	69	1	101
Crawford No. 2	37			16	7	60	263	4	1,868
Harrison No. 4	26			3	3	32	203	2	699
Vandalia No. 50	37			12	5	54	250	3	1,497
Eureka No. 5	66			15	7	88	236	5	3,734
Crawford No. 6	73			19	7	99	254	9	3,750
Treager	11			2	1	14	255	1	670
Progressive	15			2	1	18	182	1	1,312
Wizard	33			6	4	43	199	3	871
Raccoon (Idle)									
Total	1,265	50	190	384	181	2,070	6,695	138	56,002

DAVIESS COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Horney	8			1	2	11	175	1	382
Montgomery No. 3	27			8	6	41	220	4	1,098
Mutual	63			15	8	86	211	7	2,399
Mandabach (Idle)									
Total	98			24	16	138	606	12	3,879

Table Showing Number of Miners, Machine Runners and Helpers, Etc.—Con.

FOUNTAIN COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Indio	39	......	......	12	6	57	206	6	1,394
Sturm	18	......	......	2	2	22	43	2	233
Total	57	......	......	14	8	79	249	8	1,627

GIBSON COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Oswald	94	......	......	49	11	154	278	19	5,758
Fort Branch	8	......	......	2	3	13	125	1	297
Massey	74	......	......	17	7	98	182	11	3,805
Total	176	......	......	68	21	265	585	31	9,860

GREENE COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Island Valley No. 4	7	14	64	16	9	110	172	7	1,150
Black Creek	68	8	35	41	10	162	181	15	3,935
Glenburn	66	2	7	22	8	105	79	8	921
Vandalia No. 2	130	12	23	71	18	254	252	21	6,404
Vandalia No. 5	99	32	66	70	29	296	252	16	3,972
Vandalia No. 8	18	22	123	58	16	237	222	16	2,333
Vandalia No. 9	35	10	68	45	14	172	257	14	2,894
Vandalia No. 21	......	30	85	25	15	155	268	6	1,371
Gilmour	31	14	94	53	15	207	151	14	2,929
Hoosier No. 1	17	8	27	18	10	80	49	4	214
Lattas Creek	66	26	127	78	25	322	261	18	5,696
Summitt No. 2	10	18	96	50	11	185	229	22	1,822
Green Valley	......	12	66	19	9	106	152	8	999
North West	11	14	62	34	12	133	179	11	1,273
Twin No. 4	8	6	33	17	6	70	163	6	436
Twin No. 5	11	16	81	23	9	140	158	9	1,253
Antioch	51	......	......	18	8	77	210	9	4,052
Sponsler	56	......	......	13	6	75	108	8	2,026
North Linton	45	......	......	12	4	61	83	6	821
Vandalia No. 3	107	......	......	19	7	133	135	13	2,611
Vandalia No. 4	94	......	......	28	10	132	150	9	3,785
Vandalia No. 6	42	......	......	17	6	65	240	5	2,647
Tower Hill	116	......	......	18	8	142	57	5	2,098
Vulcan	27	......	......	5	5	37	79	3	674
Victoria	12	......	......	5	6	23	87	2	390
Queen	35	......	......	9	6	50	193	4	1,755
Letsinger	33	......	......	5	4	42	143	3	901
Midvale	59	......	......	13	10	82	70	3	736
Total	1,254	244	1,057	802	296	3,653	4,680	265	60,098

KNOX COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Vandalia No. 40	25	......	......	7	5	37	30	3	407
Knox	6	8	27	11	12	64	220	4	796
Lynn	7	4	25	12	9	57	227	5	829
Pine Knot	60	......	......	19	10	89	56	7	800
Freeman	......	12	50	16	11	89	192	5	1,429
Tecumseh	......	14	20	7	10	51	144	2	504
Bicknell	48	......	......	17	9	74	121	9	2,247
Prospect Hill	13	......	......	7	5	25	86	2	284
Wheatland	69	......	......	14	7	90	211	7	3,631
Total	228	38	122	110	78	576	1,287	44	10,927

Table Showing Number of Miners, Machine Runners and Helpers, Etc.—Con.

PARKE COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Mecca No. 3	74	10	7	32	9	132	237	14	3,869
Parke No. 11	20	26	57	35	11	149	226	9	1,988
Lyford No. 1	57	24	39	18	11	149	257	6	2,828
Vandalia No. 316	95	......	......	38	12	145	195	14	3,743
Vandalia No. 317	29	......	......	14	6	49	36	6	251
Harrison (not reported)	......	......	......	......	......	......	......	......	....
Mary	10	16	51	37	12	126	242	12	685
Brazil Block No. 9	65	......	......	27	8	100	198	10	2,626
Brazil Block No. 12	27	......	......	11	7	45	101	3	590
Superior No. 1	22	......	......	4	3	29	264	2	583
Superior No. 2	41	......	......	16	7	64	260	5	1,998
Superior No. 3	66	......	......	15	5	86	231	6	3,011
Superior No. 5	69	......	......	15	6	90	267	6	4,486
William Moore (New mine, not reported)	......	......	......	......	......	......	......	......	....
James Moore (New mine, not reported)	......	......	......	......	......	......	......	......	....
Total	575	76	154	262	97	1,164	2,514	93	26,658

PERRY COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Troy	11	......	......	3	2	16	248	2	308
Total	11	......	......	3	2	16	248	2	308

PIKE COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Carbon	25	......	......	10	5	40	212	6	989
Ayrshire No. 3	53	......	......	16	9	78	209	9	2,442
Ayrshire No. 4	143	......	......	42	20	205	210	19	7,138
Ayrshire No. 5	20	6	31	9	13	79	156	6	1,059
Rogers	9	......	......	2	1	12	25	1	13
Blackburn No. 1	41	......	......	8	6	55	58	5	452
Littles	141	......	......	32	12	185	190	15	6,824
Hartwell No. 1	75	......	......	17	12	104	90	6	1,282
Hartwell No. 2	48	......	......	9	3	60	152	5	1,336
Petersburg (Idle)	......	......	......	......	......	......	......	......	....
Total	555	6	31	145	81	818	1,302	72	21,535

Table Showing Number of Miners, Machine Runners and Helpers, Etc.—Con.

SULLIVAN COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Rainbow	2	18	100	31	16	167	106	13	2,346
Phœnix No. 4	......	18	96	46	16	176	140	16	3,539
Hocking	10	16	80	40	23	169	96	15	1,711
Citizens	12	10	35	17	9	83	129	6	963
Sunflower	1	12	70	18	10	111	94	8	709
Consolidated No. 25	10	12	18	20	12	72	240	5	1,285
Consolidated No. 26	5	12	52	15	13	97	46	7	285
Consolidated No. 28	2	4	29	19	9	63	50	6	134
Consolidated No. 30	......	12	59	21	13	105	144	9	948
Consolidated No. 33	17	22	121	63	14	237	182	29	2,230
Consolidated No. 22 (Idle)	......	......	......	......	......	......	......	......	......
Consolidated No. 34	12	12	66	24	13	127	24	8	1[illegible]2
Keystone	40	......	......	13	8	61	116	5	910
Jackson Hill No. 2	......	20	105	35	17	177	204	17	1,741
Jackson Hill No. 4	......	16	85	33	13	147	211	15	1,437
Dering No. 13	......	16	64	28	12	120	225	9	1,397
Dering No. 14	......	22	102	58	28	210	225	22	1,439
Semi Block (Idle)	......	......	......	......	......	......	......	......	......
Mammoth Vein	......	16	93	52	22	183	243	13	1,767
Shirley Hill No. 1	47	10	55	37	13	162	269	12	4,326
Shirley Hill No. 2	4	6	25	19	9	63	189	4	561
Shirley Hill No. 3	......	2	8	5	7	22	107	1	149
Little Giant	105	14	97	59	19	294	252	18	6,562
Kettle Creek	4	10	64	24	9	111	157	12	912
Reliance	......	14	60	24	10	108	191	7	1,027
Diamond No. 1	67	10	12	18	9	116	224	5	3,482
Black Hawk	31	4	12	4	4	55	40	2	348
Clover Leaf	7	13	61	29	11	121	185	9	1,315
Washington	10	4	23	14	15	66	12	4	45
Cummins	29	......	......	11	5	45	183	5	898
Vandalia No. 10	11	18	136	76	19	260	252	17	3,287
Dering No. 12	49	......	......	22	9	80	57	7	699
Hudson	87	......	......	36	9	132	117	5	1,471
Keeley	49	......	......	18	9	76	150	6	1,691
Total	611	343	1,728	929	405	4,016	4,860	317	49,766

VANDERBURGH COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
First Avenue	38	......	......	8	8	54	279	5	1,667
Ingleside	49	......	......	13	11	73	307	7	2,420
Sunnyside	48	......	......	13	8	69	197	10	1,954
Crescent	112	......	......	36	12	160	270	22	7,181
Diamond	39	......	......	10	10	59	243	5	1,668
Total	286	......	......	80	49	415	1,296	49	14,890

Table Showing Number of Miners, Machine Runners and Helpers, Etc - Con

VERMILLION COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Dering No. 5	152	......	......	49	7	208	245	19	13,309
Dering No. 7	150	......	......	46	15	211	262	21	12,552
Eureka	17	......	......	5	2	24	199	5	693
Crown Hill No. 1	140	......	......	25	9	174	236	16	10,419
Crown Hill No. 2	168	......	......	25	9	202	267	16	14,434
Crown Hill No. 3	......	8	9	6	4	27	298	1	190
Oak Hill	117	......	......	31	9	157	175	14	9,056
Maple Valley	104	......	......	25	9	138	259	12	10,124
Buckeye	261	......	......	48	10	319	209	21	18,965
Prince No. 1	97	......	......	34	9	140	60	12	2,192
Dering No. 8	145	......	......	22	9	176	143	7	3,165
Dering No. 15	100	......	......	10	6	116	21	10	412
Prince No. 2	20	......	......	5	4	29	25	2	20
Total	1,471	8	9	331	102	1,921	2,399	156	95,531

VIGO COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Dering No. 6	226	......	......	51	12	289	229	24	16,429
Plymouth No. 1	17	4	12	4	5	42	264	2	1,361
Atherton	7	10	32	16	9	74	192	6	1,155
Parke No. 10	90	16	20	35	15	176	225	14	4,808
Ray No. 2	122	......	......	27	9	158	154	11	4,415
Forrest	54	22	51	37	17	181	166	14	3,959
Lawton	197	......	......	51	15	263	253	35	6,416
Grant No. 2	99	......	......	41	12	152	211	20	5,079
Vandalia No. 66	120	......	......	42	16	178	277	12	6,947
Vandalia No. 67	187	......	......	52	15	254	233	20	7,912
Vandalia No. 68 (Not reported)	......	......	......	......	......	......	......	......	62
Chicago No. 6	17	......	......	3	2	22	57	2	93
Vandalia No. 69	104	2	1	41	11	159	276	10	6,740
Vandalia No. 81	59	......	......	22	12	93	278	9	3,676
Miami No. 1	147	......	......	34	10	191	262	18	7,788
Miami No. 2	111	......	......	17	7	135	260	9	4,655
Miami No. 3	171	......	......	32	9	212	243	15	7,341
Fauvre No. 1	46	......	......	11	5	62	291	5	2,172
Fauvre No. 2	30	......	......	6	7	43	239	2	1,880
Deep Vein	80	......	......	17	9	106	195	9	5,795
Sugar Valley	10	......	......	4	3	17	219	1	508
Victor	105	......	......	13	9	127	224	5	3,736
Wabash	44	......	......	10	8	62	218	4	2,862
Minshall	25	......	......	5	7	37	75	2	363
Domestic Block	19	12	52	36	16	135	221	8	1,365
Lower Vein No. 1	83	......	......	36	12	131	265	7	5,033
Total	2,170	66	168	643	252	3,299	5,527	264	112,550

WARRICK COUNTY.

NAME OF MINE.	Pick Miners.	Machine Runners and Helpers.	Loaders.	Inside Day and Monthly Men.	Outside Day Men.	Total Employes.	Days Worked.	Mules Used.	Powder.
Menden	......	4	10	3	3	20	182	2	265
Big Four	......	12	37	15	12	76	247	12	1,158
Big Vein No. 3	20	......	......	10	6	36	30	2	8
Electric	13	10	53	33	11	120	246	15	2,274
Dawson	......	10	24	9	5	48	144	5	209
Erie Canal	3	8	37	16	7	71	181	5	848
Chandler	25	6	12	7	5	55	189	4	959
Castle Garden	61	......	......	10	8	79	291	4	5,548
Star No. 1 (Idle)	......	......	......	......	......	......	......	......	......
Brizius	28	......	......	5	5	38	170	3	1,123
Elberfeld	27	......	......	4	5	36	146	3	669
Total	177	50	173	112	67	579	1,826	55	13,061
Grand Total	8,934	881	3,632	3,907	1,655	19,009	34,074	1,506	476,692

TABLE

Exhibiting a Comparative Statement of Total Tons of Coal Produced, Total Number of Employes, Total Wages Paid and Per Cent. Gain or Loss in Number of Employes, Tons of Coal Produced and Wages Paid in the Block Coal Mines for each year from 1901 to 1907.

BLOCK COAL MINE

YEAR.	Employes.	Per Cent. Gain.	Per Cent. Loss.	Tons Produced.	Per Cent. Gain.	Per Cent. Loss.	Wages Paid.	Per Cent. Gain.	Per Cent. Loss.
1901–1900...	2,742	34	....	1,090,522	....	27.8	$1,228,372 72	....	.035
1902........	2,452	....	10.5	1,162,764	7	....	1,356,098 45	10.4	....
1903........	2,293	....	.06	1,025,940	....	11.7	1,402,935 99	.34	....
1904........	2,128	....	.071	727,062	....	29.1	1,085,056 33	....	29.+
1905........	1,966	....	.076	658,735	....	.095	917,501 22	....	18.2
1906........	1,994	.014	....	746,670	13.3	....	974,549 71	.062	....
1907........	1,853	....	.07	875,233	3.81	....	1,230,199 23	2.62	....

TABLE

Showing a Comparative Statement of Total Numbers of Employes, Total Tons of Coal Produced, Total Wages Paid, Per Cent. Gain or Loss in Number of Employes in the Bitumtnous Mines of the State from 1901 to 1907.

BITUMINOUS MINES.

YEAR.	Employes.	Per Cent. Gain.	Per Cent. Loss.	Tons Produced.	Per Cent. Gain.	Per Cent. Loss.	Wages Paid.	Per Cent. Gain.	Per Cent. Loss.
1901........	9,354	19	....	5,928,681	24	....	$4,452,167 14	.35	....
1902........	10,687	14.8	....	7,600,433	18	....	5,722,814 67	.29	....
1903........	12,835	20+	....	8,966,613	17	....	7,746,636 13	.37	....
1904........	15,710	22	....	9,145,332	.02	....	8,080,348 05	.43	....
1905........	16,643	5.9	....	10,337,237	.13	....	8,436,393 43	.044	....
1906........	17,568	5.5	....	10,675,357	.032	....	8,998,491 67	.066	....
1907........	17,156	....	2.34	12,375,482	.159	....	10,487,623 31	16.5	....

TABLE

Exhibiting the Number of Miners, the Number of Inside Day and Monthly Men, the Number of Outside Day and Monthly Men, the Total Wages Earned by Same and Average Earnings Per Employe in the Block and Bituminous Mines, Each Exhibited Separately.

BLOCK COAL MACHINE MINES.

COUNTY.	Number of Miners.	Total Wages.	Average Wages.	Number of Inside Employes.	Total Wages.	Average Wages.	Number of Outside Employes.	Total Wages.	Average Wages.
Clay	....	$9,031 68	....	....	$6,681 37	....	....	$2,082 01	....
Parke	77	53,464 85	$694 34	37	25,707 14	$694 78	12	9,411 86	$784 32
Vigo	83	55,010 98	474 23	36	21,599 16	539 97	16	7,517 68	469 65
General average	160	117,507 51	$734 42	73	$53,987 67	$739 55	28	$19,011 55	$678 98

BLOCK COAL PICK MINES.

COUNTY.	Number of Miners.	Total Wages.	Average Wages.	Number of Inside Employes.	Total Wages.	Average Wages.	Number of Outside Employes.	Total Wages.	Average Wages.
Clay	828	$481,846 50	$581 94	211	$158,564 21	$751 48	107	$89,167 26	$833 33
Parke	290	183,406 11	632 43	88	66,578 06	756 56	36	33,968 36	943 56
Vigo	33	12,547 05	380 21	4	8,874 50	221 87	5	4,740 45	948 09
General average	1,151	$677,799 66	$588 87	303	$234,016 77	$772 33	148	$127,876 07	$864 02
Total general average for block employes	1,311	$795,307 17	$606 64	376	$288,004 44	$765 97	176	$146,887 62	$834 58

BITUMINOUS MACHINE MINES.

COUNTY.	Number of Miners.	Total Wages.	Average Wages.	Number of Inside Employes.	Total Wages.	Average Wages.	Number of Outside Employes.	Total Wages.	Average Wages.
Clay	398	$132,172 32	$332 09	93	$71,998 69	$774 17	49	$39,678 45	$809 76
Greene	1,792	1,181,239 07	659 11	624	401,346 68	643 18	207	152,239 61	735 45
Knox	173	114,286 48	660 61	46	37,942 63	824 83	42	32,108 54	764 48
Parke	314	164,759 87	527 26	85	60,959 42	717 16	31	24,447 74	788 63
Pike	57	15,685 25	275 15	9	6,996 11	777 34	13	4,381 94	337 07
Sullivan	2,428	1,396,247 75	575 06	829	534,989 69	645 34	365	213,101 61	583 83
Vermillion	17	10,160 87	597 69	6	3,864 31	644 05	4	2,627 49	597 69
Vigo	302	165,336 65	547 47	88	66,297 55	753 00	41	26,432 41	644 69
Warrick	264	138,969 29	526 39	83	50,061 75	603 15	43	23,713 58	551 47
General average	5,745	3,318,857 55	577 52	1,863	$1,234,456 83	$662 61	795	$518,731 37	$652 49

BITUMINOUS HAND MINES.

COUNTY.	Number of Miners.	Total Wages.	Average Wages.	Number of Inside Employes.	Total Wages.	Average Wages.	Number of Outside Employes.	Total Wages.	Average Wages.
Clay	364	$265,098 06	$728 26	96	$59,927 55	$624 24	34	$22,479 78	$661 17
Daviess	98	54,335 72	554 44	24	16,726 61	696 94	16	12,047 37	752 83
Fountain	57	26,674 61	467 97	14	7,423 80	530 27	8	5,635 56	704 44
Gibson	176	140,141 86	796 26	68	49,804 99	732 42	21	19,562 32	935 82
Green	677	321,565 87	474 98	162	87,673 70	541 19	81	45,089 05	556 65
Knox	215	91,297 54	424 63	64	25,686 88	401 35	36	13,497 64	374 93
Parke	124	73,852 82	595 58	52	24,058 37	462 66	18	8,879 29	493 29
Perry	11	6,740 51	612 77	3	2,223 95	741 31	2	1,562 71	527 70
Pike	535	247,907 66	463 37	136	87,587 12	644 02	68	35,383 97	786 35
Sullivan	254	75,096 67	295 65	100	29,064 25	290 64	49	15,494 57	389 86
Vanderburgh	286	200,574 21	701 30	80	58,428 70	730 35	49	41,285 54	842 56
Vermillion	1,471	934,415 92	635 23	325	256,514 94	789 27	98	59,948 27	611 71
Vigo	1,986	1,340,579 04	675 02	515	398,900 79	774 56	190	138,530 52	729 01
Warrick	136	88,856 53	653 35	29	14,020 95	483 48	24	10,411 35	433 80
General average	6,390	$3,867,137 02	$605 18	1,668	$1,118,042 60	$670 28	685	$430,397 94	$628 31
Total average for State	12,135	$7,981,301 74	$657 71	3,531	$2,640,503 87	$747 80	1,480	$1,096,016 93	$740 55

NOTE 1.—The mine reported as a block coal machine mine in Clay County is not included in the above averages because of the fact about half the wages reported was paid for mining Clay.
NOTE 2.—Machine runners, helpers, loaders and miners are all reported together under miners.

TABLE

Showing by Counties the Number of Tons of Coal Mined, the Number of Kegs of Powder Used and the Average Number of Tons Produced Per Keg in the Block Coal Mines of the State, the Pick and Machine Exhibited Separately; Also a General Average of Tons Produced per Keg in the Pick and Machine Mines Combined.

BLOCK COAL MACHINE MINES.

COUNTY.	Tons produced.	Kegs of powder.	Tons per keg.
Clay	7,456	704	10.5
Parke	74,927	685	109.3
Vigo	62,424	1,365	45.7
General average	13,735	2,050	67

BLOCK COAL PICK MINES.

COUNTY.	Tons produced.	Kegs of powder.	Tons per keg.
Clay	528,553	34,567	15.2
Parke	189,693	13,294	14.2
Vigo	12,180	1,361	9
General average	718,246	49,222	14.5
Total general average	855,597	51,272	16.6

NOTE 1. The total number of kegs of powder used in the block coal mines in 1907 was 51,976 kegs.

NOTE 2. About one-half the powder reported from the Clay County Machine Mines was used in mining clay and the powder reported from the Vigo County Pick Mines was reported from a new mine and the greater portion of the powder was used sinking the manway and completing the shaft bottom, etc. Neither of these amounts have been included in the above general average.

TABLE

Showing the Number of Tons of Coal Produced, The Number of Kegs of Powder Used and the Average Number of Tons Produced Per Keg in the Bituminous Mines of the State, the Pick and Machine Mines Each Shown Separately.

BITUMINOUS MACHINE MINES.

COUNTY.	Tons produced.	Kegs of powder.	Tons per keg.
Clay	265,272	5,598	47.11
Greene	2,200,265	37,602	58.5
Knox	235,479	3,558	66.1
Parke	289,918	8,685	33.3
Pike	27,822	1,059	26.2
Sullivan	2,542,854	44,097	57.21
Vermillion	16,003	190	84.2
Vigo	283,253	9,918	25.5
Warrick	314,208	5,713	55
General average	6,175,074	116,420	53

Table Showing the Number of Tons of Coal Produced, Etc.—Continued.

TABLE OF BITUMINOUS PICK MINES.

COUNTY.	Tons produced.	Kegs of powder.	Tons per keg.
Clay	429,581	15,133	28.3
Daviess	87,385	3,879	22.5
Fountain	40,099	1,627	24.6
Gibson	227,688	9,860	23.09
Greene	504,143	22,496	22.41
Knox	139,603	7,369	18.66
Parke	100,270	3,994	25.13
Perry	9,567	308	31 .
Pike	400,110	20,476	19.5
Sullivan	117,479	5,669	2.07
Vanderburgh	311,240	14,890	2.09
Vermillion	1,469,088	95,341	15.4
Vigo	2,223,522	99,906	22.26
Warrick	140,623	7,348	19.13
General average	6,200,408	308,296	20.11

RECAPITULATION.

	Tons produced.	Kegs of powder.	Tons per keg.
General average Bituminous Hand Mines	6,200,408	308,296	20.1
General average Bituminous Machine Mines	6,175,074	116,420	53.04
General average of all Bituminous Mines	12,375,482	424,716	29.13
General average of all Block Coal Mines	855,597	51,272	16.68
Total general average for the State	13,231,079	475,988	27.79

NOTE 1. The above averages represent mines only from which coal was reported.

NOTE 2. There were 704 kegs of powder reported from the bituminous mines, for which we have no coal reported and are not included in the above averages. This amount added to the powder mentioned in the foot note under the block coal tables brings the total amount of powder used in 1907 up to 476,692 kegs and the coa-represented by the two block mines mentioned in the foot note brings the total tonnage for the year up to 13,250,715 tons.

TABLE

Showing a Comparison of the Cost per Ton for Powder for the Years 1906 and 1907.

Year.	KIND OF COAL.	Tons produced.	Kegs of powder.	Price per keg.	Total cost.	Cost per ton.
1906	Machine block coal	114,869	1,691	$1 75	$2,959 25	$.0257
1907	Machine block coal	137,351	2,050	1 75	3,587 50	.0261
1906	Pick mined block coal	631,801	41,185	1 75	72,073 75	.114
1907	Pick mined block coal	718,246	49,222	1 75	86,138 50	.1199
1906	Machine bituminous coal	5,051,527	97,230	1 75	170,152 50	.0336
1907	Machine bituminous coal	6,175,074	116,420	1 75	203,715 00	.0329
1906	Pick mined bituminous coal	5,623,830	286,919	1 75	502,108 25	.0892
1907	Pick mined bituminous coal	6,200,408	308,296	1 75	539,518 00	.087

NOTE: The above table shows the total production for the state in 1907 to have cost $0.087 per ton or $0.0022 per ton less than in 1906. These figures show a net gain or saving of $29,108.37 to the miners of the state for powder used in mining in 1907.

TABLE

Exhibiting the Names of Coal Companies, Names of Mines Operated by them, the Geological Number of the Different Coal Seams Mined, the Thickness of Each Seam, the Depth from Surface to Each Seam, Pick or Machine Mines.

BLOCK COAL MINES.

CLAY COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of coal seam.	Thickness of coal seam.	Depth from surface to coal seam.	Pick or machine mine.
Brazil Block Coal Co.	Brazil No. 1	C. & E. I.	IV	3′6″	101	Machine.
Brazil Block Coal Co.	Brazil No. 4	C. & E. I.	III	3′9″	160	Pick.
Brazil Block Coal Co.	Brazil No. 7	Vandalia	III	3′6″	75	Pick.
Brazil Block Coal Co.	Brazil No. 8	C. & E. I.	III	3′6″	89	Pick.
Superior Block Coal Co.	Continental	Vandalia	IV	4′6″	65	Pick.
Superior Block Coal Co.	Relstock	C. & E. I.	IV	4′6″	85	Pick
Zellar-McClellan Coal Co.	Superior No. 4	Vandalia	IV	3′9″	80	Pick.
Zellar-McClellan Coal Co.	Superior No. 7	Vandalia	IV	3′9″	75	Pick.
Chicago-Indiana Block Coal Co.	Harrison No. 4	E. & I.	IV	4′9″	60	Pick.
Crawford Coal Co.	Crawford No. 4	Vandalia	IV	4′	60	Pick.
Crawford Coal Co.	Crawford No. 2	Vandalia	IV	3′6″	68	Pick.
Crawford Coal Co.	Crawford No. 6	Vandalia	III	3′6″	116	Pick.
Crawford Coal Co.	Crawford No. 8	E. & I.	III	3′	50	Pick.
Crawford Coal Co.	Crawford No. 9	C. & E. I.	IV	4′	86	Pick.
American Clay Manufacturing Co	Monarch	C. & E. I.	IV	3′6″	81	....
Indiana Block Coal Co	Lower Vein No. 1	E. & I.	IV	3′	58	Pick.
Eureka Block Coal Co.	Eureka No. 5	C. C. C. & St. L.	III	3′6″	116	Pick.
McLaughlin & Treager	Treager	Wagon mine	IV	4′	60	Pick.
Vandalia Coal Co.	Vandalia No. 50	Center Point Branch Vandalia	III	3′	105	Pick.
Coal Bluff Mining Co.	Glenn No. 1	C. & E. I.	IV	4′6″	215	Pick.
Coal Bluff Mining Co.	Plymouth No. 2	C. & E. I.	III	3′3″	110	Pick.
Nick Scheferman	Scheferman	Local mine	III	4′6″	60	Pick.
Hall & Zimmerman	Wizard	Central Indiana	III	3′6″	42	Pick
Crawford Coal Co.	Crawford No. 10	C. & E. I.	IV	4′6″	128	Pick.
Sam Pyria	Pyria	Local	IV	4′	40	Pick.

PARKE COUNTY.

Brazil Block Coal Co.	Brazil No. 12	C. & I. C.	III	3′6″	98	Pick.
Otter Creek Coal Co.	Mary	C. & I. C.	III	4′10″	105	Machine.
Brazil Block Coal Co.	Brazil No. 9	C. & I. C.	III	4′6″	120	Pick.
Zellar-McClellan & Co.	Superior No. 1	C. & I. C.	III	5′	108	Pick.
Zellar-McClellan & Co.	Superior No. 2	C. & I. C.	III–IV	3′6″–3′8″	135	Pick.
Zellar-McClellan & Co.	Superior No. 3	C. & I. C.	III–IV	4′	40	Pick.
Zellar-McClellan & Co.	Superior No. 5	C. & I. C.	III	3′6″	145	Pick.
Plymouth Block Coal Co	Pan-American	C. C. C. & St. L.	III	4′	70	Pick.

VIGO COUNTY.

Domestic Block Coal Co.	Domestic Block No. 1	C. & E. I.	IV	4′	110	Pick.

BITUMINOUS COAL MINES.

CLAY COUNTY.

Vandalia Coal Co.	Vandalia No. 60	Vandalia (Main Line)	VI	7′	32	Pick.
Vandalia Coal Co.	Vandalia No. 64	Vandalia (Main Line)	VI	7′	90	Pick.
Vandalia Coal Co.	Vandalia No. 65	Vandalia (Main Line)	VI	7′	100	Pick.
Ideal Block Coal Co.	Fortner	Vandalia (Main Line)	V	3′4″	110	Pick.
Collins Coal Co.	Gifford No. 1	C. & I. C.	III	4′4″	75	Pick.
Collins Coal Co.	Gifford No. 2	C. & I. C.	III	4′6″	77	Pick.
Big Vein Mining Co.	Lewis	Southern Indiana	V	8′	107	Pick.
Vivian Mining Co.	Vivian No. 1	Southren Indiana	III	5′6″	43	Pick.
Vivian Mining Co.	Vivian No. 2	Southern Indiana	IV	5′	....	Pick.
Jasonville Coal Co.	Gold Knob	Southern Indiana	III	6′6″	104	Pick.
United Fourth Vein Coal Co.	Island Valley No. 4	Southern Indiana	IV	5′6″	20	Pick.
C. Ehrlich Coal Co.	Klondyke No. 2	Vandalia (Main Line)	VI	7′	....	Pick.

BITUMINOUS COAL MINES—Continued.

DAVIESS COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of coal seam.	Thickness of coal seam.	Depth from surface to coal seam.	Pick or machine mine.
Stucky & Osborn	Stucky	Wagon mine	III	3′	Drift	Pick.
Daviess County Coal Co	Montgomery No. 3	B. & O. S. W	V	3′8″	100	Pick.
Mutual Mining Co	Mutual	B. & O. S. W	III	4′6″	100	Pick.
Mandabach Bros	Mandabach	Wagon mine	V	6′	56	Pick.
Wm. Winterbottom	Winterbottom	Wagon mine	IV	4′	40	Pick.

FOUNTAIN COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of coal seam.	Thickness of coal seam.	Depth from surface to coal seam.	Pick or machine mine.
Rush Coal Co	Indo	Clover Leaf	III	5′5″	80	Pick.

GIBSON COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of coal seam.	Thickness of coal seam.	Depth from surface to coal seam.	Pick or machine mine.
Princeton Coal & Mining Co	Oswald	Southern	V	6′10″	450	Pick.
Fort Branch Coal Co	Fort Branch	E. & T. H	V	4′6″	262	Pick.
Massey Coal Co	Massey	E. & I	VI	4′6″	50	Pick.

GREENE COUNTY.

United Fourth Vein Coal Co.	Black Creek	Southern Indiana	IV	4′8″	82	Machine.
United Fourth Vein Coal Co.	Island Valley No. 3	Southern Indiana	IV	5′6″	47	Pick.
United Fourth Vein Coal Co.	Glenburn	Southern Indiana	IV	4′6″	102	Machine.
United Fourth Vein Coal Co.	Antioch	Southern Indiana	IV	4′6″	176	Pick.
United Fourth Vein Coal Co.	North Linton	Southern Indiana	IV	4′2″	68	Pick.
Vandalia Coal Co.	Vandalia No. 2	I. & V. Branch Vandalia	IV	5′	66	Pick.
Vandalia Coal Co.	Vandalia No. 3	I. & V. Branch Vandalia	IV	5′	81	Pick.
Vandalia Coal Co.	Vandalia No. 4	I. & V. Branch Vandalia	IV	5′	55	Pick.
Vandalia Coal Co.	Vandalia No. 5	I. & V. Branch Vandalia	IV	5′	95	Machine.
Vandalia Coal Co.	Vandalia No. 6	I. & V. Branch Vandalia	IV	5′	72	Machine.
Vandalia Coal Co.	Vandalia No. 8	I. & V. Branch Vandalia	IV	5′6″	132	Machine.
Vandalia Coal Co.	Vandalia No. 9	I. & V. Branch Vandalia	IV	5′	128	Machine.
Vandalia Coal Co.	Vandalia No. 21	I. & V. Branch Vandalia	IV	5′	95	Machine.
Midvale Coal Co.	Midvale	Southern Indiana	III	7′6″	217	Pick.
Indiana Southern Coal Co.	Gilmour	Southern Indiana	IV	5′4″	152	Machine.
Southern Indiana Coal Co.	Hoosier No. 1	Southern Indiana	IV	3′7″	133	Pick.
Southern Indiana Coal Co.	Hoosier No. 2	Southern Indiana	V	7′	46	Pick.
Southern Indiana Coal Co.	Tower Hill	Southern Indiana	III	7′	132	Machine.
Southern Indiana Coal Co.	Lattas Creek	Southern Indiana	IV	5′	153	Machine.
Summit Coal Co.	Summit No. 2	I. & V. Branch Vandalia	IV	5′6″	150	Machine.
Green Valley Coal Co.	Green Valley	Southern Indiana	IV	5′2″	121	Machine.
Vulcan Coal Co.	Vulcan	Indianapolis Southern	V	6′	Slope..	Pick.
Queen Coal Co.	Queen	Southern Indiana	IV	4′7″	87	Pick.
Indiana Fairmount Coal Co.	Letsinger	Southern Indiana	III	7′6″	....	Pick.
Calora Coal Co.	North West	Southern Indiana	IV	5′	75	Pick.
Coal Bluff Mining Co.	Twin No. 4	Southern Indiana	V	6′	56	Machine.
Coal Bluff Mining Co.	Twin No. 5	Southern Indiana	IV	4′	152	Machine.
Mooney, Donnelly & Keers	Mooney	I. & V. Branch Vandalia	IV	5′	50	Pick.

KNOX COUNTY.

Knox Coal Co.	Knox	I. & V. (Vandalia)	V	7′	....	Machine.
Bicknell Coal Co.	Bicknell	I. & V. (Vandalia)	VI	4′4″	92	Pick.
Big Muddy Coal Co.	Pine Knot	I. & V. (Vandalia)	VI	4′6″	210	Machine.
Freeman Coal Co.	Freeman	I. & V. (Vandalia)	V	7′	234	Machine.
Washington-Wheatland Coal Co.	Wheatland	B. & O. S. W.	VII	5′	100	Pick.
Lynn Coal Co.	Lynn	I. & V. (Vandalia)	V	6′	200	Machine.
Tecumseh Coal Co.	Tecumseh	I. & V. (Vandalia)	V	6′6″	156	Machine.

BITUMINOUS COAL MINES—Continued.

PARKE COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of coal seam.	Thickness of coal seam.	Depth from surface to coal seam.	Pick or machine mine.
United Coal & Mining Co.	Mecca No. 3	C. & I. C.	III	5′	166	Machine.
Lincoln Coal & Mining Co.	Lyford No. 1	C. & E. I.	VI	6′6″	....	Pick.
Vandalia Coal Co.	Vandalia No. 317	Logansport (Vandalia)	III	5′	....	Pick.
W. P. Harrison	Harrison	Wagon mine	IV	4′	Slope	Pick.
Parke County Coal Co.	Parke No. 11	Logansport (Vandalia)	VI	6′6″	102	Machine.
Bridgeton Mining Co.	Bridgeton No. 1	C. & I.	IV	2′6″	Slope	Pick.
James Moore	Moore	Wagon mine	IV	4′	40	Pick.
Wm. Moore	Moore	Wagon mine	IV	5′	Drift	Pick.

PERRY COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of coal seam.	Thickness of coal seam.	Depth from surface to coal seam.	Pick or machine mine.
Bergenroth Bros	Troy	Ohio River transportation	II	3′	50	Pick.

PIKE COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of coal seam.	Thickness of coal seam.	Depth from surface to coal seam.	Pick or machine mine.
Muren Coal Co	Muren	Southern	V	4′6″	43	Pick.
D. Ingle Coal Co	Ayrshire No. 3	Southern	V	5′	22	Pick.
D. Ingle Coal Co	Ayrshire No. 4	Southern	V	4′8″	....	Pick.
S. W. Little Coal Co	Rogers	E. & I.	V	7′	Slope	Pick.
D. Ingle Coal Co	Ayrshire No. 5	Southern	V	5′	Drift	Pick.
S. W. Little Coal Co	Blackburn	E. & I.	V	6′6″	Slope	Pick.
S. W. Little Coal Co	Littles	E. & I.	V	6′6″	80	Pick.
Pokato Valley Coal Co	Hartwell No. 1	Southern	V	5′	Drift	Pick.
Pokato Valley Coal Co	Hartwell No. 2	Southern	V	5′	Drift	Pick.
W. S. Little Coal Co	Rogers No. 2	E. & I.	V	7′	80	Machine.

SULLIVAN COUNTY.

Indiana Southern Coal Co	Bunker Hill	Indianapolis Southern	VI	4′6″	72	Machine.
Indiana Southern Coal Co	Caledonia	Indianapolis Southern	VI	5′3″	106	Machine.
Indiana Southern Coal Co	Phœnix No. 4	E. & T. H	VI	6′6″		Machine.
Indiana Southern Coal Co	Cummins	Southern Indiana	VII	5′	Slope	Pick.
Indiana Southern Coal Co	Hocking	Southern Indiana	VI	5′6″	80	Machine.
Indiana Southern Coal Co	Citizens	Southern Indiana	VI	5′	165	Machine.
Sunflower Coal Co	Sunflower	Indianapolis Southern	VI	6′		Machine.
Consolidated Indiana Coal Co	Consolidated No. 25	E. & T. H	VI	5′6″	235	Machine.
Consolidated Indiana Coal Co	Consolidated No. 26	Southern Indiana		5′	110	Machine.
Consolidated Indiana Coal Co	Consolidated No. 28	Southern Indiana	VI	6′	200	Machine.
Consolidated Indiana Coal Co	Consolidated No. 29	E. & T. H	VI	5′6″	120	Machine.
Consolidated Indiana Coal Co	Consolidated No. 30	E. & T. H	VI	5′6″	197	Machine.
Consolidated Indiana Coal Co	Consolidated No. 31	E. & T. H	V	6′	53	Pick.
Consolidated Indiana Coal Co	Consolidated No. 32	Southern Indiana	V	7′	105	Machine.
Vandalia Coal Co	Vandalia No. 10	I. & V. (Vandalia)	IV	5′6″	260	Pick.
Jackson Hill Coal Co	Jackson Hill No. 2	E. & T. H	VI	5′8″	104	Machine.
Jackson Hill Coal Co	Jackson Hill No. 4	E. & T. H	VI	5′	155	Machine.
A. H. Whitsett Coal Co	Shelburn	E. & T. H	V	6′	317	Machine.
Sullivan County Coal Co	Freeman	Indianapolis Southern	VI	5′	100	Pick.
Dering Coal Co	Dering No. 12	E. & T. H	VII	5′6″	80	Pick.
Dering Coal Co	Dering No. 13	E. & T. H	VI	5′	144	Machine.
Dering Coal Co	Dering No. 14	E. & T. H	VI	5′6″	103	Machine.
Southern Indiana Coal Co	Semi-block	Southern Indiana	III	6′6″	235	Machine.
Southern Indiana Coal Co	Mammoth Vein	Southern Indiana	VI	6′	173	Machine.
Shirley Hill Coal Co	Shirley Hill No. 1	Monon	VI	5′6	110	Machine.
Shirley Hill Coal Co	Little Giant	Monon	VI	5′6″		Machine.
Hudson Coal Co	Superior	E. & T. H	VII	5′6″	112	Pick.
Kettle Creek Mining Co	Kettle Creek	E. & T. H	VI	5′3″	152	Machine.
Peabody-Alwart Coal Mining Co	Reliance	E. & T. H	VI	5′	237	Machine.
Diamond Coal & Mining Co	Hamilton	E. & T. H	III	6′6″	255	Machine.
United Fourth Vein Coal Co	Black Hawk	Southern Indiana	III	6′4″	240	Machine.
Cloverleaf Coal Co	Cloverleaf	Indianapolis Southern	IV	4′7″	307	Machine.
Carlisle Coal & Clay Co	Carlisle	E. & T. H	V	5′	391	Machine.
Shirley Hill Coal Co	Shirley Hill No. 3	I. & V	VI	5′6″	100	Machine

BITUMINOUS COAL MINES—Continued.

VANDERBURGH COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of coal seam.	Thickness of coal seam.	Depth from surface to coal seam.	Pick or machine mine.
Diamond Coal Co.	Diamond	Wagon mine	V	4′	256	Pick.
Banner Coal Co.	Avenue	Wagon mine	V	4′	265	Pick.
D. Ingle Coal Co.	Ingleside	L. & N.	V	4′	235	Pick.
Sunnyside Coal Co.	Sunnyside	L. & N.	V	4′	255	Pick.
Union Coal Co.	Union	Wagon mine	V	4′	235	Pick.
Crescent Coal Co.	Unity	L. & N.	V	4′	225	Pick.

VERMILLION COUNTY.

NAME OF COMPANY.	Name of Mine.	Railroad.	Geological number of coal seam.	Thickness of coal seam.	Depth from surface to coal seam.	Pick or machine mine.
Dering Coal Co	Dering No. 5	C. & E. I.	VII	4′10″	85	Pick.
Dering Coal Co	Dering No. 7	C. & E. I.	VI	5′6″	265	Pick.
Dering Coal Co	Dering No. 8	C. & E. I.	IV	5′6″	200	Pick.
Cayuga Brick & Coal Co.	Eureka	Consumed at brick yard	VI	5′6″	110	Pick.
Clinton Coal Co.	Crown Hill No. 1	C. & E. I.	VII	5′	164	Pick.
Clinton Coal Co.	Crown Hill No. 2	C. & E. I.	VII	4′10″	151	Pick.
Oak Hill Coal & Mining Co.	Oak Hill	C. & E. I	VII	6′6″	40	Pick.
Oak Hill Coal & Mining Co.	Maple Valley No. 1	C. & E. I.	VII	4′8″	....	Pick.
Oak Hill Coal & Mining Co.	Buckeye No. 2	C. & E. I.	VII	4′10″	110	Pick.
Oak Hill Coal & Mining Co.	Prince	C. & E. I.	VI	6′	330	Pick.
Clinton Coal Co.	Crown Hill No. 3	C. & E. I.	VI	6′	340	Machine

VIGO COUNTY.

Dering Coal Co	Dering No. 6	C. & E. I.	VI	4′8″	110	Pick.
Chas. F. Keeler Coal Co.	Atherton	C. & E. I.	VI	6′9″	165	Machine.
Coal Bluff Mining Co.	Diamond	C. C. C. & St. L.	VI	6′	54	Pick.
Coal Bluff Mining Co.	Peerless	C. & I. C.	VI	7′	101	Pick.
Coal Bluff Mining Co.	Lawton	C. C. C. & St. L.	VI	6′6″	110	Pick.
Grant Coal & Mining Co.	Grant No. 2	C. & E. I.	VI	6′6″	120	Pick.
Dering Coal Co	Dering No. 9	C. & I. C.	VI	6′6″	....	Pick.
Dering Coal Co	Dering No. 10	C. & I. C.	VI	6′6″	Slope	Pick.
Vandalia Coal Co.	Vandalia No. 66	Vandalia	VI	6′	103	Pick.
Vandalia Coal Co.	Vandalia No. 67	Vandalia	VI	6′	110	Pick.
Vandalia Coal Co.	Vandalia No. 69	Vandalia	VI	6′	120	Pick.
Vandalia Coal Co.	Vandalia No. 80	Vandalia	VI	....	....	Pick.
Vandalia Coal Co.	Vandalia No. 81	Vandalia	VI	4′4″	80	Pick.
Vandalia Coal Co.	Vandalia No. 82	Vandalia	V	6′	105	Machine.
Coal Bluff Mining Co.	Wabash	C. C. C. & St. L.	IV	5½′	300	Pick.
Lower Vein Coal Co.	Lower Vein No. 1	C. C. C. & St. L.	V	4′6″	201	Pick.
Miami Coal Co.	Miami No. 1	C. & E. I.	VI	7′	82	Pick.
Miami Coal Co.	Miami No. 2	C. & E. I.	VI	6′	50	Pick.
Miami Coal Co.	Miami No. 3	C. & E. I.	VI	7′	85	Pick.
Parke County Coal Co.	Parke No. 10	Logansport (Vandalia)	VI	6′6″	100	Machine.
Fauvre Coal Co.	Fauvre No. 1	Vandalia	VI	6′	90	Pick.
Domestic Block Coal Co.	Domestic Block No. 1	C. & E. I.	IV	4′	110	Pick.
Coal Bluff Mining Co.	Plymouth No. 1	C. C. C. & St. L.	III	....	215	Pick.
Fauvre Coal Company	Fauvre No. 2	Vandalia	V	4′6″	228	Pick.
West Terre Haute Coal Co.	Larimer	Wagon mine	VII	4′8″	110	Pick.
Deep Vein Coal Co.	Deep Vein	Vandalia	VI	6′	170	Pick.
Vigo County Coal Co.	Ray No. 2	Vandalia	VI	7′4″	95	Pick.
Indiana Southern Coal Co.	Forest	C. C. C. & St. L.	VI	6′5″	150	Machine.
Sugar Valley Coal Co.	Sugar Valley No. 1	Wagon mine	V	4′6″	185	Pick.
Coal Bluff Mining Co.	Victor	C. C. C. & St. L.	VI	6′6″	50	Pick.
Coal Bluff Mining Co.	Minshall	Big Four	III	5′	180	Pick.

WARRICK COUNTY.

Big Four Coal Company	Big Four	Southern	V	7′	Slope	Machine.
C. Menden Coal Co.	DeForrest	Southern	V	7′	65	Machine.
John Archibald Coal Co.	Star No. 1	Southern	V	4′4″	100	Pick.
T. D. Scales Coal Co.	Electric	Southern	V	7′	30	Machine.
Worsham Coal Co	Burke	Southern	V	4′4″	110	Pick.
Caladonia Coal Co.	Dawson	Southern	V	4′	87	Pick.
Erie Canal Coal Co.	Erie Canal	Southern	V	5′	130	Machine.
Chandler Coal Co.	Chandler	Southern	V	....	....	Machine.
Castle Garden Coal Co.	Castle Garden	Southern	V	4′	96	Pick.
Elberfeld Coal Co	Elberfeld	E. & I.	V	4′4″	175	Pick.

EXAMINATIONS.

Examinations of applicants of competency to serve as mine bosses, fire bosses and hoisting engineers, were held at three different times during the year of 1907. Each of the examinations were held in Terre Haute. The following table exhibits the date on which the examinations were held, the total number of candidates examined, the number passing a successful examination and the number who failed.

DATE.	Total Applicants.			Passed.			Failed.		
	M. B.	F. B.	H. E.	M. B.	F. B.	H. E.	M. B.	F. B.	H. F.
May 16	25	17	29	15	10	8	10	7	21
August 15 and 16	31	23	19	17	15	9	14	8	10
December 5 and 6	30	19	25	20	13	13	10	6	12
Total	86	59	73	52	38	30	34	21	43

The above table shows 60%+ of the applicants for mine boss, 64%+ fire boss and 41%+ applicants for hoisting engineers, passed a successful examination and received certificates.

The following is a list of the names and addresses of the successful candidates and the number and per cent. grade of each certificate issued:

MINE BOSS.

Examination held in Terre Haute, May 16 and 17, 1907.

Total candidates, 25. Total number passed, 15.

Certificate No.	*Name and Address.*	*Per Cent.*
1.	William F. Brouse, Clinton	78
2.	Thomas Connely, Clinton	78
3.	Austin G. Wilson, Edwards	77
4.	Seth Powell, Fontanet	80
5.	Fred Wiggs, Muren	78
6.	John Dawson, Dugger	83
7.	Carry Littlejohn, Hymera	80
8.	Thomas Craig, Jasonville	80
9.	Edward W. Church, Linton	80
10.	Thomas Frankland, Sullivan	76
11.	Julian O'Connor, Stanton	84
12.	James Bennett, Cloverland	78
13.	Bert Badders, Linton	78
14.	Charles M. Mallase, Sullivan	76
15.	Hamilton M. Irving, Cayuga	85

FIRE BOSS.

Examination held in Terre Haute, May 16 and 17, 1907.

Total number of candidates, 1[illegible]. Total number passed, 10.

Certificate No.	*Name and Address.*	*Per Cent.*
1.	John Gillespie, Bicknell	83
2.	William C. Keller, Linton	84
3.	J. A. Crabb, Terre Haute	76
4.	William Thomson, Bicknell	75
5.	A. J. Barrick, Jasonville	80
6.	Edward G. Lewis, Sullivan	82
7.	Arthur Debarge, Farnsworth	77
8.	Charles Burris, Jasonville	79
9.	Alex. Hunter, Farmersburg	88
10.	W. M. Brown, Chandler	76

HOISTING ENGINEER.

Examination held in Terre Haute, May 16 and 17, 1907.

Total number of candidates, 29. Total passed, 8.

Certificate No.	*Name and Address.*	*Per Cent.*
1.	Henry Carpenter, Linton	79
2.	A. J. Marshall, Sullivan	83
3.	James L. Murer, Linton	79
4.	J. L. Uland, Linton	80
5.	Hugh Vanlien, Clinton	78
6.	Andy A. Corlett, Linton	78
7.	H. H. Gudtin, Sullivan	77
8.	Frank Kimble, Princeton	76

MINE BOSS.

Examination held in Terre Haute, August 15 and 16, 1907.

Total number candidates, 31. Total number passed, 17.

Certificate No.	*Name and Address.*	*Per Cent.*
16.	A. L. Rogers, Boonville	76
17.	George Carty, Boonville	83
18.	Charles Burris, Jasonville	76
19.	Benjamin Mills, Edwards	86
20.	William J. Roberts, Burnett	81
21.	Robert Hughs, Seeleyville	84
22.	James C. Bennett, Fontanet	81
23.	Neil O. Gray, Indianapolis	87
24.	Harry Moore, Clinton	82
25.	W. H. Taylor, Shelburn	86
26.	Philip Badenbarger, Brazil	80

Certificate No.	Name and Address.	Per Cent.
27.	James Callaway, Linton	80
28.	William Stull, Linton	87
29.	Charles W. Kirk, Jasonville	81
30.	Richard Anderson, Clinton	76
31.	Charles Clayton, Fontanet	76
32.	J. E. Cochran, Sullivan	80

FIRE BOSS.

Examination held in Terre Haute, August 15 and 16, 1907.

Total number of candidates, 23. Total number passed, 15.

Certificate No.	Name and Address.	Per Cent.
11.	William Babbitt, Shelburn	83
12.	James Robertson, Bicknell	88
13.	Lon Shaw, Boonville	75
14.	W. W. Dean, Chandler	80
15.	Rice M. Hughes, Burnett	80
16.	William Ross, Fontanet	77
17.	William Brown, Chandler	87
18.	Henry Nocus, Jr., Linton	83
19.	Henry Nocus, Sr., Linton	78
20.	Charles Troye, Linton	80
21.	L. M. McDonald, Jasonville	76
22.	Dan Thomas, Seeleyville	80
23.	Morgan Russer, Rosedale	78
24.	Jno. W. Miller, Chandler	76
25.	Hamilton M. Irving, Cayuga	88

HOISTING ENGINEER.

Examination held at Terre Haute, August 15 and 16, 1907.

Total number of candidates, 19. Total number passed, 9.

Certificate No.	Name and Address.	Per Cent.
9.	Daniel Page, Linton	79
10.	Samuel Dugger, Clinton	76
11.	C. B. Seeley, Fontanet	80
12.	Lewis W. Boles, Sullivan	80
13.	H. Mitchell Bradford, Linton	85
14.	John T. Bennett, Linton	82
15.	Jeff Thompson, Center Point	85
16.	Frank Earle, Linton	81
17.	William Combs, Coalmont	79

MINE BOSS.

Examination held at Terre Haute, December 5 and 6, 1907.

Total number of candidates, 36. Total number passed, 20.

Certificate No.	Name and Address.	Per Cent.
33.	Solomon Deeble, Carlisle	82
34.	W. J. Williams, Carlisle	80
35.	Joe Robertson, Clinton	77
36.	Jesse Hamilton, Linton	80
37.	John James, Jasonville	77
38.	Preston Usrey, Linton	76
39.	William Wills, Linton	81
40.	George Fick, Terre Haute	90
41.	Clifford Hoffman, Brazil	83
42.	John Edward Haag, Bicknell	79
43.	Herbert Massie, Chandler	85
44.	John William Moss, West Terre Haute	75
45.	John Patton, Boonville	78
46.	John Smith, Jackson Hill	80
47.	Wm. Steinsberger, Brazil	76
48.	Alex. Davidson, Shelburn	82
49.	J. E. Mason, Brazil	76
50.	Walter W. Wills, Linton	82
51.	William Huntley, West Terre Haute	76
52.	Henry Horn, Princeton	80

FIRE BOSS.

Examination held in Terre Haute, December 5 and 6, 1907.

Total number of candidates, 19. Total number passed, 13.

Certificate No.	Name and Address.	Per Cent.
26.	George Epperson, West Terre Haute	89
27.	Hugh Walker, Jasonville	76
28.	James W. Mason, Boonville	89
29.	John Walters, Coalmont	78
30.	Herbert Massie, Chandler	80
31.	James Mahaffey, Boonville	80
32.	Jno. W. Cooper, Linton	80
33.	William Samson, Linton	80
34.	Jesse Hamilton, Linton	80
35.	Charles F. Hill, West Terre Haute	87
36.	Jno. Gardner, Jasonville	77
37.	Ebert Hammack, Chandler	80
38.	Emelien LeCoeg, Antioch	82

HOISTING ENGINEER.

Examination held at Terre Haute, December 5 and 6, 1907.

Total number of candidates, 23. Total number passed, 13.

Certificate No.	Name and Address.	Per Cent.
18.	Charles Good, Carlisle	81
19.	W. F. Deeble, Carlisle	79
20.	John L. Rector, Sullivan	83
21.	W. A. Haworth, Caledonia	79
22.	David Shepard, Evansville	82
23.	James H. Haseman, Linton	81
24.	Pearl O. Dunn, Linton	78
25.	Martin Shable, Linton	79
26.	Albert Robinson, Carbon	77
27.	Leon Coons, Montgomery	82
28.	Frank Dew, Jasonville	76
29.	Joseph McPherson, Carlisle	77
30.	Milton C. Griffith, Carlisle	81

CASUALITIES TO MINE EMPLOYES.

It is the duty of this department, under the statutes of Indiana, to investigate each accident to mine employes, where the attendance of a physician or surgeon is required. Under the same statute, the person in charge of each mine is required to notify the Inspector of Mines of such accidents, without delay. A strict compliance with the statute has been a serious problem with the department in the past, and because of the following reasons we have been unable to give a complete account of all such accidents, in our former reports:

Owing to the large number of new mines opened during the six years preceding 1907 and the increased number of inspections to be made, with other duties incident thereto, and an insufficient number of assistants in the department to perform these increased duties and inspections. This caused us to be unable to make sufficient inquiries concerning accidents. And because of the fact that several days' attendance in the courts is usually required of us, in each prosecution, we were unable to file prosecutions and follow them up against coal companies or mine bosses for failure to report. For these reasons we were able to secure reports of only about one-half of the accidents to mine employes. The increase in our force of two additional assistants, made by the last Legislature (the same taking effect April 10, 1907), has enabled us to give the matter closer attention during that year and compel companies and mine bosses to report all accidents required by law. As a result the number of accidents shown in the report would indicate to persons not conversant with the situation, a large increase in the number occurring over former years. Through our inspections and prosecutions made and the reports of mine bosses we show an aggregate of five hundred and four (504) accidents to employes classed as follows:

Fatal, fifty-three (53); persons permanently disabled, nine (9); serious accidents, two hundred seventy-one (271), and minor, one hundred seventy-one (171). The different causes of these accidents are shown in the annexed table.

TABLE

Exhibiting the Number of Fatal, Permanent, Serious and Minor Accidents Occurring in Indiana Mines During the Year 1907, and the Different Causes of Such Accidents.

NATURE OF ACCIDENT.	Fatal.	Permanent.	Serious.	Minor.	Total.
Falling coal	1	....	25	14	40
Falling slate	15	3	71	40	129
Kicked by mule	1	....	11	9	21
Injured by mine cars	8	1	88	73	170
Injured by mining machines	....	....	11	6	17
Smoke explosions	2	....	13	....	15
Explosions of blasting powder	12	3	6	....	21
Explosions of fire damp	2	1	11	4	18
Premature shots	1	....	7	....	8
Delayed shots	2	....	1	....	3
Shots blowing through pillars	....	....	2	....	2
Misplaced, windy or blownout shots	1	....	1	....	2
Ascending cage	3	....	....	1	4
Descending cage	1	....	3	....	4
Falling down shaft	1	....	....	....	1
Coal falling down shaft	....	....	4	2	6
Injured by mine motors	1	1	2	1	5
Injured by railroad cars	2	....	1	2	5
Miscellaneous	....	....	14	19	33
Grand total	53	9	271	171	504

DESCRIPTION OF FATAL ACCIDENTS.

Each of the above fatal accidents have been investigated by this department, acting in conjunction with the Coroner of the county wherein the accident occurred. We have also investigated each of the accidents to persons permanently disabled and all other serious accidents, as far as possible.

The following brief description of fatal accidents, sets forth by months and by counties, a detailed statement of facts and circumstances brought forth at such investigations.

JANUARY.

Sixteen deaths are recorded during this month, the first of which was the death of Otto Saxeburgh, shot firer, 33 years of age, single, who was killed on the 5th inst., in an explosion caused by a windy shot, in the Maple Valley Mine, Vermillion County. From evidence adduced at the investigation of the accident, and an examination of the mine, made by Assistant Inspector Robert Irving and myself, we learned the following: Saxeburgh and one other person were employed to do the shot firing after the miners and other workmen had left the mine, and that all the shots in the mine were tamped on fuse; also, that in firing the shots it was customary for the shot firers each to begin at a given point and continue lighting shots, one after the other, as long as there was any to light, not waiting for those previously lighted to explode. On examination, we found a number of shots in violation of the law, some of which were drilled three feet or more past the cutting or loose end; some over the maximum thickness, measured at right angles to the drill-hole and others heavily overcharged. One of the first-named, located in a narrow room-neck, on the fourth south cross-entry, was drilled three feet past the cutting or loose end, and had seamed or blown out and was evidently the cause of the explosion. The two men had commenced the shot firing at about 4 o'clock p. m., and at about 7:30 o'clock had nearly completed their work, having fired probably 150 shots. This large number of shots fired in so short a time filled the mine with a dense body of heated powder-smoke. Added to this, a large quantity of fine coal dust, thrown into the atmosphere from the drill holes, where it had been used for tamping, created a deadly mixture, ripe for the results which followed.

At the time of the accident, deceased was lighting the shots near the head of the entry, and his buddy a number of rooms further down, toward the mouth of the entry. When the shot was fired in the room-neck above referred to, it resulted in a blown-out shot, the flame of which was projected into the mixture just mentioned and a heavy explosion took place, the force of which extended down the entry about 1,000 feet from the face. Saxeburgh was found a short time later by a searching party, in the second room outside the room-neck, dead, having succumbed to the after-damp. His buddy, though somewhat affected by the smoke and after-damp, suffered no serious injury.

January 8th, Samuel Adams, top laborer, 60 years of age, was killed by falling down the hoisting shaft of the Vandalia No.

316 Mine, Parke County. Decedent was employed to do general work around the top of the mine, i. e., to look after the railroad cars, send timbers into the mine, unload dirt cars, etc. On the morning of his accident, wishing to return an empty dirt car into the mine, which had been hoisted the previous night, he opened the gate to the east compartment of the hoisting shaft at the surface landing and called to the cager in the bottom, asking for an empty cage. The cager called back, saying he would send up the west cage, which was then on the bottom. Adams then opened the west gate and leaving both gates standing open, walked back to where the empty car was standing, just outside the points of the two switches leading one to each compartment of the shaft and placing his back against the car, began pushing it, as he supposed, in on the west switch. The car, however, took the east switch, and having his back toward the shaft, this fact was not noticed by decedent until he pushed it over into the east compartment, which was then empty. Losing his balance, he fell with the car down to the top of the east cage, a distance of about 100 feet, killing him instantly. Long and constant association with one particular class of work, no matter how hazardous, usually renders workmen careless and indifferent to attending dangers, which fact is evident in this instance. Had deceased closed the east gate before leaving the shaft, or had he pushed the car, with his face toward the shaft, this accident would not have occurred. He leaves a dependent wife.

January 9th Peter Gebhart, German, timberman, 39 years of age, was killed by falling slate and timbers in the Oswald mine. Gibson County. Gebhart and a number of other workmen were engaged, on the evening of above date, removing some cross-bars and loose slate for the purpose of making room for a siding or double parting. Owing to the extreme weight on the cross-bars, it was necessary to cut the bars, or legs, under them partially in two, thus weakening them so they would break of the weight on them or could be knocked out easily. At about 6 o'clock p. m. Gebhart was cutting one of the legs under a bar with an axe, and had weakened it sufficiently, as the mine boss thought, to render it dangerous, and he ordered Gebhart to quit chopping. Decedent, however, persisted in striking a few more blows with the axe, when suddenly, without warning, the leg gave way, causing the bar and the slate overhanging it to fall on him, killing him instantly. A conformance on the part of deceased to orders given him by the person in charge would have saved his life. Gebhart leaves a wife and three children.

January 12th George Howard, American, driver, aged 18 years, single, was killed by being run over with a mine car in the Hudson mine, Sullivan County. From evidence adduced at the investigation of the accident, it was learned that Howard was not an experienced driver, having driven but a very short time, and was not thoroughly familiar with such work. It further developed that there was a short hill or grade in favor of the loaded cars, on one of the entries from which he was hauling coal; also, that when coming down this grade with a loaded trip it was necessary to use spraggs in the cars, although some of the drivers did not do so. At about 2:30 o'clock p. m. decedent was coming down this grade with one loaded car, riding in the manner drivers usually ride, i. e., by standing with one foot on the draw-bar of the car and one on the tail chain. Acting under the precedent set by other drivers, he used no spraggs, and when about 10 feet from the top of the hill, by which time the car was traveling very fast, he in some way lost his footing, falling under the car, and was dragged about 60 feet. When found he was lying under the car dead. He leaves a dependent father and mother.

January 14th marks the date of one of the most disastrous mine accidents occurring in the history of the State. Between the hours of 6 and 7 o'clock a. m. of this date, just at a time when the workmen were entering the mine preparatory to beginning the day's work (fortunately few had reached their working places, otherwise the loss of life would have been appalling), an explosion of unusual violence occurred in the south workings of the Dering No. 7 Mine, Vermillion County. This explosion resulted in the death of seven persons, five of whom were taken out of the mine dead and two so badly injured that they died a short time later. Robert M. Irving and Jonathan Thomas, my two assistants, and myself arrived at the mine at about 1 o'clock a. m. of the 15th, and together with the mine boss, mine committee and a number of other persons, made a careful examination of the mine for the purpose of ascertaining the cause and character of the explosion, i. e., whether it was an explosion of fire-damp, powder or coal dust, or a combination of the three elements, and also to learn, if possible, at what point the explosion originated. All of the dead bodies and the injured, as well as the uninjured, had been removed from the mine before this time. In addition to the inspection made by us, a most careful inquiry and examination was made for the same purpose the following day by Messrs. James Taylor, Inspector of Mines, Peoria, Illinois; Geo. M. Rice, Mining Expert, Chicago, Illinois; Evan D. John, Ex-Inspector of Mines, Carbondale, Illinois, and the following named superintendents of Indiana mines: John A. Templeton, superintendent Coal Bluff Mining Company; P. J. Mooney, superintendent Brazil Block Coal Company; Herbert Woolley, superintendent Dering Coal Company, and Henry Payne, superintendent Charles F. Keeler Coal Company. Beyond the fact that the explosion took place somewhere in the south workings, and affected a considerable area of both the main south entry and air course, we were unable to determine the exact cause or character of the explosion nor its point of origin. It was the general opinion of both examining parties (the mine committee excepted) that powder was the chief if not the sole agent in the explosion. The mine committee and a number of miners contended that the explosion was due to coal dust and fire-damp. While it is true an exceedingly small per cent of gas was occasionally noticed in the mine, coming from drill holes, old powder cracks, etc., such as is found in numerous so-called non-gaseous mines, and the mine was very dry, with considerable dust on the roadways, yet this dust was so highly impregnated with fire-clay from the mine floor it would scarcely burn when thrown on a fire, much less explode. Again, referring to the gas, it must be remembered that all of the brattices between the main entry and air course, as well as the doors and a part of the brattices on the cross-entries, were destroyed in the explosion, thus shutting off the ventilating current from all the working places in that part of the mine, and that this condition prevailed from the time of the explosion until we made our examination on the morning of the 15th, a lapse of some 18 hours. Notwithstanding these facts, we found not the slightest trace of gas, except in the faces of two of the most remote working places in that part of the mine, and the quantity there found was so small as to be barely perceptible in the safety lamp. The debris in these places was thrown toward the faces, indicating that the force came from the outside. There was a total absence of soot or charred particles of coal usually found adhering to the roof or sides of the entries or to the timbers, where coal dust has been prominent in an explosion. This combination of facts would indicate that neither fire-damp nor coal dust served as active agents in this explosion. On the other hand, in support of the contention that the explosion was due to blasting powder, we will consider the following: First, the debris was swept in different directions at different points on the same entry; for instance, on the main south, beginning at the mouth of 7 and 8 east, everything was swept toward the mouth of the entry, while farther up the entry a few hundred feet it was swept toward the face. At the face of the entry the debris was thrown outward. This same feature was true of the brattices between the two entries, i. e., some were blown in one direction and some another, indicating that several explosions, each independent of the others, had occurred at different points. Second, the unusually large number of kegs of powder used daily in the mine, each miner having from one to two full kegs in his working place, which would mean anywhere from 75 to 100 kegs in that section of the mine on the morning of the explosion. Third, these kegs are usually placed along the roadway, frequently with a large pick-hole, open, in the top of the keg. Fourth, very few kegs containing powder were found after the explosion. Fifth, an unusually large number of empty kegs, bursted from the inside, were found scattered throughout the entire affected district. Sixth, a fact not proven, but fairly well established, is that miners frequently carried powder into the mine in cloth sacks, in dinner pails and in their pockets, also that dynamite and dynamite caps were smuggled into the mine at times, to be used in conjunction with the blasting powder. Seventh, there was undisputable evidence that a large quantity of powder had been exploded at several points. Eighth, the dense volume of smoke said to have followed the explosion. Combining all of the above with the utter disregard displayed by miners for all law, either common or statutory, in handling and using powder, should be evidence preponderant to an unprejudiced mind that blasting powder, exploded in some unknown manner, was the prime, if not the sole agent in this explosion. The following are the names and nationality of those killed, also the number of dependents left by each:

Name.	*Nationality.*	*Dependents.*
Ed Wulf	Polish	Mother.
J. Phasto	Polish	Wife.
J. Joseph	Polish	Wife and 3 children.
T. Halenk	Polish	Wife and 1 child.
J. Brugus	German	Unknown.
H. Shonen	Finlander	Mother.
Leo Pike	Polish	Wife.

On the same date as above, Robert Johnson, miner, 30 years of age, was killed almost instantly by a blast in the Twin No. 4 Mine, Greene County. This accident occurred at 3:30 o'clock p. m. (firing time), and was due to what might be termed a premature shot. Johnson at the time he met with his accident was assisting a neighbor miner, Nat Sewell, in firing his shots, two in number. The shots were both tamped on fuse, one on the right and one on the left side of the room, and each man was to light a shot. The fuse on the left lighted readily, but the one on the right was slow to ignite and apparently did not catch. When they had waited until they thought they would be in danger from the shot first lighted, they ran to a place of safety, where they waited until it had exploded, immediately after which they ran back to light the remaining one, and when within eight or ten feet of the shot it exploded, the flying pieces of coal striking Johnson, injuring him so that he died within a few minutes. Sewell was also seriously injured. Decedent leaves a wife and one child. The use of fuse in shot firing has been so thoroughly condemned in our past reports that comments on this accident are not necessary.

January 15th Stephen Sacery, miner, 40 years of age, single, was instantly killed by an ascending cage in the Buckeye Mine, Vermillion County. From evidence adduced at the investigation of the accident it was learned that at about 3:45 o'clock p. m. decedent and three other persons came to the bottom of the shaft and gave the engineer two bells, notifying him they wished to come up out of the mine. On receiving the return signal, three bells, from the engineer, the four men got on the cage and gave one bell to hoist. When the cage reached the surface it was discovered Sacery was missing, and on returning to the shaft bottom a searching party found him lying in the sump, his head almost severed from the body. The three men who were with him testified he got on the cage with them and that they did not see him get off the cage or fall, and the first they knew of his absence was when the cage reached the surface. The general opinion of those present was that decedent had forgotten something and stepped off the cage to get it, and was in the act of stepping back on the cage just when the engineer started to hoist, he being but partially on the cage, was caught against the brow timber with the above result.

January 16th William Metcalf, miner, 22 years of age, single, was killed by falling slate in the Cummins Mine, Sullivan County. About 9:30 o'clock a. m. decedent was engaged in mining off a loose shot, when suddenly, without warning, a large piece of slate of roll formation, measuring 9 feet in length, 4 feet wide, 18 inches thick in the center, gave way, falling on him and killing him instantly. Deceased was considered a very careful miner, and his working place was timbered securely to within a few feet of the face. Two props had been set under the slate which fell on him. These props had been set under the thin edge, however, and the extra thickness and weight in the center of the piece of slate crowded the props out, permitting it to break off near the coal.

January 22d two shot firers, Mike Lyynskie, 39 years of age, wife and one child, and John Paska, 26 years of age, wife and three children, were killed by after-damp, resulting from a smoke explosion in the Dering No. 15 Mine. On investigating this accident it was learned an explosion occurred in this mine early in the evening of the 21st which did considerable damage. Luckily the shot firers were in a place of safety when it took place and escaped without injury. The mine was in such condition after the explosion, however, that they were compelled to leave it with their work about half completed, about one-half the shots not having been fired. On the afternoon of the day following the two men had gone into the mine for the purpose of firing the remaining shots, commencing the work about 3:20 o'clock p. m., and had fired some dozen or fifteen of the shots when a second explosion of terrific force took place. Unfortunately, the same precautions had not been taken as on the previous occasion, that is, the shot firers had not secured themselves in a safe place, and when found about 5 o'clock p. m. by a searching party both were dead, having succumbed to after-damp. It developed on inspecting the mine after the latter explosion that some sixty or seventy shots had been fired, and two-thirds at least of them were illegal. Some of them were drilled four feet and over, past the cutting or loose end. Some were six feet and more in thickness, measured at right angles to the drill hole, and others were excessively overcharged with powder. The latter generated large volumes of heated powder smoke, and the former not only added to this, both in volume and intensity of heat, but in many instances seamed or blew out the tamping, thus adding a variable quantity of fine heated coal dust to the smoke, and the flame from one of the blown out shots being projected into this mixture, but one result could possibly follow, viz., an explosion which resulted in the loss of two more lives, added to the long list of those sacrificed to the lawless methods of miners in using powder and drilling and placing shots.

February.

One fatality occurred in this month. Charles Harting, a timberman, 57 years of age, was killed by falling slate on the 6th inst. in the Vandalia No. 40 Mine, Knox County. Decedent was last seen alive a few minutes after 1 o'clock p. m. At that time he was engaged in examining and testing a piece of loose slate overlying a room parting on one of the cross-entries. At this time a fellow-workman by the name of Lawton was standing by, and after warning deceased to be careful, that the slate was dangerous, and deceased replying that he knew it was, he (Lawton) continued on his way to another part of the mine. Some little time had elapsed, and no one having seen Harting, a search was made, and when found he was lying dead under a piece of slate 3 feet wide, 12 feet long and 6 inches thick, his neck broken. No eyewitness being present, it was not known just at what time the accident occurred. He leaves a dependent wife.

March.

Five fatalities is the record for this month. The first two were the result of the same accident, which occurred on the 12th inst. in the Brazil Block No. 4 Mine, Clay County. David Hill, miner, aged 23 years, single, and Thomas Roberts, 19 years of age, single, miner, were fatally burned in an explosion of powder. Edwin Roberts, brother to deceased, was seriously burned in the same explosion. From evidence brought out at the investigation of the accident it was learned that the three men were working in adjoining places and kept their powder, paper and other supplies in the same place. About 3:10 o'clock p. m. of above date they were making up their powder, preparatory to tamping their shots, and wishing to open a fresh keg of powder which was setting near by, Hill struck a hole in the top of the keg with a pick. A spark generating from the contact of the steel and iron, exploded the powder, burning Hill so badly that he died the following day at the St. Anthony Hospital in Terre Haute, where he had been taken for treatment. Thomas Roberts died on the 19th following from injuries received.

On March 19th Francis Padget, flat trimmer, 37 years of age, married, who leaves a dependent wife and four children, was fatally injured by being crushed between two railroad cars in the yards of the Little Giant Mine, Sullivan County. At the time of his accident (11:30 a. m), Padget was standing partially between two flat cars, one of which was empty and the other under the dump being loaded. The two cars stood but a few inches apart, and decedent was attending to some trivial repair on the drawbar of one of them and did not notice a third empty car being brought down to the tipple on the same track as the ones he was standing between. His buddy, Jonathan Price, who was in the first car, noticed it, however, just as the two cars were about to strike, and called to him to get out of the way. In his excitement and not knowing which track the third empty was coming on, he jumped between the first and second cars just as they were driven together by the third, and was caught between the two drawbars and crushed so badly that he died three hours later.

March 28th Matto Gentile, miner, 35 years of age, single, was killed almost instantly by an ascending cage at the bottom of the hoisting shaft of the Crown Hill Mine, Vermillion County. At 3:30 o'clock p. m., quitting time for all labor in or about the mine except the hoisting engineer, the miners and other workmen had congregated at the bottom of the shaft as usual, waiting to be hoisted out of the mine. The State law at that time prohibited more than six persons from riding on a cage at one time, and in order that the statute be complied with, as well as for the general safety of employes, the mine management required the cagers to remain on duty to see that only the proper number of persons would attempt to ride on the cages and to give the proper signals to the hoisting engineer until all men were hoisted out of the mine. This custom was being observed as usual on the evening of the accident, and several cage loads of men had been hoisted by 3:45 p. m. At this time the east cage was on the bottom and the cager, Elmer Thomas, had given the engineer the proper signal (two bells) signifying men were coming up, and at the same time warned the men to keep back and not attempt to get on the cage until the return signal (three bells) from the engineer was given, indicating that he was in readiness to hoist. Decedent, in his hurry to get out of the mine, gave no heed to the cager's warning, and not waiting for the return signal from the engineer, attempted to get on the cage. The engineer, through some error, started to hoist the cage without giving the return signal. Just as Gentile had gotten partially on the cage it was hoisted up, catching him between the brow timbers and the bottom of the cage, crushing his skull and otherwise injuring him so that he died about fifty minutes later. Conformance to statute and obedience to orders given by the proper person in charge would have prevented this accident.

March 30th Harry Smith, driver, 25 years of age, who leaves a wife and one child, was killed by falling slate in the Oak Hill Coal Company's Mine No. 50, also in Vermillion County. Decedent and his two brothers, William and J. L. Smith, were engaged on the evening of the above date cleaning up a heavy fall which occurred on one of the main haulage roads. About 4 o'clock p. m., while they were loading a car of dirt, a large piece of slate eight feet long, three and one-half feet wide and eight inches thick suddenly gave way, falling on and catching decedent's head against the side of the car, killing him instantly. His two brothers were also struck by the slate and painfully injured, although both were able to walk home.

April.

One fatal accident occurred in this month, that of Daniel O'Donnell, driver, 25 years of age, single, who was killed instantly by being run over with a loaded mine car on the 25th inst. in the Lattas Creek Mine, Greene County. At the time he met with his death deceased was coming out of a cross-entry with a spike team (two mules) and one loaded car, riding with one foot on the tail chain, the other on the car bumper, and while coming down a short grade of about one per cent, his mules traveling in a slow trot, he in some way lost his footing and fell under the rapidly moving car, which dragged him a short distance and ran almost completely over him. When found he was lying dead with about half his body protruding from under the rear end of the car. He leaves a dependent mother in the State of Ohio.

May.

One fatal accident is the record for this month. Leo Huff, top man, 28 years of age, leaving a dependent wife and three children, was killed on the 27th inst. by a railroad car in the yards of the T. D. Seales Coal Company's electric mine, Warrick County. Decedent was employed at general work around the top of the mine, and on the above date was bringing an empty flat car to the tipple. When he attempted to apply the brake to stop the car the chain connecting the brake rod and beam either gave way or had been previously broken, causing him to lose his balance and fall down on the rail in front of the car, which ran over him, mangling both legs and one arm and inflicting injuries of which he died a short time later.

Note.—This casualty, together with that of Thomas Padget, should be reported as railroad accidents, but owing to the fact that they were mine employes we include them in the list of mine casualties.

JUNE.

Two fatal accidents occurred in this month. The first one on the 17th inst., when George Wyrick, miner, 62 years of age, was killed by falling coal in the Vandalia No. 50 Mine, Clay County. At the time he met his death decedent was engaged in under-cutting a standing shot, and had nearly completed his work when a large mass of top coal overhanging his place suddenly gave way, falling on him, crushing his head almost into a pulp. There were no eyewitnesses to the accident, but it is supposed it was due to the fact that decedent was partially deaf and did not hear the noise of the coal breaking prior to falling. He leaves a dependent wife and one child.

June 22d Hiram Miller, loader, aged 64 years, leaving a dependent wife, was fatally injured by falling draw slate in the Indiana Southern Coal Company's Forest Mine, Vigo County. At about 12:45 o'clock, noon, decedent was preparing some dummies for the purpose of tamping a shot, and while so engaged he was sitting directly under the slate which caused his death and which he knew to be loose. Suddenly, without warning, the slate gave way and a large piece, measuring ten feet in length, five feet wide and six inches thick, fell on him, crushing his chest and breaking both legs in several places. His injuries were so serious that he died ten minutes later. There were a number of props and cap-pieces available near the scene of the accident, and considering the length, breadth and thickness of the slate, two or more of them should have been set under it. Had this been done the accident in all probability would not have occurred.

JULY.

Seven fatalities is the record for this month. On the first day of the month two Italian miners, whose names were Pietro Bartalonia, 22 years of age, single, and Silvio Senlensky, 27 years of age, who leaves a wife and two children, were fatally burned in an explosion of powder in the Dering No. 5 Mine, Vermillion County. There were no eyewitnesses to this accident, and in addition to the fact neither of the men could speak the English language intelligently, they were both in such condition they could give no explanation whatever concerning the accident before their death. On investigation it was learned that the two were working buddies, having two adjoining rooms, Nos. 4 and 5, on the sixth southwest cross-entry, and that on the morning of the day of the accident they had taken into the mine two fresh kegs of powder. The accident occurred about 12:30 o'clock, noon, this hour being usually employed by miners in making up their cartridges, charging and tamping shots, etc. On inspecting their respective working places we found one of the powder kegs empty and two shots ready to fire in room No. 4. In room No. 5 we found a shot on the east side of the room which had evidently been fired since any other work had been done in the room. A shot was drilled ready to tamp on the west side of the room, and lying on the floor near the mouth of the drill hole we found their tamping tools and a quart can, such as miners use in filling cartridges, and an empty powder keg, burst from the inside, indicating that they were engaged in charging this shot when a spark from a lamp or other cause exploded the powder either in the quart can or the keg, more than likely the former, this in turn exploding the keg. Although known to be seriously burned, it was not thought at the time either of the men were fatally injured. Senlensky was taken to his home in Clinton, where he died at 10 o'clock p. m. of the same date. Bartalonia was taken to the St. Anthony Hospital in Terre Haute, where he died at 4 o'clock p. m. of the following day. An observance of the statute requiring a lamp or any other thing containing fire to be kept no nearer than six feet to powder when making up cartridges or charging shots would have prevented this accident.

July 5th James Donahay, road man, 45 years of age, who leaves a wife and five children, was killed by falling draw slate and coal in the Miami No. 2 Mine, Vigo County. Decedent was engaged about 10 o'clock a. m. laying a room parting on one of the cross-entries, and in order to make room for the parting ties, found it necessary to under-cut the coal seam at the corner of the room pillar. A shot had been previously placed behind this corner, and a portion of the lower bench of the coal seam had been mined off and loaded out by the miner who turned the room, leaving a ledge of the upper bench, together with some loose draw slate, hanging out over the point where the ties were to be placed. Before commencing to mine, Donahay sounded this overhanging ledge with a pick, and thinking it safe, proceeded to mine off the lower portion of the seam. The coal and slate were evidently much looser than he supposed, as he had struck but a few blows with the pick when the entire mass gave way, falling on him and killing him instantly.

On the same date as above accident Archie Hunter, a top laborer, 18 years of age, single, was killed instantly by a descending cage at the surface landing of the Tecumseh Mine, Knox County. This shaft was sunk but recently and little had been done in the way of development. The signal bells, speaking tube, gates and other detail of equipment were not yet complete, and but five persons were employed on each shift, two at the top of the mine and three in the bottom, who were driving entries, sinking the sump and other work incident to opening, equipping and developing a new mine. The signal bells not being in position, Hunter was employed to take the place of this part of the equipment, i. e., he would transmit by word of mouth or by gesture, to and from the men in the bottom of the hoisting shaft and the engineer, the necessary signals to hoist or lower the cages, the same as is usually done at all new mines when breaking away from the bottom. It was customary, when about to fire a blast in the bottom, for the miners to get everything in readiness and notify the top signal man, who in turn would notify and have the engineer at his post and call back to those in the bottom when all was ready, after which they would light their shot, get on the cage and call "hoist away." At about 8:30 o'clock p. m. a blast had been made ready to fire, and David Gibson, one of the miners, stepped on the west cage, which was then on the bottom, and called up to Hunter, asking if he was ready. Hunter, seeing the engineer at his post, replied in the affirmative, but at this point seems to have become confused, as he gave the engineer the signal to hoist without first having had word from those below to do so. The engineer, immediately upon receiving the signal, hoisted the cage to the surface, Gibson still remaining aboard, and when he stepped off the cage found Hunter lying dead by the side of the east hoisting compartment, his head crushed. It is presumed decedent discovered his error just about the time the engineer began to hoist, and in his excitement, wishing to ascertain if any damage was being done those below, unthoughtedly leaned out over the shaft under the east cage, which was then above him, and was struck by it in descending. He leaves a father and mother partially dependent on him for the support of younger brothers and sisters.

July 8th Homer Trueblood, loader, 18 years of age, single, was killed by falling slate in the Mammoth Vein Mine, Sullivan County. On investigating this accident it was learned that decedent and a fellow-miner by the name of Mack Smith were working buddies, loading coal together, having two working places, rooms 1 and 2, on the third northeast cross-entry. On the day of the accident they were loading in room No. 2, and had loaded nine cars of coal, working under slate, which they knew to be loose and which in fact they tried to pull down, at about 11:30 o'clock a. m. On failing to get the slate down, Smith then advised Trueblood to set some props under it. Trueblood, replying it would not fall for a while, continued with his other work. Smith had gone into room No. 1 for the purpose of drilling some holes, leaving Trueblood at work mining off some loose coal. While so engaged, a few minutes after 1 o'clock p. m. a large piece of the slate 8 feet in length, 6 feet wide, ranging from 3 to 10 inches in thickness, gave way, falling on him, crushing his skull, breaking his neck, killing him instantly. He leaves a father, mother and three younger brothers who were practically dependent on him for support.

July 19th Will Richardson, driver, 25 years of age, single, who leaves a dependent mother, was fatally injured in the Lattas Creek Mine, Greene County. Decedent was going into one of the cross-entries at about 9:30 o'clock a. m. with an empty mine car and a mule. At the time he was riding on the front end of the car. According to his statement the mule kicked him in the side, knocking him over between the car and the entry-rib, where he was caught and crushed through the hips. Confirming this statement, a large discoloration, made by the imprint of the mule's foot, was found on his side, while his badly torn clothes, as well as severe bruises on his limbs and body, were evidence of his having been dragged between the car and the side of the entry. The space between the entry-rib and the side of the car at this point was about 12 inches, and had he been caught in the right position in the space he could easily have sustained a fatal injury, yet which injury caused his death, i. e., the injury received from being kicked by the mule or from being caught between the car and entry-rib, an autopsy alone could determine. Shortly after being injured he lapsed into unconsciousness, in which state he remained until his death, which occurred at 1:05 p. m. of the same date.

July 24th Joso Bieam, miner, 34 years of age, Austrian, was killed by falling slate in the Dering Mine No. 7, Vermillion County. From evidence elicited at the investigation and an inspection of decedent's working place it was learned that the mine boss had visited Bieam on the morning of the above date, and had noticed some very loose draw slate, which he ordered him to timber and which Bieam agreed to do, after which the boss continued on his way through the mine. This conversation occurred at about 8:30 a. m., and was the last seen of Bieam by the mine boss until his death. About 11:30 a. m., while he was loading a car, a piece of the slate 6 feet long, 6 feet wide and 5 inches thick fell on him and killed him instantly. At the time of the accident Luke Surlos, Austrian, was working with him. An examination of the room where the accident occurred was made by Assistant O'Connor, and it was found to be very poorly timbered. The props were not set closer than within 30 feet of the face, except those which had been set under the edge of the slate which fell, and those which were set in many instances had no cap pieces over them, indicating that deceased was not a practical miner nor timberman. This fact was also evidently noticed by the mine boss, and knowing this and that neither the decedent nor his buddy could understand but very little English, probably did not understand his order to set the timbers, he (the mine boss) was negligent in not remaining with them until he knew the place was made safe, or he should have ordered them out of the place and caused it to be timbered by one of the regular timbermen. Deceased leaves a wife and four children.

AUGUST.

Four fatalities is the record for this month, two occurring at the same time on the 5th inst. in the Keystone Mine, Sullivan County. Frank Delshmut, the superintendent of the mine, and George Anderson, mine boss, lost their lives in an explosion of fire-damp. The facts brought forth at the investigation of this accident disclose carelessness on the part of the two men killed, astonishing to say the least. The A. H. Whitset Coal Company, former owner of the mine, failed in the latter part of July and the mine went into the hands of a receiver. July 25th was the last day on which coal was hoisted. A number of miners brought out their tools on the morning of the 29th. The fire boss on this occasion examined the mine prior to the miners going into it. These were the last persons in the mine from that date until the day of the explosion, except the mine boss, who had gone down on the morning of August 2d to start the pumps, which are located near the shaft bottom. During this idle time Delshmut was made receiver for the company, also mine superintendent, and it was while examining the mine with reference to timbers needed, pumps and other repairs necessary to start the mine he and Anderson met their death. Both men were practical miners, Delshmut having had a number of years' experience as mine superintendent and mine foreman at mines in various parts of the State, and Anderson for several months prior to his death had been serving as mine boss of this mine. Both knew the mine generated large quantities of fire-damp, and in addition to one heavy explosion, in which no one was injured, several accidents of a serious nature had occurred from the same source. In fact, one or two men were badly burned during the time Anderson had been bossing the mine. Knowing these facts, wishing to make the experiments above stated, they went into the mine about 9:30 o'clock a. m. on the 5th with open lamps and no safeguard whatever against fire-damp, and the explosion occurred about fifteen minutes later. The alarm was given at once, the fan speeded to full capacity and a searching party organized, who by entering the mine with and following the intake air current, were enabled to rescue the unfortunates. Delshmut was found badly mangled, dead, having been killed instantly. And Anderson, though alive, was semiconscious, in which state he remained until about 10 o'clock a. m. of the following day, when he died. He leaves a wife and one child. Delshmut was unmarried, but leaves a dependent father.

August 19th August Waldon, driver, 32 years of age, single, was crushed to death by loaded mine cars in the Dering Mine, No. 7, Vermillion County. About 12:30 o'clock p. m. Waldon was bringing a trip of two loaded cars out of the fifth southwest cross-entry, riding in the manner drivers usually do, with one foot on the drawbar of the car and one on the tail-chain. While coming down a hill near the mouth of the entry he either lost his footing or was crowded off the tail-chain by the mule, falling on the side of the entry, and was caught and dragged between the car and the rib. When found a few minutes later by a trapper and another driver he was lying unconscious between the cars and the entry side with one leg between the wheels under the rear car, indicating that in addition to having dragged him, the cars had partially run over him. He was crushed through the shoulders, chest and hips, and also received internal injuries, from the effects of which he died at 4:30 o'clock a. m. of the following day. He leaves a dependent father.

August 26th John Sharpless, miner, 36 years of age, single, was killed by falling slate in the Vandalia Mine No. 50, Clay County. From evidence adduced at the investigation of this accident it was learned at the time he met his death Sharpless was employed drawing pillars, and during the interim from Saturday night of the 24th and Monday morning of the 26th his working place had caved in back to the end of the pillar which he was drawing. About 9:45 o'clock a. m. of the latter date decedent, who was a thoroughly practical miner, after having, as he supposed, made the place safe, was engaged in loading a car of coal, when suddenly a large piece of slate 6 feet in length, ranging from 3 to 5 feet wide and 14 inches thick, gave way, falling on him, killing him instantly.

SEPTEMBER.

Three fatal accidents occurred in this month. The first of these occurred on the 16th inst. in the Vandalia No. 9 Mine, Vermillion County. At 3:30 o'clock p. m. of this date James Murdock, a lad but 16 years of age, working in the mine with his father, was fatally injured by falling slate. At the time of the accident he and his father, George Murdock, were on their way out of the mine and had reached a point about 139 feet from the face of the second south cross-entry off the fourth southwest, their working place, when a large piece of draw slate 7 feet square and 7 inches thick gave way and fell, catching decedent, breaking a leg and three ribs and otherwise injuring him. He died the following day. The father at the time was some four or five feet in advance of the boy, and he was also struck by the slate and painfully injured. From the evidence of several witnesses testifying at the investigation of this accident, among whom were the father and two brothers of deceased, it was learned that the slate which caused the accident was known to be loose and in a dangerous condition for several days prior to the accident, and that the mine boss had full knowledge of this fact, having been notified of the same by George Murdock, and that he (the mine boss) examined and sounded the slate on the morning of the day of the accident and promised to attend to it. In addition to having made no effort either to secure the slate with timbers or take it down, he permitted both miners, drivers and mules to pass to and fro under it during the day's work until it fell with the above result. All of which being true, but one conclusion could be reached, i. e., that the mine boss was criminally negligent of his duty. George Murdock testified that his son had been working in the mine but about five months prior to his death; he further stated that he had known the slate which caused his death was loose and dangerous a week before it fell. John Murdock, 21 years of age, testified that he had heard his father complain to the mine boss that the slate was loose; also had heard his father warn other persons not to come in the entry because the slate was dangerous, and that he (John Murdock) had examined the slate about 10 minutes prior to the accident, and that he was afraid it would fall. Possessing a full knowledge of these facts, both he and his father continued passing to and from their work under this slate, which apparently was extremely loose and liable to fall at any moment; also permitting or causing the younger inexperienced brother to do likewise. One of the following safeguards could have been adopted in this instance: When leaving the mine, some road should have been used other than the one over which the loose slate was hanging. Failing in this, as a matter of precaution for their own safety, they should have stood one or more props under the slate to steady it before passing under it, or one of them could have examined and watched for any movement of the slate, placing his hand against it, while the other two passed under it, they in turn to do likewise while he passed through. Any one of these precautionary measures would have prevented this accident, yet none of them seem to have been adopted. A summing up of all the facts tends to show George and John Murdock, father and son, were equally guilty with the mine boss of negligence in their duty to decedent.

September 26th Addison Sheets, miner, 37 years of age, wife and three children, was killed by a delayed shot in the Fauvre No. 1 Mine, Vigo County. There were no eyewitnesses to this accident. An examination of the premises and evidence brought forth at the investigation developed the following facts: On the afternoon of the above date decedent had two shots in the face of his working place, the sixth northeast cross-entry. The shots had been tamped on fuse and both had been fired; also, that decedent was found at about 3:30 o'clock p. m., a few minutes after the shot firing in the mine had commenced, unconscious, with his skull crushed. He was lying about 31 feet from the face of his working place, while near and around him were several pieces of coal which had evidently been thrown and struck him from one of the shots. He also sustained several other cuts and bruises in addition to internal injuries, from the effects of which he died while being taken to his home. One of the two shots above referred to was a snubber and one a back shot. It is presumed decedent lighted both shots, or attempted to do so, before leaving the place, the snubber having the shorter fuse, exploded first, and the back shot having the longer and possibly a faulty fuse, may have burned so long before reaching the powder that decedent thought he had failed to light it and was returning to do so, when, while within a few feet of the shot, it exploded. One more death charged to the use of fuse in shot firing.

September 27th James Black, timberman, 48 years of age, wife and 3 children, was fatally injured by falling slate in the Coal Bluff Mining Company's Lawton Mine, Vigo County. This accident occurred at about 12 o'clock, noon, on the eleventh southwest cross-entry. There was no one present at the time, and the first knowledge obtained of the accident was by Leonard Stapleton at 12:20 o'clock, while passing through the entry, found Black lying under a piece of slate 9 feet in length, 5 feet wide and 4½ inches thick. Stapleton procured assistance at once and removed the slate, when it was found decedent suffered from a broken shoulder and six broken ribs in addition to internal injuries, from which he died at 11:30 a. m. of the 30th following. It was supposed by some that he was examining the slate which caused his death, preparatory to replacing a cross-bar which had been knocked out from under it two days previous by a mine car, and that while so engaged the slate fell on him. Considering the fact the accident took place just at 12 o'clock, the hour all employes stop for lunch, also the location of his dinner pail and tools, the former being at the face of the eleventh south entry and the latter some distance outside the fall, it is probable he was on his way to lunch when the slate caught him.

OCTOBER.

Four deaths is the record for this month. On the 2d inst. Claude Luzader, cager, 29 years of age, single, was crushed to death by an ascending cage at the bottom of the hoisting shaft of the Indiana Consolidated Coal Company's No. 30 Mine, Sullivan County. On the afternoon of above date (the hoist being over) rails and track material were being lowered into the mine. At 3 o'clock Luzader had just finished unloading a cage load of such material when a number of persons came to the shaft bottom, wishing to go out of the mine. The north cage, the one on which the rails were being lowered, was then on the bottom, empty, the east bonnet was raised, however, to permit the rails being placed on the cage. Luzader rang three bells to the engineer, and stepping on the cage, started to walk across it when the engineer, without waiting for any other signal, hoisted the cage, catching the decedent between the brow timber and the bottom of the cage, crushing him to death instantly. Three bells is the signal at this mine used by persons at the bottom when wishing to stop the cage at the surface landing for the purpose of taking off picks, etc., and decedent being new at the work, having served but one day as extra cager, it is presumed thought the same signal would apply to the bottom, and unconsciously gave the three bells, intending to hold the cage stationary at the bottom until he could cross it and let the east bonnet down. The engineer, thinking he wished the cage stopped at the surface landing, hoisted it up with the above results.

October 7th Lewis Butler, machine helper, 35 years of age, who leaves a wife and one child, was injured by falling draw slate and coal in the Summit No. 2 Mine, Greene County. On the morning of the above date Butler and the machine runner, William Asher, were under-cutting room No. 21 on the fifth southwest cross-entry with an electric chain mining machine. At 10 o'clock they had just finished an under cut and the machine was backing out, when suddenly a large mass of coal and draw slate, which had evidently been broken by a previous shot, gave way, falling on Butler, breaking his right leg in two places, also injuring him internally. He was taken to his home and a physician called, who gave his opinion that the injuries were not fatal. He died, however, on the 14th inst. following from uremic poisoning.

October 15th Fred Harden, pump man, 25 years of age, single, was fatally injured in the Dering No. 5 Mine, Vermillion County. At 10 o'clock a. m. while working around an electric pump he slipped and fell, catching his hand in one of the cog wheels, lacerating his fingers badly. Blood poisoning set up later, resulting in his death on the 24th following.

October 28th Peter Papovicin, miner, 22 years of age, single, was fatally burned in an explosion of powder in the Buckeye Mine, Vermillion County. On the afternoon of above date Papovincin had drilled a hole behind a shot in his room, and in doing so struck and drilled through a piece of sulphur. At 2 o'clock he was charging the hole and had placed two charges, about two quarts of powder, in the hole, which he was trying to push back with his scraper. The button on the end of his scraper was too large to pass through the point where the sulphur lay. He then tried to force the powder through this space with an iron tamping bar, and in doing so struck the edge of the sulphur with the bar, which emitted a spark, exploding the powder in the hole, this in turn exploding an almost full keg setting near by, burning him so that he died at 1:25 p. m. of the following day at the St. Anthony's Hospital in Terre Haute. A copper tamping bar, such as is called for by statute, would have prevented this accident.

NOVEMBER.

Six fatalities occurred in this month. On the 4th inst. Carl Myers, driver, aged 18 years, single, was crushed to death between a car and mine door in the Tower Hill Mine, Greene County. At 8 o'clock a. m. decedent was coming out of the mine with a loaded trip and was riding on the front end of the car, standing with one foot on the drawbar and one on the tail chain. He was riding with his face partially toward the car. While passing through a mine door which had previously been propped open to permit him to pass through, the door in some way became loose from its fastening and swung to just as the driver was entering it. The edge of the door caught him against the end of the car, crushing him to death instantly. He leaves a dependent mother and four younger brothers and sisters.

November 7th Bernard Kurthoff, miner, 52 years of age, was killed instantly by falling slate in the Vandalia No. 6 Mine, Greene County. He leaves a dependent wife. At 9:10 a. m. decedent was at work loading a car within a few feet of the face of his room. He had the car about bedded (level full) and was reaching out over it placing small pieces of coal around the sides of the car. While so engaged a large piece of slate 13½ feet in length, 6½ feet wide and 12 inches thick suddenly gave way, falling on him, pinning him down on the edge of the car and coal. When found a few minutes later he was lying in this position under the slate, his neck broken and otherwise mutilated. The room in which decedent was working was recently driven through a fault, on which account it had been narrowed down to 10 feet in width. At the time he met with his accident he was renecking it. A large roll, comprising a part of the fault, lay directly across the place, with a slip extending up over it. A shot had been made under the heavy end of the roll on the evening of the 6th and a portion of the coal loaded out on the morning of the 7th, and the support thus removed caused the slate to fall.

November 12th records two fatalities occurring in the Vandalia No. 10 Mine, Sullivan County. At 9:30 o'clock a. m. Horace McIntire, loader, 18 years of age, single, was caught between an empty mine car and a prop and injured so he died on the evening of the

20th following. From evidence adduced at the investigation of this accident it was learned that decedent, when not engaged in loading coal at his working place, was in the habit of spending his time with the drivers, making trips for them, etc. At the hour above named he was sitting at one of the double partings when one of the drivers came in with a loaded trip. The driver hitched his mule to an empty car and walked around to uncouple it from the trip when McIntire stepped on the drawbar of the car and tail chain and struck the mule several sharp blows with a stick, causing it to leave the parting in a run. He had traveled but a short distance, however, when the car took the points of a cross-entry switch and jumped the track. McIntire, instead of jumping off the car, as he should and could have done, remained on the tail chain and was dragged up against a post which stood on the side of the road, injuring him as above stated.

At 10:30 a. m. of this same date Archie Aikman, motorman, 25 years of age, was fatally injured by being caught between a loose cross-bar and the motor on one of the cross-entries. At the hour above named decedent was taking a trip of empty cars into the cross-entry and was riding on the front end of the motor at the time and was driving it at a speed of about 6 miles an hour. A cross-bar which had evidently been knocked out of place by the loaded trip last made was lying directly across the entry, one end resting at the roof on a prop and the other about 2½ feet from the floor. Aikman did not see the timber until within a few feet of it, and was driven up against it by the motor and so injured he died about two hours later. He leaves a wife and two children.

November 12th Jules Vonzamilute, miner, 30 years of age, was killed by a blast in the Vandalia No. 5 Mine, Greene County. At firing time (3:30 p. m.) of above date Vonzamilute, having three shots tamped ready to fire, requested a fellow miner by the name of Gribbe, who was working in an adjoining room, to assist him in lighting them. The three shots were located one on each rib and one in the center of the room, and all of them tamped on fuse. Gribbe, after lighting his own shot, went over into Vonzamilute's room to assist him as requested, decedent at the time was standing about the center of the room nearly 10 feet back from the face, and motioned Gribbe to light the shot on the right hand rib. Just as the latter was about to apply his light to the fuse the shot in the center of the room exploded, hurling large pieces of coal back a distance of 25 feet from the face, some of which struck decedent, crushing his skull and injuring him otherwise so he died a few hours later. Deceased was unconscious from the time of his accident until his death, and could give no reason why he lighted the shot and remained in the room, also permitting a fellow miner to come into the room, thus endangering his life. This being true, there can be but one explanation, viz., decedent was not a practical miner, knew nothing about the use of explosives and did not realize the danger to which he was exposing himself and Gribbe.

November 14th Dell Brock, driver, 18 years of age, single, was run over by loaded mine cars and instantly killed in the Summit No. 2 Mine, Greene County. Brock was employed as a spike team driver, hauling coal from a double parting to the shaft bottom, a distance of 706 feet. There were no eyewitnesses to the accident, and when last seen alive (9:30 a. m.) decedent was leaving the double parting with a loaded trip of cars for the shaft bottom, and when found a few minutes later his trip was standing 141 feet from the siding, the two front cars in the trip off the track and Brock lying under the second car, his skull crushed and life extinct. His cap and lamp were found on the roadway about 20 feet inside the point where the trip was stopped, while above the point was a 2x4-inch cross-bar. The entry at this point also has a slight grade in favor of the loaded cars, and it is the general opinion that decedent was coming down this grade at a fast rate of speed, and striking his head against this bar, lost his balance, falling under the trip and was dragged from that point to where his body was found, the front car in the trip having passed over him.

December.

Three fatal accidents is the record for this month. The first occurred on December 18th, when Louis Harmon, miner, 75 years of age, single, was fatally injured by falling slate in the Superior No. 5 Mine, Parke County. At 3 o'clock p. m., having completed his day's work, decedent had gone back to where he left his clothes and powder box in a break-through, 70 feet from the face of his working place, and was in the act of dressing, preparatory to going home, when a large piece of slate 19 feet in length, 7 feet wide and 6 inches thick fell without warning, striking him and injuring him so that he died about one hour later while being taken home.

December 19th Frank Hawhee, driver, 26 years of age, wife and one child, was instantly killed by being run over with loaded mine cars in the Dering No. 7 Mine, Vermillion County. From evidence adduced at the investigation of this accident it was learned that at about 1:40 p. m. decedent was coming out of the mine with a trip of two loaded cars, riding with one foot on the drawbar of the car and the other on the tail chain, and while coming down a slight grade he was kicked by his mule, losing his balance and falling under the rapidly moving trip. When help arrived he was found doubled up under the first car in the trip, his head between the wheels and life extinct.

December 31st Joe Karasave, loader, 46 years of age, wife and 7 children, was fatally injured by falling slate in the Vandalia No. 8 Mine, Greene County. At 11:42 a. m. decedent was engaged at the face of his working place working down some loose coal, when a large piece of slate of a pot formation, measuring 6½ feet in length, 5 feet 5 inches wide and 3¼ inches thick, gave way without warning, falling on him, inflicting injuries of which he died three and one-half hours later.

In the following table will be found a summary of fatal accidents, showing the date on which each accident occurred, the name, occupation, age and nationality of persons killed, the number of dependents left by each death, cause of accident and the name of the mine wherein the accident occurred:

TABLE

Summary of Fatal Accidents.

Date.	NAME.	Occupation.	Age	Cause of accident.	Mine.	County.	Dependents.					Nationality.
							Wife.	Children.	Father.	Mother.	Other Dependents.	
Jan. 5	Otto Saxseburgh	Shot-firer	33	Blown out shot	Maple Valley	Vermillion	....	....	....	....	....	Findlander.
Jan. 8	Samuel Adams	Top laborer	60	Falling down shaft	Vandalia No. 316	Parke	1	....	....	....	....	American.
Jan. 9	Peter Gebhart	Timberman	39	Falling slate	Oswald	Gibson	1	3	....	....	....	German.
Jan. 12	George Howard	Driver	18	Mine car	Hudson	Sullivan	....	....	1	....	....	American.
Jan. 14	Edward Wolf	Miner	....	Powder explosion	Dering No. 7	Vermillion	....	....	....	1	....	Polish.
Jan. 14	J. Phasto	Miner	....	Powder explosion	Dering No. 7	Vermillion	1	....	....	....	....	Polish.
Jan. 14	J. Joseph	Miner	....	Powder explosion	Dering No. 7	Vermillion	1	3	....	....	....	Polish.
Jan. 14	T. Halenk	Miner	....	Powder explosion	Dering No. 7	Vermillion	1	1	....	....	....	Polish.
Jan. 14	J. Brezus	Miner	....	Powder explosion	Dering No. 7	Vermillion	....	....	....	....	....	German.
Jan. 14	H. Shonen	Miner	....	Powder explosion	Dering No. 7	Vermillion	....	....	1	1	....	Findlander.
Jan. 14	Leo Pike	Miner	....	Powder explosion	Dering No. 7	Vermillion	1	....	....	....	....	Polish.
Jan. 14	Robt. Johnson	Miner	30	Delayed shot	Twin No. 4	Greene	1	1	....	....	....	Scotch.
Jan. 15	S. Sacery	Miner	40	Ascending cage	Buckeye No. 2	Vermillion	....	....	....	....	....	Italian.
Jan. 16	William Metcalf	Miner	22	Falling slate	Cummins	Sullivan	....	....	....	....	....	American.
Jan. 22	Mike Lyyskie	Shot-firer	39	Smoke explosion	Dering No. 15	Vermillion	1	1	....	....	....	Findlander.
Jan. 22	John Poska	Shot-firer	26	Smoke explosion	Dering No. 15	Vermillion	1	3	....	....	....	Findlaner.
Feb. 6	Chas. Harling	Timberman	57	Falling slate	Vandalia No. 40	Knox	1	....	....	....	....	German.
Mar. 12	David Hill	Miner	23	Powder explosion	Brazil No. 4	Clay	....	....	....	....	....	American.
Mar. 12	Thomas Roberts	Miner	19	Powder explosion	Brazil No. 4	Clay	....	....	1	1	....	American.
Mar. 19	Francis Padget	Flat trimmer	37	Railroad cars	Little Giant	Sullivan	1	4	....	....	....	American.
Mar. 28	Matto Gentile	Miner	35	Ascending cage	Crown Hill No. 1	Vermillion	....	....	....	....	....	Italian.
Mar. 30	Harry Smith	Driver	25	Falling slate	Oak Hill No. 50	Vermillion	1	1	....	....	....	American.
April 25	Daniel O'Donnell	Driver	25	Mine car	Lattas Creek	Greene	....	....	....	1	....	American.
May 27	Leo Huff	Top laborer	28	Railroad car	Electric	Warrick	1	3	....	....	....	American.
June 17	George Myrick	Miner	62	Falling coal	Vandalia No. 50	Clay	1	1	....	....	....	Welsh.
June 22	Hiram Miller	Loader	64	Falling slate	Forest	Vigo	1	....	....	....	....	American.
July 12	Pietro Bartalonia	Miner	22	Powder explosion	Dering No. 5	Vermillion	....	....	....	1	....	Italian.
July 12	Silvio Sentsky	Miner	27	Powder explosion	Dering No. 5	Vermillion	1	2	....	....	....	Italian.
July 5	Jas. Dunahay	Road man	45	Falling slate	Miami No. 2	Vigo	1	5	....	....	....	Irish.
July 5	Archie Hunter	Top laborer	18	Descending cage	Tecumseh	Knox	....	....	1	1	....	Scotch.
July 8	Homer Trueblood	Loader	18	Falling slate	Mammoth	Sullivan	....	....	1	1	1	American.
July 19	Will Richardson	Driver	25	Kicked by mule	Lattas Creek	Greene	....	....	....	1	....	American.

July 24	Joso Bicam	Miner	34	Falling slate	Dering No. 7	Vermillion	1	4	....	....	....	Austrian.
Aug. 5	Frank Delshmut	Mine superintendent	....	Fire damp explosion	Keystone	Sullivan	....	....	....	....	....	American.
Aug. 5	George Anderson	Mine boss	....	Fire damp explosion	Keystone	Sullivan	1	1	....	....	....	English.
Aug. 19	John Waldon	Driver	32	Fell under mine car	Dering No. 7	Vermillion	....	....	....	1	....	American.
Aug. 26	John Sharpless	Miner	36	Falling slate	Vandalia No. 50	Clay	....	....	....	....	....	American.
Sept. 16	James Murdock	Miner	16	Falling slate	Vandalia No. 9	Green	....	....	1	1	....	American.
Sept. 26	Addison Sheets	Miner	37	Delayed shot	Fauvre No. 1	Vigo	1	3	....	....	....	American.
Sept. 27	James Black	Timberman	48	Falling slate	Lawton	Vigo	1	3	....	....	....	Scotch.
Oct. 2	Claude Luzader	Cager	29	Ascending cage	Con. Ind. No. 20	Sullivan	....	....	....	....	....	American.
Oct. 7	Lewis Butler	Machine helper	35	Falling slate, hand mashed	Summit No. 2	Green	1	1	....	....	....	American.
Oct. 15	Fred Hardin	Pumpman	25	Blood poisoning	Dering No. 5	Vermillion	....	....	....	....	....	American.
Oct. 28	Pietro Popovinci	Miner	22	Powder explosion	Buckeye	Vermillion	....	....	....	....	....	Roumanian.
Nov. 4	Carl Meyers	Driver	18	Between car and mine door	Tower Hill	Greene	....	....	....	1	4	American.
Nov. 7	Bernard Kurthoff	Miner	52	Falling slate	Vandalia No. 6	Greene	1	....	....	....	....	German.
Nov. 12	Horace McIntire	Loader	18	Between mine car and prop	Vandalia No. 10	Sullivan	....	....	1	1	....	American.
Nov. 12	Archie Aikman	Motorman	25	Motor and cross bar	Vandalia No. 10	Sullivan	1	2	....	....	....	American.
Nov. 12	Jules Vonzamilutc	Miner	30	Premature blast	Vandalia No. 5	Greene	....	....	....	....	....	French.
Nov. 14	Dell Brock	Driver	18	Run over by mine cars	Summit No. 2	Greene	....	....	1	1	....	American.
Dec. 18	Louis Harmon	Miner	75	Falling slate	Superior No. 5	Parke	....	....	....	....	....	French.
Dec. 19	Frank Hawhee	Driver	26	Mine cars	Dering No. 7	Vermillion	1	1	....	....	....	American.
Dec. 31	Joe Karasave	Loader	46	Falling slate	Vandalia No. 8	Greene	....	....	....	....	....	Polander.

PERSONS PERMANENTLY INJURED.

Under this head we include only the accidents resulting in the amputation of a limb, a broken back or other injuries unfitting persons to perform the duties of their usual occupation.

The following table exhibits the date of accident, the name, age and occupation of persons injured, the number of persons dependent on each for support, the nature and cause of the injury and the name of the mine and the county where the accidents occurred:

TABLE OF PERMANENT INJURIES.

Date.	NAME.	Age.	Occupation.	Dependents		Injury.	Cause of accident.	Mine.	County.
				Wife.	Children.				
Jan. 12	Samuel Oldman	29	Shot firer	1	2	Arms, hands, face burned	Powder explosion	Lower Vein	Vigo.
Jan. 12	Oliver Kelly	45	Shot firer	1	6	Face, arms, hands burned	Powder explosion	Lower Vein	Vigo.
Feb 19	Wm. Hawton		Loader	1	0	Back dislocated	Falling slate	Gilmour	Greene.
May 1	James Douglas	19	Miner	0	0	Arms, hands, face burned	Powder explosion	Lower Vein	Vigo.
June 1	Bert Griffin	22	Driver	0	0	Leg amputated	Mine car	Vandalia No. 316	Parke.
July 18	Victor Brugman	25	Jerryman	1	0	Hands, arms, face burned	Explosion fire damp	Vandalia No. 10	Sullivan.
Sept. 14	Charles Johns	20	Miner	0	0	Back broken	Falling slate	Vandalia No. 66	Vigo.
Sept. 19	Richard Creighton	26	Miner	1	0	Leg crushed	Falling slate	Vandalia No. 10	Sullivan.
Oct. 5	Wm. McClelland	25	Motorman	1	0	Leg amputated	Fell under motor	Black Creek	Greene.

TABLE

Showing the Nationality of Persons Killed or Permanently Injured and the Number of Dependents.

Nationality.	*Fatal.*	*Permanent.*	*Dependents.*
American	27	7	59
Polish	6	..	17
German	4	..	6
Italian	4	..	4
Finlanders	3	..	7
Scotch	3	..	8
Welsh	1	..	2
Irish	1	..	6
English	1	1	3
Austrian	1	..	5
Roumanian	1	..	..
French	1	1	1
Totals	53	9	118

COMPARATIVE TABLE

Showing Number of Tons of Coal Mined Each Year, the Number of Persons Employed and the Number of Tons of Coal Produced per Each Death Each Year From January 1, 1898 to January 1, 1908.

YEAR.	Tons produced.	Employes.	Fatal accidents.	Tons produced per death.
1898	5,146,920	No report.	22	233,950
1899	5,864,975	7,366	15	390,997
1900	6,283,063	8,858	18	349,059
1901	7,019,203	10,296	24	292,466
1902	8,763,197	13,139	24	365,133
1903	9,992,563	15,128	55	181,683
1904	9,872,404	17,838	34	290,364
1905	10,995,972	17,856	47	233,956
1906	11,422,027	19,562	31	368,450
1907	13,250,715	19,009	53	250,013

SERIOUS ACCIDENTS.

Under this head (as in our former reports) we include only the accidents resulting in broken bones, internal and other injuries such as we think are of a nature serious enough to call for special mention. In the following summary we exhibit the number of serious accidents occurring, the date of each accident, the name, age and occupation of persons injured, the nature, cause and extent of the injury, the number of persons dependent on each person injured for support, the length of time they were idle by reason of this injury (where we were able to ascertain the same) and the name of the mine and county wherein the accident occurred:

TABLE OF SERIOUS ACCIDENTS.

Date.	NAME.	Age.	Occupation.	Dependents. Wife.	Dependents. Children.	Days Idle.	Injury.	Cause of Accident.	Mine.	County.
Jan. 1	Brook Cheek	20	Driver	0	0	30	Back injured	Fell under mine car	Miami No. 1	Vigo.
Jan. 3	Ed. Price	55	Loader	1	0	20	Hips and back injured	Falling slate	Gilmour	Greene.
Jan. 14	Mat. Sewell	25	Miner	0	0	14	Face and hands burned	Premature shot	Twin No. 4	Greene.
Jan. 23	George Hafflye	21	Miner	1	1	42	Ankle broken	Falling slate	Vulcan	Greene.
Jan. 24	George Bennett	....	Miner	....	....	....	Body burned	Explosion of powder	First Avenue	Vanderburgh.
Feb. 2	Wm. Gray	30	Loader	0	0	25	Foot crushed	Falling coal	Mammoth	Sullivan.
Feb. 2	Everett Blair	24	Motorman	0	0	71	Fingers cut off	Between car and motor	Mammoth	Sullivan.
Feb. 19	Robert Paseve	38	Miner	....	....	....	Face and hands burned	Smoke explosion	Castle Garden	Warrick.
Feb. 19	Robert McKain	26	Miner	....	....	....	Face and hands burned	Smoke explosion	Castle Garden	Warrick.
Feb. 19	James Buck	30	Miner	....	....	....	Face and hands burned	Smoke explosion	Castle Barden	Warrick.
Feb. 19	George Zimmerman	33	Miner	....	....	....	Face and hands burned	Smoke explosion	Castle Garden	Warrick.
Feb. 19	A. Balien	18	Miner	....	....	....	Face and hands burned	Smoke explosion	Castle Garden	Warrick.
Feb. 19	Enuch Roach	22	Miner	....	....	....	Face and hands burned	Smoke explosion	Castle Garden	Warrick.
Feb. 19	John Roach	26	Miner	....	....	....	Face and hands burned	Smoke explosion	Castle Garden	Warrick.
Feb. 19	Al. Zimmerman	50	Miner	....	....	....	Face and hands burned	Smoke explosion	Castle Garden	Warrick.
Feb. 19	James Roach	40	Miner	....	....	....	Face and hands burned	Smoke explosion	Castle Garden	Warrick.
Feb. 19	Lemuel Bailey	28	Miner	....	....	....	Face and hands burned	Smoke explosion	Castle Garden	Warrick.
Feb. 19	J. A. Kelly	40	Miner	....	....	....	Face and hands burned	Smoke explosion	Castle Garden	Warrick.
Feb. 19	W. Littlefage	20	Miner	....	....	....	Face and hands burned	Smoke explosion	Castle Garden	Warrick.
Feb. 19	G. W. Littlefage	....	Top laborer	....	....	....	Face and hands burned	Smoke explosion	Castle Garden	Warrick.
Feb. 26	Lee Rice	....	Top laborer	1	2	12	Back injured	Descending cage	Gilmour	Greene.
Mar. 12	Ray Carter	24	Driver	1	0	....	Injured internally	Caught under mine car	Citizens	Sullivan.
Mar. 7	James Clipner	24	Driver	0	0	6	Face injured	Kicked by mule	Greene Valley	Greene.
Mar. 12	Edwin Roberts	17	Miner	0	0	70	Face, hands and body burned	Explosion of powder	Brazil Block No. 4	Clay.
Mar. 23	Oscar Gerl[illegible]	....	Driver	....	....	....	Hips injured	Fell under mine car	Littles	Pike.
Mar. 29	A. McGrew	22	Motorman	0	0	46	Arm broken	Between mine cars	Mammoth	Sullivan.
April 3	Chas. Lisdale	....	Miner	....	....	....	Hips injured	Falling slate	Ayrshire No. 3	Pike.
April 4	Wm. Pentland	....	Loader	0	0	20	Skull fractured	Fall of slate	Gilmour	Greene.
April 6	Wallace Reid	38	Loader	1	0	210	Arm broken	Fall of slate	Mammoth	Sullivan.
April 8	Albert Wright	18	Miner	0	0	80	Leg broken	Falling coal	Lewis	Clay.
April 13	Jas. Fagin	50	Miner	0	0	90	Foot broken	Falling slate	Summit No. 2	Greene.
April 16	Louie Clary	23	Miner	....	....	14	Injured in abdomen	Falling slate	Excelsior	Clay.
April 16	Newton Steadman	....	Shot-firer	....	....	....	Body burned	Premnature shot	Vandalia No. 67	Vigo.

TABLE OF SERIOUS ACCIDENTS—Continued.

Date.	NAME.	Age.	Occupation.	Dependents. Wife.	Dependents. Children.	Days Idle.	Injury.	Cause of Accident.	Mine.	County.
April 16	John Watkins	28	Miner	1	1		Face and arms burned	Explosion of fire damp	Wabash	Vigo.
April 17	Walter Hedge		Miner				Face and body burned	Drilling of shot exploded	Ayrshire No. 4	Pike.
April 17	Harry Monroe		Miner				Face and body burned	Explosion of fire damp	Keystone	Sullivan.
April 20	A. J. Daugherty	25	Driver	1	1	12	Hips injured	Mine cars	Lattas Creek	Greene.
April 20	Isreal Blevins		Machine runner	1	2	28	Foot crushed	Caught under machine	Jackson Hill No. 2	Sullivan.
April 22	Wm. Collins	29	Driver	0	0	26	Hips injured	Fell under mine cars	Jackson Hill No. 2	Sullivan.
April 23	C. Blevins	18	Driver	0	0	100	Hips injured	Collision of mine cars	Jackson Hill No. 2	Sullivan.
May 1	Elbert Archfield	23	Driver	0	0	30	Hips injured	Caught between mine cars	Gilmour	Greene.
May 2	Chas. Bogess	24	Driver	1	2	12	Fingers broken	Sprag and car wheel	Lattas Creek	Greene.
May 3	Emil Adonrel	28	Miner	0	0	3	Knee injured	Falling coal	Vandalia No. 5	Greene.
May 3	Orvil Aikis	21	Driver	1	0	7	Head injured	Kicked by mule	Twin No. 4	Greene.
May 4	W. W. Burgess	30	Shot firer	0	0	21	Face, hands burned	Blown out shot	Oswald	Gibson.
May 4	Charles Wood	19	Miner	0	0	30	Foot crushed	Falling slate	Treager	Clay.
May 6	Howard Geemmer	20	Driver	0	0	48	Chest bruised	Between mine cars	Mammoth	Sullivan.
May 6	Denk Thomas		Driver				Ribs fractured	Kicked by mule	Gilmour	Greene.
May 6	Charles Southwood	20	Trip rider	0	0	210	Leg broken	Car jumped track	Mammoth	Sullivan.
May 9	George Bardsley	19	Driver	0	0	6	Head fractured	Caught by mine car	Phoenix No. 4	Sullivan.
May 11	John Sills	52	Timberman	1	6	18	Shoulders, ankle injured	Falling slate	Superior No. 2	Parke.
May 12	Charles Mask	30	Shot firer	0	0	7	Hands and face burned	Delayed shot	Maple Valley	Vermillion.
May 13	Marve City	33	Loader	1	1	40	Arm fractured	Mine car	Vivian No. 2	Clay.
May 14	John Easten	50	Miner	1	4	120	Leg broken	Falling slate	Vandalia No. 10	Sullivan.
May 16	Frank Lawson	18	Driver	0	0	86	Foot crushed	Run over by mine car	Mammoth	Sullivan.
May 16	Thomas Anderson	24	Miner	1	1	6	Back injured	Falling slate	Vandalia No. 5	Greene.
May 19	Thomas Jones	22	Driver	0	0	90	Foot crushed	Fell under mine car	Maple Valley	Vermillion.
May 20	Aleson Barton	30	Miner	1	2		Crushed chest	Between mine car and prop	Electric	Warrick.
May 20	Chas. Noble	28	Miner	1	1		Body burned	Overcharged shot	Castle Garden	Warrick.
May 21	John Boyd	21	Driver	0	0	12	Hips injured	Between mine cars	Vandalia No. 60	Clay.
May 21	Sam Murphy	30	Driver	1	2	41	Foot injured	Falling coal	Vandalia No. 10	Sullivan.
May 23	Milton Webster	40	Cager	1	4		Skull fractured	Coal falling down shaft	Victor	Vigo.
May 25	Harlem McKinon	59	Miner	1	0	65	Thigh and hips injured	Falling slate	Vandalia No. 2	Greene.
May 29	George Glass	63	Miner	1	2	18	Ribs broken	Mining machine	Mecca No. 3	Parke.
May 31	Allen Rogers	25	Driver	0	0	+	Thigh injured	Falling slate	Vandalia No. 10	Sullivan.
June 3	Steve Nash	34	Jerryman	1	5	137	Back injured	Falling slate	Vandalia No. 6	Greene.
June 10	Quincy Cardesty	27	Miner	1	1	22	Head crushed	Between car mine and prop	Vandalia No. 2	Greene.

June 10	Lafe Gardner	21	Driver	1	0	14	Hand broken	Kicked by mule	Vandalia No. 2	Greene.
June 11	Bert McIntyre	32	Night watch	1	5	12	Ribs fractured	Fell over wheel barrow	Mary	Parke.
June 18	S. T. Bass	48	Miner	1	4	25	Back injured	Falling coal	Brazil Block No. 1	Clay.
June 11	Robert Roger	27	Miner	1	0	....	Foot crushed	Falling coal	Blackburn No. 2	Pike.
June 18	Wm. Drake	25	Driver	1	1	18	Hips injured	Between mine cars	Vandalia No. 60	Clay.
June 18	James Jones	37	Miner	1	1	....	Thumb broken	Falling coal	Electric	Warrick.
June 19	Emery Hart	32	Timberman	0	0	21	Back injured	Falling slate	Phoenix No. 4	Sullivan.
June 20	Ed. Colbert	40	Miner	....	4	20	Arm crushed	Between mine cars	Vandalia No. 9	Greene.
June 21	Herman Aclon	....	Cager	1	0	18	Hand mashed	Coal falling down shaft	Lattas Creek	Greene.
June 22	Wm. Terrell	49	Miner	1	4	....	Arms burned	Premature shot	Wabash	Vigo.
June 24	George Rosenburg	20	Driver	1	3	18	Hips injured	Crushed between mine cars	Caladonia	Sullivan.
June 24	Thos. Damples	50	Loader	1	1	....	Leg crushed	Falling coal	Freeman	Sullivan.
June 25	Alex. McNeil	23	Driver	1	0	7	Back injured	Falling slate	Forest	Vigo.
June 26	R. T. Grimes	50	Machine runner	1	2	30	Collar bone broken	Cause not given	Parke No. 11	Parke.
June 26	Frank Lenn	37	Shot firer	1	1	....	Arm and face burned	Premature shot	Castle Garden	Warrick.
June 26	George Hart	24	Driver	1	1	10	Teeth knocked out	Kicked by mule	Oak Hill	Vermillion.
June 27	Robert Hutchison	45	Miner	1	1	15	Back injured	Falling slate	Dering No. 7	Vermillion.
July 1	Wm. Segsman	55	Miner	1	9	18	Knee injured	Falling coal	Vandalia No. 60	Clay.
July 2	Ely Green	....	Miner	1	1	60	Crushed in chest	Falling slate	Crawford No. 2	Clay.
July 2	John A. Roberts	35	Miner	1	3	12	Face and arms burned	Explosion of fire damp	Mecca No. 3	Parke.
July 2	Charles Sharp	23	Jerryman	0	0	50	Back injured	Falling slate	Cummins	Sullivan.
July 3	Thos. Small	21	Driver	0	0	30	Hips crushed	Between mine cars	Summit	Greene.
July 8	Warren Foster	24	Miner	1	1	14	Foot broken	Falling slate	Vandalia No. 6	Greene.
July 9	James Scholtz	24	Driver	1	1	17	Side ruptured	Mine car	Dering No. 7	Vermillion.
July 10	John Claster	17	Miner	0	0	60	Ribs fractured	Falling slate	Brazil Block No. 1	Clay.
July 16	Walter Broady	20	Driver	0	0	6	Back and hips injured	Fell under mine cars	Gilmour	Greene.
July 17	Joe Hatt	21	Driver	0	0	125	Hip dislocated	Fell under mine cars	Vandalia No. 10	Sullivan.
July 18	Cecil Craig	22	Driver	1	0	57	Face, arms and hands burned	Gas explosion	Vandalia No. 10	Sullivan.
July 19	Robert Summet	....	Miner	....	....	6	Body bruised	Falling slate	Lattas Creek	Greene.
July 22	Wm. Kremer	30	Driver	1	1	....	Collar bone broken	Fell under mine cars	Massey	Pike.
July 26	Zola Thorp	43	Miner	1	3	75	Leg broken	Falling slate	Parke No. 11	Parke.
July 27	Thos. Howe	26	Driver	0	0	125	Rib broken	Falling slate	Oswald	Gibson.
July 30	John Wilson	26	Loader	1	2	54	Back injured	Falling coal	Rainbow	Sullivan.
July 30	Steve Brown	41	Road man	1	3	60	Face and body burned	Explosion of fire damp	Wabash	Vigo.
Aug. 2	George Smith	....	Driver	....	....	....	Foot crushed	Mine car	Deep Vein	Vigo.
Aug. 3	James Soutb	....	Miner	1	0	12	Back injured	Falling slate	Vandalia No. 21	Greene.
Aug. 3	Leonis Barr	....	Miner	....	....	60	Back injured	Falling slate	Miami No. 3	Vigo.
Aug. 3	Chas. Barton	25	Machine runner	0	0	50	Skull fractured	Falling slate	Little Giant	Sullivan.
Aug. 3	Fred Vassey	19	Cager	0	0	5	Arm broken	Mine car	Clover Leaf	Sullivan.
Aug. 5	Fred Hoffman	55	Miner	1	5	10	Back and hips injured	Shot through pillar	Vandalia No. 5	Greene.
Aug. 5	John Black, Jr	26	Miner	0	0	....	Hip dislocated	Falling slate	Lawton	Vigo.
Aug. 7	D. Collier	....	Electrician	1	3	12	Eye injured	Struck by fan blade	Mary	Parke.
Aug. 8	Chas. Roach	35	Machine helper	1	5	60	Ankle crushed	Mining machine	Castle Garden	Warrick.
Aug. 10	John Crawley	47	Jerryman	1	4	50	Arm broken	Falling slate	Parke No. 11	Parke.
Aug. 12	Ora Carty	....	Driver	1	0	12	Arm broken	Mine car	Buekeye	Vermillion.
Aug. 12	Wm. Travallian	....	Driver	1	1	14	Hip injured	Mine car	Buckeye	Vermillion.
Aug. 12	Tom Brantlinger	25	Driver	1	0	31	Leg broken	Between mine cars	Buckeye	Vermillion.
Aug. 15	Harley Bennett	25	Electrician	1	4	....	Breast injured	Falling slate	Hocking	Vermillion

TABLE OF SERIOUS ACCIDENTS—Continued.

Date.	NAME.	Age.	Occupation.	Dependents. Wife.	Dependents. Children.	Days Idle.	Injury.	Cause of Accident.	Mine.	County.
Aug. 16	Oliver M. Davis	28	Driver	1	1	31	Head crushed	Between mine cars	Jackson Hill No. 2	Sullivan.
Aug. 16	James Yocum	....	Miner	1	2	....	Leg broken	Falling slate	Superior No. 4	Parke.
Aug. 16	Clay Call	19	Driver	0	0	36	Four ribs broken	Between mine cars	Dering No. 6	Vermillion.
Aug. 17	Dave Beverage	39	Jerryman	1	3	6	Head cut	Falling slate	Vandalia No. 9	Greene.
Aug. 17	Jas. Howe	....	Driver	0	0	48	Head mashed	Caught between car and prop.	Phoenix No. 4	Sullivan.
Aug. 20	Wm. Cowden	19	Loader	1	0	6	Back injured	Car jumping track	Clover Leaf	Sullivan.
Aug. 20	John Burgen	24	Driver	0	0	75	Leg broken	Caught under mine car	Buckeye	Vermillion.
Aug. 20	Newton Davidson	33	Cager	1	3	45	Arm broken	Coal falling down shaft	Phoenix No. 4	Sullivan.
Aug. 21	Oscar Phillips	....	Cager	1	0	30	Arm broken	Coal falling down shaft	Phoenix No. 4	Sullivan.
Aug. 21	Eliza Coffman	16	Trapper	0	0	....	Back injured	Caught under mine car	Vandalia No. 67	Vigo.
Aug. 21	Alex. Jones	60	Jerryman	1	8	90	Shoulder dislocated	Falling slate	Brazil Block No. 1	Clay.
Aug. 22	Joseph Stout	....	Driver	....	....	50	Hip dislocated	Falling slate	Gilmour	Greene.
Aug. 22	Jas. Goodman	21	Loader	0	0	6	Leg broken	Falling slate	Clover Leaf	Sullivan.
Aug. 22	William Parker	30	Flattrimmer	1	2	30	Foot crushed	Railroad car	Phoenix No. 1	Sullivan.
Aug. 23	Henry Daechi	38	Miner	1	0	81	Hips injured	Falling slate	Black Creek	Greene.
Aug. 23	Lafe Putnan	35	Driver	1	4	24	Arm broken	Kicked by mule	Sponsler	Greene.
Aug. 24	Ed. Hassal	19	timber man	0	0	60	Leg broken	Between cage and mine car	Dering No. 6	Vermillion.
Aug. 24	F. Wheeler	15	Trapper	0	0	21	Head crushed	Between mine cars	Dering No. 6	Vermillion.
Aug. 27	George Walters	29	Driver	1	1	12	Hand mashed	Between sprag and wheel	Lattas Creek	Greene.
Aug. 27	John Murphy	30	Loader	....	....	....	Back injured	Falling slate	Gilmour	Greene.
Aug. 27	Ray Miller	27	Driver	1	1	6	Finger cut off	While coupling cars	Mary	Parke.
Aug. 28	Frank Birt	20	Driver	0	0	30	Foot mashed	Between mine cars and prop.	Black Creek	Greene.
Aug. 28	Tom Doidge	35	Mine boss	1	6	65	Foot mashed	Caught by mine car	Vandalia No. 21	Greene.
Aug. 29	Eber Percel	19	Driver	0	0	12	Hand mashed	Between mine car and prop.	Vandalia No. 9	Greene.
Aug. 31	Jasper Nickason	....	Miner	1	3	....	Hips injured	Falling slate	Domestic Block No. 1	Vigo.
Sept. 1	Peter May	52	Room boss	1	9	60	Hips injured	Falling slate	Vandalia No. 4	Greene.
Sept. 3	Johnathan Johnson	37	Miner	1	3	50	Leg broken	Falling slate	Mecca No. 3	Parke.
Sept. 3	Wm. Wake	18	Driver	0	0	12	Ribs broken	Caught under mine car	Dering No. 6	Vermillion
Sept. 5	A. Maxwell	27	Cager	1	1	12	Head crushed	Coal falling down shaft	Dering No. 6	Vermillion
Sept. 5	M. Hollingsworth	29	Loader	0	0	....	Back injured	Falling slate	Lawton	Vigo.
Sept. 6	Will Sloan	26	Driver	1	1	34	Teeth knocked out	Kicked by mule	Vandalia No. 3	Greene.
Sept. 6	A. Harris	18	Driver	0	0	4	Hips injured	Caught between car and prop.	Vandalia No. 9	Greene.
Sept. 6	D. Pirtle	24	Loader	1	2	6	Face and body burned	Explosion of fire damp	Clover Leaf	Sullivan.
Sept. 9	D. Campbell	21	Loader	1	0	42	Back injured	Falling slate	Gilmour	Greene.

Sept. 9	Albert Lee	26	Driver	1	0	7	Collar bone broken	Caught between car and roof	Black Creek	Greene.
Sept. 12	John Loth	27	Machine helper	1	0	62	Ankle dislocated	Caught in machine chain	Vivian	Clay.
Sept. 16	Chas. Jackman	38	Miner	1	0	36	Wrist broken	Falling coal	Vandalia No. 16	Parke.
Sept. 16	D. Hunce	22	Driver	1	3	36	Hip dislocated	Caught between car and roof	Dering No. 6	Vermillion.
Sept. 17	Ben Parvey	24	Miner	1	0	60	Leg broken	Falling slate	Prinee	Vermillion.
Step. 18	Chas. Reynolds	18	Driver	0	0	20	Leg broken	Falling slate	Summit No. 2	Greene.
Sept. 18	E. Powers	22	Blacksmith	1	1	....	Jaw dislocated	Fell from scaffold	Electric	Warrick.
Sept. 19	Geo. Turner	63	Miner	1	10	45	Face and body burned	Explosion of powder	Superior No. 4	Clay.
Sept. 20	Theo. Jamison	26	Driver	1	I	30	Back injured	Falling slate	Vandalia No. 316	Parke.
Sept. 20	Ray Hains	19	Driver	0	0	10	Hips injured	Crushed between mine cars	Lawton	Vigo.
Sept. 20	R. Short	17	Driver	0	0	36	Toes broken	Run over by mine car	Dering No. 6	Vermillion.
Sept. 23	Fred Wert	21	Loader	0	0	24	Toe broken	Falling coal	Lewis	Clay.
Sept. 23	Isaac Hoopgarner	34	Miner	1	4	....	Hips injured	Falling slate	Hudson	Sullivan.
Sept. 24	Chas. Coleman	26	Driver	0	0	9	Hips injured	Caught between mine cars	Con. Ind. Co. No. 25	Sullivan.
Sept. 25	C. Hauldson	20	Cager	I	0	9	Ribs broken	Descending cage	Lattas Creek	Greene.
Sept. 27	J. Boras	21	Pumper	0	0	6	Fingers cut off	Caught by pump piston	Vivian No. 2	Clay.
Sept. 27	Dal Stewart	27	Loader	1	1	+	Collar bone broken	Between mine cars	Con. Ind. Co. No. 25	Sullivan.
Sept. 30	Wm. Davis	26	Miner	1	2	37	Body bruised	Falling slate	Lattas Creek	Greene.
Sept. 30	Henry McDonald	28	Machine helper	1	2	30	Leg cut	By mining machine	Green Valley	Greene.
Sept. 30	Robert Orne	26	Driver	0	0	20	Bruised	Fell under mine car	Phoenix No. 4	Sullivan.
Oct. 2	Wm. Downer	50	Shot firer	1	0	90	Forearm fractured	Shot blowing through pillar	Oswald	Gibson.
Oct. 2	A. Carver	24	Driver	0	0	....	Foot crushed	Falling slate	Freeman	Knox.
Oct. 3	Geo. Coleman	28	Miner	0	0	60	Ankle broken	Falling slate	Vandalia	Parke.
Oct. 3	L. Bridgewater	54	Miner	1	2	....	....		Lawton	Vigo.
Oct. 3	Chas. Riley	....	....	1	0	....	Fingers broken	....	Tower Hill	Greene.
Oct. 4	Thos. Kishley	23	Driver	1	3	14	Hips injured	Caught between mine car and door	Twin No. 4	Greene.
Oct. 4	Martin Holsher	34	Miner	1	0	41	Fingers cut off	Falling coal	Vandalia No. 3	Greene.
Oct. 4	Chas. Ward	30	Loader	1	0	60	Leg broken	Caught by mine car	Rainbow	Sullivan.
Oct. 4	Wm. Spencer	20	Driver	0	0	60	Foot broken	Caught between mine cars	Rainbow	Sullivan.
Oct. 4	Wm. Bonner	24	Miner	1	0	60	Leg broken	Falling slate	Buckeye	Vermillion.
Oct. 5	Ollie Huff	20	Trip rider	0	0	30	Arm fractured	Caught between mine cars	Vivian No. 2	Sullivan.
Oct. 5	Lem Clark	27	Loader	1	0	+	Ankle fractured	Falling slate	Con. Ind. Co. No. 25	Sullivan.
Oct. 7	Frank Lenhenper	38	Machine helper	0	0	12	Back injured	Falling slate	Mary	Parke.
Oct. 8	Peter Lescano	30	Miner	1	2	50	Leg broken	Falling bowlder	Buckeye	Vermillion.
Oct. 9	Ernest Smith	25	Machine runner	0	0	....	Arm broken	Mining machine	Erie Canal	Warrick.
Oct. 9	Thos. Plen	42	Loader	1	1	+	Back injured	Falling slate	Con. Ind. Co. No. 25	Sullivan.
Oct. 9	Joe Cottrell	....	Miner	I	0	42	Foot crushed	Caught in coil rope	Forest	Vigo.
Oct. 10	N. Shepherd	21	Driver	0	0	....	Ankle crushed	Between mine cars	Freeman	Knox.
Oct. 10	Chas. Masby	40	Cager	0	0	100	Leg broken	Between mine cars	Forest	Vigo.
Oct. 14	Jas. Knowles	63	Miner	1	....	....	Ankle dislocated	Fall of coal	Atherton	Vigo.
Oct. 15	M. Lesurey	23	Loader	0	0	30	Arms and hands burned	Explosion of powder	Jackson Hill No. 2	Sullivan.
Oct. 16	E. Lemmy	21	Miner	1	1	....	Back injured	Descending cage	Vandalia No. 66	Vigo.
Oct. 17	L. C. Gleason	33	Loader	1	2	11	Face and hands burned	Explosion of fire damp	Con. Ind. Co. No. 25	Sullivan.
Oct. 17	Jas. Jackson	22	Driver	0	0	11	Back injured	Mine cars	Buckeye	Vermillion.
Oct. 17	John Michal	22	Driver	0	0	....	Back and side injured	Fell under mine car	Twin No. 4	Greene.
Oct. 18	John M. Sheeley	23	Driver	1	1	....	Ribs broken	Fell under mine car	Erie Canal	Warrick.
Oct. 18	John McNeely	24	Driver	1	1	....	Ribs broken	Fell under mine car	Erie Canal	Warrick.

TABLE OF SERIOUS ACCIDENTS—Continued.

Date.	NAME.	Age.	Occupation.	Dependents. Wife.	Dependents. Children.	Days Idle.	Injury.	Cause of Accident.	Mine.	County.
Oct. 19	Fred Atkins	18	Driver	0	0	40	Leg fractured	Between mine cars	Forest	Vigo.
Oct. 20	L. Hatchey	20	Driver	0	0	....	Wrist dislocated	Car jumping track	Letsinger	Greene.
Oct. 21	Jas. West	39	Mine boss	1	6	10	Collar bone broken	Caught by descending cage	Buckeye	Vermillion.
Oct. 21	R. Small	21	Driver	0	0	30	Internal injuries	Falling slate	Shirley Hill No. 1	Sullivan.
Oct. 23	S. Vasey	53	Lumberman	1	6	40	Leg broken	Falling slate	Domestic Block	Vigo.
Oct. 25	W. P. Williams	48	Loader	1	5		Thumb broken	Falling coal	Phoenix No. 4	Sullivan.
Oct. 25	Ben Wake	18	Driver	0	0	13	Ribs broken	Kicked by mule	Buckeye	Vermillion.
Oct. 26	John Wills	18	Driver	0	0	....	Back and side injured	Fell under mine car	Green Valley	Greene.
Oct. 26	Claude May	18	Driver	0	0	....	Head broken	Between mine cars	Sponsler	Greene.
Oct. 26	Jos. Polidew	39	Miner	1	6	19	Leg broken	Falling coal	Superior No. 5	Clay.
Oct. 26	Merl Williams	....	Driver	1	2	....	Finger broken	Caught between mine car and rib	Ray No. 2	Vigo.
Oct. 26	Wm. Weatherwax	42	Loader	0	0	20	Ribs broken	Falling slate	Big Vein	Clay.
Oct. 28	Sam Mass	30	Miner	1	4	....	Spine injured	Falling coal	Atherton	Vigo.
Oct. 30	Ed. Mass	41	Track layer	1	6	30	Body bruised	Crushed between mine cars	Tower Hill	Greene.
Oct. 24	Theo. Ashcroft	40	Loader	0	0	42	Eye injured	Premature shot	Forest	Vigo.
Oct. 24	Whit Mattox	35	Loader	0	0	42	Leg injured	Premature shot	Forest	Vigo.
Nov. 1	Clyde Webster	21	Driver	1	2	30	Hand mashed	Between car and machine	Domestic Block	Vigo.
Nov. 1	Charles Baker	30	Loader	1	1	24	Ribs broken	Falling slate	Forest	Vigo.
Nov. 4	James Dennis	30	Driver	0	0	14	Ribs fractured	Falling under mine cars	Vandalia No. 3	Vigo.
Nov. 5	J. Morris	42	Loader	0	0	....	Skull fractured	Premature shot	Reliance	Sullivan.
Nov. 6	Wm. Thomas	30	Driver	....	....	60	Leg crushed	Caught under mine car	Vandalia No. 69	Vigo.
Nov. 6	Gabe House	28	Machine helper	1	3	....	Foot crushed	By mining machine	Jackson Hill No. 2	Sullivan.
Nov. 7	Clarence Allen	19	Driver	0	0	....	Hips and spine	Fell under mine cars	St. Clair	Sullivan.
Nov. 8	Wm. Superman	20	Miner	1	0	12	Leg and head injured	Falling slate	Vandalia No. 60	Clay.
Nov. 8	T. Gardner	25	Driver	1	1	....	Hips injured	By mine cars	Vandalia No. 2	Greene.
Nov. 9	Wm. Clenhall	17	Miner	0	0	....	Fingers crushed	Falling coal	Vandalia No. 65	Clay.
Nov. 10	Horace McIntire	31	Miner	0	0	....	Hips injured	Caught between mine car and prop	Vandalia No. 10	Sullivan.
Nov. 11	John Cruse	47	Loader	1	0	....	Back and hips	Falling bone coal	Gilmour	Greene.
Nov. 11	Wm. Kelley	30	Miner	1	0	14	Leg mashed	Falling coal	Forest	Vigo.
Nov. 12	D. McKelley	58	Jerryman	1	4	30	Back injured	Falling draw slate	Forest	Vigo.
Nov. 13	Robert Tangan	60	Trapper	0	0	20	Face and hands burned	By escaping steam	Forest	Vigo.
Nov. 13	Allen Rogers	20	Driver	1	1	....	Leg crushed	Falling under mine car	Electric	Warrick.

Nov. 14	Mail All	38	Miner	1	2	....	Fingers cut off	With mining machine	St. Clair	Sullivan.
Nov. 15	Arthur Sims	26	Miner	0	0	...	Leg broken	Falling coal	Knox	Knox.
Nov. 15	John Houston	35	Machine runner	1	3	....	Hand mashed	Mining machine	Domestic Block	Clay.
Nov. 16	Henry Thompson	35	Miner	1	1	....	Leg broken	Falling coal	Brazil Block No. 1	Clay.
Nov. 17	Mike Tate	19	Driver	0	0	8	Back injured	Falling slate	Antioch	Greene.
Nov. 18	Spencer Hall	....	Cager	1	3	....	Back injured	Caught by cage	Caladonia	Sullivan.
Nov. 19	Hartley Bennett	35	Electrician	1	6	10	Foot crushed	Mining machine	Ind. Hocking	Sullivan.
Nov. 21	Wm. McClure	28	Driver	1	2	....	Back injured	Car and mine door	Union	Sullivan.
Nov. 22	Clarence Jones	18	Miner	0	0	....	Rib broken	Flying coal from shot	Lyford No. 1	Vermillion.
Nov. 23	Patrick Conway	50	Miner	0	0	....	Back injured	Flying slate	Cummings	Sullivan.
Nov. 23	Ernest Jones	15	Trapper	0	0	43	Back injured	Caught between mine cars	Vandalia No. 65	Clay.
Nov. 23	W. T. James	55	Miner	0	0	....	Back injured	Falling slate	Rebstock	Clay.
Nov. 30	Jesse Davis	55	Miner	1	2	....	Rib broken	Falling slate	Mecca No. 3	Parke.
Dec. 2	Emery Maxwell	24	Miner	1	1	....	Back injured	Falling slate	Vandalia No. 9	Greene.
Dec. 5	Robert Mattingly	22	Blacksmith	1	1	....	Finger off	Caught by cage	Freeman	Sullivan.
Dec. 7	Fred Hilton	23	Car coupler	0	0	....	Hips bruised	By mine car	Consolidated No. 33	Sullivan.
Dec. 9	John Queen	24	Loader	0	0	....	Leg broken	Falling slate	North West	Greene.
Dec. 10	Wm. Patterson:	26	Driver	0	0	....	breast crushed	Between mine cars	Dering No. 6	Vermillion.
Dec. 11	Wesley Hasket	36	Driver	1	3	....	Foot broken	By mine car	Citizens	Sullivan.
Dec. 12	L. Petti	38	Timberman	1	2	....	Hip injured	By falling slate	Rebstock	Clay.
Dec. 12	All Henderson	45	Miner	1	2	....	Back injured	Falling slate	Vandalia No. 10	Sullivan.
Dec. 12	Clarence Raves	....	Driver	1	1	....	Foot crushed	Between mine cars	Forest	Vigo.
Dec. 16	Jas. Currains	28	Jerryman	0	0	....	Hands and face burned	Gas explosion	Dering No. 13	Sullivan.
Dec. 16	Jack Sutter	50	Loader	1	3	....	Hands and face burned	Gas explosion	Dering No. 13	Sullivan.
Dec. 17	Wm. Scott	27	Motorman	1	0	....	Hips injured	Caught between motor and rib	Dering No. 13	Sullivan.
Dec. 18	L. Amony	73	Miner	0	0	....	Leg broken	Falling slate	Superior No. 5	Clay.
Dec. 18	John Galey	30	Driver	1	0	....	Side injured	Kicked by mule	Vandalia No. 69	Vigo.
Dec. 19	Harvey Cashman	20	Driver	....	....	....	Nose broken	Kicked by mule	Hamilton	Sullivan.
Dec. 20	J. Thompson	42	Boss driver	1	3	....	Knee injured	Mine car	Knox	Knox.
Dec. 20	Silas Wagner	30	Driver	1	2	....	Ribs broken	Fell on iron rail	Brazil Block No. 1	Clay.
Dec. 22	Harry Gardner	22	Timberman	1	0	....	Face and hands burned	Gas explosion	Vandalia No. 9	Greene.
Dec. 24	H. Siders	28	Miner	1	0	....	Ribs fractured	Force of explosion	Vandalia No. 9	Greene.
Dec. 24	Robert Woodruff	28	Miner	1	0	....	Face and hands burned	Gas explosion	Vandalia No. 9	Greene.
Dec. 30	Wm. Sours	22	Trip rider	0	0	....	Ankle broken	Caught by mine cars	Lattas Creek	Greene.
Dec. —	C. Clemments	23	Driver	1	0	....	Two ribs broken	Caught between cars and rib	Dering No. 7	Vermillion.

MINOR ACCIDENTS.

The aggregate of one hundred and seventy-one minor accidents includes only persons suffering slight cuts and bruises, resulting in very little loss of time, hence no mention of them will be made, other than that shown in the table of causes.

TABLE.

JANUARY.

INJURIES.	Falling coal.	Falling slate.	Falling down shaft.	Killed by mine car.	Kicked by mule.	Ascending cage.	Descending cage.	Mining machine.	Railroad cars.	Coal falling down shaft.	Delayed shots.	Premature shot.	Shots blowing through pillar.	Smoke explosions.	Explosions of powder.	Explosions of fire damp.	Misplaced and windy shots.	Mine motors.	Miscellaneous.	Total.
Fatal	...	2	1	1	...	1	...	...	...	...	1	...	...	2	7	...	1	...	...	16
Permanent	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	2
Serious	...	2	...	1	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	4
Minor	...	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2
Total	...	5	1	3	...	1	...	...	...	...	1	1	...	2	9	...	1	...	...	24

FEBRUARY.

INJURIES.	Falling coal.	Falling slate.	Falling down shaft.	Killed by mine car.	Kicked by mule.	Ascending cage.	Descending cage.	Mining machine.	Railroad cars.	Coal falling down shaft.	Delayed shots.	Premature shot.	Shots blowing through pillar.	Smoke explosions.	Explosions of powder.	Explosions of fire damp.	Misplaced and windy shots.	Mine motors.	Miscellaneous.	Total.
Fatal	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Permanent	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Serious	1	...	...	...	...	...	1	...	...	...	...	...	...	13	1	...	...	1	...	17
Minor	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2
Total	1	3	1	...	...	...	1	...	...	...	...	...	...	13	1	...	...	1	...	21

MARCH.

INJURIES.	Falling coal.	Falling slate.	Falling down shaft.	Killed by mine car.	Kicked by mule.	Ascending cage.	Descending cage.	Mining machine.	Railroad cars.	Coal falling down shaft.	Delayed shots.	Premature shot.	Shots blowing through pillar.	Smoke explosions.	Explosions of powder.	Explosions of fire damp.	Misplaced and windy shots.	Mine motors.	Miscellaneous.	Total.
Fatal	...	1	...	...	...	1	...	...	1	...	...	...	...	...	2	...	...	...	...	5
Permanent	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Serious	...	...	3	1	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	5
Minor	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	3
Total	1	2	3	1	...	1	...	...	1	...	...	...	...	...	3	...	...	...	1	13

APRIL.

INJURIES.	Falling coal.	Falling slate.	Falling down shaft.	Killed by mine car.	Kicked by mule.	Ascending cage.	Descending cage.	Mining machine.	Railroad cars.	Coal falling down shaft.	Delayed shots.	Premature shot.	Shots blowing through pillar.	Smoke explosions.	Explosions of powder.	Explosions of fire damp.	Misplaced and windy shots.	Mine motors.	Miscellaneous.	Total.
Fatal	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Permanent	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Serious	1	5	...	4	...	...	...	1	...	...	...	1	...	...	1	1	...	...	...	14
Minor	...	1	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	2	4
Total	1	6	1	4	...	...	...	2	...	...	...	1	...	...	1	1	...	...	2	19

MAY.

INJURIES.	Falling coal.	Falling slate.	Falling down shaft.	Killed by mine car.	Kicked by mule.	Ascending cage.	Descending cage.	Mining machine.	Railroad cars.	Coal falling down shaft.	Delayed shots.	Premature shot.	Shots blowing through pillar.	Smoke explosions.	Explosions of powder.	Explosions of fire damp.	Misplaced and windy shots.	Mine motors.	Miscellaneous.	Total.
Fatal	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	1
Permanent	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	1
Serious	2	6	1	10	2	...	...	1	...	...	1	...	...	...	...	...	1	...	1	25
Minor	...	1	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3
Total	2	7	1	12	2	...	...	1	1	...	1	...	...	...	1	...	1	...	1	30

MINOR ACCIDENTS—Continued.

JUNE.

INJURIES.	Falling coal.	Falling slate.	Falling down shaft.	Killed by mine car.	Kicked by mule.	Ascending cage.	Descending cage.	Mining machine.	Railroad cars.	Coal falling down shaft.	Delayed shots.	Premature shot.	Shots blowing through pillar.	Smoke explosions.	Explosions of powder.	Explosions of fire damp.	Misplaced and windy shots.	Mine motors.	Miscellaneous.	Total.
Fatal	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2
Permanent	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
Serious	4	4	...	4	2	...	...	...	...	...	1	2	...	...	...	...	...	...	2	19
Minor	...	3	...	3	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	8
Total	5	8	...	8	3	...	...	1	...	...	1	2	...	...	...	...	...	...	2	30

JULY.

INJURIES.	Falling coal.	Falling slate.	Falling down shaft.	Killed by mine car.	Kicked by mule.	Ascending cage.	Descending cage.	Mining machine.	Railroad cars.	Coal falling down shaft.	Delayed shots.	Premature shot.	Shots blowing through pillar.	Smoke explosions.	Explosions of powder.	Explosions of fire damp.	Misplaced and windy shots.	Mine motors.	Miscellaneous.	Total.
Fatal	...	3	...	...	1	...	1	...	...	...	...	...	...	...	2	...	...	...	...	7
Permanent	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	1
Serious	2	7	...	5	...	...	...	...	...	...	...	...	...	...	...	3	...	...	...	17
Minor	...	5	...	4	1	1	...	1	...	...	...	...	...	...	...	2	...	...	1	15
Total	2	15	...	9	2	1	1	1	...	...	...	...	...	...	2	6	...	...	1	40

AUGUST.

INJURIES.	Falling coal.	Falling slate.	Falling down shaft.	Killed by mine car.	Kicked by mule.	Ascending cage.	Descending cage.	Mining machine.	Railroad cars.	Coal falling down shaft.	Delayed shots.	Premature shot.	Shots blowing through pillar.	Smoke explosions.	Explosions of powder.	Explosions of fire damp.	Misplaced and windy shots.	Mine motors.	Miscellaneous.	Total.
Fatal	...	1	...	1	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	4
Permanent	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Serious	2	15	2	18	1	...	...	2	1	...	...	...	1	...	...	...	...	...	1	43
Minor	1	9	...	16	...	...	...	1	1	...	...	...	...	...	...	...	...	...	2	30
Total	3	25	2	35	1	...	...	3	2	...	...	...	1	...	...	2	...	...	3	77

SEPTEMBER.

INJURIES.	Falling coal.	Falling slate.	Falling down shaft.	Killed by mine car.	Kicked by mule.	Ascending cage.	Descending cage.	Mining machine.	Railroad cars.	Coal falling down shaft.	Delayed shots.	Premature shot.	Shots blowing through pillar.	Smoke explosions.	Explosions of powder.	Explosions of fire damp.	Misplaced and windy shots.	Mine motors.	Miscellaneous.	Total.
Fatal	...	2	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	3
Permanent	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2
Serious	2	10	1	9	1	...	1	2	...	...	...	...	1	1	...	...	...	...	2	30
Minor	4	10	...	17	1	...	...	...	1	1	...	...	...	1	...	...	...	...	3	38
Total	6	24	1	26	2	...	1	2	1	1	1	...	1	2	...	...	...	...	5	73

OCTOBER.

INJURIES.	Falling coal.	Falling slate.	Falling down shaft.	Killed by mine car.	Kicked by mule.	Ascending cage.	Descending cage.	Mining machine.	Railroad cars.	Coal falling down shaft.	Delayed shots.	Premature shot.	Shots blowing through pillar.	Smoke explosions.	Explosions of powder.	Explosions of fire damp.	Misplaced and windy shots.	Mine motors.	Miscellaneous.	Total.
Fatal	...	1	...	...	...	1	...	...	...	...	...	...	...	1	...	...	...	1	...	4
Permanent	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1
Serious	6	11	...	16	1	...	2	1	...	...	2	1	1	...	1	...	3	...	...	45
Minor	2	3	...	12	...	...	...	1	...	...	...	...	1	...	...	...	...	5	...	24
Total	8	15	...	28	1	1	2	2	...	...	2	1	2	1	1	...	4	6	...	74

NOVEMBER.

INJURIES.	Falling coal.	Falling slate.	Falling down shaft.	Killed by mine car.	Kicked by mule.	Ascending cage.	Descending cage.	Mining machine.	Railroad cars.	Coal falling down shaft.	Delayed shots.	Premature shot.	Shots blowing through pillar.	Smoke explosions.	Explosions of powder.	Explosions of fire damp.	Misplaced and windy shots.	Mine motors.	Miscellaneous.	Total.
Fatal	...	1	...	3	...	...	...	...	...	...	1	...	...	...	...	...	1	...	...	6
Permanent	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Serious	5	7	...	9	...	...	4	...	...	...	1	...	...	...	...	...	...	3	...	29
Minor	4	5	...	15	3	...	...	...	1	...	...	...	...	...	...	...	...	4	...	32
Total	9	13	...	27	3	...	4	...	1	...	2	...	...	...	...	...	1	7	...	67

MINOR ACCIDENTS—Continued.

DECEMBER.

INJURIES.	Falling coal.	Falling slate.	Falling down shaft.	Killed by mine car.	Kicked by mule.	Ascending cage.	Descending cage.	Mining Machine.	Railroad cars.	Coal falling down shaft.	Delayed shots.	Premature shot.	Shots blowing through pillar.	Smoke explosions.	Explosions of powder.	Explosions of fire damp.	Misplaced and windy shots.	Mine motor.	Miscellaneous.	Total.
Fatal	...	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	3
Permanent	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Serious	...	5	...	7	3	...	...	...	...	...	...	...	...	...	...	5	...	1	2	23
Minor	2	2	...	2	1	...	...	1	...	...	...	...	...	...	...	...	...	...	2	10
Total	2	9	1	9	4	...	...	1	...	...	...	...	...	...	...	5	...	1	4	39

Note.—By referring to the above table it will be noticed that accidents from falling slate were much more numerous during the hot summer months than in the colder ones. The table exhibits an aggregate of one hundred and twenty-nine accidents due to this cause, sixty-four, or a fraction over 49 per cent, of which occurred during the period intervening from July 1st to September 31st. July shows a total of fifteen (15), August twenty-five (25) and September, the greater portion of which was as warm as in August, shows a total of twenty-four (24), an average of twenty-one (21) accidents for each month, while the remaining nine months show an average of but seven (7) each. The excessive number of accidents occurring during these three months over any other period in the year is due directly to atmospheric changes. Mines operating the No. IV and No. VI were more productive of accidents than any of the other coal seams, No. IV ranking first. This is due to the character of the roof overlying these two seams. The roof over No. IV is a gray shale, very light in color, and carries a large per cent of lime and iron. The roof over No. VI is a darker shale of a more close, compact texture. It also carries considerable lime and iron, though not so large a per cent as No. IV. The heated air, on entering the mine, cools and forms a vapor, which settles on the roof. This is termed by miners "sweating of the roof." The lime contained in the roof is slaked by coming in contact with the moisture thus formed, exposing the iron to the increased heat, under which it expands, causing the roof to cut and slab off in pieces ranging in size from an ounce to several tons, and in addition to increasing the danger of accidents to employes, adds enormously to the operating expense of the mine. Much of the danger and expense may be obviated if the operator will prepare for this period by furnishing the mine with an abundant supply of timbers of proper kinds and instructing his mine boss to timber securely his haulage and traveling roads, air-courses, etc., before the hot season begins. The mine boss should also, during the hot season, keep careful watch over the working faces which are advanced day by day and see that the miner is furnished a plentiful supply of props or other timbers of proper length, and tolerate no negligence on his part to timber his place properly. The miner, who notwithstanding the fact should always be on the alert, may add to his own safety by using extra precaution during this period, by carefully examining the roof in his working place, setting props, cross-bars, etc., promptly when needed. Many fatalities and other injuries to workmen would be averted and an immense saving in expense innure to the operator by a strict observance of the above rules.

TABLE

Showing the Total Number of Fatal, Permanent, Serious and Minor Accidents and the Different Occupations of Persons Injured.

OCCUPATION.	Fatal.	Permanent.	Serious.	Minor.	Total.
Pick miners	24	3	86	38	151
Loaders	4	1	33	14	52
Machine men	1	....	13	11	25
Drivers	8	1	86	66	161
Timbermen	3	1	12	19	35
Trappers	....	....	4	3	7
Pump men	1	....	1	2	4
Cagers	1	....	10	4	14
Motormen	1	1	3	1	6
Electricians	....	....	3	....	3
Road men	1	....	2	4	7
Trip riders	....	....	3	....	3
Car couplers	....	....	1	....	1
Shot firers	3	2	5	....	10
Mine boss	1	....	2	....	3
Fire boss	....	....	1	....	1
Room boss	....	....	1	....	1
Mine superintendent	1	....	....	....	1
Boss driver	....	....	1	....	1
Top men	4	....	5	7	16
Grand Total	53	9	271	171	504

COMMENTS ON CASUALTIES TO MINE EMPLOYES.

Under this caption we make some comments on such accidents and causes thereof as we think demand recommended legislation.

A careful study of the foregoing tables, observing the number of accidents occurring, the different causes of same and the occupation of persons injured, etc., while they show mining in all its many details an extremely hazardous calling, the fact is in evidence that there is no occupation more prolific of accidents to mine employes than that of a mule driver. Fortunately this class of employes represents approximately only about 10 per cent of the total working force in a mine. The greatest danger attending this class of work arises from the manner in which drivers usually ride a loaded trip, i. e., by riding on the front end of the trip, standing in an upright position, one foot on the drawbar or car-bumper, which projects out about three inches, and the other on the tail-chain and one hand resting on the top of the coal in the car to steady himself. With no other support or protection than this, the driver will drive his mule down a grade or on a level, as the case may be, at a fast trot, frequently at a gallop, and while riding in this manner he is in great danger of his car striking a low joint or an obstruction on the rail, causing it to rock up and down or from side to side, jostling him so that he will frequently lose his footing and fall under the rapidly moving trip, or of being kicked off the tail chain by a vicious mule. There is also danger of the car jumping the track and crushing the driver against the entry rib or a prop and by colliding with mine cars, mine doors, slate falls and other debris on the haulage road. Or if there is more than one car in his trip he will frequently ride between the cars on the coupling, in a space ranging from fourteen to eighteen inches in width. This manner of riding a trip is probably more dangerous than the former, by reason of the fact that should the front car leave the track when traveling at even a moderate rate of speed, there is practically no chance for the driver to escape a serious if not a fatal injury by being crushed between the cars. In addition to the above, a driver must face all the dangers encountered by other employes. The table of causes and the table showing the occupation of persons injured exhibits an aggregate of five hundred and four (504) accidents occurring among twenty classes of employes. Of this number, eighty-six (86) serious and sixty-six (66) minor accidents, a total of one hundred and sixty-one (161), or nearly 32 per cent. of the whole, occurred to drivers alone. Of the eight (8) drivers fatally injured, five (5) were killed instantly by falling under and being dragged by loaded cars, one (1) by being kicked by a mule, one (1) by falling slate and one (1) crushed to death by a loaded car and mine door. The one driver who was permanently injured was run over with a loaded car, which crushed a leg so badly that amputation was necessary. Of the eighty-six (86) drivers seriously injured, twenty-eight (28) were injured by falling under loaded cars, twenty-four (24) were crushed between cars, one suffered a badly mangled hand while coupling cars, two were kicked by mules, one had a foot crushed by coal falling off a car, one was seriously burned in an explosion of fire damp, four were crushed between the tops of loaded cars and the roof, nine were injured by falling slate, two crushed between cars and props.

The sixty-six minor accidents, representing slight cuts and bruises, occurred from the same causes, conditions, etc., as the serious accidents. The above is one particular class of accidents on which we will recommend legislation.

Of the one hundred and twenty-nine (129) persons injured by falling slate, the greater number were miners, injured at or near the working faces. Many of the accidents, as shown by investigation, would have been prevented had the persons injured exercised even the most ordinary care incumbent on them for their own safety. The number might also have been reduced materially had the faces of the working places been examined immediately before each shift by a competent mine examiner.

ACCIDENTS TO MINE PROPERTY.

The year just ended has been prolific of accidents to mine property. Eight of the most notable of these accidents we deem worthy of mention, four of which occurred in the inside workings of the mines and four in the surface plants, entailing a financial loss of $47,500. There were also numerous other minor accidents, such as breaking of hoisting ropes and cages, loss of mules, mine floods, etc. The financial loss incurred at each was comparatively small, however, hence we make no special mention of them. The following is a brief description of each of the eight accidents referred to above.

Freeman Mine.

On the afternoon of July 11th the engine and boiler room at the Freeman mine, Knox County, was struck and completely destroyed by a cyclone, entailing a financial loss of $3,500. The hoisting engineer, who was at his engine when the storm struck the building, was also seriously injured.

Keystone Mine.

About ten o'clock a. m. July 5th a terrific explosion of firedamp occurred in the Keystone mine, Sullivan County, resulting in the death of the mine boss and mine superintendent and much damage to the interior of the mine. The financial loss was estimated to be about $1,000.

Knox Mine.

The most destructive mine accident for the year occurred September 26th at the Knox mine in Knox County. About 5 o'clock a. m., at a time when no one was at the mine except the night watchman, fire broke out, presumably in the boiler room, and before help could be summoned destroyed the entire surface plant, consisting of the engine and boiler room, tipple, fan house, blacksmith shop and mule barns, also doing much damage to the curbing in the hoisting shaft and manway. Two railroad cars which were standing under the tipple were also destroyed. This is an electric machine mine and was well equipped with first-class machinery, a greater portion of which was rendered useless by the fire. The property loss was estimated at $25,000. The plant was reconstructed and shipments of coal resumed November 20th. The property was insured for $6,000.

Twin Mine.

On the morning of October 8th the mule barns at the Twin Mine, Greene County, were destroyed by fire, resulting in the loss of all the buildings and seventeen mules. The financial loss was $4,500.

Oak Hill.

On October 25th a most destructive fire, the origin of which is unknown, occurred in the Oak Hill Mine, Vermillion County. The fire broke out about 7:30 o'clock a. m. in a break-through between two entries, shortly after all of the workmen had reached their working places, some of whom were rescued with much difficulty. Owing to the location of the fire it was found necessary to seal off the hoisting shaft and manway in order to smother the fire. The mine remained closed about thirty days, when it was reopened and the fire was found to be extinct. The financial loss will probably reach $10,000.

Consolidated No. 25.

On the evening of November 14th a mine fire, originating from a gas feeder being lighted by a shot, occurred at the face of one of the cross entries in the Consolidated No. 25 Mine, Sullivan County. When discovered the fire had reached such proportions it was found necessary to seal off that portion of the workings and exclude the air. The stoppings were removed in about ten days, when the fire was found to be extinct. The financial loss was about $500.

Reliance Mine.

About 9 o'clock a. m. November 27th, at which time a car of coal was being hoisted at the Reliance Mine, Sullivan County, one of the batter-braces gave way, causing the sheave wheels to be thrown out of place, one of which fell down the hoisting shaft, wrecking it from top to bottom. Nine days were required to make the necessary repairs, in addition to an expense of $500.

Hudson Mine.

The engine room at the Hudson Mine, Sullivan County, was destroyed by fire in November, entailing a financial loss of about $2,000.

IMPROVEMENTS.

One hundred and twelve thousand nine hundred and eighty-two dollars and fifty-four cents ($112,982.54) was reported to this office during the year 1907 as having been expended on improvements and repairs of mines in different counties, as follows: Clay County, $13,054.14; Daviess County, $1,520; Greene County, $11,298; Parke County, $19,604; Pike County, $2,935.80; Sullivan County, $17,230.30; Vanderburgh County, $1,625; Vermillion County, $20,-502; Vigo County, $7,563; Warrick County, $5,809. The following sets out the most important improvements and repairs made:

The Jasonville Coal Company, Clay County, expended $5,144 in the purchase of an electric motor, wire, supplies and repair work incident to installing motor haulage in their Gold Knob Mine.

The Eureka Block Coal Company, Clay County, report an expenditure of $5,899.90 for improvements and general repair work in the Eureka No. 5 Mine, but do not state the nature of improvements or repairs.

The Mutual Coal Company, Daviess County, expended $1,470 building a new tipple at their Mutual Mine.

The Central Coal and Mining Company, Greene County, during the summer months installed motor haulage in their Colora Mine at a cost of $9,693.47.

Note.—The Queen Coal Company installed electric mining machines in their Fry Mine, Greene County, but we have been unable to learn the cost of installation.

The Indiana Fairmount Coal Company, Greene County, expended $1,347 in general repair work in the Letsinger Mine.

The Tecumseh Coal Company, Knox County, sunk and equipped with a stairway the manway and completed the equipment of their Tecumseh Mine at a cost of $11,298.

The United Coal Company, Parke County, expended $7,100 sinking and equipping an air shaft and made other general repairs at their Mecca No. 3 Mine.

The Lincoln Coal Company installed a compressed air punching machine plant at their Lyford No. 1 Mine, Parke County, for which they expended $10,000.

The Brazil Block Coal Company expended $2,504 on general repair work in their No. 12 Mine, Parke County.

The Central Indiana Coal Company, Pike County, expended $1,350 installing a gasoline motor haulage in their Muren Mine.

The Consolidated Indiana Coal Company installed motor haulage at a cost of $7,500 in their No. 33 Mine, Sullivan County.

The Dering Coal Company installed a new Stevens ventilating fan and motor haulage in the Dering No. 14 Mine, Sullivan County, for which they expended $5,800.

The Hudson Coal Company, Sullivan County, expended $2,000 in general repair work in their Hudson Mine.

The Sullivan County Coal Company, Sullivan County, recurbed the hoisting shaft and made other general improvements at a cost of $1,540.30 in their Freeman Mine.

The Banner Coal Company, Vanderburgh County, expended $1,500 on general repair work in their First Avenue Mine.

The Clinton Coal Company, Vermillion County, expended $3,000 in the purchase of an electric motor, wire and other supplies necessary to install motor haulage in their Crown Hill No. 1 Mine, in addition to $15,200 expended in the purchase of six new boilers, compressors, fan, etc., at their Nos. 1 and 2 mines.

The Coal Bluff Mining Company expended $3,128 in sinking and equipping a manway at their Wabash Mine, Vigo County.

The Lower Vein Coal Company, Vigo County, built a wash house and made general repairs in their Lower Vein No. 1 Mine at a cost of $2,956.

The Big Four Coal Company, Warrick County, expended $5,500 in the construction of a haulage road to their No. 2 Mine, which is located about one mile from the railroad.

The Dering Coal Company expended $1,700 in the purchase of a new electric motor for their No. 5 Mine in Vermillion County.

The Coal Bluff Mining Company installed an electric machine plant at their Plymouth No. 1 Mine, Vigo County, but we have been unable to learn the amount of capital invested.

The remainder of the above sum total was expended on improvements of various kinds, such as mine buildings, haulage roads, ropes, cages, etc., and improving the mines in general.

MINE DIRECTORY.

CLAY COUNTY.

Name of Company.	Address of Company.	Name of Mine.
Brazil Block Coal Co.	Brazil	Brazil No. 1.
Brazil Block Coal Co.	Brazil	Brazil No. 4.
Brazil Block Coal Co.	Brazil	Brazil No. 7.
Superior Block Coal Co.	Brazil	Rebstock.
Vandalia Coal Co.	Indianapolis, State Life Bldg	Vandalia No. 50.
Vandalia Coal Co.	Indianapolis, State Life Bldg	Vandalia No. 60.
Vandalia Coal Co.	Indianapolis, State Life Bldg	Vandalia No. 65.
Zellar-McClellan Co.	Brazil	Superior No. 4.
Crawford Coal Co.	Brazil	Crawford No. 2.
Crawford Coal Co.	Brazil	Crawford No. 6.
Crawford Coal Co	Brazil	Crawford No. 8.
Crawford Coal Co.	Brazil	Crawford No. 9.
Collins Coal Co.	Brazil	Gifford No. 1.
Collins Coal Co.	Brazil	Gifford No. 2.
Coal Bluff Mining Co.	Terre Haute	Glenn No. 1.
Coal Bluff Mining Co.	Terre Haute	Plymouth No. 2.
American Clay Manufacturing Co.	Brazil	Monarch.
Big Vein Mining Co.	Terre Haute	Lewis.
Vivian Colliers Co.	Chicago, Ill.	Vivian No. 1.
Vivian Colliers Co.	Chicago, Ill.	Vivian No. 2.
Progressive Coal & Mining Co.	Brazil	Progressive.
Jasonville Coal Co.	Jasonville	Gold Knob.
Eureka Block Coal Co.	Brazil	Eureka No. 5.
McLaughlin & Treager	Brazil	Treager.
C. Ehrlich Coal Co.	Turner	Klondyke No. 2.
The Clay Product Co.	Brazil	Fortner.
The Clay Product Co.	Brazil	Continental.
Lower Vein Block Coal Co.	Brazil	Lower Vein No. 1.
United Fourth Vein Coal Co.	Linton	Island Valley No. 4.
Harrison Coal & Mining Co.	Clay City	Harrison No. 4.
Nick Schefferman	Brazil	Schefferman.
Hall & Zimmerman	Brazil	Wizard.
Crawford Coal Co.	Brazil	Crawford No. 10.
Sam Pyrah	Brazil	Pyrah.
Raccoon Mining Co.	West Terre Haute	Raccoon.

DAVIESS COUNTY.

Stucky & Osborn	Raglesville	Stucky.
Daviess County Coal Co.	Montgomery	Montgomery No. 3.
Mutual Mining Co.	Cannelburg	Mutual.
Mandaback Bros	Washington	Mandabach.
Overton Coal Co.	Raglesville	Overton.
Winklepeck & Overton	Raglesville	Winklepeck.

FOUNTAIN COUNTY.

Rush Coal Co.	Toledo	Indio.

MINE DIRECTORY—Continued.

GREENE COUNTY.

Name of Company.	Address of Company.	Name of Mine.
United Fourth Vein Coal Co.	Linton	North Linton.
United Fourth Vein Coal Co.	Linton	Sponsler.
United Fourth Vein Coal Co.	Linton	Black Creek.
United Fourth Vein Coal Co.	Linton	Dickarson.
United Fourth Vein Coal Co.	Linton	Antioch.
Vandalia Coal Co.	Indianapolis, State Life Bldg.	Vandalia No. 2.
Vandalia Coal Co.	Indianapolis, State Life Bldg.	Vandalia No. 3.
Vandalia Coal Co.	Indianapolis, State Life Bldg.	Vandalia No. 4.
Vandalia Coal Co.	Indianapolis, State Life Bldg.	Vandalia No. 5.
Vandalia Coal Co.	Indianapolis, State Life Bldg.	Vandalia No. 6.
Vandalia Coal Co.	Indianapolis, State Life Bldg.	Vandalia No. 8.
Vandalia Coal Co.	Indianapolis, State Life Bldg.	Vandalia No. 9.
Vandalia Coal Co.	Indianapolis, State Life Bldg.	Vandalia No. 21.
Southern Indiana Coal Co.	Chicago, Ill., Old Colony Bldg.	Hoosier No. 1.
Southern Indiana Coal Co.	Chicago, Ill., Old Colony Bldg.	Tower Hill.
Southern Indiana Coal Co.	Chicago, Ill., Old Colony Bldg.	Lattas Creek.
Indiana Southern Coal Co.	Chicago, Ill., Old Colony Bldg.	Gilmour.
Vulcan Coal Co.	Indianapolis	Vulcan.
Summit Coal & Mining Co.	Bloomfield	Summit No. 2.
Green Valley Coal Co.	Jasonville	Green Valley.
Queen Coal & Mining Co.	Jasonville	Queen.
Letsinger Coal Co.	Terre Haute	Letsinger.
Calora Coal Co.	Indianapolis, Terminal Bldg.	North West.
Coal Bluff Mining Co.	Terre Haute	Twin No. 4.
Coal Bluff Mining Co.	Terre Haute	Twin No. 5.
Midvale Coal Co.	Midland	Midvale.
Mooney, Donnelly & Keers	Linton	Mooney.

GIBSON COUNTY.

Princeton Coal & Mining Co.	Princeton	Oswald.
Peacock Coal & Mining Co.	Oakland City	Massey.
Fort Branch Coal & Mining Co.	Fort Branch	Fort Branch.

KNOX COUNTY.

Bicknell Coal Co.	Bicknell	Bicknell.
Freeman Coal Co.	Bicknell	Freeman.
Knox Coal Co.	Bicknell	Knox.
Lynn Coal Co.	Bicknell	Lynn.
Washington-Wheatland Coal Co.	Washington	Wheatland.
Chicago & Big Muddy Coal Co.	Bicknell	Pine Knot.
Tecumseh Coal & Mining Co.	Bicknell	Tecumseh.

PARKE COUNTY.

Bridgeton Mining Company	Bridgeton	Bridgeton No. 1.
Brazil Block Coal Co.	Brazil	Brazil No. 9.
Brazil Block Coal Co.	Brazil	Brazil No. 12.
United Coal & Mining Co.	Mecca	Mecca No. 3.
Otter Creek Coal Co.	Chicago, Ill.	Mary.
Zellar-McClellan & Co.	Brazil	Superior No. 1.
Zellar-McClellan & Co.	Brazil	Superior No. 2.
Zellar-McClellan & Co.	Brazil	Superior No. 3.
Zellar-McClellan & Co.	Brazil	Superior No. 5.
Vandalia Coal Co.	Indianapolis, State Life Bldg.	Vandalia No. 316.
Parke County Coal Co.	Rosedale	Parke No. 11.
W. P. Harrison	Rockville	Harrison.
Vivian Collieries Co	Chicago	Lyford No. 1.
James Moore	Kingman	Moore.
Wm. Moore	Kingman	Moore.

MINE DIRECTORY—Continued.

PERRY COUNTY.

Name of Company.	Address of Company.	Name of Mine.
Bergenroth Bros	Troy	Troy.

PIKE COUNTY.

Name of Company.	Address of Company.	Name of Mine.
Ayrshire Coal Co	Oakland City	Ayrshire No. 3.
Ayrshire Coal Co	Oakland City	Ayrshire No. 4.
Ayrshire Coal Co	Oakland City	Ayrshire No. 5.
Central Indiana Coal & Mining Co	St. Louis, Mo	Carbon.
S. W. Little Coal Co	Evansville	Rogers.
S. W. Little Coal Co	Evansville	Blackburn.
S. W. Little Coal Co	Evansville	Littles.
Muncie Coal & Mining Co	Muncie	Petersburg.
Winslow Gas Coal Co	Winslow	Winslow No. 4.
Winslow Gas Coal Co	Winslow	Winslow No. 5.
Central Indiana Coal & Mining Co	St. Louis Mo	Aberdeen.
S. W. Little Coal Co	Evansville	Blackburn No. 2.
Binghamton Trust Co	Hartwell	Hartwell No. 1.
Binghamton Trust Co	Hartwell	Hartwell No. 2.

SULLIVAN COUNTY.

Name of Company.	Address of Company.	Name of Mine.
Indiana Southern Coal Co	Chicago, Ill. Old Colony Bldg	Washington.
Indiana Southern Coal Co	Chicago, Ill., Old Colony Bldg.	Rainbow.
Indiana Southern Coal Co	Chicago, Ill., Old Colony Bldg	Phœnix No. 4.
Indiana Souehtrn Coal Co	Chicago, Ill., Old Colony Bldg	Cummins.
Indiana Southern Coal Co	Chicago, Ill., Old Colony Bldg	Hocking.
Indiana Southern Coal Co	Chicago, Ill., Old Colony Bldg	Citizens.
Sunflower Coal Co	Dugger	Sunflower.
Consolidated Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Consolidated No. 25.
Consolidated Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Consolidated No. 26.
Consolidated Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Consolidated No. 28.
Consolidated Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Consolidated No. 30.
Consolidated Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Consolidated No. 32.
Consolidated Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Consolidated No. 33.
Vandalia Coal Co	Indianapolis	Vandalia No. 10.
Vandalia Coal Co	Indianapolis	West Linton.
Jackson Hill Coal & Coke Co	Terre Haute, Opera Block	Jackson Hill No. 2.
Jackson Hill Coal & Coke Co	Terre Haute, Opera Block	Jackson Hill No. 4.
C. C. Heison	Shelburn	Keystone.
Sullivan County Coal Co	Terre Haute	Freeman.
Dering Coal Co	Chicago, Ill., Old Colony Bldg	Dering No. 12.
Dering Coal Co	Chicago, Ill., Old Colony Bldg	Dering No. 13.
Dering Coal Co	Chicago, Ill., Old Colony Bldg	Dering No. 14.
Southern Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Semi-Block.
Southern Indiana Coal Co	Chicago, Ill., Old Colony Bldg	Mammoth Vein.
Shirley Hill Coal Co	Indianapolis. Terminal Bldg	Shirley Hill No. 1.
Shirley Hill Coal Co	Indianapolis, Terminal Bldg	Little Giant.
Hudson Coal & Mining Co	Farmersburg	Hudson.
Kettle Creek Coal Co	Terre Haute	Pearl.
Peabody-Alwart Coal & Mining Company	Chicago, Ill.,	Reliance.
Diamond Coal & Mining Co	Chicago, Ill	Hamilton.
United Fourth Vein Coal Co	Linton	Black Hawk.
Shirley Hill Coal Co	Indianapolis, Terminal Bldg	Clover Leaf.
Shirley Hill Coal Co	Indianapolis, Terminal Bldg	Shirley Hill No. 3.
Carlisle Coal & Clay Co	Carlisle, Ind	Viola.

VANDERBURGH COUNTY.

Name of Company.	Address of Company.	Name of Mine.
Diamond Coal Co	Evansville	Diamond.
D. Ingle Coal Co	Evansville	Ingleside.
Sunnyside Coal Co	Evansville	Sunnyside.
Crescent Coal Co	Evansville	Unity.
Banner Coal Co	Evansville	First Avenue.

MINE DIRECTORY—Continued.

VERMILLION COUNTY.

Name of Company.	Address of Company.	Name of Mine.
Dering Coal Co	Chicago, Ill., Old Colony Bldg	Dering No. 5.
Dering Coal Co	Chicago, Ill., Old Colony Bldg	Dering No. 7.
Dering Coal Co	Chicago, Ill., Old Colony Bldg	Dering No. 8.
Dering Coal Co	Chicago, Ill., Old Colony Bldg	Dering No. 15.
Cayuga Brick & Coal Co	Cayuga	Eureka.
Clinton Coal Co	Clinton	Crown Hill No. 1.
Clinton Coal Co	Clinton	Crown Hill No. 2.
Oak Hill Coal Co	Clinton	Oak Hill.
Oak Hill Coal Co	Clinton	Maple Valley.
Oak Hill Coal Co	Clinton	Buckeye No. 2.
Clinton Coal Co	Clinton	Crown Hill No. 3.

VIGO COUNTY.

Coal Bluff Mining Co	Terre Haute	Lawton.
Coal Bluff Mining Co	Terre Haute	Plymouth No. 1.
Coal Bluff Mining Co	Terre Haute	Victor
Coal Bluff Mining Co	Terre Haute	Wabash.
Lower Vein Coal Co	Terre Haute	Lower Vein No. 1.
Vandalia Coal Co	Indianapolis	Vandalia No. 67.
Vandalia Coal Co	Indianapolis	Vandalia No. 69.
Miami Coal Co	Brazil	Miami No. 1.
Miami Coal Co	Brazil	Miami No. 2.
Miami Coal Co	Brazil	Miami No. 3.
Parke County Coal Co	Rosedale	Parke No. 10.
Fauvre Coal Co	Indianapolis	Fauvre No. 1.
Fauvre Coal Co	Indianapolis	Fauvre No. 2.
West Terre Haute Coal Co	W. Terre Haute	Larimer.
Deep Vein Coal Co	Terre Haute	Deep Vein.
Vigo County Coal Co	Seeleyville	Ray No. 2.
Indiana Southern Coal Co	Chicago, Ill	Forest.
Domestic Block Coal Co	Kokomo	Domestic Block No. 1.
Chas. F. Keeler Coal Co	Chicago, Ill	Atherton.
M. D. West Coal Co	Cloverland	Chicago No. 6.
Grant Coal & Mining Co	Burnett	Grant No. 2.
Sugar Valley Coal Co	West Terre Haute	Sugar Valley.
Dering Coal Co	Terre Haute	Deering No. 6.
Coal Bluff Mining Co	Terre Haute	Minshall.

WARRICK COUNTY.

Big Four Coal Co	Boonville	Big Four.
Chandler Coal Co	Evansville	Chandler.
John Archibald Coal Co	Evansville	Star No. 1.
Chas. Menden Coal Co	Evansville	DeForest.
T. D. Scales Coal Co	Boonville	Electric.
Caladonia Coal Co	Boonville	Dawson.
Erie Canal Coal Co	Boonville	Erie Canal.
J. Wooley Coal Co	Boonville	Castle Garden.
Worsham-Newburg Coal Co	Newburg	Bizius.
Elberfeld Oil, Gas & Mining Co	Elberfeld	Elberfeld.
Epworth Coal Co	Newburg	

REPORT OF THE STATE NATURAL GAS SUPERVISOR FOR THE YEAR 1907.

BY

B. A. KINNEY.

Annual Report of the State Natural Gas Supervisor.

OFFICE OF THE STATE NATURAL GAS SUPERVISOR,
MARION, INDIANA, February 1, 1908.

Prof. W. S. Blatchley, State Geologist:

SIR—I have the honor to submit to you herewith my fifth annual report as State Gas Supervisor, for the year 1907, the same being the sixteenth report from this department. In former reports I have endeavored to call your attention to the waste of gas resulting from the criminal negligence of operators and producers; also of the evil results to the gas supply from pumping stations, now mostly abandoned, and of my efforts in seeking to prevent such abuses. This report will contain a great deal of matter on this line. I have sought, however, to eliminate all matter that has been fully treated in former reports and has no special importance at this time. I have dwelt largely in this report upon the improvement in conditions in the gas fields of the State in general, of the prospecting for new gas territory and the development of the same, giving, I think, much information in detail that will be valuable and instructive to the people of Indiana.

I trust that this report will receive your approval and the approval of those who, from their interest and experience in the gas field, are capable of judging of the same.

Respectfully yours,

B. A. KINNEY,
State Natural Gas Supervisor.

ANNUAL REPORT OF THE STATE NATURAL GAS SUPERVISOR.

WELL PLUGGING.

In my last annual report I gave considerable space to the ruinous effects upon the gas fields of the State resulting from the failure or neglect of operators and producers to plug up the abandoned wells. It is of such supreme importance to the people of Indiana that this great natural resource be husbanded and saved for those to whom it is such a blessing that I again wish to urge upon all who read this, if they be engaged in the development of the gas business, the necessity of complying with the State law upon the above subject. A great majority of gas operators realize the importance of taking care of the gas fields, and I am happy to say that the laws on this subject were more generally obeyed within the last year than ever before.

There are, of course, many operators who care only for their own convenience and for their immediate profits, disregarding the rights of the landowners and those of the public at large. This class includes some gas companies, individuals drilling wells for speculation and oil operators. The last two classes, in the event of failure to obtain a good paying well in one territory and foreseeing no good prospects ahead, sometimes abandon their leases, ''pull'' their wells and seek other gas fields which promise better results, without having properly plugged the wells. Hence a great deal of my time is taken up in seeking out these abandoned wells. As I have said above, however, these law violations are growing less in number, and I have had the co-operation and sympathy of most of the producers, only a few of them having tried to obstruct me in the discharge of my duties.

The law on the subject of plugging abandoned wells was enacted by the General Assembly of 1903 and approved March 7, 1903, and I herewith give a brief synopsis of the same for the benefit of those interested who may read this report.

