

FORTY-FIRST ANNUAL REPORT

OF

DEPARTMENT OF

**GEOLOGY AND NATURAL
RESOURCES**

INDIANA

EDWARD BARRETT
STATE GEOLOGIST

1916

There are a number of misspelled words
and typographical errors in this volume
for which we ask the reader's indulgence.

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August 2, 1917.

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OTTO L. KLAUSS,

Auditor of State.

August 2, 1917.

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Secretary to the Governor.

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Secretary of State.

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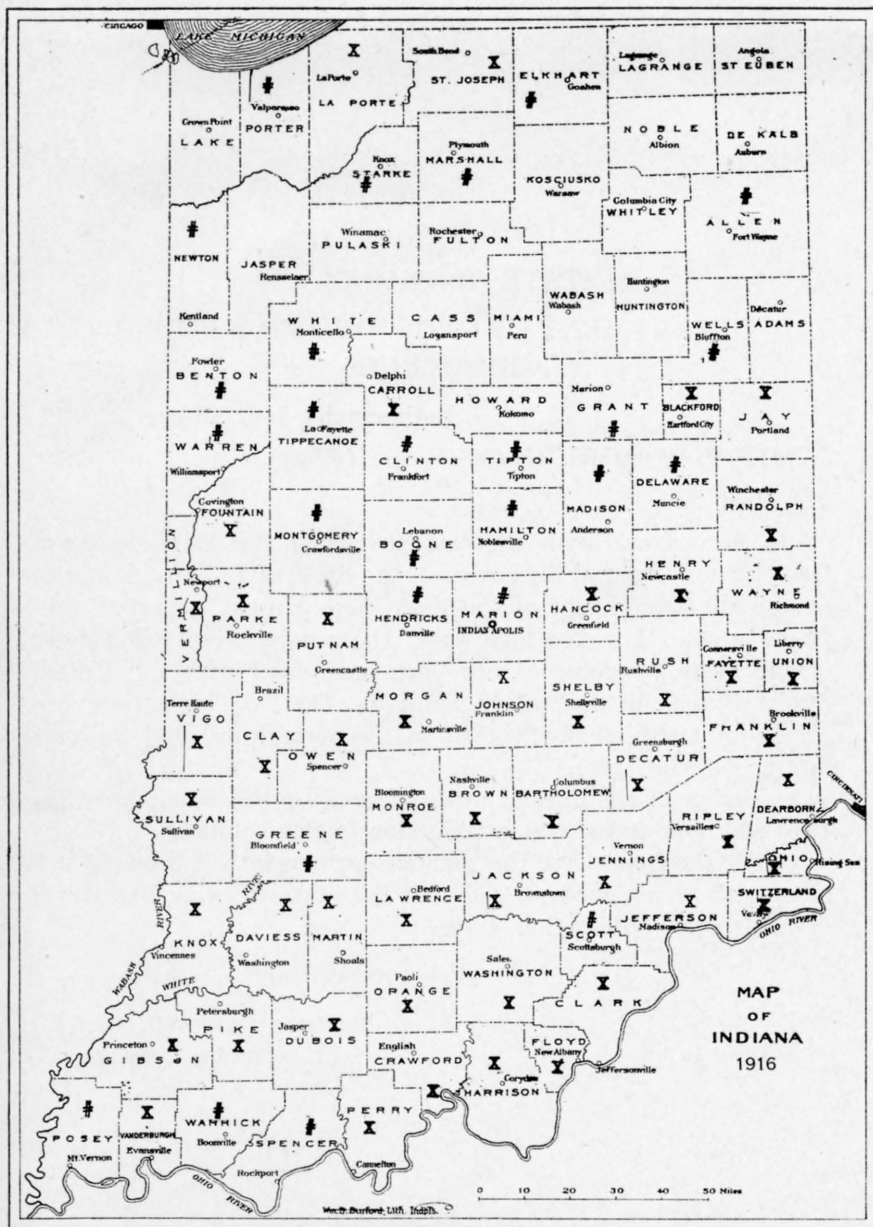
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Map showing counties in which soil survey has been made.
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 Counties surveyed in co-operation with U. S. Bureau marked #.

EDWARD BARRETT, State Geologist.

STATE OF INDIANA.
DEPARTMENT OF GEOLOGY AND NATURAL
RESOURCES

Indianapolis, Ind., August 2, 1917.

JAMES P. GOODRICH, *Governor of Indiana:*

My Dear Sir—

In accordance with the law governing the Department of Geology and Natural Resources of the State of Indiana, I submit to you the manuscript of the Forty-first Annual Report of said Department. For the fifth year the co-operative soil Survey of the State by counties has been conducted with the United States Bureau of Soils of Washington, D. C. This survey has been productive of much good to the agricultural and business interests of the State.

A review of the lines of work pursued by the Department for 1916 will be found in the introduction to this volume.

With the hope that the manuscript herewith submitted will meet with your approval, and that the State Printing Board will order its early publication, I am,

Very respectfully,

EDWARD BARRETT,
State Geologist.

INTRODUCTION.

The Department of Geology and Natural Resources is the principal medium of information for the people of the State, regarding its natural raw materials. This information is given out in the following ways:

1. By work of State Geologist and assistants in the field.
2. By publication and distribution of Annual Reports.
3. By publication and distribution of bulletins and circulars.
4. By lectures by State Geologist and assistants.
5. By office consultation with citizens of the state regarding the location and uses of natural resources.
6. By correspondence with citizens and investors.

All of the above assistance is rendered the citizens of the state, and even to citizens of other states, free of charge. In addition to the above it often becomes the duty of the State Geologist to warn citizens against fake advertisements and investments in dishonest schemes and propositions.

No other Department in the State can so well attend to the above lines of duties as a State Department of Geology and Natural Resources, located in the capital city of the State and under the management of a careful and conscientious State Geologist. Such a Department and such an official give a color of certainty and authority to recommendations regarding the State and its resources.

The principal natural resources of the State are coal, clays, limestones, sandstones, sands, gravels, oils, gas, mineral water and soils. It is the purpose and custom of the Department of Geology to investigate one or more of these resources in the field, and later give out the information gathered in the field in the different ways mentioned in second paragraph of this introduction.

The question has been asked: "Will not these investigations be completed in the near future, and will not the day come when there will be no need of a Department of Geology?" The most direct answer to such inquiries is that the development and use of our natural resources is just in its infancy.

Each year, and we dare say each month, some new use of some one of our natural resources is discovered, and this new use necessitates a new kind, or variety, of such resource. To illustrate, about twenty years ago the principal use for clay was for brickmaking. Today there are twenty varieties of brick, and each variety takes a different kind of clay, or a different mixture of clays, and clays are used in making a hundred different other products than brick and each product requires a different clay. It is a part of the work of the Department of Geology to find varieties of clay suitable for these products. Who can say that the future will not require a hundred more varieties in clays and their products? And what is true of clays is also true of the other natural resources mentioned above. Thus it is seen that the work of the Department of Geology widens and becomes more important to the citizens of the State as the years go by.

It has been the custom of the Department to elect, each year, a certain one of our resources for the major part of the investigations and work.

During the year 1916, the investigation of the Soils of the State were continued both as a State Survey, and under a co-operative agreement with the U. S. Bureau of Soils. The importance of this work is emphasized by the increased demand for agricultural food products, both in this country and in foreign countries, as a consequence of the European war. The purpose of the Soil Survey is to increase both the areal and intensive sides of farming by investigating the soils from the geological standpoint, leaving the strictly cropping or cultural side of the work to Purdue University and the Agricultural Extension Management.

The investigations conducted by the Department of Geology, covered the following points:

1. Examination of soil material in the field.
2. Topography and physiographic situation of soils.
3. Sources and derivation of materials.
4. Agencies through which material has accumulated.
5. Elements in classification of soil types.
6. Selection of samples of soil types in a county.
7. Chemical and mechanical analyses of soil types.
8. Mapping of soils by counties.
9. Writing report.

The elements entering into the above topics include:

1. Color of Soil.

2. Color of subsoil.
3. Texture of soil.
4. Texture of subsoil.
5. Structure of subsoil.
6. Substratum, if any.
7. Parent material.
 1. Glacial.
 2. Residual.
8. Hardpan, if any.
9. Drainage.
 1. Natural.
 2. Artificial (tile).

Investigation and information on all of the above points, assists the farmer materially in handling his soils, and in his cropping and cultural methods. In pursuance of the above investigations, from three to six counties are selected each field season for work. During the year 1916, work was done in four counties, viz., Benton, Carroll, Porter and Wabash. The latter county, however, was not completed in time for this report.

The work in Benton County was done by Grove B. Jenes of the U. S. Bureau, assisted by Mr. J. B. Brill of the Department of Geology. These men spent some four months in their investigations and completed a splendid soil map of the county.

Carroll County was surveyed by Mr. C. P. Erni and C. C. Beals of the Department of Geology, and the results of their work will be of benefit to the farmers and land owners of that county.

The work in Porter County was in charge of Mr. Thomas M. Bushnell of the U. S. Bureau of Soils, assisted by Mr. Wendell Barrett, an under-graduate student of Purdue University. Under these men a careful plane table map was made in the field and the soils carefully investigated and classified. The written report appears in another part of this volume.*

The review of Whitley County was written by Mr. John H. Shiltz, of Columbia City, a man who is thoroughly familiar with every feature of the county in detail. Later a detailed survey of the soils will be made and published.

In the review of the oil and gas fields it is the purpose to discuss conditions in the most encouraging portions of the state. It will

*After waiting several months for the completion of the map of Porter County by the U. S. Bureau of Soils, we are compelled to send the 41st Annual Report of the Department to press without the report on Porter County. This will appear in the 42nd Annual Report.

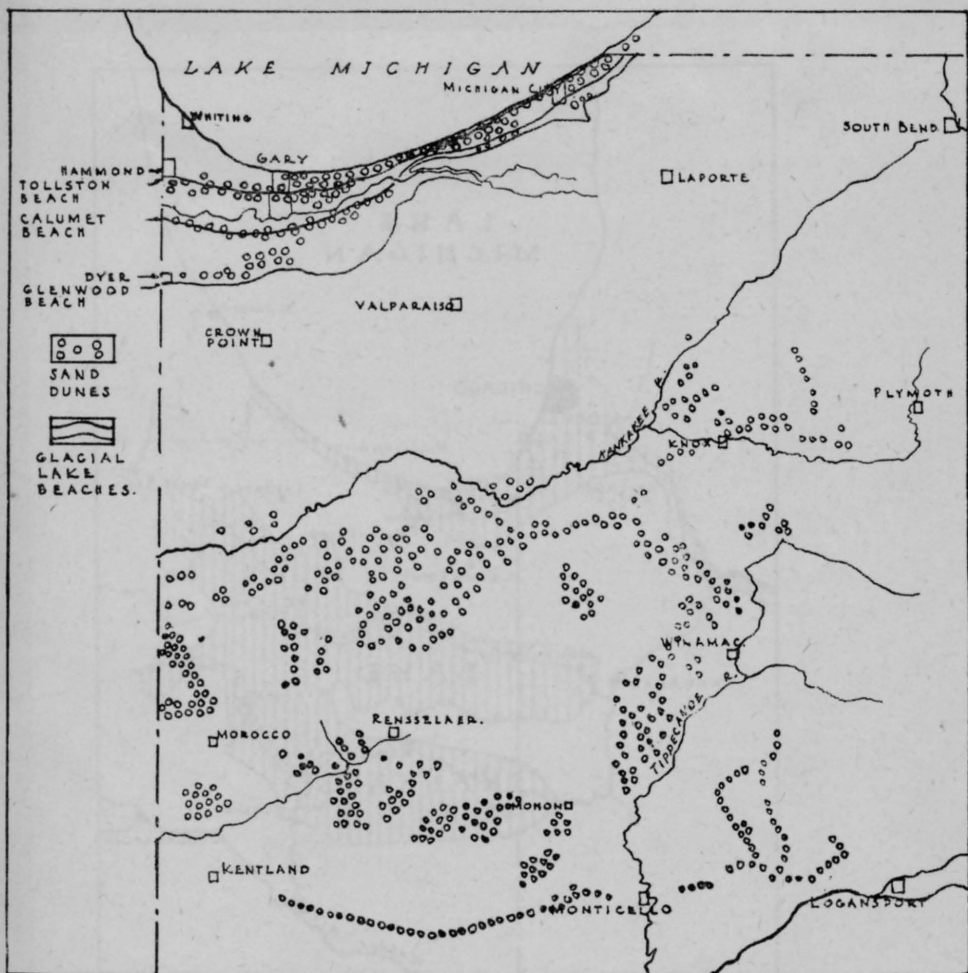
be noticed that the most encouraging prospects at present are in the southwestern quarter of the state, particularly in Pike, Sullivan, Gibson and Daviess Counties; next to these would come Martin and Spencer Counties. There are good indications of oil structures in Lawrence County, where there appears to be an anticline near Heltonville, extending in a southeasterly direction beyond the Baltimore & Ohio S. W. Railroad. The State Geologist has not yet completed his investigations regarding this prospective oil structure, but sufficient data is at hand to show that the highest point in this anticline is about two miles north of the big tunnel of the B. & O. S. W. Railroad. In the annual report of Mr. Floyd E. Wright, State Supervisor of Natural Gas, mention is made of the Heltonville Oil Well and the probable depth of the pay sand.

For more than six years the State Geologist has been advocating the preservation of regions of picturesque natural scenery for State Park purposes. He has delivered more than one hundred illustrated lectures on the following areas: Lakes, Sand Dunes, Rivers, The Shades, Turkey Run, Canyon of McCormick's Creek, Brown County, Scenes on the Ohio, Marengo and Wyandotte Caves, White Water Valley and many other choice regions. In the latter part of 1915, Hon. Samuel M. Ralston, then Governor of Indiana, appointed a State Park Commission, and this Commission has taken over on behalf of the State of Indiana, two of the above mentioned tracts for state parks, viz., "The Canyon of McCormick's Creek" and "Turkey Run", and it is hoped that in the next few years other parks will be added.

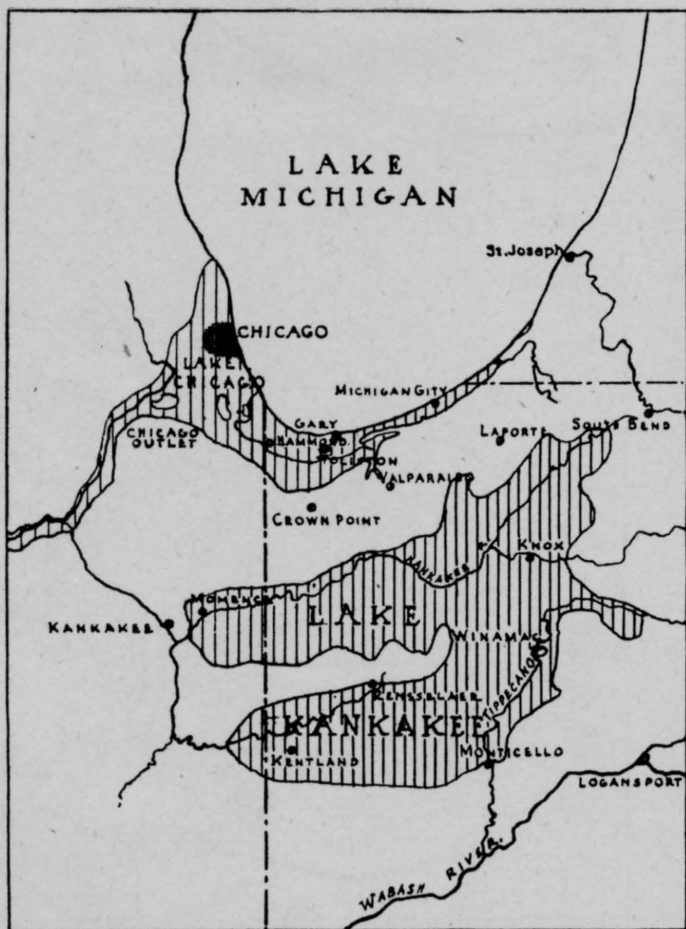
The data for the article on the Sand Dunes was furnished by Mr. A. F. Knotts, of Gary, Indiana, who has made the Sand Dunes of northern Indiana and Illinois a study for years. Mr. Knotts has treated the subject of the Dune area from a geological as well as a descriptive standpoint, thus making the article appeal to the scientist, the student, the casual reader, and the tourist.

Each year the correspondence of the State Geologist increases by reason of the growing interest of the people in the geography, geology and natural resources of the state.

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Map showing probable extent and location of Lake Beaches and Sand Dunes of former ages.



Map showing probable extent and location of former Lakes Kankakee, and Chicago.

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The Dunes of Northwestern Indiana

The Dunes Region of northwestern Indiana consists of two parts. First, that occupying the portion of the old bed and shore of the so-called "Lake Kankakee", lying mostly south of the present Kankakee River and marsh; second, that portion of the old "Lake Chicago" bed and shore lying between the present Lake Michigan shore and the Valparaiso Moraine.

The first part extends east, approximately, to the western boundaries of Marshall and Fulton Counties, south as far as Monticello in White County, and west to the state line and beyond. There are portions of this territory, of course, not covered by Sand Dunes. The "Lake Kankakee" sand dune country in Indiana and Illinois covers more than three thousand square miles. More than two thousand square miles of this area is in Indiana.

When the last great glaciers came down from the north, they came to northwestern Indiana in three great lobes. The one from the north is known as the Lake Michigan lobe, the one from the northeast as the Saginaw lobe, and the one farther east as the Huron-Erie or Erie lobe. As these great ice lobes came forward they carried with them and pushed ahead of them great masses of materials, rock, boulders, gravel, sand, earth and clay.

As they pushed forward, holding in their mighty grasp these masses of materials, they came in contact with other masses, which they ground down with incredible force into finer and finer particles, stopping at the northern and eastern edge of "Lake Kankakee". The melting of the ice sheets and the natural rainfall produced the waters of "Lake Kankakee," whose surface rose until it flowed over the western barrier in Illinois, and was at one time more than forty feet above the present water level of the Kankakee River at the state line. As the warmer weather melted away these ice sheets, which were hundreds and possibly thousands of feet thick at their termini, great volumes of water were discharged and great masses of materials released. The waters flowed in this great lake, lacustral river, to the west and poured over the western barriers into the Illinois River valley. This continued for a long period of time, for the great ice sheets



Sand Dunes. Lake Michigan in the distance.

had many advances and recessions due to changes in the climate of those remote ages.

The great masses of rock, boulders, earth and clay, that were being released, fell and remained near where they were deposited and formed the moraines. Some of the gravel was carried by the water further along than the larger masses and may now be found at or near the foot of the morains.

The coarser sand was carried further out than the gravel and the finer sand still further until it covered almost the entire lake bottom. Some of this sand formed beaches and now furnishes evidence of where the shore line of old "Lake Kankakee" used to be.

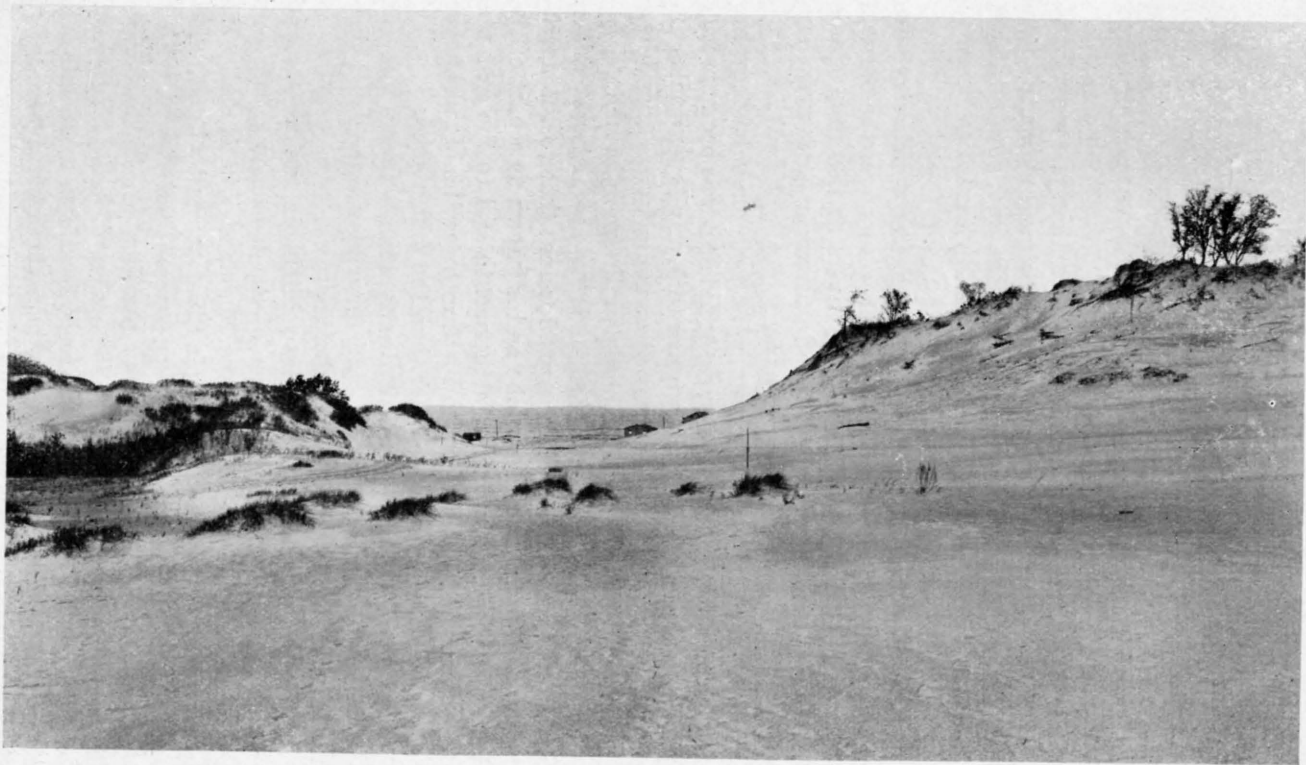
The real fine "rock dust" or "flour", out of which clays are made, was mostly carried in the turbulent waters over the barriers and down the Illinois and Mississippi Rivers to the gulf. Some of this clay material, however, found still water and was there allowed to settle and form clay deposits.

Where former moraine deposits were high enough, they appeared in this old lake as islands or extended into it as promontories or peninsulas. These islands, promontories and peninsulas inclosed bays in which the water was comparatively quiet, and here the sand was not carried and the clay deposits were formed.

The moraine to the north was made by the Lake Michigan lobe and is known as the Valparaiso Moraine; that to the north-east was made by the Saginaw lobe and is known as a part of the Kalamazoo Moraine; and that further south and to the east was made by the Huron-Erie lobe and is known as the Maxinkuckee Moraine. The latter two are older than the first named.

As the eastern lobe receded, it discharged its waters into the Wabash and Tippecanoe Rivers, and for a long time the Tippecanoe River flowed into "Lake Kankakee."

As the Saginaw lobe receded into Michigan, its waters and those from the northwestern border of the Huron-Erie lobe and the southeastern border of the Lake Michigan lobe came to the Kankakee by way of the St. Joseph River at South Bend. The Kankakee River was then a mighty stream and flowed with a swift current several miles wide at the foot of the Valparaiso Moraine. This great river kept that portion of "Lake Kankakee" occupied by it, deep and comparatively free from sand, and was filling up that portion to the south where the current was not so swift; and hence that portion of the old "Lake Kankakee" bed is much higher than the present Kankakee River valley. As the



Sand Dunes, showing action of wind in moving sand.

outlet to the west was being worn down, "Lake Kankakee" kept lowering.

If this had been gradual, the vegetation would have followed the water down and there would have been flat sand bars but no sand dunes upon the bed of the old lake. At sometime during the history of "Lake Kankakee" there was a sudden giving away of the barrier and the lake suddenly fell several feet. This left many of the sandbars exposed. The sandbars that were left high enough above the water to become dry were blown into dunes before vegetation covered and protected them from the winds. The portions kept wet were soon covered with vegetation and are today the old flat sandbars practically unchanged.

As the prevailing winds were then, as now, from the west, northwest and southwest, the sand was blown in the opposite directions, and the gradual slopes of the dunes are toward the windward sides and the steep slopes to the leeward sides. The flow of water being from the east, the opposite would be true of the sandbars.

By the time the Kankakee River was confined to its present narrow valley, the Tippecanoe had found its way into the Wabash and the Saginaw lobe had receded so far that the outwash of sand from it was not carried to any great extent into the Kankakee.

Sometimes the windward side of a dune is very near a marsh or pond, and it may be asked: Whence came the sand to form it? I have always found that the marsh or pond was made by a beaver dam or the closing of the outlet by the encroachment of another dune, and that the windward side of the dune had formerly been dry.

When at last the Tippecanoe had found its way into the Wabash, and the St. Joseph River had found its way into Lake Michigan, or old "Lake Chicago," and the ice sheets had receded so far that their waters found other outlets, the Kankakee River was reduced to about its present size and formed a narrow and very crooked channel within its present narrow valley which was once the main channel of a mighty river.

Within the old channel, which constitutes the present Kankakee River valley or marsh district, there are a few dunes, the sands for which were left no doubt when the waters of the St. Joseph River suddenly changed to Lake Michigan, by the encroachment no doubt of the Saginaw lobe. Almost all the dunes of the old "Lake Kankakee" region are upon the higher plain, south of the river, left dry or comparatively dry when the western barrier broke



Sand Slope, showing encroachment of sand on vegetation.

and caused the lake to disappear. A few of the dunes are found above and beyond the old lake shore line, but these were evidently blown there from the old shore beach.

The existence on the higher plain south of the Kankakee River, of certain low-lying tracts of moraine deposits, nearly free from sand amid bordering higher sand-covered areas, suggests that patches of stagnant ice persisted while the sand was being deposited, or that the current was then so swift at that place that the sand was not deposited, or the water so still that the sand was not carried there. Some of these deposits were evidently deposited by earlier ice sheets.

In the low valley of the Kankakee River several small moraine deposits are found. Some of them appear to have been deposited at the time the sand was being deposited, and some even after a part of the sand had been laid down.

When the Lake Michigan ice lobe began to melt back beyond the moraine it had formed, the water between the lobe and the moraine formed a lake. This lake, as it was then, is now called "Lake Chicago." This lake found its outlet southwest of Chicago at a place called the Chicago outlet.

The beach formed by Lake Chicago, at its early stage, is 638 feet above the ocean or 59.5 feet above the United States Government bench mark for Lake Michigan, which is 578.5 feet above the sea. The beach of a great lake is usually from three to five feet above the ordinary level of the water in the lake; therefore the water in "Lake Chicago" must have been about 56 feet above its present level. During its early period, which must have been a long time, for its shore is well developed, its waters were doing their work at places cutting away the moraine deposits along the shore, forming bluffs, and at other places depositing sand and gravel, making beaches. The beach at this level is now called the Glenwood Beach, because the town of Glenwood, Illinois, northwest of Dyer, Indiana, is located upon it at a point where the beach is well developed.

The beach in Indiana may be quite easily traced. It enters the state at Dyer and extends almost due east to a point about three quarters of a mile north of Merrillville; thence north easterly for about two miles; thence southeasterly for about two miles, to about one-half mile north of Ainsworth; thence east about a mile; thence northeasterly to within a mile of McCool; thence southeasterly about two and one-half miles; thence east about a mile; thence northeasterly to a point about a mile south of Chesterton:



Sand Dunes, showing destruction wrought by encroachment of sand on vegetation.

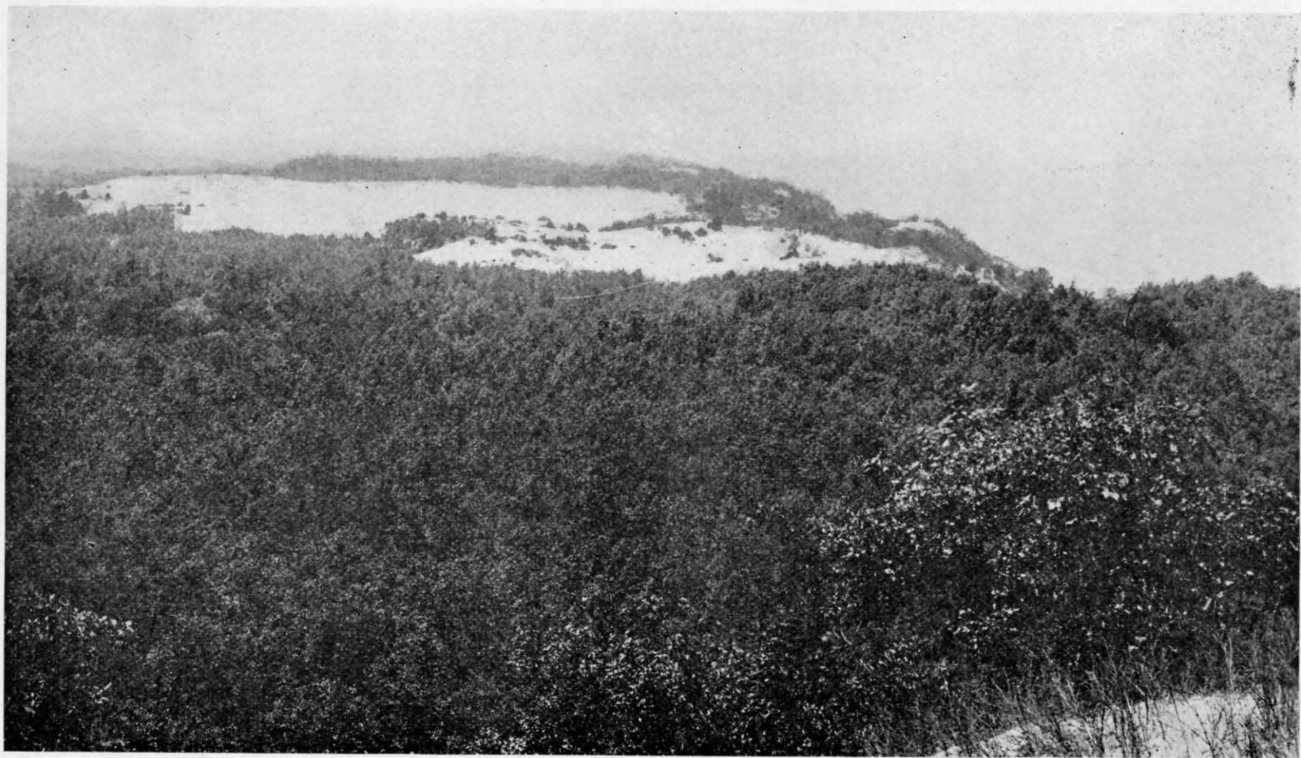
thence easterly from a mile to one-quarter of a mile south of the little Calumet River to the Laporte County line; thence westerly on the north side of the river and from one-quarter to one-half mile therefrom to a point about two miles east of the old dune park station on the Lake Shore Railroad; thence northeasterly and about parallel to the shore of Lake Michigan, and about two miles therefrom to the Michigan State line, and beyond.

After remaining at or about this level for a long time, "Lake Chicago" suddenly or quite suddenly fell about 24 feet to what is known as the Calumet Beach, so-called on account of its paralleling the little Calumet River, about a mile south thereof. This beach is in many places well marked. It passes through Hiland, along the ridge road south of Gary, through Liverpool and on northeasterly until it almost touches the Glenwood Beach east of Dune Park station and thence on northeasterly close to and almost parallel with the Glenwood beach through Michigan City, and beyond.

"Lake Chicago" fell again about 15 feet to what is known as the Tolliston Beach, so-called because it passed through the town of Tolliston now a part of the city of Gary. This beach enters the state south of Hammond, passes through Hessville, Tolliston, about Fifteenth Street in Gary; thence on easterly through Aetna, Miller, Dune Park Station and thence easterly about one-half mile from and parallel with the Lake Michigan shore up into Michigan. The Tolliston Beach is about 20 feet above the present level of the lake. The ordinary water level of the lake at the time the Tolliston Beach was made must have been from three to five feet lower than the beach, or from 15 to 17 feet higher than it is now. When it found its new outlet, probably through St. Clair Flats north of Detroit, the lake was lowered to about its present level.

Some geologists have endeavored to explain the sudden lowering of Lake Chicago from one beach to another by the recession of the ice sheets, leaving lower outlets exposed, and the rising again to the advance of the ice sheets closing up the lower outlet. It must be remembered, however, that the Chicago outlet has been worn down through the rocky barrier from its highest mark, about 59 feet to within 8 feet of the present lake level.

The wearing down may have been interrupted but not discontinued, until the last fall. The sudden subsidence may, therefore, have been caused by falls being washed out or barriers giving away in the Chicago outlet. At each fall of the lake it left



"Blow Out" on top of Sand Dune.

a great quantity of sand exposed, and as it was with the sand of the Kankakee, when left high enough to become dry, it was blown into dunes.

Along the Tolliston Beach the greatest quantity of sand was deposited, and between that beach and the present lake shore large quantities have ever since been, and are now being deposited.

To the westward, the accumulation, since the Tolliston Beach was left, has made land that has encroached upon the lake, and upon this newly made land the cities of Hammond, Whiting, East Chicago, Indiana Harbor and the northern part of Gary have been built.

East of Gary the accumulation has been added to the Tolliston Beach and by the winds piled high into great dunes. When one now speaks of the dunes he usually means the great dunes along the lake shore between Gary and Michigan City. This dune belt is from one-half to one and a half miles wide and the dunes are from 50 to 190 feet high.

The first ridge along the waters edge extends from the Gary Steel Mills in an almost unbroken line to the Michigan State line, and beyond. Back of the first ridge the ridges vary in directions and enclose innumerable little valleys, which are from 10 to 50 feet above the level of the lake and contain from a few square rods to more than one hundred acres in area.

The dunes are, with a few exceptions, covered with a great variety of trees, shrubs, vines, ferns, reeds, rushes, grasses, etc., and the little lakes, ponds and marshy places, which they many times enclose, add another great variety of vegetation.

Here many plants are found that are found no where else in Indiana. Here, as no where else, plants from the distant north grow side by side with plants from the distant south.

The current that comes down along the western coast of Lake Michigan washes away the western shore and carries the sand along to where the current strikes the southern shore where it and the other sand washed from the lake are cast upon the shore, dried by the wind and the sun and blown by the winds into dunes of every shape, form and size.