Section 1 provides: ''That before the casing shall be drawn from any well—to be abandoned—which has been drilled into the gas or oil bearing rock it shall be the duty of any person, firm or corporation, having control of said well, as well as the owner of the lands whereon such well is situated, to properly stop or plug the same in the following manner: Such hole shall first be solidly filled from the bottom thereof to a point at least 25 feet above such gas or oil bearing rock with sand, gravel or pulverized rock, immediately upon the top of which filling shall be seated a dry pine wood plug, not less than 2 feet in length, having a diameter of not less than one-fourth of an inch less than the inside diameter of the casing in such well; above such wooden plug such well shall be solidly filled for at least 25 feet with the above mentioned filling material, immediately upon which shall be seated another wooden plug of the same kind and size above provided, and such well shall again be filled solidly for at least 25 feet above such plug with said filling material. After the casing has been drawn from such well there shall immediately be seated at the point where such casing was seated a cast iron ball or a tapered wooden plug at least two feet in length, the diameter of which ball or the top of which plug shall be greater than the hole below the point where such casing was seated, and above such ball or plug such well shall be solidly filled with the aforesaid filling material for a distance of at least fifty feet."

Section 2 provides: "That an affidavit must be made by at least two persons who assisted in the plugging of such well, which is to be recorded in the recorder's office of the county where the well is located; this to be filed within fifteen days after such plugging, and shall set out in detail the manner in which the well is plugged, following the law's instructions as above, giving the depths below the surface of the plugs or iron ball."

Section 3 provides: "That in sinking wells into the gas or oil bearing rock that the water be cased off from such well."

Section 4 provides: "A penalty for any violation of this act the sum of $200 and $200 more for each ten days such violation shall continue, to be recovered in a civil action in a court of competent jurisdiction, brought in the name of the State of Indiana, for the use of the county where the violation occurred, and the county may also recover attorney's fees in case of a recovery by it."

Section 5 repeals a former law passed in 1893.

Section 6 empowers the State Gas Supervisor to enter upon any land at any time for the purpose of examining and testing any such well or wells.

The Natural Gas Supervisor has endeavored to do his duty according to the above law, but he has no means of knowing when wells are to be abandoned, and can only act in cases of violations of the law on information furnished him by outside parties. I believe all good citizens should assist me in enforcing this law as a means of preserving this gas supply. I promise in return to put the law into motion, without fear or favor, against any violators brought to my knowledge.

Among the most common violators of the law are the junk dealers, who buy the old iron and casing from defunct gas and oil wells and leave them without any attention whatever. The landowners then disclaim any responsibility for the plugging of the wells, as do also the junk men, making it difficult to locate the responsible party.

It is a matter of common knowledge among gas and oil operators that much of the oil and gas bearing rock is connected throughout the State, though in some localities it differs in porosity from others. Therefore, if by reason of a failure to properly plug an abandoned well or to case off the water from the rock when a well has been drilled, water is introduced into the rock strata, an injurious effect is produced upon the gas bearing rock for many miles in extent, and affects good producing wells many miles away from where the mischief was done.

While on the subject of well plugging I can do no better than to reproduce the suggestions of Mr. Henry C. Zeigler, president of the Heat, Light and Power Company of Muncie, the principal gas company there, who wrote to me under date of February 7, 1908. The letter contains so many good ideas as well as valuable information about the Delaware County gas field that I present it herewith verbatim:

MUNCIE, IND., February 7, 1908.

Mr. B. A. Kinney, Care Denison Hotel, Indianapolis, Ind.:

Dear Sir—Replying to your esteemed favor of the 4th, and your inquiry therein contained as to the number of wells we have drilled in the year 1907, we beg to state that the Heat, Light and Power Company has not been obliged to drill a well, and did not drill any during the year 1907, and we have a good volume, a plentiful supply for our patrons. The gas pressure is growing better gradually, and to such an extent that it is convincing proof of a general betterment.

Four years since the pressure, as taken by a committee from the Common Council of the city of Muncie during a three days' trip over the gas field of Delaware County, which same is a matter of record, showed pressures running from 0 up to 6 pounds, but very few wells registered the higher figure, the average being 1½ pounds, where wells were feeding into pipe lines and on which no pumps were connected. The six-pound pressure wells were those that were not connected to feed lines. Our wells, since the manufacturers' pumps have been abandoned, have shown a constant increase, and those on the pumps, if the gate is closed, will register from 2 to 8 pounds within five to seven minutes. We have a number that will run up to 10 pounds or better that have been on the pumps for the last year. Wells that are not on the pumps, that were practically dead four years ago, will register from 20 to 40 pounds. The writer is not disappointed, as we maintained early in the history of the gas field what the result would be when the mammoth pumps were dismantled.

In the meantime we are prone to give due credit to the State Gas Inspector's office, the good efforts of Mr. Blatchley, and his assistant, yourself, in the matter of advising the proper plugging of wells. We regret the law is not a little more explicit and far-reaching. To one who has been engaged in the natural gas and oil business for better than thirty years, we think it very important that a law should be enacted making it possible for the State Gas Inspector to appoint an assistant in every district to whom the owner of any well, when desiring to have the same pulled, should report, and that such assistant should be at the well and see that the well is plugged in accordance with the law regulating the plugging of wells. In this way only can we expect proper results from the law as now enacted.

We drop in these suggestions in the hope that you will lend your good influence towards the enactment of such a law as will bring proper results, and thus save to the citizens within the gas producing territory of the State the valuable fuel that the writer believes will be in abundance for many years if water is not allowed to flow into the gas producing strata.

Respectfully yours,

H. C. ZEIGLER.

I heartily endorse the suggestions of the writer of the above, Mr. Zeigler, on whose opinion upon the question of gas preservation I have learned long since to place a high value. His suggestion to have assistant gas supervisors appointed in each gas district to oversee the plugging or packing of wells, and to provide that no well should be plugged or packed without the presence of the Supervisor or an assistant on the ground, meets with my earnest approval. A law enacted following out the above ideas would present the most practical and efficient method of preventing the abandonment of wells without proper plugging or packing, and would help to save the gas bearing porous rock strata from salt or fresh water flowing in from abandoned wells.

PUMPING STATIONS.

In former reports the Natural Gas Supervisors have given considerable space to the subject of pumping stations. These stations, intended to reinforce the natural rock pressure by pumping the wells, have been the means of exhausting the gas supply years earlier than would have resulted had the natural pressure been depended upon. Wherever pumps have been used to increase the flow of gas from wells the gas bearing rock has been rapidly exhausted, and in many cases, in gas territories where this artificial means was applied, the gas bearing rock stratum has become saturated with water drawn in from below by the suction of the pumps.

I find where these pumping stations have been abandoned and have ceased to draw upon the gas bearing rock, that the gas wells that formerly had a very feeble pressure have, since the stopping of the pumps, shown an increased flow of gas, and new wells drilled have given promise of a long continued supply of the fuel.

About all of the pumping stations now in existence in Indiana is the one at Anderson of the Hazelwood Gas Company, the station at Richmond of the Richmond Natural Gas Company, the one of J. M. Leach on the east line of Howard County, the two stations of the Indiana Natural Gas and Oil Company, one near Fairmount, Grant County, the other at Greentown, Howard County, as stated in another part of this report, and the stations of the Southern Indiana Gas Company, of Decatur County, and the Shelbyville Gas Company, of Shelby County.

The Indiana Natural Gas and Oil Company, with a pipe line to Chicago, is the only company which now pipes gas out of the State.

I will refer the reader to the letters of H. C. Zeigler, president of the Heat, Light and Power Company of Muncie; of J. M. Leach, of Kokomo, and of Thos. Wisehart, general superintendent of the Lafayette Gas Company, made a part of this report, all of which are pertinent on the subject of pumping stations.

The Old Field.

In Madison County the conditions are much improved within the last year. The pumping stations that contributed to the exhaustion of this field have ben abandoned. The gas is no longer used for manufacturing purposes, and the supply for domestic use is increasing. What is said of Madison County is true also in speaking of Delaware County, adjoining. A number of old wells are still producing a fair flow of gas.

In Grant County two pumping stations still exist. The one owned by the Indiana Gas and Oil Company east of Fairmount, which supplied gas to Chicago, is still operating, pumping about 500 wells. They formerly pumped 3,000 wells. This pumping station more than anything else has been the cause of exhausting the Grant County field, as the gas is pumped from the gas bearing rock by artificial suction into the mains, and is then by reinforced pressure forced through the mains. It is evident from the constantly decreasing supply of gas in this territory that the field must soon be abandoned. This company still maintains a pumping station at Greentown.

The pumping station near Upland, Grant County, is still in use, being owned by the Huntington Light and Fuel Company of Huntington, Indiana, which supplies that city with gas. This station is used to force the gas through the mains, and does not pump from the wells direct. The Huntington Company has a chain of wells along its pipe line, about 300 of which are in fair condition.

At Marion the Marion Gas Company still supplies the majority of the citizens with gas. The gas supply is holding up well there. No gas is used for manufacturing purposes. The Marion Gas Company have drilled about forty wells within the last year. The Marion company depends on natural pressure, having no pumping station.

Jay County has a good supply of gas, a number of wells there showing a moderate pressure. This field was revived into life after the dismantling of the pumping stations which drew on this county's gas territory. The pumping station located at Perkinsville, belonging to the Fort Wayne Gas Company, has been dismantled and the pipe lines of the company have been taken up. This company formerly supplied the city of Fort Wayne and intermediate cities with gas.

The Lafayette Gas Company, better known as the "Deitrich Syndicate," has practically gone out of business. This company formerly supplied gas to the cities of Lafayette, Logansport, Peru and Wabash. Independent companies furnish what gas is available to these cities. A letter from Thos. Wisehart, the company's superintendent, is made a part of this report.

The condition of the gas supply in Howard County is shown by the following statement: The Plate Glass Company of Kokomo has within the last two years drilled 256 wells with an average pressure of 200 pounds. John M. Leach, of Kokomo, has drilled fifteen wells within the last year having about the same pressure. These wells are mostly in good condition.

In Hancock County conditions in the gas field are still good. Many of the wells drilled by the Southern Indiana Gas Company, which supplies Greenfield and other towns, are still producing. Gas operations are being carried on vigorously here, many wells being drilled in. A favorable report can be made also of the gas field in Shelby County. Operations there are still active, many new wells are being drilled.

In Decatur County the people are enjoying the boon of cheap gas. The citizens of Greensburg are bountifully supplied with the best fuel on earth for fifteen cents per thousand cubic feet. The farmers of Decatur County also share the privilege of using cheap gas. In fact, it is a rare sight to see a wood or coal stove in the county. In many localities every well-to-do farmer has his own gas well, from which he uses gas for heat and light for his house and outbuildings, as well as for power for a gas engine. He then supplies the needs of his neighbors, who are small farmers or tenants. The greater part of the gas supply of Decatur County comes from the Trenton rock at a depth of 800 to 1,000 feet, though there are many good wells that were drilled just into the "shale" that lies just above the limestone. There are no especially strong wells here, but the flow is strong and steady from all of them.

Many old wells that were filled up with water have been revived by cleaning and packing so as to keep out the water and are now good producers. Decatur County has never been considered in the "gas belt," but her people have enjoyed the use of gas necessary for domestic use ever since the first discovery of gas in Indiana. In the year 1907, in Decatur County, the gas companies of the county drilled 115 wells. The Greensburg Natural Gas, Oil and Water Company drilled 30 wells, the Greensburg Gas and Electric Company 40 wells, the Muddy Fork Natural Gas Company drilled 45 wells. These wells were drilled to an average depth of 900 feet; average rock pressure, 200 pounds.

The letters contained in this report, from H. C. Zeigler, J. M. Leach and Thos. Wisehart, are interesting, containing much interesting information regarding the old gas field of Indiana. The letters of Mr. Leach and Mr. Wisehart follow hereafter.

Mr. J. M. Leach writes the following letter:

KOKOMO, IND., February 11, 1908.

Mr. B. A. Kinney, Marion, Ind.:

Dear Sir—Replying to your favor of the 4th, beg to advise that I have drilled 15 wells in the past year, with an average capacity of 100,000 feet for the first 24 hours, and the average rock pressure is 225 pounds; with the exception of one well, which was drilled just east of Kokomo, the rest were drilled just north of Kokomo. Am running the pumping station in the daytime only.

Yours very truly,

J. M. LEACH.

P. S.—We are using about 125,000,000 feet per year.

Mr. Leach is a prominent manufacturer and gas producer of Kokomo.

Mr. Wisehart, Superintendent of the Lafayette Gas Company, sends me the following interesting reply to an inquiring letter of mine:

LAFAYETTE, IND., February 20, 1908.

Mr. B. A. Kinney, State Gas Inspector:

Dear Sir—Complying with your request, I here hand you statement of conditions of the various fields in my charge:

First, the Indiana field has been discontinued and abandoned. The main line from and through Tipton County to Frankfort and Crawfordsville is still intact but not in use. The pumping station at Kempton has been removed and all machinery gone. The Curtisville station is still intact but not in use.

The Lafayette Gas Company's field has been discontinued and abandoned. All field lines and wells have been removed and field generally cleaned up except the main lines through the field, and also main line to Lafayette, which is still intact, but not in use. The stations on the Lafayette plant, Kempton station boilers have all been removed, but the compressors are still intact, but not in use.

The Windfall station is still intact, but not in use. The Summitville station still intact, but not in use.

The Logansport and Wabash Valley Company have abandoned Peru, and the only towns now being furnished with gas are Converse, Swayzee, Miers, Herbst, and Geneva (the last) in Adams County.

We have a number of small wells through the western part of Grant County and the eastern part of Miami, which are furnishing gas to supply a part of these towns. The pumping station at Converse has been discontinued and removed. Main line between Converse and Peru is still intact. We are furnishing gas to Geneva, Adams County, and purpose furnishing to Decatur. We are not drilling any wells in that vicinity, however, as we are purchasing our gas from the Warren and Indiana Oil Company.

By the way, we have an especially good pressure in that portion of Jay County and in the southern part of Adams County. Last week I gauged one well that showed 320 pounds original rock pressure. The volume, however, was not of much account. We have four other wells from which we are receiving gas belonging to the said Warren Company that showed a pressure of 150 to 170 pounds, giving us ample supply for Geneva.

In making estimate of four of these wells, we found that they measured as against atmosphere about 6,000,000 feet per day of 24 hours.

Yours truly,

THOS. WISEHART,

General Superintendent of Lafayette Gas Company.

THE SULLIVAN FIELD.

Brief mention only was made in my last annual report of the gas developments in Sullivan and Vigo counties, which now promise to become fair productive gas territory. This region is known among oil and gas men as the "Sullivan Field."

SULLIVAN COUNTY.

I give below much detailed information as to the wells recently drilled in Sullivan County. There have been several wells developed which produce more than 1,000,000 cubic feet of gas per day, each. One of these is located on the Jamison farm one mile west of Sullivan. Many wells are being drilled in the same locality and throughout the county, and much activity prevails. Twelve wells that have been drilled in the last year were unsatisfactory, showing more oil than gas. Gas is plentiful here for heat and light and the city of Sullivan is now being piped for the purpose of bringing the new fuel to the doors of its citizens.

From the records of wells drilled in the Sullivan field I make note of the following:

Three wells drilled on Hoseman farm, Section 9, Gill Township, in 1904, first well drilled showing of oil at 865 feet, drilled to 900 feet; enough gas to run boilers. Second well came in in January, 1907, in Jamison sand; shot, water drowned, water flowing out yet; fair gas. Third well came in in August, 1907; abandoned, not shot.

On the P. Osborn lease, in section 12, Hamilton Township, one well was drilled in July, 1907; oil was found at 527 feet, 15 feet in the sand; well was drilled to 830 feet and shot, and abandoned.

On the Gill lease, in section 10, Gill Township, one well was drilled; showing of gas at 772 feet; drilled down to 840 feet and abandoned.

The Deitrich Syndicate in 1906 drilled a well on the Krause farm, in Turman Township. Some gas was obtained at 1,465 feet. Drilled to 1,762 feet.

In July, 1907, a well was completed on the Brokaw lease in section 18, Hamilton Township; no gas obtained; streak of Jamison sand at 760 feet; drilled to 870 feet. On the Mason lease, section 17, Hamilton Township, a well was drilled, reaching the sand at 745 feet; total depth drilled, 860 feet. A well drilled on the Hayden farm, section 26, Hamilton Township, 1,350 feet; slight showing of oil at 1,150 feet.

On the Coulson lease, section 31, Hamilton Township, a well is being drilled which has reached a depth of 775 feet; a flow of oil, five barrels per day, was developed at 738 feet, sand was reached at 734 feet, and after being shot the well flowed 10 barrels of oil per day. This well was not pumped.

On the Scott farm, section 36, Turman Township, a well was completed October, 1907, located on left side of the road. Drilled 850 feet; dry. In the same month and year a well was completed on right side of road; drilled to 900 feet; oil reached at 745 feet; six-barrel oil well. Showing of oil at 480 to 500 feet, or 15 to 20 feet in the sand. This is found to be general over this field. On the J. M. Springer lease, section 2, Turman Township, a well now being drilled is down to 1,100 feet; small showing of Jamison sand at 800 feet; water flowed at 900 feet to present depth. A well drilled and completed in June, 1907, on T. B. Springer lease, section 2, Turman Township, was abandoned at 900 feet, owing to water. Signs of oil at 400 feet; Jamison sand at 795 feet; fair showing of gas.

Three miles east of Paxton, on the Blakeman lease, section 21, Haddon Township, a well now being drilled has reached a depth of 1,100 feet; showing of oil at 660 to 710 feet; not shot.

On Jamison farm, section 31, Hamilton Township, two good gas wells were drilled and completed between April and September, 1907; gas reached at 700 feet; 30 feet drive pipe used; at 600 to 680 feet 6¼ inch casing used; No. 1 well flows 1,250,000 cubic feet of gas per day; No. 2, 1,200,000 feet; pressure, 297 pounds. The gas from these wells is being piped into the city of Sullivan.

The log of three wells drilled in the Sullivan County field is set forth, as follows:

Record of the Bailey McConnell Well, Section 28, Haddon Township, Sullivan County, Indiana.

	Feet.
Conductor	28
8-inch pipe	38
6¼-inch pipe	930
4⅝-inch pipe	1470
5 feet coal and gas	271
Salt sand	925 to 1015
Break	1027
Salt sand	1027 to 1225
Lime and slate	1225 to 1300
Sand lime-slate	1300 to 1395
Hole full water, oil	1395 to 1435
Salt sand	1435 to 1445
Slate	1445 to 1470
Dry hole	1470 to 1860
Water	1860
Good sand with oil	870
Oil at	1395

Drilled in 1905. Abandoned.

Record of W. R. Colvin Well, Section 31, Haddon Township, Sullivan County, Indiana.

		Feet.
8-inch drive-pipe		40
6¼ casing		550
Enough salt water to drill	560 to	700
Slate	700 to	842
Slate	842 to	881
Shells and sand oil at bottom	881 to	960
Shells-lime	960 to	995
Small shell sharp rock	995 to	1040
Salt sand	1040 to	1085
Slate	1085 to	1120
Salt sand	1120 to	1140
Slate and lime	1140 to	1300
4⅞ casing		1310
Sandy lime	1310 to	1370
Soft lime	1370 to	1390
Sharp sand, show oil	1390 to	1440
Good drilling	1440 to	1510
Brown sand, small show of gas		1510
Brown sand, show of oil	1565 to	1640
Good sand	1640 to	1660
Water		1687

Drilled in 1905. Abandoned.

Record of Drilling Turman Township Well, Section 8, on the Farm of John H. Krause, in Sullivan County.

Murdock Gas Company.

		Feet.
Shale		70
Sand		80
Blue shale		255
Coal, 3 feet		260
Dark shale		305
Coal		310
White limestone	310 to	340
Gray shale	340 to	510
Sand (cased)	570 to	574
Shale	584 to	680
Gray sand		910
Salt sand		960
Black sand (Robinson)		985
Shale and salt		1075
Black sand		1140
Black sand and cave		1210
Salt sand		1600
Blue lick water		1720
Total depth		1762

Casing.

	Feet.
13-inch	26
10-inch	584
8-inch	1181
6⅝-inch	1328
5-inch	1746
Oil	1475
Water	1460 to 1510

This well was drilled in 1906. Abandoned.

Gibson County.

The operations in the Princeton field, Gibson County, in the past year, show this territory to be a coming gas field of much importance. Considerable drilling for oil by the Ohio Oil Company and other companies is being done. Each completed well shows a fair flow of gas, and no well so far drilled has failed to furnish enough gas for fuel for the boilers of the oil operators who are now pumping the oil producing wells, many of which are now paying. The following statement of the record of some of these wells operated by the Ohio Oil Company and other companies, is herewith submitted:

The No. 1 well on the I. N. Montgomery lease, completed in December, 1907, drilled to depth of 1,000 feet, sand struck at 845 feet, 87 feet of drive pipe used; dry well. On the Kendall lease, well No. 16, completed in December, 1906, sand at 836 feet; drilled 30 feet in sand; drive pipe 75 feet, 10 inches; 5 to 6 barrel well. No. 17, drilled total depth 862 feet, sand at 820 feet, drive pipe 80 feet 10 inches; 65 barrel well, completed March, 1907. No. 18, completed April, 1907; total depth, 865 feet; sand at 820 feet, 80 feet drive pipe; 92 barrel well. No. 19, completed June, 1907; depth 882 feet, sand at 842 feet, drive pipe 85 feet and 10 inches; 55 barrel well. No. 20, completed in December, 1907; total depth 858 feet, sand at 836 feet, drive pipe 82 feet and 10 inches; 15 barrel well.

On the M. Howard farm, No. 8 well, completed in August, 1907; was drilled to depth of 910 feet, sand was reached at 862 feet, the drive pipe used was 62 feet long; salt water struck; dry well. On the W. F. Knight lease, No. 5 well, completed in September, 1907; sand at 892 feet, drilled 60 feet in the sand, 80 feet and 10 inches drive pipe, 800 feet of 6¼-inch casing used; 10 barrel well. On Watkins's lease, No. 1 well, completed in September, 1907;

total depth drilled 876 feet, sand at 836 feet, 81 feet and 10 inches of drive pipe; 35 barrel well; salt water encountered. No. 2 well, completed in October, 1907; total depth 863 feet, sand at 823 feet, drive pipe 78 feet and 10 inches; 80 barrel well. These wells were all drilled by the Ohio Oil Company, which is at this time drilling other wells in the same vicinity.

On Watson lease, R. Binkley farm, No. 1 well, 812 feet to the sand, drilled 52 feet in sand, 5 barrel oil well; No. 2 well, 840 feet to sand, total depth drilled 880 feet, formation lower in this well; light well. These two wells drilled by New York-Hudson Oil Company.

The Bennedum-Trees Company has lately drilled a well on the Skinner farm, near Oakland City, total depth 1,300 feet; encountered salt water; dry well. Two wells now being drilled near Oatsville, Pike County, one by the above named company, the other by the Pure Oil Company. The Pure Oil Company drilled a well on the Houchins farm, 1,300 feet in depth, salt water encountered; dry well; gas came at 650 feet. Three miles south of Winslow, Pike County, the Southern Oil Company completed not long ago a well on Rev. Woods's farm to a depth of 1,185 feet; sand at 1,160 feet; well shot; initial production of oil 180 barrels in ten days; produces some gas.

In my last report I stated that the gas field in Pike County, around Petersburg, was wholly unproductive. I can add here that all the latest drilling here for gas has resulted in "dry" wells.

On the C. Harding farm, northeast of Decker, in Knox County, a well drilled to 1,660 feet is a failure, salt water encountered; well is dry. One well being drilled west of Decker, on Jordan farm, is 1,440 feet down; a crevice in the rock is encountered; can not be filled. A dry well resulted on the Chas. Griffin lease, the well drilled by the Farmers' Oil Company, completed in October, 1907; depth 1,040 feet, sand at 1,005 feet.

For some time preceding the time of making this report the leasing of lands for gas producing purposes has been carried on, in the counties of Floyd, Scott, Clark, Harrison and Crawford. Before another year, in my opinion, the entire south end of the State will have been tested by seekers for the precious natural fuel.

A test well is being drilled at the present time in Clark County; another in Scott County. The American Car and Foundry Company, of Jeffersonville, has already drilled a well 1,400 feet in depth, and have stopped operations until they can obtain additional gas leases. This company already has leases on 12,000 acres of land in the counties named in the preceding paragraph. Other companies have, in the aggregate, double that number of acres leased.

GENERAL SUMMARY.

There are twenty-six counties in the State of Indiana in which gas is being produced and used, and in a number of these counties natural gas is the common and most generally used fuel for domestic purposes. But in what has been known as the "gas belt," Delaware, Madison, Grant, Blackford, Wells, Jay and Howard counties, many manufacturers have found the gas supply inadequate for their needs as a fuel.

Adams, Wells, Huntington, Wabash, Miami, Howard, Grant, Blackford, Jay, Randolph, Delaware, Madison, Tipton, Hamilton, Henry, Hancock, Shelby, Rush, Decatur, Franklin, Sullivan, Green, Martin, Pike, Gibson and Vigo counties are within the gas producing territory of Indiana, being 26 counties in all.

At the time of making this report there is, speaking approximately, being produced in the State of Indiana, 20,000,000 cubic feet of gas per day. The average price of gas per thousand cubic feet, over the State, is 30 cents. This represents a daily production from the flow of gas of $6,000, or $1,800,000 in one year.

Respectfully submitted,

B. A. KINNEY,
State Natural Gas Inspector.

THE STRATIGRAPHY AND PALEONTOLOGY OF THE CINCINNATI SERIES OF INDIANA.

BY

E. R. CUMINGS.

The Stratigraphy and Paleontology of the Cincinnati Series of Indiana.

BY E. R. CUMINGS.

PART I: GENERAL INTRODUCTION AND STRATIGRAPHY.

The present report is the result of studies begun in the summer of 1900, and continued with some more or less prolonged interruptions up to the present time. Parts of the field seasons of 1900, 1901, 1906 and 1907, have been spent, in conjunction with students of the Department of Geology of the Indiana University, in the study of the sections herein described and in the collection of fossils. The sections have been selected with a view to the elucidation of the differences between the northern and southern portions of the area studied, and with reference to their accessibility and to continuity of exposure. The last has presented more difficulties, perhaps, than any other requirement of the work; since continuous exposure is rare enough in any formation and especially so in a formation which, as is the case with the Cincinnati series, contains much intercalated shale. Nevertheless, as will be seen by a reference to the sections themselves, this requirement has been met with a reasonable degree of success. Wherever possible exposures in the beds of creeks have been sought, since cliff sections or those in railroad cuttings are usually so submerged in talus that it is a very difficult matter to be sure that every specimen is exactly located as to horizon—a requirement that has at all times been adhered to as paramount.

The exigencies of the last requirement will explain to some degree the failure of many rare forms to appear in the lists, and the seeming meagreness of some of the lists of species in parts of the series that in the Cincinnati region, as may be seen from the excellent paper of Nickles, have afforded a very large number. It must be remembered, however, that the forms listed in that paper and the various catalogues that have been published of the fossils of the Cincinnati group, represent the gleanings of the past half century from very numerous exposures, and by many collectors; and also that very many of them are of the rarest sort. No attempt has been made to secure rare forms. The main purpose of the work has been to fix so far as possible the range of the commoner forms, which after all are the only ones that can be of much use in stratigraphic work. I have also tried to collect in such a way as to eliminate the personal equation, in order to arrive at a more satisfactory estimate of the relative abundance of the forms. To this end I have avoided the practice of collecting large numbers of some particular species just because it happens to be abundant or especially well preserved. I have attempted in any given exposure to obtain in their proper numerical ratio every species to be found in the given exposure. One matter must be taken into consideration in the comparison of the faunules of different zones in a given section, namely, that some zones are of necessity much better exposed for collecting than others, and on that account may have a larger showing in the lists, although not really possessing a larger faunule. This is one of the sources of error that only years of careful zonal collecting can remedy; and the present report, it is hoped, will stimulate much further work of this sort in the Ordovician rocks of Indiana..

In many instances the section has been arbitrarily divided into divisions of a few feet in thickness, in order that the analysis of the section, foot by foot, might bring out the true relation of the faunules. This has been carried out in most detail in the upper part of the Tanner's creek section, where a five-foot division (one lap of the Locke level) was used, and in several cases even the top and bottom portions of the division were kept separate. That this is not an unnecessary refinement is shown by the fact that the faunule may change radically within a few inches of rock, in some cases, while in others the change comes on gradually, and is distributed through many feet of rocks.

Not only has the exact level of the fossil been determined with the utmost care, but the location of the section and any given division of the section on the map has been determined with equal care. In order to accomplish this a good large scale map was used and each division of the section accurately located and its number marked on the map. This gives the element of distribution equal precision with that of range. The system of nomenclature used for the numbering of sections and their divisions is a modification of that used by Prof. H. S. Williams, to whom all stratigraphers are deeply indebted in so many ways. According to this system, used at the Indiana University, a number is given to each State, Indiana being No. 1. Each town or locality at which collections are made then receives another number, which is written after the number indicating the State, with the decimal point between. Thus, Tanner's creek, Indiana, is 1.34. Any given section at the locality receives a letter. Thus the upper end of Tanner's creek is section A, and would be written 1.34A. The division of the section is then written after the letter as a number. Thus, 1.34A15, which would then mean Tanner's creek, Indiana, section A, number 15. All this is very compact and may be entered upon each specimen when the latter is finally installed in the museum. These numbers are also very convenient to enter upon the map or in the note-book, and upon library cards, on slides containing thin sections of the fossil, etc. They convey a large amount of information in a very small space.

In the description of the species I have, with very few exceptions, given the original description of the species in the exact words of the author. This has been done because of the great number and variety of the publications in which these descriptions have appeared, and because of the increasingly great difficulty of obtaining many of them. This report is not intended merely for the specialist, but for the amateur and local collector as well. It is intended to show what is known of the Ordovician fossils of Indiana and to serve as a stimulus to further work in the same direction. In every case where the original description of a fossil is inadequate, I have supplemented it with a further description, drawn wherever possible from my own material. I have not, however, used my own material when a better description could be gathered from the literature, and in many of the rarer forms this has been the case. I have made no attempt to revise the species and genera described in this report, except in the case of a few of the Bryozoa and Brachiopoda. Undoubtedly a great deal of revision is needed in some of the groups; but I believe that such revision should await the collection of very much additional material.

The illustrating of this report has given me the greatest trouble. I have not possessed the means to hire the illustrations made, and I have not had the time to draw them myself with pen and ink as I should have liked to have done. The only thing left to me was the method of retouched photographs, reproduced by the half tone process. This has the advantage of faithfulness to the original, but suffers perhaps more than any other method from the carelessness of the engraver and the printer. The making of the illustrations has been an immense labor, even with the potent aid of photography.

By far the most abundant fossils of the Cincinnati group are the Bryozoa. In the majority of exposures one-half or more of all the species collected will be bryozoa, practically all belonging to the one order of Trepostomata (Monticuliporidae of older authors).* The extent to which these fossils have been neglected heretofore by Indiana collectors is shown by the fact that while about 150 species of Bryozoa are listed in the present report, not more than thirty are listed in Kindle's catalog of Indiana fossils (published in 1897). Undoubtedly it has been commonly known to the various Cincinnati collectors who have made a special study of the Bryozoa, that these forms occur in Indiana; but hitherto there has been no published record of the fact. Probably the reason for the neglect of these forms is to be found in the great difficulties in the way of their study, and in the tendency of those who depend on surface characters to throw them into a few well known species. While it is possible for a specialist in the group to make a fairly sure identification on the basis of external characters, even he will make mistakes occasionally, unless assisted by thin sections, showing the internal characters. The preparation of such sections involves a great amount of labor, but it should always be considered as a necessary part of the study of these forms. In the study of the material for the present report, I have prepared over 1,500 slides aggregating over 3,000 thin sections of Bryozoa. The method of preparation of such sections is now pretty well known, and I shall briefly describe it when we come to the consideration of that group of fossils. I only wish at the present time to emphasize the *necessity* of their preparation.

Not only are the Bryozoa very abundant, but they are often most excellent zone markers. Mr. Nickles even goes so far as to subdivide the Eden and Lorraine formations into a series of bryozoan zones. Theoretically this procedure has entire justification; but as a matter of practice in the field in the hands of any but an experienced student of the Bryozoa, it is fraught with grave difficulties, because of the uncertainty of identification of most of these forms by such study as can be given them in the field; and every stratigrapher knows the value of easily recognizable forms in field work. I have therefore, whenever possible, made use of the Brachiopoda as zone markers, and have found that some even of the wide-ranging species may be thus used if due attention is paid to their zonal variations and relative abundance.

*The controversy as to whether these fossils are to be referred to the Bryozoa or to the corals may, I think, be considered as settled in favor of the former.

For such purposes the Brachiopoda are almost ideal. They are usually well preserved and abundant, and are reasonably susceptible to changing conditions of environment, though not as quick in their response to such changes as some other groups. If, however, we learn to appreciate small variations we shall be in a position to make a more extensive, and I believe, a safer use of these forms than has been thought possible by some paleontologists. I have already shown this to be the case in *Platystrophia,* and I shall try to make it as clear in some other genera. Even so long-lived and ubiquitous a form as *Rafinesquina alternata* presents zonal variations that can be utilized for our purposes. Not only can the small variations of species that mark the transition from zone to zone be utilized by the stratigrapher, but the relative abundance of a given form frequently serves the purpose of marking a zone with equal certainty, and is much easier to use. For example, the sudden appearance of *Plectambonites sericeus* in immense numbers in a certain layer of the Richmond formation has furnished a ready and reliable means of tracing the horizon of its occurrence all over the Indiana region. Now *Plectambonites sericeus* is a very long-lived and widely-distributed form, and presents exceedingly little variation throughout its range; nevertheless, for the reason stated, it proves to be a most excellent zone marker. On the other hand, some of the Brachiopoda have a very limited range in the Cincinnati rocks. This is true, for example, of *Dinorthis retrorsa* and *Zygospira headi,* which make their appearance in some abundance at one particular level and are not met with elsewhere. *Hebertella insculpta* is a form of similarly though not so severely restricted range. *Dalmanella meeki* and *Rhynchotrema dentata* mark considerably thicker zones, but nevertheless zones of very homogeneous faunal composition.

Doubtless the Pelecypoda would make very delicate zone markers, but unfortunately they are scarcely ever abundant, and are usually very poorly preserved. Much the same is true also of the Gasteropoda, while the Cephalopoda are in a still worse plight, being usually in such a state of preservation as to make their identification largely a matter of guesswork.

Of other classes, the Crinoidea are almost never represented by anything more than the segments of the stems and an occasional plate of the calyx. Inchoate calices are extremely rare. Corals have a very feeble representation throughout the greater part of the Cincinnati group, although in the Richmond formation a few species are abundant, and two, namely *Columnaria alveolata* and

Tetradium minus are excellent zone markers. The Trilobites, excepting the three species *Calymene callicephala, Isotelus maximus* and *I. gigas,* are rare and poorly preserved, and the species mentioned are such widely ranging forms and present so little variation as to be of little use. The Ostracoda in the hands of a skillful student of the class would undobtedly prove excellent zone markers, since they are nearly always present in numbers and do not range very widely. Their study is, however, a matter of great difficulty and some uncertainty, and they present the same difficulties to the field geologist as the Bryozoa. Such forms as worms and problematica need not be considered in the present connection.

Passing by the question of the usefulness of some particular species as a zone marker, it is important to consider the value of the general or total expression of the faunule.

It is perfectly possible for a given species or for several associated species to recur in several more or less widely separated zones, but it is more than unlikely that an association of many species will ever recur in precisely the same association, that is, with the same species present in the same relative numbers. The *expression* of the faunule is therefore reliable within a given rather limited area; for the faunule may change laterally as well as vertically. This last fact calls for great care in the endeavor to trace zones over considerable areas; and makes it safer in many instances to correlate by means of a particular species or a particular few species than by the faunal expression.

In what has been said so far no mention is made of the use of lithology for purposes of the correlation of more or less widely separated exposures. There is not much to say. The Cincinnati series presents a succession of shales and limestones in which there is not much that is distinctive for the purposes of correlation. Certain major details may indeed be made out, such for example, as that the Eden beds consist mainly of shale with an occasional thin layer of limestone, while the Lorraine consists largely of limestone with intercalated shale. The lower Richmond (Waynesville) formation is more predominantly shale than the middle Richmond. On the other hand the Saluda consists at Richmond almost entirely of limestone, while at Madison it consists of massive calcareous sandstones. To attempt to trace the smaller subdivisions of the Cincinnati series by means of lithology would be futile. On the whole I have considered it best to practically disregard lithology, so far as the correlation of distant exposures is concerned. Within small areas it will be found useful, if used with discretion. In one instance the lithological characters of a stratum have served in tracing it over the greater part of the region. This is the case of the shale bed at the base of the Saluda formation. Even here, however, the evidence of fossils has constantly been appealed to—in this case the presence of the Corals, *Columnaria alveolata* and *Tetradium minus*. Farther east than the Indiana region, this shale bed fails, and the faunal evidence weakens to such an extent that the discrimination of the zone in question has remained up to the present time a matter of doubt.

The area of the outcrop of the Ordovician rocks in Indiana comprises all of the counties of Switzerland, Ohio, and Dearborn, except a very small area in the northwestern corner of Switzerland; and the greater part of the Counties of Wayne, Franklin, Union, and Fayette, together with the eastern half of Ripley and the eastern edge of Jefferson. Besides this area, which constitutes one continuous tract extending from Richmond on the north to Madison on the south, and having its western boundary nearly on a straight line extending from Hagerstown, in Wayne County, to Madison, in Jefferson County; there are several isolated, and very much smaller areas, in the counties of Decatur, Ripley, Jennings and Clark.

The best known localities for the collection of fossils within this area are Richmond, Versailles, Madison and Weisburg. Besides these may be mentioned Lawrenceburg, Vevay, Moores Hill, Osgood, Laurel, Brookville, Liberty and especially the new cuts along the Big Four R. R. between Weisburg and Guilford, where there is now a continuously exposed section from the middle Utica to near the top of the Ordovician. This last series of exposures has been opened up since my collections were made from the Tanner's creek section, and it is a matter of regret that I have not had the time since to work up a new collection of material from this section. I hope at some future time to publish a revised section of Tanner's creek, based on collections from these railroad cuts. I was unfortunately in the East during the time that these cuts were being excavated and thus missed the rare opportunity to collect from the dumps as the material was carried out of the cuts. It is still possible, however, to make very full and detailed zonal collections from this locality.

I cannot conclude this introductory sketch without gratefully acknowledging the assistance that I have from time to time received from my students and others in the preparation of this report. During the first summer of my field work I was accompanied by four students, W. P. Jenkins, A. V. Redmond, John Crowley, and L. M. Moore; and during the second summer by A. V. Mauck, James Frazer, Frank Buser, and W. F. Oesterle. Most of the collecting was done in these two seasons and was very greatly aided by these gentlemen. During the summer of 1906, I was assisted in the field by G. E. Burton and Albert W. Thompson, and during the summer of 1907, by W. M. Tucker. To these men I am under especial obligations. Mr. Tucker has rendered me assistance in the preparation of the maps that accompany this report, without which I could scarcely have brought the report to a conclusion in the time at my disposal. Miss Maude Siebenthal has retouched most of the photographs that illustrate the report, and has in other ways been of great service to me. The following libraries have loaned me literature: State Library of New York, Congressional Library, Library of Chicago University, Crerar Library of Chicago, and the State Library of Indiana. In addition, Professor Charles Schuchert of Yale University loaned me books and pamphlets from his own library and the library of Yale University. Dr. Stuart Weller of Chicago University very kindly sent me several of the types in the James collection of Cincinnati fossils. To my colleague, Dr. Beede, I am also under obligations for much advice and assistance in the work. Finally, I wish to acknowledge most gratefully the kindness of Mr. W. S. Blatchley, the State Geologist, in making possible the publication and proper illustration of this report, and for many courtesies during its progress through the press.

HISTORICAL SKETCH.

The history of the investigation of the rocks of the Cincinnati group during the past three-quarters of a century has been summarized by Nickles in his paper on the Geology of Cincinnati[1] and the history of the various names of the larger subdivisions of these rocks is also given by Prosser in Bulletin No. 7 of the Ohio Geological Survey.[2] It will not be necessary, therefore, to go into the details of this part of the discussion. I shall give very briefly the history of the names, as it is outlined by Nickles, following this with a chart showing these various names and their equivalence.

This series of rocks was first known as the Blue Limestones of the West, or simply the Blue Limestone. D'Orbigny, for example, in his Prodrome lists a number of fossils from the "Blue Lime" of

[1]Jour. Cin. Soc. Nat. Hist., vol. XX, No. 2, 1902, pp. 52–60.

[2]Revised Nomenclature of the Ohio Geological formations. Geological Survey of Ohio, Fourth series, Bull. No. 7, pp. 29–36.

Ohio. These so-called Blue Limestones were at first supposed to be equivalent to the Trenton limestone of New York[3], an error that was not corrected for many years. With the extension of the careful investigations of Hall and others to the western localities, this mistake was gradually rectified. Hall in 1842[4] correlated the limestones exposed at low water in the banks of the Ohio River at Newport, Ky., with the Trenton, a correlation that subsequent studies have shown to be correct. This correlation lead to considering the overlying series of rocks as the equivalent of the Hudson River shales of New York. This latter correlation was definitely made by Hall in 1843[5]. In 1862, however, he abandoned the term, considering these rocks as younger than the New York series of shales known as the Hudson River group; but in 1877[6] he returned to the use of the term for the Ohio formations. In 1865 Meek and Worthen proposed the term "Cincinnati group," to take the place of the at that time discarded term Hudson River group.[7] This term was adopted by the second Geological Survey of Ohio. The term did not, however, find general acceptance, and in 1879 a committee of the Cincinnati Society of Natural History, with Mr. S. A. Miller as chairman, was appointed to consider the question of the names of this series of rocks. This committee reported in favor of the term Hudson River group. Their report will be found published in the Journal of the Society[8]. From this report Mr. U. P. James dissented[9]. The term Cincinnati group still continued to be used by some of the Cincinnati geologists. In 1888 Edward Orton, Sr., State Geologist of Ohio, proposed, on the grounds of the revelations of well records, to discontinue the use of the term Cincinnati group.[10] Walcott also in 1890 favored the use of the term Hudson River group for these rocks.[11] Finally Dr. Ruedemann in 1900[12] showed that the series of shales in the Hudson valley represent beds ranging in age from the basal Trenton upward; and the name Hudson River Group was quietly dropped from geological nomenclature. By default of this older name, therefore, the very appropriate name of Cincinnati group or Cincinnati series became established.

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[3]Vanuxem, Amer. Jour. Sci., vol. XVI, 1829, p. 256.
[4]Hall, Amer. Jour. Sci., vol. XLII, 1842, p. 61.
[5]Hall, Trans. Amer. Assoc. Geol and Nat., 1843, pp. 267–293.
[6]Hall, Proc. Amer. Assoc. Adv. Sci., 1877, vol. XXVI, pp. 259–265.
[7]Meek and Worthen, Proc. Acad. Nat. Sci., Philadelphia, 1865, p. 55.
[8]Jour. Cin. Soc. Nat. Hist., I, 1879, pp. 193–4.
[9]The Paleontologist, No. 4, 1879, pp. 27–28.
[10]Orton, Geol. Surv. Ohio, VI, 1888, p. 9.
[11]Bull. Geol. Soc. Amer., I, 1890, pp. 335–356.
[12]Ruedemann, Bull. New York State Museum, VIII, No. 42, 1900, pp. 564–568.

Subdivisions. In 1873 Dr. Edward Orton[4], of the Ohio Survey, subdivided the Cincinnati series into the Point Pleasant beds, exposed in the north bank of the Ohio River about twenty-five miles east of Cincinnati; the Cincinnati beds extending from the low water mark at Cincinnati to the tops of the hills at that city; and the Lebanon beds extending from the top of this division to the top of the Ordovician system. The Cincinnati beds proper, he subdivided into the River Quarry beds, 50 ft. thick, the Eden shales, 250 ft. thick, and the Hill Quarry beds, 150 ft. thick. The Point Pleasant beds belong to the Trenton series, and the balance to the Cincinnati series as now understood.

As far back as 1842, Hall had recognized the Utica shales in the Cincinnati section[5]. The rocks to which he applied the name were in part the same as the Eden shales of Orton. These rocks were also considered as equivalent to the Utica of New York by the committee of the Cincinnati Society of Natural History, alluded to above. In 1888 Mr. Ulrich correlated the beds No. XIb of his paper on the Correlation of the Lower Silurian Horizons with the black shales of the Findlay wells, which Orton correlated with the Utica shales. These beds XIb of Ulrich are the same, practically, as the Eden shales of Orton, and have, according to Ulrich, a thickness of 225 feet[6]. In volume VI of the Ohio Geological Survey, Orton is disposed to doubt the presence of the Utica in the Cincinnati section. In the Geology of Minnesota (1897) Winchell and Ulrich definitely correlate the Eden shales with the Utica shales of the eastern province[7].

In 1902 Nickles published a paper on the Geology of Cincinnati in which the term Utica is again used for these shales, and they are subdivided into three divisions, the lower, middle and upper, characterized by Bryozoa[8]. These bryozoan zones are in ascending order the *Aspidopora newberryi* beds, 80 ft. thick; the *Batostoma jamesi* beds, 120 ft. thick; and the *Dekayella ulrichi* beds, 60 ft. thick. This same subdivision of the Utica into lower, middle and upper is repeated by Nickles in Bulletin No. 5 of the Kentucky Geological Survey (1905). In this publication, however, he uses the term Eden shale in preference to Utica, and says in regard to this usage, "as the sediments [of the New York and Ohio valley

[4]Orton, Geol. Surv. Ohio, vol. I, 1873, pp. 365–449.
[5]Amer. Jour Sci. XLII, 1842, p. 61.
[6]Ulrich, Amer. Geologist, I, 1888, pp. 183–190, and p. 312.
[7]Winchell and Ulrich, Geol. and Nat. Hist. Surv. Minn., vol. III, pt. II, pp. ci–cii. and chart, p. lxxxix.
[8]Nickles, Jour. Cin. Soc. Nat. Hist., XX, No. 2, 1902, pp. 66–74.

regions] were deposited in different basins and under very different conditions, and as the faunas have scarcely anything in common, it seems better that they should bear different names; hence Orton's name Eden is revived for the formation developed in the Ohio valley." This proposed revival of the name Eden is, however, due to Foerste, who, in August, 1905, published the following opinion in Science: "The name *Eden,* well defined by Orton in the first volume of the 'Geology of Ohio' published in 1873, is revived for the strata which in the 'Geology of Cincinnati' [Nickles] are identified as Utica."[9]

Finally, in a paper on the James types of Lower Silurian Bryozoa, by Mr. Bassler (1906), is given a classification of the Cincinnati series[1], in which the term Eden is used for the greater part of these shales, with the older term Utica standing for the lower 5 ft., immediately overlying the Point Pleasant beds. To this lower 5 ft. the name Fulton is applied. In this classification the three subdivisions of the Eden shales receive the names Economy, Southgate and McMicken, in the ascending order.

To the limestone beds overlying the Eden shales, Orton, as we have seen, gave the name Hill Quarry beds, with a thickness of about 150 ft. The top of this division was marked by the "lynx beds," seen on the highest hills in the city of Cincinnati. In 1842, Emmons had applied the name Lorraine to the series of arenaceous shales exposed about Lorraine in Jefferson County, New York, and overlying the Utica shales[2]. In the chapter on the correlation of the rocks of the Cincinnati group, in their report on the Paleontology of Minnesota, Winchell and Ulrich proposed to apply this name (Lorraine) to the Hill Quarry beds of Orton[3]. Since that time the term has been more or less commonly employed. In his paper on the Geology of Cincinnati (*ante*), Nickles uses the term Lorraine group for these beds and subdivides the group into six divisions, as follows, in the ascending order: (1) Mt. Hope, or *Amplexopora septosa* beds, 50 ft.; (2) Fairmount, or *Dekayia aspera* beds, 80 ft.; (3) Bellevue, or *Monticulipora molesta* beds, 20 ft.; (4) Corryville, or *Chiloporella flabellata* beds, 60 ft.; (5) Mt. Auburn, or *Platystrophia lynx* beds, 20 ft.; (6) Warren, or *Homotrypa bassleri* beds, 80 ft. (*loc. cit.*, p. 75). This subdivision of the Lorraine was adopted by Bassler in 1903, in his paper on the Genus

[9]Foerste, Science, N. S., XXII, Aug. 4, 1905, p. 150.

[1]Bassler, Proc. U. S. National Museum, XXX, No. 1442, p. 8. This classification it is stated is in course of publication by Ulrich.

[2]Emmons, Nat. Hist. of New York, pt. II, geology of the Second District, 1842, p. 119.

[3]Winchell and Ulrich, Geol. and Nat. Hist. Surv. Minn., vol. III, pt. II, 1897, p. cii.

Homotrypa[4]. Here, also, Bassler accepts the names Utica and Lorraine. In 1905, however, Foerste[5] proposed to discard the name Lorraine and suggested the name Maysville from Maysville, Kentucky, for this division. This latter name was adopted by Nickles in his paper on the Upper Ordovician Rocks of Kentucky[6]. In Prosser's paper on the Revised nomenclature of the Ohio formations the name Lorraine is used[7]. It must be stated, however, that Prosser's manuscript was in the hands of the printer before this later suggestion of Foerste was published. Finally in the paper by Bassler on the James Types (*ante*), in the classification proposed by Ulrich, neither of the names Lorraine or Maysville are used, but the Utica, Eden and Lorraine (of other authors) are placed in a new division of larger rank, the Covington group, named from Covington, Kentucky (*loc. cit.*, pp. 8-10). In this classification the Mt. Hope and Fairmount divisions of Nickles are bracketed together as the Fairview division, and the Bellevue, Corryville, and Mt. Auburn divisions of Nickles are bracketed together as the McMillan division. These two together, therefore, constitute what has heretofore been known as the Lorraine division of the Cincinnati group. Thus out of this kaleidoscopic shifting about of names emerges a practically new set of names for this group of rocks.

For the upper division of the Cincinnati series Dr. Orton proposed the name Lebanon beds, with a thickness of nearly 300 ft. (*ante*). This division is now universally known as the Richmond formation, a name proposed by Winchell and Ulrich in the Geology of Minnesota[8]. The reason for the substitution of this name for the older name of Orton was the fact that the name Lebanon had previously been used by Safford for a member of the Trenton formation of Tennessee. In Nickles paper (*ante*), the Richmond is divided into the lower, middle and upper Richmond beds (*loc. cit.*, pp. 88-95). Judging from the fauna given, the upper Richmond of Nickles is the same as the Madison beds of Foerste (Saluda), which he named in 1896[9], and to which he has devoted a very considerable amount of study. In proposing this name, Foerste says: "In some regions these richly fossiliferous limestones and clay beds [of the upper part of the Cincinnati series] terminate quite abruptly 40 to 60 feet beneath the Clinton, and are overlaid by a very argil-

4Bassler, Proceedings of the U. S. National Museum, XXVI, 1903, p. 567, foot note.

5Foerste, Science N. S., vol. XXII, 1905, pp. 149–152.

6Nickles, Bull. No. 5, Kentucky Geological Survey, 1905, p. 17, and table, p. 15

7Prosser, Geological Survey of Ohio, Fourth Series, Bull. No. 7, p. 3. But see remarks, p. 34.

8Winchell and Ulrich, Geol. Nat. Hist. Surv. Minn., vol. III, pt. II, p. ciii.

9Foerste, Indiana Dept. Geol. Nat. Resources, 21st annual Rept., 1896, p. 220.

laceous rock, or very impure limestone, which is described in the next section under the name of the Madison bed." In the discussion that follows Foerste says: "In the vicinity of Madison, the top of the Lower Silurian is formed by a considerable thickness of argillaceous limestones, weathering on long exposure from light brown, more or less banded with darker brown, to even purplish tinted layers. . . . . The fossils in these argillaceous limestones are confined to a few layers, and by far the greater part of the layers are without fossil remains. Beneath the banded limestones occur eight feet of the *Favistella* bed, which, near Madison seems to form a well marked horizon." These banded limestones form many picturesque waterfalls in the vicinity of Madison and Hanover. The *Favistella stellata* is the *Columnaria alveolata* of the present report. The typical Madison bed, he further states, is commonly overlaid by limestone or shaly limestone containing fossils, among which are chiefly *Lophospira hammelli, Holopea hubbardi,* and *Leperditia caecigena. Labechia* and *Tetradium minus* also occur in these upper limestones. Speaking of the northern continuation of the Madison beds, Foerste says: "North and northwest of the typical Madison bed, the top of the Lower Silurian rapidly changes in character. It is replaced by a series of blue, often rather dark blue, very fine grained limestones. . . . . Lithologically, this rock is similar to the dark blue, fine grained layer forming part of the *Murchisonia hammeli* layer in more southern areas. . . . . The fine grained, dark blue limestone, taking the place of the Madison beds, is interbedded with ordinary limestones, and with clays containing ordinary limestone fossils. Sections of this type begin to be exposed in northern Jefferson County, and are typically developed at Versailles, along the whole length of Big Graham Creek, and for some distance northwards. The correspondence of this section is very well seen in the exposure immediately north of Versailles, where 29 feet of this limestone, with its intercalated beds of clay and shale, are underlaid by 11 feet of unfossiliferous brownish and bluish shales, corresponding to the shales at the base of the Madison beds near Madison. Below the shales are 12 feet of limestone and shale, containing *Tetradium minor* at many levels, and *Favistella stellata* at the very base. This is the characteristic horizon for *Favistella* in southern Indiana. . . . . From the Baltimore & Ohio Southwestern Railroad northwards, all comparison with the Madison beds is lost. The upper strata consist commonly of thin or shaly limestones, interbedded with clays, both usually abundantly fossiliferous. No demarkation can be made between these upper strata and the lower horizons of the Lower Silurian, corresponding to the separation of the Madison from the richly fossiliferous shales in southern Jefferson and Clark counties. This means that the Madison beds are replaced northwestward by limestones. . . . ."

For a complete discussion of the literature of the Madison (Saluda) beds, the reader is referred to the paper by Dr. Foerste in the 24th annual report of the Indiana Geological Survey, pp. 45-68. In this place I merely desire to indicate the general conception of the Madison beds as set forth by the author of the name in his original paper.

Finding that the name Madison beds was preoccupied, Foerste, in 1902, proposed to substitute the name Saluda for these beds, from Saluda Creek, six miles south of Hanover, Indiana. This latter name is therefore used in the present report.

For the balance of the Richmond group—the lower and middle Richmond of Nickles—the name Waynesville[1], has been proposed for the lower division (for the most part); Liberty beds for the next higher division (Nickles, *loc. cit.*, pp. 207-208); and Whitewater division for the beds next above the Liberty (Nickles, *loc. cit.*, pp. 208-209). These beds are followed by the Saluda of Foerste. Foerste, in 1905, recognizing the fact that the Whitewater division of the Richmond section cannot be differentiated in the more southerly sections, proposed the name Versailles for the two divisions, Liberty and Whitewater[2]. For the Warren division, referred to the Lorraine by Nickles in his paper on the Geology of Cincinnati, but considered by Bassler, apparently following an unpublished view of Ulrich, as referable to the Richmond, rather than to the Lorraine, Foerste also proposed the name Arnheim (from the small town of that name near Georgetown, Ohio), because of the preoccupation of the name Warren. (Foerste, *loc. cit.*, p. 150.) Of these names, Liberty is from Liberty, the county seat of Union County, Indiana; and Waynesville, from the town of Waynesville, in Ohio; while Whitewater is from the Whitewater River at Richmond, Indiana, along which through the city of Richmond these beds are well exposed.

[1]Nickles, Amer. Geologist, XXXII, 1903, pp. 205–206.
[2]Foerste, Science, N. S. vol. XXII, 1905, p. 150.

TABULATION OF THE VARIOUS CLASSIFICATIONS OF THE CINCINNATI GROUP.

Early authors.	Orton, Ohio Survey, 1873.	Winchell and Ulrich, 1897.	Nickles, 1902.	Nickles and Foerste, 1905.	Ulrich, 1906. (Bassler.)	Present report.	
Blue Limestone of Ohio, Indiana, and Kentucky. Hudson River group of many. Cincinnati group of some authors.	Lebanon	Richmond	Richmond. Upper	Richmond. Saluda	Richmond group. Saluda	Richmond. Elkhorn	Platystrophia moritura zone.
						Whitewater	Rhynchotrema dentata zone.
			Middle	Whitewater	Whitewater	Saluda	Tetradium minus zone
				Liberty	Liberty	Liberty	Strophomena planumbona zone.
			Lower	Waynesville	Waynesville	Waynesville	Dalmanella meeki zone.
			Lorraine. Warren	Maysville. Arnheim	Arnheim	Arnheim	Homotrypa bassleri zone of Nickles (Rafinesquina alternata zone.)
	Hill Quarry (in part)	Lorraine	Mt. Auburn	Mt. Auburn			Callopora rugosa zone. (Rafinesquina alternata zone.)
			Corryville	Corryville	Covington group. McMillan	Maysville or Lorraine. Upper	
			Bellevue	Bellevue		Middle	
			Fairmount	Fairmount			
			Mt. Hope	Mt. Hope	Fairview	Lower	Platystrophia zone.
					McMicken	Eden of Utica. McMicken (upper)	Dekayia ulrichi zone. (Dalmanella multisecta zone.)
	Eden (in part)	Utica	Utica. Upper	Eden. Upper	Southgate	Southgate (middle)	
			Middle	Middle	Economy		
			Lower	Lower	Fulton	Economy (lower).	Callopora onealli zone. (Dalmanella multisecta zone.)

EXPLANATION OF SECTIONS.

The detailed sections are given in the following pages without extensive comment, which is reserved till all the sections have been presented seriatim, in order that the whole subject of stratigraphy may be discussed in one place. While many sections have been measured besides those given in the succeeding pages, many of these have not yet been carefully collected from, or present nothing in addition to the points elucidated by the sections that have been included. Some of the sections, especially those near the top of the Richmond formation, along the line of contact of the Ordovician and Silurian, have not been carefully collected from as yet, and nevertheless are included because they bear upon the question of the horizon, thickness and distribution of the Saluda formation. The fauna of this formation is not extensive, but is nevertheless of very great interest, and I hope in a future paper to take it up in detail. The species listed from some of the sections of this formation were identified in the field (with the exception of the Bryozoa). In general this practice has not been followed, but the material has been removed to the laboratory and carefully studied there. All of the locality numbers will be found carefully marked in on the accompanying map.

It is necessary to explain that in a few cases the section numbers in the sections that follow do not correspond to those given in the body of the text where the localities are given after each species. This occurs in the case of section A at Richmond, Indiana (1.41A). The reason for this is that the section was measured at two different times, and that at the second measurement a somewhat different plan was adopted. All the collections are labeled, however, according to the numbers first adopted, and hence it became necessary to follow these original numbers in giving the localities after the description of each species. The numbers of section 1.41A, given on the chart, are those of the newer section. The equivalence of the old and new numbers will be found stated in the description of each section where such difference in numbering occurs. In the case of the *general* section along the Whitewater River at Richmond, numbers are used that do not correspond to those of the several sections (B, D, E), from which collections were made. The *general section* is a combination of these and bears its own numbers. In the case of the detailed section at Vevay (1.38A) the numbers are the original numbers, with the exception that I have added numbers 84 to 88 to include the portion of the section designated

Ba-h in my paper on the Vevay section. This includes most of the *Platystrophia* zone. Species given as coming from 1.38P were found loose in association with *Platystrophia lynx* at Vevay. The *general* section at Madison, Indiana, also has its own numbers, which do not correspond to those of sections A, D and E, of which it is made up.

No description of the Tanner's Creek section is given. The chart and profile are considered as quite sufficient. The thickness of the various divisions can be obtained from the chart, and the elevation of any collecting station above datum can be obtained from the profile.

Some slight explanation of the chart is perhaps needed. The species, as will be noted, are given in alphabetical order at the left. The occurrence of any given species is indicated by a straight line drawn on the chart, the weight of the line indicating the relative abundance of the species. In cases where the species is very abundant or dominant in the fauna the space is filled in solid black. At the top of the chart the localities are indicated, and by brackets are grouped into their respective sections. Along the top margin is also given a scale of feet, each space, reading across the chart, equalling five feet. The datum taken is the low water level of the Ohio River at Lawrenceburg, Indiana. In this section dip is disregarded. This does not introduce any considerable error, since the dip in the direction of the section is slight.[1] The highest exposure in the Tanner's Creek section is the Saluda division. For the remainder of the Richmond series that portion of the Richmond section coming above the Saluda, namely the Whitewater and Elkhorn divisions, is taken and added on to the Tanner's Creek section. The whole, therefore, becomes a general section of the Cincinnati series of Indiana.

LIST OF SECTIONS.

The starred sections are described in detail in this report.

5.9A*—Section opposite the mouth of the Miami river, in the Kentucky bank of the Ohio river, extending from the level of the river to the top of the hill. Eden and Lorraine.

[1]Allowance for the dip should be made, however, for section 5.9A, which is nearly six miles removed from the balance of the section. The base of section 1.34C is in reality probably not far from 60 ft., stratigraphically, above the top of section 5.9A. This makes the Eden shales about 220 ft. thick in this section, instead of 160 as the chart would seem to indicate. This discrepancy was realized too late to re-draw the chart. In the balance of the section the direction changes from nearly west to northwest, or from that of the main dip toward that of the strike; and the dip no longer introduces any serious error.

1.33A*—Section at the road metal quarry on the hill just west of Lawrenceburg, Indiana. Middle Lorraine.

1.34C*—Section along Tanner's creek from the level of the creek at Guilford to the top of the hill just east of Manchester Station, Indiana. Eden and Lorraine.

1.34B*—Section along Tanner's creek from Manchester Station to the first railroad bridge west of Harmon's station, Indiana. Upper Lorraine and Arnheim.

1.34A*—Section from the level of Tanner's creek at the second railroad bridge west of Harmon's station to the top of the first railroad cut north of Weisburg. Richmond.

1.35A—Section of the high hill in the south edge of Aurora, Indiana. Same beds as 1.33A3.

1.35B—Section along Whitaker's branch from Dillsboro station to Moore's Hill, Indiana. Shows all of Lorraine and Richmond to near base of Saluda.

1.36—Laughery creek, Indiana.

1.36B—Section of the north bluff of Laughery creek, one mile west of Milton, Indiana. Upper Utica.

1.36C—Section of the north bluff of Laughery creek, two miles southwest of Milton, Indiana. Upper Utica.

1.37A to H—All within a radial distance of four miles from Rising Sun, Indiana. Utica and Lorraine.

1.38A*—Section of the hill back of Vevay, Indiana, beginning at the head of Main Cross street. Utica and Lorraine.

1.38B*—Section along the old road (now closed) over the hill just back of Vevay. Same as 1.38A.

1.38C, D, E—Along Indian creek below Bennington, Indiana. Lorraine and Lower Richmond.

1.38F—On the east-and-west road one mile northwest of Bennington, Indiana. Liberty beds.

1.12A*—Section in the gulley just north of the north end of the south cut at Madison.

1.12B—Section along Clifty creek two miles west of Madison, Indiana. Top of Lorraine to top of Richmond.

1.12C—Section of Clifty Fall, Indiana. Saluda and Niagara.

1.12D*—Section of the North cut (Big cut) at Madison, Indiana. Liberty to Niagara.

1.12E*—Section of the south cut, Madison, Indiana. Arnheim and Waynesville.

1.12F*—Section in the north side of the highway a short distance below the Hanging Rock, Madison, Indiana. Liberty.

1.12G*—Section at the falls on Razor creek, one and one-half miles west of China, Jefferson County, Indiana. Saluda.

1.12H*—Section at the falls on Crooked creek, three miles north of Madison, Indiana. Saluda.

1.58A—Section on Indian Kentuck creek, half way between Canaan and Barberville, Indiana.

1.58B*—Section in the north edge of the village of Canaan, Jefferson County, Indiana. Saluda.

1.58C—One mile southwest of Canaan. Saluda.
1.59A—On Raccoon creek, one-half mile southeast of Olean, Ripley County.
1.59B—One-half mile southwest of Cross Plains, Jefferson County.
1.59C—One-half mile west of Cross Plains. Saluda.
1.59D*—One and one-half miles due west of Cross Plains. Saluda.
1.59E—Two miles due west of Cross Plains. Saluda.
1.59F—Three and one-half miles due west of Cross Plains. Saluda.
1.59G—Two miles north of Barbersville, Jefferson County. Saluda.
1.59H*—One mile north of Barbersville. Saluda.
1.60C—Headwaters of Big Graham creek southwest of Versailles, Indiana. Saluda.
1.60D—Two gulleys coming into Laughery creek from the west, one and one-half miles southeast of Versailles. Saluda.
1.60E—East bluff of Laughery creek, two miles southeast of Versailles. Saluda.
1.60F*—Cooper's falls, four miles south of Versailles. Saluda.
1.60G*—North fork of Cedar creek, north of Versailles. Waynesville.
1.60H*—West fork of Cedar creek from the base of the "Eighty-foot" cliff to the crossing of the Osgood and Versailles pike. Liberty to Whitewater.
1.60I*—Wash bank sixty feet high at the junction of the North and West forks of Cedar creek. Waynesville and base of Liberty.
1.61A*—On a small tributary of Laughery creek, one and one-half miles northeast of Osgood, Ripley County, Indiana. Saluda.
1.61B*—One and three-quarters miles northeast of Osgood. Saluda.
1.61C*—Two miles north of Osgood. Saluda.
1.61D and E—Three and one-half miles northeast of Osgood, on a small western tributary of Laughery creek. Saluda.
1.61F—Four miles north of Osgood. Clinton and Niagara.
1.61G—Three and one-half miles north of Osgood. Ordovician, Clinton contact.
1.62A to F*—Along the west branch of Laughery creek, four miles southwest of Batesville, Ripley County, Indiana. Saluda.
1.63A—Section on Harper's branch, three-quarters of a mile north of Oldenburg, Franklin County, Indiana. Liberty beds.
1.63B-D—Headwaters of a small southern tributary of Big Salt creek, one mile northwest of Oldenburg. Saluda.
1.63E*—On Big Salt creek, exactly four miles west of Oldenburg. Liberty and Saluda.
1.64A and B*—On a north tributary of Big Salt creek, two miles west of Hamburg, Franklin County, Indiana. Saluda.
1.64C—On Bull Fork, two miles northwest of Hamburg. Saluda.
1.64D*—On western tributary of Big Salt creek, three miles north of Hamburg. Saluda.
1.14A1—East end of the "Mound," three-quarters of a mile south of Laurel, Franklin County, Indiana. Top of Waynesville.
1.14A2—Railroad cut just across the river from Laurel. Base of Liberty beds.
1.14B—Big Sains creek from the junction with Little Sains creek (near Laurel) to 1.14G. Liberty beds.

1.14C, D—Three and a half miles southwest of Laurel. Liberty.

1.14F*, G*—On Big Sains creek, two miles northwest of Laurel. Saluda and Whitewater.

1.65A*—Headwaters of Duck creek, three miles northeast of Laurel. Saluda, Whitewater, Liberty.

1.66A*—On a small eastern tributary of the east fork of Whitewater river, two and a half miles southeast of Quakertown, Union County, Indiana. Liberty and Saluda.

1.67A*—At the quarry and along the small stream near the quarry, one mile west of the center of Liberty, Union County, Indiana. Liberty and Saluda.

1.41A*—Section along Elkhorn creek from the crossing of the Liberty pike to the falls, at the Boston pike. Base of Liberty to Clinton.

1.41B*—Small eastern tributary of Whitewater river, one and one-half miles south of Abington, Wayne County, Indiana. Base of Liberty.

1.41C*—Small western tributary of Whitewater river, four miles southwest of the Main street bridge at Richmond, Wayne County, Indiana. Base of Liberty.

1.41D*—At the quarries just south of the steel bridge, one and a half miles south of the Main street bridge at Richmond, and along the river to Main street. Liberty and Whitewater.

1.41E*—Along the West fork, Richmond, from its junction with East fork, to Thistlewaite Falls. Whitewater.

SECTIONS IN DETAIL.

Section in Kentucky opposite the mouth of the Miami River (5.9A).

	Ft.	In.
51—Covered to top of hill	112	..
50—Fragments of Strophomenoid shells	..	7
49—Shale	1	..
48—Limestone. Fragments of Brachiopods	..	6
47—Shale	1	..
46—Hard limestone with *Rafinesquina alternata*	..	5
45—Shale	2	4
44—Limestone. *Rafinesquina* abundant	..	5
43—Covered, probably shale	17	6
42—Shale	2	6
41—Limestone	5	2
40—Shale with thin layers of sandstone	8	6
39—Limestone with Bryozoa and *Rafinesquina alternata*	..	3
38—Mostly shale	10	8
37—Crystalline limestone. *Rafinesquina* and *Dalmanella multisecta*	9	..
36—Shale	2	3
35—Thin layers of bryozoal limestone	1	..
34—Shale	6	9
33—Bryozoal limestone	..	6
32—Shale	7	..

	Ft.	In.
31—Limestone, shale at top. *Dalmanella* (aa)	..	7
30—Covered	42	..
29—Compact highly crystalline limestone; few fossils	..	3
28—Shale	2	9
27—Highly crystalline limestone containing fragments of *Asaphus*	..	7
26—Shale	..	5
25—Compact limestone containing *Dalmanella multisecta*	..	5
24—Covered, probably some limestone	16	..
23—Brachiopod limestone (?)	..	4
22—Covered	8	4
21—Limestone. *Rafinesquina alternata* and Trilobites	..	3
20—Shale	6	4
19—Covered (probably shale)	16	..
18—Limestone (in place?)	..	6
17—Shale	10	8
16—Limestone. Bryozoa, *Plectambonites sericeus*	..	3
15—Shale	1	..
14—Limestone. *Dalmanella, Plectambonites sericeus*	..	2
13—Shale	..	7
12—Sandstone	..	3
11—Shale	2	9
10—Limestone with *Dalmanella*	..	3
9—Shale, possibly some sandy layers	5	..
8—Hard compact limestone, very few fossils	..	5
7—Shale	6	..
6—Layer of crystalline, crinoidal limestone	..	..
5—Partly covered, mostly shale	33	..
4—Sandy layer with *Trinucleus concentricus*	..	1
3—Shale	5	4
2—Limestone containing *Dalmanella multisecta* (aa*)	2	3
1—Shale to level of Ohio river	6	2
Total section	361	..

Section of the hill on the Kentucky shore opposite the mouth of the Miami River. 5.9B. (Near 5.9A.)

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
321	..	68	80	..	Nearly all covered to the top of the hill.
241	..	67	20	..	Partly covered, mostly limestone. *Platystrophia laticosta*, Bryozoa (aa).
221	..	66	0	6	Layer of limestone with *Callopora dalei* (aaa), *Zygospira cincinnatiensis*, etc.
220	7	65	15	..	Limestone and shale. *Callopora dalei* (aaa).
205	7	64	0	7	Hard fossiliferous limestone. Below this is a layer with *Callopora dalei* (aaa).

*a, abundant; aa, very abundant; c, common; r, rare.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
205	..	63	10	..	Shale and limestone. Limestone layers not so frequent as in the division below.
195	..	62	10	..	Limestone with shale partings. *Dalmanella multisecta* (aaa), *Dekayia ulrichi* (aa) in some layers.
185	..	61	10+	..	Covered.
175	..	60	6	..	About six feet shale.
169	..	59	30	..	Covered. Loose blocks evidently not far out of place contain *Dalmanella multisecta* (aa).
138	9	58	0	2	Thin layer of limestone. *Dekayia ulrichi* (aaa).
138	7	57	5	..	About five feet limestone.
133	7	56	0	2	Thin layer of limestone. *Dalmanella multisecta* (aaa), *Dekayia ulrichi* (aa).
133	5	55	7	..	Shale.
126	5	54	..	..	Thin lense of limestone with *Dekayia ulrichi*, *Peronopora vera*, and *Trinucleus concentricus*.
126	5	53	3	..	Shale.
123	5	52	0	5	Layer of limestone. Bryozoa (aaa).
123	..	51	4	..	Shale.
119	..	50	..	..	Layer of limestone.
119	..	49	10	..	Covered. Loose blocks of limestone.
109	..	48	6	..	Shale.
103	..	47	0	3	Crinoidal limestone.
102	10	46	4	..	Shale.
98	10	45	0	3	Thin layer of limestone. *Dekayia ulrichi* (aaa).
98	7	44	1	..	Shale.
97	7	43	0	3	Limestone. Small Bryozoa (aaa).
97	4	42	2	6	Shale.
94	10	41	0	4	Very fossiliferous limestone. *Bythopora arctipora*, *Callopora onealli*, *Dalmanella multisecta*, etc.
94	6	40	2	4	Shale.
92	2	39	0	1	Very thin layer of sandstone.
92	1	38	4	..	Shale.
88	1	37	0	1	Very thin layer of sandstone.
88	..	36	5	..	Shale.
83	..	35	0	4	Fossiliferous limestone. *Dalmanella multisecta*.
82	7	34	15	..	Shale slighty obscured by fallen blocks of limestone.
67	7	33	1	..	Limestone with shale partings.
66	7	32	0	10	Shale.
65	9	31	0	2	Limestone layer. *Dalmanella multisecta* (aa).
65	7	30	1	7	Shale.
64	..	29	0	3	Very fossiliferous limestone. *Callopora onealli*, *Dekayia ulrichi*, *Batostoma* sp., *Dalmanella multisecta*.
63	10	28	1	..	Shale.
62	10	27	0	2	Limestone.
62	8	26	0	6	Shale.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
62	2	25	0	4	Sandstone layer.
61	10	24	1	3	Shale.
60	7	23	1	2	Sandy layer.
59	5	22	0	3	Shale.
59	2	21	0	2	Layer of sandstone.
59	..	20	0	10	Shale.
58	3	19	0	3	Very fossiliferous limestone. *Dalmanella multisecta* (aaa), *Plectambonites sericeus* (c), *Calymene callicephala*, annelid jaws and crinoid segments, both abundant.
58	..	18	1	5	Shale.
56	7	17	0	2	Blue, hard, crystalline, fine-grained limestone.
56	5	16	4	..	Shale.
52	5	15	0	5+	Crystalline barren limestone.
52	..	14	3	5	Shale with two thin sandstone layers.
48	9	13	0	1	Thin layer of sandstone.
48	8	12	2	..	Soft shale.
46	8	11	0	1	Thin laminated sandstone layer.
46	7	10	5	..	Shale.
41	7	9	11	..	Partly covered. Small exposures of blue shale.
30	7	8	0	2	Thin layer of limestone.
30	5	7	5	..	Shale.
25	4	6	0	1	Crinoidal limestone.
21	4	5	4	..	Shale.
21	2	4	0	2	Layer of sandstone.
1	2	3	20	..	Shale with occasional thin layers of soft sandstone.
1	2	2	0	2	Layer of coarse grained limestone with *Trinucleus concentricus*, *Bythopora arctipora*, and *Dalmanella multisecta*.
1	..	1	1	..	Shale to the level of the Ohio river.

Section of the High Hill just west of Lawrenceburg, Indiana. 1.33A.

390	..	5	90	..	Covered to the top of the hill at the Bockhorst house.
300	..	4	32	..	Upper heavy projecting layers in the road metal quarry. *Platystrophia laticosta*, *P. lynx*, *Hebertella sinuata*, *Callopora ramosa*, *Callopora rugosa*, *Bythopora gracilis*. Same zone as 1.34C 14b.
268	..	3	13	..	Exposed between the talus and the base of the heavy layers. More shaly. Fauna same as above.
255	..	2	40	..	Covered by the talus from the cliff above. Fossils from the upper layers are very abundant in the talus.
215	..	1	215	..	Nearly all covered to the level of the Tanner's creek at the bridge across the Lawrenceburg and Aurora pike.

The exposed portion of this section is all higher than any of the exposed portion of the section opposite the mouth of the Miami River. The two sections together show nearly 100 feet of the Lorraine. The level of the creek at the base of this section is approximately the level of the Ohio River. Fossils listed 1.33A3 are from Nos. 3 and 4 of this section.

The fauna of 1.33A3 is as follows: *Callopora ramosa, C. rugosa, C. dalei* (?), *C. andrewsi, Bythopora gracilis, Dekayia frondosa, D. inflecta, D. magna, Homotrypa curvata, H. obliqua, Peronopora pavonia, Monticulipora molesta, Atactoporella mundula, A. ortoni, Petigopora gregaria, P. petechialis, Arthropora Schafferi, Escharopora sp., Aspidopora sp., Ceramoporella ohioensis, Stomatopora inflata, Proboscina frondosa, P. auloporoides, Rafinesquina alternata, R. fracta, R. ponderosa, R. nasuta, Platystrophia laticosta, P. lynx, Hebertella sinuata, Zygospira modesta, Allonychia jamesi, Cyclonema sp., Orthoceras sp.,* and several unidentifiable species of gastropods and crinoids.

Detailed Section of the Hill Back of Vevay, Indiana, Beginning at the Head of Main Cross Street, and Extending up the Gulley to Near the Top of the Hill. Nos. 86 to 88 are Along the Old Road Over the Top of the Hill.
1.38 A and B.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
390	..	88	27	..	Heavy, compact limestone. Few fossils.
363	..	87	49	..	Thin, shaly limestone. *Platystrophia lynx, P. laticosta, Hebertella sinuata, Callopora ramosa, Callopora rugosa, Monticulipora mammulata.*
313	..	86	9	..	Shaly limestone same as that above. *Hebertella sinuata, Platystrophia laticosta.*
303	10	85	0	4	Yellowish argillaceous sandstone.
303	6	84	12	..	Thin bedded limestone, containing *Platystrophia laticosta, Hebertella sinuata, Plectorthis plicatella, Escharpora falciformis, Constellaria constellata.*
291	6	83	0	6	Thicker layer of limestone. *Platystrophia laticosta, Constellaria constellata.*
291	..	82	0	4	Yellow sandy layer.
290	7	81	3	3	Covered.
287	4	80	0	4	Argillaceous-arenaceous limestone.
287	..	79	14	..	Some covered. Mostly thin layers of limestone.
273	..	78	0	5	Limestone. *Rafinesquina alternata* and *Bryozoa.*
272	6	77	3	8	Covered.
268	10	76	0	4	Compact limestone.

Total Thickness Ft.	In.	No.	Thickness of Bed. Ft.	In.	
268	6	75	0	6	Covered.
268	..	74	3	8	Coarse grained limestone.
264	3	73	1	3	Limestone. *Platystrophia laticosta, Escharopora pavonia.*
263	..	72	0	4	Coarse grained crinoidal limestone. *Rafinesquina alternata* (c).
262	9	71	3	..	Covered.
259	9	70	0	3	Fine grained limestone.
259	6	69	0	6	Shale.
259	..	68	0	5	Coarse grained limestone. *Rafinesquina alternata* (aa).
258	8	67	1	8	Covered.
257	..	66	1	..	Thick bedded, light gray limestone containing fragments of *Rafinesquina alternata* in abundance.
256	..	65	8	..	Thin bedded bryozoal limestone. *Callopora dalei, Dekayia ulrichi, Platystrophia laticosta* very small form. *Hebertella sinuata.*
248	..	64	6	..	Covered.
242	..	63	0	6	Bryozoal limestone. *Dekayia ulrichi, Callopora dalei, Platystrophia laticosta* very small form.
241	6	62	0	8	Covered.
240	10	61	1	2	Limestone. *Callopora dalei, Dalmanella multisecta.* Top of the DALMANELLA MULTISECTA ZONE.
239	8	60	8	8	Covered.
231	8	59	0	4	Dark, drab limestone. *Peronopora vera, Dekayia ulrichi, Callopora communis, Dalmanella multisecta.*
231	4	58	2	..	Covered.
229	4	57	0	7	Compact limestone. *Dalmanella multisecta* (aa).
228	9	56	25	..	Covered. (A recent restudy of this section revealed several exposed layers in this interval, containing *Dalmanella multisecta* in abundance.)
203	9	55	0	6	Coarse grained crystalline limestone. Fragments of *Dalmanella multisecta* and *Rafinesquina alternata* abundant.
203	3	54	0	6	Shale.
202	9	53	0	3	Limestone. *Dalmanella emacerata* (r).
202	6	52	0	10	Shale.
201	8	51	0	3	Gray limestone. *Dekayia ulrichi* (c).
201	5	50	2	8	Shale.
198	9	49	0	6	Coarse grained limestone. *Dalmanella multisecta. Coeloclema* sp. *Callopora.*
198	3	48	1	..	Shale.
197	3	47	0	3	Yellowish limestone.
197	..	46	2	..	Shale.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
195	..	45	5	..	Thin layers of limestone. *Coeloclema, Peronopora vera, Callopora communis, Bythopora arctipora, Dekayia ulrichi, Zygospira cincinnatiensis, Dalmanella multisecta.*
190	..	44	2	3	Shale.
187	8	43	0	6	Layers of calcareous sandstone.
187	2	42	3	..	Shale.
184	2	41	0	2	Limestone. *Batostoma* sp., *Dekayia ulrichi* (c), *Callopora communis, Bythopora arctipora.*
184	..	40	3	8	Shale.
180	6	39	0	8	Crinoidal limestone. *Dekayia ulrichi, Callopora communis.*
179	10	38	5	..	Shale.
174	10	37	2	6	Bryozoal limestone in thin layers. *Dekayi ulrichi* (aa), *Coeloclema commune* (a), *Stigmatella clavis, Callopora communis, Batostoma implicatum, Zygospira cincinnatiensis.*
172	4	36	2	6	Shale and thin limestones.
169	10	35	5	..	Bryozoal limestone. *Dekayia ulrichi, Dalmanella multisecta.*
164	10	34	2	..	Shale.
162	10	33	0	10	Hard limestone. *Bythopora arctipora, Batostoma implicatum, Dalmanella multisecta, Zyospira cincinnatiensis.*
162	..	32	2	4	Thin limestone and shale. *Callopora onealli-sigillaroides, Bythopora arctipora, Dekayia ulrichi, Batostoma implicatum, Dalmanella multisecta.*
159	7	31	0	4	Limestone. *Coeloclema* sp., *Ceramoporella ohioensis, Peronopora vera, Callopora onealli* var., *Batostoma implicatum, Escharopora acuminata, Dalmanella multisecta, Trinucleus concentricus.*
159	3	30	1	8	Shale.
157	7	29	0	7	Limestone with argillaceous material in spots. *Callopora communis?, Atactoporella* sp., *Dalmanella multisecta, Retzia granulifera.*
157	..	28	0	8	Shale.
156	4	27	0	4	Sandstone.
156	..	26	6	3	Shale with thin layers of limestone.
149	8	25	0	4	Dark crystalline limestone.
149	4	24	5	4	Shaly limestone. *Ceramoporella distincta, Callopora communis, Bythopora arctipora, Batostoma implicatum, Peronopora vera, Dekayia ulrichi?, Dalmanella emacerata, Zygospira cincinnatiensis, Acidaspis ceralepta.*

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
144	..	23	0	7	Crinoidal limestone. *Coeloclema commune, Batostoma implicatum, Bythopora arctipora, Peronopora vera, Dalmanella emacerata, Zygospira cincinnatiensis, Dalmanella multisecta, Trinucleus concentricus.*
143	4	22	2	6	Shale.
140	10	21	0	3	Limestone. *Coelclema commune* (aaa), *Callopora communis?, Bythopora arctipora, Dekayia ulrichi, Dalmanella emacerata, Plectorthis* sp.
140	7	20	0	7	Shale.
140	..	19	1	..	Thin layers of limestone with intercalated shale. *Peronopora vera, Dalmanella multisecta* (aa), *Zygospira cincinnatiensis, Dalmanella emacerata.*
139	..	18	7	..	Shale.
132	..	17	0	3	Limestone. *Batostoma implicatum, Peronopora vera, Bythopora arctipora, Dalmanella multisecta.*
131	10	16	2	6	Shale.
129	4	15	0	6	Compact limestone. *Batostoma implicatum, Dekayia obscura, D. ulrichi, Dalmanella multisecta.*
128	10	14	0	5	Shale.
128	5	13	0	5	Compact limestone. *Coeloclema alternatum* (c); *Bythopora arctipora, Callopora sigillaroides, Dekayia ulrichi, Callopora communis, Dalmanella multisecta, Batostoma implicatum.*
128	..	12	6	4	Shale with occasional thin layers of limestone.
121	9	11	0	3	Limestone mottled with argillaceous material. *Callopora onealli, C. nodulosa, Batostoma implicatum, Peronopora vera, Coeloclema alternatum* (a), *Bythopora arctipora* (c), *Dekayia ulrichi, Dalmanella multisecta, Plectambonites sericeus, Proetus* sp.
121	6	10	2	3	Shale with occasional thin even layers of limestone.
119	3	9	1	..	Thin layers of fine grained compact limestone. *Callopora onealli, Batostoma implicatum, Dalmanella multisecta.*
118	3	8	1	..	Shale.
117	3	7	0	5	Limestone mottled with argillaceous spots. *Batostoma implicatum, Peronopora vera, Dalmanella multisecta.*
116	10	6	4	..	Shale.
112	10	5	0	10	Dark blue limestone. *Coeloclema alternatum, Callopora onealli, Bythopora arctipora, Dalmanella multisecta.*
112	..	4	4	6	Shale.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
107	6	3	0	6	Dark blue limestonee containing *Dalmanella multisecta* (c), and *Plectambonites sericeus* (c).
107	..	2	6	..	Soft blue shale exposed at the mouth of the gully near the Orphan Asylum at the head of Main Cross street.
101	..	1	101	..	Covered to the level of the Ohio river.

The top of the Eden shales in this section is considered to be where the characteristic *Dalmanella multisecta* leaves off, namely, at No. 61, although a few specimens of *Dekayia ulrichi* are found in the fifteen feet above this. *Platystrophia laticosta* comes in immediately above this, and *Hebertella sinuata* within a few feet. The top of the *Platystrophia* zone is apparently reached at the top of No. 87, 123 ft. above the top of the Eden. The complete faunal lists of this section are given in a paper by the writer, published in the American Geologist, December, 1901.

Section of the Hill Above the Cemetery, One Mile Northeast of Vevay. 1.38G.

390	..	5	40	..	Mostly covered to the extreme top of the hill at an old log house.
350	..	4	78	..	Limestone and shale containing numerous specimens of *Platystrophia lynx*, and *Hebertella sinuata*. The former more abundant in the upper part and the latter in the lower.
272	..	3	25	..	Several layers in this division contain immense numbers of *Callopora communis* and *C. dalei*, and occasional specimens of a small *Platystrophia* allied to *P. laticosta*. The base of this division is formed by the lowest layer containing the *Callopora*. *Constellaria constellata* is another common fossil in this division. This is the lowest division of the Lorraine.
247	..	2	167	..	Mostly covered to the level of the pike at the foot of the hill. *Dalmanella multisecta* is the common fossil.
80	..	1	80	..	Covered to river level.

Section in the Gully that Heads at the Culvert 210 Feet North of the North End of the South Cut on the P., C., C. & St. L. R. R., Madison. 1.12A.

197	..	45	10	..	Soft, blue shale. The top of this division and of the section is at the top of the stone butment of the culvert 210 feet north of the north end of the south cut.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
187	..	44	1	2	Several layers of limestone with *Cyclonema*, *Calymene callicephala*, *Rafinesquina alternata*, etc.
186	..	43	2	8	Shaly limestone.
183	3	42	2	..	Crinoidal limestone. Bryozoa, *Rafinesquina*.
181	3	41	5	..	Limestone and shale.
176	3	40	0	3	Compact, close grained limestone. *Rafinesquina*.
176	..	39	2	4	Limestone and shale. *Zygospira modesta*.
173	7	38	0	4	Limestone. *Rafinesquina* (aaa) edgewise.
173	3	37	6	9	Argillaceous compact limestone. *Rafinesquina*.
166	6	36	0	6	Limestone. Bryozoa (a).
166	..	35	5	8	Shaly limestone.
160	4	34	0	8	Limestone.
159	8	33	2	8	Shaly limestone.
157	..	32	0	8	Limestone. *Rafinesquina*, Gastropoda, Bryozoa.
156	4	31	10	8	Shale with occasional 2 feet to 3 feet layers of limestone.
145	8	30	0	3	Limestone. *Rafinesquina* edgewise (aaa).
145	5	29	6	9	Shaly limestone. *Rafinesquina* (aa), *Modiolodon* (aa), *Zygospira modesta* (aa).
138	8	28	0	4	Blue fine grained limestone. *Zygospira modesta* (aaa).
138	4	27	1	4	Shaly limestone.
137	..	26	0	3	Blue fine grained limestone. *Zygospira modesta* (aaa).
136	8	25	13	..	Shaly limestone. *Rafinesquina*, etc.
123	8	24	0	6	Very compact, fine grained limestone. No fossils.
123	2	23	4	2	Shale and limestone with excellently preserved specimens of *Rafinesquina alternata* (aa).
119	..	22	0	3	Limestone with top layer composed of immense numbers of *Zygospira modesta*.
118	8	21	2	..	Rather coarse shale.
116	8	20	3	..	Lumpy, shaly limestone.
113	8	19	0	8	Coarse to fine grained barren limestone.
113	..	18	12	..	Lumpy, shaly limestone. *Rafinesquina alternata*, *Zygospira modesta*, *Calymene callicephala*, Bryozoa.
101	..	17	5	10	Limestone. *Rafinesquina*, *Zygospira modesta* (aa).
95	2	16	1	..	Shale with thin layers of limestone.
94	2	15	0	6	Very compact, fine grained, blue, barren limestone.
93	8	14	0	8	Shale.
93	..	13	0	5	Compact limestone. *Calymene callicephala*, *Zygospira modesta*.
92	6	12	1	3	Limestone. *Calymene callicephala* (aa), *Rafinesquina*, Bryozoa.
91	3	11	3	8	Shale with thin layers of limestone.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
87	7	10	1	..	Thin argillaceous limestone. Bryozoa (aa).
86	7	9	0	7	Massive blue limestone.
86	..	8	2	9	Limestone. *Rafinesquina, Zygospira modesta,* Bryozoa.
83	2	7	1	..	Thin, argillaceous, yellow-spotted limestone. *Platystrophia laticosta, Hebertella sinuata.*
82	2	6	1	2	Limestone. *Hebertella* (aa), *Platystrophia lynx, Rafinesquina nasuta.*
81	..	5	0	4	Bryozoal limestone.
80	8	4	1	..	Shale.
79	8	3	0	2	Limestone.
79	6	2a	0	6	Coarse crystalline limestone. *Hebertella sinuata.*
79	..	2	20	..	Thin limestone and shale, very fossiliferous. *Platystrophia lynx, P. laticosta, Hebertella sinuata, Dekayia frondosa, Monticulipora mammulata, Callopora ramosa, C. rugosa* are the common fossils. This division is exposed in the creek into which the gully empties, at a point several hundred feet down stream.
59	..	1	59	..	Covered to the low water level of the Ohio river.

The base of the exposed portion of this section represents the middle part of the Lorraine—apparently the equivalent of the Bellevue beds of Nickles. These beds comprise Nos. 2 to 7 of the section, a thickness of about 24 ft. The balance of the section, 114 ft. in thickness, falls in the *Rafinesquina* zone of this report, which is about equivalent to the Corryville, Mt. Auburn and Arnheim of Nickles and Foerste. In the present section there is no representative of the Mt. Auburn (*Platystrophia lynx*) beds. Very careful search fails to reveal a single specimen of the gerontic *P. lynx,* or any other form of that species above number 7 of the section. This 114 ft. does not represent the entire thickness of this division, in this locality, since about 20 ft. of rock is exposed in the north end of the south cut above this section, and below the *Dalmanella meeki* zone. It appears, therefore, that the interval between the top of the *Platystrophia* zone and the base of the *Dalmanella meeki* zone is at least 134 ft. This section, with the exception of numbers 1 and 2, was measured layer by layer with the tape.

The fauna of No. 1.12A2 is as follows: *Callopora ramosa* (c), *C. rugosa* (c), *Monticulipora mammulata, Pronopora pavonia, Dekayia frondosa, Bythopora gracilis, Atactoporella ortoni, Ceramoporella ohioensis, Stomatopora inflata, S. arachnoidea, Arthropora schafferi, Platystrophia lynx* (normal form *aa*), *P. laticosta, P. cypha, Hebertella sinuata* (c), *Rafinesquina ponderosa, R. nasuta,* *Plectorthis* sp., *Zygospira modesta, Crania scabiosa, Byssonychia* cf. *praecursa, Cyclora minuta, Orthoceras* sp., *Isotelus maximus, Conchiolites flexuosus, Acidaspis* sp.

Section of the South Cut at Madison, Indiana, Beginning at the Track Level at the South End of the Cut and Terminating at the Extreme Top of the Exposed Rock in the Cut. 1.12E.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
83	..	3	30	..	Heavy brown-weathering layers seen at the top of the west side of the cut. These layers contain *Dalmanella meeki* in great abundance, especially in the upper part.
53	..	2	37	6	Conspicuous brown-weathering layers seen in the east side of the cut at the north end and underlying the layers of No. 3 in the west side of the cut. Practically all of this division is repeated in the top of Section 1.12A.
15	6	1	15	6	Shale and heavy layers of limestone. Practically all covered by talus in the south end of the cut.

The fauna of No. 1.12E3 is as follows: *Dalmanella meeki* (aaa), *Rafinesquina alternata, Zygospira modesta, Leptaena rhomboidalis, Strophomena planumbona, Platystrophia laticosta, Hebertella sinuata, Plectambonites sericeus* (r), *Crania* sp., *Dicranopora emacerata, Arthropora schafferi, Peronopora pavonia, Dekayia prolifica, Homotrypa* cf. *austini, Batostoma varians, Eridotrypa simulatrix, Ceramoporella ohioensis, Rhombotrypa quadrata, Prasopora hospitalis, Bythopora delicatula, B. meeki, Callopora subnodosa, Bernicea primitiva, Stomatopora* sp., *Nicholsonella vaupeli, Tentaculites richmondensis, Acidaspis* sp., *Isotelus* sp., *Cyclonema bilix, Anomalodonta gigantea, Opisthoptera casei, Ctenodonta cingulata* (?).

Section at the Sharp Bend of the Road a Little Way Below the Hanging Rock, Madison. 1.12F.

..	..	4	..	..	*Columnaria* reef.
55	..	3	35	..	Limestone with shale partings. Contains a typical Liberty fauna.
20	..	2	20	..	Shale and limestone. Nearly all covered by talus from above.
..	..	1	..	..	Covered to river level, about 260 feet.

The fauna of No. 1.12F3 is as follows: *Rhynchotrema capax, Dinorthis subquadrata* (c), *Strophomena planumbona* (c), *Strophomena neglecta, Rafinesquina alternata, Hebertella occidentalis, H.*

Fig. 2. View of the Big (North) cut at Madison, Indiana. The heavy, overhanging layers in the upper part of the right hand (west) side of the cut represent the massive sandstone bed of the base of the Saluda. The base of this bed is the layer *a*. The layer *b* is the top of the fossiliferous limestones and shales.

sinuata, H. sp., *Zygospira modesta, Plectambonites sericeus, Platystrophia acutilirata* (*rr*), *P. laticosta, Strophomena subtenta* (r), *Dicranopora emacerata, Arthropora schafferi, Bythopora delicatula, B. meeki, B. striata, Callopora subnodosa, C.* sp. (with sharp monticules like *C. ramosa*), *Ceramoporella ohioensis, Prasopora hospitalis, Homotrypa ramulosa* (?), *H.* cf. *cylindrica, Rhombotrypa quadrata, Constellaria polystomella, Helopora* sp., *Isotelus* sp., *Calymmene callicephala, Acidaspis* sp., *Protarea vetusta, Streptelasma rusticum, Pterinea demissa, Ischyrodonta* sp., *Ortonella hainesi* (??), *Byssonychia suberecta, Cycloconcha milleri, Opisthoptera casei, Conradella dyeri, Poteriocrinites polydactylus, Glyptocrinus* sp. (plates of calyx), *Crania laelia* (rr).

Section of the Big Cut (North Cut) Madison, Indiana. 1.12D.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
146	9	24	10	..	Massive, hard, whitish limestone with numerous small cavities.
136	9	23	5	..	Massive blue limestone, full of small cavities or pits.
131	9	22	5	..	Thin layers similar to No. 23.
126	9	21	2	6	Blue shale.
124	3	20	3	10	White massive limestone, somewhat argillaceous at the top and more calcareous at the base.
120	5	19	8	3	Shale.
112	2	18	2	6	Massive white limestone. Base of the NIAGARA.
109	8	17	1+	..	Pink to salmon colored, coarse, crystalline limestone. This is the representative of the CLINTON formation.
108	8	16	4	2	Massive light colored arenaceous limestone.
104	6	15	9	8	Thick-bedded, soft, argillaceous-arenaceous limestone. (Calcareous sandstone.)
94	10	14	12	10	Argillaceous-arenaceous, somewhat calcareous thick bed. On the weathered surface streaked or banded with various colors—ash gray, buff. pink, etc. On fresh surface light brown.
82	..	13	3	6	One massive, conspicuous arenaceous layer. This forms the base of the prominently overhanging bed in the upper part of the cut.
78	6	12	7	..	Thin-bedded argillaceous-arenaceous, brownish weathering layers with calcareous streaks containing bryozoa.
71	6	11	0	4	Nothing to four inches of coarse limestone with numerous fossils. *Hebertella*, etc.
71	2	10	3	..	Arenaceous bed with lenticles of limestone containing fossils, mostly bryozoa.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
68	2	9	2	..	Limestone containing numerous large examples of *Columnaria alveolata.* Upper Columnaria reef. This layer runs under the tracks at the extreme north end of the big cut.
66	2	8	6	..	Shale.
60	2	7	1	2	Limestone containing numerous large examples of *Columnaria alveolata.* Lower Columnaria reef.
59	..	6	5	3	Thin layers of limestone alternating with argillaceous and sandy layers. The limestone layers contain numerous bryozoa and *Hebertella occidentalis*, and *Rafinesquina alternata.*
53	8	5	7	8	Arenaceous-argillaceous bed, massive in appearance on fresh exposure.
46	..	4	6	..	Blue, fossiliferous limestone, shale and some arenaceous layers.
40	..	3	10	..	Thin limestone layers with intercalated soft shale. *Rhynchotrema capax, Hebertella occidentalis, Strophomena planumbona, Streptelasma rusticum, Dinorthis subquadrata, Strophomena neglecta, Platystrophia acutilirata* (r) are the characteristic fossils.
30	..	2	8	..	Similar to No. 3, but with numerous specimens of *Plectambonites sericeus* in some layers.
22	..	1	22	..	Probably mostly shale with thin layers of limestone. Obscured by the talus from the higher layers. Base at the iron pipe on the west side of the tracks at the extreme south end of the cut.

The thickness of the Saluda beds in the present section, if the lower Columnaria reef (which corresponds to the lower Tetradium reef in the sections farther north) be taken as the base, is 50 feet (49 feet 8 inches). The thickness of the same division at Cooper's falls near Versailles is 58 feet. One and three-quarters miles south of Versailles the thickness is 53 feet. Near Osgood the thickness is between 60 and 70 feet.

The thickness of the Liberty division in the Madison section, if the *Plectambonites* horizon in the above section be taken as the base, is about 30 feet. It is also about 30 feet in the Versailles section. If the first appearance of *Hebertella insculpta* be taken as the base of the Liberty, its thickness will be about 10 or 15 feet more. In the Richmond section the Liberty division is 40 feet thick and the Saluda, Whitewater and Elkhorn 130 feet. It is evident, therefore, that the thinning of the upper Richmond beds in the Madison section is due to the absence of the Whitewater division and not to the thinning of the other divisions, as has been commonly supposed.

The fauna of No. 1.12D1-6 is as follows: *Strophomena planumbona* (*c*), *S. neglecta* (*c*), *S. sulcata* (r), *Hebertella occidentalis* (*c*), *Rafinesquina alternata, Zygospira modesta, Plectambonites sericeus, Rhynchotrema capax* (*c*), *Dinorthis subquadrata* (*c*), *Platystrophia laticosta, Hebertella sinuata, Crania scabiosa, Leptaena rhomboidalis* (*r*), *Dalmanella meeki* (*rr*), *Platystrophia acutilirata, Dicranopora emacerata, Arthropora schafferi, Prasopora hospitalis, Callopora* sp. (sharp monticules), *Bythopora meeki, B. striata, Batostoma variabile, Stomatopora arachnoidea, Constellaria* sp., *Calymmene callicephala, Isotelus* sp., *Pterinea demissa, Conradella dyeri, Streptelasma rusticum, Byssonychia* sp.

Section at the Hanging Rock, Madison.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
46	..	2	19	..	Upper argillaceous bed. The top of this division is formed by the Clinton limestone, and the base by the calcareous layer that forms the lower crest of the falls at the north end of the big cut.
27	..	1	27	..	From the calcareous layer to the upper *Columnaria* reef. Argillaceous sandstone with calcareous streaks.

The measurements here were made with the tape.

Section of the Falls in the Small Gully West of the Railroad Tracks, Just North of the Big Cut, Madison, Indiana.

45	..	6	1	3	Clinton limestone.
43	10	5	4	..	Mottled limestone forming upper crest of falls.
39	10	4	15	..	Mottled, rather soft, ash colored shaly sandstone. Somewhat calcareous.
24	10	3	2	10	Strong calcareous layer. Forms the lower crest of the falls.
22	..	2	15	..	Massive soft sandstone. Forms the conspicuous overhanging rocks in the cut.
7	..	1	7	..	Soft, sandy shale with calcareous streaks. This bed is underlain by the upper *Columnaria* reef.

Measurements with the tape.

General Section of the Cuts on the P., C., C. & St. L. R. R. at Madison, Indiana. 1.12A, E and D.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
467	..	8	107	..	From the top of the Clinton limestone to the level of the tracks at North Madison.
360	..	7	45	..	From the upper *Columnaria* reef at the extreme north end of the north cut (big cut) to the Clinton limestone.
315	..	6	65	..	From the level of the tracks at the south end of the big cut to the level of the upper *Columnaria* reef at the north end of the big cut.
250	..	5	54	..	From the level of the top of Section A to the level of the tracks at the south end of the big cut.
196	..	4	11	..	From the level of the tracks at the north end of the south cut to the top of Section A (level of the top of the stone butment of the culvert 210 feet north of the north end of the cut).
185	..	3	47	..	From the level of the tracks at the south end of the south cut to the level of the tracks at the north end of the south cut.
138	..	2	88	..	From the level of the railroad tracks at the bottom of the grade at Madison to the level of the tracks at the south end of the south cut.
50	..	1	50	..	From the low water level of the Ohio river at Madison to the level of the railroad tracks at the foot of the grade.

This section is made up from the data supplied by the engineer of the P., C., C. & St. L. R. R., in regard to the per cent. of grade and the distances through the cuts and between the cuts; and from measurements of the distance from the beginning of the grade at Madison to the south end of the south cut, and of the distance from the north end of the big cut to the top of the grade at North Madison; and from the data given in Gannett's dictionary of altitudes (fourth edition) in regard to the elevation of the low water of the Ohio river, elevation of the railroad at Madison and elevation of the railroad at North Madison. The elevation of the Clinton limestone above the north end of the big cut was determined by measurement with a tape and the barometer. The data thus obtained are as follows:

Low water level of the Ohio river 401 feet A.T.; elevation of the railroad at Madison, 450 feet A.T.; elevation of the railroad at North Madison, 877 feet A.T.; per cent. of grade, 5.89 per cent.; distance from the foot of the grade at Madison to the south end of the south cut, 1,500 feet; distance through the south cut, 800 feet; distance from the north end of the south cut to the top of section A (culvert just north of the south cut), 210 feet; distance from the top of section A to the south end of the big cut (north cut), 890 feet; distance through the big cut, 1,100 feet; distance from the north end of the big cut to the top of the grade at North Madison, 2,580 feet. Total distance from the foot of the grade at Madison to the top of the grade at North Madison, 7,080 feet. Difference in elevation between Madison and North Madison obtained by multiplying this distance by the per cent. of grade (70.8x5.89), 417 feet. Difference in elevation between Madison and North Madison according to Gannett's dictionary of altitudes, 427 feet. This small discrepancy is probably due to slight inaccuracy in the determination of the top of the grade at North Madison and the bottom of the grade at Madison. With this section the barometric measurements taken at several different times are in fair agreement. The average of these barometric measurements give the difference in elevation between Madison and North Madison as approximately 400 feet. The elevation of the railroad at North Madison above river level as obtained by Locke level in 1900 is 473 feet. This differs from the elevation according to Gannett's figures by only 4 feet. The elevation of the south end of the south cut above river level according to measurements with the Locke level made in 1900 is 140 feet. This differs from the elevation obtained by computation from the per cent of grade by only 2 feet.

Section Along the North Fork of Razor Creek Five Miles North of Madison. 1.12G.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
50	8	8	2	4	Pink, coarse grained *Clinton* limestone.
48	4	7	10	..	Mottled impure soft limestone, forming six ledges with shale partings. Weathers gray, mottled with dark specks and with a flaky surface.
38	4	6	4	4	Heavy, harder layers forming the crest of the upper part of the falls. Mottled crystalline limestone.
34	..	5	5	4	Arenaceous, shaly, soft, blocky limestone.
28	8	4	2	2	Impure crystalline limestone, mottled with yellow specks. Forms the crest of the lower part of the falls.
26	6	3	16	..	Arenaceous shale. "Shale bed." The upper layer, 1 foot 3 inches thick, is especially arenaceous.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
10	6	2	1	..	Hard, massive layer of limestone.
9	6	1	9	6	Blocky limestone with *Tetradium* throughout. *Columnaria* occurs at the base near the water level.

Section in the North Edge of the Village of Canaan. 1.58B.

47	..	4	29	..	Ordovician-Clinton contact. Limestone becoming shaly and arenaceous in the lower part.
18	..	3	11	..	"Shale bed." Base decidedly arenaceous.
7	..	2	5	..	Interval between the shale bed and the *Tetradium* reef.
2	..	1	2	..	*Tetradium* reef at the top; *Columnaria* reef at the bottom. Between this locality and Osgood the *Columnaria* does not seem to be present, or at least is very rare.

Section in an Eastern Tributary of the East Fork of Indian Kentuck Creek, Four Miles Southwest of Cross Plains. 1.59H.

67	..	13	6	..	Brownish, concretionary limestone. The Clinton rests directly upon this division.
61	..	12	2	..	*Tetradium.*
59	..	11	4	..	Hard, fine-grained limestone, thinner than Nos. 8 and 9.
55	..	10	1	..	Thick, wave-marked layer.
54	..	9	1	6	Same as No. 8, with shale partings.
52	6	8	0	6	Hard, dove colored, fine-grained, white weathering layer.
52	..	7a	14	..	Thin, impure, lumpy layers of limestone, gray, somewhat mottled; somewhat ripple marked.
38	..	7	1	..	Conspicuous hard limestone layer.
37	..	6	10	..	Soft, gray, mottled, uneven, lumpy limestone. Few fossils.
27	..	5	8	..	Soft, blocky, dark, jointed shale, somewhat ripple marked but not so arenaceous as the shale bed below.
19	..	4	0	6	Hard layer of limestone.
18	6	3	2	6	A one-foot layer of hard, blue limestone overlain by shale.
16	..	2	11	..	Ripple-marked and sun-cracked shale. "Shale bed." An arenaceous, heavy bed at the base.
5	..	1	5	..	Massive, hard layer of limestone underlain by soft shale. The base of this division is formed by the lower *Tetradium* reef.

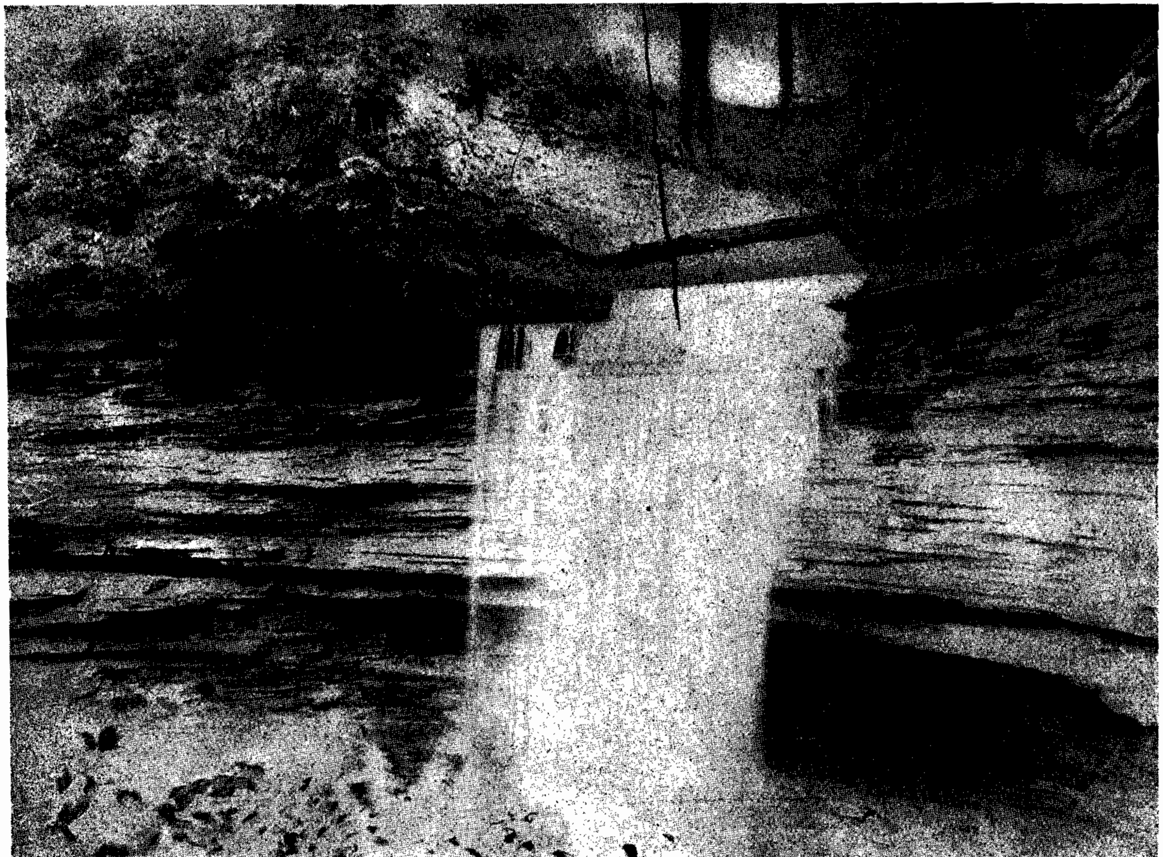

Fig. 3.—Cooper's Falls, four miles south of Versailles. The top of the "shale bed" is at *a* and the base at *b*.

Section in a Gully Entering the East Fork of Indian Kentuck Creek from the East, Four Miles Southwest of Cross Plains. 1.59G.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
58	6	5	38	..	Limestone and shale. The layers immediately under the Clinton are hard and light colored. Toward the lower part of the division the rock is more argillaceous, and somewhat inclined to be ripple marked like the shale bed.
20	6	4	15	..	Ripple-marked and sun-cracked shale. "Shale bed." Somewhat arenaceous.
5	6	3	0	8	Hard limestone layer.
4	10	2	1	10	Soft, even light colored shale.
3	..	1	3	..	Blocky shale and limestone. Base formed by the lower *Tetradium* reef.

Section Three and One-Half Miles Southwest of Olcan (in the Gully that Crosses the East-West Road Two Miles Due West of Cross Plains). 1.59D.

43	..	3	15	..	Limestone. Directly overlain by the Clinton limestone.
28	..	2	15	..	Top of this division is the upper *Tetradium* reef. Mottled soft limestone and shale. More argillaceous than the same division farther north. The base of this division is formed by the massive hard limestone that commonly overlies the shale bed.
13	..	1	13	..	Slabby, sun-cracked and ripple-marked drab shale. The "Shale bed." The base is formed by a hard layer of limestone, and this is overlain by about two feet thickness of more arenaceous rock than is seen farther north at this horizon.

Section of Cooper's Falls, Four Miles South of Versailles. 1.60F.

58	..	4	30	..	From the base of the Clinton to the crest of the falls. Limestone.
28	..	3	5	..	From the crest of the falls to the top of the shale bed. Limestone.
23	..	2	10	..	Sun-cracked and ripple-marked shale. The "Shale bed."
13	..	1	13	..	Upper eight feet soft shale underlain by a rather hard, massive, impure limestone layer about two feet thick. Underneath this the limestone is blue, mottled and interspersed with arenaceous material. The *Tetradium* reef forms the base of this division.

Height of the falls 35 feet, by tape.

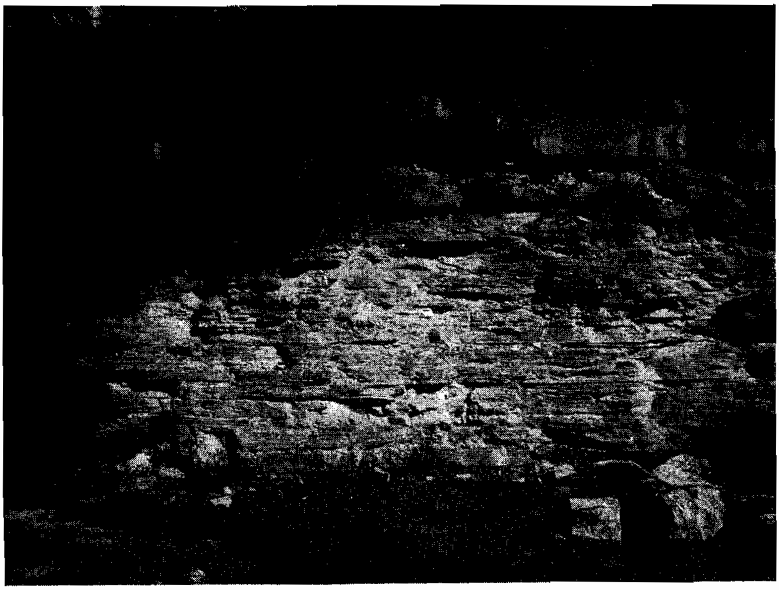

Fig. 4.—Shale bed on west fork of Cedar Creek, Versailles, upper massive layer at top of exposure *a*.

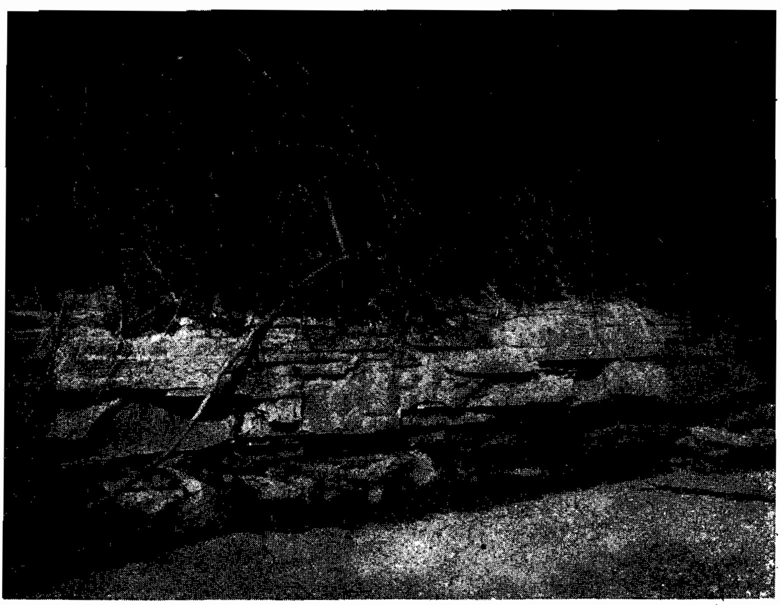

Fig. 5.—Base of shale bed at 1.59D. Here the base of the bed is becoming quite arenaceous.

Section Along the West Fork of Cedar Creek, Versailles, Indiana, from the Base of 80-Foot Cliff to the Point Where the Osgood-Versailles Pike Crosses the Creek. 1.60H.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
101	..	11	9	..	Uneven, thin-bedded, lumpy, yellow-weathering limestone. *Platystrophia acutilirata senex* (aa), *Monticulipora epidermata* (rr), *Homotrypella rustica* (c), *Homotrypa wortheni* (a).
92	..	10	5	..	At bottom of road metal quarry, near the pike, massive, hard limestone layer.
87	..	9	18	..	Coarse grained rather soft gray limestone in thick layers; thin-bedded in the top 4 feet. Mostly unfossiliferous, fossils small and obscure. Some layers contain Pelecypods rather commonly. This is the "*Mottled bed*" of this report.
69	..	8	4	..	Heavy, hard, fine-grained layers immediately overlying the "Shale bed." No fossils.
65	..	7	8	6	*Shale bed.* This bed consists of thin layers of rather hard, calcareous drab shale, conspicuously ripple-marked and sun-cracked. The layers vary in thickness from a fraction of an inch to several inches. The whole bed is conspicuously jointed, the joints (main system) running N. 73° E.
56	6	6a	2	..	Base of the shale bed, consisting of about 2 feet of very hard, barren limestone.
54	6	6	9	6	Dark-colored limestone containing *Tetradium* (aaa), especially at the base. Some of the individuals measure as much as 4 feet 7 inches in diameter.
45	..	5	8	..	Dark-colored, uneven limestone, Bryozoa (aaa). This is the *Bryozoa bed* of this report.
37	..	4	5	..	Limestone; not very fossiliferous; top a hard, thick layer.
32	..	3	7	..	Limestone in rather thick layers.
25	..	2	5	..	Exposure in bed of creek and also in the 80-foot cliff of the thick layers of limestone containing *Plectambonites sericeus* (aaa).
20	..	1	20	..	Lower 20 feet of the 80-foot cliff. Mostly limestone. *Platystrophia acutilirata*, *Rhynchotrema capax*, etc. Very fossiliferous.

Base of the section is the creek bed at the base of the 80-foot cliff. This cliff is one-half mile up stream from the junction of the north and south forks of Cedar creek, in the north bank of the creek.

The fauna of No. 11 is as follows: *Homotrypa wortheni* (*a*), *H. constellariformis, H.* cf. *austini, Homotrypella rustica* (*c*), *Mon-*

ticulipora epidermata, M. sp. (very similar to *M. mammulata*) *Bythopora meeki* (c), *Dekayia subramosa* (c), *Peronopora pavonia* var., *Rhombotrypa quadrata* (small ramose form with well developed monticules), *Callopora* sp. (sharp monticules similar to *C. ramosa*), *Ceramoporella ohioensis, Ptilodictya plumaria, Platystrophia acutilirata senex, P. acutilirata, P. laticosta, Hebertella occidentalis* (c), *H. sinuata, Rafinesquina alternata, Zygospira modesta, Streptelasma divaricans* (c), *S. rusticum* (r), *Protarea vetusta, Byssonychia richmondensis, B.* sp. (may be *B. suberecta*), *Ischyrodonta elongata, Opisthoptera casei, Protowarthia subcompressa, Schizolopha moorei, Lophospira tropidophora, Lophospira* sp.

The fauna of No. 5 is as follows: *Hebertella occidentalis, Platystrophia laticosta* (large, very plump), *Strophomena* sp., *Rafinesquina alternata, Zygospira modesta, Dicranopora emacerata* (c), *Bythopora delicatula, B. meeki, Rhombotrypa quadrata* (aaa), *Monticulipora epidermata* (rr), *Dekayia subramosa* (c), *Callopora subnodosa, Arthropora shafferi, Rhinidictya* sp. (c), *Homotrypa* cf. *austini, Homotrypa* sp. (frondescent with well-developed monticules), *Homotrypa* sp. (frondescent, smooth), *Calapoecia cribriformis* (r), *Streptelasma rusticum, Protarea vetusta* (r), *Stromatopora* sp., *Isotelus maximus, Pterinea demissa, Lophospira* cf. *ampla.*

Section of the High Wash Bank on the West Fork of Cedar Creek, Just Above the Junction with the North Fork. 1.601.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
60	..	2	40	..	Highly fossiliferous limestone and shale. *Rhynchotrema capax, Strophomena planumbona, Hebertella occidentalis, protarea vetusta Streptelasma rusticum, Batostoma varians, Bythopora meeki, Leptaena rhomboidalis* (a). *Platystrophia laticosta* (abundant in the lower five feet), *Rhombotrypa quadrata.*
20	..	1	20	..	Shale and limestone. *Dalmanella meeki* is the characteristic fossil. To creek level.

This exposure is not adapted to the making of a detailed section on account of the amount of talus on the surface of the exposure.

Section Along the North Fork of Cedar Creek, Just North of Versailles. 1.60G.

86	..	13	5	..	Fairly thick layers of limestone. *Plectambonites sericeus* (aaa). Base of the Liberty beds.
81	..	12	20	..	Covered.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
61	..	11	4	..	Thin limestone layers with shale partings. Bryozoa (aaa).
57	..	10	5	..	Covered.
52	..	9	2	..	Limestone. *Leptaena rhomboidalis, Platystrophia laticosta, Batostoma varians, Dekayia prolifica*, etc.
50	..	8	5	..	Covered.
45	..	7	1	..	Shale and limestone. *Dalmanella meeki, Platystrophia laticosta.*
44	..	6	10	..	Covered.
34	..	5	2	..	*Dalmanella meeki, Plestambonites sericeus, Leptaena rhomboidalis*, etc.
32	..	4	4	..	Thin limestone and shale. *Dalmanella meeki* (aaa).
28	..	3	10	..	Covered.
18	..	2	3	..	Several thin layers of limestone separated by bands of soft blue shale. *Dalmanella meeki* (aaa).
15	..	1	15	..	Covered to the level of Laughery creek at the mouth of Cedar creek.

Section on a Small Western Tributary of Laughery Creek, Two Miles Northeast of Osgood. 1.61A.

75	..	8	15	..	Top = base of the *Clinton*. Nearly all covered. Several compact layers exposed near the top in contact with the overlying Clinton.
60	..	7	5	..	Exposed at 1.61C near the Clinton contact shown at No. 8 of this section. Nodular limestone and shale containing numerous fossils. *Platystrophia laticosta, P. lynx, Hebertella occidentalis, Strophomena sulcata, Strophomena neglecta, Streptelasma divaricans, Protarea vetusta, Rhombotrypa quadrata, Homotrypa wortheni, Peronopora pavonia.*
55	..	6	25	..	Partly covered. The exposed portions like No. 7.
30	..	5	7	..	Soft, gray, mottled limestone. Few fossils.
23	..	4	11	..	Soft, gray, mottled limestones like No. 5. The top of this zone is formed by a layer in which *Tetradium* is very abundant. Upper reef.
12	..	3	10	..	Ripple-marked and sun-cracked gray, slabby shale. The *Shale Bed*. The upper part is formed by a strong, massive layer. *Perfectly typical.*
2	..	2	2	..	Massive layer of limestone. Forms the base of the shale bed.
..	..	1	..	..	Several feet of limestone containing *Tetradium* in abundance. This is the *lower Tetradium reef.*

Section on the West Branch of Laughery Creek, Four Miles Southwest of Batesville. 1.62D.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
49	..	9	6+	..	Shaly, nodular limestone. Fossiliferous.
43	..	8	..	8	Hard, thin layers of limestone.
42	5	7	5	10	Shaly limestone. Same as No. 9.
36	7	6	1	3	Thicker layers of limestone.
35	4	5	17	6	Soft limestone and shale. "Mottled bed."
17	10	4	4	8	Hard, massive limestone overlying the "Shale bed." Light blue.
13	2	3	6	8	Ripple-marked and sun-cracked, slabby shale. The "Shale bed."
6	6	2	1	..	Massive, drab, barren limestone, somewhat shaly in the upper part. The massive layer underlying the shale bed.
5	6	1	5	6	Somewhat arenaceous, much jointed shale, inclined to be massive in the lower part.

The base of the section is creek level.

Section on the West Branch of Laughery Creek, Four Miles Southwest of Batesville. 1.62F.

63	3	9	40	..	Covered to the top of the hill.
23	3	8	1	..	Shale like that of No. 6.
22	3	7	0	8	Compact limestone layer.
21	7	6	5	..	Ripple-marked and sun-cracked, slabby shale. Nos. 6, 7 and 8 constitute the "Shale bed."
16	7	5	1	..	Massive layer at base of Shale bed.
15	7	4	10	10	Light colored, uneven limestone layers, varying in thickness from 1 foot to 10 feet, with intercalated soft, dark colored shale. Some layers contain a few specimens of *Tetradium*. The upper few inches is a black, fine shale.
4	9	3	1	3	Massive gray limestone, with pockets of calcite and good specimens of *Tetradium*.
3	6	2	2	..	Shaly limestone and blue shale.
1	6	1	1	6	From water level to top of a layer containing *Columnaria alveolata*.

Base of the section is the level of the creek.

Section One and One-Half Miles Northwest of Oldenburg. 1.63D.

81	..	4	70	..	Covered to top of hill.
11	..	3	3	..	Massive, hard, gray, barren limestone layer.
8	..	2	7	..	Ripple-marked and sun-cracked, slabby shale. "Shale bed."
1	..	1	1	..	Massive layer below the shale bed.

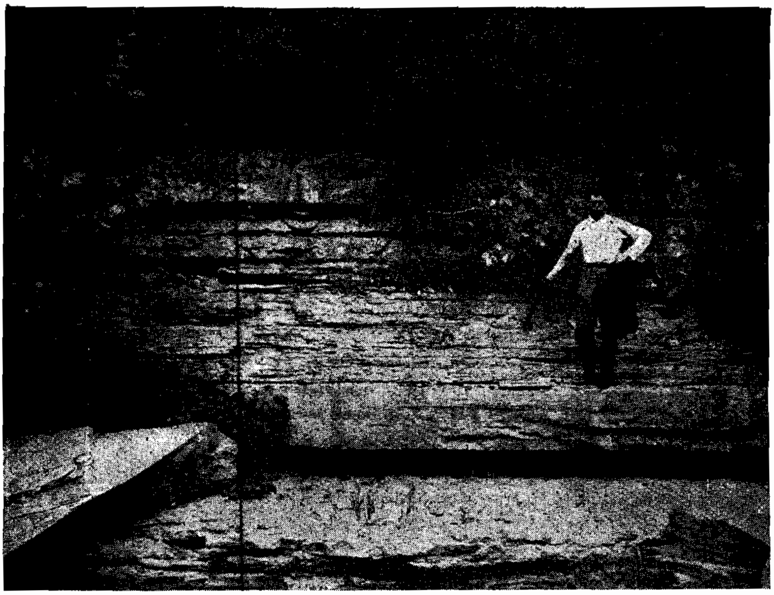

Fig. 6.—Shale bed at 1.64B. The man is standing on the lower massive limestone layer *a*, with his head opposite the upper massive layer *b*.

Fig. 7.—"Massive (limestone) bed" at the quarries 1½ miles south of Main street, Richmond (1.41D).

Section on Big Salt Creek, Four Miles West of Oldenburg. 1.63E.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
107	..	4	60	..	Mostly covered to the top of the hill. Base a massive bed of limestone a few feet in thickness.
47	..	3	4+	..	"Shale bed;" perfectly typical, but thinner than usual.
43	..	2	1	..	Massive, barren, gray limestone layer.
42	..	1	42	..	Well-defined limestone layers from 1 inch to 6 inches in thickness. The upper ten feet contains *Tetradium*. *Plectambonites sericeus* occurs in abundance a few feet above the level of the creek at the base of the section.

Section on the North Fork of Big Salt Creek, Two Miles West of Hamburg. 1.64B.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
120	..	10	11	..	Pink, coarse-grained, crystalline, massive limestone. *Clinton*.
109	..	9	40	..	Partly covered. The top layers consist of gray, shaly limestone containing *Platystrophia laticosta*, *P. lynx*, *Rhynchotrema capax*, *Hebertella occidentalis*, *Strophomena sulcata*, *Homotrypa wortheni*, *Streptelasma divaricans*. Some of the layers present very much the same lithological appearance as the upper beds containing *Platystrophia lynx* on Elkhorn creek, south of Richmond. The layers exposed at the base of this division at creek level contain *Rhynchotrema dentata* (abundant in one layer), *Strophomena sulcata*, *Monticulipora epidermata*, *Rhombotrypa quadrata*, *Peronopora pavonia*, *Platystrophia acutilirata-senex*, *P. laticosta*, *Batostoma varians*, *Streptelasma rusticum*, *Streptelasma divaricans*, etc.
69	..	8	15	..	At the base of this division *Tetradium* occurs abundantly, about 9 feet below a bed of shale that resembles to some extent the true "shale bed," but entirely lacks its associated beds.
54	..	7	20	..	Limestone and shale.
34	2	6	1	10	Very hard, gray, barren limestone. Upper massive bed.
32	4	5	3	4	Drab to gray limestone with intercalated soft shale. Probably this is the calcareous representative of the upper part of the Shale bed.
29	..	4	2	2	Typical sun-cracked and ripple-marked, slabby, drab shale. The "Shale bed."

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
26	9	3	1	9	Very hard, calcareous layer. When considerably weathered it splits up into thinner plates that resemble the layers of the shale bed.
25	..	2	4	..	Light colored, nodular, arenaceous limestone, separated from the overlying, massive layer by a thin bed of black, gritless, carbonaceous shale. At the base of this zone is a layer containing *Tetradium* in abundance.
21	..	1	21	..	Limestone with intercalated shale exposed in the bed of the creek for half a mile down stream from the locality of No. 2, and containing the characteristic fauna of the Liberty beds.

Section Along the Western Branch of Big Salt Creek, Three Miles North of Hamburg. 1.64D.

117	..	22	10	..	Hard, brownish layers of nearly barren limestone. Top in contact with the *Clinton*.
107	..	21	5	..	Blue limestone and shale.
102	..	20-19	5	..	Limestone and shale. The upper layer (No. 20) contains bryozoa very abundantly.
97	..	18	10	..	Covered.
87	5	17	0	5	Rough, hard layer of limestone.
87	..	16	13	..	Covered except at the top, which consists of soft, blue shale.
74	..	15	0	4	Irregularly jointed and cracked layer of limestone.
73	6	14	2	..	Limestone.
71	6	13	3	..	Slabby, brown to drab, sun-cracked shale.
68	6	12	6	..	Blocky, blue, much jointed, arenaceous shale. The main joints are only a few inches apart and run S. 20° W.
62	6	11	0	6	One layer of barren, arenaceous limestone.
62	..	10	1	..	Shale.
61	..	9-8	5	..	Blue mottled, coarse-grained, fossiliferous limestone. The top a hard layer containing *Streptelasma rusticum* in abundance.
56	..	7-6	15	..	Partly covered. Limestone and shale, containing *Tetradium* at the top (No. 7).
41	..	5	1	..	Hard, barren, blue, fine-grained limestone.
40	..	4	4+	..	Shaly, somewhat calcareous bed.
35	6	3	1	..	Hard, bluish gray, coarse-grained, fossiliferous limestone. Contains *Tetradium*.
34	6	2	34	..	Mostly fossiliferous limestones with intercalated soft, blue shale. Some of the limestone layers are fine-grained, hard and barren. Typical Liberty fauna.
0	6	1	0	6	Wave-marked, hard layer of limestone with *Plectambonites sericeus* abundant.

Section in a Gully Entering Big Sains Creek from the Northeast, Two and One-Quarter Miles Northwest of Laurel. 1.14F. (No. 235 of Foerste's Paper.)

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
91	..	18	5	..	Pink, coarse-grained limestone. *Clinton.* Overlain by the light-colored, hard limestones of the Niagara formation.
86	..	17	15	..	Mostly strong layers of rather barren limestone with some intercalated gray shale.
71	..	16	8	..	Brownish to yellowish, blue-mottled bed of arenaceous, soft limestone. *Platystrophia* and *Hebertella* common at the base.
63	..	15	7	..	Soft, gray, somewhat arenaceous shale, blocky and much jointed.
56	..	14	5	..	Three to five feet of overhanging layers of limestone.
51	..	13	10	..	Mostly soft, gray, blocky, somewhat arenaceous shale. Some limestone layers contain *Platystrophia acutilirata-senex* and *Hebertella occidentalis*, and numerous bryozoa.
41	..	12	10	..	Mostly like No. 13.
31	..	11-10	5	..	Combined thickness of Nos. 10 and 11 is 5 feet. Upper part a massive, hard limestone with *Tetradium* at the top. Lower part soft, gray, arenaceous shale. This is probably the upper *Tetradium reef.*
26	..	9	2+	..	Thick ledge of limestone.
24	6	8	2	..	Heavy layer, weathering into thin, conspicuously overhanging layers. Limestone.
22	6	7	3	..	Hard, nodular layers, projecting still more than those above.
19	6	6	1	6	Softer shale and limestone. Shale dark and somewhat carbonaceous.
18	..	5	1	..	Harder and somewhat arenaceous limestone.
17	..	4	2	..	*Tetradium* large and abundant.
15	..	3	3+	..	Limestone projecting in breast of lower waterfall. Underlain by very soft shale.
12	..	2-1	12	..	Shale and limestone with some thick ledges to level of Sains creek.

Section on Big Sains Creek One-Quarter Mile Up Stream from 1.14F. 1.14G.

27	..	6	15	..	Soft, nodular limestone and shale. *Rhynchotrema dentata* occurs at the top.
12	..	5	1+	..	Rather massive limestone layer.
10	8	4	3	..	Uneven, rather arenaceous shale and limestone.
7	8	3	2	..	Massive layer of limestone.
5	8	2	5	..	Limestone layers from two inches to 8 inches thick, with dark, somewhat carbonaceous shale partings.
0	8	1	0	8	Black, gritless, carbonaceous shale.

Section Along the Headwaters of Little Duck Creek, Three Miles Northwest of Blooming Grove, Franklin County. 1.65A.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
56	..	4	1	..	Hard, thick layer of limestone.
55	..	3	4	..	Partly covered, uneven layers of limestone.
51	..	2	1	..	Hard, thick layer of limestone. Contains *Tetradium.*
50	..	1	50	..	Partly covered limestone and shale, with the typical Liberty fauna. Base a layer containing *Plectambonites sericeus* in abundance.

Section Along a Small Tributary of Whitewater River, Two and a Half Miles Southeast of Quakertown, Union County, Indiana. 1.66A.

95	..	3	15	..	No rock exposed to top of hill.
80	..	2	35	..	Very little exposed rock except at the top, where, in about three feet of soft, nodular shale, the following species were found: *Streptelasma divaricans, S. rusticum, Rhynchotrema capax, Strophomena sulcata, Platystrophia acutilirata, P. laticosta, Protarea vetusta, Ptilodictya plumaria, Homotrypa flabellaris, Rhombotrypa quadrata.* At the base of this division *Tetradium* occurs in great numbers, loose, but evidently not far out of place.
45	..	1	45	..	Nearly all well exposed limestone with shale partings. At the base *Plectambonites sericeus* occurs in abundance.

Section at the Quarry and Along the Small Tributary of Silver Creek, One Mile West of the Center of Liberty, Indiana. 1.67A.

68	..	6	40	..	Nearly all exposed, limestone with shale partings. The top of this division is formed by a thick layer containing *Tetradium* in abundance.
28	..	5	10	..	Rather even, hard layers of limestone exposed in the quarry.
18	..	4	2	..	Limestone containing *Plectambonites sericeus* in abundance. Exposed in the creek just across the road from the quarry.
16	..	3	1	..	To level of the base of the quarry. At this level in the creek *Plectambonites* is very abundant.
15	..	2	10	..	Thin layers of limestone with intercalated beds of soft, blue shale. *Plectambonites* occurs at the base of this division in a wave-marked layer.
5	..	1	5	..	To the level of Silver creek.

Section Along Small Eastern Tributary of Whitewater River, One and One-Half Miles South of Abington, Wayne County. 1.41B.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
26	..	3	15	..	Shale and thin limestones, mostly loose pieces. *Rhynchotrema capax, Hebertella insculpta, Strophomena planumbona,* etc.
11	..	2	5	6	Shale and thin limestones. *Platystrophia laticosta, Strophomena planumbona, Dalmanella meeki, Batostoma varians,* etc.
5	6	1	5	6	Shale and thin limestones. *Dalmanella meeki, Platystrophia laticosta, Batostoma varians, Homotrypa flabellaris,* etc.

Section of Elkhorn Creek, Four Miles South of Richmond. 1.41A.
(Section measured in 1907.)

180	..	18	10+	..	*Clinton* at Elkhorn Falls. Ten to twelve feet thick at the falls. Probably somewhat thicker farther up stream.
170	..	17	4	..	Very soft shale, weathering rapidly to a clay. It is the presence of this shale bed that causes the Clinton ledge to overhang so conspicuously at the falls and along the upper end of the gorge. No. *1* of 1901 section.
166	..	16	6	..	Hard, brownish to greenish, coarse-grained, fairly even layers of limestone seen at creek level just below the mill and at the top of the 30-foot cliff in the north side of the gorge about one mile down stream from the falls. Contain *Platystrophia lynx-moritura* (*aa*), *Hebertella sinuata* (*a*) and *Homotrypa wortheni* (*c*). No. *2* and *10b* of 1901 section.
160	..	15a	25	..	Blocky, shaly, somewhat arenaceous limestone; fairly massive at the bottom and more shaly at the top. Fauna much the same as that of No. 16. No. *10a* of 1901 section.
135	..	15	1	..	Strong, granular, reddish layer. Fossils mostly small and poorly preserved.
134	..	14	5	..	Soft, blue, unfossiliferous shale exposed at the base of the 30-foot cliff, one mile below the falls.
129	..	13	10	..	Soft, blue shale with a few thin limestone layers exposed in the south bank of the creek about one-half mile farther down stream. No. *9* of 1901 section.
119	..	12	20	..	Some heavy, hard layers; mostly covered. These layers contain *Rhynchotrema dentata* at the base.
99	..	11	10	..	Mostly covered.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
89	..	10	5	..	Nodular limestone with *Rhynchotrema dentata* (*aa*) exposed along the creek in the open pasture just west of the road that runs straight south from Richmond. No. *8* of 1901 section.
84	..	9	15	..	Uneven, nodular, shaly, blue, highly fossiliferous limestone exposed in a long, low cliff in the east bank of the creek about one-half mile down stream from No. 10. *Rhynchotrema dentata* occurs at the top of the exposure. At the base occurs the form of *Platystrophia acutilirata* with very long cardinal angles. *Streptelasma rusticum* (*aa*) very large. No. *7* of 1901 section.
69	..	8	3+	..	Same as No. 9. This is the interval between the top of the exposure at the spring and the exposure of No. 9.
66	..	7	25	..	At the spring near the crossing of the east-and-west road in Section 29, long cliff exposure of nodular, very fossiliferous limestone and shale. *Rhynchotrema capax* (*aaa*), *Monticulipora epidermata* (*a*), *Rhynchotrema dentata* (*r*). No. *6* of 1901 section.
41	..	6	0	14+	Hard, strong, rather coarse-grained layer of limestone seen at creek level in No. 7, and in both banks of the creek for some distance down stream. It contains numerous pockets of calcite and an occasional small specimen of *Tetradium*.
40	..	5	10	..	Layers of limestone from two inches to 8 inches thick, with intercalated shale. *Rhynchotrema capax* large and abundant. *Platystrophia laticosta*, *Strophomena neglecta*.
30	..	4	10	..	Covered.
20	..	3	10	..	Mostly fairly even layers of limestone. Exposed in the south bank of the creek about a quarter of a mile east of the crossing of the Liberty pike. No. *5* of 1901 section.
10	..	2	9	..	About 200 feet up stream from the Liberty pike bridge. Mostly limestone (with shale partings). *Dinorthis subquadrata*, *Hebertella insculpta*, *Strophomena planumbona*.
1	..	1	1	..	Thick limestone layers exposed at creek level just above the Liberty pike bridge. *Plectambonites sericeus* (*aa*) occurs at creek level. No. *4* of 1901 section.

The base of this section is about 50 feet above the level of the Whitewater river at the mouth of Elkhorn creek. Occasional ex-

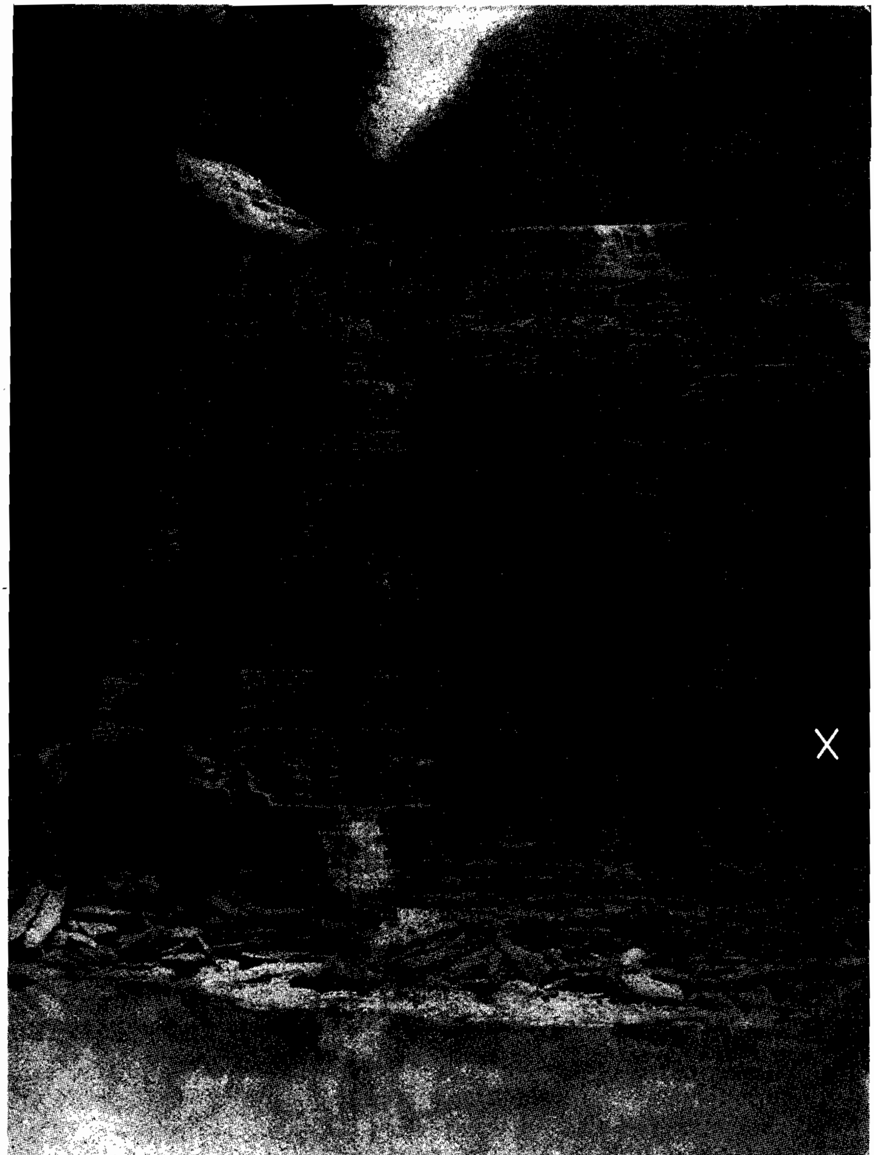

Fig. 8.—View of the cliff below the sewer at the west end of South G street, Richmond. This exposure shows the entire thickness of the Liberty beds. The *Plectambonites* layer is at X.

posures of rock occur throughout some 30 feet of this distance. *Plectambonites* occurs 25 feet below the base of this section.

Section on Small Western Tributary of Whitewater River, Four Miles Southwest of the Main Street Bridge, at Richmond. 1.41C.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
23	..	1	16	..	Very fossiliferous thin limestone and shale. *Plectambonites sericeus* (aaa), *Strophomena planumbona* (c), *Rhynchotrema capax* (c), *Strophomena neglecta, Dinorthis subquadrata, Platystrophia acutilirata* (r), *Rhombotrypa quadrata, Callopora subnodosa*, etc.
7	..	2	5	..	Limestone layers in creek bed just below No. 1. *Dinorthis subquadrata* (c), *Strophomena planumbona* (a), *Plectambonites sericeus* (rc), *Hebertella insculpta* (rr), *Crania laelia, Fenestella* sp., *Rhopalonaria venosa*, etc.
2	..	3	2	..	Limestone and shale. Same fauna as No. 2.

Section at the Quarries Just South of the Steel Highway Bridge, One and One-Half Miles South of the National Road, Richmond, and Along the River from the Bridge to the National Road. 1.41D.

No. 2 of this section is the basal member of the section.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
40	..	1	20	..	Quarries just south of the steel bridge, one mile south of the National road. Thin limestones and shale, with thicker beds at the top. *Rhynchotrema capax* (aaa), *Dinorthis subquadrata* (a), *Constellaria limitaris*, and *C. polystomella*.
20	..	2	20	..	Exposure in the east bank of the river at the mouth of a sewer nearly three-quarters of a mile south of the National road. The *Plectambonites sericeus* layer is here six feet above river level. This is the lowest exposure of the Richmond beds in the immediate vicinity of Richmond.

The fauna of 1.41D1 is as follows: *Dinorthis subquadrata* (a), *Rafinesquina alternata* (c), *Rhynchotrema capax* (aaa), *Zygospira modesta* (c), *Platystrophia acutilirata* (c), *Hebertella occidentalis* (rc), *Strophomena neglecta* (c), *S. planumbona* (c), *Streptelasma rusticum* (r), *S. divaricans* (rc), *Protarea vetusta* (c), *Dicranopora emacerata* (c), *Arthropora shafferi* (c), *Bythopora striata* (c), *B. delicatula* (rc), *B. meeki* (rc), *Batostoma varians* (rr), *Rhombotrypa quadrata* (aa), *Prasopora hospitalis* (rc), *Callopora subnodosa* (a), *Constellaria limitaris* (r), *C. poly-*

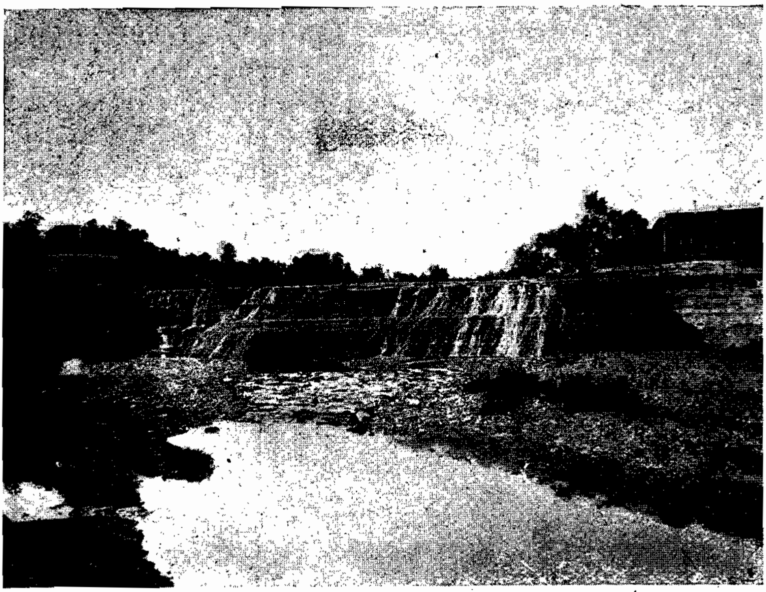

Fig. 9.—Thistlewaite Falls on West Fork, Richmond. *Rhynchotrema dentata* beds.

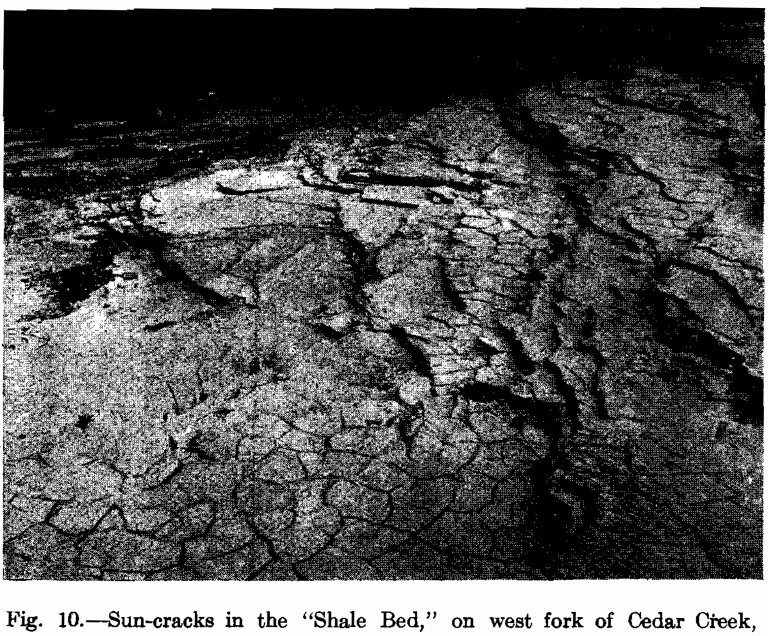

Fig. 10.—Sun-cracks in the "Shale Bed," on west fork of Cedar Creek, Versailles.

stomella, Homotrypella rustica (r), *Homotrypa flabellaris* (r), *H.* cf. *austini* (c), *Amplexopora* sp., *Ceramoporella ohioensis* (rr), *Proboscina frondosa, Calymmene callicephala* (rr), *Orthoceras* sp., *Pterinea demissa, Cyclonema* sp., *Byssonychia* sp., *Cornulites* sp. and several sp. of Ostracoda and Crinoids. This is the typical Liberty fauna.

The fauna of 1.41D2 is the same, with the addition of *Plectambonites sericeus* (aaa), *Strophomena subtenta, Fenestella* sp., *Helopora elegans,* and *Anomalodonta gigantea.*

Section Along the West Fork of Whitewater River at Richmond, Indiana. 1.41E.

In this section No. 1 is at the top of the section and No. 7 at the base.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
41	8	1	8	..	Exposures in the bank above Thistlewaite falls, on the west fork of Whitewater river, about one and one-quarter miles north of the National road bridge across Whitewater river. Thin, lumpy limestone. *Rhynchotrema dentata* (aa). Several species of Gastropods, including *Salpingostoma richmondense* (c), *Strophomena sulcata* (r).
33	8	2	10	..	Layers in the breast of the falls. Heavier layers at the top. Limestone. *Monticulipora epidermata* (c), *Platystrophia acutilirata* var., *senex* (c), *Homotrypa wortheni.*
23	8	3	5	..	West side of creek just below the falls. Bryozoa (aaa), *Monticulipora epidermata,* etc.
18	8	4	5	..	Just north of C., R. & M. R. R. bridge. Thin, shaly limestone. *Rhynchotrema capax,* highest specimens. *Plectambonites sericeus* (rr).
13	8	5	4	8	Just south of C., R. & M. R. R. bridge. *Rhynchotrema capax* (aa).
9	..	6	5	..	About one-eighth mile north of the road bridge across the west fork. *Ptilodictya plumaria,* etc.
4	..	7	4	..	A short distance north of the junction of the east and west forks of the river. Limestone and intercalated shale. *Callopora* very similar to *C. rugosa.* No specimens of *Rhynchotrema dentata.*

For the faunas of this section see the species chart.

Section Along the Whitewater River at Richmond, Indiana. 1.41D,E.

General Section.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
107	..	13	11	..	Same as No. 12. Contains *Rhynchotrema dentata.*
96	..	12	18	..	Nodular limestone and shale. Many of the layers are several inches thick and fairly continuous. *Rhynchotrema dentata* (*a*). These beds are seen along the top of the gorge from the National road to Thistlewaite falls, on the west fork of the river, about a mile northwest of Richmond. They form the falls and the exposures in the bank of the creek above the falls.
78	..	11	20	..	Soft, nodular limestone and shale exposed along the gorge from the quarries one mile south of Richmond to the falls. *Rhynchotrema dentata* occurs sparingly in the upper part of this zone. The characteristic fossils are: *Rhynchotrema capax* (except in the upper part), *Platystrophia acutilirata, Hebertella occidentalis, Monticulipora epidermata, Homotrypella rustica, Ptilodictya plumaria, Salpingostoma richmondensis.*
58	..	10	5	..	Same as No. 11. Forms the top layers of the quarries on the east side of the river one mile south of Richmond (at the steel bridge). Base of the so-called Whitewater division.
53	..	9	0	5	Firm, hard layer of limestone. This and the five divisions below are best seen at the quarries in the east bank of the river just south of the steel bridge, one mile south of Richmond.
52	5	8	1	..	Thick layer of hard limestone, separated from No. 9 by a parting of shale.
51	5	7	1	2	Shale and thin limestone.
50	3	6	2	3	Massive limestone layer that is sometimes seen in well weathered exposures to split into several thinner layers. Coarse grained and with occasional pockets of Calcite crystals. Fossils do not readily weather out.
48	..	5	0	5	Dark, soft, gritless shale, apparently somewhat carbonaceous.
47	6	4	1	..	Fairly firm layer of limestone that is seen on weathering to split into several layers. Nos. 4 to 9 probably represent the interval of the *shale bed* in the sections farther south, or the massive limestone layers associated with it.

Total Thickness. Ft.	In.	No.	Thickness of Bed. Ft.	In.	
46	6	3	40	..	Fairly even, compact layers of limestone from an inch or less to six or eight inches in thickness, with beds of intercalated shale. Some of the limestone layers are quite fine grained and barren, while others, especially toward the base, are coarser grained and very highly fossiliferous. Typical Liberty fauna. *Dinorthis subquadrata*, *Rhynchotrema capax* and *Strophomena planumbona* are the common brachiopods. *Plectambonites sericeus* occurs at the base. LIBERTY FORMATION.
6	6	2	0	6+	Strong layer of limestone containing *Plectambonites sericeus* in such abundance as to completely fill the top of the layer.
"	..	1	6	..	Very fossiliferous limestone with shale partings. *Plectambonites sericeus*, *Hebertella insculpta* and *Strophomena planumbona* are the common fossils. River level.

Nos. 1 and 2 are best exposed at the mouth of a sewer near the slaughter houses in the south edge of Richmond. No. 3 is also beautifully exposed here and along the gorge to the National road. No beds lower than the base of this section are shown in the near vicinity of Richmond.

DISCUSSION OF THE STRATIGRAPHY.

It has been seen that prior to the work of Messrs. Ulrich, Nickles and Foerste, and the writer, practically nothing definite was known regarding the detailed stratigraphy of the rocks of the Cincinnati series. In 1900 the writer published a portion of his field notes of that season and drew certain conclusions as to the faunal zones into which he proposed to divide this series of formations. These were as follows in the ascending order: *Dalmanella multisecta* zone, *Rafinesquina alternata* zone (or lower *Rafinesquina* zone), *Platystrophia* zone, *Rafinesquina fracta* zone, *Dalmanella meeki* zone, *Streptelasma* zone, *Strophomena* zone, and *Rhynchotrema capax* zone. Of these zones the further progress of the work has resulted in the definite retention of the first, third, fourth, fifth and seventh. The lower *rafinesquina* zone is a well characterized zone, as can readily be seen from a study of the faunas. It is perhaps better characterized by the abundance of *Callopora dalei* than of any other species. It is in part the Mount Hope or *Amplexopora septosa* beds of Nickles. I have found, however, that the *Platystrophia laticosta* comes in sparingly well down in this zone, and that on the lithological side it is characterized by a predomi-

Fig. 11.—Cut No. I, Tanner's Creek. Just south of Guilford station. Upper Eden shales.

Fig. 12.—Cut No. II, just north of Guilford. Upper Eden shales. Base of Lorraine at top of cut.

nance of limestone, although the shale element is greater than in the next zone. It has seemed best, therefore, to begin the *Platystrophia* zone with the setting in of the limestones and the small form of *P. laticosta*. This carries the base of the *Platystrophia* zone somewhat lower than in my former paper, and eliminates the lower *Rafinesquina* zone. The *Streptelasma* zone is not feasible, inasmuch it is now evident that this species (*S. rusticum*) is not restricted to any well characterized zone but is found in both the Liberty and Whitewater beds. The *Strophomena* (*planumbona*) zone is extended in harmony with the ideas of Nickles and Foerste to include all of the Liberty formation; and the *Rhynchotrema capax* zone gives way for reasons similar to those that apply in the case of the *Streptelasma* zone. *Rhynchotrema capax* zone might, however, be retained as a general designation of the Liberty and Whitewater divisions of the Richmond formation, to which this species is practically restricted.

Of the names that are retained in this report: The *Dalmanella multisecta* zone is a well marked and compact division, both lithologically and faunally. As will be seen from the sections 5.9A, 1.34C and 1.38A, this is the zone of predominant shale (the Utica or Eden shale of this and other reports). It is about 240 feet thick in Indiana. Nickles, as we have seen, has subdivided this zone on faunal grounds into three divisions, which he called the lower, middle and upper Utica, characterized by bryozoa, and these divisions have now received formation names (Economy, Southgate, McMicken). My study of the faunas of the lower division is not complete enough to warrant me in discussing the reality of this faunal division. The upper division is very well characterized, as long ago pointed out by Ulrich, by the great abundance of *Dekayia ulrichi*, and may well be called the *Dekayia ulrichi* zone. It is from 50 to 70 feet thick. Limestone layers are rather more numerous in this zone than in the lower portions of the *Dalmanella multisecta* zone, and the shale is somewhat lighter colored. The lithological facts are presented by the columnar sections drawn to scale, much better than is possible by description. (Sections 5.9A and 1.38A.)

The *Platystrophia* zone as the term is used in this report is the greater part of the Lorraine as it has generally been understood. It is about 100 feet thick, taking the base where the *Dalmanella multisecta* disappears and *Platystrophia laticosta* (small form) begins, and the top where the *Platystrophia lynx* and *P. laticosta* disappear. As I have remarked under the description of *P. lynx*, the gerontic (gibbous) form of that species that characterizes the

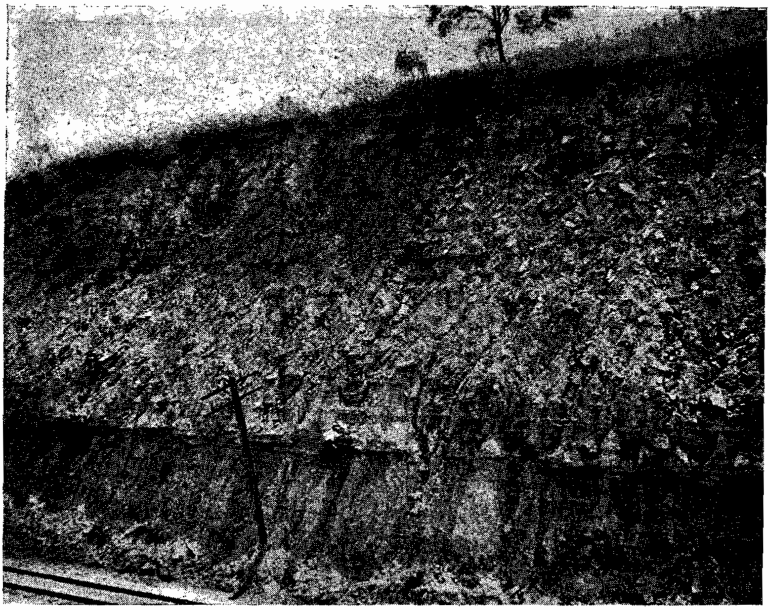

Fig. 13.—Cut No. V, Tanner's Creek. The man is standing at the base of the *Platistrophia* zone.

Fig. 14.—Cut No. VII, Tanner's Creek, showing the predominance of limestone in the typical Lorraine formation.

Mount Auburn beds of Nickles at Cincinnati and other places in Ohio is found very sparingly in Indiana, only an occasional specimen being see in a thin zone some 50 feet or more above the top of the *Platystrophia* zone, as the term is used in this report. That there is no bed of abundant specimens of this gerontic form of *P. lynx* in Indiana is a certainty. On Tanner's creek every inch of the Cincinnati series from the upper Eden shales to the top of the Liberty formation is now exposed in the railroad cuts, as can be seen from the profile published in the present report. Any such bed as caps the highest hills at Cincinnati could not possibly be overlooked. The normal form of *P. lynx* is present in considerable numbers in this section, though not by any means as abundant as in the Vevay section. At Madison and Clifty Creek, west of Madison, Indiana, the upper part of the *Platystrophia* zone is well exposed, and there is none but the normal, large form of the species. In section 1.12A every inch of the interval between the abundant occurrence of this normal form of *P. lynx* and the base of the *Dalmanella meeki* zone is exposed, and I have hunted the rocks with the greatest care without finding a single specimen of *P. lynx* in this interval. For Indiana, therefore, the gerontic *lynx* is not ordinarily available as a zone marker. The true top of the *Platystrophia* zone is where the normal *P. lynx* disappears. I may remark that on Straight Creek below Arnheim, Ohio, this horizon is some 60 or 80 feet below the point taken by Foerste as the base of the Arnheim division. It is true that in that section there is a thin bed of *Platystrophia lynx* at that elevation above what I should call the termination of the true *Platystrophia* zone (Bellevue beds). At the lower horizon on Straight Creek the *Platystrophia lynx* is present in immense numbers through a considerable thickness (50 feet) of rock, and is associated with *Hebertella sinuata*, as in the Indiana localities. This lower zone is, I am sure, the same as the zone of *Platystrophia lynx* at Vevay, Madison and elsewhere in Indiana. The *Platystrophia* zone is characterized lithologically by the predominance of limestone. In the lower part the layers are rather strong and hard, and have sometimes been quarried for foundations of houses, etc. The zone of these stronger limestone layers is the Hill Quarry beds of Orton. The upper part of the *Platystrophia* zone is characterized by thinner and more nodular limestone, especially where the *P. lynx* comes in abundantly. In the latter zone the rock is quite soft and shaly. This zone is capped by layers of hard, nearly barren limestone, in which the only common fossils are *Rafinesquina fracta* and *Cyclora minuta*.

The *Rafinesquina fracta* zone (upper *Rafinesquina* zone) or *Rafinesquina* zone, as I now propose to call it, is equivalent in part to the Arnheim formation. It is characterized throughout by the great abundance of *Rafinesquina alternata* (several varieties), and at several levels by immense numbers of *Zygospira modesta.* This latter feature can perhaps be best seen in section 1.12A. Practically this entire zone, and no others, is exposed in cuts Nos. X and XI on Tanner's Creek. On Tanner's Creek this zone is about 110 feet thick. In the Madison section (1.12A) the same zone is about 134 feet thick. Lithologically the zone is characterized by the predominance of shale, although the limestone layers are more frequent than in the Eden formation. Occasional thick, strong layers are present. It is in this zone, about 30 feet below the top, that the peculiar *Dinorthis retrorsa* occurs. Faunally the zone is marked by the coming in, toward the top, of a number of species that are characteristic of the Richmond formation—for example *Batostoma varians, Homotrypa flabellaris, Dalmanella meeki* (rare). At the same time it has a goodly number of Lorraine species at the bottom. The upper 60 feet of this zone is the Arnheim of Foerste. The lower 50 feet falls in the Corryville and Mt. Auburn of Nickles. In Indiana, however, the zone of gerontic *Platystropia lynx* is, as pointed out above, practically lacking, and the rocks from the top of the *Platystrophia* zone (of this report) to the base of the Waynesville form a unit both faunally and lithologically. If a faunal designation of the lower 50 feet is desired it might be called the *Callopora rugosa* zone. In Ohio this portion is said to be characterized by *Chiloporella flabellata.* The upper part of the *Rafinesquina* zone (Arnheim) is said by Nickles to be characterized by *Homotrypa bassleri.* According to present usage the line between the Richmond and Lorraine will fall at about the middle of the *Rafinesquina* zone. In cut No. X, on Tanner's Creek, a layer 6 inches to 10 inches in thickness, containing occasional specimens of the gerontic *Platystrophia lynx,* occurs eight and one-half feet above the level of the tracks at the north end of the cut. This layer I have taken as the equivalent of the Mt. Auburn of the Cincinnati section, and as, therefore, marking the boundary between the Lorraine and Richmond.

The *Dalmanella meeki* zone is the Waynesville division of the Richmond formation. It is an exceedingly homogeneous zone both faunally and Lithologically. *Dalmanella meeki* (or *Dalmanella jugosa*) is present throughout the zone, often in prodigious numbers. Other common fossils are *Bythopora meeki, B. delicatula,* *Eridotrypa simulatrix* (in the upper part), *Tentaculites richmondensis, Leptaena rhomboidalis* (near the top). At about the middle of the zone *Calymmene callicephala* is very abundant. This species is also found rather commonly in most of the layers of the zone. *Platystrophia laticosta* comes in abundantly near the top of this zone. All of these facts are well exhibited on the chart of the Tanner's Creek and Richmond sections. The zone is all beautifully exposed in the cuts on the new line of the Big Four Railroad along Tanner's Creek. Cut No. XIII exposes nearly the entire zone, and no others. The base of the zone may be seen in the small cut No. XII, just south of No. XIII, and the top may be studied in cuts Nos. XIII, XIV, XV, and XVI. Lithologically the zone consists of shale, for the most part, and thin, soft limestone layers, which are nearly always highly fossiliferous. Often the shells of *Dalmanella meeki* are present in immense numbers in the shale just under or over a layer of limestone. In such situations thousands of specimens of all stages of growth can be obtained perfectly free from the matrix. The bryozoa also are frequently found preserved in the same manner in the calcareous shale layers, and can then be obtained in great numbers and in the highest state of perfection.

This zone is not exposed at Richmond, but the extreme top of it may be seen near the mouth of Elkhorn Creek, four miles south of Richmond, and again about Abington, seven miles southwest of Richmond. It is well exposed along the north fork of Cedar Creek north of Versailles (1.60G), though here the base is not shown. In the high wash bank at the junction of the north and west forks of Cedar Creek (1.60I) the top of the zone is exposed, overlain by the base of the *Strophomena* zone. In the south cut at Madison, Indiana (1.12E), the lower part of the zone is exposed near the top of the cut. Here the zone is considerably thinner than in the Tanner's Creek section, namely, about 56 feet thick. It is extremely well exposed on Whitaker's Branch, along the line of the B. & O. S. W. R. R., between Cold Springs and Moore's Hill. In Ohio, the best localities are about Oregonia, Lebanon, and Oxford.

The *Strophomena* or *Strophomena planumbona* zone, as it may perhaps with greater propriety be called, is not as definitely characterized by that fossil as the zone just described is by the *Dalmanella meeki*. Several other species are present in equal or even greater strength; for example *Rhynchotrema capax, Bythopora meeki,* and *Rhombotrypa quadrata.* These latter species are not, however, restricted to the zone. The base of this zone is characterized by the presence of a number of brachiopods in enormous numbers. These are *Hebertella insculpta, Plectambonites sericeus, Leptaena rhomboidalis* and *Platystrophia laticosta,* the two last barely overlapping from the zone below. *Hebertella insculpta* is confined to about fifteen feet of rock and is abundant in only about the middle five feet of this. The first appearance of this species is taken by Foerste to mark the base of his Liberty formation. As will be seen from the chart of the Tanner's Creek section, this level is separated by only five feet from the horizon of the highest specimens of *Dalmanella meeki.* The *Strophomena planumbona* comes in exactly where *Damanella* leaves off, and *Rhynchotrema capax* comes in in the same layers with *Hebertella insculpta. Plectambonites sericeus* comes in in immense numbers in a wave-marked layer, about 18 feet above the top of the *Dalmanella meeki* zone (in the Tanner's Creek section). The occurrence of this species is perhaps more interesting than that of any others of the species in the zone. This species is not uncommon in the lower part of the *Dalmanella multisecta* zone. It is totally absent from the *Platystrophia* and *Rafinesquina* zones, and only a few specimens have been found in the *Dalmanella meeki* zone. It also occurs only very sparingly above the base of the *Strophomena planumbona* zone. An occasional specimen is seen in the Whitewater division. In the base of the *Strophomena* zone, however, the species is common through about fifteen feet of rock, and extremely abundant in several (sometimes only one) layers. It usually, in the sections seen by the writer, comes in in a wave-marked layer, six to ten inches thick. The top of this layer is usually so filled with the species that one can scarcely find a point on the rock that is not occuped by a specimen. The specimens are nearly always beautifully preserved, showing that they were not drifted, but apparently were imbedded where they grew.

This lower part of the *Strophomena* zone, characterized by the above-named abundant brachiopods, might very well be separated out as a distinct zone. *Leptaena rhomboidalis* extends nearly throughout it, and could give its name to the zone. A glance at the chart will show that with *Leptaena rhomboidalis* appear a considerable number of other species. Chief of these are *Platystrophia laticosta, Hebertella sinuata,* and *Rafinesquina loxorhytis,* which all have about the same range in this part of the section. Other species that appear or reappear at this same level are *Rhombotrypa quadrata, Prasopora hospitalis,* and *Dekayia pro-*

lifiica, all of which are common in this (*Leptaena*) zone, though extending beyond it. The *Leptaena* zone will also be found to be persistent in the Indiana region.

Faunally the *Strophomena planumbona* zone (Liberty beds) is thus seen to be pre-eminently a brachiopod zone, although other fossils are not wanting, and several of the bryozoa are abundant. It is also interesting for the number of species that represent recurrences of species that are known from lower zones. *Platystrophia laticosta* and *Hebertella sinuata* are Lorraine forms. *Leptaena rhomboidalis* occurs in the Trenton; *Plectambonites sericeus* in the Trenton and Eden formations. *Rhynchotrema capax* is apparently a lineal descendant of the Trenton *R. increbescens* (*R. inaequivalve*); and *Prasopora hospitalis,* considered by Nicholson as a variety of *P. selwynii* of the Trenton rocks, is at all events more suggestive of the Trenton faunas than of anything else.

On the Lithological side this zone is characterized by predominance of Limestone layers. Some of these layers attain a considerable thickeness (for the Cincinnati series), eight inches to a foot not being unusual. Especially toward the top of the zone the limestone layers are strong and frequently very fine-grained and barren of fossils. The most striking thing about the Liberty beds, next to their pronounced faunal characters, is the presence of these well-defined layers of Limestone, separated by comparatively thin layers of shale. In the southern part of the Indiana area the upper layers become more argillaceous, even slightly arenaceous, and contain very few fossils. This phase can be seen between Versailles and Madison.

Good exposures of this zone can be seen on Tanner's Creek, especially in the new railroad cuts (Nos. XVI and XVII); at the eighty-foot cliff on the west fork of Cedar Creek, north of Versailles; at the south end of the Big cut, at Madison; on Big and Little Sains Creeks near Laurel; along Elkhorn Creek south of Richmond; in the quarries and along the gorge south of Richmond (1.41D), and at the type locality near Liberty, Indiana.

The *Tetradium* zone or Saluda formation immediately succeeds the *Strophomena* zone, and presents the most peculiar set of lithological characters of any zone in the Cincinnati series. In the southern part of the Indiana region nearly all of the zone is argillaceous or arenaceous. The rock as it occurs at Madison and Hanover has been variously described as argillaceous limestone, arenaceous limestone, calcareous sandstone, calcareous shale, etc. As a matter of fact, even the most arenaceous portions of this rock will usually be found to contain more or less lime carbonate; and the more calcareous layers will usually contain more or less argillaceous or arenaceous material. The zone in this southern area presents every evidence of shore-line deposition. Not only the presence of the coarser terrigenous sediments, but the ripple marks and sun-cracks that abound in the more shaly layers, and the presence of reef-building corals (*Tetradium* and *Columnaria*) attest this fact. In the northern portion of the Indiana area, on the other hand, the *Tetradium* zone has been difficult to recognize, and as I shall now show has *not* heretofore been properly located in the Richmond section. In order to elucidate this point I have prepared a series of carefully measured sections from Madison on the south to Richmond on the north. These sections are plotted to scale in Pl. E. In the construction of this diagram the various sections are set up on the horizon of the lowest *Tetradium* reef which is a persistent layer in all of the sections. The sections are spaced out along the diagram to the true scale of miles, which is given on the heavy line that marks the horizon of the lower *Tetradium* reef. The vertical scale of the sections is of necessity much exaggerated, but is the same for all of the sections. This scale is given on the left margin of the Madison section.

Beginning now at Madison, the section will be seen to contain two layers characterized by *Columnaria alveolata,* separated from each other by an interval of about six feet of argillaceous rock. The upper one of these reefs, as can be seen from the sections farther north, is the horizon of *Tetradium,* which does not seem to occur at Madison. Seven feet above the upper *Columnaria* reef is the base of the thick bed of calcareous sandstone that forms the conspicuously overhanging layers in the Big cut and at the Hanging Rock, and in the Falls about Hanover. This bed in the Madison section is 18 feet thick, and is arenaceous throughout. At the top of this arenaceous bed and separating it from the more argillaceous and calcareous beds above is a hard, strong layer of limestone (best seen in the falls in a small gully just north of the Big cut). Between this limestone layer and the Clinton comes about twenty feet of drab, mottled, argillaceous limestone.

We have, then, at Madison, the coral reefs overlain by a massive bed of sandstone, and this in turn overlain by a bed of impure limestone. Now, if this series be traced northward, it will be seen that the *Columnaria* of the upper reef is replaced by *Tetradium;* the massive bed of calcareous sandstone becomes thinner and more argillaceous, and the upper bed of argillaceous limestone becomes thicker and more varied in character, so that a number of well-defined divisions can be made out. Even in section No. 2, only five miles north of Madison, these latter characters begin to appear. The comparison of these sections can be carried out sufficiently well on the diagram, so that detailed discussion of each section is unnecessary. In the Versailles section *Columnaria* is absent, but the *Tetradium* is present in great numbers through a thickness of about nine feet of rock, being especially abundant in the lower part of this interval. Above this *Tetradium* reef comes the "Shale bed" of this report. This, it will be seen, is the representative of the massive sandstone bed of the Madison section. In the Versailles section this "shale bed" is eight and one-half feet thick, and is overlain and underlain by a hard, thick, strong layer of limestone. Above this "shale bed" come 18 feet of mottled argillaceous limestone, practically unfossiliferous. This bed is overlain by five feet of massive, thick limestone, quarried here and at Osgood for road metal. Above this bed comes a zone of nodular, shaly, highly fossiliferous limestone—the upper fossil bed of this report. The fauna of this last zone is significant in containing among other species *Monticulipora epidermata* and *Homotrypa wortheni,* two of the characteristic species of the Whitewater division of the Richmond section. The most abundant brachiopod of this bed is *Platystrophia acutilirata senex,* another Whitewater species.

The characters of the "shale bed" as they are exhibited in the sections about Versailles must be carefully noted in order to appreciate the extreme usefulness of this stratum in making out the stratigraphy of the sections farther north. It consists of a very sharply defined stratum of hard, slabby, calcareous, drab shale, conspicuously ripple-marked and sun-cracked, and is always overlain and underlain by firm, thick layers of hard, barren limestone, which sometimes on prolonged weathering tend to split into laminae similar to those of the shale bed. Below this bed at an interval of a few feet comes the *Tetradium* reef, and below the latter, in some of the sections, a *Columnaria* reef. Thus is formed by the "shale bed" and its associates an unmistakable horizon.

Going farther north, the same features are presented at Osgood, in the bed of the stream along the old right-of-way east of that town. Here the *Columnaria* is very abundant and beautifully preserved. Still farther north (Section No. 8), two miles north of Osgood, the "shale bed" may be seen in the bed of a small western tributary of Laughery Creek, underlain by the usual associates, the *Tetradium* and *Columnaria* reefs. In this section there is also a *Tetradium* reef 11 feet above the "shale bed." A *Tetradium* layer is also present 15 feet above the "shale bed" in section No. 5, south of Versailles. Aside from the presence of this *upper Tetradium* reef in this section there is very little departure from the appearances presented in the Versailles section. About 23 feet above the shale bed in this section is the upper fossil bed, which here contains *Strophomena sulcata* and *Streptelasma divaricans,* two more of the characteristic fossils of the Whitewater division. This bed is separated from the Clinton by an interval of about 15 feet of apparently rather hard, barren limestone.

On West Laughery Creek, about a mile southwest of Ballstown, are numerous fine exposures of these beds. Section No. 9 is typical of these exposures. In this section the *Tetradium* reef, underlain by the *Columnaria* reef, is separated by an interval of 10 feet from the "shale bed." The latter is 6 feet 8 inches thick, and is overlain and underlain as usual by massive layers of limestone. The upper fossil bed is separated from the "shale bed" by about 23 feet of mottled limestone, and here again *Streptelasma divaricans* and *Strophomena sulcata* are common.

Two miles west of Hamburg, Franklin County, on a small western tributary of Big Salt Creek, occur exceptionally fine exposures of these beds. Here the entire interval from the "shale bed" to the Clinton is exposed. The "shale bed" is only two feet thick in this section, but between it and the upper massive layer of limestone is a stratum of three feet four inches of thin limestone layers, which undoubtedly is the calcareous representative of the upper part of the "shale bed." In this section the lower *Tetradium* reef is five feet below the "shale bed" and the upper *Tetradium* reef is 20 feet above the "shale bed." Fifteen feet above the upper *Tetradium* reef in a layer of blue, nodular, soft limestone, occur numerous typical examples of *Rhynchotrema dentata.* Associated with this species are *Monticulipora epidermata, Streptelasma divaricans, Strophomena sulcata,* and *Platystrophia acutilirata* var. *senex.* This, it will be seen, is a typical Whitewater fauna, *occurring 40 feet above the "shale bed."* It may be remarked in passing that the "shale bed" in this section in everything but its lessened thickness is perfectly typical and has all of the usual associates.

The next section of interest is five and one-half miles southwest of Laurel on a small western tributary of Big Salt Creek. In this section the two *Tetradium* reefs are present and are separated from each other by an interval of about 20 feet as in the preceding section. At the horizon of the shale bed in this section we have instead of the usual sun-cracked, slabby shale, four feet of thin limestone, overlain and underlain by the usual massive, hard, barren layers of limestone. In other words, the "shale bed" has become completely calcareous, owing to the constantly increasing distance from the shore line as we go northward. The associates are there in this case, but not the shale bed. From now on, therefore, we shall have to speak of the massive limestone bed, or "massive bed." The *Tetradium* occurs in the usual abundance in the lower part of this "massive bed." *Columnaria* is absent, as it is in all sections north of this one. In the other sections about Laurel the appearances are substantially as in the section just described, and can be sufficiently well made out in the diagram, and in the detailed descriptions of the sections. One point needs mention, namely, that in the sections on Big Sains Creek there is associated with the massive bed more or less black carbonaceous shale, of the same sort as that seen above the shale bed in the cut north of the station at Weisburg, and in association with the massive bed in the Richmond section, as will be pointed out presently. (See Figs. 7 and 16.)

East and north of Laurel, good sections are infrequent. On the headwaters of Big Duck Creek, three miles northeast of Laurel, there is, however, a very good section exposing nearly all of the layers from the *Plectambonites sericeus* stratum to the "massive bed." Here the "massive bed" is separated from the wave-marked *Plectambonites* layer by an interval of 50 feet, occupied by the typical rocks and fauna of the Liberty formation. The *Tetradium* is present in the usual abundance.

The next section is east of Whitewater River, about two and a half miles southeast of Quakertown, in Union County. Here the "massive bed" with the *Tetradium* is 45 feet above the *Plectambonites* layer.

At Liberty there is an excellent exposure of the beds named from that place, along a small stream emptying into Silver Creek about a mile west of the center of the city. The "massive bed" containing *Tetradium* is here also 45 feet above the *Plectambonites* layer.

The next section is the exceptionally fine series of exposures along Elkhorn Creek, four miles south of Richmond. In this section nearly every layer is exposed from the base of the Liberty beds to the Clinton limestone. Here, also, as in the sections just

Fig. 15.—Upper fossil bed on creek along "Right-of-way," east of Osgood, with a massive bed of limestone beneath.

Fig. 16.—Top of shale bed in Cut No. XVIII north of Weisburg station. The hammer rests on the *Tetradium* layer *a*. Just below this layer is the bed of black carbonaceous shale *b*, and below this the "shale bed" *c*.

described, is present, at an elevation of 40 feet above the *Plectambonites* layer, the "massive bed" of limestone containing *Tetradium.* Here, however, the *Tetradium* is rare and consists of small and imperfect specimens. About 40 feet above this massive bed is the base of the zone of *Rhynchotrema dentata.* The interval is here occupied by nodular limestone and shale in which there is a fauna chiefly characterized by the abundance of *Rhynchotrema capax* and *Platystrophia acutilirata.* Above the *Rhynchotrema dentata* zone, which is about 35 feet thick, come 15 feet of very soft blue shale, and above this 25 feet of blocky, argillaceous-calcareous shale, which is capped by six feet of hard, brown limestone. The latter stratum is separated from the Clinton by four feet of clay. This upper zone, between the top of the *Rhynchotrema dentata* zone and the Clinton, is characterized by the abundance of a variety of *Platystrophia lynx* (*P. lynx* var. *moritura*), and is named in this report the *Elkhorn* division of the Richmond series. Faunally it is to be known as the *moritura* zone. If we go back for a moment to the sections about Osgood, it will be seen that in the extreme top of these sections occurs a form of *Platystrophia lynx,* probably the same as that found in the Elkhorn division. In the section (1.64B) west of Hamburg there occurs directly underneath the Clinton a bed of dark-colored, coarse limestone, very similar to that in the upper part of the Elkhorn division at Richmond, and containing the same species, *Platystrophia moritura* and *Hebertella sinuata.* This association of species can also be seen in the sections west of Laurel (1.14F, etc.) in a similar limestone and at the same horizon. We evidently have here in the more southern sections the thinned representative of the Elkhorn division, as we have just seen that these sections contain a thinned representative of the Whitewater division.

In the section exposed along the Whitewater River at Richmond the "massive bed" is beautifully shown at the quarries near the Steel bridge, south of the city. Here no specimens of *Tetradium* were found after a prolonged search. The other characteristics of the bed are typical. One feature of this massive limestone bed (which in the great thickness of the layers itself is unusual for the Cincinnati group) that is seen in the more northern exposures is the presence of large pockets of calcite crystals. This feature is well shown at the quarries. Here, also, the dark carbonaceous shale is seen associated with the bed as in the Laurel and Weisburg sections. Taking this association of lithological characters in connection with the interval between this bed and the *Plectambonites* layer, and the fact that the bed can be traced almost continuously from the region of Hamburg and Laurel, where it is definitely and undeniably shown to be the same horizon as the "shale bed," and adding to this the fact that the fauna of the Whitewater occurs well above the "shale bed" at Hamburg, Osgood and Versailles, it seems to me certain that the massive bed of the Richmond section is the northern representative of the shale bed and the lower *Tetradium* reef.

What now is the general conclusion of this discussion of the stratigraphy of the *Tetradium* zone? First of all, as stated above, the "massive bed" of the Richmond section is the calcareous representative of the "shale bed" and the *Tetradium* reef. This bed has a total thickness at Richmond of about six feet. Second, the same zone in the Madison section is 30 feet thick (the shale bed plus the two coral reefs). Third, the mottled bed of the Madison section represents some portion of the Whitewater division, modified lithologically and faunally by proximity to the shore-line. Fourth, the rest of the Whitewater division and probably all of the Elkhorn division is lacking in the Madison section. This last conclusion carries with it the further conclusion that, fifth, there is an unconformity at the top of the Ordovicion system, and the Madison region was above water while these upper beds at Richmond were being deposited.

In regard to this last point, it may be said that the presence of an unconformity does not rest solely upon the facts presented above. Foerste has shown in his various papers on the Silurian rocks of Indiana that the Clinton varies greatly in thickness, being sometimes totally lacking; that it often contains fragments of Ordovician limestone, sometimes amounting to a veritable breccia; and that the surface of contact of the Ordovician and Silurian is far from uniform.

That the above interpretation of the facts shown by the sections of the upper part of the Cincinnati group is very different from past and current interpretations is very evident. To those who may be inclined to question my view of the subject I may say that the *facts* are mostly new; that our conclusions in regard to the stratigraphy of the Richmond series have heretofore been based upon very insufficient evidence; and that these sections presented and discussed in the present report are the first series of carefully measured sections of this series of rocks ever published.

GENERAL PROBLEMS.

The discussion of the stratigraphy of the Cincinnati rocks cannot be concluded without some mention of the exceedingly interesting general problems presented by both the lithological and faunal sequence represented in this series of deposits. No one who sees these rocks in the field can fail to be impressed first of all by the wonderful succession of thin argillaceous limestones and shales. Scarcely any of the limestone layers are pure; they nearly always contain more or less terrigenous material. On the other hand, most of the shale is more or less calcareous. The physical conditions suggested are those of a rather shallow epicontinental sea receiving fine silt from a low-lying land surface on which a moist climate afforded the conditions for rather complete chemical disintegration of the rocks.

The interminable succession of limestone and shale layers has ordinarily been looked upon as suggesting a continual, slow oscillation of the sea level up and down. While it may be necessary to call in this familiar process to account for some of the larger variations in the type of sediment, such, for example, as the change from predominant shale in the Eden to predominant limestone in the Lorraine; and back to shale in the lower Richmond; I am inclined to think that the possibilities in the way of alternative explanations of these changes in the type of sediment have not by any means been exhausted.

First of all, for the minuter alternation of calcareous and terrigenous sediments, I think we may look to climatic rather than to epeirogenic changes; and these climatic changes need not, it seems to me, be of great magnitude. It is well known that lime-secreting organisms, such as make up the faunas of the Cincinnati series (bryozoa, brachiopods, etc.), require, not deep, but merely clear water of the favorable temperature, and with the proper food supply. For such organisms an influx of even a small amount of mud is a prohibitive condition. It is then the cause of the alternation of comparatively clear and comparatively muddy water conditions that we seek; and it is precisely here that changes in climatic conditions—in the relative humidity—come in play. It is, of course, a well-known fact that the greater part of the silt supplied to the deltas of rivers is brought down during a comparatively small portion of the year, that is, there is an annual variation in the supply of silt. It is doubtful if this small-period fluctuation in the supply can be recognized in a geological formation.

It may account, as suggested by Gilbert, for some part of the lamination of shales. There are, however, certain more or less definite variations of longer period, in the amount of rainfall, such, for example, as the eleven-year and the thirty-six-year cycle. In addition to these there are still more pronounced climatic changes, of unknown cause, extending over long periods of time, which might account even for some of the larger variations in the type of sediment. It is thought that the variation in the amount of terrigenous sediment, necessary to produce the change from impure limestone to calcareous shale, is not necessarily very great. The influx of a small amount of mud may be sufficient to drive out such organisms as the *Trepostomata* and many of the *Brachiopoda* (some of the latter, for example *Rafinesquina alternata,* seem to have been able to accommodate themselves to a considerably increased supply of mud); and since this cuts off the supply of calcareous ooze, it acts in a two-fold way to cause the accumulation of a deposit of sediment comparatively free from lime. For, first, since the limestones of the Cincinnati series are in general impure, the indications are that *some* terrigenous material was accumulating over the sea bottom at all times, and if the usual supply of lime from lime-secreting organisms was for any reason cut off, there would arise, from this cause alone, a deposit of mud. What is needed, therefore, is a rather delicate adjustment of the majority of lime-secreting organisms to nearly clear water, and a relatively small variation in the climatic conditions on the land surface that is the source of supply of the silt. Both of these requirements find ample illustration, it seems to me, in present-day conditions.

Another cause of the interleaving of calcareous and terrigenous sediments that may legitimately be appealed to, I believe, is the shifting position and strength of currents, especially shore currents, undertow, and tidal currents; since it is these currents that are chiefly instrumental in distributing the sediments to various parts of the sea bottom. Now the rate and amount of change in the strength of shore currents and of the undertow, are dependent upon the varying strength of the wind. In time of great storms, comparatively coarse sediment may be carried out to considerable distances from land. We may very likely have in the occasional very thin layers of sandstone in the Eden shales an illustration of this last phenomenon. To what extent the varying strength of currents, due to the varying force of the wind, may have produced successive layers of shale and limestone, is a question that has not received the attention that it merits. It would seem to me that some of the thinner bands of shale intercalated with the limestone layers may have been due to this cause.

The shifting of the position and direction of currents is ordinarily due to changes in the contour of the coast line; and these may be brought about by erosion and deposition along the coast. Where the wind is variable in direction there is a continual shifting of the position and direction of shore currents from this cause. In some climates there is a seasonal change of the direction of the wind that may produce marked shifting of the position and direction of shore currents. Other changes of longer period may correspond to the long period climatic changes already mentioned. The changes in the direction, position and force of currents due to the causes enumerated above must direct the chief supply of silt, now to one part, and now to another part of the sea bottom. Probably only the longer period changes of this sort have had much to do with producing distinct beds of limestone and shale, for lime-secreting organisms could not gain a footing in a locality subject to very frequent influxes of muddy water. That the arrangement of the layers of shale and limestone in the Cincinnati series is not adverse to the above interpretation seems to me certain. Any measurement of two sections of the same stratigraphic interval in two nearby localities will always show considerable differences in the details, showing that the thinner beds are constantly pinching in and out. This indicates that the limestone was accumulating in patches over the sea bottom. While this may be due in part to the fact that organisms tend to live in colonies, it may also very possibly be due to the shifting about of the supply of terrigenous silt, in the manner above described. Another fact of frequent observation in the Cincinnati rocks that bears upon the same question is the evidence that many times great numbers of organisms were rather suddenly buried where they grew. The presence of immense numbers of perfectly preserved fossils along the plane of contact between a limestone and a shale stratum indicates this. Some more or less sudden increase in the supply of material, or change in the direction or force of the transporting agent is indicated. The presence of definite currents along the sea bottom is indicated by the rather common occurrence of immense numbers of flat shells, such as those of *Rafinesquina alternata,* arranged edgewise like the "shingle" along the bed of a stream; and a considerable agitation of the water, at times, is proved by the wave-marked layers of limestone that occur at several levels in the Cincinnati series. The latter may be due to storms of exceptional violence, or possibly to very exceptional oscillations of the water generated by earthquake shocks. Some of these wave-marked layers seem to have very wide extent, as, for example, the layer in which *Plectambonites sericeus* occurs so abundantly, near the base of the Liberty formation.

To sum up this discussion: There seems to be no necessity, in the case of the greater number of smaller alternations of shale and limestone in the Cincinnati rocks, to appeal to epeirogenic causes, as has ordinarily been done. These alternations may be explained by calling into play only the well-known processes that are going on on any sea bottom, not too deep or too far removed from the land. Even the larger variations in the type of sediment may be due to the larger variations in the same set of causes. Where a new fauna comes in suddenly, however, as in the base of the Liberty, we may probably look to epeirogenic readjustments to account for both the change in the fauna and the change in the type of sediment.

The problems presented by the faunal succession in the Cincinnati series are still more interesting than those presented by the lithological succession. In the paper by Nickles on the Geology of Cincinnati (*ante*), thirty-two species are listed, out of over 600 that occur in the Cincinnati region, as ranging throughout the Cincinnati series. For a thickness of 700 feet of rocks this is a surprisingly small number. If these species be examined, it will be seen that they also, for the most part, occur in the Trenton series, so that they represent a fauna inherited from the preceding epoch. It is interesting that only three of these widely ranging species are Bryozoa, and these three (*Stomatòpora arachnoïdea, S. delicatula* and *Ceramoporella ohioensis*) belong to the most primitive type of that class, showing the persistence of unspecialized types. A few other species that are present in the Trenton reappear here and there in the Cincinnati series but do not extend through it. Such, for example, are *Plectambonites sericeus, Platystrophia lynx, Leptaena rhomboidalis,* etc.; the first and last appearing in the Richmond formation where they are associated with a number of other species more or less closely related to Trenton forms (*Rhynchotrema capax, Dinorthis subquadrata, Streptelasma rusticum, Protarea vetusta, Prasopora hospitalis,* and a large number of Homotrypas, a genus that finds its fullest representation in the Trenton).

While, therefore, the aspect of the Cincinnati faunas is a constantly changing one, the changes seem to be due more to a rather quiet evolution within the area of the epicontinental sea occupied by these faunas, than to any pronounced irruptions of species from other provinces, if we except the influx of outsiders in the Richmond. Such facts as the reappearance of *Platystrophia lynx* in the Lorraine (it is quite lacking in the Eden) or the appearance of the large group of *Heterotrypidae* in the same formation, may be explained by the probability that these forms or their immediate ancestors were living in some portion of the same general province during Eden time. The family of Bryozoa mentioned has representatives in the Eden (*Dekayia ulrichi,* etc.) as well as in the Trenton. In the Lorraine it deployed into a large group of species, all of which are nearly enough related to represent an intra-provincial evolution. If we take another group of Bryozoa, the genus *Callopora,* which is also well represented in the Trenton, we find the Lorraine species related rather to the Eden than to the Trenton forms. *Callopora dalei* of the lower Lorraine is related to *C. communis* of the upper Eden and still more closely, probably intimately, to *C. nodulosa* of the Eden. *C. ramosa* again shows transitional forms to *C. dalei,* the latter being regarded as a variety of the former by Nicholson. Again *C. rugosa* of the upper Lorraine is an undoubted variety of *C. ramosa.* Another genus, *Amplexopora,* is represented in the upper Eden and lower Lorraine by the species *A. septosa,* and its variety *multispinosa.* Later are produced in the middle and upper Lorraine *A. cingulata* and *A. robusta,* both close relatives of *A. septosa;* and in the very top of the Lorraine, the species *A. pustulosa* (again closely related to *A. septosa*), the latter species extending on into the Richmond. The genus *Homotrypa* is represented in the Eden by a single species (or variety), *H. praecipta,* a variety of the common *H. curvata* of the Lorraine. The great deployment of these genera in the Lorraine seems to be sufficiently well explained by the more favorable conditions represented by the clearer waters of that epoch.

These favorable conditions of the Lorraine were terminated by an influx of muddy water, which gradually drove out the typical Lorraine fauna, and evidently was accompanied or perhaps produced by some more or less widespread epeirogenic disturbance. This gave us the fauna of the Waynesville, which was developed under similar conditions, and contains in some respects a similar group of species to the Eden. For example, *Dalmanella meeki* (or *jugosa*) takes the place of *D. multisecta* of the Eden, *Batostoma varians* is related rather closely to *B. jamesi* of the Eden, and *Bythopora delicatula* suggests *B. arctipora* of the Eden. There is also a small species of *Callopora* quite similar to *C. sigillaroides,* and what appears to be a species of *Dekayia* not unlike *D. ulrichi* of the Eden. In the upper part of the Waynesville the incursions of the outside species (*Leptaena rhomboidalis,* etc.) begin to be felt. One interesting fact connected with the basal member of the Richmond (Arnheim) is the presence, in a very thin zone, of the foreign species *Dinorthis retrorsa.*

The chief faunal fact of the Richmond is, as has been several times mentioned already, the coming in of a large number of species that find their nearest relatives in the Trenton series. Formerly it was quite the custom to refer these species to well-known Trenton forms. That this was a mistake has long ago been learned by the more careful studies of these faunas, which we owe to Mr. E. O. Ulrich more than to any other student of these rocks. The fact remains, nevertheless, that these species of the Liberty and Whitewater divisions of the Richmond find their nearest relatives, not in the Lorraine, but in the Trenton faunas. In my account of the Liberty formation, given above, I have brought out the leading facts bearing on this point. In the Richmond section the fauna of the Whitewater division succeeds that of the Liberty without break; but farther south in Indiana there is intercalated between these two divisions a coral reef and finally in the Madison region the Whitewater fauna is entirely lacking, the fossiliferous portion of the Richmond formation practically terminating at the base of the arenaceous Saluda beds. In the upper part of the Saluda beds in the Madison region and for a short distance northward, there is a meagre fauna (*Lophospira hammeli* and its associates). What portion of the sections farther north this zone corresponds to is not certainly known, but judging from the studies of Foerste, it should fall at about the level of my upper fossil bed (No. 11 of section 1.60H), and if this is the case, it may be a representative of some portion of the Whitewater division.

In the Richmond section there is also, as may readily be seen from the detailed section along Elkhorn Creek (1.41A), a very well-marked fauna above the Whitewater fauna, and separated from it by a band of nearly barren shale. This latter fauna is that of the *Platystrophia moritura* zone, or Elkhorn division of the Richmond. It is a very interesting fauna in that it presents a reappearance of a number of typical middle Lorraine species, as pointed out several years ago in my paper on the genus *Platystrophia*. Most interesting of these species are *Platystrophia lynx* var. *moritura* which differs very little from the large (normal) *lynx* of the top of the *Platystrophia* zone (Bellevue beds), and *Hebertella sinuata,* scarcely differing at all from the large Lorraine form. In addition to these two fossils the beds in question contain *Platystrophia laticosta,* and a *Callopora* not differing appreciably in external appearance from *C. ramosa.* On the other hand, they contain at least one form that is characteristic of the Whitewater beds, namely *Homotrypa wortheni,* and probably also the common Richmond bryozoan, *Prasopora hospitalis.* The return of these common Lorraine species of *Platystrophia* and *Hebertella* after an absence from nearly 400 feet of rock is certainly an interesting fact. It may point to the extermination of the extensive brachiopod fauna of the Liberty and Whitewater by the influx of terrigenous sediment at the beginning of the Elkhorn stage, thus leaving the field free, when the waters once again cleared, near the close of Richmond time, for the return of these old and long-lived inhabitants to their former haunts.

The presence of a coral reef separating the Liberty and Whitewater beds has already been mentioned. This zone of reef builders is best developed in the Madison region, probably because there the water was shallowest and the coast line near at hand. Tracing the coral zone northward, one of the genera, *Columnaria,* soon disappears but comes in again between Versailles and Hamburg, disappearing finally at the latter place. *Tetradium* can be traced north as shown further back, to Richmond, where it is very rare, and the specimens have the appearance of having been drifted. The presence of these corals is in line with the other evidences of the shoaling of the Richmond Sea, and the presence of a coast line not far southwest of the Madison region; a condition due, no doubt, to the culmination of the epeirogenic readjustment that had begun in Waynesville time, and had resulted, first in the lowering of some barrier, admitting an outside fauna, and finally, in Whitewater time, had probably brought the entire southern Indiana region out of water.

As to the bearing of these facts and interpretations upon other provinces, it seems to me, in the absence of equally detailed stratigraphic work in other places, to be rather too early to make any definite statements. The rocks called in this and other reports on the Cincinnati region, Lorraine, are, I am convinced, the homotaxial equivalents of the typical Lorraine of New York, or better, they are in large part equivalent. If this be true, and if the Richmond represents, as indicated above, a period of epeirogenic disturbance and readjustment, I think we are to look upon the Medina of New York as equivalent in part at least to the Richmond. Mr. Ulrich has already advanced this opinion, and I believe it will turn out to be correct. The Medina and Oneida represent the culmination of an elevatory movement and a readjustment of land and water relations that was undoubtedly widespread, and was followed by an equally widespread subsidence, that culminated in the limestone forming epoch of the Niagara. In the Indiana region there is no set of deposits that so well reprsents the culmination indicated by the Medina and Oneida sediments of the New York province as the later portions of the Richmond.

PART II: DESCRIPTION OF SPECIES.

COMPLETE LIST OF SPECIES REPORTED FROM THE CINCINNATI SERIES OF INDIANA, WITH THEIR HORIZON, SO FAR AS KNOWN.

CORALS AND SPONGES.

1. *Beatricea nodulata* Billings. See B. nodulosa Billings.
2. Beatricea nodulosa Billings. Saluda.

2a. Beatricea undulata Billings. Saluda.

3. Calapoecia cribriformis Nicholson. Lower Richmond.
4. Columnaria alveolata Goldfuss. Base of the Saluda.
5. *Columnaria inaequalis* Hall. Not a Cincinnati group species.
6. *Favistalla stellata* Hall. See Columnaria alveolata.
7. Labechia montifera Ulrich. Upper part of the Richmond formation.
8. Protarea vetusta Hall. Liberty and Whitewater divisions of the Richmond formation.
9. Strephochetus richmondensis Miller. Upper part of the Richmond formation. Whitewater.
10. *Streptelasma crassum* Hall. Not found in the Cincinnati group.
11. Streptelasma divaricans. Whitewater division of the Richmond formation.
12. *Streptelasma parvulum* Hall. Not a Cincinnati group species.
13. *Streptelasma radicans* Hall. Not a Cincinnati group species.
14. Streptelasma rusticum Billings. Liberty and Whitewater divisions of the Richmond formation.
15. *Stromatocerium richmondense* Miller. See Strephochetus richmondensis.
16. *Tetradium fibratum* Safford. The form that occurs in the Cincinnati group of Indiana is T. minus.
17. Tetradium minus Safford. Base of the Saluda and sparingly throughout the Saluda.

ECHINODERMATA.

18. Agelacrinus faberi Miller. Richmond formation.
19. Anomalocrinus incurvus Meek and Worthen. Richmond (?).
20. Dendrocrinus caesi Meek. Richmond.
21. Dendrocrinus polydactylus Shumard. Richmond.
22. Ectenocrinus simplex Hall. Richmond.
23. Glyptocrinus decadactylus Hall. Richmond (?).
24. Glyptocrinus dyeri Meek. Richmond.
25. Heterocrinus juvenis Hall. Lower Richmond.
26. *Idiocrinus subcrassus* Meek and Worthen. See Iocrinus subcrassus.
27. Iocrinus subcrassus Meek and Worthen. Lorraine. Richmond (?).
28. Lepadocrinus moorei Meek. Richmond.
29. Lepidodiscus faberi Miller. Richmond.
30. Lichenocrinus crateriformis Hall. Utica. Richmond (??).

31. Lichenocrinus dyeri Hall. Richmond.
32. Lichenocrinus pattersoni Miller. Richmond.
33. Lichenocrinus tuberculatus Miller. Richmond.
34. *Paleaster speciosa* Miller and Dyer. See paleasterina speciosa.
35. Paleaster wycoffi Miller and Gurley. Richmond.
36. Paleasterina speciosa Miller and Gurley. Richmond.
37. *Poteriocrinus casei* Meek. See Dendrocrinus casei.
38. *Poteriocrinites polydactylus* Shumard. See Dendrocrinus polydactylus.
39. *Protaster granuliferous* Meek. See Taeniaster granuliferous.
40. Urasterella grandis Meek. Richmond.
41. Taeniaster granuliferous Meek. Richmond.
42. Xenocrinus baeri Meek. Richmond.

BRACHIOPODA.

43. *Camarotoechia ventricosa* Hall. Not a Cincinnati group species.
44. Catazyga headi Billings. Richmond.
45. Crania laelia Hall. Liberty division of the Richmond formation.
46. *Crania reticularis* Miller. See Trematis reticularis.
47. Crania scabiosa Hall. Lorraine and Richmond.
48. Dalmanella emacerata Hall. Upper Eden shales.
49. Dalmanella meeki Miller. Waynesville. The characteristic fossil of this formation. (= D. jugosa James.)
50. Dalmanella multisecta Meek. Eden shales. The characteristic fossil of this formation.
51. Dinorthis retrorsa Salter. About the middle of the Arnheim.
52. Dinorthis subquadrata Hall. Middle portion of the Liberty.
53. *Hebertella borealis* Billings. Not a Cincinnati group fossil.
54. Hebertella insculpta Hall. Base of the Liberty beds. Characteristic fossil of this horizon.
55. Hebertella occidentalis Hall. Liberty and Whitewater divisions.
56. Hebertella sinuata Hall. Lorraine, Liberty, Whitewater and Elkhorn divisions.
57. Leptaena rhomboidalis Wilckens. Top of the Waynesville and base of the Liberty. Very common at this horizon.
58. *Leptaena transversalis* Wahlenberg. See Plectambonites transversalis.
59. Leptobolus lepis Hall. Lorraine.
60. Lingula covingtonensis Hall and Whitfield. Lower Eden.
61. *Orthis borealis* Billings. See Hebertella borealis.
62. *Orthis centrosa* Miller. See Platystrophia costata.
63. Orthis fissicosta Hall. Lorraine.
64. *Orthis tricenaria* Conrad. Not a Cincinnati group species.
65. Platystrophia acutilirata Conrad. Liberty and Whitewater divisions.
66. Platystrophia acutilrata var. senex Cumings. Upper part of the Whitewater division.
67. Platystrophia costata Pander. Lower Lorraine, and upper Eden (?).
68. Platystrophia lynx Eichwald. Lorraine. This is the characteristic fossil of the middle and upper part of this formation.

69. Platystrophia lynx var. laticosta Meek. Lorraine, Waynesville, Whitewater, Liberty and Elkhorn. The characteristic fossil of the lower and middle Lorraine.
70. Platystrophia lynx var. cypha James. Upper part of the Lorraine.
71. Platystrophia lynx var. moritura Cumings. Elkhorn division. This is the characteristic fossil of this division.
72. *Platystrophia unicostata.* See P. cypha.
74. Plectambonites sericeus Sowerby. Eden shales, Waynesville (rare), base of Liberty (very abundant), Whitewater (rare). This is one of the characteristic fossils of the base of the Liberty.
75. *Plectambonites transversalis* Wahlenberg. Not a Cincinnati group species.
76. Plectorthis ella Hall. Lorraine.
77. Plectorthis plicatella Hall. Lower Lorraine.
78. Plectorthis triplicatella Meek. Lower Lorraine.
79. Rafinesquina alternata Emmons. Throughout the Cincinnati group. Especially characteristic of the Arnheim.
80. *Rafinesquina alternata* var. *alternistriata.* Same as R. alternata.
81. Rafinesquina alternata var. fracta Meek. Top of Lorraine.
82. Rafinesquina alternata var. loxorhytis Meek. Top of Waynesville and base of Liberty.
83. Rafinesquina alternata var. nasuta Conrad. Upper Lorraine.
84. Rafinesquina alternata var. ponderosa Cumings. Upper Lorraine.
85. Retzia granulifera Meek. Upper Eden.
86. *Rhynchonella ventricosa.* Hall. See camarotoechia ventricosa.
87. Rhynchotrema capax Conrad. Liberty and Whitewater divisions.
88. Rhynchotrema dentata Hall. Liberty (very rare). Whitewater. This is the characteristic Brachiopod of the Whitewater division.
89. Schizocrania filosa Hall. Trenton to Lorraine.
90. *Streptorhynchus elongatum* James. See Strophomena planumbona.
91. *Streptorhynchus vetustum* James. See Strophomena vetusta.
92. *Strophomena incurvata* Shepard. Not a Cincinnati group species.
93. Strophomena neglecta Meek. Liberty and Whitewater divisions.
94. Strophomena planumbona Hall. Liberty (common), Whitewater. This is the characteristic brachiopod of the Liberty division.
95. Strophomena planoconvexa Hall. Lorraine.
96. Strophomena sinuata Meek. Lower Lorraine.
97. Strophomena subtenta Hall. Liberty.
98. Strophomena sulcata Verneuil. Top of the Liberty (rare). Whitewater division (common). This is one of the characteristic fossils of the Whitewater division.
99. *Strophomena tenuistriata* Sowerby. See Leptaena rhomboidalis.
100. Strophomena vetusta James. Lower Richmond (?). (See S. neglecta Meek.)
101. Trematis millepunctata Hall. Not common throughout the Cincinnati series.
102. Trematis reticularis Miller. Lorraine.
103. *Triplesia cuspidata* Hall. Not a Cincinnati group species.
104. Zygospira cincinnatiensis Meek. Upper and middle Eden shales.

105. Zygospira headi Billings. See Catazyga headi.
107. Zygospira modesta Hall. Throughout the Cincinnati group in nearly every layer of limestone.

BRYOZOA.

108. Amplexopora cingulata Ulrich. Middle and upper Lorraine.
109. Amplexopora multispinosa Cumings. Top of the Eden and base of the Lorraine.
110. Amplexopora petasiformis (Nicholson). Eden.
111. Amplexopora pustulosa Ulrich. Upper Lorraine and Lower Richmond.
112. Amplexopora robusta Ulrich. Middle Lorraine.
113. Amplexopora septosa (Ulrich). Lower Lorraine.
114. Arthropora cleavlandi (James). Upper Eden.
115. Arthropora shafferi (Meek). Lorraine and Richmond. A common fossil.
116. Arthrostylus tenuis (James). Upper Eden.
117. Atactoporella multigranosa (Ulrich). Lower and middle Lorraine.
118. Atactoporella mundula (Ulrich). Middle Lorraine.
119. Atactoporella newportensis Ulrich. Lower Eden.
120. Atactoporella ortoni (Nicholson). Middle Lorraine.
121. Atactoporella schucherti Ulrich. Lorraine and Richmond.
122. Batostoma implicatum (Nicholson). Middle and upper Eden. Common.
123. Batostoma jamesi (Nicholson). Middle and upper Eden.
124. Batostoma variabile Ulrich. Upper Richmond.
125. Batostoma varians (James). Arnheim, Waynesville and Liberty divisions of the Richmond. Common.
126. Bernicea primitiva Ulrich. Richmond.
127. Bythopora arctipora (Nicholson). Eden. Very common.
128. Bythopora delicatula (Nicholson). Richmond. Common.
129. Bythopora gracilis (Nicholson). Middle and upper Lorraine. Abundant.
130. Bythopora meeki (James). Waynesville, Liberty and Whitewater divisions of the Richmond. Common.
131. Bythopora striata Ulrich. Waynesville, Liberty and Whitewater divisions of the Richmond. Rare.
132. Callopora andrewsi (Nicholson). Upper Lorraine.
133. Callopora dalei (Edwards and Haime). Lower Lorraine. Very common.
134. Callopora frondosa Cumings. Whitewater division.
135. Callopora nodulosa (Nicholson). Upper Eden.
136. Callopora onealli (James). Lower Eden.
137. Callopora onealli communis (James). Upper Eden. Very abundant.
138. Callopora onealli sigillaroides (Nicholson). Eden. Common.
139. Callopora ramosa (d'Orbigny). Middle and upper Lorraine. Very common. A characteristic fossil of this part of the Lorraine.
140. Callopora ramosa rugosa (Edwards and Haime). Upper Lorraine. Common.
141. Callopora cf. ramosa. At several levels in the Richmond.

142. Callopora cf. rugosa. In the upper part of the Whitewater division.
143. Callopora subplana Ulrich. Lower Lorraine and upper Eden.
144. Callopora subnodosa Ulrich. Throughout the Richmond series. Common.
145. Calloporella circularis (James). Lower Richmond.
146. Ceramoporella distincta Ulrich. Eden.
147. Ceramoporella granulosa Ulrich. Eden and Lorraine.
148. Ceramoporella ohioensis (Nicholson). Throughout the Cincinnati series. Common.
149. Chiloporella flabellata Ulrich. Upper Lorraine.
150. Coeloclema alternatum (James). Middle and upper Eden.
151. *Coeloclema concentricum* (James). See C. commune Ulrich.
152. Coeloclema commune Ulrich. Eden.
153. Coeloclema oweni (James)*. Associated with the gerontic form of *Platystrophia lynx* in the upper part of the Lorraine.
154. Constellaria constellata (Vancleve) Dana. Lower Lorraine.
155. Constellaria constellata prominens Ulrich. Base of Lorraine.
156. Constellaria limitaris (Ulrich). Liberty division.
157. Constellaria polystomella Nicholson. Liberty and Whitewater divisions.
158. Dekayia appressa Ulrich. Upper Lorraine.
159. Dekayia aspera (Edwards and Haime). Lower and middle Lorraine.
160. Dekayia cystata Cumings. Middle Lorraine.
161. Dekayia frondosa (d'Orbigny). Lorraine.
162. Dekayia inflecta (Ulrich). Upper Lorraine.
163. Dekayia lobata Cumings. Middle Lorraine.
164. Dekayia magna Cumings. Middle Lorraine.
165. Dekayia obscura (Ulrich). Upper Eden.
166. Dekayia paupera (Ulrich). Upper Lorraine.
167. Dekayia pelliculata Ulrich. Upper Lorraine.
168. Dekayia prolifica (Ulrich). Waynesville, Liberty and Whitewater divisions of the Richmond. Especially abundant at the base of the liberty.
169. Dekayia subfrondosa Cumings. Lower Lorraine.
170. Dekayia subpulchella (Nicholson). Lower Lorraine. Whitewater (?).
171. Dekayia subramosa (Ulrich). Whitewater.
172. Dekayia ulrichi (Nicholson). Upper Eden. This is the characteristic fossil of the upper Eden.
173. Dekayia ulrichi robusta (Foord). Upper Eden.
174. Dicranopora emacerata (Nicholson). Lorraine and Richmond. Common.
175. Dicranopora fragilis (Billings). Lower Richmond (?).
176. Eridotrypa simulatrix (Ulrich). Waynesville and Liberty divisions of the Richmond.
177. Escharopora acuminata (James). Lower Eden.
178. Escharopora falciformis (Nicholson). Lower Lorraine.
179. Escharopora pavonia (Edwards and Haime). Lower Lorraine.
180. Fenestella granulosa Whitfield. Liberty and Whitewater divisions.

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*This species was collected on Tanner's creek, after the greater part of my manuscript had gone to the printer.

181. Graptodictya perelegans (Ulrich). Waynesville.
182. Helopora elegans Ulrich. Liberty, Whitewater.
183. Helopora harrisi James. Lower Richmond.
184. Homotrypa austini Bassler. Liberty, Whitewater.
185. Homotrypa communis Bassler. Waynesville. Common.
186. Homotrypa constellariformis Cumings. Saluda and Whitewater (at Versailles).
187. Homotrypa curvata Ulrich. Lower Lorraine (?), and upper Lorraine.
188. Homotrypa cylindrica Bassler. Whitewater.
189. Homotrypa dawsoni (Nicholson). Arnheim, Whitewater (rare).
190. Homotrypa flabellaris Ulrich. Liberty and Whitewater. Common.
191. Homotrypa flabellaris frondosa Cumings. Arnheim.
192. Homotrypa flabellaris spinifera Bassler. Whitewater.
193. Homotrypa nicklesi Bassler. Whitewater.
194. Homotrypa nitida Bassler. Upper Richmond.
195. Homotrypa obliqua Ulrich. Lorraine.
196. Homotrypa praecipta Bassler. Upper Utica and lower Lorraine.
197. Homotrypa ramulosa Bassler. Liberty, Whitewater.
198. Homotrypa wortheni (James). Whitewater and Elkhorn. Common.
199. Homotrypa wortheni prominens Bassler. Extreme upper part of the Liberty and Elkhorn.
200. Homotrypella rustica Ulrich. Whitewater. Common.
201. Leptotrypa calceola (Miller and Dyer). Lower Lorraine.
202. Leptotrypa clavacoidea (James). Upper Lorraine.
203. Leptotrypa discoidea (Nicholson). Upper Lorraine (?), lower Lorraine.
204. Monotrypella aequalis Ulrich. Lower and middle (?) Eden.
205. *Monotrypella quadrata* (Rominger). See Rhombotrypa quadrata.
206. *Monotrypella subquadrata* Ulrich. See Rhombotrypa subquadrata.
207. Monticulipora epidermata Ulrich and Bassler. Whitewater. This is one of the most abundant and characteristic bryozoa of the Whitewater beds at Richmond.
208. *Monticulipora irregularis* Ulrich. See Stigmatella irregularis.
209. Monticulipora mammulata d'Orbigny. Upper Lorraine. Common and characteristic.
210. *Monticulipora molesta* Nicholson. See M. mammulata.
211. Monticulipora parasitica Ulrich. Liberty and Whitewater divisions.
212. Nicholsonella vaupeli (Ulrich). Upper Lorraine and base of Liberty, and upper part of Whitewater.
213. Peronopora pavonia (d'Orbigny). Lorraine and Richmond.
214. *Peronopora decipiens* (Rominger). See P. pavonia.
215. Peronopora vera Nickles. Eden.
216. Petigopora asperula Ulrich. Middle and upper Lorraine.
217. Petigopora gregaria Ulrich. Upper Lorraine.
218. Petigopora petechialis (Nicholson). Lorraine, Richmond (?).
219. Prasopora hospitalis Nicholson. Throughout the Richmond. Common.
220. Proboscina auloporoides (Nicholson), Lorraine and Richmond.
221. Proboscina frondosa (Nicholson). Lorraine and Richmond.

222. Ptilodictya plumaria James. Whitewater.
223. Rhombotrypa crassimuralis (Ulrich). Upper part of the Whitewater.
224. Rhombotrypa quadrata (Rominger). Waynesville, Liberty and Whitewater divisions of the Richmond. A very common fossil.
225. Rhombotrypa subquadrata (Ulrich). Base of the Liberty (?).
226. Rhopalonaria venosa Ulrich. Upper part of the Waynesville and base of the Liberty.
227. Rhinidictya lata (Ulrich). Waynesville.
228. Rhinidictya parallela (James). Lower Eden.
229. Spatiopora maculosa Ulrich. Lower Lorraine.
230. Spatiopora tuberculata (Edwards and Haime). Lorraine and Richmond.
231. Stictoporella flexuosa (James). Lower and middle Eden.
232. Stigmatella clavis (Ulrich). Eden.
233. Stigmatella crenulata Ulrich and Bassler. Waynesville.
234. Stigmatella irregularis (Ulrich). Lower Lorraine. Not certainly known to occur in Indiana.
235. Stigmatella personata Ulrich and Bassler. Elkhorn.
236. Stigmatella spinosa Ulrich and Bassler. Upper Richmond.
237. Stomatopora arachnoidea (Hall). Eden, Lorraine and Richmond.
238. Stomatopora inflata (Hall). Eden, Lorraine and Richmond.

Gasteropoda and Pteropoda.

239. *Bellerophon bilobatus* Sowerby. See Protowarthia bilobata.
240. Bellerophon gorbyi Miller. Lorraine (?).
241. Bellerophon mohri Miller. Middle Richmond.
242. Bellerophon subangularis Ulrich. Middle Richmond.
243. Bucania crassa Ulrich. Uppermost beds of the Richmond.
244. *Bucania expansa* Hall. See Salpingostoma expansa.
245. Bucania simulatrix Ulrich. Whitewater.
246. Clathrospira subconica (Hall). Lorraine and Richmond.
247. Conradella dyeri (Hall). Richmond.
248. *Conradella dyeri cellulosa* Ulrich. Not found in the Cincinnati group.
249. Conularia formosa Miller and Dyer. Richmond.
250. Cyclonema bilix (Conrad). Richmond.
251. *Cyclonema bilix conicum* Miller. See C. bilix.
252. Cyclonema bilix fluctuatum (James). Richmond.
253. Cyclonema bilix humerosum Ulrich. Upper half of the Lorraine, and Richmond.
254. Cyclonema bilix mediale Ulrich. Lower half of the Lorraine. Common.
255. Cyclora minuta Hall. Lorraine and Richmond.
256. Cyclora parvula Hall. Richmond.
257. Cyclora pulcella Miller. Liberty.
258. *Cyrtolites dyeri* Hall. See Conradella dyeri.
259. *Cyrtolites inornatus* Hall. See Microceras inornatus.
260. *Cyrtolites magnus* Miller. See Oxydiscus magnus.
261. Cyrtolites ornatus Conrad. Lorraine and Richmond.
262. Helicotoma marginata Ulrich. Elkhorn.
263. Holopea hubbardi Miller. Saluda.

264. *Hormotoma bellicincta* (Hall). Not a Cincinnati group species.
265. Hormotoma gracilis (Hall). Utica. Probably does not occur in Indiana.
266. *Hormotoma trentonensis* Ulrich. Not a Cincinnati group species.
267. Hyolithes (?) dubius Miller and Faber. Richmond.
268. Hyolithes versaillesensis Miller and Faber. Richmond.
269. Liospira vitruvia (Billings). All divisions of the Cincinnati group.
270. Lophospira acuminata Ulrich. Middle Richmond.
271. Lophospira ampla Ulrich. Richmond.
272. Lophospira bicincta (Hall). Richmond.
273. Lophospira bowdeni (Safford). Lorraine.
273a. Lophospira hammeli (Miller). Saluda.
274. *Lophospira multigruma* (Miller). See Lophospira tropidophora.
275. Lophospira tropidophora (Meek). Whitewater.
276. *Lophospira ventricosa* (Hall). Not a Cincinnati group species.
277. Microceras inornatus Hall. Lorraine and Richmond.
278. *Murchisonia bellicincta* Hall. See Hormotoma bellicincta and H. trentonensis.
279. *Murchisonia gracilis* Hall. See Hormotoma gracilis.
280. *Murchisonia hammeli* Miller. See Lophospira hammeli.
281. *Murchisonia milleri* Hall. See Lophospira bicincta.
282. *Murchisonia multigruma* Miller. See Lophospira tropidophora.
283. *Murchisonia ventricosa* Hall. See Lophospira ventricosa.
284. Oxydiscus magnus (Miller). Richmond.
285. *Pleurotomaria subconica* Hall. See Clathrospira subconica.
286. *Pleurotomaria tropidophora* Meek. See Lophospira tropidophora.
287. *Protowarthia bilobatus* (Sowerby). Not an American species.
288. Protowarthia cancellata (Hall). Eden, Lorraine and Richmond.
289. Protowarthia subcompressa Ulrich. Lower Richmond.
290. Raphistoma richmondensis Ulrich. Middle Richmond.
291. *Salpingostoma expansa* (Hall). Not a Cincinnati group species.
292. Salpingostoma richmondensis Ulrich. Whitewater, upper part.
293. Schizolopha moorei Ulrich. Upper part of the Richmond. Whitewater.
294. *Tentaculites richmondensis* Miller. See Cornulites richmondensis.
295. *Tentaculites tenuistriatus* Meek and Worthen. See Cornulites tenuistriatus.
296. Trochonema madisonense Ulrich. Richmond.
297. Tryblidium indianense Miller. Richmond.
298. Tryblidium madisonense Miller. Richmond.

PELECYPODA.

299. Allonychia jamesi (Meek). Upper Lorraine.
300. *Ambonychia amygdalina* Hall. Not a Cincinnati group species.
301. *Ambonychia amygdaloidea*. See A. amygdalina Hall.
302. *Ambonychia bellistriata* Hall. Not found in the Cincinnati region. See Byssonychia radiata.
303. *Ambonychia carinata* (Goldfuss). Not an American species.
304. *Ambonychia costata* Meek. See Anomalodonta costata.
305. *Ambonychia jamesi* Meek. See Allonychia jamesi.

306. *Angellum cuneatum* Miller. See Cyrtodonta cuneata.
307. *Anodontopsis* (?) *milleri* Meek. See Orthodontiscus milleri.
308. *Anodontopsis* (?) *unionoides* Meek. See Ischyrodonta unionoides.
309. *Anomalodonta casei* Meek and Worthen. See Opisthoptera casei.
310. Anomalodonta costata Meek. Lower Richmond.
311. Anomalodonta gigantea Miller. Waynesville and Whitewater.
312. Byssonychia alveolata Ulrich. Upper Lorraine and lower Richmond.
313. Byssonychia grandis Ulrich. Lower Richmond, Whitewater (?).
314. Byssonychia obesa Ulrich. Whitewater.
315. Byssonychia praecursa Ulrich. Upper Lorraine.
316. Byssonychia radiata Hall. Eden, Lorraine and Richmond.
315. Byssonychia richmondensis Ulrich. Whitewater.
316. Byssonychia suberecta Ulrich. Lower and middle Richmond.
317. Byssonychia tenuistriata Ulrich. Richmond.
318. Clidophorus fabula Hall. Lorraine.
319. Clionychia excavata Ulrich. Richmond.
320. Ctenodonta cingulata Ulrich. Waynesville.
321. *Cycloconcha milleri* (Meek). See Orthodontiscus milleri.
322. Cymatonota typicalis Ulrich. Waynesville, Whitewater (?).
323. *Cypricardites sterlingensis* Meek and Worthen. See Whitella sterlingensis.
324. Cyrtodonta cuneata (Miller). Richmond.
325. Eridonychia crenata Ulrich. Whitewater (?), lower Richmond.
326. Ischyrodonta decipiens Ulrich. Whitewater.
327. Ischyrodonta elongata Ulrich. Middle Richmond.
328. Ischyrodonta miseneri Ulrich. Whitewater.
329. Ischyrodonta modioliformis Ulrich. Whitewater.
330. Ischyrodonta ovalis Ulrich. Middle Richmond.
331. Ischyrodonta truncata Ulrich. Middle Richmond.
332. Ischyrodonta unionoides (Meek). Lower Lorraine.
333. *Megaptera casei* Meek and Worthen. See Opisthoptera casei.
334. Modiolodon declivis Ulrich. Middle Richmond, Arnheim (?).
335. Modiolodon obtusus Ulrich. Lower Lorraine, Waynesville (?).
336. Modiolodon subovalis Ulrich. Richmond.
337. Modiolodon subrectus Ulrich. Richmond.
338. Modiolodon truncatus (Hall). Lorraine.
339. *Modiolopsis cincinnatiensis* Hall and Whitfield. See Whiteavesia cincinnatiensis.
340. Modiolopsis concentrica Hall and Whitfield. Waynesville.
341. *Modiolopsis modiolaris* Hall. See Modiolodon obtusus.
342. *Modiolopsis pholadiformis* Hall. See Whiteavesia pholadiformis.
343. Modiolopsis versaillesensis Miller. Waynesville (probably).
344. Opisthoptera casei (Meek and Worthen). Liberty, Whitewater, Elkhorn.
345. Opisthoptera obliqua Ulrich. Richmond.
346. Orthodesma canaliculatum Ulrich. Richmond.
347. *Orthodesma parallelum* (Hall). Not a Cincinnati group species.
348. Orthodesma rectum Hall and Whitfield. Lower Richmond.
349. Orthodesma subangulatum Ulrich. Richmond.
350. Orthodontiscus milleri Meek. Lower Richmond.

351. Ortonella hainesi (Miller). Whitewater.
352. Pterinea corrugata (James). Waynesville.
353. Pterinea demissa (Conrad). Lorraine and Richmond. A common fossil.
354. *Pterinea insueta* (Emmons). Very probably not a Cincinnati group species.
355. Rhitimya byrnesi Miller. Richmond.
356. Sedgwickia fragilis Meek. Lower Lorraine. May not occur in Indiana.
357. Sphenolium richmondense Miller. Middle Richmond.
358. Tellinomya hilli Miller. Saluda.
359. Whiteavesia cincinnatiensis (Hall and Whitfield). Lower Eden.
360. Whiteavesia pholadiformis (Hall). Richmond.
361. Whitella obliquata Ulrich. Lower Richmond.
362. *Whitella sterlingensis* (Meek and Worthen). Probably does not occur in Indiana.
363. Whitella umbonata Ulrich. Lower Richmond.

CEPHALOPODA.

364. Cyrtoceras amoenum Miller. Richmond.
365. *Cyrtoceras hallianum* d'Orbigny. Not a Cincinnati group species.
366. *Cyrtoceras lamellatum.* See C. lamellosum.
367. *Cyrtoceras lamellosum.* See C. hallianum.
368. Cyrtoeeras tenuiseptum Faber. Richmond.
369. Cyrtoceras thompsoni Miller. Upper Richmond (?).
370. *Endoceras approximatum* Hall. Not a Cincinnati species.
371. *Endoceras magniventrum* Hall. Not a Cincinnati species.
372. Endoceras proteiforme Hall. Throughout the Cincinnati group.
373. Gomphoceras indianensis Miller and Faber. Richmond.
374. Gyroceras baeri (Meek and Worthen). Middle Richmond.
375. *Ormoceras tenuifilum* Hall. Not a Cincinnati species.
376. Orthoceras bilineatum Hall. Richmond.
377. Orthoceras byrnesi Miller. Upper Lorraine.
378. Orthoceras carleyi Hall and Whitfield. Upper Lorraine (?).
379. Orthoceras duseri Hall and Whitfield. Lower Richmond.
380. Orthoceras gorbyi Miller. The horizon of this species is not known.
381. Orthoceras junceum Hall. Lower Eden. Probably does not occur in Indiana.
382. Orthoceras mohri Miller. Waynesville.
383. *Orthoceras spinale.* The identity of this species is not known. No such species is known from the Cincinnati group of Indiana.

CIRRIPEDIA.

384. *Plumulites jamesi* Meek. See Lepidocoleus jamesi.
385. *Turrilepas jamesi* (Meek). See Lepidocoleus jamesi.
385a. Lepidocoleus jamesi (Meek). Richmond. Probably also in the other divisions of the Cincinnati group.

OSTRACODA.

386. *Beyrichia chambersi* Miller. See Ceratopsis chambersi.
387. *Beyrichia hammeli* Miller and Faber. See Ctenobolina ciliata hammeli.
388. *Beyrichia oculifera* Hall. See Ceratopsis oculifera.
389. *Beyrichia striato-marginata* Miller. See Eurichilina striato-marginata.
390. Bollia pumila Ulrich. Richmond.
391. Ceratopsis chambersi (Miller). Eden. Richmond (?).
392. Ceratopsis chambersi robusta. Ulrich. Lower Richmond.
393. Ceratopsis oculifera (Hall). Lorraine.
394. Ctenobolina ciliata hammeli (Miller and Dyer). Arnheim.
395. Entomis madisonensis Ulrich. Saluda.
396. Eurychilina striato-marginata Miller. Saluda.
397. Leperditia caecigina Miller. Saluda.
398. Primitia cincinnatiensis (Miller). Richmond.
399. Primitia impressa Ulrich. Waynesville (?).
400. *Strepula quadrilirata simplex* Ulrich. See Tetradella quadrilirata simplex.
401. Tetradella quadrilirata (Hall and Whitfield). Lower Richmond.
402. Tetradella quadrilirata simplex Ulrich. Richmond.

TRILOBITA.

403. Acidaspis ceralepta (Anthony). Eden.
404. Acidaspis cincinnatiensis Meek. Eden, Lorraine.
405. Acidaspis crosotus James. Eden.
406. Calymmene callicephala Green. Eden, Lorraine and Richmond. A common fossil.
407. Ceraurus icarus (Billings). Whitewater.
408. Ceraurus pleurexanthemus Green. Lower Lorraine and base of Waynesville.
409. Dalmanites breviceps Hall. Waynesville.
410. Dalmanites callicephalus (Hall). Probably not found in the Cincinnati group.
411. Isotelus maximus Locke. Rather common in all divisions of the Cincinnati group.
412. *Isotelus gigas.* See I. maximus.
413. *Phacops callicephalus.* See Dalmanites callicephalus.
414. *Phacops gallicephalus.* See P. callicephalus.
415. Proetus spurlocki Meek. Lower Lorraine.
416. Trinucleus concentricus Eaton. Lower Eden.

ANNELIDA.

417. *Conchiolites conica.* See Cornulites flexuosus Hall.
418. Cornulites flexuosus (Hall). Throughout the Cincinnati group.
419. *Ortonia minuta.* See Cornulites minor.
420. Cornulites minor (Nicholson). Lower Lorraine.
421. Cornulites richmondensis (Miller). Waynesville.
422. Cornulites tenuistriatus (Meek and Worthen). Richmond.

SPONGES AND CORALS.

DIAGNOSES OF GENERA.

BEATRICEA Billings.

Cylindrical or angulated stems, often fluted and ranging in size to over ten feet in length and a foot in diameter. A central tube with cystose tabulae and a peripheral vesicular structure characterize the fossil. (Grabau).

CALAPOECIA Billings.

Corallum massive or branching. Corallites prismatic, polygonal, generally hexagonal. Tabulae numerous. Numerous short, well marked septa. Mural pores large, disposed in vertical rows between the septa. (Zittel).

COLUMNARIA Goldfuss.

Corallum massive, hemispheric, pyriform or irregularly spheroidal. Often of large size. Composed of prismatic or polygonal corallites, which radiate outward from the base of attachment. Walls of corallites not excessively thickened, and contiguous: corallites in contact throughout, except sometimes near their mouths. Walls imperforate. Septa well developed and lamellar, extending from the top to the bottom of the visceral chamber, not quite reaching to the center of the tube. A long and short series alternate with each other. Tabulae very numerous and well developed, complete and nearly horizontal, not placed at corresponding levels in contiguous tubes. (Nicholson.)

LABECHIA Milne-Edwards and Haime.

Corallum a laminar expansion, attached by a portion of the base, the remainder of the lower surface covered by a concentrically striated epitheca. Upper surface with rounded or elongate, solid tubercles, separated by an imperforate calcareous membrane. Internal structure consisting of a great number of cylindrical calcareous columns directed vertically upward from the basal epitheca, their upper ends forming the surface tubercles. Interspaces between the columns occupied by a series of lenticular vesicles with their convexities directed upward. (Nicholson.)

PROTAREA Milne-Edwards and Haime.

Encrusting. Cells simple, polygonal. Small sharp points at the angles of most of the calices. Calices shallow. Septa less trabecular than in most of the *Poritidae.* Toothed at the margin; the teeth nearest the center simulating a small columella. No pali. (Edwards and Haime.)

STREPTELASMA Hall.

Turbinate, often curved. Septa numerous, alternately long and short; the free edges of the longer septa twisted together in the center to form a pseudocolumella. Tabulae few or absent. Position of the principal septum is recognizable on the exterior by a system of pinnately diverging costal ridges. (Zittel.)

TETRADIUM Dana.

"*Coralla aggregata, tubulis cellisque quadrangulatis composita, septis parietibusve tenuissimis; cellis lamellis angustis* 4 *stellatis.*

"Coralla massive, consisting of 4-sided tubes, and cells with very thin septa or parietes; cells stellate, with 4 narrow lamellae.

"This genus is near Receptaculites, but differs in having very thin parietes, and four distinct rays within the cells, one to each side. The species answering to the description, is a fossil of uncertain locality, in the collections of Yale College, New Haven. The cells are about half a line in breadth. The name, from the Greek τετρας, *four,* alludes to the quadrate structure."—Dana, Zoophytes of the Wilkes Exploring Expedition, 1846, p. 701.

DESCRIPTION OF SPECIES.

BEATRICEA NODULOSA Billings.

Plate I, figs. 1a, 1b.

Beatricea nodulosa Billings, 1856. Geol. Surv. Canada, Rep. Progress for 1856 (1857), p. 344.

"*Description.*—The surface of this species is covered with oblong, oval, subtriangular projections from one to three lines in height, each terminating in a rounded blunt point which is nearer to one end of the prominence than the other. Some of the projections are six or seven lines in length at the base, and half as wide. Generally they are smaller, and often with a nearly circular base; the distance between them is from one to three lines. They exhibit in some specimens a tendency to an arrangement in rows following the length of the stem. In some instances these rows wind around the stem in spirals. In addition to these characters, the whole surface is fretted with minute points, and these when partially worn show a perforation in the centres.

"In a specimen three inches in diameter, the diameter of the central tube is three-quarters of an inch; the transverse septa are thin, very concave, and at distances from each other varying from one line to one inch.

"*Locality and formation.*—Anticosti, at Wreck Point, Salmon River and Battery Cliff. Lower Silurian."—Billings, *loc. cit.*

Saluda formation in Indiana.

BEATRICEA UNDULATA Billings.

Plate I, fig. 1.

Beatricea undulata Billings, 1856. Geol. Surv. Canada, Rep. Progress, for 1856 (1857), p. 344.

"*Description.*—The surface of this species is sulcated longitudinally by short, irregular, wave-like furrows from two lines to one inch across, according to the size of the specimen. In other respects it appears like *B. nodulosa.* The largest specimen is ten feet five inches in length, about eight inches in diameter at the large end, and six inches and a-half at the smaller extremity. Another short fragment is fourteen inches in diameter.

"All the specimens of both species are replaced by carbonate of lime, but show more or less perfectly the septate character of the central tube and the concentric arrangement of the layers of the stem. They are generally broken up into short pieces.

"*Locality and formation.*—Cape James, Table Head, two miles east of Gamache Bay, and numerous other localities in the Middle Silurian."—Billings, *loc. cit.*

Saluda formation in Indiana.

CALAPOECIA CRIBRIFORMIS (Nicholson).

Plate I, figs. 3-3b; Plate V, fig. 1.

Columnopora cribriformis Nicholson, 1874, Geol. Mag., N. S. decade II, vol. I, p. 253, fig. 1.

"*Spec. Char.*—Corallites for the most part hexagonal or pentagonal, averaging about one line and a half in diameter, sometimes more or less. Septa in the form of strong vertical ridges, from twenty to twenty-four in number, equally developed, never reaching the centre, or extending more than quite a short distance into the interior of the corallite. Between each pair of septa is a row of large oval or circular mural pores, so that there are from twenty to twenty-four rows of these openings in each corallite, generally about four on each face. Not only are the rows of pores thus extraordinarily numerous, but the pores are of unusually large size, and are placed close together, about three of them occupying the space of one line measured either vertically or transversely. The walls of the corallites thus assume a completely cribriform appearance, and look as if composed of a series of vertical pillars (the septa) united by horizontal cross-bars. Tabulae, in the specimens observed, imperfect, from three to four in one line.

"At first sight, especially when viewed from above, *Columnopora cribriformis* presents a striking resemblance to *Columnaria alveolata,* Goldfuss; the shape and size of the corallites being alike in both species. The specimens of *Columnaria alveolata* which are found in the Trenton limestone, so far as I have seen, have, also, short septa, in the form of strong ridges, which extend inwards for a very small distance; and this still further increases the resemblance just spoken of. In the latter species, however, the walls of the corallites are compact, and are not perforated by pores, and this of itself is a sufficient point of distinction. On the other hand, *Columnopora cribriformis* is distinguished from all the massive species of *Favosites,* both by the well-marked septa and by the large size and enormous number of the mural pores. From *Michelinia, C. cribriformis* is separated by the fact that the tabulae are certainly not vesicular, whilst the pores are much larger and more closely set than in any species of the former genus, and the septal system is at the same time much better developed. In the only specimens I have seen, the tabulae of *C. cribriformis* are poorly preserved, and nothing is left of them except their bases. This state of things, however, is quite commonly observable in specimens of *Columnaria* and *Favosites;* and I entertain no doubt but that the tabulae of the present form were really complete and in all respects well developed."—Nicholson, *loc. cit.*

This species is reported by Nicholson from the Cincinnati group, near Cincinnati, Ohio.

Nicholson has shown the calices in his figure, reproduced in this report, as considerably smaller than in the fine specimen which I figure. He says, however, in his description that in the size of the corallites the species does not differ from *Columnaria alveolata,* and in giving the dimensions of the corallites in another place he allows some latitude in this respect. The large specimen figured by me was found loose at Richmond, Indiana. I have also seen a small specimen from the Liberty formation on Tanner's Creek, Indiana, and another in the base of the Saluda on Cedar creek, near Versailles, Indiana. (1.34A15a.)

COLUMNARIA ALVEOLATA Goldfuss.

Plate I, figs. 4, 4a.

Columnaria alveolata Goldfuss, 1826, Petrefacta Germaniae, p. 72, pl. xxiv, figs. 7 a-c.=*Favistella stellata* Hall.

"*Columnaria hemispherica, tubis e basi radiantibus inaequalibus longitudinaliter striatis, lamellis stellarum remotis e centro radiantibus et marginalibus alternis.—Petrefactum calcarem e calcareo transitorio Americae septentrionalis.*"—Goldfuss. (The above description is taken from the second edition of the Petrefacta, 1862).

This is the form commonly known in the Ohio valley region as *Favistella stellata* Hall (1847) and shown by Nicholson to be the true *Columnaria alveolata* Goldfuss.*

Nicholson's very excellent description of *C. alveolata* is as follows:

"*Spec. Char.*—Corallum massive, subhemispheric, or pyriform, often attaining a very considerable size. Corallites prismatic, hexagonal or pentagonal, but often more or less drawn out along one axis, the larger ones being from rather less than two to over three lines in their long diameter, and having numerous smaller tubes interspersed amongst them. Walls of the corallites more or less amalgamated, the line of division between contiguous tubes still remaining quite distinct. Mural pores apparently wanting. Septa unequally developed, alternately large and small, the latter quite rudimentary, and the former extending usually across two-thirds of the distance between the wall and the axis of the visceral chamber, or even reaching the last-mentioned point. The septa are thin and flexuous, but completely lamellar, and the number of each series varies from about twelve to fifteen or more. Tabulae complete, horizontal, or somewhat flexuous, about six in the space of two lines. Calices polygonal, unequally-sized, moderately deep, with thin margins, usually closely contiguous, but sometimes sep-

*The form described by Hall from the Black River formation of New York as *C. alveolata* Goldfuss is not that species, and has been renamed *C. halli* by Nicholson, Paleozoic Tabulate Corals, 1879, p. 200.

arated by slight interspaces; the floor formed by the uppermost tabula, the surface of which is striated by the radiating septa.''—Nicholson, Paleozoic Tabulate Corals, 1879, p. 195, pl. x, figs. 1, 1a.

In the Richmond formation of Indiana this species marks one of the most persistent zones in the whole formation, namely the base of the Madison beds or Saluda formation (Foerste). Here the characteristic hemispherical heads occur in great numbers. The bed of the creek along the old right-of-way east of Osgood, is one of the best localities known to the writer, although they may be found in abundance at and about Madison. Between Versailles and Madison for a considerable interval, this coral is very rare, and its place seems to be taken by a very large species of *Tetradium*.

LABECHIA MONTIFERA Ulrich.

Plate I, figs. 2-2b.

Labechia montifera Ulrich, 1886, Contributions to American Paleontology, p. 33, pl. ii, figs. 9, 9a.

''This species forms large crusts, rarely more than 5 mm. in thickness, upon foreign bodies. (Usually species of *Orthoceras*.) The surface is undulating and elevated at intervals of 6 mm., more or less, into large conical monticules, the slopes of which are marked by irregularly intermittent, radiating ridges; the intervening spaces between the monticules is covered quite uniformly by numerous unequal small granular eminences, of which about ten occur in 5 mm.; sections prove these to be the projecting ends of vertical pillars. In transverse sections * * * the pillars are of an irregularly stellate form; their size is variable, but those occupying the monticules are always the largest. The intermediate spaces are crossed by a variable number of faint, curved lines, representing the cut edges of lenticular vesicles which occupy the space between the pillars. In vertical sections * * * the pillars are seen to be rather unequal, and separated from each other by a loosely-woven vesicular tissue. The vesicles vary much in size, but are disposed to arrange themselves in obscure layers.

''It is possible that this species ought not to be considered as congeneric with *L. conferta*, E. and H. (the type of the genus) as the differences between them may be of greater importance than I now believe them to be. In transverse sections of *L. conferta*, the vertical pillars appear as simple, round columns, and look quite different from the irregularly stellate section presented by the pillars of *L. montifera*. Another but less important difference is found in the different habits of growth. Thus *L. montifera* is an encrusting form, while *L. conferta* grows into free laminar expansions, covered on the lower side by a concentrically striated epitheca. Another species, forming masses as much as one foot in length, is not uncommon in the upper part of the Cincinnati group at Clarksville, O., and other localities. Specimens of *L. montifera* are rather rare at the same horizon. The specimen figured was collected at Madison, Indiana."—Ulrich, *loc. cit.*

I have seen a number of good specimens of this species in the upper part of the Richmond formation (Saluda) in the vicinity of Osgood, Indiana. One very fine specimen, completely covering the conch of an *Orthoceras,* firmly imbedded in the rock of a creek bed about four miles northeast of that place, was seen, at a horizon a little below the base of the Saluda. The other specimens seen were about twelve feet above the base of the Saluda. Ulrich does not give the horizon of the type, but doubtless it came from a similar level.

PROTAREA VETUSTA Hall.

Plate I, fig. 5.

Porites ? vetusta Hall, 1847, Pal. New York, vol. I, p. 71, pl. xxv, figs. 5 a-b.

"A subhemispheric coral, composed of irregular concentric laminae; cells vertical to the laminae; openings upon the surface, nearly circular, with internal vertical lamellae which reach half way to the centre.

"To some extent, this specimen presents the character of PORITES, in a great degree of perfection. The surface of the specimen being weathered, the radiating lamellae are often obliterated. The centre of the cells are also destitute (perhaps from weathering) of the fine elevated points characteristic of some recent species of PORITES.

"This is the only species known to me in the lower term of our system, which presents, in any degree of perfection, the characters of recent PORITES."—Hall, *loc. cit.*

The diameter of the calices of Hall's species is not stated in the above description. As measured on his figure in the Paleontology of New York, the average is rather less than a millimetre. In the specimen figured by me the diameter of the calices averages rather over one millimetre, in many instances one and one-half. The diameter of the calices of *P. verneuili* E. and H. is stated to be about three millimetres. No figure of the latter is given, and the description is very meagre, but the size of the calices would seem to me to preclude the possibility of our species being the same. Whether the common Richmond form is to be referred to Hall's species or not, does not seem to me to be a question to decide on the basis of so slight a variation in the size of the calices as I have indicated above. It can be settled only by a careful comparison of the Richmond and Trenton forms point by point. For the present, therefore, I prefer to refer the Richmond form, as has heretofore been done, to the species *P. vetusta.*

1.34A13a, 13b, 14a, 16, 17, 18, 19, 20, 22....1.41A4, 6, 7, 8, C1, 2, 3, D1, 2, 3, E1, 2, 3, 4, 5....1.12F3.

A study of these localities shows that the species is restricted to the Liberty and Whitewater divisions of the Richmond formation.

STREPHOCHETUS RICHMONDENSIS Miller.

Plate II, figs. 3-3b.

Stromatocerium richmondense Miller, 1882, Jour. Cincinnati Soc. Nat. Hist., vol. v, p. 41, pl. ii, fig. 1-1b.

"This is a small, globular or spheroidal sponge, consisting of numerous, irregularly concentric, more or less wrinkled, calcareous laminae, separated by interlaminar spaces, filled with minute cortical tubes. It is destitute of the larger orifices and canals that usually occur in *Stromatopora,* and I have been unable to ascertain that the concentric laminae are perforated by canals; they are apparently more dense than the intervening spaces, but it is not supposed that they constituted a barrier to the circulation. The sponge appears to consist of minute tubes radiating from a central point, in all directions; these are cut short by a laminar covering, which forms a basis for the minute radiating tubes to spread in all directions, from its outer surface, until they are likewise arrested by another covering, which, in turn, forms the basis for radiating tubes, and so on to the 10th or 15th covering. These coverings appear in cut and weathered specimens as irregularly concentric laminae. In magnified sections it shows an apparent vesicular structure, but no spicules have been determined. I have referred the species to *Stromatocerium* because it agrees with that genus in its general texture, and seems to be destitute of the larger canals and superficial openings that characterize the genus *Stromatopora.*

"It occurs in great abundance, in some of the rocky strata, in the upper part of the Hudson River group, at Richmond, Ind.

Dr. John T. Plummer, in a communication to the *American Journal of Science,* many years ago, called the specimens 'pisolitic balls embedded in the solid rock.' He said these pisolitic strata vary from two to ten feet in depth, and are frequently found blended with the marlite. However, I did not find them in such massive strata, but there are some layers of rock about three or four inches in thickness, largely made up of specimens of this little sponge, that may be found on the high ground immediately above the railroad bridge, in the northern part of the city. It is found at other places, in that locality, and may be regarded as a common species." —Miller, *loc. cit.*

This species occurs at Richmond in the upper part of the Whitewater division.

STREPTELASMA DIVARICANS Nicholson.

Plate I, figs. 6, 6a.

Palaeophyllum divaricans Nicholson, 1875, Pal. Ohio, II, p. 220 pl. xxii, figs. 10, 10b.

"Corallum usually free, sometimes apparently attached, compound, formed of conical, turbinate corallites, which are produced by lateral gemmation, or rarely by fission, and which are directed outward from the parent, usually at a more or less open angle, and are never in actual contact with one another[?]. The number of corallites in the corallum, so far as observed, varies from two to six. Septa from fifty-eight to sixty-two, alternately large and small, the large ones becoming twisted as they approach the center of the visceral chamber, where they unite with one another laterally, and form a more or less developed central mass of vesicular tissue [pseudocolumella]. No dissepiments or columella. Tabulae unknown. Wall with a well-developed epitheca, with longitudinal ridges corresponding with the septa within, and also with faint encircling striae and a few shallow annulations of growth. Calice deep, with a flattened space at the bottom. Free edges of the septa not furnished with spines or denticulations. Apparently no fossette.

"The best preserved specimen which came under my notice consists of two corallites, one budded from the side of the other at nearly right angles. The largest corallite has a length of nearly ten lines, a diameter of calice of seven lines, and a depth of calice of four lines. Another specimen consists of six nearly equally sized corallites, apparently produced by parietal gemmation, and having a length of five or six lines, and a diameter at the calice of about five lines. Another specimen consists of two large corallites which appear to have been produced by fission, being attached only by their pointed bases, and being nearly in contact with one another. The length of the largest of these corallites is more than an inch and a half, and its diameter at the calice is ten lines. Another specimen, precisely similar in its mode of growth, is attached to the dorsal valve of *Rhynchonella dentata,* Hall, the length of the largest corallite being only three lines, and the diameter of the calice the same.

"The specimens from which the above description was taken in most respects closely resemble *Streptelasma corniculum,* Hall, especially as concerns their twisted septa; but they possess a much smaller number of septa (if specimens of the same size be compared), and they are always rendered composite by the production of lateral buds or by cleavage.

"With *Palaeophyllum rugosum,* Billings, the present species cannot be confounded for a moment, the former constituting large masses of scarcely separate corallites, which vary from one to six lines in diameter." Nicholson, *loc. cit.*

The types are said to be from the Cincinnati group, Cincinnati, Ohio. This is certainly in error. The species is strictly a Richmond form, and I have not seen it except in the upper part of the latter formation. In the Whitewater division at Richmond it is common, and at other localities where beds of this age are exposed I have collected the species, especially in the vicinity of Laurel, Indiana. It is quite constantly associated with *Rhynchotrema dentata.* In the description above, the fact is mentioned that one of the specimens was attached to the valve of *R. dentata.* This species may accordingly be taken as one of the markers of the Whitewater division of the Richmond formation. Its range is by no means as great as that of *Streptelasma rusticum.*

1.41A4, 5, 6, 7, 8, C2-3, D1, 2, 3, E4, 5, 6 and the localities mentioned above. I have a number of specimens from Tanner's Creek that are probably referable to this species. They come from the upper part of the Liberty formation.

STREPTELASMA RUSTICUM (Billings).

Plate II, figs. 2-2b.

Petraia rustica Billings, 1858, Geological Survey of Canada, Report of Progress for 1857, p. 168 (not figured).

"*Description.*—Straight or slightly curved, covered with a strong epitheca, which is more or less annulated with broad, shallow undulations; radiating septa about one hundred or usually a little more; much confused in the centre, where they form a vesicular mass [pseudocolumella]; every alternate septum much smaller than the others, only half the whole number reaching the centre. Length from two inches and a half to three inches and a half. Diameter of cup one inch to one inch and a half; depth of cup half an inch or somewhat more.

"This species appears to be the same as that described by Edwards and Haime under the name of *Streptelasma corniculum*. The true *S. corniculum* of Mr. Hall is a very different species, being always shorter and much curved."—Billings, *loc. cit.*

This species is reported by Billings from the Hudson River (Cincinnati) group of Canada; and there is very little doubt that it is specifically identical with the very common form of the Richmond of Indiana and Ohio. Several other species of *Streptelasma* have from time to time been reported as occurring in the Cincinnati rocks, but it seems certain that aside from *S. divaricans* this is the only species to be accredited to these rocks in the Cincinnati region.

This species has ordinarily been reported as occurring throughout the Richmond formation, but I have not found it in the Waynesville or Arnheim members of that formation. It is especially characteristic of the Liberty and Whitewater divisions. It is generally absent in the Saluda and Elkhorn divisions.

1.34A11, 12, 13a, 14a, 15a, 15b, 16, 17, 18, 19, 20, 21.... 1.41A4, 5, 6, 7, 8....1.41D1, 2, 3....1.41C1, 2-3....1.41E1, 2, 3, 4, 5, 6....1.12D1-6, E3, F3.

TETRADIUM MINUS Safford.

Plate II, figs. 1-1c.

Tetradium minus Safford, 1838, Am. Jour. Sci., 2d ser., vol. XXII, p. 238. (Not figured.)

"We include in this species massive specimens (generally small), the tubes of which are only from one-fourth to one-third of a line in breadth. The tubes in some specimens are quite regular, in others, though generally four-sided, are more or less irregular and have the aspect on the upper surface of Chaetetes. Lamellae as in T. fibratum."—Safford, *loc. cit.*

The specimens of this species seen in the Richmond formation are often of great size, one measured by the writer being nearly five feet in diameter. It characterizes very strictly the Saluda division of the Richmond, and is especially abundant and persistent at the base of this division, where it is often associated with *Columnaria alveolata*.

ECHINODERMATA.

DIAGNOSES OF GENERA.

ANOMALOCRINUS Meek and Worthen.

Revised by Wachsmuth and Springer.

General form depressed, calyx comparatively large, rather shallow, subglobose; arrangement of plates extremely irregular, scarcely two plates being of equal size. Basals five, small, subequal, partly hidden by the column. Radials irregular, all differing in size and form, simple or compound, sometimes divided vertically. The left antero-dorsal radial is compound, composed of two pieces; that of the opposite side and the anterior radial are simple. The left postero-lateral radial is the largest plate in the calyx, and either simple or bisected vertically, composed of two nearly equal parts. The lower segment of the left antero-lateral is subquadrangular, the angle along the baso-radial suture being so obtuse as to form almost a straight line; upper side truncate and slightly convex. The upper segment is irregularly hexagonal, truncate above and below, much wider at the lower than the upper side, widest across the lateral angles. The two together have almost the dimensions of the single radials, but, in place of being wider than high, they are higher than wide, with a narrow concavity for the reception of the brachials. The fifth radial—the right postero-lateral one—rests against the truncate upper side of a large azygous plate, and as this stands in line with, and has nearly the form and proportions of the lower section of the compound radial, and the radial plate the form of its upper segment, the two appear in the specimen as forming jointly another compound radial.

There is also among the rays a great diversity in the number of brachials, and this gives to the specimen that abnormal, irregular outline which is so characteristic of the genus. Some of the rays have two, others three brachials, while the right posterior ray has generally four or more.

Arms long, bifurcating at regular intervals, widely divergent, rather stout at their origin; tapering upward. They are composed of a succession of rather long, quadrangular pieces, interrupted only by the axillaries which are pentangular, and which divide the main arm, and each division of the arm, into two equal parts. The pinnules are slender, composed of long pieces, given off from every arm joint, but at one side only in succession—not alternately—until the next bifurcation of the arm, when on both divisions they all change to the opposite side. By this arrangement there are always 8 to 10 pinnules in succession, first on one side, then on the other. The first pinnule occurs on the second arm plate, not on the first, but every succeeding plate is pinnulated with the exception of the bifurcating ones. The proximal pinnule after each bifurcation is considerably heavier and longer, almost arm-like, and bifurcating, the others are simple. The arm furrows are shallow but wide, only one side having sockets for the reception of pinnules.

The ventral sac is tubular, and rests upon the left side of the posterior radial as in the Heterocrinidae. The proximal plate of the tube is large, subquadrangular, and is succeeded by other apparently large pieces. Of the plates on the ventral side little is known.

Column very large, almost circular, pentapartite, highly ornamented; central canal large, star-shaped, the projections located interradially. The structure of the column along the axial canal resembles that of *Barycrinus,* and *Vasocrinus,* with which *Anomalocrinus* agrees also in the form of the calyx. (Wachsmuth and Springer.)

DENDROCRINUS Hall.

General form of the crinoid elongate and slender. Calyx obconical, higher than wide, unsymmetrical. Underbasals five, similar in form, scarcely of medium size, but extending beyond the column. Basals five, the largest plates in the calyx; four of them equal, hexagonal, the fifth or posterior one heptagonal, truncate above for the support of a large anal plate. Radials alternating with the basals all around, simple in four of the rays, pentagonal and of about equal size. The right posterior radial is compound, divided by a horizontal suture into two halves, which taken together, have about the form of the simple plates, only slightly longer. Brachials two to five, some long and narrow and others short and wide. Anals one, subquadrangular. Arms long, branching; ambulacral furrow deep. Pinnulae wanting. Dome unknown. Ventral sac strongly developed, composed of numerous small, hexagonal, alternately interlocking plates of equal size, strengthened by little transverse or slightly oblique costae, and so arranged as to present an ascending zigzag appearance. Column pentagonal, or, exceptionally, round. (Wachsmuth and Springer.)

ECTENOCRINUS Miller.

General form very elongate; calyx small subcylindrical, moderately expanding; basals five, unequal; radials irregular, four plates in three series, before the bifurcation of the free arms, and three in each of the other two series; arms ten, long; pinnules strong; azygous plates three, following each other, but not in a direct line; vault unknown; column very long, round, tripartite, and attaching by an expanding base. This genus is founded upon *Heterocrinus simplex* Hall, as the type, because the genus *Heterocrinus* was founded upon *H. heterodactylus* as the type, which is quite widely removed from *H. simplex.* (Miller.)

GLYPTOCRINUS Hall.

Calyx obconical or subglobose; plates thin, often highly ornamented; the fixed brachials passing imperceptibly into arm plates, and the interbrachials into disk plates; the arms rising vertically from the edge of the tegmen. Basals five, of uniform size, forming a small cup. Radials and costals of nearly equal size; the second costal hexagonal. Distichals varying in number, there being but two in species in which palmars take part in the calyx; but when the second bifurcation takes place in the free arms, they are quite numerous, frequently six to eight or more in the calyx, followed by several others in the free arms. When this is the case, the second distichal gives off a large pinnule; while in the other the proximal pinnule is developed into an arm. Arms rarely branching beyond the second bifurcation, rising vertically from the calyx; they are long, slender, rounded on the back, and composed of a single series of short, slightly wedge-shaped pieces, which do not interlock. Pinnules slender, closely arranged; the proximal ones the stoutest, and frequently incorporated into the calyx. Interbrachials definitely arranged; the first large, resting upon the sloping upper faces of the radials; there being two plates in the second row, and two, sometimes three, in the higher ones. The anal side widest, having generally three plates in the second and all succeeding rows. Interdistichal spaces large, composed of numerous small plates; some species also having interpalmars. Ventral disk depressed-hemispherical, very slightly extending above the level of the arm bases; the ambulacra subtegminal, except near the periphery, where some of the small covering pieces are exposed, but the course of the ambulacra is indicated by surface ridges. Plates of the disk very minute and irregularly arranged, decreasing in size toward the arms. The arrangement of the larger plates at the summit is also irregular, being unlike that of orals, which probably are not represented. Column round; axial canal large, pentalobate, the lobes directed interradially, except in one species in which the stem is pentangular and the central canal radially disposed. (Wachsmuth and Springer.)

HETEROCRINUS Hall.

Redefined by Wachsmuth and Springer.

Calyx small, subcylindrical, tapering but slightly from the column upward. Basals five, more or less unequal, without underbasals; the so-called underbasals of Meek representing the upper stem joint. Radials very irregular, and varying among the rays in number as well as in size. There are two segments in the two antero-lateral rays, while the three remaining rays have but one, this, however, nearly as large as the two in the other rays. The two plates at the right posterolateral side consist of the azygous piece —the lower one—and of the radial, which upon its upper side supports the brachials, giving off laterally a small ventral tube. Arms ten, composed of single joints, alternately united by syzygy, with strong pinnules from every second joint. Column tripartite, almost circular; axial canal large, pentalobate, the lobes directed interradially. (Wachsmuth and Springer.)

IOCRINUS Hall.

General appearance somewhat similar to *Pentacrinus*; comparatively larger than *Heterocrinus*; arms longer and more frequently bifurcating; calyx more broadly spreading, and perfectly symmetrical up to the top of the radials, giving the form of a short, inverted, pentagonal pyramid with the five sides deeply concave. Underbasals undeveloped. Basals small, pentagonal. Radials comparatively large, strong, all pentagonal, and of the same height; their upper margins truncated for nearly their entire breadth for the junction of the succeeding pieces. Brachials three to four in each ray, the upper one auxiliary, and supporting the first free divisions of the arms. In the right posterior ray there is interposed between the true brachials and radial plate a pentagonal bifurcating piece, which is evidently free and movable like the brachials, and of the same width. This peculiar plate, which is truly radial, supports on its right sloping side the usual number of brachials, and on the left a row of quadrangular plates vertically arranged, extending to the tips of the arms, and forming the posterior wall of a large ventral tube. In external appearance these plates resemble the brachials and arm plates, only they are somewhat higher and not quite as wide; they are gibbous, and form an elevated ridge, which causes this appendage to resemble an arm or a branch of the ray, and so it was considered by Hall in his description of *Heterocrinus polyxo*. Both sides of the mesial ridge are indented to accommodate other plates, of which there are two to each median plate, one abutting against the middle part, and the other opposite the suture. These lateral plates are delicate, three or four times wider than high, and, like the other, longitudinally arranged. Each of them contains a rather deep furrow, which in perfect specimens is arched over by a row of wedge-shaped plates which stand out prominently and appear very much like pinnulae. Arms bifurcating frequently, gradually tapering; arm pieces like the free radials, all projecting at the upper edge, thereby producing a sort of imbrication. Pinnulae unknown. Column strong, distinctly pentagonal, the angles in line with the radial plates of the body. (Wachsmuth and Springer.)

LEPADOCRINUS Conrad.

Body oblong or ovoid, consisting of four series of plates; first series four; second series five; third series four; fourth series five; pectinated rhombs three to five; arms three or four, recumbent, and consisting of a double series of interlocking plates, resting in shallow grooves; plates poriferous, column tapering. (Miller.)

LICHENOCRINUS Hall.

"Bodies parasitic on shells and other foreign substances. Form discoid or depressed-convex, with a proboscidiform appendage rising from the center. Disc composed of an indefinite number of polygonal plates, and apparently having no distinct mode of arrangement. Proboscis perforate, and in the known species formed of five ranges of short plates alternating and interlocking at their margins. The fossils for which this generic name is proposed are small parasitic scab-like bodies, usually found adhering to the smooth surfaces of shells and other foreign substances." (Hall, original diagnosis.)

PALAEASTER Hall.

Stellate, disc small; two ranges of plates in each ambulacral groove, and two on either side, adambulacral and marginal; four ranges of pores in each groove; oral plates in pairs at the base of the rays; dorsal plates polygonal, sometimes spinous, madreporic tubercle. (Miller.)

PALAEASTERINA McCoy.

Pentagonal, depressed, with plated disc that fills up the angles, leaving the rays but slightly produced; ambulacra shallow, bordered by subquadrate plates. (Miller.)

TAENIASTER Billings.

No disc or marginal plates; rays long, flexible, spinous; adambulacral plates elongated; two rows of ambulacral pores; ossicles contracted in the middle. (Miller.)

XENOCRINUS Miller.

Basals four, forming a low cup, which is decagonal at the upper end; five of its sides supporting the five radials, the five others the interradials and anal plates. This arrangement gives to the basals, owing to their abnormal number, a very irregular form, no two of the plates being alike. Radials generally a little larger than the costals. Costals two, the sides bending abruptly inward and forming highly elevated ridges; the distichals to about the fifth or eighth plate form part of the calyx. The lower of these plates are larger, and more or less resemble the costals, while the upper ones are more like free arm plates. Arms ten, simple, rather stout; composed of very short cuneiform pieces, which at the tips of the arms slightly interlock. Interradial spaces deeply impressed; composed of numerous minute pieces without definite arrangement; they rest upon the basals, separating the rays from their bases up. Anal interradius wider than the four others; divided longitudinally by a row of folded plates, which like the radials have a prominent ridge upon the outer surface, and a groove at the inner floor. The ridge ends in a small protuberance containing the anal opening, which points upwards. Interdistichal spaces also deeply depressed, and filled by irregular, minute plates, which, like those between the main rays, pass imperceptibly into the disc. Ventral disc comparatively flat, composed throughout of very small pieces; orals being unrepresented, and the disc ambulacra subtegminal. Column quadrangular, with pentangular central canal, the angles of which are directed interradially. (Wachsmuth and Springer.)

DESCRIPTION OF SPECIES.

ANOMALOCRINUS INCURVUS (Meek and Worthen).

Plate III, figs. 1-1c.

Heterocrinus ? (*Anomalocrinus*) *incurvus* Meek and Worthen, 1865, Proc. Acad. Nat. Sci. Philadelphia, p. 148.

"Body expanding rapidly from the base to the summit of the first and second radial pieces, where it is more than twice as wide as high; composed of the five basal, five first radial, and two second radial pieces. Basal pieces pentagonal, of moderate size, wider than long, and forming together a low, rapidly-expanding, pentagonal cup. First radial pieces in three of the rays from three to five times as large as the basal pieces, wider than long, two hexagonal and one heptagonal—all with their superior lateral angles strongly incurved between the arms, and each with a strong protuberant, rounded facet above, for the reception of the small succeeding radials. In the remaining two rays, the first pieces are smaller and lower than those of the others, and each pentagonal in form, with the upper side horizontally truncated its entire breadth, for the reception of a larger second radial, which in these two rays agrees in size and form, as well as in being included as a part of the walls of the body, with the large first pieces of the other rays. Succeeding radials not more than one-third as wide as those included in the walls of the cup, and forming small, rounded, widely separated free arms, consisting of one to three quadrangular and one pentagonal pieces to each ray. Arms above the first bifurcation on the second or third pentagonal free radial, in two of the rays seen, bifurcating again on the third piece, and, in one instance, sending off nearly at right angles from the second piece after the first division, a strong tentacle, or small lateral branch.

"First anal piece pentagonal, longer than wide, and resting between the left sloping side of a large second primary radial and the right sloping side of a first primary radial, with rather less than half its length projecting above the former, and without extending down so as to bring its base in contact with any of the other plates below. In the individual examined, this piece is strongly incurved, and supports on its inner truncated end an oblong, narrow second anal, which in its turn supports a smaller third piece, all of which are arranged in a right line, and probably form one side of a proboscis.

"Surface smooth, or only with traces of fine granules. Sutures a little concave. Column comparatively strong and rounded near the base, where it is composed of short joints, and marked with obscure, regular longitudinal striae.

"Height of body on the anal side, 0.28 inch; do. on the opposite side, 0.22 inch; greatest breadth above (allowing for a slight accidental compression) about 0.38 inch; breadth of free arms at their connection with the body, 0.08 inch; breadth of column at its connection with the base, 0.16 inch.

"This species presents points of analogy both to *Heterocrinus,* Hall, and *Hybocrinus,* Billings, and yet seems to differ from both to such an extent that if we could be sure some of its peculiarities are not abnormal in our specimen we would be inclined to view it as the type of a new genus. As we have seen but the one specimen, however, which is not complete in all its parts, we have concluded to place it, for the present at least, as the type of a subgenus under *Heterocrinus.* It differs from the typical species of that genus in having the column round instead of pentagonal, and in having only the first primary radial pieces in three of the rays, and two in each of the others, included as a part of the walls of the body; while its preceding primary radicals are very narrow, and form small, rounded, distinctly separated arms, instead of being nearly as wide as those soldered in the walls of the cup. Another peculiarity is the strongly incurved superior lateral angles of the large radial pieces around the margin of the cup between the arms.

"In the rather unsymmetrical form of the body, the slender proportions of the free arms, and its general aspect, it resembles *Hybocrinus,* from which it differs in having but one anal piece connected with the walls of the cup, and in having two of the rays and two of the primary pieces included in the wall, while its free arms bifurcate twice or oftener, instead of being simple from their origin."—Meek and Worthen, *loc. cit.*

The type is from the "upper part of the Cincinnati group" at Cincinnati, Ohio.

1.12E3 (?).

DENDROCRINUS CASEI Meek.

Plate IV, figs. 2-2b.

Dendrocrinus casei Meek, 1871, Amer. Jour. Sci., 3d ser., II, p. 295 (not figured).

"Column very distinctly pentagonal, the angles at the connection with the body being continuous with strong ridges passing up the sutures between the basal pieces and to the middle of the subradials. Body pentagonal-obconic, a little wider above than high. Base wider than high, strongly pentagonal, being deeply excavated up the middle of each piece, and very prominent at the lateral sutures; basal pieces wider below than high, pentagonal in form, with the mesial angle above salient, and the superior lateral sloping sides much longer than the lateral. Subradial pieces of moderate size, those seen, hexagonal in form, and all very convex in the middle, from which point they send one strongly elevated ridge to meet others on each of the surrounding plates, and others coming up the sutures between the basals, while on each side of all these ridges, excepting sometimes those passing to the first radials above, there is usually a smaller, less elevated ridge; the surface of the body being thus divided by these ridges into very profoundly excavated triangular spaces, in the middle of which the corners of the body plates meet. First radial pieces, excepting one of the anal side, larger than the subradials, about as wide as high, with a general pentagonal outline, the upper side being longest and deeply excavated for the reception of the comparatively narrow free radials or arm pieces; one on the right of the anal series, shorter than the others, pentagonal in form, and supporting above another larger radial that is included as a part of the wall of the body, and corresponds with the first radials in the other rays, excepting that it is shorter; all convex and sending a strong ridge to each of the contiguous body plates below, while a number of much smaller ridges pass horizontally across from one to another of these pieces on each side. Arms or free rays comparatively rather narrow, distinctly rounded on the outer or dorsal side, and composed of transversely oblong pieces that are about twice as wide as long below the first bifurcation; in the first ray on the right of the anal series, bifurcating on the fourth free piece, beyond which they are seen to be long and composed of proportionally narrow pieces; but their mode of bifurcation, if they divide again, and their structure in the other rays, cannot be made out from the specimens at hand. Anal series unknown.

"Ventral extension of the body more than four times as long as the latter, and as seen flattened by pressure, of greater breadth; as usual, composed of numerous small equal, hexagonal, alternately interlocking pieces, that are strengthened by little oblique costae so arranged as to present an ascending zigzag appearance. Surface, excepting the strong costae of the body plates, and the smaller ones of the ventral part, without ornamentation.

"Height of body to top of first radials, 0.39 inch, greatest breadth at top, 0.32 inch. Length of incomplete ventral extension, 1.95 inch; breadth of same as flattened, near upper end, 0.65 inch; breadth of arms below the first bifurcation, 0.12 inch.

"This beautiful species seems to be a true *Dendrocrinus,* as it can be seen to have two of the primary radials on the right of the anal series, included as a part of the walls of the body, while all its other parts seem to conform to the structure of that group. The differences between *Dendrocrinus* and *Poteriocrinites* are not very great, and it is thought by some that the former should stand only as a subgenus under *Poteriocrinites.* If so, the name of this species when written in full would be *Poteriocrinites* (*Dendrocrinus*) *casei.* In general appearance it resembles *Palaeocrinus angulatus* of Billings, but it differs in having the costae of its body, in part, with a smaller one on each side; while its column is very much more strongly pentagonal. Of course, it also differs in the generic character of having its ventral part extended upward nearly or quite as long as the arms.

"It may be that the species here described is the same figured by Mr. Christy, in his 'Letters on Geology,' as a Pentacrinite (without a specific name), as it came from the same horizon, and from about the same region of the country. It does not, however, agree *exactly* with his figures in details.

"The specific name is given in honor of L. B. Case, Esq., of Richmond, Indiana, to whom I am indebted for the use of the finest specimen of it I have seen. I am also under obligations to C. B. Dyer, Esq., of Cincinnati, for the use of two smaller, and nearly as good specimens. Figures of the species, with a full description, will be given in the Ohio Geological Report."—Meek, *loc. cit.*

The type is from the Richmond formation at Richmond, Indiana. It has also been found near Oxford, Ohio.

DENDROCRINUS POLYDACTYLUS (Shumard).

Homocrinus polydactylus Shumard, Trans. St. Louis Academy of Science, vol. I, 1857, p. 78.

I have not been able to obtain a copy of part I of the first volume of the Transactions of the St. Louis Academy of Science, and therefore am unable to quote the original description.

A fragment of a considerable portion of the base of the calyx of this rather common species was found at Madison (1.12F3). I reproduce herewith Meek's very excellent figure of the species from the Ohio Paleontology.

ECTENOCRINUS SIMPLEX (Hall).

Plate IV, figs. 10, 10a.

Heterocrinus simplex Hall, 1847, Pal. New York, I, p. 280, pl. lxxvi, figs. 2 a-d.

"Body slender, very gradually expanding above the base, and composed of five regular divisions above the pelvic plates; pelvic plates five, four of them irregularly pentagonal, and one with the lateral and upper margins equal; costal plates in two of the divisions single, hexagonal, and supported on the straight upper edges of the pelvic plates, those of the three other divisions double, the lower one pentagonal with the lateral margins short, the second one quadrangular; scapular plates quadrangular, with the upper sides concave and supporting a pentagonal arm-joint; arm-joint supporting on its oblique upper edges a double series of obliquely quadrangular or rhomboidal plates, which gradually diminish in size; column subpentagonal, composed (near the pelvis) of alternating thicker and thinner plates.

"This species is readily identified by its structure, which is peculiar in the form of four of its pelvic plates, and the double or subdivided costal plates in three of the divisions; the body and arms, when closed together, present a slender subcylindrical form, scarcely attracting attention, from their resemblance to a collection of small individual columns. The small fragment of a column attached, which is crushed, can scarcely be characterized, but it is clearly pentagonal."—Hall, *loc. cit.*

The types are from the Lorraine, at Cincinnati, Ohio. The species is reported in Kindle's list from Madison, Indiana. Probably it does not occur there.

GLYPTOCRINUS DECADACTYLUS Hall.

Plate IV, fig. 9.

Glyptocrinus decadactylus Hall, 1847, Pal. New York, I, p. 281, pl. lxvii, figs. 1 a-f; pl. lxxviii, figs. 1 a-u.

"Body cupshaped, with ten arms, which support twenty tentaculated fingers; plates all marked by strong elevated radiating ridges; pelvic plates five, pentagonal, supporting upon their upper oblique edges five heptagonal costal plates, which are succeeded by five hexagonal second costals in a direct line; scapular plates heptagonal, resting directly upon the straight upper side of the second costals, and supporting on their two upper oblique edges two hexagonal arm-joints, which in turn support a second arm-joint, and this one two hexagonal hand-joints, the latter sustaining the fingers; fingers composed of a column of fimbriated joints, which are quadrangular below and cuneiform above; column round or obtusely pentagonal, varying in its character at different distances from the body.

"In addition to the regular series of plates supporting the arms and fingers, there are numerous intermediate ones, of which a hexagonal intercostal plate, a first pair of hexagonal interscapular plates, and a second pair of heptagonal interscapular plates, the latter truncated above, are always regular and uniform. Between these last interscapular plates there is usually an irregular interscapular joint, and several pectoral plates. The number and arrangement of the latter does not appear to be always uniform; but I have not been able to find specimens where every part could be satisfactorily examined. Between each pair of arms there are three or more plates, and between each pair of fingers one or more plates at the base. The capital plates, and their arrangement, are shown in the enlarged figure of the crown, fig. 1 *d*, pl. 77. [Pal. N. Y. vol. I.] The mouth is depressed and obscure.

"The body of this species is readily recognized by the strong radiating ridges which mark the surface of all the plates below the tentaculated fingers. The surface is also marked by five more prominent ridges, which, proceeding from the first costal plates, bifurcate on the scapular plate, the divisions extending to the base of each pair of fingers. In these characters of the surface, and in its general structure, it resembles some the species of the Genus ACTINOCRINUS, from which it differs in having five instead of three pelvic plates. There is some difficulty in making out the entire structure, since the plates usually adhere very closely, and some of the pectoral and interbrachial plates are very small. The important parts, however, and the plates proceeding to the arms, are readily and clearly determined.

"This fossil is usually found destitute of the column; and I have not been able to decide satisfactorily whether all the fragments found with it are parts of the same, or belong to two species. The first, which evidently belong to this species, and form the upper part of the column, consist of joints, having a small base resting upon the broader disc of the next one below, giving more freedom of motion. Other portions have the upper surface of the disc excavated, and the column appears to be composed of a series of cups, alternating in size and placed one within the other, having the upper edges either smooth or fimbriated. These columns have usually a distinct round alimentary canal, with the upper and lower surface marked by fine rays, more deeply impressed near the edge. In other parts of the column, where the plates are more nearly equal in size, the upper and lower surfaces have a pentapetalous impression or elevation radiating from the alimentary canal. This character, in fine, becomes the prominent and characteristic one of the greater proportion of the fragments of columns which we find; and they present all the variety of broad equal smooth joints with even surfaces, or of similar joints with a thin plate interposed, and of columns composed of moniliform joints with smaller ones between; or of distant rounded joints, sometimes deviating slightly from a cylindrical form."—Hall, *loc. cit.*

Column round, with large pentalobate axial canal; the nodal joints a little the widest. The supposed infrabasals of this species are really the upper stem joint. (Wachsmuth and Springer.)

The probable presence of this species is indicated at a number of localities by the characteristic segments of the column. I have seen no calices, however, and therefore have not entered the species in any of my faunal lists.

GLYPTOCRINUS DYERI Meek.

Plate IV, fig. 8.

Glyptocrinus dyeri Meek, 1872, Proc. Acad. Nat. Sci. Philadelphia, p. 314.

"Body globular-subturbinate, being wider than high, with sides rounding under to the base. Sub-basal pieces obsolete, or, if present, not exposed externally. Basal pieces (subradials of some) very small, and projecting as a thin rim below, much wider than high, and presenting a trigonal general outline, though the lateral angles are doubtless minutely truncated. First radial pieces of moderate size, heptagonal in form, and wider than long; second and third a little smaller, the second being hexagonal, and the third pentagonal, and supporting on its superior sloping sides the first divisions of the rays. Secondary radial or supraradial series each composed of from eight to eleven pieces, rapidly diminishing in length upward to the second bifurcation or commencement of the arms, just below which a few of the smaller pieces seem to be free and bear pinnulae on their inner sides; farther down, the second and fourth secondary radials of each ray give off, alternately on each side, small divisions that do not become free, but are soldered into the interradial walls, though they can be traced to the summit of the body, where they merely give origin to pinnules.

"Anal area a little wider than the interradial areas. First anal plate of about the same size as the first radials, hexagonal in form, and supporting in the next range three pieces, arranged with the middle one higher than the others; while above these, three smaller pieces can be seen arranged in the same way in the third range, and three to four or five in the fourth, which is as far up as they can be traced. The middle plates of this series form a direct vertical row, that have a rather prominent mesial, rounded ridge extending all the way up from the middle of the lowest piece, of about the same size as those passing up the primary and secondary radial series, while the other plates on each side and other parts of the lowest pieces are ornamented with radiating costae of smaller size, like those on the interradial pieces.

"Interradial areas not excavated below, but becoming moderately concave above; first interradial pieces of about the size of the second primary radials, hexagonal in form, and supporting two other somewhat smaller pieces in the next range, that bear between their superior sloping sides a fourth smaller piece, while above these there are two pieces in the next range that connect with the pieces of the little lateral divisions of the secondary radials, and perhaps some other small intercalated pieces filling the upper part of the interradial areas.

"Axillary areas flat, and each occupied below by a hexagonal or heptagonal piece of about the size of the second piece of each secondary radial, while the space above is occupied by several much smaller pieces.

Arms four to each ray, rounded on the dorsal sides, slender, of moderate length, very gradually tapering, simple, and composed of very short, slightly wedge-formed pieces, each of which bears a pinnule at its larger inner lateral end; pinnules slender, rather closely arranged, deeply furrowed on the inner side, and apparently composed of rather long joints.

"Surface of body plates all ornamented with distinct radiating costae, starting from the center of each piece, and passing one to each of its sides so as to connect with others on each contiguous piece; of these costae, those passing up the middle of each of the radial series are a little larger and more prominent than those of the interradial plates, while they bifurcate with the rays so as to send a division up each of the secondary radial series, toward the upper part of which they become more prominent and rounded, being there of about the size of the free arms. Column unknown.

"Height of body, 0.60 inch; breadth, about 0.68 inch; length of arms, 1.05 inch; thickness of same, 0.05 inch; number of joints, in a space of 0.10 inch near the base, eight.

"This beautiful species reminds one, by its sculpturing, of the common typical species *G. decadactylus,* from which, however, it may be at once distinguished by its proportionally broader and shorter body, with sides rounding regularly under to the column instead of being obconical. It also has proportionally more slender arms, and differs materially in having, in each secondary radial series, from nine to eleven pieces between the first bifurcation of each ray and the arm bases, instead of only two. In the form of its body, it agrees more nearly with *G. ornatus* of Billings; but it differs materially from that species in having twenty arms instead of only ten, as well as in less important details.

"The specific name is given in honor of Mr. C. B. Dyer, of Cincinnati, Ohio, to whom I am indebted for the use of the very fine specimens from which the description was made out."—Meek, *loc. cit.*

Column round; the nodal joints somewhat larger; the axial canal pentalobate, and moderately large. (Wachsmuth and Springer.)

The type is from about 100 feet below the tops of the Hills at Cincinnati, Ohio. The species is reported in Kindle's list from Madison, Indiana.

HETEROCRINUS HETERODACTYLUS Hall.

Plate III, figs. 5, 5a.

Heterocrinus heterodactylus Hall, 1847, Paleontology of New York, vol. I, p. 279, pl. lxxvi, figs. 1 a-c.

"Body short, rounded, subcylindrical, tapering above and below; pelvis composed of five small pentagonal plates, which are succeeded by the same number of larger costal plates, and these again by five scapulars; arms irregularly subdivided; column pentagonal, composed of thick joints, which are nodulose at the angles; joints alternating in size as they approach the pelvis.

"This is a peculiar species, remarkable for the small size of the body when compared with the column. The irregularity of the arrangement of the plates in the arms and fingers is likewise a striking characteristics of the species, which is constant in two specimens from different localities. In one of the arms, the scapular plate supports a regular series of six or more plates of similar form without division. The arms at the right and left of this one are again unlike each other. The one on the left has three regular and gradually diminishing joints above the scapular, and of the same form; the last one supports the cuneiform joint, which again supports a double row of joints (or a pair of fingers). The arm on the right of the first mentioned, consists of a pair of quadrangular joints, each of which supports a cuneiform joint. In the remaining two arms, no plates have been traced beyond the scapulars, and consequently the entire form of the species cannot be determined. Sufficient is visible, however, to show the irregular character of the arms, from which its name is given."—Hall, *loc. cit.*

Reported by Hall from the Hudson River group (Cincinnati series) of New York and Ohio. To this species I have referred segments of the column of a common crinoid from many localities in the Utica and Lorraine. As I have seen no complete specimens of the species I have not listed it in the faunas of the various sections.

HETEROCRINUS JUVENIS Hall.

Plate III, figs. 3-3b.

Heterocrinus juvenis Hall, 1866, 24th Rep. New York State Museum, p. 212, pl. 5, figs. 9, 10. (Advance sheets.)

"Body minute, the greatest diameter of the cup not exceeding a line, and the height from the base to the top of the first arm plates a line and a half.

"Basal plates appearing only as triangular points at the lower lateral angles of the adjacent subradials. Subradial plates wider than high, hexagonal. Three of the first radial plates higher than wide, each supporting a single smaller arm plate, which presents the appearance of having had another plate above; the other two radial plates are short, quadrangular; one of them supporting a small plate above, and the other one a wedge-form plate, upon which rest two other small plates, one larger than the other; the largest of these has the position and appearance of an anal plate.

"Surface of plates smooth.

"Column distinctly pentangular, nearly as large as the diameter of the calyx, composed of alternating thick and thin plates.

"This crinoid may be only the young of some previously described species; but as there have been several individuals found, all presenting the same characters and of about the same size, I have thought proper to designate it as a distinct species for the present."—Hall, *loc. cit.*

The type is from the upper part of the Cincinnati group at Lebanon, Ohio.

IOCRINUS SUBCRASSUS (Meek and Worthen).

Plate IV, figs. 7, 7a.

Heterocrinus subcrassus Meek and Worthen, 1865, Proc. Acad. Nat. Sci. Philadelphia, p. 148. (Not figured.)

"This species agrees so nearly with the last [*Heterocrinus crassus*] in most of its characters as to render a detailed description unnecessary. It will be readily distinguished, however, by its smaller size, as well as its less robust appearance, and the different aspect of its arms. This latter difference consists in the more slender appearance of all the divisions, and particularly in the joints of which they are composed having their upper margins projecting beyond the base of each succeeding piece above, so as to present a kind of upward imbricating appearance and roughness, not seen in the arms of *H. crassus.*

"As in the last, its rays bifurcate first on the fifth and sixth pieces, and one of them gives off a branch (?) on the left side of the second radial, above which it bifurcates regularly on the sixth piece. After the first regular division on the last radial piece, some of the arms are seen to divide again on the fourth, others on the fifth, and others on the sixth pieces, after which one division is known to bifurcate on the sixth piece, and still again on the thirteenth.

"Breadth of body at the summit of the first radial pieces, 0.27 inch; height of do., 0.13 inch; length of rays from top of first radial pieces to the first bifurcation, 0.21 inch; entire length of arms from first division to extremities, about 1.50 inch. Breadth of column at its connection with the base, 0.15 inch."—Meek and Worthen, *loc. cit.*

The type is from the "upper part of the Cincinnati group" at Cincinnati, Ohio. Reported from Madison, Indiana, by W. T. S, Cornett. Probably does not occur there.

LEPADOCRINUS MOOREI (Meek).

Plate IV, figs. 6-6b.

Lepocrinites moorei Meek, 1871, Amer. Jour. Sci., 3d ser., II, p. 296. (Not figured.) (= *Lepadocystis moorei.*)

"Body obovate. Base forming nearly one-fourth the height of the body, its four pieces being about as wide as long, of nearly equal size, and irregularly pentagonal in form, excepting one on the anal side, which is hexagonal. The five pieces of the second range of irregular form and size, two on the anal side being longer than wide, and extending up to form the lower margin of the principal opening, which is moderately large, and placed about one-third the length of the body below the top. Arrangement of the plates above not clearly made out. Pectinated rhombs four, comparatively large, one situated at the suture between one of the basal pieces and the contiguous piece of the next range above, on the anterior side of the body; another on the side to the left of the opening, and arranged with its longer axis directed transversely, on a line with the opening, while the other two are nearly on a line with the right side of the opening, on three plates that corner together, the arrangement being such that their longer axes diverge at right angles upward; in these, 15 to 20 of the little bars may be counted.

"Recumbent arms short, or confined mainly to the upper side, or extending down nearly to the opening on the anal side, another to the two rhombs to the right of the opening, a third to that on the left, and the fourth to the anterior side, the direction of all being thus nearly or quite at right angles to each other. Column thick at the base of the body, but tapering rapidly below; as usual, composed of very thin pieces. Surface of body plates marked by distinct radiating lines.

"Height of body, 0.46 inch; breadth, about 0.36 inch; thickness of column at its connection with the base, 0.14 inch.

"This species seems to agree well with the genus *Lepocrinites* of Conrad, excepting in the very unusual character of having four rhombs instead of only three. As one of these, however, seems to be merely rudimentary, or in other words, not perforated by little slits, I can scarcely think its presence a generic character.

"I believe this is the first example of this group of *Cystideans* that has been found in the Lower Silurian, in this country. It occurs, however, in the upper part of the lower series, where some of the other fossils begin to resemble Upper Silurian types.

"It has been proposed to correct the orthography of Mr. Conrad's genus to *Lepadocrinus,* and if this orthography should be adopted, the name of our species would be written *Lepadocrinus* or *Lepadocrinites Moorei.* The most usual custom, however, has been to retain the original orthography of generic names in such cases."—Meek, *loc. cit.*

The type is from the Richmond formation at Richmond, Indiana.

LEPIDODISCUS FABREI (Miller).

Plate IV, fig. 11.

Agelacrinus faberi Miller, 1894, Jour. Cin. Soc. Nat. Hist., XVII, p. 156, pl. viii, figs. 24, 25.

"This species is founded upon a single specimen, that is very much broken up and attached to the valve of an *Orthis occidentalis.* It is about the size of an average *Agelacrinus cincinnatiensis.* The body is circular, depressed planoconvex, and composed of numerous squamiform plates that imbricate inward from the periphery toward the center. The larger plates occur in the rim that surrounds the extremities of the arms. The arms are much broken up in our specimen, but there seem to be four sinistral and one dextral, composed of interlocking plates, as is usual in this genus. The surface of all the plates is densely and beautifully tuberculated.

"This species is distinguished from all others, in rocks of the same age, by the tuberculated plates. It is also distinguished from *Agelacrinus cincinnatiensis* and *A. pileus* by the absence of the great number of small plates that form the periphery in those species, and also by having the larger plates of the body, in the rim, that surrounds the ends of the rays.

"Found by Mr. C. L. Faber, in whose honor the specific name is proposed, in the extreme upper part of the Hudson River Group, about half way between Osgood and Versailles, Indiana, and now in his collection."—Miller, *loc. cit.*

LICHENOCRINUS CRATERIFORMIS Hall.

Plate IV, figs. 12-12b, Plate III, fig. 2.

Lichenocrinus crateriformis Hall, 1866, 24th Rep. New York State Museum (Advance sheets), p. 217, pl. vii, fig. 7.

"Body small, distinctly subpentagonal, subdiscoid, with an elevated margin and strongly depressed center; composed of medium-sized polygonal plates. Proboscis minute, central.

"This species differs from the preceding [*L. dyeri*] in its more elevated margin, and in the absence of the five prominences of the disc; the proboscis is much smaller in proportion to the size of the body, and the whole is composed of a smaller number of larger sized plates."—Hall, *loc. cit.*

1.12E3 (?).

LICHENOCRINUS DYERI Hall.

Plate IV, fig. 5.

Lichenocrinus dyeri Hall, 1866, 24th Rep. New York State Museum (Advance sheets), p. 216, pl. vii, figs. 1-6.

"Body small, discoid, depressed in the middle, with five slight elevations midway between the center and the edge of the disc. Proboscis strong, composed of short plates. Disc composed of very small polygonal plates. Surface smooth."—Hall, *loc. cit.*

A more adequate description of this species is given by Meek in the Ohio Paleontology, as follows:

"Body depressed-discoidal, nearly circular, or obscurely pentagonal in outline; composed of a great number of very small, slightly convex, nearly or quite smooth pieces, of very unequal size and form, the larger ones often somewhat longer than wide, with their longer diameters directed inward and outward; central depression small; column-like appendage comparatively stout at its basal, or attached end, where it is sub-pentagonal, or nearly round, and composed of about five or six ranges of very short, distinctly and regularly interlocking pieces; perforation at base pentagonal, and scarcely equalling one-third the diameter of the appendage at that point. Interior unknown.

"Diameter of an apparently adult individual, 0.32 inch; convexity about 0.09 inch; thickness of column-like appendage, at its connection with the body, 0.08 inch; length unknown."

The type is from the top of the hills at Cincinnati.

Reported in Kindle's list from Ripley County, Indiana.

LICHENOCRINUS PATTERSONI Miller.

Plate IV, figs. 4, 4a.

Lichenocrinus pattersoni Miller, 1879, Jour. Cin. Soc. Nat. Hist., II, p. 118, pl. x, figs. 6, 6a.

"Body robust, round or sub-circular, plano-convex, with a depression around the column, composed of numerous plates of unequal size, having no regular geometrical form, and disposed without any definite order of arrangement. If the plates, in the specimen illustrated, could be arranged, in regular concentric series, there would be, about eighteen ranges, between the column and the circumference.

"The plates are smooth.

"The column-like appendage is large, round and composed, as in other species, of five ranges of thin plates.

"The plates, in this species, are as large as the plates in *L. crateriformis,* and as numerous as in *L. dyeri,* but they have neither the arrangement nor form of either."—Miller, *loc. cit.*

According to Miller this species probably occurs at Versailles, Indiana, "in the upper part of the Hudson River Group."

LICHENOCRINUS TUBERCULATUS Miller.

Plate IV, fig. 3.

Lichenocrinus tuberculatus Miller, 1874, Cin. Quar. Jour. Sci., I, p. 346, fig. 38.

"Body discoidal, circular in outline; lower surface, or surface of attachment, flat, or conforming to the surface to which it is attached; upper surface strongly convex or subhemispheric, with a deep circular depression in the central part, around the column; upper surface of body composed of numerous, irregularly arranged, thin, pentagonal or hexagonal plates, nearly uniform in size, smooth on the under side and highly convex or tuberculated on the outer surface. Excluding the plates immediately surrounding the column, within the central depression, which are much smaller than the others, the remainder will number about one hundred. Interior filled with upright lamelliform plates, radiating from a central point, on which the exterior plates appear to repose. Column pentagonal, length unknown.

"Diameter of a medium-sized specimen 3/12 inch, convexity 1/12 inch; but Mrs. M. P. Haines, of Richmond, Indiana, to whom I am indebted for the specimen engraved, informs me that she has recently found specimens varying from 1/12 to 6/12 of an inch in diameter.

"It is distinguished from *L. crateriformis,* which species it most resembles, by its tuberculated plates. It differs, too, in its greater convexity, more abrupt central depression, and greater uniformity in the size of its plates.

It is found in the vicinity of Richmond, Indiana, in the upper part of the Cincinnati Group. Small specimens, very closely resembling this species in general outline, are found near Clarksville, in Clinton County, Ohio, but differing, in the specimens examined, in this important regard, that the plates appear to be smooth instead of tuberculated."—Miller, *loc. cit.*

PALAEASTERINA SPECIOSA Miller and Dyer.

Plate III, fig. 8.

Palaeasterina speciosa Miller and Dyer, 1878, Jour. Cin. Soc. Nat. Hist., I, p. 30, pl. i, fig. 7.

"Pentagonal; rays obtuse at their apices; greatest distance from point to point about 2 1/2 inches; breadth of body between rays about 1 1/3 inches, and distance from tip of ray to next adjoining tip on either side about 1 1/2 inches.

"The marginal plates are small and somewhat hemispherical, near the termination of the rays, they gradually enlarge and become square, and then rectangular as they approach the disc, until at the narrowest part of the disc or body of the fossil they are twice as long as wide. There are about 50 marginal plates between the apex of one ray and the next one adjoining, or in a perfect specimen of this size about 250.

"The back or dorsal side is covered with numerous plates (probably in a complete specimen of this size there would be 1,000 or more), which are very prominent in the center or somewhat conical, and seem to have been joined together with deeply serrated edges. The plates have from three to eight of these indentations, which give them a beautiful star-like appearance.

"The ambulacral grooves are narrow and deep, as shown by the sharp ridges on the back of the specimen. The small dorsal plates which cover the ambulacral pieces are exfoliated in some places, and show two rows of ambulacral plates coming evenly together, and forming the sharp ridge."—Miller and Dyer, *loc. cit.*

Reported by Kindle from Richmond, Indiana, on the authority of James.

URASTERELLA GRANDIS Meek.

Plate III, figs. 6-6b.

Stenaster grandis Meek, 1872, Amer. Jour. Sci., 3d ser., III, p. 258. (Not figured.)

"Attaining a very large size, with the body or disc comparatively small, or only of the breadth of the united inner ends of the five rays. Rays long, slender, gradually tapering, and very flexible, widest at their immediate connection with the body, where they seem to be more or less depressed, but becoming more nearly terete farther out. Dorsal side of body and arms composed of numerous subtrigonal pieces that rise into pointed tubercles, or sometimes assume almost the character of short spinules, and are arranged in quincunx, so as to form about eight rows near the middle of the rays; those of the outer two rows being a little larger than the others. Dorsal pores apparently rather large, and passing through between the concave sides of contiguous pieces. Ventral side of body unknown. That of the rays composed of the usual single row of transverse ambulacral pieces on each side of the well defined, rather deep, and moderately wide ambulacral furrows. Adambulacral pieces rather more than twice as long as wide, with their longer diameters at right angles to the ambulacral furrows, and rounding over from end to end so as to be most prominent in the middle; while they do not connect with each other by flat sides, but have little projecting processes, and corresponding sinuses, apparently for the purpose of imparting greater flexibility to the rays.

"Breadth of body, 0.63 inch; length of rays, 2.40 inches; breadth of same at their connections with the body, 0.36 inch. Diameter across from the tips of rays on opposite sides, about 5.50 inches.

"Not having seen the under side of the body of this species, I am not quite sure that it is exactly congeneric with Mr. Billings's typical species of *Stenaster*. It does not show the peculiar contraction of the inner ends of the rays, seen in his *S. Salteri*, from which it also differs in a marked degree in the much greater length and slenderness of its rays. In these characters, however, it agrees more nearly with his *S. pulchellus* and *S. Huxleyi*; though it differs from the first specifically in having proportionally larger rays, with more numerous dorsal pieces, and in attaining a much larger size. I had suspected that it might possibly be the *S. Huxleyi*, but on comparing drawings, and the foregoing description, sent to him for that purpose, with his typical specimen of *S. Huxleyi*, Mr. Billings writes that he has no doubt whatever that it is entirely distinct.

"The specimen shows a few short spines connected with the adambulacral pieces; but neither their exact mode of attachment, nor their arrangement, can be very clearly made out. They seem, however, to connect with these pieces along their joining edges, instead of springing from their crests.

"Adopting the suggestion already made by another, that the name *Stenaster* for this group should be replaced by McCoy's name *Urastrella,* previously suggested, incidentally, for apparently congeneric forms, the name of the species here described would become *Urastrella grandis.*"—Meek, *loc. cit.*

The type of this species is from the Richmond formation at Richmond, Indiana.

TAENIASTER GRANULIFERUS (Meek).

Plate III, fig. 7.

Protaster ? granuliferus Meek, 1872, Amer. Jour. Sci., 3d ser., IV, p. 274. (Not figured.)

"Disc small, apparently circular; rays rather slender, and of unknown length. Dorsal surface of disc and rays covered by an integument composed of innumerable minute grains of calcareous matter. Ventral side of disc not well exposed in the specimen but apparently provided, in the interradial spaces, with minute spines directed outward. Oral pieces not well exposed in the specimen. Arm-pieces regularly alternating, but apparently rectangular at their inner ends, and not interlocking along the minute mesial impressed line, longer transversely than in the direction of the length of the rays; each largely excavated at its anterior outer end so as to form a large pore, or pore-like depression, and divided transversely by a furrow into two parts, the anterior one of which is very short, and the posterior longer and marked by a minute pit at its inner end; about eight or nine of these pieces in each range of each ray included within the margin of the disc. Outer arm-pieces (adambulacral of some) smaller than those of the inner ranges, and placed edge upward, with an oblique outward direction so as to imbricate outward or toward the extremities of the rays; each bearing one or more minute articulating spines.

"Breadth of disc, about 0.43 inch; breadth of arms at their inner ends, 0.10 inch.

"The only specimen I have seen that is certainly known to belong to this species is very imperfect, being merely an incomplete disc, and the inner ends of the rays. It does not conform to the characters of *Protaster* given in Prof. Forbes's diagnosis, in all respects, since its disk, especially on the upper side, is covered by an integument composed of a vast number of very minute grains of calcareous matter, instead of distinct imbricating scales. It is therefore not improbable that perfect specimens would show other characters that would warrant the establishment of a new genus or sub-genus for such forms, in which case the name *Alepi-*

daster might be applied to the group, which would probably also include *Protaster gregarius* of Meek and Worthen.

"I have intentionally avoided, in the foregoing description, the use of the terms ambulacral and adambulacral pieces, applied by some in describing the arms of species of *Protaster* and similar forms, because it seems doubtful whether these terms can be properly applicable to such types. I should certainly think not, *if these types belong to the Ophiuroidea* (in which no ambulacral furrows exist) instead of to the *Asteriodea.* According to Dr. Wright, however, *Protaster Miltoni* of Salter has a well developed madreporiform body, and hence would belong to the *Asteroidea.* Yet it is very curious that these types seem to have no proper ambulacral canals, and we have apparently no positive evidence that the viscera of the animal were not confined to the disc, as in the *Ophiuroidea.*"—Meek, *loc. cit.*

The type of this species is from the Richmond formation at Moores Hill, Indiana.

XENOCRINUS BAERI (Meek).

Plate IV, figs. 1, 1a.

Glyptocrinus baeri Meek, 1872, Amer. Jour. Sci., 3d ser., III, p. 260. (Not figured.)

"Body of about medium size, globose-obconoidal. Sub-basal pieces apparently not developed, or very small. Basal pieces short and pentagonal. First primary radials of comparatively moderate size, presenting a general pentagonal outline; second a little narrower than the first, but of nearly the same length, with a general heptagonal outline; third a little narrower than the first, but of nearly the same length, with a general pentagonal form. Secondary radials, consisting of about four pieces in succession, on each upper sloping side of each third primary radial; the first two or three of each series only about one-third smaller than the second primary radials, while above these the succeeding pieces soon become much shorter free brachials. Interradial pieces numerous, small, of very unequal size, and without any regularity of arrangement. Anal series unknown, but probably consisting of a mesial series of hexagonal pieces resting one upon another, and a greater number of much smaller pieces irregularly arranged on each side. Axillary spaces each occupied by some six or more very small pieces.

"Arms ten, rather long, simple, widest a little above their bases, and thence gradually tapering to their ends; composed of very short pieces, so strongly cuneiform as to appear almost to taper to nothing alternately on opposite sides, while each supports a pinnule at its thicker end, along the inner margins. Pinnules very long, moderately short, nearly in contact, and composed of pieces three to four times as long as wide. Surface of body plates without costae or striae; those of the primary and secondary radial series more prominent than the much smaller pieces filling the interradial spaces, and thus forming somewhat flattened ridges, more or less interrupted at the sutures, and abruptly beveled at the sides; interradial and axillary areas roughened by a minute projecting central point on each of the little pieces filling them.

"Column of moderate thickness, apparently nearly round, or perhaps subpentagonal near the base, and composed of alternately thicker and thinner pieces, the former of which project a little beyond the others.

"The body of the only specimens of this species I have seen, are too much distorted by pressure to afford accurate measurements, but it seems to have been about 0.45 inch in height, by a little less in breadth; while its arms measure 0.07 inch in breadth at the widest part, a little above the top of the body, where about eight arm pieces may be counted in a length of the same extent.

"This species will be readily distinguished from all of the described forms of the genus, resembling it in other respects, by having only ten simple arms, and by the large number and small size of its interradial pieces. In the latter character it resembles *G. nealli*, of Hall, from which, however, it differs materially in almost every other respect, but more particularly in having only ten instead of twenty arms, which are also stouter. Its interradial and axillary spaces likewise differ materially in not being distinctly excavated, and in having each of the little pieces by which they are filled provided with a little projecting point.

"The specific name is given in honor of Dr. O. P. Baer, of Richmond, Indiana, to whom I am indebted for the use of the specimens from which the description has been prepared."—Meek, *loc. cit.*

Lower arm joints rectangular. Anal side divided by a longitudinal row of anal plates, shaped like the radials and costals. Column quadrangular, with obtuse angles; the joints extended outward into long knife-like edges. (Wachsmuth and Springer.)

The type is from the Richmond formation at Richmond, Indiana.

BRYOZOA.

METHODS OF STUDY.

The Trepostomatous Bryozoa require, as indicated in the introduction, certain special methods of study. A few of the more common and characteristic forms may readily be recognized in the field without special preparation, but for the greater number, and for all forms, if the maximum of accuracy is required, means must be employed to ascertain the internal characters. The method now employed with great success is that of the preparation of thin sections. Before describing this method, however, I wish to call attention to a method suggested by Mr. Bassler, which I also had made some use of prior to his publication. The method in question consists of slightly etching with acid (HCl, preferably) a smoothed portion of the surface of the specimen, and moistening with water, when the structural details can be quite distinctly seen with a good hand lens. This method is very simple and expeditious, and will suffice for the identification of almost any of the commoner and better known forms, or for use in preliminary sorting, prior to selecting the specimens for more careful investigation.

For the more careful and complete study of the internal characters nothing can take the place of thin sections.

These may be prepared in the following very simple manner. Procure a piece of sandstone such as is used for the finer grades of grindstones and whetstones; or, better still, purchase a few pounds of emery, or carborundum (the latter is the best material, and can be obtained at small expense from the Carborundum Co. of Niagara Falls) of a medium grade of fineness. In addition to the coarser sandstone or carborundum a very fine-grained razor hone, or the finest floated carborundum (No. FFF) should be obtained. For grinding with the carborundum it will be necessary to have several pieces of plate glass, or smoothed pieces (plates) of iron or copper. The other supplies needed are an alcohol lamp, or a Bunsen gas burner, if gas is available, and a mounting stage, which may be made by supporting a thin, flat metal plate on a couple of uprights at a sufficient height so that the lamp or Bunsen burner may be placed beneath it. A pair of blacksmith's nippers, and a fairly thick grade of microscope slides, cover glasses (7/8 in. square, for most purposes) and Canada balsam, which can be obtained in collapsible tubes from Bausch & Lomb, or Queen & Co., complete the list of apparatus.

Before starting to make the section the specimen should be carefully inspected to ascertain the proper place to nip off the small fragment for grinding. In general at least two kinds of sections will be needed of each specimen—one parallel with the surface (tangential) and another cutting the zooecia lengthwise (longitudinal). The pieces should, therefore, be nipped off in such positions that these two kinds of sections can be obtained by proper grinding. The fragments should now be ground on the sandstones or carborundum plates, keeping the plates well supplied with water, until a smooth, well-polished surface, cutting the zooecia in the required direction, is obtained. The specimen is next dried and cemented to a glass slide in the following manner: place a drop or two of the balsam on the slide and lay the slide on the mounting stage, which should not be too hot. Let the balsam simmer until the volatile matter is evaporated so that when the balsam is cold it will be hard and firm, but not too brittle. The proper degree of evaporation can be easily ascertained by picking up a tiny drop of the hot balsam on the point of a needle and cooling it, and then pressing the drop down upon some hard surface (of stone or metal). When the hardened drop snaps quickly off the needle, the balsam is ready to receive the polished fragment of the fossil. If the balsam is still tough or sticky, the evaporation should be carried farther. The specimen may be placed in the balsam on the slide, smoothed side against the glass, before the evaporation is complete, and the evaporation continued. Great care should be taken to make sure that no bubbles remain between the specimen and the glass. The tendency to the formation of bubbles may generally be avoided if the stage is kept at a moderate temperature. When the balsam has reached the required consistency, the slide with the fragment adhering to it is removed and allowed to cool. It may be cooled quickly by placing it on a dry cool piece of metal or stone. When cold the balsam should be hard and firm and without any tendency to pull. The specimen is now found to be securely cemented to the glass, and the grinding can be begun. Lay the slide with the specimen downward, upon the coarse sandstone or carborundum plate, and place the thumb near one end of the slide and the first and second fingers near the other end and rub the specimen against the plate, which should be kept well supplied with water, using a moderate and steady pressure, and keeping the slide always as nearly parallel to the grinding plate as possible. Continue the grinding on the coarse plate till the specimen is reduced to the thickness of thin cardboard, and then transfer to the fine grinding plate or razor hone, and continue the grinding till the specimen is so thin that all the structural details can be readily seen with a microscope magnifying about 20 diameters.

The thin flake of rock may now be covered with a cover glass in the usual manner, or, since in the grinding, the slide has probably become more or less scratched and disfigured, the flake may be warmed until the balsam is softened, and pushed, with the needles, off onto another clean slide, and then mounted.

If the balsam is too soft, the thin flake will be pulled to pieces and ruined. On the other hand, if the balsam is too hard and brittle, the flake will probably, at some stage of the grinding, separate from the slide entirely and be broken or lost. Only experience can teach one the proper degree of evaporation of the balsam. The properly mounted slide should be immediately labeled, and numbered in a manner to indicate the horizon and locality of the specimen, and the balance of the specimen from which the piece for grinding was nipped, should receive a duplicate label and number.

A great deal of time may be saved by using a diamond saw both for cutting the piece to be sectioned from the original specimen, and for trimming the greater portion of the fragment from the slide after it is cemented down preparatory to grinding. By doing this, much time may be saved in the grinding. A perfectly satisfactory foot-power diamond saw may be arranged by obtaining a foot-power emery wheel and putting the saw on the chuck in place of the emery wheel. The necessary accessories for keeping a supply of water on the edge of the wheel and preventing the water from flying in the face can be supplied by any one with a little ingenuity and at a trifling expense. The apparatus which I have used to cut many hundreds of sections cost about twelve dollars, exclusive of the diamond saw. The latter can be obtained from a number of dealers, and will cost in proportion to the diameter of the saw. At present the price is about eight dollars for a six-inch saw.

DIAGNOSES OF GENERA.

AMPLEXOPORA Ulrich.

Zoarium ramose, subramose or massive, in the ramose forms arising from an expanded base. Surface smooth or monticulose. Zooecia prismatic, polygonal, thin walled in the axial region and more or less thickened as they pass into the peripheral region, the flexure at the transition from the immature to the mature region usually abrupt. Boundary line between adjacent zooecia as seen in sections usually very distinct. Acanthopores always present and sometimes strongly indenting the walls; never of great size. Diaphragms complete, usually horizontal, but sometimes inclined, or simulating cystiphragms.

ARTHROCLEMA Billings.

Zoarium jointed, composed of numerous subcylindrical segments, celluliferous on all sides, arranged in a pinnate manner; articulation both terminal and lateral. Segments of three kinds, primary, secondary and tertiary. The first set forms the strong central stem, of which each part has normally one or two sockets on opposite sides for articulation with the smaller segments of the second set. The latter generally articulate in like manner, terminally with each other and laterally with the still more slender segments of the third set. Zooecia subtubular, each occasionally with a diaphragm, their apertures ovate, oblique, the inferior border more or less prominent, arranged in rows between longitudinal ridges. Interspaces usually striated, often grano-striate. (Ulrich.)

ARTHROPORA Ulrich.

Zoaria bushy, spreading in a plane, composed of numerous, essentially equal segments; joints simple, bifurcating, or with several short lateral branchlets, the extremities solid and rounded for articulation with succeeding segments. Zooecial apertures elliptical, surrounded by a delicate peristome. Interspaces with one or more thread-like ridges, variously disposed, sometimes short and vermicular, at other times forming continuous longitudinal wavy lines, or ranged in a concentric manner about the apertures. Peristomes and ridges each with a row of minute papillae. Interior with the primitive cell elongate, narrow, one or both hemisepta, and lined with minute dots between the zooecia in the peripheral region. Mesial laminae zigzag in transverse sections, without "median tubuli." (Ulrich.)

ARTHROSTYLUS Ulrich.

Zoaria bushy, branching dichotomously, the whole consisting of numerous, exceedingly slender, subquadrate, equal segments, joined to each other by terminal articulation. Zooecia arranged in three (perhaps more) rows, usually between longitudinal ridges; the fourth face, commonly the widest, with longitudinal striae only. (Ulrich.)

ASPIDOPORA Ulrich.

Zoarium consisting of one, or two or more superimposed, thin expansions, each 1 mm. or less thick, rarely parasitic, generally free, with an epithecal covering on the concave lower side; typically composed, according to age, of from one to many sub-equal parts, each gently convex, with the zooecia increasing in size from their margins to near their centers. Acanthopores usually present, always small. Diaphragms horizontal and closely set in the mesopores, usually wanting in the zooecial tubes, but one or more cystiphragms occur in most of the latter. (Ulrich.)

ATACTOPORELLA Ulrich.

Zoarium generally forming thin crusts over foreign bodies, rarely lobate or subramose. Surface commonly with monticules. Zooecia with very thin inflected walls, their apertures irregularly petaloid; internally with cystiphragms. Mesopores angular, numerous, often completely isolating the zooecia; at first open and distinctly tabulated, but, when fully matured, largely or entirely filled by a deposit of sclerenchyma. Acanthopores very numerous, varying in size with the species, encroaching more or less upon the zooecial cavity. (Ulrich.)

BATOSTOMA Ulrich.

Zoaria irregularly ramose, with a large basal expansion. Zooecial walls thin, and irregularly flexuous in the axial region, more or less thickened in the peripheral. In the most typical species the walls are irregularly ovate, thick and ring-like in tangential sections, with neighboring zooecia in contact only at limited points, the mesopores numerous, closed at the surface, and irregular in shape and size, and the acanthopores abundant and with a larger central cavity than usual. Species vary from these to forms having polygonal, thin-walled zooecia and very few mesopores and acanthopores. Diaphragms strong, horizontal, complete, few or wanting in the axial, more abundant in the peripheral region. In the axial region of transverse sections the tubes are divisible into two sets, one larger than the other. (Ulrich.)

BERNICEA Lamouroux.

Zoaria incrusting, forming circular or irregular patches. Individual zooecia as in *Stomatopora* and *Proboscina,* but contiguously arranged in more or less regular spreading series.

BYTHOPORA Miller and Dyer.

Zoaria consisting of usually very slender branches, though in one species they may attain a diameter of a centimeter or more. Surface smooth, or, in one species, with small spine-like nodes. Mesopores usually few or almost lacking, rarely abundant. Apertures of zooecia usually oblique, elongate in the direction of the branch, narrowing, in the typical species, above. In *B. meeki* they may be circular or even subpolygonal. Acanthopores well developed, sometimes numerous; rarely wanting. Diaphragms almost wanting in the zooecia, sometimes fairly numerous in the mesopores. Wall structure granular in *B. meeki.*

CALLOPORA Hall.

Zoarium usually ramose, rarely subfrondescent, or pyriform; surface smooth or tuberculated. Zooecial tubes with thin walls, varying according to the number of mesopores from circular or oval to polygonal in cross-section. Apertures closed in the perfect state by centrally perforated and often radially marked or ornamented plates, which are left behind as growth proceeds to form floors (diaphragms) of succeeding layers. Mesopores angular or rounded, more or less numerous, sometimes surrounding the zooecia; closely tabulate. Zooecial tubes attaining their full development slowly, with closely arranged diaphragms in the attenuate proximal ends, and fewer or no diaphragms in the middle part of their length. In the peripheral region these structures commonly increase again in number. Transverse sections show that in the axial region the tubes are of two sizes, the larger ones with six, seven, and most commonly eight sides, the smaller set four or five-sided. (Ulrich.)

Zooecial walls amalgamated; acanthopores entirely lacking.

CALLOPORELLA Ulrich.

Zoaria free or encrusting, thin expansions. Surface smooth or undulated. Zooecial tubes cylindrical, with thick walls, separated by one or two rows of angular mesopores. Zooecial apertures subcircular, arranged in regular intersecting series. Diaphragms numerous, straight. Acanthopores small, few.

CERAMOPORELLA Ulrich.

Zoaria incrusting, often becoming massive by superposition of numerous thin layers. Zooecial tubes short, their walls thin. Apertures more or less oblique, hooded, commonly of oval shape. The hoods are directed away from the centers of small maculae marking the surface at rythmical intervals. Mesopores abundant, often completely isolating the zooecia, their apertures usually open, sometimes closed by a thin membrane. Diaphragms only rarely present. (Ulrich.)

CHILOPORELLA Ulrich.

Zoaria rising up in flabellate fronds or compressed branches, from a greatly expanded heavy crust. Zooecial tubes long; very thin walled, large, and of irregular shape in the axial region. Walls much thickened near the surface. Apertures ovate, the lunarium conspicuously elevated. Mesopores numerous. Diaphragms few, generally absent. (Ulrich.)

COELOCLEMA Ulrich.

Zoaria ramose, branches hollow, lined internally with a striated epitheca. Surface with or without maculae. Zooecial tubes short, with rather thick walls; apertures suboval. Peristome complete, but highest at the posterior side, making the aperture appear more oblique than it really is. Lunarium scarcely distinguishable in tangential sections. Mesopores fairly numerous, rather equally distributed among the zooecia. Diaphragms usually absent; occasionally one may be observed closing the apertures. (Ulrich.)

CONSTELLARIA Dana.

Zoaria growing from a slightly expanded base, into erect fronds, or more or less flattened, sometimes anastomosing, branches. Cells of two kinds, true zooecia with subcircular apertures, surrounded by a slight peristome; and angular thin-walled interstitial cells. At subregular intervals the surface exhibits apparently solid stellate maculae, that may be more or less elevated above the general plane of the surface, or depressed below it. Between the slender and often bifurcating rays of the macula an equal number of small groups of true cells occur, which may be placed on a plane with the surrounding surface, or, as is more commonly the case, be more or less prominently elevated into a radially divided monticule. The true cells are best developed in the inter-monticular spaces, where they are more or less isolated by interstitial cells, the mouths of which are, however, closed at the surface; in consequence, the interstitial spaces and maculae appear to be solid. In sections, the axial region is seen to be occupied only by the true zooecial tubes; here they are polygonal, with very thin walls, and few or no diaphragms. As they approach the surface their walls are slightly thickened, and a large number of thin-walled interstitial tubes are abruptly developed. These sometimes have flexuous walls, and are divided by a large number of horizontal diaphragms, which, especially just beneath the surface of fully matured examples, are closely crowded, and placed upon the same level in contiguous tubes. Small spiniform tubuli are numerous, but only in fully matured zoaria. (Ulrich.)

DEKAYIA Milne-Edwards and Haime.

Emended by Cumings.

Zoarium ramose, or variously compressed, or lobed, or frondescent; growing upward from a more or less broadly expanded basal attachment. Surface smooth or variously ornamented with monticules, maculae or spines. The cells in the monticules and maculae may be either larger or smaller than the average. Zooecia polygonal, subpolygonal or rounded. Mesopores few to numerous, angular. Acanthopores always present, typically of two sizes, the smaller present only in the mature region. Interzooecial walls always thin in the axial region, and sometimes in the mature region; at times considerably thickened in the mature region, always consisting (in sections of the mature region) of three elements: a median zone (usually light colored), in which are lodged the mesopores and acanthopores; a definite dark band on either side, bounding the median zone and encircling the zooecia; and a band (usually light colored) of sclerenchyma immediately encircling the zooecial cavity. Diaphragms few or almost lacking, to numerous; nearly always straight and horizontal. Only in exceptional cases are a few cystoid diaphragms present. When mesopores are present the diaphragms are more numerous in the mesopores. (Cumings.)

I see no reason to modify my contention that the genera *Heterotrypa* and *Dekayella* should be combined with the genus *Dekayia* to form a single genus. This is not the place to go at length into the discussion of this point; but since Mr. Ulrich has recently in a revision of the Trepostomata adhered to his original grouping of the species here referred to the genus *Dekayia*, a word of explanation is demanded for rejecting his views. Ulrich and Bassler say "as to the value of the three genera discussed by Mr. Cumings, we do not deem this the proper place to go into the subject in detail. However, we still consider the three genera distinct and very convenient in classification if not wholly natural groups. It is true that Ulrich some years ago expressed the idea of combining the three genera, but this was at a time when *Dekayella* was the only genus of the three of which species were known in the Mohawkian and Utica, and when it seemed quite probable that the Lorraine species of *Dekayia* and *Heterotrypa* were derived from the earlier genus. Now typical species of both *Dekayella* and *Heterotrypa* are known to range side by side through the Mohawkian and Cincinnatian groups." And again, "Cumings has shown that acanthopores of all sizes, grading from that of the small set to the large kind are present in the same section of various species of *Dekayia*, *Heterotrypa*, and *Dekayella*. We admit that this is so if the section passes through all the stages of growth from the very mature part of the zoarium to the less mature regions."

We pass by the matter of convenience of the three groups into which Ulrich has divided these species, since the only satisfactory basis for a genus is the *natural group*. The question seems to be as to whether two sets of acanthopores are present in all three groups or are confined to the single group of *Dekayella*. Ulrich and Bassler contend that the latter is the case if the fully mature portion of the zoarium alone is considered. Any one is at liberty to examine figures 7, 10, 12 and 14, on plate ix of my paper on the revision of these genera, and conclude whether they cut the mature or the immature region of the zoarium. These sections, as any one knows who is familiar with the appearance of tangential sections of the Trepostomata, cut the fully matured portion of the zoarium; and they just as surely contain the two sets of acanthopores. Figure 9 cuts just at the passage from the immature to the mature portion of the zoarium, and also shows the two sets of acanthopores. In the type species of the genus *Dekayia*—*D.*

aspera, two sets of acanthopores are shown *in the fully matured region* of the zoarium, as shown in figure 10, plate ix, of my paper, and again in figure 10, plate x. There is besides these facts the important fact that the species *Dekayia subfrondosa* Cumings, shows these two sets of acanthopores beyond any question, and in the basal portion of the zoarium has the polygonal zooecia and few mesopores of *Dekayia* (s. s.) and in the terminal branches has the rounded zooecia and the numerous mesopores of *Dekayella* Ulrich. While it has the tabulation of the zooecia in *Heterotrypa*, and it is also a definitely frondescent species as in *Heterotrypa*. Taken together these three genera form one single compact group, with a fair representation throughout the Mohawkian and Cincinnatian series. This group presents within itself no more variation than the genus *Homotrypa* which has the same or greater range and is more prolific of species.

DICRANOPORA Ulrich.

Zoarium large when complete, composed of numerous small ligulate joints. The segments are flattened, from one-fourth of an inch to one inch in length, with the edges subparallel to near the upper end where they suddenly diverge, and are dichotomously divided into two short branches, the ends of which are thickened and solid, and articulate with the next succeeding segments. Cell-mouths ovate to subquadrate, and arranged between raised longitudinal lines. Usually the cells in from one to three rows along the margins have an oblique direction. No interstitial cells. (Ulrich.)

ERIDOTRYPA Ulrich.

Zoaria ramose, branches slender. Zooecia more or less oblique with thick walls, the tubes intersected by diaphragms only. The latter may be wanting in the axial region, are in most cases absent for a short distance within the apertural edge, but always present and close together in the turn from the axial into the narrow peripheral region. Mesopores with close-set diaphragms, varying in number, sometimes abundant, at other times very few. Acanthopores small, never numerous, sometimes wanting. (Ulrich.)

ESCHAROPORA Hall.

"Coral consisting of a solid cylindrical or subcylindrical stem, gradually tapering above, expanded and attached by root-like ramifications below; surface entirely celluliferous; mouths of cellules oval, scarcely contracted, enclosed in a rhomboidal space formed by elevated oblique lines which cross the coral in two directions; cellules consisting of oval tubes of nearly equal dimensions throughout, which radiate in an ascending direction from an imaginary axis." (Hall, original diagnosis.)

Zoaria bifoliate, simple or branching, pointed below, and articulating into a spreading base as in *Ptilodictya.* Zooecia arranged in regular diagonally intersecting series throughout. In the small species these rows extend in a continuous line across the fronds, but in the larger forms their course is interrupted at more or less regular intervals by the development of raised clusters of large cells. Apertures rounded, elliptical or subcircular, set into sloping areas; the latter generally of rhomboidal or hexagonal shape and sharply defined, in other cases longitudinally confluent, and connected by a narrow channel. (Ulrich.)

FENESTELLA Lonsdale.

"Professor Phillips having informed me that the late Mr. Miller of Bristol employed the word *Fenestella* to distinguish a mountain limestone coral possessing generic characters similar to those of the fossils represented Pl. 15, f. 15 to 19, I have conceived it my duty to adopt the name, though not published; and I have ventured to call one of the species *Fenestella Milleri,* as a tribute of respect to departed talent.

Gen. Char.—A stony coral, fixed at the base and composed of branches which unite by growth and form a cup. Externally the branches anastomose, or regularly bifurcate; internally they form a network, the intervals being generally oval. One row of pores on each side of the branches externally, the openings being circular and projecting when perfect. The branches, when regularly bifurcated, are connected by distant, transverse processes, in which no projecting pores are visible. In well-preserved specimens of the base of apparently old corals, the pores or foramina on one side of the branch have united by growth to those on the side of the adjoining branch, and constitute solid bars, either stretching transversely and simply across the intervals, or uniting obliquely three and sometimes more together."—Lonsdale, Murchison's Silurian System, p. 677. 1839.

The above is the original diagnosis of this genus by Lonsdale. In the Geology of Russia and the Ural Mountains, Lonsdale so modified his diagnosis of the genus as to include a very much wider range of forms, having the zooecia on either the inside or outside of the zoarium. Within recent years the genus has been very narrowly restricted (see Ulrich in Zittel-Eastman Textbook of Paleontology) to forms like *Fenestella plebeia,* with the zooecia on the inside of the zoarium. That this is not in keeping with the original diagnosis of the genus can be seen by anyone who will read it as quoted above. In my studies on the development of *Fenestella* I have shown that whether or not the zooecia are on the inside or outside of the zoarium is a matter of very considerable importance in the *Fenestellidae*; and hence that it follows that the restriction originally placed on the genus by Lonsdale, limiting it to forms with the zooecia on the *outside* of the zoarium, is important and should still enter into any diagnosis of *Fenestella.* That the genus as at present constituted is still an unnatural group is certain; and much redistribution of the species into other and probably several new genera will be required when the ontogeny of the various forms is finally worked out. Such work is necessarily slow and favorable material exceedingly scarce, nevertheless it is, I believe, the only way to place this group of fossils in a satisfactory condition taxinomically. In the meantime it is probably not wise to disturb the present arrangement of the species, however unsatisfactory it may be. The only species known from the Cincinnati group has, if I am not mistaken, the zooecia on the outside of the zoarium, as have the majority of the keeled species of the older rocks. Nothing is as yet known concerning its ontogeny, although I have made considerable effort to obtain favorable material, which is so far lacking.

GRAPTODICTYA Ulrich.

Zoaria rising from a pointed articulating base into continuous dichotomously divided narrow fronds. Zooecia with subcircular apertures, surrounded by a low peristome, subpolygonal in outline. Interspaces depressed, generally linear, sometimes with one or two fine tortuous elevated lines; vertically lined in longitudinal sections, but with the lines interrupted. Median laminae straight in transverse sections. (Ulrich.)

HELOPORA Hall.

"Simple or branching cylindrical stems, often swelling at the upper extremity, poriferous on all sides; pores oval or subangular, arranged between longitudinal elevated lines." (Hall, original diagnosis.)

Zoaria consisting of numerous, subequal, small, cylindrical segments, articulating terminally, poriferous on all sides. Zooecial tubes somewhat oblique, geniculated or proceeding to the surface in a straight line. Apertures slightly oblique or appearing direct, suboval, arranged in diagonally intersecting series (section *a*) or between more or less well defined longitudinal ridges (section *b*). In section *a* the apertures are usually without a peristome, but an acanthopore occurs immediately beneath each. In section *b* the acanthopores are wanting, but a peristome, generally incomplete and prominently elevated posteriorly, is present. Axial tube very slender. (Ulrich.)

Ulrich believes that further study of the two sections of this genus as here constituted will result in their separation into distinct genera.

HOMOTRYPA Ulrich.

"Zoarium ramose to subfrondescent; surface smooth, or with more or less prominent monticules. Cells circular, ovate or polygonal, with moderately thin walls. At intervals there are groups of larger-sized cells, which again sometimes inclose small stellate maculae, consisting of much smaller, angular cells. The surface extensions of spiniform tubuli may often be observed at the angles of the cells. In the axial portion of the branches or fronds, the tubes are immature, and may be crossed by straight diaphragms; usually diaphragms are entirely wanting in this region. The tube-walls are excessively thin until they reach the peripheral regions, when they are much thickened, and bend outward to open at the surface. In the peripheral or mature portion of the zoarium, the tubes are provided with a series of cystoid diaphragms; the space intervening between their flexuous inner line, and the opposite wall of a tube, is crossed by equally numerous straight diaphragms. The tube-walls are perforated by rather large connecting foramina. In the tuberculated species the spiniform tubuli are numerous, but very small, and not easily recognized, while in the smooth forms they are much larger, and constitute a conspicuous feature in sections. The internal structure of the small tubes, which form the maculae of some species, is not remarkably different from that of the ordinary tubes. The only difference that I have been able to detect is found in the fact that cystoid diaphragms are but rarely developed in them." (Ulrich, original diagnosis.)

According to Bassler, the species of *Homotrypa* may be classed into two well-defined groups. In the typical section (*Homotrypa curvata* group), diaphragms as well as cystiphragms, are present in the peripheral region. The second (*Homotrypa communis* group) seldom, if ever, has the diaphragms developed either in the axial or the peripheral region of the zooecial tubes. This group is the more common in the Richmond formation. Ulrich's statement, therefore, in regard to the presence of diaphragms in the mature region will hold only for the *curvata* group—the only one known at the time his diagnosis of the genus was drawn up.

The acanthopores, which are practically lacking in some of the species recently described, do not present the peculiarity with regard to the tuberculated and smooth species that Ulrich mentions in his original description, although that, again, was true of the species known at the time his diagnosis was written. In the *communis* group they commonly present an indistinct or fuzzy appearance in tangential sections. Several of the recently described species show the communication pores very beautifully. In fact, they are a very common sight in thin tangential sections of the thick-walled species generally. I believe there can no longer be any doubt of the verity of these structures.

This is one of the most important and abundantly represented genera of the Trepostomata. It is well represented in the Mohawkian series and again abundantly represented in the Richmond formation, with a meagre representation in the Utica, and a fair representation in the Lorraine. The *communis* group is confined to the Richmond formation, as now defined.

LEPTOTRYPA Ulrich.

The genus *Leptotrypa* has recently been restricted by Ulrich and Bassler to a fraction of the species formerly referred to it. This is eminently proper since the genus as until recently constituted formed an incongruous group. The type species is found to belong to the Amalagamta and is placed in the *Heterotrypidae* (sic.). As restricted, the genus includes several parasitic forms (*L. minima, L. ornata* and *L. clavicoidea,* and several undescribed species). Ulrich and Bassler give the following very brief diagnosis of the genus as restricted:

Zoarium forming thin, evenly spread, parasitic expansions; acanthopores very small, never abundant; no mesopores.

MONOTRYPELLA Ulrich.

This genus has recently been restricted by Ulrich and Bassler to the genotype and such other ramose *Amplexoporidae* as differ from *Amplexopora* only in the absence of acanthopores. The genotype (*M. aequalis*), or rather the specimen from which the original set of figured sections were cut, is certainly without acanthopores, but, Ulrich and Bassler state, no other of the specimens that have heretofore been referred to that species is without them. These authors are inclined to treat the original specimen of *M. aequalis* as unique, although they admit the bare possibility that it may be an abnormality. It would seem to me better, since all the other species except the genotype and *M. pulchella* have now been removed from the genus, to entertain the view that the genotype is abnormal and remove it to the genus *Amplexopora*, thus doing away entirely with the genus *Monotrypella*, which seems to rest on such an insecure foundation. The species *M. quadrata* and its near relatives are removed by Ulrich and Bassler to the new genus *Rhombotrypa*.

MONTICULIPORA d'Orbigny.

"Cellules serrees, poriformes a la surface, d'un ensemble rameux ou encroutant couvert de petites sailles coniques."—d'Orbigny, Prodrome de Paleontologie, p. 25, 1850.

The above diagnosis is quoted merely as a matter of historical interest. The forms placed in the genus *Monticulipora* by d'Orbigny, under the original diagnosis, would constitute a very considerable section of the Order Trepostomata as now understood. By successive restrictions the genus has come to consist of only a few very closely related and characteristic species. For this restriction we are indebted to our foremost student of the fossil Bryozoa, Mr. E. O. Ulrich. The following is Ulrich's diagnosis of the genus:

"Zoarium massive, lobate, subramose, laminar, incrusting, or frondescent. Surface usually tuberculated, sometimes even. Monticules closely arranged, usually conical, often elongated or compressed. Zooecia polygonal, generally rather small, with thin and, internally, peculiarly granulose walls. Mesopores few, generally absent entirely. Cystiphragms present in the zooecial tubes, both in the axial and peripheral regions of the zoarium, usually in continuous series, but often isolated. Acanthopores small, more or less numerous."

Recently a few forms heretofore referred to the genus, as restricted, have been removed to the new genus *Orbignyella* by Ulrich and Bassler. The forms so removed lack the granulose wall structure of *M. mammulata* and have less clearly defined cystiphragms. As now constituted the wall structure is the most important character of the genus *Monticulipora*.

NICHOLSONELLA Ulrich.

Zoaria consisting of irregularly intertwining flattened branches or fronds, sometimes laminated. Zooecia tubular, with a few diaphragms in the mature region. Apertures circular, with a faint granose peristome. Interspaces wide, occupied by numerous angular mesopores, that more or less completely isolate the zooecia. Walls of both the zooecia and mesopores thin, and in the mature region traversed longitudinally by minute tubuli. The interzooecial spaces are filled by a calcareous deposit, into which the minute tubuli continue, but in which the mesopore walls become unrecognizable. Mesopores with rather thick and numerous diaphragms. (Ulrich.)

PACHYDICTYA Ulrich.

Zoaria bifoliate, consisting of irregular wide branches, large and small, and more or less undulating, leaf-like expansions, or of narrow, subparallel-margined, and dichotomously branching stipes. Margins acute, with a nonporiferous border, obliquely striate or granostriate. Surface with small maculae and, about them or taking their places, clusters of zooecia of more or less obviously larger size than the average; occasionally montiferous. In other cases these clusters are represented by the marginal rows of apertures which are commonly of larger size, with wider interspaces, and less regularly arranged than those of the central rows. Zooecial tubes arising rather abruptly from the mesial laminae, the primitive cells with thin walls, longitudinally arranged, of elliptical, semi-cordate, or subquadrate form, in most cases partially separated from neighboring cells by small interstitial vesicles. Toward the surface their walls are thickened, often ring-like, subelliptical in cross-section, usually completely isolated, the interspaces solid excepting that they are traversed by one or more, straight or flexuous, series of minute tubuli. One or more (the number depends upon age of example) complete diaphragms in each zooecial tube. Apertures usually elliptical, rarely subangular, the "closures" with a subcentral small opening. Interspaces grano-striate, concave and forming a peristome about the zooecial apertures, or thrown up into longitudinal ridges. Median tubuli between the halves of the double mesial plate. (Ulrich.)

PERONOPORA Nicholson.

Zoarium laminar or encrusting. Two distinct sets of tubes are present, distinguished by their size and structure. The large tubes (zooecia) are furnished with incomplete tabulae (cystiphragms) of the type of those found in the corresponding tubes of *Prasopora*. The mesopores are numerous, interspersed among the zooecia, sometimes partially aggregated into clusters; their tabulae always more numerous, close set, horizontal, and complete. Acanthopores are usually largely developed, though occasionally apparently wanting. The walls of the zooecia are thickened and seemingly fused together in adjoining tubes, their primitively duplex character being entirely lost. (Nicholson.)

The above diagnosis is slightly modified from the original diagnosis of Nicholson, the changes being merely in the substitution of the modern terminology for his.

Nicholson's *Peronopora frondosa* is our *P. pavonia*; his *P. molesta* is our *Monticulipora molesta* and his *P. cincinnatiensis* is our *Monticulipora cincinnatiensis,* while his *P. ortoni* is our *Atactoporella ortoni.* It will be seen therefore that the present conception of the genus is quite different from that of Nicholson. The genus was restricted to its present significance by Ulrich in 1882. As now understood the genus is restricted to bilaminar forms such as *P. decipiens* Rominger (=*P. pavonia* d'Orb.); and the addition of this restriction is almost the only change that need be made in the above diagnosis of Nicholson. The zoaria are, however, never genuinely incrusting, though they do frequently arise from a broadly expanded base. The surface is sometimes smooth, and sometimes has low-rounded monticules. Maculae of smaller cells than the average are quite commonly present and sometimes form a conspicuous feature. The zooecia spring from either side of a double median plate or lamina, are at first prone, but rapidly turn outward and emerge at right angles to the surface. Apertures circular or subpolygonal. The other characters as in the diagnosis of Nicholson, given above.

PETIGOPORA Ulrich.

Zoaria consisting of small, more or less circular patches, on the surface of other bryozoa, or of brachiopods, etc. Always thin, with short, direct zooecia, no mesopores, and rather large acanthopores. The acanthopores sometimes give rise to spines at the surface. Diaphragms few or lacking. Walls rather thick at the surface.

It is quite possible that some of the species referred to this genus are the young of species of *Dekayia*. In some cases, however, they have a different range from any species with which they might reasonably be thus associated; and in such cases it is hard to believe that they can be young stages. Some of the species are quite common and widely ranging forms.

PRASOPORA Nicholson and Etheridge Jun.

Zoarium consisting of concavo-convex, hemispherical, subglobular, conical, pyriform or more or less irregular masses with a wrinkled epitheca on the basal surface. Upper surface either smooth or with more or less prominent monticules. Zooecia polygonal or rounded, thin-walled, usually more or less completely isolated from each other by small angular mesopores; direct. Acanthopores nearly always present, but scarcely ever abundant or large. Diaphragms numerous and close-set in the mesopores; less abundant and more widely spaced in the zooecia, where they are always accompanied by a well-developed, usually overlapping series of large cystiphragms. In some species the cystiphragms are isolated and present semicircular, semielliptical or pyriform outlines, at times one being superposed upon another. They may occur on one or both sides of the zooecial wall. The diaphragms nearly always spring from the backs of the cystiphragms.

This genus is most abundantly represented in the Trenton rocks, is absent in the Utica and Lorraine and is represented by a single abundant species in the Richmond of Ohio, Indiana and Illinois.

PROBOSCINA Audouin.

Zoaria adnate, creeping over the surface of brachiopods, corals, other bryozoa, etc. Zooecia subtubular, more or less immersed in the coenenchyma, with circular erect apertures. Arranged in two or more continguous series. This feature constitutes the chief difference between this genus and *Stomatopora*. Budding lateral or terminal, or both.

This genus, although having a very small specific representation, is present in most of the divisions of the Ordovician rocks from the Black River formation to the top of the Richmond, and usually in considerable abundance of individuals.

Under the diagnosis of the genus *Stomatopora* will be found a discussion of the status of that genus and the present one.

PTILODICTYA Lonsdale.

"Thin, elongated expansions, having on each surface small quadrangular cells not convex, which penetrate the coral obliquely, and are arranged with respect to the surface, along the middle of the specimen, parallel to the elongated direction of the coral, but on the sides obliquely from it. Surface, a very thin calcareous crust traversed by slightly raised ridges, marking the boundaries of the cells; towards the margin the crust thickens, the indications of the cells are less distinct, and at the edge are invisible; but cells are traceable close to the margin where the crust has been removed; opening of the cells small, transversely oval ? no indication of a central partition parallel to the surface." (Lonsdale, Murchison's Silurian System, p. 676, 1839.)

This genus, which has been the receptacle at various times of a large and varied assortment of more or less unrelated forms, was restricted to its present bounds by Ulrich in 1893, in the Geology of Minnesota, p. 165. I have ventured to quote the original diagosis of Lonsdale as a matter of historical interest, in view of the increasing difficulty of obtaining access to Murchison's great work. Ulrich's diagnosis is as follows:

Zoaria bifoliate, simple, unbranched, lanceolate or falciform. terminating below in a solid, striated, pointed base, which originally fitted loosely in the centrally situated cup-shaped depression or socket of a small basal expansion. The latter grew fast to foreign bodies, is radially striated, and has small cell openings in the furrows between the striae. In very young examples, and in certain small species in which this condition seems to be permanent, the entire zoarium consists of longitudinally arranged, narrow, oblong-quadrate zooecia. As growth proceeds new zooecia, both wider and differently arranged, were added on each side. These lateral zooecia may be arranged in oblique or transverse rows, so as to produce the "pinnate" or "plumose" arrangement prevailing in the typical species, or they may form diagonally intersecting rows, with groups of large cells or subsolid spots raised at regular intervals into monticules. Zooecial apertures subquadrate. rhomboidal, or rounded, the shape depending largely on their arrangement. Both hemisepta usually well developed. Primitive cell, with thin walls, subelongate, hexagonal, or lozenge-shaped, in contact at all sides. In the vestibular or outer region, the walls are more or less thickened, solid, and with a double row of exceedingly minute dots; the latter rarely preserved and seen only in tangential sections. No median tubuli. (Ulrich.)

RHINIDICTYA Ulrich.

"Zoaria composed of narrow, compressed, dichotomously divided branches, with the margins sharp, straight, and essentially parallel; attached to foreign bodies by a continuous expanded base. Zooecial apertures subcircular or elliptical, arranged alternately in longitudinal series between slightly elevated, straight or flexuous ridges, carrying a crowded row of small, blunt spines. Space immediately surrounding apertures sloping up to summits of ridges." (Ulrich.)

RHOMBOTRYPA Ulrich and Bassler.

"Ramose *Amplexoporidae* with zooecial tubes in the axial region regularly quadrate or rhombic in cross-section. Acanthopores usually wanting, always shallow, rarely distinguishable internally. True mesopores absent, but wall-less tabulated interzooecial spaces occur in several of the species." (Ulrich and Bassler.)

This genus has recently been erected by Ulrich and Bassler for the reception of the species of which the well-known *Monotrypella quadrata* (Rominger) is the type. The chief and almost the only difference between *Monotrypella* and the new genus is in the quadrate of rhombic cross-section of the zoöecia in the immature region of the latter. Since this peculiarity seems to be very constant, however, there seems to be ample warrant for the establishment of the genus.

The quadrate zooecia are usually best seen in cross-sections of the branch; but they are also frequently beautifully shown at the ends of branches, and sometimes, especially in small individuals, they form a conspicuous feature of the greater portion of the entire surface of the branch, and give it a characteristic and unmistakable appearance. The genus is not known to occur in rocks older than the Richmond formation, but it is quite characteristic of the latter. It is represented by one species in the Lockport shales of the Niagara series.

RHOPALONARIA Ulrich.

"Zoarium adnate, excavating the surface of the host so as to become usually about half embedded in it; consisting, so far as known, of fusiform internodes or cells connected by extremely delicate tubular stolons, the whole arranged in a primate manner. Zooecia unknown, probably deciduous and developed by budding from a subcentrally situated pore in the internodes." (Ulrich and Bassler.)

The only evidence usually seen of the presence of this genus is the peculiar pits excavated by the stolons in the surface to which the organism was attached. These tell us nothing about the zooecia except their arrangement. The oldest known species is *R. venosa* from the Richmond formation.

SPATIOPORA Ulrich.

"Zoaria forming thin parasitic crusts upon foreign bodies, the shells of *Orthoceras* being the most favored. Surface even or with monticules. Zooecia short, with direct and more or less irregularly shaped apertures. Lunarium scarcely perceptible even in thin sections. Mesopores very few, usually absent, when present occurring chiefly as 'maculae.' Interspaces often with large blunt spines (? acanthopores). Walls of zooecia moderately thin, with the characteristic structure pertaining to the family." (Ulrich.)

STICTOPORELLA Ulrich.

"Zoaria bifoliate, growing from a broad basal expansion into narrow, parallel-margined, branching stipes, simple leaf-like fronds, or cribrose expansions. Zooecia with the primitive portion tubular, unusually long, generally without hemisepta, the inferior one only occasionally being present. Apertures elliptical, placed at the bottom of a sloping area, the latter usually polygonal. More or less numerous, thick-walled, untabulated mesopores occur between the zooecial apertures and line the zoarial margins. Maculae, composed of clustered mesopores, and sometimes of zooecial apertures of larger size than the average, commonly scattered over the surface of the frondescent species. Tangential sections of favorably preserved specimens show that both the zooecia and the mesopores are separated from each other by a sharply defined line of minute pore-like dots. True median tubuli and diaphragms wanting." (Ulrich.)

STIGMATELLA Ulrich and Bassler.

"Zoarium variable, ranging from incrusting to irregularly massive or ramose. Zooecia angular, rounded, or irregularly petaloid, the shape depending upon the presence (or absence) of mesopores and the number of acanthopores. Typically the zoarial surface exhibits at regular intervals maculae or spots composed of mesopores, although in some species the usual monticules or clusters of large cells occur. Acanthopores always present but variable in number, intermittent, developed chiefly in narrow zones, sometimes inconspicuous but more often so numerous as to give the surface a decidedly hirsute appearance. Mesopores, when present, developed in mature region only, their number variable even for the same species. The zooecial tubes have thin walls in the axial region and these become but slightly thickened in the peripheral region, where a few unusually delicate diaphragms are inserted. In vertical sections the walls exhibit at rather regular intervals in the peripheral region thickenings somewhat similar to those occurring in *Stenopora.* These thickenings occur approximately at the same height in the walls, and tangential sections through these zones give the full development of acanthopores. Minute structure of walls as shown in tangential sections, of the type that characterizes the *Heterotrypidae.*" (Ulrich and Bassler.)

Ulrich and Bassler have recently erected this genus to receive several forms that have heretofore been referred to the genera *Monticulipora, Monotrypa* and *Leptotrypa* of Authors, and for a number of recently described species. The distinguishing character is the periodic thickening of the walls, and the intermittent development of the acanthopores. Of described species this genus includes *Leptotrypa clavis, L. irregularis* and *Monticulipora dychei.*

STOMATOPORA Bronn.

Zoaria adnate, forming delicate dichotomously branching chains of zooecia, creeping over the surface of foreign bodies. These branches frequently inosculate in such a way as to give to the whole expansion a reticulate or web-like appearance. The individual zooecia are tubular, pear-shaped, oval, club-shaped, sometimes almost hemispherical; arranged in one or more series; more or less immersed in the coenenchyma. Apertures round, salient, sometimes notably drawn out; usually situated at the distal end of the zooecium, but sometimes near the middle of its upper surface. Walls finely porous.

This diagnosis will, I believe, admit both the Ordovician and Mesozoic forms commonly referred to this genus. There is no question, however, that this is an unnatural group as it stands. I cannot take the space at the present time to discuss the various points which arise in a critical consideration of the great array of species which it is the habit of students of the Bryozoa to refer to this genus and to the genus *Proboscina.* I wish only to call attention to the work of Mr. W. D. Lang of the British Museum, which is along precisely the lines that may be expected to yield the most valuable results, and which has already been the means of showing us the artificiality of the group as at present constituted. Mr. Lang's studies are still in progress, and I sincerely hope that he will at some time take into consideration the older Paleozoic as well as the Mesozoic species. It seems to me certain that these species, so widely separated, in time will be found to fall into distinct genera. As Lang has already pointed out, the genera *Stomatopora* and *Proboscina* are polyphiletic in origin, "and in some cases a given species of *Proboscina* may be at the head of a series of forms, the simplest of which are undoubtedly *Stomatopora.*" In like manner I believe it will be found that *Stomatopora* as at present constituted will afford material for a number of genera standing as radicals of lines leading into various genera of Cylostomata besides the genus *Proboscina.* These genera will be found to converge in the older rocks into a few (and possibly one) very simple types. The ordovician type of *Stomatopora* comes surprisingly near fulfilling the conditions not only of a primitive Cyclostome, but of a primitive Bryozoan. The time is not yet ripe to go into this fertile subject further than to make suggestions, and this I have done in my paper on the Development of Paleozoic Bryozoa, to as great an extent as the facts at hand permit. The method of Lang is in entire agreement with my own, namely, to study first the ontogeny (or rather the astogeny) of the individuals of a species and then to construct the genera strictly on the basis of phyletic relationships thus pointed out. This is the method of Hyatt and Beecher and Jackson, that has already proved so valuable in the rearrangement of the genera of the Brachiopoda, Cephalopoda, and Trilobita.

DESCRIPTION OF SPECIES.

AMPLEXOPORA CINGULATA Ulrich.

Plate VI, figs. 1, 1a; Plate XXVI, fig. 3.

Amplexopora cingulata Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., V, p. 254, pl. xi, figs. 5-5c.

"Zoarium ramose, consisting of cylindrical or subcylindrical branches, which divide dichotomously at irregular intervals, and vary in diameter from three to seven-tenths of an inch. The surface is perfectly smooth, and destitute of monticules. When in the best state of preservation, the cell-apertures are subpolygonal, the walls are moderately thin, and occupied by small granules. In the usual condition the cell-apertures are rounded, the walls comparatively thick and smooth. The surface also shows groups of from seven to fifteen cells, of a larger size than the average, their diameter varying from 1/80th to 1/60th of an inch, while that of the smaller ordinary cells is almost constantly about 1/90th of an inch.

"Tangential sections show that the cells are of one kind (*i. e.,* no interstitial tubes are present), and that, between the groups of larger cells, they are of a very uniform size. The original polygonal walls can still be readily recognized; but their internal cavities are more or less rounded by a secondary deposit of dark, concentrically laminated sclerenchyma, which has a variable thickness in the different sections. The original line of demarkation between adjoining tubes is always more or less distinctly preserved, and is made especially conspicuous by the numerous small spiniform tubuli, which, in this species, are developed only on the line of junction. One is situated at each angle, and one or two more on the line between the angles.

"Longitudinal sections show that the tubes in the axial region have very thin walls, and are traversed by remote horizontal diaphragms, from two to three times the diameter of a tube distant from each other. As they approach the surface, they bend outward rather abruptly, their walls are much thickened, and the diaphragms become much more numerous. The tube-wall in the peripheral region is divided into four longitudinal portions, by three distinct dark lines. The two inner portions represent the original walls of two adjoining tubes, and are composed of a fibrous structure, the fibers being directed obliquely upward to meet along the dark central line. The two outer zones, which are of a darker color than the inner layers, represent the secondary deposits within the original polygonal walls of the tubes. The diaphragms in the outer portion of the tubes are usually nearly horizontal. All of my sections, however, show a few very peculiar diaphragms. In the section they are represented by two curved plates which spring from the opposite walls of the tube, nearly meeting, either in the center, or nearer one side of the tube-cavity, when they proceed as nearly parallel lines downward to the next straight diaphragm. Their shape was undqubtedly that of a funnel, of which the position of the lower tublar portion, with regard to the expanded mouth, was somewhat erratic.

"In transverse sections the tubes in the axial region have very thin walls, and are strictly polygonal." Ulrich, *loc. cit.*

To this species I have referred a specimen from the lower part of the Lorraine, that seems to possess all of the characters enumerated above except that I have not detected any of the infundibular diaphragms mentioned by Ulrich. The walls are also not quite as thick as represented in Ulrich's figures.

1.34C14a.

AMPLEXOPORA PETASIFORMIS (Nicholson).

Plate VI, figs. 3, 3a; Plate XXVI, fig. 2.

Monticulipora (*Monotrypa*) *petasiformis* Nicholson, 1881, Genus Monticulipora, p. 190, fig. 40.

"*Spec. Char.*—Corallum small, discoidal, from six to eighteen lines in diameter, somewhat variable in shape, but always with a flat or concave base, which may be in part attached parasitically to some foreign body, but is always covered with a concentrically striated epitheca over the rest of its extent. From this basal plate the short corallites spring nearly at right angles throughout, and they either form a thin disc, or they give rise, more commonly, to an expansion which is thin at its edges, but is prominently elevated towards its center, thus resembling in form the 'cap' of many mushrooms. In other cases, there may be two of these prominences; and, whether single or double, the superior elevation may project above the base to a considerable height as compared with its width at the base. The maximum height varies from three lines to nearly one inch. The upper surface is covered with the calices, which are thin-walled, polygonal, and approximately equal in size, varying from 1/80th inch to 1/60th inch in diameter. There are no small interstitial corallites of any kind, but the surface shows numerous clusters of tubes which are slightly larger than the average, and which are very slightly elevated above the general level. The walls of all the corallites are thin and delicate, no thickening taking place as the surface is approached. The tabulae are numerous, complete, equally developed throughout the entire length of the corallites, straight or slightly curved, and mostly from 1/100th to 1/90th inch apart.

"*Obs.*—This form from its general aspect would be set down as a near relation of *Monticulipora petropolitana,* Pand., from which, however, it is even superficially separable by its peculiar and seemingly constant form. In its minute structure the present species is quite distinct from *M. petropolitana,* Pand., and, in fact, possesses characters which sufficiently distinguish it from all the forms externally like it. Tangential sections show that there is a total absence of small interstitial tubuli, and that, except for the previously mentioned existence of clusters of corallites of a size slightly above the average, the tubes are approximately alike in size. The walls are exceedingly thin, but nevertheless, in sections sufficiently thin, show a distinctly duplex character, the boundary lines between the walls of contiguous tubes being expanded into angular nodal points at their angles of junction. Long sections show that there is no difference in internal structure between the average corallites and the clusters of slightly larger tubes which are interspersed amongst these, all being furnished with numerous complete tabulae. The two species most nearly allied in structure to the present form are *M. undulata,* Nich. (the rounded examples from the Hudson River Group), and *M. irregularis,* Ulrich. From the former of these, *M. petasiformis* is distinguished by its different external shape, by the fact that its corallites spring perpendicularly from a basal epithecal plate, instead of radiating from a basal or central point, by the absence of even a few small corallites, and by the much greater development of the tabulae, these structures not being disposed at corresponding levels in contiguous tubes. From *M. irregularis,* Ulrich, the present species is readily separated by its want of the nodulated surface and radiated corallites of the former, and by the great abundance of its tabulae."—Nicholson, *loc. cit.*

5.9A6....1.34C6.

AMPLEXOPORA PUSTULOSA Ulrich.

Plate VI, figs. 4-4b, Plate XXVI, fig. 1.

Amplexopora pustulosa Ulrich, 1890, Geol. Illinois, VIII, p. 451, pl. xxxvi, figs. 3-3e.

"Zoarium subramose, lobate or irregularly compressed, of an average thickness of eight mm. Surface rarely smooth, generally set with low monticules, about 2.6 mm. apart from center to center, consisting of groups of larger cells with a few small ones. Zooecial walls a little flexuous, thickened somewhat in the cortical region. Zooecia polygonal, hexagonal and pentagonal, about nine in two mm. Apertures subpolygonal, those in the monticules one-half larger than the others. In the axial region the diaphragms are about twice their diameter apart, but become more numerous as the peripheral region is reached, where they are somewhat less than a tube diameter apart. Acanthopores fairly numerous, commonly situated at the angles. Usually there are two or three superposed mature regions with diaphrams very crowded where the transition from one to the next takes place.

"This species differs in several important respects from *A. septosa* Ulr. In that species acanthopores are more numerous and project into the visceral cavity, tubercles are wanting or but slightly elevated and the growth is strictly ramose."—Ulrich, *loc. cit.*

1.34B4-5. Occurs abundantly just above the level of the gerontic *Platystrophia lynx* layer in cut No. X on Tanner's Creek.

AMPLEXOPORA ROBUSTA Ulrich.

Plate VI, figs. 5-5b.

Amplexopora robusta Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 82, pl. i, figs. 1-1b.

"Zoarium ramose, consisting of cylindrical, oftener of flattened branches, dividing dichotomously at rather frequent but irregular intervals, and usually varying in diameter from .4 inch to .7 inch. A very large specimen in my cabinet has a length of 4.3 inches; the central stem is flattened, and varies in diameter from 1.1 inches to 1.7 inches. The bases of two branches are on one side, and three on the other, the mean diameter of which is about .6 inch. Monticules are not developed. The cells are moderately thin-walled, polygonal, and consist of one kind only (*i. e.*, the interstitial cells are wanting); their arrangement is quite regular, and, when well preserved, show at the angles of junction the elevated points of the spiniform tubuli. At intervals of about .15 inch the surface exhibits conspicuous clusters of cells larger than the average, with a mean diameter of 1/60th of an inch. The smaller or ordinary cells have a diameter varying from 1/100th to 1/90th of an inch.

"Tangential sections show that the cell-walls are comparatively thin and polygonal, and that their cavities are only occasionally rounded by a secondary deposit of sclerenchyma; and further that the original line of separation between adjoining cells is always more or less distinctly marked. The spiniform tubuli do not constitute a conspicuous feature in sections of this species, and unless carefully examined might be overlooked. With an occasional exception they always occupy the angles of junction of the cells. (Their appearance is very well represented by the figures.) Lastly, in many sections some of the cell-cavities inclose a small circular ring, that is due to the peculiar funnel-shaped diaphragms seen in longitudinal sections.

"In longitudinal sections the tubes in the 'immature' region are thin-walled, and crossed by straight diaphragms from two to four tube-diameters apart. The nearly equal curve of the tubes, from the axis of the branch to the peripheral portion, constitutes a characteristic feature of the species. As they enter the peripheral or 'mature' region their walls are considerably thickened, and the diaphragms become much more numerous, being from less than one-half to one tube-diameter distant from each other. The funnel-shaped diaphragms noticed in the preceding species (*A. cingulata*) are much more numerous in this species. Not infrequently two or three open into each other in such a manner that by the coalescence of the contracted parts of the superimposed funnels, a smaller irregular tube is found within the proper tube-cavity. These diaphragms in their normal condition are represented in the section by two thin converging lines, springing from the walls of the tubes, and nearly meeting near the center of the tube cavity. Frequently, however, one of these lines is missing. In this case the diaphragm extends from one wall nearly across the tube toward the opposite wall.

"Superficially, the species above described resembles the type of the genus, though not nearly enough to be confounded with it by one experienced in the determination of this group of fossils. The cell-walls are thinner, and the groups of larger cells more conspicuous in *A. robusta* than in *A. cingulata.* Internally, the comparatively thin cell-walls and numerous funnel-shaped diaphragms, and the small number of spiniform tubuli of *A. robusta* will further distinguish it from that species. Care must be taken in separating the species from *Monotrypella aequalis,* Ulrich, which the smaller specimens of *A. robusta* strongly resemble. The former, however, is restricted to the lower 150 feet of the strata exposed at Cincinnati, O., while the latter is limited to a few feet of strata at least 225 feet higher in the series."—Ulrich, *loc. cit.*

A description of this species is inserted because, although I am not sure that I have any specimens that can certainly be referred to it, nevertheless it must quite certainly occur in Indiana.

AMPLEXOPORA SEPTOSA Ulrich.

Plate VI, figs. 6-6b; Plate XXVI, fig. 4.

Atactopora septosa Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., II, p. 125, pl. xii, figs. 7-7c.

"A ramose species, growing from an expanded base, by which it is attached to foreign bodies. Branches bearing considerable resemblance to those of *Chaetetes* (*Monticulipora*) *pulchellus* or *fletcheri.* Surface exhibiting low, broad and rounded tuberosities;

which are placed at distances apart of about one line, and carry groups of larger tubes than those of the ordinary size. Tubes small polygonal, quite regularly arranged, without any minute interstitial cells; walls thin; about eight of the tubes, of average size, occupy the space of one line; about six of the tubes of larger size occupy the same space. Pseudo-septa well developed, more easily detected in slightly worn specimens than in those perfectly preserved; from one to five in each tube.

"In longitudinal sections the tubes are seen to be nearly vertical in the middle of the branch; here they have very thin walls, and are crossed by excessively thin and remote tabulae; they then bend abruptly outward, and as the surface is approached the tabulae are more closely set, and the walls become stouter; here, also, the pseudo-septa make their appearance, as is demonstrated by the darker lines which extend parallel with, and between, the true walls of the tube. The diaphragms are so thin that they can easily be overlooked.

"In tangential sections the pseudo-septa are very conspicuous and usually number three or four in each tube. Transverse sections show the tubes in the center of the branch to be polygonal, without minute intercellular tubuli, and with very thin walls.

"From an external examination, when the pseudo-septa are not visible, it is not an easy matter to distinguish specimens of this species from certain varieties of *Chaetetes* (*Monticulipora*) *pulchellus*; but when worn there is no difficulty, as the septa, when viewed through a hand lens, give a peculiar and characteristic appearance to the specimens. Of course, tangential sections will immediately demonstrate their distinctness. The ramose growth of the species will distinguish it from the other species of *Atactopora*."—Ulrich, *loc. cit.*

This is a very characteristic and easily recognized species, owing to the presence of a very large number of acanthopores that conspicuously indent the zooecia. The "pseudo-septa" mentioned in the above description are these acanthopores. Tabulae are rather numerous in the mature region and are frequently more or less curved, sometimes appearing to run into each other, as seen in longitudinal sections. This feature, however, is not peculiar to the present species, but characterizes more or less constantly all the species of *Amplexopora*. The boundary line between adjacent zooecial walls is very well marked.

1.34C13....1.38Ba, and at other localities in the base of the Lorraine.

AMPLEXOPORA SEPTOSA var. MULTISPINOSA Cumings.

Plate VI, figs. 2-2b; Plate XXVI, fig. 5.

Amplexopora multispinosa Cumings, 1901, Am. Geol. XXVIII, p. 376, pl. xxxiv, figs. 7-10.

"Zoarium consisting of frequently branching cylindrical or sub-cylindrical stems of an average diameter of from 8 to 10 mm. Surface with inconspicuous maculae. Cells of average size about 0.2 mm. in diameter.

"In longitudinal sections the cells are seen to be thin-walled in the axial region and without diaphragms. They bend somewhat abruptly toward the surface, becoming greatly thickened and at the same time developing in the passage from the immature to the mature region a considerable number of diaphragms, many of which are curved or even coalesce, giving the false appearance of cystiphragms. Near the surface diaphragms are again lacking.

"In tangential sections, cutting the mature region, the cell-walls are thick, with very clearly defined true walls thickly interspersed with small acanthopores and covered by a copious deposit of secondary sclerenchyma."—Cumings, *loc. cit.*

This form is very close to *A. septosa* and is not considered by Bassler as distinct from that species. The examination of a considerable number of specimens, however, from a number of localities has convinced me that there are rather constantly two groups of the *A. septosa,* one in which the walls are conspicuously indented by the acanthopores (the typical *A. septosa*) and one, the present form, in which the walls are seldom indented. It has seemed to me, therefore, wise to retain the name *multispinosa* as a varietal designation. Besides Milton and Vevay, Indiana, the form occurs in the Tanner's Creek section.

1.34C8, 13....1.38A24-32....1.35C5.

AMPLEXOPORA FILIASA.

Plate V, fig. 2; Plate VII, figs. 1-1b.

Amplexopora filiasa Ulrich and other American authors (not d'Orbigny). For figures of this form see Ulrich, Geol. Ill. VIII, pl. xxxvi, figs. 7, 7a.

I am at a loss to whom to credit this species. That it is not the *Monticulipora filiasa* of d'Orbigny is shown by the figure of a thin section recently published in the Annales de Paleontologie (Tome II, Fasc. II). The figure referred to suggests *Monticulipora epidermata* Ulrich and Bassler, although M. Thevinin (*loc. cit.*) suggests *Prasopora falesi* James. I cannot determine from the figure published by Thevinin whether his reference is correct or not, in as much as the wall structure cannot be made out from the figure. At all events *M. filiasa* d'Orbigny is certainly not the same as the species commonly referred to it in this country. Whether Edwards and Haime had the same species as the one figured by Thevinin, cannot be determined from their meagre description. Nicholson evidently had the form now commonly known as *Amplexopora filiasa,* and if that is the case should probably be credited with the species. This point cannot be settled, however, until Edwards and Haime's type is investigated. Very probably d'Orbigny's type set of specimens contained several species. Whether d'Orbigny indicated any particular specimen as the type, or, if not, upon what basis M. Thevinin made his selection of the type, I do not presume to say.

The form commonly known in this country as *Amplexopora filiasa* is a massive species, sometimes attaining a diameter of several inches, and more or less lobate. The surface is covered with rather small monticules and the zooecia are regularly polygonal, and without mesopores. Internally the zooecia are thin-walled, even in the mature region, acanthropores are few and small, and the zooecia are crossed by straight diaphragms, from less than a tube diameter to several tube diameters apart, and present in the immature as well as the mature region. The wall structure is as in other species of *Amplexopora.*

This species is not uncommon near the top of the Lorraine.

1.38P.

ARTHROPORA CLEAVELANDI (James).

Plate XXVI, fig. 10.

Ptilodictya cleavelandi James, 1881, The Paleontologist, No. 5, p. 38. (Not figured.)

"Polyzoary, so far as observed, consisting of slightly oval, or flattened two-edged fronds, about half a line wide, and ¼ to ½ an inch long. Giving off short lateral branches, varying from nearly right to acute angles, from half a line to one line apart, arranged, generally, in an alternating manner, but in some cases opposite to each other. Fronds celluiferous on both sides, with five or six rows on each face of the main stem, of oval, or sub-circular cells, arranged alternately, and four or five rows on the branches. No elevated or dividing line at the lateral margins of the fronds, as in some other species of this genus. Four or five cell apertures, in the space of half a line, measuring diagonally across the frond. The best preserved specimens show the cell walls as distinct, and a depressed, sinuous line between, with the margins of the cell mouths slightly raised. Internal structure not observed.

"This species bears some resemblance to *Pt. shaferi,* Meek (Pal. of O., vol. 1, p. 69, pl. 5), but differs materially in the *rounded, non*-striate, instead of flat, sharp *striate* edges of the fronds of that species; and the single depressed line between the cell apertures, instead of a striate surface."—James, *loc. cit.*

This species, according to Bassler (James Types, p. 14), is characterized by slender generally non-bifurcating segments, and by the numerous and small lateral branchlets springing out at nearly right angles from the main stem. According to the same author *Ptilodictya grahami* James and *Ptilodictya dubia* James are synonyms of *Arthropora cleavelandi.*

1.34C8, 9, 10, 11.

ARTHROPORA SHAFFERI (Meek).

Plate XXVI, fig. 9.

Ptilodictya (*Stictopora*) *shafferi* Meek, 1872, Proc. Acad. Nat. Sci. Phila. (February, 1872), p. 317. (Not figured.)

"Polyzoum small and delicate, consisting of slender, compressed divisions, that give off on each side rather closely arranged, regularly alternating, lateral branches of the same breadth as the main stems, from which they diverge at an angle of about forty degrees; lateral branches in the same way giving off on each side very short lobe-like, alternating projections; lateral margins of all parts very narrow, sharp, and minutely striated longitudinally, in well-preserved specimens; pores apparently without raised margins, more or less oval longitudinally, alternatly disposed in longitudinal and oblique rows, so as to present a quincuncial arrangement; the number of longitudinal rows varying from five to about seven in the breadth of a stem or branch; spaces between the pores, measuring transversely to the stems and their divisions, about equal to the breadth of the pores, but greater, measuring in the direction of the oblique and longitudinal rows; all the interspaces ornamented, in perfectly preserved specimens, by very minute, more or less waved or flexuous striae.

"Size of entire polyzoum unknown; breadth of stems and branches, 0.05 inch; number of pores in 0.05 inch, measuring in the direction of the oblique rows, about 4 to 6, and, in the same space, measuring longitudinally, from 3 to 4.

"This very delicate little form will be readily distinguished from the other known Silurian species by its small size and peculiar plumose mode of growth, and particularly by its very minute striae between the pores. *Stictopora raripora,* Hall, from the Clinton group of New York, is as delicate a form, but differs materially in its mode of growth, and particularly in its very much less numerous pores.

"The specific name is given in honor of Mr. D. H. Shaffer, of Cincinnati, Ohio, to whom I am indebted for the use of a very fine specimen of it; I also have good specimens from Mr. Dyer's collection."—Meek, *loc. cit.*

The above description, together with the figure given herewith, will make the identification of this fairly abundant species easy.

1.33A3....1.34C13, 14b....1.34A1, 3, 7, 8, 14b, 15a, 16, 17, 18b, 19-21, 20, 21....1.34B1-3, 4-5....1.41A4, 5, 6, 9, 10a, 10b.... 1.41B1, 2, 3....1.41C1, 2, 3....1.41D1, 2, 3....1.41E3, 6.... 1.12A2....1.12E3....1.12F3....1.12D1-6.

ARTHROSTYLUS TENUIS (James).

Plate XXVI, figs. 8-8c.

Helopora tenuis James, 1878, The Paleontologist, No. 1, p. 3.

"Polyzoary minute, consisting of straight, angular or cylindrical stems, with a single row of cells on the face exposed; cell apertures oblong, with raised margins, arranged between strong longitudinal lines, and separated about the distance of their longer diameter; about 6 cells in the space of a line, including the interspaces. Examples examined are unbranched, from 1/4 to 1/2 an inch long, and 1/8 to 1/10 of a line in diameter.

"Some specimens have a depressed line on the highest part and a row of much raised oblique cell mouths on each side—others show only striated faces, no cells; and some have swollen terminations. All examples observed lie upon the surfaces of other substances, no detached specimens found, consequently but one face of any *one* example can be seen."—James, *loc. cit.*

The following corrected description is given by Bassler (1906): "The zoarium is jointed, but specimens showing the segments still in connection are not common. The segments are very slender, straight, needle-shaped rods, about 5 mm. in length, slightly expanding toward the obtusely rounded upper extremity. The latter articulates with the pointed lower ends of generally two succeeding segments, the complete zoarium appearing to consist of extremely delicate and regularly bifurcating branches. Cross sections of a segment are subquadrangular in shape, three of the sides being concave and equal in width, while the fourth side is slightly convex and half again as wide. Each of the three equal sides bears a row of zooecia, while 6 to 8 longitudinal striae mark the fourth side. The zooecial apertures are oval, and when perfect have a delicate and prominent equally elevated rim; 9 zooecia in 2 mm."

According to Bassler this species is not uncommon throughout the Eden shales. The types are from the lower division at Cincinnati, Ohio.

1.34C8, 9.

ATACTOPORELLA MULTIGRANOSA Ulrich.

Plate VII, figs. 2, 2a.

Atactopora multigranosa Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., II, p. 122, pl. xii, figs. 1-1b.

"A parasitic bryozoan, attached to species of *Orthoceras*; growing in large, thin expansions, frequently in superposed layers, and more developed in certain portions than in others; greatest thickness of any crust observed about three-fourths of a line. Surface presenting numerous, irregularly distributed monticules, which sometimes have a portion of the summit compact, but usually the entire macula is composed of an aggregation of larger-sized tubes than the average; the height and diameter of the tubercles vary, but their average dimensions are about one-quarter of a line in height by one-half a line in diameter. With the aid of a magnifier the entire surface is seen to be covered with minute granules; they are so numerous that in well-preserved specimens the outlines of the tube orifices cannot be traced. Tubes small, rather thin-walled, of unequal sizes, from ten to fourteen of those situated between the monticules, occupying the space of one line, without any minute interstitial tubuli. Tube mouths polygonal or floriform, their margins carrying a row of inwardly projecting, minute tubercles or granules.

"From *A. hirsuta* this species is distinguished by its more profusely granulated tube walls, groups of larger sized calices, and in the less compact monticules. The growth of *A. multigranosa* is peculiar, being very irregular, in consequence of a greater development at some parts of the colony than at others; in *A. hirsuta* the thickness of the expansion is nearly equal in all parts. In *A. ortoni*, Nicholson, there are no groups of larger sized tubes, the monticules are conical, and regularly arranged."—Ulrich, *loc. cit.*

Middle Lorraine.

ATACTOPORELLA MUNDULA Ulrich.

Plate VII, figs. 3, 3a; Plate XXVI, fig. 6.

Atactopora mundula Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., vol. II, p. 123, pl. xii, figs. 4, 4a.

"Bryozoary parasitically attached to the fronds of *Chaetetes* (*Monticulipora*) *mammulatus* [*Heterotrypa frondosa* ?]; grows in thin expansions of less than one inch in diameter; thickness less than one-half a line. Surface at regular intervals raised into rather prominent tubercles, placed a little more than one line apart (measuring from center to center), and arranged in diagonally intersecting lines; surface of monticules occupied by calices of the ordinary size. Tubes polygonal, with thick walls, the interstitial spaces occupied by numerous minute tubuli, that are best observed in worn specimens. Tube mouths small, of very irregular shape, but of nearly equal size, ten to twelve in the space of one line; Pseudo-septa well developed, varying from two to five in each tube. No spines nor granules appear to have been developed; the superior ends of the septal ridges, however, sometimes are a little prominent, and thus simulate spines.

"Although closely related to *A. ortoni*, Nicholson, this species has certain characters by which it can be easily distinguished from that form. In that species the walls of the tubes are rather thin and granulated, and there are no true intertubular cells, while in *A. mundula* the walls are thick, not granulated, and are provided with numerous interstitial cells. The monticules are larger and not compact as they are in *A. ortoni*. Worn examples of *A. multigranosa* bear some resemblance to this species, but the thinner walls, non-tubular intercellular spaces, irregular growth and disposition of the maculae in that species will serve to distinguish them."—Ulrich, *loc. cit.*

I have one good specimen of this species, figures of which I give.

1.33A3.

ATACTOPORELLA NEWPORTENSIS Ulrich.

Plate VII, fig. 4; Plate XXVI, fig. 7.

Atactoporella newportensis, Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., vol. VI, p. 250, pl. xii, figs. 4-4b.

"Zoarium robust, growing upon foreign objects, lobate, or throwing off subramose shoots. At intervals of about .12 of an inch, measuring from center to center, the surface is elevated into more or less prominent, rounded, and often elongated monticules, the summits and slopes of which are occupied by cells a little larger than the average. Cells rather regularly arranged in intersecting series, from eleven to thirteen of the ordinary size in the space of .1 inch, with subcircular or ovate apertures, having an average diameter of 1/150th of an inch. On finely preserved examples the apertures are surrounded by a slightly elevated rim or peristome, which is often a little inflected at the points occupied by the numerous, though very small, spiniform tubuli. Interstitial cells numerous, but as usual with species of this genus, they are not readily detected externally.

"Internally this species is in many respects precisely like *A. typicalis*. In tangential sections the cells are seen to be somewhat unequal, narrower, the walls less inflected, and the spiniform tubuli smaller than in that species. Externally they differ in their surface markings, the zoarium of *A. typicalis* being prevalently entirely smooth, while that of *A. newportensis* is generally strongly tuberculated, besides being of more robust growth. The cell apertures also are never so distinctly petaloid as in the type species." —Ulrich, *loc. cit.*

Lower Eden.

ATACTOPORELLA ORTONI (Nicholson).

Plate VII, figs. 5, 5a; Plate XXVI, fig. 11.

Chaetetes ortoni Nicholson, 1874, Quar. Jour. Geol. Soc. London, XXX, p. 513, pl. xxix, figs. 15-15b.

"Corallum forming exceedingly thin crusts, not more than from one-sixth to one-eighth of a line in thickness, attached parasitically to submarine objects. Crusts usually constituting small circular expansions, or irregular and indefinite in form. Surface exhibiting numerous, minute, rounded or obtusely conical eminences, which are placed at intervals apart of a half a line, more or less. The tubercles are somewhat compact at their summits, and carry upon their sides corallites which are a little or not at all larger than the average. The corallites are somewhat oblique to the surface, moderately thick-walled, subequal, without any minute intercalated tubuli. Calices small, subpolygonal or oval, from ten to twelve in the space of one line; their margins thick and surmounted by minute and crowded miliary granules, which are rounded and not spinous, and which are placed almost in contact with one another.

"In appearance, this species, but for its extreme thinness and the small close-set surface-turbercles, might be confounded with *C. papillatus*. On examination with a high power, however, it is readily distinguished from all the known incrusting species of *Chaetetes* by the fine and close granulation of the margins of the calices, giving to the surface quite a peculiar appearance. All the specimens I have seen of this singular species are parasitic upon *Strophomena alternata*; and I am informed by Mr. James that it is rarely found attached to any thing else. In spite of the granulated margins of the calices, it appears to be a genuine *Chaetetes,* and I see no reason for removing it from this genus.

"I have named the species after my friend, Prof. Edward Orton, of the Geological Survey of Ohio, from whom, as well as from Mr. U. P. James, I have received the specimens from which the above description is drawn."—Nicholson, *loc. cit.*

According to Ulrich, who has carefully investigated the internal characters of this species, tangential sections show that the somewhat petaloid zooecia are separated from each other by an extensively developed series of rather large angular mesopores. In most sections taken near the surface these interzooecial spaces appear solid, and it is only occasionally that the mesopores can be certainly identified. Each zooecium is surrounded by a circle of medium-sized acanthopores, and it is the projecting ends of these at the surface that gives to the latter its strikingly hirsute appearance. In vertical sections it is shown that the zoarium may consist of several superimposed layers. The zooecia rise rather abruptly from the substratum and proceed directly to the surface. They are occupied by a series of cystoid diaphragms, and by a smaller number of straight diaphragms. In the mesopores the diaphragms are numerous.

This species is not uncommon near the top of the Lorraine.
1.33A3....1.34B1-3....1.12A2....1.38Bb, c, d.

ATACTOPORELLA SCHUCHERTI Ulrich.

Plate VII, figs. 6, 6a.

Atactoporella schucherti Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., vol. VI, p. 251, pl. xii, figs. 5-5b.

"Zoarium parasitically attached to shells and other foreign bodies, over which it forms thin irregular expansions, usually less than an inch in diameter, and rarely more than .03 of an inch in thickness. The surface generally exhibits at intervals of .1 inch or more slightly raised eminences. When in a good state of preservation the cellular structure is almost entirely obscured by the innumerable surface extensions of the large spiniform tubuli, in many of which the perforation at the apex is clearly shown. When worn, the cell apertures are rounded, about ten in .1 of an inch, with thick interspaces, occupied by the shallow calices of numerous interstitial cells, which in old examples are not readily detected.

"The distinctive characters of the species are well brought out in tangential sections. The cell walls are thin, and between the numerous and large spiniform tubuli are of about equal thickness throughout. Excepting when the section cuts the zoarium just beneath the surface, it is difficult to discriminate between the interstitial cells and true zooecia. But, when near enough to the surface, the former are mostly filled with transparent calcite, while the latter are filled with particles of the surrounding matrix, and when this fails they may be more certainly distinguished by the possession of the crescentic edges of the cystoid diaphragms. The interstitial cells are numerous, but very unequal in size; as a rule, they completely isolate the true cells. The arrangement, size and character of the spiniform tubuli are well shown in the figures referred to.

"In vertical sections, unless they follow the direction of the growth of the colony, the same difficulty of distinguishing the interstitial from the true cells in experienced. This is mainly due to two reasons: First, the cystoid diaphragms, a series of which is apparently developed in each of the proper zooecial tubes, are always attached to the concave side of the tube, and unless the section passes along the direction of growth, these diaphragms present the same appearance that those of the ordinary straight kind do. Secondly, we find that the horizontal diaphragms of the interstitial tubes are but little, if at all, more numerous than the cystoid diaphragms of the true zooecia. There is one feature, however, by means of which I believe the two sets of tubes may be at all times distinguished, namely, the interstitial tubes are crossed by diaphragms at regular intervals throughout their length, while the true cells, near their apertures, are always filled by the surrounding matrix. The spiniform tubuli are very conspicuous in these sections, and nearly always show the central lucid line, which in several instances appears to be crossed by numerous horizontal partitions.

"This species differs from all the others of the genus known to me in the size and prominence of the spiniform tubuli. Compared more critically with *A. mundula* we find the following differences. In that species the spiniform tubuli are considerably smaller, and less prominent, the intertubular spaces narrower, and, in consequence the interstitial cells smaller and less numerous, while the diaphragms in the interstitial tubes are about twice as numerous in a given space.

"Named in honor of my esteemed friend, Mr. Charles Schuchert, who kindly gave me, among other interesting forms, a large and most beautifully preserved example of this species."—Ulrich, *loc. cit.*

1.33A3 (?)....1.41E6....1.12A2.

BATOSTOMA IMPLICATUM (Nicholson).

Plate VII, fig. 7; Plate VIII, fig. 2.