Here along the southern shore of Lake Michigan are the greatest dunes anywhere to be found along the shores of the great lakes. Mount Tom, located immediately upon the waters edge, is 190 feet high and covers more than one hundred acres. It is almost due north of Porter and Chesterton, in latitude forty-one degrees and



Sky line view of Sand Dunes. Mt. Tom in distance to right.

forty minutes north, and longitude seventy-eight degrees and three minutes west. Near it are many other dunes almost equal in height and many of them much greater in area.

At many places along the lake, dunes are now being made, sometimes growing many feet in height and greatly in area; in a year covering up great growing trees, and at other places dunes are being blown away, uncovering trees that have been buried, perhaps, for centuries. These great bare tree trunks are now being resurrected, but not to life; they stand up now, gaunt and black, silent witnesses of their own murder.

Always the fight is between the sand and the trees, bushes, shrubbery and other vegetation. It is almost an even fight; in many places the vegetation has conquered at least for a while, but in others the sand has mastered.

The formation of the dunes is easily understood. As the wind, which is carrying or driving along the sand, meets an obstruction, such as a tree, a shrub, a bunch of "sand" or "dune grass" that flourishes upon the highest and driest dune, or a clump of "sand" or "dune willows" that grow everywhere on the sand regardless of soil or moisture—anything that will impede the wind, its current is interrupted, and in the quieter area in the lee of the obstruction, some of the sand is dropped. A little pile or drift of sand accumulating in such a place is the beginning of a dune. The "dune grass" and the "dune willows" grow and go up with the dune. The growing dune itself becomes an obstruction against and beyond which more sand lodges, and thus the dune grows until the height of the dune itself, or some other cause, stops its growth.

When the dune stops growing, it is soon covered over with a great variety of "dune vegetation," which preserves it for a while at least, but eventually a place made bare by the uprooting of a tree, a snow slide, the burning away of the great vegetation or the burrowing of some wild animal, may start a "blowout," which may increase until the whole dune is destroyed; but many times the trees, felled by the sand being blown away from their roots, form a new lodging place for other sand and the "blowout" may in time be filled up and covered anew with vegetation.

Destruction and construction usually go hand in hand. The wind takes up and drives along the sand, not only from the beach, but from the surface of bare dunes; it is carried or rolled up over the crest to be dropped on the lee-ward side, where it is piled just as steep as its nature will permit. This movement is known as the

migration of the dunes. In this migration, dunes cover up forests, fill up rivers, ponds, and small lakes and invade low-lands and fields.

Thus we see that the dunes are not fixed, but moving, slowly, silently, irresistibly, mysteriously.

“The dunes, the dunes; they drift and flow,
Like billowy waves of ocean wild;
No rest their changing contours know,
Heap upon heaps the winds have piled.”

See the shining shifting sand, spotless perhaps; not a twig or a pebble nor a mark of any kind on it, except the little ripples on its surface, like those on the sea shore or the shore of the great lake at its base, left by the receding waves.

Near the base of this mountain of sand, piled steep and high, the grass and shrubbery are becoming covered; a little further up, the trees stand half submerged; still nearer the top you can see only the very tops of great trees; so on they will be literally buried alive and die from suffocation.

Back to windward, trees that have been buried, perhaps, for ages, are being uncovered, leaving their denuded trunks standing like ghostly monuments of an arboreal graveyard.

To the geologist the dunes are very interesting.

To the botanist they are unique.

To the naturalist they are a wonderful field of study.

To the artist and poet they are an inspiration.

SANDLAND.

Sandland at twilight,

All hushed in brooding gray—

A place to find your heart again

And cast your cares away.

Duneland at sunrise,

Life's glory risen new—

The arms of freedom flinging wide

The gates your dream saw thru.

Sandland in starlight—

The night-song's voice is dear,

And folds the peace you thought of God

Where held your heart its fear.

Duneland at noon time—

What sorry stuff is gold,

That royal pride and miser greed in foolish passion hold.

Sandland in shadow—
 Or shining in the sun—
 What care you for the fame of men
 Or what their wars have won?
 For Duneland is dearest
 Because no place is there
 For echoes of the battle field
 Or sears its victims wear.

Give me for a solace
 The shelter of the dunes,
 The songs that die in city streets,
 Again are laughing tunes,
 My dream of mighty temples
 And victories of trade.
 Ah! Foolish dreams, for the truth
 Is Duneland's wonder made.

I may go back to trading,
 To kingscraft, law or art—
 But here, beside this castled strand
 I leave my honest heart.
 I need it not where commerce grinds
 The souls of men to dust—
 So, leave it where there is no fear,
 To sing the songs it must.

The beach along the shore of Lake Michigan, near the dunes is four or five feet above the ordinary level of the water and is from fifty to one hundred yards wide, and, like the beach of old "Lake Chicago", is composed of sand and gravel, mostly sand.

At the shore line the sand is from eight to twelve feet deep and extends out to where the water is twenty-five or thirty feet deep. Beyond this depth and at some places not so deep, clay banks may be found, evidently the remains of moraine deposits left by the retreating glaciers. Around and between these clay deposits are usually sand pockets, or bars, not yet washed ashore.

The water along the shore near the Dunes is quite shallow for several hundred feet from the shore and affords many miles of beautiful bathing beaches.

Recently an effort was made to secure a portion of the dunes and the adjacent shore for a park. At a hearing conducted by the Secretary of the Interior, at the City of Chicago, on the 30th day of October, 1916, many distinguished naturalists, scientists, artists, nature-lovers, business and professional men from all over the country, appeared and in glowing terms pleaded for the preservation of the dunes as a National Park. On the 26th day of February, 1917, the Secretary made his report to the United

States Senate, strongly recommending that the United States Government secure and preserve as a National Park from 9,000 to 13,000 acres of the dune lands along the southern shore of Lake Michigan. On the 10th day of April, 1917, Articles of Association were filed in the office of Secretary of State of Indiana, incorporating the National Dunes Park Association, the purpose of which is to secure a public park, natural, if possible, to be located north of the towns of Porter and Chesterton, beginning one-half mile west of Mt. Tom and extending eastward along Lake Michigan toward Michigan City.

Soil Survey of Benton County, Indiana

BY

GROVE B. JONES, of the U. S. Department of Agriculture, In Charge, and J. BAYARD BRILL, of the Indiana Department of Geology.

W. E. McLENDON, Inspector.

SOILS.

The soils of Benton County like those of other glaciated regions are derived from the drift brought down from the north. This drift material which consists of sand, gravel, clay and boulders, was deposited by the late Wisconsin ice sheet upon the uneven surface of the bed rocks. This mantle ranges in thickness from a few feet to 262 feet or more. This greater depth as shown by well borings, is found along the eastern border of the county, following approximately the present course of Pine Creek to within three miles of the southern boundary. There it turns and crosses to the southwest corner. This was evidently at one time a deeply eroded valley now filled with glacial debris to a level with the surrounding country.

According to the Indiana Geological Survey, the basal formations underlying the glacial drift consist of shales, sandstones and very little limestone. The New Albany Shale of the Devonian Period occurs beneath the till in the northeast corner of the county, and is the oldest of the underlying rock formations. Above this are the Knobstone shales of the lower Carboniferous period which underlies a large proportion of the eastern half of the county. The only rock exposure in the area is found along the dredged channel of Pine Creek in Pine Township, section 24, and is of this formation.

The rocks underlying the western half of the county belong to the Coal Measures and consist mainly of Meron Sandstone with a very little Coking coal and Mansfield Sandstone in the southwest corner.

These formations, however, are so deeply covered by the

unconsolidated glacial drift as to have no direct influence upon the soils. The surface soil throughout the county is of a silty texture and is the result of the weathering of the underlying till. The different types of soil recognized are due to the different conditions to which this till has been subjected.

Almost the entire county formerly existed under very poorly drained and even swampy conditions, giving rise to a great extent of dark colored soils. Only along the natural drainage ways is found the light colored, timbered soil. Even the ridges throughout the prairie lands, which have the external appearance of moraines, have a dark surface soil due to inadequate natural drainage.

The Carrington soils are the result of the weathering of the glacial till under prairie conditions. The surface soils are dark-brown to black and the subsoils are of lighter color, usually light-brown to yellowish. The topography is undulating to gently rolling. The silt loam is the only member of the series mapped in Benton County.

BROOKSTON SERIES.

The surface soils are dark-brown or dark brownish-gray and the subsoils are yellow and gray mottled with yellow as the dominant color. The upper subsoils may be dull drab in color, but as a rule the color brightens with depth until at from 18 to 24 inches it becomes almost a solid yellow or yellowish-brown. Partially weathered very friable and loose calcareous till is encountered at a depth of 27 to 36 inches. The topography is level to very gently undulating. The natural drainage is poor. Nearly all areas have been drained artificially and are now under a high state of development, producing heavy yields of corn, oats, hay crops, sugar beets, etc.

The Clyde series is characterized by dark-brown to black surface soils with subsoils of gray, drab or mottled gray and yellow. They have been formed in glacial lakes and ponds through the reworking of the soil material and the accumulation of a great quantity of decayed organic matter. The series is represented in Benton County by a single type, the Clyde silty clay loam.

The soils of the Miami series are brown, light-brown or grayish, underlain by heavier textured subsoils of yellowish-brown sometimes with mottlings of brown and light gray. The topography is gently undulating to rolling and the drainage is usually good. The soils are derived through weathering of glacial till

of a generally calcareous nature. The Miami silt loam is the only type of this series found in Benton County.

The Wabash soils are dark-brown to black and contain a high per cent of organic matter. The subsoils are drab to gray. This series is typically developed in the first bottoms of streams of the Central Prairie States and the material is derived mainly from the associated soils. Very little is found in Benton County and only of the silt loam type.

Muck was formed by the accumulation and decay of vegetable matter in undrained depressions.

CARRINGTON SILT LOAM.

The surface soil on the Carrington silt loam is a brown or dark-brown to black, mellow silt loam, 10 to 15 inches deep. The subsoil is a brown silt loam, passing at about 16 to 20 inches into a brown to yellowish-brown heavier silt loam, which in turn is underlain by a yellowish brown silty clay loam, which becomes gritty below thirty inches. Below the 3 foot section boulder till containing sand and gravel is encountered.

The usual variations in shades of brown and yellow of both the soil and subsoil are due to the difference in elevation and natural drainage. On the crests of the higher ridges the organic matter content in the soil is lower than in the typical soil and the color approaches that of the Miami types. These areas, however, as well as some few supporting a timber growth have been included with the Carrington silt loam because the organic matter content is higher than the average for the Miami soils. This condition obtains chiefly in the vicinity of Oxford and in sections 34, 35 and 36. Parish Grove Township.

In a few small areas, notably in the northern part of the county, the top soil is more sandy or loamy but on account of their small extent such areas could not be shown on the soil map.

A few large boulders were originally scattered over the surface of the type, but most of these have been removed.

The Carrington silt loam embraces the greater part of the better drained prairie land of Indiana and Illinois and with its flat phase constitutes a large per cent of the total area of Benton County. The topography varies from undulating to moderately rolling. The drainage conditions of the type vary in different localities depending largely upon the topographic features. On the more rolling areas natural drainage is fairly well established. It is not perfect, however, and tile drains are found to be highly

beneficial. Over the more level areas artificial drainage is necessary in order to insure the production of good crops.

Practically all of this type is under cultivation, the exceptions being farm woodlots and a few natural groves used for pastures.

The Carrington silt loam is well adapted to the production of corn and oats and has been devoted almost exclusively to the cultivation of these crops for a number of years. The yields vary considerably but the average for each is about 40 bushels per acre. Much of the type has been subjected to the almost continuous production of these two grains for a considerable period and the yields at present are said to be lower than formerly.

Clover and timothy are grown to some extent and their acreage is being extended, especially on farms where the amount of livestock is being increased. Clover is commonly sown with oats, but it is claimed that a better and more certain stand is obtained when it is sown alone in July or August.

Alfalfa is being successfully grown, but the acreage is limited at present. Three cuttings, are secured and the yield for the season ranges from 4 to 5 tons per acre. About 2 tons of crushed limestone per acre together with careful preparation of the soil and care in eliminating weeds are essential factors in securing a good stand.

Soy beans and sweet clover do well on this soil, wheat and rye are rarely grown. Potatoes are grown successfully, but not on a commercial scale. Fruit and vegetables are grown only for home use.

Commercial fertilizer is not commonly used. It is sometimes applied to corn with increased yields. All available stable manure is applied to the soil, but the supply is usually insufficient.

The most common rotation practiced consists of corn one year, oats one year, sometimes followed by clover one year.

Farm values on this type range from \$200 to \$250 or more an acre.

The organic matter which this type naturally contains should be maintained by the addition of manure. More livestock should be raised. By growing clover, soy beans and alfalfa, the nitrogen content of the soil can be increased through their ability to collect this constituent from the air.

BROOKSTON SILT LOAM.

The soil of the Brookston silt loam, consists of a very dark brown or black silt loam having an average depth of about 14

inches. From 14 to 28 inches the material is a grayish-brown silty clay loam, with faint mottlings of yellow which become more pronounced with depth. The remainder of the 3-foot section is a mottled brown, gray and yellow silty clay loam or clay which becomes decidedly gritty at about 30 inches. Glacial drift material containing sand, gravel and stones forms the substratum and continues to an indeterminate depth. Small, well decomposed, iron concretions are found throughout the subsoil. Small areas of both the Carrington silt loam and the Clyde silty clay loam have been included in this type since it is impossible to draw a definite boundary line in many instances.

The topography is flat to gently undulating. On this account and also on account of the impervious subsoil, the natural drainage is inadequate. Tile drains and open ditches are common and practically all of this soil is now under cultivation.

This type is the most important soil in the county and practically its entire acreage is devoted to the growing of corn and oats. The yields for each average 40 bushels per acre. Clover does well and in locations when the water table is at least $2\frac{1}{2}$ feet below the surface alfalfa thrives.

Many of the larger farms are located on this phase and it is not uncommon to see fields of corn or oats embracing several hundred acres.

Fall plowing is extensively practiced when oats ground is to be planted to corn. The average depth is about 6 inches. Commercial fertilizers are not used except in a few instances where 75 to 100 pounds of a mixture containing phosphoric acid and potash in varying amounts are applied to corn land. Owing to the present prohibitive price of potash, very little of this element is used.

A few farmers grow soy beans along with corn for ensilage and also for fattening hogs, thus securing a more balanced ration. Soy beans are meeting with favor and their acreage is being gradually increased. Some rape is sown with oats for sheep pasture.

Legumes and manure should be used more extensively in order to maintain the organic matter originally possessed by this soil. Ground limestone at the rate of 3 to 5 tons per acre has proved highly beneficial to land of this nature in other sections and it is believed that this practice will soon be followed in Benton County.

Farm values range from \$200 to \$250 an acre, but at present very little of this land is on the market. In 1915, one farm near Fowler sold for \$266 an acre.

MIAMI SILT LOAM.

The soil of the Miami silt loam to a depth of 6 to 10 inches is a gray or brownish-gray, friable silt loam. The soil is usually free from stone and gravel and contains a considerable percentage of very fine sand.

The subsoil is a yellow or yellow and gray mottled, slightly heavier silt loam, which at a depth of 15 to 20 inches grades into a yellowish-brown slightly mottled, silty clay loam. Below this the underlying material consists of a brownish sandy silt or clay, in which the percentage of coarse sand and gravel increases with depth. Mottlings and gray streaks are not uncommon throughout the subsoil.

This type of soil closely resembles the typical Carrington silt loam in texture, but it is easily distinguished and has been separated from that in this survey on account of its lighter color and because of the fact that it supports a timber growth. The type as a whole is deficient in organic matter. Where closely associated with the typical Carrington silt loam, the surface soil is rather higher in organic matter and more productive than the typical soil. This condition is found in the northern part of the areas along Pine and Mud Creeks and the soil becomes gradually darker as it extends away from the stream channel.

The surface of most of this type is undulating and the natural drainage is good. Along Mud Pine Creek the surface is more rolling and the slopes steeper. It is in this area that the type is found more typically developed.

The Miami silt loam is not an extensive type in Benton County, but to the south it occupies nearly 30 per cent of Warren County.

The type owes its origin to the weathering of calcareous till. It embraces the greater part of the original timbered areas of the county and at present hickory, bur oak, red oak and some white oak and walnut are found growing upon it.

The Miami silt loam is easily tilled and requires the least artificial drainage of any of the soils in the county. However, tile draining frequently improves its physical condition. It is devoted to the same crops as the Carrington silt loam, but the yields are somewhat smaller. Yields are largest during wet seasons as the crops grown are frequently injured by drought.

Corn and oats average about 40 bushels per acre. This type is generally recognized as the best soil for wheat and where good

cultural methods are practiced, yields of 18 to 35 bushels are obtained. Clover does well and some rye is grown for pasture. While the yields of crops are usually somewhat lower than on the more fertile prairie soils, farmers generally state that the quality is superior.

Practically the same cultural methods are practiced as upon the prairie soils with the exception of fall plowing. This practice is not followed because of the tendency to wash.

Liberal applications of stable manure increase the productivity of this type. It not only adds humus, but also improves the physical condition of the soil and increases its moisture holding capacity. Nitrate of soda with either sulphate of potash or acid phosphate will usually give increased yields. Applications of finely ground limestone at the rate of 1 to 3 tons per acre are also beneficial.