Monticulipora (*Heterotrypa*) *implicata* Nicholson, 1881, Genus Monticulipora, p. 147, pl. ii, figs. 7-7e; and fig. 27, p. 148.

"*Spec. Char.*—Corallum dendroid, of small flattened stems, which average about three lines in width, and from a line and a half to two lines in thickness, giving off branches at short intervals. The calices are mostly about 1/70th to 1/80th inch in diameter, irregularly oval, often indented on one or both sides, thick-walled, with numerous blunt spines projecting from their margins. Between the ordinary calices are the occasional apertures of smaller tubes. The average corallites are thin-walled in the center of the corallites, but become greatly thickened as they approach the surface, the original lines of demarkation between adjoining tubes being never entirely obscured. Smaller corallites are developed in variable number between those of average dimensions. Interspersed also in the thickness of the walls of the corallites, or occupying their angles of junction, are numerous circular hollow tubes, the upper terminations of which appear on the surface as the blunt spines previously alluded to. Remote, complete, and approximately horizontal tabulae are developed in the tubes, being somewhat more numerous in the small corallites than in the large ones.

"*Obs.*—Not having met with any published account of this species, I am not sure that it has been actually described by Mr. Ulrich, to whom we already owe so much excellent work on the fossils of the Cincinnati Group; but it has been named by him in his catalogue of the Fossils of the Cincinnati Group, and Mr. Nickles has been good enough to present to me some specimens of it. Under the circumstances, I should not have been justified, perhaps, in treating of it at all in this place; and my only apology for giving even the above short description of its characters is, that it possesses a structural feature which I should have felt unwilling to have passed over without notice. It illustrates, namely, in a remarkable manner, those peculiar structures which occur in so many of the *Monticuliporae* and *Stenoporae,* and which I have termed 'Spiniform corallites' [now known as Acanthopores]. Thus, if we examine a tangential section, we observe at the angles of junction of the normal corallites, or between the thick walls of two adjoining tubes, a number of clear circular spaces of comparatively large size (from 1/500th to 1/450th inch in diameter). Some of these clear spaces preserve the same character throughout, but most of them exhibit centrally either a dark spot or small, clear ring. These spaces are, therefore, clearly sections of tubes, and there can be no doubt that the spines which stud the thick walls of the calices are the upper terminations of these same tubes. I have not succeeded in detecting any opening at the apices of these spines, though their tubular nature would lead one to expect that such must exist. I have, however, I think, succeeded in satisfying myself that their cavities, as seen in long sections, are crossed by distinct horizontal *tabulae.* This is a point of importance, as tending to confirm my views that these hollow spines, in this and in the many other cases in which they occur, are really of the nature of very peculiarly modified and specialized corallites."—Nicholson, *loc. cit.*

This well-marked species, which Nicholson has very adequately described, is common in the Utica formation wherever exposed. It can readily be distinguished from *B. jamesi,* when well preserved, by the markedly spinose exterior and the small number of mesopores. Internally, it differs in several characters from the latter species: in the greater thickness of the zooecial walls, the smaller number of mesopores, and the large size of the acanthopores, and in the fact that these structures commonly indent the zooecia, giving the latter a more or less irregular shape.

5.9A6, 14, 21, 31, 29....1.34Co, 5, 6, 7, 8, 9, 13....1.38A9, 11, 13, 17, 23, 24, 31, 32, 33, 37.

BATOSTOMA JAMESI (Nicholson).

Plate VII, figs. 8, 8a; Plate VIII, fig. 1; Plate XXVII, figs. 6, 6a.

Chaetetes jamesi Nicholson, 1874, Quar. Jour. Geol. Soc. London, XXX, p. 506, pl. xxix, figs. 10-10b.

"Corallum of cylindrical or subcylindrical hollow branches, the diameter of which is from 3 to 5 lines; or of somewhat lobate and subpalmate masses, the extremities of which are rounded. Branches in the ramose forms dividing dichotomously at irregular intervals, irregularly thickened and nodulose. Corallites oval or circular in section, of unequal sizes. The larger corallites about six in the space of one line, with very thick walls, the margins of the round or subpolygonal calices being obscurely tuberculated or granulated. The larger corallites are separated by extremely minute cylindrical tubuli, the number of which varies in different parts of the corallum. The surface exhibits no eminences or tubercles, or groups of large-sized corallites, but typical specimens exhibit at irregular intervals stellate spaces, which are either solid or minutely punctate, and have a diameter of two-thirds of a line.

"This species is related to *Chaetetes tumidus*, Phill., of the Carboniferous rocks, especially in the rounded, thick-walled corallites, separated by minute intermediate tubes. I have, however, compared it with specimens of the latter, and find it to be clearly distinguished by the larger size and much thicker walls of the corallites, the generally greater number of the minute intermediate tubules, the tuberculated margins of the calices, and the existence of the curious stellate, solid or porous interspaces. The value of this last character is diminished by the fact that some specimens, otherwise the same, do not exhibit these spaces in a conspicuous manner. The tuberculated margins of the calices, though this feature can only be detected with the use of a high magnifying power, remind one of the species generally considered as belonging to the genus *Stenopora*."—Nicholson, *loc. cit.*

This well-marked species does not possess hollow stems, as stated above; Nicholson's mistake probably being due to his seeing specimens in which the axial region had disappeared through weathering. The rather small rounded stems and large oval zooecia with a well developed series of mesopores are the chief superficial characters of this species. Internally it presents the characteristic structure of the genus *Batostoma*. In tangential sections cutting the mature region the walls are seen to consist of rather thick dark rings of dense sclerenchyma, those of neighboring zooecia generally widely separated from each other, though occasionally in contact, and the intervening space occupied by angular and irregularly shaped mesopores. Imbedded in these walls or occupying the line of contact of the walls of adjacent zooecia are numerous rather small acanthopores. The projecting ends of these upon the surface of the zoarium give it, in well preserved specimens, a minutely spinose or granular appearance. In longitudinal sections the zooecia are seen to be crossed by rather infrequent complete diaphragms. In the mesopores these are four or five times as abundant as in the zooecia. The walls in the axial region are thin and the zooecia polygonal in shape. This species differs from the associated *B. implicatum* in the greater development of mesopores, the more nearly circular shape of the zooecia, the smaller size of the acanthopores, the less thickness of the walls, and superficially in the fact that *B. implicatum,* when well preserved, presents a decidedly spinose appearance owing to the great number of large acanthopores.

5.9A2....1.34Co, 5, 6, 7, 8, 9, 10, 11....1.38A7.

BATOSTOMA VARIABILE Ulrich.

Plate VIII, fig. 4; Plate XXVI, fig. 13.

Batostoma variabile Ulrich, 1890, Geol. Illinois, VIII, p. 460, pl. xxxv, fig. 5; xxxvi, fig. 1 (not pl. xxxv, figs. 4b-4e=*B. varians* (James)).

"Zoarium exceedingly variable; encrusting, lobate, digitate, ramose and subfrondescent. Surface smooth, showing inappreciably elevated clusters of larger cells. Walls of zooecia in axial region thin, faintly and irregularly flexuous; much thickened in the mature region; the tubes are polygonal, approach the surface with a gradual curve, and are mainly in contact, with the divisional line between those adjoining sharply marked. Apertures angular, averaging six in two mm. Mesopores angular, varying in number, generally few as in the sections figured. Diaphragms few in the immature region, three or four in the narrow cortical region, the one or two nearest the surface concave; in the mesopores they are moderately abundant. Acanthopores fairly numerous, usually situated at the angles between the zooecia.

"The name '*variabile*' is given to this species because different examples exhibit considerable variations in the mode of growth, in the number and arrangement of the mesopores, in the amount of thickening of the walls in the cortical region, and some other features.

"This form bears much resemblance to the *B. jamesi* Nich., which, however, has oval zooecia separated by many mesopores, while this species has the zooecia polygonal and often in contact, with fewer mesopores and diaphragms."—Ulrich, *loc. cit.*

This is the original description by Ulrich, which has been found to include, according to Bassler,* two good species, one of which is the *B. varians* James sp., a species having a different range, being found abundantly in the lower and middle Richmond, while *variabile* as restricted by Bassler (*loc. cit.*) is confined to the uppermost beds of that formation.

*Proc. U. S. National Museum, vol. XXX, 1906, pp. 18, 19.

The following is Bassler's description of *Batostoma variabile* as restricted:

"*B. variabile,* as thus restricted, forms robust, cylindrical or subcompressed, usually infrequently dividing stems, 10 mm. or more in diameter. The surface of the zoarium is smooth, but maculae of conspicuously larger zooecia are present. The zooecia are thin-walled and angular at the surface with mesopores practically absent. Below the surface the zooecial walls are so thickened by deposits of tissue along their sides that a tangential section through this region gives a rounded aspect to the apertures. Six to seven of the ordinary zooecia occur in 2 mm. Acanthopores sometimes large and occupying all the zooecial angles, but at other times not a conspicuous feature. Distribution of diaphragms and other internal features as shown on Plate VII [of Bassler's paper].

"Because of the absence of mesopores, this species shows with unusual distinctness in tangential sections, the black line separating the walls of continguous zooecia, a characteristic feature of this as well as a number of other genera of the Monticuliporoids. The large, smooth, ramose zoarium, angular contiguous zooecia, few mesopores, and conspicuous clusters are characters sufficient to distinguish this form from other species of the genus.

"The specimens figured by Ulrich from the Richmond group at Savannah, Illinois, cannot be determined with certainty on account of their ill-preserved internal structure, but it is probable that they belong to neither of the two species under discussion." —Bassler, *loc. cit.*

I have referred but a single specimen to this species, namely one from Madison, Indiana, from the beds immediately underlying the Saluda formation.

1.12D1-6.

BATOSTOMA VARIANS (James).

Plate VII, fig. 9; Plate VIII, figs. 3-3b; Plate XXVI, fig. 14.

Chaetetes varians James, 1878, The Paleontologist, No. 1, p. 2. (Not figured.)

"A coral resembling *Chaetetes jamesi,* Nicholson, is found in the upper beds of the *Cincinnati group.* Its mode of growth seems to differ in some respects, being spread over shells, in thin lays, in some cases; in others, branching out in a digitate manner from lobate, palmate and irregular-shaped forms; the average calices are scarcely as thick walled as typical *Jamesi,* and the stellate spaces rather more conspicuous. Should it prove a distinct species, I propose for it the name *varians* (Chaetetes varians)."—James, *loc. cit.*

In the large size of the zooecia, peculiar appearance and number of the acanthopores, and in the wall structure this species is quite similar to *B. jamesi* of the Eden formation. It differs from that species, however, in the slight development of mesopores in *B. varians,* while they are very abundant in *B. jamesi,* and in the polygonal shape of the zooecia and usually irregular form and larger size of the zoarium of *B. varians.* This species is very abundant in the Waynesville division of the Richmond formation. It is also found in the Arnheim division and sparingly in the Liberty division. It can usually be recognized at a glance by its unusually large zooecia, though in this respect it might be confused with the associated *Rhombotrypa quadrata,* which can, however, be readily distinguished by the rhombic zooecia nearly always to be seen at the ends of branches.

1.34A10, 11, 12, 13, 14b, 15a, 16, B4-5....1.41B1, 2, C2-3, D1, A5, E3....1.12E3.

BERNICEA PRIMITIVA Ulrich.

Plate XXVI, fig. 12.

Bernicea primitiva Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., vol. V, p. 157, pl. vi, fig. 4.

"Zoarium attached to foreign bodies, and forming small subcircular or irregular patches. Cells small, mostly immersed, somewhat irregular in their arrangement, with the rounded and slightly oblique apertures raised conspicuously above the general surface. Cell apertures usually about twice their own diameter distant from each other; about eight occupy the space of .1 inch."—Ulrich, *loc. cit.*

The general aspect of this species is very similar to *Proboscina,* from which it differs in the fact that it forms expansions which are continuous rather than reticulated, as in the latter genus.

Several good specimens were obtained from the Richmond formation.

1.41B1....1.12E3.

BYTHOPORA ARCTIPORA (Nicholson).

Plate VIII, fig. 8; Plate XXVI, figs. 15, 15a.

Ptilodictya (?) *arctipora* Nicholson, 1875, Ann. Mag. Nat. Hist., 4th ser., XV, p. 180, pl. xiv, figs. 4-4b.

"Polyzoary forming a cylindrical, slightly branched frond, which is not sharp-edged, exhibits no non-celluliferous borders, and shows no traces of a central laminar axis. Cells arranged in obscurely longitudinal alternating rows, apparently perpendicular to the surface, and radiating in all directions from an imaginary axis. Cell-mouths very much compressed, much longer than wide, expanded below and attenuated superiorly, where they are often much twisted and bent. Upon the whole, the cells are pyriform in shape, with their narrow ends directed upwards, about eight occupying the space of one line measured vertically, and twelve the same space measured diagonally. The cells are not always in contact, especially in their upper portion; and their borders are always distinctly marked off by impressed lines; but they are not arranged between elevated longitudinal ridges. The margins of the cells are very thick and conspicuous, not granulated, tuberculated, or spinigerous.

"The best-preserved fragment examined had a length of eight and a half lines, dividing at its summit into two branches, its diameter being rather more than one-third of a line.

"From its cylindrical form, and the absence of a laminar axis or of non-poriferous margins, it would seem certain that this singular form is not a *Ptilodictya*; but I am at a loss to know where it should properly be placed, its extreme minuteness rendering its generic affinities very uncertain, owing to the impossibility of making out the details of its internal structure. It has, however, some affinity with *Ptilodictya* (?) *raripora,* Hall, from the Clinton Group, and I have therefore referred it provisionally to this genus."—Nicholson, *loc. cit.*

There is nothing particularly characteristic in the internal structure of this species. It is a typical *Bythopora*. This is a common and characteristic species in the Eden shales.

5.9A2, 6, 8, 10, 21, 29, 31, 35....1.34C5, 6, 8, 9, 10, 11.... 1.38A5, 11, 13, 15, 17, 19, 21, 23, 24, 32, 33, 41.

BYTHOPORA DELICATULA (Nicholson).

Plate VIII, fig. 7; Plate XXVII, fig. 1.

Chaetetes delicatulus Nicholson, 1874, Quar. Jour. Geol. Soc. London, XXX, p. 505, pl. xxix, figs. 8-8b.

"Corallum very slender and delicate, ramose, composed of cylindrical stems, terminating in rounded, sometimes thickened extremities, and apparently springing in some cases from a horizontal footstalk. Stems sometimes apparently simple, more commonly branched dichotomously, the division taking place at acute angles; diameter of the stems and branches from one-quarter of a line to half a line, rarely reaching two-thirds of a line. Corallites very oblique to the surface, opening by oval apertures, the length of which corresponds with the axis of the stem and exceeds the breadth. Calices in diagonal rows, about eight in 1 line measured longitudinally, and from twelve to fourteen in the same space measured diagonally. When perfect and unworn, the lower lip of the calices is thin and prominent. The calices are all of equal size, and the surface is destitute of monticules or tubercles.

"This is one of the commonest fossils of the Hudson River formation, both in Canada and the United States. From its very minute size, I am left somewhat uncertain as to the true position of this abundant little fossil. It is, I think, certainly the form which has generally been quoted as a slender variety of *Stenopora fibrosa*; but even if this species were to be retained, our examples could not be placed under it. It is likewise apparently one of the forms which has been figured by Hall under the name of *Chaetetes lycoperdon* (Pal. N. Y. vol. i, pl. 24, fig. 1*k*, caet. excl.). It is most closely allied to *Chaetetes gracilis*, James, but it is readily separated by the absence of minute tubuli interspersed amongst the larger corallites, by the much greater obliquity of the corallites and their much thinner walls, and by the uniformly slender habit and stunted growth. From *C. fletcheri*, Edw. & H., it is also distinguished by the size of the corallites and their oblique direction.

"Of the fossils of the later rocks, *C. delicatulus* runs a considerable chance of being confounded with *Helopora fragilis*, Hall, which it much resembles superficially. It is, however, readily distinguished by its almost always being branched, by the form of the calices, and by the fact that the calices are not arranged between longitudinal elevated lines."—Nicholson, *loc. cit.*

The above description indicates very well the external features of this species. Internally it does not differ materially from *B.*

gracilis, except in the absence of mesopores and diaphragms. It is abundant at several levels in the Richmond formation.

1.34B4-5....1.34A3, 4, 8, 9, 10, 14b, 15a, 15b, 16a, 16b, 17, 18a, 19-21, 22, 23....1.41E2, 3, 4, 5....1.41A5, 6, 9, 10a, 10b.... 1.41D1, 2, 3....1.41B1, 2, 3....1.12F3.

BYTHOPORA GRACILIS (Nicholson).

Plate VIII, figs. 6-6b; Plate XXVII, figs. 2, 2a.

Chaetetes gracilis Nicholson, 1874, Quar. Jour. Geol. Soc. London, XXX, p. 504, pl. xxix, figs. 7, 7a. (Named, but not described or figured, by James, 1871, Cat. Foss. Cin. Group.)

"Corallum dendroid, the branches cylindrical or subcylindrical, from less than 1 line to 2 lines in diameter, dividing dichotomously at short intervals. Corallites very small and crowded, from ten to twelve in the space of 1 line, thick-walled, opening obliquely on the surface by oval or circular calices, between which are placed excessively minute circular tubuli. The surface exhibits no elevations or tubercles, but is entirely smooth; and there are also no groups of larger-sized corallites, the ordinary corallites being all nearly of a size.

"This species is allied to *C. fletcheri,* Edw. & H., from which it is distinguished by the thick-walled nearly equal corallites, and the oblique and very small calices, the dimensions of which are much more minute than in the latter form. My description is drawn from type specimens furnished by Mr. U. P. James."—Nicholson, *loc. cit.*

The likeness to *Chaetetes fletcheri* E. & H., is only of the most superficial sort, and does not extend to any of the internal characters. Internally this species presents much the same characters as *B. meeki* and *B. delicatula,* from which it differs chiefly in point of size, being larger than the latter and smaller than the former. In the mature region the walls are very thick, and completely amalgamated, the lumen of the zooecium being always surrounded by a dark ring of dense sclerenchyma. The space between these dark rings is occupied by lighter colored, and evidently less dense material, in which are imbedded the moderately developed series of minute mesopores, and the still more minute thick-walled acanthopores. Carefully prepared sections show that the interzooecial walls are traversed by very minute punctae, apparently running at right angles to the direction of the zooecia. Whether these run through from one zooecium to another I have not been able to demonstrate.

In longitudinal sections the zooecia are seen to be crossed by an occasional diaphragm, and these are more numerous in the mesopores. The zooecia in the axial region have very thin walls and no diaphragms.

1.33A3....1.34A1 (?) .... 1.34B1-3, C14b .... 1.12A2 .... 1.38Bh....1.38P, and everywhere in the Upper Lorraine.

BYTHOPORA MEEKI (James).

Plate VIII, figs. 5, 5a; Plate XXVII, fig. 5.

Chaetetes meeki James, 1878, The Paleontologist, No. 1, p. 1. (Not figured.)

"In the upper beds of the *Cincinnati Group* I find a form of coral—abundant—much like *C. gracilis* in *general features,* the chief difference being in the larger size of the branches, some of them nearly one-half inch in diameter; the typical *gracilis averaging* not over one *line.* Should this prove distinct on further examination, I propose for it the name MEEKI (Chaetetes meeki) in honor of the late F. B. Meek."—James, *loc. cit.*

The internal characters of this species are identical with those of *Bythopora gracilis* (which see), for which reason Nicholson considers it as merely a variety of the latter. It has, however, a quite different range and is a considerably larger form, for which reasons I follow most recent students in considering it as a distinct species. It occurs in the Waynesville formation and is common in the Liberty formation.

1.34A8, 9, 11, 12, 13, 17, 19, 20, 21, 22, 23....1.41A4, 7, 8, B1, 2, D2, C1, E1, 2, 3....1.12D1-6, E3. F3.

BYTHOPORA PARVULA (James).

Plate XXVII, fig. 3.

Helopora parvula James, 1878, The Paleontologist, No. 1, p. 3. (Not figured.)

According to Bassler (James Types), "the zoarium of this species consists of very slender cylindrical branches, seldom exceeding 0.4 mm. in diameter, dividing at irregular, but very long intervals, and bearing four or five rows of elongate oval zooecia, rounded behind and drawn out in front, separated from each other longitudinally by spaces equal to their longer diameter. Measuring lengthwise about 5 zooecia in 2 mm. Narrow, channeled interspaces separate the rows of zooecia. Mesopores and acanthopores obsolete or apparently wanting. Diaphragms sparingly developed."

Distinguished from other species of Bythopora by its extremely slender branches and widely separated zooecial apertures. *B. arctipora,* an associated form, has larger branches and closer set zooecia.

Upper part of the Eden shale. My specimen is from Guilford, Indiana.

BYTHOPORA STRIATA Ulrich.

Plate XXVII, fig. 4.

Bythopora striata Ulrich, 1889, Cont. to the Micro-Paleontology of the Cambro-Silurian Rocks of Canada, pt. II, p. 36. (Not figured.)

"This name is proposed for a species represented in the Manitoba collections and sometimes found associated with *B. delicatula,* Nicholson, at Middletown and other localities in Ohio, where the upper beds of the Hudson River group are exposed. The branches of its ramose zoarium are usually more slender than those of that species, being rarely more than one millimetre in diameter. They also bifurcate at shorter intervals, the length of the latter varying between two and four mm. The apertures of the zooecia too, are more oblique and drawn out anteriorly, and are arranged between somewhat irregular rounded longitudinal ridges, with five or six in a space of two mm. long. Ten to fourteen of the ridges suffice to encircle a branch. These ridges are strongest near the base of the zoarium, gradually fading away toward the growing extremities of the stems.

"In *B. fruticosa,* Miller and Dyer, *B. arctipora,* Nicholson (species) *B. delicatula,* Nicholson, and other species known to me, an arrangement of the apertures of the zooecia in diagonally intersecting series prevails, while in *B. striata,* near its base at any rate, the longitudinal arrangement is the most conspicuous."—Ulrich, *loc. cit.*

As the original description of this species was not accompanied by a figure I am not altogether certain that I am correct in referring my specimens to it. I give a figure of the form which seems to me to correspond to Ulrich's description. It is a very minute species and not uncommon in the Richmond formation in association with *B. delicatula.* Some specimens show a striated base similar to that described by Ulrich.

1.34A7, 8, 9, 14a, 15b, 16b, 18, 19, 20, 21, 22....1.41A2, 4, 5, B1, 3, C1, 2-3, D1, 2, E6....1.12D1-6, F3.

CALLOPORA ANDREWSI (Nicholson).

Plate VIII, figs. 9, 9a; Plate XXVII, fig. 7.

Chaetetes pulchellus Nicholson (non Edwards and Haime) 1874, Quar. Jour. Geol. Soc. London, XXX, p. 503, pl. xxix, figs. 5-5b.
Monticulipora (*Heterotrypa*) *andrewsi* Nicholson, 1881, Genus Monticulipora, p. 128, pl. v, figs. 1, 1a; and fig. 21, p. 129.

"Corallum variable in form, usually of subcylindrical branches, which have a diameter of from 2 to 6 lines, sometimes forming flattened and expanded subpalmate fronds, sometimes inosculating. Corallites thin-walled, polygonal, unequal in size, about eight of the average ones occupying the space of 1 line. Surface exhibiting rounded or somewhat stellate groups of larger corallites, of which two or three occupy the space of half a line, and which sometimes have very minute intermediate tubuli between them. These groups of larger corallites generally comprise from five to seven individuals, and they are placed about 1 line apart; they are very slightly or not at all elevated above the general surface, so that there are no conspicuous tubercles.

"The characters of this species are so well marked as to render its recognition very easy, even in small fragments."—Nicholson, *loc. cit.*

Internally this species exhibits very beautifully the peculiar structure of the genus *Callopora*. Toward the surface the walls are much thickened and ring-like and are separated from each other by a set of small rounded mesopores. In longitudinal sections the zooecia and mesopores are seen to be crossed by a well developed series of straight diaphragms, which are very close together in the mesopores.

1.33A3....1.34B1-3, C14b.

CALLOPORA FRONDOSA n. sp.

Plate IX, figs. 1, 1a.

This species does not seem to differ materially in internal characters from the associated *C. subnodosa*, but it has a frondescent rather than a ramose or subfrondescent zoarium. The zooecia are a little larger than in *C. subnodosa* and the diaphragms a little less crowded.

1.41A6, E6.

CALLOPORA NODULOSA (Nicholson).

Plate IX, figs. 2-2c; Plate XXVII, fig. 8.

Chaetetes ? nodulosus Nicholson, 1874, Quar. Jour. Geol. Soc. London, XXX, p. 506, pl. xxix, figs. 9, 9*a*.

"Corallum dendroid, minute, of small cylindrical stems, which branch dichotomously at intervals of 2 lines, and have a diameter of from two-thirds of a line to 1 line. Corallites prismatic or hexagonal, directed somewhat obliquely to the surface, of two sizes. Larger corallites opening by subcircular or oval apertures, the long diameter of which coincides with the axis of the stems; from six to eight in the space of 1 line measured vertically. Smaller corallites in the form of minute circular tubuli interspersed amongst the larger tubes. Surface exhibiting numerous minute, sometimes conical, sometimes transversely elongated elevations or tubercles, which are placed at distances of about half a line apart, and give the surface a characteristic nodulose appearance.

"This very distinct species is more nearly allied to *C. dalei* than to any other; but it is very readily separated by its much more slender and graceful proportions, and the much smaller size of the proportionally remote tubercles. One specimen, indeed, which can hardly be referred elsewhere, exhibits on transverse section about twelve very distinct radiating septa meeting in the center of the corallites. Though all the other examples possess tabulae and have all the characters of *Chaetetes,* this raises the suspicion that possibly the form may require, on more extended investigation, to be removed from *Chaetetes.*"—Nicholson, *loc. cit.*

This species has the internal features characteristic of the genus *Callopora,* as shown in the figures published by Nicholson in the Genus Monticulipora, and reproduced herewith. It is a very small, slender form, occurring at a lower level than *C. dalei,* which it somewhat resembles.

5.9A6....1.34C8, 9, 10, 11....1.38A11 (?).

CALLOPORA ONEALLI (James).

Plate IX, figs. 3-3b; Plate XXVII, figs. 9, 10.

Chaetetes (?) *onealli* James, Catalogue of Lower Silurian fossils of the Cincinnati group, 1875, p. 2.

"Corallum dendroid; slender cylindrical branches, dividing, generally, dichotomously at irregular distances, and in some cases anastomosing; branches from half a line to two lines in diameter. Calices generally oval, but in some cases the variation may be from subcircular to polygonal, and from eight to ten in the space of a line, measuring lengthwise of the stem, varying considerably in size, occasionally one much larger than the average. Walls of corallites rather thick; minute tubes often between the apertures. The increase of corallites seems to be by fission. A cut section shows the stronger corallites as starting at the center, growing parallel with the length of the stem and following the direction and dividing with the branches, the outer ones curving to the surface obliquely, although the apertures appear to be direct." James, *loc. cit.*

According to the excellent description of Nicholson (Genus Monticulipora, p. 118), the species shows in tangential sections "that the corallum is composed of two distinct sets of corallites, large and small. The larger corallites are oval, about 1/100 inch, or rather less, in their long diameter, and, in this region, furnished with thickened walls. Each tube is surrounded by a ring-like wall of its own, and adjacent tubes are united to one another by sclerenchyma, in which run the numerous small corallites, these latter varying much in shape and size, but being usually sub-angular.

"Transverse sections show that in the central region of the corallum all the tubes are thin-walled and polygonal, only becoming thickened in the circumferential portion. Lastly, vertical sections show that the corallites in the axial region are not only thin-walled, but also remarkable in the shortness and slight curvature of their outer thickened portions. These sections also show that tabulae are nearly or quite absent in the center of the stems, but developed in fair numbers in the peripheral region, their direction, owing to the slight curvature of the corallites, being often nearly parallel to the outer surface. The small interstitial corallites are also seen to be provided with much more numerous and more closely-set tabulae than is the case in the large tubes. All the tabulae are, as a rule, complete, and horizontal or slightly curved; but in some cases a few of the tabulae in the throat of the large tubes may become so bent as to unite with one another, and to form a small number of lenticular vesicles in this region."

This form and *C. sigillaroides* seem to differ only in size—the latter form being a somewhat larger variety. *C. onealli* is common only in the lower member of the Eden Shales, though found sparingly at higher levels.

1.34Co, 7, 8, 10, 11....1.38A15, 37.

CALLOPORA ONEALLI var. COMMUNIS (James).

Plate VIII, fig. 10; Plate XXVII, fig. 11.

Monticulipora (*Heterotrypa*) *o'nealli* ? var. *communis* James, 1882, The Paleontologist, No. 6, p. 47, pl. i, fig. 8.

"Corallum, as generally found, much broken, cylindrical or subcylindrical stems from one to three lines in diameter, branching at variable distances in different directions at acute angles, but masses of considerable size—from one inch to six or eight inches or more in diameter—are sometimes found, in which the stems anastomose frequently in a very irregular manner. Most specimens exhibit masculae or 'monticules,' raised very little or none at all above the general surface, occupied by calices much larger than the average, and sometimes clusters of the smaller tubules. Calices generally oval or subcircular, occasionally somewhat angular; interstitial tubuli numerous, sometimes nearly or quite surrounding the larger cells, and of various shapes; an average of about six calices in the space of one line in the longitudinal direction of the stem, and seven or eight transversely. Apertures of cell walls thin at the surface of unworn specimens, but thickened immediately below, as shown by abraded examples, mostly found in that condition.

"In tangential section the cells are oval or subcircular, walls much thickened and distinctly defined by a dividing space, interstitial tubuli circular or angular. Section of a cylindrical stem, cut longitudinally, shows the corallites as very thin walled centrally, and taking a longitudinal direction with a very slight outward inclination till near the surface, where they make a decided curve and open obliquely. Tabulae remote in the axial part, none observed in the space of one-fourth of an inch in the example used for this description, but near the surface they become distinct, in some cases depressed or bent downward in the middle, or taking an oblique direction across the corallites; the smaller tubes are more closely tabulate. In a transverse section of the axial portion the tubes are thin walled, circular or angular, and occupied by cruciform dissepiments, the interstitial pores variable in shape.

"The interior structure of this species bears quite a close resemblance to M. sp. *o'nealli,* James, but the exterior differs materially, in being of a much more robust habit, in the maculae of larger calices, and groups of small pores. It is considered, by some, to be M. (Chaetetes) sp. *approximata,* Nicholson, but, clearly, it is not the form described and figured by Prof. N. as *approxi-*

matus in the 2d vol. of Ohio Paleontology, 1875, and again in his valuable work on 'Monticulipora,' 1881, where he gives it (approximata) as a synonym for M. sp. *ramosa,* var. *dalei,* E. & H."—James, *loc. cit.*

This variety is distinguished from *C. onealli* by its much larger branches and by the general absence of mesopores. For the internal characters the student is referred to the description of the latter species. In the var. *communis* the mesopores, which are present in deep sections, seem to pinch out as the surface is approached.

This variety is usually found in great numbers near the top of the Eden formation (Utica), being most abundant just below the zone of *Callopora dalei,* and associated with the latter in the lower part of its (*dalei*) range.

5.9A31....1.34C8, 9, 13, 14a....1.38A11, 13, 15, 21, 23, 24, 29, 31. A similar form was collected from the base of the Waynesville formation on Tanner's Creek (1.34A4).

CALLOPORA ONEALLI var. SIGILLAROIDES (Nicholson).

Plate IX, fig. 4.

Chaetetes sigillaroides Nicholson, 1875, Pal. Ohio, II, p. 203, pl. xxii, figs. 9, 9a.

"Corallum ramose, of small dichotomously dividing branches, the diameter of which is rather over one line. Calices regularly oval or sub-circular, their longer diameter corresponding with that of the stems, arranged in diagonal lines, about six in one line, measured diagonally, and from four to five in the same space, measured vertically. Between the average calices are a few minute sub-cylindrical tubuli. In the center of each calice, as a general rule, is a small, circular, secondary calice, about half the diameter of the main calice, and surrounded by a distinct wall, the general appearance of the calices thus somewhat resembling the markings of *C. sigillaria.* Walls of the corallites thin. Surface smooth, or with a few low, scattered, and irregular tuberosities, which in no way differ from the general surface, and always form a quite inconspicuous feature.

"As a general rule, fragments of this species can be recognized with the greatest ease by the peculiar appearance due to the existence of small circular calices within the main calices. In parts of some of the specimens, however, these secondary calices appear to be absent, and then the species is rcognizable by its large, oval, thin-walled calices, arranged in diagonal rows, and separated by minute tubuli, its smooth surface, and its small dimensions. Whether the appearance of secondary calices is due to the formation of perforated diaphragms over the mouth of the tubes at their final period of growth or not, I am not prepared to say."—Nicholson, *loc. cit.*

The opercular foramen (secondary calice of Nicholson) seen in this species is common to all species of the genus, but is perhaps rather more frequently seen in this than in other ordovician species. The opinion which Nicholson hints at that these "secondary calices" may be due to the formation of perforated diaphragms over the mouths of the ordinary calices, is now known to be precisely the true interpretation of these structures. In other words the zooecium is closed by a perforated operculum—a generic character of *Callopora.* The specimen figured by Nicholson in the Ohio Paleontology is 3.5 mm. in the diameter of the stem. Bassler states that the average diameter of the stems of *Sigillaroides* is 4 or 5 mm. Since there is really no distinction between *onealli* and the variety *sigillaroides,* except that of size, I have usually placed specimens with a diameter of less than 3 mm. under the species *onealli,* and specimens with a diameter of 3 mm. or over in the variety *sigillaroides.* It is stated by Bassler that the form *sigillaroides* possesses long, graceful branches without a tendency to anastomose as in *onealli.* My observation has been that the majority of species of *Callopora* will under certain circumstances anastomose. This is seen in *C. communis* to a marked degree, and is not uncommon in *C. dalei,* and *C. ramosa.* The true relation of *C. sigillaroides* and *C. onealli* seems to me to be that under favorable conditions of growth (nourishment, temperature, clearness of the water, etc.) the stems become larger (*sigillaroides*) and under unfavorable conditions they grow smaller (*onealli*). The variety *communis* is based on more substantial characters.

1.34Co, 2, 5, 6, 7, 8, 10, 11, 13....a similar form occurs near the base of the Waynesville formation, 1.34A3, 4.

CALLOPORA RAMOSA d'Orbigny.

Plate IX, figs. 5, 5a; Plate X, fig. 1; Plate XXVII, figs. 13, 13a.

Monticulipora ramosa d'Orbigny, 1850, Prodrome de Paleontologie, I, p. 25. (Not figured.)

"375, ramosa, d'Orb., 1848. *Cerioposa ramosa,* Readle (envoyé sous ce nom). Espèce rameuse dont les branches sont rondes. Etats-Unis, Cincinnati, Ohio (Blue Lime)."—d'Orbigny, *loc. cit.*

The original description of this species is wholly inadequate for its recognition. Edwards and Haime's very excellent figure has made its identification comparatively sure and this identification is now finally confirmed by the photographic reproduction of illustrations of the types in the collection of d'Orbigny, including a photograph of a thin section, in the Annales de Paléontologie, Tome 1, pl. ix (Paris, 1906).

Since the original description of this species is inadequate I quote here the excellent description given by Nicholson in the Monograph of the Genus Monticulipora (1881).

"*Spec. Char.*—Corallum dendroid, of cylindrical or elliptical branches which divide dichotomously, and vary from one to, generally, three or four lines in diameter. Surface covered with numerous conical or somewhat elongated 'monticules,' which are placed at intervals of from half a line to a line, and are not occupied by corallites of specially large or small dimensions. Calices sub-polygonal, with slightly thickened margins, about 1/90th inch in long diameter, surrounded by the openings of numerous small interstitial tubes. Corallites conspicuously divided into two series, the small ones being very numerous, and surrounding the larger tubes in a single row, sometimes completely isolating the latter, and being exceedingly variable in shape and size. In internal structure, both sets of corallites are traversed by complete horizontal tabulae, which are, however, much more numerous in the small tubes than in the large ones. Walls thickened towards their mouths, and apparently fused with one another.

"*Obs.*—The external characters of this species are so well known that they require no further remark here, its numerous conical monticules and the abundance of the interstitial corallites being sufficiently distinctive features. As regards internal structure, thin tangential sections exhibit in a striking manner the conspicuous division of the corallites into two sets of tubes, large and small, and the great development of the latter. The large tubes are very uniform in size, generally oval or circular in shape, and moderately thick-walled—the thickening of the wall, however, never proceeding to the extent that obtains in forms such as *M.* (*Heterotrypa*) *gracilis*, James, *M.* (*Heterotrypa*) *tumida*, Phill., and allied types. The small corallites are very variable in size and form, and are principally developed at the angle of junction of the large tubes; but they are commonly so numerous as to form a complete zone round the large corallites, though such a zone never consists of more than a single row. In tangential sections taken just below the surface, each of the large corallites is seen to be surrounded by a well-marked ring of sclerenchyma, all the tubes, however, being firmly united together. Between the bounding-rings of the larger corallites are situated the small tubes, which, in sections of this nature, are mostly oval or rounded. On the other hand, in tangential sections taken at a somewhat deeper level the marginal rings of the larger corallites are more completely separated from one another, and the small corallites are increased in size by the reduction of their bounding-walls, while their shape becomes more or less angular.

"Vertical sections show that the internal structure of the large and small tubes is conspicuously different, both sets of corallites being traversed by complete horizontal tabulae, which are greatly more numerous in the small tubes than in the large ones. The 'monticules' do not appear, as a rule, to differ in structure from the general mass of the corallum, but they seem sometimes to comprise a larger proportion of small tubes than is usually the case in the intervening parts of the skeleton. In the axial region of the corallum, as shown both in longitudinal and transverse sections, the corallites are thin-walled and polygonal, but they possess an abundance of tabulae. In the outer portion of their course, the corallites become thickened, their walls assuming a fibrous and laminated structure."—Nicholson, *loc. cit.*, pp. 110-113.

Callopora ramosa is a characteristic fossil of the middle and upper Lorraine formation throughout the Ohio and Indiana region and is at certain levels extremely abundant. In the lower part of its range it seems to present characters somewhat transitional to *C. dalei*. The above description and the figures reproduced herewith are amply sufficient for its identification.

1.33A3....1.34B1-3, 4-5, C14b, 1.12A2, 1.38P. Rather common at all of these localities.

CALLOPORA DALEI (Milne-Edwards and Haime).

Plate VIII, fig. 11; Plate XXVII, fig. 12.

Chaetetes dalii Milne-Edwards and Haime, 1851, Monographie des Polypiers Fossiles des Terrains Palaeozoiques, p. 266, pl. xix, figs. 6, 6a.

"Polypier dendroide, à rameaux cylindriques, larges de 6 a 8 millimètres; présentant à leur surface de petits mamelons coniques saillants, distants de 2 ou 3 fois leur diamètre. Calices à bords un peu épais, subégaux, subcirculaires, n'ayant qu'un tiers ou même un quart de millimètre.

"Silurien (inférieur) *Etats-Unis*: Ohio.

"Coll. de Verneuil."—d'Orbigny, *loc. cit.*

Edwards and Haime fortunately accompanied their meager description with very excellent figures, in consequence of which the identity of this species is in no doubt. Nicholson redescribed it in his monograph of the Genus Monticulipora as a variety of *C. ramosa*, and several years before this in the Quarterly Journal of the Geological Society of London and in the Ohio Paleontology as *Chaetetes approximatus*. In internal characters there is no particular difference between this form and *C. ramosa*. Externally it differs only in the small size of the monticules, and even in this particular it is an easy matter to find transitional forms between *C. dalei* and *C. ramosa*.

I have reproduced the figure of *C. approximatus* (= *C. dalei*) from the Ohio Paleontology, since it presents the usual appearance of the form under consideration. I believe that on the average, however, the monticules in typical specimens are rather smaller than shown in Nicholson's figure.

Callopora dalei occurs in the base of the Lorraine and extreme top of the Utica in immense numbers. In the lower part of its range it is associated with *Callopora communis* and in the upper part with *C. ramosa*. I have quite constantly used the stratum in which this species comes in in such numbers as the dividing line between the Utica and Lorraine. Associated with it is a small variety of *Platystrophia laticosta*, so that it seems really to mark the initiation of the *Platystrophia* zone. It is also at this point that the proportion of Limestone in the series begins to become predominant, and that others of the lithological and faunal characters of the Lorraine are initiated. It is also at about this level that the *Dalmanella multisecta* disappears.

5.9A41....1.34C13, 14a.

CALLOPORA RAMOSA var. RUGOSA (Milne-Edwards and Haime).

Plate X, fig. 2; Plate XXVII, figs. 14, 14a.

Chaetetes rugosus Milne-Edwards and Haime, 1851. Monographie des Polypiers Fosslies des Terrains Palaeozoiques, p. 268, pl. xx, figs. 6, 6a.

"Polypier rameux et très-semblable au *Chaetetes ramosus*, les calices ont à peu près la même largeur; mais il on diffère en ce que les monticules, qui sont très-allongés horizontalement, tendent à s'unir antre eux, de manière à simuler de gros bourrelets transversaux très-saillants. Ces bourrelets n'ont guère plus d'un millimètre d'épaisseur, et sont distants entre eux de 2 fois autant. Les calices sont tous presque égaux et larges d'un quart de millimètre.

"Silurien (inférieur). *Etats-Unis*: Cincinnati (Ohio).

"Coll. de Verneuil, où ce Polypier est indiqué sous le nom de *Ceriopora rugosa* (Dale Owen) qui probablement n'a pas été publié."—Milne-Edwards and Haime, *loc. cit.*

The relation of this form to *Callopora ramosa* is here pointed out by Edwards and Haime, and appealed so strongly to Nicholson that he placed the form as a variety of that species, a disposition with which the present author is inclined to agree. Connecting forms between the two certainly abound, and their range is much the same—*ramosa* appearing at a somewhat lower horizon and not extending its range quite as high as *rugosa*. Nicholson's description follows:

"*Obs.*—This form was originally defined as a distinct species by Milne-Edwards and Haime (Pol. Foss., p. 268, pl. xx, figs. 6, 6a), and is at first sight readily distinguished from typical examples of *M. ramosa,* D'Orb., by its external characters. In place, namely, of the conical monticules of the latter, the surface now exhibits numerous well-defined elevations, which are transversely elongated, so as to constitute so many discontinuous transverse ridges. These ridges vary in length; but they do not extend round the stems, and are usually sharp-edged, and are placed about half a line apart. In spite of this conspicuous difference, the more minute external and internal characters of *M. rugosa,* E. & H., are precisely similar to those of *M. ramosa,* D'Orb. Not only are the characters of the calices and interstitial tubes identical, but no difference of the smallest specific weight can be detected on a comparison of corresponding thin sections of the two forms. This will be rendered evident by a comparison of tangential and vertical sections of the type-form of *M. ramosa,* D'Orb., with similar sections of *M. rugosa*, E. & H. In the latter, as in the former, the corallum is composed conspicuously of two series of corallites, the large ones being oval or sub-polygonal, about 1/90th to 1/80th inch in diameter, and surrounded by numerous small tubes. The structure of the walls of the corallites is also the same, and both show exactly corresponding features in longitudinal sections. Upon the whole, therefore, there can be no hesitation in concluding that the mere external difference in the form of the monticules, being un-accompanied by any features of internal or structural difference, ought not to be allowed to count as of more than varietal value.'' —Nicholson, Genus Monticulipora, 1881, pp. 113-115, pl. ii, fig. 3, and figs. 19A and B, p. 114.

It is now well known that there is surprisingly little variation in the internal characters of the various species of the Genus *Callopora;* hence the grounds which here lead Nicholson to consider *C. rugosa* as a variety of *C. ramosa* would not have much force in the face of good external differential characters. It is precisely the latter, however, that are lacking; for while typical examples of the two forms look very unlike, nevertheless any large collection is sure to contain a considerable number of specimens that cannot consistently be referred to either one of the two forms, but fall in an intermediate position. It is this fact that leads me to reduce the form *rugosa* once more to varietal rank.

1.33A3....1.34C, 14b, B1-3, 4-5....1.12A2....1.38A65, Ba-h. A form with the same external characters occurs in the Elkhorn division on Elkhorn Creek, near Richmond, Indiana, 1.41A10a.

CALLOPORA SUBPLANA Ulrich.

Plate X, figs. 4, 4a; Plate XXVII, fig. 15.

Callopora subplana Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., V, p. 253, pl. xi, figs. 7-7b.

''Zoarium ramose, the branches cylindrical, from .2 inch to .5 inch in diameter, and dividing dichotomously at intervals varying from .6 inch to one inch. Cells polygonal in unworn examples, subpolygonal or rounded in worn specimens. The surface exhibits clusters of from four to eight cells, that occasionally are slightly elevated above the general surface, and are conspicuously larger than the ordinary cells which surround them. The latter vary in diameter from 1/70th to 1/60th of an inch (i. e., six to seven cells may be counted in the space of .1 inch), while those composing the clusters may attain a diameter of 1/40th of an inch, though their usual diameter is only about 1/50th inch. The interstitial cells are comparatively few, being most numerous and noticeable between the large cells of the clusters mentioned. Over the other portions of the surface they usually occur at the angles of junction of the ordinary large tubes. They are, however, always inconspicuous, and easily overlooked.

''In longitudinal sections the tubes in the axial region of the zoarium, have very thin, flexuous, and often crimped walls. Diaphragms are usually not developed here, excepting a few (six to nine) in the young tubes just above the point of their origin. These are placed at distances apart equaling about two of their diameters at the point of crossing. As the tubes bend outward to reach the surface their walls are thickened, the interstitial tubes make their appearance, and numerous diaphragms are developed in the large tubes, the latter often inosculate, while the distance between them usually varies from one-fourth to one-half of the diameter of the tube crossed. The diaphragms in the interstitial tubes are always complete and equally crowded in all.

"Tangential sections show that the tubes just below the surface have much thickened walls, their visceral chambers being rounded or oval. The walls of adjoining tubes are seemingly fused together, so that the original boundary line cannot be detected. The cavity of each tube is surrounded by a secondary deposit of dark, concentrically laminated sclerenchyma, while the original wall is represented by apparently structureless (in this section) sclerenchyma, of much lighter shade. The interstitial cells are variable in size and shape, and comparatively much reduced in number, being, as a rule, less numerous than the proper tubes.

"The characters which distinguish *C. subplana* from all other species of the genus known to me from the Cincinnati Group, are found in its robust growth, the large size of the cells, the conspicuous clusters, and the proportional paucity of the interstitial tubes."—Ulrich, *loc. cit.*

1.34C2, 5, 9....1.38Ba.

CALLOPORA SUBNODOSA Ulrich.

Plate X, figs. 5, 5a.

Callopora subnodosa Ulrich, 1890, Geol. Illinois, VIII, p. 417, pl. xxxiii, figs. 5-5c.

"Zoarium ramose; stems subcylindrical, from six to twelve mm., or even more in diameter. Surface sometimes nearly smooth, usually tubercled. Tubercles rounded, never conical, more or less elevated, composed of apertures rather larger than the average, and numerous mesopores. Zooecial walls comparatively thin throughout. Zooecia approaching the surface in a gentle curve, about seven in two mm.; with circular apertures, ranging from 0.18 to 0.27 mm. in diameter; surrounded by a variable number of angular or subcircular mesopores. The zooecial tubes expand very gradually from the point of their origin until they attain their normal size. In the first part of their course, they have several diaphragms about their own diameter apart; after that, diaphragms become rare and may be entirely absent in the rest of the zooecial tube. The mesopores are tabulated very closely throughout; about three diaphragms in a space equaling their own diameter.

"This species differs from the common *C. ramosa* d'Orbigny in the less prominent monticules, which are rounded instead of conical. The tabulation of the tubes in the two species is also very different. Though very distinct from *C. elegantula* Hall, the type of the genus, it is more nearly related to that form than is any other known species of the genus."—Ulrich, *loc. cit.*

This is the only species of *Callopora* so far reported from the Richmond series. That there are several other species in these rocks is certain, although I have not specimens in sufficient number at present to warrant the establishment of the new species. Two of these forms I have figured, and another from the lower part of the Waynesville has the superficial appearance of *C. sigillaroides.* Speaking more particularly of the specimens with the general appearance of *C. subnodosa,* I find some variation in the extent of the tabulation of the zooecia, which is not always as simple as indicated by Ulrich. In many of the specimens that do not seem to me to be specifically separable from *C. subnodosa,* the zooecia are tabulated throughout their length. Other specimens commonly associated with the typical form have instead of the low-rounded monticules, quite sharp monticules, similar to those of *C. ramosa,* and others still are entirely devoid of any monticules at all, and yet have the internal and other characters of *C. subnodosa.* As to whether we are dealing here with the variants of a single species or with several distinct species I am not yet in a position to say, but I suspect that the former is the case.

C. subnodosa (and its varieties) is a common fossil in the Richmond series.

1.34A10, 14a, 14b, 15, 16, 17, 18, 19, 20, 21, 22, B4-5....1.41A4, 5, 6, 7, 8, 9, B1, 2, 3, C1, 2-3, D1, 2, 3, E1, 2, 3, 4, 6....1.12E3, F3.

CALOPORELLA CIRCULARIS (James).

Plate X, figs. 6-6c.

Monticulipora (*Heterotrypa*) *circularis* James, 1882, The Paleontologist, No. 6, p. 46. (Not figured.)

"Corallum, concavo convex; the concavity of the base corresponding with the convex upper surface, causing an even thickness of from less than half a line to about one line in different specimens; size, varying from one-fourth of an inch to one inch in diameter; circular in outline; surface, even and destitute of 'monticules,' or groups of larger calices than the average; apertures of cells of unworn specimens, sharp, but they are seldom found in that condition, nearly all, as far as observed, being more or less abraded, showing the cell walls as much thickened; calices, subcircular, or somewhat angular in some cases, uniform in size, seven or eight in the space of one line, sometimes arranged in regular, slightly curved rows of from four to twelve or more; no minute tube apertures observed. The concave base of unworn examples is covered with a very thin, delicate epitheca, showing very fine concentric lines, and radiating striae, worn ones show the bases of the corallites. Specimens partly embedded in the surface of rocks are as often found base upward as downward; detached specimens are not uncommon, all indicating the free habit of the species.

"Sections of the *interior* show two series of tubes, a larger and a smaller, the larger, only, being noticeable at the *surface.* In *tangential* sections the larger tubes are mostly circular with distinct borders; the smaller, which surround the others in some cases, are the most numerous, and vary greatly in shape. In a tranverse section, taken just *above the base,* the larger tubes seem to be slightly expanded, and the smaller not occupying so much space, otherwise it is very much like the *tangential* section. In *vertical* section the tubes take a somewhat bent or tortuous course, and are tabulate from the base to the upper surface, the smaller ones generally more closely than the larger. In most cases, the tabulae are horizontal, but in some they take an oblique or bent course across the corallites.

"Some specimens found associated with this exhibit a *slight* tendency to forming 'monticules,' but in other respects they seem identical.

"In outline and habit of growth this resembles M. sp. *discoidea,* James, but in other respects it is materially different, particularly the *interior* structure."—James, *loc. cit.*

The internal characters of this species (the *C. harrisi* of Ulrich) are substantially the same as in *Callopora,* and it is not improbable that it may prove to represent the young of some species of that genus.

1.33A3.

CERAMOPORELLA DISTINCTA Ulrich.

Plate X, fig. 7; Plate XI, figs. 2, 2a.

Ceramoporella distincta Ulrich, 1890, Geol. Illinois, VIII, p. 464, pl. xxxix, figs. 6, 6a.

"Zoarium forming thin, parasitic expansions upon monticuliporoids or Orthocerata; by the formation of successive superimposed layers, large masses may result. The layers vary in thickness from 0.5 to 1.0 mm. Surface even, though sometimes appearing monticulose owing to the zoarium adapting itself to the irregularities of the surface to which it is attached. Zooecia thin-walled, at first prostrate, then becoming abruptly direct or almost so, more or less triangular or pyriform, and with well marked lunaria. In young examples very oblique, almost imbricating. Apertures with thin obliquely projecting peristome, more elevated posteriorly, oval in shape, about 0.2 mm. in their longer diameter, arranged in regular series, about seven or eight in three mm. Mesopores shallow, developed in great numbers, usually arranged in a single or double linear series, between the sides of the zooecia, occasionally completely isolating a zooecium. In the fully matured perfect condition their apertures are closed by a thin membrane.

"This very pretty species is distinguished by its small cells and rather widely separated zooecia apertures. Their oval form and the continuation of the peristome around the anterior margin are also quite distinctive."—Ulrich, *loc. cit.*

Not uncommon in the Utica formation.

1.34C2, 5.

CERAMOPORELLA GRANULOSA Ulrich.

Plate XI, figs. 3-3a.

Ceramoporella granulosa Ulrich, 1890, Geol. Illinois, VIII, p. 466, pl. xli, figs. 2, 2a.

"Zoarium forming masses, consisting of many superimposed layers, the initial layer being attached to some foreign body; in the type specimen a species of *Pachydictya*. Surface even, granulose with groups of larger cells. Zooecia oval, direct to the surface. Lunarium prominent, narrow, occupying from one-fourth to one-third the circumference of the wall. Apertures somewhat oblique, irregularly oval, from 0.2 to 0.3 mm. in diameter, in diagonally intersecting series, about six in two mm. A considerable number of rather small irregular mesopores are scattered about among the zooecia. Rather abundant thin diaphragms intersect the tubes.

A large number of small dark spots, precisely like acanthopores in tangential sections occur in the walls. Vertical sections, however, show that unlike these structures they do not form continuous thick-walled tubuli, but that they are developed at successive levels corresponding with the diaphragms.

"The granules, numerous diaphragms, and less regular arrangements of its parts, distinguish this species from *C. distincta,* which it resembles in the size of the zooecia. I am not acquainted with any other species that would admit of closer comparisons." —Ulrich, *loc. cit.*

This form or a variety occurs in the Arnheim, near Harman's Station, Indiana.

CERAMOPORELLA OHIOENSIS (Nicholson).

Plate XI, figs. 4-4g.

Ceramopora ohioensis Nicholson, 1875, Pal. Ohio, II, p. 265, pl. xxv, figs. 10-10e.

"Polyzoary incrusting, forming thin expansions attached to the surface of Brachiopods or Corals, and consisting, typically at any rate, of a single layer of oblique cells. Cells arranged in intersecting diagonal lines, and disposed in a somewhat concentric manner round more or fewer central points; their upper walls thin and arched; the cell-mouths oblique, and, when most perfect, semicircular in shape. About eight cells in the space of one line.

"Such are the appearances presented by this fossil when quite perfect, and its examination in this condition leaves no doubt as to the propriety of placing it in Hall's genus *Ceramopora.* Worn examples, however, exhibit very different characters, and when the entire original surface has been abraded it is sometimes difficult or impossible to determine whether one is dealing with this or some entirely different form.

"When slightly worn, the appearances shown in fig. 10*b* [of Nicholson's paper] are exhibited. The delicate front wall of the cell has now disappeared, and the cavity of the cell appears to be divided into two distinct compartments, a larger and a smaller, both of a somewhat triangular shape, by an oblique internal septum. Other smaller cavities appear in addition in the walls separating the different cells.

"When more deeply worn down, or under certain conditions not clearly understood, the cells appear in the form of rounded or oval apertures, arranged in diagonal rows, but separated by a vast number of small rounded foramina, which appear to be the mouths of interstitial tubuli. In this condition the fossil presents much the appearance of certain species of *Chaetetes* (*Monticulipora*).

"The best examples of this singular polyzoon that I have seen grow in the form of thin crusts, rarerly exceeding one-fourth of a line in thickness, upon *Strophomena alternata* and upon various species of *Chaetetes*. In some examples, it would seem that several layers of cells are superimposed on one another; but I do not feel satisfied as to the real nature of these specimens. Not uncommonly the cells are concentrically disposed round a number of irregular areolae, each of which is formed by a number of cells radiating from a central point. Young examples form circular crusts, with a slightly cupped center, from which the cells radiate in every direction. Lastly, examples are not uncommon which appear to have the form of small branching stems. Some of these, certainly, are merely constituted of thin crusts growing upon various ramose species of *Chaetetes*. Others, however, appear to be entirely composed of the polyzoon itself, without the intervention of any foreign body; and it is possible that these will eventually prove to be a distinct species."—Nicholson, *loc. cit.*

The internal characters of this species present little complexity and are sufficiently well indicated by the figures. *C. ohioensis* is a common fossil ranging throughout the Cincinnati group.

1.33A3....1.34C5, 7, 11, 13, 14a, 14b, B1-3, A1, 3, 7, 8, 9, 15b, ...1.41A4, 5, 6, 7, 8, D1, 2, E1, 2, 3, 4, 6....1.12A2, E3, F3.

CERAMOPORELLA WHITEI (James).

Ceramopora whitei James, 1878, The Paleontologist, No. 2, p. 12, (Not figured.)

"Polyzoary a thin crust grown upon foreign substances,—generally corals—sometimes spread all around, and in and over the inequalities of very irregular surfaces of bodies of considerable size —3x6 inches, less or more. The cells seem to be mostly direct, but in some places may be slightly oblique and very little elevated at the apertures. An average of about 10 cells in the space of a line measuring in any direction, very irregular in shape and size—circular, oval, triangular and other forms. Distributed irregularly over the surface are slightly elevated areolae, where the cells are generally smaller than the average on other parts. Cell walls very thin. A *few* minute tubules between some of the larger cells.

"This species differs from Professor Nicholson's typical form of *C. Ohioensis* in most of its features materially. The cell apertures are disposed in a confused manner (seemingly) over the surface of various shapes and sizes, and but slightly oblique or elevated, if at all, and somewhat smaller. That species is generally found grown upon shells, this *rarely*.

"*C. Ohioensis* is described as having the cells arranged in intersecting diagonal lines, and disposed in a somewhat concentric manner round more or fewer central points; their upper walls thin and arched; the cell-mouths oblique, and when most perfect, semi-circular in shape. About 8 cells in the space of one line. Our species is quite different from this description, the cells *not* being arranged in intersecting diagonal lines in a somewhat concentric manner round fewer or more central points."—James, *loc. cit.*

This species is redescribed by Bassler as follows (James Types, p. 29):

"The zoarium forms thin crusts over foreign bodies, but by the superposition of numerous layers may become massive. Each zoarial layer is short, rarely exceeding 1.5 mm. in thickness. Surface smooth, the maculae or clusters of rather thick-walled mesopores not being elevated. Zooecia small, more or less angular, thin-walled and direct, about 7 in 2 mm. Mesopores generally few, sometimes absent altogether. Lunarium occupying from one-fourth to one-third of the zooecial circumference, seldom overarching the zooecial cavity and always a more or less inconspicuous feature of the surface. The internal structure is essentially the same as in other species of the genus and is more clearly brought out by the figures," etc.

Not reported from Indiana, so far as I am aware. It may be expected to occur in the upper Lorraine and Richmond formations.

CHILOPORELLA FLABELLATA Ulrich.

Plate XI, figs. 1, 1a, Plate XII, figs. 1-1b.

Fistulipora flabellata Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., II, p. 28, pl. vii, figs. 26-26b.

"Polyzoary forming irregular, fan-like expansions, carrying cell mouths on both sides. Thickness usually varying from one to two lines. Surface sometimes raised into broad and inconspicuous monticules, carrying tubules of the ordinary size. Cells oval, with apertures a little arched, arranged in bent and rather irregular rows; about five cells occupying the space of one line, the distance between them being equal to a little more than their diameter.

"Intertubular space occupied by a great number of minute cells, which are nearly equally distributed between all the tubes of larger or ordinary size.

"Longitudinal sections show the tubules to be nearly vertical in the middle of the polyzoary, and then gradually bending outwards to the surface. Tabulae are very sparingly developed. These sections clearly demonstrate that the interstitial tubuli observed on the surface, are not of the nature of a coenenchyma, but are only aborted cells. They are developed only near the surface. In the central portions of a transverse section, the tubes are angular, of unequal size and irregular form, with no minute tubuli between them."—Ulrich, *loc. cit.*

1.34B4-5.

COELOCLEMA ALTERNATUM (James).

Plate XII, figs. 2-2d; Plate XXVII, fig. 16.

Ceramopora alternata James, 1878, The Paleontologist, No. 1, p. 5.

"Polyzoary consisting of hollow, branching, cylindrical or compressed stems from one to four lines in diameter, with irregular swellings; the hollows filled with foreign matter, (clay). Cell apertures of the most perfect specimens, elevated, oblique, arched, subcircular or oval; five or six in the space of a line including the interspaces; generally arranged in alternating rows, sometimes in a diagonal manner around the branches. Spaces between the cells equal to their diameter, or a little more or less on different examples. Slightly cut longitudinal sections of some specimens show the cells arranged in diagonal, alternating rows of a lozenge-shape, with minute interstitial pores. Distributed over the surface about two lines apart, are spots, sometimes slightly elevated, bearing fewer cell apertures and more or less of the small pores. The surface of worn or weathered examples—mostly so found—are nearly smooth; destitute in most cases of prominent cell mouths, but show more minute interstitial tubes and divisions, than perfect specimens."—James, *loc. cit.*

James's description together with the figures given herewith is adequate for the identification of this species, which is a very common fossil in the middle and upper part of the Eden formation.

5.9A31....1.34Co, 5, 6, 7, 8, 10, 11....1.38A5, 11, 13.

COELOCLEMA COMMUNE (Ulrich).

Plate XII, figs. 3-3c; Plate XXVII, fig. 17.

Diamesopora communis Ulrich, 1890, Geol. Illinois, VIII, p. 469, pl. xxxix, fig. 3a; and pl. xli, figs. 5-5b.

"This species is closely related to the preceding [*D. vaupeli*—*C. alternatum*], but differs in being more robust in growth, in having well marked maculae, with subsolid centers, from which the cell apertures radiate out in all directions. The apertures immediately surrounding the maculae are also slightly larger than the others, while an obscure concentric arrangement prevails. On the whole, the cell apertures are also somewhat larger, and the peristomes thicker.

"Position and locality: Cincinnati group.

"This form is commonest in the layers exposed in the river bank opposite Cincinnati, O., where *D. vaupeli* is not known to occur. It has a vertical range of about 125 feet, and in the last 25 feet, the two species are found associated."—Ulrich, *loc. cit.*

Bassler* has shown in a recent paper that the *Ceramopora concentrica* James, is a synonym of *Ceramoporella ohioensis;* and hence that *Coeloclema concentrica* (James) is a synonym of *C. commune* (Ulrich) instead of the reverse being the case.

Coeloclema commune is abundant in the Eden, and in the upper Eden it is associated with *C. alternatum,* from which it may be distinguished by the absence of maculae in the latter species.

5.9A31....1.34C5, 7, 8, 9....1.38A21, 24, 37.

CONSTELLARIA CONSTELLATA Dana. (Van Cleve MS.)

Plate XII, figs. 4-4e; Plate XXVII, fig. 19.

Constellaria constellata Dana, Zoophytes of the Wilkes Expedition, 1846, p. 537.

"GENUS CONSTELLARIA. We separate under this name a species with the compressed branches, internal structure, and surface cells of many of the above genus [*Stenopora*], but having the verrucae oblong and arranged in stellate groups over the surface, a character of physiological importance. Glomerate forms may also occur. A species of this genus is named *Ceriopora constellata* on the plates of Western fossils by Van Cleve. The genera Pelagia and Lichenopora, described in the appendix to the Madreporacea, have a similar stellate arrangement, but they are of doubtful character, and the last has been referred to the Bryozoa group.

*Bassler, Proc. U. S. National Museum, vol. XXX, pp. 25, 26.

A recent species described by Michelin, *Lichenopora glomerata,* is quite similar to the Constellaria in its surface and the size of the cells; but there are no characters stated which decide that it belongs with the Favositidae."—Dana, *loc. cit.*

The internal characters of this species were very carefully described by Ulrich (Cincinnati Society, 1883, p. 267), under the name *Constellaria florida,* proposed by him for a supposedly new species in 1882. From his description I condense the following:

Tangential sections cutting just beneath the surface of the zoarium present two phases. The usual appearance is as follows: The maculae which at the surface appear to be subsolid are seen in the section to be composed of numerous very thin walled, often elongated, angular interstitial cells, which in the center of the macula are larger than the true zooecia, while in the extremities of the rays they are not more than half as large. Between these rays five to fifteen of the zooecia are aggregated into irregularly elliptical groups. The zooecia in these groups are subelliptical in shape. In the intermonticular spaces the zooecia are circular in shape and thicker walled. They are sometimes completely isolated by a series of large mesopores, though more usually they are in partial contact. Sections cut from a sufficiently matured example show the second phase as follows: In this phase the walls of the zooecia are comparatively thick and the mesopores are scarcely at all visible. In their place is a mass of sclerenchyma interspersed with small dark spots, each enclosing a smaller lucid spot. These latter are probably small foramina.

Longitudinal sections show that the axial region is occupied by rather large and very thin walled zooecia in which diaphragms are nearly lacking. As they approach the surface the zooecia bend outward abruptly, and in the mature region a very large number of rapidly expanding mesopores are developed, in which diaphragms occur, becoming crowded as the surface is reached. These diaphragms are as a rule complete and at about the same level in adjoining tubes. A common fossil in the lower part of the Lorraine.

1.34C13, 14a....1.38P.

CONSTELLARIA CONSTELLATA var. PROMINENS Ulrich.

Plate XXVII, fig. 18.

Constellaria florida var. *prominens* Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 269, pl. xiv, fig. 3.

"Figures 3 and 4 represent two varieties, which are sufficiently marked by their external characters to render their separation from the more typical forms of the species usually an easy task. I therefore propose the name of *prominens* for fig. 3. It is distinguished by its large and remarkably prominent monticules, which, so far as observed, never coalesce. Their diameter will average about .15 of an inch; their height about .05 inch; in the space of one half inch square, about sixteen may be counted. The branches are usually sub-cylindrical, with an average diameter of about .4 of an inch.

"This variety is apparently restricted to a few feet of strata, and marks an horizon about 200 feet above low water mark."—Ulrich, *loc. cit.*

This species seems to mark the boundary between the Eden and Lorraine formations.

1.34C13....1.38A65.

CONSTELLARIA LIMITARIS Ulrich.

Plate XIII, fig. 2; plate XXVIII, fig. 2.

Stellipora limitaris Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., II, p. 126, pl. xii, figs. 8-8c.

"Grows in cylindrical or sub-cylindrical, sometimes hollow branches, the diameter of which varies from three to five lines; or in small lobate or sub-palmate masses. Branches in the ramose examples dividing dichotomously at varying distances, irregularly thickened and nodulated. Surface with the tube-mouths on all sides, the tubes cylindrical and radiating in all directions from an imaginary central axis. Scattered, generally over the entire surface, are numerous stellate spaces, each of which has a diameter of a line or a little more, sometimes considerably depressed, but usually on a level with the surrounding surface; the number of the rays radiating from the body of the star varies from five to eight; these frequently bifurcate once or twice, and unite with those emanating from the adjacent stars, thus producing a sort of network. The stars are usually regular in outline, sometimes elongated, and arranged in rather irregular transverse or oblique rows, three stars generally occupying a space of three and a half lines; it is however not very rare to find specimens with a portion of the surface destitute of the stellate spaces. The central area and the rays of the stars are composed of aggregations of very minute subangular tubuli, but appear to be solid, unless examined with a sufficiently high magnifying power. The surface between the stellate maculae is covered with small circular calices, the margins of which, in protected parts, are slightly raised; from six to eight tube orifices occupy the space of one line. Intertubular space about one third as thick as the width of the tube mouths, and minutely tubular.

"Longitudinal sections of the branches present the tubes as proceeding in a gentle curve from the middle or axis of the branch to the surface, and as they approach the surface and have arrived to within one line of the same, they bud off one or two more slender tubes; the tubes before they have been thus multiplied are traversed by complete and close tabulae, a little more than one tube diameter apart. Near the surface the tubes are of two kinds, smaller and larger ones; the former are at intervals collected into groups, which represent the stellate maculae on the surface; between these the remaining tubes are placed alternately, one larger and one or two smaller; the large tubes representing the true cells, while the smaller ones represent the minute tubuli in the intercellular spaces. The diaphragms in both kinds of tubes are close set, about two thirds of a tube diameter distant from each other.

"In transverse sections the tubes near the margin are seen to be cut longitudinally, while in the center they are divided transversely, and here they are thin-walled and generally with an hexagonal outline.

"In sections taken parallel with and close to the surface, the stellate spaces are seen to be occupied by a network of sub-angular cells. The tubules are circular, and fill up the space not occupied by the maculae; they are separated by a similar network of minute cells as those composing the maculae.

"This species in its external characters approximates closely to *Fistulipora*, McCoy, since the stellate and intertubular spaces in their structure are essentially the same as the cellulose tissue, of which the intertubular spaces and maculae, in most of the species of that genus, are composed. *Fistulipora* (*Callopora*) *incrassata*, Nicholson, has star-like spaces, occupied by very minute tubuli, but these spaces have no radiating ridges surrounding them. In *S. limitaris* there are also none of these ridges, and in these two species the resemblance is very manifest. On the other hand, in sections of *S. limitaris,* taken parallel with and close to the surface, we find a striking similarity to sections of the same kind of *Chaetetes decipiens,* Rominger, and *C. frondosus* D'Orbigny, while in longitudinal sections much affinity is presented to several ramose species of *Chaetetes.* The species of *Stellipora* and their numerous varieties, in fact are connecting links between *Chaetetes* and *Fistulipora. Stellipora anthelloidea,* Hall, is distinguished from this species, exteriorly, by its sub-frondescent growth, by having the spaces between the rays of the stellate maculae raised, and the tubes smaller. Interiorly we find that the tubes in the middle of the branch or frond are crossed by remote tabulae, and as they approach the surface the curve is more abrupt than is the case in *S. limitaris.*"—Ulrich, *loc. cit.*

This beautiful species is found associated with *C. polystomella* in the Richmond formation. It is readily distinguished from that species by the fact that the rays of the maculae are not elevated, but rather depressed, and also by the fact that *C. limitaris* is a ramose or sub-ramose species, while *C. polystomella* is frondescent. *C. fischeri* which somewhat resembles it in the appearance of the surface is not an associated species, and besides is also frondescent.

1.34A13b, 14a, 14b....1.41D1.

CONSTELLARIA POLYSTOMELLA Nicholson.

Plate XIII, figs. 1-1b; Plate XVIII, fig. 1.

Constellaria polystomella Nicholson, 1875, Pal. Ohio, II, p. 215, pl. xxii, figs. 7, 7a.

"Corallum in all essential points of structure resembles the preceding [*Constellaria antheloidea*], consisting of erect, flattened, palmate expansions, the thickness of which is from two to three lines. Surface covered with very prominent stars, formed of a series of elevated ridges radiating from a central depressed area, and surrounded by depressed interspaces. Each star is usually composed of from eight to as many as thirteen elevated ridges, some of which are smaller than the others. The ridge-like elevated rays are occupied by comparatively large sized circular calices, which are also present, though not so closely set, in the interspaces between the stars. The central areas of the stars are occupied by innumerable excessively minute circular pores, which appear to be the openings of coenenchymal tubuli, and similar pores exist everywhere between the corallites which are placed in the intervals between the different stars. Each star is (in the best preservd portions of the coral) circumscribed and separated from the adjacent stars by a distinct hexagonal border, which has no great width, and is occupied solely by the coenenchymal tubuli, and not by the ordinary corallites.

"Though undobtedly closely allied to *Constellaria antheloidea*, Hall [=*Constellaria constellata* Dana], it seems to me that *C. polystomella* is sufficiently distinguished by the fact that the different stars are definitely bounded in the latter and appear to occupy definite polygonal areas, whilst in the former no line of demarkation can be detected between the different stars other than that afforded by the outer terminations of the elevated ridges. In addition to this character, however, the present species would seem to be distinguished by its very prominent stars, by the large number of rays which are generally present in each individual star, and by the conspicuous presence, both in the central areas of the stars and also in the interspaces between the different corallites elsewhere, of very numerous and very minute cylindrical tubuli, which can hardly be regarded as other than coenenchymal."—Nicholson, *loc. cit.*

This species is sufficiently distinct from *C. constellata,* and occupies a quite different position in the section from that species. *C. polystomella* is confined to the Richmond formation and *C. constellata* to the Lorraine. The figures of tangential and longitudinal sections given herewith will indicate the internal characters better than pages of description.

1.34A12, 14a, 14b....1.41D1, E3....1.12F3.

DEKAYIA APPRESSA Ulrich.

Plate XIII, fig. 3.

Dekayia appressa Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 152, pl. vi, figs. 7-7b.

"Zoarium in rare instances subfrondescent, usually ramose, and from one to three inches in height. Branches flattened, dividing frequently, from .3 to .4 of an inch in width, and from .15 to .25 of an inch in thickness. Surface without monticules, but presenting groups of cells somewhat larger than the average, at intervals of about .075 inch, measuring from center to center. When the pellicle is preserved, and this is often the case, the spiniform tubuli are, though rather small and few, apparent enough. But when the pellicle is not preserved they are not readily detected.

Cells thin-walled, with the exception of the groups mentioned, in all probability consist of one kind only, those of the ordinary size having a diameter of 1/130th inch, while that of those in the clusters may exceed 1/90th inch. An occasional small cell is met with, that, though I much doubt it, may be of the nature of an interstitial cell.

"Longitudinal sections show that the tubes in the axial region are nearly vertical, and that in their course to the surface they bend abruptly outward, their walls, which, as usual, are very thin in the axial region, becoming but slightly thickened as they enter the peripheral portion. Diaphragms are but rarely developed in the 'immature,' or axial region, and only from five to ten in the 'matured' portion of a tube, where they are placed at distances apart of from one-half to one tube-diameter. Occasionally a small and short tube may be detected in which the diaphragms appear to be a little more closely set than is the case in the ordinary tubes. The spiniform tubuli being few and of rather small size, are not a conspicuous feature in sections of this kind.

"In tangential sections the cells are thin-walled and angular, the groups of larger ones being often very distinct. On account of the thin cell-walls the spiniform tubuli, though of comparatively small size, are very apparent, occupying the angles of junction of every three, four or five cells.

"The frequently branching, sometimes anastomosing zoarium of this species, does not resemble very closely any associate form. Some of the smaller specimens of *Dekayella ulrichi*, Nicholson sp., occurring over two hundred feet lower in the series, bear some external resemblance to fragments of *D. appressa*. The numerous interstitial tubes, and rounded cell-apertures of the former, amply serve the purpose of distinguishing them."—Ulrich, *loc. cit.*

1.34B1-2.

DEKAYIA ASPERA Milne-Edwards and Haime.

Plate XIII, figs. 5-5b; Plate XXVII, fig. 20.

Dekayia aspera Milne-Edwards and Haime, 1851, Monographie des Polypiers Fossiles des Terrains Palaeozoiques, p. 278, pl. xvi, figs. 2, 2a.

"Polypier en masse subramifiée et un peu irrégulière. Calices petits, polygonaux, à murailles simples, peu inégaux, présentant à leur angles et à des distances variables dès cônes très-saillants, compactes, aigus et striés. qui donnent un aspect spinuleux à la surface. Largeur des calices, un quart de millimètre. Planchers horizontaux.

"SILURIEN (inférieur). Etats-Unis: Cincinnati (Ohio).

"Coll. de Verneuil."—Milne-Edwards and Haime, *loc. cit.*

Owing to the unusually characteristic surface features of this well known species, the rather meager description of Edwards and Haime is sufficient for its recognition, and coupled with his figure leaves no doubt as to the identity of the form. The internal characters, however, are equally interesting and characteristic, and I therefore take the liberty of appending a further description of this important species.

Zoarium consisting of somewhat flattened stems attaining a diameter of several cm. Surface smooth except for the unusually conspicuous spines caused by the projection at the surface of the large set of acanthopores. This gives an unmistakable appearance to the species. The zooecia are polygonal and thin walled, and mesopores are practically absent. No monticules or maculae of any kind.

In tangential sections the zooecia are thin walled, polygonal, and in complete contact at all points. An occasional smaller zooecium, probably a young individual, is seen. The most striking feature of such sections is the enormous acanthopores, at times nearly as big as an ordinary zooecium. Interspersed among these large acanthopores, and plainly visible, *even in the mature region,* are a number of smaller acanthopores of about the size normal to *D. frondosa.* The wall structure is much the same, also, as in the latter species.

In longitudinal sections the zooecia are seen to bend very gradually outward from the immature region and to reach the surface at nearly a right angle. No diaphragms or other structures are present, except rarely a diaphragm or two near the surface. The large acanthopores are shown by longitudinal sections to extend into the immature region, and sometimes to cross over from one zooecium to another. They are in fact a very conspicuous feature of such sections. This is the only feature that causes longitudinal sections of this species to differ from similar sections of *D. magna.*

1.34C13, 14a....1.38P.

DEKAYIA FRONDOSA (d'Orbigny).

Plate XV, figs. 1-1e; Plate XXVIII, fig. 9; Plate XXIX, fig. 1.

Monticulipora frondosa d'Orbigny, 1850, Prodrome de Paléontologie, I, p. 25. (Not figured.)

"*376. Frondosa, d'Orb., 1848. Espèce à larges frondes dont les monticules sont coniques et très-espacés. *Etats-Unis,* Cincinnati, Ohio."—d'Orbigny, *loc. cit.*

The status of *Monticulipora frondosa* d'Orb. has finally been determined by the publication of sections of the type specimen in the collection of d'Orbigny. It proves to be the form identified as such by Ulrich in 1882* and referred to the genus *Heterotrypa.* The first publication of figures of thin sections of the type of this species is in a recent paper by Ulrich and Bassler,† and a reproduction of a photograph of a section has been published still more recently in the Annales de Paleontologie, Tome I, pl. ix, fig. 10, together with a figure of the type (pl. ix, fig. 9). The writer's *Dekayia perfrondosa* therefore becomes a synonym of *D. frondosa.*

The following description of the species is based on specimens in the writer's collection:

The zoarium is in general frondescent, though massive or submassive forms occur, especially in the upper part of its range. The large example figured by Milne-Edwards and Haime is a good example of the frondescent form, and I have figured in this report an example of the massive form. I suspect that as a matter of fact the massive forms are the basal portions of the species, and that in all cases when fully grown, it developed fronds. O'Orbigny's specimen is a small, somewhat irregular frond, with the typical surface characters. Superficially the fronds are set with rather small, usually sharp, monticules, although in such examples as figured by Edwards and Haime, the monticules are rather low and rounded, if he has correctly indicated them. I must say that monticules of this sort are the exception. In the type, the monticules are spaced about 3 mm. from center to center, as measured on the photograph given in the Annales de Paleontologic. The zooecia vary from polygonal to circular in shape, the latter form occurring where the mesopores are more abundant. The latter are not aggregated in the monticules, notably, but are distributed rather uniformly throughout the zoarium.

In tangential sections cutting the mature region the zooecia are moderately thick walled and circular, touching each other at

*Jour. Cin. Soc. Nat. Hist., V, p. 133 and p. 235.

†Smithsonian Miscellaneous Collections, vol. 47, p. 25, pl. xi, figs. 1-3.

several points, except in the case where the mesopores are numerous, when they are completely isolated by the latter. The lumen of the zooecium is surrounded first by a zone of light-colored sclerenchyma, and this in turn by a narrow zone of dark-colored sclerenchyma, the remaining space between neighboring zooecia consisting of light-colored material, in which the mesopores are lodged. The walls of the latter are rather indefinite. The wall structure, just described, characterizes in a general way all species of the genus.

Longitudinal sections show that the zooecial walls are very thin in the axial region, and become thickened immediately upon passing into the deep mature region. In the latter, diaphragms are abundant, in some specimens, and only moderately abundant in others. In the section of the type, as figured in the Annales de Paleontologie, they are abundant. In the mesopores, diaphragms are about twice as abundant as in the zooecia. An occasional curved diaphragm is present.

Acanthopores are present in moderate number, and are usually of small size, though in some specimens an occasional acanthopore of large size can be demonstrated. This species is found throughout the greater part of the Lorraine, and at some horizons is common.

1.33A3....1.34B1-3, 4-5, C13, 14a, 14b....1.12A2....1.38Ba-h.

DEKAYIA FRONDOSA var. CYSTATA Cumings.

Plate XIV, figs. 1, 1a; Plate XXVIII, fig. 3.

Dekayella cystata Cumings, 1901, American Geologist, XXVIII, p. 375, pl. xxxv, figs. 1-6a.

"Zoarium consisting of flattened branches, at times 30 mm. or more in width. Surface covered with small conical monticules, about three in the space of 5 or 6 mm. Cells 0.2 mm. to 0.15 mm. in diameter. The monticules are composed of groups of cells larger than the average, interspersed with a greater or less number of very minute cells (mesopores). The latter are practically confined to the regions of the monticules.

"Tangential sections reveal the characteristic cell structures of the genus, with the large and small sets of acanthopores.

"Longitudinal sections show numerous diaphragms about one-half cell diameter apart in the large cells and much more numerous in the mesopores. A peculiarly characteristic thing is the presence of an occasional cystiphragm, especially near the surface.

"Observation: This species might easily be mistaken for *Heterotrypa subpulchella,* from which it differs in the two sets of acanthopores and the presence of curved diaphragms."—Cumings, *loc. cit.*

1.34B4-5, C14b....1.38P. 1.33A3.

DEKAYIA INFLECTA (Ulrich).

Plate XV, figs. 2-2a.

Heterotrypa inflecta Ulrich, 1890, Geol. Illinois, VIII, p. 414, pl. xxxvii, figs. 2-2d.

"Zoarium frondescent, seldom over four cm. in width, six cm. in height, and five mm. thick; usually only about three in thickness. Surface smooth or with slight elevations of cell apertures somewhat larger than the average. Zooecial tubes bending abruptly into the cortical region, with walls slightly flexuous in the axial region. Zooecia apertures circular, 0.14 to 0.18 mm. in diameter, with about eight in two mm. A large but variable number of angular mesopores scattered among the zooecia, rather more numerous in the clusters. Diaphragms only one or two in each zooecial tube; numerous in the mesopores. Acanthopores present in considerable numbers, frequently indenting the visceral cavity, in well preserved specimens very conspicuous on the surface, giving it a hirsute appearance.

This species is distinguished externally from *H. frondosa* D'Orbigny, its nearest ally, by its much more delicate growth, strictly frondescent form, monticules wanting or but little elevated, conspicuous acanthopores and larger number of mesopores. Internally it has very few diaphragms, which structures are abundant in *M. frondosa.*"—Ulrich, *loc. cit.*

This is another of the species of *Dekayia* with numerous and strong acanthopores, as in the *D. ulrichi* group. In the specimen figured herewith, the acanthopores are distinctly of two sizes. It is altogether a more delicate species than *D. frondosa* in its zoarial habits and is distinguished superficially by the fact that the acanthopores strongly inflect the zooecia, from which fact the name is derived. It is not a common form.

1.33A3.

DEKAYIA ULRICHI var. LOBATA Cumings.

Plate XXVII, fig. 21.

Dekayella ulrichi var. *lobata* Cumings, 1902, American Geologist, XXIX, p. 203, pl. ix, fig. 2; pl. x, fig. 5; pl. xi, figs. 3, 4.

"Zoarium consisting of irregularly lobed and greatly compressed branches or of wavy true fronds arising from a cylindrical base which is doubtless attached by an expansion as in other frondescent species. An average frond has a thickness of 4 mm. to 5 mm. and a breadth of 20 mm. or more. Surface nearly smooth, often completely so; but showing in some specimens subsolid sometimes slightly elevated maculae of cells somewhat smaller than the average. Zooecia round, about 45 to the centimeter and from 0.16 mm. to 0.2 mm. in diameter. Mesopores numerous, angular, filling all the interstices between the zooecia. The surface of some specimens seems to be covered in places with a thin pellicle, as in other species of *Dekayia*.

"Longitudinal sections show that the diaphragms are approximately horizontal, fairly crowded in the mature region and considerably more numerous in the mesopores, which are constricted at the level of each diaphragm. The walls present the peculiar beaded appearance characteristic of *D. ulrichi*.

"Tangential sections near the surface show that the zooecia are ring-like in the mature region, with fairly thick walls. The acanthopores are fairly abundant, and of two sizes, the smaller somewhat more numerous. The ratio of the diameters of the largest and smallest acanthopores seen, is about as four to one." —Cumings, *loc. cit.*

This species is not uncommon in the lower portion of the Lorraine near Manchester Station, Indiana.

1.34C14a.

DEKAYIA MAGNA Cumings.

Plate XIII, figs. 6, 6a; Plate XXVIII, fig. 8.

Dekayia magna Cumings, 1901, American Geologist, XXVIII, p. 375, pl. xxxiv, figs. 1-6.

"In form and general appearance this closely resembles *D. aspera* E. & H. The zoarium consists of irregular flattened branches (as in the Lawrenceburg specimen) or more frequently of robust frequently branching masses (as in the Vevay specimen) of a diameter of 40 mm. or more. Spines can occasionally be detected upon the surface.

"Tangential sections show that the cell walls are thin with usually a well defined median lamina. Acanthopores few, *small.* Diaphragms extremely few; occasionally one or two near the surface.

"Observation: This form might be considered as identical with *D. aspera* but for the small size and less frequency of the acanthopores.

"*Locality*: Vevay and Lawrenceburg, Indiana, in the *Platystrophia laticosta* zone."—Cumings, *loc. cit.*

After the above description was published, I about came to the conclusion that I had been dealing with an abnormal example of *Dekayia aspera.* I am still, however, unable to demonstrate the large acanthopores which characterize the latter species, and it therefore seems to me to be best to retain the present designation, provisionally, at least.

1.34C14b....1.33A3....1.38P.

DEKAYIA OBSCURA (Ulrich).

Plate XIV, figs. 3, 3a.

Dekayella obscura Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 89, pl. i, figs. 4-4b.

"Zoarium ramose, consisting of slender ramulets, .18 to .25 of an inch in diameter, dividing dichotomously at intervals of .4 inch or more. Monticules are not developed, the surface usually being smooth. Cells from 1-120th to 1-110th of an inch in diameter, with moderately thick walls, and subangular apertures. When in a good state of preservation, the cell-orifices over large patches of the surface are entirely covered, or only partially, by a very thin pellicle or membrane. It is developed from the margin of the aperture inwardly, and when not fully completed, an irregular opening is left in the center. The boundary lines of the cells are now thin, and project but little above the pellicle. The interstitial cells are numerous, and vary much in shape and size, but are always more or less angular. At intervals of about .1 inch, they are usually aggregated into unequal clusters. The spiniform tubuli are of two kinds, large and small, the former may be observed very readily at the surface, and they often show the minute orifice at their summits. About five may be counted in the space of .1 inch. The latter are smaller and much more numerous, and can not be detected except on perfectly preserved examples. They are developed in the cell-walls, and three or four surround each cell.

"In tangential sections the proper cells are subcircular, and have thick walls. Each cell-cavity is encircled by a thin band or ring of dark sclerenchyma, the thinner original walls having a lighter color. The interstitial cells are numerous, unequal and angular, those constituting the clusters or 'maculae' being separated from each other by rather thin walls. The large spiniform tubuli are distinct enough, but the smaller ones can not always be detected. Especially is this the case in examples taken from a shaly matrix. In other specimens they are more apparent.

"Longitudinal sections show that diaphragms, with an occasioal exception, are entirely absent in the axial region, where the walls of the tubes are also very thin. The tubes approach the surface in a gradual curve, and as they enter the peripheral regions, their walls are thickened, sometimes becoming slightly beaded. Very thin straight diaphragms are developed, crossing the tubes at distances apart of from one to one-third tube diameter. The interstitial cells are divided by diaphragms, only a little more crowded than those in the proper zooecia. The large spiniform tubuli make their first appearance in the axial region, and in their course to the surface, they frequently cross obliquely over the tubes (see figure). The smaller ones are first developed in the 'mature' or peripheral region, and can always be seen when the section passes through the face of a tube. The figure on Plate I [of Ulrich's paper] represents two tubes so divided.

"In transverse sections the tubes in the central portion of the branch are slightly larger than nearer the margin. The walls are excessively thin, and polygonal, often nearly circular. Numerous smaller and more angular cells (young) occupy the interspaces left between them. The margin of the section cuts the tubes longitudinally, where they have the same appearance as in the peripheral regions of a vertical section."—Ulrich, *loc. cit.*

This delicate species is the genotype of Ulrich's genus *Dekayella*. It occurs sparingly associated with *D. ulrichi*.

1.34Co, 2, 5, 6. 7, 8, 9.

DEKAYIA PAUPERA Ulrich.

Plate XV, figs. 3, 3a; Plate XXVIII, fig. 6.

Dekayia paupera Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 153, pl. vi, figs. 10, 10a.

"Zoarium ramose, the more or less flattened branches growing upward from a large and thinly expanded base, to a height of one and one-half inches or a little more; varying in thickness from .15 to .3 of an inch, and in width from .2 to .8 of an inch. Surface without monticules. Cells polygonal, with excessively thin walls, the ordinary ones having a diameter of about 1/120th of an inch. At intervals there are distinct groups of large cells, some of which have a diameter exceeding 1/70th of an inch. True interstitial cells are apparently wanting, the few small cells occasionally seen being doubtless young ones. The spiniform tubuli I have not been able to detect at the surface. Pellicle not observed.

"In longitudinal sections the excessively thin-walled tubes in the axial region are seen to be crossed by few remote diaphragms. The tubes approach the surface with a gentle curve, the thickening of the walls that usually takes place as they enter the peripheral region is scarcely perceptible in this species. The diaphragms are quite numerous in the 'mature' or peripheral region, being about one tube diameter distant from each other. When the section passes through the spiniform tubuli they are, despite their small size, readily detected by the thickened appearance they give to the cell-walls between which they are placed. I have not been able to find any traces of interstitial tubes.

"Tangential sections of this species are remarkable for excessively thin-walled angular cells, between every five or six of which the spiniform tubuli, which are smaller than in any other species of the genus, and inconspicuously isolated. The groups of large cells, mentioned in the description of the surface characters, are of course, quite distinct in this kind of section.

"This species is closely allied to *D. appressa* in its growth and general features. Under the hand glass that species is seen to have somewhat smaller cells, less conspicuous clusters of large cells, and thicker tube-walls. Internally the much smaller spiniform tubuli of *D. paupera* will serve to distinguish them."—Ulrich, *loc. cit.*

1.38P.

DEKAYIA PELLICULATA Ulrich.

Plate XIII, figs. 4, 4a; Plate XXVIII, fig. 5.

Dekayia pelliculata Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 150, pl. vi, figs. 9, 9a.

"Zoarium ramose, with smooth, thick, mostly rounded, sometimes flattened branches, arising from a large basal expansion, and gradually tapering from the base, where the diameter varies from

.5 to 1.0 inch, to their terminal ends, where the diameter is usually not over .3 inch. On well-preserved examples the cell apertures over large patches of the surface are covered by a thin pellicle, the cell walls appearing as only very faintly elevated lines upon its surface, while the surface extensions of the spiniform tubuli are more distinct and prominent than when the pellicle is wanting. About five may be counted in .1 inch. At distances apart of about .1 inch, the surface shows clusters of cells slightly larger than those of the average size, interspersed among which are small and unequal aggregations of much smaller cells, that in all probability represent the apertures of interstitial tubes. Cells with moderately thin walls, angular, those of the ordinary size varying in diameter from 1/120th to 1/100th of an inch, while that of those forming the clusters mentioned rarely exceed 1/90th of an inch.

"In longitudinal sections the tubes in the axial region have, as usual, excessively thin walls, and are only occasionally provided with an isolated diaphragm, these structures becoming, however, more numerous in the peripheral region, where they cross the tubes at distances apart of from one-half to one tube diameter. The cells turn very abruptly from the axial into the peripheral region, becoming at the same time slightly thickened, and proceeding in their course to the surface they follow a line drawn at a right angle to the longitudinal axis of the branch. In the peripheral region may be noticed quite a number of small, obscurely beaded tubes, in which the diaphragms are somewhat more closely set than in the proper zooecia, and always cross the tube at the periodic points of stricture. In other tubes again the diaphragms are remote and sometimes entirely wanting. On the whole the tabulation of this species is peculiar. The spiniform tubuli are always distinctly visible, and have the usual structure.

"Tangential sections show that the cells are thin-walled, and more or less angular, that the spiniform tubuli are comparatively small, and occupy the angle of junction between every three or four cells, and that they are further isolated by being situated between two to four small interstitial cells. From five to fifteen of the latter also occupy the interstices between the larger cells of the clusters, which even in these sections are not very striking.

"This species is distinguished from *D. aspera* externally by its more regularly dendroidal growth, smooth surface (so far as monticules are concerned), and less conspicuous spiniform tubuli.

Internally the much more numerous diaphragms, and interstitial tubes, beside the smaller spiniform tubuli, present weighty points of difference."—Ulrich, *loc. cit.*

I have remarked in my discussion of the genera *Heterotrypa, Oekayia,* etc., that the presence of a pellicle over the mouths of the zooecia does not seem to me to be a character of any especial importance. The species above described, does, however, possess sufficiently distinctive characters, in the form of the zoarium, number of the mesopores and acanthopores, and the presence of close-set diaphragms in the mesopores, to make it valid.

1.34C13....1.38P.

DEKAYIA PROLIFICA (Ulrich).

Plate XV, figs. 4-4b; Plate XXIX, fig. 3.

Heterotrypa prolifica Ulrich, 1890, Geol. Illinois, VIII, p. 413, pl. xxxvii, figs. 1-1d.

"Zoarium frondescent, or subramose with much flattened branches, varying in thickness from four to twelve mm., and at times attaining a height of ten cm. Low rounded tuberosites arranged in irregularly intersecting lines and composed of cells a little larger than the average, commonly surrounding a cluster of mesopores, serve to break up the monotony of an otherwise smooth surface. Zooecial tubes curving in the axial region, direct throughout the peripheral region, where the walls become considerably thickened. Zooecia apertures sub-polygonal, about eight in two mm. and 0.15 to 0.18 mm. in diameter. Interspaces occupied by calareous matter; where very wide by a few mesopores with illy defined walls. Most of the mesopores are found in the clusters. A few diaphragms in the axial region; in the transition period they become more numerous; in the cortical region they are close set, a tube diameter or less apart. In the outer portion of this region they are often concave, sometimes tending to the infundibular form. Mesopores more closely tabulated than the zooecial tubes. Acanthopores a little more than one-third as numerous as the zooecia; when not situated at the angles, generally inflecting the zooecial cavity a little.

"This species approaches quite closely to *H. frondosa* d'Orb., having a somewhat similar growth; but in that species the zooecia are more angular, the walls thinner, mesopores far more numerous and the acanthopores rather more abundant.

"Position and locality: Cincinnati group. A common form in the upper beds at Blanchester, Ohio. It also occurs at Wilmington, Ill. The *H. frondosa* is restricted to the lower half of the Cincinnati group."—Ulrich, *loc. cit.*

To my mind there is very little difference between this species and *D. frondosa.* The main and almost the only reason for separating them is the difference in range, the latter species occurring only in the Lorraine. It is certain that *D. prolifica* is the Richmond representative of *D. frondosa* of the lower horizon.

1.34A10, 11, 12, 13a....1.41A7, E1, 3, 4....1.12E3.

DEKAYIA SUBFRONDOSA Cumings.

Plate XIV, figs. 6-6c; Plate XXVIII, fig. 10.

Dekayia subfrondosa Cumings, 1902, American Geologist, XXIX, p. 204, pl. ix, figs. 7, 8; pl. x, fig. 3; pl. xi, fig. 1.

"Zoarium growing upward from an expanded cylindrical basal attachment into flat fronds of a thickness of 10 mm. to 15 mm. and a breadth of as much as 60 mm. A specimen nearly complete, except the cylindrical base has a height of 110 mm. The frond has a tendency to give off compressed branches along the free edges. Entire surface covered with small rather abruptly elevated monticules with an average diameter of 1.5 mm.; from 12 to 13 occupy one square centimeter. At the apices of the monticules the cells are smaller than the average. Cells mostly of one kind, 0.25 mm. in diameter, 40 cells to the cm.

"The internal structure of this species as seen in tangential sections is highly instructive. In tangential sections cutting the mature region the cells are seen to be rather thin walled, the walls of adjacent zooecia being apparently amalgamated. That this is not the case is well shown in fig. 8, Pl. X [of above paper] where the section cuts a portion of the zoarium that has been fractured and infilled with calcite along the fracture. The zooecia are spread apart, the wall formerly apparently common to two zooecia being now half on one side, half on the other of the calcite seam. Where an acanthopore is present the zooecial wall separates from it cleanly. Indeed, the acanthopore is sometimes left completely isolated in the calcite, showing that these structures belong to neither zooecial wall. The attention of those who deny the duplex character of the interzooecial wall should be called to this phenomenon.

"Only a moderate number of small tubes are seen throughout the main part of ordinary tangential sections. Fig. 8 Pl. IX [of above paper] shows a cluster of small tubes in a portion of a section in which the walls are also thicker than usual. Tangential sections of the branchlets, however, present almost identically the same appearance as sections of *D. ulrichi robusta.*

"Acanthopores are numerous and conspicuously of two sizes. They are not confined to the angles of the zooecia, but frequently indent their walls.

"Longitudinal sections show that the mature region is very deep, the thickness of the zooecial walls varying but little from where the tubes bend outward, to the surface. The large acanthopores are conspicuous features of such sections. The walls present the beaded appearance characteristic of the genus. This, I believe, is in some cases due to the fact that the section cuts in and out of the side of an acanthopore. The large acanthopores traverse the entire mature region and are sometimes present even in the axial region. Diaphragms are abundantly developed, horizontal or, rarely, curved or infundibular, from one-third to two tube-diameters apart in the zooecia, and closer set in the mesopores. The walls of the latter are constricted where the diaphragms join them."—Cumings, *loc. cit.*

This species seems to me to quite completely break down the line between *Heterotrypa* and *Dekayia* and *Dekayella* as formerly understood. In the form of the zoarium it certainly would be considered as a specimen of *D. frondosa.* The presence of two *well marked* sets of acanthopores would throw it into the genus *Dekayella,* and the absence of mesopores in some regions of the zoarium would suggest *Dekayia.* Tangential sections of the branches can scarcely be distinguished from sections of *Dekayia robusta.*

1.34C13.

DEKAYIA SUBPULCHELLA (Nicholson).

Plate XVI, figs. 1, 1a; Plate XXVIII, fig. 11.

Chaetetes sub-pulchellus Nicholson, 1875, Pal. Ohio, II, p. 196, pl. xxi, figs. 6, 6a.

"Corallum branched, the branches usually hollow, always more or less compressed, and sometimes so much flattened as to become frondescent. Greatest diameter of the branches, from four lines to nearly an inch. The average corallites are circular or polygonal in form, with comparatively thin walls, about eight in the space of one line, with or without a few very minute cylindrical tubuli interspersed amongst them. Intercalated amongst the ordinary corallites are rounded or sub-stellate spaces, about one line in diameter, and placed nearly one line apart, which are occupied by tubes of two kinds. The exterior of each of these spaces is formed by a ring of corallites which are slightly larger than the average, about six of them occupying one line. Inside of this ring is a series of from twenty to forty excessively small cylindrical tubuli, forming a little cluster of pin-like punctures or perforations. The composite clusters of large and small corallites thus constituted are very slightly or not at all elevated above the general surface, and they melt away insensibly at their margins into the ordinary corallites.

This species is closely allied to *C. pulchellus,* Edw. and Haime. but appears to be distinguished sufficiently from it by the flattened and compressed form of the branches, and the composite character of the hardly elevated tubercles, which do not consist throughout of large sized corallites, but have an external ring of large tubes surrounding an internal cluster of very minute tubuli. I have found these characters constant in a large number of individuals, and consider, therefore, that I am justified in describing this form under a distinct title."—Nicholson, *loc. cit.*

The supposed hollow branches of this species are due to the weathering out of the immature region. The figures given herewith will sufficiently indicate the internal characters, which do not differ materially from those of *D. prolifica* except in the greater thickness of the walls and the greater size and number of the acanthopores. The tangential section figured in this report (from a specimen labeled by Ulrich) certainly shows two sets of acanthopores as in the so-called genus *Dekayella.*

1.34C14a.

DEKAYIA SUBRAMOSA (Ulrich).

Plate XV, figs. 5, 5b; Plate XXIX, fig. 2.

Atactopora subramosa Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., II, p. 124, pl. xii, figs. 6-6c.

"This is not a truly parasitic species, though attached by a broadly expanded base to foreign objects. In certain positions of the bryozoary there appears to have been an excessive growth, the consequence of which was the development of large nodes, or of short and thick branches. Diameter of branches about four lines. Surface without monticules. Tubes small, polygonal, quite irregular in size and arrangement, and with numerous minute intertubular cells; the latter are at irregular intervals collected into groups; of the interstitial tubuli the groups alone are distinguishable on the surface, those interspersed between the ordinary tubes being apparently closed, and can only be detected in thin sections. Tube calices of irregular shape, usually nearly closed by accretions to the margins; in the open calices the margins are thick and smooth; pseudo-septa not invariably developed, few in number, probably never more than three, and generally only one or two in each tube. From eight to ten, or even twelve tubes occur in the space of one line.

"Longitudinal sections show the tubes to be transversely divided by diaphragms, placed at corresponding levels in contiguous tubes. The diaphragms are about two-thirds of a tube diameter apart. The tube walls in the lower portions of the tubes are very thin; they become thicker as the surface is approached. A peculiar feature is the periodic swelling of the walls at heights coincident with the tabulae. In the minute tubuli the diaphragms are more closely set than in the larger tubes.

"It would be quite impossible to confound this species with any other form, since it differs more or less in nearly all particulars from those previously described."—Ulrich, *loc. cit.*

For the identification of this species I have depended principally upon the external form of the zoarium, and the fact that the well-known *D. prolifica* is considered as only a variety of it. The 'pseudo septa' mentioned in the above description are evidently the acanthopores, which more or less indent the zooecia. For the internal characters the student is referred to the figures, and to the description of *D. prolifica.*

1.41E2, and common in the "upper fossil bed" at Versailles.

DEKAYIA ULRICHI (Nicholson).

Plate XIV, figs. 4-4b; Plate XXVIII, fig. 7.

Chaetetes fletcheri Nicholson (non Edwards and Haime), 1874, Quar. Jour. Geol. Soc. London, XXX, p. 504, pl. xxix, figs. 6, 6a. *Monticulipora* (*Heterotrypa*) *ulrichi* Nicholson, 1881, Genus Monticulipora, p. 131, fig. 22, p. 132.

"Corallum ramose, branches from 1½ to 3 lines in diameter, cylindrical or subcylindrical, often irregularly swollen at intervals, dividing dichotomously usually at considerable intervals. Corallites with moderately thick walls, the average ones of unequal sizes, about eight in the space of 1 line, and having very minute tubuli sparingly interspersed amongst them. Surface smooth, destitute of tubercles, but occasionally showing groups of corallites which are very slightly larger than the average.

"The examples of this species which I possess from the Clinton group (Upper Silurian) agrees entirely with the description given by Edwards and Haime, being smooth, and simply having a moderate number of very minute tubes irregularly intercalated amongst the ordinary corallites, these latter varying slightly in their dimensions. On the other hand, the Lower-Silurian examples which I have referred to this species, though also smooth, and also having minute tubuli sparsely interspersed amongst the larger corallites, exhibit distinct groups of corallites which are of rather larger size than the average, and which are not set upon distinct elevations. They thus approach *C. pulchellus,* from which they are hardly distinguishable except by the fact that the groups of large sized corallites are not nearly so conspicuous, the individual corallites which compose them being only very slightly above the average size. On the contrary, in *C. pulchellus* the groups of large-size corallites are very conspicuous, as the corallites composing them are nearly or quite twice as large as the ordinary ones. Perhaps the Lower-Silurian forms here regarded as referable to *C. fletcheri* may constitute a distinct variety either of this or of *C. pulchellus.*"—Nicholson, *loc. cit.*

As is well known now, this species is not the same as the Silurian *Chaetetes fletcheri,* under which name Nicholson described it, as he himself pointed out (Genus Monticulipora, p. 131) when he came to investigate the internal characters.

Its external characters are indicated above, with the exception that a very abundant series of mesopores is usually developed, the zooecia are ring-like, and the acanthopores frequently in well preserved material give rise to minute spines at the surface. The zoaria are characteristically smooth and cylindrical, and of medium size, the specimen figured (after Nicholson) being about typical. As to internal characters, in tangential sections cutting the mature region, the zooecia are seen to be nearly always circular, with moderately thick walls, and surrounded by small angular mesopores. Scattered among the zooecia and imbedded in their walls are a moderate number of acanthopores of two sizes, the greater number being small and not conspicuous, while there are occasional much larger ones, that seem to arise much deeper in the zoarium than the smaller ones, the latter being confined to the mature region. In longitudinal sections the zooecia and mesopores are both seen to be crossed by well defined and complete diaphragms, rather more crowded in the mesopores. These are much less frequent in the axial region. The zooecia bend rather abruptly from the axial into the mature region, and emerge at right angles to the surface, where their walls become considerably thickened.

This species is abundant in the upper part of the Eden Shales (Utica) which it characterizes.

5.9A31, 35, 41, 44....1.34Co, 5, 6, 7, 8, 9, 10, 11....1.38A9, 11, 13, 21, 24, 31, 35, 37, 39, 41, 45, 49, 51, 53, 59, 63, and at all other localities where beds of equivalent age are exposed.

DEKAYIA ULRICHI var. ROBUSTA (Foord).

Plate XIV, figs. 2-2b; Plate XXVII, fig. 22.

Dekayella robusta Foord, 1884, Ann. Mag. Nat. Hist., ser. 5, XIII, p. 341, pl. xii, figs. 2-2d.

"Corallum ramose, frequently branching. Branches thick, usually cylindrical, sometimes compressed. Surface covered with small but tolerably conspicuous monticules, situated about 3 millimetres apart, and bearing cells of a somewhat larger size than those in the intermediate spaces. The apertures of the corallites are polygonal in outline, and in places where the surface is well preserved some of the larger of the spiniform corallites may be seen with a hand lens. Of the larger corallites about four occupy the space of 1 millimetre, of the smaller about five.

"*Microscopic characters.*—Tangential sections reveal clearly the dimorphic character of the corallum, which is provided with two kinds of tubes, large and small; both are of polygonal form, and their outline is inflated in many places by the occurrence of numerous spiniform corallites. These also are of two kinds: The larger are usually situated at the angles formed by the junction of four or five cells, and fill a space quite as great as that occupied by some of the interstitial cells; the smaller are generally found to be in the substance of the cell-walls, about midway between two angles. The spiniform corallites form a very conspicuous feature in tangential sections of this species, and give to such sections a highly characteristic appearance. Under a moderately high power traces of the original walls of the corallites may be discerned in tangential sections; but as a rule this structure appears to have been destroyed in the process of fossilization. In longitudinal sections the two sets of tubes are clearly brought into view. In the larger ones there are numerous horizontal, sometimes slightly oblique, tabulae, situated at from one-half to one tube-diameter apart; they begin in the axial region of the corallum, and are about equally developed in their course from thence to the peripheral region. The smaller tubes do not differ in the character of their tabulation from the larger ones, except that the tabulae in the former are a little more frequent than they are in the latter. There is a feature worthy of note in the structure of the walls of this species, and that is a periodic inflation, which reminds the observer of a similar structure characteristic of the genus *Stenopora* (Lonsdale). Mr. Ulrich draws attention to a like feature in his description of a Cincinnati-group species of *Dekayella—D. obscura,* Ulrich (Journ. Cincinnati Soc. Nat. Hist. vol. vi, p. 150).

"On leaving the axial region the tubes rapidly thicken towards the surface, the spiniform corallites being seen at frequent intervals piercing the corallum and intermingling with the ordinary corallites. The spiniform corallites appear to originate in the axial region of the corallum, as they may be seen in sections cut as deeply as it is possible to make them without destroying the walls of the tubes.

"It may be well here to enumerate the chief characters which separate this species from the only two known to the writer, viz.: *Dekayella ulrichi,* Nicholson, and *D. obscura,* Ulrich—both from the Cincinnati Group of Ohio. From the former of these the present type may be distinguished as follows:—by its much more robust habit of growth, by the possession of monticules, and by the much greater number of its tabulae and spiniform corallites. The exceedingly small and delicate corallum of *D. obscura,* Ulrich, would be sufficient alone to differentiate it from *D. robusta,* and added to this the great development of the tabulae and spiniform corallites in the latter make the distinction between the two forms sufficiently clear."—Foord, *loc. cit.*

The internal characters of this species are substantially the same as those of *D. ulrichi,* and the same as may be seen in similar sections of the branches of the *Dekayia subfrondosa* described by me.

1.34C9, 10, 11, 13.

DICRANOPORA EMACERATA (Nicholson).

Plate XXXII, figs. 13-13b.

Ptilodictya emacerata Nicholson, 1875, Ann. Mag. Hist. 4th ser., XV, p. 179, pl. xiv, figs. 2-2b.

"Polyzoary consisting of minute, narrow, linear fronds, which branch dichotomously, and have the form of a much flattened, acutely pointed ellipse in transverse section. Width one third of a line; length of largest specimen observed, two lines. Cells elliptical, their long axes corresponding with that of the branches, about six or seven in the space of one line measured longitudinally. There are four, five, or rarely six rows of cells in the frond. When four rows of cells are present, two of these (in the centre) are longitudinal, and one row on each side is composed of cells directed in an obliquely ascending manner. When there are five rows, as is most commonly the case, the three central ones are longitudinal and the lateral row on each side is oblique. When there are six rows, two central ones are longitudinal and two on each side oblique. The cell-mouths are much longer than wide, and each row is separated from the next by an elevated line. The lateral margin of the frond on each side forms an obtuse non-celluliferous edge, the width of which is so small that it can not always be detected. A central axis was not clearly determined, but is doubtless present.

"The only previously recorded species of the genus to which *Ptilodictya emacerata* presents any close resemblance is *P. fragilis,* Billings, from strata of the same age in Anticosti (Cat. Sil. Foss. of Anticosti, p. 9). Our species, however, is distinguished from the latter by its uniformly more minute dimensions, the smaller number of rows of cells in the frond, and the possession in genreal of no more than a single row of cells on each side. *P. fragilis,* on the other hand, has a width of from two-thirds of a line to one line, with from eight to ten rows of cells, and two or three rows of oblique marginal cells on each side. It is possible our form is only a variety of *P. fragilis*; but in the absence of figures of the latter, and in the face of the differences above mentioned, I think it safest to regard *P. emacerata* as a distinct species."—Nicholoson, *loc. cit.*

This species is found in nearly every layer of the Liberty formation, in the Tanner's Creek section and in other parts of the Richmond and Lorraine.

1.34A11, 12, 13b, 14, 16b, 17, 18, 19, 20, 21, 22, 23....1.41A4, 5, 6, B1, 3, C1, 2-3, D1, 2, 3, E2, 3, 5, 6, 7....1.12D1-6, E3, F3.

ERIDOTRYPA SIMULATRIX Ulrich.

Plate XVI, figs. 4-4b; Plate XXIX, figs. 5-5a.

Batostomella simulatrix Ulrich, 1890, Geol. Illinois, VIII, p. 432, pl. xxxv, figs. 1-1g.

"Zoarium dendroidal, throwing off cylindrical branches from two to five mm. in diameter. Surface smooth, with clusters not at all or but slightly elevated, in which the interspaces between the cells are wider and mesopores more numerous than elsewhere. Zooecial tubes a little irregular in their course in the axial portion, quite oblique in the peripheral zone where the walls become considerably thickened. Apertures of zooecia oval, owing to the obliquity of the tubes, about 0.2 mm. in their longer diameter and about eight in two mm. measuring longitudinally. Zooecial tubes for a short distance after their origin rather closely tabulated, afterwards the diaphragms become about two tube diameters or less apart. Mesopores moderately abundant, with rather close-set diaphragms. Acanthopores very small.

"In the oval form of the cells, the numerous mesopores, the frequent closure of the cell apertures by perforated opercular structures, this species is remarkably like *Callopora sigillaroides* Nich., but its internal structure is altogether different. Internally it can scarcely be distinguished from *B. trentonensis* Nich., from the Trenton limestone of Ontario, but the smaller size of this species, and its rather more oval apertures and different horizon discriminate the form from that."—Ulrich, *loc. cit.*

This species occurs chiefly near the top of the Waynesville member of the Richmond series, but also sparingly in the succeeding Liberty formation.

1.34A8, 9, 10, 14a, 14b, 15a, 16a, 16b....1.12E3.

ESCHAROPORA ACUMINATA (James).

Ptilodictya acuminata James, 1875, Catalogue of Lower Silurian Fossils of the Cincinnati group, p. 3.

"Polyzoary ensiform; transversely suboval; enlarging very gradually upwards from the pointed base; two series of elevated lines crossing each other diagonally on the upper part, but becoming almost or quite parallel and close together as they near the base, giving to the point a solid appearance. Cells about eight in the space of a line, measuring diagonally; rhomboidal or suboval on the upper part, but become more and more elongated towards the base and disappear before reaching it. A longitudinal elevated line on each side where the diagonal lines meet; somewhat carinate.

"Different examples vary in length from half an inch to more than one inch, and in width, at the broadest part, from three-fourths of a line to one and a half lines; in thickness from one-half to one line.

"The surface of this species resembles *P. falciformis,* Nicholson, but in other respects it differs materially; *P. falciformis* is quite flat, much larger, broader, and thinner, and generally, expands rapidly from the point or base; some specimens are over four inches long, from one-half to three-fourths of an inch wide and only about half a line thick; the edges thin and sharp; exceptional long narrow specimens of *falciformis* are found, but they are very thin and frail. *P. acuminata* approaches in form to a compressed cylinder, is quite convex, rounding to the carinated sides, and expands very gradually from the base.

"It bears some resemblance, also, to *Phaenopora ensiformis*, Hall, from the Clinton group of New York, but differs essentially in the direction of the elevated lines and the nearly solid base."—James, *loc. cit.*

This is probably a narrow and less robust variety of *Escharopora falciformis. E. acuminata* is characteristic of the Eden formation and *E. falciformis* of the lower part of the Lorraine.

5.9A2.

ESCHAROPORA FALCIFORMIS (Nicholson).

Plate XVI, figs. 5, 5a.

Ptilodictya falciformis Nicholson, 1875, Ann. Mag. Nat. Hist., 4th ser. XV, p. 177, pl. xiv, figs. 1-1b.

"Polyzoary consisting of a single, unbranched, or slightly branched, elongated, flattened and two-edged frond, the form of which is curved or falciform, and which gradually expands from a pointed base till it reaches a width of two lines within a distance of less than half an inch above the base. The total length may exceed two inches; but the width, in typical examples, rarely exceeds two and a half lines. The transverse section is acutely elliptical, the thickness in the middle not exceeding half a line; and the flat faces of the frond are very gently curved and not angulated. A central laminar axis, though often undemonstrable, can sometimes be clearly shown to exist. The edges of the frond are thin and sharp, formed by a narrow band, which is marked with longitudinal or slightly oblique striae and by the apertures of minute imperfect cells. Both sides of the frond are celluliferous, the cells being apparently perpendicular to the surface, and being arranged in intersecting diagonal lines, which form angles of about 30° with the sides of the frond, and thus cut one another at about 60°. The mouths of the cells are oval or somewhat diamond-shaped, their long axis coinciding with that of the frond, alternately placed in contiguous rows, about eight in the space of one line measured diagonally; the outermost rows very slightly smaller than the others. Walls of the cells moderately thick; no surface-granulations, tubercles, spines, or elevated lines. The mouths of the cells parallel with the general surface, neither lip being especially prominent, and the plane of the aperture not being oblique.

"As a general rule the polyozoary is simple, unbranched, and falciform. I have seen, however, in the fine collection of Mr. Dyer, of Cincinnati, some specimens in which the frond bifurcates at its distal extremity, and at least one example in which it splits into three divisions. I have also seen examples of what may probably prove to be a distinct species, in which the frond is very much wider than is normally the case.

"This beautiful species is allied to *Ptilodictya* (*Escharopora*) *recta,* Hall, on the one hand, and to *P. lanceolata,* Goldf., *P. gladiola,* Billings, and *P. sulcata,* Billings, on the other hand. The specimens from which the above description is taken were sent to me with the label of *Escharopora recta* attached to them; and at first sight they certainly closely resemble this species, especially in the disposition of the cells in intersecting diagonals of great regularity. It is certain, however, that they are distinct from Hall's species—the chief differences consisting in the fact that the frond of *P. falciformis* is greatly flattened, so that the transverse section is acutely elliptical instead of being 'cylindrical or subcylindrical', whilst the edges are sharp and non-celluliferous, and the entire frond is regularly curved and sabre-shaped instead of being straight. Hall states that *E. scharopora recta* is not branched, but possesses root-like processes. Judging, however, from his figures, it would seem probable that his specimens have been drawn and described in an inverted position, and that this form is in reality dichotomously branched.

"From *Ptilodictya lanceolata,* Goldf. the present species is readily distinguished, more especially by the disposition of the cells, which are in regularly intersecting diagonal lines; whereas in the former there is a central series of longitudinally arranged cells, flanked on each side by diagonal rows directed like the barbs of a feather.

"With *Ptilodictya gladiola,* Billings, our species agrees in the shape of the frond; but it is proportionally twice as wide, whilst the cells are oval instead of being rectangular or oblong, and are disposed in decussating diagonals instead of in longitudinal lines as in the former.

"Lastly, *Ptilodictya sulcata,* Billings, whilst resembling *P. fal-*

ciformis in shape, is distinguished by the nearly square cells with intercellular sulci, and by the fact that the cells are arranged in longitudinal lines.''—Nicholson, *loc. cit.*

5.9A41....1.34C13, 14a, 14b.

ESCHAROPORA PAVONIA (Milne-Edwards and Haime) not d'Orbigny.

Plate XVI, fig. 6; Plate XXIX, fig. 6.

Chaetetes pavonia Milne-Edwards and Haime, 1851, Monographie des Polypiers Fossiles des Terrains Palaeozoiques, p. 267, pl. xix, figs. 4, 4a.

''Polypier en lames frondescentes, épaisses seulement de 2 ou 3 millimètres, à mamelons à peine saillants, larges et peu éspaces. Calices polygonaux, souvent tétragonaux, ceux des mamelons plus grands que les autres, et larges d'un tiers de millimètre.

''SILURIEN (inférieur). *Etats-Unis:* Cincinnàti (Ohio).

''Coll. d'Orbigny, de verneuil.''—Milne-Edwards and Haime, *loc. cit.*

It seems impossible to believe that the form figured by Edwards and Haime (*loc. cit.*) is the same species or even congeneric with the type of *Ptilodictya pavonia* d'Orbigny as recently figured in the Annales de Paleontologie, Tome I, pl. IX (Paris, 1906), and which proves to be the same as the common *Peronopora decipiens* (Rominger). I have therefore, since the two forms fall in widely separated genera, concluded to retain the name *Escharopora pavonia,* crediting it to Edwards and Haime instead of to d'Orbigny. This involves the least change, and I believe there can be no doubt as to the identity of Edwards and Haime's species. It will of course be necessary to substitute *Peronopora pavonia* (d'Orb.) for *Peronopora decipiens* (Rominger). Evidently the specimens in the type lot of d'Orbigny represent at least these two distinct species and possibly more.

In order to supplement the meagre description of Edwards and Haime I quote below the very full description of Nicholson:

''*Spec. Char.*—Corallum forming a thin undulating expansion, often of considerable extent, and varying from half a line to about two lines in thickness. The expansion grew in an erect position, and it consists of two layers of corallites, which have their bases fixed to a medium plane marked by a delicate undulating calcareous membrane, and which open on opposite sides of the corallum. The corallites vary from a quarter of a line to a line in total length, and though oblique at their origin, they almost immediately bend outwards, so as to open nearly at right angles to the general surface, or with only a slight obliquity to it. The calices have the form of elongated pentagons, with rounded angles, their long diameter being from 1-110th to 1-90th inch. Their size is tolerably uniform, and there are no minute interstitial tubes. The calices are often arranged in tolerably regular obliquely intersecting lines; and the surface shows low rounded elevations, which are often obscurely marked, are arranged in diagonal rows at intervals of from a line to a line and a half, and are occupied by calices which are not conspicuously larger or smaller than the average. The walls of the corallites are at first thin; but they rapidly become thickened, the lines of demarkation between adjacent tubes still remaining recognizable. A few remote, complete, and horizontal tabulae are developed in the interior of the tubes; but these are not recognizable in all the corallites, and are often placed at corresponding levels in adjoining tubes.

"*Obs.*—This beautiful species presents a considerable superficial resemblance to *Ptilodictya,* and has been referred to this genus. It wants, however, the definitely circumscribed and peculiarly marked lateral margins of the fronds of this Polyzoan type, and, what is more important, it is without the peculiarly striated central lamina of the *Ptilodictyae.* It is true that the bases of the corallites in *M. pavonia,* D'Orb., [E. & H.] are so united with one another as to give rise to an irregular calcareous membrane, which separates the two halves of the corallum; but none of the specimens that I have seen exhibit any tendency to split along the line of this membrane, nor can the corallites be forcibly removed from one side of it, exposing the median lamina as a definite structure. In both these respects the *Ptilodictyae* would show quite different phenomena. The reasons just given would equally prevent my accepting the view held by Mr. E. O. Ulrich that this form should be referred to *Heterodictya,* Nich., since this genus differs from *Ptilodictya* principally in the possession of tabulae. On the other hand, the general aspect of *M. pavonia,* D'Orb., is not at all remarkably different from that of the thin fronds of *M. frondosa,* D'Orb., while it exhibits low 'monticules'; and there is nothing in its internal structure which is irreconcilable with the view that it is a *Monticulipora.* In the meanwhile, therefore, I shall leave this type within the limits of the genus *Monticulipora,* till more definite evidence may be forthcoming as to its proper position.

"So far as external characters go, *M. pavonia,* D'Orb., is easily recognized by its thin undulated corallum, which carries on both sides the sub-equal, oval, or pentagonal calices, these being often arranged in decussating lines, and elevated at intervals into low and inconspicuous monticules. As regards its internal structure, we have seen that the corallites are bilaterally disposed on the two sides of a central plane, as is shown by vertical sections taken at right angles to the flat surfaces of the corallum. All the corallites are of the same kind, approximately equal, and averaging 1-100th inch in diameter. At first thin-walled, they rapidly have their cavities contracted by a secondary deposit of sclerenchyma. When viewed in tangential sections the visceral chambers of the corallites thus appear to be oval; but the original independence of the corallites is shown by the persistence of the pentagonal boundary lines between adjoining tubes, occupying the middle line of the thickened wall. In these sections the visceral chambers are sometimes encroached upon by a single blunt tooth-like projection on one side; but I can give no precise explanation of this phenomenon. There is no appearance of any interstitial series of tubes between the ordinary corallites, nor are any 'spiniform corallites' present. Tabulae, as seen in long sections, are few in number, sometimes apparently wanting, but, when developed, always complete and horizontal, and often placed at the same level in adjoining tubes, and thus marking stages of growth."—Nicholson, Genus Monticulipora, pp. 195-198, 1881.

To this description should be appended the remarks of Ulrich in regard to the systematic position of the species. After quoting Nicholson to the effect that the form in question lacks the striated margin of *Ptilodictya* and is without the peculiarly striated central lamina of that genus Mr. Ulrich says:

"The first character * * * is, of course, not developed along the growing margin of the fronds, but in all specimens preserving the 'articulating process', the non-poriferous margin may be traced along the edges of the lower portion of the frond. * * * Judging from the above quotation, it would appear that Dr. Nicholson has entirely misconceived the character of the median laminae of the *Ptilodictyonidae.* If I understand him correctly, he believes that the axis is constituted by a *definite structure* from which the two layers of cells may be striped. This impression is manifestly erroneous, nor do I know of a single double-leaved Bryozoan in which such a structure may be demonstrated. In *Ptilodictya* the facts are, simply, that we have two layers of cells which are grown together back to back by the adhesion of the epithecal laminae of each layer. * * *"—Ulrich, Jour. Cin. Soc. Nat. Hist. V, p. 164.

The species has since been referred by Ulrich to the genus *Escharopora**, a genus very nearly related to *Ptilodictya*.

Since *Escharopora pavonia* (E. & H.) is an undoubted Bryozoan, it serves to emphasize the difficulty of Nicholson's position in contending that the *Monticuliporidae* (in the broad sense of older authors) belong to the Corals: for Nicholson referred the form, as will be noted from the above description, to the genus *Monticulipora*.

This species characterizes the lower part of the Lorraine.

1.34C14a, 13....1.38Ba, b.

FENESTELLA GRANULOSA Whitfield.

Plate XXIX, figs. 7, 7a.

Fenestella granulosa Whitfield, 18‹7, Annual Report of the Wisconsin Geological Survey for the year 1877, p. 68. (Not figured.)

"Bryozoum, growing in small fan-shaped or funnel-formed fronds, which rise from a root-like base, by which they have been attached to foreign substances. Longitudinal rays slender, rather closely arranged, and frequently bifurcated; giving to the lower part of the frond a somewhat irregular mode of growth, but becoming more regular above. From three to four of the rays may be counted in the space of one millimetre, in the upper part, but seldom more than three in the lower. Fenestrules subquadrangular, longer than wide, but extremely variable in size and form, and about as wide as the diameter of the rays. Pores small, slightly oval, scarcely exsert, generally four to each fenestrule, one of which is situated at the junction of the transverse dissepiment; rays carinate between the pores; dissepiments narrower than the rays. Non-poriferous surface of the rays convex, distinctly but very minutely granulose, the granules closely and irregularly arranged, sometimes numbering as many as six in the width of the ray opposite the fenestrule."—Whitfield, *loc. cit.*

This is interesting as the oldest form of a type of Bryozoan structure that became predominant in the later Paleozoic. It does not seem to me probable that the various species referred to the genus *Phylloporina* have any ancestral relation to *Fenestella*.

*Geol. Nat. Hist. Surv. Minnesota, III, pt. I, p. 167.

Some of them may bear some such relation to *Polypora*. I should be inclined to look for the ancestors of *Fenestella* in such forms as *Arthroclema* and related genera.

Fenestella cannot be said to be a common species at any horizon, although at one level in the Liberty formation I have seen quite a number of specimens of it.

1.34A12, 13a, 16b....1.41A9, D2, C2-3....1.12D1-6.

GRAPTODICTYA PERELEGANS Ulrich.

Plate XXIX, fig. 8.

Ptilodictya perelegans Ulrich, 1878, Jour. Cin. Soc. Nat. Hist., Vol. I, p. 94, pl. iv, figs. 16, 16a.

"Polyzoary frequently and alternately branched, sharp edged, the branches being acutely elliptical in cross section, about one quarter of a line in thickness centrally, and one and a quarter line wide. Cells covering the surface on both sides, with the exception of a rather broad non-celluliferous border lining the branches. The bases of the cells on the two aspects of the frond are separated by a thin laminar axis. Cell-mouths circular, with a conspicuously elevated rim, arranged in transverse rows, as well as in very regular intersecting diagonal lines, which form an angle of about thirty degress with the sides of the branches; about seven cells in the space of one line measuring both longitudinally and transversely.

"Intertubular spaces quite as wide as the cell-openings, and ornamented, when perfectly preserved, by slightly raised and flexuous lines. The non-poriferous border occupies, on each side, about one seventh of the entire width of a branch, and is marked with very fine, and but slightly waved striae, the direction of which forms an angle of about fifteen degrees with the margin of the branches.

"This beautiful species is allied to *P.* (*Stictopora*) *elegantula,* of Hall, but that species does not branch so frequently, has the cell-mouths val, [oval?] and larger, while the intertubular species [spaces ?] are thinner than they are in this species; the direction of the striae on the non-poriferous margin of Hall's species, forms a much larger angle with the edge of the branch than it does in *P. perelegans.*"—Ulrich, *loc. cit.*

1.34A8.

HELOPORA ELEGANS Ulrich.

Plate XXIX, fig. 9.

Helopora elegans Ulrich, 1893, Geol. Nat. Hist. Surv., Minnesota, p. 194, fig. 11.

"Segments small, subcylindrical, obtusely hexagonal in cross-sections, about 3.0 mm. long and 0.3 mm. in diameter; upper extremity truncate, the lower rounded and tapering slightly. Zooecia in six longitudinal ranges, their apertures narrow-elliptical, slightly depressed in front, their length apart, arranged alternately in adjoining rows. Entire surface beautifully grano-striate, the striae flexuous, forming connected peristomes, with a short row of granules between the ends of the apertures and a continuous row at each angle of the segment. The latter winds itself between the zooecial apertures so as to arrange them into longitudinal series, with seven or eight in the length of the segment.

"Of all the species known to me *H. alternata* seems to be the nearest to this. The differences between them are however too obvious to require pointing out. *H. harrisi* occurs in the same beds, but its segments are longer and more slender; its zooecia smaller, and the surface marking quite different."—Ulrich, *loc. cit.*

1.34A12....1.41A4, D2.

HELOPORA HARRISI James.

Plate XXIX, figs. 10-10b.

Helopora harrisi James, 1883, The Paleontologist, No. 7, p. 58, pl. ii, figs. 3, 3a.

"The numerous well defined sections of this species, lying upon and embedded in the surface of a small slab of limestone, examined for this description, consist of delicate stems, with generally a single row of much elongated oval cells, on the *exposed* face, but occasionally—seldom—two rows are shown; the number of rows of cells on any one section undetermined, two at least, and may be three or four on some or all specimens; the difficulty in ascertaining this point definitely is in not being able to obtain detached examples, owing to the extreme delicacy of the stems; in removing them from the slab they crumble into small particles. The fragments or sections of branches are from one to two lines in length, and from 1-8th to 1-10th of a line in breadth, with about 6 of the oval elongated cell apertures to one line. Sides of the specimens drawn together at the ends of apertures, giving them a chain-like appearance, resembling, somewhat, a transverse section of a single row of tubes of Halysites; sometimes this feature is less pronounced than in most cases, the sides then being nearly parallel, and not drawn in or but slightly so. Occasionally the sections show swollen terminations. They are, no doubt parts or joints (?) of a Polyzoary of considerable size, as indicated by the profusion of fragments on both sides of the slab about 4x4½ inches.

"Exceedingly fine longitudinal lines may be seen on the general surface, with a good lens.

"This species differs from *Helopora tenuis* [*Arthrostylus tenuis*], James, in the elongated instead of circular cell apertures, the constrictions between the cells, and the absence of a striated nonporiferous face as shown on one side of that species; also in the larger size of the stems."—James, *loc. cit.*

The above description is incorrect in a number of details. I quote therefore parts of the excellent description by Ulrich (Geol. Minnesota, III, 1893, p. 195):

"Segments * * * hexagonal in cross section; upper extremity slightly expanded, conical or pyramidal, with the angles prominent, the lower end striated, tapering, obtusely pointed or slightly bulbous; between the ends the sides are nearly parallel. Zooecia in six longitudinal ranges, their apertures small, narrow-elliptical, often drawn out anteriorly, their margins thickened, about twice their length apart, with seven (usually) on each of the six faces. Peristomes connected lengthwise, their sides being coincident or merged into the moderately developed ridges forming the angles of the segment. The latter are nearly always straight. Interspaces between the ends of the zooecial apertures occupied by a low rounded ridge, rising and spreading at each end into the peristomes. The best preserved examples exhibit a row of exceedingly minute papilae on the peristomes and angle-ridges."

Reported from various Indiana localities by Ulrich.

HOMOTRYPA AUSTINI Bassler.

Plate XVI, figs. 7-7b; Plate XXIX, figs. 11, 11a.

Homotrypa austini Bassler, 1903, Proc. U. S. National Museum, XXVI, p. 584, pl. xxiv, figs. 5-9.

"The branches of this neat species are small, cylindrical, 4 to 8 mm. in diameter, and divide rather frequently. Surface smooth. Zooecia small, polygonal to rounded, thick walled, nine to ten in 2 mm. Acanthopores numerous, four or more often surrounding a zooecium and generally visible at the surface as blunt spines.

Mesopores, except an occasional one in the maculae, wanting. The zooecia in the axial region are without diaphragms and have thin, crinkled walls, the greatest amount of crinkling occurring just before the peripheral region is reached. As a rule, both cystiphragms and diaphragms are absent in the peripheral region of the ordinary zooecia, but in those of the maculae there is an abundance of the former.

"This species is named after its discoverer, Dr. George M. Austin, of Wilmington, Ohio, who, notwithstanding arduous professional duties, finds time for enthusiastically collecting and studying the fossils of that region."—Bassler, *loc. cit.*

To this species I have referred a number of specimens having small smooth zoaria and an almost total absence of Cystiphragms or diaphragms. These depart in certain particulars from the typical *H. austini*, as described by Bassler, but I am not at present prepared to make any other disposition of them.

1.34A16, 19-21....1.41D1, 2, E1, C1....1.12E3.

HOMOTRYPA COMMUNIS Bassler.

Plate XVII, figs. 1-1d; Plate XXIX, fig. 12.

Homotrypa communis Bassler, 1903, Proc. U. S. National Museum, XXVI, p. 581, pl. xxiii, figs. 1-4.

"Zoarium of subcylindrical or more commonly compressed branches from 5 to 10 cm. high and 4 to 8 mm. in thickness. Surface smooth, with clusters composed of larger cells and mesopores. Apertures direct, polygonal, rather thick-walled, with about nine in 2 mm. Acanthopores seldom seen on the surface, but sections show a zooecium to be surrounded by from four to seven. Walls thin and crinkled in the axial region, much thickened in the peripheral. Diaphragms wanting in both regions. Cystiphragms few, generally restricted to the region transitional to the mature condition.

"Externally this species sometimes resembles *H. curvata,* but internally is very different. The only associated form with which it might be confounded is *Bythopora meeki* (James), which often bears a superficial resemblance. Sections show the two species to be very distinct."—Bassler, *loc. cit.*

1.34A11, 12, 13a, 14a, 14b.

HOMOTRYPA CONSTELLARIFORMIS n. sp.

Plate XVII, figs. 2-2b.

The zoaria of this interesting species are small, subcylindrical, to cylindrical, smooth stems with star-shaped groups of mesopores, giving to the surface much the appearance of *Constellaria limitaris*, but with the mesopores much less numerous and less regularly arranged. The mesopores sometimes run out from the center of the macula in chains between which are peculiar sinuous channels, unlike anything known to me in any other species of the Trepostomata. In some cases the maculae seem to be entirely composed of these peculiar channels. This feature gives to the surface a most extraordinary and beautiful appearance. In tangential sections the maculae are seen to be composed entirely of small mesopores and the chain-like arrangement is also apparent here. The ordinary zooecia are fairly thin-walled, about as in *H. flabellaris*, and are usually occupied by the cut edges of cystiphragms. Acanthopores are few and of small size. Mesopores are few or lacking outside of the maculae. In longitudinal sections are seen numerous well developed cystiphragms and diaphragms in the mature region and an occasional diaphragm in the immature region, the zooecia curve gradually into the mature region and emerge at right angles to the surface. In the specimen figured the mature region has been duplicated by overgrowth. This does not seem to be a general character of the species.

The majority of the specimens were obtained from the base of the Whitewater division in the railroad cut north of Weisburg Station, and loose from the top of the first cut south of the station. A single specimen was found in the "upper fossil bed" at Versailles (Whitewater).

HOMOTRYPA CURVATA Ulrich.

Plate XVII, figs. 3-3b; Plate XXIX, fig. 13.

Homotrypa curvata Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., V, p. 242, pl. x, figs. 7-7d.

"Zoarium ramose, consisting of compressed, often greatly flattened branches. An average specimen has a height of over two inches, a width of about seven tenths of an inch, and a thickness of two tenths of an inch. The most conspicuous feature of the surface is found in the small, stellate maculae, which, under a low magnifying power, appear to be solid, but, as is shown by a higher power, are composed of very shallow, and angular, small cells. These maculae are on a level with the general surface, and occur at intervals of about .11 of an inch, measuring from center to center. The ordinary cells are usually rounded, though sometimes slightly angular, have moderately thick walls, with a diameter varying from 1/140th to 1/130th of an inch. The cells immediately surrounding the stellate maculae are larger, and may attain a diameter of 1/90th of an inch. When the specimen examined is in a good state of preservation, the surface spines (spiniform tubuli) may be detected. They never constitute a conspicuous feature of the surface.

"Tangential sections show that the tubes in the outer or 'mature' portion of the zoarium have thickened walls, more or less rounded visceral cavities, and that they are apparently completely amalgamated with one another. The walls, between the narrow lucid ring which surrounds each of the tubes, has a peculiar granular structure, and is crossed by the connecting foramina, of which my sections show three or four to enter each tube. The spiniform tubuli are numerous, of moderate size, and have the usual appearance. In longitudinal or vertical sections the tubes in the axial region have excessively thin, and slightly flexuous walls, and are crossed by diaphragms at distances apart of from one to two tube-diameters. As they bend outward into the peripheral region, their walls are much thickened, the diaphragms occur at shorter intervals (one-third to one-half a tube-diameter), and correspondingly crowded series of cystoid diaphragms are developed in nearly all the tubes. Lastly, the spiniform tubuli may be recognized.

"In transverse sections the tubes are polygonal, the walls excessively thin, and the calcite filling them is divided by irregular cruciform lines, that often are so distinct as to cause the observer some trouble to exactly determine the outlines of the tube walls. (The same feature occurs in many other species of the *Monticuliporidae.*)"—Ulrich, *loc. cit.*

1.33A3....1.34A11, C13, 14a....1.38Ba.

HOMOTRYPA CURVATA var. PRAECIPTA Bassler.

Plate XVIII, fig. 4; Plate XXX, figs. 7, 7a.

Homotrypa curvata var. *praecipta* Bassler. 1903, Proc. U. S. National Museum, XXVI, p. 575, pl. xxiii, fig. 15.

"This varietal name is proposed for the only *Homotrypa* known in the Utica. It has the internal characters of *H. curvata,* but differs in the growth of the zoarium. Its branches are cylindrical, smooth, about 6 mm. in diameter, and divide at short intervals, while the zoarium of *H. curvata* takes the form of broad, compressed branches, dividing at less frequent intervals. Thin sections show that the Utica form generally exhibits more acanthopores, but the number of acanthopores varies slightly in every species."—Bassler, *loc. cit.*

This form was first noted by the writer in 1902* as occurring in the upper Utica; and is reported by Bassler (*loc. cit.*) from the middle Utica. It also occurs in the lower Lorraine.

1.34C13.

HOMOTRYPA CYLINDRICA Bassler.

Plate XVII, figs. 4, 4a; Plate XXIX, fig. 14.

Homotrypa cylindrica Bassler, 1903, Proc. U. S. National Museum, XXVI, p. 585, pl. xxii, figs. 8-13.

"Zoarium ramose, branches long, cylindrical, from 4 to 15 mm. in diameter, dividing dichotomously at intervals of from 3 to 4 cm. Surface varying from smooth to tuberculated, the maculae or monticules generally somewhat transversely elongated. Zooecial apertures thick walled, usually angular, direct, about nine in 2 mm. Mesopores few, seldom occurring outside of the clusters. Only well-preserved examples show at the surface the numerous and very large acanthopores characteristic of the species. The walls of the zooecia in the axial region are thin and but little crenulated, but in the mature region they become so thickened as to almost equal in breadth the diameter of the zooecial cavity. Cystiphragms well developed. Diaphragms very few, if present at all, the structures simulating them probably being large cystiphragms.

"The large and numerous acanthopores and the thickness and minute structure of the walls give a very characteristic, even bizarre, appearance to tangential sections. The number of acanthopores varies, the normal number being four to five when they are large to five to nine smaller ones around a zooecium. In vertical sections the acanthopores are seen not only to proceed directly to the surface parallel with the zooecial walls, but they also sometimes cross them obliquely."—Bassler, *loc. cit.*

1.41A7, 8, D3, E3, 4, 5....1.12F3.

HOMOTRYPA DAWSONI (Nicholson).

Plate XVII, figs. 5, 5a; Plate XXX, fig. 1.

Monticulipora (*Heterotrypa*) *dawsoni* Nicholson, 1881, Genus Monticulipora, p. 141, pl. v, figs. 3-3f.

"*Spec. char.*—Corallum having the form of an undulated expansion, of unknown size, and about two lines in thickness. Surface covered with numerous close-set prominent monticules, which are markedly elongated, are placed about a line, or less, apart, and are occupied by corallites which do not differ conspicuously in

*Cumings, American Geologist, XXIX, p. 215, foot note.

size from those forming the mass of the corallum. Calices polygonal, thin-walled, about 1-90th inch in diameter, without any regular series of small apertures, but occasionally exhibiting at their angles of junction a minute circular opening. Normal corallites sub-equal, polygonal, at first thin-walled, but becoming slightly thickened as they approach the surface. In the center of the flattened corallum they are furnished with delicate, wavy, or crimped walls, and are vertical in direction, being in this part of their course entirely free from tabulae. They then gradually bend outwards, with a very slight inclination, their walls becoming at the same time thickened, and a moderate number of complete horizontal tabulae being developed.

"In addition to the normal corallites (which are mostly of one kind) there are numerous thick-walled, circular tubuli ('spiniform corallites') developed at the angles of junction of the former, or in the thickness of their walls.

"*Obs.*—In its general form, mode of growth, and external appearance, this species might perfectly well pass as an example of either *M. mammulata,* D'Orb., or *M. molesta,* Nich. The only superficial characters which would lead to its separation are, that the normal calices are not intermingled with a series of smaller apertures, and that the prominent monticules are certainly more elongated and compressed than is usual in examples of the above. In its internal structure, however, *M. Dawsoni* is fundamentally different from either *M. mammulata,* D'Orb., or *M. molesta,* Nich., and exhibits a quite peculiar assemblage of characters.

"In tangential sections the corallum is seen to be composed almost wholly of one series of normal corallites, which are similar in internal structure, and approximately equal in point of size. Near to the surface, the walls of these corallites are moderately thickened, though the lines of demarkation between adjoining tubes are not obliterated; and they are uniformly polygonal in shape. Only an occasional interstitial corallite, properly socalled, is present; but there are numerous minute, circular, thick-walled, darkly-outlined tubuli ('spiniform corallites'), the apertures of which upon the surface may occasionally be detected. So far as can be made out, the corallites of the monticules are in no important respect different from those making up the bulk of the corallum; though this point is one difficult to settle absolutely, as a tangential section necessarily cuts the tubes of the monticules at a lower level than it intersects those of the corallum generally, and therefore exhibits the former at a point where their walls are relatively thinner.

"Vertical sections taken at right angles to the plane of the frond, show that the precise arrangement of the tubes differs from what is observable in *M. frondosa* D'Orb., on the one hand, and in *M. mammulata,* D'Orb., and *M. molesta,* Nich., on the other hand. In *M. frondosa,* D'Orb., the corallites of the two sides of the colony spring from the opposite sides of a more or less complete calcareous lamina, which occupies the mesial plane of the colony, and which is seen in a still more perfect form in *M. pavonia,* D'Orb. In *M. mammulata* D'Orb., and *M. molesta,* Nich., again, the corallites of the two halves of the corallum have their origin in an apparently irregular mesial mass of cellular tissue, formed by the bases of the tubes, and there is no sign of any central lamina. In the present species no central lamina exists, but the tubes are quite vertical in the middle line of the frond, each bending outwards, with a very gradual inclination to reach the surface on one side or the other. In the vertical portion of their course, the corallites are thin-walled, and their walls are wavy or are sharply undulated from side to side, and I have not been able to detect any tabulae in this region. In the outer part of their course, on the other hand, the walls are somewhat thickened, while a moderate number of tabulae are now developed. There is mostly no difference observable in the tabulation of the corallites, though here and there a small-sized tube with close-set tabulae may be detected; and the tabulae are in all cases complete and approximately horizontal.

"The only two species of *Monticulipora,* known to me, with which the present form could be confounded, are *M. mammulata,* D'Orb., and *M. molesta,* Nich.; and the differences in its minute structure, as above described, are so marked as to render it unnecessary to compare it in detail with either of these types.

It is to be remembered that the *Monticulipora mammulata* of Nicholson is the *Dekayia frondosa* of the present paper, and that *M. frondosa* mentioned in the above discussion is the form now known as *Peronopora decipiens,* or *Peronopora pavonia* as it should now be called.

Nicholson failed to discover the really important characteristic of his *Monticulipora dawsoni,* namely the presence of cystiphragms. This important feature was pointed out by Ulrich in 1882* with the suggestion that Nicholson's section probably was prepared from a portion of a frond not fully matured. Bassler† has recently published very good figures of a tangential and longitudinal section of

*Ulrich, Jour. Cin. Soc. Nat. Hist., V, pp. 241, 242.
†Bassler, Proc. U. S. National Museum, XXVI, p. 581, pl. XXV, figs. 9, 10.

the species. These with the present illustrations will serve, in connection with Nicholson's very full description, to indicate the form and internal characters of this rather rare species.

1.41E6, and from the Waynesville formation near Brookville, Indiana.

HOMOTRYPA FLABELLARIS Ulrich.

Plate XVIII, figs. 1-1b; Plate XXX, fig. 2.

Homotrypa flabellaris Ulrich, 1890, Geol. Illinois, VIII, p. 411, pl. xxxii, figs. 3-3c.

"Zoarium consisting typically of fan-shaped fronds; an almost perfect specimen gives the following measurements: width 45 mm., height 50 mm., thickness 5 mm. Surface smooth, with obscure maculae about four mm. apart, measuring from center to center. Peripheral portion of zoarium narrow. Walls of zooecial tubes flexuous or crenulated in the axial region, and very thin even in the cortical region. Zooecia apertures angular, slightly oblique, from eight to ten in two mm., those in the maculae from a third to a half larger than the average. Mesopores few, gathered into clusters in the maculae. Zooecial tubes provided with a few remote straight diaphragms in the axial region. Diaphragms moderately numerous in the mesopores. Cystiphragms form a short series in each tube. Acanthopores few, very small.

"A very close variety occurs in the upper beds of the Cincinnati group, at Blanchester, Ohio, which has the maculae a little more pronounced, and a tendency to a ramose growth. The thin walls and flabellate growth distinguish *H. flabellaris* from the hitherto described species of the genus."—Ulrich, *loc. cit.*

In the majority of well matured specimens from Indiana localities, seen by me, the mature region is fairly deep, with well developed series both of cystiphragms and diaphragms. The walls are rather thin, even in the mature region, and acanthopores are moderately well developed. The most characteristic surface feature is the maculae of larger zooecia, among which a considerable number of mesopores are distributed, often radiating out from the center of the macula, so as to give the latter a somewhat star-like appearance. Some of the specimens in the writer's collection have low, rounded monticules. The latter are not as conspicuous as in the variety, *frondosa*. The typical *H. flabellaris* is an abundant fossil in the middle members of the Richmond series.

1.34A12, 13a, 14a, 14b....1.41A2, 6, 7, 8, B1, D1, 3, E1, 2, 3, 4, 6.

HOMOTRYPA FLABELLARIS var. FRONDOSA Cumings.

Plate XVIII, figs. 3-3b; Plate XXX, fig. 3.

Homotrypa frondosa (Edwards & Haime) Cumings, 1902, American Geologist, XXIX, p. 208, pl. x, figs. 11, 12; pl. xi, figs. 2, 5; pl. xii, fig. 1.

"Zoarium frondescent, wavy, 4 to 6 mm. thick and 30 to 50 mm. or more in width. The surface is studded with large rounded stellate monticules which are sometimes slightly elongated in the axial direction of the frond. Monticules usually well elevated, never conical, somewhat spreading at the base. On an average, nine occupy a space of one square centimeter. They are 2 mm., to 2.5 mm. in diameter, and occupied by cells larger than the average. Ordinary cells very uniform in size, 0.2 mm. in diameter; the diameter of the large cells in the monticules is frequently as much as one-third mm. Fifty cells of the ordinary size may be counted in one cm. An occasional mesopore may be detected at the angles of the zooecia.

"The internal structure of this species is that of a typical *Homotrypa* (cf. *H. curvata*). In tangential sections, taken near the surface, the cells are thick-walled, with distinct true walls, and copious deposit of sclerenchyma. The large cells of the monticules are a conspicuous feature of such sections. Only an occasional acanthopore can be detected.

"Longitudinal sections show that the zooecial walls in the axial region are thin, slightly wavy, and that diaphragms are here lacking. In the mature region the walls become greatly thickened, the true walls being seen as a double dark median line. A series of overlapping cystiphragms is present in practically every tube, and horizontal diaphragms in moderate number cross from the backs of the cystiphragms to the opposite wall. The cystiphragms are usually of the concave but are occasionally on the convex side of the wall. In fig. 12, Pl. X. [of the above paper], a very large zooecium is shown at *a* and a splitting of the interzooecial wall at *b*, which may very well produce on the surface the effect of lines radiating from the apices of the monticules, causing them to appear stellate."—Cumings, *loc. cit.*

As will be seen under the discussion of *Dekayia frondosa* (q. v.) this is not the *Monticulipora frondosa* of d'Orbigny, as the writer thought at the time the above description was written. This fact only goes to show the utter impossibility of making a satisfactory identification of species of Trepostomata on the basis of external characters alone.

Homotrypa frondosa is very close to *H. flabellaris* and ought to stand as a variety of that well known species. Its well developed monticules and almost total absence of acanthopores are sufficient to distinguish it.

1.34B4-5.

HOMOTRYPA FLABELLARIS var. SPINIFERA Bassler.

Plate XVIII, fig. 2.

Homotrypa flabellaris var. *spinifera* Bassler, 1903, Proc. U. S. National Museum, XXVI, p. 580, pl. xxi, figs. 11-15.

This variety agrees with *H. flabellaris* in all essential characters save one, namely, that at rather regular intervals among the zooecia very large acanthopores are developed, the place of a zooecium often being occupied by one. This gives the otherwise smooth surface of the zoarium a spiny aspect. The acanthopores often originate in the axial region and proceed to the surface irrespective of the course of the zooecia."—Bassler, *loc. cit.*

1.41A6, 8, E1, 3, 6, 7, D3.

HOMOTRYPA NICKLESI Bassler.

Plate XVIII, figs. 6, 6a; Plate XXX, fig. 4.

Homotrypa nicklesi Bassler, 1903, Proc. U. S. National Museum, XXVI, p. 586, pl. xxii, figs. 4-7.

"In growth and external features this species resembles *H. communis,* but is readily distinguished by the less robust growth and the tendency to branch more frequently. The internal structure further distinguishes the two, since *H. nicklesi* is of the *H. curvata* group, while *H. communis* is of the group to which it gives its name. Surface smooth, with regularly disposed maculae of larger cells and mesopores. Zooecia with moderately thick walls, about nine in 2 mm. Acanthopores not present at the surface and usually also absent in sections. Diaphragms absent in the axial region, appearing in the transitional zone to the peripheral region and increasing in number toward the surface. Cystiphragms in a moderately crowded series in the peripheral region.

The well-developed diaphragms and cystiphragms and the almost complete absence of acanthopores, together with the growth and surface features, characterize this species. The specific name is in honor of Mr. John M. Nickles, who collected the species."—Bassler, *loc. cit.*

1.41E3.

HOMOTRYPA NITIDA Bassler.

Plate XVIII, figs. 5, 5a; Plate XXX, figs. 5, 5a.

Homotrypa nitida Bassler, 1903, Proc. U. S. National Museum, XXVI, p. 586, pl. xxv, figs. 5-8; pl. xx, fig. 15.

"Zoarium of small frequently branching, more or less cylindrical stems, usually 4 or 5 mm. in diameter. Surface smooth. Maculae large, composed of zooecia, which are often twice the diameter of the ordinary cells; 10 zooecia in 2 mm. Diaphragms few in the axial region, not very abundant in the peripheral region, where also the cystiphragms are large but not abundant. Acanthopores small, few, usually wanting.

"This species is closely related to *H. gelasinosa,* and may be only a variety of that form. The larger maculae and acanthopores and flabellate growth of the latter are deemed of sufficient value to distinguish it from *H. nitida.*"—Bassler, *loc. cit.*

Reported by Bassler from the Richmond formation, near Osgood, Indiana.

HOMOTRYPA OBLIQUA Ulrich.

Plate XIX, figs. 1-1b; Plate XXX, fig. 6.

Homotrypa obliqua Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., V, p. 243, pl. x, figs. 6, 6b.

"Zoarium ramose, branches cylindrical or compressed, from two to four-tenths of an inch in thickness. Typically the surface is covered by rather prominent and closely arranged monticules, the summits of which carry cells with thicker walls than the average. The monticules are not a constant feature in this species, examples with an almost entirely smooth surface being of frequent occurrence. The ordinary cells are polygonal, have rather thin walls, more or less oblique apertures, and a diameter varying from 1/120th to 1/110th of an inch. In the axial region the tubes are thin-walled, polygonal, subequal, without diaphragms, and almost vertical in direction, as they pass into the peripheral region, bending outward very gradually, their walls become thickened, and a moderate number of both straight and cystoid diaphragms are developed. The tubes appear to be of one kind only. Tangential sections show, often in a very distinct manner, the connecting foramina, and a structure of the tube walls precisely similar to that of *H. curvata.* The spiniform tubuli are small, and more or less numerous, but never conspicuous, and developed at the angles of junction of the cells, or in the substance of their walls.

"In its typical form this species may be readily distinguished from the preceding by its tuberculated surface. The more nearly smooth examples can be distinguished by the thicker cell walls, stellate maculae, and the much more flattened branches of *H. curvata.*"—Ulrich, *loc. cit.*

1.33A3....1.34B1-3, C14....1.38Ba-h.

HOMOTRYPA RAMULOSA Bassler.

Plate XIX, figs. 2-2b; Plate XXX, fig. 8.

Homotrypa ramulosa Bassler, 1903, Proc. U. S. National Museum, XXVI, p. 585, pl. xxv, figs. 1-4.

"Zoarium consisting of subcylindrical or somewhat compressed stems from which branches proceed frequently and without regularity; an average example is 8 cm. high and 8 to 12 mm. in thickness. Surface with low broad monticules, the center of each usually occupied by a star-like cluster composed of mesopores only and surrounded by cells slightly larger than the average. Apertures polygonal, direct, ten to eleven in 2 mm. Mesopores restricted almost entirely to the clusters. Acanthopores few and rather small, although now and then one of large size may be present, and these in vertical sections have thin transverse partitions. Diaphragms are developed in the zooecial tubes as the peripheral region is approached and are quite numerous near the surface. Cystiphragms of rather small size line the tubes as usual in the peripheral region; in a tangential section they appear much less curved than is generally the case, sometimes showing as a straight line across the cell cavity.

"The small cells and much branched growth externally, and the strong development of both diaphragms and cystiphragms in the peripheral region, are characteristics which readily distinguish this from other Richmond species."—Bassler, *loc. cit.*

1.34A11, 12....1.41A8, B1, E4....1.12E3.

HOMOTRYPA WORTHENI (James).

Plate XIX, figs. 3-3c; Plate XXX, fig. 9.

Monticulipora (*Monotrypa*) *wortheni,* James, 1882, The Paleontologist, No. 6, p. 50. Pl. I, fig. 2.

"Corallum consisting of cylindrical or flattened stems, from one to two lines in diameter, branching at irregular intervals, sometimes dichotomously; surface occupied by small, prominent monticules, arranged in alternating, longitudinal rows, about one line apart; calices subcircular or angular, from 10 to 12 in the space of one line. Slopes of monticules occupied by calices of the ordinary size or slightly larger, but the apices are, apparently, solid. No interstitial tubuli observed in the specimens examined. Margins of apertures of corallites tolerably thick.

"In a longitudinal section of the *interior* the tube walls are very thin, simple and somewhat wavy or tortuous, with a gentle outward inclination each way from the axial part, but near the surface the outward curve is more rapid, and the walls much thickened, showing a duplex character; the tubes opening at the surface more or less obliquely. No tabulae observed in the central region, and but few in the outer part of the thickened walls. In *tangential* section the cells are suboval, or subcircular, thick walled, and each surrounded by a distinct open space; faint indications of small 'spiniform' corallites distributed, sparsely, at the angles of some of the larger tubes. A *transverse* section shows the very thin walls of the corallites in the central region, of various angular shapes, and the sudden thickening of the walls, and duplex character, and few direct, horizontal tabulae near the surface.

"*Externally,* at first sight, this species resembles *M. ramosa,* D'Orbigny var. *dalei,* E. & H., but when examined under a magnifier the marked difference is apparent. *Internally,* they differ widely."—James, *loc. cit.*

This description indicates fairly well the chief external characteristics of this species of *Homotrypa,* but fails to bring out the really important internal characters. For the latter, I quote the recent excellent description by Bassler in his paper on the genus *Homotrypa:*

"In tangential sections the striking characters are the thick walls, numerous acanthopores, and wide intermural space with its dotted structure. Here also communication pores are well shown. Vertical sections show that the walls in the axial region are thin and rather straight, but become greatly thickened in the peripheral, where a series of cystiphragms larger than usual is developed with a corresponding number of diaphragms.

"The sharply tuberculated branches of this * * * species readily distinguish it from associated forms."

1.34A13a, 16....1.41A7, 8, 10a, D3, E1, 2, 3, 6.

This species is abundant in the Whitewater division of the Richmond formation, which it characterizes. It is found abundantly in the "upper fossil bed" on the west fork of Cedar Creek at Versailles, in association with other Whitewater species. This bed, it will be remembered, is *above* the shale bed and the coral reefs that mark the base of the Saluda.

HOMOTRYPA WORTHENI var. PROMINENS Bassler.

Plate XXX, fig. 10.

Homotrypa wortheni var. *prominens* Bassler, 1903, Proc. U. S. National Museum, XXVI, p. 584, pl. xxiv, figs. 15, 16.

"The very prominent, elongated monticules will distinguish this variety. The zoarium also differs from the cylindrical branches of *H. wortheni* by forming broader, subcompressed to flat fronds. Internally the variety and species are practically identical."—Bassler, *loc. cit.*

This form is reported by Bassler as abundant in the highest beds of the Richmond along Elkhorn Creek near Richmond, Indiana. I have also found it at the same place and in the top of the Tanner's Creek section.

Elkhorn.

HOMOTRYPELLA cf. RUSTICA Ulrich.

Plate XIX, figs. 5, 5a; Plate XXI, fig. 4; Plate XXX, fig. 11.

Homotrypella rustica Ulrich, 1893, Geol. Nat. Hist. Surv. Minnesota, III, pt. I, p. 234, pl. xviii, figs. 31-33.

"Zoarium irregularly ramose, branches 5 to 10 mm. in diameter. Low swellings on the surface, scarcely to be called monticules, occasionally present. Surface very rough under a hand lens, the acanthopores being strong and numerous, though not materially inflecting the zooecial walls. Zooecial apertures rounded, about eleven in 3 mm. Mesopores abundant, though but rarely separating the zooecia completely, of unequal sizes, rounded at the surface.

"*Internal characters:* In tangential sections, showing the characters immediately beneath the surface, the zooecia are rounded, with only moderately thick walls, the mesopores sharply defined, subangular, of unequal sizes, and averaging three or four to each zooecium, the acanthopores strong, perhaps two to each zooecium, and situated chiefly in the zooecial walls, which they occasionally only cause to bend inwardly. At a deeper level the walls are thinner, the acanthopores smaller, and the mesopores larger. At both levels the zooecia almost uniformly exhibit the cut edges of cystiphragms. In vertical sections the most striking feature of the species is the abundant tabulation of all the tubes. Diaphragms occur all through the axial region, and both the mesopores and acanthopores began earlier than usual. The outward curving of the tubes also is unusually gradual. The diaphragms in the two sets of tubes are subequally distributed, and it is often difficult to discriminate between them when the curved edges of the cystiphragms are not shown. At about the middle of the curve nine or ten diaphragms occur in 1 mm.; nearer the surface they are a little closer, while more toward the center of the branch they are further apart. The cystiphragms are unusually superficial in this species, forming crowded series almost to the mouths of the zooecia.

"The species is distinguished from *H. granulifera* and *H. mundula* by the greater number and open character of the mesopores; from *H. multiporata* by its larger zooecia, fewer and more unequal mesopores, and more crowded as well as different tabulation of the tubes. *H. instabilis* has thicker walls, and is quite different in other respects."—Ulrich, *loc. cit.*

The above description applies to a specimen from Minnesota. In his citation of localities Ulrich mentions the fact that he had applied in manuscript the name *rustica* to a common species occurring in the upper beds of the Cincinnati group in the Cincinnati region. The latter is, I take it, the species which I have collected in considerable numbers in the Whitewater division at Richmond, and about Laurel and Versailles, Indiana. The Indiana specimens are altogether more robust than the Minnesota specimen, and the acanthopores are more numerous, and commonly indent the zooecia, so that at the surface the latter present an appearance very much like what is commonly seen in species of *Atactoporella,* to which genus the writer at first supposed the specimens to belong, until the zoarial characters were more fully understood. The species is far too common to have been overlooked by as expert a collector as Mr. Ulrich, and I consequently entertain no doubt but that I am right in referring the specimens in my collection to the above species. No other species with which it is associated can possibly be confused with it, and further comparison is therefore unnecessary.

1.41E2, 3, 4, 5, 6, 7, A5, 6, D1, 2, 3....1.60H11, and in addition at several localities, associated with *Rhynchotrema dentata,* in the vicinity of Laurel, Indiana, and in the "upper fossil bed" in the section on the west fork of Cedar Creek, north of Versailles (No. 11 of the section).

LEPTOTRYPA CALCEOLA (Miller and Dyer).

Plate XX, figs. 1-1c.

Monticulipora calceolus Miller and Dyer, 1878, Jour. Cin. Soc., Nat. Hist., I, p. 26, pl. i, figs. 11, 11a.

"This little coral, so far as our observation has extended, is always found in the shape of a little wooden shoe. For the purpose of describing it, we will regard the upper end, as shown in the figure, as the anterior, and the lower as the posterior; and from the assistance furnished by a longitudinal microscopic section, kindly prepared for our use by Dr. J. H. Hunt, we are enabled, as we think, to define the manner of its growth.

"We may suppose a single embryo from an egg, or in the form of a ciliated anamalcule, floating free in the waters of an ocean; then becoming a simple bryozoon, and secreting a single, calcareous, cup-shaped cell, and forming for itself an epithecal covering for its base. It now increases by gemmiparous reproduction, each little bryozoon attaching itself by a point to the parental extension of the epithecal covering, and gradually enlarging its cup-shaped cell by the side of its parent. We now have the commencement of this coral at the upper side of the anterior end. This method of growth at once forms a concave base, which is prolonged into a circular expanding cup. The bryozoa upon the lower side, instead of attaching themselves by a mere point to the epithecal covering now secrete this material for part of the side of each cup, and thus form each individual cell into a little horn-shaped cavity, upon the concave side of which other bryozoa attach. The result of this method of growth is the extension of the expanding cup-shaped basal cavity, formed by the multiplicity of bryozoa, into a circular-horn shaped cavity, with the mouth at the posterior end as shown in the illustration.

"The epitheca is thin and concentrically wrinkled. The corallites are subequal in size, the larger ones collected into groups. They are thin walled and arranged in diagonal lines, somewhat like the arrangement in *Monticulipora quadrata*. The calices are hexagonal, polygonal, round or otherwise variable in form (though the hexagonal ones seem to be the most common), and measure from 8 to 12 in the space of a line. The larger calices are sometimes gathered into tubercles, while other specimens are free from these elevations. Specimens vary from 1-5th to 3-5ths of an inch in length, and from 1-6th to 1-3d of an inch in width, and appear to have always been free from attachment to other substances.

"This species we separate from all others by its form and method of growth. We regard it as belonging to the class bryozoa, because regular calcareous partitions or tabulae are not found in the microscopic sections, and because we believe its method of growth was gemmiparous, and that each animal resided in a separate cell. It may be that the genus *Monticulipora* belongs to the true polyp corals, and if so, it may be that our species should be arranged in a new genus, but we prefer to leave it in this genus rather than attempt to found another without special study of all the Silurian forms.

"This species is not uncommon on Mount Auburn, at an elevation of about 400 feet above low-water mark at Cincinnati."—Miller and Dyer, *loc. cit.*

Miller and Dyer were mistaken in their statement that this species does not possess tabulae, as is shown by Nicholson's sections reproduced herewith. As to the manner of growth, it seems to be the general opinion of those who have studied numbers of specimens of the species that in spite of its suggestive shape, it did not grow on foreign bodies, and that the basal membrane is a true epitheca.

1.34C13 (?).

LEPTOTRYPA CLAVÁCOIDEA (James).

Plate XX, figs. 3-3c.

Chaetetes clavacoideus James, Catalogue of the Lower Silurian fossils of the Cincinnati group, 1875, p. 1.

"Corallum clavate, cylindrical; in some cases expanding upwards, others tapering, and others of nearly uniform size the whole length; surface, generally, without tubercles; calices polygonal and from eight to twelve in the space of a line, sometimes with groups of larger size than the average; walls of corallites thin.

"The examples of this species so far examined are built upon the tapering ends of very small orthocera; cut transverse and vertical sections show the corallites radiating at right angles with the longer axis of the corallum and arching over at the apex. In some cases the central object has decayed, leaving the corallum hollow or filled with clay. Diameter of different specimens from four to eight lines; length from one to two inches, or more. I have one specimen showing small tubercles over the surface with calices extending uniformly over the tubercles."—James, *loc. cit.*

The internal structure of this species is thus described by Nicholson (Genus Monticulipora, p. 182):

"Tangential sections show that the corallites are uniformly thin-walled and polygonal, slight nodes being often formed at the angles of junction of contiguous tubes. Their size is very uniform, though groups of corallites of slightly larger dimensions than the rest are certainly occasionally developed. In any case, there exists no series of small interstitial tubes. Vertical sections show that there is no difference whatever in structure between any one set of corallites and any other. In none are the walls thickened towards the surface, but they are uniformly thin throughout, and are often slightly wavy. The course of the tubes is straight, there being no curvature near their bases, and they increase in number in passing outwards by the interpolation of fresh tubes. In a great number of the tubes no tabulae exist at all; but an occasional tabula is sometimes developed near the mouth of the tube, or at some depth below the surface."

1.34C14a, B1-3.

LEPTOTRYPA DISCOIDEA (Nicholson).

Plate XX, figs. 2-2f.

Chaetetes discoideus Nicholson, 1874, Quar. Jour. Geol. Soc. London, XXX, p. 511, pl. xxx, figs. 4-4d. (Named, but not descibed or figured, by James, 1871, Cat. Foss. Cin. Group.)

"Corallum free, discoid, plano-convex, sharp-edged, from 5 to 8 lines in diameter, and about 1 line in greatest thickness. Under surface concave, covered with a very thin, smooth, and not regularly striated epitheca, which usually exhibits two or three concentric wrinkles. In general the epitheca is so delicate as to reveal clearly through its substance the bases of the superjacent corallites. Upper surface gently convex, not exhibiting any tubercles or elevations of any kind. Corallites subequal; calices with moderately thin walls, polygonal, from eight to ten in the space of one line. No groups of larger-sized corallites, nor any very minute intermediate tubuli.

"I do not feel altogether certain that this form is distinct from the young of *Chaetetes petropolitanus*. It is, however, a common form, and is very constant in its dimensions. Apart from its discoidal plano-convex form, it is distinguished by its great tenuity (comparatively speaking), the sharp thin edges of the disk, the absence of surface-tuberosities or groups of large-sized corallites, and the extreme thinness of the epitheca, which is transparent and is not regularly striated concentrically. But for one character, I should have been disposed to have placed this species under

Chaetetes (*Nebulipora*) *lens*, McCoy; and that is the absence in our examples of any groups of large-sized corallites, whereas their presence is a marked feature in the latter. The under side of *C. discoideus* resembles *Lichenalia calycula*, James; but it may be distinguished by the absence of radiating striae, and by other characters as well. The above description of the species is drawn from type specimens forwarded to me by Mr. U. P. James."—Nicholson, *loc. cit.*

Comparison with *Chetetes petropolitanus* is now unnecessary, owing to the fact that that name is known to stand for so much confusion in the matter of identifications by various authors as to be practically meaningless. The external characters of the present species are very well described above, and the internal characters are sufficiently well illustrated in the plate accompanying this report (after Nicholson, Genus Monticulipora) to make further description unnecessary.

1.34C14a. (?)

MONOTRYPELLA AEQUALIS Ulrich.

Plate XX, figs. 4-4c.

Monotrypella aequalis Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., V. p. 247, pl. xi, figs. 3-3a.

"Zoarium somewhat irregularly ramose, the branches cylindrical or compressed, and from two to five-tenths of an inch in diameter. Surface, often, smooth, usually however exhibiting low, rounded monticules, which are occupied by clusters of large cells, the diameter of which does not exceed 1/55th of an inch. The ordinary cells are thin-walled and polygonal in shape, with an average diameter of about 1/90th of an inch. Occasionally a few cell-apertures, having a slightly smaller diameter than the ordinary cells, may be observed among the large cells occupying the monticules. The latter are arranged at distances apart of about .15 inch, measuring from center to center.

"In tangential sections the tubes are regularly polygonal, with moderately thickened walls, and in contact with each other on all sides. The line of demarkation between contiguous tubes is sometimes clear and distinct, while at other times it is scarcely detectable. The walls are occasionally thickened at the angles of junction of the tubes, giving somewhat the appearance of spiniform tubuli. It is quite evident though that these nodal thickenings are not of this nature.

"Longitudinal sections show that the tabulation of the larger tubes composing the clusters observed at the surface, is not different from that of the ordinary tubes, the diaphragms in all the tubes being straight and usually horizontal, in the axial region either wanting or remote, and in the peripheral portion of the branch, closely set, and often crowded. These sections also show that true interstitial tubes are entirely absent.

"In transverse sections the tubes in the axial region are subequal and polygonal, with very thin walls, while around the margin, where the tubes are cut longitudinally, they have the same appearance as in the peripheral portion of a vertical section.

"This species is nearly allied to the European *M. pulchella*, E. and H., a Wenlock Limestone species, from which it differs principally in having more numerous diaphragms, and the line of demarkation between adjoining tubes less strongly marked."—Ulrich, *loc. cit.*

The anomalous or exceptional nature of this species, the genotype of *Monotrypella* is mentioned under the diagnosis of that genus. The specimen of which I give a tangential section seems to be devoid of acanthopores and to possess the internal characters of the present species. My specimen also comes from about the same general horizon. Possibly some of the specimens referred by me to this species will be found to contain acanthopores and consequently to be referable to some other species.

1.34Co, 5, 6, 8.

MONTICULIPORA EPIDERMATA Ulrich and Bassler.

Plate XX, figs. 5-5c; Plate XXX, fig. 12.

Monticulipora epidermata Ulrich and Bassler, 1904, Smithsonian Miscellaneous Collections, XLVII, p. 17. (Not figured.)

"This species is so abundant and characteristic of the middle Richmond of Ohio and Indiana and also so easily recognized by the external characters which are clearly shown in Quenstedt's figures (loc. cit.) that we think it desirable to describe its internal characters. Unfortunately these cannot be illustrated at this time. As the species is distinct from *M. mammulata* and marks a different stratigraphic horizon, the above new name is proposed for its future designation.

"*M. epidermata* is readily distinguished from *M. mammulata*, with which it has generally been identified by collectors, by differences in their respective methods of growth. Both are massive species [sic], but the Richmond form grows into large flat or irregularly hemispherical masses, sometimes as much as 300 mm. in width and 150 mm. in height, and always, in the hundreds of specimens seen by us, having a more or less flattened though strongly undulated epithecated base. *M. mammulata* never attains such large proportions, and its masses are irregularly lobate or more or less rounded, instead of depressed hemispheric. Another distinction lies in the mesopores, which are more numerous in *M. epidermata.* The following description sums up the characters of this new species.

"Zoarium of broad, thick, lamellate expansions or masses, sometimes reaching the dimensions mentioned above. Base always lined with an epitheca and more or less flattened and concentrically wrinkled. Surface with rather closely arranged maculae, which sometimes form sharp tubercles and again rounded monticules. Zooecia small, rather thin-walled, angular where mesopores are less common and rounded where they are abundant; 10 to 11 zooecia in 2 mm.

"In tangential sections the zooecial walls exhibit the usual granulose structure characteristic of the genus. Acanthopores small, rather inconspicuous, appearing more like granules. The mesopores are small, 2 to 3 usually to each zooecium. Vertical sections show the mesopores tabulated with straight diaphragms one-half to one tube-diameter apart. Cystiphragms line the zooecial tubes in both regions and are accompanied by a corresponding number of diaphragms."—Ulrich and Bassler, *loc. cit.*

In July, 1907, the writer received Tome II, Fascicule II of the Annales de Paleontologie, in which on page 18 (90) are figured thin sections of the type of *Monticulipora filiasa* d'Orbigny, which may prove to be the above described species. The sections figured in the Annales are certainly to my mind much more suggestive of *M. epidermata* than of *Prasopora falesi* (James), with which the writer in the Annales, A. Thevinin, seems to think it should be identified. His figures leave something to be desired, inasmuch as it is not possible from them to determine whether the zooecial walls have the granulose structure of the genus *Monticulipora* or the well defined acanthopores of *Prasopora.* This question will be further discussed under *Amplexopora filiasa.*

This well-defined species of *Monticulipora* is very abundant in the Whitewater division of the Richmond, which might very well be called the *M. epidermata* zone. I have, however, found it sparingly outside of Richmond, in Indiana. It occurs at Weisburg (one specimen from the base of the Whitewater) and at Versailles (in the Whitewater ?) and more abundantly about Laurel (also in the Whitewater ?). These specimens from southern localities are all small, but their internal structure leaves no doubt of their complete identity with the above species. They afford very interesting evidence bearing on the stratigraphy of the upper members of the Richmond series, as is pointed out elsewhere in this report.

1.34A19-21....1.41A6, 7, 8, D3, E2, 3, 4, 5, 6, 7....1.60H11, and at the localities named above.

MONTICULIPORA MAMMULATA d'Orbigny.

Plate XXI, figs. 1-1c; Plate XXXI, figs. 1, 1a.

Monticulipora mammulata d'Orbigny, 1850, Prodrome de Paleontologie, I, p. 25.

"*374. mammulata, d'Orb., 1848. *Ceriopora mammulata,* Readle (envoye sous ce nom). Espèce en lame dont les monticules sônt allongés. Etats-Unis, Cincinnati, Ohio (Blue Lime)."—d'Orbigny, *loc. cit.*

Since the above description by d'Orbigny might apply to any one of a large number of frondescent bryozoa of the Cincinnati group, I quote here the very full description of this form given by Ulrich in the Journal of the Cincinnati Society of Natural History, vol. V, p. 234 (1882).

"Zoarium occurring as irregularly lobate masses, often of considerable size, that usually tend to throw off compressed processes, which in many specimens become frondescent; or, it may take the form of extended and undulated, often palmate, expansions, varying in thickness from 2 inch [.2 inch?] to .4 or .5 inch. Surface covered with numerous prominent, typically conical, often elongated monticules. The last feature is produced by the fusion of two or three of them. They are quite regularly arranged in series, in which sometimes five, usually, however, six, may be counted in the space of .5 inch. Cells polygonal, thin-walled, subequal, from 1/120th to 1/130th inch in diameter, those occupying the summits of the monticules being scarcely larger than those in the intervening spaces. Smaller or interstitial (?) cells may occasionally be observed, more frequently on the monticules where they are wedged in between the ordinary cells. When the cell-walls are perfectly preserved, they show the spiniform tubuli as minute granules.

"Longitudinal sections show conclusively that the zoarium is divided into successive 'immature' and 'mature' zones. In the first, the cell-walls are very thin, and the tubes are almost invariably crossed only by straight or somewhat obliquely directed diaphragms, at distances apart of about one tube-diameter. This zone is very narrow, and soon a 'mature' zone is entered, when the walls are slightly thickened, the diaphragms more crowded, and the greater number of the ordinary tubes have along one or both sides a series of cystoid diaphragms; now there is also developed a limited number of much smaller tubes, which differ, at least near their point of origin, from the ordinary tubes in having more closely arranged diaphragms. In consequence, they have there the usual appearance of interstitial tubes. This character they may retain throughout the zone, but as they enter the next succeeding 'immature' zone, their character has changed to that of an ordinary tube. The spiniform tubuli can not often be detected in a section of this kind.

"A tangential or rather transverse section may present three different phases, according as it may pass either through the 'immature' (1st), or fully 'mature' (3d) stage; or (the 2d) if it cut the tubes just as they enter into the last stage. In the first, the tubes have excessively thin walls, and are always apparently of one kind only, and thoroughly simple. In the second the walls are still very thin, and the appearance is like that of the preceding stage, excepting that we now observe quite a large number of smaller cells, wedged in among the ordinary tubes. In the third stage, the walls have become appreciably thickened, the smaller tubes, noticed in the second stage, have all, excepting a few among the cells occupying the monticules, changed their character, so that they can no longer be distinguished from the ordinary cells. This stage is further marked by the development of a large number of very small spiniform tubuli. Of the different phases above described, a single section may show only one, or, if large, all three.

"The normal mode of growth of *M. mammulata* is unquestionably the same as in other massive or discoidal forms of the *Monticuliporidae*. The frondescent examples of the species have an entirely different structure from such truly frondescent forms as *Heterotrypa frondosa*, D'Orb. (not Nicholson), or *Homotrypa dawsoni* (*M.* (*Heterotrypa*) *dawsoni*, Nicholson). In the latter, as well as in all the ramose species, the frond or branch is divided into an axial and a peripheral region, and the structure of the tubes in these two regions, as is shown on page 125 of this JOUR-

NAL, is widely different. No such difference can be shown to exist between the axial and peripheral portions of any frondescent specimen of *M. mammulata*. What we do find is precisely similar to the structure and mode of growth observed in the massive or lobate examples of the species, viz.: the 'immature' and 'mature' zones (respectively equivalent to the axial and peripheral regions of the ramose and truly frondescent forms), are reproduced at successive levels, one above the other, and it can not be said that the fronds are ever divided into dissimilar axial and peripheral regions.

"Dr. Nicholson, in his description of this species, under the name of *Monticulipora* (*Peronopora*) *molesta* (see syn. above), fails to recognize several important characters, and besides gives an incorrect measurement. He gives the diameter of the cells as from 1/80th to 1/90th inch. I have not seen any specimen of this species in which the ordinary cells had a greater diameter than 1/120th of an inch, nor do the cells in his tangential sections, as figured by him, appear to have a greater diameter. At any rate, it is certain that the cells in that figure are not so large as those figured of some other species, which, according to the measurements given by him, ought to be smaller. He did not recognize the nature of the interstitial (?) tubes, but regards them as true interstitial tubes, and of the same nature as in *Peronopora decipiens*, Rominger, and *Heterotrypa frondosa*, D'Orb.; but as I have above stated, this is not their true nature. His tangential section cuts the tubes transversely through the 2d phase mentioned by me in my description of the tangential section of this species, and because it shows a larger number of the intercalated small tubes, I believe that it was prepared from one of the frondescent examples, tangential sections of which always present a greater number of the small tubes than do transverse sections of the massive specimens. This I consider due to the fact that in the frondescent forms the divergence of the tubes is much greater than in the massive examples, making it necessary that the young cells be more numerously and rapidly developed in the former than in the latter.

"I would suggest and recommend that Nicholson's name *molesta* be retained as a varietal designation for the frondescent examples of this species, as some title, by means of which it may be distinguished from the massive and lobate examples, is, if not really necessary, at least desirable."—Ulrich, *loc. cit.*

All possible doubts as to whether this form is really the *Monticulipora mammulata* of d'Orbigny have been finally removed by the publication in the Annales de Paleontologie of a photograph of a thin section of the type in the collection of d'Orbigny (loc. cit., Tome I, pl. ix, fig. 1). The type as figured on the preceding plate, fig. 10, of that work, is the ramose form to which, according to Ulrich's suggestion, we should apply the varietal name *molesta.* In view of this last fact it would seem to be best to either discard the name *molesta* or apply it rather to the massive form. In the present report I have not distinguished between the two forms, so that both the frondescent and massive forms are included in the following citation of localities.

1.33A3....1.34B1-3....1.38Ba-h....1.34C14, and generally in the upper part of the *Platystrophia* zone.

MONTICULIPORA PARASITICA Ulrich.

Plate XXI, figs. 2-2b; Plate XXXI, fig. 2.

Monticulipora parasitica Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., V, p. 238, pl. x, figs. 3, 3a.

"Zoarium usually attached to *Streptelasma* (*corniculum?*); the layers according to age, may vary in thickness from excessively thin to nearly .1 inch. The surface of the *Streptelasma* often carries a number of these parasitic patches, which, as they increase their diameter by lateral development, at last join each other. The line of junction is always marked by a slightly elevated, calcareous ridge. Not infrequently one proves the strongest, and gradually grows over the other colonies. Regularly arranged in decussating aeries, and at distances apart of about .1 inch, the surface presents small conical monticules, the summits of which usually appear to be solid, as they are occupied by minute cells; while on their slopes they carry the apertures of slightly larger cells than the average. The largest of these have a diameter of 1/85th of an inch. The spaces between the monticules are flat, and are occupied by the polygonal, and moderately thin-walled, ordinary cells, their diameter varying from 1/110th to 1/100th of an inch. Interstitial cells (if they can be so called) are developed only in the monticules, the summits of which are usually occupied by their apertures.

"Tangential sections show the tubes to be polygonal and thin-walled. Their angles of junction are usually thickened, and the small space thus formed incloses, almost invariably, a minute lucid spot. They represent in all probability very small spiniform tubuli. The appearance of the best section examined leaves me little room to doubt that the tube walls were really pierced by numerous and excessively minute foramina. Where these are not clearly shown, the wall has a peculiar granular appearance. Within the visceral chamber of each of the ordinary cells, the intersected cystoid diaphragms are shown. In a large number the cut edges of the cystoid diaphragm give the appearance of a secondary oval cell, within the polygonal walls of the tubes. Between the groups of slightly larger cells, a few thick-walled minute tubes (interstitial) may generally be observed.

"Longitudinal sections show that all the matured tubes have one or both sides lined by a series of cystoid diaphragms, while the space between the double series, or single series and opposite wall, is crossed by straight diaphragms, which are placed at distances apart of about one-third of a tube-diameter.

"I know of no associated species with which *M. parasitica* might for a moment be confounded. It is probably more nearly allied to the *M. cincinnatiensis,* Nicholson, than to any other species described from the Cincinnati group. The larger, more closely arranged, and much more prominent monticules of that species, constitute a point of difference so decided and readily apparent, that examples of the two may be distinguished at a glance."—Ulrich, *loc. cit.*

The specimen figured by me may not belong to this species, in as much as it has well developed mesopores. Its habit and superficial appearance are, however, the same as those of Ulrich's species. In its internal characters it is more like *M. cincinnatiensis* James sp. The specimen figured is from the base of the Liberty formation, near Weisburg, Indiana.

1.34A12....1.41A7, D3, E4.

NICHOLSONELLA VAUPELI Ulrich.

Plate XXI, figs. 3-3c; Plate XXXI, fig. 3.

Heterotrypa vaupeli Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., vol. VI, p. 85, pl. I, figs. 2-2b.

"Zoarium very irregular in its growth, forming twisted, and always more or less inosculated loose masses, several inches in diameter, consisting of convoluted fronds, varying in thickness from .15 inch to .3 inch. This irregularity of growth, which is very characteristic of the species, is caused by the frequent elevation of the face of a frond into a secondary frondescent growth, which eventually anastomoses with other similar divisions of the zoarium. The surface is sometimes nearly smooth, but usually is studded with small, rounded or conical monticules, the summits of which are subsolid, each being occupied by a small 'macula' of interstitial cells. The arrangement of the monticules and maculae, in conformity with that of the cells, is very regular. Measuring from center to center, seven may be counted in the space of .5 inch. The cell-apertures are circular, and regularly arranged in decussating series, which are more or less curved around the monticules. One or two rows of cells immediately surrounding each of the small 'maculae,' are conspicuously larger than the ordinary cells, their *apertures* having a diameter varying from 1-150th to 1-100th of an inch, while the diameter of the cell-apertures in the interspaces is about 1-200th of an inch. Measuring along one of the series, twelve cells may be counted in the length of .1 inch. On an example of this species the cell-interspaces are comparatively thick, and may show, according to the stage of development and state of preservation, either all, or one or two, of three different appearances. In the first (probably due to attrition), the interspaces are smooth and apparently solid. In the second, they carry numerous small pits, representing the orifices of the interstitial cells. In the third the apertures of the interstitial cells are obscured by an exceedingly large number of small spines or granules. The last phase doubtlessly represents the zoarium in its perfect and fully matured stage.

"Tangential sections, according to the depth at which the zoarium is divided, may show one or both of two distinct phases. In the first (the one usually obtained on account of the unusual brevity of the 'matured' portion of the tubes) the cells have moderately thin walls, are subangular or nearly circular, and in contact at limited points, the intervening spaces being occupied by smaller and angular interstitial cells. The spiniform tubuli, if any at all can be detected, are small and inconspicuous. In the second phase, which is obtained by cutting the cells of a fully matured specimen just below the surface, the interstitial cells appear to be almost entirely suppressed by the remarkably great developm[illegible] of spiniform tubuli, which are ranged in one or two closely-crowded series around the cell cavities. Fig. 2*a*, Pl. I [of Ulrich's paper], represents a portion of a section somewhat intermediate between the two phases described.

"Longitudinal sections show that the tubes in the axial region have very thin and somewhat flexuous walls; that they approach the surface gradually, and that the peripheral or 'mature' belt on each side of the frond is very narrow, and, as they enter the latter region, that their walls are thickened. In the proper zooecial tubes the diaphragms are usually wanting throughout the axial region, and they are never numerous even in the peripheral portion of the zoarium. In the interstitial tubes they are numerous, and generally very thick.

"In its internal structure this species is very remarkable, and differs widely from *H. frondosa.* One peculiarity in its structure I can as yet not fully understand. That the interstitial cells are actually suppressed as the zoarium becomes fully matured, I must doubt. I would rather believe that the spinform tubuli, which are developed in the spaces that in the earlier stages of the growth of the zoarium were occupied by interstitial cells, have sprung from the surface of diaphragms which covered the interstitial cells. I am upheld in this belief by finding, what appears to me to be, corroborative evidence: namely, on many diaphragms of the interstitial tubes I can detect one or two rather faintly delineated, hollow processes, extending upward from the diaphragm toward the one next succeeding. If this is not deceptive, then we have a curious analogy with such more recent bryozoa as *Heteropora pelliculata,* Waters (a recent species), in which the orifices of the interstitial cells are closed by a *perforated* pellicle. The only difference (as regards this point) between such forms and *H. vaupeli* being that in the latter the surface of the pellicle or diaphragm is elevated into a hollow spine, instead of being perforated by a simple foramen.

"Examples of *H. vaupeli* are readily distinguished from all the other frondescent *Monticuliporidae* described from the Cincinnati group, by their peculiar growth, circular cell-apertures, and regular arrangement of the cells and monticules. When in a good state of preservation the most striking characteristic is found in the granular cell-interspaces."—Ulrich, *loc. cit.*

This extremely well-marked species is common at one or two levels in the Lorraine, and I have collected a form that does not seem to be specifically distinct, from the Liberty and Whitewater divisions of the Richmond series. Nothing need be added to the above very full description.

1.33A3....1.34A11....1.41D3, E3....1.38Bb and H.

PERONOPORA PAVONIA (d'Orbigny).

Plate XXII, figs. 1-1c; Plate XXXI, figs. 4, 4a.

Ptilodictya pavonia d'Orbigny, 1850, Prodrome de Paleontologie, I, p. 22 (not figured).=*Peronopora decipiens* (Rominger), Proc. Acad. Nat. Sci. Philadelphia, 1866, p. 116.

"*369. pavonia, d'Orb., 1848. Espèce en grandes lames frondescentes souvent très-épaisses à leur base. Etats-Unis, Cincinnati, Ohio."—d'Orbigny, *loc. cit.*

Under the description of *Escharopora pavonia* (E. and H.) the fact that the type of *Ptilodictya pavonia* d'Orb. is the same species as our *Peronopora decipiens* (Rominger) is pointed out. This is made certain by the recently published figures of d'Orbigny's type.* These figures, which are very excellent photographic reproductions, show the type natural size, a portion of the surface enlarged ten diameters and a section perpendicular to the surface, also enlarged ten diameters. The form and surface characters of the specimen would convince any one that it is a *peronopora*; and no possible doubt remains after a glance at the section, which shows very clearly the median lamina and closely tabulated tubes with the series of cystiphragms, characteristic of the latter genus. It is a typical *Peronopora decipiens.* If one compares these figures of d'Orbigny's type with the figures of *Chaetetes pavonia* on pl. 19 of the Monographie des Polypiers Fossiles, of Milne-Edwards and Haime, it is at once evident that they do not represent the same species, or even the same genus. Edwards and Haime's form is quite certainly our *Escharopora pavonia,* as I have pointed out under that species. Since the two are generically distinct we are at liberty to retain the name *pavonia* for both species, and this I have thought best to do. Rominger's name, *decipiens,* must, however, now be dropped, and this species of *Peronopora* be known from now on as *P. pavonia.*

Peronopora pavonia d'Orb. has as synonyms, besides *Chaetetes decipiens* Rom., *C. frondosus* of Nicholson, Quenstedt and James. The latter was due to the mistake of Nicholson in wrongly interpreting the figure of *C. frondosus* given by Edwards and Haime.*

The characters of *Peronopora pavonia* are briefly as follows:

Zoarium laminar to submassive, in large examples usually more or less convoluted. One specimen in the collection has overspread the shell of *Rafinesquina alternata* as a large expansion from which the laminar portion of the frond arises. The frond consists

*Annales de Paleontologie, Tome I, pl. IX, 1906.

*Polypiers Fossiles, 1851, pl. XIX, fig. 5.

of two laminae, each with a well-defined epitheca, grown together back to back, so that the result is a frond celluliferous on both faces, and with a median, double, thin, wavy plate. Superficially, the zooecia are for the most part rounded, and more or less surrounded by mesopores. The latter are less abundant than in the species *P. vera,* and sometimes are comparatively few. Acanthopores are fairly abundant and of medium size, and in well preserved specimens give a distinctly spinose appearance to the surface. In tangential sections the zooecia are seen to have walls of medium thickness, without granules or tubules as in *Monticulipora* and *Homotrypa.* The mesopores are angular and sometimes completely isolate the zooecia. The latter are round, and only occasionally indented by the acanthopores. In longitudinal sections the median double lamina is clearly shown, and arising from it with a very short immature region the zooecia proceed directly to the surface. The zooecia are crossed by a number of diaphragms, which are more numerous near their inner ends. Lining one (the posterior) wall of the zooecia is a series of overlapping cystiphragms. The mesopores are crossed by closely set, straight diaphragms.

This species is rather common in the Lorraine and Richmond.

5.9A41....1.33A3....1.34A1, 3, 7, 10, 11, 12, 13, 14.... 1.34C13, 14a, 14b, B1-3, 4-5....1.41A6, B1, E1, 2, 3, 4, 6.... 1.12E3, A2....1.38Ba-h.

PERONOPORA VERA (Ulrich) Nickles.

Plate XXII, figs. 2-2b; Plate XXXI, fig. 5.

Peronopora vera Ulrich, 1888, Am. Geol., II, p. 40. (Named but not described or figured.) Nickles, 1905, Kentucky Geol. Surv., Bull. No. 5, p. 46, pl. ii, fig. 1.

In as much as the original mention of this species was not accompanied by either description or figure, the species should according to the rules of nomenclature be accredited to Nickles, who has recently described and figured it in the work indicated above. The description given by Nickles is as follows:

"Zoarium consisting of bilaminar fronds, from 2 to 6 mm. thick and 10 or more cm. in height. Fronds usually somewhat undulating and occasionally producing fronds at right angles. Some specimens branch rather frequently, others rarely. Surface smooth, except for clusters of larger cells which sometimes rise a little above the general level. Apertures circular, 7 or 8 of the ordinary size in 2 mm. Apertures in the clusters considerably larger than the others. Usually a large number of circular or subangular mesopores occupy the rather wide interspaces as well as the angles of junction. Often the center of a cluster is occupied with a large number of mesopores. In some specimens few mesopores are present. Occasionally a specimen shows a large number of small acanthopores at the surface, and these may also be seen in some sections. Zooecia have a very short immature region; in the mature region they have a linear series of overlapping cystiphragms and a few diaphragms."—Nickles, *loc. cit.*

This is the common species of the Eden formation.

5.9A6, 25, 29, 31....1.34C5, 6, 7, 11....1.37E2-4....1.38A5, 9, 17, 19, 23, 31.

PETIGOPORA ASPERULA Ulrich.

Plate XXII, figs. 3-3c.

Petigopora asperula Ulrich, Jour. Cin. Soc. Nat. Hist., VI, p. 157, pl. vi, figs. 4-4c.

"Zoarium adhering to foreign objects, such as the shells of *Strophomena alternata,* etc., consisting of thin subcircular expansions, from .2 to .5 of an inch in diameter, and .03 to .08 of an inch in thickness. The surface is studded with small conical elevations, arranged in quite regular intersecting series, six or seven in the length of .4 of an inch. They are occupied by cells but slightly, if at all, larger than those of the ordinary size; it is usual, however, to find the apices occupied by one or several spiniform tubuli, often considerably larger than those in the intervening spaces. Cells small, somewhat unequal in size, from thirteen to fifteen in the length of .1 of an inch. The cell-walls are moderately thin between the angles of junction of the cells, the majority of these being occupied by very large and prominent spiniform tubuli.

"Longitudinal sections show numerous spiniform tubuli, the proper tube-walls moderately thin, and no diaphragms. The tubes are at first inclined, but soon bend upward and proceed in a direct line to open at the surface.

"In tangential sections the cell walls between the numerous spiniform tubuli are quite thin, and occasionally preserve in a faint manner the divisional line between adjoining cells. The walls are somewhat thicker, and the spiniform tubuli larger than ordinary, in the groups of cells occupying the monticules at the surface.

"This species does not resemble either *P. gregaria,* or *P.*

petechialis, very closely, differing from both these species in having distinct monticules and more conspicuous spiniform tubuli. *P. petechialis* forms very small conical zoaria, never, so far as I have been able to observe, more than .12 of an inch in diameter. Its vertical range is extended, I having collected typical specimens in the Upper Trenton rocks of Kentucky, and at nearly all elevations in the Cincinnati group. The range of *P. asperula* is much less extended, being apparently restricted to the strata between 300 and 450 feet above low water mark in the Ohio river [at Cincinnati, O.]."—Ulrich, *loc. cit.*

1.33A3....B1-3, C14a.

PETIGOPORA GREGARIA Ulrich.

Plate XXII, figs. 4-4c.

Petigopora gregaria Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 155, pl. vii, figs. 3-3c.

"Zoarium consisting of small patches usually from .1 to .3 of an inch in diameter, and .04 inch in thickness, adhering to foreign bodies. Nearly all of my specimens are attached to *Heterotrypa frondosa* D'Orb. A narrow, usually smooth, but sometimes slightly wrinkled, germinating membrane forms the outer margin, which is slightly elevated, and developed in advance of the young marginal cells. Surface without monticules, and covered uniformly by the apertures of equal sized cells, twelve or thirteen of which are ranged in a series .1 of an inch in length. Interstitial cells wanting. Spiniform tubuli may be detected on well-preserved examples by viewing the cells obliquely. In all cases, however, they project so little that they are easily overlooked.

"Longitudinal sections show that the tubes in the central portion of the zoarium are vertical, those nearer the margin being inclined at an increasing angle. Their walls, when not including one of the large spiniform tubuli, are moderately thin, and often somewhat flexuous. The epithecal membrane is very thin and generally undulated. Diaphragms appear to be wanting.

"Tangential sections show that, with the exception of an occasional young tube, the cells are of nearly uniform size and of one kind only. Between the angles of junction, the majority of which are occupied by the comparatively large spiniform tubuli, the walls are thin and appear to be amalgamated, no divisional line being visible between the walls of adjoining cells."—Ulrich, *loc. cit.*

1.33A3.

PETIGOPORA PETECHIALIS (Nicholson).

Plate XXII, figs. 5, 5a.

Chaetetes petechialis Nicholson, 1875, Pal. Ohio, II, p. 213, pl. xxii, figs. 5-5a.

"Corallum incrusting, forming small circular patches, from less than half a line to a line and a half in diameter, attached by their bases parasitically to some foreign body, and more or less strongly convex above. The surface is usually smooth, but not uncommonly exhibits a single central elevation or tubercle. The calices are subcircular and subequal, with moderately thick walls, their margins not tuberculated or granulated, entirely without minute interstitial tubuli, their size very small, from fourteen to sixteen occupying the space of one line. The corallites in the center of the mass are nearly perpendicular, but they become more or less oblique toward the margins.

"It is possible that this may be a young form of some other incrusting species, such as *C. papillatus* McCoy; but I do not think this is the case. At any rate, in the absence of any specimens by which this could be connected directly with any other known form, I have thought it best to place it under a separate title, since it is not only common in its occurrence but is also very common in its size and other characters. It is distinguished by its forming very minute, circular, and convex patches, by the absence of interstitial tubules, and by the extremely small size of the calices. All the examples which I have seen are attached parasitically to the exterior of *Strophomena alternata* and different species of *Chaetetes,* and in general many colonies are found attached to the same object. I am indebted for the specimens from which the above description is drawn to the kindness of Mr. U. P. James."—Nicholson, *loc. cit.*

It is quite likely that many times minute encrusting species identified as the above, might turn out, on investigating their internal characters to be the young of other species. It is not an easy matter, however, to obtain satisfactory sections of these minute bodies, and the entire specimen is nearly always sacrificed in the operation. My identifications are for the most part based on the external appearance.

1.33A3....1.34A1, 3, 8, 9, B1-3, 4-5, C14a.

PRASOPORA HOSPITALIS (Nicholson).

Plate XXIII, figs. 1-1b; Plate XXXI, fig. 6.

Monticulipora (*Prasopora*) *Selwynii* var. *hospitalis* Nicholson, 1881, Genus Monticulipora, p. 209, fig. 45.

"The type form of *M. Selwynii* occurs in the Trenton Limestone of Canada; but there is found in the Cincinnati formation of Ohio a form which possesses a very similar internal structure, and which I propose, in the meanwhile, to separate as a distinct variety, under the name of *M. Selwynii,* var. *hospitalis,* Nich. In its habit and size, and in some of the minor points of its organization, this form differs considerably from the typical examples from the Trenton Limestone, which I have selected as the basis for the preceding specific diagnosis; but as it is clearly a very close ally of *M. Selwynii,* I prefer to regard it at present as nothing more than a very strongly marked variety.

"*M. Selwynii,* var. *hospitalis,* is invariably an attached form, all the numerous examples which I have seen being fixed to the exterior of the shells of Brachiopods. In form they are hemispheric, rarely nearly globular, and their general size is from six to ten lines in diameter, and from three to four to seven or eight lines in height. Tangential sections show a close correspondence in general structure with the type-form of *M. Selwynii,* from the Trenton Limestone. The corallum is composed of large and small corallites, the former being oval or circular in shape, and varying from 1-50th to 1-70th inch in diameter, each showing an excentrically perforated tabula. The small corallites are numerous, sub-angular, and wedged in between all the larger tubes, occasionally being aggregated into star-shaped groups or 'maculae'. Besides the normal two kinds of corallites, a considerable number of thick-walled hollow spines ('spiniform corallites') may be observed, which I have not detected as present in the examples from the Trenton Limestone.

Vertical sections show the same marked difference in the tabulation of the large and small corallites as has been previously noticed in the type-form, with some differences. The large tubes are always doubly tabulate, one set of tabulae forming a series of large lenticular vesicles, the convex sides of which are directed inwards towards the center of the visceral chambers, while the remaining tabulae are horizontal and remote, and extend from the lateral wall of the corallite to the inner margin of the above-mentioned vesicles. In some of the tubes we may occasionally notice the convex tabulae to form isolated vesicles, as they usually do in the specimens from the Trenton Limestone; but they are more commonly so apposed to one another as to form vertical rows of lenticular cells, the inner margins of which unite so as to constitute an apparent median septum to the corallite. The small corallites are uniformly furnished with numerous complete, horizontal tabulae. Upon the whole, I have little doubt that the specimens now described from the Cincinnati Group of Ohio are not specifically separable from the true *M. Selwynii* of the Trenton Limestone."—Nicholson, *loc. cit.*

The above description by Nicholson is entirely adequate. At present *P. hospitalis* is generally considered as a species distinct from *P. selwynii.* It is peculiar in being the only species of this genus in the Cincinnati group and also in the fact that it presents certain characters not found in the typical members of the genus occurring in the Trenton, namely large and abundantly developed acanthopores. In form, *P. hospitalis* is fairly typical, although rather more inclined to form irregular masses than its Trenton relatives, which are usually very regularly hemispherical or subconical in form. The specimen figured herewith is about typical of the more regular zoaria of the Richmond form. Occasionally thin crusts are found, probably the basal portion of an incompletely developed colony. On the other hand fusiform or club-shaped masses are occasionally met with.

P. hospitalis is very common in the Richmond series of rocks, and comes as near ranging throughout the series as any species that I know of. In the Waynesville, however, it is lacking except at the very top of the formation, and I am not aware of its occurrence in the Arnheim, which has lately come to be considered as a member of the Richmond series.

1.34A10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22....1.41A2, 4, 5, 6, 7, 8, 10a, B2, C1, D1, 2, 3, E1, 3, 4, 5, 6, 7....1.12E3, D1-6, F3.

PROBOSCINA AULOPOROIDES (Nicholson).

Plate XXXII, figs. 4, 4a, and 5.

Alecto auloporoides Nicholson, 1875, Pal. Ohio, II, p. 267, pl. xxv, figs. 2-2b.

"Polyzoary creeping, adnate, of narrow branches, which divide at more or less acute angles, and repeatedly inosculate, so as to give rise to a complicated network, the meshes of which are usually more or less elliptical, and have a long diameter of one line, less or more. Cells tubular, partially immersed, but free close to their apertures, sometimes uniserial, but more commonly arranged in two alternating rows, and sometimes irregularly disposed at the points of anastomosis of the branches. About six or seven cells in the space of one line. Cell apertures terminal, circular, of the same diameter as the tube, the last portion of the cell being more or less conspicuously elevated above the general surface.

"This form seems to have been usually regarded as identical with *Aulopora arachnoidea,* Hall, to which it bears a considerable superficial resemblance; but it is certainly distinct, and it seems to me to be an unequivocal *Alecto.* It is nearly allied to *A. frondosa,* James, from which it is distinguished mainly by its much more slender habit and graceful form, and by its generally having its cells arranged in a single or double series."—Nicholson, *loc. cit.*

1.33A3....1.34A10, 11, 12, C14a....1.41D3, E3, 4.

PROBOSCINA FRONDOSA (Nicholson).

Plate XXXII, figs. 3-3b.

Alecto frondosa Nicholson, 1875, Pal. Ohio, II, p. 266, pl. xxv, figs. 3-3b.

"Polyzoary creeping, adnate, of reticulating and anastomosing branches, which sometimes become more or less completely confluent, and thus give rise to a thin expanded crust, or which may be partially reticulated and partially confluent. When the branches form a network, the meshes are usually extremely variable in size and disposition, but they are in general more or less oval, and have a long diameter of from half a line to a line or more. The cells are uniserial on the narrowest branches, but biserial, triserial, or multiserial on other parts of the coenoecium; elongated and tabular, immersed below, but free toward their aperture, the terminal portion of the tube being more or less elevated above the general surface. Cells from six to eight in the space of one line. Cell-mouths terminal, circular, of the same diameter as the tube.

"There does not appear to be any reason for doubting that this is a true *Alecto.* It is nearly allied to *A. auloporoides,* especially as regards the size and form of the cells; but the greater width of the branches, and their common coalescence into crusts, together with the greater number of the rows of cells over most parts of the coenoecium, communicate to the fossil quite a peculiar appearance, and appear to be characters of specific value. The above description is drawn from type specimens kindly furnished by Mr. U. P. James. The examples that I have seen are parasitic upon the valves of *Orthis* and *Strophomena,* and upon various species of *Chaetetes.*

"I have seen one specimen, in the collection of Mr. Dyer, of Cincinnati, in which the spaces between the cells are very minutely porous or tubular, and I am informed by Mr. James that a similar specimen exists in his cabinet. It is possible these may constitute a distinct species."—Nicholson, *loc. cit.*

Further description is not necessary for the identification of this species. It is not uncommon in the Lorraine and Richmond formations.

1.33A3....1.34A12, 19-21, B1-3, C13....1.41D1, E4, 6.

PTILODICTYA PLUMARIA James.

Plate XXIV, fig. 1; Plate XXXII, fig. 6.

Ptilodictya plumaria James, 1878, The Paleontologist, No. 1, p. 4.

"Polyzoary plumose, pointed at the base, divided into three lobe-like parts by longitudinal depressions commencing near the base, which flatten out gradually as they approach the upper part, with a row of elongated, oblique pits in each depression directed outward and upward; the lower part of the central lobe gently curving from the base upward to about half the length of the specimen; the lateral lobes expand quite rapidly, and to thin edges—one side at a sharper angle than the other. On the surface are several rows of slightly radiating low nodes. Quite strong longitudinal wavy lines on the central lobe, from eight to ten in the space of a line, between which, measuring in the same direction, are about ten circular or oval cell apertures in the space of a line. The cells on the lateral lobes are quite indistinct on the only specimen yet examined, caused by weathering. A small portion of the upper part is covered with rock; the exposed part measures one and three-quarter inches in length, and seven-eighths of an inch in width at the broadest part."—James, *loc. cit.*

According to Bassler, James' type is from Warren County, Ohio. The species occurs at a number of localities in Ohio and Indiana.

1.34A17 (?)....1.41E6.

RHINIDICTYA LATA (Ulrich).

Plate XXXII, figs. 7, 7a.

Dicranopora lata Ulrich, 1882, Jour. Cin. Soc. Nat. Hist., V, p. 166, pl. vi, figs. 16, 16a.

"The segments of this species are about one inch in length; their width at the lower or simple end is about .08 inch; at the bifurcated end the width is usually about .16 inch; the greatest thickness rarely reaches .03 inch. The two articulating branchlets are remarkably short, being generally only about .05 inch; they are only indicated by a narrow cleft in the widest end of the segment. Cells with thick walls and very small oval apertures. There are about ten longitudinal rows of cells near the lower end, and at least twenty just below the bifurcation. Measured along the length of a segment eight cells occupy the space of .1 inch. There are two rows of obliquely arranged cell-apertures along each of the acute margins.

"The wide segments, thick cell-walls, and remarkably short articulating branchlets constitute the distinguishing features of the species."—Ulrich, *loc. cit.*

1.34A9.

RHINIDICTYA PARALLELA (James).

Plate XXXII, fig. 8.

Ptilodictya parallela James, 1878, The Paleontologist, No. 1, p. 5. (Not figured.)

"Polyzoary a flattened, linear, unbranched, two-edged frond, about one line wide, longest example observed one inch. Surface gently convex celluliferous on both faces; edges very thin and sharp. Eight or ten alternating rows of elliptical cells arranged between longitudinal lines; one row on each edge having an oblique direction. Cell apertures not raised, five or six in the space of a line measuring longitudinally."—James, *loc. cit.*

The above description is adequate for the recognition of the species. According to Bassler, *R. granulosa* James is the same species as *R. paralella,* the granulose individuals representing merely the more mature stages of the species.

1.34C13, 14a.

RHOMBOTRYPA CRASSIMURALIS Ulrich.

Plate XXIII, figs. 2-2c.

Monotrypella crassimuralis Ulrich, 1890, Geol. Illinois, VIII, p. 452, pl. xxxviii, figs. 2-2f.

"Zoarium dendroid, dividing dichotomously or otherwise at intervals from ten to eighteen mm.; branches with low rounded monticules, whose centers are about two mm, apart. Zooecial tubes after passing through the axial region with a steady curve, open at the surface with direct circular apertures, 0.1 mm. in diameter, arranged in regular curved series, about eight in two mm. Interspaces thick, flattened centrally, then sloping down to the zooecial cavities; thickest on the monticules, where a few illy defined mesopores are generally distinguishable. Tangential sections vary considerably in the appearance of the interspaces, sometimes showing open spaces of diverse form and size between the ring-like walls of the zooecia; at other times the interspaces seem to be filled with a light colored calcareous deposit. In transverse sections the tubes in the axial portion of the branch are very thin walled and regularly rhomboidal or pentagonal. Diaphragms wanting in the axial, very few in the mature region; numerous and thick in the interspaces.

"This species belongs to the same section of the genus as *M. quadrata* Rominger, and *M. subquadrata* Ulrich, though differing very obviousy from them. All three agree in having the tubes in the axial region regularly rhomboidal. Another peculiar feature is the habit of changing the direction of the rhombs at intervals of about one mm. This peculiarity is readily noticed in rough vertical fractures, which exhibit concentric, alternately smooth and rough or toothed spaces, each about one mm. wide. In thin vertical sections each change is marked by the origin of a number of rapidly enlarging young tubes.

"The most striking feature of the species is the extreme thickness of the interzooecial spaces. This character alone readily distinguishes the species from its nearest allies."—Ulrich, *loc. cit.*

To this species I have referred a peculiar small, irregular, massive, tuberculated specimen from near the top of the Whitewater division at Richmond, Indiana. A section of this specimen is figured in this report. The external characters do not correspond to Ulrich's description, but the internal characters seem to be identical.

1.41E1.

RHOMBOTRYPA QUADRATA (Rominger).

Plate XXIII, figs. 4-4b; Plate XXV, fig. 5.

Chaetetes quadratus Rominger, 1866, Proc. Acad. Nat. Sci. Philadelphia, 1866, p. 115 (not figured).

"In the blue limestone of Madison and Richmond, Ind., a well-marked form of Chaetetes is found ln abundance, which I do not see described. I propose for it the name *Chaetetes quadratus.*

"It grows in coarse ramifications, with an even or slightly monticulose surface. Tube orifices vary in size in different specimens from one-fourth to one-third of a millimeter; those on the maculae are somewhat larger; they are contiguous, polygonal or quadrate, separated by thin walls. Intertubular cells entirely wanting.

"The quadrate tube form is particularly obvious on the terminal surface of branches, or on transverse sections. On the sides of the branches the quadrate tube form gives the surface a fanciful appearance, which I cannot better explain than by comparing it with certain decorations of watch cases, consisting of concentric circle lines crossing each other."—Rominger, *loc. cit.*

The quadrate form of the zooecia as seen especially on the growing ends of branches makes the identification of this species an easy matter. I have found considerable variation in the form of the zoarium, although there is surprisingly little in the internal characters. The zoarium varies from submassive to strictly ramose; and the surface is either smooth, which is the usual appearance, or possesses low broad monticules. In size my specimens run all the way from small cylindrical stems a few mm. in diameter to large masses several centimeters in extent. The specimen figured is a subfrondescent branching form of rather large size.

This is one of the most persistent and abundant bryozoa in the Richmond formation.

1.34A10, 11, 12, 13, 14, 15, 16, 17, 18b, 19-21, 22....1.41A4, 5, 6, 7, 8....1.41C1, D1, 2, 3, E2, 3, 4, 6, 7....1.12E3, F3.

RHOMBOTRYPA SUBQUADRATA Ulrich.

Plate XXIII, figs. 3-3b.

Monotrypella subquadrata Ulrich 1882, Jour. Cin. Soc. Nat. Hist., Vol. V, p. 249, pl. xi, figs. 4-4b.

"Zoarium ramose, the branches slender, cylindrical, and from one to nearly two-tenths of an inch in diameter. Surface smooth, without monticules or clusters of large cells. Cells usually quadrate or rhomboidal, the apertures circular or broadly elliptical, and arranged in regular, more or less curved diagonal lines; at other times the arrangement is peculiarly irregular. Their walls are moderately thick, and on an average twelve may be counted in the space of .1 inch. A few smaller cells (which sections show to be of the nature of interstitial tubes) are intercalated among the ordinary cells.

"Tangential sections show that the tubes have moderately thick walls, which preserve, more or less distinctly, the primitive boundary line between adjoining tubes. Small interstitial tubes are always shown, and although their number varies in different sections, they are never numerous.

"In longitudinal sections the tubes in the axial region of the branch have very thin walls, and diaphragms are usually wanting in this region. As they approach the surface their walls are moderately thickened, and comparatively remote horizontal diaphragms are developed (from one-half to two tube-diameters distant from each other). Occasionally the section cuts one of the interstitial tubes, in which the diaphragms are about nearly as numerous as in the ordinary tubes. The development of young tubes, by gemmation, takes place simultaneously in all the tubes at a point on a line crossing the branch at regular intervals, with a strong upward curve. Eight or nine of these intervals occur in the space of .3 inch. In transverse sections the tubes in the central portion of the branch are thin-walled and strictly quadrate or rhomboidal.

"In many respects this species closely resembles *M. quadrata*, Rominger, and might almost be regarded as a dwarfed variety of that species, were it not for the certain presence of interstitial cells in *M. subquadrata*. Another difference is found in the size of the cells, Rominger's species having from seven to eight in the space of .1 inch, while in the new species there are about twelve in the same space. Besides, *M. quadrata* is a much more robust species with branches varying in diameter from three to six-tenths of an inch.

"As before remarked, I can not at present consider the existence of interstitial tubes in *M. subquadrata*, as of more than specific importance, in so far as it has reference to the separation of the species from *M. quadrata*."—Ulrich, *loc. cit.*

If I correctly understand the characters of this species my collections contain but a single specimen, from the base of the Liberty formation at Richmond, Indiana. I am not sure, however, but that I may have given more latitude to the common species *R. quadrata*, than the author of the above species would approve of. At a number of levels I have found small ramose forms that seemed to differ in no other respect from the typical *R. quadrata,* than in their small size and shape. Since I did not detect any mesopores in these specimens I concluded in each case to refer them to the species *quadrata.* If these small forms are to be referred to the above species, its range and distribution would be considerably extended.

RHOPALONARIA VENOSA Ulrich.

Plate XXXI, figs. 7, 7a.

Rhopalonaria venosa Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., II, p. 26, pl. vii, figs. 24, 24a.

"Polyzoary creeping, adnate, branched, and forming a very delicate network. Branches linear, with a straight central stripe or series of cells, which has two branches springing, usually from every junction of the cells, though sometimes at that of the second with the third; these branches are again divided in a similar manner, and anastomose; this peculiar mode of growth gives the polyzoary very much the appearance of the venation in a leaf. Cells uniserial, long acutely elliptical, and joined together at their contracted ends; length of the cells somewhat variable, but generally about four occupy the space of two lines. Cell mouths not clearly determined, but appear to be situated near the middle of the cell.

"This form has only been observed, incrusting *Streptelasma corniculum* [=*S. rusticum*]. On account of the great delicacy of the fossil, the fronds themselves are rarely found, but instead we find a series of impressions on the exterior coat of the *Streptelasma,* which very well represent the fronds and cells of the same."—Ulrich, *loc. cit.*

The specimen of this species figured in this report is spread over the shell of *Rafinesquina alternata.* Another specimen was obtained at Richmond, Indiana. The types are from Waynesville and Clarkesville, Ohio. According to Ulrich and Bassler it is confined to the Richmond group.

1.34A11....1.41C2-3.

SPATIOPORA MACULOSA Ulrich.

Plate XXXII, fig. 9.

Spatiopora maculosa Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 167, pl. vii, fig. 6.

"Zoarium forming large and very thin parasitic expansions, usually adhering to the shells of *Orthoceras,* but in a few instances to other objects. The surface shows at intervals of .18 inches, measuring from center to center, distinct groups of large cells, which, very rarely, however, are slightly elevated above the general level of the surface. The diameter of the cells in these clusters not infrequently exceeds 1/55th of an inch, while that of the ordinary cells averages about 1/110th of an inch. The cell-walls are moderately thin, and at many of the angles are elevated into more or less prominent spiniform tubuli, which are larger and somewhat more numerous among the cells of the clusters mentioned. The cell-apertures are more or less irregular in shape, and never, on account of the thickened wall angles, are strictly angular. Interstitial cells are entirely absent. The internal structure shows no striking peculiarities, and much resembles that of the type species.

"This species is not uncommon in the Cincinnati Group. It is distinguished from *S. aspera* by the more distinct groups of larger cells, smaller and less prominent spiniform tubuli, which are only to be observed in finely preserved examples, the greater number of specimens found being entirely smooth."—Ulrich, *loc. cit.*

To this species I have referred a specimen from the top of the hill back of Vevay, Indiana.

SPATIOPORA TUBERCULATA (Milne-Edwards and Haime).

Plate XXXII, fig. 10.

Chaetetes tuberculatus Milne-Edwards and Haime, 1851, Monographie des Polypiers Fossiles des Terrains Palaeozoiques, p. 268, pl. xix, figs. 3, 3a.

"Polypier très-mince, encroûtant. Les mamelons sont comprimés et allongés dans une même direction longitudinale, assez saillants, long de 2 ou 3 millimètres, large d'un ou d'un demi, distants entre eux de deux fois leur largeur. Le sommet des mamelons est un peu compacte. Calices peu inégaux, de forme un peu variable; ceux des mamelons pourtant un peu plus grands, et larges d'un tiers de millimètre. Cette espèce est très-voisne du *Chaetetes mammulatus;* elle paraît en différer pourtant par ses mamelons toujour plus allongés et moins saillants, et ses calices sont un peu plus grands.

"SILURIEN (inférieur). *Etats-Unis* (Blue limestone): Cincinnati, Oxford, Springfield, Lebanon (Ohio).

"SILURIEN (supérieur). *Angleterre:* Dudley.

"Coll. de Verneuil, T. W. Fletcher."—Milne-Edwards and Haime, *loc. cit.*

A free translation of the above description will suffice for its identification.

Zoarium very thin, encrusting. The monticules are narrow and elongate in the direction of the greatest length of the zoarium, quite sharp, two or three mm. long, about one or one half wide and separated from each other by about twice their breadth. The tops of the monticules are nearly solid. Zooecial apertures somewhat unequal in size, varying somewhat in form, those of the monticules rather larger, about a third of a millimetre in diameter. This species is nearly related to *Chaetetes mammulatus* from which it differs in the fact that its monticules are always more elongate and not so sharp, and the zooecial apertures are slightly larger.

This and other species of the genus are commonly found growing over the shells of Orthocerata. Nicholson has described *S. corticans,* which he afterwards considered as a synonym of the present species, and Ulrich later described *S. montifera* a species with much more conspicuous monticules. Nickles and Bassler consider Nicholson's species valid. All of these species have the elongated monticules, drawn out in a common direction. The internal characters are indicated under the diagnosis of the genus.

Reported from Indiana in Kindle's list. It occurs in the Lorraine and Richmond formations.

STIGMATELLA CLAVIS (Ulrich).

Plate XXIV, figs. 2, 2a; Plate XXV, fig. 3.

Leptotrypa clavis Ulrich, 1883, Jour. Cin. Soc. Nat. Hist., VI, p. 161, pl. vi, figs. 3, 3a.

"Zoarium growing parasitically, usually upon crinoid columns, but not infrequently upon the stems of small branching bryozoa. In thickness it varies from .02 to .15 of an inch, the largest specimen seen being about one inch in length. Those growing upon the crinoid columns usually being club-shaped or subfusiform, while those upon other objects are variously and irregularly shaped. Surface presenting at intervals of .1 inch, small clusters of cells a little larger than the average, which in a few specimens are slightly elevated above the general level of the surface. Cells of one kind only, rather unequal in size, and irregular in arrangement, with moderately thin walls, and an average diameter of 1/130th of an inch, while the diameter of those in the groups seldom exceeds 1/100th of an inch. When in a good state of preservation the spiniform tubuli are quite prominent and pointed, and being numerous, give the zoarium a characteristically hirsute appearance.

"Longitudinal sections show a spiniform tubulus between nearly all of the thin and straight tube-walls. Their internal cavity is distinctly shown and comparatively large. Diaphragms are usually developed at remote intervals, though often wanting. No interstitial tubes have been observed.

"In tangential sections the cells are seen to be thin-walled and of rather unequal size. Spiniform tubuli of moderate size are plentifully developed, placed at the cell-angles and often at points between, in which case the walls are forced into their respective cell-cavities on each side. No special series of small cells are observed in these sections.

"This species is probably most nearly allied to *L. ornata,* from which it differs principally in having more numerous spiniform tubuli, which are also much more conspicuous, both externally and internally. These differences will also apply to the other species." —Ulrich, *loc. cit.*

Ulrich and Bassler have recently placed this species in their genus *Stigmatella.*

1.34C5, 6, 7, 11.....1.33A3.

STIGMATELLA CRENULATA Ulrich and Bassler.

Plate XXIV, figs. 4-4d.

Stigmatella crenulata Ulrich and Bassler, 1904, Smithsonian Miscellaneous Collections, XLVII, p. 34, pl. ix, figs. 1-4; pl. xiv, figs. 1, 2.

"Zoarium composed of cylindrical, subcylindrical or compressed, frequently dividing stems 10 mm. or more in diameter, arising from a broad base and forming a clump probably seldom more than 50 mm. high. Surface even, but in well preserved mature specimens spinulose because of the many acanthopores. Maculae well marked, generally composed of mesopores which make up the characteristic 'spots' but sometimes formed exclusively of zooecia larger than the ordinary. Zooecial apertures small, about 9 in 2 mm. with their walls thin and often beautifully inflected by the numerous small acanthopores. Mesopores present, variable in number but usually few and mostly aggregated in the maculae. In the axial region the zooecial tubes have thin, finely crenulated walls, and occasionally a diaphragm or two. In the mature region the walls increase slightly in thickness, mesopores and acanthopores develop, and thin diaphragms cross the zooecial tubes and mesopores at varying though always comparatively remote intervals." —Ulrich and Bassler, *loc. cit.*

I have one specimen of this species from the top of the Waynesville formation, near Abington, Indiana.

STIGMATELLA IRREGULARIS (Ulrich).

Plate XXV, figs. 2, 2a.

Chaetetes irregularis Ulrich, 1879, Jour. Cin. Soc. Nat. Hist., II, p. 129, pl. xii, figs. 10-10b.

"This form grows in small, free, and exceedingly irregular, masses, having a diameter varying from less than three lines to fifteen lines. Surface rarely nearly smooth, but is generally irregularly and strongly nodulated. Apertures of tubes polygonal, nearly equal in size, from eight to ten occupying the space of one line; walls of tubes comparatively thin. Interstitial tubuli are entirely absent.

"Longitudinal sections of this species have a peculiar and unique appearance. The tubes are seen to radiate from various centers, which correspond in number to that of the prominent nodules observed on the surface. Transparent sections were taken from many specimens, but no tabulae were observed crossing any of the tubes. When the tubes are cut transversely they are seen to be thin-walled and polygonal, with sometimes a small or young tube interpolated. The calcite filling the tubes is of darker and lighter shades, giving sections a peculiar appearance, and when the ends of the tubes are observed, it is divided by quite regular but faint cruciform lines, as in *C. quadratus* and several other forms.

"This species is allied to *C. lycopodites,* but is easily distinguished by its peculiar growth, and in having no diaphragms crossing the tubes. It is also related to *C. subglobosus,* but that species differs in having a more regular form, larger calices, and flexuous or wrinkled tube-walls. *C. irregularis* marks a horizon of about five hundred and fifty feet above low water mark in the Ohio river at Cincinnati, and is nearly always found where that elevation is exposed."—Ulrich, *loc. cit.*

Ulrich and Bassler have recently placed this species in their new genus *Stigmatella.* I am not sure that I have seen any specimen in Indiana. It is listed in Kindle's list of Indiana fossils, though from the locality given (Hamilton County) I am sure that either he or his authority is in error. Probably Hamilton County, Ohio, is meant. I have included it, however, because it is most likely to be found within this State.

STIGMATELLA PERSONATA Ulrich and Bassler.

Plate XXIV, figs. 3-3d.

Stigmatella personata Ulrich and Bassler, Smithsonian Miscellaneous Collections, XLVII, p. 35, pl. xii, figs. 1-3.

"This is one of the non-mesopored species of the genus and forms smooth, branching zoaria very much like *S. crenulata* and *S. spinosa.* From the former it is distinguished by having fewer acanthopores, no mesopores, and in lacking the crenulation of the walls in the immature region. From *S. spinosa* it is separated by its larger zooecia, 7 to 8 being found in 2 mm. while 10 are required in that species to cover an equal distance. The acanthopores in *S. personata* also afford a difference, being but seldom more numerous than the junction angles which they usually occupy. In *S. spinosa,* it will be remembered, they are so abundant that they almost completely surround the zooecium."—Ulrich and Bassler, *loc. cit.*

The only specimen of this species seen by me comes from near the top of the Richmond series on Elkhorn Creek, near Richmond, Indiana.

STIGMATELLA SPINOSA Ulrich and Bassler.

Plate XXV, figs. 1-1d.

Stigmatella spinosa Ulrich and Bassler, 1904, Smithsonian Miscellaneous Collections, XLVII, p. 34, pl. ix, figs. 5-8.

"The method of growth in this species is similar to that obtaining in *S. crenulata,* but under a lens *S. spinosa* is distinguished at once by having no mesopores and so many small acanthopores indenting the zooecial walls that the surface appears granulose rather than spinose, which term applies better in other species of the genus. Continuing the comparison with *S. crenulata,* the zooecia are found to be a little smaller, about 10 occurring in 2.0 mm., and the axial portion of the tube walls straighter.

"Thin sections of this species are both beautiful and instructive. In vertical sections the periodic development of the acanthopores, which is a feature of the genus, is shown especially well. Diaphragms few and of irregular distribution."—Ulrich and Bassler, *loc. cit.*

This form is reported by Ulrich and Bassler as occurring in the Richmond formation at Versailles, Indiana.

STOMATOPORA ARACHNOIDEA (Hall).

Plate XXXII, figs. 2-2c.

Aulopora arachnoidea Hall, 1847, Pal. New York, I, p. 76, pl. xxvi, figs. 6 a-c; and fig. in foot note, p. 76.

"Coral consisting of a fine weblike expansion, diffusely branching and anastomosing, attached to the surface of other bodies; tubes narrow, slender, short, subclavate or straight, single; mouth slightly elevated, opening obliquely upwards, smaller than the cell below.

"This very delicate species, in some portions of its extent, bears considerable resemblance to *Alecto dichotoma* of the Jura limestone (LAMOROUX, *Exp.*, p. 84, t. 81, f. 12-14; BLAINVILLE, *Man. d'Act.*, p. 464, t. 65, f. 1; *Aulopora dichotoma,* GOLDFUSS, *Petrefacta,* pag. 218, pl. 65, fig. 2); but other portions develop a structure scarcely compatible with this genus, and I have therefore placed it under the Genus AULOPORA. The illustration below presents a magnified view of a distinct part from that shown on the plate, and exhibits the essential characters of AULOPORA. It is the only species of the genus known to me in the lower term of our system, and on this account is more interesting as showing the early commencement of this peculiar form of coral, which is known only in a fossil state. The lowest position in which it has been known previously, is in the Wenlock limestone, and the upper limestone of the Caradoc (Silurian System, p. 676); others occur in the Eifel (Devonian), and other species are known in the Oolite and Jura limestones.

"This is not a common fossil in the Trenton limestone, though it has been seen in several localities widely separated, thus proving its great geographical range."—Hall, *loc. cit.*

The reference of this delicate species to the coral genus *Aulopora* is of course no longer permissible. Whether it should be associated with such forms as *Stomatopora inflata,* etc., in the genus *Stomatopora,* is a question that can not be adequately discussed at this point. I have taken occasion to call attention to the unsatisfactory condition of the genus *Stomatopora* and its related genera in the diagnoses of those genera. *S. arachnoidea* has the zooecia immersed, in this respect more nearly resembling the two associated species of *Proboscina* than the other species of *Stomatopora* such as *S. inflata.* To me the uniserial arrangement, or otherwise, does not seem to be a character of generic importance, and as I have remarked elsewhere in this report, the genera will ultimately have to rest on characters of higher phylogenetic importance.

S. arachnoidea is a widely distributed and extensively ranging form, being found in the Utica, Lorraine and Richmond.

5.9A31....1.34B1-3, C9, 13....1.41B1....1.12A2, D1-6.

STOMATOPORA INFLATA (Hall).

Plate XXXII, figs. 1, 1a.

Alecto inflata Hall, 1847, Pal. New York, I, p. 77, pl. xxvi, figs. 7 a-b.

"Coral attached, arachnoid; tubes short, much expanded above, contracting at the aperture, and narrowing rapidly below; mouths large, opening obliquely upwards.

"This coral resembles the last in its mode of growth and general appearance; but the tubes are more expanded or vesicular above, and the little mouths are proportionally more distinct. It is clearly referrible to the Genus ALECTO, in its mode of growth, form, and arrangement of cells, which proceed one from the other, each base being a little below the aperture of the previous one."—Hall, *loc. cit.*

This species is commonly seen growing over the shell of *Rafinesquina alternata,* or over other bryozoa, and in the Richmond formation on the *Streptelasma rusticum.* It is a very delicate form, but from the uniserial arrangement of the zooecia and their peculiar swollen form it is easily distinguished.

1.33A3....1.12A2....1.41A7, D3, E2, 3.

BRACHIOPODA.

DIAGNOSES OF GENERA.

CATAZYGA Hall and Clarke.

Shells rather large, subcircular or ovoid; valves more convex than in Zygospira. A low median sinus in both valves; surface with a great number of fine radiating striae. Muscular impressions of pedicle valve well defined, pedicle cavity deep, with a deeply excavated, short, sharply defined longitudinally striated impression in front of it. In the brachial valve is a broad anterior and narrow, elongate, posterior pair of scars. Spirals essentially the same as in *Zygospira,* but with the apices of the cones converging toward the median line in a plane just below the surface of the brachial valve. Jugum persistently posterior in its position, originating as in *Atrypa,* the lateral lamellae bending downward toward the bottom of the brachial valve and directed forward in lines that are parallel for a short distance. Thence they bend inward and upward, meeting in a short angle in the space just behind the apices of the spirals. (Hall and Clarke.)

CRANIA Retzius.

Shell inequivalve, inarticulated, without perforation for a pedicle; subcircular in outline, generally somewhat transverse across the posterior margin; attached by the apex or the entire surface of the lower valve. Ventral valve depressed—conical or conforming to the surface of attachment. Dorsal valve more or less conical with a subcentral, posteriorly directed apex. Surface of the valves usually smooth, sometimes spinose or with concentric or radiating striae. In the interior of both valves are two pairs of large adductor scars, the posterior of which are close upon the margin and widely separated, the anterior near the center of the shell and close together, more approximate in the lower than in the upper valve. These posterior scars are often strongly elevated on a central callosity which surrounds their broad and thickened margins. Impressions of the pallial genital canals anterior. The margin of the lower valve is usually coarsely digitate. Shell substance calcareous, strongly punctate. (Hall and Clarke.)

DALMANELLA Hall and Clarke.

Shells plano-convex or subequally biconvex. Pedicle valve usually the deeper, often gibbous, elevated at the umbo and arched over the cardinal area. Hinge line generally shorter than the greatest width of the shell. Often a more or less conspicuous undefined median fold and sinus on the pedicle and brachial valves respectively. Surface with fine rounded bifurcating radiating striæ. Teeth in the pedicle valve quite prominent, thickened at their extremities and supported by lamellae which are produced forward surrounding a rather short suboval or subquadrate muscular area. Cardinal process in the brachial valve extends forward to the bases of the crural plates where it is broadened and continued thence as a median ridge separating the muscular impressions. The inner surface of this process is divided by a faint median furrow which produces two lobes at the posterior extremity, and each of these lobes is again divided making the process quadrifid. In some cases the two median divisions coalesce, making the process appear trifid. In some species at maturity and in others from abnormal growth this process becomes a broad plug which fills the entire delthyrial opening. Dental sockets small; crural plates often greatly elevated, especially in the plano-convex species, usually ending abruptly. Muscular impressions quadruplicate, sometimes with radiating ridges extending from the lateral and anterior margins. (Hall and Clarke.)

DINORTHIS Hall and Clarke.

Relative convexity of the valves reversed (*i. e.* the dorsal valve the most convex). Surface with strong rarely bifurcating plications. Delthyrium sometimes partially closed. Muscular area in pedicle valve subquadrate, bounded by extensions of the dental lamellae. In the brachial valve the muscular impressions are obscure; cardinal process erect, broad and frequently bilobed on its posterior face. Shell structure impunctate. (Hall and Clarke.)

HEBERTELLA Hall and Clarke.

Shells with convexity of the valves reversed. Surface covered with numerous fine, rounded, closely crowded plications, crossed by lamellose growth lines. Teeth in the pedicle valve large and supported by thick lamellae which are continued as a strong ridge around a short obcordate muscular area. This area is medially divived by a prominent ridge upon the summit of which lies the linear scar of the adductors. The flabellate lateral impressions are sometimes divisible into their two components, diductors and adjustors, and in old individuals the impression of the pedicle muscle is often distinct. Dental sockets in the brachial valve narrow and inclosed beneath, and on the inner side by the strong crural plates. Cardinal process elongate and simple, sometimes thickened, often crenulate, but not lobed at its posterior extremity. The process unites with the inner bases of the crural plates and is produced forward as a median ridge dividing the four muscular scars, which are distinctly developed only in old shells. Shell structure fibrous impunctate, the plications of the surface sometimes tubulose. (Hall and Clarke.)

In some of the later species of this genus the shell is coarsely punctate.

LEPTAENA Dalman.

Redefined by Hall and Clarke.

Shells plano-convex when young, concavo-convex at maturity. Surface with conspicuous concentric wrinkles over the flatter portions of the valves. Where these cease the valve is often more or less abruptly deflected. Whole exterior covered with fine radiating, thread-like striae, crenulated, in well preserved specimens, with fine concentric lines. Outline transversely subquadrate or semi-oval. Hinge line straight, making the greatest breadth of the shell; extremities often sub-auriculate. Cardinal area narrow, slightly wider on the pedicle valve, not denticulate. Delthyrium in the pedicle valve covered by a convex deltidium, perforated at the apex by a foramen which is closed at maturity or encroaches upon the apex of the valve. Deltidium most conspicuous in the early stages of growth. Teeth very divergent and quite conspicuous, generally supported by lamellae which are continued around the subcircular muscular area of the narrow umbonal cavity. The muscular scars consist of a narrow median or adductor, inclosed by flabelliform diductors. In the brachial valve the area is linear, the delthyrium is progressively filled by the growth of a callosity, which is often deeply grooved along the center and sometimes perforated in the line of division between the branches of the cardinal process. Cardinal process consists of two sessile diverging apophyses which have broad, flat, striated surfaces of attachment, and are extended beyond the hinge line. The sockets are moderately deep; crural plates usually not sharply defined, but are continued in a curving line along the inner surface of the valve, partially embracing a pair of broad, ovate muscular impressions which are marked by arborescent ramifications; recurving and again incurving, these ridges partially surround a pair of smaller muscular areas, lying in front of the first. Posterior pair of muscular impressions divided by a ridge which originates at the cardinal process. Second pair of impressions separated by a low slender median septum which is a continuation of the interrupted posterior ridge. The muscular area is divided into the following scars: a large posterior pair (posterior adductors) the surface of which is covered with arborescent ridges; an anterior pair (anterior adductors) close together at about the center of the valves; an elongate narrow median scar apparently divided throughout its length by a faint ridge. At the line of geniculation, the interior surface is frequently elevated into a very prominent, sharp, or abruptly rounded crest. Spiral callosities for the support of the brachia have been observed. (Hall and Clarke.)

LEPTOBOLUS Hall.

Shells small, fragile, subovate in outline; shell substance semiphosphatic. Exterior with concentric growth-lines. Interior of the pedicle valve with a notably large cardinal area, which is sharply grooved. Beneath this area is a broad depression extending nearly across the shell and divided by a low median ridge, which bifurcates at its extremity, leaving between its branches a small central muscular impression. This impression is bounded on its sides by a crescentic muscular fulcrum, which extends parallel with the margins to the anterior portion of the shell. At a point back of their centers each gives off a transverse branch extending inward and backward. In the brachial valve the cardinal area is also well developed and distinctly grooved. The limits of the muscular scars are indicated by three septal ridges, one axial and one on either side. All these ridges are bifurcated at their anterior extremities. (Hall and Clarke.)

LINGULA Bruguiere.

Shell sub-equivalve; elongate-ovate, subquadrate or subtrigonal in outline; slightly gaping at both extremities; brachial valve somewhat shorter and with a slightly thickened hinge-line. Surface smooth, or concentrically and radially striated. Pedicle long, protruding from between the beaks of the two valves. Pedicle valve with a distinct cardinal shelf or area, divided by a depression widening from the apex anteriorly (the "deltidium"). Deltidium bounded at the sides by elevated ridges, which at the anterior ends are each developed into a small callosity. Muscular impressions numerous, but usually distinct. In recent species there are twelve upon each valve. These are: the *umbonal,* near the beaks; the *lateral,* produced by three pairs of muscles; the *anteriors;* the *middles;* the *externals;* the *centrals* and the *transmedians.* The muscular region in each valve is surrounded by the *parietal bands* which leave more or less distinct impressions on the shell. The anterior internal surface of each valve bears traces of two strong pallial sinuses, which nearly meet in the axial line before reaching the anterior margin. In front of and behind these are radiating vascular markings. Shell substance composed of alternating lamellae of chitinous and calcareous material. (Hall and Clarke.)

LINGULASMA Ulrich.

Shells large, subquadrate, linguliform, sub-equivalve; brachial valve considerably the deeper. Beaks apical, cardinal margins gently sloping to the sides. Surface with concentric or radiating lines and bead-like granules. Shell substance thick, largely calcareous. Interior of pedicle valve with low, concave platform which extends over one-half the length of the shell, and is not hollowed on its anterior wall. Pedicle area largely inclosed within the shell, making a distinct sheath or shelf, beneath which lie the apical portions of the central and lateral muscular scars. Crescentic scars scarcely defined. Brachial valve deep, with high platform of about the same extent as that on the other valve, sloping inward near its anterior margin and continued axially into a strong septum which reaches nearly to the front of the valve. Anterior walls of the platform broadly excavated, and close against the base of the septum hollowed out into short conical cavities. Crescent strongly developed, sharply pointed backward at its center. Its lateral curves are broad, reaching to the edge of the platform. Directly in front of its central angle lies a short, sharp, median ridge, which disappears near the center of the platform. Lateral and central muscular scars well developed. (Hall and Clarke.)

PLATYSTROPHIA King.

Contour spiriferoid; hinge line and area long and straight, nearly equally developed on the two valves. Both valves very convex, the brachial being the more so, and bearing a very strong median fold corresponding to a deep sinus on the opposite valve. Surface marked with strong, usually sharp, radial plications, a variable number of which are on the fold and sinus. External surface, when well preserved, finely granulose. Delthyrium open in both valves, somewhat larger in the pedicle valve, and in old and very gibbous shells it has often encroached upon the umbonal region of the valve. Teeth thick and very prominent; muscular area comparatively small, and often, in old shells, deeply excavated in the substance of the shell. Not readily divisible into component scars. The cardinal process of the brachial valve is a simple linear ridge, always small and sometimes nearly obsolete. Dental sockets comparatively small; crural plates large and thick, uniting at their inner bases and produced into a prominent median ridge. Muscular area quadruplicate. Shell structure very compact and finely fibrous, without punctation. (Hall and Clarke. Cumings.)

PLECTAMBONITES Pander.

Redefined by Hall and Clarke.

Shells usually small, normally concavo-convex. Surface with very fine striae, often alternating in size. Hinge line making the greatest width of the shell, extremities often subauriculate. Cardinal area narrow in both valves, sometimes obscurely crenulated on the margins. Pedicle valve with a moderately broad delthyrium, which is partially closed by a convex plate, but mostly occupied by the cardinal process of the opposite valve. Apical foramen sometimes retained. Teeth prominent and supported by thickened plates, which are continued in broad outward curves for more than half the length of the valve, returning and uniting in the umbonal cavity, thus limiting two linguliform muscular scars, inclosing a more or less clearly defined adductor impression. Dental sockets in brachial valve deep, often appearing to transect the cardinal area. Cardinal process simple and erect, but by its coalescence with the short prominent crural plates the posterior face appears trilobate. The crural plates end abruptly as in *Orthothetes*; becoming thickened at about the middle of their length, giving origin to two low ridges or septa, which at first approach each other, and thence continue forward with a slight divergence, thus forming the inner boundaries of two elongate muscular scars, which are less sharply defined on their outer margins. The muscular area is rendered quadripartite by two short transverse or oblique posterior furrows. Vascular impressions radial, sometimes digitate. Shell substance fibrous, sparsely punctate. (Hall and Clarke.)

PLECTORTHIS Hall and Clarke.

Valves subequally convex, plications strong, simple or duplicate. Cardinal area of pedicle valve low. Shell substance impunctate. Muscular scars, dental lamellae, and cardinal process as in *Orthis* (s. s.). (Hall and Clarke.)

The present writer is inclined to doubt the value of this genus, in as much as the fact that the plications may be duplicate is practically the only distinction between it and the genus *Orthis* (*sensu stricto*).

RAFINESQUINA Hall and Clarke.

Shells normally concavo-convex. Surface ornamented by radiating striae, of alternating size, crossed and crenulated by finer concentric striae. Cardinal margins without denticulations. Interior of the pedicle valve with the muscular area not strongly limited; consisting of two broad flabellate diductor scars enclosing an elongate, more distinctly defined adductor. The faintness of the limitation of this area is in marked contrast to the sharply defined muscular area in the corresponding valve of *Leptaena*. In the brachial valve the cardinal process is more closely sessile than in *Leptaena*, and there is frequently a linear callosity between the branches. The posterior adductor scars have the arborescent markings of *Leptaena rhomboidalis*, and these impressions are the only ones well defined, the anterior scars being narrow and rarely retained with distinctness. From the anterior margin of the muscular area radiates a series of irregular furrows and nodose ridges, which are to some extent of vascular origin. (Hall and Clarke.)

RHYNCHOTREMA Hall.

Shells large, thick, often gibbous. Deltidial plates in adult shells of great size, thickened and coalesced with the bottom of the valve, their outer surface being concave. The pedicle passage encroaches upon the substance of the valve, the foramen lying behind the apex and the passage itself inclosed by the thickened deltarium. The teeth rest upon the thickened lateral walls of the valve, and there appears to have been no development of dental lamellae, unless at a very early period in the life of the shell. Median septum in the brachial valve thickened and extending more than one-half the length of the shell; the small cardinal process rests upon the posterior extremity of the septum. The bases supporting the crura are divided by a very narrow median cleft, and are remarkably broad and stout, and abruptly deflected to the deep dental sockets. The crura arise from the middle of this comparatively broad hinge-plate, instead of from the margins of the dental sockets. The muscular impressions are usually strongly developed; a deep scar of the pedicle muscle beneath the deltidial plates; the adductor impression in the pedicle valve often very marked. Adductors of the brachial and diductors of the pedicle valve more or less distinctly defined. (Hall and Clarke.)

Shell rostrate, surface covered with strong angular radiating plications; a well defined fold on the dorsal valve and corresponding sinus in the ventral valve, a variable but always small number of plications in the fold and sinus.

SCHIZOCRANIA Hall and Whitfield.

Shells subcircular in outline, inequivalve, unarticulated. Pedicle valve flat or concave; apex subcentral. A deep triangular notch extends from just behind the beak to the margin, where its arc is about one-sixth of the periphery. The apex of this pedicle notch is occupied by a triangular transverse plate or listrium, varying in size with the age of the shell, but extending from one-fourth to one-third the length of the opening. Surface marked by concentric growth-lines. No muscular impressions visible. Brachial valve more or less convex, beak marginal. Surface radially striated. The interior bears a pair of strong posterior adductor scars, lying close together in the umbonal region, their outline is subovate, and they frequently appear to be divisible into anterior and posterior elements. In front of them at about the center of the valve, are the small and faint anterior adductor impressions. A low median ridge extends from the apex to beyond the center of the valve. Shell-substance of perlaceous calcareous laminae, the inner layers appear to be corneous. (Hall and Clarke.)

STROPHOMENA Rafinesque (de Blainville).

Restricted by Hall and Clarke.

Shells transversely subsemicircular or semielliptical. Greatest width along the hinge line. Concavo-convex; surface with fine radiating striae, which are equal or alternate in size. Pedicle valve slightly convex at the umbo but becomes rapidly concave toward the middle; apex perforated except in old age. Cardinal area conspicuous, nearly vertical, delthyrium closed by a convex deltidium. Teeth widely divergent and supported by plates which are produced into elevated ridges nearly surrounding the muscular area. Latter relatively short, subcircular in outline, deeply excavated and divided medially by a more or less distinctly defined longitudinal ridge, which is often continued over the pallial region. Brachial valve concave at the umbo, becoming strongly convex farther forward; cardinal area narrow, delthyrium rudimentary or incomplete. Dental sockets deep, continued as narrow grooves or indentations across the cardinal area. Crural plates extended laterally with a slight curve, not supported by septa; united at their inner margins to form a callosity upon which rests the short, bilobed cardinal process, which scarcely extends beyond the hinge line. The muscular surface of this process is cordate in outline and is placed at a low angle to the plane of the area. A low median ridge extends forward from the hinge plate, separating two large adductor scars, in front of which are two narrow elongate impressions. Vascular and ovarian markings frequently well defined. Shell-substance fibrous, strongly punctate. (Hall and Clarke.)

TREMATIS Sharpe.

Shell subcirclar or transversely oval in outline. Pedicle valve unevenly convex, more or less depressed over the posterior region; apex at or behind the center; directly beneath it begins the pedicle fissure, which transects the shell, vertically widening to the posterior margin with straight or outwardly curving edges. Brachial valve evenly convex, with its apex marginal and slightly projecting. Interior of pedicle valve shows a faint median furrow extending from the angle of the fissure to the apex of the shell. This groove widens at its apical termination and may represent a point of muscular attachment. Sides of the fissure often with callosities. From the apex of the valve extend radiating and branching vascular sinuses. Posterior margin of brachial valve much thickened and broadly grooved for the extrusion of the pedicle. This thickening does not form a cardinal area or shelf. Adjuster and posterior adductor scars directly beneath and in front of this thickening. These scars separated by a faint median septum, which passes forward, becoming more prominent over the tongue-shaped median elevation which separates the large central scars. These impressions are oblique and not simple, each appearing to be composed of two, or three, distinct scars, making a posterior, median and anterior pair. Posterior pair small, sometimes quite sharply defined; central pair much larger, anterior pair narrow. Entire impression deeply excavated. Surface of both valves more or less completely covered by a beautiful ornamentation consisting of punctures or small pittings of various depth, arranged either in quincunx or in radiating rows. Shell-substance with an outer calcareous layer and inner corneous lamellae. The outer layer is coarsely punctuated by the pittings constituting the surface ornamentation. The corneous layers are impunctate. (Hall and Clarke.)

ZYGOSPIRA Hall.

Shells usually small. Outline subcircular or transversely oval. Contour subplano-convex. Surface sharply plicate. Pedicle valve with a median plicated ridge. Umbo narrow and prominent; beak acute and incurved. Foramen elongate, rarely apical, enclosed by the deltidial plates. Hinge line long and straight; cardinal extremities rounded. A distinct false area is formed by a pair of ridges diverging from the beak toward the cardinal extremities. On the interior the teeth are moderately well developed and unsupported by dental lamellae. The brachial valve is depressed convex in the umbonal region and bears a more or less conspicuous median sinus. The hinge plate consists of two broad, stout processes, diverging outwardly, grooved on their summits and separated from each other by a narrow, sharp cleft. They form both the socket walls and crural bases, and are supported by a low median ridge. Muscular impressions obscure in the typical species. Crura short and straight at their union with the primary lamellae, making a rectangular curve. The first half volution of the ribbon lies just within the margins of the valves, and the number of volutions is small. The spirals have their bases parallel to the lateral slopes of the pedicle valve and their apices directed obliquely toward the center of the opposite valve. Jugum continuous, variable in position and shape; its apex always angular and directed anteriorly. (Hall and Clarke.)

DESCRIPTION OF SPECIES.

CATAZYGA HEADI Billings.

Plate XXXIII, figs. 1-1c.

Athyris headi Billings, 1865, Paleozoic Fossils, I, p. 147, figs. 125-127.

"*Description.*—Broad oval or sub-pentagonal; both valves convex; sides and front margin occasionally somewhat straight. Ventral valve rather strongly convex, most elevated about the middle or a little above; beak closely incurved, in contact with the umbo of the dorsal valve; umbo somewhat carinated; an obscure mesial sinus which is usually so slightly impressed as to constitute only a flattening of the shell extends from the front margin to within one-third of the length from the beak, where it becomes obsolete; on each side of the sinus the shell descends with a somewhat flat slope to the sides. Dorsal valve not so convex as the ventral; often with an obscure mesial sinus.

"Surface with fine rounded radiating ridges, closely crowded together, of a nearly uniform size, from eight to ten in the width of two lines.

"Length about 10 lines; width a little less than the length.

"This species is dedicated to the late John Head, Esq., by whose unfortunate death science has sustained a grievous loss.

"*Locality and formation.*—On the south shore of the St. Lawrence opposite Three Rivers. Hudson River formation."—Billings, *loc. cit.*

Richmond formation, Madison, Indiana.

CRANIA LAELIA Hall.

Plate XXXIII, fig. 2.

Crania laelia Hall, 1866, 24th Rep. New York State Museum (advance sheets), p. 220, pl. vii, fig. 16.

"Shell small, discoid or moderately convex on the upper valve, somewhat narrowed towards the cardinal border. Apex of the dorsal valve minute, not prominent, situated about one-third the length of the valve from the cardinal margin.

"Surface marked by fine but very sharply elevated radiating striae, which are sometimes tortuous, and frequently increased by implantation. Ventral valve and interiors not observed.

"This is a distinct and well marked species, not easily to be mistaken for any other now known to me. Its nearest analogue is *C. crenistria* of the Hamilton group; but the striae are sharper, with the apex more appressed, and somewhat differently situated." —Hall, *loc. cit.*

This species is easily recognized by its sharp radiating striae.

1.41C2-3, D2, 3....1.12F3.

CRANIA SCABIOSA Hall.

Plate XXXIII, figs. 3-3a.

Crania scabiosa Hall, 1866, 24th Rep. New York State Museum (advance sheets), p. 220, pl. vii, fig. 15.

"Shell somewhat less than medium size, usually discoid or little elevated, but sometimes prominent, irregular in outline; margin thickened. Apex of dorsal valve eccentric, varying in different individuals. Surface of valve having usually strong lamellose lines of growth, which are sometimes obscured by the roughness of the substance to which the specimen is attached, showing through the shell or causing it to grow irregularly, by which it often assumes the features of the foreign body. Ventral valve unknown.

"This species is not uncommon; usually found attached to shells of other brachiopoda, and sometimes on CHAETETES and other substances. The valves of *Orthis lynx, Orthis occidentalis* and *Streptorhynchus planumbona* are often found with several individuals so crowded together as to give quite an irregular outline to the specimens."—Hall, *loc. cit.*

1.38P....1.33A3....1.41C1, D2, E6....1.12A2, D1-6.

DALMANELLA TESTUDINARIA var. EMACERATA Hall.

Plate XXXIII, figs. 5, 5a.

Orthis emacerata Hall, 1860, 13th Report of the New York State Museum of Natural History, p. 121. (Not figured.)

"Shell semielliptical, length and width about as five to seven; hinge-line nearly equalling the width of the shell. Dorsal valve flat, with a slight depression down the center; area extremely narrow. Ventral valve depressed convex, slightly elevated at the beak, which is inclined over the area, but scarcely incurved; an undefined elevation extending from the umbo towards the front, and sometimes quite to the margin of the shell; area narrow, almost linear.

"Surface finely striated; striae bifurcating, curving upwards, and running out on the hinge-line. Interior of the dorsal valve with two small teeth and a small cardinal process; valves thin.

"This species has the form and general characters of *Orthis testudinaria*; but the shell is much thinner than that species ordinarily is in the same formation, and the striae are finer, there being at least twenty more on the margin in shells of equal size. The depression in the center of the dorsal valve, and elevation in the center of the ventral valve, are far less conspicuous or scarcely marked in some specimens, while the hinge-line is always proportionally longer than in *O. testudinaria.*

"*Geological formation and locality.* In the shales of the Hudson River group near Cincinnati, Ohio. Received from Mr. Carley, and also collected in Iowa and Wisconsin."—Hall, *loc. cit.*

The larger size, greater proportional length of the hinge, and mesial depression of the dorsal valve will sufficiently distinguish this species from the associated *D. multisecta.* It is much less abundant than the latter species.

5.9A14, 37....Also from the Eden shales on Tanner's Creek near Guilford.

DALMANELLA TESTUDINARIA var. MEEKI (Miller).

Plate XXXIII, Figs. 6-6g.

Orthis meeki Miller, 1875, Cincinnati Quarterly Journal of Science, vol. II, p. 20.

"Shell small, plano-convex, rather depressed, transversely truncato-suboval, the length being about five sixths its breadth; hinge line, perhaps, always a little shorter than the greatest breadth of the valves; lateral margins generally rounding to the hinge, most prominent at, or a little behind, the middle, and rounding to the front, which is usually somewhat straightened, or very faintly sinuous at the middle; or, presents a regular semi-circular outline.

"Dorsal valve nearly flat, or slightly convex on each side of a shallow, mesial sinus, that commences very narrow at the beak, and usually widens rather rapidly to the front; beak very small, scarcely projecting beyond the edge of the area, and not incurved; area low at the middle, and narrowing off to nothing at the lateral extremities of the hinge, slightly arched, and directed obliquely backward; foramen very small, and filled by the cardinal process. Interior very shallow, and provided with a slender mesial ridge that extends about half way forward from the hinge, between the muscular impressions, which are not usually well defined; scars of posterior pair of adductor muscles smaller, and usually deeper, than the anterior, and situated close back under the brachial processes; those of the anterior pair three or four times the size of the posterior, suboval in form, and extending to near the middle of the valve; cardinal process very small and trifid; brachial processes, comparatively rather stout and prominent; internal surface having the radiating striae of the exterior rather distinctly impressed through, as it were, in consequence of the thinness of the shell, and finely granular, the granules being apparently connected with the punctate structure of the shell.

"Ventral valve compressed convex, the greatest convexity being near, or a little behind, the middle, along a more or less prominent undefined ridge, that sometimes, but not always, imparts a subcarinate appearance to the central and umbonal regions; beak small, projecting somewhat beyond that of the other valve, abruptly pointed, and rather distinctly arched, but not strongly incurved; area about twice as high as that of the other valve, and with its sharply defined edges sloping to the lateral extremities of the hinge, directed and arched obliquely backward with the beak; foramen having near the form of an equilateral triangle, but rather narrowed upward to the apex of the beak, and partly occupied by the cardinal process of the other valve. Interior showing the teeth to be moderately prominent; concavity for the muscular impressions very shallow, small, somewhat bifid anteriorly, and not defined by a very distinct marginal ridge; scars of divaricator muscles apparently narrow, and situated on each side of a shallow mesial depression, which seems to include, far back at its posterior end, those of the very small adductors, merely separated from each other by a hair line; impressions of the ventral adductor muscles apparently wider and shorter than those of the divaricators; striae and fine granules of the interior as in the other valve.

"Surface of both valves ornamented by numerous, distinct, radiating striae, that usually bifurcate about three times between the beak and the free margins; posterior lateral striae so strongly curved that a part of them run out on the hinge line. Numerous, very minute, regularly disposed, concentric lines may be seen by the aid of a magnifier, most distinctly defined in the furrows between the much larger radiating striae; while a few distant subimbricating, stronger marks of growth are usually seen in the adult shells.

"Length of a medium-sized, mature specimen, 0.60 inch; breadth, 0.75 inch; convexity, 0.25 inch."—Miller, *loc. cit.*

Miller says further that his species is the same as described and figured by Meek in the Ohio Paleontology as *Orthis emacerata* Hall, and that Meek's specimens came from Hamilton, Butler County, Ohio, and (probably) from Cincinnati, Ohio. Meek does not say *where* his types came from. He says that the species occurs at Cincinnati, at an elevation of 250 feet above the Ohio River, and that he has specimens differing but little from the typical form, from higher horizons, both at Cincinnati and Butler

County, Ohio. He also states that he has specimens from near the top of the (Cincinnati) group from Hamilton, Ohio. *Presumably* his types came from these localities.

In regard to the status of this species, it may be said first of all that it is *not Orthis emacerata* Hall, as supposed by Meek. A further complication has arisen, however, owing to the fact that James, in 1879, four years after Miller described his species, described under the name of *Orthis jugosa,* the common form from the Richmond formation, which was included by Miller in his species *meeki.* I am making an effort to obtain both James's and Miller's types in order to ascertain whether there is really a nameable difference between the two forms. In the meantime, if the specimens figured by Meek represent the Cincinnati form, I should be inclined to the opinion that there is very little difference, except in size, between them and the Waynesville form. I believe that I could match any of Meek's figures with specimens from Weisburg, Versailles, or Madison, Indiana. I have reproduced several of Meek's figures, and have given several figures of specimens from Versailles and Madison. The latter would certainly be *D. jugosa,* if we recognize James's name, but for the present I prefer to retain them under Miller's name of *D. meeki.*

1.34A3, 4, 5, 7, 8, 9, 10, 11, B4-5....1.41B1, 2....1.12D1-6, E3.

DALMANELLA TESTUDINARIA var. MULTISECTA (Meek).

Plate XXXIII, figs. 4-4c.

Orthis emacerata var. multisecta Meek, 1873 (James in MS.), Pal. Ohio, I, p. 112, pl. viii, figs. 3a-d.

"This form, although somewhat variable, differs from the last [*Orthis emacerata*] in being smaller, slightly less transverse, and in having its dorsal valve generally flatter, with usually, but not always, a less defined mesial sinus; and its ventral valve with a less prominent mesial ridge. Its surface striae are also a shade finer, and the minute concentric lines in the furrows between the striae more distinct. The granules of its entire internal surface are likewise a little finer and more crowded.

"The cavity for the reception of the muscular scars of its ventral valve is also proportionally a little smaller, and sometimes differs from that of the last, in wanting the bilobed character anteriorly, seen in the same part of that shell. There are, again, some slight differences in the form and proportions of the muscular scars of its other valve, but I am not quite sure that these are constant.

"The external differences mentioned above give these shells a perceptibly different aspect, when we place, side by side, a trayful of each, the form under consideration having altogether a more delicate and less robust appearance. It may be specifically distinct from the last, but I am not clearly satisfied that it is more than a variety of the same. It differs from Mr. Davidson's figures of *O. testudinaria* quite as strongly as the last; but it is possible that both may be only varieties of that species."—Meek, *loc. cit.*

The description given by Meek of this pretty little Brachiopod is entirely adequate. *D. multisecta* is a smaller species than any other representative of the genus in the Cincinnati region. Its nearly circular outline is also a feature that marks it off from the associated *D. emacerata.*

Dalmanella multisecta is the characteristic brachiopod of the Utica formation (Eden shale) of Ohio, Indiana and Kentucky. It is found in nearly every limestone layer in the formation, except in the very lowest part. In many of the layers of the middle and upper Utica this species completely fills the rock. The specimens illustrated are from the upper Utica at Guilford, Indiana, from the top of the railroad cut just south of the station. At this point the species can be obtained by the thousands, in every stage of development from nepionic shells to the adults.

5.9A2, 10, 14, 21, 27, 29, 31, 44....1.34Co, 5, 6, 7, 8, 9, 10, 11, 13....1.38A3, 5, 7, 9, 11, 13, 15, 17, 19, 23, 29, 31, 32, 33, 35, 45, 49, 59, 61.

DINORTHIS RETRORSA (Salter).

Plate XXXIII, figs. 7-7d.

Orthis retrorsa Salter, 1858, Mem. Geol. Surv. Great Britain, II, pt. I, p. 373, pl. xxvii, figs. 3, 4.

"Ventral valve gibbous, the center rather raised. Dorsal flat, broadly depressed along the middle, edge not recurved; beak suppressed; area at an obtuse angle with the valve.

"This variety, if it can be considered so, comes nearest the var. *subjugata* of Hall's descriptions; it is quite distinct from *O. anomala,* Schloth."—Salter, *loc. cit.*

This interesting Orthid seems to be confined to a single layer of the Arnheim formation, where it is fairly common. I can not believe with Davidson and others that this well marked form is merely a variety of *Orthis porcata* McCoy, neither do I entertain Meek's doubts as to its being the species named by Salter. The best available description is undoubtedly that of Meek in the Ohio Paleontology, from which I condense the following description:

Medium size, transversely suboval to subquadrate, the length being about four-fifths the breadth. Hinge-line shorter than the greatest breadth of the valves, with the lateral extremities abruptly rounded, or very obtusely subangular. Lateral margins more or less convex in outline, and rounding to the front, which is regularly rounded, or somewhat straightened along the middle. Valves decidedly unequal or concavo-convex. Dorsal valve evenly convex, most prominent near the middle with the anterior and lateral slopes more gradual than the posterior. Beak incurved; area of moderate height, more or less strongly incurved so as to sometimes stand at right angles to the plane of the valves; foramen broadly triangular. Ventral valve convex at the point of the beak, and thence sloping toward the lateral and anterior margins; the anterior central, and sometimes the lateral regions, being more or less concave; beak obtuse or abruptly pointed, and strongly inclined forward; cardinal area broad-triangular, well defined, flat, and so distinctly inclined forward as to place the apex of the beak some distance in front of the hinge margin. Foramen narrow-triangular, being often a little higher than wide, and extending to the apex of the beak. Interior of the ventral valve with the muscular cavity quadrangular, deep, scarcely reaching to the middle of the valve, and sharply defined by a raised margin, which is perfectly straight and uninterrupted across the front, in some specimens, and reflected toward the beak in others, while its lateral margins are somewhat wavy. Ventral adjustor muscle scars moderately distinct from those of the long triangular diductors. Adductor scars well defined, subcordate, tapering anteriorly to a narrow point between the anterior extremities of the diductors. Hinge teeth apparently rather small and weak. Vascular markings consisting of two principal trunks, starting from the anterior-lateral angles of the muscular cavity, and each immediately dividing so as to send one branch obliquely outward and backward, with more or less subdivisions; and another forward with an inward curve, and also giving off more or less subdivisions on the anterior lateral side. Surface ornamented by rather coarse rounded radiating striae, some of which on the ventral valve are entirely simple, and others bifurcate once or twice; while on the dorsal valve they increase in number by the implantation of shorter ones between the longer. A few rather distinct lamellae of growth are usually seen near the free margins of adult specimens. Under a magnifier minuter concentric lines may be seen crossing the striae and interspaces; very minute granules are also present, having the appearance of minute spine bases that sometimes leave pits when entirely worn off.

1.34B4-5....I have also seen the species rather common at a similar horizon on Whitaker's Branch near Cold Springs, Indiana.

DINORTHIS SUBQUADRATA Hall.

Plate XXXIV, figs. 1-1b.

Orthis subquadrata Hall, 1847, Pal. New York, vol. I, p. 126, pl. xxxii A, figs. 1a-o.

"Subquadrate, the cardinal line forming one side, the sides and base being nearly straight, with the angles rounded; cardinal line less than the width of the shell, extremities curved; area small, partially common to both valves; foramen moderate, triangular, partially common to both valves; dorsal valve nearly flat or slightly depressed near the margin, elevated towards the beak, which is small and well defined; ventral valve regularly convex, with a shallow sinus along the center, producing a slight elevation of the dorsal valve in front; surface marked by uniform subangular radii, which bifurcate near the beak, and again towards the margin, those near the cardinal line curving upwards; radii crossed by fine elevated concentric lines, which are very distinct in the depressions between the rays.

"This form and the three succeeding ones [*O. Occidentalis, O. sinuata,* and *O. subjugata*] are often confounded; but if the following points are observed there will be little difficulty in distinguishing the one under consideration by the external characters, the internal markings being quite distinct.

"The form of a perfect specimen is subquadrate, as shown in the figures; the surface is evenly marked by radii which bifurcate twice, very rarely three times, before reaching the margin: the upper lateral ones curve upwards, so as often to run out upon the cardinal line, or the rounded slope near its extremity. This character is never observed in either of the following species. The visceral impression in the dorsal valve is subquadrangular, and broad below, the base being nearly on a straight line. The foramen of the ventral or convex valve is partially filled by a thick medial tooth, which projects above the plane of the area, and is deeply striated on the two sloping upper and outer sides. * * *"
—Hall, *loc. cit.*

This species is reported by Hall from Cincinnati (?) and Oxford, Ohio, Maysville, Kentucky, and Madison, Indiana. It is in reality strictly a Richmond form, and has never been found below the Liberty formation. Hall in his description has reversed the usage of the terms dorsal and ventral. Otherwise the description is quite satisfactory. The form is easily recognized by its subquadrate outline and depressed form. *D. subquadrata* is first met with a little above the base of the Liberty formation, where it is very abundant, being the dominant Brachiopod; and specimens are occasionally met with throughout the remainder of the Liberty and Whitewater divisions.

1.34A16, 17, 18, 19....1.41A4, 6, 7, 8, C1, 2-3, D1, 2, E2, 3, 6 ....1.12D1-6.

HEBERTELLA INSCULPTA Hall.

Plate XXXIV, figs. 2-2d.

Orthis insculpta Hall, 1847, Pal. N. Y., I, p. 125, pl. xxxii, figs. 12a-c.

"Shell resupinate; dorsal [ventral] valve depressed-convex; beak elevated, not incurved; cardinal line less than the width of the shell; area short; surface marked by fine elevated radii, which are bifid on the umbo, and again regularly bifid or trifid towards the margin of the shell; transversely marked by strong elevated concentric lines, which are particularly prominent between the radii, giving an indented or sculptured appearance to the surface; interior of the dorsal valve showing marks of the visceral impression, which is peculiarly sculptured.

"This species, of which a single valve only has been seen, is so peculiarly marked as not to be mistaken among all the other species of ORTHIS in the lower rocks. The cavity under the foramen is large and deep, marked on its lower and outer extremities by two pointed sacs, and margined by a thickening of the shell around; the visceral impression on the outside of this cavity is of a double auricular form, and sculptured by curved elevated lines. The inner margin of the shell is impressed by the outer radii.

"This very peculiar form is usually associated with the following forms in the Blue limestone of Ohio. [*O. dichotoma, O. subquadrata, O. occidentalis,* etc.] Its very beautiful sculpture, both internally and externally, is sufficient to distinguish it from all other species in the rock."—Hall, *loc. cit.*

The figures given herewith will convey a much better idea of the peculiarly striking vascular markings of this species than any amount of description. Externally the marked crenulation of the striae by strong concentric lamellae is the most conspicuous feature. The general arrangement of the muscular impressions is very much as in *Hebertella occidentalis* and *H. sinuata.*

The most interesting thing with regard to this species is its limited range. So far, with a few possible exceptions, it has been found only in a zone a few feet thick at the base of the Liberty formation. It is taken by Foerste and Nickles to mark the base of this formation. I have collected a specimen from the Whitewater division, at Richmond, that although not well preserved, seems from its external characters to belong to this species. It has never been found, so far as I am aware, below the base of the Liberty formation.

1.34A13a, 13b, 14a, 14b, 15a, 16....1.41B3, C2-3, E4.

HEBERTELLA OCCIDENTALIS Hall.

Plate XXXIV, fig. 4.

Orthis occidentalis Hall, 1847, Pal. New York, I, p. 127, pl. xxxii A, figs. 2a-m; xxxii B, figs. 1a-i.

"Resupinate, transversely somewhat oval, or longitudinally semioval; length and breadth about as 5 to 7; cardinal line equal to the greatest width of the shell; area large, triangular, partially common to both valves; foramen narrow, triangular, reaching to the apex of the dorsal valve; dorsal valve convex towards the beak, and usually flattened or slightly convex towards the margin (in old shells a broad depression in front); beak much elevated, straight, not incurved; ventral valve regularly convex, with a slight depression along the center; beak slightly projecting beyond the cardinal line, and incurved; surface marked by subangular radii, which bifurcate at one-half or two-thirds the distance from the beak to the base; radii crossed by fine sharp elevated concentric lines, which are usually well preserved in the spaces between the radii.

"This species, in some of its phases, approaches in general aspect to the last [*O. subquadrata*], but differs in essential particulars. The length from beak to base is proportionally less than in the last; the depth of the two valves together, when not compressed, is greater; the beak of the dorsal valve is more elevated, the area larger and foramen longer; the beak of the ventral valve is likewise a little more incurved; the radii are stronger, and do not bifurcate near the beak; the concentric elevated lines are sharper and finer; the striae are straight and direct, the last ones not bending upwards as in *O. subquadrata*. As the shell becomes advanced, the dorsal valve presents an increasing depression towards the margin, which finally becomes a broad, not distinctly defined sinus. At the same time the slight depression in the center of the ventral valve, similar to that in the last species, does not reach the margin, and finally becomes obsolete. The slight elevation in front, shown in the last, is exactly reversed in this species.

"These characters, when once observed, will not fail in enabling the student to identify the species, and to distinguish it from any others in the same geological position.

"The internal structure is not as well known as in the last, the interior of the dorsal valve not having been seen. The interior of the ventral valve corresponds in general character to the last; the small medial ventral tooth does not, however, reach as high as the plane of the area, and it is thin and sharp, while the last is thick. The interior surface is marked nearly to the beak with the impressions of the external radii; while in the last these markings reach only a short distance from the margin."—Hall, *loc. cit.*

Here, as in all of Hall's earlier descriptions, the terms dorsal and ventral are used in the opposite sense from their present usage. Between this and *Hebertella occidentalis* var. *sinuata* there is a perfectly graded series of intermediate forms. The character that I have taken as diagnostic of the species *occidentalis* is the presence of a slight sinus in the dorsal valve, usually most conspicuous at a point about a third of the distance from the beak to the front margin, although sometimes extending all the way from a little in front of the beak to the front margin, and with the sinus of the ventral valve producing a pronounced indentation of the margin. The variety *sinuata*, on the other hand, has typically a small fold on the dorsal valve, beginning near the point of greatest convexity of the valve and extending forward to the frontal margin. Transitional forms between the two species are seen in the lower part of the Richmond formation.

Hebertella occidentalis is especially characteristic of the Whitewater division of the Richmond formation, where it is found quite constantly associated with both the long-hinged and the short-hinged (*P. senex*) forms of *Platystrophia acutilirata*. In the upper part of the Liberty this form is found, but its place is soon taken in the lower beds by the small form of *H. sinuata*.

1.34A18, 19, 20, 21, 22....1.41A4, 5, 6, 7, 8, C1, 2-3, D1, 2, 3, E1, 2, 3, 4, 5, 7....1.12D1-6, F3.

HEBERTELLA OCCIDENTALIS var. SINUATA Hall.

Plate XXXIV, figs. 3-3e.

Orthis sinuata Hall, 1847, Pal. New York, I, p. 128, pl. xxxii B, figs. 2a-s.

"Semioval, with a sinus in front; cardinal line scarcely equal to the width of the shell; dorsal area large, triangular; foramen triangular, reaching to the beak, the upper margins sloping rather abrutply from the beak; ventral area narrow linear, foramen broad triangular, with a distinct medial tooth, which reaches as high as the area; dorsal valve convex, its greatest elevation at the point of the beak, which is acute; a depression along the center, which becomes a sinus in older shells; ventral valve regularly convex in young specimens, gibbous, somewhat emarginate and elevated in front in older specimens; surface marked by strong, regular, rounded striae which bifurcate in a nearly uniform manner about half way to the base; striae crossed by elevated sub-imbricating concentric lines. A few imbricating lines of growth are distinct toward the margin of the older shells.

"This species is distinguished from the last by the stronger and more prominent striae, which are likewise more regularly bifurcating. The beak of the dorsal valve is more elevated and acute, giving a greater height to the dorsal area. The ventral valve is about equally convex or gibbous with the last, while it never exhibits any depression along the center. The depression or sinus in the dorsal valve is usually more abrupt, deeper, and often accompanied by a corresponding elevation on the ventral valve, which does not occur in the preceding species [*O. occidentalis*]. The young shells of the species under consideration are more gibbous that the last, and have the beak of the dorsal valve more elevated and acute, differing conspicuously in this respect from the previous one.

"The variations produced by age, and the difficulty of obtaining a series of specimens, often produce a confusion in regard to these similar species, and it will frequently be found a difficult task to make the proper disposition of specimens.

"In the young shells of this species, looking upon the ventral valve, the beak of the dorsal valve is distinctly seen projecting beyond the umbo; but as the shell grows older, this part of the ventral valve becomes gibbous, and projects beyond the line of the beak of the opposite valve."—Hall, *loc. cit.*

The terms dorsal and ventral are here used in the opposite sense from their present signification. This variety is to be distinguished from the species *occidentalis* by the presence of a small fold in the dorsal valve where the latter species has a small sinus. The other distinguishing characters mentioned by Hall will be found to be unreliable, except in the typical Lorraine form of the variety *sinuata.*

This variety was formerly supposed to be restricted to the Lorraine. It is, however, present in the Lower Richmond formation, being replaced in the Whitewater division by the species *occidentalis.* In the Elkhorn division of the Richmond formation, the large, Lorraine type of *H. sinuata* recurs in association with *Platystrophia lynx* (var. *moritura*) and *Platystrophia laticosta.*

1.33A3....1.34A10, 12, 13, 14, 15, 16, B1-3, C14a, 14b.... 1.41A2, 10a, 10b, B3....1.12E3, D1-6, F3, A2.

LEPTAENA RHOMBOIDALIS Wilckens.

Plate XXXIV, figs. 5-5d.

Conchita rhomboidalis Wilckens, 1769, Nachricht von selten Versteinerungen, p. 77, pl. viii, figs. 43-44.

I have been unable, after repeated efforts, to obtain a copy of the above publication in which the original description of this species occurs. I shall be under the necessity, therefore, of departing from the usual procedure of first giving the original description of the species.

This species has been so many times described and is so characteristic that with the excellent figures given herewith very little in the way of further description will be needed.

Leptaena rhomboidalis has the ventral valve convex and the dorsal valve concave as in *Rafinesquina.* In contour the shell presents a very considerable degree of variation. Some specimens are twice as broad as long, while in others the length and breadth are nearly equal. The hinge line is nearly straight, but may make a very slight bend at the beak in some specimens. The area of the dorsal valve is very narrow and of about the same breadth throughout its length. The area of the ventral valve is somewhat broader, especially at the beak. The angle which the two areas make with each other varies with the age of the specimen from an obtuse to an acute angle. At the beak of the ventral valve, in well preserved material, is a well defined circular foramen. The surface of both valves is covered with fine radiating striae, and is especially characterized by broad, rounded, concentric undulations or rugae to the number of five or six (more or less). This latter character gives to the shell an appearance that is extremely striking, and unlike that of any other brachiopod in the Cincinnati region. The striae are crossed by fine concentric lines, giving the entire surface of the shell a beautifully crenulated appearance. The front portion of the valves is abruptly bent dorsad, sometimes at right angles to the plane of the posterior portion of the valves. This feature is not as prominent in the Richmond group specimens as in those of higher formations (Niagara, etc.).

The interior of the ventral valve has a well defined muscular platform extending about half way from the beak to the front margin and quite similar in shape to that of *Rafinesquina alternata*. It is margined by a well defined ridge, and has a low indistinct mesial elevation.

The cardinal process in the interior of the dorsal valve is prominent and bifid, and projects well above the hinge-line. From in front of the process a low round septum extends forward to the geniculation of the valve. Immediately in front of the process this ridge gives off on either side a thick lateral branch that bends outward and then inward so as to enclose a nearly circular pit that lodges the adductor muscle—one on each side of the median septum. Impressions of the Brachia are occasionally seen on the interior surface of this valve.

This species, as ordinarily understood, presents one of the most extraordinary examples of the persistence of a species known. It is known from the Trenton, is common in the Richmond formation, is a characteristic species of the Niagara series, is common in portions of the Devonian rocks and is known from the lower part of the Mississippian system. This is indeed remarkable, if all of these forms are to be referred to a single species. On this latter point there is room for a good deal of question. For my part, I am inclined to think that a careful study of all of these forms will show that they fall into a number of well defined species.

In the Cincinnati series the species is found only in the Richmond formation, and not by any means in all of the members of that formation. It especially characterizes the upper part of the Waynesville formation, but extends for from ten to twenty feet up into the Liberty formation. In the top of the Waynesville formation the species is very abundant.

1.34A10, 11, 12, 13a, 13b, 14a, 14b, 15a....1.12D1-6, E3.

LEPTOBOLUS LEPIS Hall.

Plate XXXIV, figs. 6, 6a.

Leptobolus lepis Hall, 1871, 24th Report of the New York State Museum, p. 226, pl. vii, figs. 19, 20.

"Shell minute, ovate, or broadly elliptical in outline, about three-fifths as wide as long, and seldom exceeding seven-hundredths of an inch in length; moderately convex, the greatest convexity being about one-third of the length from the beak; ventral area thickened; pedicel groove strongly defined; muscular impression broad, extending more than one-third the length of the valve; muscular ridges of the dorsal valve strongly marked, the central one extending two-thirds the length of the shell, the lateral ones diverging from each other at an angle of about forty-five degrees and extending nearly to the middle of the valve. Extremities bifid.

"Surface of valves concentrically marked by fine lines of growth."—Hall, *loc. cit.*

The types of this species are from the Cincinnati group at Cincinnati, Ohio.

1.34C14a.

LINGULA COVINGTONENSIS Hall and Whitfield.

Plate XXXIV, fig. 7.

Lingula covingtonensis Hall and Whitfield, 1875, Paleontology of Ohio, vol. II, p. 67, pl. i, fig. 1.

"Shell rather below the medium size, broadly and very regularly oval, or elliptical in outline, the breadth and length being as three to four, the apex of the shell scarcely more pointed than the basal margin; surface of the valve very regularly convex transversely, but in a longitudinal direction much more prominent toward the beak, becoming gradually more flattened toward the front of the shell.

"Surface of the shell marked by sharply elevated, rather distant, concentric lines; without other markings of any kind; substance of the shell very thin.

"The example used in description appears to be a dorsal valve, and is probably somewhat shorter, and more rounded posteriorly, than the ventral valve. The shell is somewhat remarkable for its regular oval form and symmetrical outline, and in this respect differs from any shell of the genus with which we are acquainted."—Hall and Whitfield, *loc. cit.*

The type is from about twenty-five to fifty feet above low water level of the Ohio River at Cincinnati, Ohio.

I am not sure that I have detected the species in Indiana. Some imperfect specimens from near the water level of the Ohio, opposite the mouth of the Miami River, may belong to this species.

PLATYSTROPHIA ACUTILIRATA (Conrad).

Plate XXXV, figs. 3-3d.

Delthyris acutilirata Conrad, 1842, Jour. Acad. Nat. Sci. Philadelphia, VIII, pt. II, p. 260, pl. 14, fig. 15.

"Ventricose, with about thirty-two sharp, very prominent ribs, and four larger costae on the mesial fold of the upper valve, which is elevated, flattened at the sides, and convex on the back; hinge extremely winged and acute; inferior mesial fold very profound; beaks nearly equally prominent; cardinal area moderate, widest on the inferior valve, profoundly impressed or obliquely inclined.

"*Locality.*—Falls of the Ohio River, Kentucky. Silurian shale."—Conrad, *loc. cit.*

The locality given by Conrad for this common Richmond group species is in error.

This is the most anomalous in form of any species of the Orthidae, and one can readily pardon the early describers for referring it to the genus *Delthyris* (*Spirifer*), for its superficial resemblance to a *Spirifer* is all but complete. The triangular foramina of both areas would, however, distinguish it from that genus, and the internal characters are altogether different.

As shown in the writer's paper on the Morphogenesis of Platystrophia, *P. acutilirata* is a derivative of *P. lynx* through *P. laticosta.* The intermediate forms may be seen in the basal part of the Liberty formation, where *P. laticosta* is, in places, very abundant. All of the specimens of *acutilirata* found at this horizon are of the decidedly angular form of *P. laticosta* and usually not as acuminate or as greatly produced at the cardinal extremities as the form found farther up in the formation and in the lower part of the Whitewater division. The latter form has the plications more rounded and the fold of the dorsal valve and sinus of the ventral valve less strongly accentuated. At the same time the cardinal extremities are sometimes so produced as to cause the breadth to be as great as three times the length of the shell. The angle between the hinge-line and the lateral margin may, in such specimens, be as small as 40°. The number of plications varies from 18 or 19 to 37 or 38, of which three are almost invariably in the sinus, and four on the fold.

For the short winged (gerontic) form found in association with *Rhynchotrema dentata* in the upper part of the Whitewater division of the Richmond, I have proposed the varietal name of *senex*, and it will be found next described under that caption.

1.34A11, 12, 13, 14, 15, 16, 17, 18a, 21, 22, 23....1.41A4, 5, 6, 7, 8, C1, 2, 3, D1, 2, 3, E2, 3, 4, 5, 6, 7....1.12D1-6, F3.

PLATYSTROPHIA ACUTILIRATA var. SENEX n. var.

Plate XXXV, figs. 4-4c.

Platystrophia acutilirata, gerontic form, Cumings, 1903, Amer. Jour. Sci., 4th ser., XV, pp. 36, 37.

This form is so characteristic of the upper part of the range of *Platystrophia acutilirata* that it seems to me best to give it a varietal designation, although in 1903, when I first called attention to the form, I did not think it necessary to call it by any special name. The features that distinguish this shell are as follows:

Though *P. acutilirata* is a much smaller shell than *P. lynx* of the Lorraine, yet the thickening of the shell in gerontic stages is greater both relatively and absolutely. The acuminate cardinal extremities are so thickened that this region of the shell becomes filled up with shelly deposit. The thickening of the central and anterior region of the shell is very great, so that the actual room left for the lodgement of the soft organs of the animal is less than in unthickened shells of a much lower index, and less both relatively and absolutely in gerontic stages than in ephebic stages of the same individual. The convexity of the shell is also considerably greater than in any other type of *Platystrophia*, the height being in extreme cases 1.5 greater than the length, while in *P. lynx* the extreme is 1.04, or height and length nearly equal, and in *P. laticosta* it is 1.14.

The changes in contour due to senescence are profound. The cardinal angle (the angle between the hinge line and the lateral margin of the shell) may be in normal acuminate types of *Platystrophia acutilirata* as low as 45° or even in some cases less; but in the variety under consideration it becomes as great as 84° or even 90°; the extreme variation is perhaps from 40° to 90°. This of course produces a most striking difference in the appearance of the shell, and is liable to cause the careless collector to confuse this variety with *P. lynx*, from which, however, it differs radically in derivation. Probably the onset of unfavorable conditions, which are manifest in the changed lithological character of the beds containing this variety, as well as in the coming in of a more strongly molluscan fauna, is largely responsible for the peculiar modification of the shell in *Platystrophia*, which characterizes the present variety.

1.41A8, D3, E1, 2, 3, 4....1.60H11.

PLATYSTROPHIA COSTATA Pander.

Plate XXXV, figs. 6, 6a.

Porambonites costatus Pander, 1845, Beitrage zur Geognosie des russischen Reiches, p. 96, pl. xi, fig. 3.

I have been unable to obtain the publication in which the original description of this species is given. In 1902 I had an opportunity to consult this rare work and I have published a tracing of the original figure, in my memoir of the genus *Platystrophia*.

This little species, the *P. dentata* of Meek (*P. crassa* James) is characterized most of all by its small plump shell with only one plication in the sinus and two on the fold. The hinge line is usually slightly shorter than the breadth of the shell farther forward. The form of the areas and the strength of the plications is relatively about the same as in the other species of the genus.

Very little is known about the interior of the valves.

I have not collected any specimens of the typical form of this species from any point in Indiana. In the lower part of the Lorraine I have found an occasional specimen suggesting a diminutive variety of this species, and I have listed them under this name. They have the same number of plications and one plication in the sinus, but are not as plump as the typical form.

The typical (American) form is found at Cincinnati in the Fairmount division of Nickles, that is in the lower part of the Lorraine division, often, as I am informed, in considerable numbers. The Dyer collection, at Harvard, contains great numbers of this species, from Cincinnati.

1.34C13, 14a.

PLATYSTROPHIA LYNX (Eichwald).

Plate XXXV, figs. 1-1g, 7-7c.

Terebratula lynx Eichwald, 1830, Naturhistorische Skizze von Lithauen, Volhynien und Podolien, p. 202, foot note. (Not figured.)

"*Spirifer, cardine elongato, recto, vertice utriusque valvae prominulo, utraque valva sulcata, stratis singulis transversis ex* *testae incremento exortis, numerosissimis, margine dentato; media parte unius valvae prominula, quadrisulcata, alterius vero parte eadem exclavata, profunda.''*—Eichwald, *loc. cit.*

I have pointed out in my paper on the Morphogenesis of Platystrophia that in all probability the original types of both *P. biforata* and *P. lynx* belong to the *biplicate* form of the genus. The evidence for this is the fact that all of the Russian specimens, whether of *P. biforata* or *P. lynx,* seen by me are of the form mentioned. It is doubtful if the question could be settled any more satisfactorily even by an examination of the original types themselves, since the critical character which distinguishes the biplicate and triplicate types of the genus, namely the method of origin of the plications of the fold and sinus at the beaks of the valves, is quite likely to be obliterated in the genotypes, which in the case of both *P. biforata* and *P. lynx* were found in the drift. However this may be, there is no ground upon which a distinction may be based between the two types excepting the one mentioned. In this country the form so common at the tops of the hills at Cincinnati has always been referred to the species *P. lynx.* This is the form which presents gerontic modifications and consequently exceptional thickening of the shell and an exceptional robustness of contour, as pointed out in my memoir on the genus. It does as a matter of fact closely resemble in general appearance the Russian form to which Eichwald applied the name of *Terebratula lynx.* If the Russian form is of the same biplicate type as *P. biforata* of Schlotheim, there is no reason for separating the two specifically, and the name *lynx* falls to the ground unless we retain it as I have done for the multiplicate forms of the American Ordovician having *at the beak* one plication in the sinus and two on the fold, and at the front usually three plications in the sinus and four on the fold. *P. biforata* will then indicate the form with two plications in the sinus and three on the fold *at the beaks* and a variable number further forward. The reasons for this restriction are fully set forth in my paper on the genus and cannot be repeated here. The usual distinction which paleontologists have attempted to make between *P. biforata* and *P. lynx,* based on the general form and number of plications of the shell is of no value whatever in a species so variable. *P. lynx* as thus redefined by me will include not only the Cincinnati form mentioned above, but all American Ordovician forms having usually more than two plications in the sinus at maturity, and a hinge line of moderate length, together with a moderately low fold and sinus. This includes forms heretofore referred to both *P. lynx* and *P. biforata* by workers in this country. The only American Ordovician form that belongs to *P. biforata* as above defined is a small form found in the basal part of the Ordovician in the Champlain basin and Canada. The distinction between *P. lynx* and the other associated forms in the Ordovician rocks of this country will be sufficiently evident from the figures and descriptions of these associated forms, and the present species may therefore be passed over without further comment.

The range of *Platystrophia lynx* is considerable. Small, but typical forms are found commonly in the Trenton of New York, Canada, Minnesota, Kentucky, Tennessee, etc., and the species is very common in the Lorraine. I have shown also that a variety of this species, very closely related to the typical form (var. *moritura*) occurs in the extreme upper part of the Richmond formation. In the Indiana region the chief horizon of *Platystrophia lynx* is in the upper part of the Lorraine, where it is often very abundant and of large size. The best locality known to me for obtaining large numbers of this species is at Vevay, near the tops of the hills. Here I have collected thousands of good specimens. Nowhere in Indiana have I found more than a very few specimens of the very gibbous form of this species that characterizes the top of the Lorraine on the highest hills at Cincinnati (Mount Auburn). I may remark in this connection that at Georgetown, 40 miles east of Cincinnati, along Straight Creek below Arnheim, the zone characterized by the gerontic *lynx* seems to be separated by a very considerable thickness of rock from the zone of the normal form of this species, and along Tanner's Creek the only specimen of the gerontic form that I have seen is also from a horizon considerably above that of the normal form, in what I have called the *Rafinesquina* zone. In his paper on the Geology of Cincinnati Nickles lists *P. lynx* from the Mt. Auburn beds only, with a variety from the Bellevue beds, some 60 feet lower down in the section. What he means by this variety, I do not profess to know. If it is the normal form of the species, the two are evidently separated in the Cincinnati section by about the same interval as in the other sections mentioned, and the Bellevue would correspond to the top of my *Platystrophia* zone.

1.33A3....1.34B1-3, 14b....1.12A2....1.38Ba-h.

PLATYSTROPHIA LYNX var. CYPHA (James).

Orthis (*Platystrophia*) *cypha* James, 1874, Cin. Quar. Jour. Sci., vol. I, p. 20. (Not figured.)

"Shell medium size; extremely gibbous; hinge line forming spine-like projections, being over two thirds longer than the greatest breadth of the shell below; shell broader than long; convexity equaling the body below the hinge extensions; cardinal area narrow, and finely striated at right angles with the length. Dorsal valve, remarkably elevated mesial fold, with slopes commencing a little below the beak, and extending to the front, at an angle of about 80 degrees to the main body of the shell, where they turn at nearly right angles and continue to the free margins; beak incurved, not elevated above the other valve; the mesial fold consists of two costae. Ventral valve, beak incurved, not elevated, nearly in contact with the other valve. Sinus very profound, extending to the front, which is bent over to nearly half the thickness of the shell beyond the cardinal line of the dorsal valve; one strong elevated plication in the center of the sinus, and an obscure rudimentary one on each side; lateral slopes concave.

"Twenty-two to twenty-six angular costae on each valve, about eight of which commence on the cardinal line, and do not extend to the beak.

"The line of junction of the two valves is nearly flat, or slightly rounded, and has a remarkably zig-zag appearance, forming, where the sinus and mesial fold join, the letter W.

"Interior unknown.

"Width along the cardinal line one and a half inches, half way below the hinge line less than one inch; length three quarters of an inch.

"This shell resembles somewhat some of the larger specimens of *O. crassa,* Meek, but it is more gibbous, has a more profound and lengthy sinus, greater length of hinge line, and finer and more numerous costae."—James, *loc. cit.*

I have recently received from Dr. Weller, of the University of Chicago, the type lot of this variety from the James collection. Among the several specimens represented in this type set are a couple corresponding exactly to my form *unicostata,* mentioned and figured in my paper on the genus *Platystrophia,* one fairly typical though rather short example of *P. acutilirata,* and a specimen of *P. laticosta.* Since the description given by James applies especially to the form with one plication in the (very profound) sinus (my form *unicostata*), it may be well to recognize James' name as a varietal designation. The variety differs from the typical *laticosta* only in the somewhat greater depth of the sinus, and in the presence of only one plication in the sinus. It does not bear any close relation to *P. costata* (the *P. crassa* of James).

I have usually found the form in the upper part of the Lorraine, sometimes in association with *P. lynx* and *P. laticosta.*

PLATYSTROPHIA LYNX var. LATICOSTA (Meek).

Plate XXXV, figs. 2-2b.

Orthis (*Platystrophia*) *laticosta* Meek, 1873, Pal. Ohio, vol. I, p. 116, pl. x, figs. 4a-f.

"This form scarcely attains to more than two-thirds the bulk of the largest specimens of the var. *lynx,* and is always less gibbous, proportionately wider on the hinge line, with more angular posterior lateral extremities, and, even in the largest individuals, it is a much thinner shell. It likewise differs in having its mesial sinus wider and much more profound at the front, and its mesial fold more elevated and angular; while its lateral slopes are decidedly more compressed, those on each side of the sinus being always concave, and the margins of the sinus very prominent and angular, which, together with the prominence of the mesial fold, and the greater length of the hinge line. impart a general angularity of appearance not seen in the var. *lynx.* In the sinus there are nearly always three plications, the lateral two being smaller than the middle one, or sometimes rudimentary; while occasionally one of them is obsolete, leaving the large one, as usual, in the middle, and a smaller one on one side only. The mesial fold has generally four plications (never more), the middle two being usually larger and more prominent than the others, and separated by a larger and deeper furrow. Its lateral slopes have generally only from five to seven large, simple, angular plications on each side of the fold and sinus; these being decidedly larger than on specimens of the var. *lynx,* of corresponding size.

"Internally, the ventral valve of this variety only differs from that of the var. *lynx,* in having the cavity for the muscular scars much less deeply impressed, owing to the fact that the shell did not thicken within, as in that form, as it advanced in age. The interior of its dorsal valve shows the same rudimentary cardinal process; while its muscular scars (which I have not seen in this valve of the var. *lynx*) are moderately defined, the posterior pair being corrugated, and much larger, as well as more widely separated, than the anterior.

"In figuring this variety in the first volume Paleont. New York, Prof. Hall compares it with the var. *dentata* of Pander, mentioning some points of difference. It attains a much larger size, however, than that variety, and differs in having nearly always three plications, instead of only two, in the sinus, which is deeper, and its mesial fold more prominent, thus giving the general aspect of the shell greater angularity of outline.

"The specimens for which Mr. James retains the name *O. profundo-sulcata*, in his list, are much smaller than the average size of the form here under consideration; but, with that exception, and their usually rather shorter hinge, and somewhat less compressed lateral slopes, they seem to me to differ very little, if any, from specimens of the same size of the variety under consideration. On the other hand, they only differ from the young of the variety *lynx* in generally having the mesial sinus deeper, and the fold more prominent, with, perhaps, in most cases one or two plications less on the lateral slopes. I have, therefore, found it very difficult to distinguish this as a variety from young or dwarfed examples of the varieties *lynx* and *laticosta*, though its more prominent fold, etc., bring it nearer the latter. Figs. 2 *a, b, c, d,* of plate 10 [of Meek's paper], show the form and usual size of this variety. It occurs 300 feet above the Ohio, at Cincinnati.

"Length of the largest example seen, 0.86 inch; breadth (at hinge line), 1.40 inches; convexity, 0.88 inch."—Meek, *loc. cit.*

In my memoir on the Morphogenesis of *Platystrophia,* I have discussed this variety and its phases at some length. In my paper with Mr. Mauck on the variation of *Platystrophia,* I have shown that this variety is connected by an indefinite number of intermediate forms with the typical *P. lynx.* A real new species is achieved in *P. acutilirata,* between which and *lynx* the present form is transitional.

Platystrophia laticosta is a very persistent form. It is found first in the lower part of the Lorraine—a very small form. In the middle and upper part of the Lorraine it is found in association with the normal form of *P. lynx,* and it is here also that the greatest number of transitional forms to the last named species are seen. In the top of the Lorraine, *P. lynx* disappears, but *P. laticosta* is still found sparingly in the Arnheim formation. In the greater part of the Waynesville formation all forms of *Platystrophia* fail. but in the upper part of this formation *P. laticosta* reappears in great numbers and typical form, though not attaining as great size as in the upper part of the Lorraine. From this point it continues till well toward the top of the Liberty formation. There is then another hiatus in the Whitewater division, where *P. acutilirata* is dominant. The final appearance of *P. laticosta* is in the Elkhorn division of the Richmond, where it is once more common, being here also once more associated with *P. lynx*. In the Saluda formation *P. laticosta* is also present at one or two levels. The occurrence of this fossil is thus seen to be extremely interesting.

1.33A3....1.34A8, 10, 11, 12, 18b, 22, B1-3, C13, 14a, 14b.... 1.41A10a, 10b, B1, 2....1.12A2, F3, D1-6, E3....1.38A63, 73, 83, Ba-h....1.60H11.

PLATYSTROPHIA LYNX var. MORITURA n. var.

Plate XXXV, figs. 5, 5a.

Platystrophia lynx, upper Richmond form, Cumings, Amer. Jour. Sci., 4th ser. XV, pp. 24, 25.

This form of *P. lynx* is perhaps sufficiently distinct to warrant a varietal designation; at least such a designation will be a matter of great convenience in as much as the form marks a very definite zone at the extreme top of the upper division (Elkhorn) of the Richmond formation. In my paper on the Morphogenesis of Platystrophia (1903) I have this to say of the present variety:

"In the extreme upper part of the Ordovician (Madison beds) of Richmond, Weisburg and Laurel, Indiana, the writer found a variety of *Platystrophia lynx* which is of exceptional interest. As is well known, the so-called Richmond beds (*Rhynchotrema* zone) contain exclusively the variety *acutilirata* associated almost constantly with *Hebertella occidentalis.* At about 50 ft. below the Clinton at Laurel and about 13 ft. to 15 ft. at Richmond, comes in a large and decidedly transverse variety of *P. lynx* associated with *Hebertella sinuata.* This association is a point of great importance since it shows that these two forms of *Platystrophia* and *Hebertella,* so constantly met with together in the Lorraine, have lived on together at some point through the *Rhynchotrema* hemera and here under a recurrence of favorable conditions reappear, the former with some modification, the latter with scarcely any.

"This form of *Platystrophia lynx* has eight to eleven plications on the lateral slopes, and the index may be as great as 1.9. A number of individuals (5 out of 100) show a reduction of the lateral plications of the fold and sinus. * * *

"That such a tendency to eliminate plications should affect 5 individuals out of 100, while in the Lorraine not more than one out of a thousand exhibits anything analogous, is certainly not without profound significance. There are in the present collection two specimens of *Platystrophia lynx* from Vevay, Indiana, both of which have three plications on the fold: One individual has four in the umbonal region; and the other never developed but three at any stage. The first has an abnormally low index (1.1) and bears every evidence of lateral cramping during growth. This would account for the failure of the fourth plication. The early growth stages of the second specimen also show an abnormally low index and the failure to develop the full number of plications is therefore probably due to the same cause. The Richmond shells, on the other hand, are very transverse at all stages, especially so in the adult. The correct explanation of the obsolescence of plications in this type as well as in the *laticosta* and *costata* types where it is still more pronounced, is probably to be sought in a readjustment of the brachia, producing an elevation and narrowing of the fold."—Cumings, *loc. cit.*

The distinctive characters of this variety by which it may be readily recognized, are the proportionally great breadth of the shell, and the less convexity of the valves, together with a proportionally narrower fold and sinus with a tendency to obsolescence of the lateral plications of the same. It can be distinguished from the *P. acutilirata* var. *senex,* by the much greater gibbosity of the latter and the presence of growth varices near the beak which have a decidedly lower cardinal angle than that of the adult. This latter character infallibly differentiates the two forms when the shell is well enough preserved to show it.

This variety of *P. lynx* presents the closest resemblance to *P. biforata* of the Silurian, of any form known to me. It is, however, very distinct from the latter species. *P. biforata* as restricted by me (loc. cit. pp. 41-44) has always *at the beak* three plications on the fold and two in the sinus, while *P. lynx* and all the other Ordovician species and varieties above the basal Trenton, have always *at the beak* one plication in the sinus and two on the fold, no matter how many there may be farther forward.

Since my paper on *Platystrophia* was published in 1903, I have made a more extensive study of the Saluda formation in which I supposed this species occurred, with the result that, as explained elsewhere, I have come to the conclusion that there is a well defined faunal zone above the typical Saluda, and that it is in this upper zone that *P. moritura* occurs. This can be best seen at Richmond, because it is there that the *moritura* zone is typically developed, and most completely marked off from the underlying zones. From about Osgood northward, however, there is in the upper part of what has been heretofore designated the Madison beds or Saluda formation, a zone of rather barren, dark colored limestone in which the present form, together with its nearly constant associate, *Hebertella sinuata,* is found. This is, I believe, the southern representative of the Elkhorn division of the Richmond section. It will be noted in this connection that, according to my studies, the Whitewater division of the Richmond series is *above* and not below the typical Saluda; in other words that the Saluda is represented in the Richmond section by the massive bed of limestone about 130 feet below the Clinton, this latter bed being the true horizon of *Tetradium minus.*

1.41A10a, 10b, and at the top of the Ordovician section about Laurel, Hamburg, and Osgood.

PLECTAMBONITES SERICEUS (Sowerby).

Plate XXXVI, figs. 1-1c.

Leptaena sericea Sowerby, 1839, Murchison's Silurian System, p. 636, pl. xix, fig. 1.

"Semicircular; finely striated longitudinally, with a silky lustre; a few striae deeper than the others; larger valve convex, the other nearly flat; front not concave, considerably deflected at the edge. Length 5 lines, width 10 lines.

"In general form this resembles *L. lata* of the Ludlow Rock, but has much finer striae and more angular sides. The front also is straighter, and there are no indications of spines. Sometimes a few concentric lines of growth are conspicuous."—Sowerby, *loc. cit.*

The most interesting fact in regard to this species is its great range and distribution. It was described from British specimens, but occurs commonly at a number of levels in the Ordovician of this country ranging from the Trenton to the Richmond. The only other species known in the Cincinnati group is *P. plicatellus* Ulrich, a small species found in the lower Eden shales. Near the base of the Liberty division of the Richmond, *P. sericeus* comes in in such immense numbers in a number of layers, and especially in the top of a strongly wave-marked layer, as to completely fill the rock to the exclusion of almost every other fossil. This horizon is one of the most constant and readily traced of the entire Cincinnati group. My description and figures are drawn from specimens taken from this horizon at Versailles.

The most striking superficial characteristic of the species is that mentioned by Sowerby, namely, the silky luster due to the finely fibrous nature of the shell substance and the unusually smooth and glossy surface, with its very fine striae. The general aspect of the shell is decidedly transverse, except in young specimens, the breadth being ordinarily twice the length. In young specimens the length and breadth may be nearly equal. The cardinal line is ordinarily straight, only occasionally slightly arched. Greatest breadth at the hinge. The cardinal angles are usually slightly auriculate, and often sharply pointed. The contour of the lateral and anterior margins varies from smoothly rounded or nearly semicircular to subrectangular. Dorsal valve concave, especially so in fully mature specimens. Beak obsolescent, and area very narrow. Interior of the dorsal valve with a zone of small but distinct pustules over the anterior and lateral portions, arranged in a somewhat radial manner. Cardinal process conspicuous, triangular, trifid at the apex, and merging laterally with the crura which are pointed laterally outward in a line parallel with the hinge line. The lamellae arising from the anterior margins of the crura run forward and inward so as to nearly meet in the median line of the valve, enclosing together with the cardinal process a distinct triangular pit, lying directly in front of the process. These lamellae are continued forward as two prominent ridges, slightly diverging, to near the front of the valve, where they become, in old shells, much thickened, and often support a number of tubercles. The internal adductors were inserted between these ridges; and outside of them, sometimes outlined by a well defined ridge are the impressions of the external adductors. In the middle of the interior impression is to be seen, in well preserved specimens, a third ridge, or septum, very much smaller and thinner than the other two, but of about the same length.

The ventral valve is convex, somewhat more strongly curved than the other valve. Area narrow. The interior of this valve does not present the interest of the dorsal valve and it is much less often seen in collections. The teeth are small. Arising from the bottom of the valve directly beneath each tooth is a small ridge extending obliquely forward and outward about one-third of the way across the valve. In the median line of the valve a third ridge arises at the pedicle opening and after running forward about a third of the way to the front of the valve bifurcates, the two branches running for a short distance nearly parallel with the ridges mentioned above. These ridges are thus seen to bound the two diductor scars.

Surface of both valves ornamented with excessively fine radiating striae, every fourth or fifth one being slightly larger than the others.

5.9A2, 6, 8, 10, 14....1.34A9, 15b, 16a, 16b, 17, 18a, C6.... 1.41B1, C1, 2-3, D2, E4....1.12E3, D1-6, F3....1.38A3, 11.

PLECTORTHIS ELLA Hall.

Plate XXXVI, figs. 2-2c.

Orthis ella Hall, 1860, 13th Report of the New York State Museum of Natural History, p. 121. (Not figured.)

"Shell small, ovate: valves nearly equally convex; hinge-line extremely short, being scarcely more and sometimes less than one-third the width of the shell, and scarcely affecting the contour of the margin, which slopes from the beak of the ventral to the lateral margins a little above the middle of the valve. Dorsal valve gibbous subcircular; the beak extending a little above the hinge-line, and the area extremely short. Ventral valve broadly ovate, sloping from the beak; beak produced beyond the line of the opposite valve, and pointed, not incurved; area twice as long as high; foramen narrow and extending to the apex of the beak, and sometimes truncating the extremity.

"Surface marked by from fifteen to twenty simple, abruptly rounded or subangular plications.

"This small *Orthis* is so peculiar, as not to be readily mistaken for any other known in our strata. The short hinge-line and area, and produced beak of the ventral valve, are characteristic features. In some specimens the area is obscure or undefined, and the shell has much the aspect of TREMATOSPIRA. It is a rare species, and I have not seen more than twenty individuals, all of which preserve the characters given above, the variation being mainly in the number of striae: those with fewer striae are frequently more gibbous than the others. Length about one-third of an inch; the width a little more.

"*Geological formation and locality.* In the calcareous shales of the Hudson-river group, near Cincinnati, Ohio. From the collections of Mr. S. T. Carley and Mr. U. P. James."—Hall, *loc. cit.*

The above description, which is based on Cincinnati specimens, does not need any additions. I have doubtfully referred several imperfect specimens from the top of the Lorraine at Vevay to this species.

PLECTORTHIS PLICATELLA Hall.

Plate XXXVI, figs. 3-3f.

Orthis plicatella Hall, 1847, Pal. New York, I, p. 122, pl. xxxii, figs. 9 a-g.

"Broadly semioval, nearly equivalve, length and breadth about as 3 to 4; surface marked by strong radiating plicae, which are usually simple, about 20 to 28 on each valve, crossed by simple elevated concentric lines, which are more distinct in the depressions between the costae, and often obscure or obsolete upon their exposed surfaces; valves nearly equally convex, without sensible depression or elevation on either one, meeting at the edges in a straight line; cardinal line not extending beyond the width of the shell; area narrow; dorsal foramen extending to the beak.

"This species bears some resemblance to *Orthis radians* of SOWERBY, but it proves clearly distinct on comparison with his description; the plications are never so few as 15, and the shell is never concave in front. The equal convexity of the valves, and uniform, strong, somewhat sharp plications, are distinguishing characters. The proportionate greater extension of the hinge line, and less distance from beak to base, distinguish this shell from any variety of *O. pectinella,* even when the surface only can be seen." —Hall, *loc. cit.*

This species occurs quite commonly in the Lorraine, especially the lower part, associated with *Platystrophia laticosta.*

1.34B1-3, C13, 14a....1.38Ba-c....1.12E3.

PLECTORTHIS PLICATELLA var. TRIPLICATELLA (Meek).

Plate XXXVI, figs. 4-4b.

Orthis triplicatella Meek, 1872, Amer. Jour. Sci., 3d ser. IV, p. 281. (Not figured.)

"Note.—Among the specimens sent to me from Cincinnati, Ohio, by Mr. A. S. Miller of that city, there are two examples of an *Orthis,* agreeing in form and general appearance with *O. plicatella,* but differing in being considerably larger, and in having a *decidedly* lower ventral area, with the beak of the same valve more incurved than in any authentic specimens of that shell I have ever seen. It also presents a curious triple arrangement of the costae, caused by each of them giving off a smaller one on each side at about half the distance between the beak and the free margins, the main rib always continuing larger and much more prominent than the others to the margin; while the spaces between each bundle thus formed are proportionally wider and deeper than we see in *O.*

plicatella as usually found. These characters give this shell a peculiar appearance that leads me to think it will probably be found to belong to an undescribed species. As I know nothing of its internal characters, however, and the species of this type of *Orthis* are known to be quite variable, I feel some doubts about the propriety of describing it as a new species. It seems to me, however, to differ from the *O. plicatella* and *O. fissicosta* in more important characters than they differ from each other. Should other collections show this form to be a distinct species, I would propose for it the name *O. triplicatella.*

"The larger of the two specimens seen measures 0.70 inch in length, 1.40 inch in breadth, and 0.40 inch in convexity."—Meek, *loc. cit.*

1.34C13, 14a.

RAFINESQUINA ALTERNATA (Emmons).

Plate XXXVII, fig. 1-1e.

Strophomena alternata Emmons, 1842, Geol. N. Y., Rep. 2d District, p. 395, fig. 3.

"No. 3. *Strophomena alternata,* whose striae or markings are alternately fine and coarse. This character is possessed, however, by other species, and hence is not in itself to be relied upon as specific."—Emmons, *loc. cit.*

This is, with the possible exception of *Zygospira modesta,* the commonest and most widely distributed brachiopod of the entire Ordovician system. Its range extends from the Trenton to the Richmond, both formations inclusive; and it is common in both Europe and America wherever the Ordovician rocks are exposed.

The original description by Emmons would not serve to identify the species, but fortunately Emmons accompanied it with a good figure, which I reproduce (plate xxxvii, fig. 1b) together with figures of several specimens from the Ordovician of Indiana. The figure of Emmons shows a shell with a ratio of length to breadth of 1.35, and with the lateral slopes at very nearly a right angle to the hinge line which is perfectly straight. The figure also indicates a shell of only moderate convexity. According to Hall (1847), the length and breadth are about as 12 to 15 (ratio 1.25), and the hinge line is a little longer than the width of the shell farther forward, and slightly reflected at the extremities. "Dorsal valve depressed convex, sometimes more convex in the middle, suddenly deflected near the margin and flattened toward the cardinal line;

ventral valve concave, gradually or sometimes suddenly inflected towards the basal margin [the terms dorsal and ventral are here used in the opposite sense from their present usage]; surface marked by fine rounded radiating striae, which alternate at unequal intervals with coarser ones; striae increasing in number toward the margin of the shell, crossed by fine elevated concentric lines and a few imbricating lines of growth."—(Hall, *loc. cit.*, p. 102.)

Among the innumerable forms of this ubiquitous species it is often difficult to say whether one is dealing in any given case with the species *alternata* or with some variety. The form figured by Emmons seems to be a sort of average or model form, for the shell index (ratio of length to breadth) varies widely both in the direction of a less and of a greater ratio. The convexity may be much less and is also often much greater, as is indicated by the figures. The hinge line may be much shorter than the width of the shell farther forward, or it may be much longer. The shell may be very thin and fragile (as in the variety *fracta*) or very strong and massive (as in the form called *ponderosa*). Where these differences are well marked they have been distinguished by varietal designations; but it must be confessed that forms are constantly met with that can with difficulty be placed in any of the published varieties; and one must either put a very liberal interpretation upon the limits of these varieties or be constantly making new varieties. I have preferred the former course.

5.9A21, 31, 37, 41, 44, 50....1.33A3....1.34A1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22....1.34B1-3, 4-5....1.34C5, 8, 9, 10, 13, 14a, 14b....1.41A4, 5, 6, 7, 8, 9, 10a, B1, 2, 3, C1, 2-3, D1, 2, 3, E1, 2, 3, 4, 5, 6, 7....1.12A2, D1-6, E3, F3. and practically all other localities where the Cincinnati series is exposed.

RAFINESQUINA ALTERNATA var. FRACTA (Meek).

Plate XXXVII, figs. 5, 5a.

Strophomena alternata var. *fracta* Meek, 1873, Pal. Ohio, I, p. 91, pl. vii, figs. 3a-e.

"Very thin and fragile, smaller than the typical form, much compressed, decidedly semi-oval, the length equalling or slightly exceeding the breadth; lateral extremities rectangular, and not deflected; lateral margins generally straight or a little convex in outline behind, and rounding forward to the regularly rounded front; surface as in the typical form, excepting that there are usually more strongly marked imbricating laminae of growth around near the free margins; interior of dorsal valve with muscular scars removed proportionally farther forward from the cardinal process than in the typical and other varieties.''—Meek, *loc. cit.*

This form occurs, sometimes in immense numbers, in the upper part of the Lorraine formation. It is often difficult even among thousands of specimens to find a single perfect one, owing to the exceptionally fragile nature of the shell.

1.33A3....1.34B1-3, 4-5, 1.34C14b....1.38P.

RAFINESQUINA ALTERNATA var. LOXORHYTIS (Meek).

Plate XXXVII, figs. 2, 2a.

Strophomena alternata var. *loxorhytis* Meek, 1873, Pal. Ohio, I, p. 91. (Not figured.)

''Attains a large size, moderately convex antero-centrally, or rather depressed; much extended on the hinge line, with lateral extremities acutely angular, flattened and scarcely deflected; area very narrow; both valves marked near the cardinal margin, toward the lateral extremities, by six or eight distinct, very oblique wrinkles on each side.''—Meek, *loc. cit.*

Miller states that this form is found in the upper part of the Cincinnati group, about 600 to 800 ft. above low water mark in the Ohio River (at Cincinnati), and that it is not common. The form of which figures are given herewith is from the Waynesville formation. I have not seen any form at a lower level that seemed to me to answer to Meek's description, although Nickles lists it from the Lorraine (Fairmount division). The Richmond form seems to me to correspond very closely to Meek's description, except that the oblique wrinkles at the lateral extremities are faint or lacking. It appears to the writer, however, that such wrinkles are apt to occur in old shells of almost any species of *Strophomena* or *Rafinesquina,* and are not diagnostic.

RAFINESQUINA ALTERNATA var. NASUTA (Conrad).

Plate XXXVII, fig. 4.

Strophomena nasuta Conrad, 1842, Jour. Acad. Nat. Sci. Philadelphia, VIII, pt. II, p. 260. (Not figured.)

''Triangular; longer than wide, slightly winged; inferior valve with the umbo and disc flattened; towards the base suddenly and concentrically bent towards the upper half; concentrically wrinkled; radii distinct, rather remote, with three or four minute intermediate lines; base projecting and angular in the middle.

"This species resembles *S. alternata* and *S. deltoidea* in having one or two of the central lines larger than the rest, but it is a much flatter and proportionally longer shell."—Conrad, *loc. cit.*

The comparison of this shell with the typical *R. alternata* of the Cincinnati group shows that it is a somewhat smaller form, characterized especially by the drawing in of the anterior-lateral margins so as to give it a somewhat triangular aspect, as indicated by Conrad. The middle portion of the anterior margin may even be produced into a distinct lobe. The valves are also decidedly more abruptly deflected at the anterior third than is the case in the typical form, thus greatly increasing the convexity of the ventral valve, and to a less degree the concavity of the dorsal valve. The space between the valves is accordingly relatively greater than in the typical form. In surface ornamentation the variety does not differ materially from *R. alternata.*

Found in the middle part of the Lorraine. 7.33A3....1.12A2 ....1.34C14b....1.34B1-3....1.38P.

RAFINESQUINA ALTERNATA var. PONDEROSA.

Plate XXXVII, figs. 3, 3a.

I am not sure that this is the form that has received the name *ponderosa* from collectors and was figured under this name by Hall in 1847. The name has never been formally proposed, so far as I am aware, and I therefore here propose it for the fairly well characterized form of *Rafinesquina alternata* common in association with *Platystrophia lynx* and *Hebertella sinuata* in the middle part of the Lorraine (Bellevue).

It differs from the normal type of the species in much the same way that the very gibbous *Platystrophia lynx* of the "lynx" beds does from the normal form of that species: that is, it is very massive, as compared with the normal form, and all the muscular and vascular markings are very deeply impressed. The cardinal process is unusually large. The general outline of the shell is not particularly different from that of the normal form of the species. I should not say, as Hall does, that it represents merely the old individuals of the normal form, but that it represents a gerontic phase of the species that affected nearly all of the individuals at certain horizons.

RETZIA GRANULIFERA Meek.

Plate XXXVI, figs. 5-5c.

Retzia (*Trematospira*) *granulifera* Meek, 1872, Proc. Acad. Nat. Sci. Phila. (February, 1872), p. 318. (Not figured.)

"Shell transversely oval, the length being about four-fifths the breadth, moderately convex, the convexity of the two halves being very nearly equal; lateral margins rather narrowly rounded in outline; front and anterior margins broadly rounded, or perhaps the former sometimes straight or slightly sinuous in outline in the middle; cardinal margin nearly straight on each side, and sloping at an agle of about 140° from the beaks toward the lateral extremities. Dorsal valve nearly evenly convex, its greatest prominence being perhaps slightly behind the middle; provided with about thirteen simple, angular, radiating plications or costae, five of which on the middle are smaller than the others (the middle one being smallest and not continued to the beak), and form together a very low, flattened mesial elevation, scarcely rising above the general convexity; beak rather strongly incurved. Ventral valve of much the same form as the other, excepting that its beak is somewhat more prominent, perforated, and incurved upon that of the other valve; while two of the middle costae are much smaller than the others, and the first one on each side of these is intermediate in size between the smallest central ones and the largest on the lateral slopes; these four smaller ones being a little depressed so as to form a shallow mesial sinus that is not continued to the beak. Crossing all of these plications of both valves, are numerous fine lines of growth; while the entire surface, as seen under a magnifier, is occupied by minute projecting points, like grains of sand; and, between these, a higher magnifying power shows the whole surface to be very minutely and regularly punctate.

"Length, 0.37 inch; breadth, 0.50 inch; convexity, 0.27 inch.

"Until the distinctions between the genus *Retzia* and the proposed genus *Trematospira* (if any exist) are better defined, and the interior of the species here described can be determined, it is not possible to say to which of these groups it most properly belongs.

"Specifically, however, it seems to be closely allied to *Trematospira gibbosa* of Hall, from the Hamilton group. Yet it differs, not only in having two to three more plications on each side, but also in having five instead of three a little raised to form the mesial fold of the dorsal valve (the middle one being also much smaller), and four depressed to form the mesial sinus (the middle two being much smaller than the others). It so nearly resembles the New York form, however, that I should almost be inclined to suspect that it might be only a variety of the same species, if it were not found at a so much lower horizon. It must be very rare, as I have only heard of the single typical specimen being found."—Meek, *loc. cit.*

Further description of this species is unnecessary. I have seen but a single undoubted specimen of this species. This is the specimen listed by me several years ago from the Eden shales at Vevay, Indiana.

RHYNCHOTREMA CAPAX (Conrad).

Plate XXXVI, figs. 6-6h.

Atrypa capax Conrad, 1842, Jour. Acad. Nat. Sci. Philadelphia, VIII, pt. II, p. 264, pl. xiv, fig. 21.

"Profoundly ventricose, with about twelve angular prominent ribs, transversely wrinkled, and four ribs on the mesial fold of the upper valve, which is wide, not profoundly elevated; inferior valve with a profound mesial fold, and very prominent ribs; greatest depth of the two valves nearly equal.

"*Locality.*—Richmond, Indiana, in Silurian shale."—Conrad, *loc. cit.*

Without figures, Conrad's original description would scarcely enable one to distinguish this species from numerous other Rhynchonellids. The presence of four plications on the fold and three in the sinus is an absolutely constant character. The ratio of height to length varies within very wide limits, young shells being always less gibbous than older ones. In fact, the nepionic and neanic shells ar very thin, the length being several times greater than the height. In very old (gerontic) shells, especially those found in the Whitewater division of the Richmond formation, the height may exceed the length by a considerable amount. The ratio of breadth to length is also subject to considerable variation, though not as much as the ratio of height to length. In old shells the beaks are closely incurved and appressed and encroached upon by the pedicle. The plications are strong and angular, and crossed by numerous closely arranged sharp lamellae of growth, especially conspicuous toward the front of the valves, giving to the shell a very characteristic appearance.

This is, besides *R. dentata,* the only Rhynchonellid in the Cincinnati group. Comparison between the two species is scarcely necessary, the single plication of the sinus of *R. dentata* alone sufficing to distinguish it from the present form. *Rhynchotrema capax* ranges from the base of the Liberty formation to the middle of the Whitewater division, except that it is found sparingly, if at all, in the Saluda in the southern part of the Indiana area. It has heretofore been supposed to range throughout the Richmond, but that this is a mistake is conclusively shown by recent careful collecting. It is especially characteristic of the Liberty division.

1.34A13, 14, 15, 16, 17, 18, 19, 19-21, 22....1.41A4, 5, 6, B3, C1, 2-3, D1, 2, 3, E4, 5, 6, 7....1.12D1-6, E3, F3. I have also collected this species near Bennington, Versailles, Osgood, Hamburg, Brookville, Laurel, Liberty and many other localities in Indiana, where the middle and upper parts of the Richmond formation are exposed.

RHYNCHOTREMA DENTATA Hall.

Plate XXXVI, figs. 7-7d.

Atrypa dentata Hall, 1847, Pal. N. Y., I, p. 148, pl. xxxiii, figs. 14a-c.

"Pyramidal, subtriangular; breadth somewhat greater than the length; cardinal line short; margins of the shell sloping abruptly downwards; surface marked by about eight or nine strong and deep plications, two of which are much elevated on the mesial fold of the ventral valve; dorsal valve with the sinus broad, deep and angular, with a single plication in the center, extremely elevated in front; plications crossed by zigzag or advancing and retreating filiform lines; beak of the dorsal valve small, acute, incurved, with no visible perforation. * * * "—Hall, *loc. cit.*

This species, while very constant in the number of plications on the valves, and absolutely constant, so far as I have observed, in the number of plications of the fold and sinus, nevertheless changes most remarkably, as the shell becomes older, in the convexity of the valves. In very old and gibbous individuals, the height may exceed the length of the shell, while in young individuals the height is only a small fraction of the length. The youngest stages seen (about 1 mm. in length) are decidely long and thin. Hall's description, together with the figures, will suffice for the identification of the shell, especially since there is no other with which it can be confused—*R. capax* having constantly four plications on the fold and three in the sinus. The chief interest of *R. dentata* is in the fact that it marks a well defined zone of the upper part of the Richmond formation, and is also narrowly restricted in distribution.

The best place to collect it is undoubtedly at Richmond, Indiana, where it is abundant in the Whitewater division, which it characterizes. South from Richmond I have seen the species at a horizon similar to that of its occurrence at Richmond, in the vicinity of Laurel, Indiana, and still farther south near Hamburg, Indiana. South of this point I have not seen the species except an occasional specimen at a horizon considerably lower. In the Tanner's Creek section I found two specimens at a level near the base of the Liberty formation (1.34A13a, 14a) and again on Whitaker's Branch in Dearborn County, near Moores Hill, at a similar horizon. In the latter place a single specimen was seen. At the higher horizon, only, and at Richmond and vicinity only, in Indiana, does the species run through any considerable thickness of rock. At all other localities and levels, in this State, the species is either rare or confined to a few inches or at the most a few feet of rock. No specimen, so far, has ever been found at Madison, Indiana.

This is another of the species of importance in working out the stratigraphy of the extreme upper part of the Richmond formation. Its associates in this connection are *Homotrypa wortheni, Monticulipora epidermata, Streptelasma divaricans, Homotrypella rustica,* and *Strophomena sulcata.*

1.34A13a, 14a....1.41A6, 7, 8, D3, E1, 2, 4, 5, 6, and in the vicinity of Laurel, Hamburg, and Moores Hill, Indiana.

SCHIZOCRANIA FILOSA Hall.

Plate XXXIV, figs. 8, 8a.

Orbicula ? filosa Hall, 1847, Pal. New York, I, p. 99, pl. xxx, figs. 9a-d.

"Orbicular; one valve more or less convex; apex marginal; surface radiated with numerous fine elevated thread-like striae, which are more or less prominent, depending on exfoliation of the shell; intermediate striae coming in between the others as they recede from the beak, but the striae are not bifurcate.

"It is with some hesitation that I refer this shell to the genus ORBICULA, since it presents same variation from the usual type. The young specimens are very convex, almost conical, but gradually become depressed and expanded as they increase in age and size.

"A single specimen, which is partially exfoliated, presents the marks of three visceral or muscular impressions, arranged somewhat like those of CRANIA; but since the shell differs as widely from types of that genus as it does from ORBICULA, I should scarcely feel authorized to place it under that genus, in the present state of our knowledge regarding it. The strongly striated surface presents a deviation from the general character of shells belonging to LINGULA or ORBICULA; but it is otherwise of the same texture—black and glossy, as those shells. It likewise occurs associated with them, proving that its habitat was similar, deviating no more from these genera than they do from each other.

"As the shell exfoliates, the surface becomes smoother, and the striae are nearly lost, except upon the margins."—Hall, *loc. cit.*

The types are from the upper part of the Trenton limestone at Middleville, New York. It is reported in Kindle's list from Madison, Indiana. I have not met with any specimens of it.

STROPHOMENA NEGLECTA (James).

Plate XXXVIII, figs. 1-1b.

Streptorhynchus neglecta James, 1881, The Paleontologist, No. 5, p. 4. (Not figured.)

"Shell resupinate; cardinal line longer than the greatest breadth of the shell farther forward, and more or less deflected at the extremities of different specimens; lateral margins sloping inward at first, then rounding regularly to the front. Cardinal line of the *dorsal* valve linear, straight and slightly projecting over the area of the other valve; umbone flat, slightly concave near the beak in most cases, more or less highly convex at the middle, of different examples, and curving abruptly to the lateral and front margins. Surface covered with crowded, radiating striae, which are fine and delicate at and just below the beak, becoming larger as they advance toward the margins, where they are rounded and strong; striae increased as the surface widens, by implantation, but not always of a uniform size; in some cases they vary considerably, and are irregularly arranged, from one to three or four of the smaller placed between two of the larger. Unworn examples show the whole surface covered with very fine, delicate, sharp, crowded, concentric, raised lines, crossing the radiating striae, which are distinctly seen under an ordinary magnifier. About ten of the radiating striae in the space of one line, at a quarter of an inch forward of the beak, and three or four near the free margins.

"*Ventral* valve: a strongly marked deltidium; cardinal area flat and moderately broad, sloping gently each way from the projecting beak, to the extremities of the lateral margins, and standing at an angle of 70 degrees or more with the dorsal valve; convex near the beak, and on the umbone; and different examples more or less deeply concave near the middle, curving, to correspond with the other valve, to the free margins. Surface of this valve covered with radiating striae and concentric lines, similar to the dorsal valve.

"The only feature of the *interior* of this species that can be referred to at this time is the deltoid process of the dorsal valve, which differs materially from specimens and figures of other species; it is prominent, stands at a high angle with the valve, is bi-lobed, each lobe divided by a deep, strong depression or slit, commencing at the beak and widening to the ends of the lobes.

"The breadth of the shell along the cardinal line, of different specimens, varies from 1½ to 2½ inches, and from 1 to over 1½ inches from beak to front. Other examples, supposed to be the young of this species, are much smaller. In outline and dimensions most of the specimens resemble some forms of *Strophomena alternata,* Conrad."—James, *loc. cit.*

Strophomena filitexta Meek (non Hall) is considered as a synonym of this species. The appearance of the interior of the dorsal valve of this species is thus described by Meek: "In the bottom of the valve three low, nearly parallel ridges start forward, from near the base of the cardinal process, the middle one of which is shortest, while the lateral extend to or a little beyond the middle of the valve. Two others also originate behind the middle, between these three, and extend forward parallel to each other, farther than any of the others. Between these four longer ridges three very slender much smaller raised lines may also somtimes be seen, while a large area of the central region of the valve, including the ridges mentioned, and a considerable space on each side of them, is occupied by small but distinct granulations, that show a tendency to arrange themselves in radiating lines."

The majority of the specimens of this species seen by the present writer have been the interiors of the dorsal valve, hence the foregoing description will, together with Meek's figures, prove of very considerable value in the identification of the species. I know of no other species with a similar set of internal characters.*

*Since the above was written I have received from Dr. Weller, the types of *Strophomena neglecta,* from the James collection. There are two specimens of somewhat different size and aspect, neither showing the interior of either valve. One of the specimens corresponds very well with the above description given by James. The other may not be the same species. Both are marked as coming from Cincinnati, although in view of the loose way of labeling material, formerly in vogue, this may not necessarily be taken very literally. I am quite convinced, however, that the larger specimen, which corresponds best with James' description, is

1.34A16, 17, 18, 19, 20, 21, 22....1.41A6, C1, 2-3, D1, 2, 3, E1, 2, 3, 4, 5, 6....1.12D1-6, F3.

STROPHOMENA NUTANS Meek.

Plate XXXVIII, figs. 5-5c.

Strophomena nutans Meek, 1874, Paleontology of Ohio, vol. I, p. 77, pl. vi, figs. 1 a-f.

"Shell under medium size, sub-trigonal, strongly concavo-convex, comparatively thick and strong; hinge about equalling the breadth of the valves; lateral margins usually somewhat straightened behind, where they meet the extremities of the hinge nearly at right angles, while anteriorly they converge to the middle of the front, which is prominent, and very narrowly rounded, or almost angular in outline.

"Dorsal valve remarkably convex in the central or anterior central region, from which it rounds down abruptly to the lateral and anterior margins, and slopes strongly posteriorly, the anterior lateral slopes being usually somewhat compressed, so as to impart to the middle of the anterior region a degree of prominence, somewhat like a mesial ridge, near the margin; whole umbonal region flattened; area narrow, or sublinear, and directed nearly backward; beak not distinct from the edge of the area. Interior with the bifid cardinal process short; sockets deep, sub-trigonal, and very oblique; socket-ridges rather prominent, thin, and continued obliquely forward and outward, with an inward curve, so as to form the lateral margins of the muscular impressions, which are well defined, rather deep, strongly striated, and separated by a short, mesial ridge coming from the base of the cardinal process; while near the middle of the anterior edge of each there is sometimes a little oblique prominence; central region in front of the muscular impressions, sometimes showing four obscure parallel

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not the same species as the specimen from which Meek drew up his description of the internal characters of the dorsal valve of his *S. filitexta*. In the set of types of the species *S. vetusta*, from the James collection, is a specimen showing the interior of a dorsal valve, which corresponds in every particular with the description of the dorsal valve of *S. filitexta*, given by Meek. This specimen, however, does not possess the wrinkles at the cardinal extremities that are supposed to characterize *S. vetusta*, and in other respects does not closely resemble the specimens of the type set in which the latter character is shown. If the dorsal interior, above mentioned, is really an interior of *S. vetusta*, which I very much doubt, then the specimens listed in the present report as *S. neglecta* James, are to be referred to *vetusta*, instead. The status of most of the species of *Strophomena* is at present in such an unsatisfactory condition, however, that I hesitate to make any changes from the ordinary usage, till such time as the genus can be revised with all the forms from all the horizons and localities at hand.

ridges running directly forward, and separated from each other by three shallow, narrow furrows, in the middle of each of which there is a raised line; traces of other smaller and more obscure ridges sometimes extend forward and laterally on each side of those described, while the whole internal surface is usually minutely granular.

"Ventral valve nearly flat, with a backward slope in the umbonal region, and distinctly concave farther forward, in the anterior central region; while the anterior and lateral margins are abruptly curved downward parallel to those of the other valve; beak scarcely distinct from the margin of the area, which is of moderate height, flat, and extends the entire length of the hinge, with usually but little taper toward the lateral extremities; foramen rather broad trigonal, and covered above by the convex pseudo-deltidium, which is broadly and deeply sinuous on its inner edge, for the reception of the cardinal process, and a kind of pseudo-deltidium of the other valve, formed by the continuation of the socket plates. Interior with the anterior and lateral margins geniculated so as to form a marginal ridge that is deeply and somewhat regularly furrowed across, while the ovarian spaces within this marginal ridge are more or less flattened, and sometimes granulated; hinge teeth moderately prominent, transversely sub-trigonal, and striated on their anterior and posterior faces; while from their inner bases the prominent dental ridges extend forward and curve together, so as to form a strongly elevated margin to the deep, sub-circular cavity for the reception of the muscular impressions; muscular cavity scarcely reaching the middle of the valve, usually with its rim slightly notched (not emarginated) at the middle of the front; while within its bottom it is provided with a slender mesial ridge, with the narrow adductor muscular scars on each side of it, and on the outside of these most of the remaining space seems to be occupied by the striated scars of the divaricator muscles, there being only a very small notch-like impression close to the hinge tooth on each side, apparently left by the ventral adjustor muscles.

"Surface of both valves ornamented by very fine, closely arranged, simple radiating striae, that increase by intercalation, and are either nearly equal, or sometimes have every third, fourth or fifth one slightly larger than those between; while on well preserved specimens, very minute, crowded, concentric striae may be seen, by the aid of a strong magnifier, crossing the much larger radiating striae.

"Length of a mature specimen, 0.80 inch; breadth, 0.93 inch; convexity, 0.50 inch."—Meek, *loc. cit.*

Mr. Meek cites his specimens from the "upper part of the Cincinnati group" in Butler, Warren and Clinton counties, Ohio. The species occurs in Indiana associated with *S. planumbona* in the Liberty formation.

STROPHOMENA PLANOCONVEXA Hall.

Plate XXXVIII, figs. 3-3e.

Leptaena planoconvexa Hall, 1847, Pal. New York, vol. I, p. 114, pl. xxxi B, figs. 7 a-d.

"Shell resupinate, sub-planoconvex, often distinctly inequilateral and oblique; ventral valve moderately convex; dorsal valve nearly flat or slightly concave; cardinal line extending considerably beyond the width of the shell, and often produced into small acute ears; surface marked by rather coarse radiating striae, which bifurcate towards the margin of the shell; apex usually, and perhaps always, perforated; foramen closed; cardinal area narrow.

"The most obvious characters of this shell are its resupinate form, the nearly flat dorsal valve, and frequent inequality of the two sides, or the greater extension of the cardinal line on one side. In these features alone it is dissimilar to all the other species of the genus in the lower strata. In its nearly flat valve it approaches to the ORTHIS; while the extension of the cardinal line, and closed foramen, are characters belonging to LEPTAENA, as well, also, as its general habit, which is different from the true ORTHIS.

"In some of its varieties, and particularly in the ventral valve being flat near the beak, it resembles the last species [*Leptaena deflecta*], but differs essentially from it in the coarser nearly equal striae and absence of concentric elevated lines, as well as other important characters."—Hall, *loc. cit.*

Reported by Hall from numerous localities in Ohio, Indiana, etc., in the Cincinnati series.

The terms dorsal and ventral are used by Hall in the opposite sense from their present usage.

1.34C14a.

STROPHOMENA PLANUMBONA Hall.

Plate XXXVIII, figs. 4-4d.

Leptaena planumbona Hall, 1847, Pal. New York, vol. I, p. 112, pl. xxxi B, figs. 4 a-e.

"Shell resupinate, robust, length and breadth as 9 to 11; cardinal line straight, suddenly deflected at the extremities, equal to or greater than the width of the shell; sides a little contracted just below the cardinal extremities, leaving slightly salient angles; ventral [dorsal] valve flat or slightly depressed near the beak, elevated and very convex in the middle, somewhat abruptly and concentrically deflected towards the margin; dorsal [ventral] valve flat on the disc, slightly elevated towards the beak, and deflected to correspond to the other valve; surface marked by radiating striae, every third, fourth or fifth of which is alternated by a stronger one; entire surface (in perfect specimens) marked by fine concentric elevated lines, and a few imbricating lines of growth.

"This is a very neat, symmetrical species, presenting very little variation of form. The concentric lines are often obliterated, and the surface shows only the radiating striae. The remarkable flatness, which often amounts almost to a depression of the convex valve near the beak, is a distinguishing character in all the specimens I have examined. The sides of the shell are suddenly constricted just below the extremities of the hinge line, producing small salient ears; the ventral [dorsal] valve is very convex just forward of the middle, and the opposite valve equally concave."—Hall, *loc. cit.*

It has become the custom to refer this species to *S. rugosa* of Rafinesque and de'Blainville, following a suggestion made by King in 1850, only three years after Hall's species was named. The most recent discussion on this subject that has come to my notice is a note on the species by Mr. J. M. Nickles, in the American Geologist (Oct. 1903). With the opinion of Nickles I quite agree. No one who has collected numbers of this species can look at the figures given by de'Blainville and believe that they were intended to represent the common *Strophomena planumbona.* They may or may not have been intended to represent *Leptaena rhomboidalis.* I believe, with Nickles, that we should go back to Hall's name, *planumbona,* and I have therefore quoted his as the original description rather than de'Blainville's.

This is a very common species in the Richmond formation, or rather in the division now known as the Liberty formation. This zone it characterizes better, perhaps, than any other species.

1.34A12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22....1.41A4, 5, B2, 3, C1, 2-3, D1, 2, E1, 3, 6....1.12D1-6, E3.

STROPHOMENA PLANUMBONA var. SUBTENTA Hall.

Plate XXXVIII, figs. 6-6g.

Leptaena subtenta Hall, 1847, Pal. New York, I. p. 115, pl. xxxi B, fig. 9a-b.

"Resupinate, semioval; ventral valve convex in the middle; cardinal extremities deflected, somewhat abruptly curving towards the margin, and flattened on the umbo; surface marked by fine equally bifurcating striae, which are crenulated by concentric lines, obliquely wrinkled on the cardinal margin; interior of the hinge showing two projecting tooth-like processes, with a narrow space between them for the passage of a ligament; lateral teeth spreading widely.

"I find, among the drawings of Mr. CONRAD, the figure of a Trenton species, with this name attached. I have not seen the same in New-York, but the specimen figured is from a western locality. It bears all the essential marks of the species cited, and I have therefore introduced it under that name. It will, doubtless, be found again in New-York. The cardinal margin bears some resemblance to CHAETETES, but a careful examination does not show any spires. The strong oblique wrinkles form a distinguishing feature."—Hall, *loc. cit.*

The localities given by Hall are Oxford, Ohio, where the species is said to be associated with *Dalmanella testudinaria* (probably *D. meeki*), *Rafinesquina alternata,* and *Plectambonites sericeus*; and at Trenton Falls, New York (doubtfully). This association would make the type come from about the base of the Liberty formation.

Schuchert considers this form a variety of *S. planumbona,* and with this I fully agree. In fact, I am almost prepared to go still further, and not even distinguish it as a variety. My observation leads me more and more to the conclusion that the oblique wrinkles seen on the cardinal extremities of species of *Strophomena* and *Rafinesquina* and related genera are due to slight causes (old age, especially) that affect occasional individuals rather than the species, or any considerable section of it. As to the differences in internal features, one will certainly despair if one tries to separate the two forms on this basis. The form figured by Meek (internal valve of his *S. plicata*) does indeed look quite different from the figure of the interior of the ventral valve of *S. planumbona* on the same plate. I have figured the ventral valve of another specimen, however, which might with almost equal propriety be referred to *S. planumbona, S. subtenta,* or *S. planoconvexa.* Why we should give such latitude to variations in *Rafinesquina alternata,* and so narrowly restrict them in *Strophomena,* is a question that must occur to any one familiar with the two genera. The tendency to call these forms of *Strophomena* species seems to me to be due more to caprice and accident than to anything in the relations of the forms to one another. I wish to take issue squarely with those who call every slight difference in form *specific.*

This variety occurs at the following localities:

1.34A13b, 15b, 17, 19, 21, 22....1.34A12....1.41D2....1.12F3.

STROPHOMENA SINUATA Meek.

Plate XXXVIII, figs. 2-2e.

Strophomena sinuata Meek, 1873, Pal. Ohio, I, p. 87, pl. v, figs. 5a-f.

"Shell semicircular, or forming rather more than a semicircle, moderately convex, with valves nearly equal, the dorsal being most convex in the central and anterior regions, and the ventral near the umbo; hinge nearly or quite equalling the greatest breadth; lateral margins forming more or less nearly right angles with the hinge line, or sometimes rounding to the same, and rounding regularly to the front, which forms a semicircular curve, with rarely a slight sinuosity at the middle.

"Dorsal valve flat at the beak, which is not distinct from the cardinal margin, usually a little raised in the middle at the front, so as to form a low, broad, undefined mesial prominence; cardinal area narrow and inclined backward; interior with a low, small, deeply bipartite cardinal process, from which diverge three small ridges, the two lateral of which extend obliquely outward to form the margins of the rather well defined sockets for the reception of the teeth of the other valve, while the third ridge is central, and extends a short distance forward; muscular scars not visible in any specimen examined.

"Ventral valve moderately convex at the umbo, which is not very prominent or arched, and has a minute perforation at the apex; front with usually a broad, shallow, undefined depression;

lateral regions more or less nearly flat; cardinal area well developed, tapering to the lateral extremities, flat, and inclined more or less obliquely backward; foramen closed by a prominent, triangular deltidium; interior showing small, somewhat saucer-shaped cavity, formed by the low, sharp dental laminae, extending forward from the inner side of the rather well-developed oblique cardinal teeth, and curving a little toward each other, without meeting at their inner ends; muscular scars not visible in any specimen examined.

"Surface of both valves ornamented with rather coarse radiating striae, most of which bifurcate once or oftener, while occasionally a shorter one is intercalated between two longer, crossing the whole, occasional small marks of growth, and finer, but obscure, concentric striae may be seen by the aid of a lens, on well preserved specimens.

"Length of a rather large specimen, 0.65 inch; breadth, 0.88 inch; convexity, 0.30 inch."—Meek, *loc. cit.*

The type is from the Cincinnati formation about 350 feet above low water of the Ohio, at Cincinnati, Ohio. I have seen it at a similar horizon near Manchester Station, on Tanner's Creek.

STROPHOMENA SULCATA (de Verneuil).

Plate XXXVI, figs. 10-10d.

Leptaena sulcata de Verneuil, 1848, Bull. Geol. Soc. France, 2d ser., vol. V, p. 350, pl. iv, fig. 4a, 4b.

"Coquille plate, subquadrangulaire, ornée de stries fines et dichotomes comme la précédente [*L. planoconvexa*]. Valve dorsale légèrement bombée, offrant vers le front un sinus pronocé qui relève le bord de la valve ventrale. Aréa triangulaire surbaissée. Ouverture large, fermée par un deltidium complet. Crochet percé d'un petit trou rond. Valve ventrale légèrement bombée; area presque nulle, présentant, vis-à-vis du deltidium de la valve opposée, une ferme toute communication du dedans au dehors. Malheureusement l'intérieur des valves nous est inconnu.

"*Rapports et différences.*—Extrêmement voisine de la précédente, cette espèce n'en diffère que par son contuor général et par le sinus de la valve dorsale. Ce sinus est constant, et la fait distinguer, dans la plupart de collections d'Amérique où nous l'avons vue, sous le nom que nous lui donnons ici.

"*Gisement et localités.*—Le *L. sulcata* se trouve avec l'espèce précédente dans le calcaire bleu des Etats d'Ohio et d'Indiana. Ce calcaire, comme celui de Trenton, appartient au système silurien inférieur.''—d'Verneuil, *loc. cit.*

This species is commonly found in association with *Rhynchotrema dentata,* but it also occurs sparingly at lower horizons, and its distribution is considerably more extended. I have never found it, however, except in the upper divisions of the Richmond formation.

In form this species is the most peculiar of any of the Strophomenas of the Cincinnati group, though it somewhat resembles *S. sinuata.* It is a small shell of semicircular outline, rather thicker than is usual in the genus, and with rather coarser plications. The convexity of the valves is nearly equal, but at the front the dorsal valve possesses a peculiar elevation or low fold, corresponding to a sinus in the ventral valve. The beaks are very small and the area of the dorsal valve narrow, while that of the ventral valve is well defined and rather high. Foramen with a convex deltidium. Apex perforated by a small circular aperture.

1.34A19-21, 23....1.41A7, 8, C1, D3, E1, 2....1.12D1-6. I have also collected it at Laurel, Indiana, and about Hamburg, and Osgood, not far from the top of the Saluda formation. This zone may represent the thinned southern end of the Whitewater division.

TREMATIS MILLEPUNCTATA Hall.

Plate XXXIV, figs. 9-9c.

Trematis millepunctata Hall, 1866, 24th Rep. New York State Museum (advance sheets), p. 221, pl. vii, figs. 22-25.

''Shell small, suborbicular, transverse on the ventral side and lenticular in profile. Ventral valve strongly convex below the middle, more depressed above; with a narrow deeply depressed pedicle-opening, the margins of which are flattened for a space nearly equal to the breadth of the opening. Dorsal valve more elongate, most convex above the middle; the beak pointed and projecting considerably beyond the opposite valve; with a depressed or concave triangular area. Interior of the dorsal valve marked near the middle by two comparatively large semicircular or reniform muscular scars, the breadth across the two more than equal to one-third of the diameter of the valve; the center of the valve has also a slight mesial septum.

''Surface strongly punctate in concentric curves passing from the center of the shell outwards, extending through the shell near the front of the valves, and distinctly marking the cast: inner layers of the shell not punctate.

"Specimens of this species have been sent from Cincinnati, and published and figured as the *T. terminalis* of Emmons. It differs from that species, however, in being more transverse, with a less convexity of the ventral valve and more prominent beak of the dorsal valve; and also in the character of the punctate structure. The Trenton species is distinctly punctured, the puncta passing through the shell, showing most distinctly on partially exfoliated specimens; while in this species they are entirely confined to the exterior layers of the shell. It is also destitute of the radiating striae always found on *T. terminalis* when the shell is partially exfoliated.

"The specimens of this species usually measure about half an inch in length and five-eighths of an inch in width. I have received them from Mr. S. P. Carley, Mr. U. P. James, and other sources."—Hall, *loc. cit.*

1.34A13a, 15b, 17.

TREMATIS RETICULARIS (Miller).

Plate XXXIV, fig. 10.

Crania reticularis Miller, 1875, Cincinnati Quarterly Journal of Science, vol. II, p. 280, fig. 22.

"Surface marked by punctures, arranged, as shown in the figure, in a peculiarly beautiful manner. The rows of punctures, from the cardinal margin, on each side the apex, curve downwards a little, as they ascend toward the apex. The rows as they leave the lateral margins form the same curves, so that the rows soon cross each other, giving the punctures the rhomboidal form, and the surface the checkered appearance, formed by curved lines gradually approaching and crossing each other, like 'engine turnings' on a watch-case.

"Length of a specimen, 0.08 inch; width, 0.11 inch; convexity, 0.04 inch.

"The specimen figured is one of a number found, attached by the lower or ventral valve to the under side of a worn piece of *Tetradium fibratum*, near Brookville, Indiana, by Mr. Ed. R. Quick, a collector of that place. The specimens vary in form considerably, but the punctate surface is as distinct and uniform as it is in *Trematis millepunctata*. The shell has the same appearance that the shells have in the latter genus, and it may be that it is a true *Trematis.*

"The acute apex and the variability of form, however, have induced me, at present, to class it with *Crania.* The lower valve and interior are unknown."—Miller, *loc. cit.*

ZYGOSPIRA CINCINNATIENSIS Meek.

Plate XXXVI, figs. 9-9b.

Zygospira cincinnatiensis Meek, 1873, Pal. Ohio, vol. I, p. 126, pl. xi, figs. 5 a-c.

"This variety or species differs from the last [*Z. modesta*], in its larger size, greater proportional breadth, more prominent mesial elevation, with a larger and deeper sulcus along its middle, and in the deeper mesial sinus of its dorsal valve, and the more spreading character of its lateral plications. Its plications likewise differ in being proportionally coarser, and more angular, and more frequently show a disposition to bifurcate, particularly those on the sides of the mesial elevation of the ventral valve, and within or near the mesial sinus of the dorsal valve. Its lateral margins are likewise generally more compressed; and the beak of its ventral valve rather more strongly incurved.

"Under a strong magnifier, in a favorable light, extremely minute, regular and closely crowded concentric striae may sometimes be seen on the sides of the plications, and other protected parts of the shell. These are similar to those sometimes seen on the last, but more distinct.

"Although this is possibly a distinct species from the last, it would, I should think, be rather difficult to distinguish young or small examples of it from that shell. Hence, I am inclined to think that it may be only a robust variety of the same.

"Length of one of the largest examples, 0.41 inch; breadth, 0.52 inch; convexity, 0.25 inch."—Meek, *loc. cit.*

This species occurs at a number of levels in the upper part of the Eden formation.

1.34C2, 5, 6, 7, 8, 9, 10, 11....5.9A29, 31, 35....1.38A17, 21, 24, 37, 45.

ZYGOSPIRA MODESTA Hall.

Plate XXXVI, figs. 8-8i.

Atrypa modesta Hall, 1847, Pal. New York, vol. I, p. 141, pl. xxxiii, fig. 15.

"Suborbicular or planoconvex, with the beak extended; width a little greater than the length; cardinal line distinctly marked and somewhat extended; dorsal valve convex, with an elevated ridge along the center, occupied by four plates which are stronger than the others; beak prominent, incurved and perforated, the perforation extending below the beak and occupying a portion of the area; ventral valve depressed-convex, broadly oval or nearly circular, with a broad but ill-defined sinus along the middle, the central plication stronger than the others, with a smaller one on each side; each valve with about 18 simple rounded plications; surface obscurely punctate.

"This neat and beautiful little species well merits the name bestowed upon it by Mr. SAY, which I am happy to preserve. It is a rare species in New-York, while it is abundant in Ohio, Indiana and Kentucky. It is, in a large number of specimens examined, very constant in the characters given above. The central elevated portion consists of four stronger plications, which appear to be in two pairs, from being separated in the middle by a deeper and wider groove, while the groove between each pair is narrower than between the other plates of the shell. These characters, with the stronger plication in the center of the ventral valve, are constant, and apparently reliable in distinguishing the shell. The mesial sinus on the ventral valve, which is scarcely conspicuous in young shells, becomes deeper and more strongly marked in older ones, and produces a strong depression in the front of the shell."—Hall, *loc. cit.*

No other species known to me from the Cincinnati series is as ubiquitous as the species described above. It occurs in the great majority of my collecting zones from the middle Eden to the top of the Cincinnati series. Even *Rafinesquina alternata,* with its varieties is not more persistently present than *Zygospira modesta.* Nor have I observed that the latter species presents any degree of variation. Certainly not enough to warrant an additional name. Though usually not particularly abundant, in several zones it becomes the leading fossil, occasionally completely filling the rock. This is the case especially in the Rafinesquina zone at several levels. In the Lorraine the species is usually common, and in washings from this formation, specimens of *Z. modesta* of all sizes from the nepionic stage, half a millimetre in diameter, to the adults, are so common that one almost tires of picking them out. In the Richmond formation it is usually less common, but nearly always present.

5.9A8, 25, 29, 31, 44, 50....1.33A3....1.34A1, 3, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, B1-3, 4-5, C5, 10, 11, 13, 14a, 14b....1.41A2, 4, 5, 6, 7, 8, 9, 10a, 10b, B1, 2, 3, C1, 2-3, D1, 2, 3, E2, 4, 5, 6....1.12A2, D1-6, E3, F3....1.38A11, 13, 17, 21, 23, 24, 29, 31, 32, 37, 41, 55, 63, Ba-h, and at practically all other localities.

GASTEROPODA AND PTEROPODA.

DIAGNOSES OF GENERA.

BELLEROPHON Montfort.

Symmetrically involute, subglobose shells, with or without an umbilicus, the latter never very large in the typical section; volutions more or less rounded on the back; aperture generally expanded, usually with a callosity on the inner lip; outer lip with a more or less deep emargination behind which there is a well developed slit-band or an elevated blunt keel; surface sculpture consisting of more or less strongly developed striae of growth only. (Ulrich.)

BUCANIA Hall.

Restricted by Ulrich.

Shell consisting of from three to five more or less depressed volutions coiled in one plane, with generally a wide umbilicus and not greatly—never abruptly—expanded aperture. Surface markings consisting of equal or unequal revolving riblets and lines of growth, together producing a more or less cancellated appearance. Revolving lines wavy or wrinkled, oblique, especially in the umbilicus, crossing from the ventral side of a whorl to the dorsal slit-band in the space of about one-half a volution. Frequently they are interrupted by strong lamellae, the wavy edges of which are parallel with the lines of growth and the apertural margin. Aperture transverse and somewhat reniform in the typical section, higher and relatively larger in the *B. nashvillensis* section. In the former the lips are thin, the outer one sinuate, and the sinus prolonged into a rather long narrow median slit; in the latter the lip is rather thick and the slit shorter. Slit-band distinct, raised or depressed. (Ulrich.)

CLATHROSPIRA Ulrich.

Shell depressed-conical, sometimes sublenticular; base more or less convex, its bulk usually nearly equal to the apical part; umbilicus very small or wanting; volutions not very numerous, sometimes slightly turriculate or strongly angular near the mid-height; aperture oblique, subquadrate, the inner lip slightly reflected or merely thickened, the outer deeply notched at the peripheral angle; no slit; band nearly vertical and situated upon the periphery of the whorls. The surface beautifully cancellated. (Ulrich.)

CONRADELLA Ulrich.

Shell coiled symmetrically, general form as in *Cyrtolites* and *Oxydiscus,* the volutions enlarging gradually and being strongly keeled dorsally. Aperture oval or subcordiform, widest in the middle or below, without callosities of any kind, nor with a sinus in the outer lip. From the aperture to a point about half around the dorsal circumference of the last volution there is a narrow open slit lying between two sharply elevated edges; behind this point the slit is closed over and forms an ordinary slit-band with distinct lunulae. Surface with close or distant transverse imbricating lamellae, the anterior edges of which are zigzagged and sometimes greatly spread out. Lamellae plicated, the successive folds often arranged so as to form small revolving ridges; over all very fine lines of growth. (Ulrich.)

CYCLONEMA Hall.

Shells turbinate or conical, thin, spire short, composed of few more or less ventricose volutions; no umbilicus; surface sculpture consisting of numerous revolving lines and small ridges crossed obliquely by sharp lines of growth; aperture oblique, varying from rounded to subquadrate; inner lip more or less thickened, reflected, always excavated. (Hall, Ulrich.)

CYCLORA Hall.

Subglobose, shell thin, spire short, consisting of a few whorls; columella smooth, slightly reflected over a minute umbilicus, aperture circular. (Hall.)

CYRTOLITES Conrad.

Shell coiled in the same plane, symmetrically or nearly so; volutions two or three, scarcely contiguous, the last occasionally free, enlarging gradually, carinated on the back and often on the sides, giving a subquadrate cross-section; aperture not abruptly expanding, with or without a median notch in the outer lip; no slit-band; shell thin, without callosities of any kind; surface sculpture reticulated or cancellated, consisting of straight or obliquely curved regular transverse lines connected by short oblique lines. (Ulrich.)

HOLOPEA Hall.

Shells conical, ventricose, more or less oblique or nearly direct; aperture round ovate; margin entire; surface marked by simple fine curved striae, or cancellated. (Hall.)

The above is Hall's original diagnosis of the genus. Ulrich thinks that the group formed by the species now referred to *Holopea* is composite and contains material for several genera.

HORMOTOMA Salter.

Shell elongate, beaded, practically imperforate, composed of rather numerous (eight to fourteen) rounded or subangular whorls; aperture acuminate subovate, narrow and more or less prolonged below; outer lip with a broad and deep V-shaped notch and no slit; band median or submedian, generally obscure, of moderate width, flat or slightly concave, in the perfect condition margined on each side by a delicate raised line; surface marked with lines of growth only; these are never very sharp and always sweep backward very strongly, from below especially, to the band. (Ulrich.)

HYOLITHES Eichwald.

Shell symmetrical, conico-pyramidal, composed of calcium carbonate, posterior portion often divided off by a transverse septum; one side flattened, and the margin of the flattened side projecting somewhat above the opposite wall. Surface with fine transverse striae, or longitudinally striated, or both.

CONULARIA Miller.

Shell rectilinear, inversely conical, rectangular to rhombic in cross-section, with usually sharp edges, acute or truncated posteriorly. Each of the transversely striated or ribbed lateral faces divided into longitudinal halves by a superficial groove, corresponding internally to a median ridge. Posterior portion of the shell divided off by septa. Aperture constricted by four triangular or linguiform incurved lobes of the anterior margin. (Pilsbry.)

LIOSPIRA Ulrich.

Shell sublenticular, the spire low, depressed conical, almost smooth, the sutures very close, scarcely distinguishable; volutions subrhomboidal in section, flat, gently convex or slightly concave above, sharply rounded at the periphery, convex below, and not infrequently angular at the edge of the umbilicus. The latter is usually present but may be filled entirely by an extension of the inner lip, in other cases it may be open during the younger stages only. Aperture deeply notched; band scarcely distinguishable as such, wide, situated on the narrow outer edge of the whorls though chiefly upon the upper side. Surface markings very delicate, rarely preserved, consisting generally of exceedingly fine transverse lines bending strongly backward on the apical side to the peripheral band over which they continue with little interruption to sweep sharply forward again on the lower side. Faint revolving lines occasionally observed. (Ulrich.)

LOPHOSPIRA Whitfield.

Shells with more or less elevated spires; whorls closely coiled throughout or only in the upper part, the last often exhibiting a tendency to become disconnected; whorls angular on the periphery and bearing from one to five distinct carinae; central or peripheral keel strongest and most prominent carrying the band, which is obtusely rounded, or more or less distinctly trilineate, with the median line heavier and more prominent than the other two; axis rarely, if ever, solid; an umbilicus, usually of very small size, nearly always present. Inner lip generally thickened, often slightly twisted, turning around the umbilicus so as to form a kind of hollow pillar. Outer lip more or less deeply notched, but the center of the notch, which lies at the peripheral angle, is never prolonged into a slit. Surface markings parallel with the apertural edge; occasionally cancellated by fine spiral lines. (Ulrich.)

MICROCERAS Hall.

Convolute, volutions few, horizontal, rapidly diminishing from the aperture; aperture subrhomboidal; shell subcarinated upon the back, chambered? (Hall.)

Minute shells, gregarious in habit, in form like *Cyrtolites*. Always of a black or brownish color, with the surface perfectly smooth and generally glossy. Possibly dwarfed varieties of other species. (Ulrich.)

OXYDISCUS Koken.

Strongly compressed, disciform shells; volutions embracing very little, expanding gradually to the aperture, sharply keeled; aperture somewhat lanceolate or subtriangular, without an inner callosity; outer lip with a deep V-shaped excision, continuing in the dorsal keel as a long and very narrow slit; behind the slit the summit of the keel may show a more or less distinct band with lunulae, or merely a delicately bordered raised line. Surface markings consisting of growth lines only. These bend strongly backward in passing from the ventral side of the whorl to the keel. (Ulrich.)

PROTOWARTHIA Ulrich.

Aperture large but not abruptly expanded, the outer lip bilobate, with a broad and more or less deep sinus but neither a slit nor band; dorsum convex, never carinate; umbilicus closed; surface markings very fine, generally consisting of more or less obscure crowded lines of growth and delicate revolving striae. The inner lip forms a thin granulose deposit over the dorsum of the inner end of the last whorl and extends on each side around the umbilical region. This portion is covered with interrupted or inosculating lines. (Ulrich.)

RAPHISTOMA Hall.

Shell sublenticular or plano-convex, the spire flat, the sutures close; volutions triangular in section, sharply angular and generally thin at the periphery; there is neither a slit nor a band; umbilicus varying in size but nearly always present; aperture turning backward slightly so as to form a shallow notch at the outer angle; lines of growth only; on the flattened upper surface these are slightly sigmoid and usually interrupted by a raised line between the two curves; passing over the acute edge they turn strongly forward and finally back again into the umbilicus. (Ulrich.)

SALPINGOSTOMA Roemer.

Shell symmetrically coiled in one plane; volutions numerous, enlarging gradually, scarcely ever embracing, the consequence being a large open umbilicus. Aperture abruptly expanded at maturity, trumpet-like; peristome thin, the outer portion slightly sinuate. Inner volutions with a slit band as in *Bucania.* This is replaced in the outer half of the last whorl by a long narrow opening or slit which, however, does not extend to the apertural expansion, but is closed some distance behind it. Surface marked with simple or sublamellose lines of growth and more or less oblique. irregular and sometimes interrupted or wavy revolving lines. (Ulrich.)

SCHIZOLOPHA Ulrich.

In every respect like *Lophospira* excepting that the apertural notch is prolonged into a long parallel-edged slit. (Ulrich.)

TROCHONEMA Salter.

Shell turbinate, umbilicated; spire varying in height, base generally flattened yet sometimes quite ventricose; whorls not numerous (4-8), varying from strongly angular to rounded, always with two more or less prominent ridges or angles between which lies a broad vertical, usually flat or concave, peripheral space; a third ridge usually near the suture, while a fourth usually surrounds the umbilical cavity. Other, but smaller ridges, may occur though chiefly on the basal half of the whorls. Lines of growth crossing the whorls from above obliquely backward, often vertical and not infrequently inclined in the opposite way on the peripheral band. In the last case the outer lip is broadly notched at the extremity of the upper peripheral angle. Aperture usually very oblique; peritreme complete; inner lip varying in thickness, not reflected. (Ulrich.)

TRYBLIDIUM Lindström.

Shell patelliform, obvoate, narrowest anteriorly, forming a very low cone; apex anterior, nearly marginal. Muscular scars in seven or eight disconnected pairs, arranged in an oblong circle, the anterior pair drawn out and meeting in front beneath the beak. Surface usually marked by concentric lines of growth only; occasionally also by obscure broad radial plications. (Ulrich.)

DESCRIPTION OF SPECIES.

BELLEROPHON GORBYI Miller.

Plate XXXIX, figs. 1-1b.

Bellerophon gorbyi Miller, 1891, Geol. Nat. Hist. Indiana, XVII, p. 694, pl. xiv, figs. 7-9.

"Shell medium size, involute, longer than wide. Volutions expanding very moderately, rounded over the dorsum, and subangular on the sides. Umbilicus deep, sides converging with a slightly convex outline from the subangular sides. Mesial band or keel narrow, subangular. Aperture wider than high, subelliptical or reniform. Lip moderately thickened at the inner whorl, but not spreading, thinner on each side of the sinus in the outer margin. Surface beautifully sculptured and ornamented by numerous waving lines that curve forward from the mesial band on the dorsum and backward over the subangular sides, without interruption, and down the converging sides to the umbilicus.

"This is a beautiful species, and distinguished from all others, in rocks of the same age, by the reniform aperture, subangular sides and surface ornamentation.

"Found by Prof. S. S. Gorby, in the Hudson River group, in

Dearborn County, Indiana, and now in his collection. The specific name is in honor of the collector.''—Miller, *loc. cit.*

BELLEROPHON MOHRI Miller.

Plate XXXIX, figs. 2-2a.

Bellerophon mohri Miller, 1874, Cincinnati Quarterly Journal of Science, I, p. 306, fig. 30.

''Shell involute; outer volution abruptly expanded at the aperture, both in length and breadth; inner volutions comparatively small; dorsum angulated and strongly keeled; outer lip, rapidly expanding in a rounded outline upon each side of a shallow sinus, curving abruptly at the point of greatest expansion, and, with the inner lip, forming a line nearly at right angles with the plane of the volutions; inner lip thickened and bearing a prominent node in the middle; surface nearly smooth in the specimens examined, but faint traces of fine lines may be observed, curving with the shape of the shell downward from the sinus, at the outer edge of the expanded aperture.

''Aperture two inches in breadth, while the body whorl, just at the commencement of the expansion, is only one-half inch across it in the same direction.

''This species is remarkable for the strongly carinated dorsum, and for the great expansion of the aperture in proportion to the size of the inner whorls composing the body of the shell.

''The specific name is given in honor of Paul Mohr, Sr., of Cincinnati, an experienced and extensive collector of fossils and minerals, and member of the Cincinnati Society of Natural History.

''I found the species at Richmond, Indiana, in the upper part of the Cincinnati Group, associated with *Cypricardites hainesi.*''—Miller, *loc. cit.*

According to Ulrich, not uncommon in the upper part of the Richmond formation at Richmond, Indiana. (Whitewater?)

BELLEROPHON SUBANGULARIS Ulrich.

Plate XXXIX, figs. 3-3b.

Bellerophon subangularis Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 920, pl. lxiv, figs. 14-16.

''Having no umbilicus this species is related to *B. clausus* and *B. recurvus,* but it is distinguished at once from both by its subangular dorsum, and relatively narrower and somewhat triangular aperture. Its surface markings are rather distinct and regular;

on the dorsal slopes they sweep backward gently to the carina."—Ulrich, *loc. cit.*

The types are from the Richmond formation, Richmond, Indiana.

BUCANIA CRASSA Ulrich.

Plate XXXIX, figs. 4-4b.

Bucania crassa Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 893, pl. lxvii, figs. 46-48.

"This species, though closely resembling *B. frankfortensis* and *B. nashvillensis* in many respects, will be distinguished almost at a glance by its uniformly convex instead of subangular dorsum. This difference, in conjunction with a greater relative width of the whorls, causes the aperture to be proportionally wider. The lower lip also, though strong, has a longer slope and its surface is less convex. The umbilicus is somewhat smaller and more abrupt than in *B. frankfortensis,* and the shell is more globose.

"The specimen figured has suffered considerably from maceration, the slit-band and all, excepting the strongest of the surface markings, being quite obliterated. On two other specimens, neither as complete as the one illustrated, there is a low, yet well defined, rounded dorsal ridge, and in one this is accompanied on each side by a faint furrow, while anteriorly it terminates in an open slit about 17 mm. long. Whether this dorsal ridge was originally flat or concave on the summit, and bore lunulae, we are unable to say. Still it is to be expected that such a condition obtained on the perfect shell. As to the surface markings, what remains of them indicates a sculpture similar to that shown in our figures of *B. lindsleyi* and *B. nashvillensis.*

"The shell in this and the species with which we have compared it is unusually thick for the genus, especially on the ventral side of the volutions, and casts of the interior must look very different from the shells themselves. We have not, however, seen any casts which seemed at all likely to belong to either."—Ulrich, *loc. cit.*

The types are from the uppermost beds of the Richmond formation at Richmond, Indiana.

BUCANIA SIMULATRIX Ulrich.

Plate XLII, figs. 9, 9a.

Bucania simulatrix Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 892, pl. lxiii, figs. 48, 49; pl. lxvii, fig. 45.

"Shell large, known from casts of the interior only. These consist of three or four comparatively slender and loosely coiled volutions, leaving a large umbilicus in which all the inner whorls are clearly exposed. Volutions somewhat reniform in section, narrowly rounded in the ventral third of the sides, the ventral surface gently concave, the dorsal part of the section nearly semi-circular. Last volution obtusely carinated, with the dorso-ventral diameter increasing toward the aperture more rapidly than is the case with the inner volutions, the height and width of the whorl just behind the aperture being about equal, while at the smaller end the two dimensions are respectively about as three to five. Aperture somewhat triangular-ovate, wide below, the expansion taking place chiefly at the lower part of the sides. In the cast the expansion appears very abrupt, but doubtless it is much less so in the shell itself. Inner lips slightly reflexed at the sides, thick centrally; outer lip broadly and deeply sinuate. Surface markings unknown; slit long. The best specimen seen has the following dimensions: entire hight 46mm.; hight of aperture 29mm.; greatest width of same 33mm.; width and hight of last volution just behind the aperture about 23mm.; hight and width of inner end of same 5 and 8.5mm. respectively; greatest diameter of umbilicus about 23mm.; length of slit about 31mm.

"The hight in this species is relatively greater than in *B. frankfortensis,* which we consider as more closely related than any of the other species. The aperture also is less nearly triangular, the apertural margin as seen in a side view, less uniformly curved, the umbilicus larger, and the volutions more evenly rounded on the back. The next species, *B. crassa,* is a more closely coiled and heavier shell, having, therefore, also a smaller umbilicus. The form of the mouth and sinus is also different. Casts of *B. simulatrix* resemble those of the associated *Salpingostoma richmondensis* in a remarkable degree. For comparison see the description of that species." —Ulrich, *loc. cit.*

The types are from the Richmond formation, Richmond, Indiana.

CLATHROSPIRA SUBCONICA (Hall).

Plate XLI, figs. 8-8b.

Pleurotomaria subconica Hall, 1847, Pal. New York, I, p. 174, pl. xxxvii, figs. 8 a-e. Also p. 304, pl. lxxxiii, figs. 3 a-e.

"Trochiform; spire elevated, apex acute; volutions about five, flattened above, with a projecting carina just above the suture; last volution strongly carinated on the outer edge, and marked with a spiral band, ventricose below; aperture transverse, subquadrate, angular on the outer side and round below; surface marked by fine striae, which bend gently backwards from the suture, and more abruptly on the lower part of the whorl; spiral band a distinct groove, margined by sharp elevated edges, upon which the striae bend backwards in an abrupt curve; below this the striae bend gently forward, and thence curving backwards, terminate in the umbilicus; longitudinal striae crossed by transverse sharp elevated lines which are finer than the longitudinal ones.

"This is a beautiful trochiform shell, with a symmetrical conical spire, and beautifully cancellated surface. The finer concentric striae are often obliterated from wearing or maceration, the longitudinal ones only remaining, and these also are often obliterated. The spiral band is distinct on the last volution, and the striae upon it appear to be crowded into ridges. The suture is formed just at the lower margin of the band, leaving it visible at the lower edge of the higher volutions. In casts of this species, the outer angle of the last volution is distinctly carinated, as also the lower margin of the higher volutions."—Hall, *loc. cit.*

Occurs probably at many localities in Ohio and Indiana in the Lorraine and Richmond formations. According to Ulrich there is considerable doubt of the occurrence of this species in the Cincinnati region.

CONRADELLA DYERI (Hall).

Plate XXXIX, figs. 8-8c.

Cyrtolites dyeri Hall, 1871, 24th Report of the New York State Museum, 1872, p. 230, pl. viii, figs. 7, 8. (Advance sheet published in 1871.)

"Shell small, laterally compressed, consisting of two or more volutions, the outer one embracing the inner for about half its breadth, bearing a moderately wide umbilicus, in which may be seen a portion of the preceding volution; sides of the volution convex, obtusely subangular near the margin of the umbilicus into which it curves abruptly and more gradually declines with a slight convexity, toward the salient subcarinate dorsum. Transverse section cordiform, broadest near the umbilical margin.

"Surface of shell marked by from eight to twelve nearly equidistant revolving ridges, with sometimes smaller intermediate ones, and also crossed by numerous closely arranged transverse lamellose ridges having a double backward flexure between the revolving lines, and a general retral direction towards the keel of the shell.

"The species differs in its surface markings from any of the forms heretofore described."—Hall, *loc. cit.*

The character of the surface markings will make the identification of this pretty species an easy matter.

1.34A16b....1.12D1-6....1.12F3.

CONULARIA FORMOSA Miller and Dyer.

Plate XLII, fig. 2.

Conularia formosa Miller and Dyer, 1878, Jour. Cin. Soc. Nat. Hist., I, p. 38, pl. i, figs. 12, 12a.

"This species in general form is pyramidal, somewhat quadrangular, angles furrowed, and sides somewhat rounded as in *C. trentonensis.* The surface is marked by rounded furrows, separated by obliquely transverse ridges, extending from each angle of the shell diagonally towards the mouth, and meeting those from the opposite angle in the middle of each side. These ridges are ornamented with small nodes or tubercles at the junction with the striae, which cross the furrow on the side toward the apex of the shell. The rounded furrows are crossed by striae, which are about twice as numerous as the transverse ridges, and which terminate on the ridge toward the mouth of the shell in a small tubercle. The longitudinal striae do not cross the transverse ridges, nor are they continued in straight lines on the opposite sides (the magnified view is erroneous in this respect), but on the contrary the striae, which cross the furrows, commence at the ridge toward the apex, at a point between the tubercles, and crossing the furrow toward the mouth terminate at the tubercles.

"This species is readily distinguished from *C. trentonensis,* which it most resembles in general form, by the tubercles on the transverse ridges. Even badly exfoliated specimens may be distinguished by the aid of a pocket magnifier.

"The specimen illustrated is from the collection of C. B. Dyer, and was found in the upper part of the Cincinnati Group, near Versailles, Ind., by Dr. W. H. H. Hunter. Another specimen, showing very prominent tubercles, was collected by Dr. C. A. Miller, on the top of the hills near the city of Cincinnati, and is now in S. A. Miller's collection."—Miller and Dyer, *loc. cit.*

CYCLONEMA BILIX (Conrad).

Plate XL, figs. 2-2d.

Pleurotomaria bilix Conrad, 1842, Jour. Acad. Nat. Sci. Philadelphia, VIII, pt. II, p. 271, pl. 16, fig. 10.

"Spire conical; volutions four; sides subrectilinear at base, suddenly contracted at the suture; surface with spiral raised striae alternated in size; large volution abruptly rounded in its greatest circumference; base flattened and striated.

"*Locality.* Richmond, Indiana, in limestone of the age of the rocks of Salmon river series, New York. Lower Silurian.

"This species is the constant associate of PTERINEA *carinata,* in the limestone of the west, termed 'Cliff limestone.' This species of *Pterinea* is limited in New York to the Salmon river shales, and eminently characterises the formation."—Conrad, *loc. cit.*

This species, or rather forms supposed to belong to it, has been the cause of a good deal of confusion to collectors. We are indebted to Ulrich for a restriction of typical *C. bilix* to the Richmond group form, and the erection of a considerable number of new species, some of which are described elsewhere in this report. The differences between these forms are in most cases exceedingly slight, nevertheless they ordinarily have different ranges. Whether or not they should be considered as species or only good varieties may be left for discussion in some more appropriate place. I have taken my figure from Ulrich rather than Conrad, because the former is certainly better suited to illustrate the characters of the species.

1.34A10, 16a, 20, 21....1.41C2-3, D1, 3, E1, 2, 3.

CYCLONEMA BILIX var. FLUCTUATA (James).

Plate XL, figs. 3-3b.

Cyclonema fluctuata James, 1874, Cincinnati Quarterly Journal of Science, I, p. 152 (not figured).

"Shell turbinate, depressed; breadth greater than the length; volutions four or five increasing rapidly in size, the first one flattened on the under side; aperture suboval, oblique; suture broad and deep; inner lip thickened, outer lip thin and sharp. Surface marked by revolving lines, varying in size and distinctness, in some examples being sharp and prominent, in others scarcely visible to the naked eye, crossed by fine striae, or lines of growth, which, to the sharply defined ones, give the shell a beautifully ornamented appearance. Volutions with oblique undulations, and a broad revolving depression near or above the center, most conspicuous on the body whorls, sometimes extending to the apex.

"Height of a large specimen about 1¼ inches, breadth 1½ inches. Small ones less than ⅝ths of an inch in height and breadth."—James, *loc. cit.*

This form is considered as a variety of *C. bilix* by Ulrich. It is reported from the upper part of the Cincinnati group by James from several localities in Ohio and Indiana. Ulrich reports it in considerable abundance from Richmond and Versailles, Indiana.

CYCLONEMA HUMEROSUM Ulrich.

Plate XL, figs. 5-5c.

Cyclonema humerosum Ulrich, 1897, Geol. Nat. Hist. Minnesota, III, pt. II, p. 1061, pl. lxxviii, figs. 43-46.

"The average size in this species is somewhat greater than in either of the preceding forms, [*C. inflatum* and *C. varicosum*] while the apical angle is generally wider and more constant, the majority of the specimens varying comparatively but little either way from 85°. The principal feature, however, is a strongly developed shoulder, giving a deeper suture than in any other species of the genus. This shoulder may be rounded or, especially in the Richmond group form, quite angular. In the latter the slope of the outer side of the last whorl is very often distinctly concave, and not infrequently undulated in the direction of the lines of growth. The same conditions occur less frequently though quite as well marked in the Lorraine form. The surface markings are fairly constant. About ten principal subequal carinae occur on the outer slope of the body whorl, and about the same number of smaller ones on the periphery and base. The larger ones usually alternate with a much thinner set."—Ulrich, *loc. cit.*

Reported by Ulrich as very abundant in the upper half of the Lorraine group at Cincinnati, and not rare at several horizons in the Richmond group at Waynesville, Clarkesville, Oxford and other localities in Ohio, and at Richmond, Versailles and other points in Indiana. I have collected an abundant species or variety of *Cyclonema* in the Rafinesquina zone along Tanner's Creek since the new railroad cuts were opened there, that apparently is this species. This zone is not well represented in my Tanner's Creek section because, at the time, there were few exposures of these beds. At the present time they are completely and beautifully exposed in the cuts.

CYCLONEMA MEDIALE Ulrich.

Plate XL, figs. 4, 4a.

Cyclonema mediale Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 1059, pl. lxxviii, figs. 29, 30.

"Distinguished from *C. Bilix* Conrad, by its more ventricose whorls and stronger revolving carinae. The under side of the whorls is fuller and the outer side (seen in the spire) is always distinctly and uniformly convex, there being no sign of a shoulder at the suture, nor of the median concavity, both of which occur quite generally in Conrad's species. The suture is comparatively shallow. There are two common varieties, one having three widely separated strong carinae on the upper slope followed below by the smaller and gradually decreasing and crowding ridges or lines, the last occurring usually about the middle of the base. Much thinner revolving lines generally occur between the larger. In the other variety the revolving ridges are more equal in size and distribution, and at least three more in number. On the body whorl they number between fifteen and twenty, but not more than eight or ten of these show on the next whorl above, while in the first variety but four are shown. The apical angle for the whole shell varies greatly but always is narrower for the upper turns than it is for the last two or three.

"The strongly carinated variety resembles and probably was derived from *C. varicosum* Hall, but its whorls are less convex and the upper part of the spire more slender, the entire shell of *C. mediale* consisting of six or seven whorls, while *C. varicosum* probably never has more than five volutions. The columellar lip also is straighter and both the revolving and transverse ridges and lines stronger in Hall's species."—Ulrich, *loc. cit.*

This species of *Cyclonema* is, according to Ulrich, the common form in the lower part of the Lorraine formation of Ohio and Indiana. No doubt most collectors have been in the habit of identifying this form as *C. bilix*. The latter, as will be seen, is a Richmond form.

1.33A3, 1.34C14b, B1-3. . . .1.38P.

CYCLORA MINUTA Hall.

Plate XL, figs. 6-6c.

Cyclora minuta Hall, 1845, Amer. Jour. Sci., XLVIII, p. 294. (Not figured.)

"Smooth; volutions about three, rapidly expanding towards the mouth; spire moderately elevated; aperture round and well defined. The last whorl forms the principal part of the shell.

"Height of shell 1-30 to 1-20 of an inch.

"This species is exceedingly numerous among those obtained by Mr. Carly, there being twice as many of this one as of all the others."—Hall, *loc. cit.*

There is still some doubt as to whether this and other minute species generally comprised under the name of *Cyclora* may not be the young of other species of Gastropods. They occur, however, in enormous numbers at horizons where other species are rare or lacking, a fact which admits of the interpretation that they are good species. It is also possible that all of these small shells are casts. The height of the spire and the form of the aperture seem to be the only characters in which this and the next species differ.