The price of land of this type ranges from \$135 to \$150 an acre.

CLYDE SILTY CLAY LOAM.

The Clyde silty clay loam consists of a dark gray or black silty clay loam, about 10 inches deep, underlain by a drab or gray plastic silty clay, becoming mottled pale gray and yellow. Some variations in the type are found which are due largely to the different degrees of drainage. In the more poorly drained areas there has been a greater accumulation of organic matter and the surface soil is more friable and in places approaches muck.

This type is scattered throughout the county, the largest bodies being found in the vicinity of Boswell, Earl Park and Wadena. It is derived from reworked glacial material and occupies the depressions and low-lying flat areas along the minor drainage ways. The natural drainage is poor, but practically all of the type has been reclaimed.

This soil is well adapted to corn and the greater part of it is devoted to this crop. In acreage yields it is the leading corn soil of the county. The average is about 45 to 50 bushels per acre. In exceptionally wet seasons even the artificial drainage maybe insufficient and the corn may be drowned out. Millet is then sown in its place and later cut for feed. Oats do fairly well, but have a tendency to lodge. A heavy growth of blue grass offers excellent pasturage.

Methods of cultivation are the same as on the Carrington soils, but care must be taken not to work the ground when too wet. Fertilizers are not used.

The price of farms containing much of this type is high, ranging from \$200 to \$250 per acre.

WABASH SILT LOAM.

The Wabash silt loam is not typically developed in Benton County and is of limited extent. As mapped it includes a mixture of soils of alluvial origin, ranging from a fine sandy loam to clay or silty clay loam. The color is dark-brown to black to a depth of 8 to 16 inches.

The subsoil is quite variable in depth and character. It consists for the most part of a dark colored or drab, mottled with yellow, loam to clay loam or clay. The lower subsoil may consist of a heterogeneous mixture of clay, sand and gravel. This condition obtains principally along Pine, Mud Pine and Sugar Creeks shortly before they leave the county. In their upper reaches as well as along the smaller streams, the soil is frequently poorly drained material similar to Clyde silty clay loam. In this phase, the soil contains a high percentage of organic material, is subject to more frequent overflows and in origin is not wholly alluvial. It constitutes material that has been formerly classed as meadow.

With the exception of a very few spots, this soil is used for pasturage. The native growth consists of wild grasses, iron weed, elm and willow.

Muck is composed of decayed and decaying vegetable material mixed with a small quantity of mineral matter washed in from the adjoining higher lands. The soil is very black with a characteristic looseness and fluffiness when dry. This is underlain by a brown fibrous peat which in turn rests upon a brown or yellowish-brown, light textured loam. Occasionally, however, the lower subsoil is a yellow to drab silt loam or clay.

This soil occupies slight depressions and varies in depth from a few inches in the small areas to over 3 feet in the larger bodies. On the soil map a few small areas of shallow muck or chaffy land are included in the Clyde silty clay loam.

Natural drainage being very poor, tiling and ditching have been resorted to in order to bring this soil into productiveness. It is an unimportant soil type in Benton County, as its total acreage

is only about 1 square mile. It is confined to a few small areas in the northern and eastern parts. Some of it is planted to corn which makes a good yield if not injured by early frosts, and the remainder is used as pasture. Blue grass thrives well.

No specialization of crops has been attempted because of the small acreage. Celery, onions, lettuce and cabbage might be profitably raised for local markets if the soil were thoroughly drained and properly fertilized. A complete mixture of 4 per cent nitrogen, 8 per cent phosphoric acid, and 10 per cent potash is generally used to fertilize muck soils, potash proving the most effective element. Applications of ground limestone are often necessary to reduce the soils acidity.

SUMMARY.

Benton County is situated on the western boundary of Indiana, the third county south of Lake Michigan. It embraces 414 square miles, or 264,960 acres.

The topography varies from level to gently rolling with the greatest elevations in the north-central portion, the drainage flowing out of the county in all directions. The streams are all small and tile drains and open ditches have been constructed, forming an excellent drainage system.

The first settlement was made about 1800 and the county was organized in 1840. It now has a population of 12,688. Fowler, the largest town and county seat, has a population of 1,600.

Good transportation and shipping facilities are furnished by five railroads and there are 425 miles of improved roads.

The mean temperature for the summer months is 72.6 degrees and for the winter 27.1 degrees with an average growing season of 165 days. The average annual precipitation is 38.59 inches.

Agriculture consists almost entirely of grain farming. Over 75 per cent of the acreage is devoted to corn and oats alone. The remainder is given over to forage crops and a little wheat. Corn averages about 37 bushels per acre and oats about 33 bushels.

Hog raising is the principal branch of the live-stock industry. The county produces from 35,000 to 37,000 head each year. Some cattle and sheep are fed for the market.

Much of the land is in large holdings, making the average size of the farms about 200 acres, 53.7 per cent of these are operated by tenants.

Land values are high. The Miami type sells at about \$150 per acre and prairie land at from \$200 to \$250 or more.

Benton County is a part of the "Grand Prairie" which extends westward over Illinois and the soils are characteristic of prairie lands. Besides muck, four series of soils, each represented by one type were recognized and mapped.

The Brookston silt loam is the most important soil in the county. It is a dark brown to black silt loam with a mottled yellow subsoil. Nearly all of the type is under cultivation, corn and oats are the principal crops grown.

The Carrington silt loam occupies a large per cent of the entire acreage. This is a dark-brown prairie soil, well suited to the production of corn, oats, clover and grass. The topography is gently rolling to nearly level.

The Miami silt loam is next in extent and is locally known as clay land. It is light colored, timbered and well drained and was the first of the soils to be brought under cultivation. It is well suited to general farming and is an especially good grass soil.

The Clyde silty clay loam is the heaviest soil of the area and occupies the depressions or more poorly drained portions of the prairie lands. With thorough artificial drainage it is a strong corn and oats soil.

The Wabash silt loam embraces all the alluvium or first bottom lands along the larger natural drainage ways. Only small areas of their type are under cultivation to corn. The remainder is used as pasture.

Muck is mainly decayed vegetable matter. Only a few small areas were mapped. Corn is the only crop grown and yields are good. It supports a good growth of blue grass.

Soil Survey of Benton County, Indiana

By GROVE B. JONES, of the U. S. Department of Agriculture,
In Charge, and J. BAYARD BRILL, of the Indiana
Department of Geology.

DESCRIPTION OF THE AREA.

Benton County, Indiana, adjoins the Illinois State line and is the third county south of Lake Michigan. It is bounded on the north by Newton and Jasper Counties, on the east by White and Tippecanoe, on the South by Warren County, and on the west by the State of Illinois. It is rectangular in shape, 23 miles long and 18 miles wide, and embraces 414 square miles, or 264,960 acres.

The surface is high and gently rolling with three ridges extending in an easterly and westerly direction which determine the direction of the surface drainage. Gravel Hill, 3½ miles north-west of Fowler, is the highest point in the county, having an elevation of 857 feet above sea level, while the lowest portions are along the eastern, southern and western borders with altitude varying from 700 to 765 feet above ocean level. The slopes are broad and gentle, expanding into great stretches of undulating prairie land.

The natural drainage of the county is through small streams which have their rise within its boundaries. Pine Creek, the largest, drains the eastern part, Sugar Creek, the northern, Mud Pine Creek, the southern and Mud Creek the western. Natural drainage is immature and overflow or bottom lands are of small extent. A system of surface ditches has been constructed throughout the county, the largest of which are from 4 to 8 feet deep and from 7 to 12 feet wide, giving an adequate outlet to the numerous smaller ditches and underground drains.

The first settlements in Benton County were made about 1830 and the county organization was effected in 1840. The population of the county is small, 12,688, because of the large land holdings

in the western and northwestern parts. In the southern and eastern parts the lands are divided into smaller farms and the population is accordingly greater. Here too, are located more of the smaller towns. Fowler, situated in the center of the county, is the largest town and the county seat and has a population of about 1,600. Next in size are Oxford, Boswell, Otterbein, Ambia, Talbot and Swannington in the southern part and Earl Park, Freeland Park, Raub and Wadena in the northwestern quarter. These with many sidings and grain elevators furnish shipping points for their respective localities. In the northeastern part of the county there are no towns or villages and trading is carried on through Remington and Goodland to the north.

All portions of the county except the northeastern are well supplied with steam lines. The Cleveland, Cincinnati, Chicago and St. Louis Railroad, main line of the Big Four, crosses the county diagonally southeast and northwest. The Chicago and Eastern Illinois crosses the center and the Chicago, Indiana and Southern, the western part, both in a north and south direction. These three railroads furnish direct service with Chicago. A branch of the Chicago and Eastern Illinois connects Freeland Park with Milford, Illinois. The Lake Erie and Western Railroad runs east and west through the southern part of the county, about 2 miles north of the Warren County line. Unlike most portions of Indiana, Benton County has no electric lines.

Chicago, Indianapolis and Lafayette are the principal markets and of late many farmers have found it more profitable to haul their products, especially hogs, to Lafayette, than to ship them.

The county has an unusual mileage of improved roads and no one part has been favored. There are over 425 miles surfaced with crushed limestone and gravel and further improvement is added each year.

The towns and villages have excellent high schools and some of the rural districts have been combined into union schools.

The county is one of the most prosperous in the State and each year finds better farm buildings and a greater use of labor-saving machinery. Telephone service and rural mail routes reach all parts of the county.

CLIMATE.

Wide variations in temperature are characteristic of the climate of Benton County. The precipitation is fairly well distributed

throughout the year, but lack of rainfall is sometimes detrimental to crops unless care is taken to employ proper methods of cultivation. The mean annual precipitation is 38.59 inches and the average snowfall is 22.8 inches. The average date of the last killing frost in spring is April 26, and of the first in fall is October 8th, which gives an average of 165 days for the growing season.

AGRICULTURE.

Benton County has as large a proportion of productive soils as any county in the State, the only portions unsuited to agriculture being the narrow strips of overflow land along the larger streams.

Settlement was first made about 1831, along Pine Creek in the southeastern part and later spread to the other wooded sections of the county. Small fields were planted to corn and potatoes and a little later wheat and broom corn were added to their products, but cattle raising became the principal industry, the vast stretches of prairie furnishing excellent pasturage. About 1845 settlers began to encroach upon the higher portions of the unsettled prairies, making use of small open and "mole" ditches, but it was not until about 1875 that tile draining was resorted to and the reclamation of the wettest lands was begun.

At the present time the predominate type of agriculture is grain farming. Corn and oats have always been the leading crops. The following table compiled from census data shows the trend of agriculture during a period of 30 years:

AVERAGE

Year	Corn	Oats	Wheat
1880	98,455	12,962	3,528
1890	84,305	52,400	717
1900	110,057	73,343	67
1910	109,864	83,897	681

Corn and oats are the main money crops and in 1910 these two grains occupied about 75 per cent of the total acreage in the

county. Grain dealers give 6,150,000 bushels as a conservative estimate of the amount of these grains delivered at the elevators annually. To this must be added the amount fed on the farms, giving a total which shows the great productiveness of the soils, all of which grow these grains profitably. Some farmers claim that corn yields are greater on the darker soils but the quality better on the lighter or Miami type. The average yield throughout the county is about 37 bushels per acre, though the yields range from 20 to 75 bushels.

Benton County grows more oats than any other county in Indiana, and produces one-fourteenth of the total oats crop of the State. In 1915, about 5,000,000 bushels were produced on 87,385 acres. The yield was unusually high, averaging 60 bushels over the entire county, because of the very wet season. From year to year the yields range from 20 to 60 bushels per acre with an average of about 33 bushels.

While it is possible to grow wheat on the better drained soils of the county, its production has declined until very little is grown. According to the census of 1910, there were 681 acres which produced 11,299 bushels. Few attempts are made to grow wheat on the prairie soils because of the loss through winter killing by heaving.

The growing of clover is increasing. The best stand is secured when the ground has been prepared thoroughly and the clover is sown by itself in July or August. This method is little followed, however, the general practice being to sow or drill the clover with the oats and to let it stand a year before again planting the land to corn. Where grown for seed the average yield is about one bushel per acre. Some few grow mammoth clover to plow under to enrich the land.

Little rye is grown. Millet is often planted where the corn has been drowned out and is later cut for feed. Rape is sometimes sown with oats for pasturage.

Alfalfa was first grown in the county about 10 years ago, but it is only within the last 3 or 4 years that much interest has been shown in this crop. As little livestock is raised, alfalfa is not essential as a feed and the soil has not yet been sufficiently robbed of its fertility by continuous planting to grain to cause the owner to think of alfalfa growing as anything but allowing the ground to lie idle for a year.

To grow alfalfa successfully most of the soils in the county require applications of barnyard manure, and about 2 tons of crushed limestone per acre to reduce their acidity. The land is plowed in the early spring and worked down to a good seed bed and the seed is sown about the middle of July or the first of August. If the weeds are carefully kept out and the alfalfa let alone the first year, there will be 3 cuttings the second year with a yield of 4 to 5 tons per acre. It is recognized that a more extensive growth of this crop would prove of great benefit to the soils.

Hay is an unimportant crop. In 1910, 12,191 acres were given over to tame and cultivated grasses and produced a little over one ton to the acre. This is fed on the farm, but is not sufficient to supply the local need, many farmers feeding oats straw in its stead.

Potatoes and other vegetables are grown by all farmers for home use, but not for shipping. Nearly every farm has a small orchard of apples and a few pear, peach and cherry trees.

In the cultivation of corn, when it follows clover or oats, the prevailing method is to plow the ground in the fall, but if it follows corn, the plowing is left until spring. The ground is then worked down with disc and spike-toothed harrows until the seed bed is in a firm mellow condition. If the season permits, corn planting is begun the first of May and the crop is given from 3 to 6 or more cultivations, with the common corn cultivator. Most of the corn is husked from the standing stalk, shelled and hauled to the elevators. Very little is shocked and consequently the stover or portion remaining after the ear has been removed is a total loss, making a waste of one-third the crop. If more livestock were raised and the stover used as feed this loss could be eliminated. During the last few years there has been an increase in the number of silos and a corresponding increase in the percentage of the corn cut for ensilage. Later methods are being followed along this line and where formerly the corn was put into the silos while still green, it is now allowed to ripen until the kernels are rather hard and the husks are partially dry. Soy beans are often sown with the corn, making the ensilage a more balanced ration. A good practice sometimes followed, called "hogging it," is the turning of hogs into the corn, for not only is the soil enriched, but the labor of husking is saved. Soy beans planted with the corn serve as excellent feed and increase the fertility of the soil.

Reid's yellow dent, Leaming and Boone County white are the leading varieties of corn planted.

Different methods are used in the cultivation of the oats crop. Some disc the stubble land once, sow the oats broadcast with an end gate seeder, 3 to 3½ bushels per acre, and then disc again, following this with the spike-toothed harrow. Others sow the oats and then double disc but this has proved to be inadvisable, as some of the seed gets too deeply covered. The best method seems to be to double disc the stubble land first, then harrow and drill in the oats, using about 2½ bushels of clean seed to the acre. In 1915, smut reduced the yield of oats about 10.6 per cent, but farmers are learning to treat their seed with formaldehyde and the loss should be less each year.

The common rotation is corn and oats, clover is sometimes sown with the oats and allowed to stand a year, making a three year rotation.

Very little commercial fertilizer is used, not over 15 carloads a year. All manure available is put upon the soils, but because of the large acreage under cultivation and the scarcity of stock, especially on rented farms, the supply falls far short of the need. The lighter colored type of soils or "clay" lands are much benefited by the application of 1 per cent nitrogen, and 10 to 12 per cent phosphoric acid and the black prairie soils, by the use of as high as 8 per cent potash with from 10 to 16 per cent phosphoric acid. When used on corn, about 75 to 150 pounds per acre are applied, but this practice is little followed. When the growing of alfalfa is attempted it is necessary to use 2 tons of crushed limestone per acre along with barnyard manure. The growing of clover, soy beans and other leguminous plants for fertilizers should be more extensive.

Hog raising and feeding is the most important branch of the livestock interests and the industry is increasing. Oak Grove Township leads in the number raised and in 1915 reported 4,075 head. The entire county produces between 35,000 and 37,000 each year.

Cattle raising was formerly the main industry of the county, but is now relatively unimportant. A few farmers buy feeders in the Chicago and Kansas City markets in the early fall and place them on the market in the spring or following fall.

There are three small commercial dairies which supply the needs of the larger towns. Some cream is shipped out of the county but the industry is insignificant. There are no creameries.

Some sheep are shipped in from the northwest and fattened for the market. On the large holdings where the farming is done by tenants little livestock of any kind is raised. The breeding of pure bred cattle mainly Herefords and Shorthorns has been undertaken by a few farmers. In general the class of stock kept is improving. The county is noted for its fast horses, Dan Patch and William being some of its products.

The numerous large holdings make the average size of farms in Benton County, comparatively large. About 200 acres is the average. There are several estates containing from 1,000 to 6,000 acres or more.

In 1910, 53.7 per cent of the farms were operated by tenants, renting mainly on the share basis. The owner receives one-half of all grains delivered to the elevator. \$6 per acre is the usual price paid in addition for privilege of pasture and hay land. Cash rent varies from \$5 to \$12 an acre, but about \$8 is the average.

Quite a contrast is evident in the buildings on farms operated by the owners and on those farmed by tenants. On the latter, the buildings are few and very small, usually only a house and barn. A lack of hay capacity is noted everywhere.

Machinery of late design is quite generally found. A number of tractors are in use.

Farm labor which is mainly American is scarce and generally inexperienced. Monthly wages vary from \$25 to \$30 with board for single men, while married men receive \$30 to \$40 and the use of a tenant house. During corn husking the pay is per bushel, the single man receiving 3 to 3½ cents together with board and the married man 1 cent more without board.

Carroll County

GENERAL DESCRIPTION OF THE AREA.

Carroll county is situated in the third tier northwest of Indianapolis, in the northwestern part of Indiana. It comprises an area of about 376 square miles, or 240,640 acres. It is bounded on the north by White and Cass counties, on the east by Cass and Howard, on the south by Clinton and Tippecanoe, and on the west by Tippecanoe and White and the Tippecanoe River. The general outline of the county is rectangular, being about 22 miles from north to south, by about 20 miles from east to west, but lacking in the northeast corner, an area of about 3x8 miles, and in the southwest corner, an area of about 4x9 miles. The county is traversed by the Wabash and Tippecanoe Rivers, by Deer Creek, Wild creek and their tributaries.

Carroll county was organized as a corporate body in 1828, following an act of the Indiana Legislature. It was named in memory of Charles Carroll, a signer of the Declaration of Independence. The county seat was established at Delphi on May 24, 1828. According to the 1910 census, the county had a population of 17,970, of which 263 were of white foreign birth. This is a decrease, since the 1900 census shows a population of 19,933 and the 1890 census, one of 20,021.

There are thirteen townships in Carroll county: Adams, Burlington, Carrollton, Clay, Deer Creek, Democrat, Jackson, Jefferson, Madison, Monroe, Rock Creek, Tippecanoe and Washington. Delphi is the largest town, with a population of 2,161 in (1910). It is centrally situated at the junction of the Wabash Railroad and the Chicago, Indianapolis, and Louisville branch of the Monon. The Fort Wayne and Northern Indiana Traction Line also passes through Delphi. The county seat has several prospering industries, among them being a canning factory, paper mill, machine-shop and wagon works. There are several limestone quarries and lime kilns, which produce excellent material for road building and agricultural purposes. A new courthouse of Bedford limestone is under construction at a cost of about \$175,000. These industries furnish employment for from 400 to 500 men. Other important towns are Flora (1,386), Burling-

ton (789), Camden (557), Cutler, Ockley, Rockfield, Bringhurst, Burrows and Yeoman. Besides these there are settlements at Patton, Sleeth, Pittsburg, Owaseo, Walker, Radnor, Koro, Darwin, Carroll, Fisher, Tecoma, Hopedale and Lockport.

Most of the produce of Carroll county goes to Chicago although Indianapolis and eastern markets get a part.

Carroll county ranks well as regards improved roads. There are in the county $43\frac{7}{8}$ miles of stone or macadam roads, and $378\frac{5}{8}$ miles of gravel roads, all in good repair. There are 59.01 miles of steam railroads operated in Carroll county by the C. I. and L. branch of the Monon, the Vandalia and the Wabash Railroad. The Fort Wayne and Northern Indiana Traction Company operates 15.62 miles of electric line in the county.

Most of the drainage of the area is accomplished by natural means, although there are some six or eight hundred miles of open and tile drains.

CLIMATE.

The climatic conditions in Carroll county are typical of north Central Indiana. The year is divided almost equally by the average dates of the first killing frost in the fall and the last in the spring. The frosts and cold weather are usually limited to the time between September 30th and May 3rd, but have been known to occur several weeks earlier and later than these dates.

According to the Weather Bureau data recorded at Delphi, the winter mean temperature is 26 degrees Fahrenheit, but there are often great and sudden changes of weather so the season becomes a series of cold waves and thaws, with an average snowfall of 20 inches. The recorded maximum temperature of 70 degrees and a minimum of 26 degrees for January shows what extremes may occur. Other seasons show equal variability. While the summer mean is 72 degrees, the temperature may go above 100 degrees or drop to 40 degrees.

The following weather bureau data was recorded at Delphi and applies equally well to the whole county:

NORMAL MONTHLY, SEASONAL AND ANNUAL TEMPERATURE AND PRECIPITATION AT DELPHI, IND.

Month.	Temperature.			Precipitation.			Snow.
	Mean.	Absolute maximum.	Absolute minimum.	Mean.	Total amount for the driest year (1895).	Total amount for the wettest year (1907).	Average depth.
	<i>°F.</i>	<i>°F.</i>	<i>°F.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>	<i>Inches.</i>
December.....	29.7	64	—12	2.49	4.88	5.53	4.2
January.....	25.1	70	—26	2.64	2.64	7.00	8.8
February.....	25.5	67	—24	2.34	0.90	0.32	7.4
Winter.....	26.8	70	—26	7.47	8.42	12.85	20.4
March.....	37.5	85	—3	3.18	1.06	3.93	5.2
April.....	49.9	93	13	3.17	1.97	1.91	0.5
May.....	60.9	97	25	4.60	1.06	2.87	.0
Spring.....	49.4	97	—3	10.95	4.09	8.71	5.7
June.....	70.7	99	37	4.40	1.42	5.50	0
July.....	74.4	104	41	3.74	2.68	6.43	0
August.....	71.7	100	37	3.03	2.69	3.86	0
Summer.....	72.3	104	37	11.17	6.79	15.79	0
September.....	65.0	100	25	2.91	2.81	3.94	0
October.....	51.9	91	18	2.09	0.76	1.31	.....
November.....	39.0	77	0	3.23	4.30	2.31	1.9
Fall.....	52.0	100	0	8.23	7.87	7.56	1.9
Year.....	50.1	104	—26	37.82	27.17	44.91	28.0

AGRICULTURE.

The land in Carroll county was first farmed by white settlers about the year 1825. Forests, which at this time covered almost the whole of Indiana, furnished much valuable timber, and were bountifully supplied with game, both for food and for trade. In the early days the Wabash and Erie Canal facilitated the exportation of produce and encouraged trade. Saw mills were common and the timber was used for boat building, houses and barns, vehicles and plow-manufacturing. The western side of the county borders on the "Grand Prairie," which remained marshy and uncultivated until the fifties. The prairie was drained by means of dug and scraper ditches, and cattle grazing was soon the dominant industry, being supplanted later, however, by crops of corn and oats. Dredge-ditching has, in recent years, reclaimed much marshy land, insuring better and larger crops.

Carroll county now has 2,239 farms embraced in 227,000 acres—an average of 101.7 acres to the farm. The farm property of the county is valued at \$27,321,614, showing an increase of \$13,995,045 over 1900. The average value of land per acre is \$93.69, and increase of \$52.39 since 1900. Corn growing is the more widely practiced industry, although live stock feeding and other grain growing types of farming are important. Corn leads all others as regards acreage planted, there being 69,009 (3,339,118 bushels) acres of this crop according to the census of 1910. Wheat is second to corn with an acreage of 34,076 (626,845 bushels). Then comes oats with 21,545 acres or (610,793 bushels). Buckwheat and rye are of some importance, about 338 acres being devoted to these two crops.

These grain crops are disposed of in various ways. The corn and wheat crops are a source of cash when sold to elevators. Corn is also utilized for feeding work stock. Straw is sold in town or used for bedding. The wasteful practice of burning straw and stubble has practically ceased. The total value of cereal grown in Carroll county is \$2,560,628.

Hay is an important crop of this area. According to the 1910 census there were 17,982 acres (24,533 tons) of "hay and forage" grown in the county. Of this, about 2,067 acres is marsh hay. Timothy leads all other hays in acreage with a total of 9,527 acres (12802 tons). Three thousand six hundred and forty-seven acres are devoted to timothy and clover mixed, while 2,610 tons of clover were obtained from 2,423 acres when it was planted

alone. One hundred and sixteen acres of alfalfa yielded exactly two tons to the acre in 1909. Although not a general crop, by any means, the acreage of alfalfa has been increased in recent years. Millett, Hungarian grass and a few other wild, salt, or prairie grasses are grown to a noticeable extent.

Sufficient vegetables are grown for home use by farmers and gardeners. Irish potatoes are the most important "special crop," there being 84,559 bushels raised from 841 acres in 1909, almost 100 bushels to the acre.

There are about 96,987 fruit trees in the county, producing 70,098 bushels a year. Apples, peaches, pears, plums, and cherries are grown for local use, as are grapes, strawberries, blackberries, raspberries and nuts.

The total value of domestic animals on the farms in Carroll county in 1909 was \$2,245,767. There were 16,870 cattle, 10,854 horses, 516 mules, 57,204 hogs, and 11,793 sheep at this time.

Dairy products, poultry, and bees constitute an important item of farm income. In 1909 there was \$87,848 worth of poultry, 1,248 colonies of bees valued at \$3,275, and \$134,453 worth of dairy products sold.

The local distribution of crops in this area indicates that the farmers recognize the adaptability to crops of the soils in Carroll county. Corn is grown on all types of soil, but best results are obtained from the well-drained black lands of the prairie and the deep Wabash valley. Good crops of corn are produced on the reclaimed marshes. Oats is adapted to the same soils and conditions as corn, and does well on even wetter lands. The prairie is well suited to grain farming, although the productiveness could be increased by the feeding of some live stock. Wheat is confined almost entirely to the light-colored soils.

Rye is usually grown on poor, thin ground where other crops would not thrive. It is valuable as a protection to slopes which might wash. It is the logical crop for the sandy portions of the county. Rye, however, in the sandy soils, is being replaced by cowpeas.

Carroll county farms are, for the most part, well up-to-date, with good equipment and intelligent farming methods. Comfortable farm homes, with conveniences of town, with the addition of the R. F. D. and the automobile, has made living in the country much more agreeable than in the past. Adequate barns for stock, cribs and granaries for crops for home consumption, are provided. Improved farming implements constitute \$591,143 of the farm values in 1909.

The system of farming in this area is typical of the surrounding country. Part of the corn land is broken to an average depth of about six inches in the fall, and the remainder in the spring during April or May, according to the weather. The clods are disced and harrowed down to a good seed bed and most of the crop is planted in May, by means of machines with fertilizer attachment which applies commerial fertilizer. The crop is laid by in July, after from three to five cultivations.

In the preparation for oats, the soil is broken or possibly only disced and harrowed if the weather is wet in the spring. It is seeded by drills in March at the rate of one and one-half to two bushels per acre. The oats crop is harveted about the time that the corn is laid by. Threshing begins as soon as the straw is dry.

Wheat may be drilled between corn rows in the fall or sown on stubble ground which has been broken and finely pulverized by discing and harrowing. It is harvested just before oats and in the same manner.

The hay crops are sown on oat or wheat ground early in the spring and occupy the land after the nurse crop is removed.

The fields may be pastured in the fall, and the hay crop cut the following season. Timothy is usually allowed to stand several years until it becomes thin. When timothy and clover are sown together, the first crop is largely clover, but it dies out and leaves only timothy for succeeding crops. Clover alone is cut for hay in June, and for seed in the fall if the growth warrants.

The most common rotation on the prairie land is corn and oats or corn, corn, oats. On the "clay" lands, corn, wheat and clover are often successful combinations. The growth of legumes is a vital necessity. Other rotations include timothy in place of clover.

Farmers in Carroll county depend on their manure and the feeding of stock to build up their land, and they use comparatively small amounts of commercial fertilizer. In 1909, 153 farms spent an average of \$29.00 for commercial fertilizers.

It is advantageous to the farmers to feed to their livestock as much of their corn as possible, since corn marketed as pork or beef brings much better prices. The principal profits derived from the feeding of cattle lie in the gains made by hogs following them, and in the improvement of soil.

Each year some sheep are pastured on stubble and finished with a little grain. They gain in value quickly and at the same time are valuable to clean orchards, fence corners, etc., of weeds.

Poultry is almost clear profit to the farmer, since most of their food is gleaned from the field, barnyard or near the granary.

Dairy products, sufficient for home consumption with an excess for the markets, are another source of revenue, over \$90,000 having been realized from their sale during the year 1909.

During recent years farm labor has become a large item of expense. The census of 1910 reports that 1,150 Carroll county farmers spent \$159,711 in cash and \$49,531 in rent and board, for farm labor in 1909. About \$1.00 per day, with board and room, is the average amount paid to farm hands. Work is sometimes exchanged between the farmers, especially during harvest times.

The following table indicates a few of the changes which have taken place in Carroll county during the last decade:

	1910	1900	% Increase.	% Increase.
Value of all farm property	\$27,321,614	\$13,326,569	105.0	.....
Average value of land per acre	\$93.69	\$41.3	57.0	.....
Farms operated by tenants	857	832	.03	.....
Farms operated by owners	1,366	1,558	.....	12.3
Population	17,970	19,953	.....	9.9

SOILS.

Definition. Soils consist of the broken and decomposed portions of rocks mixed with more or less organic matter in various stages of decomposition. To the agriculturist it is that portion of the earth's surface into which the roots of plants may penetrate and obtain nourishment.

Soil and Subsoil. No sharp distinction between the soil and subsoil has yet been generally accepted. A change of color from the darker surface layer (due to the presence of humus or ferric hydroxide) to the lighter subsoil layer has generally been regarded as the basis of separation, but this distinction breaks down in the arid region where the humus content is scanty or is wholly lacking.

Of the distinction to be noted between the soil and subsoil, the most important is the presence of humus in the former. The

depth to which humus is found varies to some extent with the kind of plant growth. It is often found to extend in notable quantities to the lower limit of the growth of the roots of annual plants. Variation in the root habit of plants, therefore, causes a variation in the depth of the soil as determined by the humus content. Fertilization tends to change the structure, chemical composition and degree of compactness of the soil. In swamps and marshes the humus tint may reach to such depths as to invalidate the distinction between soil and subsoil based on humus content.

Since the humus is porous and has a high water absorbing and retaining capacity, and since the surface layer may be composed of much finer particles, it is clear that the water content of the soil and subsoil may vary both in time of drought and in wet weather. Aeration is also more perfect in the surface soil, thus bringing about many chemical changes and tending to make available the necessary plant food.

Another difference between soil and subsoil is the clay content. Usually the subsoil is more clayey than the surface soil, making the former more impervious and more retentive of moisture and plant food than the latter. The subsoil should tend to accumulate a larger potential supply of plant food because the finer particles are the richest in plant food. This is due to the tendency of the descending water to carry the finer particles with it into the subsoil. This tendency to deplete the soil is counteracted between rains when the ascending capillary water brings the soluble salts towards the surface where they are left upon the evaporation of the water. Thus the soil is periodically enriched. In an arid region this causes such a large accumulation of salts as to be injurious to the plants.

The subsoil is usually more calcareous than the upper soil and this difference is so great in some cases that the surface soil may require an application of lime while the subsoil still contains a large amount of lime. This accumulation of lime in the subsoil may be so great as to produce a solid subsoil condition or hardpan. It is noteworthy that the subsoil is in a less weathered condition, consisting more or less of unweathered particles of rock. This condition is due largely to the absence of humus and the associated carbonic acid and other acids. In the arid region, this difference between the soil and subsoil largely disappears. This is due, partly, to the fact that the plant remains oxidized so rapidly that they are in some cases completely "burned up," and partly to the fact that the plant roots penetrate so deeply into the subsoil in quest of water and plant food that the soil is only slightly enriched.

Effect of Clay. It takes only a very small percent of clay to materially add to the tilth or give open texture to a soil largely composed of sand because of its binding properties. This is well shown in the following table from Hilgard:

Very fine soil.....	0.5% to 3%	clay.
Ordinary sandy loam....	3% to 10%	"
Sandy loams.....	10% to 15%	"
Clay loams.....	15% to 25%	"
Clay soils.....	25% to 35%	"
Heavy clay soils.....	35% to 45%	"

While pure clay does not contain any thing of value as a food for the growing plant yet it does contain within its mass the necessary minerals in easily soluble form. Among these are the highly important substances potash, lime, soda, etc.

The importance of the clay as a plant food carrier is shown in the following table given by Bowman:

RELATION OF SOLUBLE MATTER TO SOIL CLASS

Conventional Name	Clay.	Finest Silt.	Fine Silt.	Medium Silt.	Coarse Silt.
Per cent in Soil.	21.64%	23.56%	12.58%	13.67%	13.11%
Diameter of Particles.....	?	mm. .005 = .011	mm. .013 = .016	mm. .002 = .027	mm. .033 = .038
Constituents....	%	%	%	%	%
Insoluble residue.....	15.96	73.17	87.96	94.13	96.52
Soluble silica....	33.10	9.95	4.27	2.35	.....
Potash (K ₂ O)....	1.47	0.53	0.29	0.12	.....
Soda (Na ₂ O)....	1.70	0.24	0.28	0.21	.....
Lime (Ca O)....	0.09	0.13	0.18	0.09	.....
Magnesia (Mg O).....	1.33	0.46	0.26	0.10	.....
Iron sesquioxide (Fe ₂ O ₃).....	18.76	4.76	2.34	1.03	.....
Manganese (Mn O ₂).....	0.30	0.00	0.00	0.00	.....
Alumina (Al ₂ O ₃).....	18.19	4.32	2.64	1.21	.....
Phosphoric acid (P ₂ O ₅).....	0.18	0.11	0.03	0.02	.....
Sulphuric acid (S O ₃).....	0.06	0.02	0.03	0.03	.....
Volatile matter..	9.00	5.61	1.72	0.92	.....
Totals.....	100.14	99.30	100.00	100.21	.....
Total soluble matter...	75.18	20.52	10.32	5.16	.....