1.34A1, 7, 8, 9, 10, 11, B4-5, C13....1.12A2.

CYCLORA PARVULA Hall.

Turbo ? parvulus Hall, 1845, Amer. Jour. Sci., XLVIII, p. 294. (Not figured.)

"Spire elevated, volutions about four, smooth; first whorl angulated upon the centre towards the aperture; outer edge of the aperture projecting downwards.

"Height of shell 1/15 of an inch."—Hall, *loc. cit.*

Reported from Versailles, Indiana, in Kindle's list.

CYCLORA PULCELLA Miller.

Plate XL, figs. 7-7b.

Cyclora pulcella Miller, 1882, Jour. Cin. Soc. Nat. Hist., V, p. 231, pl. ix, figs. 9-9b.

"Shell small, rather wider than high, whorls three, which increase rapidly in size, suture well defined, aperture somewhat circular, umbilicus moderately large. Surface ornamented with numerous fine lines, extending from the suture a little obliquely backward. The cast of this species bears a resemblance to *Cyclora minuta,* from which it is distinguished by its larger size and more rapidly swelling volutions. The shell is distinguished by these differences, and also by the surface ornamentation.

"Shell about a line in height, and about a line and a half wide.

"The author collected this species in the upper part of the Hudson River Group, near Versailles, Indiana."—Miller, *loc. cit.*

CYRTOLITES ORNATUS Conrad.

Plate XL, figs. 8, 8a.

Cyrtolites ornatus Conrad, 1838, Annual Report of the New York Geol. Surv. p. 118. (Not figured.)

"*Cyrtolites ornatus.*—Shell with transverse rounded ribs and fine striae; periphery acutely carinated. Length, 1 inch. *Locality,* Washingtonville, Oswego county [N. Y.]."—Conrad, *loc. cit.*

The following very excellent description is quoted from Ulrich and Scofield:

"Shell varying in diameter between 12 mm. and 30 mm., with the average at about 23 mm. Volutions two or three, rapidly increasing in size, strongly and sharply carinate dorsally, rhombic subquadrate in section; sides prominent and subangular or narrowly rounded along a line about three-fifths of the hight of the volution within the dorsal carina, the dorsal slopes gently convex and distinctly undulated by strong slightly curved transverse furrows and subangular ridges, the ventral or umbilical slopes almost flat and usually without undulations; ventral side with a sharp central furrow for the reception of the dorsal carina of the preceding volution. Umbilicus well defined, wide and deep, the edge wavy. Aperture a little wider than high, the height equalling usually a trifle more than half the greatest diameter of the shell, more or less rhombic-subquadrate, the outline often becoming a little rounded with age. Entire surface covered with a delicate network formed of raised lines running almost straight across the whorls and short connecting lines arranged alternately, the result being somewhat similar to the pitting of a thimble. In a good light the network is generally distinguishable without the aid of a magnifier, and, excepting three specimens, quite uniform in strength in different shells, there being on the outer half of the last whorl nearly always seven or eight of the transverse lines and eight or nine of the short lines in 2 mm. In the excepted specimens the network is more compact, there being over the outer part of the last whorl from ten to twelve of the transverse lines in the same space. On another, with the reticulation unusually coarse, the number averages between six or seven. On the last specimen a good magnifier brings out some very fine lines of growth running through the network. It is important to note that there is no perceptible backward curvature of the transverse lines in nearing and crossing the dorsal carina."—Ulrich and Scofield. Geol. Minn. vol. III, pt. II, p. 860.

Reported in Kindle's list from Versailles and Madison, Indiana. According to Ulrich it occurs in the Lorraine and Richmond.

HELICOTOMA MARGINATA Ulrich.

Plate XL, fig. 10.

Helicotoma marginata Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 1036, pl. lxxiv, fig. 39.

"Of this species we have seen but the unique example of which a view of the upper side is given on plate LXXIV [of Minn. Rept.]

It is remarkable chiefly because the lower part of the outer side of its whorls is so prominently developed that it projects like a broad flange."—Ulrich, *loc. cit.*

The type is from the extreme top of the Richmond formation at Elkhorn Falls near Richmond, Indiana.

HOLOPEA (?) HUBBARDI Miller.

Plate XL, figs. 11, 11a.

Holopea hubbardi Miller, 1893, Geol. Nat. Hist. Indiana, XVIII, p. 318, pl. ix, figs. 39, 40.

"Shell a little below medium size, depressed conical; width a little more than the height; whorls three, moderately and uniformly ventricose, the last one constituting nearly the entire shell, or four-fifths of it; suture moderately deep; aperture subcircular; umbilicus well defined; surface with close, fine striae, curving backward and indicating the growth of the shell.

"The size, shape of the mouth and umbilicus will distinguish this species from all others that have been defined.

"Found by J. F. Hammell and Prof. George C. Hubbard, in the Hudson River Group, at Madison, Indiana, and now in their collections and in mine. The specific name is in honor of Prof. George C. Hubbard, one of the collectors."—Miller, *loc. cit.*

HYOLITHES (?) DUBIUS Miller and Faber.

Plate XLII, fig. 3.

Hyolithes ? dubius Miller and Faber, 1894, Jour. Cin. Soc. Nat. Hist., XVII, p. 155, pl. viii, fig. 23.

"This is a very small species, rarely exceeding two-tenths of an inch in length. Transverse section circular. It increases very little in size from the commencement at an obtuse point. Sometimes it seems to be slightly curved. All the specimens are casts and very smooth. We are not sure that it is a *Hyolithes,* but if it is not it is quite anomalous, and deserves specific name. Fragments of Trilobites occur in the same association, but they are beautifully preserved, the tubercles on *Calymene* never appearing better; while this species is like *Hyolithes versaillesensis,* with which it is associated, and it would seem, therefore, impossible that it should represent the broken spines of trilobites.

"It is quite common in the upper part of the Hudson River Group, at Versailles, Indiana, associated with *Palaeoconcha faberi, cyclora pulcella, Hyolithes versaillesensis,* and other small fossils. It is in the collections of both authors."—Miller and Faber, *loc. cit.*

HYOLITHES VERSAILLESENSIS Miller and Faber.

Plate XLII, figs. 4, 4a.

Hyolithes versaillesensis Miller and Faber, 1894, Jour. Cin. Soc. Nat. Hist., XVII, p. 155, pl. viii, figs. 20-22.

"This is a small species, ordinarily about two-tenths of an inch in length, and never exceeding three-tenths of an inch in length. Transverse section subtrigonal, and sometimes one angle becomes so obtuse as to make a transverse section planoconvex. One side is always much wider than either of the others, and the angles adjacent thereto are usually much more acute than the other one. The broad side is slightly convex. The apex is sharp-pointed. All our specimens are casts and very smooth. While there are not many characters to ascribe to this species, nevertheless it is doubtless a *Hyolithes* quite different from anything hitherto described.

"It is quite common in the upper part of the Hudson River Group, at Versailles, Indiana, associated with *Palaeoconcha faberi*, *Cyclora pulcella*, and other small fossils. It is in the collections of both authors."—Miller and Faber, *loc. cit.*

LIOSPIRA VITRUVIA (Billings).

Plate XL, figs. 14-14b.

Pleurotomaria vitruvia Billings, 1865, Paleozoic Fossils, I, p. 171.

"*Description.*—Shell sub-lenticular; spire depressed conical, smooth; apical angle from 120° to 130°; whorls three. On the upper side the whorls make a nearly smooth flat slope from the apex to the margin, which is narrowly rounded, and shows some indications of a band. Below the margin convex, gradually increasing in prominence to the edge of the umbilicus which is rather sharply angulated. In the umbilicus the whorls are nearly flat and sometimes forming an indistinct staircase to the apex. The umbilicus is about one-third the whole width, abruptly ascending from the angulated edge to the apex. Surface nearly smooth.

"The whole of the aperture has not been observed, but several silicified fragments show that the inner lip is nearly straight and approaching the vertical, slightly convex in its upper, and concave in the lower half, giving an obscure sigmoid curve. It is much extended downwards, making the depth of the body whorl at the angle of the umbilicus at the aperture more than one-third the whole height of the shell.

"Width from 12 to 18 lines; height from 9 to 12 lines.

"This species is allied to both *P. americana* and *P. progne*, but differs from the former in having the whorls flat in the umbilicus instead of rounded, while the latter has the umbilicus closed.

"*Locality and formation.*—Paquette's Rapids, on the Ottawa River; Black River limestone."—Billings, *loc. cit.* Reported from Ohio and Indiana by Ulrich.

LOPHOSPIRA ACUMINATA Ulrich and Scofield.

Plate XL, fig. 15.

Lophospira acuminata (or var. of *L. perangulata*) Ulrich and Scofield, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 973, pl. lxxiii, fig. 8.

"Hight 10 mm. or less; apical angle about 42°. Volutions seven or eight, all contiguous; peripheral carina very prominent, trilineate, the central part of the band sharply angular; lower carina very strong, upper carina wanting; no umbilicus.

"Resembles and perhaps is merely a later variety of *L. perangulata* Hall, yet readily enough distinguished by its more depressed and more numerous volutions, especially considering that it is a smaller shell. It differs further in being relatively higher, the apical angle being narrower, in the greater prominence of the carinae, and in wanting the umbilicus which is so constantly present in Hall's species. A variety of *L. pulchella* is rather abundantly associated with this species at Spring Valley, Minnesota. It may be distinguished at once by its relatively stronger upper keel, *L. acuminata* being without this keel."—Ulrich and Schofield, *loc. cit.*

Reported by Ulrich from the Richmond group at Richmond, Indiana, and Blanchester, Ohio, and from near Spring Valley, Minnesota.

LOPHOSPIRA AMPLA Ulrich.

Plate XLI, figs. 1-1b.

Lophospira ampla Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 981, pl. lxxiii, figs. 52-54.

"Hight of Lorraine group specimens, 20 to 32 mm.; of Richmond group specimens, 22 to 50 mm.; apical angle 70° to 80°. Volutions about six, the last equalling about two-thirds of the total hight. Upper carina thick, near the suture, present on all volutions; lower carina nearly obsolete, represented by a broad swelling or low ridge, above which to the prominent peripheral band the surface is more or less concave. Inner lip very thick, almost or entirely covering the minute umbilicus, very broad and turned obliquely downward and forward in the basal half. Surface markings very strongly curved, unequal, on the whole not sharply defined.

"Closely related to *L. oweni,* yet easily distinguished by the greatly thickened, broad and obliquely extended inner lip. The apical angle also is greater, and the lines of growth are more curved, especially at the base, while the upper carina does not fade away on the last volutions as in that species. The presence of this carina distinguishes from the associated and otherwise similar *L. multigruma* Miller. *L. medialis,* which is usually much smaller, with the same number of volutions, a smaller apical angle and more distinct umbilicus, also has no such carina."—Ulrich, *loc. cit.*

This species is reported by Ulrich from the Lorraine formation at Cincinnati, Ohio, and at Covington, Kentucky; and from the Richmond group at Richmond, Indiana.

LOPHOSPIRA BICINCTA (Hall).

Plate XL, figs. 16-16b.

Murchisonia bicincta Hall, 1847, Pal. New York, I, p. 177, pl. xxxviii, figs. 5 a-h.

"Obliquely subconical; spire elevated, acute; volutions four or five, angular, rapidly enlarging towards the aperture; last one ventricose below, tricarinate, the lower carina hidden by the suture of the next volution at the upper inner angle of the aperture; central carina on the outer angle of the volution, margined on either side by a sharp elevated line, with a narrow groove between, producing a double spiral band; aperture oblong, angulated below; surface marked by fine sharp striae, which bend gently backwards, and are but slightly undulated in passing the first carina, from whence they turn more suddenly backwards to the mesial band, making an abrupt retral angle, and then bending forwards below, pass in a vertical direction to the suture. In the last volution the striae pass vertically to the lower slight carina which corresponds with the suture in the other volutions, and from thence bend slightly backwards, curving into the umbilicus.

"The minute description here given will be found perfectly applicable to entire and unworn specimens; but it is often found in fragments and casts, with the surface markings more or less obliterated. The double spiral band becomes obsolete, and only a single ridge is manifest; the lower carina on the last volution is not visible in casts, and there is but an obscure indication of the upper one. The entire casts, therefore, present scarcely more than the single marginal angle, indicating the direction of the mesial band, and, in this respect, correspond with *P. angulata* cited above; but the volutions in our shell are more ventricose."—Hall, *loc. cit.*

So much confusion exists among collectors in regard to this species, or rather in regard to forms that are commonly supposed to belong to this species, that it seems to me advisable to quote at length the description by Ulrich given in the Paleontology of Minnesota.

"Volutions five or six, subangular; last one ventricose below, tricarinate, the upper ones bicarinate, the lower carina hidden by the suture; central or peripheral angle margined on either side by a sharp elevated line, with a narrow groove between, the angle, therefore, being composed of three lines of which the central one is a little stronger and more prominent than the lateral ones; lower carina thin, abruptly raised, the space between it and the peripheral angle scarcely concave and almost perpendicular; upper carina sharp, rather strong, removed a little more than a third of the biconcave upper slope of the volution from the suture; aperture somewhat obliquely subelliptical, higher than wide, narrow below, subangular at the lower inner corner; inner lip but little thickened, slightly twisted, never completely covering the minute umbilicus; outer lip very slightly sinuate. Surface marked by fine sharp subequal striae, curving backward very gently from the suture to the peripheral band; beneath the latter they pass in a vertical direction to the lower carina which scarcely interrupts their course to the umbilicus, near which only a slight backward curve is noticeable. On the most perfect specimen seen all the transverse lines present the appearance of being minutely papillose or toothed, while the central line of the peripheral band is crossed by straight lines of which there are nearly twice as many in a given space as those coming from above and below.

"The most marked and important feature of this species is in the exceeding shallowness of the sinus or notch in the outer lip."—Ulrich, Paleontology of Minnesota, 1897, p. 964.

As thus redefined and restricted, the species occurs in the Trenton rocks of Minnesota, Illinois and New York, Black River group of Kentucky, and Richmond group of Minnesota. It is reported in Kindle's list from Madison and Ripley County, Indiana; but in view of what has been said above it is doubtful if the species occurs at all in Indiana.

LOPHOSPIRA HAMMELI Miller.

Plate XLI, figs. 3-3a.

Murchisonia hammeli Miller, 1893, Geol. Nat. Hist. Indiana, XVIII, p. 319, pl. ix, figs. 41, 42.

"Species a little below medium size; conoidal; height one-third more than the breadth; volutions four or five; suture very indistinct; umbilicus closed. The body whorl bears two furrows, two sharply angular revolving ridges, and one less angular and fading away toward the mouth. Above the body whorl there are only two angular revolving ridges on each whorl. The aperture is partly formed by the last whorl; the inner lip is thickened, the outer one is thin. The aperture and revolving angular ridges will distinguish this species.

"Found by J. F. Hammel and Prof. Geo. C. Hubbard, in the Hudson River group, at Madison, Indiana. The specific name is in honor of one of the collectors."—Miller, *loc. cit.*

I have not seen the types of this species, but judging from the above description and Miller's rather poorly executed figure, it appears to belong to the genus *Lophospira*. It occurs at the extreme top of the Ordovicion (Saluda) at Madison, Indiana.

LOPHOSPIRA TROPIDOPHORA (Meek).

Plate XLI, figs. 2-2d.

Pleurotomaria (*Scalites?*) *tropidophora* Meek, 1872, Amer. Jour. Sci., 3d ser. IV, p. 278. (Not figured.)

"Shell rather small, obliquely rhombic in general outline, as seen in a side view; height somewhat greater than the breadth; spire conical, with an apical angle varying from 70° to 90°; volutions four to four and a half; each flattened, or sometimes slightly concave above, with an outward slope from the suture to a prominent angle that passes around the middle of the body-turn, and below the middle of those of the spire, to which it imparts a somewhat turreted appearance; suture moderately distinct, but not channeled; lower side of body-volution sloping rapidly inward from the mesial angle, a little below which there usually revolves an obscure, undefined ridge; aperture rhombic subquadrate; surface nearly smooth, but sometimes showing under a magnifier very obscure lines of growth, that curve very strongly backward as they approach the angle around the middle of the body-volution, both above and below—thus indicating the presence of a deep sinus i-the lip, that widens rapidly forward, though there is no defined revolving band at the angle.

"Length or height, 0.55 inch; breadth about 0.50 inch.

"This shell possesses some of the characters of both *Pleurotomaria* and *Scalites*. In general appearance it is most like some types of the former; but it seems to be entirely without the revolving band seen on the species of that genus. Its lines of growth, however, have the very strong, oblique backward curve seen in those of *Scalites* (in which group there is no revolving band), thus showing that its lip, when entire, must have had a deep notch at the termination of the angle of the body-whorl. This notch, however, does not appear to terminate in a deep sharply cut slit, as we most generally see in *Pleurotomaria,* but it seems to have terminated at, and widened rapidly forward from, the angle of the volutions. Specifically, this shell is related to *Pleurotomaria selecta* of Billings, from which it differs in having its striae of growth nearly obsolete, and in wanting the revolving angle just below the suture, seen in that species."—Meek, *loc. cit.*

Ulrich considers *L. multigruma* Miller sp. as a synonym of *L. tropidophora* Meek.

1.41E1, 5, A6.

MICROCERAS INORNATUS Hall.

Plate XL, figs. 9, 9a.

Microceras inornatus Hall, 1845, Amer. Jour. Sci., XLVIII, p. 294. (Not figured.)

"Volutions about two, rapidly diminishing; spire equally depressed on either side, obtusely carinated or angular upon the back; carina more conspicuous near the mouth, and gradually becoming obsolete; aperture somewhat quadrangular; surface smooth.

"Largest diameter 1/20 of an inch."—Hall, *loc. cit.*

There is little to be added in regard to this shell, which is chiefly characterized by its very small size, carinate volution, and smooth surface.

1.34A1, B1-3, C10.

OXYDISCUS MAGNUS (Miller).

Plate XLI, fig. 5.

Cyrtolites magnus Miller, 1878, Jour. Cin. Soc. Nat. Hist., I, p. 103, pl. iii, fig. 10.

"Shell consisting of three or more volutions, very gradually increasing in size and rolled in the same plane. Each outer volution embraces one-third or more of the inner one. Dorsal side sharp and well defined. Greatest convexity of each whorl near the inner side, which is sub-angular. Transverse section of a whorl sub-triangular. Umbilicus alike on either side, rather wide and deep, and showing about one-third of each inner turn.

"The surface of the shell, in the specimen examined, has been too much eroded to determine the external markings.

"The greatest diameter of the shell is 1 1/10th inches; convexity about 3/10ths of an inch, though it was probably more expanded at the aperture, which is not preserved in our specimen.

"The description is founded upon a single specimen collected by Mrs. Warren Shumard, in the upper part of the Cincinnati group, near Richmond, Indiana, and presented by her to Mrs. M. P. Haines, from whom it was received for definition and illustration."—Miller, *loc. cit.*

PROTOWARTHIA CANCELLATA (Hall).

Plate XXXIX, figs. 6-6b.

Bellerophon cancellatus Hall, 1847, Pal. New York, I, p. 307; pl. lxxxiii, figs. 10 a-c.

"Involute, subglobose; aperture expanded, bilobate; dorsal line subcarinated ?; surface cancellated by fine concentric and longtitudinal striae; concentric striae arching on the side and meeting in a sharp angle upon the dorsal line; aperture with a sinus in the dorsal margin.

"The concentric striae are usually the more conspicuous, the others being scarcely visible, except under a magnifier. The only entire specimen seen is crushed, so that the original form cannot be clearly defined; but the marking of the surface is sufficient to distinguish it from any other species in the lower strata."—Hall, *loc. cit.*

This is, according to Ulrich, the common form identified by Hall and other American authors as *Bellerophon bilobatus* Sowerby. The latter form probably does not occur in American faunas. The present form is said to occur in the Trenton, Utica, Lorraine and Richmond groups at numerous localities in Minnesota, Wisconsin, Iowa, Illinois, Kentucky, Ohio, Indiana, Tennessee, New York and Canada.

PROTOWARTHIA SUBCOMPRESSA Ulrich.

Plate XXXIX, figs. 5-5b.

Protowarthia subcompressa Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 873, pl. lxiii, figs. 40, 44.

"Shell, large, compressed-subglobose, the greatest hight and width about as six is to four; back broadly rounded, sides somewhat flattened, umbilicus closed, wanting; aperture semi-ovate, outer lip thin, inner lip moderately thick and reflexed in the umbilical regions; callosity extending over the whole front of the inner volution, apparently smooth; sinus broad and about as deep, the depth decreasing slightly with age; apertural lobes rounding very gently to the sinus where the outline makes a rather sharp curve. Surface marked by fine lines of growth and near the aperture by some obscure wrinkles. The callosity which extends over the inner volutions exhibits the usual fine irregular revolving lines in the umbilical regions. When the shell is removed, the cast shows a narrow furrow down the center of the back and several more faintly on each side. Greatest diameter 41 mm.; smallest diameter 29 mm.; width of aperture 27.5 mm.; hight of same (central) 19.5 mm.; width of inner volution 13 mm.; depth of sinus 7 or 8 mm.

"This fine species, besides attaining a greater size than *P. cancellata,* differs from it in being narrower and in wanting, as far as known, the delicate revolving lines of that species. The umbilical callosity of the inner lip is also less and does not slope outwardly, the edge only being reflected. *Bellerophon morrowensis* Miller and Dyer, which also may belong to *Protowarthia,* is sufficiently known. According to the descriptions, it seems to differ in having the dorsal side sharply angular. *P. planodorsata* has a wider aperture, revolving lines, and a flat dorsum."—Ulrich, *loc. cit.*

Versailles, Indiana, and Butler County, Ohio.

RAPHISTOMA RICHMONDENSE Ulrich.

Plate XLI, figs. 6-6b.

Raphistoma richmondense Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 941, pl. lxviii, figs. 7-9.

"Shell 15 to 20 mm. in diameter, the spire almost flat, the hight between one-third and two-sevenths of the width; volutions four, very slightly convex on the upper side, *i. e.,* within the outer edge, which forms a thin elevated rim; umbilicus very small in casts, apparently closed in shells. Surface striae fine and subequal on upper side, making the usual sigmoid curve, the change in curves occurring near the middle of the whorls. Just before reaching the peripheral rim the striae make another short backward turn. Beneath the periphery the striae are more unequal; at first they turn forward, then more directly inward.

"This species resembles the Chazy *R. calyx* Billings, but is smaller and relatively wider. In *R. crevieri,* of the same author and formation, the edge is blunter, and the lines of growth curve more strongly beneath it. *R. peracutum* has an umbilicus and differs in several other respects. A very similar species, differing only in that it has a small umbilicus, occurs in the Stones River group in Tennessee."—Ulrich, *loc. cit.*

The types are from Richmond, Indiana, where according to Ulrich good specimens are rare.

SALPINGOSTOMA EXPANSUM (Hall).

Plate XL, figs. 1-1b.

Bucania expansa Hall, 1847, Pal. New York, I, p. 186, pl. xl, figs 7 a-d.

"Convolute, trumpet shaped; volutions three or four, subangular, the last one elongated, rapidly enlarging and abruptly expanded at the aperture; aperture broadly semicircular or sublunate, with a sinus at the dorsal side; dorsal line obtusely carinated; section of the last volution, below the aperture, subtriangular; of the inner volutions, subelliptical, with the extremities obtusely angular; original surface striated. Specimen a cast.

"This shell is not unlike *Bellerophon cornuarietis* (Sowerby, *Min. Conchology,* tab. 469, fig. 2); but the volutions in that species are represented as not contiguous. The species under consideraiton differs from either of the two preceding in a very obvious manner. The broadly expanded aperture and obtuse carina of the last volution are prominent features; and in fragments the subtriangular form of sections of the last volution are often sufficient to enable us to identify the species. The strongly marked carina commences at the base of the last volution, and continues to the aperture. The volutions are closely pressed against each other, the convex dorsal side producing a corresponding depression on the ventral side of the contiguous volution."—Hall, *loc. cit.*

This is *not* a Cincinnati group species, but is so commonly reported by collectors from rocks of this region that it has seemed best to reproduce Hall's original figures and description. The species that is commonly mistaken for it according to Ulrich is the *S. richmondense.*

SALPINGOSTOMA RICHMONDENSE Ulrich.

Plate XXXIX, figs. 7, 7a.

Salpingostoma richmondense Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 903, pl. lxvii, figs. 39, 40.

"Shell slightly exceeding medium size, the hight, including apertural expansion, 50 to 55 mm.; known from casts of the interior chiefly. These consist of about three strong volutions, the inner ones wide, depressed, sharply rounded on the sides, broadly and evenly convex on the back, less convex and with a very slight central cavity on the ventral side, the whole giving a transversely elongate subelliptical cross-section, whose width is a little more than twice the hight. Dorso-ventral diameter of last volution increasing very rapidly in the outer half, while the transverse diameter enlarges very slowly. Just behind the apertural expansion, where the volution is more or less compressed laterally, the dimensions in three specimens (casts) are as follows: Width 22, 23 and 24 mm.; hight 26, 27 and 27 mm. At the opposite side of the shell the volution is about 15 mm. wide and 7 mm. high in all three specimens. The umbilicus is of the usual size for the inner volutions, but for the entire shell it is comparatively small. This is because the angular or narrowly rounded boundary moves gradually toward the ventral side of the volutions, causing the wall of the umbilicus to become more and more abrupt. Just behind the aperture it is nearly or quite perpendicular, the ventral surface of the volution being almost flat. Apertural expansion abrupt, apparently not very wide, with recurved edges, broadly ovate in outline, slightly narrower above than below. Dorsal slit about 20 mm. in length, beginning the same distance or somewhat more behind the apertural expansion. The slit is represented by a rough (fractured) ridge on casts. Behind it the cast is smooth, but in front of it there is a more or less distinct broad furrow.

"The surface markings have been observed only on the back of the second volution. Here they consist of about seven irregular revolving ribs on each side of a very narrow elevated slit-band. At intervals of about 1.5 mm. the ribs are interrupted by tranverse lamellae. Where they are shown the volution has a width of 7 mm.

"Collectors have heretofore identified this species with Hall's

Bucania expansa from the Trenton of New York, but a comparison proves it quite distinct. In the first place, though of about the same size, there is one volution less. Next, the last volution is relatively narrower and higher just behind the aperture, and the latter very differently outlined. Finally, the last volution is nowhere triangular as is the case in the Trenton species. Compared with *S. buelli* and *S. sculptilis* the outer volution will be found much larger especially as regards the dorso-ventral diameter.

"In practice the most difficult perhaps to separate from this species is the associated *Bucania simulatrix.* Though of widely different affinities, casts of these two species, especially when, as is usually the case, the aperture is imperfect, are very apt to be confused. Still, after familiarizing one's self with certain differences, they may be distinguished almost at a glance. In the first place, the volutions of the *Bucania* are more slender. This difference is particularly striking in an apertural view, the small end of the outer volution, in specimens of the same hight, being at least a fourth wider in the *Salpingostoma.* In the *Bucania* again the width of the last volution continues to increase quite uniformly instead of being almost constricted near the aperture. When the latter is preserved the difficulties have vanished, for this part is readily distinguishable."—Ulrich, *loc. cit.*

The types of this species are from Richmond, Indiana, from the Richmond formation. My specimens are all from the Whitewater division, occurring in association with *Rhynchotrema dentata.* It seems to be most abundant near the top of this division.

1.41A8, E1, 4.

SCHIZOLOPHA MOOREI Ulrich.

Plate XLI, figs. 7-7c.

Schizolopha moorei Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 992, pl. lxv, figs. 31-37.

"Hight of Richmond group form 28 to 38 mm., width 27 to 41 mm.; apical angle of same 75° to 82°; hight of Lorraine group form from 20 to 29 mm., width variable, usually about the same as the hight; apical angle 65° in one instance, 83° in another, usually about 75°. Of whorls there are at least six in the shell, but casts of the interior, in which form the species occurs almost invariably, rarely if ever preserve more than three or four, the first two or three having been filled with shelly matter. In casts it is only the last whorl that is strongly carinate on the periphery, the upper ones being more or less rounded. The umbilicus is variable, being as a rule relatively larger and less steep in the Richmond group form, which we regard as the typical one for the species, than it is in the Lorraine group variety. On the shell of the latter the edge of the narrow umbilicus is angular. That a similar angle surrounds the umbilicus in the typical form is doubtful, though we have seen no specimen showing this part of the shell. Very few casts give any idea whatever of the surface markings. As seen on gutta percha impressions of natural molds of the exterior, they appear as rather coarsely lamellose and strongly recurved lines of growth. The convexity of the slit-band seems to grow less with age, the elevated line on each side of it stronger.

"*Formation and locality.*—Lorraine group at numerous localities in the vicinity of Cincinnati, Ohio; reappears in the upper part of the Richmond group, of which it is one of the most characteristic fossils, at many localities in Indiana and Ohio, being perhaps the most abundant at Richmond in the former state and at Oxford in the latter."—Ulrich, *loc. cit.*

TROCHONEMA MADISONENSE Ulrich.

Plate XLII, figs. 1-1b.

Trochomena madisonense Ulrich, 1897, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 1051, pl. lxxvii, figs. 23-25.

"A large shell agreeing in most particulars with *T. umbilicatum,* but having relatively higher and more ventricose whorls, while the ridge, which generally surrounds the umbilical depression in this genus, is quite obsolete. The shell is thicker, the surface markings stronger, the mouth very oblique and with thicker lips. Casts of the interior of the two species are more alike than their exteriors, yet those of the present may be distinguished by the greater separation of the whorls due to the removal of a greater thickness of shell. There is a wide notch in the outer and upper portions of the peritreme which, with the somewhat triangular form of the aperture in a ventral view, suggests relations with *T. eccentricum.* Figures of that shell are given on the same plate with those of this species, so that it is scarcely necessary to compare them further."—Ulrich, *loc. cit.*

The types are from the Richmond formation at Madison, Indiana.

TRYBLIDIUM INDIANENSE Miller.

Plate XXXIX, fig. 11.

Tryblidium indianense Miller, 1891, Geol. Nat. Hist. Indiana, XVII, p. 695, pl. xiv, fig. 14.

"Shell patelliform, oval, narrowed anteriorly, widened posteriorly; greatest width behind the median, transverse axis of the shell. Apex within the anterior third of the shell, moderately elevated. Greatest convexity of the shell immediately behind the apex. Shell sloping very gradually toward the posterior part of the shell and more abruptly in front of the apex, until it approaches the margin, where it graduates into a wide, very gently convex marginal slope, which in front becomes nearly flat. Surface of the shell, though not well preserved in our specimen, evidently concentrically lined, but if other ornamentation existed, it is wholly obliterated.

"The internal scars are unknown, but from external appearance of the shell, there is no reasonable doubt about the generic reference.

"Found by A. C. Benedict, in the Hudson River group, in Fayette County, Indiana, and now in his collection."—Miller, *loc. cit.*

TRYBLIDIUM MADISONENSE Miller.

Plate XXXIX, fig. 10.

Tryblidium madisonense Miller, 1893, Geol. Nat. Hist. Indiana, XVIII, p. 318, pl. ix, fig. 38.

"Shell medium size; apex high and almost straight above the anterior line of the shell; the shell slopes from the apex and arches a little toward the posterior part of the shell, but laterally and in front it descends abruptly to the margin; transverse section ovate; surface marked with fine, close, concentric lines and a few coarser ones, all of which appear to indicate lines of growth, instead of surface ornamentation; internal scars unknown.

"The high apex and anterior position of it seem to distinguish this species.

"Found by J. F. Hammel, in the Hudson River group, at Madison, Indiana, and now in his collection."—Miller, *loc. cit.*

PELECYPODA.

DIAGNOSES OF GENERA.

ALLONYCHIA Ulrich.

Shell attaining a large size, a little obliquely subovate in outline, strongly convex, most gibbous somewhat above and in front of the middle, but with the point of greatest convexity situated farther behind the anterior extremity than in any of the other genera of this family; beaks large, tumid, incurved, not terminal. Hinge line short, not alated posteriorly; just beneath the beaks a more or less well-defined, lobe-like protuberance of the anterior side contains the byssal opening and usually forms the most anterior part of the shell. Surface radially costate. Hinge short, apparently edentulous, ligamental area high; posterior adductor scar large, deeply sinuate above, situated somewhat behind the middle of the valves; pallial line simple, extending up the anterior side to the umbonal cavity. (Ulrich.)

ANOMALODONTA Miller.

Equivalve, inequilateral, byssal sinus on the anterior side, immediately below the beak, cardinal tooth or elevation beneath the umbone sloping posteriorly from the beak. Cartilage grooves running from the cardinal tooth beneath the beak to the termination of the wing posteriorly, and varying in number in the same species with the size and age of the shell, and having the same number of cartilage grooves on the anterior side of the cardinal tooth, that run together as they pass into the byssal sinus, immediately beneath the beak, which vary in number under the same circumstances. Adductor muscular impression on the anterior side, below the byssal sinus. The other muscular impression probably placed posteriorly on the wing. (Miller.)

Concerning this genus Ulrich makes the following comment:

"Dr. Miller is certainly in error when he says that there is an 'anterior muscular scar below the byssal sinus'. The depressed subtriangular space, which he mistook for a muscular impression, is without doubt due to some abnormal thickening of the internal surface of the valve. The pallial line also is clearly shown in the specimens."—(Ulrich, Geol. Ohio, VII, 1893.)

BYSSONYCHIA Ulrich.

General aspect as in *Ambonychia,* Hall, excepting that the beaks and umbones are not so full. A well-defined byssal opening in the upper half of the anterior side. Hinge with a striated ligamental area, several small cardinal teeth and generally two or three slender lateral teeth near the posterior extremity. Posterior adductor impressions large, situated a little behind the center of the valves. Pallial line simple, terminating in the rostral cavity. (Ulrich.)

CLIDOPHORUS Hall.

The shells of this genus may be characterized as equivalved, inequilateral; hinge without teeth or crenulations; surface (particularly in casts) marked by an oblique linear depression, extending from the anterior cardinal margin towards the base, indicating the place of the clavicle; surface concentrically striated. (Hall.)

CLIONYCHIA Ulrich.

Shells equivalve, moderately convex, subalate posteriorly; beaks terminal, comparatively small, not very prominent and but little incurved. Cardinal line straight, rather long, forming an angle of less than 90° with the anterior side. Surface marked concentrically only. No byssal opening, the margins closing tightly all around. Muscular impressions situated in the postero-cardinal third, large, bilobed, the lower lobe much larger than the upper. Pallial line simple, extending from the posterior adductor to the rostral cavity. Hinge plate of moderate strength, without cardinal or lateral teeth, excavated longitudinally for a linear ligament. Upper part of anterior edge thickened, producing a more or less well-marked impression in this part of casts of the interior. Anterior pedal muscle attached a short distance behind the beaks. (Ulrich.)

CTENODONTA Salter.

Shell equivalve, closed, usually largest anteriorly, occasionally subequilateral, with the beaks situated sometimes behind the middle, but usually more or less in front of that point; surface marked by concentric lines of growth; beaks approximate, generally small and never very prominent. Ligament external, rather small, situated immediately behind the beaks; no striated area nor internal cartilage pit. Hinge more or less arcuate, sometimes very gently, at other times bent almost at a right angle; with series of small curved or geniculated transverse teeth, which diminish in size more or less gradually from the extremities to the beaks; the series are continuous and gradually pass into each other in the typical section of the genus, but in other sections they are often interrupted beneath the beaks. Adductor muscular impressions two in each valve, subequal, nearly always readily distinguishable, and sometimes very deeply impressed, situated just beneath the anterior and posterior extremities of the hinge; scars of small foot-muscles have been observed in a number of species, one immediately above or in front of each of the adductor scars; pallial line indistinct, simple, submarginal. (Ulrich.)

CYMATONOTA Ulrich.

Elongate solen-like shells, gaping more or less at both ends, with the hinge line long and extending in a straight line anterior and posterior to the small beaks; ventral and dorsal margins subparallel. Hinge plate very thin, edentulous; valves united by a delicate linear external ligament seemingly extending the full length of the hinge. Test very thin, marked externally with fine concentric lines, and on each side of the hinge line short wave-like furrows. Pallial line and muscular scars so faintly marked that even in the best preserved specimens they can not be made out with certainty. (Ulrich.)

CYRTODONTA Billings.

Shell varying from transversely or obliquely ovate to subcircular, moderately ventricose. Beaks prominent, rather tumid, incurved, situated in the anterior third, fourth or fifth of the shell. Surface marked with concentric lines of growth. No lunule nor escutcheon. Hinge plate strong, nearly straight, often with a narrow and not sharply defined ligamental area. Cardinal teeth well developed, subequal, generally obliquely curved, sometimes nearly horizontal, two to four in each valve, situated mostly in front of the beaks. Posterior lateral teeth usually two or three in each valve, strong, elongate, more or less curved and slightly oblique, situated near the extremity of the hinge. Adductor muscular scars placed immediately beneath the two sets of teeth, both subovate, the posterior very faint, the anterior only moderately impressed. Pallial line simple. (Ulrich.)

ERIDONYCHIA Ulrich.

This genus includes, as far as known, a small and comparatively unimportant group of Lower Silurian shells, agreeing with *Bys-*

sonychia in all respects except that their hinges are entirely without cardinal and posterior lateral teeth. A well defined, striated ligamental area, however, is present, and in the type species several obscure and irregular small ridges beneath the posterior extremity of the external area remind of the internal ligament supports of *Anomalodonta*. But the oblique cardinal fold of the latter genus is not represented, and the acuminate beaks and oblique form of the shells gives them a peculiar expression, so that no other course seemed open than to erect a distinct group for their especial benefit. (Ulrich.)

ISCHYRODONTA Ulrich.

Short or moderately elongate, thick bivalve shells, having small, anteriorly situated beaks, with the hinge line straight or arcuate and extended posteriorly. Hinge plate wide and strong, without posterior lateral teeth, but with two strong cardinal teeth in the left valve, and one large one, and occasionally a small one on each side of it, in the right valve. Ligament internal, posterior to the beaks, linear, supported by from one to three subcardinal ribs. Anterior adductor impression large, deep, subovate, sharply defined on the inner and upper side by a ridge extending from the cardinal teeth to the base of the scar. A small pedal muscle was attached to the under side of the hinge plate immediately above the inner side of the anterior adductor scar. Posterior muscular scar faintly defined, generally but little larger than the anterior scar, situated a little distance beneath the posterior extremity of the hinge. Pallial line simple. Test thick, chiefly calcareous, without the dark epidermis of the *Modiolopsidae* and *Ambonychidae*. (Ulrich.)

MODIOLODON Ulrich.

Ovate shells of the same general type as *Modiolopsis* and *Modiomorpha,* but having from one to three oblique cardinal teeth in each valve. (Ulrich.)

MODIOLOPSIS Hall.

Restricted by Ulrich.

Shell more or less elongate, usually subovate, widest posteriorly; valves moderately ventricose, closing tightly all around. Beaks small, near the anterior extremity; umbones depressed by a flattening or depression which crosses the valves obliquely and widening causes a straightening or sinuation of the basal outline. Hinge of moderate strength, rarely straight, generally somewhat arcuate, without well-marked teeth; an obscure oblique thickening beneath the beak of one valve and a corresponding depression in the other occasionally distinguishable. Ligaments linear, external and internal, chiefly the former. Anterior adductor impression subovate, large, sharply defined on the inner side, occupying the greater part of the small anterior end. Posterior scar very faintly impressed, large, subcircular, situated near the center of the posterior third of the cardinal slope. Pallial line simple. Anterior pedal muscle forming a minute pit in the under side of the hinge plate beneath the beak. Posterior pedal muscles large, attached just above and in front of the adductor. (Ulrich.)

OPISTHOPTERA Meek.

Shell equivalve, usually triangular in outline, with the beaks of moderate size, incurved and terminal, and the hinge line straight and very long, in most cases forming a great posterior wing; length greater than the height; anterior side more or less abrupt. In the typical section the greatest height is in the anterior half, and the surface marked with numerous and frequently bifurcating costae. In another group of species provisionally regarded as congeneric, the posterior part of the shell is the highest, and the radiating costae few and mostly simple. Byssal opening, muscular scars and pallial line as in *Anomalodonta* and *Byssonychia*. Hinge with two small cardinal teeth in each valve, but so far as known no posterior lateral tooth; external ligamental area usually narrow; no internal ligament. (Ulrich.)

ORTHODESMA Hall and Whitfield.

Restricted by Ulrich.

Shell elongate, usually increasing slightly in height posteriorly. Anterior end comparatively long, contracted in front of the beaks. Valves moderately convex, usually with a strong umbonal ridge and a broad mesial depression in front of it, their edges fitting tightly along the straight or sinuate ventral margin, but leaving a narrow gape at each end. Umbones prominent, wide, compressed, often extending posteriorly as low cardinal ridges between which the hinge line is sunken. Hinge plate edentulous, very thin, long, extending in almost a straight line from the posterior cardinal angle, past the beaks, nearly to the anterior extremity of the shell. Ligament linear, internal and external, the latter chiefly. Posterior muscular scar large, very faint, elongate ovate; anterior scar large, though scarcely half the size of the posterior, well defined, ovate or approaching semicircular in shape, the vertical diameter the longest. Pallial line simple. Shells thin, marked externally with more or less distinct concentric striae and wrinkles. (Ulrich.)

ORTHODONTISCUS Meek.

Shells rather small, rounded or ovate, subequilateral; valves equal, moderately convex, with small beaks and no umbonal ridge. Surface marked with very fine concentric lines and occasionally with obscure rays on the post-cardinal slope. External ligament occupying a narrow groove extending both anterior and posterior to the beaks. Hinge with one strongly defined, subtriangular cardinal tooth beneath the beak of the right valve, with a small pit just in front of it and a corresponding large pit and a small tooth in the left valve. Posterior lateral teeth long, two in the left valve and one, two or three in the right. Anterior lateral teeth similar to the posterior laterals only shorter. The large cardinal tooth (in the right valve) is usually divided into three radially disposed portions. Pallial line simple, muscular impressions well defined, though not deep, the posterior slightly the larger, both with a small pedal muscle scar above and occupying the small spaces between the adductor scars and the opposite extremities of the two sets of lateral teeth. (Ulrich, diagnosis of *Cycloconcha*=*Anodontopsis*.)

ORTONELLA Ulrich.

Shell subquadrate, highest posteriorly, equivalve, very inequilateral, with moderately prominent beaks and umbonal ridge. Surface with concentric lines of growth. Hinge as in *Cyrtodonta,* Billings, excepting that the cardinal teeth are relatively stronger and placed immediately beneath the beaks. A well defined lunule and escutcheon present. Adductor muscular scars subequal, the posterior one very faintly impressed, ovate, and situated just beneath the posterior extremities of the lateral teeth, the anterior very deep, sharply defined on the inner and upper sides by a clavicular ridge extending obliquely backward from the hinge plate. Pallial line simple, distinct. Small pedal muscle attached to the under side of the hinge plate immediately over the anterior adductor scar. Casts of the interior marked by an oblique umbonal sulcus. (Ulrich.)

PTERINEA Goldfuss.

Shell equivalve, inequilateral, with both sides alate, the anterior alation short and the posterior drawn out. Cardinal margin more or less oblique, internal ligamental area linear. Two or more parallel teeth beneath the umbo, and several long posterior teeth. Umbones anterior. Two large muscular impressions. (Goldfuss—translation.)

The valves are *inequivalve,* the right valve being flat, or nearly so. The anterior teeth obscure, transverse; the posterior elongate and nearly parallel to the cardinal margin. Posterior adductor scar large; anterior small, strong, inserted below the anterior wing. Pallial line simple. Byssal notch in the smaller valve.

RHITIMYA Ulrich.

Shell elongate, moderately ventricose, the dorsal and ventral margins subparallel, gaping slightly at one or both ends. Beaks rather prominent, situated from one-third to one-fifth of the entire length behind the anterior extremity; posterior umbonal ridge rounded, never very prominent; mesial sulcus very wide, generally very shallow, often, however, causing a sinuosity in the ventral margin. Lunule very narrow, true escutcheon wanting, ligament external, attached to the edges of the valves, extending the greater part of the hinge line posterior to the beaks. Hinge apparently edentulous, test very thin. Muscular and pallial attachments exceedingly faint, not satisfactorily observed; posterior scar large. Surface marked with unequal concentric lines and furrows, gathered into a series of strong folds on the anterior end. On the posterior half or more, the ventral part especially, the concentric lines are crossed by closely arranged radiating series of small granules or spines. (Ulrich.)

SEDGWICKIA McCoy.

This genus was founded by McCoy on Carboniferous species. It is very doubtful if the Ordovician forms referred to this genus belong there.

SPHENOLEUM Miller.

Shell large, equivalve, inequilateral, elongate, cuneiform, ventricose; umbones prominent; beaks incurved at the anterior end; cardinal line at an angle of fifty or sixty degrees from the basal line, and appearing wing-like toward the posterior end; lunule present; no escutcheon; ligament external; muscular scars and hinge-line unknown. (Miller.)

Surface concentrically lined; occasionally with radiating striae. Ligament probably both internal and external. (Ulrich.)

WHITEAVESIA Ulrich.

Shell ovate, more or less elongate, narrowing anteriorly. Valves moderately ventricose, fitting each other tightly. Anterior end short, but not excessively so. Base gently convex, occasionally straight, never sinuate. Mesial sulcus wanting. Beaks comparatively large, full and rather prominent. Umbonal ridge generally strongly rounded, sometimes subangular. Surface with concentric lines of growth and often with radii or divaricating folds; the radii sometimes restricted to the inner side of the shell, showing on casts of the interior and not on the exterior of the shell itself. Muscular scars and pallial line as in *Modiolopsis,* excepting that in the majority of the species they are very faintly impressed. Hinge plate edentulous, very narrow, especially so under the beaks, a little wider and grooved on each side for the reception of a linear internal ligament. A similar external ligament probably also present. (Ulrich.)

WHITELLA Ulrich.

Shell thin, obliquely quadrangular or suboval, equivalve, inequilateral, more or less ventricose. Umbones very prominent, the beaks strongly incurved; umbonal ridge prominent, subangular or sharply rounded. Cardinal margin straight or slightly convex, the edges inflected to form a sharply defined escutcheon extending beyond the beaks sometimes quite to the anterior extremity of the shell; area finely striated longitudinally. Hinge line straight, from one-half to two-thirds the length of the shell, with two to five rather oblique folds or teeth in front of the beaks. Posterior portion of the hinge apparently edentulous. Ligament probably both external and internal, the latter only along the posterior third of the hinge line, where it was supported by an internal ridge in each valve. Two simple adductor impressions, the posterior one very faint; pallial line simple, marginal; interior of shell lined with a nacrous film. Surface of shell with fine concentric lines, and sometimes with stronger concentric undulations. (Ulrich.)

DESCRIPTION OF SPECIES.

ALLONYCHIA JAMESI (Meek).

Plate XLIII, fig. 2.

Megambonia jamesi Meek, 1872, Proc. Acad. Nat. Sci. Phila., 1872 (February), p. 321. (Not figured.)

"Shell attaining a rather large size, a little obliquely subovate in general form, rather convex, the most gibbous part being somewhat above and in front of the middle, more or less abruptly cuneate posteriorly and below; basal outline regularly rounded; posterior margin rounding into the base, and ascending with a convex curve and forward inclination to the posterior extremity of the hinge, which is not in the slightest degree alate; anterior margin rounding into the base below, and slightly sinuous under the lobe-like protuberance, or rudimentary wing above, which is convex, slightly more prominent than the margin below, and defined from the swell of the umbonal regions on each side, by an oblique sulcus extending to the hinge margin in front of each beak; hinge equaling about two-thirds of the antero-posterior diameter of the valves; beaks rather prominent, or rising distinctly above the hinge line, but slightly oblique, and distinctly incurved; umbonal slopes broadly rounded; longer axis of the valves moderately oblique to the hinge line. Surface ornamented by very regular, rounded, simple, and depressed radiating costae, a little wider than the furrows between, and numbering about five in a space of 0.30 inch, near the middle of the lower margin.

"Height, about 2.05 inches; antero-posterior diameter, 2.16 inches; convexity, 1.50 inch.

"The only specimen of this species I have seen is a cast of the exterior, with portions of the ventral and anterior ventral margins broken away. The beak of its right valve projects rather decidedly above that of the left; but I think this is due to accidental displacement of the valves, rather than to any inequality in their size. It shows distinct indications of a well-defined, moderately wide cardinal area, widest under the beaks, and narrowing to the extremities of the hinge.

"Mr. James referred this species, in his list of the Cincinnati fossils, with a mark of doubt, to the Lower Helderberg species, *M. spinneri* of Hall. But, in addition to the rather widely different geological horizons from which these two shells were obtained, they seem to me to differ so materially in form as to be clearly distinct species, even if similarly marked, while the typical specimen of *M. spinneri* shows no traces of the regular radiating costae seen on the species here described. It is true that the specimen of that species figured is an internal cast, and ours a cast of the exterior, which might account for the difference of surface characters, but this would not produce the degree of difference in form, obliquity and general physiognomy. To me, it appears to be much more nearly like the typical species *M. cardiiformis,* from the New York Upper Helderberg limestone, though clearly distinct in having much larger costae as well as a wider and more defined cardinal area."—Meek, *loc. cit.*

Identified from the Lorraine at Lawrenceburg, Indiana.

1.33A3.

ANOMALODONTA COSTATA Meek.

Plate XLII, figs. 6, 6a.

Ambonychia costata Meek, 1874, Paleontology of Ohio, vol. I, p. 130, Pl. xii, figs. 5 a-c. Named but not described by James, 1871, Catalogue of the Lower Silurian Fossils of the Cincinnati Group, p. 13.

"Shell of about medium size, moderately oblique, sub-ovate, very thin, rather compressed, the left valve being apparently a little more convex than the other; basal margin regularly rounded; posterior margin apparently broadly convex in outline; anterior side truncated, or a little concave above, and rounding into the base below; beaks pointed terminal, rather oblique, and rising moderately above the cardinal margin; umbonal slopes not angular, or very prominent; hinge line straight, short, and ranging at an angle of about 60° to the longer axis of the valves. Surface of both valves ornamented by about twenty simple depressed, radiating costae (narrower than the flat interspaces) and fine concentric striae of growth.

"Length, measuring obliquely from the points of the beaks to the most prominent part of the basal margin, about 1.63 inches; anterio-posterior diameter, about 1.10 inches; convexity of the two valves, 0.54 inch.

"This form will be readily distinguished from the other known species by its small number, and more widely separated costae, and rather compressed, narrow form. It also differs from *A. radiata* [*Byssonychia radiata*], in having its costae separated by flat interspaces, instead of 'regularly concave grooves, narrower than the radii.' "—Meek, *loc. cit.*

The types are from 350 feet above low water of the Ohio river at Cincinnati, Ohio.

1.34C14b.

ANOMALODONTA GIGANTEA Miller.

Plate XLIII, figs. 1-1b.

Anomalodonta gigantea Miller, 1874, Cincinnati Quarterly Journal of Science, I, p. 17, figs. 7, 8, 9.

"Shell equivalve, inequilateral, alate posteriorly and compressed, more convex toward the umbones and anterior side, anterior side abruptly declining, beaks rather sharp and slightly incurved. Surface marked by 30 to 40 strong radii, same width as intermediate spaces, which are concave grooves marked with concentric striae, giving much the same external appearance as those of an *Ambonychia radiata.* Shell marked exteriorly, toward the margin, with lines of growth and concentric striae, which cross the radii, rendering it likely that concentric striae crossed the radii over the whole surface of the shell, though they appear now to be smooth. Byssal sinus immediately below the beak anteriorly, about ¼ of an inch in diameter in a large specimen. Height of the shell from 2 to 4 inches, greatest breadth about 1/5 less. Shell quite thick about the umbones and wing, but thinner toward the base. Large cardinal tooth or elevation beneath the umbones, and sloping posteriorly from the beak. The cardinal elevation on the left valve having a depression to receive a corresponding elevation, though slight, on the right valve. From the cardinal tooth there are from 4 to 18 lateral cartilage grooves extending posteriorly to the end of the wing, and terminating with the shell, and there are the same number of cartilage grooves on the anterior side of the cardinal tooth that immediately run together as they pass into the byssal sinus. The cartilage grooves vary in number with the age and size of the shell. The shell is thickened on the anterior side, and appears to show lines of growth passing through the sinus to its base. A large muscular impression is found near the anterior margin, half way from the sinus to the base of the shell, and there are appearances that indicate another muscular impression on the posterior wing of the shell, near its termination. Greatest depth of a valve in a large specimen, ½ an inch.

"This is the largest bivalve yet known in the Cincinnati Group. It may readily be distinguished from the *Anomalodonta alata* by the surface markings, though the general outline form of the two shells are nearly the same.

"I found this species near Versailles, Indiana, about 40 miles west of Cincinnati, and about 300 feet below the Upper Silurian rocks; and I also found what I believe to be a cast of the same at Richmond, Indiana. I do not know that it can be found elsewhere, but the probabilities are that it can be found in the upper part of the Cincinnati Group, from Madison to Richmond, and at other places."—Miller, *loc. cit.*

Miller's specimens evidently came from somewhere in the Waynesville formation. They could not have come from as low as 300 feet below the Silurian, and have come from Versailles at all, since the total thickness of the Versailles section is only about 170 feet.

Concerning this species Mr. Ulrich, who has given it very careful study, has this to say:

"Dr. Miller is certainly in error when he says that there is 'an anterior muscular scar below the byssal sinus.' The depressed triangular space which he mistook for a muscular inpression is without doubt due to some abnormal thickening of the internal surface of the valve. Nothing of the kind has been observed in any other of the numerous specimens observed by me, while the true position of the large muscular scar, which was left by the posterior adductor, and not the anterior, is unequivocally shown in several cases. The pallial line also is clearly shown in the specimens, and as it runs through the space to which the muscle was supposed to have been attached and on to the cavity of the beak, it affords the very best evidence in favor of the view here adopted." (Ulrich, Geol. Ohio, vol. VII, 1893, p. 637.)

1.34A3, 10....1.41A6, 7, D2, E2, 4....1.12E3.

BYSSONYCHIA ALVEOLATA Ulrich.

Plate XLII, figs. 7, 7a.

Byssonychia alveolata Ulrich, 1893, Geol. Ohio, VII, p. 631, pl. xlviii, figs. 1-3.

"Shell of medium size, moderately convex, obliquely acuminate-ovate, wider than usual, with the basal half of the outline semicircular; cardinal margin somewhat shorter than the middle length of the shell; umbones full, beaks but little incurved, separated; ligamental area very large; beneath the beaks the anterior side is impressed, forming an obscurely defined subcordate lunule, in the lower part of which the byssal opening is situated. Surface marked by about fifty rounded radiating costae.

"The large ligamental area indicates relationship with *B. grandis* and *B. obesa,* both of which are restricted to a higher horizon. The first is sufficiently distinguished by its carinate umbones; the second is a more erect shell, with a shorter hinge line, narrower area, and differently shaped byssal depression. The wide area should separate the species at once from *B. radiata* with which a careless collector might confound it.

"*Formation and locality:* Middle beds of the Cincinnati group, Cincinnati, Ohio."—Ulrich, *loc. cit.*

1.34A15a, 19-21, C13, 14a, 14b.

BYSSONYCHIA GRANDIS Ulrich.

Plate XLIV, figs. 1, 1a.

Byssonychia grandis Ulrich, 1893, Geol. Ohio, VII, p. 631, pl. xlvi, figs. 6-9.

"Shell large, ventricose, subquadrate, the length and hight as ten is to thirteen; anterior margin sinuate above, broadly convex in the lower two-thirds; outline of basal half semicircular; hinge line about two-thirds as long as the shell is at the middle of the hight. Beaks projecting less than usual, carinate, flattened on the anterior side; apices separated widely, the intervening space occupied by a broad, striated ligamental area. Upper part of the anterior side with a broad and deep impression in the bottom of which lies the byssal opening. Surface marked with about forty radiating costae. These are rounded and broad in the lower half of the shell. Posterior lateral teeth small, two, situated near the extremity of the hinge.

"This species probably attained a larger size than any other known. It may be equaled in this respect by the associated *B. cultrata,* a species that resembles it in its outline and in having carinate umbones as well. But the present species is readily distinguished from that one by its greater convexity, coarser and therefore fewer costae, and by the large depression around the byssal opening, this part of the shell being quite flat in that species. The ligamental area, furthermore, is of a peculiar type and much narrower in *B. cultrata,* allowing the beaks to come into close proximity. Despite the somewhat striking agreements, I am well satisfied that the two species are widely distinct. In *B. robusta,* Miller, sp., the whole anterior side is flattened, the outline different, and the beaks do not curve forward as in this species, nor are they as widely separated. Despite these and other differencies, I wish it to be understood that I think it just possible that *B. grandis* is not distinct from the species *intended* by Mr. Miller. I tried to see his types but failed because they were packed away. I am therefore obliged to rely upon his illustrations and to assume that they are correct. Comparing my specimens with his figures it will be noticed that in the convexity of the valves and the number of costae the two species agree very well, but in all other respects they are so obviously different that we are forced to regard them as specifically distinct. The carinate umbones will distinguish the species from all the other forms of the genus.

"There remains to mention that the outline of the shell and the coarse rays, which however are rounded instead of flattened, remind one of *Anomalodonta gigantea,* Miller. That species, however, is not so ventricose, and is without the large depressed area which surrounds the byssal opening of *B. grandis*.

"*Formation and locality:* Upper beds of the Cincinnati group. Oxford and Clarkesville, Ohio."—Ulrich, *loc. cit.*

1.34A1, 8, B4-5. . . . 1.41E1.

BYSSONYCHIA OBESA Ulrich.

Plate XLII, figs. 8-8b.

Byssonychia obesa Ulrich, 1893, Geol. Ohio, VII, p. 630, pl. xlv, figs. 10-12.

"Shell usually of less than medium size, obese, ovate in outline except where the full and prominent beaks project beyond the regular curve; hinge short, rounded behind; byssal opening small, situated high, the inner margin thickened so that a decided depression is formed in the anterior side of casts of the interior. Radii from forty-two to forty-five; length from 20 mm. to 33 mm.; height (from beak to base) from 26.5 mm. to 40 mm.; thickness from 15 mm. to 25 mm. In one specimen that differs a little from the rest these measurements are respectively 27 mm., 38 mm. and 20 mm.

"This species rarely occurs except in the condition of casts of the interior, but these are easily distinguished from *B. radiata* Hall, sp., with which collectors have generally identified them, by their more ventricose valves, more rounded form, and deeper byssal excavation. From *B. vera* the species is separated by its greater size, and more ventricose valves. *B. grandis* is much larger and has carinated beaks, they being flattened on the anterior side; *B. suberecta* is a more erect shell and has a longer hinge. Probably nearer than any of these species, at any rate in the general expression of casts of the interior, is the Galena limestone species described by Meek and Worthen as *intermedia* (*Ambonychia intermedia*). Young specimens may be difficult to distinguish from that species, but I have not yet seen any of *B. obesa* that were as small as the largest of *B. intermedia*. Aside from the point of size, comparison shows that the Galena species is, relatively speaking, higher, and that the outline is less rounded, especially in the postero-cardinal region.

"Two large specimens from a lower horizon (about fifty feet below the tops of the hills at Cincinnati), may belong to an early variety of this species. As, however, they had at least fifty radii we might be equally justified in regarding them as examples of a gigantic variety of *B. vera*. The length of the larger of the two is about 60 mm.

"*Formation and locality:* Near the top of the Cincinnati group at Richmond, Indiana, where it occurs in association with *B. richmondensis,* Ulrich, and *Ortonella hainesi,* Miller, sp."—Ulrich, *loc. cit.*

1.34A17 (?)....1.41A7, 8, D1, 3, E1, 2, 3, 5, 6. A common Whitewater species.

BYSSONYCHIA PRAECURSA Ulrich.

Plate XLIII, figs. 3, 3a.

Byssonychia praecursa Ulrich, 1893, Geol. Ohio, VII, p. 633, pl. xlv, figs. 1, 2.

"This form I regard as a small forerunner of *B. richmondensis, B. robusta,* and possibly of *B. cultrata* as well. The shape agrees best with *B. richmondensis,* the principal difference being in the hinge line which is always longer and sometimes quite equal to the greatest length of the shell. The number of the costae varies from thirty-eight to forty-two, the average number being the same as for *B. robusta* and ten less than in *B. richmondensis.*

"In the number of costae and in the outline *B. praecursa* is very much like the typical form of *B. radiata,* Hall, sp. As a rule, however, the latter is a little more oblique, the hinge shorter and the central part of its valves a trifle wider. But the principal difference lies in the flattening of the anterior side in *B. praecursa.*

"*Formation and locality:* Loraine shales, Loraine, New York; also in the equivalent middle beds of the Cincinnati group, at Covington, Kentucky, and Cincinnati, Ohio."—Ulrich, *loc. cit.*

1.12A2.

BYSSONYCHIA RADIATA (Hall).

Plate XLIII, fig. 4.

Ambonychia radiata Hall, 1847, Pal. New York, I, p. 292, pl. lxxx, figs. 4 a-l.

"Equivalve, obliquely ovate, extending into acute curving beaks; anterior slope nearly straight above, and rounded below; posterior slope oblique, scarcely alate; surface marked by twenty-five to forty strong simple radii, which are crossed by fine concentric striae; radii flattened upon the top; the intermediate spaces are regularly concave grooves, narrower than the radii, and marked by concentric striae.

"This species has usually been referred to *Pterinea carinata* of GOLDFUSS, but it appears to me specifically distinct. The figure of that author, which is larger than figs. 4 *a, b* of our plate, represents the shell as having twenty-three or twenty-four radii, which are proportionally stronger than in this shell, while specimens of equal size with the figure of GOLDFUSS have from thirty-five to forty radii upon each valve. On this account, principally, I am disposed to consider the succeeding species [*Ambonychia carinata*] as identical with that of GOLDFUSS.

"I regard both this and the following species as differing sufficiently from PTERINEA of GOLDFUSS to be separated from that genus, and to constitute species under the Genus AMBONYCHIA, which is destitute of an anterior wing, while the posterior side is expanded, though scarcely alate, never showing the distinct wing which marks the AVICULA and nearly all the species of PTERINEA.

"These specimens, though from different and widely distant localities, have all the same essential characters, and the radii are always smaller and more numerous than the one cited. It differs from *A. bellistriata* and *A. orbicularis* of the Trenton limestone, both of which have finer radii and are of different form.

"*Position and locality*: This is one of the most common fossils of the Hudson-river group, being found throughout the greater part of its thickness, but is unknown in the Trenton limestone or Utica slate. It is abundant at Boonville and Turin, in Lewis County [New York]; at Loraine, Jefferson County; at Pulaski, Washingtonville and Mexico, Oswego County; near Rome in Oneida County; and I have seen a single specimen from the altered slates near Waterford, Saratoga County. This species is likewise common in many western localities, and I have specimens from Cincinnati and Oxford (Ohio), Madison (Indiana), and Maysville (Kentucky)."—Hall, *loc. cit.*

1.34B4-5, C14b....1.41A8.

BYSSONYCHIA RICHMONDENSIS Ulrich.

Plate XLIV, figs. 2, 2a.

Byssonychia richmondensis Ulrich, 1893, Geol. Ohio, VII, p. 632, pl. xlv, figs. 3, 4.

"Shell large, high, triangular in a cardinal view, the anterior side being flat; height, length and thickness of an average specimen, respectively, 57 mm., 37 mm. and 30 mm. Beaks rather prominent, triangular, carinate, curving very slightly forward, and rather widely separated in casts. Anterior outline nearly straight, the margin projecting a little in the lower part; base strongly convex, posterior margin broadly rounded; hinge line about two-thirds as long as the middle length of the shell, ranging at an angle of about 95° with the anterior margin. Byssal opening large, in casts appearing as an acutely elliptical low prominence, situated about its length beneath the summits of the beaks. Costae of moderate strength; their number, though not certainly determined, is not less than fifty. Posterior adductor scar and pallial line as shown on plate 45 [of Ulrich's paper].

The shell of this species has not been observed, but the casts are not uncommon, and with their broadly flattened and nearly straight anterior sides are so easily distinguished from all other species of the genus, except *B. robusta,* Miller, sp., that a name for them has long been desirable. In 1880 (*loc. cit.*) Mr. Miller referred these casts to his species *robusta,* but in a recent conversation he admitted that they probably belonged to a distinct species. *B. robusta*, as figured, is relatively not so high and has coarser rays, their number being only about forty, while in *B. richmondensis* there are at least ten more. *B. cultrata* is closely related, but differs decidedly in its outline, being a wider shell and not so convex. The flattening of the anterior side also is confined to the upper part, while in the lower part the outline curves forward in a much greater degree.

"*Formation and locality:* Associated with *Rhynchonella dentata,* Hall, and *Ortonella hainesi,* Miller, sp., in the upper beds of the Cincinnati group at Richmond, Indiana."—Ulrich, *loc. cit.*

This species is considered by Ulrich as equivalent in part to *Byssonychia robusta* Miller, 1880, Jour. Cin. Soc. Nat. Hist., III, p. 315.

The types are from the Richmond formation at Richmond, Indiana, where the species is associated with *Rhynchotrema dentata*.
1.34A19-21, 22....1.41A6....1.60H11.

BYSSONYCHIA SUBERECTA Ulrich.

Plate XLIV, figs. 3-3b.

Byssonychia suberecta Ulrich, 1893, Geol. Ohio, VII, p. 634, pl. xlv, figs. 13-15.

"Shell exceeding the medium size for the genus, moderately convex, suberect, the length and height as five is to six. Hinge line forming an angle of about 105° with the anterior margin; this is a few degrees wider than the posterior angle. Anterior outline gently sinuate in the upper half, and in the central part bending forward enough to give the shell the appearance of leaning backward rather than forward; posterior margin broadly convex; basal half with a semicircular curve. Beaks full, rounded, not very prominent, bending somewhat forward and strongly incurved. Greatest convexity in the umbonal region, but taking the surface as a whole it is more uniformly rounded than in any other species of the genus. Radiating costae rather small, fifty-five to fifty-eight on each valve. Ligamental area about 3 mm. wide, almost vertical, so that in a dorsal view it appears as very narrow, with five or six distinct longitudinal striae. Cardinal teeth apparently three in each valve. Strong posterior lateral teeth are present, but whether more than one in each valve could not be learned from the material at hand. Byssal opening long though very narrow. Muscular and pallial impression as usual for the genus. In casts of the interior the beaks are comparatively erect and obtusely pointed.

"This species has an outline that is closely similar to that of *B. cultrata*. The two species are also associated in the same strata, but can be distinguished at once by the rounded instead of carinated beaks of *B. suberecta*. The latter is also a little smaller. *B. radiata* is probably more nearly allied, but has fewer costae and is a much more oblique shell.

"*Formation and locality:* Upper beds of the Cincinnati group, at Waynesville, Ohio, and Versailles, Indiana."—Ulrich, *loc. cit.*
1.34A4 (?), 20....1.41A5, 7, E1, 6....1.12F3.

BYSSONYCHIA TENUISTRIATA Ulrich.

Plate XLIII, figs. 5, 5a.

Byssonychia tenuistriata Ulrich, 1894, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 500, fig. 39.

"Shell rather small, subovate, moderately ventricose in the umbonal region and anterior half, compressed in the postro-cardinal region where the surface is distinctly concave; anterior slope strongly convex, but scarcely abrupt; beaks small, projecting but little, moderately incurved. Hinge line comparatively short, the outline passing rather gently into the broadly-rounded posterior margin; basal line strongly convex, curving uniformly into the ends; anterior side slightly concave above, neatly convex below. Byssal opening small, its position high, it and the surface around it appearing in casts as a distinct impression immediately beneath the beaks. Surface marked by very fine radiating striae and obscure concentric varices of growth, both showing through the marginal parts of the shell, so as to be visible on good casts of the interior. The total number of the radiating striae is probably more than seventy. Near the base of the specimen figured eleven were counted in the space of 5 mm.

"This species is closely related to *B. vera* Ulrich, from the Utica horizon of the Cincinnati group of Ohio, differing from it chiefly in its finer radiating striae and more impressed byssal opening. *B. intermedia* M. and W., of the Galena, has coarser striae and is a more ventricose shell.—Ulrich, *loc. cit.*

Reported by Ulrich from the Richmond formation at Richmond, Indiana.

CLIDOPHORUS FABULA (Hall).

Plate XLIV, figs. 6, 6a.

Nucula fabula Hall, 1845, Amer. Jour. Sci., XLVIII, p. 295. (Not figured.)

"Shell twice as wide as long, smooth; beaks moderately prominent; crenulations along the hinge-line very obvious; muscular impressions on the anterior side of the beaks very distinct in the cast.

"Width of largest specimen 1/12 of an inch; generally less."—Hall, *loc. cit.*

Our view of this species rests rather upon the description of Meek than upon the inadequate description of Hall, given above. I therefore quote Meek's description in full:

"Shell minute, or very small, transversely-subelliptic, moderately convex; extremities narrowly rounded, the anterior end being narrower than the posterior; basal margin forming a broad semi-elliptic curve; beaks rather depressed, slightly tumid, and placed a little in advance of the middle; dorsal margin sloping gently from the beaks, the anterior slope being rather less gradual than the other, and, in the cast, a little concave in front of the beaks. Anterior muscular impressions distinctly defined by the internal ridge, which leaves a rather deep furrow just in advance of each beak in casts of the interior.

"Lenth, 0.06 inch; height, 0.03 inch; convexity, about 0.02 inch."

1.34B4-5.

CLIONYCHIA EXCAVATA Ulrich.

Plate XLIV, figs. 4, 4a.

Clionychia excavata Ulrich, 1893, Geol. Ohio, VII, p. 651, pl. li, figs. 4, 5.

"Shell as seen in a cast of the interior, of medium size, erect, strongly convex, subquadrangular, straight above, slightly sinuate anteriorly, and rounded below and posteriorly; post-cardinal angle obtuse, perhaps rounded; length of hinge line about two-thirds of the greatest width (length) of the shell; length and height respectively as six is to seven. Beaks compressed, scarcely projecting above the hinge, separated by an unusually wide interval; between and beneath them the greater part of the upper half of the anterior side of the shell is deeply excavated. Muscular scar situated lower than usual, placed just behind the center of the valves. Surface of cast with distant lines of growth in the outer half.

"The hinge is shorter and the anterior excavation larger than in *C. lamellosa* and *C. erecta,* two species of the lower Trenton rocks of Minnesota and Wisconsin."—Ulrich, *loc. cit.*

The types are from the Richmond formation at Richmond, Indiana.

CTENODONTA CINGULATA Ulrich.

Plate XLIV, figs. 5, 5a.

Tellinomya cingulata Ulrich, 1879, Jour. Cin. Soc. Nat. Hist. II, p. 23, pl. vii, figs. 19, 19a.

"Shell of medium size, nearly circular, with a slight prolongation of the posterior end, thus giving a little obliquity to the shell; anterior and basal borders regularly rounded; posterior cardinal margin slightly rounded and sloping to the point of greatest extension; beaks small, obtusely pointed, and not incurved; valves moderately convex, somewhat depressed just posterior to the beaks, and along the cardinal margin.

"Hinge plate wide, regularly, and rather strongly arched, occupied by eight to ten teeth on each side of the middle, those at the extremities bent to about a right angle, becoming more and more straight toward the center.

"Surface ornamented by from six to eight very fine concentric lines.

"Muscular impressions and pallial lines not observed.

"Length, 0.72 inch; height, 0.68 inch: convexity, 0.22 inch.

"This species is related to *T. pectunculoides,* Hall, but its more circular form, less prolonged posterior border; the fine concentric striae and its larger size, will serve to distinguish them externally, while its smaller number of teeth, wider hinge-plate, and more abrupt curvature of the same, will separate them internally."—Ulrich, *loc. cit.*

The types are from the top of the Richmond formation at Marble Hill, near Madison, Indiana.

1.12E3.

CYMATONOTA TYPICALIS Ulrich.

Plate XLV, figs. 1-1c.

Cymatonota typicalis Ulrich, 1893, Geol. Ohio, VII, p. 662, pl. lv, figs. 1-5.

"Shell elongate with the dorsal and ventral margins parallel, the length three and one-half times the height, the greatest thickness, which is a little behind the center, about two-thirds of the height; anterior end nearly vertical, rounded but not uniformly, the turn into the hinge line being rather abrupt; posterior margin rounded, slightly oblique, most prominent in the lower half; ventral margin gently concave. Beaks appressed, scarcely prominent, situated one-fifth of the length of the shell behind the anterior extremity; umbonal ridge and mesial sulcus rather distinct features, cardinal region anterior to the beaks sharply compressed. Surface with fine equal striae anterior to the beaks, of which not over half continue over the flanks of the shell where they take on an irregular character, some being much stronger than the others; or several may be united into a fold. The umbonal ridge is almost smooth, but the upper part of the posterior cardinal slope is marked with rather regular, strong, oblique folds."—Ulrich, *loc. cit.*

The types are from the Richmond formation at Waynesville, Ohio.

1.34A8....1.41E6.

CYRTODONTA CUNEATA (Miller).

Plate XLV, fig. 2.

Angellum cuneatum Miller, 1878, Jour. Cin. Soc. Nat. Hist., I, p. 106, pl. iii, fig. 11.

"Shell medium size, equivalve, much elongated from the cardinal line to the base, middle part subcylindrical, where width and depth are sub-equal; lower half wedge-shaped; umbones high, angular, and prominent anteriorly; beaks acuminate and incurved over the cardinal line; hinge line straight, short, and nearly at right angles to the longer axis of the valves. The cast is a little convex on the anterior side, where there is some evidence of a byssus, and slightly winged on the posterior margin. Surface marked by concentric lines.

"The specimen illustrated I collected in the upper part of the Cincinnati Group, at Richmond, Indiana."—Miller, *loc. cit.*

ISCHYRODONTA DECIPIENS Ulrich.

Plate XLV, figs. 3-3c.

Ischyrodonta decipiens Ulrich, 1893, Geol. Ohio, VII, p. 673, pl. liv, figs. 16-19.

"Shell scarcely attaining medium size, moderately convex, the beaks small, the umbonal ridge distinguishable though not strong, the outline almost regularly oval excepting that the cardinal region is produced and angular at the posterior extremity. Surface marked with numerous, strong and more or less irregular concentric lines of growth. Cardinal teeth nearly horizontal, three in the right valve, the central tooth much the largest, and two in the left valve. Posterior to the cardinal teeth the hinge plate bears three or four slightly diverging slender ridges, which served as supports for the internal ligament. Muscular impressions subequal, strongly marked, the anterior one especially; pallial line distinct. Internal umbonal ridge undefined so that the surface of casts of the interior is comparatively even.

"This species is founded upon an excellent series of specimens, most of them recently obtained from Prof. Joseph Moore and Mr. John Misener of Richmond, Indiana. One specimen I had for at least ten years believed to belong to the similar *Ortonella hainesi* Miller, sp., and it is the likelihood of confusion with that species that has suggested the name *decipiens.* A careful comparison, however, brings out a number of differences that will appear very obvious to the student after he has once made himself familiar with them. First, the surface markings are much coarser in the *Ischy-*

rodonta; next, the outline will be found to be not strictly the same; then the *Ortonella* has a well developed lunule and escutcheon, while the margin of the valves of the *Ischyrodonta* are not in the least inflected; finally that shell has a different hinge, having true posterior lateral teeth.

"Compared with species of this genus, *I. ovalis* will be found to have a thinner hinge plate and more regularly oval shape, while *I. truncata* is a higher shell, with fewer concentric surface markings, and much more oblique cardinal teeth."—Ulrich, *loc. cit.*

Reported by Ulrich from near the top of the Cincinnati group at Richmond, Indiana.

ISCHYRODONTA ELONGATA Ulrich.

Plate XLV, figs. 4, 4a.

Ischyrodonta elongata Ulrich, 1890, Am. Geol., VI, p. 175, figs. 12 a-c.

"Of this species only casts of the interior have been seen. These may be described briefly as follows: Shell rather large transversely elongate-ovate, widest posteriorly, strongly convex, with point of greatest convexity a little in front of the middle. Beaks prominent, compressed, almost terminal. Cardinal margin convex; posterior margin rather strongly convex, and generally somewhat straightened in the lower half; basal margin straight or faintly sinuate; anterior end abruptly rounded, very short. Anterior muscular scar deep, subquadrate, situated beneath the beaks. Just above it the small accessory scar.

"The much greater length of this shell distinguishes it from *I. truncata,* with which it is associated. The outline is much like *Modiolopsis modiolaris* Conr., but the casts of that species are not so convex and the beaks less prominent.

"Associated with this species and *I. truncata* I found several examples of a form apparently intermediate in character between the two. They are, unfortunately, not in very good condition, but as far as they admit of comparison it would appear that they represent nothing more than a slightly elongate variety of *I. truncata.*" —Ulrich, *loc. cit.*

Reported from near the top of the Cincinnati Group at Oxford, Ohio, and Richmond, Indiana.

1.34A18b.

ISCHYRODONTA MISENERI Ulrich.

Plate XLV, figs. 5-5a.

Ischyrodonta miseneri Ulrich, 1893, Geol. Ohio, VII, p. 675, pl. liv, figs. 10, 11.

"This species, as far as known, is very similar to *I. elongata*, and a detailed description is scarcely necessary. Though agreeing in most respects very closely with that species, a comparison still brings out differences that doubtless will suffice in discriminating between the two species. The shell of *I. miseneri* is considerably smaller (the largest seen is about 38 mm. in length), comparatively a little shorter, and subtriangular in outline. The posterior margin is more oblique and considerably higher, and its junction with the straight cardinal margin angular, while the post-cardinal region is distinctly alate and thus quite different from the rounded and sloping character of this part of the outline in *I. elongata*. The umbonal ridge furthermore is a more decided feature. Of the other species *I. decipiens* is much shorter, *I. modioliformis* longer, and more produced and obliquely rounded posteriorly.

The specific name is given in honor of Mr. John Misener of Richmond, Indiana, who collected and from whom I received the best specimens of the shell seen."—Ulrich, *loc. cit.*

According to Ulrich this species occurs at Richmond, Indiana, in association with *Rhynchotrema dentata,* that is in the Whitewater division.

ISCHYRODONTA MODIOLIFORMIS Ulrich.

Plate XLV, figs. 6-6c.

Ischyrodonta modioliformis Ulrich, 1893, Geol. Ohio, VII, p. 676, pl. liv, figs. 4-9.

"Shell scarcely attaining medium size, moderately convex, modiola-like, elongate subovate, the base straight or very gently sinuate, the back straight for a short distance behind the beaks, then curving very gradually down into the very obliquely rounded posterior margin; anterior end short, sharply rounded, much narrower than the posterior. Beaks small, situated a short distance behind the anterior extremity; both the mesial sulcus and the umbonal ridge are but little developed. The cardinal slope and the posterior part of the surface is marked with rather strong, subregular, concentric furrows, of which from ten to fourteen may be counted in the space of 10 mm. Besides these furrows a set of very fine concentric lines, barely visible to the unaided eye, are to be observed on well preserved specimens. The anterior part of the surface seems to be smooth, the furrows at any rate ceasing suddenly a short distance in front of the middle of the shell.

"In casts of the interior a narrow and more or less distinct umbonal ridge may be traced from the beak to the pallial line a short distance behind the center of the cast, while in front of the ridge there is usually a well defined depression or sulcus. Anterior muscular scar strongly elevated, very oblique, sharply defined on the upper side, occupying the greater part of the small anterior end and extending a little posterior to the points of the beaks. Posterior scar very faintly impressed, nearly twice the size of the anterior, situated just within the sloping post-cardinal border of the cast. Pallial line distinct only in the ventral part of the valves. Close to the cardinal border of the casts a long and slightly impressed line represents the support of the internal ligament. Of cardinal teeth there seem to have been but two, one in each valve, the right above the left. The scars left by the small pedal muscles occupy the usual position immediately in front of the cavity between the filling of the beaks.

"This well marked species, of which I have seventeen specimens, is probably nearest *I. elongata.* It is, however, a much smaller shell and readily distinguished by its narrower form, more oblique posterior margin, and different surface markings, the concentric lines of growth extending almost uniformly over the whole surface in that species.

"In a general way *I. modioliformis* greatly resembles several species of *Modiolopsis,* but that it is not really related to them is proved by the fact that it has the shell structure, cardinal teeth and small anterior pedal muscles of a true *Ischyrodonta.*"—Ulrich, *loc. cit.*

The types are from the Richmond formation at Richmond, Indiana.

1.41E1, 4.

ISCHYRODONTA OVALIS Ulrich.

Plate XLV, figs. 7-7b.

Ischyrodonta ovalis Ulrich, 1892, Geol. Nat. Hist. Surv. Minnesota, Ann. Rep. XIX, p. 242, fig. 27 a-d.

"Shell small, moderately ventricose, almost regularly elliptical in outline, with the greatest width and thickness midway between the ends; width and length about as two is to three. Beaks small, situated near the anterior extremity, compressed by a flattening of the surface which, expanding, extends over the greater part of the ventral slope. Edges of valves meeting at the center of the ventral margin, apparently gaping a little at the ends. Umbonal ridge prominently rounded, cardinal slope abrupt, very little concave. Surface marked with strong lines of growth and a few finer concentric striae, both inclining to be irregular.

"Hinge plate arcuate, widening posterior to the beaks, grooved as for the reception of an internal ligament. Cardinal teeth two, projecting downward and backward from the hinge plate, which is thin at this point, and supported by an internal process that seems to extend up into the cavity of the beak, and projects on each side of the teeth so as to give the whole the appearance of a quadrifid tooth. Anterior muscular scar rather small, occupying the anterior extremity of the shell.

"This species is not strictly congeneric with the types of *Ischyrodonta* (Amer. Geol., vol. 6, pp. 173-175), but there is no other established genus known to me offering a closer agreement, and before I can consider the erection of a new genus as fully justified, I wish to see the main peculiarities of the shell confirmed in other species. The uncertainty of the position of the species is increased by the fact that it might be referred, with equal propriety perhaps, to the genus *Matheria,* of Billings. I infer therefore that we are dealing with an undescribed generic type having somewhat intermediate relations between *Matheria* and *Ischyrodonta.*"—Ulrich, *loc. cit.*

Reported by Ulrich from the uppermost beds of the Cincinnati group, near Richmond, Indiana.

ISCHYRODONTA TRUNCATA Ulrich.

Plate XLV, figs. 8-8c.

Ischyrodonta truncata Ulrich, 1890, Am Geol., VI, p. 174, figs. 11 a-e.

"Shell of medium size, moderately convex, subquadrate to broad-oval, widest posteriorly. Cardinal margin straight or faintly arcuate, nearly as long as the shell. Anterior end very short, rounding uniformly into the convex basal margin. From here the edge makes a sharp turn (in the post-basal region) into the somewhat truncate but convex posterior margin, meeting the posterior extremity. Surface of the thick shell smooth between a limited number of impressed lines of growth.

"Hinge plate thick and wide, flat; the cardinal teeth strong.

Anterior muscular impression deep, its outline somewhat top-shaped, pointed below where the well marked pallial line runs into it. Posterior scar very faint, large subcircular, situated near the postero-cardinal angle. In casts of the interior the beaks are prominent, compressed, while a well marked furrow extending from the beaks nearly to the center of the base, gives rise to an obtuse umbonal ridge of which no sign is apparent on the exterior of the shell. Another but less deep and shorter furrow occurs in the space between this and the anterior muscular scar.

"An average specimen of the typical form has the following dimensions: Greatest length, 35 mm.; greatest hight, (from posterior extremity of hinge line to posterior portion of base) 30 mm.; from postero-cardinal angle to antero-basal region 31.5 mm.; from beaks to postero-basal region 35 mm.; greatest convexity of a cast of the interior of a specimen of the same size, 16 mm.

"This species ought not to be confounded with any other known to me from the Cincinnati rocks. I have seen specimens of it labelled *Cypricardites hainesi* S. A. Miller, a shell occupying the same horizon, but there is little reason for confusing the two since Miller's species has posterior cardinal teeth, is less convex, and not so high posteriorly."—Ulrich, *loc. cit.*

This species is reported by Ulrich from Richmond, Indiana. near the top of the Cincinnati group (Whitewater division).

ISCHYRODONTA UNIONOIDES (Meek).

Plate XLVI, figs. 1, 1a.

Anodontopsis ? unionoides Meek, 1871, Amer. Jour. Sci., 3d. ser., II, p. 299. (Not figured.)

"This species has at least all the external characters of the genus, including the last, but nothing is known of the nature of its hinge. Specifically it differs from the species *Milleri,* not only in being very much larger than the adult size of that shell, but in having its anterior outline more regularly rounded, and its posterior obliquely subtruncated above, and with its most prominent part below the middle. Its ventral margin is also much straighter in outline; while its beaks are more depressed and placed decidedly nearer the anterior side, and its dorsal margin is not declining on the posterior side of the beaks as in the last. It likewise differs in having its posterior umbonal slopes more convex on a line from the beaks to the posterior basal margin.

"Length, 1.73 inches; height, 1.11 inches; convexity, 0.63 inch."—Meek, *loc. cit.*

Reported by Meek from the same locality as *A. milleri.* (=*Orthodontiscus milleri.*)

MODIOLODON DECLIVIS Ulrich.

Plate XLVI, figs. 2, 2a.

Modiolodon declivis Ulrich, 1893, Geol. Ohio, VII, p. 654, pl. liii, figs. 3, 4.

"Of this species also only casts of the interior have been seen. These are so much like those of *M. subrectus* that a detailed description is unnecessary. On comparing the casts we find that *M. declivis* is more elongate, the length being twice as great as the height; the ventral margin is slightly sinuate instead of straight, and the dorsal margin arcuate, the posterior part sloping downward in a manner quite unusual in this family of shells. The two ends are nearly equal, the posterior one being therefore relatively narrower than in *M. subrectus.*"—Ulrich, *loc. cit.*

The types are from the Richmond formation, at Richmond, Indiana.

1.34B4-5 (?)

MODIOLODON OBTUSUS Ulrich.

Plate XLVI, figs. 4, 4a.

Modiolodon obtusus Ulrich, 1893, Geol. Ohio, VII, p. 654, pl. lii, figs. 20, 21.—*Modiolopsis modiolaris,* Hall and Whitfield, 1875, Pal. Ohio, Vol. II, plate II, fig. 17. (Not *M. modiolaris,* Hall, 1847, nor *Pterinea modiolaris,* Conrad, 1838.)

"Shell large, compressed-convex, oblong, subovate or obscurely quadrangular, highest behind, though unusually wide and blunt in front. Cardinal margin very long, distinctly arcuate, passing gradually into the regularly curving anterior margin; post-cardinal angle obtuse, sometimes rounded but always projecting beyond the line of a regular curve; posterior margin nearly erect, not strongly curved, except at the base where the outline turns rapidly forward into the basal line, which may be straight or more or less sinuate. Ventral and dorsal margins nearly parallel in the posterior two-thirds, the height in this part of the shell comparing with the length about as six to eleven, while the height at the beak is represented by a little more or less than four. Beaks small, scarcely distinguishable, situated very near the anterior end; umbonal ridge inconspicuous, low, defined only on the lower side by the broad mesial depression. Surface marked by rather fine concentric lines of growth. Shell thick, especially in the anterior part. Anterior muscular scar large, deep, of rounded or ovate shape. Hinge plate wide, furnished with long cardinal teeth immediately over the muscular scar. There appear to be three teeth in all, one large one in the right valve and two more slender in the left.

"In a form obtained from the upper beds of the Cincinnati group, which I shall consider provisionally as belonging to this species, the anterior end is narrower and the anterior muscular scar almost straight on the inner side. A good specimen measures as follows: length, 79 mm.; central height, 43 mm.; anterior height, 23 mm. It is this variety that seems to correspond with the figure given, as above cited, by Hall and Whitfield as of *Modiolopsis modiolaris.* If this specimen is correctly represented by their drawing, it cannot belong to Conrad's species nor even to the genus *Modiolopsis*, since it had well developed cardinal teeth.

"This large shell finds its nearest congeners in the three species described on the preceding pages and figured on plate 53 [of Ulrich's paper], but as the means for comparison are thus at hand and as the differences between the forms must be obvious to every one, it is not necessary to point them out."—Ulrich. *loc. cit.*

Hall and Whitfield report this species from Cincinnati, Ohio. The typical form of the species occurs at Cincinnati about 350 feet above low water of the Ohio River.

1.34A8.

MODIOLODON SUBOVALIS Ulrich.

Plate XLVI, figs. 3-3b.

Modiolodon subovalis Ulrich, 1893, Geol. Ohio, VII, p. 655, pl. li, figs. 11-13.

"Shell, as seen in casts of the interior, subovate, highest posteriorly, rather compressed-convex, thickest a little above the middle, the hight and length about as two is to three; length varying in different specimens between 35 mm. and 50 mm. Dorsal outline slightly arcuate; posterior margin somewhat oblique, generally a little straightened (scarcely truncate) in the upper half and well rounded in the lower, at other times more uniformly curved; base broadly rounded, ascending anteriorly; anterior end very short and small, regularly curved. Beaks very small, scarcely distinguishable, situated far in front; no distinct umbonal ridge; mesial sulcus comparatively deep in the umbonal half, not sharply defined however anywhere.

"Anterior muscular scar very faint, prominent, occupying about half of the small anterior end; pallial line moderately distinct, submarginal posterior scar very faint, back of cast deeply channeled, indicating either a strong hinge plate or an escutcheon in the shell, the former most likely. Cardinal teeth were present but they are not shown clearly enough in casts to be described. Surface of casts with a few distant lines of growth.

"This species is closely related to *Modiolopsis truncata,* Hall, but may be distinguished by its more nearly oval outline, and deeper mesial or umbonal sulcus. In the outline it is more like the type of the genus *M. oviformis* but the casts of that species are not channeled dorsally in any degree comparable with *M. subovalis.*

"Respecting the generic position of the species, I see nothing to oppose an arrangement with *Modiolodon.* The same applies also to *Modiolopsis truncata,* because it is unquestionably congeneric with *M. subovalis.* Until the latter was discovered and studied I found Hall's species (*truncata*) most troublesome to classify, and for a time I was inclined to place it into the new genus *Eurymya,* founded upon *Modiolopsis plana,* Hall."—Ulrich, *loc. cit.*

From the Richmond formation at Versailles, Indiana, and reported in Kindle's list from Richmond, Indiana.

MODIOLODON SUBRECTUS Ulrich.

Plate XLVI, figs. 5-5a.

Modiolodon subrectus Ulrich, 1893, Geol. Ohio, VII, p. 653, pl. liii, figs. 5, 6.

"This species is known only from casts of the interior. Of six specimens the largest is 47 mm. long and 27 mm. high, the smallest 29 mm. long and 17 mm. high. Cardinal and basal margins nearly straight and subparallel, diverging slightly posteriorly; posterior margin obliquely subtruncate, obtuse-angular above, more prominent and strongly rounded in the lower half; anterior end short, small, the upper margin sunken considerably beneath the dorsal outline. Beaks compressed, prominent anteriorly, situated well forward, on a line with the back, scarcely incurved, separated by a well defined, wide, channel-like depression extending posteriorly from the points of the beaks half the length of the cast. Umbonal ridge and sulcus strong, extending from the beaks obliquely downward to the central third of the base; and producing a decided compression of the antero-basal third of the cast. Anterior muscular scar very strong, obliquely ovate, large, occupying the greater part of the small anterior end. The inner side of the elevated scar is marked with about six horizontal folds. Pallial line and posterior adductor impression indistinct. The casts exhibit no indications of the surface markings. The hinge plate seems to have been strong, while of cardinal teeth the evidence at hand indicates two in each valve, one larger than the other.

"The casts of this species might be confounded with those of small specimens of *Ischyrodonta elongata,* Ulrich, but a careful comparison will show that the *Modiolodon* is narrower posteriorly, the dorsal and ventral margins being more nearly parallel and also straighter; the ventral margin is not sinuate, and there is no small pedal muscular scar above the anterior adductor impression, while the inner side of the latter is thrown into folds instead of being sharply edged. Excepting the following species there is no other known to me with which it need be compared.

"That *M. subrectus* is not an *Ischyrodonta* is shown by the black film so characteristic of the *Modiolopsidae* which is retained by two of the specimens. The absence of the small pedal muscles over the anterior adductor impressions also is significant."—Ulrich, *loc. cit.*

The type is from the Richmond formation, Richmond, Indiana.

MODIOLODON TRUNCATUS (Hall).

Plate XLVI, figs. 6, 6a.

Modiolopsis truncatus Hall, 1847, Pal. New York, I, p. 296, pl. lxxxi, figs. 3 a-b.

"Oblique, transverse, sub-trapezoidal; the cardinal and basal margins diverging from the anterior extremity, convex; beaks near the anterior extremity, with an obscure elevated ridge extending obliquely to the base; posterior extremity obliquely truncate; muscular impression very distinct, a little in advance of the beaks, and at the anterior extremity, in the cast projecting beyond the margin.

"This shell differs but little from some of the varieties of *M. modiolaris;* but it is proportionally broader, and the beaks are closer to the anterior extremity, while the muscular impression seems to be placed upon the very margin of the shell. It is much less common than *M. modiolaris,* and the few specimens examined appear to be constant in the characters given. It bears a close resemblance to the figure of DE VERNEUIL cited above.

but it is less ventricose, our specimen being crushed and destitute of the shell."—Hall, *loc. cit.*

Reported by Hall from Cincinnati, Ohio. Reported from Indiana in Kindle's list.

MODIOLOPSIS CONCENTRICA Hall and Whitfield.

Plate XLVII, fig. 3.

Modiolopsis concentrica Hall and Whitfield, 1875, Pal. Ohio, II, p. 86, pl. ii, fig. 18.

"Shell of medium size; elongate ovate in outline; broadest near the posterior end, and contracted in front of the beaks. Hinge line arcuate, gradually declining toward the extremity and rounding into the posterior margin, which is more sharply rounded below than above the middle; basal line gently curved, becoming a little sinuate at or about the anterior third of its length; anterior end narrowly rounded. Beaks small, and compressed on the back, projecting but little above the hinge. Surface of the valves moderately convex when not distorted by pressure; most prominent above the umbonal ridge, which is low, and broadly rounded; not forming a conspicuous feature of the valve. A very slight and rather undefined mesial sulcus crosses the valves from the beak to the sinus of the basal margin.

"Surface of the shell marked on the cardinal slope and posterior end by regular, even, concentric furrows, from three to four of which occupy the space of an eighth of an inch in their strongest parts. These furrows are most distinctly marked near the cardinal margin, and become obsolete in crossing the umbonal ridge; existing on the basal portions and anterior end only as fine, irregular, concentric striae of growth. Anterior muscular impression strongly defined and proportionally large; forming a rather distinct, subcircular or reniform protuberance on the anterior end of the casts; posterior impression not observed; pallial line often distinct on the anterior half; partly composed of detached transverse pustules.

"The specimens of this shell observed in collections have generally been found among and considered as identical with those of *Modiolopsis modiolaris,* but it is always of much smaller size, being generally not more than two-thirds as long when fully grown as the ordinary sized individuals of that species, and although the general form is very similar, the concentric markings of the cardinal slope and posterior end readily distinguish them. These markings are of such a nature that they are usually preserved on all specimens retaining any specific markings. The specimens are frequently much distorted by compression, and when the pressure has been vertical, or in the direction of the plane of the shell, the convexity is considerably increased, often causing them to appear nearly cylindrical.

"The species resembles very closely *Modiomorpha concentrica* of the Hamilton formations of New York (*Modiola concentrica* of authors) in its general appearance and surface markings, so much so that it might readily be mistaken for that shell; but the concentric, undulating striae becoming obsolete on the umbonal and anterior portions of the shell, will serve, we think, as an unfailing means of distinguishing them—the striae on that species continuing over all parts."—Hall and Whitfield, *loc. cit.*

The types are from Waynesville, Ohio. Reported from Indiana in Kindle's list.

MODIOLOPSIS VERSAILLESENSIS Miller.

Plate XLVI, figs. 7, 7a.

Modiolopsis versaillesensis Miller, 1874, Cincinnati Quarterly Journal of Science, I, p. 150, figs. 18, 19.

"Equivalve, inequilateral, oblong, expanded and compressed posteriorly; basal margin contracted or arched upward, below the beaks; cardinal line straight; beaks near the anterior extremity, and slightly more prominent than those of the *Modiolopsis modiolaris;* umbones subangular and extending obliquely, posteriorly; surface marked by concentric lines; muscular impression circular and deep, below and anterior to the beak; mesial ridge between it and the umbonal cavity; hinge line plain and smooth, except a slight ligamental depression below the beak.

"Length of specimens examined varying from ¾ inch to 2½ inches; breadth and thickness in proportion to the length.

"This species differs from the *Modiolopsis modiolaris,* in having a more prominent beak, more angular umbones, different hinge line, and ligamentary attachments, and in having the muscular impression farther anterior to the beak. Casts of the two species might not be distinguishable from each other.

"This species was found by me at Versailles, Indiana, about 300 feet below the rocks of the Upper Silurian, and associated with *Anomalodonta gigantea, Anodontopsis* (?) *Milleri, Pleurotomaria tropidophora, Tellinomya occidentalis,* etc."—Miller, *loc. cit.*

Apparently Miller obtained the species from the Waynesville formation, or the base of the Liberty. His statement that the specimens came from a level 300 feet below the Upper Silurian is interesting in view of the fact that the total thickness of the Versailles section does not exceed 170 feet.

OPISTHOPTERA CASEI Meek and Worthen.

Plate XLVII, figs. 1, 1a.

Ambonychia (Megaptera) casei Meek and Worthen, 1866, Proc. Chicago Acad. Sci., vol. I, p. 23. (Also Geol. Surv. Ill., vol. III, 1868, p. 337.)

"Shell trigonal, compressed, subequivalve, extremely inequilateral, posterior side long, compressed and strongly alate; the wing very large, produced, pointed, and not separated from the alate posterior margin by a distinctly defined sinus; margin below the wing, sloping obliquely forward to the basal angle; cardinal margin the longest part of the shell, straight and much compressed from immediately behind the beaks. Anterior side truncated nearly vertically from the beaks, about half way down the front, thence sloping slightly backwards to the basal angle. Basal margin produced downwards, and terminating in a distinct angle, slightly in advance of the middle. Umbonal slopes very prominent, angular, or sometimes apparently bicarinate, straight, and extending from the beaks, near the anterior margin, to the most prominent part of the base, ranging at an angle of about 65° below the horizon of the hinge-line, and provided with a longitudinal sulcus below the middle of the valves. Beaks straight, rising a little above the cardinal margin, and quite terminal. Surface ornamented with distinct, irregular, alternately larger and smaller, thread-like radiating striae, with less distinct concentric lines, and a few distinct, stronger marks of growth, which sometimes form prominent, imbricating, subspinous projections on the umbonal angle.

"Length, as inferred from the direction of the lines of growth, about 2 inches; height, 1.73 inches; convexity, 0.64 inch."—Meek and Worthen, Geol. Surv. Ill., vol. III, 1868, p. 337.

I have not been able to obtain the Proc. Chicago Acad. Sci., 1866.

The description is followed by a discussion of the generic relations of the species, which I omit.

The type is from Richmond, Indiana.

1.12E3. F3....1.60H11.

OPISTHOPTERA OBLIQUA Ulrich.

Plate XLVII, figs. 2-2b.

Opisthoptera obliqua Ulrich, 1893, Geol. Ohio, VII, p. 646, pl. xlix, figs. 6-8.

"Shell small, trianuglar, highest in the posterior third, and thickest along the oblique anterior side; hinge line as long as the shell, posterior margin vertical, gently convex, basal margin narrowly rounded; anterior side very abrupt, almost flat, forming an angle of about 55° with the hinge. Beaks rather large, prominent, but little incurred [*sic.*] and separated by a considerable interval in casts of the interior. Ligamental area very wide. Surface marked with small, apparently bifurcating costae, of which those near the cardinal margin are if anything smaller than elsewhere. On the whole they may be described as subequal.

"This species doubtless is closely related to *O. extenuata*, the two species being very similar in their anterior halves. Still, it is highly improbable that they will ever be confounded, since they are so different posteriorly, this part of the outline being vertical and slightly convex in the present form and deeply sinuate centrally and prolonged above in that one. The ligamental area also is much larger in *O. obliqua*. Compared with *O. alternata* it is found that the valves though more convex are not as uniformly rounded, the anterior side more oblique and much more abrupt, and the costae of nearly equal size instead of alternately large and small. None of the other species are near enough to require comparisons.

"Associated with *O. obliqua* we find *Byssonychia richmondensis*, another species having the anterior side flat. But as it attains a much larger size, is relatively much higher and almost erect, and has a much shorter hinge, they are not likely to be confused."—Ulrich, *loc. cit.*

Richmond formation, Richmond, Indiana (Whitewater division).

ORTHODESMA CANALICULATUM Ulrich.

Plate XLVII, figs. 4-4b.

Orthodesma canaliculatum Ulrich, 1894, Geol. Nat. Hist. Surv. Minnesota, III, pt. II, p. 520, pl. xxxvii, figs. 7-11.

"Shell elongate, the length three times the hight; cardinal and basal margins straight, nearly parallel; posterior margin oblique, rounding into the hinge line, below which it slopes backward with a gentle curve to the postero-basal extremity where it turns abruptly into the basal line; anterior end contracted in front of the beaks. of moderate length, rounded, most prominent a little above the middle. In a side view the beaks project very little, are compressed by a broad shallow sulcus which crosses the valves and occupies a large part of the anterior three-fifths of the shell; umbonal ridge rather distinct, extending from the beaks to the postero-basal extremity. In a cardinal view of casts of the interior, the only condition in which the species has been noticed, the hinge line is strongly depressed, lying at the bottom of a wide and deep channel, deepest between the widely separated beaks and gradually shallowing posteriorly. Casts usually almost smooth, exhibiting only a small number of obscure concentric furrows. One specimen preserves a small part of the shell and this shows that near the dorsal edge the outer surface is marked with somewhat regular raised lines, about six of them in 5 mm. The best preserved casts exhibit in the posterior half of the mesial sulcus a number of obscure radii. Anterior muscular scar sharply defined at the inner side, rather small, broad-oval or circular, occupying the middle two-fourths of the upper half of the anterior end. Posterior impression somewhat larger than the anterior, subcircular, with a narrow prolongation extending forward nearly parallel with the posterior cardinal margin. Pallial line distinct in the anterior half, consisting (on the casts) of a straight row of obscure pustules extending in a slightly oblique direction from the base of the anterior adductor impression toward a point much nearer the ventral border.

"There are several peculiar features about this species. (1) I have never seen its valves séparate, a fact indicating, if it is not fully accounted for by the next circumstance, a strong ligament. (2) Its natural position seems to have been with the anterior end down, and so it is commonly found in the shales, and in consequence is often greatly shortened by pressure. (3) The channel-like depression of the hinge; and (4) the unusual course of the anterior half of the pallial line. These peculiarities distinguish the species readily from all others of the genus known."—Ulrich, *loc. cit.*

Reported from the upper beds of the Cincinnati series in Ohio and Indiana (Ulrich).

ORTHODESMA RECTUM Hall and Whitfield.

Plate XLVII, figs. 6, 6a.

Orthodesma recta Hall and Whitfield, 1875, Pal. Ohio, II, p. 94. pl. ii, figs. 7, 8.

"Shell elongate, solen-like in outline, two and a half to three times as long as wide, the cardinal and basal lines posterior to the beaks straight and parallel; anterior end abruptly contracted beneath the beaks to one-half the width of the body of the shell, somewhat extended and abruptly rounded at the extremity; posterior end as broad as the body of the shell, obliquely rounded, longest at the postero-basal angle, and gently sloping backwards to the extremity of the hinge line; beaks small and compressed; surface of the valves between the umbonal ridge and the anterior contracted portion depressed, forming a broad, shallow, and undefined sulcus, strongest toward the beaks, and becoming obsolete or lost in the general flattening of the shell before reaching the basal line, in which it scarcely produces any perceptible feature.

"The surface of the valves is marked by irregular, concentric lines of growth, and by several stronger undulations, which become somewhat regular on the posterior slope for a short distance below the hinge line. There are also appearances of one or two obscure secondary ridges on the cardinal slope between the umbonal ridge and the cardinal margin, extending from near the beak to the posterior end of the shell. This latter feature is extremely faint, and may be often not observable.

"The species is not readily confounded with any other found in the same geological position, except, perhaps, *O. curvata,* from which it may be distinguished by the contraction of the basal line and the greater posterior breadth of the shell in that species. It somewhat resembles *Orthodesma parallela=Orthonota parallela*, Hall, Pal. N. Y., Vol. I, p. 299, pl. 82, fig. 7, from the Hudson River group of New York, but it differs in the greater contraction of the anterior end, the broader beaks, the broad, undefined depression of the median portion of the valves, and in the form of the posterior end of the shell, which in that species is rounded, while in this one it is obliquely truncate. The surface characters also differ very materially in the two forms, that one having fine, even, regular, concentric lines over the anterior two-thirds of the valves." —Hall and Whitfield, *loc. cit.*

The type is from the Richmond formation at Waynesville, Ohio. It is reported in Kindle's list from Madison, Indiana. I have not seen any specimens of it.

ORTHODESMA SUBANGULATUM Ulrich.

Plate XLVII, figs. 7, 7a.

Orthodesma subangulatum Ulrich, 1893, Geol. Ohio, VII, p. 660, pl. lv, figs. 21-23.

"This species is closely related to *O. rectum,* H. and W., the type of the genus, but may be distinguished by a number of minor differences, chiefly in the matter of outline. The shell is more elongate, the posterior height being less and only about one-third of the entire length. The ventral margin is straighter and sinuate rather than convex, while the central and dorsal outlines are more nearly parallel. The anterior end is uniformly rounded instead of being oblique with the most prominent point in the upper part. Finally, the posterior margin is a little more oblique. Of other differences we may mention that the umbones seem to have been somewhat smaller and merely flattened instead of sulcate, while the umbonal ridge is stronger and more curved.

"The Trenton species *O. subnasutum* (*Modiolopsis subnasuta,* Meek and Worthen), is higher posteriorly, while *O. curvatum,* Hall and Whitfield, has a more rounded posterior end and more sinuate ventral margin. None of the other species are near enough to require comparisons."—Ulrich, *loc. cit.*

Upper beds of the Cincinnati group, Richmond, Indiana.

ORTHODONTISCUS MILLERI Meek.

Plate XLVII, figs. 8-8c.

Anodontopsis ? milleri Meek, 1871, Amer. Jour. Sci., 3d ser. II, p. 297. (Not figured.)

"Shell ovate, rather compressed or only moderately convex, the greatest convexity being a little above and slightly in advance of the middle, extremities more or less narrowly rounded, basal margin longitudinally semi-oval in outline, the most prominent part being near the middle; cardinal margin sloping from the beaks at an angle of 130° to 135° and rounding into the lateral margins; beaks only moderately prominent, somewhat obtuse and not very convex, placed more than one-third the length of the valves from the anterior end. Surface smooth, or only with obscure lines of growth.

"Length of a medium sized adult specimen, 0.83 inch; height, 0.59 inch; convexity, 0.30 to 0.33 inch.

"It is not without considerable doubt that I refer this shell to McCoy's genus *Anodontopsis,* since it does not seem to correspond exactly in its hinge characters to his description of that genus, if I correctly understand him. As the hinge of *Anodontopsis*, however, has not yet been illustrated, and different authors do not always describe the same hinge exactly in the same way, I have concluded to refer our shell, for the present, provisionally to *Anodontopsis*. If a new genus, however, it may be called *Orthodontiscus*.

"Prof. McCoy described the hinge of his genus as follows: 'Hinge line shorter than the shell, with a posterior long slender tooth or cartilage plate extending just below it (double in the right valve), and another similar but shorter one in front of the beaks,' and then adds that there is 'occasionally one small cardinal tooth beneath the beak.'

"In the shell here described, the hinge may be characterized as having one rather well defined, subtrigonal, or somewhat obliquely extended cardinal tooth under the beak of the right valve, and a corresponding pit under the beak of the left valve, with sometimes a slight prominence or rudimentary cardinal tooth just in advance of this pit; while of posterior lateral teeth there is in the right valve one long tooth ranging parallel to the cardinal margin, with a parallel furrow above and below it for the reception of two posterior laters in left valve, the lower one of which is more prominent, and the upper merely linear or rudimentary. The furrow between these two posterior lateral teeth of the left valve is well defined, and receives the tooth between the two furrows in the other valve. Below the lower of these furrows on the posterior side of the right valve, there is a very slight marginal ridge, that may sometimes assume the character of a second posterior lateral, but it is most prominent anteriorly, where it connects with the cardinal tooth, of which it seems to be rather an oblique posterior prolongation than a distinct tooth. On the anterior side there is one shorter anterior lateral tooth in the right valve, also ranging parallel to the hinge margin, and above and below this a little furrow for the reception of two small anterior laterals in the left valve, which receive between them that of the right valve.

"The pallial line is certainly simple, and the muscular impressions well defined, the posterior one being larger than the other, and provided with a small accessory scar above just under the posterior ends of the posterior lateral teeth. The ligament or cartilage was probably small and internal, as there are no traces of an external ligament to be seen, the valves fitting close all along the hinge margin. No lunule or escutcheon is to be seen in any of the specimens.

"The specific name is given in honor of S. A. Miller, Esq., of Cincinnati, Ohio, who sent on to the Smithsonian Institute the first specimens of this shell I have seen. I am also indebted to him for some broken valves showing the hinge. For the use of a good specimen showing the hinge of the left valve I am likewise under obligations to C. B. Dyer, Esq., of Cincinnati."—Meek, *loc. cit.*

This shell is said by Meek to come from forty miles west of Cincinnati, from above the middle beds of the Cincinnati group. In Kindle's list it is said to come from Versailles, which would make it a Richmond group form.

ORTONELLA HAINESI (Miller).

Plate XLVII, figs. 9-9d.

Cypricardites hainesi Miller, 1874, Cincinnati Quartely Journal of Science, I, p. 147, figs. 12, 13.

"Equivalve, inequilateral; margins subparallel, diverging posteriorly; beaks sharp, projecting over the hinge line and slightly incurved; umbones subangular, with a ridge extending posteriorly and curving toward the base, where it becomes obsolete; cardinal teeth unknown; lateral teeth two, one much longer than the other; muscular impression below the beak anteriorly.

"The cardinal teeth, in the valve, figure 13 [of Miller's paper], being destroyed, as shown by the letter *t*, the number and character could not be ascertained.

"Surface marked by fine concentric lines.

"Length 1 3/20 inches; width, 19/20 inch; greatest depth through the umbones 12/20 inch.

"The specific name is given as a compliment to Mrs. M. P. Haines, an earnest and devoted naturalist of Richmond, Indiana, who has collected a very fine cabinet and studies to appreciate it."—Miller, *loc. cit.*

From what Miller says about the locality at which this species was found, it would correspond to some portion of the Whitewater division. Ulrich says it is found associated with *Rhynchotrema dentata* about forty feet below the top of the Richmond formation (Whitewater division).

PTERINEA CORRUGATA (James).

Avicula corrugata James, 1874, Cincinnati Quarterly Journal of Science, I, p. 239. (Not figured.)

"Shell (left valve) oblique, subrhomboidal; cardinal line greater than the breadth of the shell farther forward; umbone prominent; beak compressed; anterior ear rounded on a line with the margin of the shell; posterior ear triangular, extending beyond the margin below. Anterior umbonal slope abrupt; posterior slope gradual to the point of the ear and the back margin. Surface marked by crowded concentric lines of growth, strongly corrugated from the umbone to the front, giving to that part of the surface a finely sculptured appearance, but not extending to the wings or ears.

"Breadth, measuring along the cardinal line, about one inch; length from the back obliquely to the front, seven eighths of an inch."—James, *loc. cit.*

Reported by James from the Richmond formation in Wayne County, Indiana (Richmond?).

PTERINEA DEMISSA (Conrad).

Plate XLVIII, fig. 1.

Avicula demissa Conrad, 1842, Jour. Acad. Nat. Sci. Philadelphia, VIII, p. 242, pl. xiii, fig. 3.

"Elevated; inferior valve plano-convex, concentrically wrinkled, and occasionally slightly furrowed; anterior wing triangular, the upper margin on a line with that of the posterior wing, which is extended beyond the line of the posterior extremity; beneath the wing the posterior margin is nearly straight, and but slightly oblique; upper valve flat, and concentrically furrowed with wide, shallow, concave grooves; summit of umbo on a level with the hinge line."—Conrad, *loc. cit.*

Hinge line much longer than the body of the shell. Anterior wing extended, when perfect, into a rather long acute point, forming nearly one-third of the length of the hinge, measured from the point of the beak. Posterior wing large, rather obtusely pointed, and extending as far as the body of the shell below; a line drawn from the beak to the center of the base forms an angle of about 65 or 70 degrees with the posterior hinge line. Left valve strongly convex; right valve concave. (Meek.)

1.41A6, 7, 10b, B1, D1, 3, C2-3, E1....1.12E3, F3.

PTERINEA INSUETA (Emmons).

Plate XLVIII, fig. 2.

Avicula insueta Emmons, 1842, Geol. New York, Rep. Second Dist., p. 399, fig. 110, No. 5.

"No. 5. *Avicula insueta,* belongs to the Mohawk valley. I did not find it in the slate of the Second district."—Emmons, *loc. cit.*

This shell is reported from Madison by Cornett, but quite certainly does not occur there or anywhere else in the Cincinnati group.

RHYTIMYA BYRNESI (Miller).

Plate XLVIII, figs. 3-3a.

Orthodesma byrnesi Miller, 1881, Jour. Cin. Soc. Nat. Hist., IV, p. 76, pl. I, figs. 7-7b.

"Shell of medium length and breadth, but proportionally very thin. Cardinal and basal margins sub-parallel, but gradually diverging posteriorly to the posterior third of the shell. The cardinal line is straight, posterior to the beaks, for about one third of the length of the shell, from which point it gradually declines to near the extremity, which is abruptly rounded. Anterior end contracted beneath the beaks, and beautifully rounded in front. Basal line concave in the middle part, for about one half the length. Beaks small but nearly or quite uniting; umbones flattened, and, from which, there is a shallow expanding depression, directed a little posteriorly, and crossing the valves to the basal line.

"Surface of the valves marked by concentric lines, and covered by numerous little spines.

"Length, 1 2-10 inches; height, 5-10 inch; thickness, 25-100 inch.

"This species is founded upon a specimen preserving the shell, and also upon the matrix from which the shell was taken, collected by Dr. R. M. Byrnes, in whose honor I have given the specific name, in the upper part of the Hudson River group, near Weisburg, Indiana, and now belonging to his collection. It is peculiar in preserving the markings of the spines which covered the surface, in the matrix, and also preserving the bases of them on the shell, which may be readily observed with an ordinary magnifier. It will be distinguished from other species by the fact that its thickness is only half its height, and only one fifth its length, as well as by other peculiarities. As this species was covered with numerous spines, it becomes interesting to know whether other species in the same genus were also thus ornamented."—Miller, *loc. cit.*

Richmond formation, Weisburg, Indiana.

SEDGWICKIA FRAGILIS Meek.

Plate XLVIII, figs. 4, 4a.

Sedgwickia ? fragilis Meek, 1872, Proc. Acad. Nat. Sci. Phila., 1872, p. 323. (Not figured.)

"Shell rather small, apparently very thin, longitudinally oblong or suboval, rather distinctly convex along the umbonal slopes from the beaks toward the posterior basal margin, and down near the anterior side, while just under the beaks a rather strongly marked impression descends, widening and deepening as it approaches the base; basal margin subparallel in its general outline to the dorsal, but diverging more or less posteriorly, where it is most prominent and distinctly sinuous toward the front; posterior margin wider than the anterior, and more or less truncated; anterior extremity very short, and rounded or somewhat truncated; hinge line straight, and shorter than the entire length of the valves, apparently very slightly inflected behind the beaks, which are raised a little above the cardinal margin, incurved, contiguous, flattened on the outer sides, and placed near the anterior end, with a slight forward inclination. Surface ornamented with moderately distinct lines and irregular minute wrinkles of growth.

"The only specimens of this species yet known to me are too imperfect to afford exact measurement, though they seem to have been, when entire and undistorted, about 0.90 inch in length, 0.73 inch in height, and 0.40 inch in convexity. They present some appearance of having been gaping behind and in the anterior ventral region. One specimen looks as if it had been truncated, with a backward obliquity from below upward behind, but this may be due to distortion.

"I am far from being satisfied that this shell is congeneric with the forms for which Prof. McCoy proposed the name *Sedgwickia,* as nothing can be determined from the specimens yet known in regard to its hinge and muscular and pallial impressions. Possibly it would be nearer right to call it *Modiolopsis fragilis*; but there is something in its physiognomy that suggests affinities to Carboniferous types referred to *Sedgwickia* and *Allorisma.*"—Meek, *loc. cit.*

Doubtfully reported from Madison, Indiana.

The type is from 350 ft. above low water mark at Cincinnati, Ohio.

SPHENOLEUM RICHMONDENSE Miller.

Plate XLVIII, fig. 5.

Sphenoleum richmondense Miller, 1889, North American Geology and Paleontology, p. 513, figs. 925, 926.

"Shell large, cuneiform, ventricose, beaks incurved at the anterior end, pointed; umbones high, defined; cardinal line at a high angle, having a wing-like posterior end; anterior end rounded below the lunule. Distinguished from S. cuneiforme, which it much resembles, by its shorter form and more angular umbones. Possibly more specimens may show a gradation from one form to the other, and if so, this specific name will fall into the synonomy. Collected by Charles Faber in the upper part of the Hudson River group, at Richmond, Indiana."—Miller, *loc. cit.*

TELLINOMYA HILLI Miller.

Plate XLVIII, fig. 6.

Tellinomya hilli Miller, 1874, Cincinnati Quarterly Journal of Science, I, p. 230, fig. 20.

"Shell somewhat oval in outline, the posterior end prolonged, with the cardinal border nearly straight, until it bends somewhat circurlarly to the point of greatest extension; anterior end quite regularly rounded; basal margin forming a semi-elliptic curve; beaks near the anterior end moderately prominent, greatest convexity immediately behind the beaks; surface smooth. Hinge line occupied by three small teeth anterior to the beak and ten small teeth posterior to it. Some difficulty has been experienced in determining the number of teeth from their indistinct character in the specimen examined, and it may be that there are actually more than we have stated. Muscular impressions and pallial line not observed.

"The very slight curvature of the hinge line and the minute character of the teeth, as well as their straight transverse character, may leave some doubt as to whether or not this shell belongs to the genus *Tellinomya*.

"The specific name is given in honor of Dr. H. H. Hill, of Cincinnati, who has been an active collector in various departments of natural history for a number of years, and very prominent in the organization and management, from the beginning, of the Cincinnati Society of Natural History. His private cabinet sparkles with mineral gems, is ornamented with the rarest and finest specimens of the workmanship of the Indians and Mound Builders, and bears upon its shelves many of the choicest fossils of the Cincinnati group.

"I found this species in the upper 50 feet of the Cincinnati group, about three miles south of Osgood, Indiana, and nearly fifty miles west of Cincinnati. The valves were found quite abundant, though not well preserved, on slabs, associated with *Beyrichia striato-marginatus*. An entire specimen was not found."—Miller, *loc. cit.*

Imperfect specimens in the writer's collection may belong to this species. Saluda.

WHITEAVESIA CINCINNATIENSIS (Hall and Whitfield).

Plate XLVIII, figs. 7, 7a.

Modiolopsis cincinnatiensis Hall and Whitfield, 1875, Pal. Ohio, II, p. 88, pl. ii, figs. 14, 15.

"Shell of medium size or smaller; elongate ovate, or narrowly sub-elliptical in outline; widest posteriorly, and abruptly contracted in front of the beaks; hinge line slightly arcuate, and a little more than half as long as the shell posterior to the beaks; posterior margin obliquely sloping, with a slight convexity, from the extremity of the hinge line to the postero-basal angle, which is the point of greatest length of the shell. Basal line gently curving throughout its length in most cases, but in some examples becoming slightly sinuate opposite or a little posterior to the beaks. Anterior end narrow, not very extended, and sharply rounded. Beaks small, appressed; projecting but little above the hinge line, and situated just within the anterior third of the length of the shell. General surface of the shell moderately convex; most prominent along the posterior umbonal ridge, which is sharply rounded or obscurely angular; umbonal slope abrupt and slightly convex. An obscure, shallow mesial depression extends across the valves from the beaks, reaching the basal line just behind the anterior third of the length.

"Surface marked by numerous, irregular, concentric lines of growth, which are often strongly marked, but without any definite arrangement; a little stronger on the anterior portion of the shell than elsewhere. The substance of the shell is thin, and the surface, when perfect, quite polished.

"This species bears considerable resemblance to the larger specimens of the form identified with and figured as *M. anodontoides,* Conr., in Paleontology of New York, Vol. I, p. 298, pl. 82, fig. 3*b,* but differs in the greater breadth posteriorly, and in being much contracted in width in front of the beaks. From the other forms given on the same plate as the same species it differs more strongly, and can not be readily confounded with them. The specimen represented by fig. 3*a* of the same plate, which is the original of the species used by Mr. Conrad for description, and that which must be considered as possessing the true specific characters, is much more angular along the umbonal ridge; the hinge line is proportionally longer, and the anterior end of the shell shorter and broader than in the species under consideration."—Hall and Whitfield, *loc. cit.*

Reported by Hall and Whitfield from near the base of the Cincinnati formation at Cincinnati, Ohio; and in Kindle's list from Richmond, Indiana. It almost certainly does not occur in the Richmond formation.

WHITEAVESIA PHOLADIFORMIS (Hall).

Plate XLVIII, fig. 8.

Modiolopsis pholadiformis Hall, 1851, Report on the Geology of the Lake Superior Land District, p. 213, pl. xxx, figs. 1 a-c; pl. xxxi, fig. 1.

"Shell oval-obovate, elongate; base slightly arcuate in the middle; convex in the middle and compressed towards the posterior extremity; umbones prominent, hinge-line slightly arched, and, in some specimens, nearly straight; muscular impression large and strong, near the anterior extremity; surface marked by strong folds or ribs, which, originating on the hinge-line, diverge and curve gradually downward to the base.

"All the specimens of this peculiar species, which I have examined, are more or less distorted, so that we may not be fully acquainted with the form. The peculiar surface-marking, however, is unmistakable, and in nearly all the specimens is preserved, in some degree, even in casts. There appears to be considerable difference in the size of these ribs in different specimens, and it is possible that we have among them two species, which, for the present, however, we prefer to regard as one. The form in many specimens is similar to that of *M. modiolaris,* but in the surface-markings it is very distinct. In some specimens, however, from the same locality, which appear to belong to *M. modiolaris,* I have observed concentric ribs similar to those in the species now described. In that species, however, they appear more arched, and confined to the region of the hinge-line, gradually losing themselves in the concentric striae, and are quite obsolete toward the base. Nevertheless, we have never observed this feature in the New York specimens, and these western ones, thus marked, prove a distinct species.

"*Geological Position and Locality.*—This species occurs in the marly beds, constituting the higher portions of the Hudson-river group, on the eastern shore of Little Bay des Noquets. It is associated with *M, modiolaris* and *Ambonychia radiata,* with two or three species of Orthoceratites."—Hall, *loc. cit.*

Reported by Miller from Richmond, Indiana.

WHITELLA OBLIQUATA Ulrich.

Plate XLVIII, figs. 10-10d.

Whitella obliquata Ulrich, 1890, Am. Geol., VI, p. 177, 178, fig. 13 a-e.

"Shell large, oblique, subrhomboidal in outline, produced in the postero basal region, ventricose, with point of greatest convexity above the middle; beaks rather small, prominent, slightly incurved, situated one fourth of the length of the hinge line from its interior extremity, umbonal ridge well marked, the cardinal slope concave. Anterior end small, narrowly rounded above, merging gradually into the evenly and only moderately convex ventral margin. Posterior end sharply curved and produced below, gently convex and sloping forward in the upper half to meet the slightly convex, cardinal margin. Escutcheon well marked, wide, shallowest in front of the beaks. Anterior muscular scar elongate. Hinge thin, the posterior half simple, the anterior half, of the left valve, with two long slightly oblique teeth just beneath the beak, and two shorter parallel ones at the anterior extremity.

"The dimensions of cast of the interior, of the average size, are as follows: greatest length 50 mm.; greatest hight 38 mm.; greatest convexity 24 mm. A large specimen is 59 mm. long, and 42 mm. high.

"This species is related to *W. sterlingensis* (*Dolabra sterlingensis, M. and W.*) but has a longer hinge line, is less convex, wider posteriorly, and more oblique, the angle included between the hinge line and the umbonal ridge being much narrower. *W. hindi* (*Cyr-*

todonta hindi Billings) is much more acutely produced posteriorly, being besides on the whole a more elongate shell, with the umbones also more tumid.''—Ulrich, *loc. cit.*

Ulrich reports this shell from the upper beds of the Cincinnati group at several localities in Indiana and Ohio.

WHITELLA UMBONATA Ulrich.

Plate XLVIII, figs. 9-9c.

Whitella umbonata Ulrich, 1890, Am. Geol., VI, p. 178, figs. 14 a-d.

''A detailed description of this species is scarcely necessary, since the main point in identifying it is to distinguish from *W. obliquata.* On comparison it will be found that the beaks and umbones are much larger than in that species, the postero-dorsal slope shorter and more abrupt, the hight comparatively greater and the outline in general somewhat different, particularly in the ventral region where the margin is more convex than in *W. obliquata.* *W. quadrangularis* (*Cypricardites quadrangularis* Whitfield) is much shorter and more erect.

''In a large specimen the hight and length are respectively 47 mm. and 60 mm.; in a small specimen 38 mm. and 45 mm.; greatest convexity of the latter 25 mm.''—Ulrich, *loc. cit.*

This species is reported by Ulrich as occurring at Blanchester, Middletown and other localities in Ohio and Indiana, in the upper beds of the Cincinnati group (Richmond).

CEPHALOPODA.

DIAGNOSES OF GENERA.

The generic disposition of the species of Cephalopoda described in this report is, it must be confessed, unsatisfactory. Nevertheless, I do not see how they can well be placed in the various genera erected by Hyatt, until very much further study has been devoted to them with special reference to the young stages of growth; and just at present the material is not available for such studies. This is especially true of the species referred to the genus *Orthoceras,* since most of them are founded on fragments which lack the critical characters that might enable one to place them in their proper genera. As restricted by Hyatt *Orthoceras* is not an Ordovician genus; nevertheless I believe it is better for the present to leave the species from the Cincinnati group, which have ordinarily been referred to that genus, where they are, awaiting a final revision when adequate material is at hand. In the case of the species which is identified with *Cameroceras proteiforme,* if it is that species, I believe we should recognize the distinctions insisted upon by Hyatt and place the form in the genus *Endoceras,* as restricted by that author. I have accordingly disposed of it in that way.

CYRTOCERAS Goldfuss.

Shell long, conical, gently curved, aperture sometimes contracted; siphuncle straight or expanded between the septa, and variable in position, but usually at the outer edge. (Miller.)

ENDOCERAS Hall.

Smooth or annulated orthoceracones. Funnels reaching from septum of origination to the next apicad of this, but no farther. Septa pass entirely around the siphuncle. Organic deposits in the form of endocones, and taper off at the center into a spire that is sometimes tubular and hollow, or again flattened and elliptical. This is the *endosiphuncle.* (Hyatt.)

GOMPHOCERAS Sowerby.

Stout short orthoceracones and cyrtoceracones similar to some species of *Phragmoceras,* but straighter, stouter, and less compressed in form, and gerontic aperture less contracted laterally. Hyponomic sinus shorter, and curvature exogastric. (Hyatt.)

GYROCERAS DeKonink.

Discoid, rolled in one plane; volutions in contact or open, but not embracing; transverse section circular, elliptical, scutiform, or polygonal; body chamber large and sometimes straight or tangent to the spiral; opening hollowed out on the exterior border like the Nautilus; septa arched and frequently project, curving backward; siphon slender, cylindrical, and usually subcentral toward the convex border, but sometimes found within the concave border; surface tuberculous, having imbricating excrescences or ringed with projecting fringes from the septa. (Miller.)

ORTHOCERAS Breynius.

Shell conical, straight, or nearly so; body chamber large, behind which the shell is composed of numerous chambers separated by convex, transverse septa, with simple edges, at right angles to the longer axis of the shell; siphuncle central, subcentral or eccentric, cylindrical or dilated in the chambers; surface smooth or transversely or longitudinally striated, or furrowed. (Miller.)

DESCRIPTION OF SPECIES.

CYRTOCERAS AMOENUM Miller.

Plate XLIX, fig. 1.

Cyrtoceras amoenum Miller, 1878, Jour. Cin. Soc. Nat. Hist., I, p. 105, pl. iii, fig. 8.

"Shell large, gently arched, and very gradually tapering; section slightly elliptical, the dorso-ventral diameter being a little more than the transverse. Body chamber contracted toward the front. Septa moderately arched. In the specimen figured, the body chamber is followed by six thin chambers before reaching what appear to represent the mature size; another specimen shows only five of these thin chambers between the body chamber and the mature sized shell chambers. Where on the back of a shell the septa are nearly 2-10ths of an inch distant, the transverse diameter of the shell 1 3-10ths inches, and the dorso-ventral diameter 1 5-10ths inches. Measuring on the side, however, the transverse diameter of the shell is equal to the thickness of almost nine shell chambers. Siphuncle small, and situated very close to the margin on the dorsal or outer side of the shell. Outer shell and surface unknown.

"The specimen illustrated has a dorso-ventral diameter of 1 4-10ths inches, and transverse diameter a little over 1 2-10ths inches. It contains twenty-three chambers, including the thin ones, between the body chamber and the broken end in a length of 2½ inches.

"I collected the specimens at Richmond, Indiana, in the upper part of the Cincinnati group, and near the top of the bluffs which abut the river."—Miller, *loc. cit.*

Whitewater.

CYRTOCERAS HALLIANUM d'Orbigny.

Cyrtoceras halleanus d'Orbigny, 1850, Prodrome de Paleontologie, I, p. 1. (Not figured or described.)

"9. Halleanus, d'Orb., 1884, *C. lamellosum,* Hall, 1847. Palaeont. of New-York, t. I, p. 193, pl. 41, fig. 2 (non Verneuil, 1842). Etats-Unis, New-York, Trenton-limestone."—d'Orbigny, *loc. cit.*

This species reported in Kindle's list as occurring at Madison, Indiana (on the authority of Cornett), is not a Cincinnati group species.

CYRTOCERAS TENUISEPTUM Faber.

Plate XLIX, figs. 2, 2a.

Cyrtoceras tenuiseptum Faber, 1886, Jour. Cin. Soc. Nat. Hist., vol. IX, No. 1, p. 18, pl. i, figs. 3 a-c.

"Specimen medium size, with slight curvature and tapering very slightly. Composed of twenty thin septa, equal in width and rather circular in section. Siphuncle small and dorsal. Specimen is thirty two *mm.* in length, and measures in section seventeen *mm.* in its greater, and fifteen *mm.* in its lesser diameter.

"3a is a dorsal view of a larger specimen of the same species, having five septa and a body-chamber showing the sinus. The body-chamber is 27 *mm.* in length, and measures in section 23 *mm.* in its greater, and 20 *mm.* in its lesser diameter. This specimen has a thick shell, but shows no external markings. It also shows that a coral had begun its growth in the body-chamber and extended somewhat beyond it. This species has about seventeen septa to an inch. 3a is a remarkable specimen, as it is the only one figured and known to me of this group with a complete body-chamber.

"Collected by the author in the Cincinnati group near Waynesville, O., and at Versailles, Ind."—Faber, *loc. cit.*

CYRTOCERAS THOMPSONI Miller.

Plate XLIX, Figs. 3, 3a.

Cyrtoceras thompsoni Miller, 1893, Geol. Nat. Hist. Indiana, vol. XVIII, p. 323, pl. x, figs. 7, 8.

"Shell medium sized, rather rapidly increasing in size and slightly but regularly curved; transverse diameter one-fifth greater than the dorso-ventral; broadly rounded on the dorsal and ventral sides and more narrowly rounded on the lateral sides; transverse section elliptical.

"Septa very slightly arched, almost transverse in the young shell and distant from each other in the younger shell about one-tenth the transverse diameter, but nearer the body chamber in maturer shells about one-twelfth the transverse diameter; siphuncle very small and close to the outer margin. Outer shell thin and smooth or marked by fine transverse lines of growth, of which there is some evidence on the specimen described.

"Our specimen is from the middle part of the shell and shows no part of the body chamber. Part of the outer shell is quite well preserved. It will be distinguished from other species by the transverse elliptical section, close septa and gentle curvature.

"Found in the Hudson River Group, at Longwood, Fayette County, Indiana, and now in the collection of A. C. Benedict. The specific name is in honor of Prof. Maurice Thompson, late State Geologist of Indiana."—Miller, *loc. cit.*

ENDOCERAS PROTEIFORME Hall.

Plate L, figs. 1-1d.

Endoceras proteiforme Hall, 1847, Pal. New York, I, p. 208, pls. xlv, to l. and liii.

"General form cylindrico-conical, more or less elongated, often compressed, tapering somewhat unequally in different specimens; young specimens terminating in an extremely acute point; surface marked by distinct transverse striae, which usually appear like narrow subimbricating bands, with one edge well defined and more elevated than the other, more or less distinctly striated longitudinally; striae varying from extreme tenuity to distinct elevated thread-like lines; section circular; septa distant from one fifth to one fourth the diameter; siphuncle eccentric or submarginal.

"I am able to characterize three distinct varieties of this species, which are the prevailing forms; these depend mainly on the surface markings of the young shell. The old shells are recognized by a large submarginal siphuncle, which usually contains a smooth cylindrico-conical embryo tube or sheath. This tube is sometimes irregularly tapering, and always free from visible surface markings or sculpture. Within this embryo tube are the young shells, sometimes perfectly formed Orthocerata, and at other times destitute of septa or siphuncle. These young shells are also frequently found separate from the parent shell or embryo tube, when we are compelled to rely upon the surface markings for their determination. The position of the sipuncle, convexity of septa, and some other characters, are usually constant in all the varieties, which only exhibit a change in the character of the surface. In the absence of septa and siphuncle, which is of common occurrence in the young shell, the character of the surface is reliable for determining the species.''—Hall, *loc. cit.*

The characters of this species are better indicated by Hall's figures, which I reproduce, than by the above description, which is rather vitiated by the fact that these fossils were not thoroughly understood at that time. The great siphones of these huge Cephalopods, as remarked by Clarke, were favorite retreats for other species of Cephalopods, and to such adventitious species belong the so-called young shells mentioned by Hall, and upon which he based several of his varieties. The specimens that have come under my notice in Indiana are all of rather small size, as compared with the immense size of some of the examples known from the New York formations. They seem to have all the characters of *E. proteiforme,* however, aside from size, and I see no reason for making any other disposition of them.

All of my specimens, which are imperfect fragments, are from the Richmond formation.

1.34A17, 19....1.41A9.

GOMPHOCERAS INDIANENSE Miller and Faber.

Plate XLIX, figs. 4-4b.

Gomphoceras indianense Miller and Faber, 1894, Jour. Cin. Soc. Nat. Hist., vol. XVII, p. 137, pl. vii, figs. 3, 4, 5.

''Shell medium or a little above medium size. Transverse section ovate. Ventral or narrow side of the ovate outline nearly straight, while the opposite or dorsal side is strongly arched from the apex to the mouth. Body chamber forming nearly half the length of the shell; the specimen illustrated has part of the tenth air chamber, and another specimen has part of the eleventh air chamber preserved, and apparently it approximates close to the apex. Probably, if complete, these specimens would not have more than thirteen or fourteen air chambers. Septa moderately concave, the concavity not amounting to the depth of an air chamber, and almost equally distant from each other, from the apex to the body chamber. The increase in the diameter of the shell is not followed with a corresponding increase in the distance of the septa from each other, or in the length of the air chambers. The sutures curve forward over the dorsal or convex side of the shell. The greatest transverse diameter is in the lower half of the body chamber. The siphuncle is marginal on the straight or ventral side, and abruptly expands in the cavities of the short air chambers to two and a half or three times its diameter at the septa. The aperture is unknown.

"The external shell is thin, transversely wrinkled and smooth. The surface being smooth, the transverse wrinkles do not appear as lamellose lines of growth, nevertheless the wrinkles may mark stages of growth in the shell, though they do not conform to the septa or sutures.

"This species does not resemble *Gomphoceras eos* from rocks of about the same geological age. *Gomphoceras eos* is longitudinally ovoid, but not transversely ovoid. This species is not longitudinally ovoid, for the lateral sides are flattened, the ventral side nearly straight or slightly convex and the dorsal side convex, but transversely it is more or less ovoid. *Gomphoceras eos* has proportionally a much shorter and more robust body chamber, more numerous air chambers and more arcuate septa, and the siphuncle is eccentric in the middle of the greater diameter of the shell. We have a good specimen of *Gomphoceras eos*, having eight body chambers, and will give some measurements for comparison. The body chamber is 1 85/100 inches long; 2 60/100 inches in diameter dorso-ventrally or through the siphuncle; and 3 20/100 inches in diameter laterally; the length of the air chambers is 1 65/100 inches, making the total length of the entire specimen 3 50/100 inches; the lateral diameter of the last or eighth air chamber is 2 10/100 inches, and dorso-ventrally nearly 2 inches, though it is broken on the siphuncular side so the latter measurement is not accurate. The specimen illustrated has a body chamber 1 80/100 inches long; 2 80/100 inches in diameter dorso-ventrally; and only 2 inches in diameter laterally; the length of the two specimens does not differ very much; but the eighth air chamber in the specimen illustrated has a dorso-ventral diameter of 1 80/100 inches and a lateral diameter of only 1 40/100 inches. The outer shell and aperture of *Gomphoceras eos* are unknown, but our cast shows a deep notch at the ventral side of the aperture, which indicates that the species here described is not congeneric with it.

"Mr. Faber collected three specimens of this species, one of which is illustrated, in the upper part of the Hudson River group, near Versailles, Indiana, and Prof. Hubbard and Mr. J. F. Hammel collected a number of specimens in the same range, associated with *Cyrtocerina madisonensis,* near Madison, Indiana."—Miller and Faber, *loc. cit.*

I have specimens from the Richmond formation on Tanner's Creek, too imperfect for certain identification, that may belong to this species.

GYROCERAS BAERI (Meek and Worthen).

Plate LI, fig. 1.

Trochoceras ? baeri Meek and Worthen, 1865, Proc. Acad. Nat. Sci. Philadelphia, 1865, p. 263. (Not figured.)

"Shell subdiscoidal, consisting of about two or three rather rapidly enlarging volutions, which are more broadly rounded on the outer surface than on each side, and about one-fourth wider transversely than their dorso-ventral diameter; each inner whorl slightly impressing the inner side of the succeeding turn. Umbilicus a little more than half the dorso-ventral diameter of the outer volution, and showing all the inner volutions. Spire apparently scarcely rising above the upper surface of the last turn. Septa rather distinctly concave on the side facing the aperture, separated on the outer side of the whorls, at a point where the dorso-lateral diameter is about 1.25 inches, by spaces measuring 0.35 inches—all showing a very slight backward curve on the rounded periphery, and passing nearly straight across each side. Surface, siphon, and non-septate portion of the shell unknown.

"Greatest breadth of the septate part of the shell, 5 inches; height (estimated), about 2.50 inches. Dorso-ventral diameter of the volutions, increasing about three-fold each turn.

"The specimen from which this description was drawn up is defective on one side, so that it is not easy to determine whether or not its whorls are coiled in the same plane, though they have the appearance of being somewhat oblique, and hence we have placed it provisionally in the genus *Trochoceras.* Should it be found, however, when more nearly entire specimens can be examined, that its whorls are coiled all upon the same plane, it would belong either to the genus *Lituites* or *Nautilus,* and hence its name would become *Lituites Baeri,* or *Nautilus Baeri.*

"The typical specimen does not show the position of the siphon, but a fragment found near the same locality, and at the same horizon, apparently of this species, though possibly belonging to another shell, has the siphon placed about its own breadth outside of the center. It pierces the septa from without inwards or backwards, as in *Nautilus.*

"At a first glance this shell would seem to resemble *Cryptoceras* (*Lituites*) *undatus,* as represented by fig. 3, pl. 13, vol. i. Palaeontology of New York, but on a closer inspection it will be at once seen to differ materially in the more rapid increase in the breadth of its whorls, and in the proportionally smaller size and greater depth of its umbilicus, as well as being apparently not coiled on a plane.

"The specific name is given in honor of Dr. O. P. Baer, of Richmond, Indiana, to whom we are indebted for the use of the typical specimen."—Meek and Worthen, *loc. cit.*

The type is from the Richmond formation at Richmond, Indiana.

ORTHOCERAS BILINEATUM Hall.

Plate LI, figs. 2-2b.

Orthoceras bilineatum Hall, 1847, Pal. N. Y., vol. I, p. 199, pl. xliii, figs. 2 a-d.

"General form cylindrical, gradually tapering, marked by slightly arched or undulating rounded annulations distant about two fifths the diameter; surface marked by longitudinal sharp elevated lines, which alternate with finer lines in equal number; transversely marked by fine scarcely visible striae, which are interrupted by the longitudinal lines; section circular; siphuncle eccentric.

"Two series of longitudinal lines, one being more than twice the elevation of the other, are distinguishing features of this fossil. The annulations are more arched on the back than in the last species [*O. textile*], but still rounded. The transverse fine striae, under the magnifier, give a kind of varicose appearance, being closely arranged and slightly arched between the longitudinal ones, following the oblique direction of the annulations. The difference in the size of the longitudinal and transverse lines is a striking peculiarity of the species, rendering it readily distinguishable from the last."—Hall, *loc. cit.*

Hall's types are from the lower shaly strata of the Trenton limestone at Middleville, Turin and Lowville, New York. The species is reported in Kindle's list from Madison, Indiana, but it very probably does not occur in the Cincinnati series.

ORTHOCERAS BYRNESI Miller.

Plate LI, fig. 4.

Orthoceras byrnesi Miller, 1875, Cincinnati Quarterly Journal of Science, II, p. 126, fig. 13.

"Shell medium size, very long, and slowly tapering; arch of the chambers about equal to the distance between the septa, and distant about one seventh the diameter of the shell; siphuncle eccentric or crossing from one side to the other, and consisting of a series of slightly ovate enlargements in each chamber. The greatest diameter of the siphuncle is as much or a little more than the distance between the septa, while the septa are pierced with holes about two thirds the diameter of the siphuncle.

"The distance between the septa does not always increase uniformly, as the shell enlarges its diameter, but take a large number of chambers and the increased distance between the septa becomes manifest. It is likely that the increased distance between the septa is more uniform in rapidly tapering shells than in the longer and more slowly changing ones.

"Found on the hills back of Cincinnati; range unknown.

"Specific name given in honor of Dr. R. M. Byrnes, of Cincinnati."—Miller, *loc. cit.*

On the basis of strong similarity of the longitudinal section to that figured by Miller, I have referred a specimen from Manchester Station, Indiana, from the upper part of the Lorraine to this species. I admit that from the imperfect nature of the specimen the identification is worth very little.

ORTHOCERAS CARLEYI Hall and Whitfield.

Plate LII, fig. 1.

Orthoceras carleyi Hall and Whitfield, 1875, Pal. Ohio, II, p. 98, pl. iv, fig. 19.

"Among the fossils received for examination from the Hudson River formation there is a very interesting specimen of *Orthoceratite,* which does not appear to belong to any described species, but is in such a state of preservation as to present but few distinguishing features. Still, the conditions under which it presents itself are of such a nature as to make it one of considerable interest. The specimen consists of an inner septate tube of a little more than five inches in length, with a diameter at the lower end of about three-eighths of an inch, by about seven-eighths of an inch at the upper end, giving an increase of half an inch in the length of five inches, or one-tenth of the length. This tube is surrounded by two others, one within the other; each of the three being separated by a space of about an eighth of an inch on either side, giving to each about the same degree of expansion. The spaces between the tubes are filled with sedimentary matter; that between the inner and middle tube being composed chiefly of finely comminuted organic remains, while that between the two outer tubes is composed of fine silt chiefly, and in some places of crystalline matter. The septa of the inner tube are closely arranged, eight of the spaces measuring one inch where the upper end of the space measured is seven-eighths of an inch in diameter, those below being a little closer. These are all either empty spaces, or filled only by crystalline matter. There is not the least evidence of septa or partitions of any kind across the spaces between the several tubes. The specimen lies imbedded in the rock, and weathered away to near the center of its diameter, but the section at the end shows that the inner tubes rest upon, or nearly upon, the inner surfaces of the surrounding ones, as though they had settled to this position after they had been imbedded in the sediment. These conditions would seem to indicate that there had been no very intimate connection between the several tubes, and that the spaces between the outer ones and the inner septate portion had been open to the access of foreign matter, while the inner septate portion had been closed, or that the outer tubes had been independent of each other, and of the inner ones, and had only drifted into each by accident. If this has really been the case, these outer tubes must be only the terminal chamber or chambers of habitation, and must have been of unusual length, as the degree of tapering would carry the middle tube to within a few inches, if perfect at the lower end, of the point of a specimen nearly or quite fifteen inches in length. The probability, however, is that they are only fragments of outer chambers that have drifted upon the inner ones by accident.

"The first sight of the specimen might be taken for a beautiful example of the genus *Endoceras*; but true examples of this genus are septate in the outer tubes, while the inner ones are free from septa. The reverse is, however, the case in the example before us." —Hall and Whitfield, *loc. cit.*

The type is from the Richmond formation at Fayetteville, Brown County, Ohio. I am very uncertain about its occurring in Indiana.

ORTHOCERAS DUSERI Hall and Whitfield.

Plate LII, figs. 2-2b.

Orthoceras duseri Hall and Whitfield, 1875, Pal. Ohio, II, p. 97, pl. iii, figs. 2-4.

Shell of medium size, rather rapidly and gradually enlarging from below upwards, the diameter increasing to twice the size in the space of four and a half inches. Transverse section circular; length of the outer chamber not determined. Septa moderately concave, and closely arranged, but gradually increasing in distance with the increased size of the shell—six chambers occupying the space of one inch where the diameter of the shell is one and a half inches at the upper one of those measured; nearer the joint there are ten to twelve in the same distance where the diameter is only three-fourths of an inch. Siphuncle eccentric, situated a little nearer to the center than to the margin; very small where it passes through the septa, but expanding within the chambers to about four times its diameter at the other point, and forming a flattened bead-like body within each chamber.

"Surface of the shell apparently smooth, except that the edges of the septa are raised above the general level, in the form of narrow rings. This feature may possibly be due, in part at least, to an expansion of the septa during the process of petrifaction, but it would scarcely seem to be the case, as the feature is too regular, and only shows where the external shell is wholly or partly preserved. The rings are often some little wider on the surface than the thickness of the septa. Where the surface is most perfectly preserved there is also a finely reticulate or net-like character, dividing the surface into small rhombic figures of microscopic dimensions, having their longest diameters corresponding to the length of the shell, and presenting a surface similar to that frequently produced by the attachment of bryozoans; but the regularity is so great that this can not have been the origin of the feature; neither have the rhombs anything like a radial structure or direction in any part, as would have been the case if they were the result of the growth of a bryozoan. Along one side of the shell and directly opposite to the position of the siphuncle, there is a narrow, raised, longitudinal line, extending the entire length of the tube, but slightly interrupted just above each one of the annular rings.

"The species resembles somewhat the *O. crebriseptum,* Hall (Paleontology of New York, Vol. I, p. 313, pl. 87), but increases much more rapidly in size, and does not possess the longitudinal markings of that species. In the rapid expansion of the tube it corresponds nearly with *O. Sieboldi,* Bill., from the island of Anticosti; but the septa are much more numerous, that one having seventeen in the space of seven inches, while this one has the same number in the space of two and one half inches."—Hall and Whitfield, *loc. cit.*

The type is from the Richmond formation at Waynesville, Ohio. I have with great hesitation listed a specimen as this species, coming from a slightly lower horizon on Tanner's Creek, Indiana.

ORTHOCERAS GORBYI Miller.

Plate LII, fig. 3.

Orthoceras gorbyi Miller, 1893, Geol. Nat. Hist. Indiana, XVIII, p. 322, pl. x, fig. 2.

"Shell about medium size, among species from the Hudson River Group, very long, slowly and gradually enlarging from below upward, and increasing in diameter only .04 of an inch in an inch in length; transverse section subcircular; septa very moderately concave, closely arranged, thirteen of them occurring in a distance equal to the diameter of the shell, where the diameter is 1.1 inches; surface marked by broad furrows or undulations that cross the shell at an angle of twenty or twenty-three degrees from the ventral to the dorsal side. The two specimens examined are casts, but one of them bears a few fine longitudinal lines that indicate the surface of the shell was so marked; body chamber and siphuncle unknown.

"This species will be distinguished by its elongate form, close septa and inclined undulations.

"Found by A. C. Benedict, in the Hudson River Group, in Franklin County, Indiana, and now in his collection. The species is named in honor of the State Geologist."—Miller, *loc. cit.*

ORTHOCERAS JUNCEUM Hall.

Plate LI, figs. 5-5c.

Orthoceras junceum Hall, 1847, Pal. New York, I, p. 204, pl. xlvii, 3 a-f.

"Slender, terete-cylindrical, tapering very gradually; septa thin, distant from one fourth to one third the diameter; outer chamber deep; siphuncle small, central; section circular; surface finely striated transversely, but without longitudinal striae.

"This species presents a surface marked precisely similar to *Endoceras proteiforme,* var. *lineolatum*; but the shell is much more slender and gradually tapering, the siphuncle being always central. The septa, towards the outer chamber, are more closely arranged, sometimes two or three in the usual space of a single one.

"This is a constant species, presenting no important variation in its characters. All the specimens seen are imperfect, and the interior is often filled with crystalline matter, which obliterates the septa and siphuncle. The outer chamber, though incomplete, is proportionally very deep. Very little variation in size has been observed in all the specimens obtained."—Hall, *loc. cit.*

Reported in Kindle's list from Madison, Indiana. This is a Trenton species and very probably does not occur in Indiana. I have given figures and description, however, because Nickles in his list of Cincinnati fossils includes it among the species reported from the Utica formation. If he is correct, it may possibly be found in rocks of the same age in Indiana.

ORTHOCERAS MOHRI Miller.

Plate LI, fig. 3.

Orthoceras mohri Miller, 1875, Cincinnati Quarterly Journal of Science, II, p. 124, fig. 10.

"Shell elongated, tapering very regularly, at the rate of about 0.16 inch to the inch, to an acute point. Septa rather strongly arched, and distant about one fourth the diameter of the shell. (Measurement of three different polished specimens produced the following result: Diameter 0.62 inch, septa distant 0.15 inch; diameter 0.50 inch, septa distant 0.12 inch; diameter 0.25 inch, septa distant 0.06 inch.) Siphuncle central, and having the appearance of a connected series of oval beads, with the larger ends directed forward, and gradually diminishing in size, as the distance between the septa becomes less and less. Greatest diameter of the siphuncle about or a little more than one fourth the diameter of the shell. Outer chamber more than one fourth the length of the shell, measuring to the end of the siphuncle. Outer surface of the shell in good specimens smooth, and not showing the septa within.

"Polished specimens show septa commencing to form in the body chamber, in advance of the siphuncle; those near the siphuncle approaching, while those more distant only commencing to leave the outer shell.

"I found this species near Versailles, Ind., about 300 feet below the Upper Silurian rocks, associated with *Anodontopsis milleri, Anomalodonta gigantea, Modiolopsis Versaillesensis, Cyrtolites ornatus,* showing the outer shell and surface markings, and other fossils better preserved than I have found them elsewhere. The specific name is given in honor of our paleontological friend, Paul Mohr, Sr., Esq."—Miller, *loc. cit.*

Probably from somewhere in the Waynesville formation. There is not 300 ft. of Ordovician rock in the Versailles section.

OSTRACODA.

DIAGNOSES OF GENERA.

CERATOPSIS Ulrich.

Valves somewhat obliquely subovate, widest posteriorly, straight dorsally, with a thick rounded semicircular marginal ridge, and two submedian ridges extending obliquely upward from the marginal ridge, the anterior one reaching the dorsal edge, the other shorter and smaller; post-dorsal end of marginal ridge raised into strong spine-like or mushroom-shaped process, beaded or fimbriated along one edge or around the flattened top. Free edges of carapace as in *Ctenobolina,* being thick, and having 'false borders.' (Ulrich.)

CTENOBOLINA Ulrich.

Carapace small, elongate-suboval, strongly convex, the posterior two-fifths more or less decidedly bulbous or subglobular, and separated from the remainder by a deep, narrow and more or less oblique sulcus extending with a gentle curve from the dorsal margin more than half the distance across the valves toward the postero-ventral border. The anterior three-fifths often with another oblique but less impressed sulcus. Valves equal, the dorsal margin straight, hingement simple, the ventral edge thick, and the true contact margins generally concealed, in a lateral view, by a 'frill' or flattened false border; surface granulose, smooth, or punctate. (Ulrich.)

ENTOMIS Jones.

Shell subovate or fabiform; valves with a slightly curved submedian vertical furrow extending to hinge line; in front of furrow occasionally a rounded tubercle. Surface marked generally with raised, concentric, transverse or longitudinal lines. (Ulrich.)

EURYCHILINA Ulrich.

Carapace with a long, straight hinge line; semicircular, oblong-subquadrate, or somewhat rounded in outline; generally with a well defined subcentral vertical sulcus and a more or less prominent node immediately behind it. Except at the dorsal side, the valves are sourrounded by a wide marginal area, externally either flat or convex, and usually marked in a radial manner; on the inner side deeply concave, an outer wall being raised almost to the level of the true or closing edge of the valve; area terminated in most cases by a narrow rim-like border. Hinge simple. Surface beautifully reticulated, pitted, granulose or smooth. (Ulrich.)

LEPERDITIA Ronault.

Carapace more or less convex, often large, suboblong or semi-ovate in outline, with an oblique backward swing; dorsal edge straight, often angular at the extremities; ventral outline rounded, sometimes a little produced at the middle; greatest thickness in the ventral half, the lower edge usually being also blunt; valves unequal, the right the larger and overlapping the left; overlap chiefly ventral, simple, or the further entrance of the ventral edge of the left valve is prevented by two or more papillae set within the overlapping edge of the right; hinge simple. Surface frequently horny in appearance, smooth in most cases, granulose or minutely punctate in others; a small tubercle or "eye-spot" is generally present on the antero-dorsal fourth, and a large, rounded subcentrally situated sunken muscle-spot is seen on the inner side of the valves and not infrequently distinguishable on the exterior also. (Ulrich.)

PRIMITIA Jones and Holl.

Carapace small, varying in outline, usually subovate, but the hinge is always straight; valves equal, never overlapping, generally provided with a narrow border; in, or to one side of, the middle of the dorsal half, a well-marked pit or sulcus; the pit may be rounded or situated subcentrally, or it may be drawn out vertically so as to extend from the dorsal margin half across the valve; on one or both sides of the sulcus the surface may be raised into a low, rounded or ridge-shaped prominence. Surface of valves punctate, reticulate, or without ornament; in rare cases it seems to have been minutely granulose. (Ulrich.)

TETRADELLA Ulrich.

Carapace somewhat oblong, often subquadrate, never tumid, with the hinge line straight. Surface depressed, with a semicircular ridge; within the enclosed space two simple or slightly modified, equal or unequal, and more or less nearly vertical ridges unite below with the marginal ridge and extend upward from it, one in many cases failing to reach the dorsal margin. Free edges usually with a simple flattened border; in one case (*T. subquadrata*) thick and with the contact margins concealed by a "false border." Surface smooth or granulose. (Ulrich.)

DESCRIPTION OF SPECIES.

BOLLIA PUMILA Ulrich.

Plate LIII, figs. 12, 12a.

Bollia pumila Ulrich, 1890, Jour. Cin. Soc. Nat. Hist., vol. XIII, p. 117, pl. xii, figs. 1a, 1b.

"Valves oblong-subelliptical, the anterior end somewhat narrower than the posterior, and with the point of greatest extension near the antero-dorsal angle; from here the edge curves backward into the uniformly convex ventral portion; posterior end rounded, nearly vertical, forming an obtuse angle where it joins the dorsal margin; the latter is never quite straight, but protrudes more or less in the central third of its length. A narrow ridge runs nearly parallel with the free edges, the abruptness with which it rises above them varying slightly. The ends of the inner or horse-shoe shaped ridge characterizing the genus are bulbous and project a little beyond the dorsal margin; the curved portion thin, generally a little oblique, and well separated from the marginal ridge.

"Size: Length, 0.86 mm.; height, 0.52 mm.

"This species is smaller than usual in this genus. Its chief peculiarity is the bulbous enlargement of the ends of the horse-shoe ridge. It is too clearly distinct from *B. persulcata,* Ulr., to require comparisons."—Ulrich, *loc. cit.*

The types are from the Richmond formation at Weisburg, Indiana. It is also known from other localities in Ohio and Indiana.

CERATOPSIS CHAMBERSI (Miller).

Plate LIII, figs. 1, 1a.

Beyrichia chambersi Miller, 1874, Cin. Quar. Jour. Sci., vol. I, p. 234, fig. 27.

"Shell small, subreniform, dorsal margin straight, nearly as long as the entire length of the shell, basal margin subelliptical; anterior end wider than the posterior. The body of the valve is crossed by two broad, deep sulci, one of which is situated immediately behind the eye tubercle in the anterior third, the other in the middle third of the shell. The projecting basal margin is marked with a depression throughout its length, and bordered with a carinated edge.

"The eye tubercle is about as long as the breadth of the shell, and rises like a half cone from the extreme anterior end, with the flattened face in the rear marked by fine oblique lines, very much resembling in appearance, when magnified, the teeth of a comb.

"Greatest length of the shell about 1/15 inch; breadth, one-third less.

"This species is readily distinguished from all others by the remarkable eye tubercle. In other respects it most nearly resembles *B. oculifer* (Hall), though not exactly corresponding with it.

"I first found it in the excavation for Columbia Avenue, in Cincinnati, about 150 feet above low water mark; subsequently I found it at Richmond, Indiana, in the upper part of the Cincinnati group, thus indicating that its range is coextensive with the exposure of the blue limestone. I found, however, only one slab at Richmond and two at Columbia avenue bearing the fossil, and do not know of any others having been found, but, considering its great range, we must expect to find it in some locality in great abundance, and the only reason this has not thus far been accomplished is most likely owing to the extreme minuteness of the fossil.

"The specific name is given in honor of our most eminent naturalist and learned entomologist, V. T. Chambers, Esq., of Covington, Ky."—Miller, *loc. cit.*

Miller, above, reports this species from the Richmond formation at Richmond, Indiana. From the statements of Ulrich, however, there would seem to be some doubt about the typical form of the species occurring in the upper part of the Cincinnati series. Apparently he would refer the Richmond forms to his variety *robusta.*

CERATOPSIS CHAMBERSI var. ROBUSTA Ulrich.

Plate LIII, figs. 2, 2a.

Ceratopsis chambersi var. *robusta* Ulrich, 1894, Geological and Natural History Survey of Minnesota, vol. III, pt. II, p. 677, fig. 50.

"This designation is proposed for the variety which occurs in the upper beds of the Cincinnati group at numerous localities in Ohio, Indiana and Kentucky, and in the equivalent Hudson River group strata of Minnesota. So far as known it is not to be found below the horizon of *Orthis subquadrata* Hall, and *Rhynchotreta capax* Conrad. It differs from the typical form of the species in having all the ridges somewhat thicker, and the post-median one much larger. In many cases the latter is nearly or quite equal to the anterior ridge, and extends like it entirely across the valve. The ventral portion of the carapace also is thicker, and the marginal ridge subangular where the contour turns abruptly inward to the false border."—Ulrich, *loc. cit.*

Reported by Ulrich from Richmond and Versailles, Indiana. Liberty (?).

CERATOPSIS OCULIFERA Hall.

Plate LIII, figs. 3, 3a.

Beyrichia oculifer Hall, 1871, 24th Report of the New York State Museum, p. 232, pl. viii, figs. 9, 10.

"Carapace small, seldom exceeding seven-hundredths of an inch in length, by three to four-hundredths in the greatest breadth in the largest specimens; valves obliquely subreniform, broadest near the anterior end, with a straight hinge line, which is a little shorter than the greatest length of the valve; anterior end projecting beyond the hinge; center moderately convex, with a proportionally broad, deep channel just within the margin, extending all around it, except for a short distance at the posterior extremity near the dorsal margin. The body of the valve is crossed obliquely by two deep furrows, having their origin on the dorsal margin, the posterior one situated a little more than one-third of the length of the valve from the posterior extremity and extending fully two-thirds across it; the anterior furrow is situated just behind the anterior third of the length, and in its lower portion is more strongly curved forward than the other. Eye tubercle large, pedunculated, very prominent, and spreading at the top, its surface equal to about one-third the width of the valve, and its height at the posterior margin equal to the breadth of the top, while the anterior margin is but little elevated, giving an obliquely sloping circular surface, with a denticulated border. This surface, under a strong magnifier, is seen to be covered by fine eye-like facets, similar to those of the eyes of Triliobites of the genus ILLAENUS.

"This species is very distinct from any other described, in the form and strength of the transverse furrows, and especially in the great prominence of the club-shaped eye tubercle. So far as can be ascertained, it is the first species of this group of crustaceans in which the eye facets have been detected."—Hall, *loc. cit.*

1.34C10.

CTENOBOLINA CILIATA var. HAMMELI (Miller and Faber).

Plate LIII, fig. 6.

Beyrichia hammeli Miller and Faber, 1894, Jour. Cin. Soc. Nat. Hist., XVII, p. 157, pl. viii, fig. 26.

"Carapace medium size, dorsal margin straight and nearly as long as the greatest length of the valves. Anterior and posterior extremities broadly rounded, the anterior being slightly the wider of the two. Greatest width of the valves at the anterior third, where the width is to the length of the dorsal margin about as three is to four. Basal margin rounded, and slightly advancing at the anterior third. Valves moderately convex, with a border on the anterior, posterior, and basal margins, separated from the valve by a sharply-defined line or groove. The border on the basal margin is about one-sixth the width of the valve, and it narrows to about two-thirds that width at the antero-dorsal angle, and to about one-third that width at the postero-dorsal angle. The body of the valve is constricted by two sulci, directed obliquely backward from the basal border of the shell; the anterior one arises at the groove separating the border from the body of the shell, at the antero-basal margin, and when half way across the valve bifurcates, the stronger sulcus directed forward toward the antero dorsal margin, and the shallower one fading out before it reaches the dorsal margin of the shell. There is thus formed, anterior to this sulcus, a large, convex, rounded area, and between the branches of this sulcus and the dorsal margin a depressed, convex, subtriangular area. Between the two oblique sulci there is a convex ridge more prominent than the rounded area in front, and which extends farther toward the basal margin than either the anterior or posterior convex areas. The posterior oblique sulcus fades out before it reaches the dorsal margin. The area between the posterior oblique sulcus and the posterior extremity of the valve is wider, but not as prominent as the more central ridge between the oblique sulci.

"The surface of the valves is distinctly granulous. The margin of the border, as seen from the interior side of the shell, is fringed or ciliated in the same manner as *Beyrichia ciliata*.

"This species, when compared with *Berychia ciliata,* is proportionally wider; has a wide border, while that species has only a linear border; has deeper sulci and a more convex ridge between them. Judging from some recent publications on the Ostracoda, there are those who would affix a new generic name to this species, but what light that would shed upon its characters, or how it would advance knowledge or assist in classification, we are unable to understand. We think it is a true *Beyrichia*.

"Found in the upper part of the Hudson River Group, by one of the authors, at Versailles, Indiana, associated with *Cyclora pulcella, Palaeoconcha faberi, Hyolithes versaillesensis,* and other small fossils.

"The specific name is in honor of Mr. J. F. Hammel, the well-known geologist of Madison, Indiana."—Miller and Faber, *loc. cit.*

ENTOMIS MADISONENSIS Ulrich.

Plate LIII, figs. 8, 8b.

Entomis madisonensis Ulrich, 1890, Jour. Cin. Soc. Nat. Hist., vol. XIII, p. 107, pl. vii, figs. 12a, 12b.

"Valves oblong-ovate, the back straight but short, the ends subequal and curved almost uniformly into the much more gently convex ventral edge. Sulcus deep, nearly central, extending from the dorsal edge fully two-thirds across the valve, bending forward a little at its lower extremity. Anterior half moderately convex; posterior half more so, and rising abruptly from the sulcus. Surface smooth.

"Size: Length, 1.3 mm.; height, 0.78 mm.

"This, and a much larger form from the Niagara of Indiana, are the only species of *Entomis* at present known to me from American rocks. Though apparently a true species of the genus, *E. madisonensis* does not seem to be very closely related to any of the European forms.

"The strong sulcus will distinguish it from species of *Primitia.*"—Ulrich, *loc. cit.*

The types are from the uppermost beds of the Cincinnati series at Madison, Indiana, where it is said to be rare.

EURYCHILINA STRIATOMARGINATA Miller.

Plate LIII, fig. 9.

Beyrichia striato-marginata Miller, Cin. Quarterly Jour. of Science, I, p. 233, fig. 26.

"Shell small, semi-elliptical; dorsal margin straight, rounded at both ends; basal margin elliptical. Valves strongly convex, with a single depression extending from the middle of the dorsal margin, at right angles, about half the breadth of the shell. Border one third the width of the shell, and finely striated or lined from the shell outward.

"Length about 4/60th inch, and width about 2/60th inch; convexity nearly as great as the width.

"I found this species in the upper fifty feet of the Cincinnati group, about fifty miles west of Cincinnati and about three miles south of Osgood, Indiana."—Miller, *loc. cit.*

Saluda.

LEPERDITIA CAECIGENA Miller.

Plate LIII, figs. 10-10c.

Leperditia caecigena Miller, 1881, Jour. Cin. Soc. Nat. Hist., vol. IV, p. 262, pl. vi, figs. 5, 5a.

"Length usually about 12/100 inch, breadth about 8/100 inch, and thickness about 4/100 inch.

"General form subovate. Hinge line straight, a little more than half the length of the valves. Anterior end narrower than the posterior, extending but little beyond the hinge line, when it rapidly curves into the ventral line below. The posterior part is broadly rounded, and constitutes beyond the hinge-line full one-third the length of the valves. Valves most convex at the posterior third. Surface smooth and eye-tubercle obsolete.

"This is a true Leperditia, as one valve overlaps the other.

"The author collected this species in the upper part of the Hudson River group at Versailles, and near Osgood, Indiana. The specimens illustrated and described are in his collection."—Miller, *loc. cit.*

Reported by Ulrich from near Madison, Indiana.

PRIMITIA CINCINNATIENSIS (Miller).

Plate LIII, figs. 11-11d.

Beyrichia cincinnatiensis Miller, 1875, Cincinnati Quarterly Journal of Science, II, p. 350, fig. 25.

"This is the smallest *Beyrichia,* known to me, in the Cincinnati rocks. It belongs to the unisulcate group of 'simplices,' and is very closely related to the *Leperditia.* General form elliptical, with a straight dorsal edge. Surface of the valves smooth, convex, with a single depression extending from the middle of the dorsal margin across about or a little over half the breadth of each valve. Ventral and terminal margins bordered by a very narrow depressed rim.

"Length of specimen about 2/100 inch; breadth about two thirds the length.

"It is found associated with *B. quadrilirata,* on slabs, about three miles east of Weisburg on the I. & C. R. R., and with the same fossil and *B. chambersi* about two miles north-east of Fort Ancient, on the L. M. R. R. The rocks at each of these places are about 300 feet below the upper Silurian."—Miller, *loc. cit.*

Arnheim.

PRIMITIA IMPRESSA Ulrich.

Plate LIII, figs. 7-7d.

Primitia impressa Ulrich, 1890, Jour. Cin. Soc. Nat. Hist., vol. XIII, p. 131, pl. x, figs. 3 a-c, 4 a-c.

"A small, ovate species, rather tumid, with the dorsal and ventral margins nearly equally convex, and the ends equal, or the anterior slightly the widest. The free margins usually with an indistinct flange. Sulcus situated centrally, or a little in front of the middle, unusually deep, extending from the dorsal edge nearly half the distance across the valve, terminating abruptly. Just behind the sulcus a more or less faint swelling.

"Size: Length, 0.6 mm.; height, 0.36 mm.

"The valves of this species are more convex than those of *P. fabulina,* Jones and Holl, and *P. humilis,* Jones and Holl, to both of which it is closely related. Both of those species differ further in having the posterior end wider, and the point of greatest convexity further removed from the dorsal edge. There is no species known to me from American rocks resembling this sufficiently to make comparison necessary."—Ulrich, *loc. cit.*

1.34A1, 3, 4, 7, 8 (?).

TETRADELLA QUADRILIRATA Hall and Whitfield.

Plate LIII, figs. 4, 4a.

Beyrichia quadrilirata Hall and Whitfield, 1875, Pal. Ohio, II, p. 105, pl. iv, figs. 6, 7.

"Carapace minute, the larger individuals seldom exceeding three-hundredths of an inch in length, and often not more than that size. Form sub-quadrangular, longer than wide, the proportions being about as two to three, and a little the widest at the anterior third of the length. Dorsal margin straight, a little less than the length of the valve; ends squarely rounded, and the basal line scarcely flattened. General surface of the valves flattened, but marked by transverse furrows, four in number, three of which are distinct and deep, extending across, or nearly across, the valve; the fourth is less distinctly marked and extends but little more than half way across the valve. The furrows divide the surface of the valves into transverse ridges, which are situated, one at each end, and one at each third of the length. Those situated at the ends are narrow and abruptly elevated; that at the anterior third of the length does not reach quite to the dorsal margin; while that of the posterior third is much the strongest, rapidly widens in the lower part, and divided along the middle by the fourth, or smaller furrow, which gives it the character of a strong ridge, bifurcating in the lower half. The central furrow is wider than the others, oblique in its direction, and somewhat curved in its course toward the ventral border. The margin of the valves is strongly and abruptly depressed below the general surface, forming a narrow, flange-like projection around the ends and basal portions. Surface of the crust not spinose or granulose under a lens of moderate power.

"The species somewhat resembles *B. trisulcata,* Hall, from the Lower Helderberg group, in the general expression of the valves, but differs in the relative position of the furrows. The specimens vary considerably in the strength of the ridges, these, in some cases, being broad and rounded, as in the specimen figured, while in others they are sharp and narrow, leaving broader furrows between."—Hall and Whitfield, *loc. cit.*

The types are from the Richmond formation near Waynesville, Ohio. The species is also reported by Ulrich from Richmond and Versailles, Indiana, from the Richmond formation.

TETRADELLA QUADRILIRATA var. SIMPLEX Ulrich.

Plate LIII, figs. 5, 5a.

Strepula quadrilirata var. *simplex* Ulrich, 1889, Contributions to the Micro-Paleontology of the Cambro-Silurian rocks of Canada, II, p. 55, pl. ix, fig. 13.

"Figure 13, plate IX [of Ulrich's paper] represents a variety from Stony Mountain, Manitoba, that may be designated as var. *simplex.* It differs from the typical form in having the postero-median ridge simple instead of bifurcated below. The vertical plates which divide the anterior edge of the typical form into shallow cavities seem also not to have been developed except to a very limited extent. A very similar variety occurs in the Trenton shales of Minnesota."—Ulrich, *loc. cit.*

Reported by Ulrich from Weisburg, Indiana, from the Richmond formation.

CIRRIPEDIA.

LEPIDOCOLEUS JAMESI (Hall and Whitfield).

Plate LIII, figs. 13-13d.

Plumulites jamesi Hall and Whitfield, 1875, Pal. Ohio, p. 106, pl. iv, figs. 1-3.

"General form of the plates triangular, with the apex a little inclined to one side, the lateral margins gradually and rapidly diverging from the initial point, one of them considerably longer than the other. Basal margin sigmoidal, the convex portion situated next to the longest lateral face, the concave portion to the shorter, and the shorter lateral margin deflected downwards in some cases (probably the marginal row of plates).

"The surface of the plates is flattened or slightly convex on the sides, and very faintly depressed along the middle, the whole marked by rather closely arranged, annulating, and scaliform transverse lines parallel with the basal or sigmoidal margin, and marking stages of growth. These transverse lines are usually faintest near the apex, and gradually increase in width with the increased growth of the plate, but in some cases they are quite irregular in their distances.

"The length from the apex to the basal margin of the plate is usually a little greater than the transverse diameter, and seldom exceeds a sixteenth of an inch, the largest specimens seen not measuring a line in their greatest diameter."—Hall and Whitfield, *loc. cit.*

I have seen many fragments of a species probably the same as the above, though I do not feel that the identification is a sure one.

5.9A8....1.34A3, 4, 7, 8, 10, 12, 15a....1.34C8.

TRILOBITA.

DIAGNOSES OF GENERA.

ACIDASPIS Murchison.

Cephalon semicircular or semielliptical, thickened margin spinous and genal angles produced into spines of greater or less length. Glabella with one large median lobe and two on either side, one or more spines frequently project backward from the posterior margin of the glabella. Eyes prominent. Thorax with eight or nine segments; pleurae laterally extended into long spines, ridged. Pygidium small, margined with spines.

CALYMMENE Brogniart.

Body oval in outline, possessing the power of enrolement to perfection; glabella conical, strongly convex, divided by three pairs of deep lateral grooves; eyes small; hypostoma quadrate, notched. Thorax of thirteen segments, axial furrows deep; pygidium of from six to eleven segments, not distinctly marked off from the thorax. (Beecher.)

CERAURUS Green.

Body very much depressed and slightly tapering. Cephalon scarcely trilobate; cheeks large, flat, with small remote oculiform tubercles; posterior (genal) angle of the cephalon spinous. Thorax with twelve articulations. Pygidium rounded at the end, but terminating on each side with two slightly curved spines. (Green.)

DALMANITES Emmrich.

Glabella with three well-marked lateral furrows; genal angles produced into spines; eyes large, prominent, and with many distinct facets; pygidium triangular, frequently pointed or mucronated, with more than eleven segments, sometimes twenty or more. (Beecher.)

ASAPHUS Brogniart.

Cephalic and caudal shields of nearly equal size, with broad infolded margin; glabella expanded, nearly smooth; free cheeks large; hypostoma deeply forked; eyes large and prominent; thoracic segments eight; pygidium not strongly segmented, often nearly smooth. (Beecher.)

Subgenus ISOTELUS DeKay.

Same as in *Asaphus*, but with broad unsegmented pygidial axis at maturity.

PROETUS Steininger.

Head-shield semicircular, with thickened marginal rim; glabella well defined, extending nearly to the anterior margin, lateral furrows obsolescent, basal lobes often present. Eyes large, crescentic, near the glabella; thoracic segments usually ten, pleura grooved; pygidium semicircular, margin entire, axis elevated, segmented; limb ribbed. (Beecher.)

TRINUCLEUS Lhwyd.

Cephalon with a broad, regularly pitted border, produced behind into long genal spines; glabella prominent; thorax of six segments; axis narrow; pygidium triangular, wide, short. (Beecher.)

DESCRIPTION OF SPECIES.

ACIDASPIS CERALEPTA (Anthony).

Plate LIV, figs. 1, 1a.

Ceratocephalia ceralepta Anthony, 1838, Amer. Jour. Sci., XXXIV, p. 379, figs. 1, 2.

"*Ceratocephala ceralepta.*—Clypeo antice rotundato, subplano, granulato.

"Margine crenulata.

"Cornibus prorsum expansibus et gracilibus.

"The buckler is semi-lunate, surface covered with fine granulations resembling shagreen; its margin is raised, presenting a rounded rim, over which pass two antennae, distant from each other where they pass over about one fourth of an inch. These antennae extend one third of an inch beyond the rim, and are only one third of a line in diameter, forming a character from which we derive our specific name, 'ceralepta' (slender horned); their extremities are broken off, and it would appear that they have been several lines longer; they diverge a little at their extremity, being about one line more distant there than at the margin of the buckler; they are inserted about one line within the rim. Between the horns there is a triangular process extending from the rim back as far as their insertion; this has two deep sulci on each side, separating it from the antennae. No abdomen or tail has yet been found, which could be identified as belonging to this species.

"Only two specimens are known to have been found, both by myself. They were discovered among the rubbish thrown down from a quarry, half a mile from this place [Cincinnati]. Millions of fragments may be found there of Calymenes, Isoteli, etc., and we may hope a more perfect specimen of our own species.

"When first shown to some scientific friends, it was pronounced a part of Ceraurus pleurexanthemus, and Dr. J. Green so judged it from an imperfect cast shown him. Those who have since had an opportunity of comparing my specimen with a Ceraurus Pleurexanthemus found in this vicinity this spring, have discovered that it cannot be confounded with it. Among those who thus doubted at first, and afterwards became convinced, I may mention Dr. J. A. Warder of this place, who, on a recent visit to Springfield, Ohio, found among some fossils belonging to his sister a specimen of what he deems another species belonging to the same genus with the present. On consultation, we have concluded to form a new genus, to be called Ceratocephala (*horned head*)."—Anthony, *loc. cit.*

The figures given herewith (after Meek) are of two fragments similar to those from which the above original description was drawn up. Anthony's description applies to the pygdium which he mistook for the cephalon of his species, as pointed out by Meek, the "antennae" being the two pygidial spines.

I have referred fragments from the Utica formation at Vevay (1.38 A 24 and 29) to this species.

ACIDASPIS CINCINNATIENSIS Meek.

Plate LIV, fig. 2, 4(?).

Acidaspis cincinnatiensis Meek, 1873, Pal. Ohio, I, p. 167, pl. xiv, fig. 3.

"Cephalic shield, and most of the thorax unknown. Pygidium, exclusive of its spines, about three times as wide as long, and approaching a sub-semicircular outline; its anterior margin being straight all the way across, and about one-third of its posterior margin in the middle transversely truncated, while on each side of this the posterior lateral margins are straight to the anterior lateral angles; mesial lobe prominent at the anterior end, where it is about as wide as each lateral lobe, but becoming rapidly depressed and narrowed posteriorly, composed of only two well defined segments; lateral lobes flat, excepting a ridge that extends obliquely backward and outward from the anterior segment of the mesial lobe, across each, to the posterior lateral margins, where these ridges terminate in prominent, rounded, diverging spines; while the posterior lateral margins between these spines and the lateral angles are each armed with four smaller slender spines directed obliquely backward and outward; four similar smaller spines also occupy the truncated middle part of the posterior margin between the larger ones. Surface smooth, excepting a few very minute scattering asperities on the spines.

"Of the thoracic segments, the posterior one, and a part of the next one in advance of it, are seen in connection with the pygidium in the matrix. These show that the posterior extremity of the mesial lobe of the thorax is about as wide as the lateral lobes, moderately arched upward (not forward), and nearly or quite smooth, while the lateral lobes are flat. The pleurae of the posterior thoracic segment are smooth, and have each a strong mesial ridge extending straight outward to the lateral extremity, where it curves abruptly backward, and is produced into a long, sharp spine, extending as far backward as the longest spines of the pygidium, or farther. The anterior margin of each of these pleurae has also the character of a more slender, depressed marginal ridge, that likewise terminates in a backward curve, but much smaller lateral spine, just in front of the larger one, while there is behind the larger mesial ridge a narrower, flat margin, that runs out to nothing before reaching the outer extremity.

"Length of pygidium, exclusive of spines, 0.19 inch; breadth of do., 0.55 inch. Transverse diameter of first thoracic segment in advance of pygidium, 0.70 inch; length of each pleurae, 0.23 inch; anterior-posterior diameter of the same, 0.08 inch; length of larger lateral spine of each, 0.38 inch.

"That this species is distinct from the form I have referred to Dr. Locke's *A. crosotus,* seems to be evident, not only from its much larger size, but because it shows no traces of the rather distinct, closely set granulations seen on all parts of that species, and differs in other details. In many respects it appears to be closely related to *A. prevosti* of Barrande, so far as we have the means of comparison; but still it wants the distinct surface granulations of that form, and hence would doubtless be found to present other differences, if we had the entire fossil to compare.

"I have also before me a right, movable cheek of an *Acidaspis* from Cincinnati, that may, judging from its size and general appearance, belong to this species. Its posterior extremity is produced in the form of a long, stout, rounded spine, covered with little asperities, while the margin of this cheek is armed by about twelve short digitations. The inner or under side of this specimen is represented by our figure 4, of plate 14 [of Meek's paper]. Fig. 5 of the same plate represents the inner side of another similar cheek, with a more slender terminal spine, longer digitations, and a greater breadth between the eye and the digitate margin, from a higher position in this series, at Dayton, Ohio.

"Mr. James's collection also contains two specimens of the glabella of one or two species of *Acidaspis,* with a long spine projecting backward from the occipital portion. They differ enough in details to belong to two distinct species, and yet may belong to varieties of the same form. Of course, without other specimens showing these parts in connection, it is not possible to determine what relations they may bear to the pygidium for which I have proposed the name *A. cincinnatiensis.* I suspect, however, that one or the other, or both, belong to that species, and yet they may be quite distinct from it. It was evidently to one of these forms that Dr. Locke referred, in Vol. XLV, p. 223, of the Am. Jour. Sci. and Arts, published in 1843, as possibly belonging to his *A. crosotus.* They are certainly distinct from that form, however, not only in their much larger size, and the possession of the long appendage to the back part of the head, but in the form and comparative sizes of the lateral lobes of the glabella. They seem to be related to *A. grayi* of Barrande, though differing in details.

"If these specimens should be found to belong to a distinct species from any of those yet named, I would propose for it the name *Acidaspis rhynchocephalus,* in allusion to the beak-like appendage of the back of the head."—Meek, *loc. cit.*

I have seen only a few small fragments that may belong to this species.

1.12E3.

ACIDASPIS CROSOTUS (Locke).

Plate LIV, figs. 5, 5a.

Ceraurus crosotus Locke, 1842, Amer. Jour. Sci., XLIV, p. 346, wood-cut.

"*Messrs. Silliman*—I enclose to you a drawing of a new species of trilobite, evidently of the genus Ceraurus of Green. It is one of the smallest, and at the same time one of the most elegant of this family of extinct crustaceans; this drawing being magnified three times in linear dimensions. Fragments of this species have been repeatedly found in the rocks of this vicinity, especially the fringed margin of the shield; but it was not until last summer that I procured a specimen so nearly entire as to determine its generic relations. When Dr. Green established the genus of Ceraurus, it consisted of only one species, the *Pleurexanthemus.* But now that other species very closely allied to that are found, the justice of his discrimination is very apparent. I have named this new species *crosotus,* from the Greek word, signifying fringed. Dr. Green's description of his species—'Clypeo, postice arcuato, angulo externo in mucronem valde producto, occulis minimis remotis, post abdomine in spinam arcuatam utrinque extenso'—applies quite well to the *crosotus*; but this last differs from the former in having the shield pectinate or fringed anteriorly. The spines of the shield and of the several ribs are more nearly straight. Besides the spines terminating the ribs, there are six slender teeth, similar to those of the anterior fringe, attached, not to ribs, but to the terminal margin of the tail, four of them between the two last costal spines, at *a,* and the other two outside or anterior to the same, at *b.* Each of the costal arches is marked by *two* tubercles or 'pimples' (one in the other species), one on its middle, and the other at the commencement of the free spine in which each costal arch terminates. These tubercles form four rows or lines down the body, two on each lateral lobe, the inner one being in the direction of the distant eyes."—Locke, *loc. cit.*

As I have seen only small fragments referable to this species I have reproduced the figure given by Meek in the Ohio Paleontology. From Meek's description I condense the following additional points:

Subovate or sub-elliptic in outline. Cephalon semicircular in outline, lateral angles produced into slender, sharp, somewhat curved spines that extend outward and backward to about opposite the fifth or sixth segment. Glabella with an oblong, subelliptic outline, the widest part being somewhat behind the middle and behind the eyes. Two lateral lobes on each side, of slightly oval outline, with their long diameters directed a little obliquely outward and forward; the posterior slightly larger than the anterior, and both separated from the middle lobe of the glabella by well defined furrows. Anterior lobe about as large as all four of the lateral lobes, twice as wide as the narrow part of the glabella and apparently rounded in front. Between the lateral lobe and each eye is a sort of outer or supplementary lobe as large as each two of the lateral lobes, and from the outer side of each of these protrudes the small prominent palpebral lobe. Eyes unknown, but apparently small. Neck segment large, prominent, with a central tubercle, and well defined by the neck furrow, which arches forward in the middle. Thorax nearly twice as long as the cephalic shield, and about one-fourth wider than long, exclusive of the produced extremities of the pleurae, segments slightly arching upward, but not forward. Lateral lobes comparatively rather depressed and rounding off gradually toward the lateral margins. Pleurae terminating in sharp spines directed outward and more or less backward, the posterior ones being longer and directed more backward. Pygidium small, and with its mesial lobe composed of about three or four segments; lateral lobes consisting apparently of about four segments, each of which terminates in an acute spine, the lateral ones of which are larger than the others, and curved backward. Entire surface rather coarsely granular, the granules being larger on the head than elsewhere; while on each pleura a large granule occurs at a point about half way out to the knee, at which point there is also some appearance of another granule.

I have referred to this species fragments from near Guilford. 1.34C6.

CALYMENE CALLICEPHALA Green.

Plate LIV, figs. 6-6c.

Calymene callicephala Green, 1832, Monograph of the Trilobites of North America, p. 30, cast No. 2.

"Clypeo antice attenuato, figura liliiformi in fronte depicta; oculis minimis; abdomine quatuordecim articulis; corpore plano.

"The buckler is subtriangular; on the front there is a figure in high relief, somewhat resembling a *fleur de lis,* or, perhaps more, the capital of a Corinthian column. The oculiferous tubercles are rather lower down on the cheeks than usual. The articulations of the abdomen and the tail cannot well be distinguished from each other; fourteen in all may be easily counted. The middle lobe of the abdomen is nearly equal in breadth throughout. The ribs, or costal arches, are not grooved or bifurcated at their extremities. Length nearly two inches and a half.

"This beautiful species is in the Philadelphia Museum, where it is labeled as being found in 'Hampshire, Virginia.' It is mineralized by a dark yellowish limestone. It differs from C. Blumenbachii in the form and number of its articulations; in the shape of the head; in having only two flat tuberculous elevations on the front; and in other particulars.

"In the cabinet of the New York Lyceum, and in that of J. P. Wetherill, Esq., there are some examples of this species from the Miami river, near Cincinnati, Ohio. I have also seen it from Indiana, in a dark coloured limestone, very much distorted. It has never been found at Trenton Falls, or at any other locality, as far as my knowledge extends, which yields the true C. Blumenbachii." —Green, *loc. cit.*

The illustrations given herewith will make the identification of this common and characteristic species easy, without further description. It is perhaps the most sought after by amateur collectors of any fossil in the Cincinnati series, and in the more accessable localities perfect specimens are becoming increasingly rare. Its range is coextensive with the Cincinnati series, though it is abundant at comparatively few levels.

5.9A2....1.34A1, 3, 7, 8, 10, 11, 13b, 14a, 14b, 15a, 15b, 16b, 17, 19-21, 22....1.34B4-5....1.34C5, 6, 7, 10, 11, 13, 14a.... 1.41B1, 3....1.41C1, 2-3....1.41D1, 2....1.41E4....1.12A2.... 1.12D1-6....1.12E3.

CERAURUS PLEUREXANTHEMUS Green.

Plate LIV, figs. 9-9b.

Ceraurus pleurexanthemus Green, 1832, Monograph of the Trilobites of North America, p. 84, cast No. 33, fig. 10.

"Clypeo postice arcuato, angulo externo in mucronem valde producto; oculis minimis remotis, post-abdomine in spinam arcuatam acutam utrinque extenso.

"The exact contour of this species cannot be perfectly ascertained from our specimens; it seems, however, to have been lunate. The horns of the crescent which form the posterior angles are very distinct, and they project like curved spines, some distance on each side of the head. The middle lobe or front is faintly scalloped on each side along the cheeks. The cheeks are rather large, and are furnished with two small oculiform tubercles, very remote from each other, and quite near to the anterior portion of the buckler. The abdomen is composed of twelve articulations. The lateral lobes of the abdomen are flat, and each of the ribs, at about half their extent, is marked on the upper surface, with an elevated pimple. These little pustules are nearly on a line with the oculiferous tubercles of the buckler, and present two parallel ranges down the body, one on each side of the middle lobe, and are terminated by a curved spine, which projects to some distance beyond the tail of the animal. Length, one inch and a fourth.