Physical Properties. In former years, it was thought that the chemical analysis of a soil was of the most importance, but since the subject has been better understood, the physical side has gained in emphasis. A factor of prime importance to the agriculturist is the absorbing capacity of a soil and its ability to retain and furnish moisture to the growing plant as needed. In fact the ability of a soil to furnish an adequate amount of water to the growing crop is of far more importance than its chemical ingredients. Pure sand holds water poorly so that sand ordinarily is a dry soil. At the other extreme, clay holds moisture very tenaciously, so that a pure clay soil is usually soggy and apt to be very wet. A mixture of the two, forming a loam is not subject to either objection and is an ideal soil. A loam in the humid region always has a very luxuriant growth of vegetation where it has an adequate supply of water.

One of the effects of the presence of humus is to produce granules, forming a mellow, easily worked soil. Where a soil is cultivated without adding to the supply of humus, the soil becomes more compact and run together, producing decreasing crops, and reducing the moisture retaining capacity. Cultivation loosens the soil promoting aeration, and increases the amount of available plant food.

Chemical Properties. A chemical analysis of a soil will show the amounts of the different plant foods such as nitrogen, phosphorous, potassium, calcium, etc.; but the difficulty is that it does not give even a hint as to the form in which the elements occur in the soil. The analysis shows correctly the total organic carbon, but as a rule, this represents about one-half the organic matter; so that 20,000 pounds of organic carbon in the upper six inches of an acre represents 20 tons of organic matter. But this 20 tons is largely in the form of old organic residues that have accumulated during the centuries because they were so resistant to decay; so 2 tons of clover plowed under as a green manure would have greater power to liberate plant food for a growing crop than all the 20 tons of old residue of old organic remains. This is true of other chemicals as well.

Liberation of plant food. Ground limestone and decaying organic matter are the principle materials which the farmer can utilize most profitably to bring about the liberation of plant food. The ground limestone corrects the acidity of the soil and thus encouraged not only the nitrogen gathering bacteria which lives

in the nodules found on the roots of the growing plants of clovers, cow-peas, alfalfa and other leguminous plants, but also the nitrifying bacteria in the soil which have the power to make into plant food the insoluble and unavailable organic products. At the same time the products of this decomposition also make available the insoluble minerals found in the soil, such as the potassium and magnesium as well as the insoluble limestones and phosphates which can be applied by the agriculturist in a very low priced form.

One of the chief sources of loss of organic matter in the corn belt is the burning of corn stalks. If farmers would only realize the loss they incur they certainly would discontinue the practice. Probably no form of organic matter acts to form good tilth better than the plowing under of corn stalks. It is true they decay slowly but that only prolongs the desired conditions of the soil. The nitrogen in a ton of stalks is $1\frac{1}{2}$ times that of a ton of manure, while a ton of dry stalks when ultimately incorporated with the soil is equal to four times that amount of average farm manure, but when they are burned the humus making element and nitrogen are both gone and lost to the soil.

Upland Soils. The upland soils of Carroll County are mapped in 3 series; namely: Clyde, Miami and Shelby types, and in addition, the miscellaneous type known as muck. These types are all due to a difference in soil content and color and to surface conditions resulting from erosion. The Miami and Clyde series occur side by side, perhaps coming from a similar glacial till but those areas having better natural drainage and smaller amount of organic remains for humus become the light colored clay land or Miami series while the depressed areas with poor drainage or no drainage in swamp or marsh conditions, become the black or brown areas known as the Clyde series; or where there was a great abundance of partly decomposed organic matter they became muck. While some of the Miami series near the streams which was badly dissected by valley and gully heads on account of the erosive work of running water is placed in the Shelby series, from the standpoint of physical composition, it is identical with the Miami series.

Alluvial Soils. The alluvial soils of Carroll county are the sediments deposited in the stream valleys by flood waters. The sediments came from the uplands adjacent to the valleys of the different streams, and a certain kind of upland gave rise to a

definite type of alluvial soil. The darker colored soils are classed in the Wabash series, while the lighter colored alluvial soil is placed in the Genesee series. The Fox series consists of terrace soils, deposited perhaps by the glacial waters which were a great deal more abundant than the waters of the present time. The meadow land has not been mapped but much of the land along the smaller streams, classed as Genesee, belongs in this type.

MIAMI SILT LOAM.

Characteristics. The following characteristics of the Miami silt loam are given by the publications of the United States Bureau of Soils:

"The Miami silt loam consists normally of a dark gray or light brown, friable, silty clay loam having an average depth of about 10 inches. The surface soil is usually somewhat deeper over level or depressed areas and shallower on steep slopes and over the crests of ridges. When moist the surface color is almost a uniformly grayish or yellowish brown, but when thoroughly dry it becomes a light ashy gray.

"The immediate subsoil to a depth varying from 20 to 30 inches is a yellow or yellowish-brown silty clay loam. This is underlain by a yellowish brown, or brown gritty or sandy clay, usually containing an appreciable amount of coarse sand, gravel and boulders. As a rule this stony material consists chiefly of limestone, although crystalline erratics of various kinds form a part of the coarse grained material."

The different soil areas mapped as the Miami silt loam will vary from the above type description in one or more particulars but will agree in the main. The Miami silt loam has a level to undulating or rolling surface and occurs throughout the county, with the Clyde series occurring in the depressions. It forms about half of the total area of the county and is also known as the Miami silty clay loam.

Origin. The Miami silt loam in common with other members of the Miami series is due to the glaciation of the region in which it occurs. The retreating ice left the till with a very uneven surface composed of numerous ridges and valleys or depressions. During the process of erosion and weathering since that time, the ridges have tended to become lower, thus filling the depressions with the organic remains and the finer sediments from the higher land. The better natural drainage and lack of a large amount of

humus would produce a light colored soil with a high clay and silt content. This condition is well shown along the larger water courses where the surplus water rapidly drains away producing a wide strip of the Miami series on either side without any or with very few areas of the Clyde series even in the largest depressions.

Drainage. The fine texture and uniform structure causes ground water to move slowly and makes natural drainage inadequate in the Miami silt loam. This condition can be remedied by the use of tile drainage but care should be exercised by not using too small tile as lateral lines. The drains not only remove the surplus water in the wet weather thus lowering the ground water table, but also help to aerate the soil in the dry weather. In most cultivated soils, the pore space is from 25 to 50% of the volume and this is the maximum water capacity or saturation capacity. The amount of this space occupied by water for the maximum development of most plants is from 40 to 50% of the pore space which leaves one half or more to be occupied by air. The presence of a large amount of oxygen in the soil is essential to the best growth of the plant crops as well as the liberation of the necessary plant food.

Tilth. It is well to bear in mind that aside from fertility, drainage, and tillage, one of the main factors of a good soil is good physical condition or tilth. The Miami silt loam is in good tilth but since it has a small per cent of sand is very fine grained and easily injured by the tramping of live stock in the spring and fall on the stalk or stubble ground and by plowing or working the ground when too wet. Clods will result from these practices and it usually requires considerable time and work to put the soil in good tilth again. An occasional application of ground limestone followed by a crop of clover or some soiling crop will produce good tilth. In fact good physical condition depends to a large extent upon the amount of humus present in the soil.

Crops. Corn, wheat, oats, clover and timothy do well on the Miami silt loam. It is not as good corn land as the Clyde, but it produces good crops where the soil is well cared for. To do the best a field should not be in corn two years in succession. Wheat and oats do well, in fact the Miami silt loam is better for wheat and oats than any member of the Clyde series as it is apt to grow too rank and fall down when grown on the latter soils. Clover and timothy do well, but it is better not to grow the timothy alone as it has a strong tendency to deplete the fertility of

the soil. Some potatoes are grown on the Miami silt loam but it does not give a high yield. Some orchards are grown on this type and seem to give good results. The more hilly or rolling ground should be selected for orchard land.

Improvement. As has been stated before, the Miami silt loam should be kept in good tilth by proper drainage, cultivation, and the growing of crops for soiling purposes. All the manure produced on the farm should be carefully taken care of and spread over the land where it is most needed. It is well to follow a rotation with the corn planted on clover sod. The number of crops and kinds used in the rotation will depend on the size of the farm and the type of farming practiced but should include one (two would be better) year of clover. Where the ground seems to be "clover sick" only an application of ground lime is needed to insure a change. Commercial fertilizers may be resorted to under some conditions but we believe that they should not be constantly used with all crops.

MIAMI LOAM.

Properties. The Miami loam is a transition between the silt loam and the sandy loam and the boundary between them is usually arbitrary. It has a higher per cent of sand and has perhaps a little darker color than the silt loam.

The subsoil of the Miami loam has a higher per cent of sand and fine gravel than the silt loam and is variable in color and texture. On the one hand it grades into the silt loam type while on the other it may be sandy, grading into the sandy loam. One of the chief characteristics is the high per cent of sand in the top soil.

The difference in the character of the till as left by the glacier and the removal of the silt by weathering and eroding agents are probably responsible for the present structure of the Miami loam. The topography is similar to that of the Miami silt loam.

Drainage. The drainage of the Miami loam is usually good, on account of the open porous structure of the soil and the large amount of sand and gravel present in the subsoil. In some cases, however, the subsoil is hard and compact producing a poor natural drainage. In such cases artificial drainage would be beneficial and greatly increase the producing capacity of the soil.

Crops grown. The crops grown on this type are similar to those of the Miami silt loam and they yield as good crops. Owing

to the presence of sand it can be more readily kept in a state of good tilth, but it quickly responds to good farming methods. The same farming methods will apply equally well to the Miami loam and the silt loam types.

Location. The Miami loam is not so extensive as the Miami silt loam and occurs largely as the upland type along the borders of the streams. Owing to its location it is not, perhaps, valued as high as the Miami silt loam.

MIAMI FINE SANDY LOAM.

Characteristics. The upper 6 to 8 inches of the Miami fine sandy loam consists of a grayish-brown fine sandy loam, or fine loamy sand. The subsoil is a yellowish-brown heavy loam grading at about 18 inches into a sticky, fine sandy loam or clay loam. The most extensive area occurs in Deer Creek township while small areas are found in Adams and Tippecanoe townships. The topography is level to gently undulating with an occasional ravine where a small stream has formed a V-shaped valley.

Drainage. The drainage of the Miami fine sandy loam is good and is apt to be somewhat droughty in more sandy areas. It absorbs water readily and the soil water moves easily.

Crops grown. This type produces good yields of corn, oats, wheat, clover and potatoes. Apples, pears, peaches, grapes and small fruits should do well in this type of soil.

The fine sandy loam is easily cultivated and requires less labor to secure a good seed bed than the other upland soils. The yields are slightly below those of the heavier types.

The application of barnyard manure and green manures is very important. Clover and other leguminous crops should be grown for green manure.

CLYDE SILTY CLAY LOAM—HEAVY PHASE.

Characteristics. The United States Bureau of Soils gives the following description of Clyde silty clay loam:

“The surface soil of the Clyde silty clay loam to an average depth of 10 inches is a dark-brown to black sticky, silty clay loam. When wet it is a dull black in color and decidedly plastic and clay like. Upon becoming partially dried it assumes a lighter brown or gray or grayish brown color and usually develops a granulated or crumb-like structure. Nearer the margins of the areas of this

type the color is usually a lighter brown, the surface soil may have a depth of only 5 or 6 inches, and the admixture of coarse grained material sometimes renders it rather more loamy than the typical area.

"The subsoil to a depth ranging from 15 to 20 inches is most frequently a dark brown or almost black silty clay loam which becomes gradually lighter colored with depth and at about 2 feet grades into a drab or dark blue sticky clay loam. This is most frequently underlain by a yellow or mottled yellow and gray plastic clay loam."

The Clyde silty clay loam grades on the one hand into the peat and muck series while on the other hand it merges into the surrounding Miami soils.

The topography is naturally level with perhaps an occasional slight elevation on the surface.

Origin. The Clyde silty clay loam in common with the Clyde series is due to depressions in the surface after the retreat of the glacier. The depressions had very poor natural drainage and became marshes and swamps in the case of the Carroll County soils. The areas are connected in most cases by long narrow, usually parallel lines where the water slowly drained from the higher swamps to the lower ones and finally reached the smaller tributaries of the streams. The swamps slowly filled with organic remains from the surrounding higher land in addition to the rank vegetation that flourished in the swamps themselves. The organic matter settled to the bottom where it decayed and became mixed with the fine clay sediment that was washed in to the depressions. The poor drainage produced the heavy phase while the better and more free drainage gave rise to the silt loam with a bright yellow to reddish subsoil at a depth of two feet.

Drainage. The Clyde series of soil types requires artificial drainage to lower the water level below the surface of the soil. In fact, when the country was first settled, the black land was all under water, but after thorough drainage it was considered the best soil type.

The Clyde silty clay loam contains a very high per cent of humus which united with the clay forms a porous friable, soil which absorbs moisture readily and is easily cultivated.

Crops grown. The Clyde soil is the leading corn land of the country. It yields 50 to 75 and sometimes 80 to 90 bushels per acre. Timothy is a good crop to grow on the more chaffy phases

where other crops have a tendency to dry up. Oats yield well and wheat does good but both crops tend to produce too rank a growth of straw and consequently to lodge. Wet, open winters are bad for wheat. The open, loose, texture admits water freely and freezing heaves the soil pulling the wheat out of the ground. A relatively dry winter season with a few inches of snow for protection, is followed by good results.

The Clyde silty clay loam or silty loam as it is sometimes called occurs typically in Democrat, Burlington and Jefferson townships with some areas in other parts of the county. It occupies a large part of the county. The muck is always associated with or surrounded by this soil type.

CLYDE SILTY CLAY LOAM.

Properties. The Clyde silty clay loam is a grayish brown to brownish-black soil with an average depth of about 10 inches. The subsoil is grayish brown in color, increasing in clay content as it descends and at about 18 inches to 2 feet grading into a mottled bright yellow material sometimes streaked with a reddish color but not with the steel gray. This characteristic difference between it and the flat phase is due to better drainage. The decidedly lighter steel gray mottling of the flat phase is due to stagnant or very poor drainage. This type occurs in shallower depressions than the heavy phase, and the surface soils are not so dark; in some cases the color is almost midway between the surrounding gray Miami soils and the dark Clyde silty clay loam.

Crops grown. The Clyde silty clay loam is well adapted to the growing of corn, clover, wheat, oats and timothy. It is first and last a corn soil, in fact in some parts of the county that crop seems to be the only one grown.

A crop rotation should be practiced including a crop of clover or some leguminous crop every 4 or 5 years to enrich the soil. The farmers are planting the soy bean in the corn rows and also as separate crops. This will help to improve the soil.

Location. The Clyde silt loam is developed throughout the county but more particularly in Washington, Monroe and Madison townships and comprises about $\frac{1}{8}$ of the county.

CLYDE LOAM.

Characteristics. The Clyde loam is a black loam of variable texture and about 10 inches deep. It ranges from the silt type to the sandy type. The subsoil at about 18 inches grades into a mottled gray or yellowish material sometimes with a reddish tinge and usually containing a varying amount of fine sand.

Crops grown. The drainage conditions are the same for the loam as for the silty clay types, and artificial drainage is required. The crops produced are similar to those grown on the other types of the Clyde series and the yield is not materially different. The methods of farming are similar also to those for the Clyde series in general.

GENESEE FINE SANDY LOAM.

Characteristics. The Genesee fine sandy loam has been described in the United State Bureau of soils publications as follows:

"The soil consists of a light-brown to dark brown moderately heavy fine sandy loam from 10 to 20 inches deep. The subsoil has about the same texture as the soil, but is usually slightly lighter in color. There are in places slight variations from the typical soil, owing to local erosion and to deposition of sand and silt over small areas by overflow waters. Streaks of sand and silty material are sometimes encountered in the soil mass. Most of the type is subject to annual or frequent overflow."

The Genesee series form the flood plains of the smaller streams and to some extent of the Wabash and Tippecanoe rivers. Some of the areas mapped as Genesee are the same as those usually called meadow land. The two were not separated. The boundary between the Clyde series and the Genesee series is not distinct. Since the Genesee fine sandy loam is an alluvial soil, it varies in short distances owing to the variation in the currents of the streams at various flood stages. Near the streams and across the sharper bends where the currents were swift, the coarser particles were deposited; and in many cases the soil has a large proportion of coarse sand. Near the larger bends or where the water found settling basins, or where the water was less turbulent, the finer material was deposited, giving rise to the heavier and more silty type, usually of a darker color. Mixture of the fine clay or silty materials with the right proportion of sand is the basis of the Genesee fine sandy loam.

Agricultural conditions. The bottoms are flooded annually or oftener and in places are cut by smaller branches and creeks tributary to the main stream. The drainage is usually good and the land dries rapidly after a rain. It is a soil that is friable, easy to till, and where protected from overflow is admirably adapted to corn, oats, clover or timothy. A great deal of the rougher land is in pasture.

The fertility of the Genesee fine sandy loam is renewed each time it is flooded by high water making the growing leguminous crops of less importance. Thorough cultivation is necessary to keep down the large number of weeds springing up from the seed brought in by high water.

GENESEE LOAM.