"This remarkable organic relic was found near Newport, in the State of New York. It is embedded in black limestone shale, and so exceedingly depressed is this animal that a very thin lamen of the slate removed from the surface would destroy every vestige of its appearance. I am indebted to my early friend, Professor T. R. Beck, for the use of this valuable petrifaction, which now belongs to the cabinet of the Albany Institute."—Green, *loc. cit.*

Of this species I have seen only an imperfect, but unmistakable, pygidium from the base of the Lorraine at Manchester, Indiana, and another fragment from the base of the Waynesville formation near Harmon's Station, Indiana. For the identification of the first I am indebted to the late Dr. C. E. Beecher, to whose opinion on such points only the highest regard can be paid. So far as I am aware, the species has not heretofore been reported from this horizon of the Cincinnati region. 1.34 C 13 and 1.34 A 3.

CERAURUS ICARUS (Billings).

Plate LIV, figs. 8, 8a.

Cheirurus icarus Billings, 1859, Canadian Naturalist and Geologist, vol. V, p. 67. (Also Geol. Canada, Report of Progress—1863—page 219, fig. 231.)

DALMANITES BREVICEPS Hall.

Plate LIV, figs. 10, 10a.

Dalmania breviceps Hall, 1866, 24th Report of the New York State Museum, p. 223, pl. viii, figs. 15, 16. (Published in 1866, republished in 1872.)

"Body broadly ovate in general form, having its greatest width across the base of the cephalic shield. Head subcrescentiform, the anterior margin very slightly produced in front of the glabella. Frontal lobe of glabella transversely elliptical, the breadth nearly twice as great as the length, separated from the anterior lobe by deep narrow furrows. Anterior lobe transversely subovate, prominent; middle and posterior lobes obsolete; occipital ring narrow, distinctly defined.

"Eyes very prominent, with five lenses in the central vertical range, but the number of vertical ranges cannot be determined; palpebral lobe depressed. The outer border of the movable cheeks is thickened and rounded, and the space between the border and the eye depressed. The posterior spines long and broad, reaching to the sixth thoracic segment.

"Thorax with the axial lobe highly convex and the lateral lobes strongly geniculate, subequal in width, rapidly tapering posteriorly from the fourth or fifth segment. Segments curved forward on the top of the axial lobe, and the furrows on the pleura strongly marked.

"Pygidium obtusely pointed behind, the lateral borders inclosing an angle of about 120°, the anterior border rounded; the number of articulations not clearly defined, but apparently numbering about ten or twelve, besides the terminal one; those of the lateral lobes have been more numerous.

"The entire surface, so far as can be seen on the specimen, has been finely pustulose.

"This species differs from all others described, in the short cephalic shield, and in the absence of middle and posterior glabellar lobes. In general form, it resembles *Dalmania callicephalia* of the Trenton limestone of New York; but differs conspicuously in having spines on the posterior angles of the cephalic shield."—Hall, *loc. cit.*

Doubtfully reported from Madison, Indiana.

ISOTELUS MAXIMUS Locke.

Plate LV, fig. 1. (*Isotelus gigas.*)

Isotelus maximus Locke, 1838, 2d Annual Report of the Geol. Surv. Ohio, p. 247, figs. 8, 9.

The description given by Locke in 1838 of this species is of so untechnical a sort as to be of very little value, were it not for the figures with which he accompanies it. I extract from his remarks whatever can be said to have any special bearing upon the diagnostic characters of the species in question.

Locke's specimen has a "kind of shovel shaped termination at both ends * * * large eyes, placed on the highest part of his body, * * * The animals were of various sizes, from less than an inch in length to 21 inches * * * [the specimen] is a fragment of the under margin of the tail or post abdomen of the animal, and when viewed sideways, exhibits a convex and a concave part precisely like the 'moulding' called the 'O-gee' * * * I am not sure that my specimen is not actually an overgrown megalops of Green; the character 'cauda suborbiculari limbo lato,' applies exactly, and the only definable difference which I can perceive between Dr. Green's specimen and my own is that the length of the post abdomen in his specimen is two thirds of its width, while in mine *it is less than two thirds.* The size, which is hardly a character, is very different, his being 5 inches, and mine 21 in length. I merely propose it as a new species, under the name of maximus, leaving it for those who have the means of more extensive comparisons than I possess to determine the question."—Locke, *loc. cit.*

Clarke has pointed out in the Paleontology of Minnesota that the sole distinction between this species and the *Isotelus gigas* is in the presence of genal spines in *I. maximus* and the absence of these structures in *I. gigas.* The spinous individuals are also in the New York and Minnesota specimens always smaller. Locke has indicated spines in the sketch which he gives of his extraordinarily large specimen. In general, my observation indicates that even very large individuals in the Cincinnati region possessed the genal spines. I have not seen any perfect specimens of either species of *Isotelus*; in fact, the majority of the specimens are in an exceedingly fragmentary condition, but several of these of very considerable proportions show the genal spine.

The general features of the two species can readily be seen in the figure of *I. gigas* (after Hall) given herewith. The following points brought out in Clarke's description apply to both species:

The cephalon and pygidium are elongate sub-triangular, the extremities subacute, slightly flattened or extenuate. The facial sutures meet at an acute angle at, or just behind the frontal margin. The glabella is obscurely defined, and more obscurely lobate, traces only of the lateral furrows being visible in an oblique light. The cheeks bear an intramarginal furrow, above which their general surface is elevated into a more or less conspicuous node, crowned by the eye. The occipital ring and furrow are quite obsolete. The axial furrows of the thorax are quite distinct, the axis itself broad, considerably more than one-third the width of the thorax. The lobation of the pygidium is very obscure, the dorsal furrows hardly distinguishable.

So far as I can determine, the common species in the Cincinnati region possesses the genal spines, and should therefore be referred to *Isotelus maximus.* Many of the fragments seen, however, do not show this critical part of the species, and in such cases no specific determination could be attempted. Specimens showing the spines were obtained at the following localities:

5.9A14....1.33A3....1.34A3, 4, 5, 15b, 16, 18b, 19-21.... 1.34C13....1.41C2-3, E6....1.12A2.

PROETUS SPURLOCKI Meek.

Plate LIV, fig. 13.

Proetus spurlocki Meek, 1872, Amer. Jour. Sci., 3d series, III, p. 426. (Not figured.)

"General form, exclusive of the spines of the cephalic shield, ovate-subelliptic, with moderate convexity. Cephalic shield having the form of half an ellipse divided through its shorter diameter, its posterior margin being straight, and its anterior narrowly rounded; posterior lateral angles produced into long sharp spines, that extend back nearly or quite the entire length of the thorax; glabella a little less than one-third the breadth of the posterior part of the head, separated from the cheeks on each side by a well defined furrow, but without having the neck furrow behind distinctly marked; other characters of the glabella unknown; eyes sublunate, nearly their own length in advance of the posterior margins of the cheeks.

"Thorax apparently shorter than the head, showing in the specimen examined only seven segments (one or two being probably concealed by the slipping backward of the cephalic shield); mesial lobe moderately prominent, scarcely equalling the breadth of the lateral lobes anteriorly, and tapering more rapidly backward, with its segments not arching forward. Lateral lobes less convex than the middle one; pleurae nearly straight and transverse, and furrowed for a little more than half way out, with their outer extremities merely rounded in front, and nearly rectangular behind, without any distinct backward curvature.

"Pygidium semicircular, scarcely one-half as long as the cephalic shield, and provided with a smooth flattened margin; mesial lobe moderately prominent, narrower than the lateral, tapering posteriorly, where it terminates rather abruptly, without passing quite upon the flattened margin, showing only very obscure traces of five or six segments on its anterior half. Lateral more depressed than the mesial one, and with flattened margins rather more than one-third the breadth at the anterior end of each, and each showing obscure traces of six or seven furrowed segments.

"Entire surface smooth.

"Length of a specimen apparently very slightly shortened by the slipping of the cephalic shield a little back upon the thorax, 0.33 inch; breadth at the widest part across the posterior part of the head, 0.25 inch; length of head, 0.27 inch; do. of pygidium, 0.11 inch.

"Until I saw the published figure of *Proetus parviusculus* Hall, I had thought it possible that this might be the same, although it did not seem to agree in several characters with those mentioned in the previously issued description of that species. On comparing it with the figure of that form, however, it will at once be seen to present well marked differences. In the first place, its cephalic shield is decidedly longer in proportion to its breadth, and more narrowly rounded in front; while the posterior lateral spines of its cheeks are nearly or quite twice the proportional length of those in *P. parviusculus*. Its eyes are also placed decidedly farther forward, and its neck segment is much less distinctly defined. When we come to its thorax, we also see equally well marked differences, its pleurae not being curved backward and falcate as in that species, nor having their furrows extending so far outward. It almost certainly has one or two segments less, though the slight slipping backward of the cephalic shield leaves some little room for doubt on this point. I have, however, also an inferior specimen before me, belonging to the collection of Dr. H. H. Hill of Cincinnati, believed to belong to this species, and this certainly has only eight thoracic segments. Again, the pygidium of our species differs in having distinctly flattened, smooth and very obscure furrowed segments on the lateral lobes, that do not extend out upon this border, while upon that of *P. parviusculus* the segments are strongly defined, without furrows, and extend very nearly or quite to the border, so as scarcely to leave any flattened margin.

"The specific name is given in honor of T. W. Spurlock, Esq., of Cincinnati, who discovered some of the new fossils loaned to the Ohio Survey, and is well known in that city for his long devotion to the study of the natural sciences."—Meek, *loc. cit.*

The above description needs no supplementing. I have a fragment referable to this species from the base of the Lorraine at Manchester Station, Indiana. 1.34C13. The type is from 100 ft. below the tops of the hills at Cincinnati, O.

TRINUCLEUS CONCENTRICUS (Eaton).

Plate LIV, fig. 11.

Nuttainia concentrica Eaton, 1832, Geol. Textbook, p. 34, pl. i, fig. 2.

"Fillet in the form of a semi-ellipse cut in the direction of its transverse diameter, and truncated so as to present the two ends of the fillet in the line of the same diameter; punctures of the fillet in about 4 or 5 concentric arcs, separated by alternating arcs of fine elevated ridges; middle lobe of the head narrower than the side lobes, more prominent, and tapering posteriorly; whole animal short-ovate; side lobes wing-like, flat, with very narrow joints. The head is found in great numbers in the transition limerock of Glenn's Falls, and in the wacke variety of transition argillite on the Champlain Canal, between Waterford and the Mohawk. Three figures, 7 A, B, C, Plate IV, of Brogniart, found in Russia by Stokes, are the heads of this species; but Stokes did not find the bodies. Fig. 6 of the same is probably a species of this genus. The head excludes all these species from the genus Asaphus."—Eaton, *loc. cit.*

The pitted margin of the cephalon and three conspicuous pear-shaped lobes, and the long straight genal spines, are sufficient to distinguish this species, which is unlike any other Trilobite in the same formations. The thoracic segments are rarely seen, but fragments of the cephalon are abundant at several horizons in the Eden shales.

5.9A2, 4....1.34C5....1.38A23, 29.

ANNELIDA.

DESCRIPTION OF SPECIES.

CORNULITES RICHMONDENSIS (Miller).

Plate XLII, fig. 5.

Tentaculites richmondensis Miller, 1874, Cincinnati Quarterly Journal of Science, vol. I, p. 234, fig. 28.

"Tube free or detached, straight, conical, gradually tapering from the aperture to an obtuse point. Surface marked by strong encircling annulations or constrictions, which are crossed by very fine, regular, longitudinal striae.

"Length of a specimen about one inch; diameter at the aperture about 1¼ lines; width of the annulations at the aperture about half line, which gradually diminish to less than one-quarter that size, and become nearly obsolete as they approach the closed end of the tube.

"While some of the tubes appear to be slightly curved toward the point, yet the numbers observed, which are broken across each other and across coral stems and other inequalities of the surface with which they came in contact, indicate that the tubes were very slightly, if at all, flexuous.

"They were found in the upper part of the Cincinnati group, near Richmond, Indiana, by Mrs. M. P. Haines, on slabs, dispersed and scattered in every direction, in great abundance. They do not appear to have ever been attached to each other or to any other body, nor to have lived in clusters, yet on one particular slab, not more than six inches square, in the cabinet of Mrs. Haines, there may be more than a hundred tubes scattered, wholly without order, in every direction. A slab, however, of that size, with a dozen of these tubes on it, may be regarded as a reasonably good specimen.

"The tubes have a marked resemblance to *conchiolites ? flexuosa* (Hall), though they may be readily distinguished by their much larger size, straight instead of curved form and free instead of attached habit. While I think that the latter are not always curved nor always attached, yet that is the general condition in which they are found, but this species does not appear to have ever been attached, and it is doubtful whether it was in the least flexuous in its living state."—Miller, *loc. cit.*

The type as indicated above is from Richmond, Indiana. The specimens which I have referred to this species are usually rather smaller than indicated above, though in other respects they conform to the description. Miller's figure does not show any longitudinal striae, though he mentions such in his description. All of the specimens in my collection show the longitudinal striae very plainly. An example of this species is shown natural size on the upper end of the slab containing a number of specimens of *Dalmanella meeki* from Versailles, Indiana. (Pl. XXXIII, fig. 6g.) If I have correctly identified it, it occurs rather abundantly in the lower part of the Richmond formation, wherever the latter is exposed in Indiana.

1.34A3, 4, 7, 8, 9, 10, 11....1.41B1, 1.12E3.

CORNULITES TENUISTRIATUS (Meek and Worthen).

Tentaculites tenuistriatus Meek and Worthen, 1865, Proc. Acad. Nat. Sci. Phila., 1865, p. 254. (Not figured.)

"Shell attaining a rather large size, gradually tapering, and a little curved; annulations large, prominent, rather obtuse near the smaller end; separated by rounded constrictions of about 0.10 inch breadth at the larger extremity of a specimen one inch or more in length. Surface marked by numerous, very fine, regular, closely arranged longitudinal striae, most distinctly marked in the rounded depressions between the annulations. Aperture circular.

"Length, 1.16 inches; breadth at the aperture, measuring upon one of the rings, 0.25 inch; do. between the rings, 0.19 inch; space occupied by four rings and the three intervening spaces at the larger end, 0.30 inch; while the same space includes six rings at the smaller end.

"This species resembles rather closely the enlarged figure of a form from the same horizon, referred by Prof. Hall to his *T. flexuosa* (pl. 78, fig. 26, Palaeont. N. Y. Vol. 1); but its annulations are sharper, and its longitudinal striae more crowded; while the natural size of the New York species is much smaller.

"Dr. Shumard has also described, under the name *T. incurvus* (Missouri Report, p. 195), a similar form, though his species is much smaller, with more crowded rings, while it also differs in having minute annular striae."—Meek and Worthen, *loc. cit.*

Reported in Kindle's list from Richmond, Indiana. I have not succeeded in obtaining a figure or specimen of this species.

CORNULITES FLEXUOSUS (Hall).

Plate XXXII, fig. 11.

Tentaculites ? flexuosus Hall, 1847, Paleontolgy of New York, vol. I, p. 92, pl. xxix, figs. 6 a-d.

"Tubes single or aggregate, adhering, more or less curved at the tip or along the whole length; surface marked by strong annulations, which are crossed by fine longitudinal striae; annulations somewhat irregular; interior distinctly septate; septa with the concave sides upwards.

"The mode of growth and the interior structure here developed give us more information regarding the habits of this hitherto doubtful fossil than we have before possessed. If the species in question is a true TENTACULITES, of which perhaps we may have some doubt, it appears to have been developed like many of the corals, viz., a simple tube affixed at the base, occupied by an animal which secretes calcareous matter, building up the walls of the cell, and extending across it transverse septa as the tube became elongated. The structure of the tube, however, allies it more nearly with Crinoideans than with Corals; and it is probable that it was inhabited by a simply constructed animal of the same order.

"The specimen fig. 1*a* [of Hall's paper] first attracted my attention by its curved tip, showing that it must have been attached to some other body. A further careful search among a large number of specimens from Lowville enabled me to discover the attached group, which shows that an exudation of calcareous matter attached them firmly to the shell, while a group of the cells of *Chaetetes lycoperdon* have commenced their growth on the same.

"I have referred this, with some hesitation, to the genus TENTACULITES, both on account of its general form and mode of adhering to other bodies, as well as from its internal structure, which, however, has not heretofore been shown in the true TENTACULITES. All the other species known in our strata are straight, rigid, and gradually tapering to a point, always separate, and never known as adhering to other bodies."—Hall, *loc. cit.*

The type is from the Trenton Limestone, Lowville, New York. The specimen of which I give a figure is from the upper part of the Utica formation on Tanner's Creek, near Manchester, Indiana. This is, if I am not mistaken, the form commonly known as *C. conica*. The reference of this species to the worms instead of the genus *Tentaculites* now rests upon secure evidence.

PLATE I.

Page

Beatricea undulata Bill.................................... 700

1. General view of specimen. N.*

Beatricea nodulosa 701

1a. Longitudinal section. N.

1b. Transverse section. N.

Labechia montifera Ulr..................................... 704

2. Portion of a large specimen which has overgrown an Orthoceras. U.**

2a. Vertical section of a specimen from Waynesville, O. U.

2b. Transverse section of the same. U.

Calapoecia cribriformis Nich............................. 701

3. View of a small specimen. Natural size. N.

3a. Portion of the surface, enlarged. N.

3b. Interior of a corallite, showing the septa and mural pores, enlarged. N.

3c. Section of a specimen from Richmond, Indiana, showing the tabulae and mural pores. x about 1.5.

Columnaria alveolata Goldf.............................. 703

4. Longitudinal section of a specimen from Osgood, Indiana, natural size.

4a. Transverse section of the same specimen.

Protarea vetusta Hall.. 705

5. Surface of a portion of a specimen from Richmond, Indiana. x 2.

Streptelasma divaricans Nich.............................. 707

6. Small specimen with a single lateral bud. N.

6a. Another specimen with four corallites. N.

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*Figure after Nicholson.

**Figure after Ulrich.

Plate I.

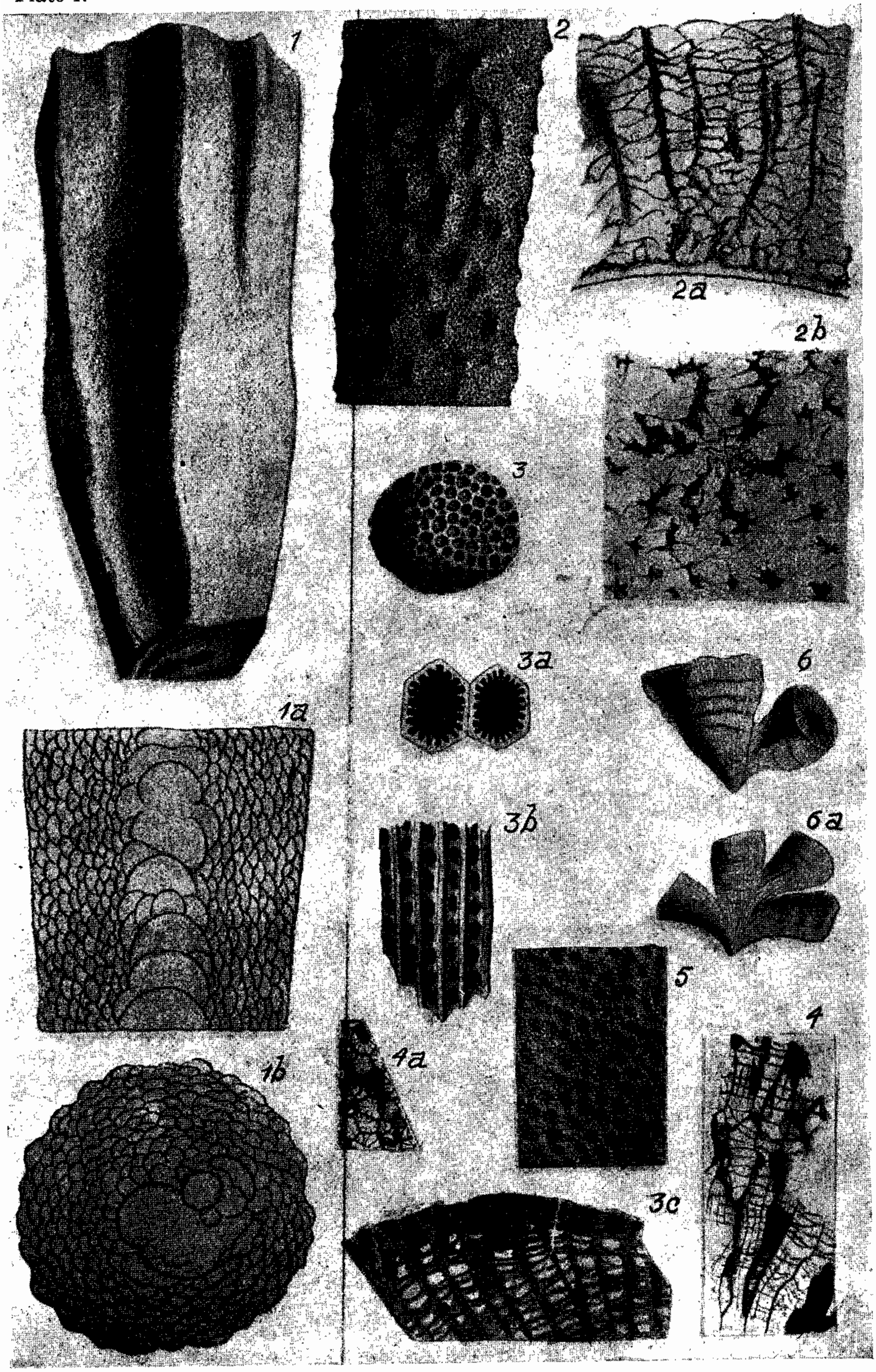

PLATE II.

*Figure after Miller.

Plate II.

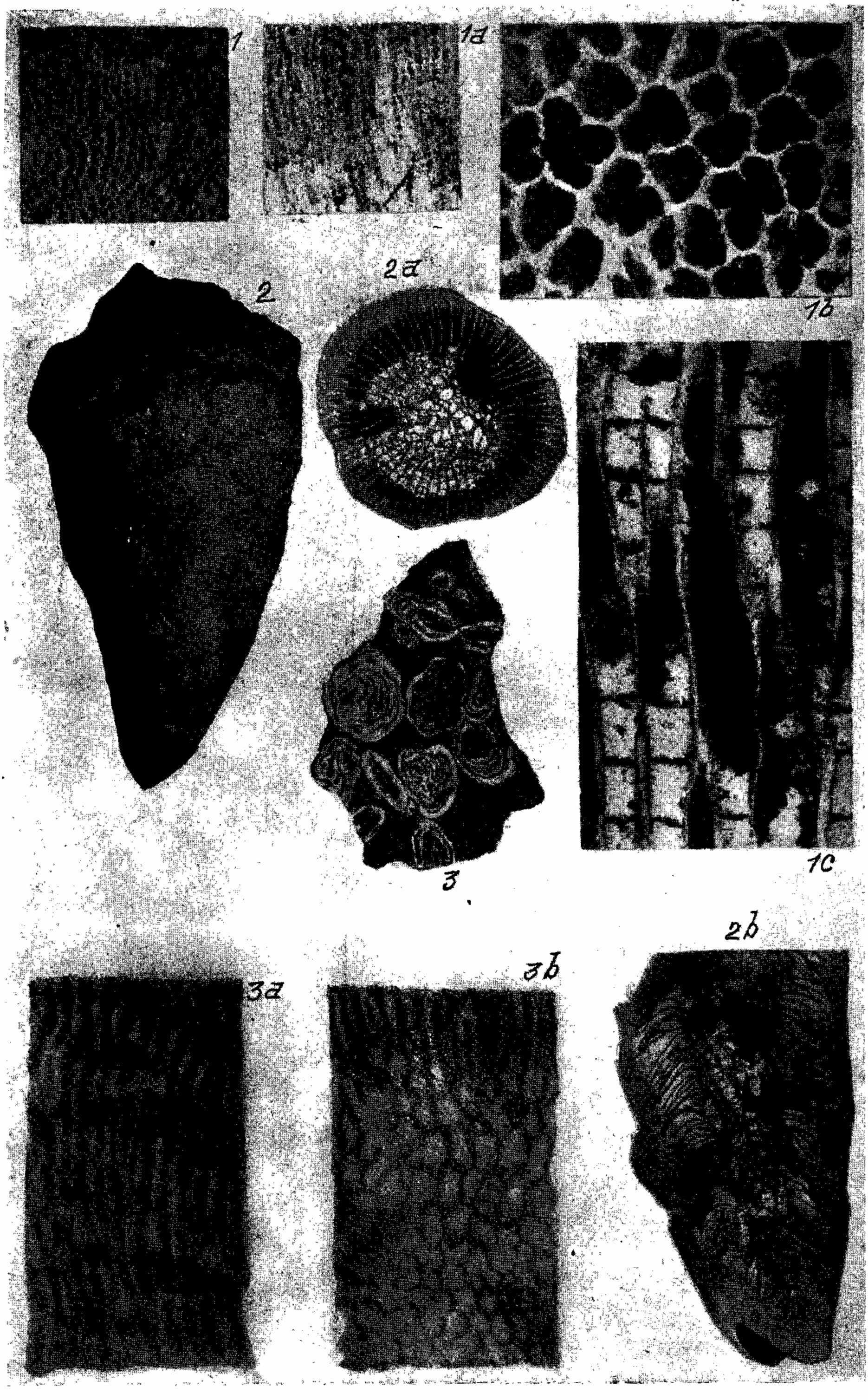

PLATE III.

Page

Anomalocrinus incurvus Meek and Worthen........................ 716

1. Anterior view of a specimen from the Miller collection. M.*

1a. Posterior view of same. M.

1b. An end view of the column at 0.43 inch above the root. M.

1c. An end view of the column near the body. x 2.5. M.

Lichenocrinus crateriformis Hall................................ 728

2. A large individual growing on the shell of Dalmanella, and showing the column-like appendage, broken at its free end. James collection. Natural size. M.

Heterocrinus juvenis Hall.. 725

3. Side view of body, arms, and part of the column. M.

3a. Posterior view of a specimen. x 2. M.

3b. One of the discs of the column. x 2.5. M.

Dendrocrinus polydactylus Shumard............................... 719

4. Posterior view of the body and arms with portion of the column attached. M.

Heterocrinus heterodactylus Hall................................ 724

5. Posterior view. x 1. M.

5a. Same enlarged. M.

Urasterella grandis Meek... 731

6. Dorsal view of a specimen with two of the arms folded over so as to show their ventral sides. Haines collection. M.

6a. Piece of one of the rays enlarged. M.

6b. Dorsal side of same more highly magnified. M.

Taeniaster granuliferous Meek.................................. 733

7. Ventral view of a specimen showing part of the disc and portions of the rays. x 2. M.

Palaeasterina spcciosa Miller and Dyer.......................... 731

8. Dorsal view. Dyer collection. M. D.†

---

*Figures after Meek.

†Figure after Miller and Dyer.

Plate III.

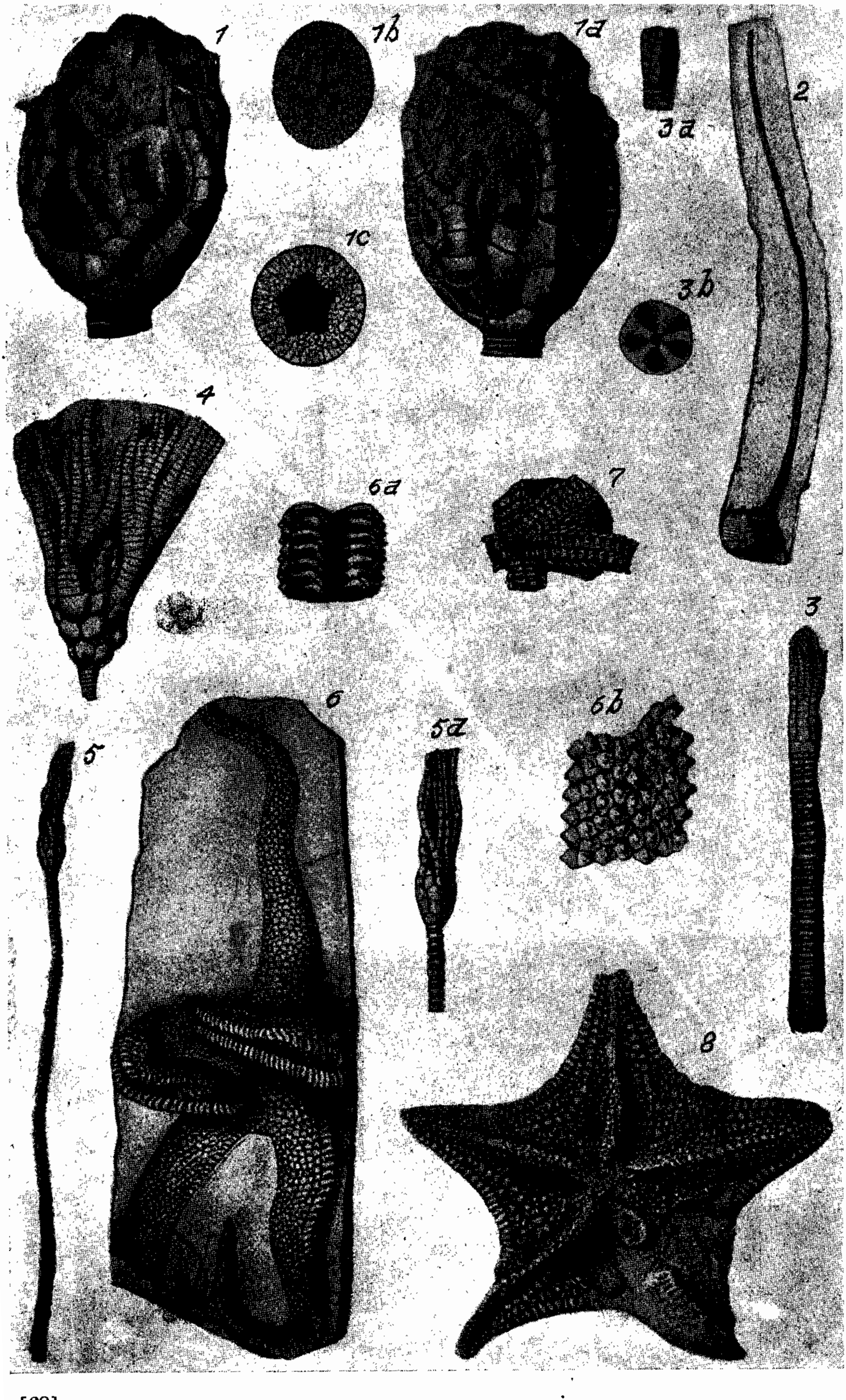

PLATE IV.

Page

Xenocrinus baeri Meek.. 734

1. Specimen consisting of the arms and pinnulae only. M.

1a. Side view of the body and arms with the pinnulae. M.

Dendrocrinus casei Meek.. 717

2. Anterior view with portions of some of the arms and part of the column attached. M.

2a. Posterior view of young individual. Dyer collection. M.

2b. End view of the column. M.

Lichenocrinus tuberculatus Miller.................................. 730

3. Upper surface of a specimen from Richmond, Indiana. Haines collection. x 2. Miller.

Lichenocrinus pattersoni Miller.................................. 729

4. Top view of a specimen from Kentucky opposite Cincinnati. Miller. x 2.

4a. Same, natural size. Miller.

Lichenocrinus dyeri Hall.. 729

5. A specimen showing the upper side of the disc with its numerous very small pieces, and the base of its appendage in the middle. Dyer collection. M.

Lepadocrinus moorei Meek.. 727

6. Side view of body and part of column. x 1. M.

6a. Another view of same showing the anal opening. M.

6b. Top view, enlarged. M.

Iocrinus subcrassus Meek and Worthen............................ 726

7. Posterior view of a specimen showing the anal series of pieces. M.

7a. Side view of body and arms with a piece of the column. M.

Glyptocrinus dyeri Meek.. 722

8. Posterior view of body and lower part of arms. M.

Glyptocrinus decadactylus Hall.................................. 720

9. Side view of the body and lower part of the arms of an unusually fine specimen. M.

Ectenocrinus simplex Hall.. 720

10. Oblique posterior view of a specimen. M.

10a. Side view of body and portion of the arms of a specimen that seems to have had the upper portion of its arms broken away and subsequently restored during the life of the animal. M.

Lepidodiscus faberi Miller.. 728

11. Enlarged view of an imperfect specimen on the shell of a brachiopod. Ml.

Lichenocrinus crateriformis Hall.................................. 728

12. Basal layer of platform showing its upper or inner structure exposed by the removal of the disc plates and internal laminae. x 2. M.

12a. Upper side of disc with the long appendage removed. x 3. M.

12b. Side view of a similar specimen. x 2 M.

Plate IV.

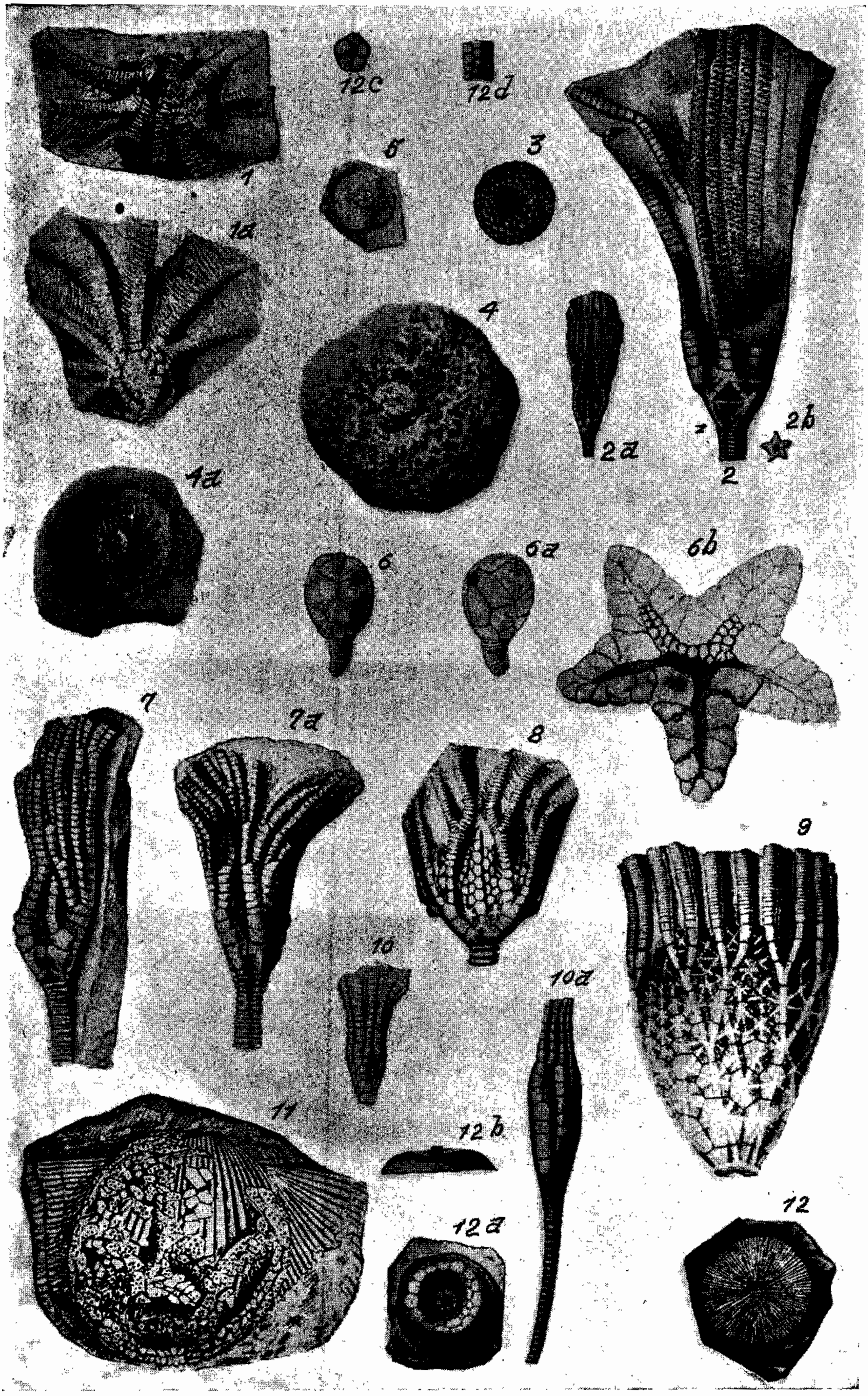

PLATE V.

Page

Calapoecia cribriformis Nicholson.................................... 701

1. View of a fine specimen from Richmond, Indiana. Natural size.

Amplexopora filiasa (American authors, non d'Orbigny)............. 765

2. View of a large specimen of this species from the upper part of the Lorraine at Vevay, Indiana.

Plate V.

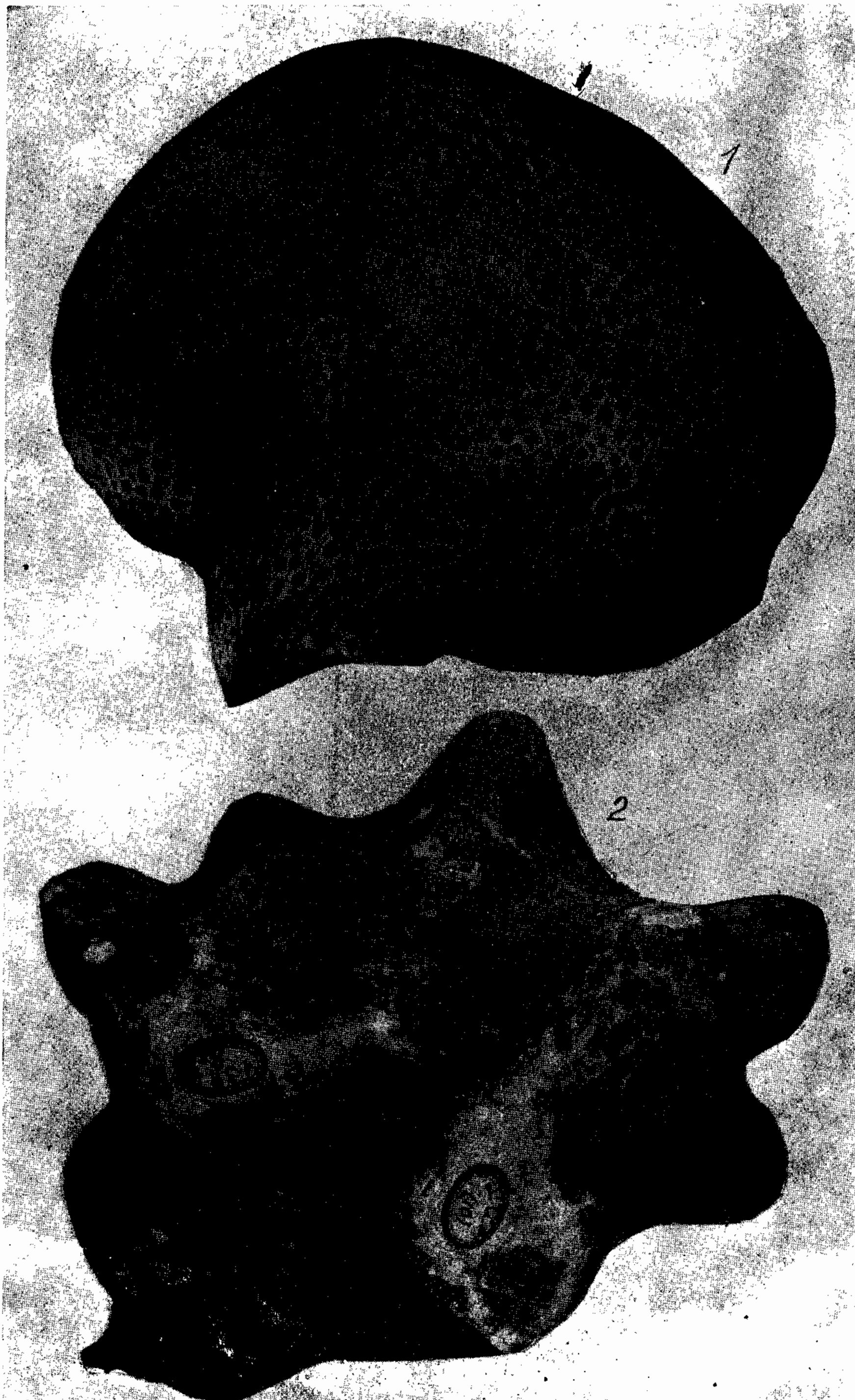

PLATE VI.

Page

Amplexopora cingulata Ulrich.................................... 758

1. Longitudinal section. x 18. U.

1a. Tangential section near the surface. x 18. U.

Amplexopora septosa var. *multispinosa* Cumings.................... 765

2. Longitudinal section of a specimen from the Upper Utica at Milton, Indiana. x 18.

2a. Tangential section of the same. x 18.

2b. Portion of the surface. x 9.

Amplexopora petasiformis Nicholson............................ 760

3. Tangential section. x 18. N.

3a. Longitudinal section of the same. x 18. N.

Amplexopora pustulosa Ulrich................................. 761

4. Longitudinal section. x 18. U.

4a. Tangential section. x 18. U.

4b. Portion of the surface. x 9. U.

Amplexopora robusta Ulrich.................................... 762

5. Longitudinal section. x 18. U.

5a. Tangential section. x 18. U.

5b. Portion of the surface. x 18. U.

Amplexopora septosa Ulrich.................................... 763

6. Longitudinal section of a specimen from the base of the Lorraine at Vevay, Indiana. x 18.

6a. Tangential section cutting the deeper portion of the mature region. x 18.

6b. Tangential section of the mature region. x 20.

Plate VI.

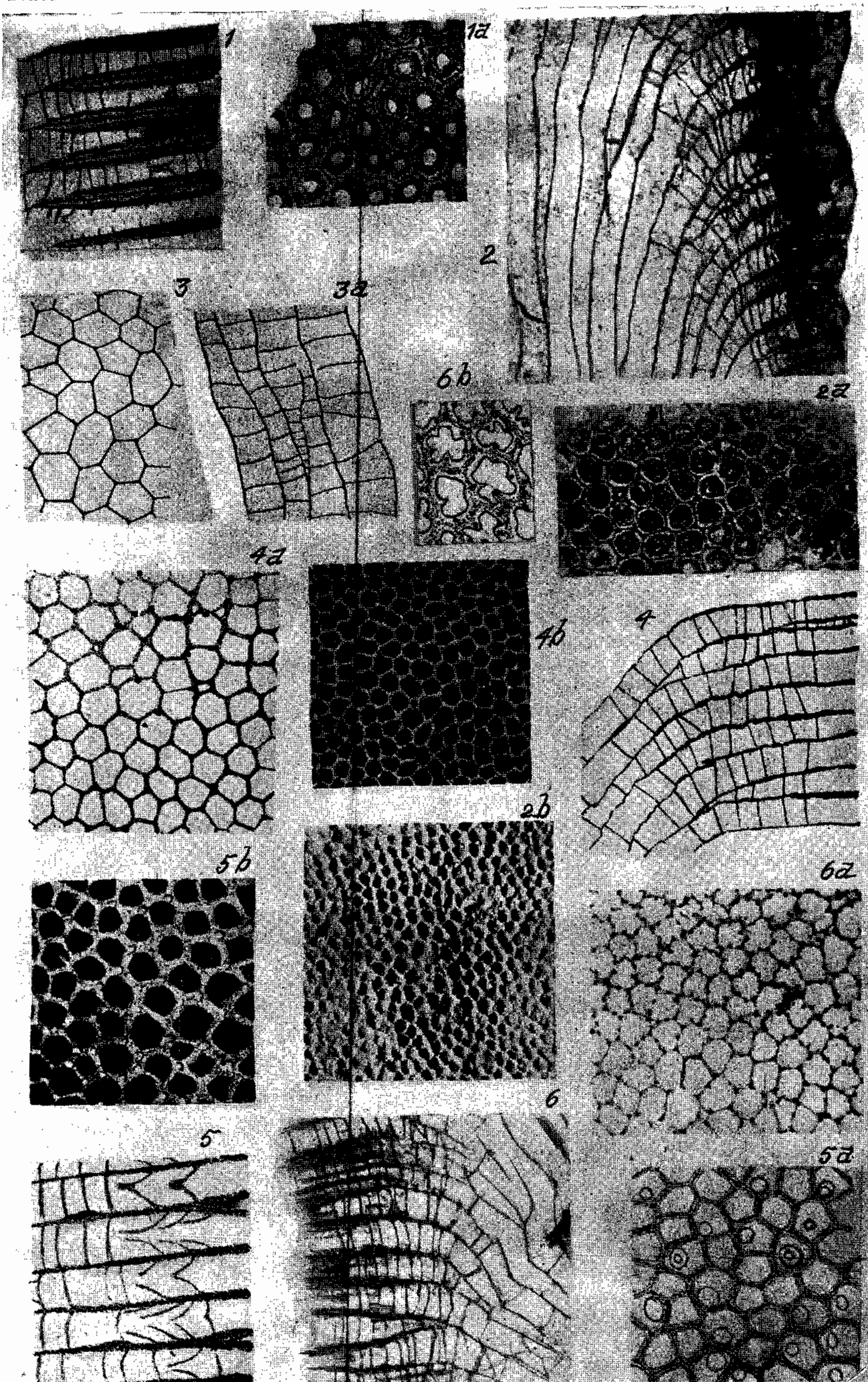

PLATE VII.

Page

Amplexopora filiasa (of American authors) 765

1. Longitudinal section of a large specimen from the upper part of the Lorraine at Vevay, Indiana. x 18.

1a. Tangential section of the same. x 18.

1b. Portion of the surface of the same. x 9.

Atactoporella multigranosa Ulrich 769

2. Tangential section. x 18. U.

2a. Vertical section. x 18. U.

Atactoporella mundula Ulrich 770

3. Vertical section of a specimen from the Lorraine at Lawrenceburg, Indiana. x 18.

3a. Tangential section of the same. x 18.

3b. Longitudinal section of a typical specimen. x 18. U.

Atactoporella newportensis Ulrich 770

4. Tangential section. x 18. U.

Atactoporella ortoni Nicholson 771

5. Tangential section. x 18. U.

5a. Vertical section. x 18. U.

Atactoporella schucherti Ulrich 772

6. Portion of a tangential section. x 50. U.

6a. Tangential section. x 18. U.

Batostoma implicatum Nicholson 774

7. Tangential section of the mature region of a specimen from near Guilford, Indiana. x 18.

Batostoma jamesi Nicholson 775

8. Tangential section of the mature region of a specimen from Guilford, Indiana. x 18.

8a. Longitudinal section of the same. x 18.

Batostoma varians James 778

9. Longitudinal section of a specimen from near Weisburg, Indiana x 18.

Plate VII.

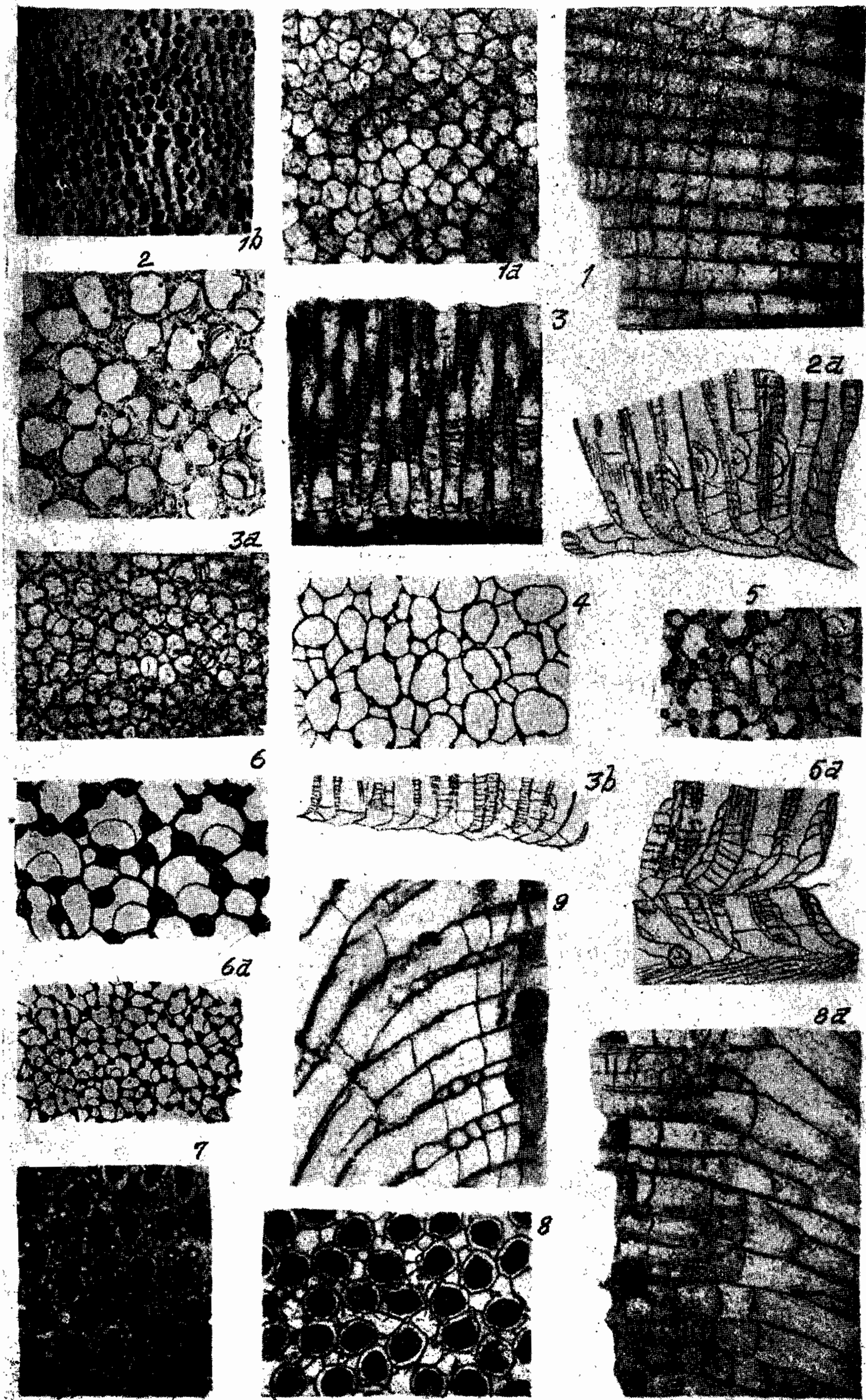

PLATE VIII.

Page

Batostoma jamesi Nicholson.. 775

1. Surface of the same specimen as Pl. VII, fig. 8. x 9.

Batostoma implicatum Nicholson....................................... 774

2. Surface of a specimen of this species from Guilford, Indiana. x 9.

Batostoma varians James.. 778

3. Surface of a specimen from near Weisburg, Indiana. x 9.

3a. Tangential section of the mature region of the same. x 18.

3b. Tangential sections of the mature and immature regions of another specimen. x 18. U.

Batostoma variabile Ulrich.. 777

4. Longitudinal section of a specimen of this species. U.

Bythopora meeki James.. 783

5. Longitudinal section of a specimen from the top of the Waynesville formation near Weisburg, Indiana. x 18.

5a. Tangential section of the mature region of another specimen. x 18.

Bythopora gracilis Nicholson.. 782

6. Tangential section of the mature region of a specimen from the Lorraine at Lawrenceburg, Indiana. x 18.

6a. Surface of a specimen of this species. Enlarged. N.

6b. Surface of the species still further enlarged. N.

Bythopora delicatula Nicholson.. 781

7. Portion of the surface of a specimen, enlarged. N.

Bythopora arctipora Nicholson... 780

8. Portion of the surface of this species greatly enlarged. N.

Callopora andrewsi Nicholson.. 785

9. Portion of the surface of a specimen of this species from Lawrenceburg, Indiana. x 9.

9a. Surface of a specimen enlarged. N.

Callopora onealli var. *communis* James.............................. 788

10. Portion of the surface of a specimen from Manchester Station, Indiana. x 9.

Callopora dalei Edwards and Haime..................................... 792

11. Portion of the surface of a specimen from Manchester Station, Indiana. x 9.

Plate VIII.

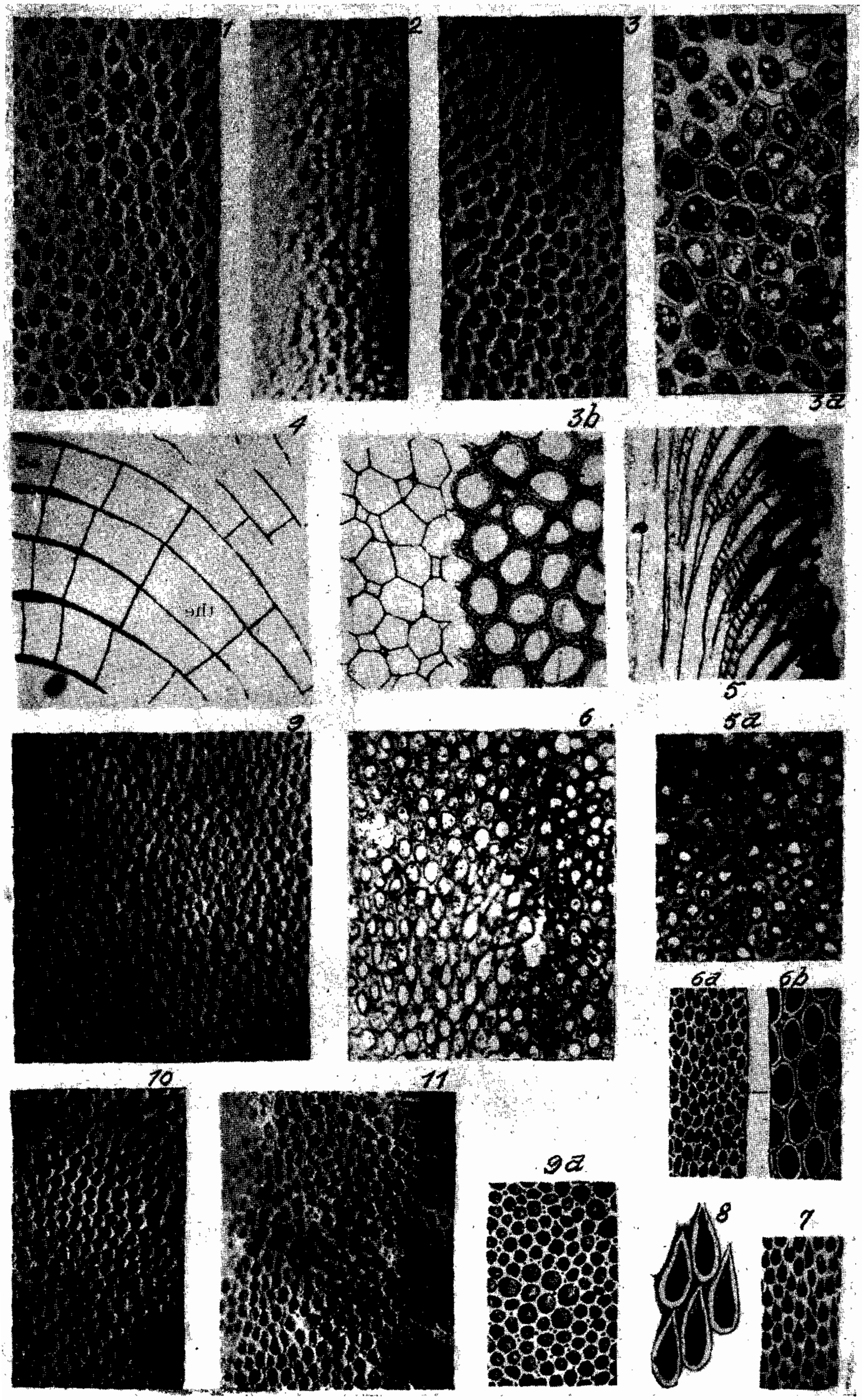

PLATE IX.

Page

Callopora frondosa n. sp. 785

1. Tangential section of a specimen from the Whitewater division at Richmond, Indiana. x 18.

1a. Longitudinal section of the same. x 18.

Callopora nodulosa Nicholson 786

2. Longitudinal section. x. 18. N.

2a. Cross section. x 18. N.

2b. Tangential section. x 18. N.

2c. Portion of the surface. x 18. N.

Callopora onealli James 786

3. Portion of a specimen from Guilford, Indiana. x 9.

3a. Longitudinal section. x 18. N.

3b. Tangential section. x 18. N.

Callopora onealli var. *sigillaroides* Nicholson 789

4. Longitudinal section of a specimen of this species. x 18.

Callopora ramosa d'Orbigny 790

5. Longitudinal section of a specimen from Lawrenceburg, Indiana. x 18.

5a. Surface of same. x 9.

Callopora cf. *ramosa* .... ——

6. Longitudinal section of a specimen from Weisburg, Indiana, from the top of the Liberty formation. x 18. The surface characters of this specimen are practically identical with those of typical *C. ramosa.*

Plate IX.

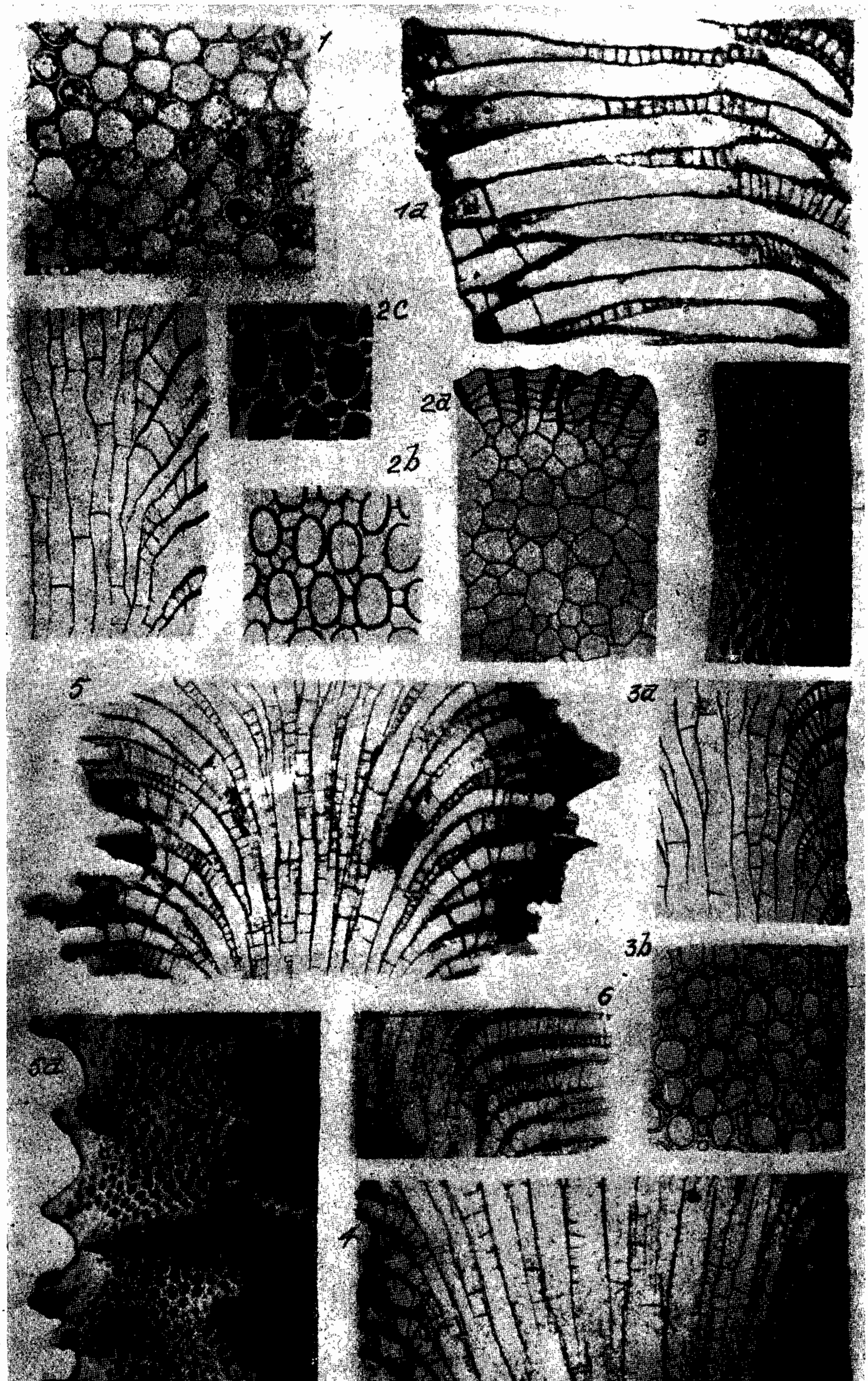

PLATE X.

*Annales de Paleontologie.

Plate X.

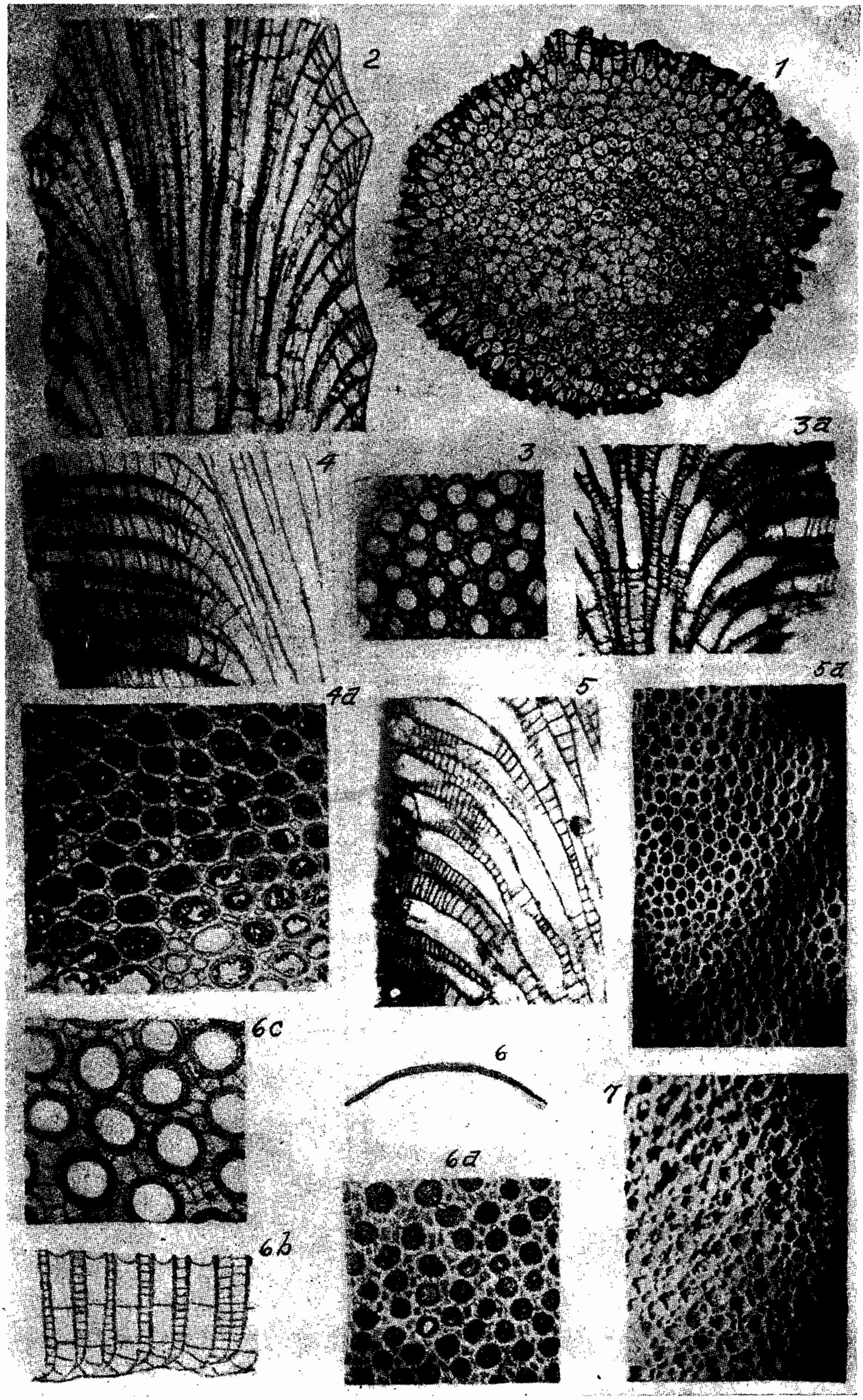

PLATE XI.

Page

Chiloporella flabellata Ulrich.. 802

1. Tangential section. x 18. U.

1a. Longitudinal section of a specimen from Manchester, Indiana, very doubtfully referred to this species. x 18.

Ceramoporella distincta Ulrich.. 799

2. Tangential section. x 18. U.

2a. Vertical section. x 18. U.

Ceramoporella granulosa Ulrich.. 799

3. Longitudinal section. x 18. U.

3a. Tangential section. x 18. U.

Ceramoporella ohioensis Nicholson.. 800

4. Tangential section. x 18. U.

4a. Vertical section. x 18. U.

4b. Representation of a portion of the surface of a worn specimen supposed by Nicholson to belong to this species. Enlarged. N.

4c. Portion of the surface of another worn specimen, doubtfully referred to this species by Nicholson. N.

4d. Surface of a specimen from near Weisburg, Indiana, having an appearance similar to that of fig. 4c. A tangential section of this specimen is given in fig. 4g. x 9.

4e. Surface of a specimen from Guilford, Indiana, presenting the appearance shown in fig. 4b. x 9.

4f. Longitudinal section of a specimen from the Lorraine at Vevay, Indiana. x 18.

4g. Tangential section of a specimen from the top of the Waynesville formation near Weisburg, Indiana. x 18. The specimen is growing upon a species of *Callopora*.

Plate XI.

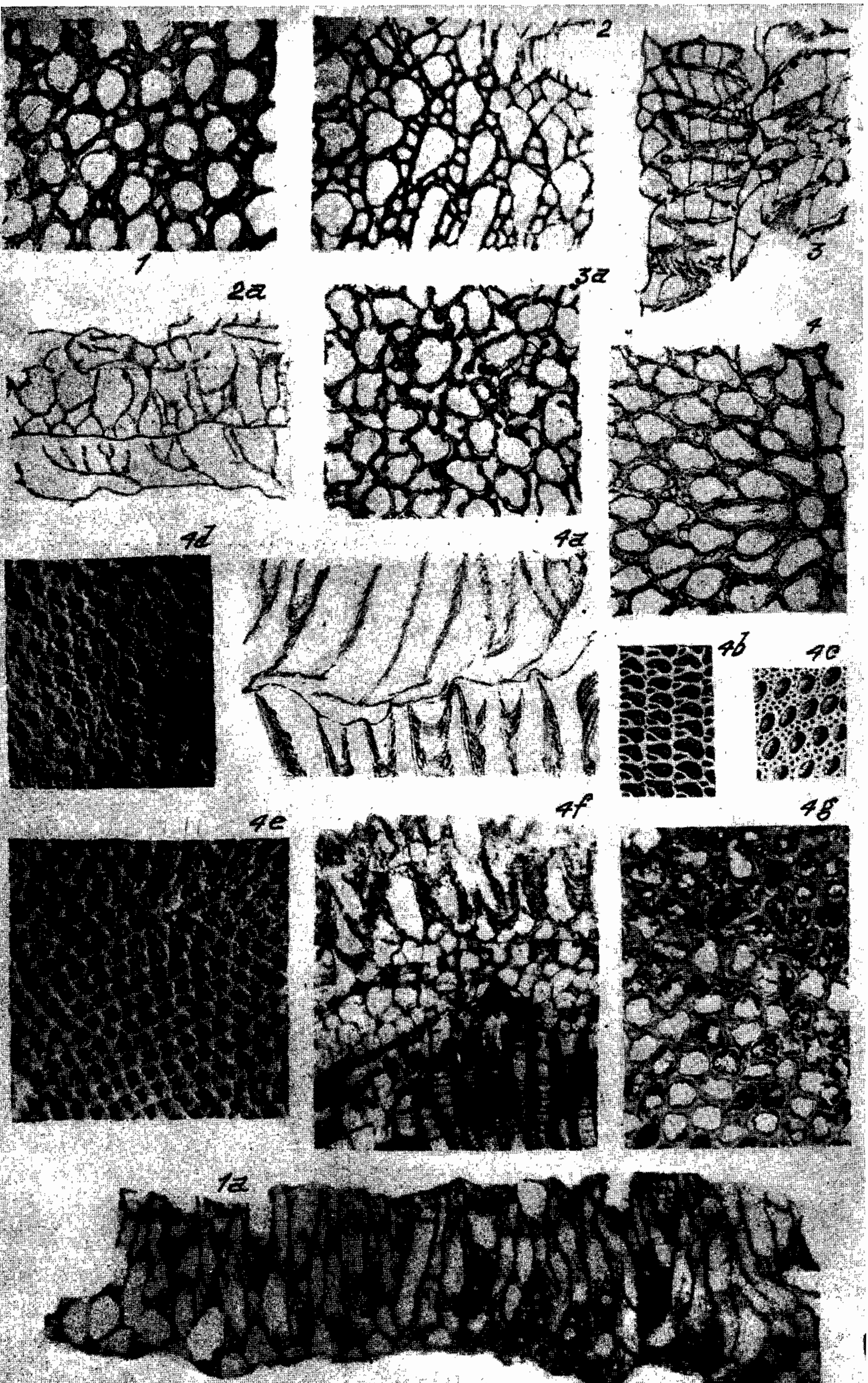

PLATE XII.

Page

Chiloporella flabellata Ulrich.................................... 802

1. Transverse section of this species. x 18. U.

1a. Longitudinal section. x 18. U.

1b. Surface of a specimen from Manchester, Indiana, referred to this species. x 9.

Coeloclema alternatum James.................................... 803

2 and 2a. Longitudinal sections. x 18. U.

2b. Portion of a transverse section. x 18. U.

2c. Portion of the surface. x 9. U.

2d. Portion of the surface of a specimen from Vevay, Indiana. x 9.

Coeloclema commune Ulrich.................................... 804

3. Tangential section. x 18. U.

3a. Tangential section of a specimen from the Utica formation at Vevay, Indiana. x 18.

3b. Portion of the surface, showing one of the maculae. x 9. U.

3c. Portion of the surface of a speceimen from Guilford, Indiana, showing one of the maculae. x 9.

Constellaria constellata Dana.................................... 804

4. Portion of the surface of one of the star-like clusters that constitute the chief feature of the genus. U.

4a. Tangential section of the fully mature region. x 18. U.

4b. Tangential section of the immature region. x 18. U.

4c. Portion of a tangential section of the mature region. x 50. U.

4d. Longitudinal section. x 18. U.

4e. Portion of a tangential section of a specimen from the base of the Lorraine at Vevay, Indiana. x 18.

Plate XII.

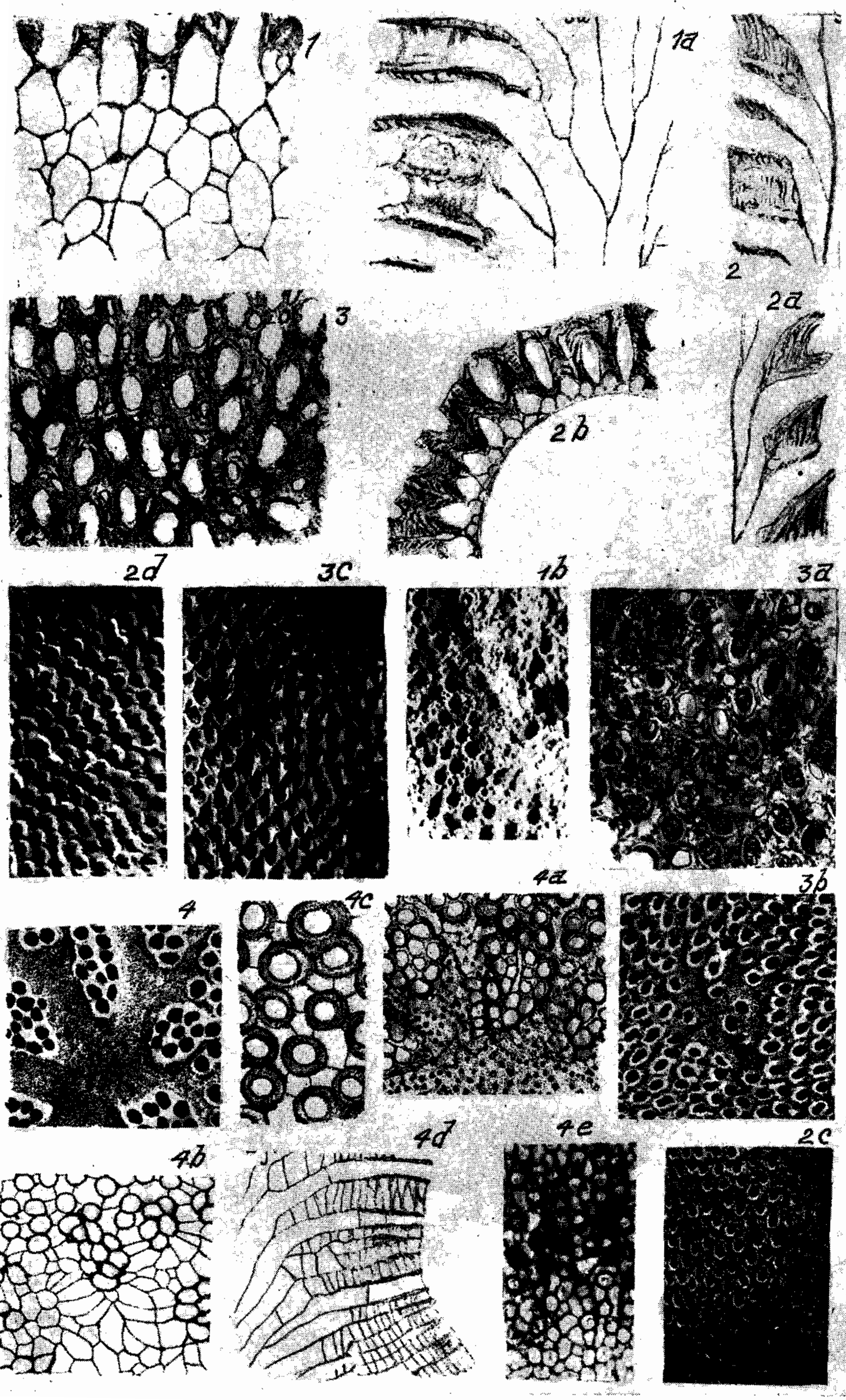

PLATE XIII.

Page

Constellaria polystomella Nicholson.. 808

1. Tangential section through one of the star-shaped maculae of this species. Weisburg, Indiana. x 18.

1a. Longitudinal section of same. x 18.

1b. Portion of the surface of a somewhat abraded specimen. The same as 1a and 1. x 9.

Constellaria limitaris Ulrich.. 806

2. Very perfectly preserved surface of a specimen from Weisburg, Indiana. x 9.

Dekayia appressa Ulrich.. 809

3. Tangential section of a specimen of this species from the collection of the Yale Museum. x 18.

Dekayia pelliculata Ulrich.. 818

4. Tangential section of a specimen from the Lorraine formation at Vevay, Indiana. x 18.

4a. Longitudinal section of the same. x 18.

Dekayia aspera Edwards and Haime.. 810

5. Longitudinal section of a very perfect specimen of this species in the Redfield collection of the Yale Museum. x 18.

5a. Tangential section of the mature region of the same. x 18.

5b. Surface of the same. x 9.

Dekayia magna Cumings.. 815

6. Tangential section of a specimen from the Lorraine at Lawrenceburg, Indiana, showing the small acanthopores. x 18.

6a. Longitudinal section of the same. x 18.

Plate XIII.

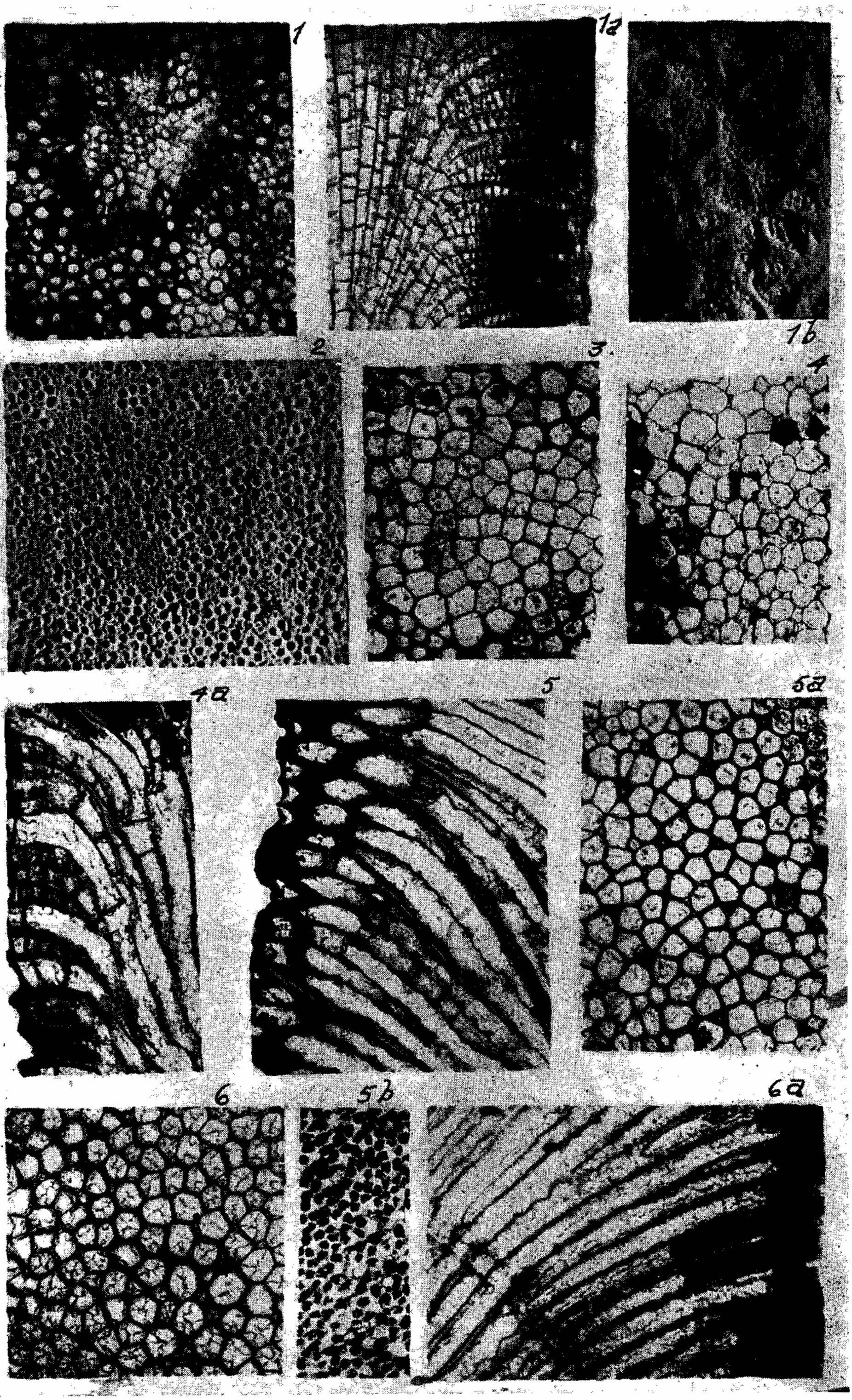

PLATE XIV.

Page

Dekayia frondosa var. *cystata* Cumings............................ 813

1. Tangential section of a specimen from the Lorraine formation at Vevay, Indiana. x 18.

1a. Longitudinal section of the same. x 18.

Dekayia ulrichi var. *robusta* Foord................................ 826

2. Longitudinal section of a specimen from the upper part of the Utica formation at Manchester Station, Indiana. x 18.

2a. Tangential section. x 18.

2b. Portion of the surface. x 9.

Dekayia obscura Ulrich.. 816

3. Tangential section of the mature region of a specimen in the collection of the Yale Museum. x 18.

3a. Portion of the surface of a specimen from Guilford, Indiana. x 9.

Dekayia ulrichi Nicholson... 824

4. Tangential section of a specimen from the upper Utica at Vevay, Indiana. x 18.

4a. Tangential section of the fully mature region of a specimen from near Guilford, Indiana. x 18.

4b. Surface of another specimen from Guilford, Indiana. x 9.

Dekayia cf. *ulrichi*.. ——

5. Tangential section of a small ramose species from the base of the Waynesville formation near Harmon's Station, Indiana, which may be a variety of this species. x 18.

Dekayia subfrondosa Cumings...................................... 821

6 and 6a. Portions of a tangential section cutting the submature region and showing the two sets of acanthopores. x 18.

6b. Longitudinal section of the same. Base of the Lorraine formation at Manchester Station, Indiana. x 18.

6c. Portion of the surface of same. x 9.

Plate XIV.

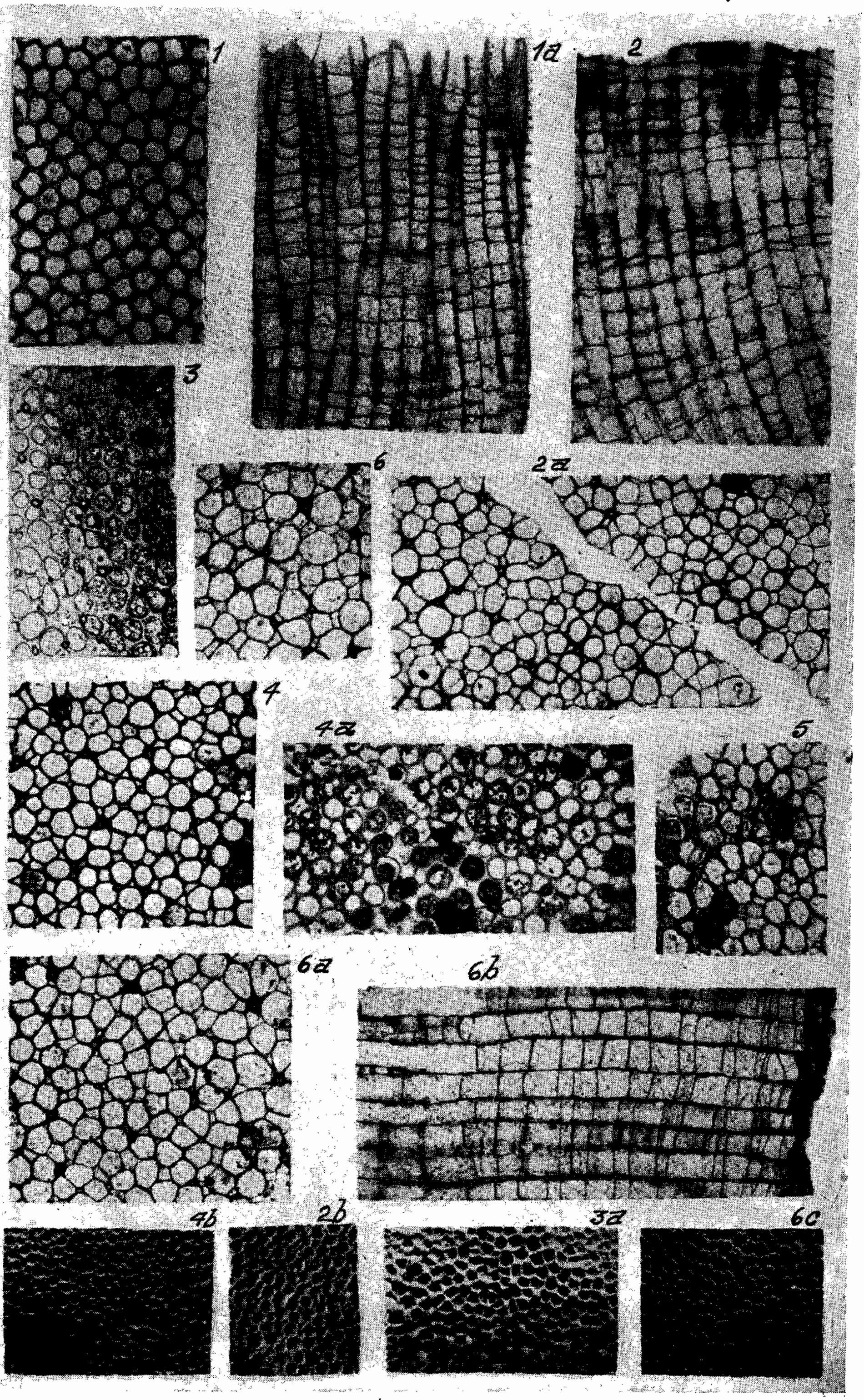

PLATE XV.

Page

Dekayia frondosa d'Orbigny.................................... 812

1. Longitudinal section of the type in the collection of d'Orbigny. x 10. A. P.

1a. Longitudinal section of a specimen from the Lorraine at Vevay, Indiana. x 18.

1b. Tangential section of the immature region of a specimen from the base of the Lorraine at Manchester Station, Indiana. x 18.

1c. Tangential section of the submature region of a specimen from the same locality and horizon. x 18.

1d. Tangential section of the mature region of a finely preserved specimen from Brookville, Indiana. x 18.

1e. Surface of same. x 9.

Dekayia inflecta Ulrich.. 814

2. Longitudinal section of a specimen in the Yale Museum, labeled by Mr. Ulrich. x 18.

2a. Tangential section of same. x 18.

Dekayia paupera Ulrich.. 817

3. Longitudinal section of the type. x 18. U.

3a. Tangential section of same. x 18. U.

Dekayia prolifica Ulrich.. 820

4. Tangential section of a specimen from the top of the Waynesville formation near Weisburg, Indiana. x 18.

4a. Longitudinal section of another specimen from the same place. x 18.

4b. Surface of a specimen from the Arnheim formation near Harmon's Station, Indiana. x 9.

Dekayia subramosa Ulrich.. 823

5. Tangential section of the submature region of a specimen from the Whitewater division at Richmond, Indiana. x 18.

5a. Longitudinal section of same. x 18.

Plate XV.

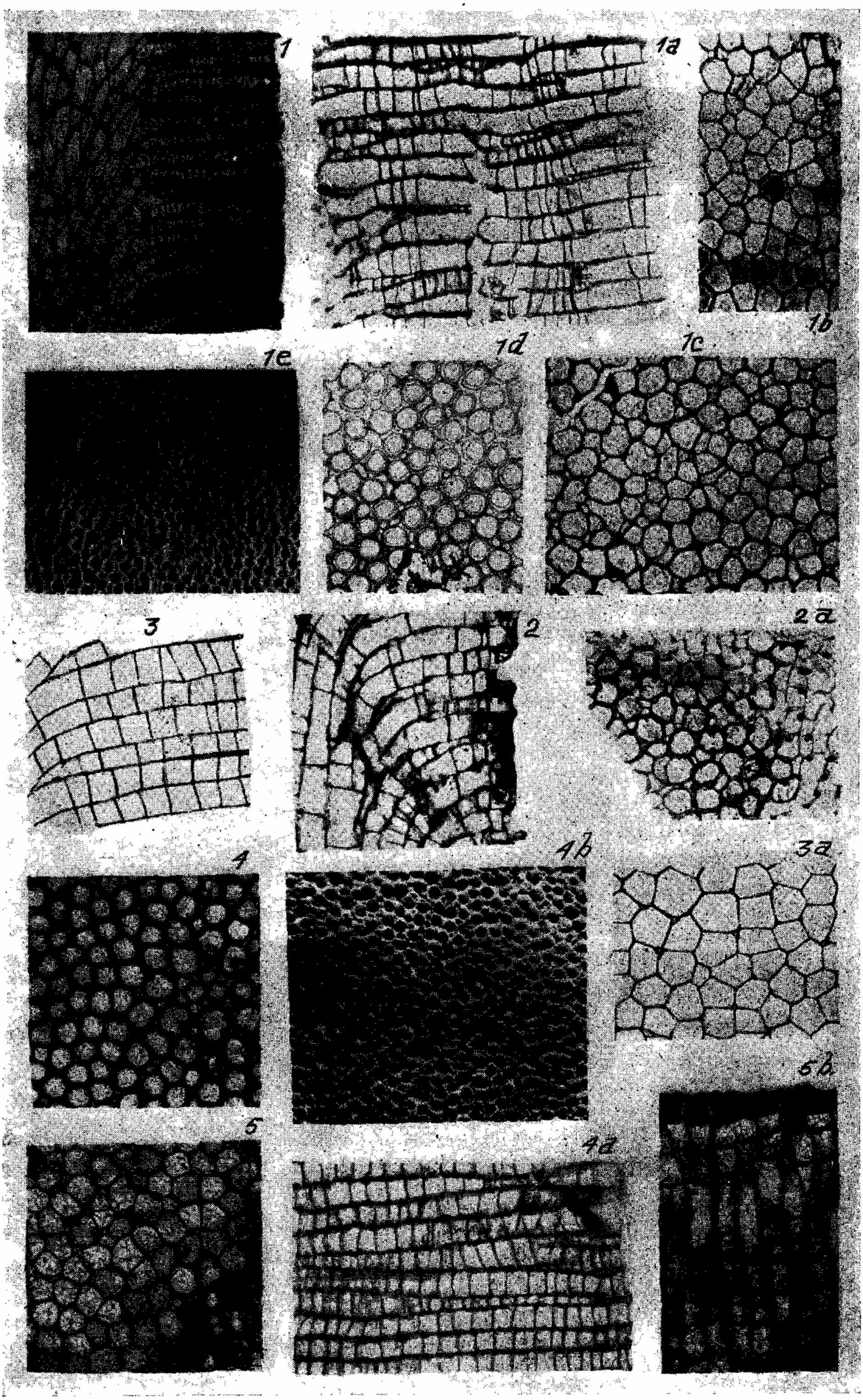

PLATE XVI.

Page

Dekayia subpulchella Nicholson.. 822

1. Tangential section of a specimen in the Yale Museum, labeled by Mr. Ulrich. x 18.

1a. Portion of the surface of a specimen showing the maculae of mesopores. N.

Dekayia sp... ——

2. Longitudinal section of a specimen from the Whitewater division at Richmond, Indiana, showing the presence of an occasional acanthopore of great size in the immature region. x 18.

2a. Tangential section of the same. Showing an occasional acanthopore of extraordinary size. x 18.

Dekayia prolifica? 820

3. Longitudinal section of a specimen from Richmond, in which the walls of the zooecia are unusually thick. Probably a form of *D. prolifica*. x 18.

Eridotrypa simulatrix Ulrich.. 828

4. Tangential section of a specimen from the base of the Waynesville formation near Harmon's Station, Indiana. x 18.

4a. Longitudinal section of a typical example of the species. x 18. U.

4b. Surface of a specimen. x 9. U.

Escharopora falciformis Nicholson.................................. 830

5. Tangential section of a specimen from the Utica formation at Vevay, Indiana. x 18.

5a. Surface of a specimen from the Lower Lorraine at Manchester Station, Indiana. x 9.

Escharopora pavonia Edwards and Haime........................... 832

6. Surface of a well preserved specimen from the base of the Lorraine at Manchester Station, Indiana. x 9.

Homotrypa Austini Bassler.. 838

7. Tangential section of the type. x 20. B.*

7a. Longitudinal section of the type. x 20. B.

7b. Portion of a tangential section. x 50. B.

*Figures after Bassler.

Plate XVI.

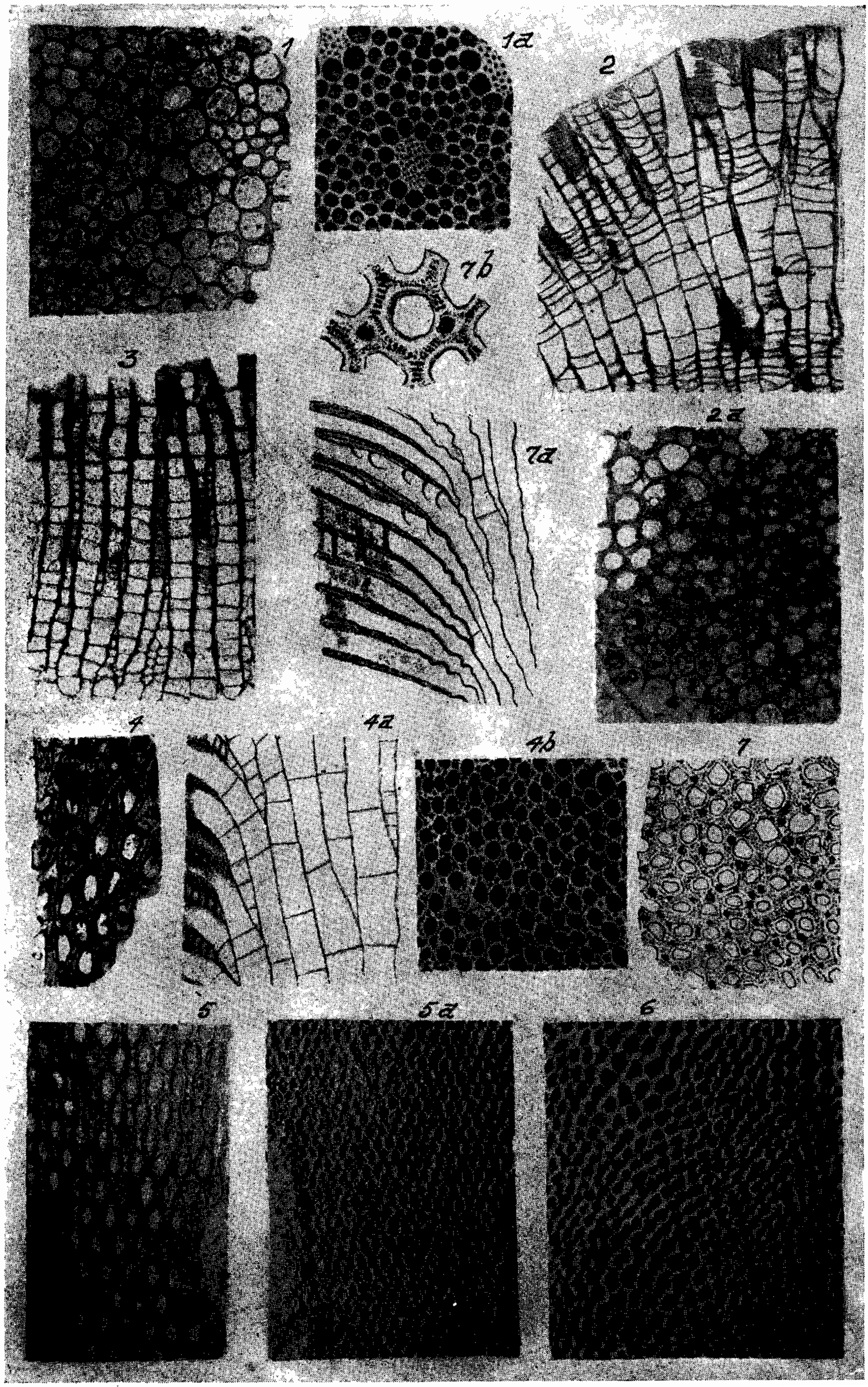

PLATE XVII.

Page

Homotrypa communis Bassler.. 839

1. Tangential section of the type. x 20. B.

1a. Longitudinal section of the type. x 20. B.

1b. Tangential section of a specimen from the base of the Liberty formation near Weisburg, Indiana. x 18.

1c. Longitudinal section of the same. x 18.

1d. Surface of same. x 9.

Homotrypa constellariformis n. sp.................................. 839

2. Longitudinal section of a specimen from the top of the Liberty formation at Weisburg, Indiana. x 18.

2a. Tangential section of the same specimen. x 18.

2b. Surface of same. x 9.

Homotrypa curvata Ulrich.. 840

3. Longitudinal section of a specimen from the Lorraine formation at Vevay, Indiana. x 18.

3a. Tangential section of the submature region of the same specimen. x 18.

3b. Surface of the same specimen. x 9.

Homotrypa cylindrica Bassler....................................... 842

4. Longitudinal section of a typical specimen from the base of the Whitewater division at Richmond, Indiana. x 18.

4a. Tangential section of the same specimen. x 18.

Homotrypa dawsoni Nicholson....................................... 842

5. Longitudinal section of a specimen from Brookville, Indiana. x 18.

5a. Surface of same. x 6.

Plate XVII.

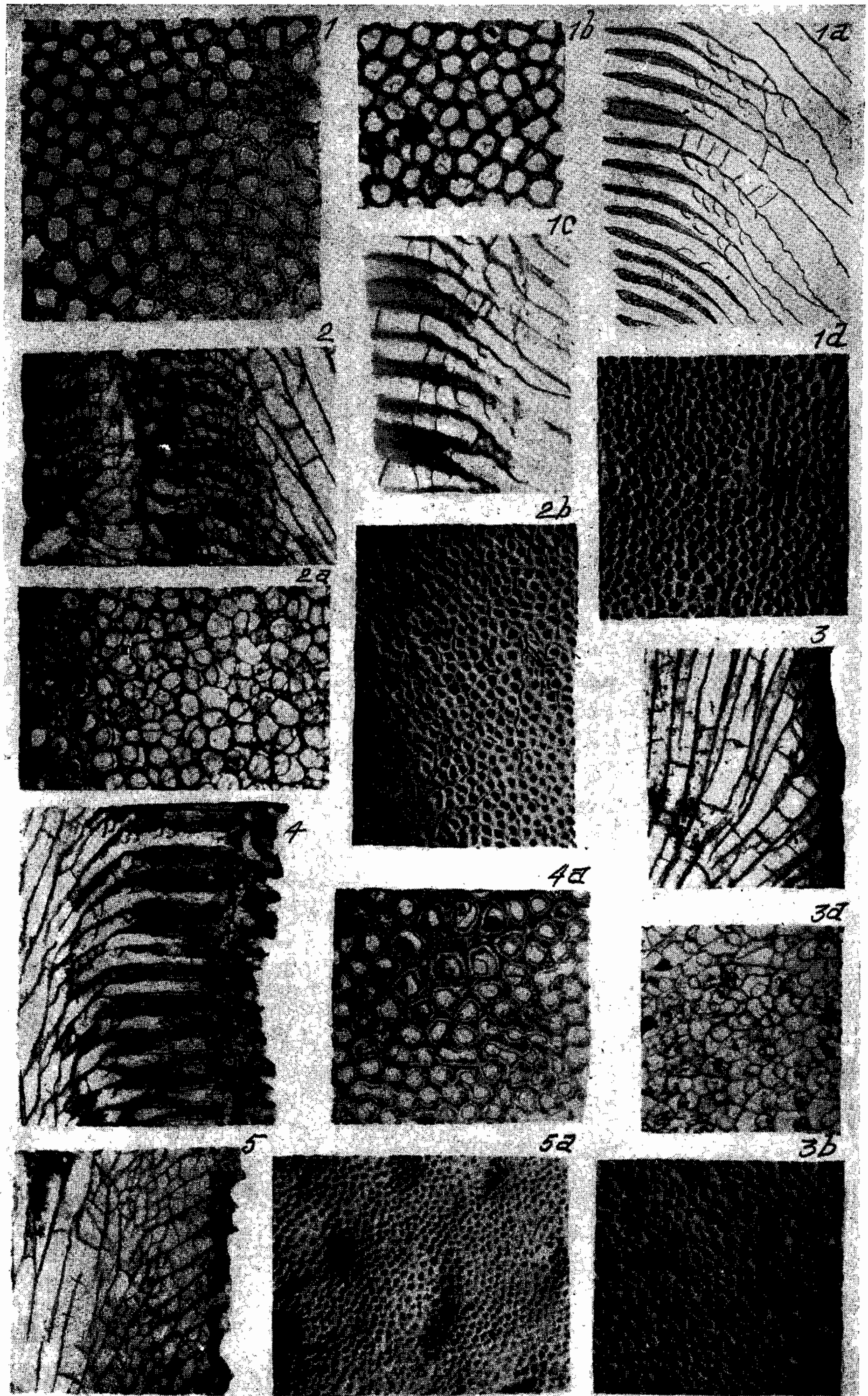

PLATE XVIII.

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Homotrypa flabellaris Ulrich.. 845

1. Longitudinal section of a typical specimen of this species, from the base of the Liberty formation near Weisburg, Indiana. x 18.

1a. Tangential section of same. x 18.

1b. Surface. x 9.

Homotrypa flabellaris var. *spinifera* Bassler......................... 847

2. Tangential section of a specimen of this variety, from the Whitewater division on Elkhorn creek, near Richmond, Indiana. x 18.

Homotrypa flabellaris var. *frondosa* Cumings....................... 846

3. Portion of the surface of the type. x 9.

3a. Tangential section of the same. x 18.

3b. Longitudinal section of the same. x 18.

Homotrypa curvata var. *praecipta* Bassler......................... 841

4. Portion of the surface of a specimen from the base of the Lorraine formation at Manchester Station. x 18.

Homotrypa nitida Bassler.. 848

5. Longitudinal section of the type. x 20. B.

5a. Tangential section of the type. x 20. B.

Homotrypa nicklesi Bassler.. 847

6. Longitudinal section of the type. x 20. B.

6a. Tangential section of the type. x 20. B.

late XVIII.

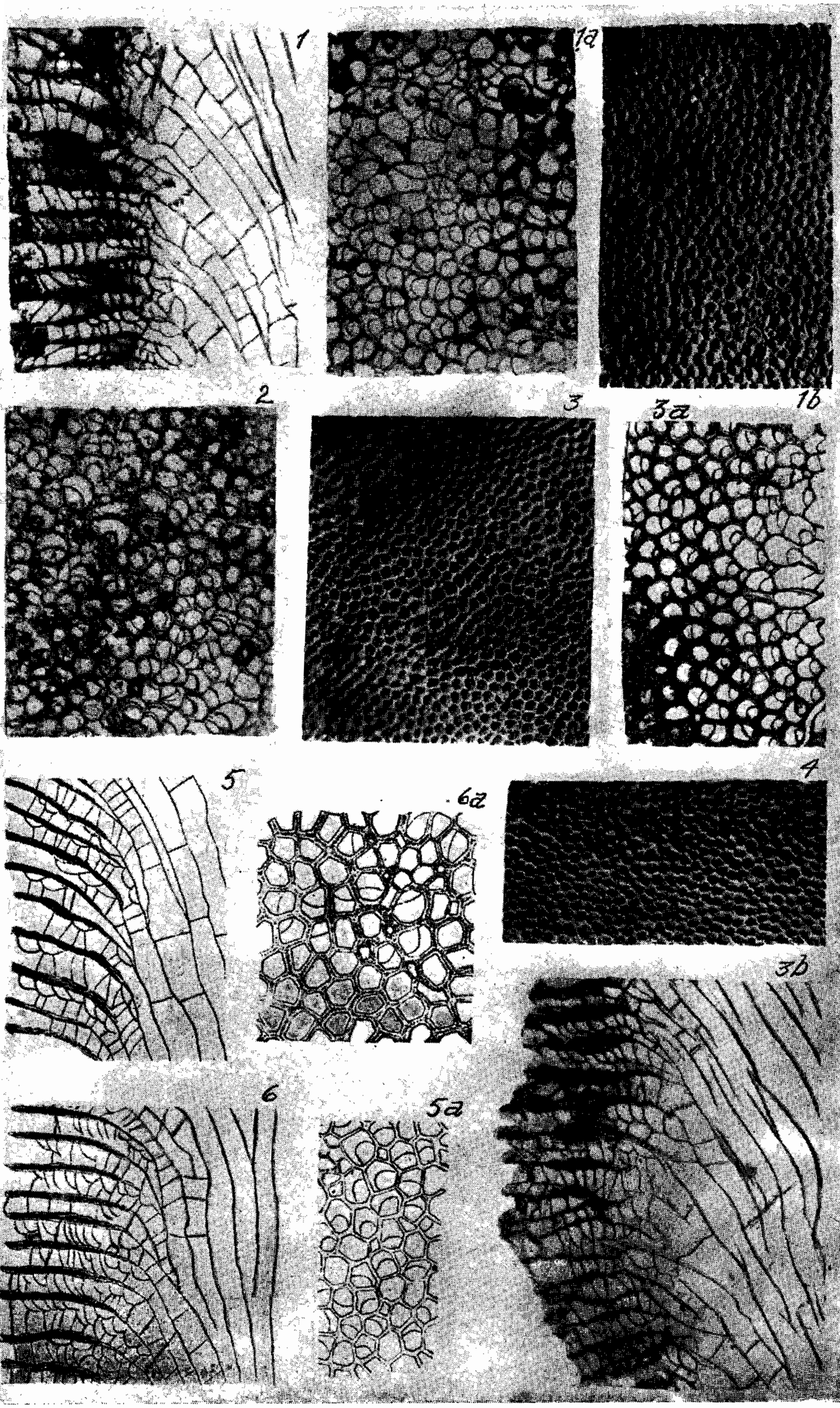

PLATE XIX.

Page

Homotrypa obliqua Ulrich.. 848

1. Tangential section of a specimen from the Lorraine formation at Lawrenceburg, Indiana. x 18.

1a. Longitudinal section of the same specimen. x 18.

1b. Cross section of the same specimen. x 18.

Homotrypa ramulosa Bassler.. 849

2. Longitudinal section. x 20. B.

2a. Portion of a longitudinal section. x 50. N. (This figure is inverted.)

2b. Tangential section. x 50. B.

Homotrypa wortheni James.. 849

3. Longitudinal section. x 20. B.

3a. Longitudinal section of a specimen from the extreme top of the Richmond series at Richmond, Indiana. x 18.

3b. Tangential section. x 20. B.

3c. Portion of a tangential section. x 50. B.

Homotrypa sp.. ——

4. Longitudinal section of a species found in the Liberty formation near Weisburg, Indiana. x 18.

4a. Tangential section of the same specimen. x 18.

Homotrypella cf. *rustica* Ulrich.. 851

5. Longitudinal section of a specimen from the Whitewater division at Richmond, Indiana. x 18.

5a. Tangential section of the same specimen. x 18.

Plate XIX.

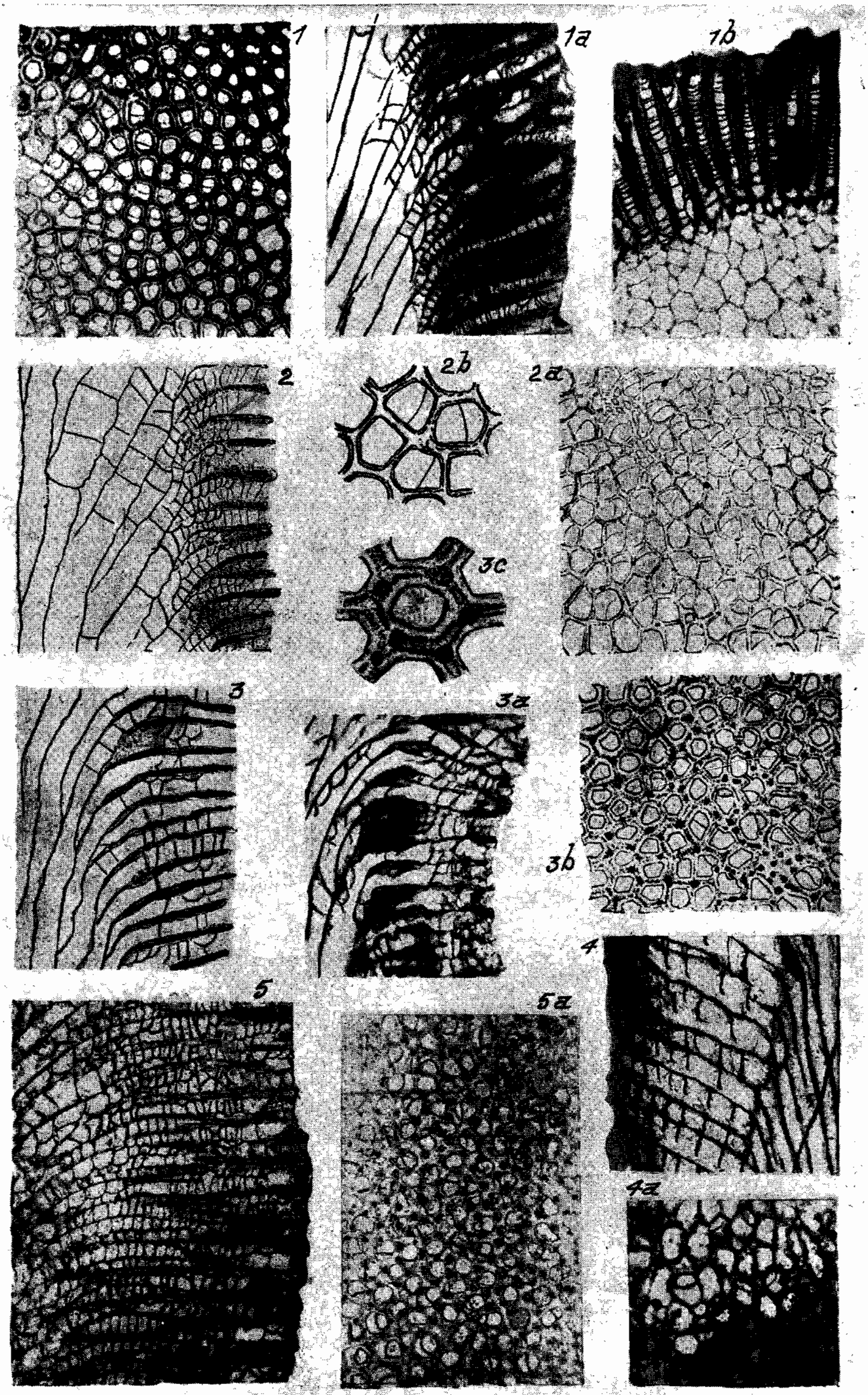

PLATE XX.

Page

Leptotrypa calceola Miller and Dyer.................................... 853

1. Vertical section. x 18. N.

1a. Tangential section. x 18. N.

1b. Portion of the surface. x 18.

1c. Specimen of the entire zoarium, natural size. N.

Leptotrypa discoidea Nicholson.................................... 855

2. Tangential section. x 50. N.

2a. Portion of a longitudinal section. x 50. N. (This figure is inverted.)

2b. Tangential section. x 18. N.

2c. Longitudinal section. x 18. N.

2d-2f. Several views of a complete specimen, natural size. N.

Leptotrypa clavacoidea James.................................... 854

3. Transverse section. x 7. N.

3a. Portion of a tangential section. x 18. N.

3b. Portion of the surface. x 18. N.

3c. An average specimen of the natural size. N.

Monotrypella aequalis Ulrich.................................... 856

4. Longitudinal section of the type. x 18. U.

4a. Tangential section of the type. x 18. U.

4b. Surface of the type. x 18. U.

4c. Tangential section of a specimen from the Utica formation near Guilford, Indiana, which seems to possess the characters of this species. x 18.

Monticulipora epidermata Ulrich and Bassler........................ 857

5. Tangential section of a specimen from the Whitewater division at Richmond, Indiana. x 18.

5a. Tangential section, cutting the fully mature region of another specimen. x 18.

5b. The deeper portion of a longitudinal section of the last. x 18.

5c. Longitudinal section of the specimen of fig. 5. x 18.

Plate XX.

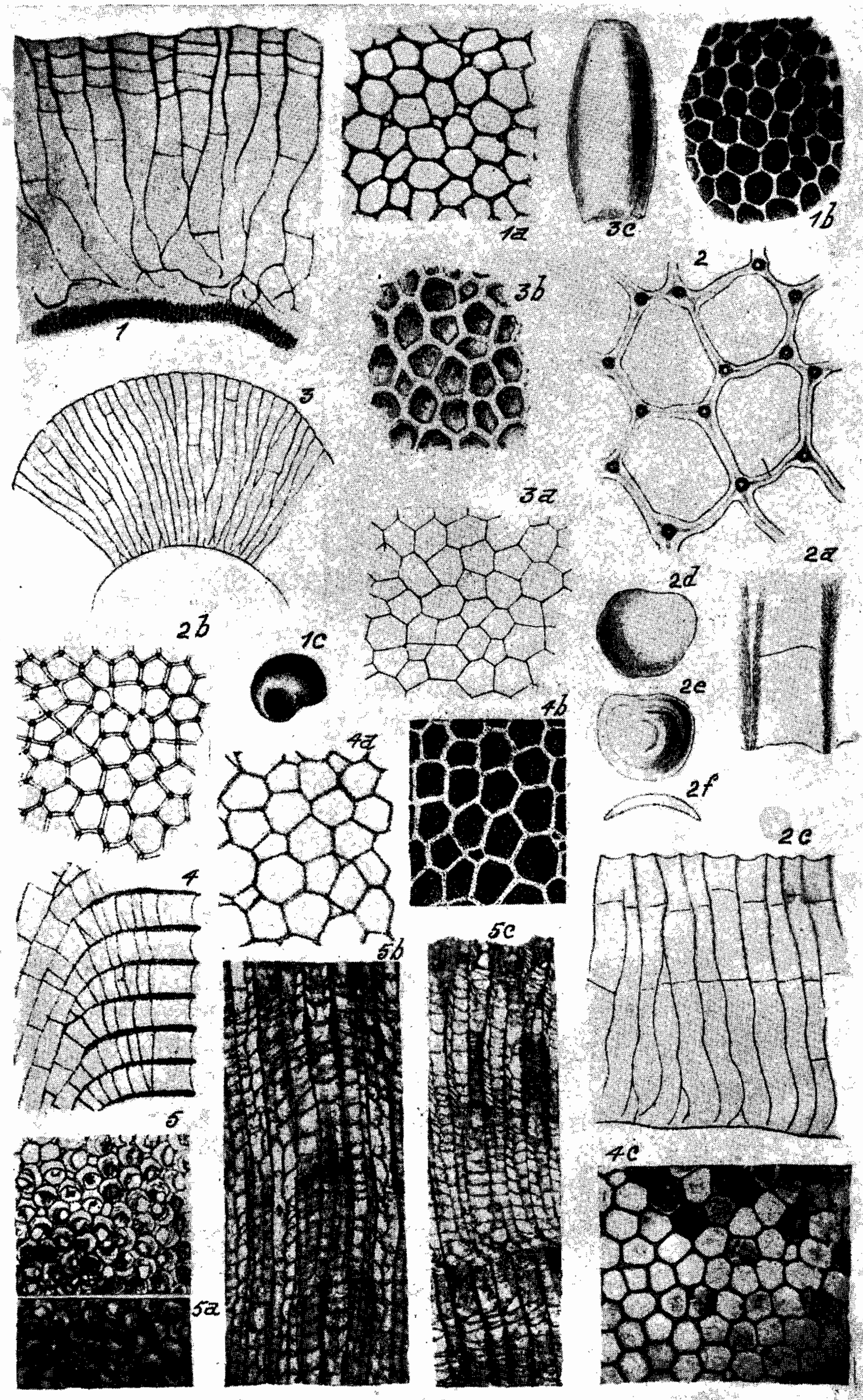

PLATE XXI.

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Monticulipora mammulata d'Orbigny.............................. 859

1. Longitudinal section of the type in the collection of d'Orbigny. x 10. A. P.*

1a. Longitudinal section of a specimen from the Lorraine, at Lawrenceburg, Indiana. x 18.

1b. Tangential section of the same specimen. x 18.

1c. Surface of a specimen from the same locality. x 9.

Monticulipora parasitica Ulrich.................................. 862

2. Vertical section of a specimen from the base of the Liberty formation, near Weisburg, Indiana. x 18.

2a. Tangential section of the same specimen. x 18.

2b. Portion of the surface of the same specimen. x 9.

Nicholsonella vaupeli Ulrich...................................... 863

3. Tangential section of the fully mature region of a specimen from the top of the Waynesville formation near Weisburg, Indiana. x 18.

3a. Deeper section of a specimen from the upper Lorraine at Vevay, Indiana. x 18.

3b. Longitudinal section of a specimen from the same locality. x 18.

3c. Surface of the specimen of fig. 3a. x 9.

Homotrypella cf. *rustica* Ulrich.................................. 851

4. Portion of the surface of this species. x 9.

*Annales de Paleontologie.

Plate XXI.

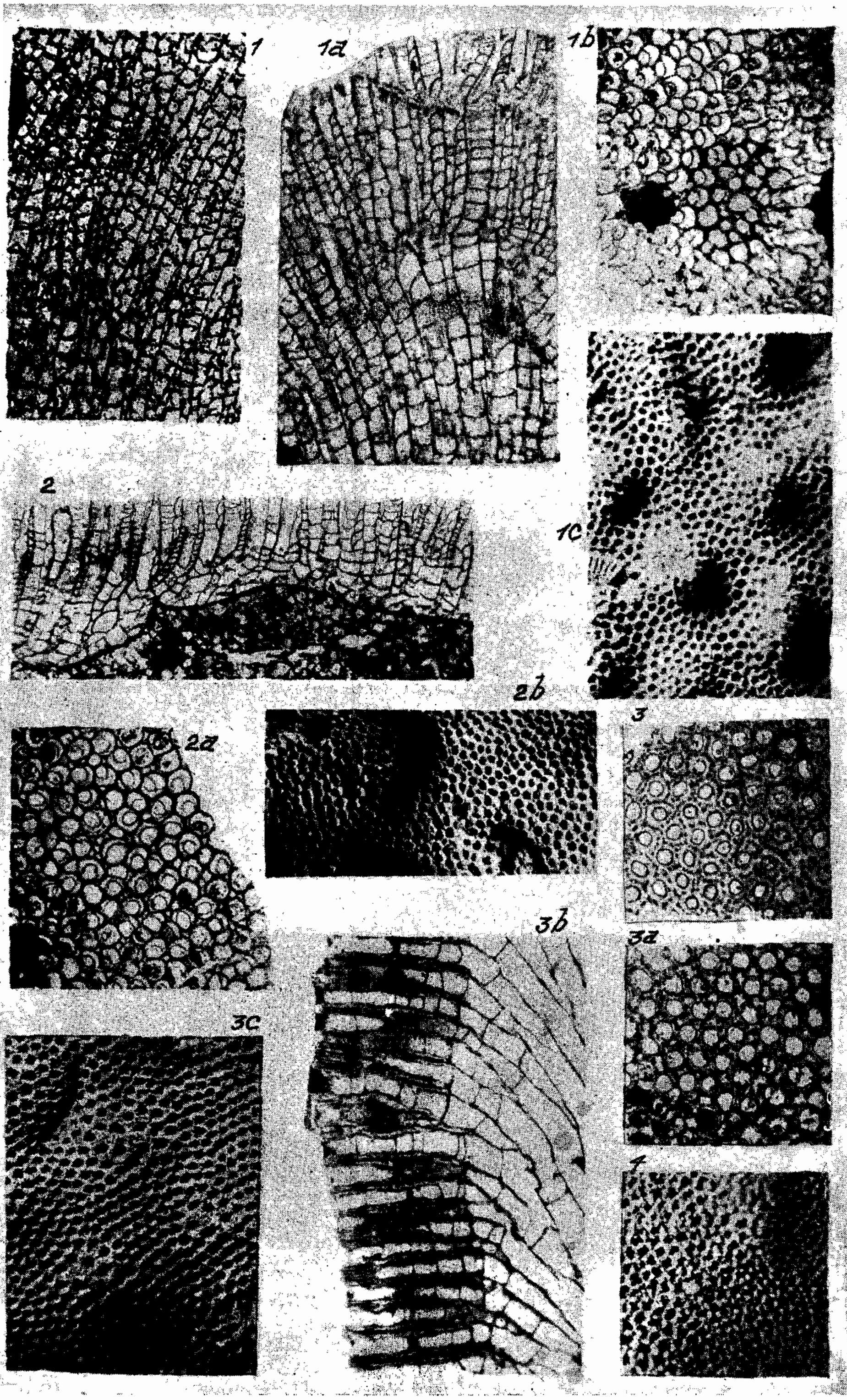

PLATE XXII.

Page

Peronopora pavonia d'Orbigny.. 866

1. Longitudinal section of a specimen from the Lorraine formation at Lawrenceburg, Indiana. x 18.

1a. Tangential section of the same specimen. x 18.

1b. Surface of a large and very perfect specimen from Lawrenceburg, Indiana. x 9.

1c. Longitudinal section of the type in the collection of d'Orbigny. x 10. A. P.

Peronopora vera Nickles.. 867

2. Longitudinal section of a specimen from the Utica formation near Rising Sun, Indiana. x 18.

2a. Tangential section of the same specimen. x 18.

2b. Portion of the surface of same. x 9.

Petigopora asperula Ulrich.. 868

3. Tangential section of the type. x 18. U.

3a. Vertical section. x 18. U.

3b. Surface. x 18. U.

3c. View of an entire specimen, natural size. U.

Petigopora gregaria Ulrich.. 869

4. Tangential section. x 18. U.

4a. Vertical section. x 18. U.

4b. Surface of a specimen. x 18. U.

4c. Several specimens of the natural size. U.

Petigopora petechialis Nicholson.. 870

5. Portion of a frond of *Dekayia frondosa* upon which are several specimens of this species. Natural size. N.

5a. One of the specimens magnified. N.

'late XXII.

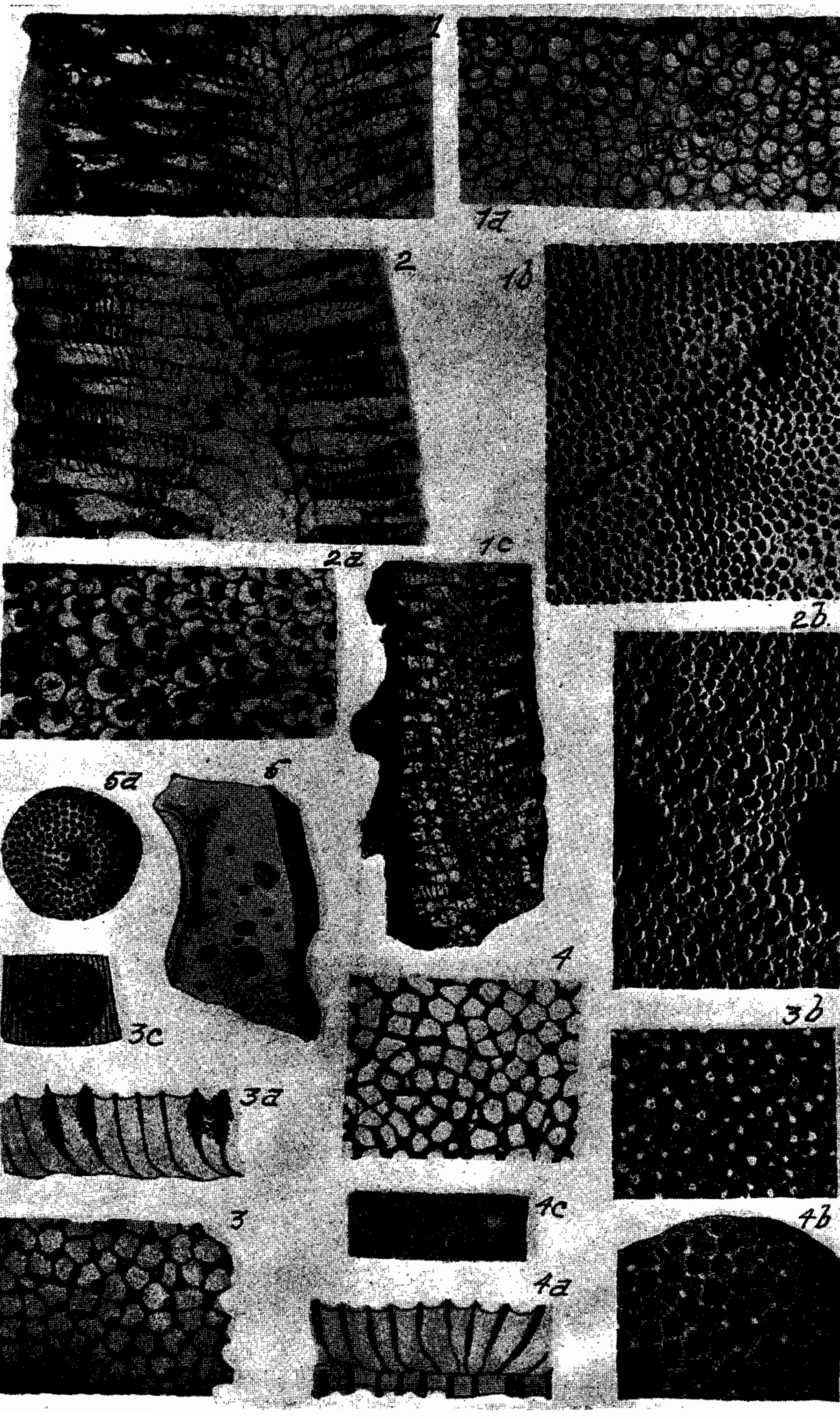

PLATE XXIII.

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Prasopora hospitalis Nicholson.................................... 871

1. Tangential section of a specimen from the top of the Waynesville formation near Weisburg, Indiana. x 18.

1a. Longitudinal section of the same. x 18.

1b. Portion of the surface of another specimen from the same locality and horizon. x 9.

Rhombotrypa crassimuralis Ulrich.................................... 876

2. Longitudinal section of the type. x 18. U.

2a. Tangential section. x 18. U.

2b. Portion of the surface. x 18. U.

2c. Section of a specimen from near the top of the Whitewater division at Richmond, apparently of this species. x 18.

Rhombotrypa subquadrata Ulrich.................................... 877

3. Longitudinal section of this species. x 18. U.

3a. Tangential section. x 18. U.

3b. Portion of the surface. x 18. U.

Rhombotrypa quadrata Rominger.................................... 877

4. Section across the stem of a specimen of this species from the base of the Liberty formation near Weisburg, Indiana. x 18.

4a. Tangential section of another specimen from the same place. x 18.

4b. Portion of the surface of the last. x 9.

Plate XXIII.

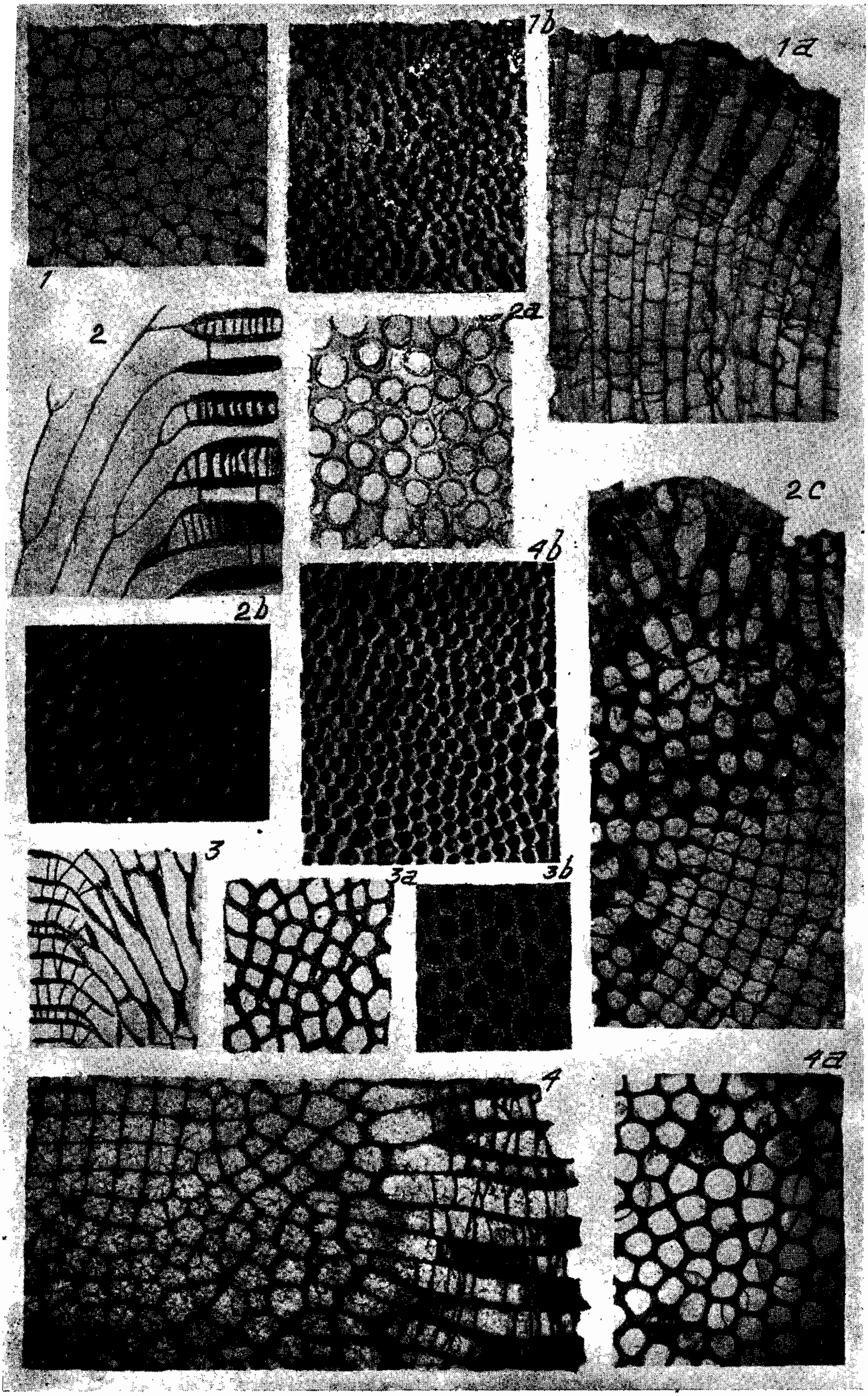

PLATE XXIV.

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Ptilodictya plumaria James.................................... 874

1. Tangential section of a specimen from the Whitewater division at Richmond, Indiana. x 18.

Stigmatella clavis Ulrich.. 881

2. Tangential section of a specimen from Lawrenceburg, Indiana. x 18.

2a. Vertical section of the same. x 18.

Stigmatella personata Ulrich and Bassler.......................... 884

3. Longitudinal section. x 20. U. and B.*

3a. Tangential section of the same. x 20. U. and B.

3b. Portion of a tangential section. x 50. U. and B.

3c. Tangential section of a specimen from the top of the Richmond formation, on Elkhorn creek, near Richmond, Indiana. x 18.

3d. Longitudinal section of the same. x 18.

Stigmatella crenulata Ulrich and Bassler.......................... 882

4. Longitudinal section of this species. x 20. U. and B.

4a. Tangential section. x 20. U. and B.

4b. Portion of a longitudinal section, showing the structure of the walls that characterizes the genus. x 35. U. and B..

4c. Tangential section of a specimen from the top of the Waynesville formation near Abington, Indiana. x 18.

4d. Longitudinal section of the same specimen. x 18.

*Figures after Ulrich and Bassler.

Plate XXIV.

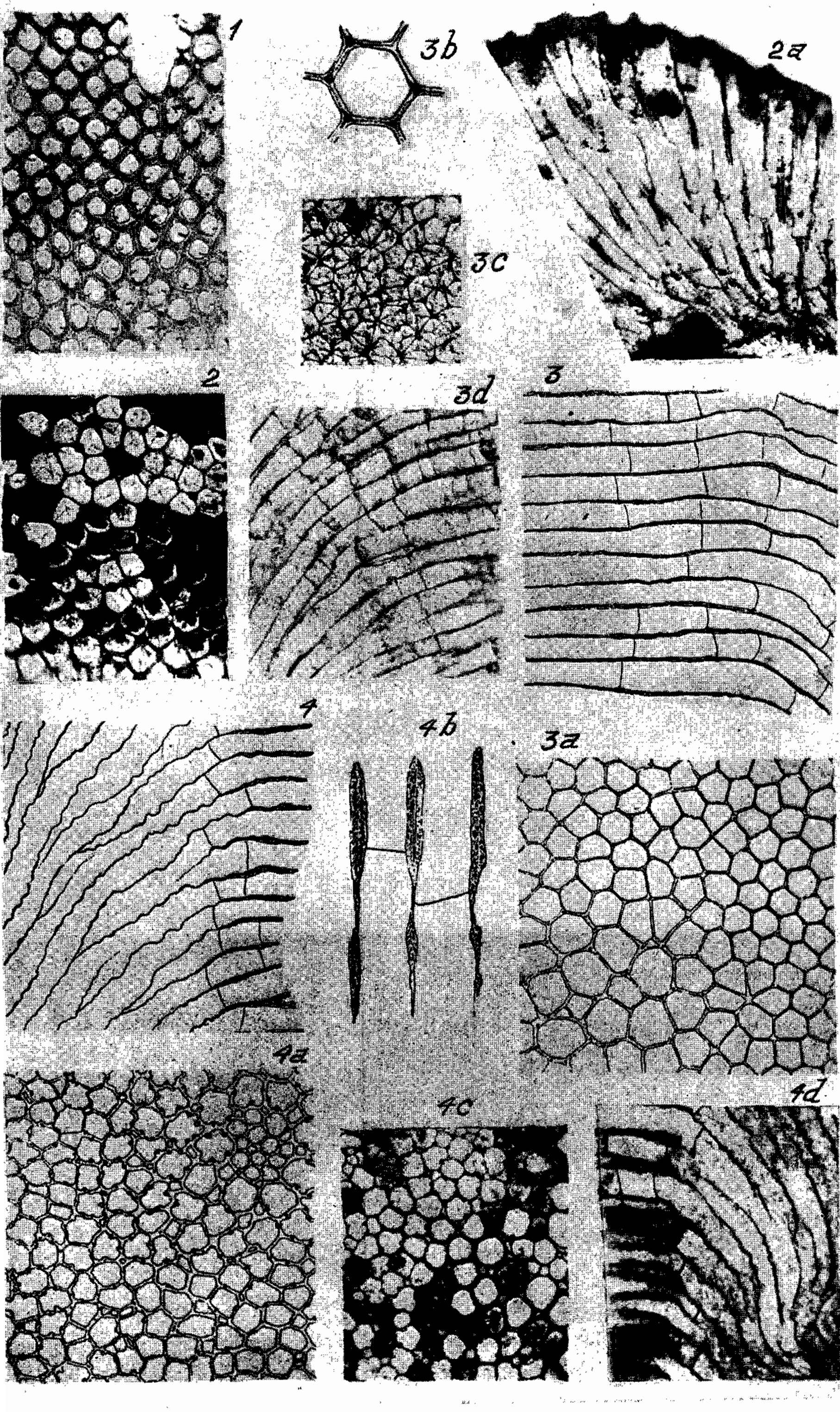

PLATE XXV.

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Stigmatella spinosa Ulrich and Bassler............................ 884

1. Tangential section. x 20. U. B.

1a. Portion of a tangential section. x 50. U. B.

1b. Longitudinal section. x 20. U. B.

1c. Portion of a longitudinal section. x 50. U. B.

1d. A specimen of this species from the Waynesville formation on Tanner's creek. Tangential section. x 18.

Stigmatella irregularis Ulrich.. 883

2. Longitudinal section of this species. x 20. U. B.

2a. Portion of a tangential section. x 50. U. B.

Stigmatella clavis Ulrich.. 881

3. Portion of a tangential section. x 50. U. B.

Amplexopora sp.. ——

4. Longitudinal section of a specimen from the extreme top of the Liberty formation at Weisburg, Indiana. x 18.

4a. Tangential section of the same. x 18.

4b. Longitudinal section of a specimen from a little lower in the Liberty formation near Weisburg. x 18.

4c. Deep tangential section of a specimen of the same species from Richmond, Indiana. x 18.

Rhombotrypa quadrata Rominger................................ 877

5. View of a specimen of this species, natural size. From the top of the Waynesville formation on Tanner's creek, Indiana.

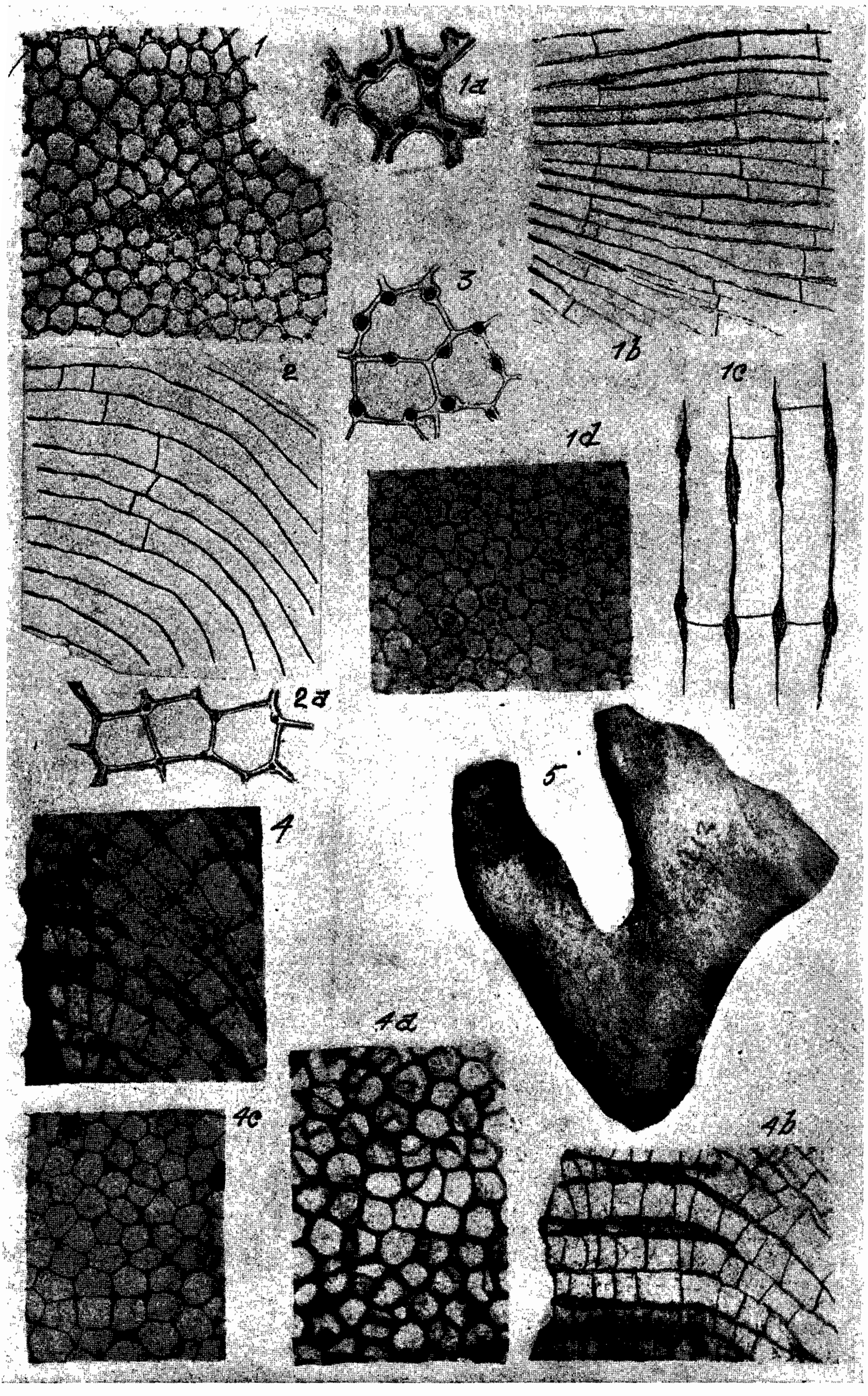
1
1a
1b
1c
1d
2
2a
3
4
4a
4b
4c
5

PLATE XXVI.

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Amplexopora pustulosa Ulrich.................................... 761

1. View of a specimen, natural size. U.

Amplexopora petasiformis Nicholson................................ 760

2. View of a typical specimen, natural size. N.

Amplexopora cingulata Ulrich.................................... 758

3. Specimen from the middle Lorraine at Manchester Station, Indiana.

Amplexopora septosa Ulrich.................................... 763

4. Specimen from the base of the Lorraine, Vevay, Indiana.

Amplexopora septosa, var. *multispinosa* Cumings.................... 765

5. Specimen from the lower Lorraine or upper Utica near Milton, Indiana.

Atactoporella mundula Ulrich.................................... 770

6. Large example of this species growing upon the frond of *Dekayia frondosa*, from Lawrenceburg, Indiana.

Atactoporella newportensis Ulrich................................ 770

7. Typical specimen of this species. U.

Atactoporella ortoni Nicholson................................ 771

11. Portion of the surface of a specimen. x 55.

Arthrostylus tenuis James.................................... 768

8. Reverse of a spécimen. U.

8a. Celluliferous face, enlarged. U.

8b. Cross section of the stem. U.

8c. A zoarium of this species, natural size. U.

Arthropora shafferi Meek.................................... 767

9. A fine example of this species from the base of the Liberty formation near Weisburg. x 18.

Arthropora cleavelandi James.................................... 766

10. A typical example of this species. Cincinnati, Ohio. x 6. B.

Bernicea primitiva Ulrich.................................... 779

12. Portion of the surface. x 18. U.

Batostoma variabile Ulrich.................................... 777

13. A specimen of this species, natural size. U.

Batostoma varians James.................................... 778

14. A specimen from the Richmond formation near Weisburg, Indiana.

Bythopora arctipora Nicholson.................................... 780

15. Specimen natural size. N.

15a. Specimen from the Utica shales at Guilford, Indiana. x 9.

Plate XXVI.

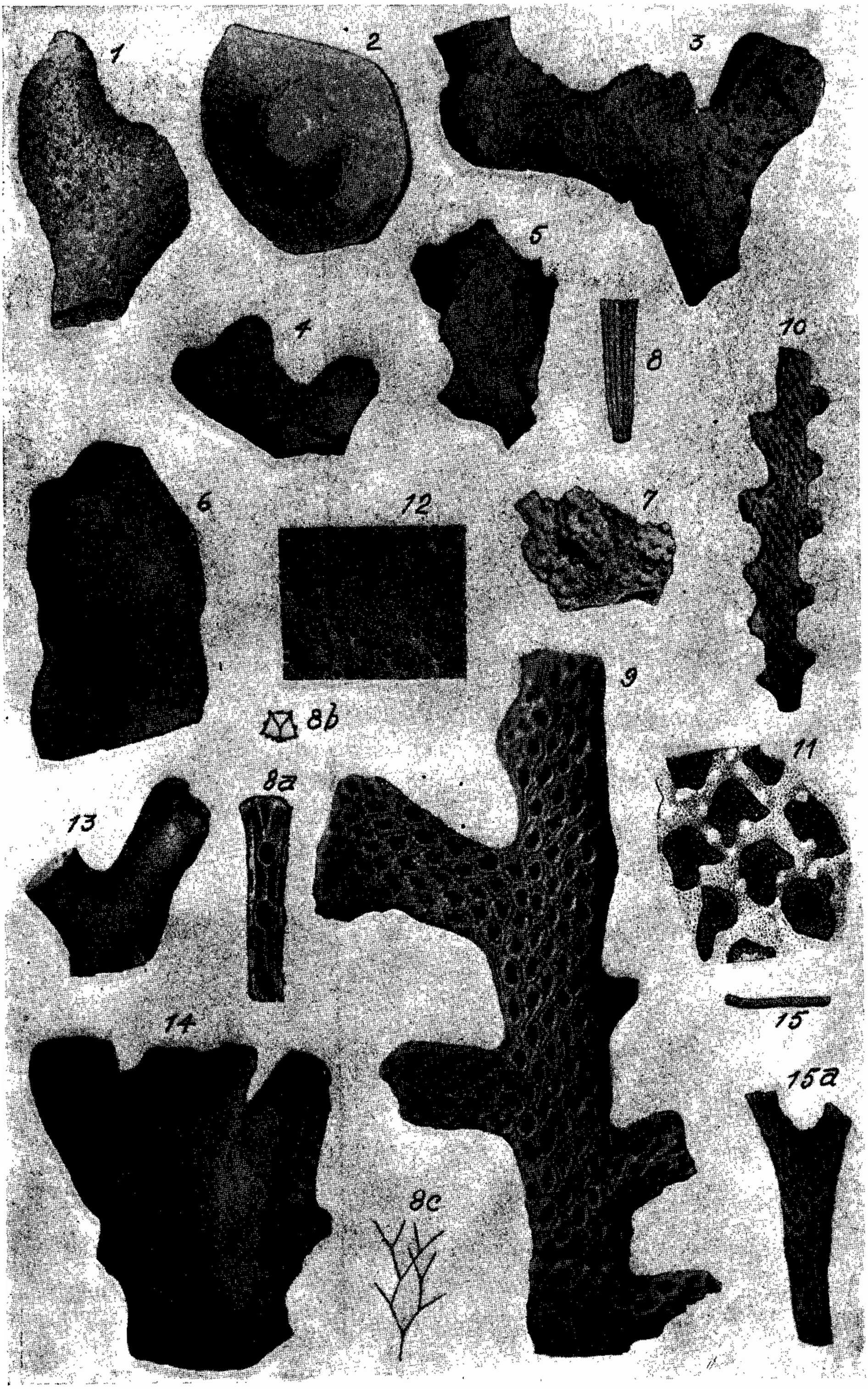

PLATE XXVII.

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Bythopora delicatula Nicholson.................................... 781

1. Typical specimen of this species. N.

Bythopora gracilis Nicholson.................................... 782

2 and 2a. Two typical specimens of this species from the upper part of the Lorraine, near Manchester Station, Indiana.

Bythopora parvula James.................................... 783

3. A specimen from the upper Utica near Guilford, Indiana, apparently belonging to this species. x 9.

Bythopora striata Ulrich.................................... 784

4. A specimen from the base of the Liberty formation near Weisburg, Indiana, which seems to belong to this species. x 18.

Bythopora meeki James.................................... 783

5. A rather small example of this common species from near Weisburg. Indiana.

Batostoma jamesi Nicholson.................................... 775

6. An example of the lobate form of this species. N.

6a. A ramose example from Guilford, Indiana.

Callopora andrewsi Nicholson.................................... 785

7. A good example of this species from Lawrenceburg, Indiana.

Callopora nodulosa Nicholson.................................... 786

8. A typical specimen. N.

Callopora onealli James.................................... 786

9. A specimen from Guilford, Indiana. x 9.

10. A specimen about intermediate in size between typical *C. onealli* and *C. sigillaroides*.

Callopora onealli var. *communis* James.................................... 788

11. A specimen from the Eden shales at Cincinnati. x 1.5. B.

Callopora dalei Edwards and Haime.................................... 792

12. Typical example of this species. N.

Callopora ramosa d'Orbigny.................................... 790

13. Figure of the type in the collection of d'Orbigny. A. P.

13a. Specimen from the Lorraine near Manchester Station, Indiana.

Callopora ramosa var. *rugosa* Edwards and Haime.................. 793

14. Typical example of this species. N.

14a. A specimen in which some of the rugae run almost completely around the stem.

Callopora subplana Ulrich.................................... 795

15. Specimen from Vevay, Indiana. Lorraine formation.

Coelocleina alternatum James.................................... 803

16. Typical specimen of this species. U.


6
2
2a
1
7
8
6a
4
11
9
10
3
13
5
12
14a
13a
18
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17
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22
21
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Page

Coeloclema commune Ulrich.. 804

17. Typical example of this species. U.

Constellaria constellata var. *prominens* Ulrich........................ 806

18. A fragment of the natural size. U.

Constellaria constellata Dana....................................... 804

19. A typical example of this species. U.

Dekayia aspera Edwards and Haime.................................. 810

20. A beautifully preserved specimen of this species in the Redfield collection of the Yale Museum.

Dekayia ulrichi var. *lobata* Cumings................................ 815

21. A subfrondescent example of this variety from the Lorraine at Manchester Station.

Dekayia ulrichi var. *robusta* Foord................................. 826

22. An irregular and imperfectly preserved specimen of this species from the Lorraine at Manchester Station, Indiana.

PLATE XXVIII.

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Constellaria polystomella Nicholson.............................. 808

1. A fine specimen of this species from the base of the Liberty formation near Weisburg, Indiana.

Constellaria limitaris Ulrich.................................... 806

2. A good example of this species from the Liberty formation near Weisburg, Indiana.

Dekayia frondosa var. *cystata* Cumings.......................... 813

3. A typical specimen of this species from Vevay, Indiana.

Dekayia ulrichi var. *lobata* Cumings............................ 815

4. A nearly frondescent form of this variety from Manchester Station, Indiana.

Dekayia pelliculata Ulrich....................................... 818

5. A small specimen of this species from Vevay, Indiana.

Dekayia paupera Ulrich... 817

6. A specimen of this species from Vevay, Indiana.

Dekayia ulrichi Nicholson.. 824

7. A typical example of this species. N.

Dekayia magna Cumings.. 815

8. A specimen of the branching form of this species from Lawrenceburg, Indiana.

Dekayia frondosa d'Orbigny....................................... 812

9. A massive form of this species from Vevay, Indiana.

Dekayia subfrondosa Cumings...................................... 821

10. Figure of the type of this species. From Manchester Station, Indiana.

Dekayia subpulchella Nicholson................................... 822

11. A typical example of this species. N.

Plate XXVIII.

PLATE XXIX.

Page

Dekayia frondosa d'Orbigny.. 812

1. Figure of the type in the collection of d'Orbigny.

Dekayia subramosa Ulrich.. 823

2. Figure of the type. U.

Dekayia prolifica Ulrich.. 820

3. Figure of a beautiful frondescent example of this species from the Liberty formation near Weisburg, Indiana.

Dicranopora fragilis? Nicholson (or *Rhinidictya* sp.)................ —

4. A segment possibly belonging to this species, from the Liberty formation near Weisburg. x 18.

Eridotrypa simulatrix Ulrich.. 828

5 and 5a. Two zoaria of this species of the typical form. U.

Escharopora pavonia Edwards and Haime.. 832

6. A beautifully preserved specimen of this species from the Lorraine at Manchester Station, Indiana.

Fenestella granulosa Whitfield.. 835

7. Reverse of a specimen of this species from the Liberty formation near Weisburg, Indiana. x 9.

7a. Obverse of another specimen from the same place. x 9.

Graptodictya perelegans Ulrich.. 836

8. Portion of the surface of this species. x 18. U.

Helopora elegans Ulrich.. 837

9. A typical example of this species. The natural size is shown in the small figure to the left. U.

Helopora harrisi Ulrich.. 837

10. A segment of this species. Natural size shown in the small figure to the right. U.

10a. Portion of the segment still further magnified. U.

10b. Cross section of a segment. U.

Homotrypa austini Bassler.. 838

11. Figure of a typical specimen of this species. B.

11a. Another specimen. B.

Homotrypa communis Bassler.. 839

12. A typical specimen of this species from the base of the Liberty formation near Weisburg, Indiana.

Homotrypa curvata Ulrich.. 840

13. A well preserved example of this species from Vevay, Indiana.

Homotrypa cylindrica Bassler.. 842

14. A typical specimen of this species. B.

Plate XXIX.

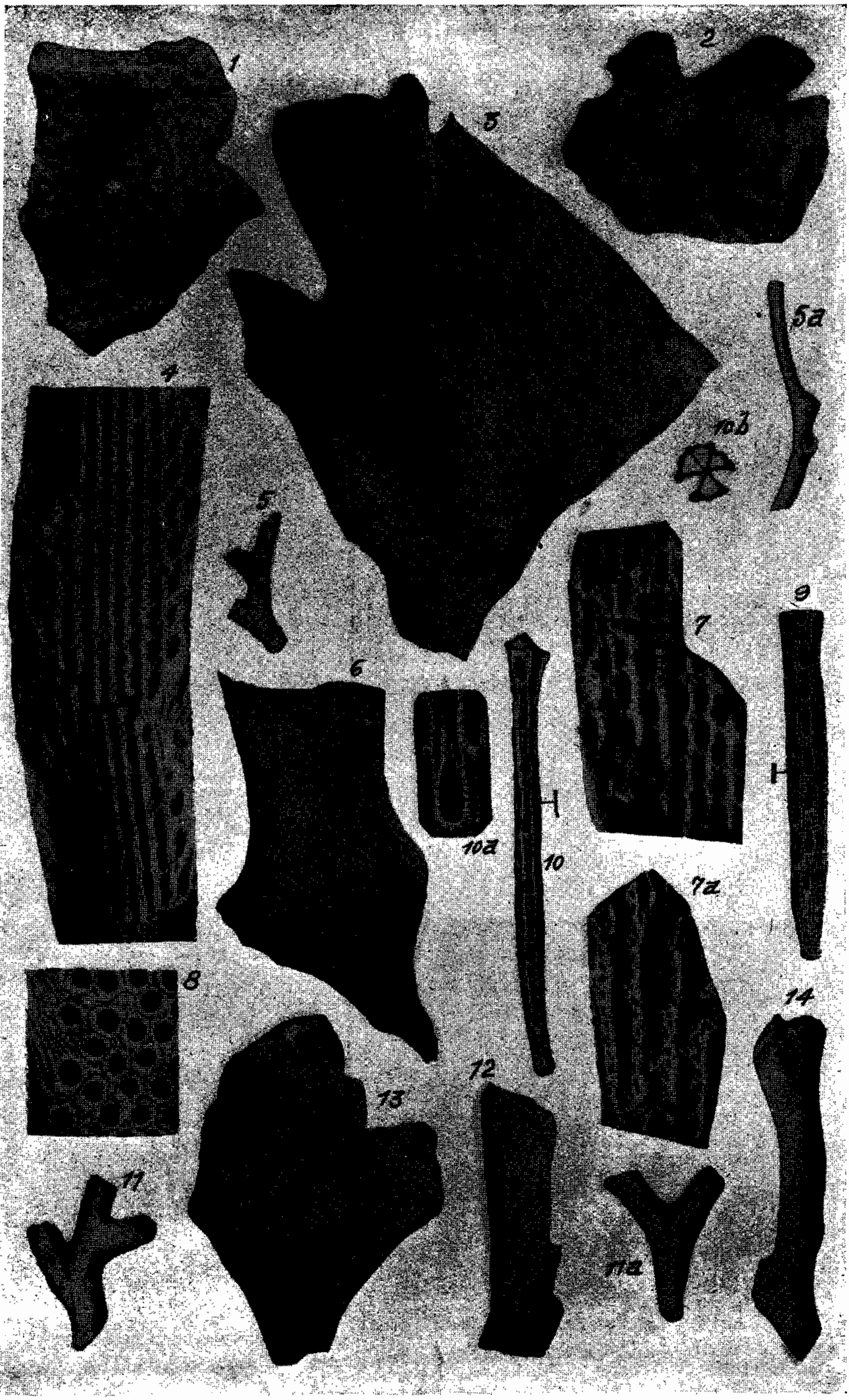

PLATE XXX.

Page

Homotrypa dawsoni Nicholson.................................... 842

1. A large and beautifully preserved specimen of this species from Brookville, Indiana.

Homotrypa flabellaris Ulrich.. 845

2. A typical example of this species from the base of the Liberty formation near Weisburg, Indiana. The photograph fails to show the very low and inconspicuous monticules.

Homotrypa flabellaris var. *frondosa* Cumings........................ 846

3. A fine specimen of this variety from the Arnheim formation near Harmon's Station, Indiana. This is the type of the variety.

Homotrypa nicklesi Bassler.. 847

4. Typical example of this species. B.

Homotrypa nitida Bassler.. 848

5 and 5a. Two examples of the typical form of this species. B.

Homotrypa obliqua Ulrich.. 848

6. A specimen of this species from the Lorraine at Lawrenceburg, Indiana.

Homotrypa curvata var. *praecipta* Bassler......................... 841

7. A specimen of this variety from the base of the Lorraine at Manchester Station, Indiana.

7a. A view of one of the types. B.

Homotrypa ramulosa Bassler.. 849

8. A view of the type. B.

Homotrypa wortheni James.. 849

9. View of a specimen from Richmond, Indiana. B.

Homotrypa wortheni var. *prominens* Bassler........................ 851

10. View of a typical example. B.

Homotrypella cf. *rustica* Ulrich.................................... 851

11. View of a specimen of this species from the Whitewater division at Richmond, Indiana.

Monticulipora epidermata Ulrich and Bassler....................... 857

12. View of a medium sized example of this abundant species from the Whitewater division at Richmond, Indiana.

Plate XXX.

PLATE XXXI.

Page

Monticulipora mammulata d'Orbigny............................. 859

1. From a photograph of the type in the collection of d'Orbigny. A. P.

1a. A specimen of the more massive form of the species from the Lorraine at Lawrenceburg, Indiana.

Monticulipora parasitica Ulrich............................. 862

2. A specimen of this species growing on a specimen of *Streptelasma rusticum*. From the base of the Liberty formation near Weisburg, Indiana.

Nicholsonella vaupeli Ulrich............................. 863

3. A finely preserved specimen of this species from the Lorraine at Vevay, Indiana.

Peronopora pavonia d'Orbigny............................. 866

4. Photograph of the type in the collection of d'Orbigny. A. P.

4a. A large and very beautiful specimen from Brookville, Indiana, in which the maculae are elevated very slightly into low monticules.

Peronopora vera Nickles............................. 867

5. A fragment of the zoarium of this species from near Rising Sun, Indiana.

Prasopora hospitalis Nicholson............................. 871

6. A small but typical specimen of this common species from the base of the Liberty formation near Weisburg, Indiana.

Rhopalonaria venosa Ulrich............................. 879

7. A specimen from Weisburg, Indiana. x 2.

7a. A portion of the type. x 3. U.

Plate XXXI.

PLATE XXXII.

Page

Stomatopora inflata Hall.. 886

1. View of a typical specimen enlarged. The natural size shown below in the small figure. N.

1a. Several zooecia still further enlarged. N.

Stomatopora arachnoidea Hall.................................. 885

2. Portion of a zoarium considerably enlarged to show the form of the zooecia. N.

2a. A zoarium growing on the stem of a species of Trepostomata. Natural size. N.

2b. The same enlarged. N.

2c. A specimen from the Eden shale at Guilford, Indiana, apparently belonging to this species, though more slender and with wider spacing of the zooecia than shown in Nicholson's figures. x 9.

Proboscina frondosa Nicholson.................................. 873

3. Portion of a zoarium, enlarged. N.

3a. Small portion of a zoarium, still further enlarged to show the shape of the zooecia. N.

3b. Small portion of a zoarium of this species (?) from Guilford, Indiana. x 9.

Proboscina auloporoides Nicholson............................... 872

4. Portion of a zoarium enlarged. N.

4a. Small portion of a zoarium still further enlarged to show the form of the zooecia. N.

5. A few branches of this species associated with a *Stomatopora*. Versailles, Indiana. x 9.

Ptilodictya plumaria James...................................... 874

6. Basal portion of a frond of this species. U.

Rhinidictya lata Ulrich... 875

7. Part of a zoarium, natural size. U.

7a. Portion of the surface. x 18. U.

Rhinidictya parallela James..................................... 875

8. View of the type. x 6. B.

Spatiopora maculosa Ulrich...................................... 879

9. Portion of the surface of the type, showing one of the maculae of larger zooecia. x 18. U.

Spatiopora tuberculata Edwards and Haime........................ 880

10. Portion of the surface of the type enlarged. E. and H.*

Cornulites flexuosa Hall 1067

11. A specimen referred to this species from the base of the Lorraine formation near Manchester Station, Indiana. x 18.

*Figure after Edwards and Haime.

Plate XXXII.

Page

Cornulites sp. .... ——

12. A specimen of a species common on *Dekayia frondosa* and other Bryozoa.

Dicranopora emacerata Nicholson 827

13. A specimen of this species enlarged. Natural size shown in small figure to right. N.

13a. Cross section of stem enlarged. N.

13b. Portion of branch still further enlarged. N.

PLATE XXXIII.

Page

Catazyga headi Billings.. 896

1. Ventral view. M.

1a. Dorsal view. M.

1b. Profile view. M.

1c. Anterior view. M.

Crania laelia Hall.. 897

2. Several specimens of this species on the shell of a Strophomena. M.

Crania scabiosa Hall... 898

3. A group of examples of this species on the shell of Rafinesquina alternata. M.

3a. Specimen from the Waynesville formation at Versailles, Indiana, showing several examples of this species on the shell of Rafinesquina.

Dalmanella testudinaria var. *multisecta* Meek...................... 901

4. Ventral valve of a specimen from the upper Eden shales at Guilford, Indiana.

4a. Dorsal view of a specimen from the same locality.

4b. Interior of the dorsal valve.

4c. Interior of the ventral valve.

Dalmanella testudinaria var. *emacerata* Hall........................ 898

5. Dorsal valve. H. and C.

5a. Interior of the dorsal valve enlarged. H. and C.

Dalmanella testudinaria var. *meeki* Miller.......................... 899

6. Interior of the dorsal valve of a specimen of this species from Minnesota. H. and C.

6a. Interior of the ventral valve. M.

6b. Interior of the dorsal valve. M.

6c-6f. Various views of a number of examples of this species from Madison, Indiana.

6g. View of a portion of a slab from Versailles, Indiana, showing the great abundance of this species in the Waynesville formation.

Dinorthis retrorsa Salter.. 902

7. Ventral view of a very perfect specimen. M.

7a. Dorsal view. M.

7b. Profile view. M.

7c. Interior of the ventral valve of a large individual. M.

7d. Portion of the surface enlarged. M.

Plate XXXIII.

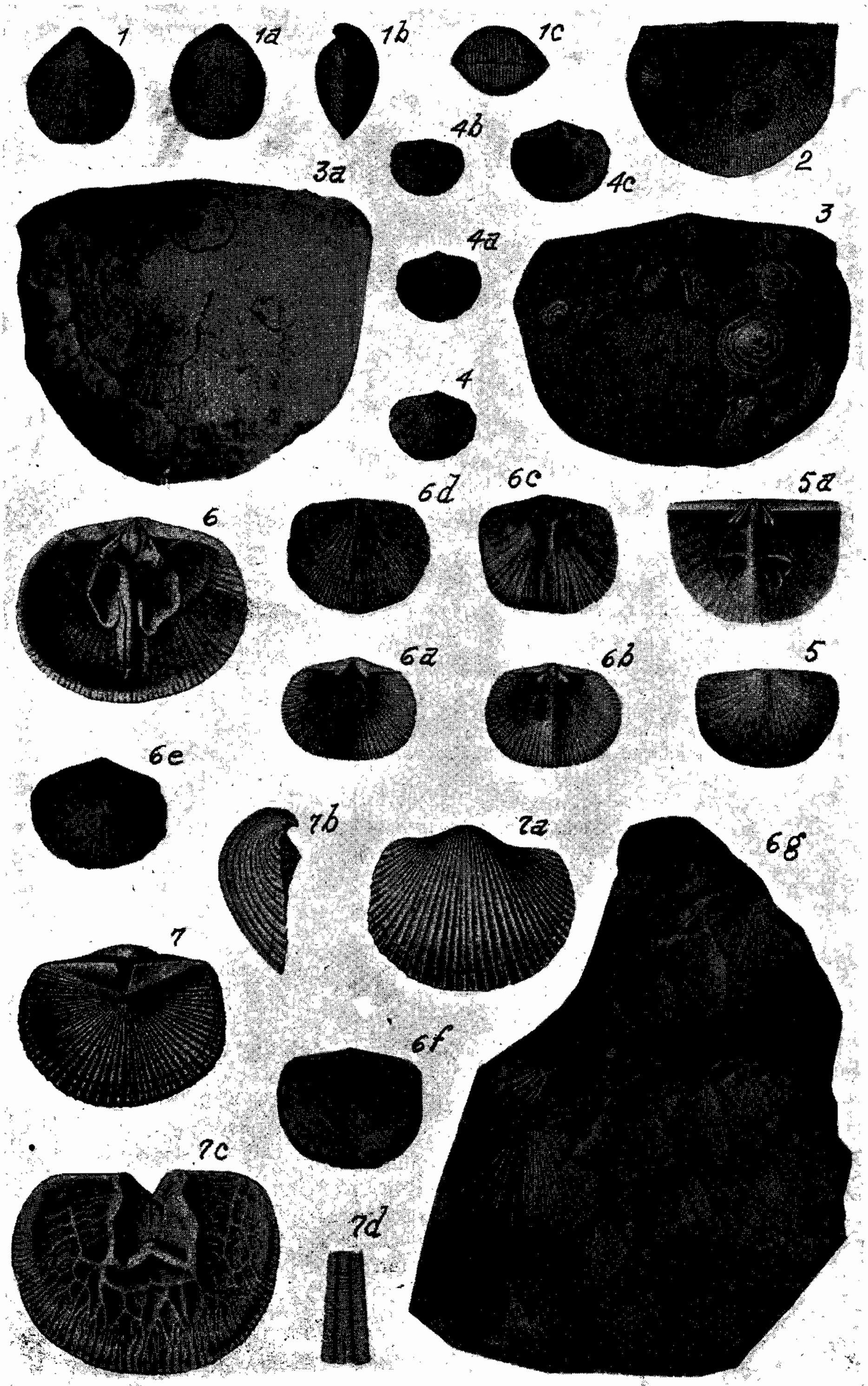

PLATE XXXIV.

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Dinorthis subquadrata Hall 904

1. Dorsal view of a specimen from Oxford, Ohio. H. and C.

1a. Posterior view. H. and C.

1b. Interior of the ventral valve. H. and C.

Hebertella insculpta Hall 905

2. Dorsal valve of a specimen of this species from Weisburg, Indiana.

2a. Ventral view.

2b. Posterior view.

2c. Interior of the dorsal valve.

2d. Interior of the ventral valve.

Hebertella occidentalis var. *sinuata* Hall 908

3. Ventral view of a specimen from the Waynesville formation at Versailles, Indiana.

3a. Dorsal view of a smaller specimen.

3b. Anterior view.

3c. Posterior view.

3d. Interior of the ventral valve of a specimen from Weisburg,Indiana.

3e. Interior of the dorsal valve of a specimen from Vevay, Indiana (Lorraine).

Hebertella occidentalis Hall 906

4. Dorsal view of a specimen from Richmond, Indiana, showing the sinus in the dorsal valve.

Leptaena rhomboidalis Wilckens 909

5. Ventral view of a specimen from Versailles, Indiana.

5a. Interior of the ventral valve of a specimen from the same locality.

5b. Interior of the dorsal valve of a specimen of the so-called variety *tenuistriata* Meek. M.

5c. Portion of the surface enlarged. M.

5d. Section of the two valves united. M.

Leptobolus lepis Hall 911

6. Interior of the ventral valve. H. and W.

6a. Interior of the dorsal valve. H. and W.

Lingula covingtonensis Hall and Whitfield 911

7. View of the exterior of the ventral (?) valve, from a gutta-percha cast. H. and W.

Schizocrania filosa Hall 933

8. Enlarged view of an upper valve. H. and W.

8a. Enlarged view of the ventral valve. H. and W.

Trematis millepunctata Hall 943

9. Dorsal view of a specimen from Cincinnati, Ohio. H. and W.

9a. Ventral side of the same specimen. H. and W.

9b. Interior of a ventral valve. H. and W.

9c. Profile view. H. and W.

Trematis reticularis Miller 944

10. View of the type. M.

Plate XXXIV.

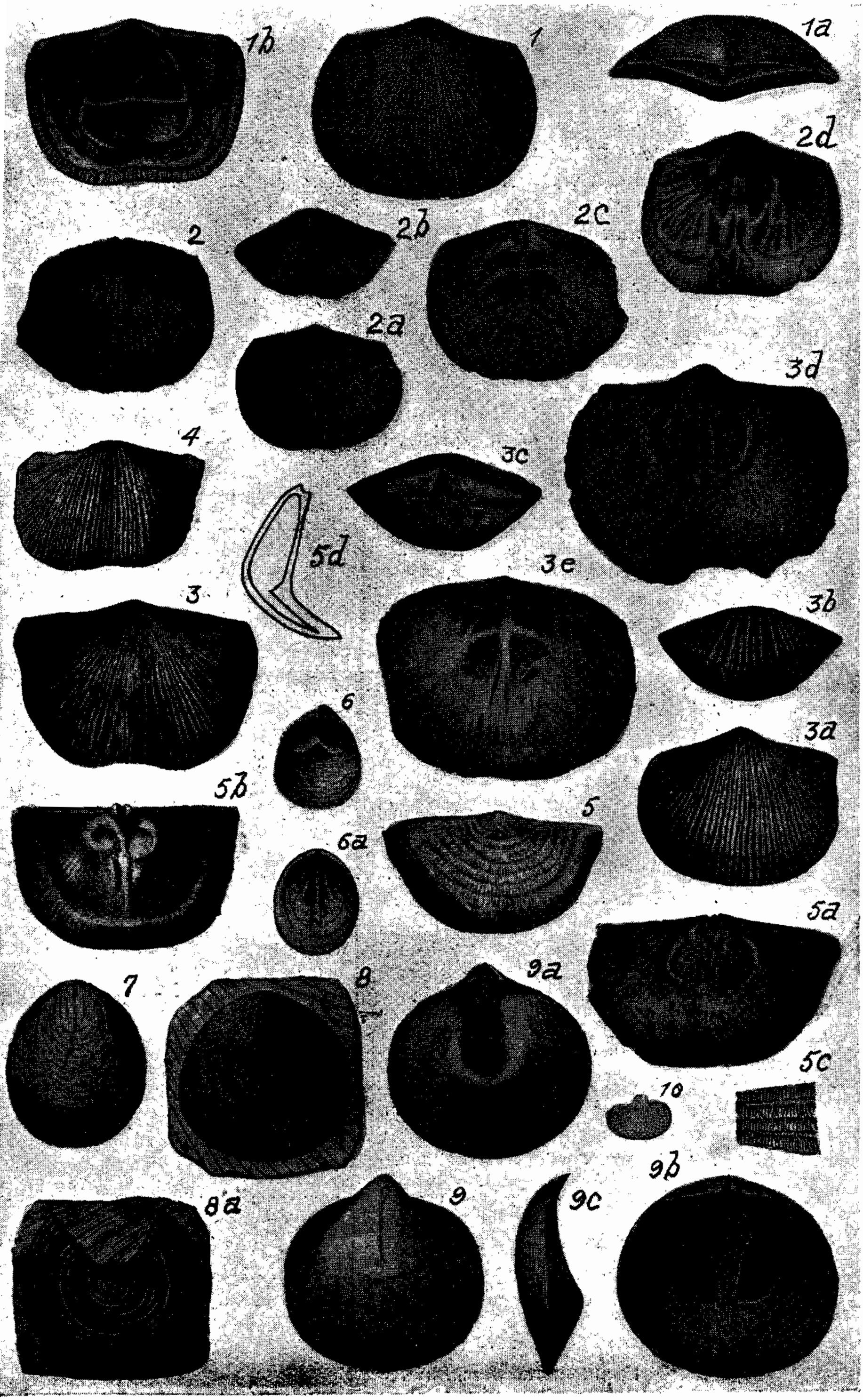

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PLATE XXXV.

Page

Platystrophia lynx Eichwald.................................... 914

1. A specimen of the normal type from the middle part of the Lorraine at Vevay, Indiana.

1a. A somewhat more gibbous specimen from the same locality, anterior view.

1b. Posterior view of the same.

1c. Profile view of a similar specimen.

1d. Interior of the ventral valve, showing the deeply impressed muscular pit.

1e. Interior of the dorsal valve.

1f. Outline drawing of a specimen from the "Lynx" beds of Cincinnati. This is the gerontic form of the species, found in the top of the Lorraine, at Cincinnati.

1g. Ventral view of the same.

Platystrophia lynx var. *laticosta* Meek............................ 918

2. Ventral view of a specimen from the base of the Liberty formation at Versailles, Indiana.

2a. Dorsal view of a similar specimen.

2b. Ventral view of a larger and somewhat more acuminate specimen from the same locality.

Platystrophia acutilirata Conrad................................. 912

3. A specimen of this species from Weisburg, Indiana, intermediate in form between *P. laticosta* and the typical *P. acutilirata.*

3a. A similar, though somewhat larger form from Versailles, Indiana.

3b. A more extended form from Richmond, Indiana.

3c. A very much extended form from Richmond.

3d. A similar form from Versailles, Indiana.

Platystrophia acutilirata var. *senex*.............................. 913

4. A specimen of this form from the Whitewater division at Richmond, Indiana.

4a. A specimen from the same locality, which is still shorter on the hinge-line.

4b. Profile of another specimen showing the extreme incurvature of the beaks, and the exceptional gibbosity.

4c. A section of the same to show the great thickening of the shell.

Platystrophia lynx var. *moritura*................................ 920

5. Ventral view of a specimen from Elkhorn creek, near Richmond, Indiana.

5a. Dorsal view of a larger specimen.

Platystrophia costata Pander...................................... 914

6. Ventral view of a specimen of this species from Cincinnati, Ohio.

6a. Anterior view of the same specimen.

Platystrophia lynx (nepionic stage)............................. 914

7. Dorsal view of a young specimen 1 mm. in breadth, from Vevay, Indiana. x 22.

7a. Ventral view of same. x 22.

7b and 7c. Profile of the dorsal and ventral valves respectively. x 22

Plate XXXV.

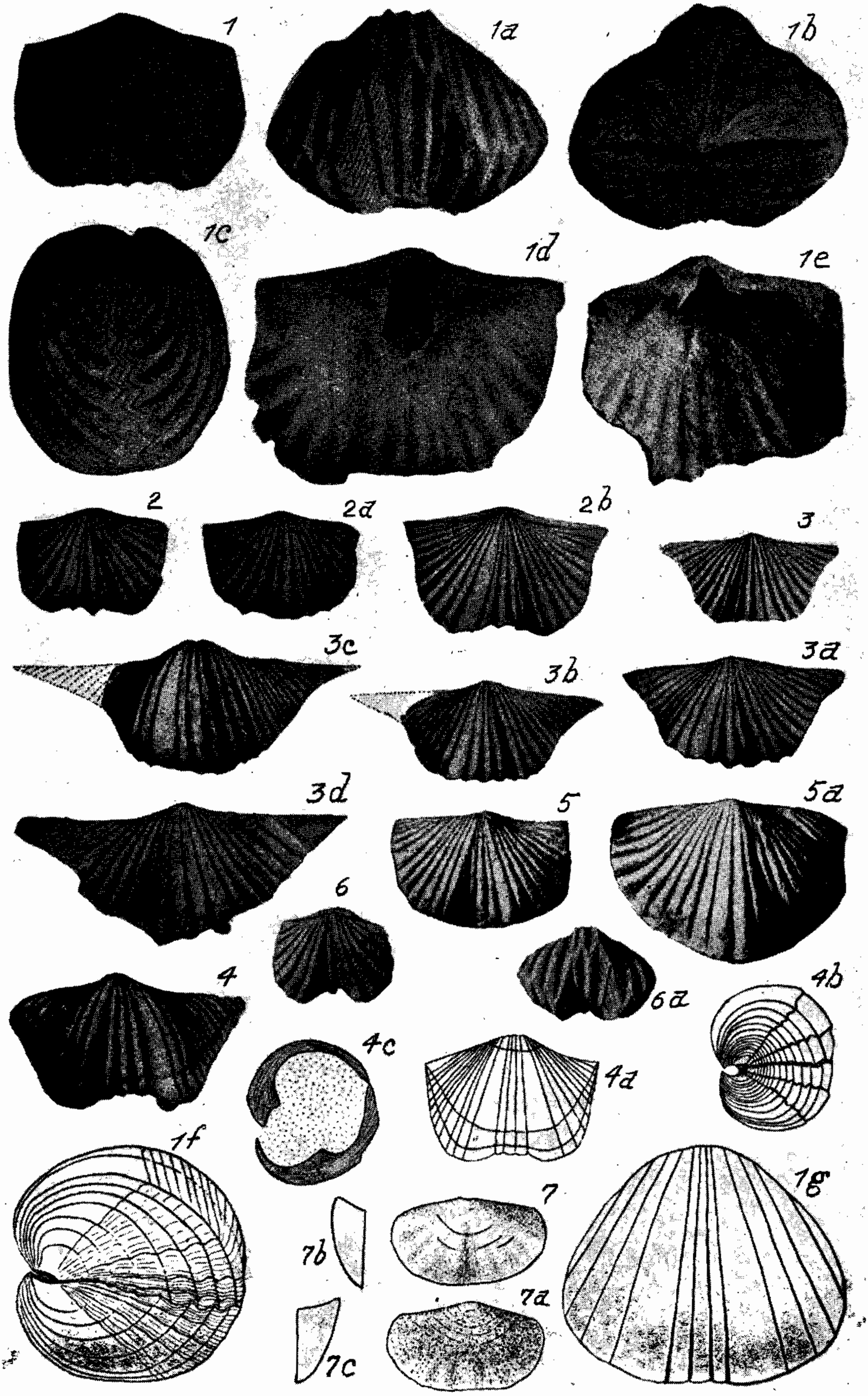

PLATE XXXVI.

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Plectambonites sericeus Sowerby.............................. 922

1. Photograph of a portion of a slab from the base of the Liberty formation at Versailles, Indiana, showing the abundant occurrence of this species at that horizon.

1a. View of the interior of the dorsal valve of a specimen. x 1.5. M.

1b. Interior of the ventral valve. x 1.5. M.

1c. Dorsal view. x 1.5. M.

Plectorthis ella Hall.. 924

2-2c. Dorsal, anterior, posterior and profile views of this species. M.

Plectorthis plicatella Hall.. 925

3-3d. Profile, anterior, posterior, dorsal and ventral views of this species. M.

3e. Dorsal view of a form intermediate between this species and the var. *triplicatella*. M.

3f. Interior of the dorsal valve of same. M.

Plectorthis plicatella var. *triplicatella* Meek........................ 925

4. Profile view. M.

4a. Dorsal view. M.

4b. Portion of the surface enlarged. M.

Retzia granulifera Meek.. 930

5. Ventral view. M.

5a. Dorsal view. M.

5b. Profile view. M.

5c. Portion of the surface enlarged to show the granules. M.

Rhynchotrema capax Conrad...................................... 931

6. Dorsal view of an adult specimen. M.

6a. Ventral view of same. M.

6b. Profile view of a large, somewhat gibbous specimen. M.

6c. Anterior view of the same specimen as 6. M.

6d. Interior of the dorsal valve. M.

6e. Interior of the ventral valve. M.

6f. Ventral view of an unusually broad specimen from Weisburg, Indiana.

6g. Ventral view of an unusually narrow specimen from Weisburg, Indiana.

6h. Profile of a very gibbous specimen from Richmond, Indiana.

Rhynchotrema dentata Hall.. 932

7. Dorsal view. M.

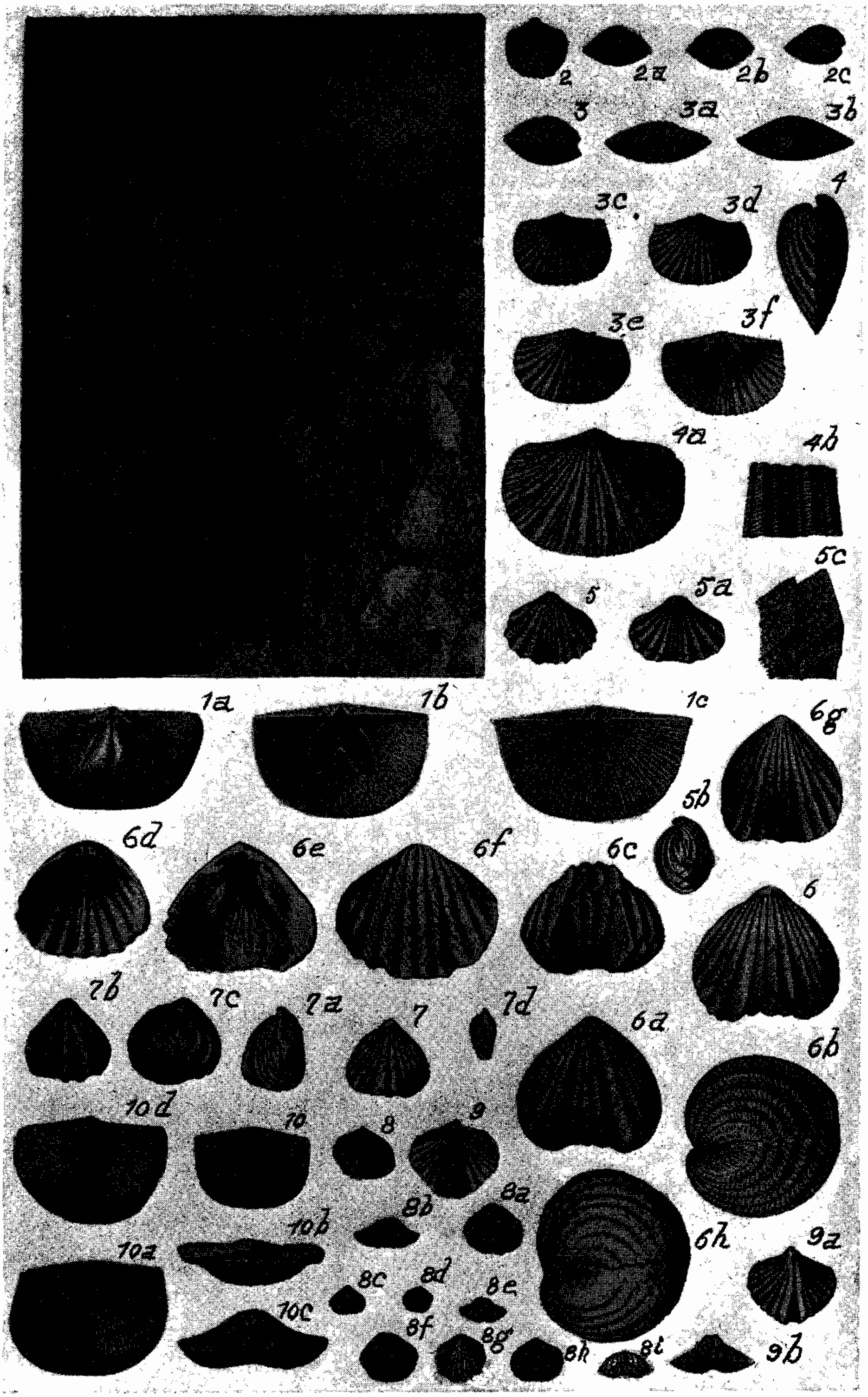
7a. Profile view. M.

7b. Ventral view of a normal specimen from the Whitewater division at Richmond, Indiana.

7c. Profile view of an unusually gibbous specimen from the same locality and horizon.

7d. Profile view of a young specimen from the same locality.

Plate XXXVI.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Zygospira modesta Hall.. 946

8-8b. Ventral, dorsal and anterior views of a number of specimens of the normal size from Lawrenceburg, Indiana.

8c-8d. Dorsal and ventral views of two small specimens. Same locality.

8e, 8f and 8h. Posterior, ventral and dorsal views of other specimens from the same locality.

8g. Ventral view. M.

8i. Anterior view. M.

Zygospira cincinnatiensis Meek.................................. 945

9-9b. Dorsal, ventral and anterior views of this species. M.

Strophomena sulcata Verneuil.................................. 942

10. Dorsal view of a rather small specimen. M.

10a. Ventral view of a larger individual. M.

10b. Posterior view. M.

10c. Anterior view. M.

10d. Ventral view of a specimen from the Whitewater division at Richmond, Indiana.

PLATE XXXVII.

Page

Rafinesquina alternata Emmons.................................... 926

1. Dorsal view of a rather narrow specimen, resembling exactly in outline the var. *fracta*, but with much more massive shell. Weisburg, from the Liberty formation.

1a. Ventral view of a very large, flat form from the lower Richmond at Versailles, Indiana.

1b. View of the type specimen figured by Emmons. E.*

1c. Interior of the ventral valve of the normal form of the species. M.

1d. Profile of a very thin specimen from the lower Richmond at Versailles, Indiana.

1e. Portion of the surface of No. 1a enlarged.

Rafinesquina alternata var. *loxorhytis?*............................. 928

2. Dorsal view of a specimen from Weisburg, Indiana (base of the Liberty formation) that has the general form of this variety.

2a. Profile of a similar specimen from Versailles, Indiana.

Rafinesquina alternata var. *ponderosa*.............................. 929

3. Dorsal view of a specimen from the Lorraine at Lawrenceburg, Indiana.

3a. Interior of the dorsal valve of a similar specimen from the same place.

Rafinesquina alternata var. *nasuta* Conrad.......................... 928

4. Ventral view of an example of this variety. M.

Rafinesquina alternata var. *fracta* Meek............................ 927

5. Dorsal view of a large specimen. M.

5a. Section of the two valves showing the depressed form. M.

*Figure after Emmons.

Plate XXXVII.

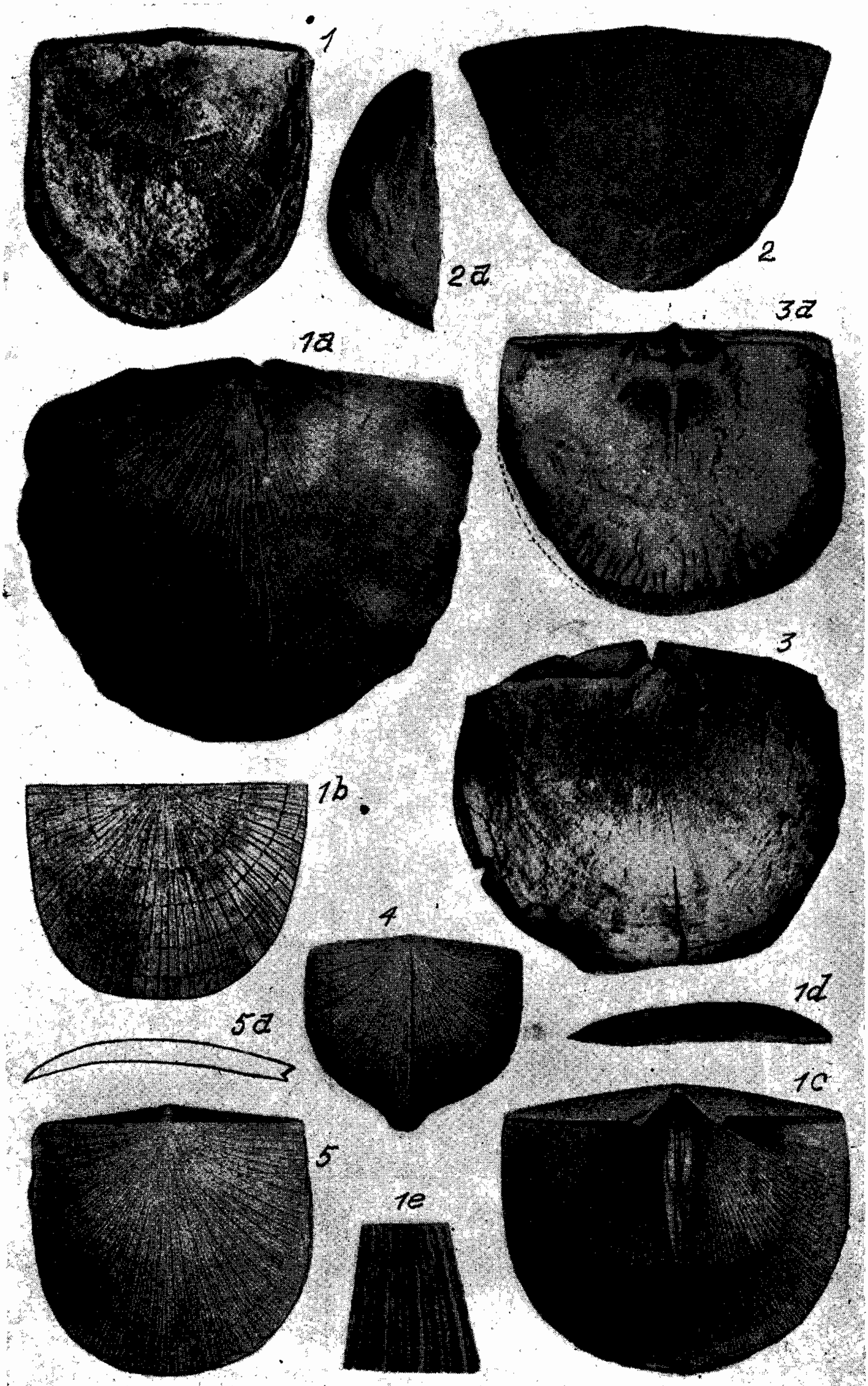

PLATE XXXVIII.

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Strophomena neglecta James? 934

1. Interior of the dorsal valve. M.
1a. Interior of the ventral valve. M.
1b. Dorsal valve. M.

Strophomena sinuata Meek 941

2-2c. Posterior, anterior, dorsal and ventral views of this species. M.
2d. Interior of the ventral valve. M.
2e. Interior of the dorsal valve. M.

Strophomena planoconvexa Hall 938

3-5b. Dorsal, ventral and posterior views of this species. M.
3c. Interior of the ventral valve. M.
3d. Interior of the dorsal valve. M.
3e. Section through the two valves. M.

Strophomena planumbona Hall 939

4. Dorsal view of this species. M.
4a. Interior of the ventral valve. M.
4b. Interior of the dorsal valve. M.
4c. Section of the two valves. M.
4d. Portion of the surface enlarged. M.

Strophomena nutans Meek 936

5. Ventral view. M.
5a. Interior of the ventral valve. M.
5b. Section of the two valves. M.
5c. Portion of the surface enlarged. M.

Strophomena planumbona var. *subtenta* Hall 940

6. Ventral view of this species. M.
6a. Interior of the ventral valve. M.
6b. Interior of a ventral valve of this variety (?) from Weisburg, Indiana.
6c. Dorsal view of another specimen from the same place.
6d. Section of the two valves. M.
6e. Portion of the surface enlarged. M.
6f. Dorsal view of another specimen.
6g. Posterior view. M.