Properties. This soil consists of a light-brown loam to sandy or silty loam. The subsoil is very similar in texture to the soil but is usually lighter brown in color. Below 18 to 20 inches, the substratum is frequently made up of horizontal beds of sand and clay.

The Genesee loam is an alluvial soil and its variation in structure is due to the same causes as in the case of the sandy loams. It has a level to somewhat broken topography and occurs along the course of the streams.

Agricultural conditions. The Genesee loam is used for the growing of grain crops, particularly corn. It is productive, easily cultivated, and readily kept in good tilth. A great deal of the land is used for pasture purposes.

The drainage is usually good but it does not stand dry weather so well as soils with a very high clay content.

FOX FINE SANDY LOAM.

Characteristics. "The surface soil of the Fox fine sandy loam is known to be gray in color, a fine sandy loam in texture, and in places somewhat sticky when wet. The subsoil is lighter in color than the soil and at the top has the same texture, becoming heavier with depth. At 24 inches it is a fine sandy clay, below which it becomes lighter, a bed of fine sand often being encountered within the three foot sections. There is always a substructure of gravel containing at least 25 per cent of limestone pebbles. This type may occur as a glacial outwash plain or a glacial stream terrace. the surface is level or pitted, and sometimes slightly rolling owing to erosion."

This is the type description of this soil as given by the publication of the U. S. Bureau of Soils.

The Fox sandy loam occurs as a terrace soil along the Tippecanoe and Wabash rivers where in some instances it resembles long sandy ridges. Some areas grade into almost pure sand. The surface is level to gently undulating on account of the effects of erosion.

Agricultural conditions. The natural drainage is good with a tendency in places to drought in long dry spells.

WABASH LOAM.

Properties. The following type description of the Wabash loam is given by the U. S. Bureau of Soils:

"Owing to its wide distribution and its alluvial origin from the wash of soils of different textures, this type shows a wide local variation. It is generally a brown loam about 10 inches deep, often containing small quantities of sand and in local areas some gravel. The subsoil is usually a heavy brownish-yellow loam 20 to 40 inches deep, overlying a gravelly loam. The type occurs as first bottoms along the streams and small rivers and much of it is subject to periodical overflow. It is a first class corn soil, producing 35 to 60 bushels per acre. This type could be used more extensively for the production of canning crops, such as sugar corn, green peas, tomatoes," etc.

The surface of the Wabash loam is level to slightly undulating. It occurs along the Wabash river, forming part of the flood plain.

The natural drainage is good only requiring artificial drains to conduct the water from the uplands to the river.

Crop conditions. This type of soil is very highly prized for farming purposes. It is friable, easily cultivated and responds readily to good farming methods. Very little is for sale and brings \$200 per acre when sold, if close to market.

WABASH SILT LOAM.

Properties. The wabash silt loam is described by the U. S. Bureau of Soils as follows:

"The type includes a dark-brown to black silt loam about 12 inches deep, underlain by a heavy silt loam of lighter color. Sometimes, however, the dark color extends to three feet or more. The soil is of alluvial origin. It occupies stream bottoms subject

to overflow, and is often poorly drained. When well drained it produces heavy crops of corn and grass and fair yields of small grain."

Having a small amount of sand, the Wabash silt loam retains moisture well but will readily form clods when stirred too wet. It will not form a good tilth readily when cloddy on account of the presence of a large amount of silt or clay.

Agricultural conditions. Where well drained, corn does well on the Wabash silt loam, but it is not always a good practice to pasture the stalks especially when the ground is not frozen.

WABASH FINE SANDY LOAM.

Properties. The Wabash fine sandy loam is similar to the other types of the Wabash series of soils occurring in Carroll County, except that the sandy loam contains more sand. In places it becomes very sandy.

The natural drainage of this type is very good. The soil absorbs moisture rapidly and it dries very quickly after a rain. This is due to the porous condition of the subsoil.

Crops grown. The crops grown on this are similar to those of the other Wabash soils and the yields are not materially different.

The agricultural practices are similar to those in vogue in the other types of Wabash soils and it requires the same kind of treatment.

Almost all of the Wabash fine sandy loam is in cultivation and is highly valued as farm land.

SHELBY SILT LOAM.

Characteristics. In physical composition, the Shelby silt loam is the same as the Miami silt loam but the basis of separation is a difference of surface conditions. It is rather broken and deeply dissected by streams erosion. It occurs near the streams mainly in Adams township. This type should be left in forest growth as much as possible to prevent erosion and stream etching. This type of soil would be good for orchards. The crops grown on the Shelby silt loam are similar to those of the Miami silt loam and do not give materially different crop yields from those of the Miami soils.

MUCK.

Characteristics. Muck is a dark-brown to black mixture composed of the organic remains of swamp vegetation in various stages of oxidation, mixed with varying quantities of sand, clay and silt. It ranges from two or three feet to many feet in thickness. On the outer margins, the muck merges into the Clyde series.

Most muck is too chaffy for farm crops. Corn many times grows nicely until it becomes knee high when it turns yellow and dies, and the smaller grains grow too rank and lodge badly. Timothy does well on muck soil. It is well adapted to the growth of onions, celery, cabbage, Irish potatoes, beets, turnips, cauliflower, and other vegetables. The agricultural condition may be improved by the liberal use of barnyard manure and potash salts.

MEADOW.

Meadow represents the variable soil conditions encountered in the narrow, trough like valleys of the creeks. It consists of alluvial material varying from almost pure sand to silt or clay and is usually subject to overflow with every high water. Part of it is in cultivation but most of it is in pasture, trees, underbrush and weeds. This type is not shown separately on the map but is included with the Genesee series.

SUMMARY.

Fourteen soil types are recognized and mapped in Carrol county. The Miami, Clyde, Muck and Shelby soils occur on the uplands, the Fox, upon the terraces, and the Genesee and Wabash in the first, or overflow bottoms.

Three types of the Miami soils are mapped, the silt loam, loam and fine sandy loam. They are best adapted to wheat and oats.

The Clyde series includes the silty clay loam, the silty clay loam, heavy phase and the loam. This is the corn land, but the smaller grains and hay also do well.

The Fox fine sandy loam occurs on the higher terraces. It is well drained.

The Genesee is represented by the loam and fine sandy loam, alluvial soils that are subject to frequent overflow. They are well suited to corn.

The Muck is of small extent and unimportant.

The Wabash series has three representatives, the loam, silt loam and fine sandy loam. They are well drained and suited to corn and the small grains.

Soil Survey of Whitley County.

This county is situated in the northern part of the state, and is bounded on the north by Noble county, on the east by Allen county, on the south by Huntington and Wabash counties, and on the west by Wabash and Kosciusko counties, and at present comprises about 210,458 acres of land. It was originally composed of nine congressional townships when organized in 1838, and as fixed by the Legislature of 1833 and 1834. In June, 1859, the area was changed by the addition of twelve sections of land taken from the south side of township thirty-three north, range eight east, in Noble county. The following altitudes show its elevation above sea level and are taken from "A Dictionary of Altitudes in the United States" by Henry Garrett, viz:

Columbia City—P. Ft. W. & C. Rwy.....	839
" " —L. & T. Rwy. (Vandalia).....	829
" " —Rwy. Crossing.....	832
" " —Weather Bureau.....	841
Larwill —P. Ft. W. & C. Rwy.....	951

Larwill is west of Columbia City about eight miles and on the western edge of a most interesting moraine formation, which will be described further on in this sketch.

Whitley county was named in honor of Col. William Whitley, of Lincoln county, Kentucky, who was killed at the battle of the Thames, in Canada, in the war of 1812. Its surface is generally rolling and uneven, diversified by a few marked irregularities and only a limited area of level land. The surface configuration is due mainly to glacial action which by time was altered by erosion. The entire county, with the rest of northern Indiana, was overspread by glaciers which buried the work of the geologic ages of periods before the Past Tertiary of Cenozoic, or recent time, with a mass of drift composed of heterogeneous mixtures of ground-up rocks, mud and debris, containing boulders, gravel, sand, clay and mud in varying proportions and deposited over the entire county, as well as elsewhere, when the great ice sheet covered this section of the United States. The drift of the uplands is called boulder clay, as it is believed to be composed from the grinding up of boulder during the moving process of this great mass of

glacial ice. This clay is the most characteristic of the ice age deposits. It is a stiff clay mixed with angular and rounded gravel, boulders, and varying amounts of sand. It undoubtedly has been modified on the surface, to a great extent, by the action of water, frost and disintegration. In the valleys the drift shows clearly the assorting agency of running water. The drift boulders are representative of the metamorphosed granites, gneiss, etc., from the north; and representatives from the original bed-rock and the different ages of geologic time are found also. The deposits of the drift material vary in thickness but may be about 220 feet in portions of the county as determined by deep well borings. In its physical conditions, or Ice Age make-up, Whitley county is very interesting. It occupies a portion of the great Saginaw-Erie moraine, and the crest of this moraine, forming the divide or water-shed between the Tippecanoe river and Eel river drainage systems of Indiana, passes through the northern part of the county. The greater part of the county is on the Eel river side of the moraine. Perhaps nowhere else in the northern part of Indiana does the surface of the drift present features so strongly marked and contrasted in character.

In the townships of the south and southeastern part of the county the surface is best described by saying it is flat or level except that portion in the extreme southeastern corner near the site of the old Wabash and Erie canal. Here the surface is much broken, equal to the most ragged parts of the north and western portions of the county. In this flat or level portion of the county the surface is sufficiently sloping for drainage, but this can only be determined by the general course of the streams. The surface of this part of the county resembles that of a large sheet of wrapping paper which has been wet and then dried, the depressions and elevations having very little relief and no defined boundaries. The only relief from unbroken monotony is afforded by the channels of the streams. This area had many marshes but these have now all been reclaimed by systems of drainage, and show their location only by a slight depression and no definite margin as they would on more rolling surfaces. The swamps here were not of the muck type as they are in the broken areas. But few boulders are contained in this soil which is a part of that enormous mass of mud which settled quietly to the bottom from this great sheet of ice, and is designated as ground-up moraine material to a very fine state. The drainage of this region is accomplished by several streams which flow east, south and

southwest, carrying away the waters toward the Wabash-Erie channel. Indian Creek and Big Indian Creek flow eastward and empty into the Aboite Creek in Allen county. Calf Creek and Clear Creek flow south through Huntington county, emptying into the Wabash or Little River. Sugar Creek and Stony Creek wind sluggishly westward to Eel river, carrying the waters from the northern part of this level area. Nearly all of these streams have been opened by dredges and are now classed as county ditches. Small and almost imperceptible ridges form the watersheds between these streams.

The northeastern quarter of the county and the entire western side has the general and usual features of morained surfaces called crumpled. A portion of the western side is unique and will receive special notice. The northern part of the county presents a distinct morainic crest extending in the main from northeast to southwest. South of this ridge the surface is divided by other or secondary ridges, with valleys between through which flow the waters of Blue River and its tributaries in a southwesterly direction and emptying into Eel River near the center of the county. Eel river entering the county from Allen county flows in a southwesterly course and forms the main drainage channel of the county. These rivers and their tributaries have been deepened and straightened by dredging almost through the entire county. Eel river flows through a rich and beautiful valley, varying in width not exceeding a mile. The slope on either side being gradual and comparatively without bluffs except along its upper course. In section one, township thirty, range eight, two very curious depressions extend back from the river into the hills. One is narrow and about a half mile long, the other is smaller and separated from the first by a narrow ridge like a canal tow-path. These depressions, undoubtedly, at one time were small lakes.

In a part of Columbia township and part of Richland township is a tract of glacial formation which is difficult to describe, and in doing this I can do no better than quote from a local history, viz: "The country is entirely occupied by deep, irregular, elongated valleys with narrow, sharp winding ridges between, all in inextricable almost confusion. In a somewhat extensive study of the great morainic belts of North America, by personal observation and published reports, Prof. Charles Dryer says he has never seen or found described anything nearly resembling this area. It covers in all about forty square miles and the greatest distance of level probably does not exceed 100 feet, yet this little

patch of the earth's surface is unique. The roads through it were originally very crooked to avoid the marshes, and, though somewhat improved by drainage and good graveling, will always remain of the crooked type. In whatever direction one travels, it is one continuous succession of steep descents and ascents. The ridges are composed of rather barren clay and the valleys occupied originally by marshes and tamarack swamps. The relief might be imitated by taking a block of plastic clay and gouging it with some blunt instrument in the most irregular manner possible, somewhat as the ancient Babylonians did their brick. It is one of nature's cuneiform inscriptions, and as difficult of interpretation as those of the Euphrates valley. This type of topography may be called chasmed. It is now impossible to imagine with any definiteness of detail the process by which this little bit of the face of the earth was put in its present shape. Another strange peculiarity is that a country which so abounds in depressions is almost devoid of lakes. This condition continues to and beyond the west line of Richland township to about the center, north and south, or the entire west side of township 31, range 8.

Black Lake, section 27, and Wilson Lake, section 32, range 8, lie upon the northwestern border of this region. The former originally covered about forty acres, is shallow and almost free from vegetation. An unusually high and precipitous ridge separates the two. From these lakes Spring Creek flows southward through the chasms to Eel river near South Whitley. North of the middle of Richland township, the surface smooths out, decidedly retaining similar features in a much milder form, and may be called gently sloping. This comparatively smooth interval extends westward nearly to the county line, and to the north occupies the greater part of Troy and Etna townships. Although the contrasts between the precipitous chasms on the east and the gentle undulations on the west is very strong, it is impossible to draw more than an approximate line. The village of Larwill is situated upon this boundary, which extends thence southward and southwest and toward the northeast, passing between Loon and Crooked Lakes."

LAKES—STREAMS—DRAINAGE.

The surface of the northern part of the county is interspersed with a chain of lakes which can challenge comparison with any other group of Indiana lakes for beauty and attractiveness, and interest to the sportsman and student of Botany. Blue Lake in

Smith township occupies portions of four sections and is of unusual interest as a resort. Shriener, Cedar and Round Lakes, known as Tri-lake is as pretty a group of lakes as anyone can wish to see. Shriener and Cedar occupy valleys running parallel and separated from each other by a ridge about a quarter of a mile wide upon which are built beautiful cottages and a hotel. This is Tri-lake resort. This ridge is low at the west and precipitous near the east end. Cedar and Round Lakes occupy the same valley and lie north of the ridge. Catfish Lake lies at the western end of Shriener Lake, in the same valley, from which it is separated by a low ridge about 36 rods wide. These lakes and their watershed surroundings all drain their excess water through one stream running south emptying into Blue River, which is also the drainage outlet of Blue Lake and surrounding watershed; all belonging to the Eel river drainage system. Crooked Lake lies to the west of Cedar Lake and separated from it by a distinct ridge or crest which forms the watershed between the Tippecanoe and Eel river drainage systems. The surface around these lakes is rather elevated and the banks in places are quite precipitous. Loon Lake, Goose Lake, Winter Lake, New Lake and Old Lake form an interesting group to the west of the Tri-lake group. The four latter lie in one valley, north and south, and separated only by low ridges. Loon Lake is in a parallel valley to the east. The two valleys are separated by a ridge probably one half mile wide. All of these drain northward into the Tippecanoe drainage system. Big Cedar, Robinson, Black, Wilson and a number of very small lakes comprise the lake system in Whitley county. Big Cedar, Robinson and some small lakes drain westward out of this county. Black and Wilson Lakes, as has been mentioned, drain south through Spring Creek into Eel river. The northwest portion of the county, not included in the lake drainage, is drained wholly by small streams or ditches which carry the waters westerly and northward into streams connected with the Tippecanoe system. Outside of the lake drainage described, the balance of the county is thoroughly and systematically drained by natural streams, which, with a few exceptions, have all been straightened, deepened and improved by dredges, so that now they are only artificial streams occupying the original creek and river valleys. These have practically all been mentioned in the topography of the county. The streams of the county, with but few exceptions, flow in a general southwesterly direction into the Wabash River using Eel river as a conveyer.

GEOLOGY.

Two different places show the drift to be about 220 feet in depth. It is tantalizing to think that within 220 feet of the surface is an abundance of fine and durable building stone of unlimited quantity yet practically so distant that it is useless for any known purpose at the present time. It may be a storage room for something to be utilized at some future time. Scattered throughout the drift, except in the flat portion of the county, as described in the topography, in varying quantities is an abundance of granite and other boulders; these are used extensively for foundations for buildings. Conglomerates, quartz and rocks of varying compositions are scattered throughout the drift especially so on the ridges. A boulder belt can be traced from section 34, Smith township, in a southwesterly direction to section 32, Union township, both townships in range 10, beyond it is not noticeable. Its extent is about seven miles in length and from one-half to one mile in width. This belt of boulders is very noticeable, having well defined boundaries. The boulders are principally of granitic formation, varying in size from small to very large—as much as six feet in diameter. Along the axis of this belt were it extended southward toward Huntington, in Huntington county, until it intersected with the boulder region there, several pronounced boulder localities would be encountered, one of which is in sections 35 and 36 of Washington township, or townships 30, range 9. I give this as a probability, not as a fact, that perhaps there may be a boulder belt of immense size extending from the above continuously to the Wabash river and continuing along the course of that river. Peatbeds are found in many places; and bog-iron ore is also found in several localities. However neither peat nor bog-iron are found in sufficient quantities to be of any consequence otherwise than an interesting geological item. Nearly all the lake beds and many of the beds of its muck swamps contain an abundance of marl which, at some future time, may be a source of much wealth. There is an abundance of clay soils from which brick and drain tile of the finest quality are manufactured. There are different qualities of this clay, and the supply of it is almost unlimited and liberally distributed over the entire county. Sand and gravel ridges are located here and there over the entire county, and especially so in the valleys of Blue and Eel rivers in abundance. Some deep beds of gravel are being worked in various places in the low lands of level areas from which the

gravel is lifted with machinery. The sand and gravel from these ridges and deep beds is utilized in the building of highways, streets, and concrete work of all description. This material is all of excellent quality and unlimited in quantity.