Plate XXXVIII.

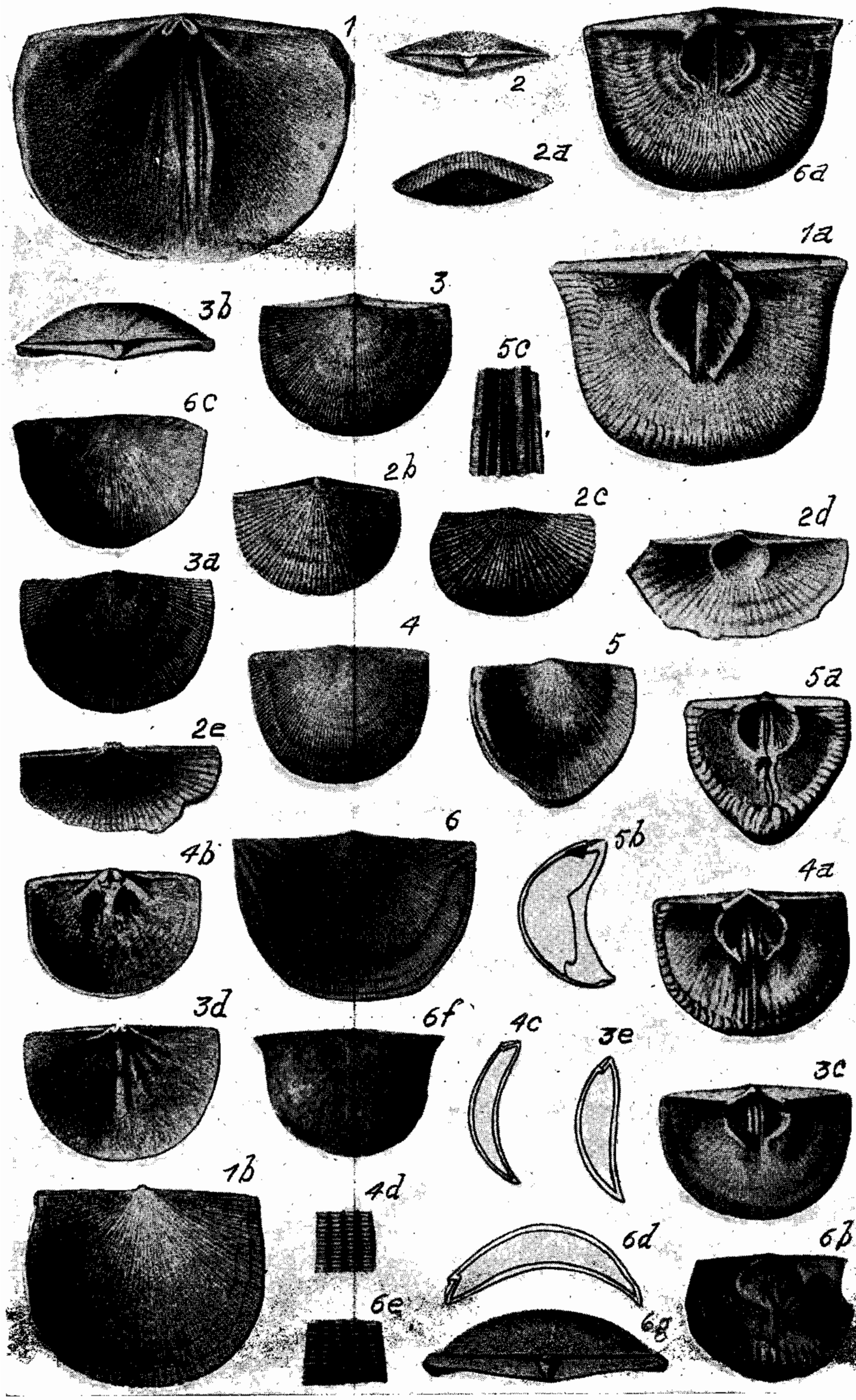

PLATE XXXIX.

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Bellerophon gorbyi Miller 953

1-1b. Three views of the type. Miller.

Bellerophon mohri Miller 954

2-2a. Apertural and side views of specimens from Richmond, Indiana. U.

Bellerophon subangularis Ulrich 954

3-3b. Three views of the type. From Richmond, Indiana. U.

Bucania crassa Ulrich 955

4-4b. Three views of the type. From Richmond, Indiana. U.

Protowarthia subcompressa Ulrich 972

5-5b. Three views of the type from the Richmond formation at Versailles, Indiana. U.

Protowarthia cancellata Hall 971

6-6a. Two views of a rather small cast of the interior of a small specimen from the Trenton of Minnesota. U.

6b. Surface of a specimen from the Utica (Eden) formation at Covington, Ky. x 4.5 and 9. U.

Salpingostoma richmondensis Ulrich 974

7-7a. Two views of a nearly complete cast of the interior from Richmond, Indiana. U.

Conradella dyeri Hall 957

8-8a. Side views of two specimens enlarged to show the surface markings. M.

8b. Apertural view in outline. M.

8c. Portion of the surface still further enlarged. U.

Conradella dyeri var. *cellulosa* Ulrich .... ——

9. Surface of this variety enlarged. U.

Tryblidium madisonense Miller 977

10. Side view of this species. Miller.

Tryblidium indianense Miller 977

11. Top view of the type of this species. Miller.

'late XXXIX.

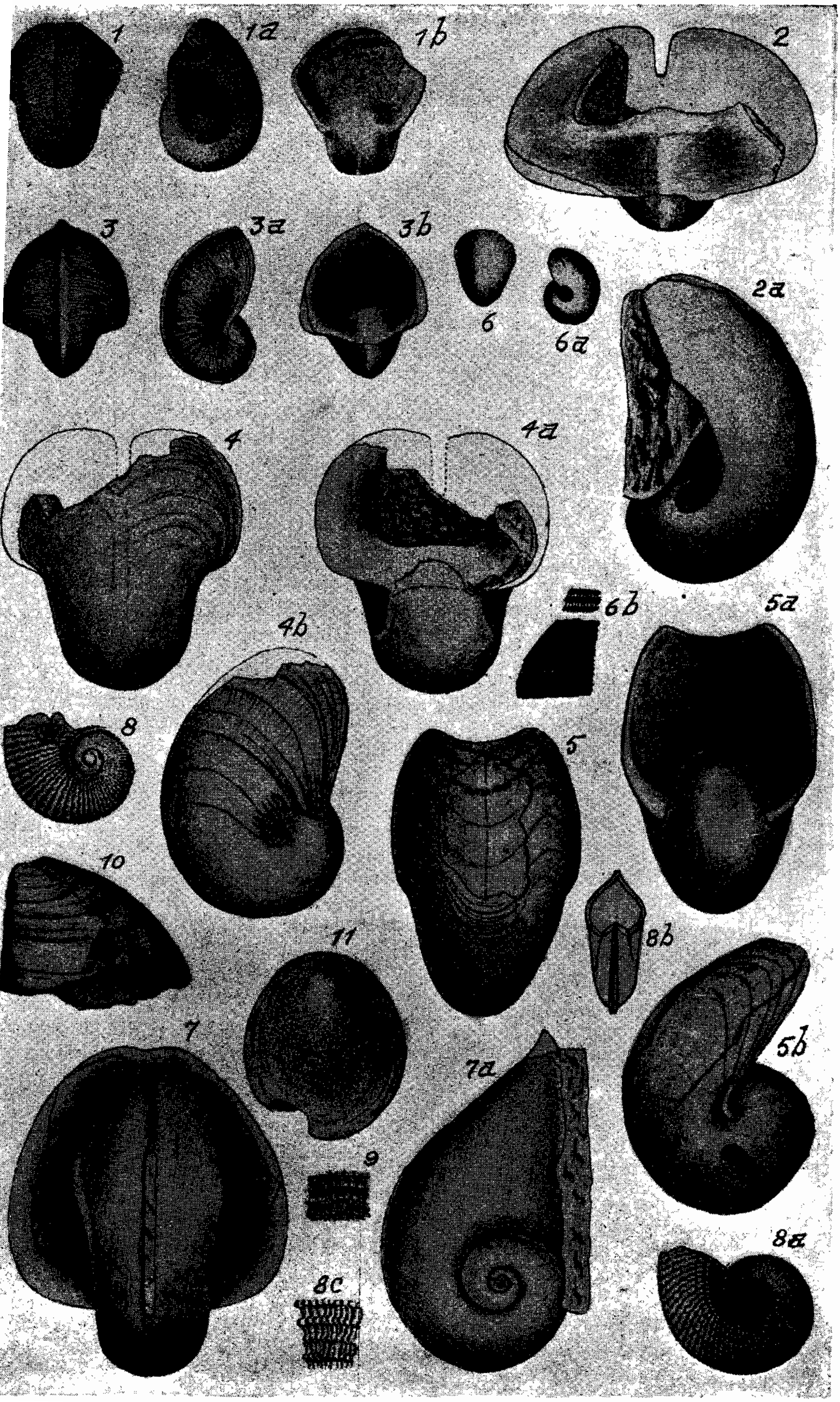

PLATE XL.

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Salpingostoma expansum Hall 973

1-1b. Three views of the type specimen, from the Trenton of New York. Hall.

Cyclonema bilix Conrad 958

2 and 2c. Two specimens of the form called var. *conicum* by Miller. U.

2d. Dorsal view of a rather large example from Versailles, Indiana. U.

2a. A smaller specimen from Waynesville, Ohio. U.

2b. Dorsal view of a specimen from Clarksville, Ohio. U.

Cyclonema bilix var. *fluctuatum* James 959

3. Dorsal view of a perfect specimen of this form from Versailles, Indiana. U.

3a and 3b. Two views of the apex of the same. x 5. U.

Cyclonema mediale Ulrich 960

4a. Dorsal view of a specimen from Covington, Ky. U.

4. Under side of another specimen from Covington. U.

Cyclonema humerosum Ulrich 960

5 and 5b. Two views of a typical specimen from Cincinnati, Ohio. U.

5a. A large and strongly marked specimen of the Richmond formation variety of this species from Waynesville, Ohio. U.

5c. Apertural view of a form abundant at Cincinnati, Ohio. U.

Cyclora minuta Hall 961

6-6c. Four views of typical examples of this minute species. x 6. M.

Cyclora pulcella Miller 962

7-7b. Three views of the type from Versailles, Indiana. x about 8. Miller.

Cyrtolites ornatus Conrad 962

8. Side view of a gutta-percha cast from a natural mold. M.

8a. Portion of the surface of the same magnified. M.

Microceras inornatus Hall 970

9. Side view. x 6. M.

9a. Apertural view. x 6. M.

Helicotoma marginata Ulrich 963

10. Top view of a specimen from the extreme upper part of the Richmond formation at Richmond, Indiana. Below is shown the profile in outline. U.

Holopea (?) *hubbardi* Miller 964

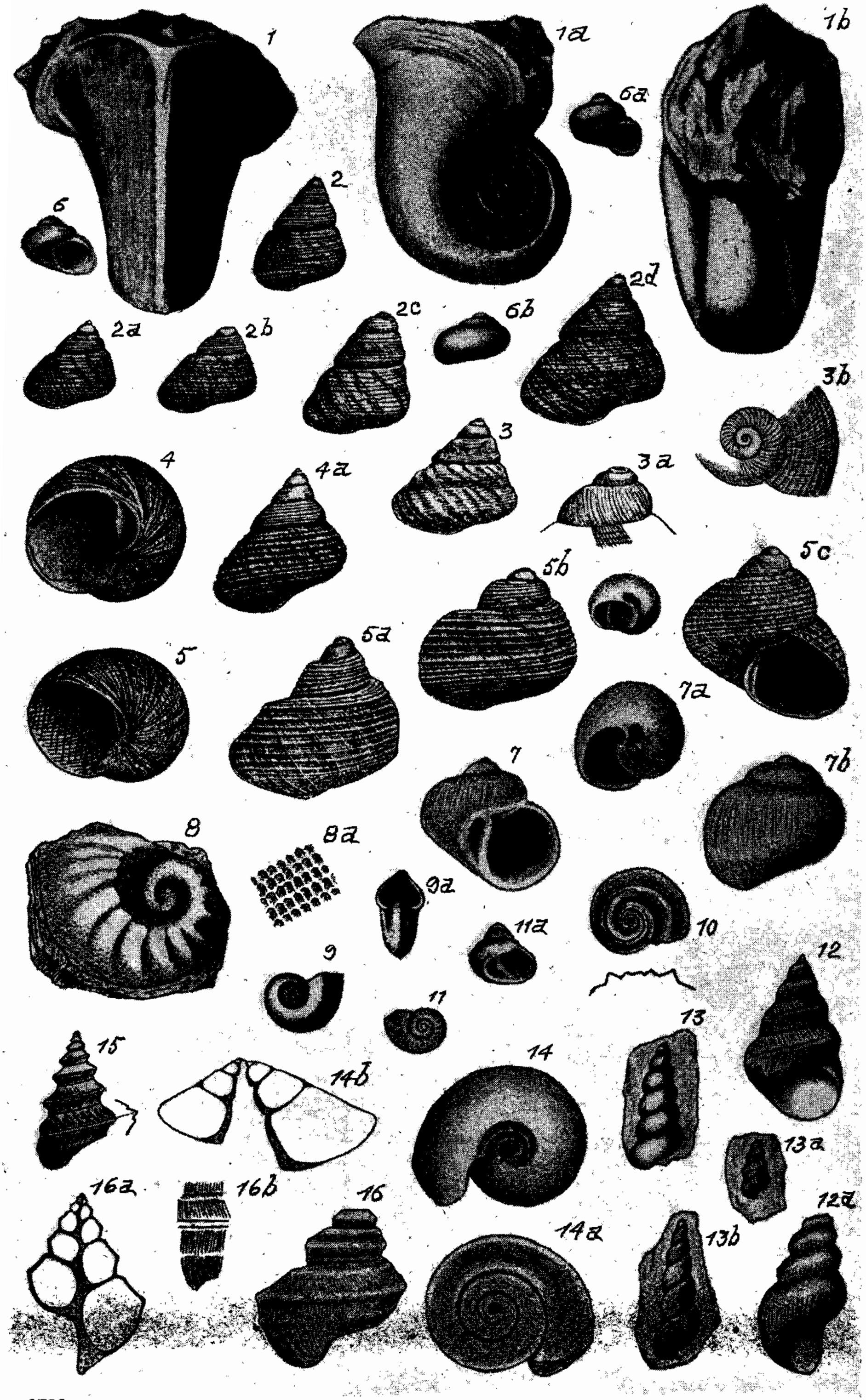
11 and 11a. Top and apertural views of this species. Miller.

Hormotoma bellicincta Hall .... ——

12. A specimen showing the surface markings. Hall.

12a. View of another less perfect specimen. Hall.

Plate XL.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Page

Hormotoma gracilis Hall.. ——

13 and 13b. Two casts of this species. Hall.

13a. Small specimen preserving the surface markings. Hall.

Liospira vitruvia Billings.. 965

14 and 14a. Two views of a cast of the interior from Beloit, Wisconsin. U.

14b. Vertical section of a specimen from Cannon Falls, Minnesota. U.

Lophospira acuminata Ulrich and Scofield.......................... 966

15. Specimen of this species from Richmond, Indiana. U. and S.

Lophospira bicincta Hall.. 967

16. Large cast of the interior preserving some of the external markings. Beloit, Wisconsin. U.

16a. Vertical section of an elongated specimen from Dixon, Illinois. U.

16b. Portion of the surface of a specimen from Murfreesboro, Tennessee. x 2. U.

PLATE XLI.

Page

Lophospira ampla Ulrich 966

1 and 1b. Apertural and dorsal views of a large specimen from the Lorraine formation, Newport, Ky. U.

1a. Apertural view of a large specimen from the Richmond formation, Boyle county, Kentucky. U.

Lophospira tropidophora Meek 969

2. A specimen of the usual form from the Lorraine group, Newport. Ky. U.

2a. A form from the Richmond group at Madison, Indiana. U.

2b. Portion of the last whorl of a smaller example from the Richmond formation, Butler county, Ohio. U. x 2.

2c and 2d. Two views of the form to which Miller gave the name *multigruma*. Miller.

Lophospira hammeli Miller 969

3 and 3a. Apertural and dorsal views of this species. Miller.

Lophospira bowdeni Safford .... *

4. A large specimen, imperfect at both ends, from the Richmond formation, Boyle county, Kentucky. U.

4a. Last whorl and aperture of another specimen from the same locality. U.

4b. A narrow, elongate specimen from the same locality. U.

Oxydiscus magnus Miller 970

5. Side view of the type. Miller.

Raphistoma richmondense Ulrich 972

6 and 6a. Two views of a specimen from Richmond, Indiana, retaining some of the shell. U.

6b. Portion of the surface of the last part of the whorl of same. x4. U

Schizolopha moorei Ulrich 975

7. View of a nearly perfect cast from Richmond, Indiana. U.

7a. Vertical section of an unusually high example of the Cincinnati form. U.

7b. Gutta-percha impression from a natural mold of a Richmond specimen. U.

7c. Basal view of No. 7. U.

Clathrospira subconica Hall 956

8. Cast of a specimen from Minneapolis, Minn. U.

8a and 8b. Two views of a cast from the Stone's River group at Beloit, Wis. U.

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*Safford gave no description of this species. For an excellent description see Geol. Nat. Hist. Surv., Minnesota, vol. III, pt. II, p. 986.

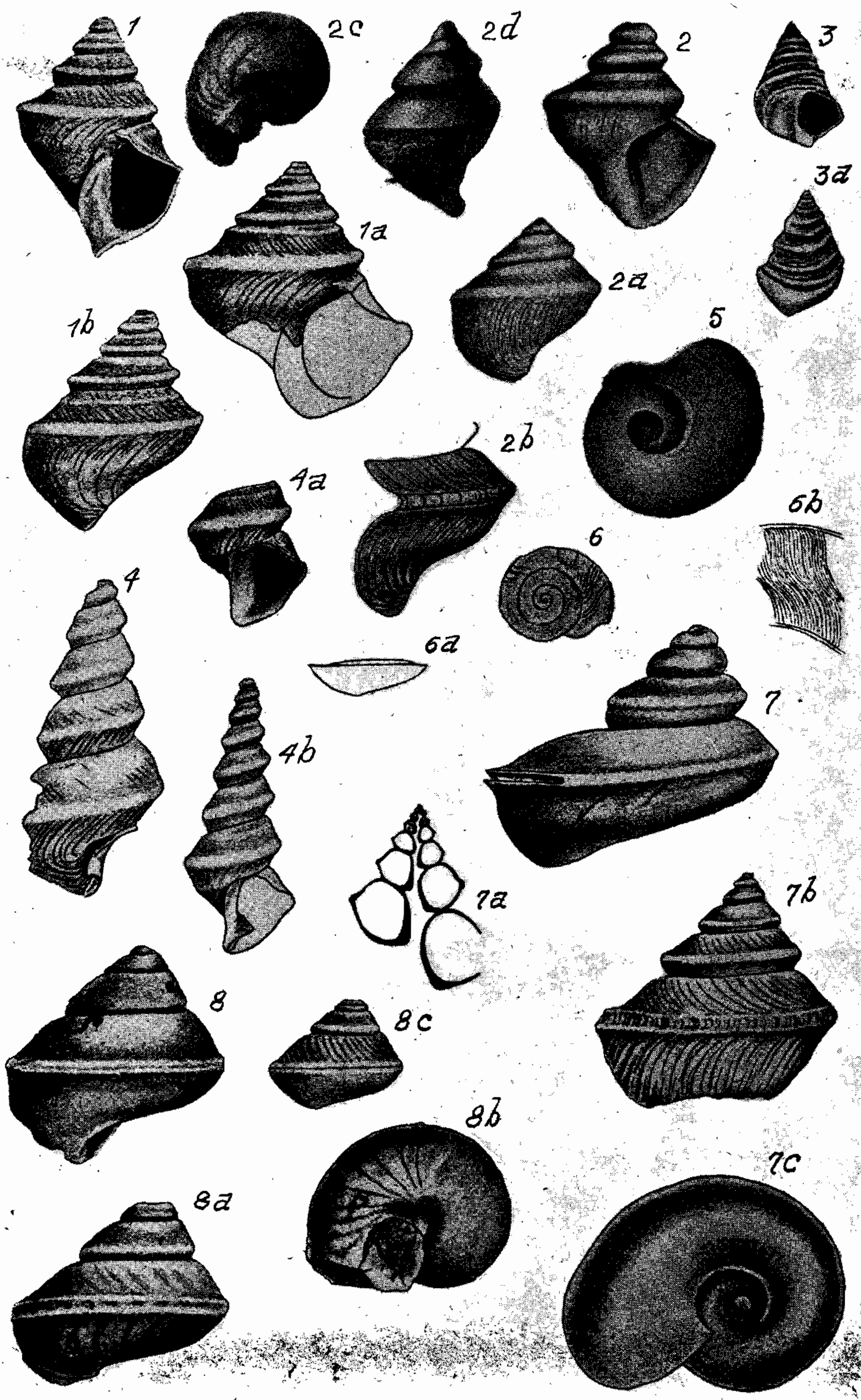
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PLATE XLII.

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Trochonema madisonense Ulrich.................................... 976
1-1b. Three views of the type of this species. U.

Conularia formosa Miller and Dyer.................................... 958
2. View of the type. M. and D.*

Hyolithes (?) *dubious* Miller and Faber.................................... 964
3. View of the type. M. and F.**

Hyolithes versaillesensis Miller and Faber.................................... 965
4 and 4a. Several views of the type. M. and F.

Cornulites richmondensis Miller.................................... 1065
5. View of the type. x 1½. Miller.

Anomalodonta costata Meek.................................... 987
6 and 6a. Two views of the type. M.

Byssonychia alveolata Ulrich.................................... 989
7-7a. Two views of a right valve of this species. In one view the left valve is restored. U.

Byssonychia obesa Ulrich.................................... 991
8-8b. Three views of a cast of the interior of the medium size, from Richmond, Indiana. U.

Bucania simulatrix Ulrich.................................... 955
9-9a. Two views of this species. From Richmond, Indiana. U.

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*Figures after Miller and Dyer.
**Figures after Miller and Faber.

Plate XLII.

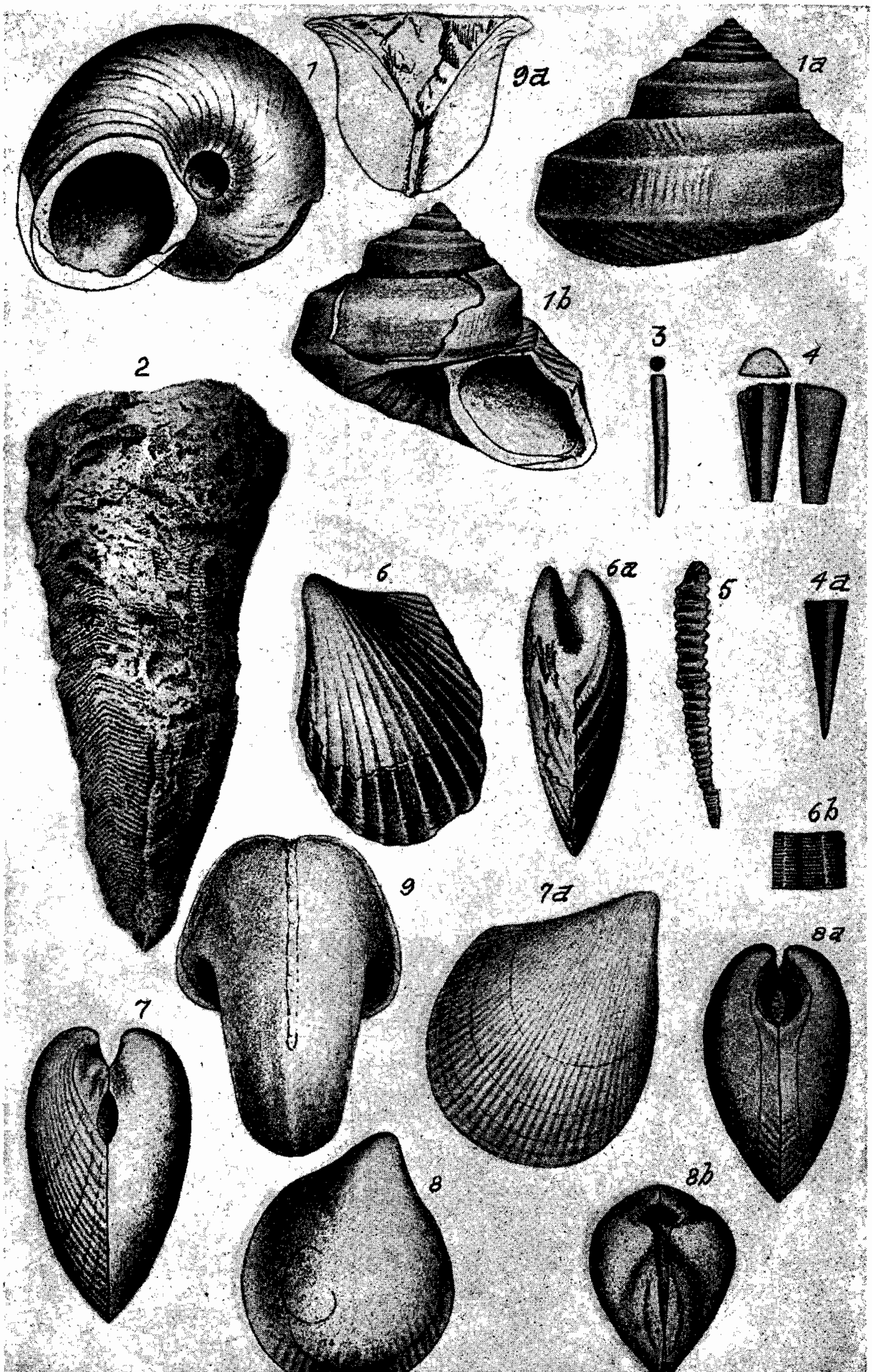

PLATE XLIII.

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Anomalodonta gigantea Miller.. 988

1. Very good cast of the interior of a left valve, with the ligamental area restored. U.

1a and 1b. Internal views of the original types of the genus and species, from Versailles, Indiana. U.

Allonychia jamesi Meek.. 986

2. An excellent cast of the interior of the right valve of this species. U.

Byssonychia praecursa Ulrich.. 992

3 and 3a. Two views of the type. U.

Byssonychia radiata Hall.. 993

4. Exterior of the left valve, showing the surface markings. Hall and Whitfield.

Byssonychia tenuistriata Ulrich.. 996

5 and 5a. Two views of the type, from Granger, Minnesota. U.

Plate XLIII.

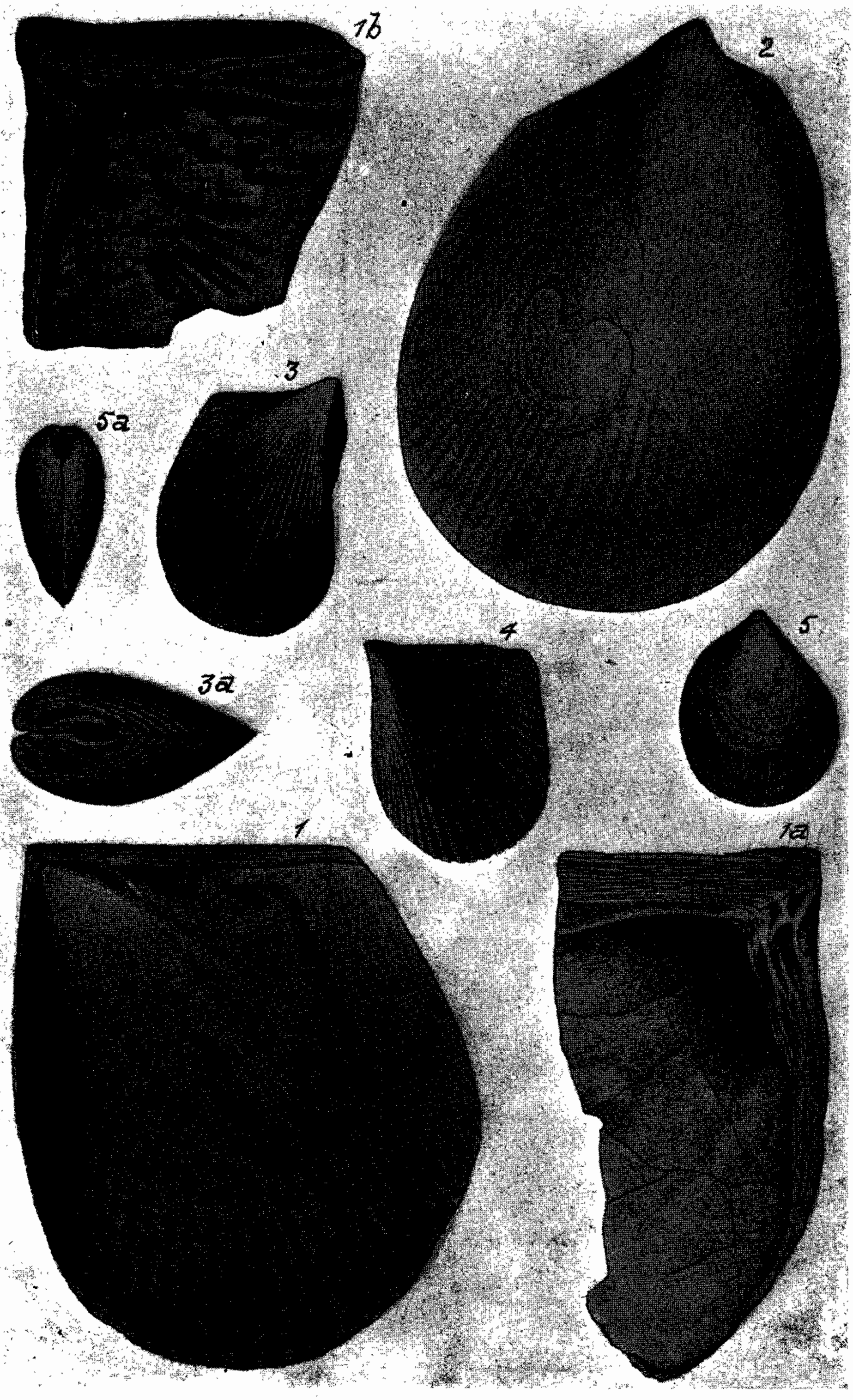

PLATE XLIV.

Plate XLIV.

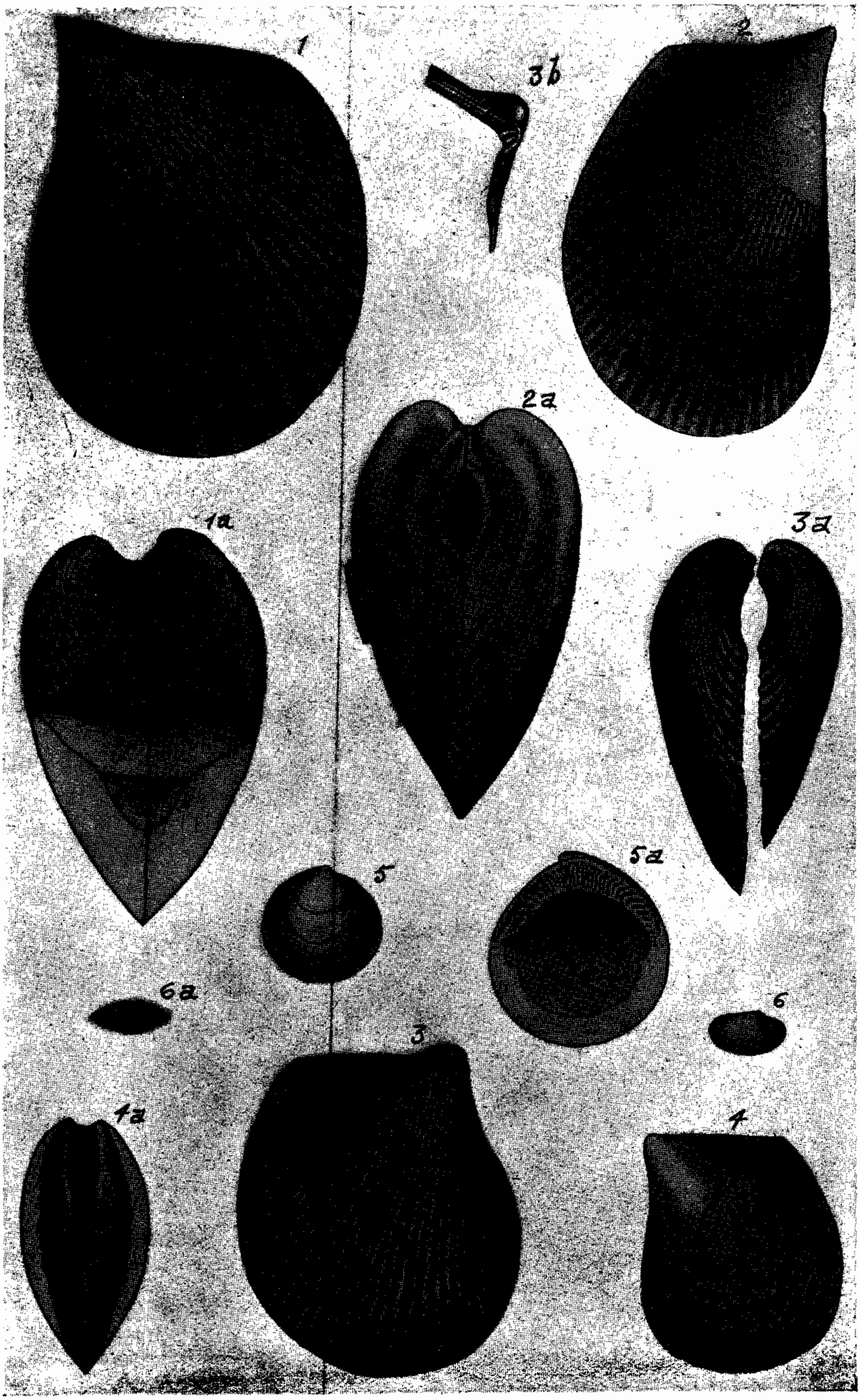

PLATE XLV.

Page

Cymatonota typicalis Ulrich 998

1 and 1b. Left side and dorsal views of an imperfect cast of the interior, from Waynesville, Ohio. U.

1a. Left side of a nearly complete cast of the exterior. U.

1c. Dorsal view of same in outline. U.

Cyrtodonta cuneata Miller 999

2. View of the type. Miller.

Ischyrodonta decipiens Ulrich 999

3, 3b and 3c. Three views of a nearly perfect right valve. U.

3a. Interior of the largest left valve seen (by Ulrich). Near Richmond, Indiana. U.

Ischyrodonta elongata Ulrich 1000

4. Left valve of the original type of the species. U.

4a. Smaller mold of the exterior, from Richmond, Indiana. U.

Ischyrodonta miseneri Ulrich 1001

5. Right side of a specimen from Richmond, Indiana. U.

Ischyrodonta modioloformis Ulrich 1001

6. Small example of this species, differing somewhat, especially in the basal region, from the typical form of the species. U.

6a. The right side of a nearly perfect cast of the interior. U.

6b. Dorsal view of another cast of the interior. U.

6c. From a gutta-percha impression of a portion of the exterior. x 2. U.

Ischyrodonta ovalis Ulrich 1002

7-7b. Three views of the original type of this species. U.

Ischyrodonta truncata Ulrich 1003

8-8c. Various views of this species. U.

Plate XLV.

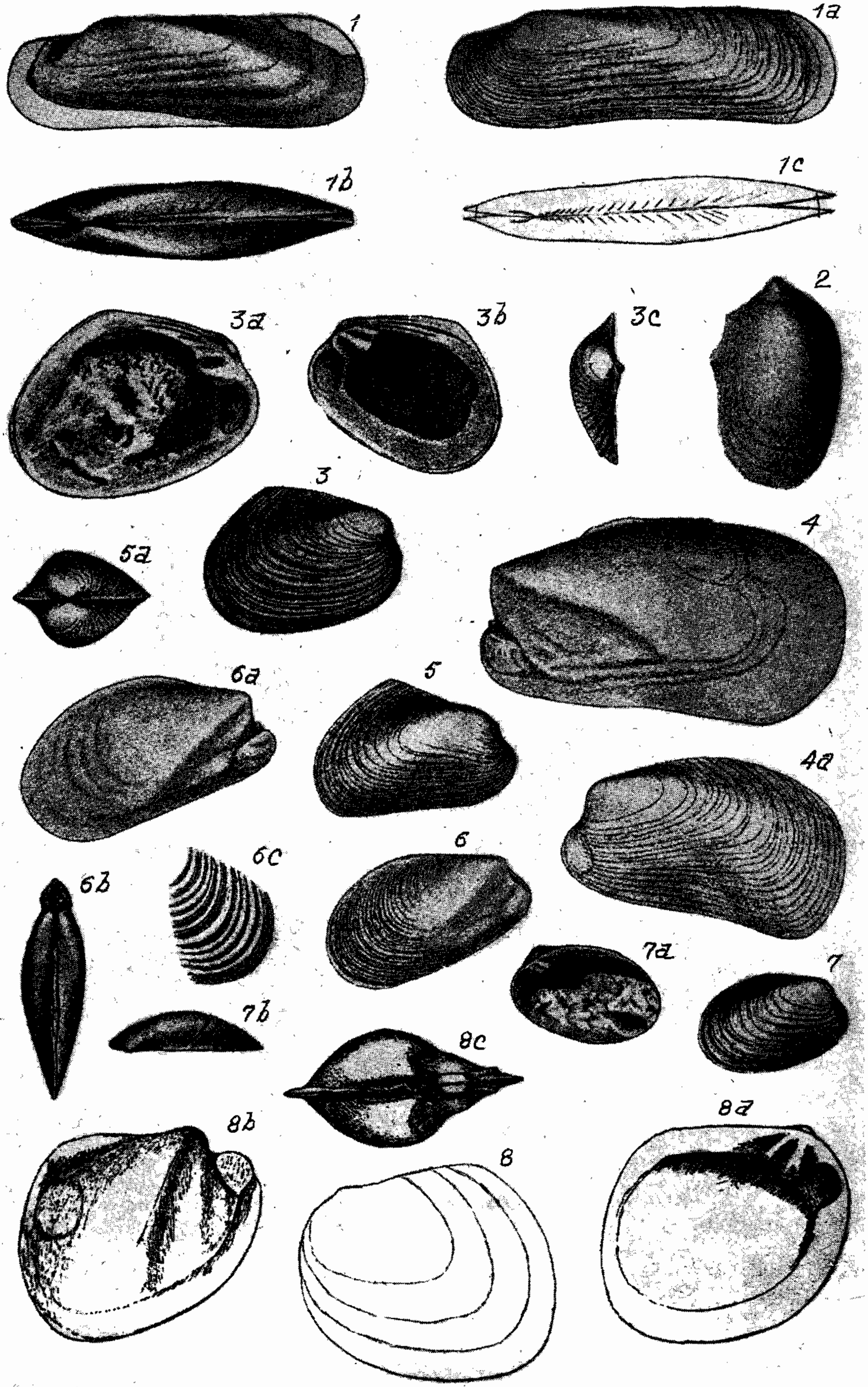

PLATE XLVI.

Page

Ischyrodonta unionoides Meek 1004

1 and 1a. Two views of the type. M.

Modiolodon declivis Ulrich 1005

2 and 2a. Right side and cardinal view of a cast of the interior of a specimen from Richmond, Indiana. U.

Modiolodon subovalis Ulrich 1006

3. Left side of a cast of the interior, From Versailles, Indiana. U.

3a and 3b. Right side and cardinal view of a cast from the Richmond formation at Versailles, Indiana. U.

Modiolodon obtusus Ulrich 1005

4 and 4a. Impressions of the exteriors of a left and right valve of this species from Cincinnati, Ohio. U.

Modiolodon subrectus Ulrich 1007

5 and 5a. Left side and cardinal view of a small but characteristic cast of the interior. Richmond, Indiana. U.

Modiolodon truncatus Hall 1008

6. The right side of an internal cast from Versailles, Indiana. U.

6a. Left side of a cast of the interior from Cincinnati, Ohio. U.

Modiolopsis versaillesensis Miller 1010

7 and 7a. View of the exterior of a left valve and the interior of a right valve of this species. Miller.

Plate XLVI.

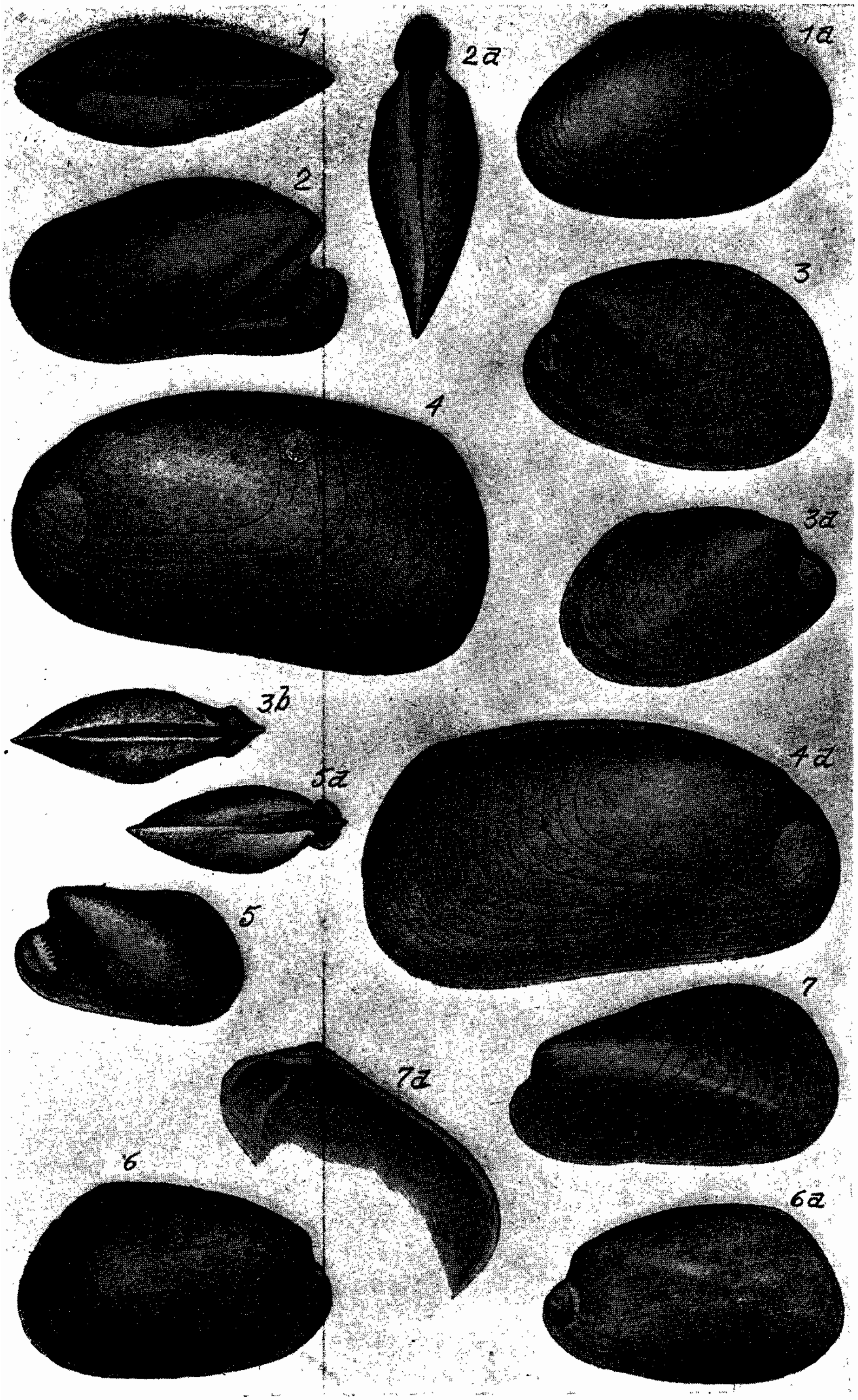

PLATE XLVII.

Page

Opisthoptera casei Meek and Worthen.............................. 1011

1. Gutta-percha impression of a natural mold of the exterior of a specimen from Marion county, Kentucky. U.

1a. Left side of a cast from Richmond, Indiana. U.

Opisthoptera obliqua Ulrich.. 1012

2. Right side of a specimen from Richmond, Indiana. U.

2a. Anterior view of the same. U.

2b. Dorsal view of a good cast from Richmond, Indiana. U.

Modiolopsis concentrica Hall and Whitfield.......................... 1009

3. View of a small specimen retaining both valves and showing the surface markings. H. and W.

Orthodesma canaliculatum Ulrich...................................... 1012

4 and 4b. Right side and cardinal views of a nearly perfect cast of the interior. Waynesville, Ohio. U.

4a. Incomplete cast of the anterior end, showing obscure rays across the central half. U.

Orthodesma parallelum Hall.. ——

5. Right side of the type. Hall.

Orthodesma rectum Hall and Whitfield................................ 1014

6 and 6a. Right sides of two specimens showing the range in size. H. and W.*

Orthodesma subangulatum Ulrich...................................... 1015

7 and 7a. Left side and cardinal views of a specimen from Richmond, Indiana. U.

Orthodontiscus milleri Meek.. 1015

8. Interior of a left valve of a large specimen. M.

8a and 8b. Left side and dorsal view of a medium sized specimen. M.

Ortonella hainesi Miller.. 1017

9. Right side of a perfect, though rather small, and typical specimen. U.

9a. Antero-dorsal view of same. U.

9b. Interior of a left valve. U.

9c. Nearly entire mold of the interior of a right valve showing impressions of the posterior lateral teeth. U.

9d. Dorsal view of an excellent cast of the interior. From Richmond, Indiana. U.

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*Figures after Hall and Whitfield.

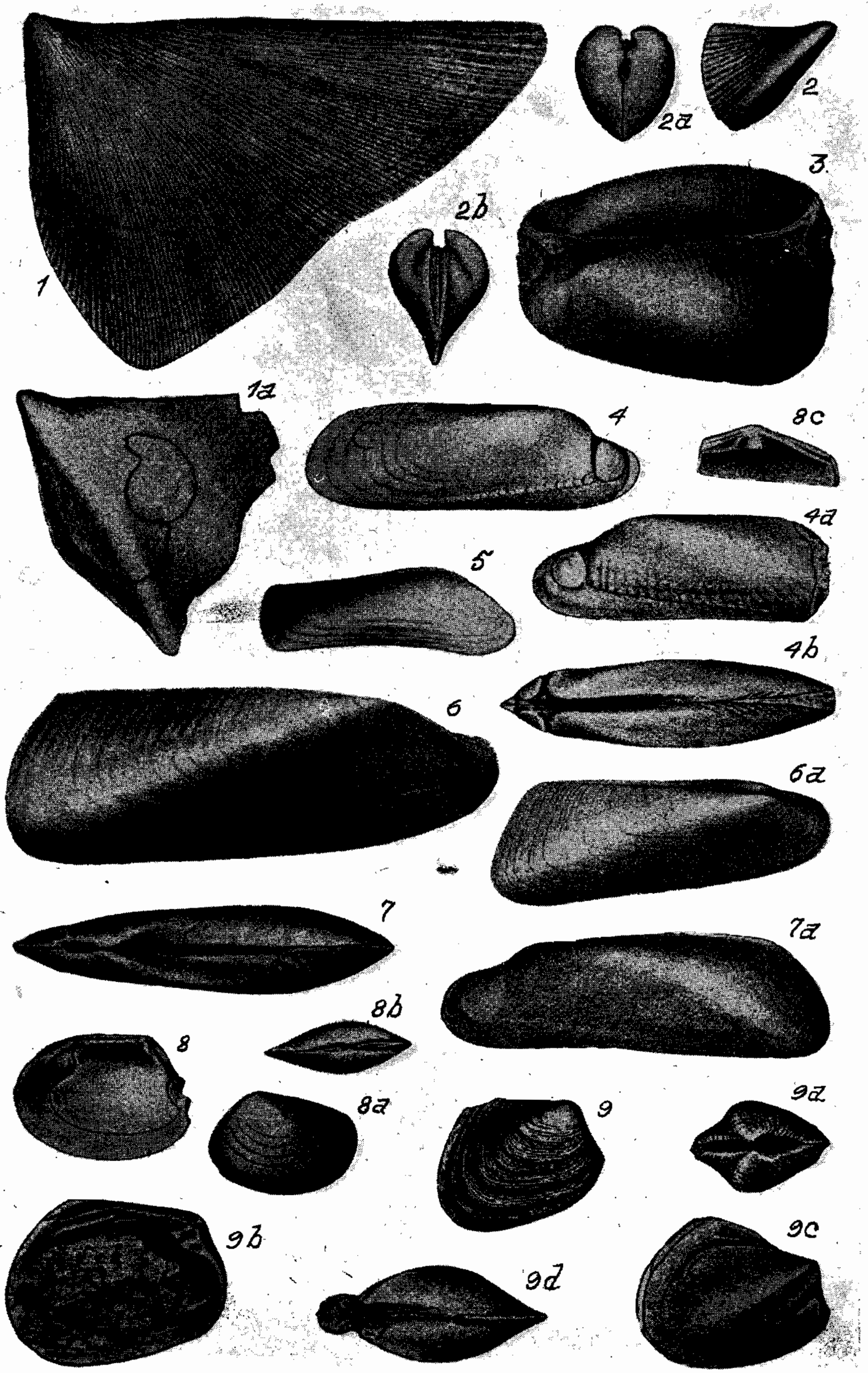
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PLATE XLVIII.

Plate XLVIII.

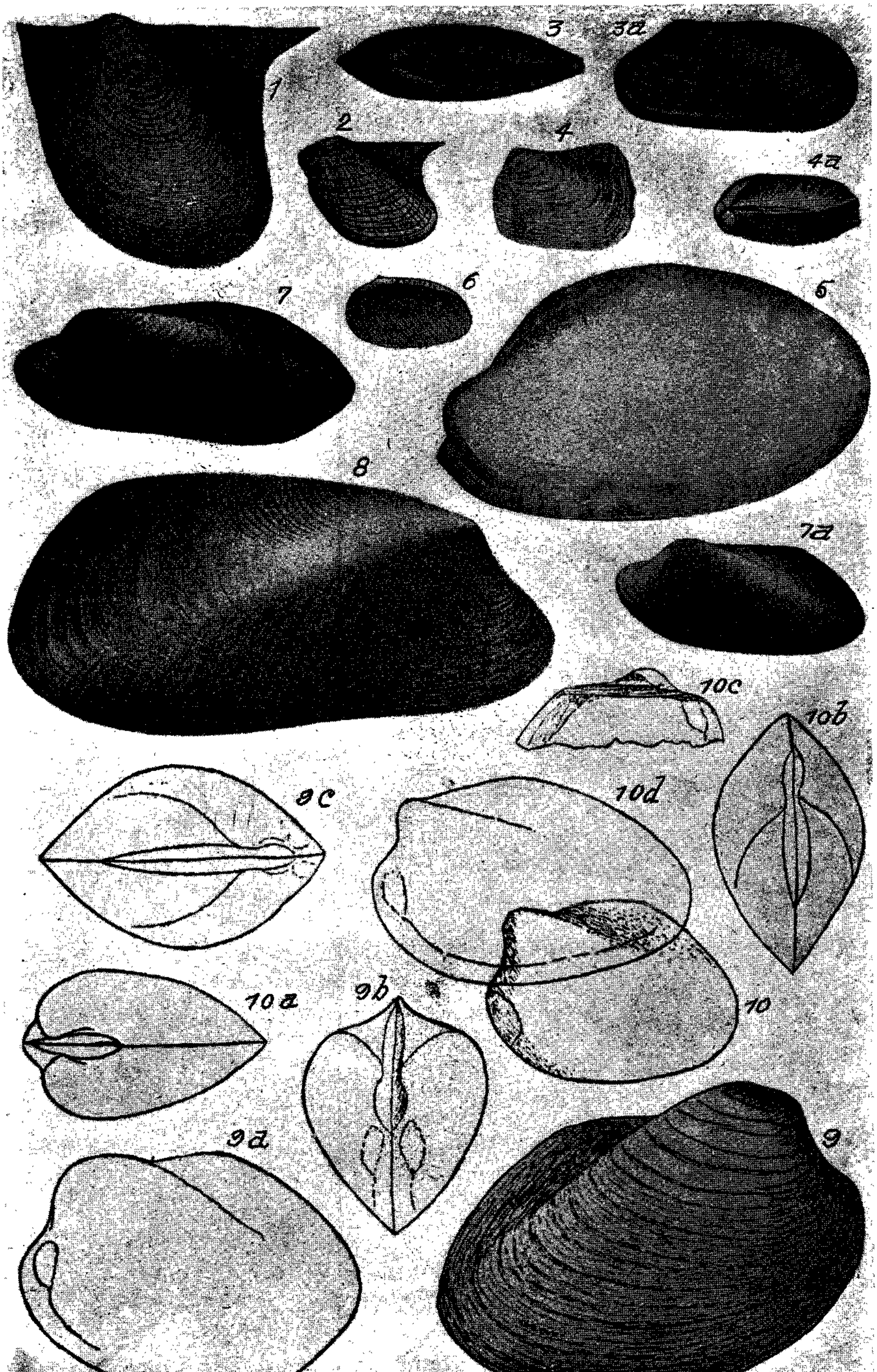


PLATE XLIX.

Page

Cyrtoceras amoenum Miller.. 1027

1. View of the type. Miller.

Cyrtoceras tenuiseptum Faber.. 1028

2. View of a small specimen with twenty septa. Faber.

2a. Specimen showing body chamber. F. (fig. *3a* of Faber).

Cyrtoceras thompsoni Miller.. 1029

3-3a. Two views of the type. Miller.

Gomphoceras indianense Miller and Faber........................... 1030

4. Body chamber and ten septa. M. and F.

4a. Outline of a transverse section. M. and F.

4b. Outline of the tenth septum and position of the siphuncle. M. and F.

Plate XLIX.

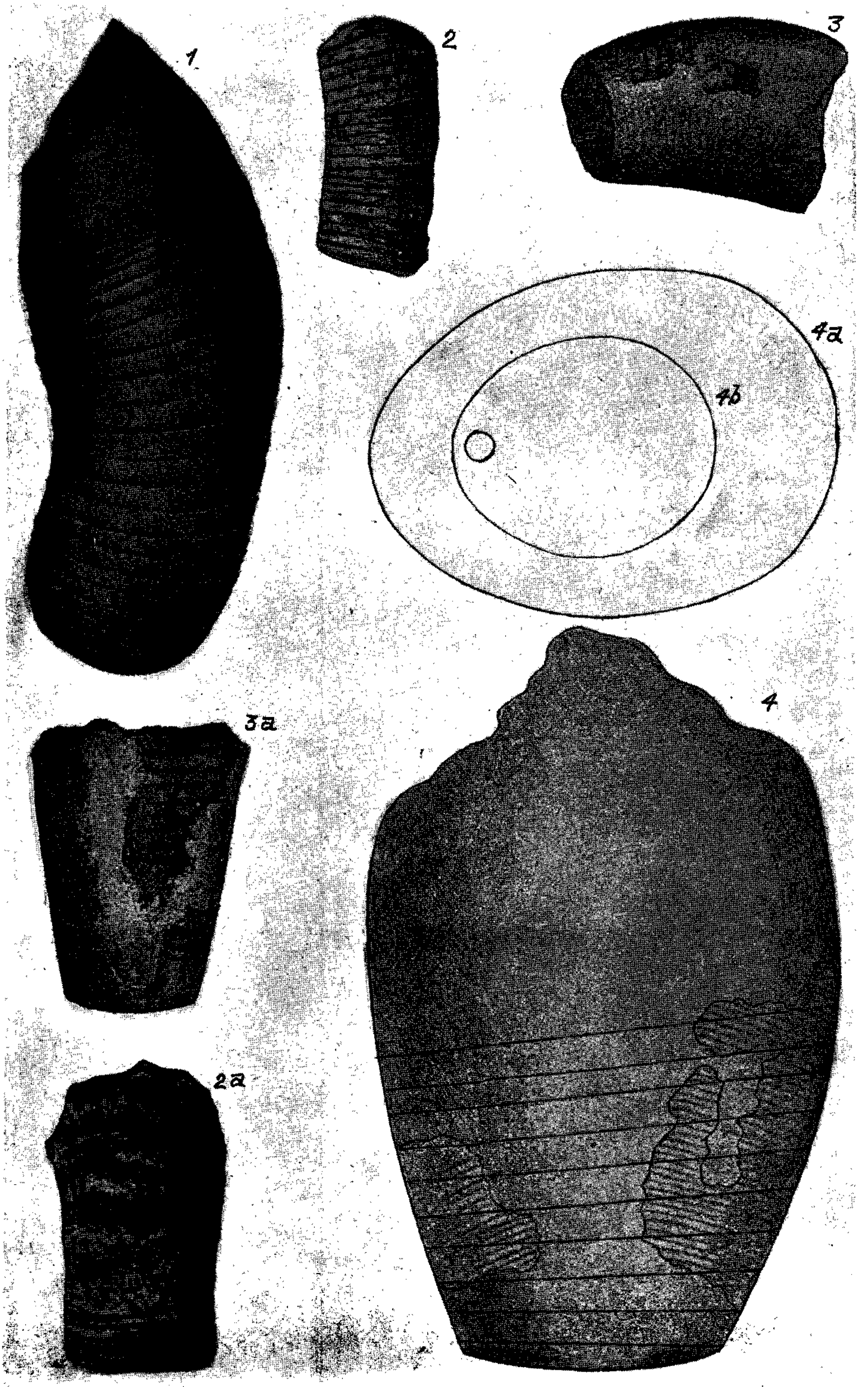


PLATE L.

Page

Endoceras proteiforme Hall.. 1029

1. Specimen showing the siphuncle with portions of several of the camerae still in position. Hall.

1a. A similar specimen giving a natural section of the camerae. H.

1b. View of a similar specimen. Siphuncle somewhat broken. H.

1c. Specimen showing twelve camerae. H.

1d. Transverse section of the last. H.

Plate L.

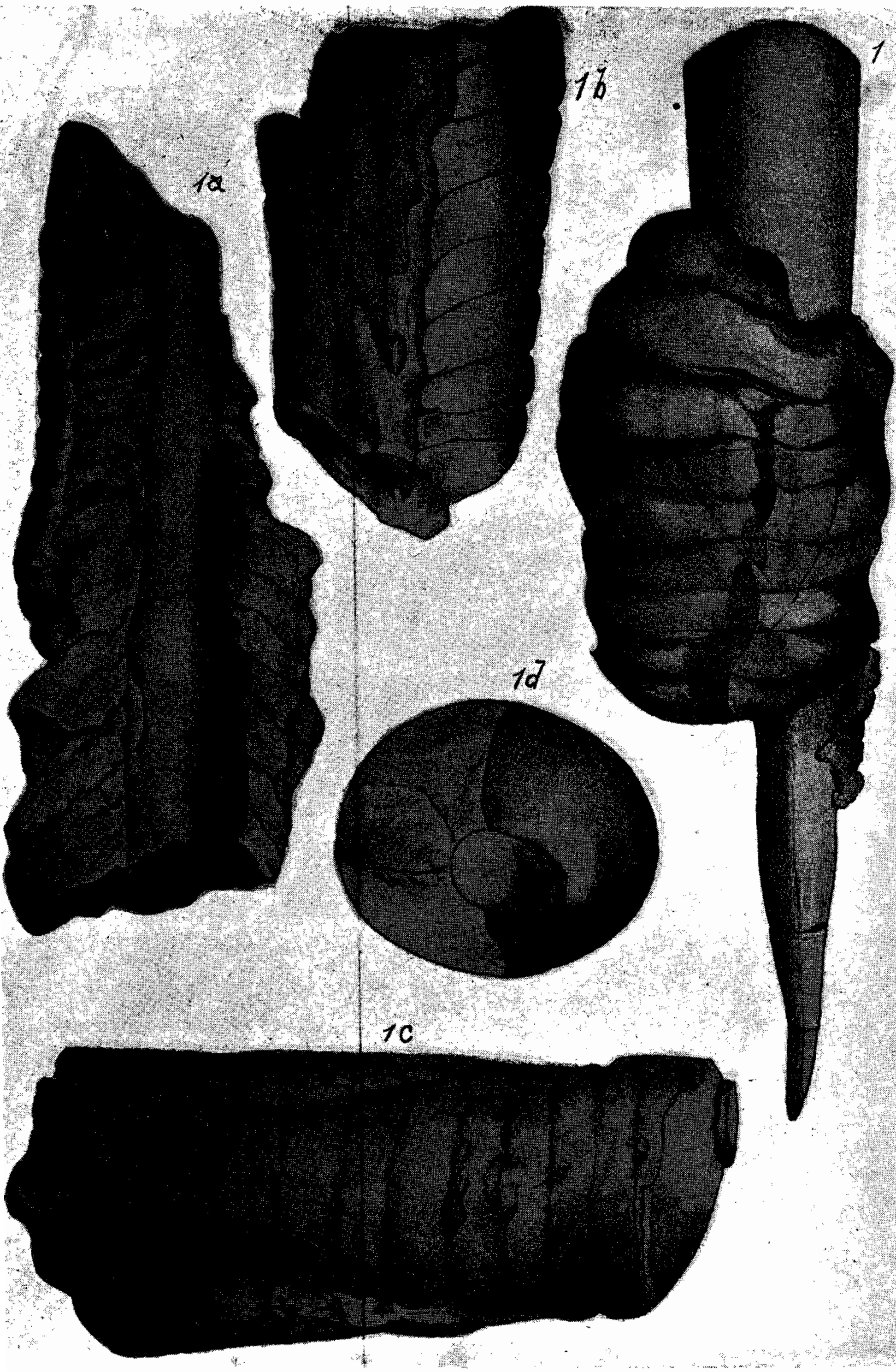


PLATE LI.

Page

Gyroceras baeri Meek and Worthen 1032

1. View of the type. M.

Orthoceras bilineatum Hall 1033

2-2a. Two fragments of this species preserving the surface markings. H.

2b. Enlargement of a portion of the surface. H.

Orthoceras mohri Miller 1038

3. Longitudinal section of the type. Miller.

Orthoceras byrnesi Miller 1034

4. Longitudinal section of the type. Miller.

Orthoceras junceum Hall 1037

5-5c. Various views of the type specimens. H.

Plate LI.

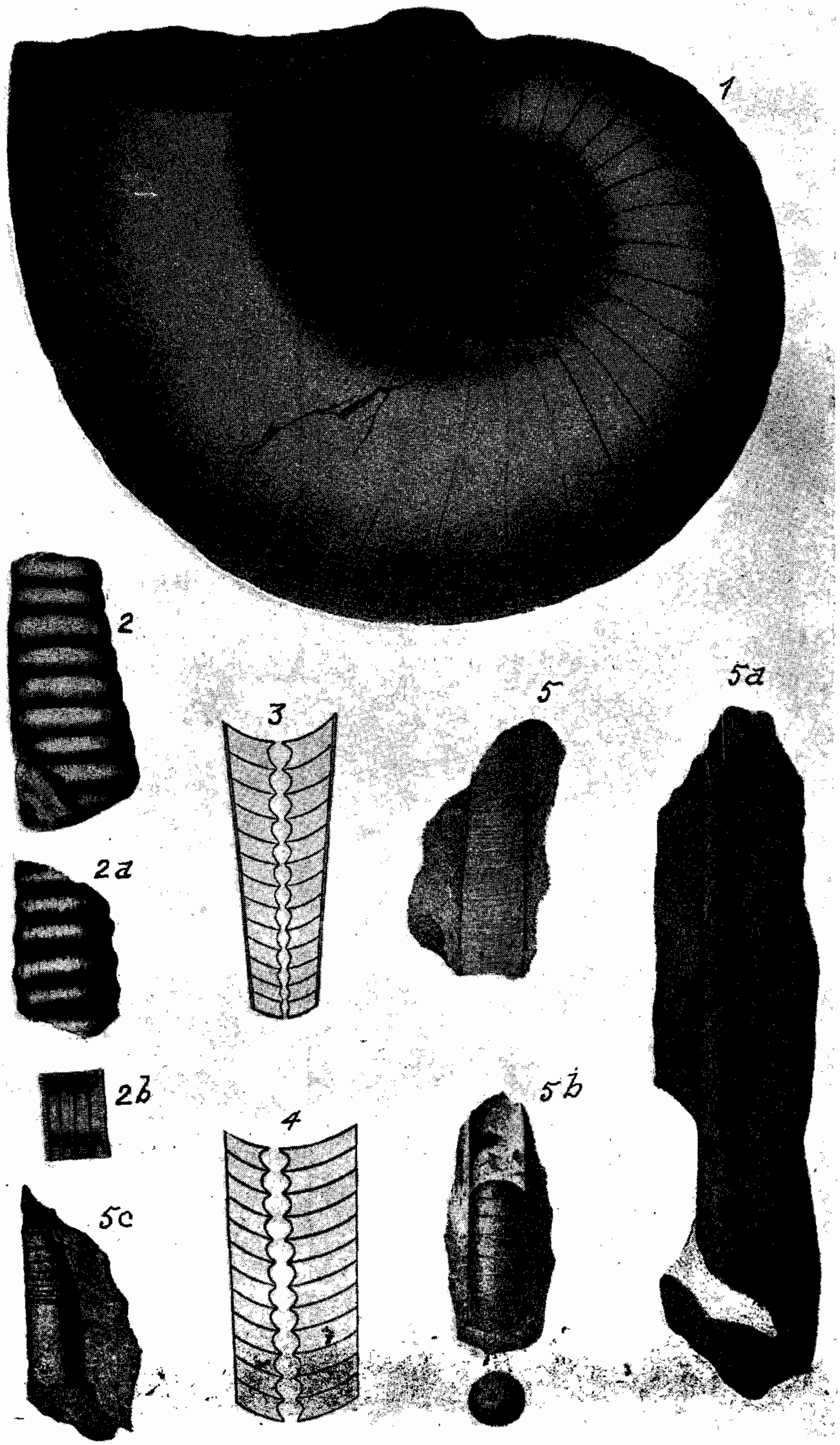


PLATE LII.

Plate LII.

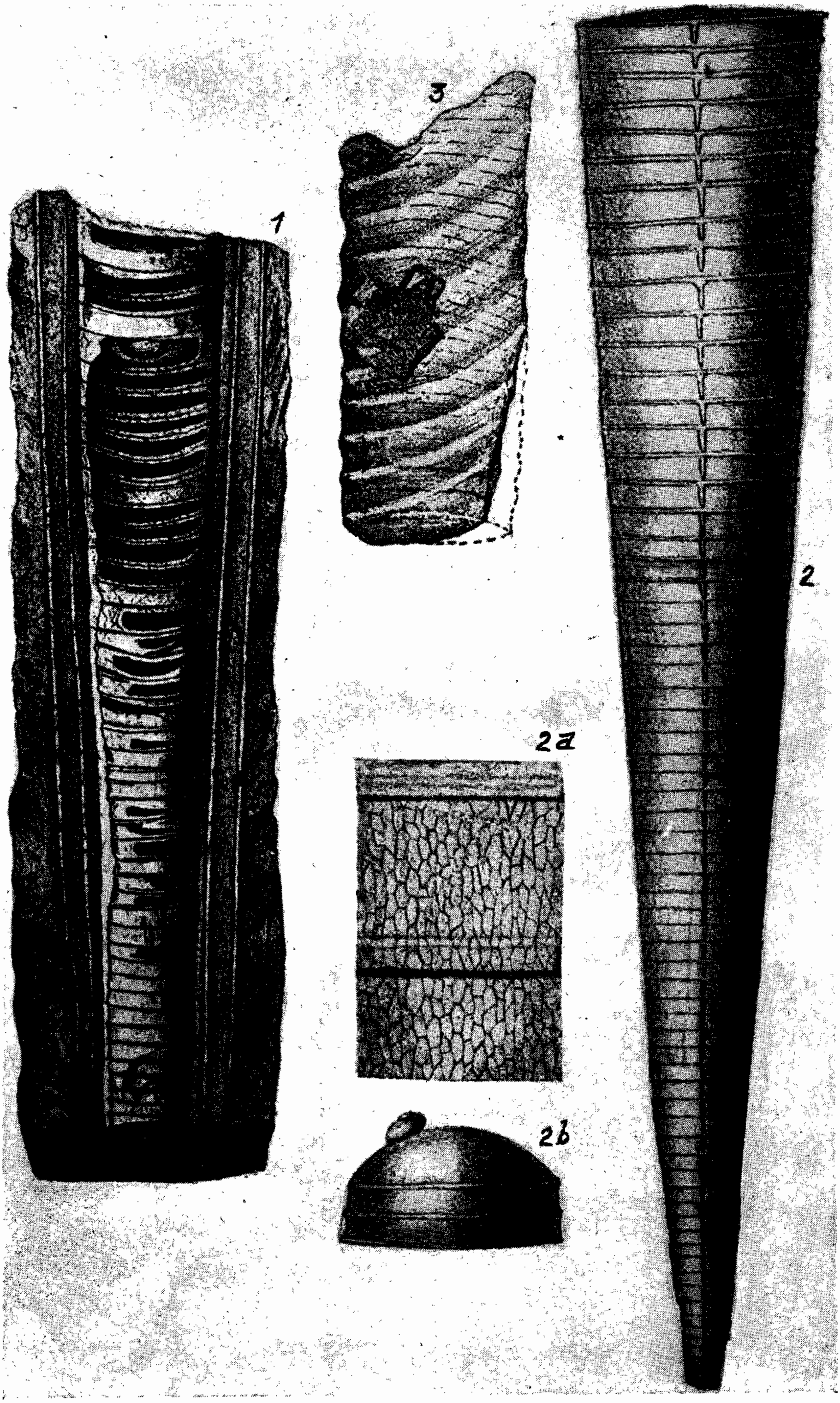


PLATE LIII.

Page

Ceratopsis chambersi Miller.. 1042

1. Lateral view of a right valve. H. and W.

1a. Partial profile view of a left valve. H. and W.

Ceratopsis chambersi var. *robusta* Ulrich.......................... 1043

2-2a. Lateral and posterior views of an entire carapace of this species. U.

Ceratopsis oculifera Hall.. 1044

3. Lateral view. H. and W.

3a. Basal profile view. H. and W.

Tetradella quadrilirata Hall and Whitfield.......................... 1048

4. View of a left valve, showing the character of the ridges and sulci. H. and W.

4a. Basal profile in outline. H. and W.

Tetradella quadriliata var. *simplex* Ulrich.......................... 1049

5. View of a left valve. U.

5a. Profile. U.

Ctenobolina ciliata var. *hammeli* Miller and Faber.................. 1045

6. View of a right valve. x 12. M. and D.

Primitia impressa Ulrich.. 1048

7-7d. Two right valves, illustrating slight differences, with anterior and dorsal views of each. From Savannah, Ill. U.

Entomis madisonensis Ulrich.. 1046

8. Left valve. x 18. U.

8b. Ventral view of same. x 18. U.

Eurychilina striatomarginata Miller.................................. 1046

9. View of this species. x about 20. Miller.

Leperditia caecigena Miller 1047

10. A large right valve showing a small eye spot. x 3. U.

10a-10c. Left, posterior and ventral views of a complete example of the medium size. Both specimens are from near Madison, Indiana. x 3. U.

Primitia cincinnatiensis Miller.. 1047

11. Anterior view of an average specimen. U.

11a. Dorsal view of a complete carapace, differing in several points from the typical form of the species. U.

11c. Left side of the same specimen. U.

11b. Interior of a right valve. U.

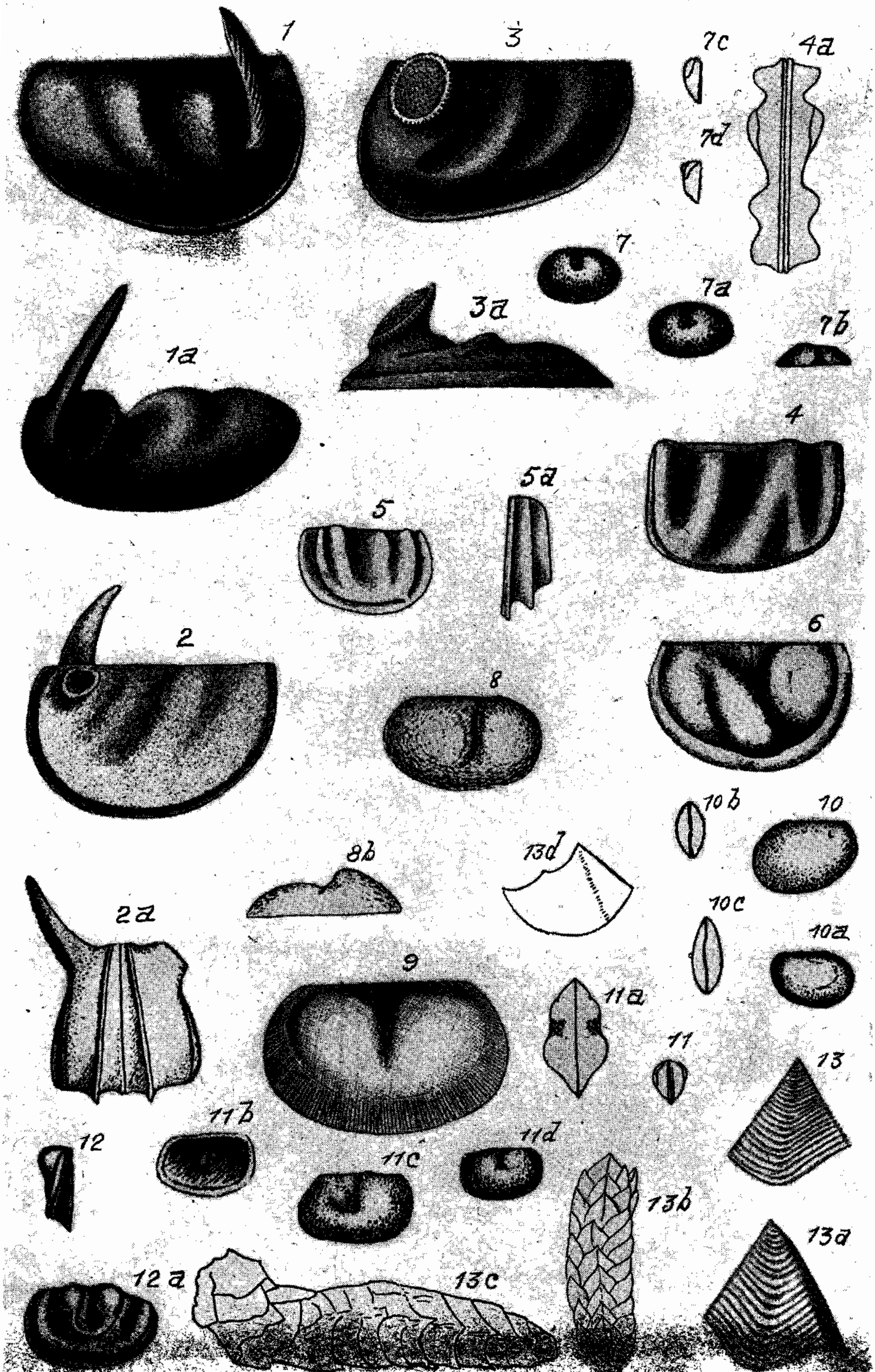
11d. Right side of specimen No. 11. U. All x 20.

Bollia pumila Ulrich.. 1042

12. End view of a valve of this species. U.

12a. Side view. Both x 20. U.

Plate LIII.



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Page

Lepidocoleus jamesi Hall and Whitfield.......................... 1050

13-13a. Detached plates of this species from Cincinnati, Ohio, greatly enlarged. H. and W.

13b. An outline of a very perfect specimen (after Woodward), supposed by Hall and Whitfield to be congeneric with their *Plumulites jamesi*, but evidently not to be so considered.

13c. An entire example of this species. Outline drawing from a figure by Faber.

13d. One of the plates of same specimen. Outline after Faber.

PLATE LIV.

Page

Acidaspis ceralepta Anthony.. 1052

1. A pygidium apparently belonging to this species. M.

1a. Another pygidium referred to this species. M.

Acidaspis cincinnatiensis Meek...................................... 1053

2. Pygidium and part of one of the thoracic segments. M.

Acidaspis sp... 1055

3. A left free cheek, apparently of a distinct species. M.

Acidaspis sp... 1053

4. A right free cheek, inside view. May belong to *A. cincinnatiensis.* M.

Acidaspis crosotus James.. 1055

5. A nearly perfect specimen. x about 4. M.

5a. A mould of the exterior of another specimen, apparently of this species. x about 4. M.

Calymene callicephala Green... 1057

6. Lateral view of a very perfect specimen in the enrolled state, which is the usual way in which this species occurs. M.

6a. View of a perfect enrolled specimen from Cincinnati, Ohio, showing the pygidium and Cephalon.

6b. Similar view of No. 6. M.

6c. View of the under side of a portion of the cephalon of a specimen showing the hypostome. x 2. M.

Acidaspis sp... ——

7-7a. Two glabellae of a species, or possibly two species of *Acidaspis.* M.

Ceraurus icarus Billings... 1059

8. A large, nearly perfect specimen. Haines collection. M.

8a. A view of the cephalic shield of an enrolled specimen. M.

Ceraurus pleurexanthemus Green...................................... 1058

9. A view of a large imperfect specimen from the Trenton formation of New York. H.

9a. Pygidium of another specimen, showing the characteristic long spines. H.

9b. Portion of the surface magnified. H.

Dalmanites breviceps Hall... 1059

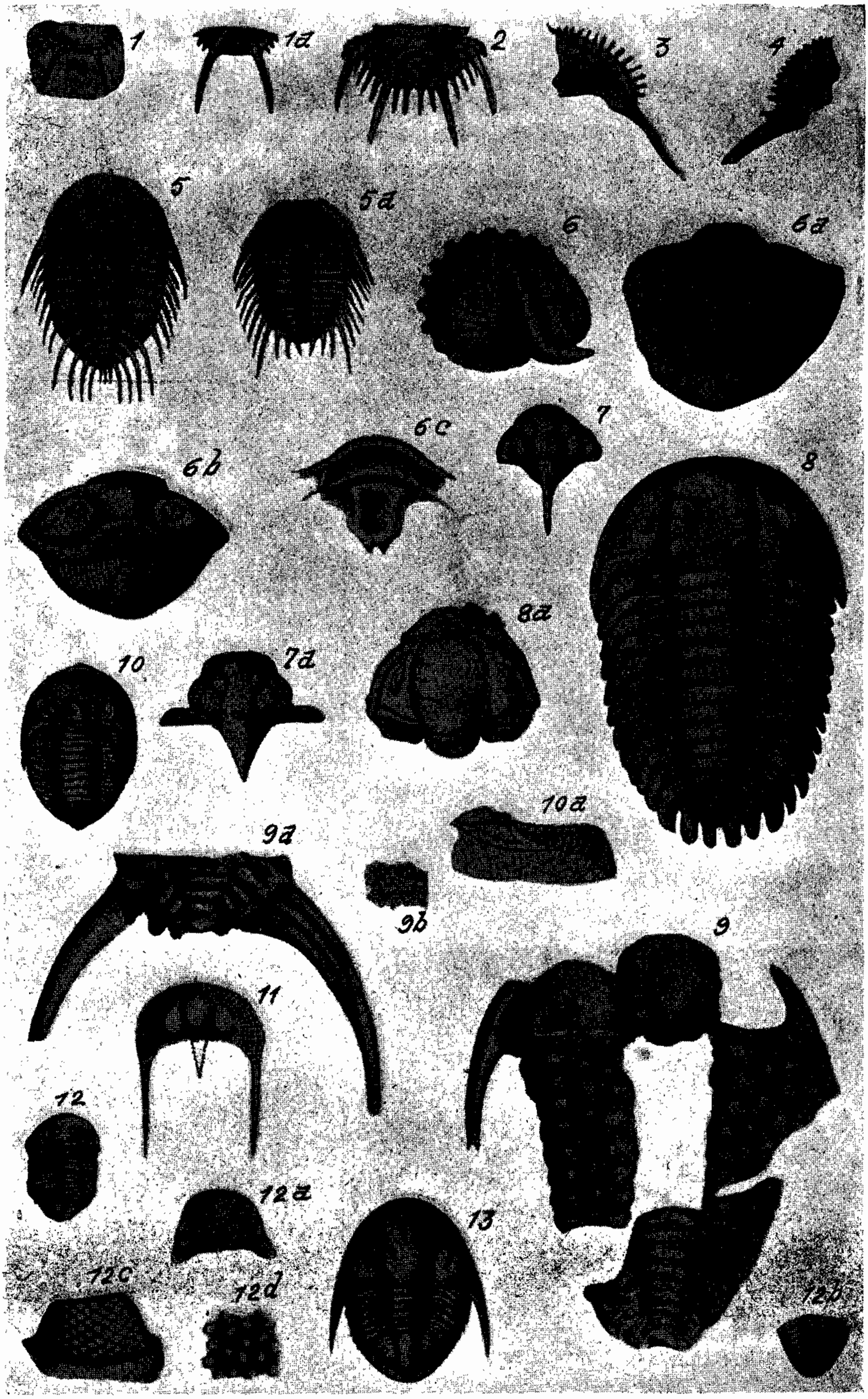
10. View of the type specimen. H. and W.

10a. Outline profile of the same. H. and W.

Trinucleus concentricus Eaton....................................... 1064

11. View of the cephalon of this species. Specimen from the Trenton of New York. H. Slightly modified.

Plate LIV.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Page

Dalmanites callicephalus Hall .... *

12. View of a complete specimen of this species. H.

12a. Enlarged view of the cephalon. H.

12b. Pygidium. H.

12c. Enlarged view of one of the eyes, showing the facets. H.

12d. Portion of the surface magnified. H.

Proetus spurlocki Meek 1062

13. A specimen with the cephalon slightly injured by abrasion, and slipped slightly backward so as to hide one or more of the thoracic segments. M.

*This is a Trenton species.

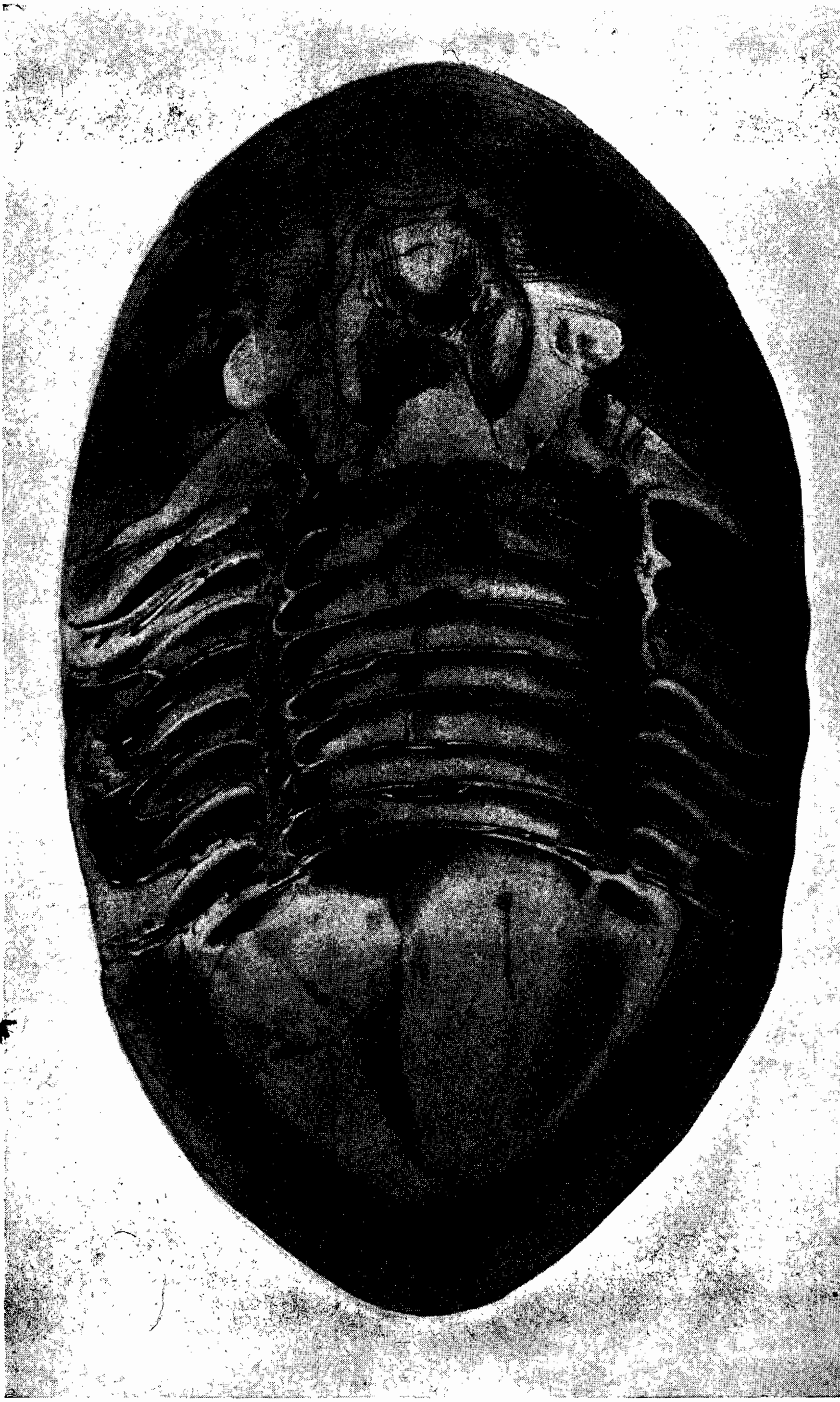
PLATE LV.

Page

Isotelus gigas DeKay.. 1060

1. View of a nearly perfect specimen of this species, but with the test more or less exfoliated so as to show the hypostoma. From the Trenton limestone of New York. H.

Plate LV.



A PRELIMINARY LIST OF THE HYMENOMYCETES OR MUSHROOMS OF INDIANA.

BY

DONALD REDDICK.

A Preliminary List of the Hymenomycetes or Mushrooms of Indiana.

By Donald Reddick.

The Phanerogamic flora of the State of Indiana has been thoroughly studied by various systematists at different times, and at present the advent of a new species into the flora, or the establishing of a new range or station for an old, is cause for considerable note.

Among the seedless plants, the ferns, rusts and most of the parasitic fungi are quite well known, but with one exception practically nothing has been done with the Hymenomycetes, the Toadstools, Mushrooms, Punks, etc., and in fact their great importance is but little appreciated. The fact that these plants in general are not attractive to many persons, the great difficulty of preserving them for study, the scanty literature on the subject, as well as the broad field for work along other lines, will in part account for the fact that this group of plants has not been studied more carefully. Then, too, Indiana is behind many of her sister States in this general line of scientific work. Many States maintain a State Botanist, and one of his duties is to collect and preserve specimens of all forms of plant life occurring within the State.

The distribution and time of occurrence of these forms will shed light upon many economic and physiological problems which have heretofore been too little understood. The cause of decay in timber, the disintegration of dead material and the production of foul and offensive odors can in some cases be attributed solely to these forms. The devastations made upon our forests and their consequent diminution in quantity and quality make it necessary for us in some way to prevent or at least check the loss by decay.

Also such studies should make it possible for many persons to secure forms for food and relish, and much valuable material for this purpose would become available to the general public. But above all things, any investigation which puts within our grasp the keys of nature, which will help to unlock her secrets and solve her problems, must be counted worthy of consideration.

In 1892 Dr. L. M. Underwood, as director of the Biological Survey of Indiana, published a list of all "Cryptogams" known to occur within the State. Quite a number of fleshy and woody fungi were collected, but as these were placed in a private herbarium, which is not now in Indiana, there is probably at the present time not an herbarium in the State containing anything like a complete collection of these plants.

In the autumn of 1904 the writer began a study of the higher fungi in the vicinity of Crawfordsville, and the work was continued throughout the college year. Owing to the extreme dryness during this season, collecting was not good, for many species that would have occurred normally did not develop. Then, too, late spring and summer species have not been collected, and the herbarium left at Wabash College must of a necessity be wanting in a large number of species which occur in profusion during this time. It is hoped that at some future time the complete list of fleshy and woody fungi occurring in the State may be collected, authenticated herbarium specimens left on file, and complete descriptions with notes on distribution and time of occurrence preserved with them.

This paper has been prepared under the direction of Professor M. B. Thomas, and if it contains anything of merit, great credit is due him for valuable assistance and kindly encouragement. Thanks are due Mr. H. H. Whetzel for practical lessons in collecting and also for the determination of many species. Many of the specimens sent him were determined by Professor Geo. F. Atkinson or Mr. H. S. Jackson. Professor Atkinson has also very kindly made valuable criticisms, and these have been incorporated in this paper. I am also particularly indebted to Professor Atkinson for use of most of the appended plates, which are taken from his "Mushrooms, Edible, Poisonous, Etc.," from some of his bulletins issued from the New York (Cornell) Experiment Station, or from his private collection of photographs. Professor E. A. Burt kindly determined the Thelephoraceae sent to him. In the list, credit for determination or confirmation of my determinations has been given. Quite a number of specimens have not yet been determined with certainty nor confirmed by one who is an authority, and those are not included in the list, but preserved for further study.

CLASSIFICATION.

The classification of the fungi is even at the present time in a very unsettled condition, and changes are constantly being made as investigators are coming to know more perfectly the life history and relations of the many groups. The system of Fries dominated as late as 1880, but this has been largely replaced at the present time by the system of Saccardo or of Engler und Prantl. Arbitrarily the classification according to Schröter in Engler und Prantl has been adopted in this paper. Briefly, all fungi are divided into two large groups: (1) alga-like fungi (Phycomycetes), (2) those not resembling the algae (Eumycetes). The Eumycetes are divided into two classes: (1) those having their spores encased in sacs or asci (Ascomycetes), and (2) those having their spores borne naked on the ends of basidia (Basidiomycetes). It is with that portion of the Basidiomycetes in which the basidia are borne together in a compact layer or hymenium (Hymenomycetes) that we shall concern ourselves.

Vegetative.

The thallus or vegetative portion of these plants is made up of multiseptate, cylindrical, much branched anastomosing filaments of very small diameter which ramify in every direction in the substratum upon which they are growing. Frequently mycelial threads are matted together, forming a cord or in some cases a thick, hard rhizomorph (Fig. 12). It sometimes happens also that thick sclerotia, often weighing several pounds, are formed. The fungus may vegetate for a long time, and during this period large quantities of material in highly concentrated form are stored up for a subsequent rapid reproduction. In a favorable time, in warm weather and usually after a rain, the fruiting or reproductive stage is developed, and this is the stage with which we are more or less familiar and which affords the means of classification of the plants.

Reproductive.

The simplest form of fruiting body in the Hymenomycetes is that of the Hypochnaceae, where a cob-webby mass of mycelium spreads out over the surface of the substratum and sends up small club-shaped bodies (basidia), which are rather loosely aggregated. In the next Family (Thelephoraceae) (Fig. 21) the basidia are more closely packed and form a continuous smooth hymenium. Some of the plants are not effused but are reflexed and thus afford a protection to the young spores. In the Family Hydnaceae (see Fig. 16) the hymenium covers the surface of spines while in the Polyporaceae (Figs. 17-18-22) the hymenium is on the inner surface of tubes; the tubes varying in character from cylindrical to labyrinthiform and from deep pores to shallow depressions formed by reticulated elevations. In the next Family, the Agaricaceae, the hymenium is spread over radiating lamellae or gills and all the forms are pileated. It is to this Family that most of our fleshy fungi belong.

After the basidia are formed each basid sends out from one to six small filamentous processes, sterigmata, and upon the ends of these the spores are borne; one spore on each sterigma and each spore carrying with it the possibilities of developing a new plant.

HISTORICAL.

Since the time of the Greeks and Romans mushrooms have been held in high esteem as food. Juvenal tells us of an old Roman, who in his enthusiasm was led to exclaim, "Keep your corn, O Libya, unyoke your oxen, provided only you send us mushrooms." Horace says that "the best mushrooms are found growing in fields," while Pliny gives practical instructions for collecting "those earthy excresences called mushrooms."

During the time of Nero, mushrooms stood in good repute, and at court banquets they were served to the guests. On one occasion, desiring a new form of amusement, the "deadly amanitas" were ordered served, with the result that the entire number of guests succumbed, as well as a large number of centurions, tribunes, etc. Spenser in the Faerie Queene casts a pall of superstition about the "earthy excresences" in the lines,

"The gristly tode stool grown there mought I see
And loathed paddocks lording one the same."

In Shelley's time mushrooms were in even worse repute, as shown in these lines,

"And plants, at whose name the verse feels loath,
Fill'd the place with a monstrous undergrowth,
Prickly and pulpous, and blistering and blue,
Livid, and starr'd in a lurid dew."

Long years of scientific research have not yet been able to dispel all these superstitions.

TOXICOLOGY.

It has been determined that the cases of fatal mushroom poisoning are confined almost entirely to the action of one genus of the Agarics, the genus Amanita. The members of this genus all have well defined and conspicuous characteristics which will readily distinguish them from all others.

If one acquaints himself with those characteristics and avoids all such forms, he can feel reasonably safe from serious poisoning, for those other forms which do produce sickness cause such violent reactions in the stomach that they are soon expelled. Dr. Underwood reports three Amanitas collected in the State in July, but thus far we have been unable to find any representatives of this genus.

Cases of fatal poisoning have been reported for species of certain other genera, but these are quite rare, and then, too, there is always the question of correct determination of the species. However, in all cases, as will readily be seen, it is better to know edible species rather than depend upon the exclusion process.

The toxic substances isolated from these mushrooms are few in number. *Muscarine* is an extremely violent poison, .06 grs. being a severe dose for man. This alkaloid is found most abundantly in Amanita muscaria.

Choline, or neurin, is an alkaloid which readily goes over into muscarine.

Phallin, the exact chemical nature of which is not known, though it is thought to be of an albuminous nature, is the substance which makes Amanita phalloides so deadly poison. When taken into the system the substance acts directly upon the blood corpuscles. The corpuscle is dissolved and the serum escaping from the vessels into the alimentary canal soon drains the system of its vitality. There is no unpleasant taste to the mushroom containing the alkaloid and no ill effects are experienced until from ten to fourteen hours after eating. For this reason, this is the most deadly of all the mushrooms, and should be given a wide berth.

Helvellic acid is a very deadly poison, sometimes found in Helvella esculenta, especially in old specimens. Several mycologists who have made repeated personal tests state that this plant is edible. It seems altogether probable that this dangerous property does not appear except in old specimens, and the safe plan is never to use old specimens of this or any other mushroom.

CHEMISTRY OF THE MUSHROOM.

Chemical analysis of mushrooms shows a very high percent of nitrogenous material, and this has been taken as an indication that the nutritive value of mushrooms is very high. Tables, showing the relative food value of mushrooms compared to other forms of food, have been constructed, and many extravagant statements are made about the great waste of "vegetable meat" and the possible substitution of a mushroom diet for the meat. Later investigation with digestive fluids has shown that the available nitrogen content is extremely small and that the food value compared with that of other substances is ridiculously small.

However, it is altogether probable that the digestive processes taking place in the human system can not be exactly duplicated in the chemical laboratory, and that the food value of mushrooms has not only been exaggerated but perhaps also underestimated. But even if the mushrooms prove practically valueless as food, their esculent qualities will always create a demand for them, and their value as a condiment will hardly be overestimated.

RAISING MUSHROOMS.

Each year sees an increasing consumption of mushrooms, and a constant growth in demand for this product. As a consequence many people have turned their attention to the raising of mushrooms.

One very essential thing in the raising of mushrooms is the temperature influence, and it is to unfavorable conditions in this respect that many can ascribe their failure to grow a crop. Many of the natural caves and worked-out coal mines of the State would afford excellent location for large mushroom establishments. The temperature remains practically constant during the entire year, and there would always be an abundance of moisture, so that a continuous crop could be harvested. With the increased development of communication between widely separated localities by means of the interurban roads, the important time element required for the product to go from producer to consumer could be reduced to a minimum.

The mushroom industry, like any other, has its difficulties, but there is now some excellent literature on the subject, and any one exercising care and patience can feel reasonably sure of a good crop and a profitable investment of capital and labor. For private purposes old caves and cellars are valuable places for the raising of mushrooms, and while the yield is not so large, it shows as great a return for the time and labor as the raising of ordinary garden "truck."

It seems highly probable that if people knew as much in general about mushrooms as they do about raising cabbages or tomatoes, there would be few homes which did not have a little mushroom bed just as they now have a little plot for the raising of early spring vegetables.

Recently (November, 1905) there has been issued from the Bureau of Plant Industry of the U. S. Department of Agriculture a bulletin by Dr. B. M. Duggar, entitled "The Principles of Mushroom Spawn Making." This bulletin contains results of investigations of Dr. Duggar, who is the most experienced commercial mushroom man in the United States, and contains much valuable information along all lines of mushroom culture.

COLLECTING FUNGI FOR THE HERBARIUM.

The proper collection and preparation of specimens of fungi for the herbarium involves a number of special processes. It is essential that considerable care be exercised in the collection of the specimens, and to do this properly one should equip himself with a few handy tools. For collecting trips an excellent outfit consists of a wicker basket, having a hinged lid which is almost as deep as the basket itself; some small pasteboard boxes, a number of squares of tissue paper, and paraffin paper, and a small pick and hatchet. The basket can be easily carried on the arm, and the deep lid is a convenient receptacle for holding the specimens before wrapping in tissue paper. If photographs are to be made, some of the best and most typical specimens should be carefully wrapped and placed in an upright position in one of the pasteboard boxes. If this precaution is not observed, geotropic irritability will in a number of cases soon cause the pileus to assume its normal position with reference to the earth, and this makes the photographs unsatisfactory. A small pick has been found especially valuable, particularly in the case of woody forms. A portion of the substratum can be chipped out and the sporophore obtained free from bruises or blemishes.

It is always well to look over all the available material in order to secure for the herbarium only the most typical and desirable specimens. Many mushrooms have a bulbous or rooting base, which is imbedded in the substratum and must be carefully extracted.

The specimens may be placed upon a square of the tissue paper, and by gathering the four corners together and twisting quite a tight enclosure can be formed. In this way average specimens will keep twenty-four hours or longer if not bruised. When bruised or broken many specimens change color or begin rapid decay. Different stages in the development of the sporophore are desirable, as many evanescent characteristics can only be found in the young specimens.

Too much stress can not be put upon the importance of taking field notes, and this is especially true for beginning students. Frequently specimens are found which can be determined only with difficulty and possibly not at all. As a dried specimen at best does not retain nearly all the characteristics of the living plant, and as many of these characteristics are necessary for the determination of the species, notes should be kept of them. These field notes should include such important things as character of soil or substratum, moisture, color and appearance of pileus, presence or absence of milky juice, whether there is a change of color when bruised, character of veil, etc.

Upon the return from the trip spore prints should be made of all gill forms. These are prepared by placing the pilei with gills downward on white or black paper, which ever may be necessary to show the color of the spores in mass. It may be advisable to at once write out very carefully a complete description of the plant and then begin the determination by means of the proper keys. Written description does not allow the judgment to be biased by text statements which do not agree with one's own when made without prejudice. Where a compound microscope is available careful spore measurements should be made, for in some cases the separation of two closely related species is based upon the size of the spores. These measurements and the spore print, together with the description, should accompany the herbarium specimen. When possible, photographs should be made of typical plants to show details of structure.

After this the plant should be dried rapidly, though too much heat is to be avoided as it destroys detail.

Woody or very thin specimens will usually dry spontaneously and retain their form and characteristics better than when subjected to artificial heat. Passing a current of air at 100° F. over the fleshy specimens for from three to five hours gives good results. Very watery specimens can be put on blotting paper, as this aids in taking up water. Any oven which will allow free circulation of air can be used or, as Professor Burt suggests, a kerosene lamp with a fine screen suspended over it at a proper height will answer the purpose very well.

When the specimens are dry they may be fumigated with carbon bisulphide and filed away in boxes. If there is not space, the plants may be pressed and placed in packets on regular herbarium folders. As the specimens come from the oven they are often very brittle, and before being filed away must be moistened and pressed. Most specimens will absorb sufficient moisture in a day or two to make them pliant. If they do not, a tight box containing moist sphagnum or blotting paper may be used. The specimens can then be flattened down to fit in a packet or may be pressed between blotters. When pressing, the weight should not be too heavy, and great care should be exercised not to press too flat, as valuable characters are thus spoiled.

Fumigation is necessary to keep out insects and moulds. Those specimens which have not been subjected to heat are likely to contain insect eggs and larvae, and these would soon consume the entire substance. To get rid of these pests the specimens are placed in a small box or can in which has been poured a little carbon disulphide. The gas from this liquid readily kills the larvae but not the eggs, so that after a time the process must be repeated in order to destroy any larvae that have developed later. All fungi should be thus fumigated at least once a year, as insects often feed upon the dried specimens.

COLLECTING FOR THE TABLE.

Hunting mushrooms for the table is a favorite pastime with some people, and would be with very many more could they feel sure that the mushrooms they gathered were not poisonous. Most people use but a single species for food. All others than those having a veil and pink gills when young are, to them, toadstools and deadly poisonous, or only those having a wrinkled conical cap are edible, and all umbrella-shaped ones are poisonous. To a certain extent this is a good policy, for one should, according to Dr. Peck, before experimenting, "know individual species just as we know edible flowering plants." But the collector, by having such a limited range, often tramps over great masses of mushrooms that have esculent qualities, at least not inferior to the ones for which he is searching. If one acquaints himself with a half dozen of the most common edible fungi he may feel sure that he will usually be able to secure these delightful condiments during all the summer months. Morels are the earliest, and while not hymenomycetes, are mentioned because of their very general occurrence in the State. Coprinus micaceus (Fig. 14) may be mentioned because of its prolific fruiting abilities. After almost every rain one may find about the base of stumps or old shade trees a great mass of this glistening Coprinus springing up. During the summer we have the common field mushroom, Agaricus campestris (Fig. 6), and in the autumn a great profusion of forms, the most conspicuous of which is the "shaggy mane" Coprinus comatus (Fig. 5). These mushrooms have well defined and easily recognizable characteristics which readily distinguish them from all others, and if one knows how to identify these four species he need never want for mushrooms.

Insect larvae often feed upon the flesh, and obviously a mushroom filled with larvae or their burrowings is valueless. Generally speaking, the old specimens are not as good as young ones, and, by some, old specimens are thought to have poisonous properties. No one would think of attempting to eat the "shaggy mane" when old, for it is a black, inky mass. Similar changes, though not so evident, often take place in other mushrooms when old.

Mushrooms for the most part deteriorate rapidly after being picked, and if it is desirable to keep them for any great length of time they should be cooked. Mushrooms may also be dried and kept indefinitely like dried fruit. The drying should be as rapid as possible without burning. When thoroughly dry they may be stored in an atmosphere free from moisture until wanted.

The oyster mushroom, Pleurotus ostreatus (Fig. 7), on account of its size and abundance, is quite desirable for this purpose. While not considered as delicious as others, the broth made by boiling is excellent for seasoning soups, gravies, etc.

DISSEMINATION OF SPORES.

The general occurrence of the same species of fungi over wide areas differing greatly in character, and the multitude of fruiting bodies in any one locality, show that spore dissemination is quite extensive. Every fruiting body bears millions of spores, and each spore carries with it possibilities of the formation of a new plant. The fact that the fungi are not increasing in numbers on the face of the earth shows that a vast majority of these spores perish.

Probably the most effective agent in spore dissemination is the wind, which may carry these bodies for miles. Animals also aid in dissemination. The spores would often become attached to the bottom of the foot, and as the animal moves on they are distributed. If these spores should be dropped in a favorable place they could reproduce the plant.

The smaller animals, such as squirrels, carry about many spores in their fur and some of these drop off in the hollow or broken tree in which they live. Birds carry spores over long distances very easily in their scales or feathers.

Insects, particularly the beetles, are also an aid in dissemination. These are often found in old fruiting bodies, and when they escape, covered with spores, they become agents for the dissemination of the fungus.

OTHER MEANS OF DISSEMINATION OF FUNGI.

While many spores are formed and disseminated and thus many chances given for the development of new plants, the difficulty with which spores germinate, through the result of unfavorable natural conditions, is very great, and for this reason comparatively few plants are formed in this way. The practiced mushroom grower does not depend upon spore planting to produce his crop, but obtains spawn bricks (nutrient substance permeated with mycelium) to inoculate his beds. Spawn will withstand dessication and extremes of temperature, and yet when moistened and put in a cool place will revive and continue its growth.

An interesing observation upon the natural dissemination of mycelium was noted in the case of one plant, Collybia dryophila. A large number of the fruiting bodies of this plant were found about an old stump in an orchard. Some distance away others of the same species were found occurring in a more or less regular row. This seemed to be rather peculiar, and further investigation showed that this row was just over the path of a mole. By tracing the ridge it was found to circle about and apparently have its origin in the base of the stump. For a hundred feet or more along this ridge plants of this species were found in quantity while no others were discovered in that vicinity. This would seem unmistakable evidence that mycelium had been carried by the mole and distributed along its burrow.

Certain wood boring beetles, plant, in the finely ground wood, with the newly deposited eggs, mycelium of fleshy fungi which develops when the larvae appear, and furnishes food for their growth.

Some ants maintain a fungus garden for their own delectation, and when the nest is disturbed it is as much a duty to preserve bits of mycelium for a new planting as it is to care for the eggs.

The carpenter may cut through old and infected timber. The next use of the tool may be in sawing new timber. Small particles of dust from the old timber will have adhered to the saw and are thus transferred to the new structure. Also quite often diseases are distributed to new timbers by placing them in contact with the decayed parts which in part they are to replace.

GERMINATION OF SPORES.

One of the difficulties of mushroom raising is encountered in obtaining "spawn." The "spawn" is secured from the so-called "virgin spawn," which is the mycelium of the mushroom, taken from the natural habitat or where it has grown spontaneously in manure heaps. There is always danger of contamination in this method and subcultures should be made to eliminate undesirable species.

As early as 1860 Hoffman succeeded in germinating the spores of a number of Hymenomycetes, among the list Agaricus campestris, but for this species, as he says, they were developed only with difficulty "and very often not at all." Brefeld in 1877 was able to germinate the spores of about 160 species of Basidiomycetes, but it was not until 1893 that Constantin and Matruchot announced a method by which they were able to germinate spores and to grow spawn in pure culture. Details of the method were kept secret, and at the present time this method of obtaining "virgin spawn" from the development of spores is controlled by one large company in France, and is kept a secret.

Most of the work of germinating these spores has been done solely with the view of determining the life history of the fungus and no practical use has been made of the results. But in 1902 Miss Margaret Ferguson began a series of experiments at Cornell University on the "germination of the spores of Agaricus campestris and other Basidiomycetous Fungi." Great variations in conditions of temperature and media were experimented with, and many thousand cultures made. Some interesting results were obtained; for example, spores which had been cast and kept in a sterile dish for nine months were germinated in sterile water at 28° C. The purpose of this extended study was to determine if possible the best stimulus for germination, whether a temperature or media condition or the presence of certain chemical elements or compounds. Almost by accident an observation of some old cultures was made which gave rise to a series of experiments along a different line and finally led to the conclusion, "that if a few spores are able to germinate under the cultural conditions, or if a bit of the mycelium be introduced into the culture, the growth resulting will, in either case, cause or make possible the germination of nearly all of these spores of the culture, provided, of course, that the other conditions are not such as to inhibit germination." Use of this method is now being made by the Pure Culture Spawn Company, Pacific, Mo.

With the possibility of successfully producing, in quantity, the pure spawn of Agaricus campestris and others, comes the problem of improving our mushroom product. If agricultural crops can be improved by the artificial selection of the best and most perfectly developed seeds, it seems probable that the same thing can be accomplished with mushrooms by selecting tissue or spores for reculture from that sporophore which shows the most remarkable development in size, esculent qualities, etc.

During recent personal investigation along this line it was found that spores cast from a sporophore of Coprinus micaceus could be germinated in quantity under sterile conditions. Spores were placed in a hanging drop of pure distilled water with a sterile needle, incubated at 28° C for twelve hours. At that time a few spores were observed to have sent out a protuberance twice the length of the spore, while a great many others had short tubes. In twenty-four hours practically all the spores had developed, and many of them had formed long branched mycelial filaments.

CHEMISTRY OF DECAY ON LIVING WOOD.

The fungi are probably of greater economic importance in their relation to timber, both living and dead, than in any other way. We little appreciate the total damage resulting from the work of fungi, for their action is so slow and for so much of the time inconspicuous. We can not even approximate the annual loss to our forest trees and structural timbers due to the fungi alone. There are a number of factors that are indirectly connected with the phenomenon of decay. Bacteria are omnipresent and may be found wherever there is moisture. They are not prime factors in decay, but their function is a secondary one in disintegration; insects, such as wood borers, ichneumon flies, locusts, etc., offer means of entrance for fungi into the trees; squirrels and birds with claws and beaks make holes in the bark which will sometimes form the lodging place of a fungus spore; mechanical movements, as in freezing and thawing, will produce cracks which give easy access to vital parts. The action of high winds is often sufficient to upturn trees and, in falling, limbs of healthy trees are often broken or shattered, thus forming infection courts for fungi. Snow also frequently produces this effect. It is exceptional, though not unknown, for a fungus to make its way through the thick epidermis and cortex of a living tree without the aid of some one of these methods of entrance.

Many of the wood destroying fungi are saprophytic; a comparatively small number parasitic. There are, however, parasitic species, and their action is very widespread and far-reaching. Very few of the Hymenomycetes are aggressive parasites, but Armillaria mellea (Fig. 12) is one which is common with us. This toadstool attacks the roots of sound, healthy trees, penetrates the thick walls of the epidermis and, sending out tiny filaments into the cells, there sap the vitality of the tree. This fungus has been found in a number of places about Crawfordsville and over the State, and if the truth were known it alone is doubtless responsible for great destruction of living trees. This fungus is able to send out its black rhizomorphs through the ground for considerable distance and thus is able to travel from one tree to another.

More often members of this Order are nearer saprophytes or facultative parasites. A tree is blazed or a branch broken off by some accident. The wood about the injury is dead; the weathering action of the elements softens the wood; it retains moisture and we have an ideal place for the development of a spore; spores are blown there by the wind, germinate, and send out their mycelial filaments. The dead central portion of the tree is slowly disintegrated and from contact with this living cells are reduced in vitality and ultimately die. (See Figs. 18-19.)

Very often the fungus excretes an enzyme which not only kills the living cell but makes the contents of dead ones soluble and available for food. Dr. Von Schrenk has shown that starch grains in the medullary ray cells of Ash were attacked and completely dissolved before the advent of the mycelium in that immediate vicinity. The conclusion is that "in this case a diastatic enzyme given off by the mycelium preceded the latter for some distance."

These actions are taking place constantly in the forest timber and are very important diseases, having well defined diagnostic characters with which every well trained forester or woodman is acquainted.

Fungi are not capable of assimilating directly food stuffs, and like animals are dependent upon plant life for their existence. Generally speaking, the presence of a fruiting body of a fungus upon a stick of timber is a sure evidence that the value of the timber is deteriorating and is sufficient evidence for its condemnation for structural purposes. Exceptions to this have been noted, particularly in the case of the "blue" wood of our conifers. The "blueing" is caused by the presence of a Pyrenomycete, Ceratostomella pilifera Winter. It is an established fact that trees affected with the blue fungus are tougher and more resistant than unaffected timber. The explanation for this unusual occurrence offered by Dr. Von Schrenk is that in the "blue" wood we have an enormous number of filaments, all extending radially through the wood. These filaments occur in bunches, much interwoven, scattered at regular intervals through the wood. Even if the tensile strength of one hypha is not very great, when it comes to 4,000,000 bundles these may have some effect in holding masses of wood fibre together, and it is possible that these hyphal bundles are responsible for the toughness.

ACTION OF FUNGI IN DEAD WOOD.

Other changes are also going on in the forest which without the assistance of other agents producing injury are equally important from the fact that they are disintegrating old logs, leaves, etc., and returning to the soil and air the elements contained in them. Every old log or dead branch has its "sweet knots," its brackets or shelves, or its clusters of toadstools; these are only the external evidences of what is taking place within. There the hyphal filaments of the fungus are slowly penetrating to every part of the log and gradually decomposing its substance. Some species attack only the cell contents, mainly starch, and are seldom found on very old logs. Others attack principally the secondary cell products, such as cutin, lignin, etc., while still others have become adapted to living upon the cellulose of the cell wall. The action in any case is to break down complex compounds into simple ones; appropriate certain substances for temporary use, and give off others, the gases, to the air, and the solids to the soil. A method for determining some of the end products of decomposition was devised as follows: a large retort flask was fitted tightly to one neck of a gas wasing bottle and the other neck fitted with a gas washing U tube. Chips of a pine stick infected with a fungus disease were placed in the bulb of the retort flask. The washing bottle contained potassium hydroxide and this was kept free from carbonic acid by means of potassium hydrate in the U tube. At the end of a week sufficient gas had been given off and absorbed to draw the potassium hydroxide up the tube and into the bulb of the retort. This shows that carbon dioxide had been given off in considerable quantities even when the available free oxygen must have been entirely consumed. A few drops of Nessler's reagent added to a few cubic centimeters of the solution gave an intense brown coloration, showing the presence of a large quantity of ammonia. This simple experiment accounts for four of the most essential elements in all plants, namely, carbon, oxygen, nitrogen and hydrogen. Pure cellulose of the empirical formula $C_6H_{10}O_5$ in wood includes from 50 per cent to 80 per cent of the total solids. By combination with oxygen in burning or in slow oxidation by the action of ferments, this complex molecule is broken up into two simple molecules, carbon dioxide and water. Other carbohydrates occurring in plant tissue are starch $(C_6H_{10}O_5)n$; sugar $C_{12}H_{22}O_{11}$ and $C_6H_{12}O_6$; as well as many other gums, resin, etc.; all those substances having very complex molecules.

The fact that nitrogen was given off in some quantity in ammonia (NH_3) gives evidence of the fact that nitrogenous materials were present in the cells of the wood. Chemical analysis shows about 15 per cent of nitrogen in dry matter of plants. Nitrogenous compounds are more complex in composition than the carbohydrates and are not so well understood. Some of the compounds of nitrogen occurring in plants are albumins, albuminates, peptones, alkaloids, etc. The alkaloids include such substances as quinine, nicotine, phallin, ergotine, muscarine, etc.

The various colorings in old wood are chiefly due to the action of fungi or certain of the albuminoids in carbohydrates mentioned above. When the starch grains stored in the medullary ray cells are not attacked, radially split wood appears dotted with irregular glistening white patches. Pure cellulose is white and when infiltrated substances only are acted upon and the cellulose left we have the characteristic "white rot." If other substances, than the tannin, are taken away we have the characteristic "brown rot," etc.

In some cases the coloring is in the fungus itself and the green sometimes occurring in wood is due to the presence of a large mass of fungal filaments each containing a small amount of the green substance, xylinderine. Vuillemin established this fact by dissolving out the coloring matter with an alkali, leaving the wood fiber undisturbed. The relation of the blue coloring of wood to the fungus present is now being worked out by Dr. Von Schrenk.

PHYSICS OF DECAY.

As the chemistry of decay has been shown to vary with the different species of fungi present, so also physically there is a variation in the methods in which the wood structure breaks down. In all cases there is a change in the physical character of the wood, as is shown by the decrease in the specific gravity, etc.

Polyporus fulvus has the property of destroying the middle lamella of the cells, thus allowing them to readily fall apart. Lignified cellulose is the essential element in strength, and when a fungus absorbs the lignin from the cell walls the cell collapses completely and wood so affected is of no value commercially.

The commonest wood destroying fungus occurring in structural timbers is Merulius lacrymans. This plant is capable of thriving on a limited water supply and in an atmosphere containing only a small per cent of oxygen. For this reason the decay can go on on the inside without being detected. Often a piece of timber infected with this disease, dry rot, which looks to be perfectly sound, can be struck with a hammer and the whole mass completely powdered. Warping and twisting of structural timbers is also sometimes due to this disease. Timber unequally exposed to moisture is attacked more vigorously on the side where there is the most moisture.

In general, the essential physical properties of wood are affected by fungi and the tendency is to reduce or completely destroy the value of the timber.

THE RELATIVE IMPORTANCE OF FUNGI AND BACTERIA IN DECAY.

Dr. Dhingra, in speaking of bacteria as scavengers with reference to a fallen tree in a forest, says: "The hard woody substance is first softened by various fungi which grow into it; next wood eating insects appear, and finally bacteria completes the action." To determine just the relative importance of fungi and bacteria in decay the following experiment was devised: Branches from five of our common woods occurring on the campus were taken and thin cross-sections in large quantities were made of each, and these distributed in test tubes. The woods used were Maple, Acer saccharinum; Locust, Robinia pseudocacia; Walnut, Juglans nigra; Beech, Fagus ferruginea, and White Oak, Quercus alba. The tubes were plugged with cotton and steamed at 100° C. on three successive days, thus insuring complete sterility.

Pure cultures of three different fungi were obtained by plating on a decoction of wood ager. Two species of pyrenomycetes and a common mould—Mucor, sp., (?) were used. Bacteria infesting old logs were also isolated and grown in pure culture. Two species were found: B. subtilis and B. sp. ?. Three sets of tubes were then inoculated from these cultures under sterile conditions. One set was inoculated with fungi only; three species on each of five different woods; another with fungi and bacteria; and the third set with bacteria only. Frequent examinations were made to secure intermediate stages, but few good ones were obtained. However, at the end of three months the following very noticeable changes were observed:

In set one, most of the material, except where it was packed too tightly in the tube, was blackened and looked old and rotten or was reduced to an unorganized mass. Microscopical examination showed that the cellular structure was completely destroyed. In set two, where bacteria were also present, the reaction had gone no further than in set one, but the black unorganized masses were present. In the third set, with bacteria alone, no apparent change in the wood either in general appearance or minute anatomy could be detected. The wood looked as bright and fresh as that which had not been treated, but otherwise had been subjected to the same conditions of air, heat and moisture. This experiment, then, demonstrates the fact that certain fungi are capable of completely disintegrating woody tissue without the aid of other organisms, such as bacteria. The fact that the species of bacteria used did not produce decay determines the action for only those two forms and others may be found that are direct agencies in decay. The experiment does, however, prove that bacteria are not necessary to decay and in many cases are undoubtedly only incidental.

The Role of Moisture in Decay.

It has been established that no chemical reaction takes place between substances except in the presence of water. As the decay of timber is largely due to the chemical reaction of certain enzymes upon the constituents of various parts of the wood cell, it follows that water must be present wherever there is decay. This would seem to conflict with our conception of "dry rot," but if we will consider what the terms dry air and dry wood mean there will be no conflict between the statements. The dryest air always contains a considerable amount of water vapor, and wood which has been thoroughly dried in an oven, when exposed to the air, takes up considerable moisture. Then, too, it has been demonstrated by Hartig that in the case of Merulius lacrymans, the "dry rot" fungus, that long rhizomorphic cords of mycelium often reach from the moist basement timbers to the very highest points in a building and in this way sufficient moisture is carried up to allow the development of the fungus.

Water is essential for plant growth and development, and when there is no moisture there can be no plants, hence no decay.

Methods of Preventing Decay.

If structural timber is so located that it can be protected from moisture at a small expense we need have little fear of rotting timber. That timber exposed to ordinary usage may be well preserved if protected from excessive moisture is shown by the fact that a well known lumber firm is willing to substitute modern steel structures, provided that they be allowed to retain the timber, for certain covered bridges in the State. These bridges are of walnut and are in an excellent state of preservation. On the other hand, wood completely immersed in water does not decay. In this case the absence of oxygen, a necessary adjunct of moisture, is the factor which prevents decay. The durability of submerged wood is shown by the fact that in a certain town in Wales many of the oak spiles used in the construction of a dock five hundred years ago are still doing service. The raising of logs from bottoms of streams has become a profitable business, because such timber when brought up and dried makes a more desirable and resistant grade of lumber than ordinary timber.

River and lake men claim that the transporting of timber by water actually adds value to it. Just what the action of water is is not clear, but it is probable that the sugars and other soluble substances favorable for fermentation are dissolved out; also the protoplasmic contents of the living cells may be replaced by water, and this would allow seasoning to take place much more rapidly later, water being more volatile than a protoplasmic solution.

Different kinds of woods have different inherent resisting properties. Railroad men recognize this in the selection of structural and tie timbers. Oak is, in this section, considered the best, while beech is almost worthless. Beech ties have a life of from two to three years, oak ties from seven to nine. This may be partially explained by the difference in structure of the wood. Oak timber is made up of thick-walled, densely-packed fibers, while in many other species the cells are not so compact. However, Catalpa, a wood of comparatively loosely aggregated cells, proves to be a very durable wood. The resisting power of wood, then, seems to be mainly due to the presence of certain infiltrated substances which are not favorable to the growth of fungi: pitch and resin in the soft wood of the Conifers; tannin in the cells of the oak, etc.

In the days when timber was plentiful the natural resistance of wood to decay was sufficient to meet all demands placed upon it, and that of treating timber with preservative was not even considered. At the present time, however, the demand for good timber is greater than ever before and the price is gradually being raised. Those corporations making use of large amounts of timber are now confronted with an ever increasing expense. This increased cost of timber, together with the inability in some cases to get the desirable wood at all, has forced many concerns to seriously consider methods of treating inferior and cheaper grades of wood in order to get as good returns for the money invested as they were formerly able to do by using the best grades of timber. Extensive experiments along this line are now being conducted with tie timbers under the direction of the government. Various seasoning conditions and many special treatment methods are being tried.

The seasoning of timber has long been practiced, for it is generally known that wood thoroughly seasoned gives better and longer service than when used green. Seasoning is not only a drying process but other accompanying changes are hardly less important. The change in the protoplasmic contents, though not well known, is very important, and for this reason timber cut in winter when there is little protoplasmic activity and no assimilation, is preferable to that cut in the summer when every cell is filled with sugars, starches and albuminous substances. As air drying is a slow process, requiring at least months, artificial means of producing the same result are often employed. This is done by exposure to live steam. The increase in temperature causes the air in the wood cells to expand, thus driving out a portion of the cell contents and coagulating any remaining substances.

Many years ago, and even very commonly now, wood intended to be put in contact with the ground was first charred on the outside. It was found that this made the wood more resistant to decay. Later, painting and then impregnating with toxic salts or coal tar products was employed, and scores of "timber preservatives" have been offered upon the market at different times. The effective substance has been generally confined to such salts as copper sulphate, zinc sulphate and chloride, mercuric chloride and coal tar products. In these processes sufficient quantities of the fungicide are injected into the cells of the wood to destroy or prevent the growth of fungi. The amount is usually rather small and the greatest difficulty encountered is due to the fact that these salts are soluble in water, and when the treated timber comes in contact with anything moist, osmotic and diffusion currents set up, thus allowing the salts to gradually leach out. After a certain limit is reached fungi are able to live and the injected substance becomes worthless.

The more important processes will be enumerated.

Creosoting.—This process consists essentially of placing the timber in a large iron cylinder, exhausting the air, heating by steam to soften the cell walls and dissolve the cell contents, and then forcing in hot creosote under pressure. This is one of the best processes, but its extensive use is prohibited by the great cost.

Burnettizing.—This process consists of impregnating the timber with a solution of zinc chloride by the same method as in the above.

Vulcanizing.—This process consists of treating the timber with a low temperature in a vacuum. It is claimed that a chemical change in the sap of the wood is thus produced, converting it into a germicide.

The Boucherie Process consists in the impregnation of timber with copper sulphate, either by pressure or vacuum. But when iron comes in contact with this salt in the presence of moisture a chemical reaction will take place with the formation of iron sulphate and free copper. Thus it would seem that about the rails and spikes of a railroad track the desired effect would not be produced and the value of the spikes would be impaired.

Kyanizing consists essentially in the impregnation of timber with mercuric chloride by steeping in a concentrated solution of that salt.

The following untried method for obtaining the desired result without the salts leaching out after impregnation is suggested: Steep the timber in a solution of arsenic trioxide until thoroughly impregnated with the salt. After this place the timber in a receiver and exhaust the air. Hydrogen sulphide could be admitted to the receiver and would readily enter the wood. This would cause the formation of arsenic tri-sulphide within the cells and this salt while insoluble in water has toxic properties.

DISTRIBUTION.

The problems of distribution of fungi over a given area and the influences that seem to control this are difficult to determine. That certain influences are at work and that they secure a certain constancy is made evident to any one studying the group.

It seems altogether probable that the nature of the soil constituents, other conditions being the same, is the factor determining the presence or absence of these forms. These plants have become adapted to living under certain conditions, and the changing of conditions means the destruction of the plant. One never finds the field mushroom in the woods any more than he does a morel in the field. This is even more strikingly illustrated by the fact that the transplanting of forms to localities which had apparently the same conditions has always resulted in failure. That soil influences are often all determinative is appreciated by most students of plants, for certain forms are always sought in localities apparently having the same soil conditions.

The controlling influence in the formation of the reproductive bodies are even more difficult to determine. A very large factor must be the regular sequence and periodicity of the vegetative and reproductive functions so evident in higher plants. It is unquestionably true that these periods may vary considerably, but in some cases they occur with such regularity that they have established certain well recognized seasons when fruiting is practically sure to occur. The morels are the most striking example of this and their time of fruiting is confined to very narrow limits.

Certain other forms are not so restricted in this particular, and some interesting variations are worthy of note. Coprinus micaceus can be found any time in the warm weather if other conditions are suitable, and moisture seems to be the determinative factor in the time of development of this species. Hypholoma (sp.) was found in the autumn after hard frosts and freezes and young specimens have been brought in which were frozen solid, but which, when thawed out, continued to grow. This same species was one of the earliest found in the spring.

Variations in the size of the fruiting body of the same species are often noted and seem to be affected most largely by food, temperature and moisture. There is usually a limited amount of substance that can be used in the formation of the fruiting body. In some cases this is used in elaborating a few large sporophores, while in others a large number of small ones are formed. As an example of this the pileus of a specimen of Collybia radicata was found measuring six inches across and the stipe nine inches in length. This same species has been found in poorer soil in mature condition where the pileus did not measure more than one inch across and the stipe not more than one half inch in length.

Sunlight, except for the retarding effect upon protoplasm, has no direct relation to the size of the fruiting body.

Variations in color frequently occur, and there seems to be no explanation for the cause of it, for often plants growing in identically the same location will show quite wide variations. This is, in some cases, due to the different ages of the fruiting bodies, but in specimens of Mycena leaiana sporophores which seemed to be of the same age and growing under exactly the same conditions varied in color from a rich red to a pale lemon color.

Such variations can only be noted with continued study over a long period of time, but those that have been noted will be recorded in the list.

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SEPARATION OF THE ORDER HYMENOMYCETINEAE.

A. Fruiting body mould like or cobwebby, of loosely interlacing hyphae. Basidia standing out loosely.....................I. Hypochnaceae

AA. Fruiting body firm, made up of thick anastomosing hyphae. Hymenium of palisade-like basidia standing close together.

B. Hymenophore smooth, slightly warted or wrinkled.

C. Fruiting body mostly of cuticular, leathery or woody texture; resupinate or conchoid, rarely upright, funnel-shaped, pileate or branched ....II. Thelephoraceae

CC. Fruiting body mostly of fleshy, seldom of cartilaginous or leathery substance, upright, cylindric, clavate or of spreading branches ....III. Clavariaceae

BB. Hymenophore made up of evident elevations or tubes which are covered with the hymenium.

C. Hymenophore made up of warts, spines or saw-toothed plates... IV. Hydnaceae.

CC. Hymenophore fashioned otherwise.

D. Hymenophore made up either of regular tubes, plates, or more or less leaf-like projections which are fastened together entirely or partially into honeycomb-like cells or labyrinth-like winding corridors...................V. Polyporaceae

DD. Hymenophore made up of leaf-like folds or well-defined dichotomously branched plates, which are either free on the under side or only anastomose in the matrix.............. VI. Agaricaceae

SEPARATION OF THE FAMILY HYPOCHNACEAE.

The Hypochnaceae are very closely related to the Thelephoraceae, and are only to be distinguished from them by the floccose texture and the loose anastomosing hyphae.

A. Spores white, smooth, seldom punctate.

B. Basidia with few sterigmata.

C. With two sterigmata.

D. Basidia like inverted pears with distorted snouts............ Urobasidium

DD. Basidia clavate, no snouts....................MATRUCHOTIA
CC. Basidia with 2-4, seldom 6 sterigmata..............HYPOCHNUS
BB. Basidia with numerous sterigmata.
C. Sterigmata small ................................AUREOBASIDIUM
CC. Sterigmata very large.........................PACHYSTERIGMA
AA. Spores colored; mostly spiny.............................TOMENTELLA

SEPARATION OF THE FAMILY CLAVARIACEAE.

Fruit body of leathery, fleshy, gristly or firm waxy substance; cylindric or clavate; simple or more or less coral like. Basidia close together with 1, 2 or 4 spores. The Clavariaceae are especially delineated by the form of the fruit body. Only in the Thelephoraceae and very seldom in the Hydnaceae do similarly arranged forms occur. They are distinguished from the Thelephoraceae in that for the most part they are translucent; Thelephoraceae are not.

A. Fruiting bodies very small, not divided.
B. Basidia with 1 or 2 sterigmata.
C. Spores colored ....................................BAUMANNIELLA
CC. Spores hyaline.
D. Fruit body pileate, basidia with 1 sterigma..GLOEOCEPHALUS
DD. Fruit body clavate, basidia with 2 sterigmata....PISTILLARIA
BB. Basidia with 4 sterigmata.
C. Fruit body clavate to filiform.......................TYPHULA
CC. Fruit body inflated above, hollow................PHYSALACRIA
AA. Fruit bodies mostly of considerable size; usually branched.
B. Hymenophore mostly cylindric or compressed, not leaf-like.
C. Fruit body fleshy...................................CLAVARIA
CC. Fruit body not fleshy.
D. Fruit body cartilaginous, drying coriacious........PTERULA
DD. Fruit body almost leathery, covered with a felt-like tomentum ............................LACHNOCLADIUM
BB. Hymenophore leaf-like, compressed...................SPARASSIS

SEPARATION OF THE FAMILY THELEPHORACEAE.

A. Hymenium with projecting cystidia.
B. Fruit body resupinate or effused, fixed firmly to the substratum.
C. Spore wall colorless.
D. Contents of the spore colorless.
E. Spores not horned..........................CORTICIUM
EE. Spores with long horns....................MICHENERA
DD. Contents of spores colored.....................ALEURODISCUS
CC. Spore walls colored.
D. Fruit body gelatinous, drying cartilaginous.........ALDRIGEA
DD. Fruit body fleshy to leathery..................CONIOPHORA
BB. Fruit body only partly attached; effuso-reflexed or stipitate.
C. Substance of the fruit body made up of different layers........ STEREUM

CC. Substance of the fruit body of only one layer.
D. Fruit body leathery.
E. Hymenium not ribbed.
F. Hymenium almost smooth or beset with warts........ THELEPHORA
FF. Hymenium entirely smooth.............. HYPOLYSSUS
EE. Hymenium ribbed.
F. Ribs radiating, later warty.............. CLADODERRIS
FF. Ribs with warty spines................. BECCARIELLA
DD. Fruit body not leathery.
E. Fruit body nearly gelatinous to fleshy...... PHLEBBOPHORA
EE. Fruit body membranous; seldom fleshy or fleshy leathery.
F. Fruit body covered on the outside with the hymenium. CRATERELLUS
FF. Fruit body covered on the inside with the hymenium.
G. Fruit bodies solitary................... CYPHELLA
GG. Fruit bodies densely crowded............ SOLENIA
AA. Hymenophore with projecting bristle-like cystidia.
B. Cystidia one celled.
C. Cystidia simple, not branched.
D. Substance of the fruit body of one layer.
E. Fruit body resupinate...................... PENIOPHORA
EE. Fruit body clavate, stalked.................. SKEPPERIA
DD. Substance of the fruit body of more than one layer........ HYMENOCHETAE
CC. Cystidia stellately branched.................... ASTEROSTROMA
BB. Cystidia of spine-like groups of cells...................... BONIA

SEPARATION OF THE FAMILY HYDNACEAE.

Fruiting bodies variously shaped; of leathery, corky, woody or fleshy consistency. Hymenophore free; on the outside of the fruiting body standing out in the form of warts, knobs, spines or tooth-like plates. Basidia mostly 4-spored, seldom 1-spored.

A. Hymenophore without a base, composed of spines; basidia 1-spored. MUCRONELLA
AA. Hymenophore with a base.
B. Hymenium with cystidia.
C. Cystidia simple, unbranched.
D. Basidia mostly 1-spored, fruit body white, fleshy......... KNEIFFIELLA
DD. Basidia 4-spored, fruit body corky............ HYDNOCHAETE
CC. Cystidia stellately branched....................... ASTERODON
BB. Hymenium without cystidia.
C. Fruit body with crested folds or wrinkles.
D. Folds smooth on the apex........................ PHLEBIA
DD. Folds cut into comb-like teeth at the apex........ LOPHARIA
CC. Fruit body not having crested folds.
D. Covered with short frumentaceous warts.
E. Warts almost hemispherical, smooth on the apex, rounded. GRANDINIA

EE. Warts many parted on the apex, ciliate........ODONTIA
DD. Hymenophore with evident spines (see DDD).
E. Spines knob-like, thick, tufted or scattered irregularly, obtuse ....RADULUM
EE. Spines with subulate tips.
F. Fruit body Clavaria-like, cylindric..........HERICIUM
FF. Fruit body otherwise.
G. Spores colorless ....HYDNUM
GG. Spores colored ....PHAEODON
DDD. Hymenophore with lamellate teeth.
E. Fruit body leathery ....IRPEX
EE. Fruit body fleshy or membranous...........SISTOSTREMA

SEPARATION OF THE FAMILY POLYPORACEAE.

A. Hymenophore resupinate; when young made up of wrinkles; these become flattened uneven hollows or corridors lined with tender walls.
B. Fruiting body effused or effuso-reflexed, no stalk......MERULIUS
BB. Fruiting body stalked; stalk bearing several pilei over each other. MYCODENDRON
AA. Hymenophore made up of tubes, deep spiral corridors, honeycomb-like cells (vein bound) or concentrically blending plates.
B. Substance of the fruit body entering the dissepiments of the tubes, etc., the latter not special plates free from the fruiting body.
C. Tubes, corridors or honeycomb-like cells growing compactly.
D. Hymenophore of roundish very small tubes.
E. Substance of the dissepiments differing from that of the pileus.
F. Fruiting body entirely resupinate..............PORIA
FF. Fruiting body dimidate, pileate; sessil or stalked.
G. Fruiting body from the beginning of more or less woody consistency ....FOMES
GG. Fruiting body otherwise.
H. Volvate ....CRYPTOPORUS
HH. Not volvate.
I. Fruiting body when young of fleshy consistency, later hardening ......POLYPORUS
II. Fruiting body of membranous, leathery or stupose consistency ....POLYSTICTUS
EE. Substance of the dissepiments not differing from that of the pileus ....TRAMETES
DD. Hymenophore not made up of symmetrical rounded tubes (see DDD).
E. Hymenophore of elongate or labyrinthiform corridors.
F. Corridors labyrinthiform ....DAEDALIA
FF. Corridors elongate, plate like..............LENZITES
EE. Hymenophore of angular honeycomb-like cells.
F. Fruit body leathery or corky; sessil......HEXAGONIA
FF. Fruit body of more or less gelatinous consistency.
G. Fruit body uniformly gelatinous..........LASCHIA

GG. Fruit body partially leathery; hymenium gelatinous ....GLOEOPORUS

DDD. Hymenophore gill-like; fruit body mostly fleshy, seldom leathery.

E. Hymenophore made up of radially extending, ribbed, blending lamellae ....FAVOLUS

EE. Hymenophore made up of concentric lamellae........... CYCLOMYCES

CC. Tubes standing isolate.

D. Fruit body membranous, resupinate.

E. Tubes in the centre with cylindric papillae...THELEPORUS

EE. Tubes without papillae...................POROTHELIUM

DD. Fruit body more or less fleshy; not resupinate....FISTULINA

BB. Substance of the fruiting body only loosely bound to the hymenophore, the latter of a distinct plate easily separable.

C. Fruit body with a lateral stalk or sessil...........HENNINGSIA

CC. Fruiting body with a central stalk.

D. No veil or volva.

E. Fruit body of firm gelantinous consistency...CAMPBELLIA

EE. Fruit body of fleshy consistency.

F. Spore wall colorless.

G. Spore wall hyaline, spore print white......SUILLUS

GG. Spore wall livid, spore print pink........TYLOPILUS

FF. Spore wall colored; spore print brown.......BOLETUS

DD. Fruit body with more or less evident veil or volva.

E. Inner veil only present.

F. Spore print black....................STROBILOMYCES

FF. Spore print brown or yellow...............BOLETOPSIS

EE. Volva only, present .....................VOLVOBOLETUS

SEPARATION OF THE FAMILY AGARICACEAE.

(Adapted from Atkinson's "Mushrooms, Edible, Poisonous, etc.")

Fruiting body mostly fleshy, seldom of cuticular or leathery composition. Pileate; stipe central, eccentric or lateral. Hymenophore of radiating anastomosing folds or wrinkles but mostly of plates, which for the most part are free, seldom anastomosing in the matrix or dichotomously branched.

A. Spores white.

B. Plants fleshy, putrescent, do not revive well on moistening.

C. Gills acute on the edge.

D. Trama of pileus of interwoven threads, not vesiculose.

E. Gills thin, not much broadened towards the pileus.

F. Stipe central or subcentral.

G. Stipe fleshy, pileus easily separating from the stipe, gills usually free.

H. Volva and annulus present.......AMANITA

HH. Volva present, annulus wanting.......... AMANITOPSIS

HHH. Volva wanting, annulus present....LEPIOTA

GG. Stipe fleshy or fibrous and elastic, confluent with the cap and of the same texture (see GGG).
H. Annulus present, volva wanting, gills attached to the stem..........ARMILLARIA
HH. Annulus and volva wanting.
I. Gills sinuate...............TRICHOLOMA
II. Gills decurrent ....CLITOCYBE
GGG. Stipe cartilaginous, pileus confluent with the stipe but of a different texture.
H. Gills decurrent, pileus umbilicate........ OMPHALIA
HH. Gills not decurrent.
I. Margin of the pileus at first involute, pileus flat or nearly so, somewhat fleshy ....COLLYBIA
II. Margin of the pileus at first straight, pileus campanulate, thin......MYCENA
FF. Stipe eccentric (rarely subcentral)....PLEUROTUS
EE. Gills broadened towards the pileus, waxy.......... HYGROPHORUS
DD. Trama of the pileus vesiculose, plants rigid but fragile.
E. Plants exuding a milky juice when bruised....... LACTARIUS
EE. Plants not exuding a milky juice when bruised..... RUSSULA
CC. Gills obtuse on the edge, fold-like or vein-like but prominent.
D. Gills decurrent, dichotomous............CANTHARELLUS
DD. Gills decurrent, plants parasitic on other mushrooms.... NYCTALIS
BB. Plants tough, either fleshy or gelatinous, membranaceous, corky or woody, reviving when moistened.
C. Edge of gills split into two lamellae and revolute........ SCHIZOPHYLLUM
CC. Edge of gills not split into two lamellae.
D. Stipe easily separating from the cap.
E. Plants tough and fleshy, membranaceous or leathery. MARASMIUS
EE. Plants gelatinous and leathery..........HELIOMYCES
DD. Stipe continuous with the cap.
E. Edge of gills acute.
F. Edge of gills usually serrate...........LENTINUS
FF. Edge of gills entire.......................PANUS
EE. Edge of gills obtuse.
F. Gills dichotomous......................XEROTUS
FF. Gills fold-like, irregular.................TROGIA
AA. Spores pink, rose, flesh or salmon color (see AAA).
B. Stipe central.
C. Pileus easily separating from the stipe, gills free.
D. Volva present, annulus wanting..............VOLVARIA

DD. Volva and annulus wanting..................PLUTEUS
CC. Pileus confluent with the stipe and of the same texture, gills attached, in some becoming almost free.
D. Stipe fleshy to fibrous, margin of pileus at first incurved.
E. Gills sinuate ....ENTOLOMA
EE. Gills decurrent ....CLITOPILUS
DD. Stipe cartilaginous.
E. Gills decurrent, pileus umbilicate...........ECCILIA
EE. Gills not decurrent, easily separating from the stipe.
F. Pileus slightly convex, margin at first incurved... LEPTONIA
FF. Pileus campanulate, margin at first straight..... NOLANEA
BB. Stipe eccentric or none and pileus lateral..........CLAUDOPUS
AAA. Spores yellow or rusty brown (see AAAA).
B. Gills not separating readily from the pileus.
C. Universal veil arachnoid, gills powdery from the spores.... CORTINARIUS
CC. Universal veil not arachnoid.
D. Stipe central.
E. Volva or annulus present on the stripe.
F. Annulus present ....PHOLIOTA
FF. Volva present ....LOCELLINA
EE. Volva and annulus wanting.
F. Gills free from the stem..............PLUTEOLUS
FF. Gills attached.
G. Gills dissolving into a gelatinous or powdery condition, but not diffluent ......BOLBITIUS
GG. Gills not dissolving.
H. Stipe fleshy.
I. Gills adnate or decurrent.....FLAMMULA
II. Gills sinuate.
J. Cuticle of the pileus silky or bearing fibrils ....INOCYBE
JJ. Cuticle of the pileus smooth, viscid... HEBELOMA
HH. Stipe cartilaginous or sub-cartilaginous.
I. Gills decurrent ....TUBARIA
II. Gills not decurrent.
J. Margin of the pileus inflexed........ NAUCORIA
JJ. Margin of the pileus straight from the first ....GALERA
DD. Stipe eccentric or none....................CREPIDOTUS
BB. Gills usually separating readily from the pileus, forked or anastomosing at the base, or connected with vein-like recticulations ....PAXILLUS
AAAA. Spores dark brown or purplish brown (see AAAAA).
B. Pileus easily separable from the stem, gills usually free.
C. Volva wanting, annulus present ....AGARICUS

CC. Volva present, annulus wanting..................CHITONIA
CCC. Volva and annulus wanting ....PILOSACE
BB. Pileus confluent with the stem, gills attached.
C. Veil present.
D. Annulus present, gills attached.............STROPHARIA
DD. Annulus wanting, veil remaining attached to the margin of the pileus ....HYPHOLOMA
CC. Veil wanting or obsolete.
D. Stipe fragile, margin of the pileus at first straight..... PSATHYRA
DD. Stipe tenacious, margin of the pileus at first incurved.
E. Gills sub-triangularly decurrent ....DECONIA
EE. Gills not decurrent ....PSILOCYBE
AAAAA. Spores black.
B. Gills deliquescing more or less, or pileus thin, membranous and splitting between the lamellae and becoming plicate........ COPRINUS
BB. Gills not deliquescing, etc.
C. Spores elongate, fusiform, plants with a slimy envelope.... GOMPHIDIUS
CC. Spores globose or ovoid.
D. Gills variegated from groups of dark powdery spores.
E. Annulus present ....ANNELARIA
EE. Annulus wanting, veil present ....PANAEOLUS
DD. Gills not variegated ....PSATHYRELLA

LIST OF SPECIES.

THELEPHORACEAE.

Corticium lilacine-fuscum B. & C. Det. Professor E. A. Burt.
On Beech. Nov. '05.

Corticium oakesii B. & C. Det. E. A. B.
On Elm. Covington Hill Jan. '05.

Corticium scutellare B. & C. Det. E. A. B.
On Maple. Nov. '04.

Peniophora allecheri Bres. Det. E. A. B.
On Basswood. April '05.

Hymenochaete cinnamonea (Pers.) Bres. Det. E. A. B.
On Maple. April '05.

Hymenochaete rubiginosa Schrad. Det. E. A. B.
On Dead Oak. April '05.

Stereum cinerascens Schw. Det. E. A. B.
On Maple. April '05.

Stereum fasciatum Schw. Det. E. A. B.
On Maple. April '05.

Stereum frustulosum (Pers.) Fr. Det. H. S. Jackson.
Common.

Stereum fuscum (Schrad.) Bres. Det. E. A. B.
On Maple. Nov. '04.

Stereum hirsutum Fr.. Det. E. A. B.
Common everywhere.
Stereum rameale Schw. Det. E. A. B.
On Wild Cherry. April '05.
Stereum versicolor Fr. Det. H. H. Whetzel.
On Beech. Nov. '04.

HYDNACEAE.

Hydnum coralloides Scop. Conf. H. H. W.
On Maple. Nov. '04.
Hydnum erinaceus Bull. (Fig. 16.)
On Hickory. Nov. '04.
Hydnum ochraceum Pers. Det. H. S. J.
On Maple. Nov. '04.
Phlebia hydnoides Schw. Det. E. A. B.
On Rotten Oak. April '05.
Grandinia-sp. Det. E. A. B.
On Poplar. Nov. '04.
Irpex sinuosa Fr. Det. H. S. J.
Nov. '04 and Apr. '05.

POLYPORACEAE.

Merulius tremellosus Schrad. (Fig. 22.) Det. Prof. G. F. Atkinson.
Trametes cinnabarina Fr. Det. G. F. A.
On Maple. Nov. '04.
Trametes *sp.* (?).
On Willow.
Polystictus conchifer Schw. Det. H. S. J.
On Elm. March '05.
Polystictus pergamenus Fr. Det. G. F. A.
On base of Maple tree.
Polystictus hirsutus Fr. Det. H. S. J.
Very common everywhere and very variable.
Polystictus versicolor Fr. Det. H. H. H.
Very common everywhere.
Polyporus arcularius (Batsch.) Fr. Det. G. F. A.
Common everywhere on logs, etc.
Polyporus adustus Fr. Det. G. F. A.
On old logs. Dec. '04.
Polyporus epileucus Fr. (?) Det. H. H. W. & H. S. J.
Polyporus fumosus Fr. Det. H. S. J.
On Maple. Nov. '04.
Polyporus gilvus Schw. Det. H. S. J.
On Beech, Maple, etc.
Polyporus pubescens (Schw.) Fr. Det. H. H. W. & H. S. J.
On Maple. Nov. '04.
Polyporus resinosus (Schrad.) Fr. Det. H. H. W.
On Maple log. Nov. '04.

Polyporus sulphureus Fr. Figs. 18-19. Det. H. H. W.
On Beech. Nov. '04.
Gleoporus conchoides Mont. Det. H. S. J.
On Maple. April '05.
Fomes "applanatus" Fr.
Very common everywhere, on living and dead trees.
Daedalia ambigua Berk. Det. G. F. A.
On Maple; found only once. Nov. '04.
Daedalia confragosa Pers. Det. H. S. J.
On Maple. April '05.
Daedalia quercina Pers. (Fig. 20.)
On ends of railroad ties, etc.
Daedalia unicolor Fr. Conf. H. S. J.
On Maple. April '05.
Lenzites betulina Fr. Conf. H. S. J.
On Maple Nov. '04.
Favolus europaeus Fr. Det. H. H. W.
Common April and November.
Boletinus porosus Pk. Conf. H. H. W.
Oct. '04.

AGARICACEAE.

Agaricus campestris Linn. Edible. (Fig. 6.) Conf. H. H. W.
Common—Found in fields and pastures—on campus.
May 5, '05, Sept. 30, '04.
Agaricus placomyces Pk. Edible. Conf. H. H. W.
About stumps on Campus, September '04.
Armillaria mellea Vahl. Edible. (Fig. 12.)
Very common and abundant on wood and about stumps.
Anellaria scitula Massee (?).
Bolbitius vitellinus Fr. Det. G. F. A.
On dung about campus, May 10, 1905.
Claudopus nidulans (Pers.) Pk.
On rotten wood; found only once, Nov. '04.
Clitocybe cartilaginea Bull. Det. G. F. A.
Under Chestnut tree and on Campus; common.
Sept. 24, '04; April 25, '05.
Clitocybe cyathiformis Bull. Edible. Conf. H. H. W.
On ground in Campus, Sept. 27, 1904.
Clitocybe illudens Schw. Not edible. (Fig. 8.) Conf. H. H. W.
About stumps.
Clitocybe nebularis Batsch. Edible. Conf. H. H. W.
On grassy lawns, Sept. '04.
Clitocybe pithyophila Fr. Conf. H. H. W.
On Campus about stumps. Oct. '04.
Collybia dryophila Bull. Edible. Det. G. F. A.
Extremely common everywhere in spring.
Collybia radicata Relh. Edible. Conf. H. H. W.
Very common April to October.

Collybia velutipes Curt. (Fig. 10.) Conf. H. H. W.
Common April to October.
Coprinus atramentarius (Bull.) Fr. Edible. Conf. H. H. W.
October '04.
Coprinus comatus Fr. Edible. Conf. H. H. W.
Common May to September.
Coprinus ebulbosus Pk. Edible. Det. H. H. W.
Coprinus lagopus Fr.
On dung, April '05.
Coprinus micaeceus (Bull.) Fr. (Fig. 14.) Edible. Conf. H. H. W.
Very common everywhere about stumps and in lawns April to November.
Crepidotus versutus Pk. Conf. H. H. W.
On rotten wood. May '05.
Galera ovalis Fr. Det. G. F. A.
On dung after rains, April, etc.
Hypholoma appendiculatum Bull. Edible. Det. G. F. A.
Very abundant about old stumps and in sod, April and May.
Hypholoma sublateritium Schaeff. Edible. (Fig. 11.) Conf. H. H. W.
Oct. and Nov. Common everywhere about stumps.
Lentinus lecomtei Fr. Det. G. F. A.
Very common on logs and stumps, April and November.
Lepiota americana Pk. Edible.
Found only once about a stump.
Lepiota naucina Fr. Edible.
September, etc. In sod.
Lepiota procera Scop. (Fig. 4.)
In lawns, June.
Marasmius rotula (Scop.) Fr. Det. H. H. W.
On bark and twigs, April and May.
Mycena leaiana Berk. Det. H. H. W.
May to November. On rotten logs. Abundant.
Mycena galericulata Scop. Conf. H. H. W.
On logs and in leaf humus. May '05.
Panaeolus retirugis Fr. Edible. (Fig. 9.) Conf. G. F. A.
Everywhere on dung, April and May.
Panus stipticus Fr. Det. H. H. W.
Found only once—on old log, November, '04.
Pholiota unicolor Vahl.
On rotten logs—April.
Pholiota praecox Pers. Edible. Det. G. F. A.
In grassy places. May.
Pholiota spectabilis Fr. Det. G. F. A.
On rotten stumps and logs, April and May.
Pleurotus applicatus Batsch. Det. G. F. A.
On bark and dead trees, October.
Pleurotus ostreatus Jacq. Edible. (Fig. 7.)
Common on logs and stumps, May to October.
Pleurotus sapidus Kalchbr. Edible. Conf. G. F. A.
On logs and stumps much like P. ostreatus.

Pluteus cervinus Schaeff. (Fig. 13.)
About an old stump.
Psathyra conopilea Fr. Conf. G. F. A.
Common in sod after rains, April and May.
Psathyrella disseminata Pers.
Common about old stumps after rains, April and May.
Schizophyllum commune Fr.
One of the most common, April to November.
Stropharia stercoraria Fr. Det. G. F. A.
On dung after rains.
Tricholoma melaleucum Var. polioleucum Fr. Det. G. F. A.
After rains in sod, April and May.

The following common gastromycetes have also been found:

Lycoperdon bovista Linn. Edible.
Lycoperdon gemmatum Batsch. Edible. (Fig. 23.) Det. H. H. W.
Very common everywhere in autumn.
Lycoperdon giganteum Batsch. Edible.
Lycoperdon pyriforme Schaeff. Edible. Det. H. H. W.

Wabash College, Feb. 1, 1907.

Fig. 1. Amanita muscaria Linn. (Natural size.) This poisonous plant has been found in the State, and probably occurs frequently during the summer months. The cap is orange, while the scales are whitish. After Atkinson.

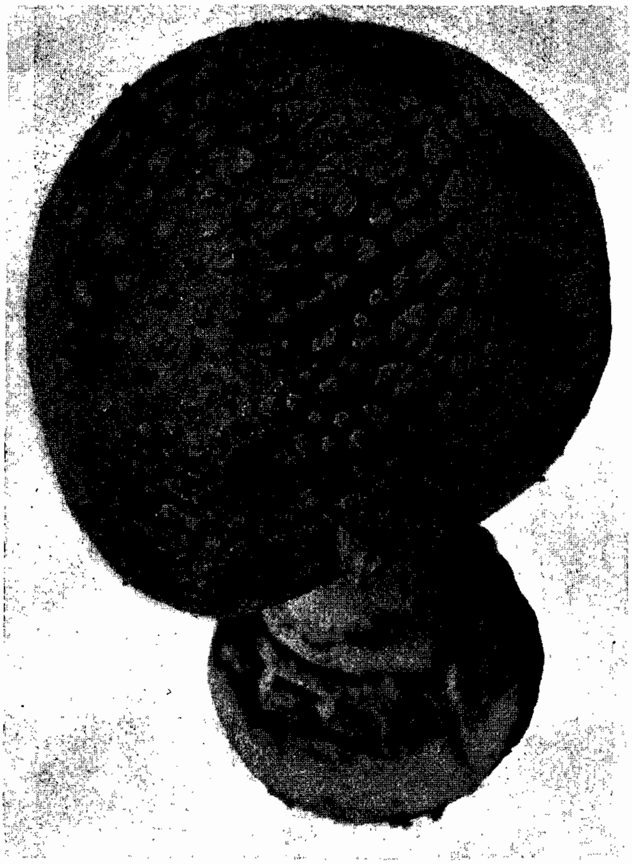

Fig. 2. Amanita muscaria. (Natural size.) Showing the scales on the cap which are remnants of the universal veil or volva.

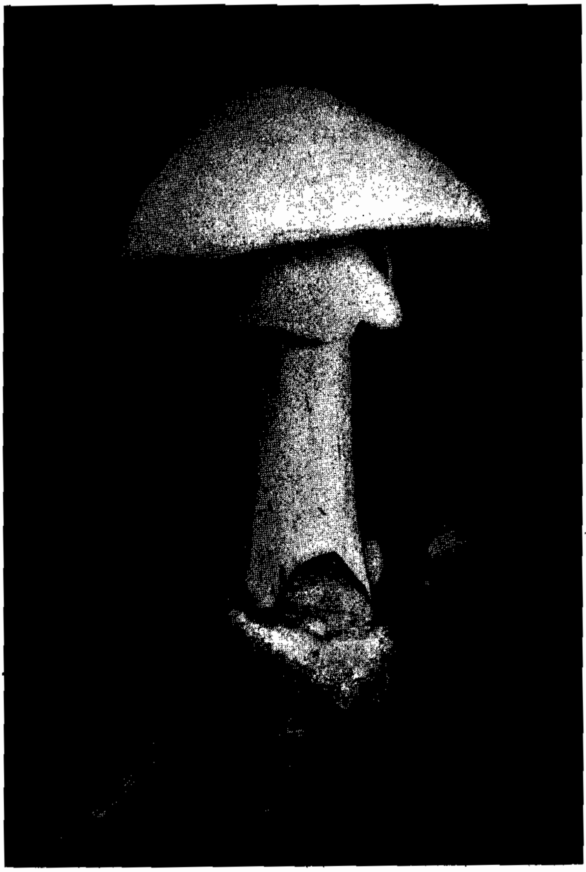

Fig. 3. Amanita verna Bull. (Natural size.) This plant, which is deadly poison, has often been mistaken for the common mushroom. The presence of the volva at the base serves to distinguish it. (Both this and Fig. 2 after Atkinson.)

Fig. 4. Lepiota procera Scop. (Three-fourths natural size.) An edible plant occurring in lawns, pastures, etc. After Atkinson.

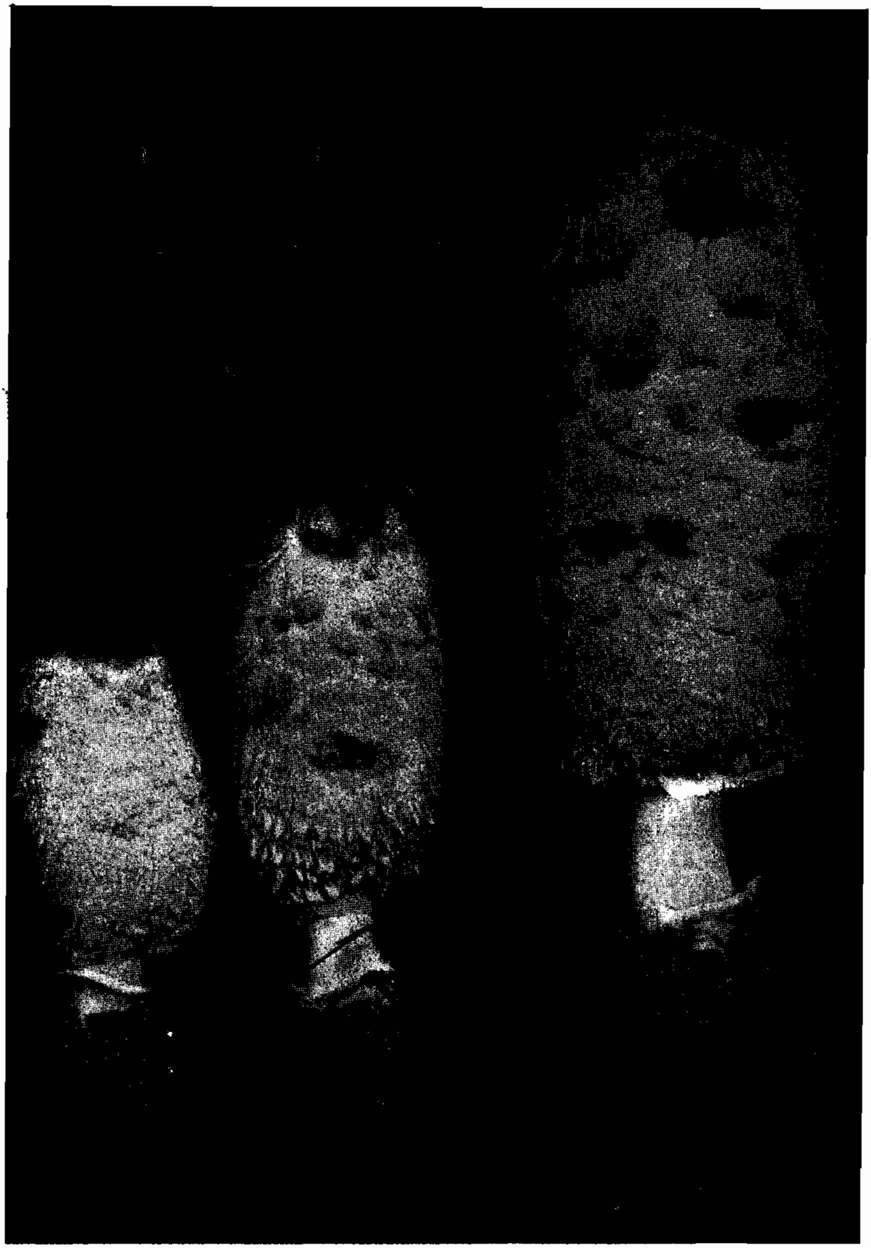

Fig. 5. Coprinus comatus Fr. (Natural size.) This large edible plant occurs very commonly in grassy places. At maturity the gills deliquescé to an inky fluid. After Atkinson.

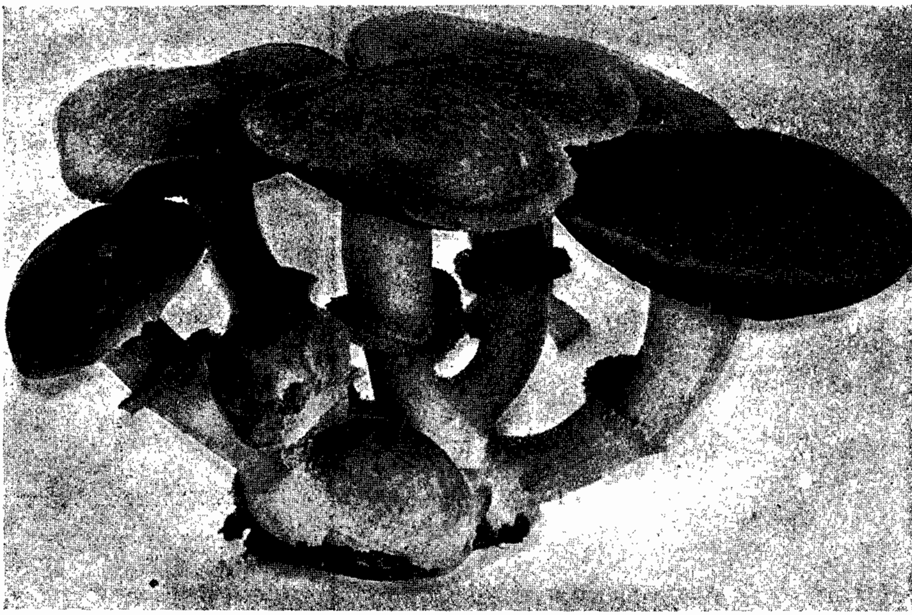

Fig. 6. Agaricus campestris Fr. (Two-thirds natural size.) Our common edible field mushroom. Photograph made from specimens grown in the greenhouse from pure culture spawn. After Atkinson.

Fig. 7. Pleurotus ostreatus Jacq. (Natural size.) This plant is edible and occurs in great abundance on old logs, trees, etc. After Atkinson.

Fig. 8. Clitocybe illudens Schw. (Natural size.) Not edible. Entire plant saffron yellow. Photo, G. F. Atkinson.

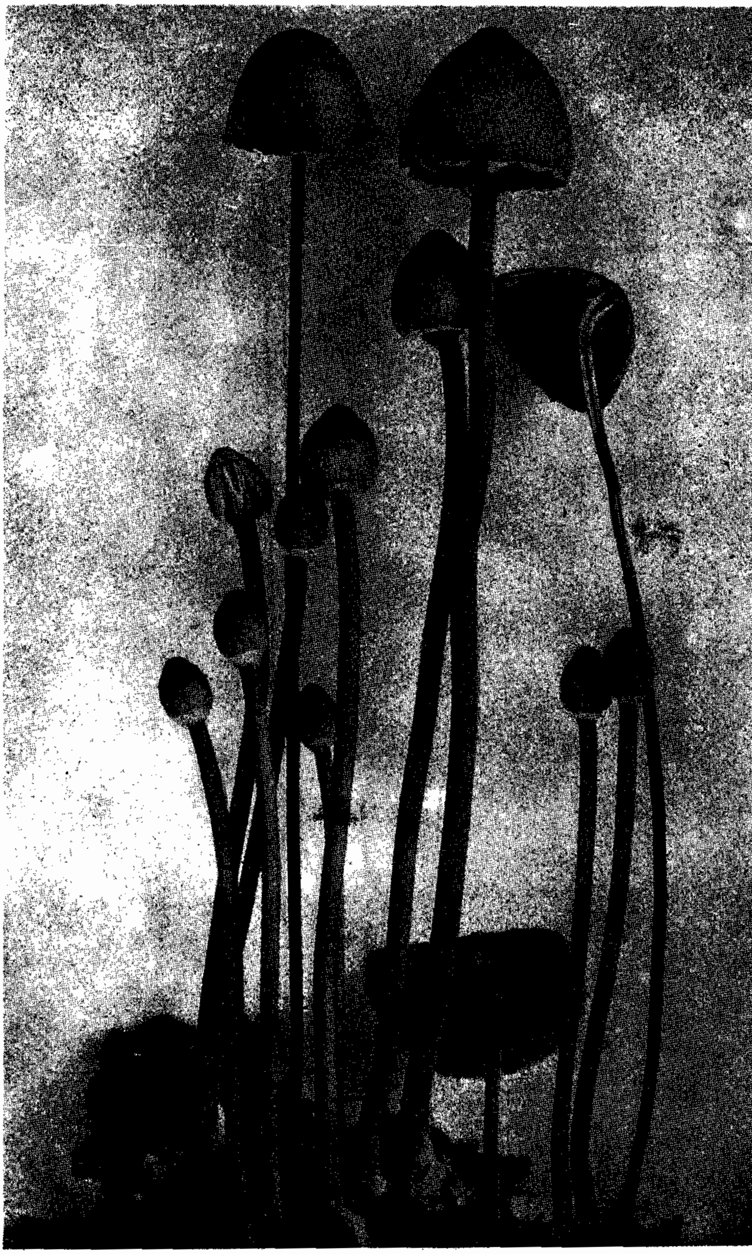

Fig. 9. Panaeolus retirugis Fr. (Natural size.) A dung-inhabiting species. Edible. Photo, Atkinson.

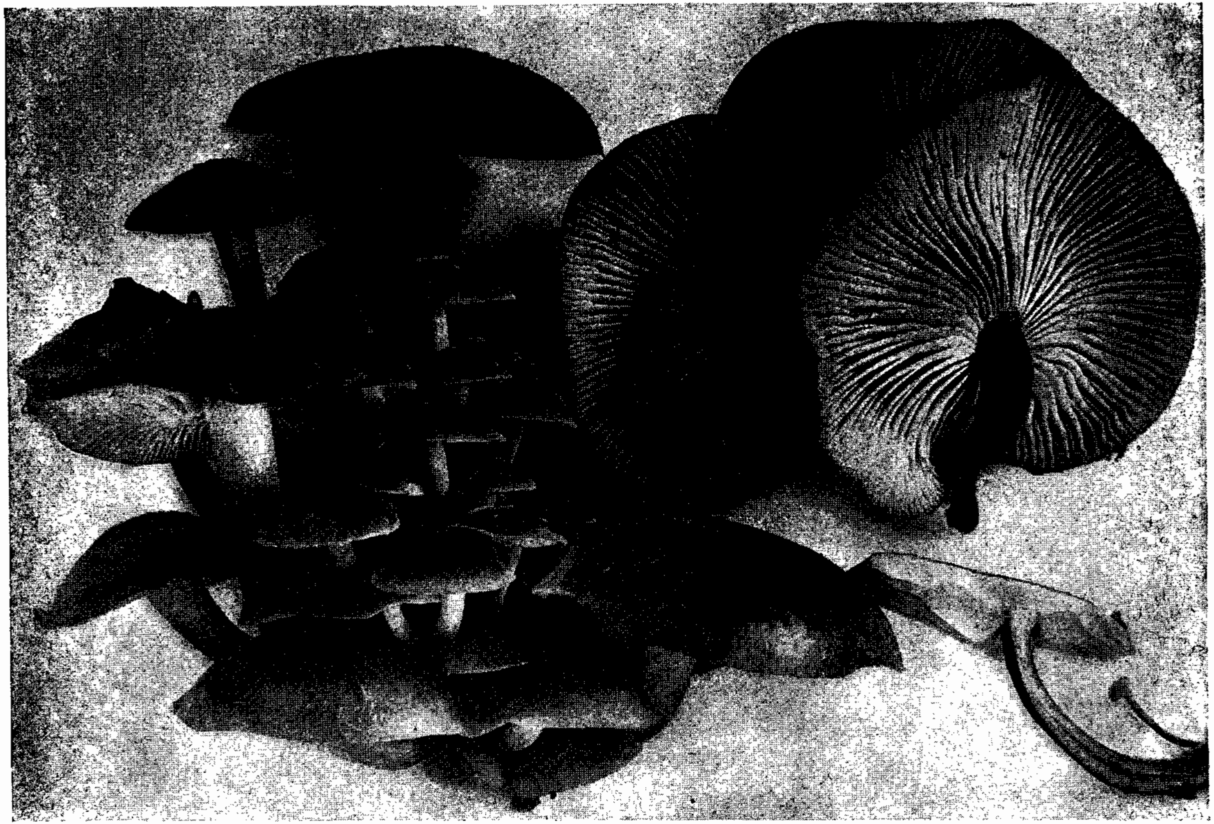

Fig. 10. Collybia velutipes Fr. (Natural size.) Found on logs or occasionally on living trees. Very tough. Photo by Atkinson.

Fig. 11. Hypholoma sublateritium Schaeff. (Natural size.) A brick red plant occurring abundantly about stumps, etc. Edible, but sometimes bitter. Photo, Atkinson & Reddick.

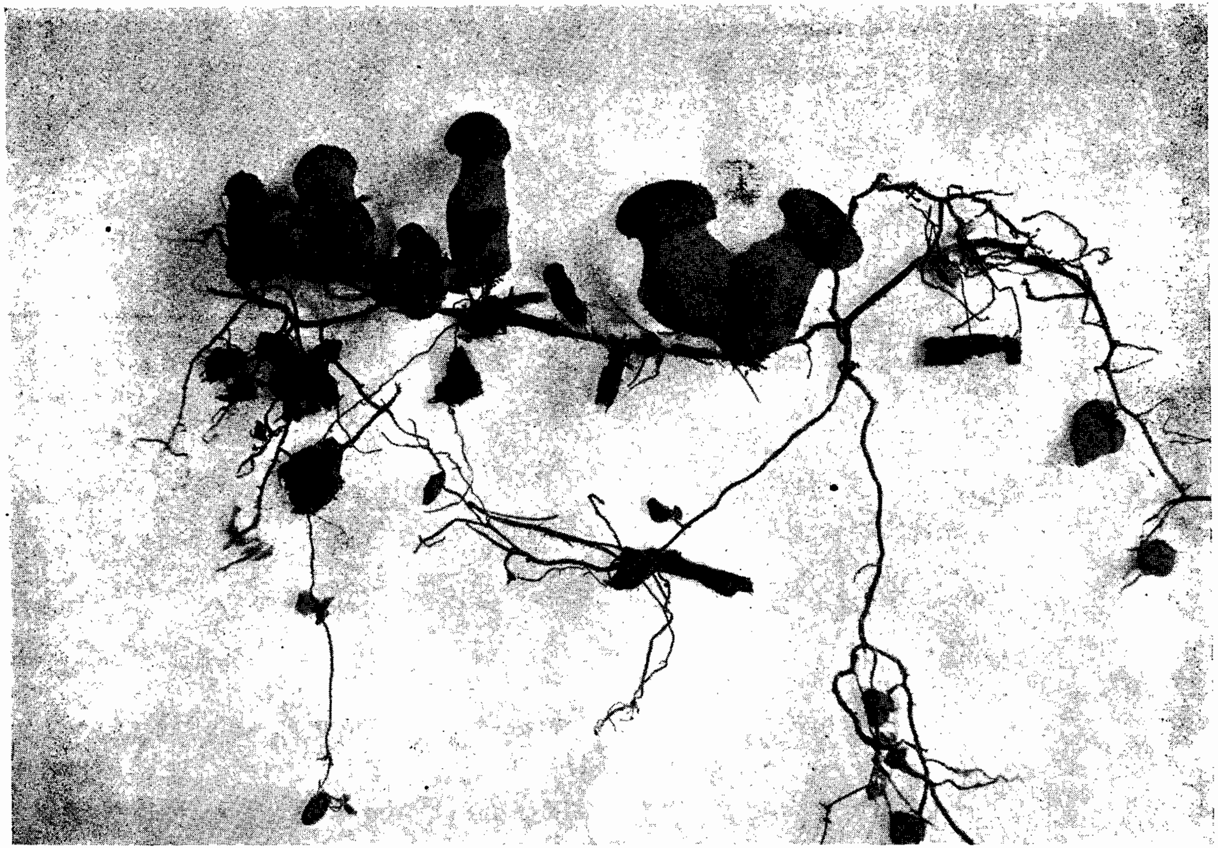

Fig. 12. Armillaria mella Vahl. (Natural size.) From the living roots of a maple tree. The plants are all young. This plant is sometimes parasitic, and black rhizomorphs attached to bits of the wood can be seen. Photo, Whetzel.

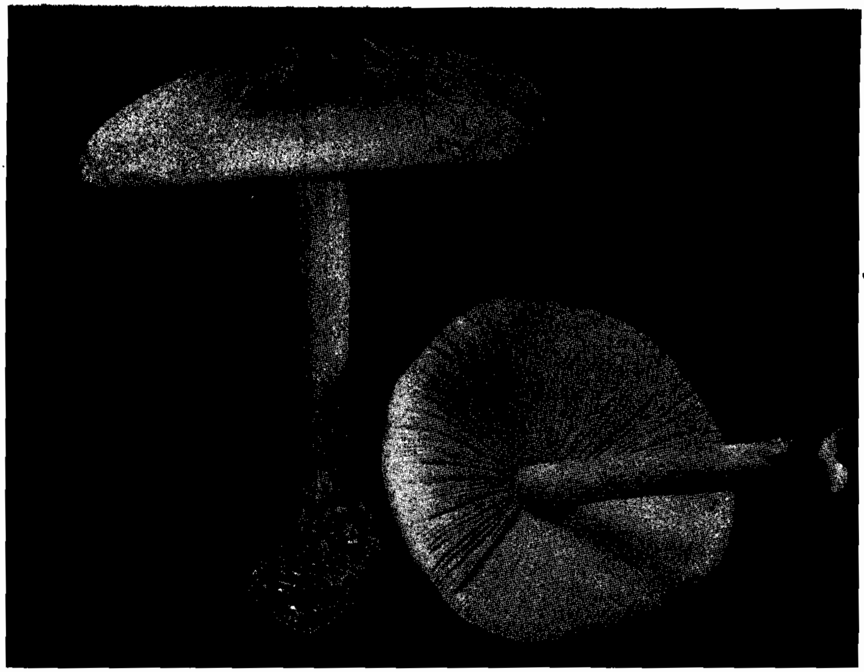

Fig. 13. Pluteus cervinus Schaeff. (Natural size.) A pink spored plant found most frequently on sawdust or rotting stumps.

Fig. 14. Coprinus micaceus (Bull) Fr. (Natural size.) An edible species very common in lawns and about dead stumps, etc. This plant may be recognized by its tawny cap and the minute glistening scales on the surface. Original.

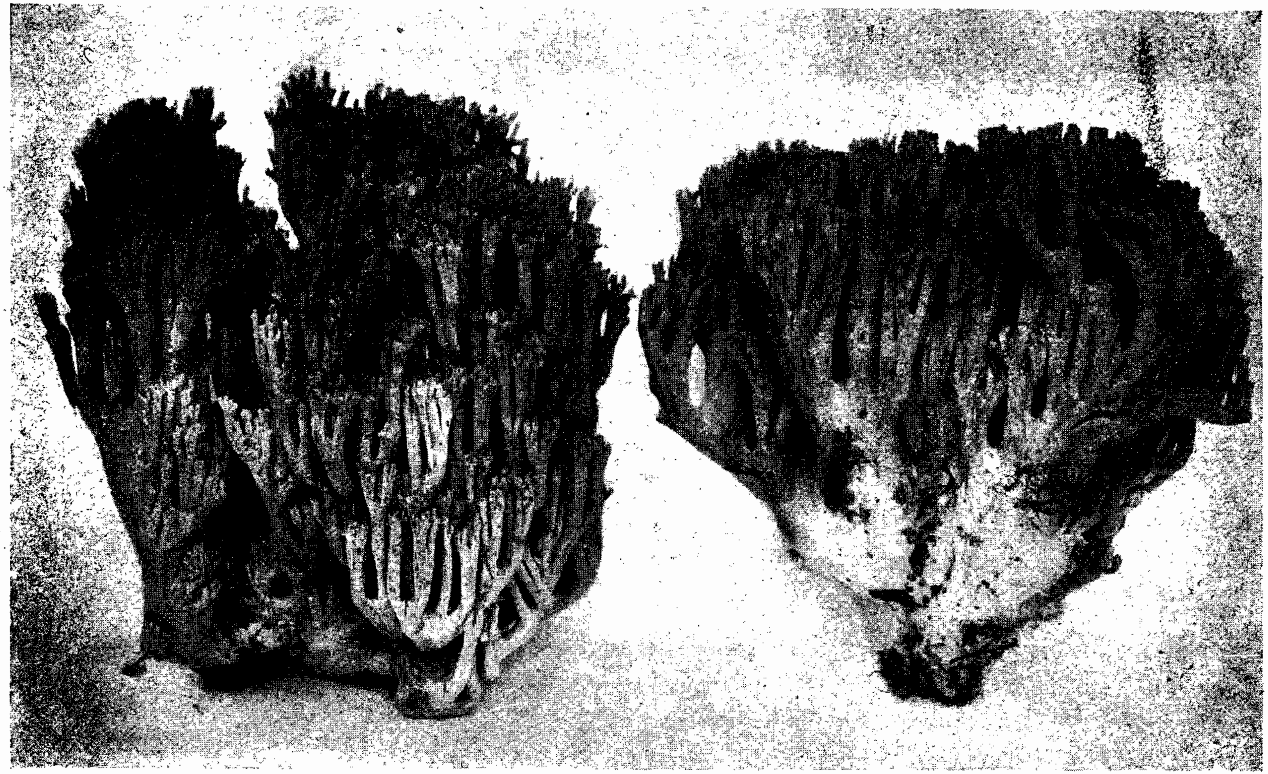

Fig. 15. Clavaria flava Schaeff. (Natural size.) All Clavarias are edible. Photo by Atkinson.

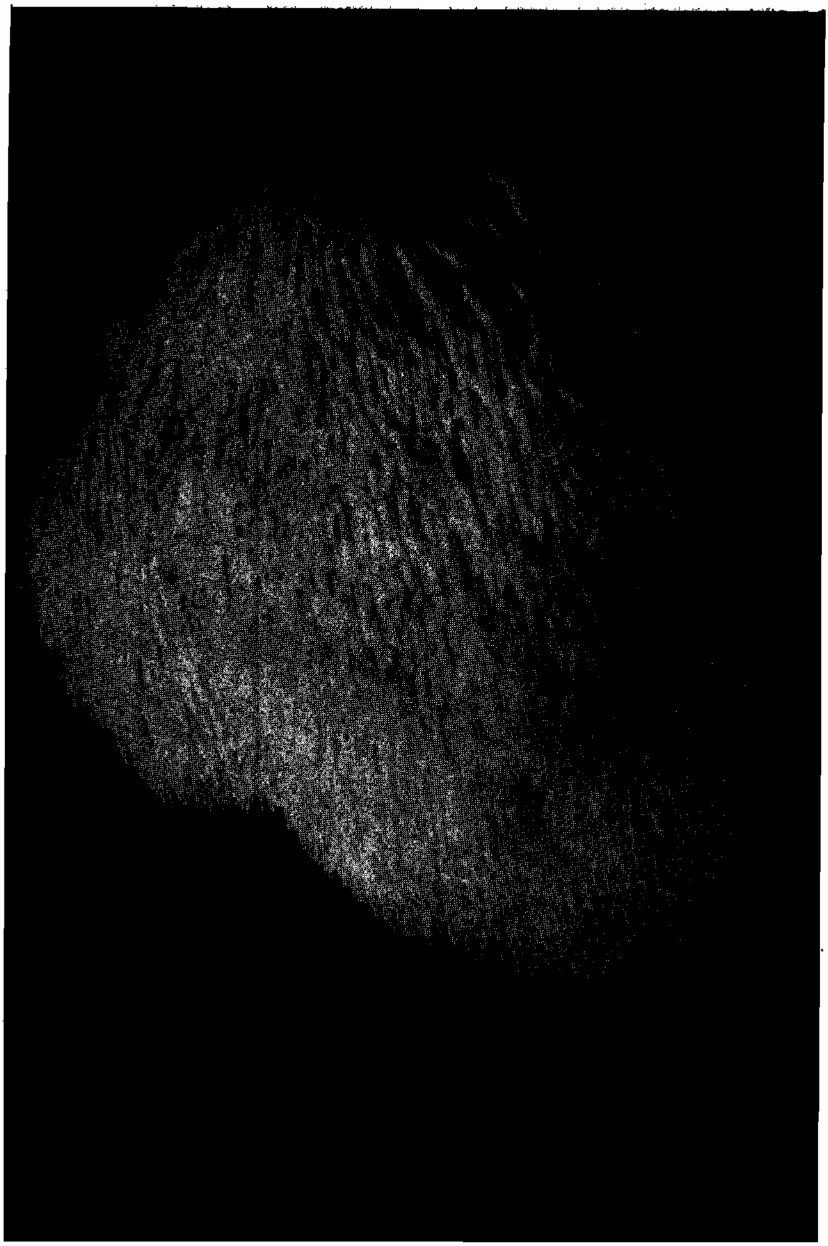

Fig. 16. Hydnum erinaceus Bull. (Natural size.) This and other similar species of Hydnum occur frequently on logs and trunks of trees. After Atkinson.

Fig. 17. Boletus edules Bull. (Natural size.) This large edible plant undoubtedly occurs frequently during the summer months. Many of the Boleti are poisonous.

Fig. 18. Polyporus sulphureus (Bull) Fr. (Reduced.) This is a wound parasite and occurs frequently on improperly pruned shade trees. After Atkinson.

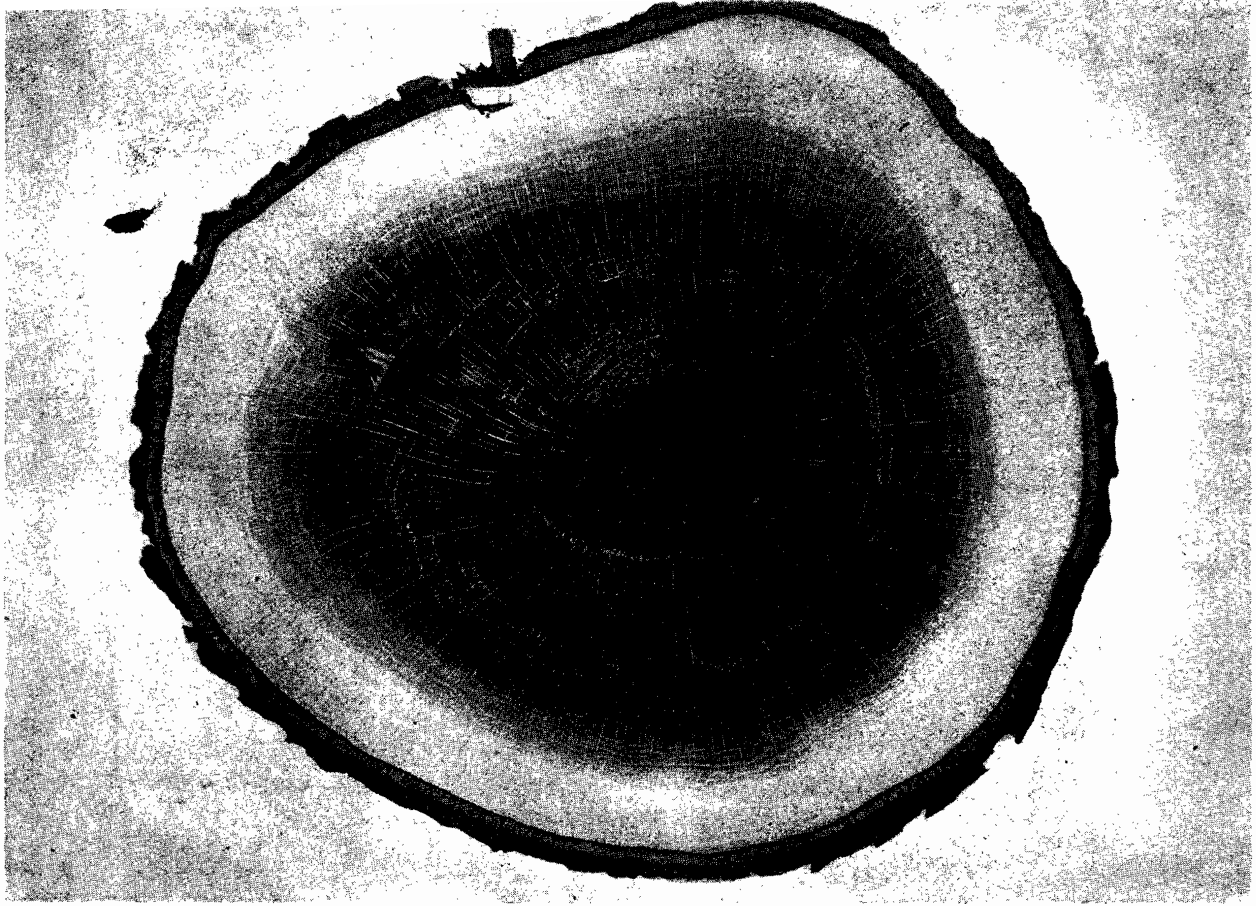

Fig. 19. Beech wood affected by Polyporus sulphureus. The mycelium absorbs water and causes the tree to check and crack. When cut with a coarse saw large bits are torn out and even with a fine saw the wood is not left smooth as is shown in the photograph. After Atkinson.

Fig. 20. Daedalia quercina (L) Pers. (Natural size.) As the name implies this plant is most often found on oak. It is especially destructive to oak railroad ties. Photo, Atkinson.

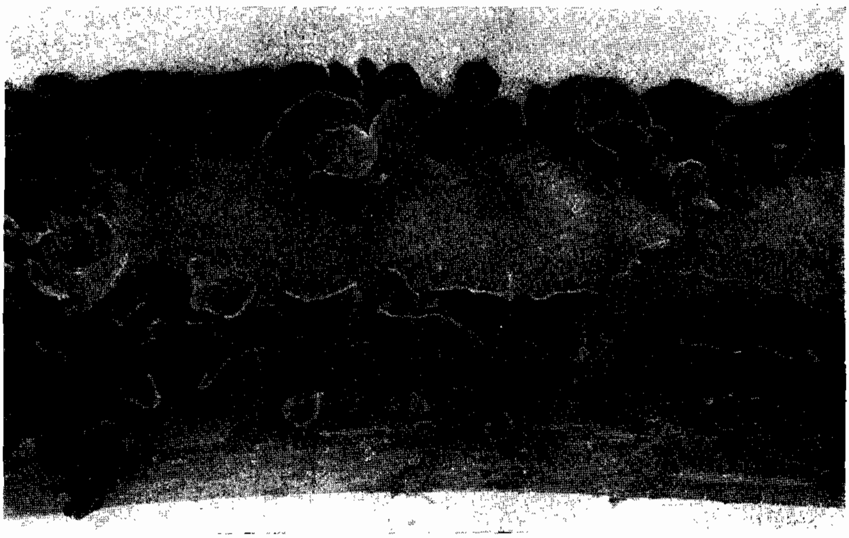

Fig. 21. Hymenochaete tabacina Lev. (Natural size.) On a rotten limb. For the most part the plant is effused over the surface of the limb, but the margin is free and reflexed. Photo, Atkinson.

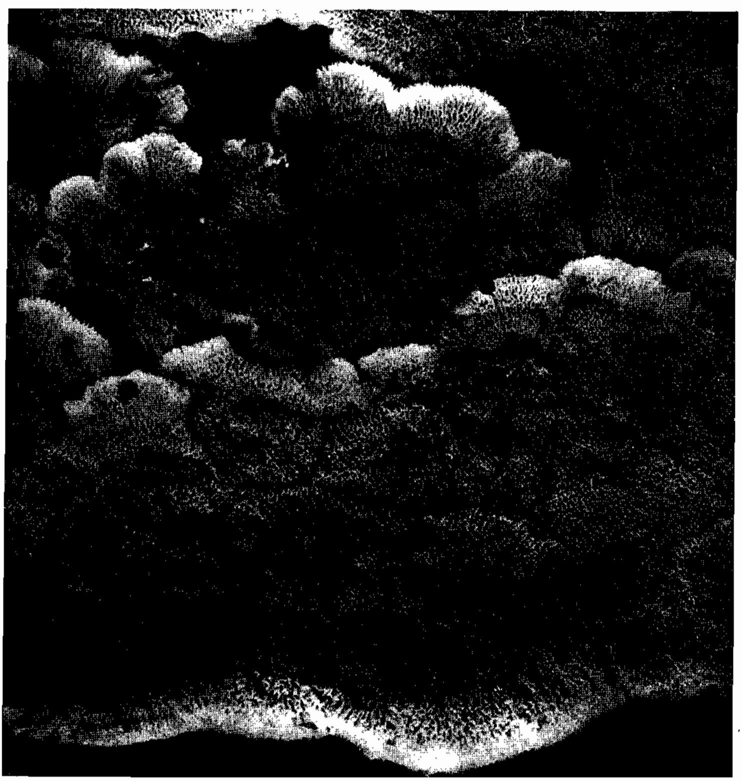

Fig. 22. Merulius tremellosus Schrad. (Natural size.) One of the Polyporaceae which is entirely effused or only partly reflexed.

Fig. 23. Lycoperdon gemmatum Batsch. (Natural size.) All the puff balls are edible as long as they are white on the inside.

Fig. 24. Morchella esculenta (L) Pers. (Natural size.) This ascomycetous fungus is widely known as "the mushroom" and is the most highly prized of all edible fungi.

GENERAL INDEX.