AGRICULTURE.

The surface soils represent nature's patchwork of variety, and all are well adapted to grazing and tillage. All the agricultural crops adapted to this climate are cultivated. Cattle, sheep and swine form the animal products of the soil. Dairying, also allied with soil conditions, in recent years is making rapid progress. Some horse are raised, mostly for domestic purposes. Fruits can be grown in abundance when given the proper care.

SOILS.

The real source of wealth in this county is the soil, and it has responded most liberally. It consists mostly of clay of different varieties which has been enriched with the accumulation of vegetable matter for many centuries. Being the result of the Ice Age, it is naturally fertile in mineral constituents and responds most liberally when handled with proper care. Some areas are sandy in varying proportions, but these are not extensive. The level part of the county is made up of the finer or mud particles of the drift debris and is now a very rich soil. The valleys are of sedimentary formation, the ingredients being carried there by erosion of the uplands and by overflow during many ages. Here one would naturally expect to find the richest soil. There are some areas of muck, not extensive, however, which are utilized chiefly for raising onions. This character of soil requires liberal applications of fertilizers to make it productive. The clay soils require liberal applications of humus to make them friable and porous, and to liberate the plant food. Rotation of crops is generally practiced as a conservation of soil fertility.

PALEONTOLOGY.

The paleontology is represented altogether in surface finds on the cultivated fields and in the creek gravels. The specimens of fossils are of the "tramp" variety. They were brought here by the agency of the ice sheet. The fossils are chiefly interesting as furnishing possible information as to the source of the debris brought here by the great ice agency. The representative fossils are such

as are found described and classified in the Van Cleve and Hall lists of corals and shells. My own cabinet contains a generous number of coral specimens of different varieties which I gathered in going over this county. It also contains some brachiopods, crinoid stems and two trilobites found here. One of the trilobites was found in the creek gravels north of Columbia City and the other in bank gravel near South Whitley along Eel river.

NATURAL WONDERS.

The only natural wonders are the numerous sink-holes scattered across the entire northern part of the county. These are nothing more than morainic kettled hole lakes which became filled and covered over with a morass of vegetable growth during the countless years of nature's growth and change. As a rule high elevations or hills surround these holes, and a narrow valley leads from them. Occasionally a deep saucer-like depression occurs on high elevations, which, upon examination, shows that it must have been a small area of water and became gradually filled up by the accumulation of vegetable debris and washed in soil.

ARCHAEOLOGY.

Many centuries before the appearance of white people in this country, it was occupied by the Indians. When the Indians lived here nature was complete and perfect. The soil furnished him riches in abundance. The forests were complete and untouched as God and nature made them. In them the Indian found an abundance of game, which yielded him meat for his sustenance and raiment for his body. Likewise from the streams he secured fish and small furs for his comfort. In this land of plenty the Indian lived like a prince, for his wants were few and easily satisfied, his ambitions lowly, and his hopes eternal. But to all of this there came an end. There came from across the seas the white man, that "prince of parasites," the self-styled heir to all the ages, conquerer, civilizer, and also despoiler and devastator of nature. He first came as a discoverer, then as a trader and trapper among the Indians, and last as a settler, always a despoiler of the land the Indian loved so well. No country has such beautiful legendary lore as America, left it as a priceless heritage by the vanishing representatives of the prehistoric people—the Indians.

In the memory of white man this territory was inhabited by representations of the Miami and Pottawattomi tribes, chiefly by

small bands or sub-divisions of Miamis. The Eel river tribe or band were Miamis who had located on Eel river near Logansport and wandered from there up and down the river, and thus into Whitley county. The last of them, with a few exceptions, were removed in 1837. Those from Whitley and nearby in Allen and Huntington counties were loaded on canal boats at Racoon Village in the southeast corner of the county. The Indians retained four reservations in this county; Seek's Village, Beaver, Chapiene and Racoon's Village. As late as 1833, local history claims there were about two hundred Indians in the county distributed in the following villages, viz: Racoon Village, Blue Lake, Seek's Village, Beaver Reserve and Coesse's section just south of Columbia City. Chief Coesse died in 1854, and his only son is buried on the home farm near where the present farm buildings are located. His wife and daughters remained on the farm until 1868.

Situated as this county is on the Indian trail from Vincennes by way of Eel river to the Maumee, one would surely seek for some interesting Indian history. This was preserved for future generations by a number of citizens on July 26, 1906. This little band of citizens visited the Island, the spot of executions thereon, the battle ground of the two dominant tribes, Miamis and Pot-tawattamis, the spot of the burned cabins, Indian cemeteries, the spot of the massacre at Pages' Crossing, the bridge across Beaver Run, Little Turtle's Village, Seek's Village, and the location of the homes of both these chiefs; also the portages and trails. While doing this they also gathered and received much Indian lore connected with the history of this county. There is an absence of mounds of prehistoric earthworks, but implements of war, the chase and articles of adornment and ceremony are somewhat plentiful.

The artifacts of these people of prehistoric ages at first were very crude, were chipped only, and hardly have the semblance of being made for any special purpose. Later on they were shaped into form by chipping and pecking. Following this advancement he began smoothing and polishing his implements by grinding and rubbing them until they were things of beauty. He then, too, began making ornaments for his person. His pride for beautiful things increased with his advancement and culture. These artifacts consist of mortars and pestles, axes, celts, scrapers, arrows points, spear points, drills, perforators, hair fasteners, knives, saws, awls, pipes, hammers, mauls or mallets, rubbing stones,

and many ornaments and ceremonies. Their mortars are not so common, very few being found here. The pestles are more plentiful and this fact is conclusive that the aborigine used a cavity in some fallen tree, instead of a rock, for his mortar. The general form of the pestle is cylindrical and varies very much in size. Those in my collection vary from four to twelve and one-half inches in length, and from two to two and one-half inches in diameter. Axes, celts and flint implements are numerous and are found everywhere on our farms. These are the most interesting of all the relics we find, because they show great ingenuity in manufacture. They vary in size and form. Some are rudely finished, while others are beautifully polished and finished without a flaw to mar the marvelous beauty of the implement. The Indian must have felt proud of a fine axe or tomahawk as evidenced by the great amount of work it necessitated to make a fine one. The Indian's axe has a groove around the poll or upper part. I have two specimens that have a groove up and over the poll connecting with the groove around the axe. This type is very rare. The grooved axes found here do not differ materially from those found in other places only that they, in general, are not so large. The celt, commonly called a hatchet or tomahawk, is as numerous as the axe and shows as much workmanship and skill in its manufacture as does the axe, only that it has no grooves. The flint implements are found everywhere and nearly every person has found some of them. These consist of arrow and spear points, saws, knives, scrapers, hoes, perforators and drills. In size these run from one-half inch to eight inches long and are made from all the varieties of flint and the very finest moss agate, quartz, obsidian and jasper. These were all made away from here for the material is not found here. The most are Ohio flint ridge material, while the agates, sugar quartz and obsidian came from long distances—the agates and obsidian from the far west and the sugar quartz from Wisconsin. The axes, celts, mortars, pestles, hammers and rubbing stones were made from bowlders like those scattered all over the surface of the farms.

There is another class of objects, widely different in form, but which may be classed together. Different names have been given to them which may have been based upon their appearance or upon a theoretical idea of their purpose. They are classed in general as ceremonial objects and classified as banner stones, drilled ceremonials, pierced tablets, gorgets, pendants, bird-shaped objects, boat-shaped objects, etc. Thomas Wilson in his work

says: "The names thus given may or may not be correct, but are as good as others that have been suggested in their stead. They should be retained until something more correct can be given." Moorhead in his "Stone Age" classifies them under the general term of "Problematical Forms." All of these objects are found in Whitley county, although not in great numbers. They are well polished and symmetrically formed and made of slate often beautifully banded or striped. They all have holes drilled in them. My cabinet contains specimens which are partly made and apparently were rejected or lost. These show that they were shaped before drilling commenced. The beautiful symmetry and fine-finish entitles these articles to be classed as objects of fine art.

Prehistoric man appreciated the luxury of a pipe and enjoyed the effect of tobacco. Smoking was probably his most pleasing occupation. In making his pipe and smoking tube, he displayed the greatest care and ingenuity. They were made to represent many species of animal and bird. Even the human form was outlined in his pipe. In most cases, however, he simply made a pipe which he could use and enjoy. The pipes and tubes are nearly all made of slate and red sandstone or cathinite. I have a monitor pipe of green stone found on an adjoining farm.

A few fragments of pottery were found on a farm in Thorn-creek township and near a small lake or pond. These fragments are in my collection. Copper and iron implements are sparingly found. My collection has in it a copper spear point, the only one that I know of in the county; and iron spear point and four iron hatchets. These iron tomahawks are more plentiful. Several skeletons were exhumed in the gravel banks while removing gravel for building purposes, but nothing was found with these. Badly rust eaten scalping knives have been picked up on the village sites. Two of these are in my collection.

Occasional firepits or ovens are found near the lakes and rivers. These are merely holes dug in the earth and walled up with stone.

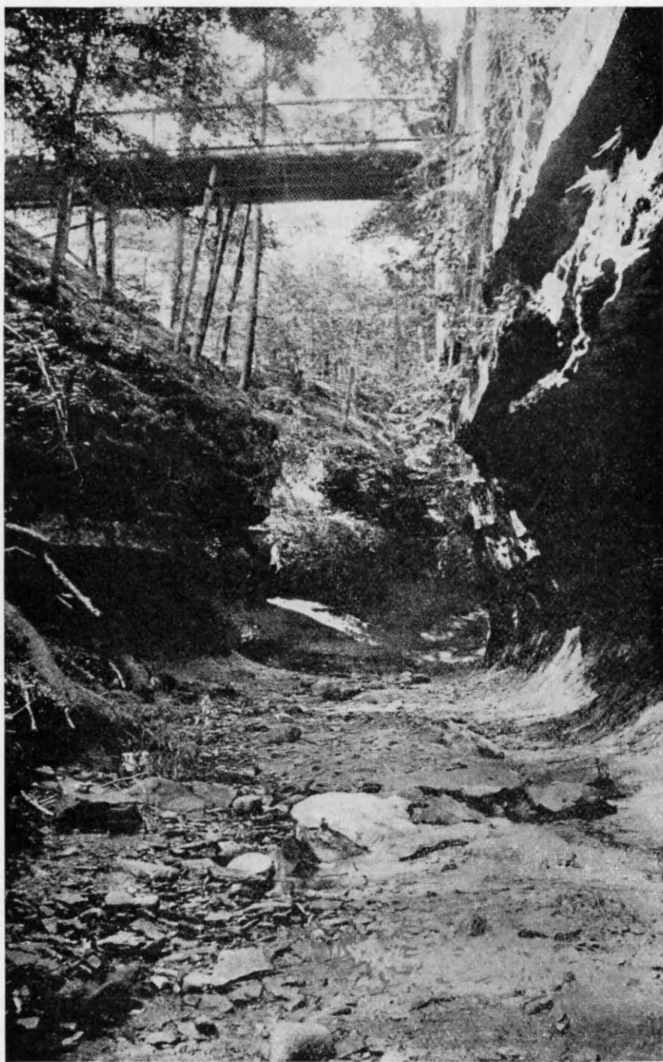
Remains of the ancient and long extinct animals have been unearthed while ditching and dredging the lowlands. Bones of the mastodon have been found in several localities. These leviathans of the animal kingdom while foraging on the grass near the swamps of that time mired their huge forms in the soft earth where their bones have lain for untold centuries. Remains of the smaller animals of recent time are also found in the lowlands

which are being drained, cleared and farmed. Teeth of the buffalo and beaver, antlers of the elk and deer are in evidence.

In conclusion I will say that I have based the part of this article relating to fossils and archaeology upon material in my own collection. There are several collectors in the county and everything that is found is invariably placed in some collection.

JOHN H. SHILTS.

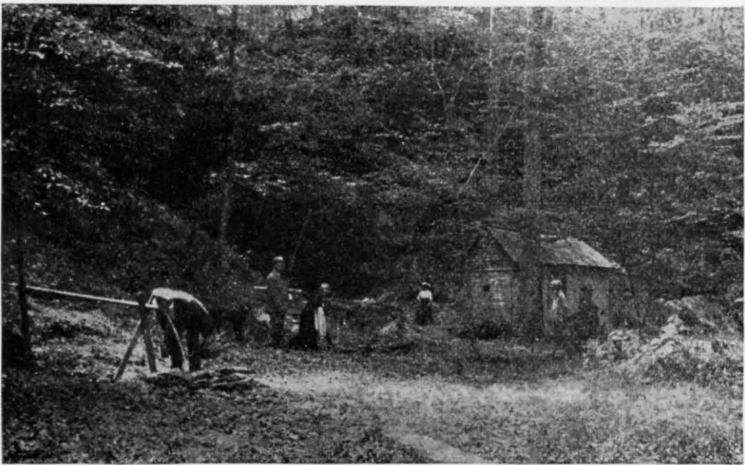
Columbia City, Indiana.



Head of Canyon at "Shades," showing rustic bridge and "Devil's Punch Bowl."

The Beautiful Shades.

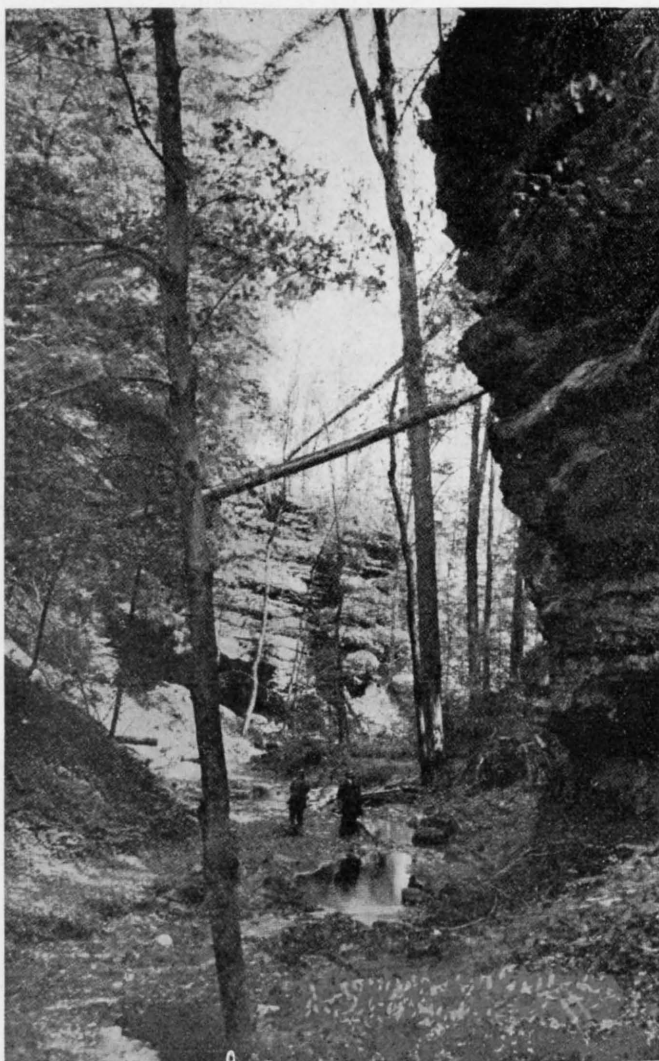
There is no more rugged or picturesque scenery in Indiana than that which occurs in the Mansfield sandstone area. This formation extends from Benton county on the north in a direction a little east of south to the Ohio river, comprising parts of Benton, Warren, Fountain, Montgomery, Park, Putnam, Clay, Owen, Greene, Martin, Lawrence, Orange, Dubois, Crawford and Perry counties. In these counties the streams have cut their channels down through this sandstone, forming perpendicular walls near



"The Springs" at "Shades."

the stream channels, varying in height from forty or fifty to two hundred and more feet. These sandstone walls often have a castellated appearance, and at times the streams have undercut the cliffs so that the crest of the cliff overhangs the stream, or valley below, often as much as fifteen to twenty feet, overhanging vines in festoons grouped from the brow of the cliffs. In places the wall of the cliff is in a series of steps. On these steps a little soil has found lodgment, from which wild flowers and vines grow and droop over the parts of the cliff below. As a rule, vegetation is dense and primeval, consisting of huge trees, thickets of underbrush and matted and tangled vines.

Perhaps the most beautiful and picturesque region carved in the Mansfield sandstone is the region known as the Shades, in the southwestern part of Montgomery county, on Sugar Creek



Massive sand stone cliff at "Shades."

and some of its small tributaries, about sixty miles northwest of Indianapolis. Here the Mansfield sandstone stands out in bold headlands and cliffs, in several places having the exposed face

of one hundred and fifty to two hundred and ten feet in perpendicular height.

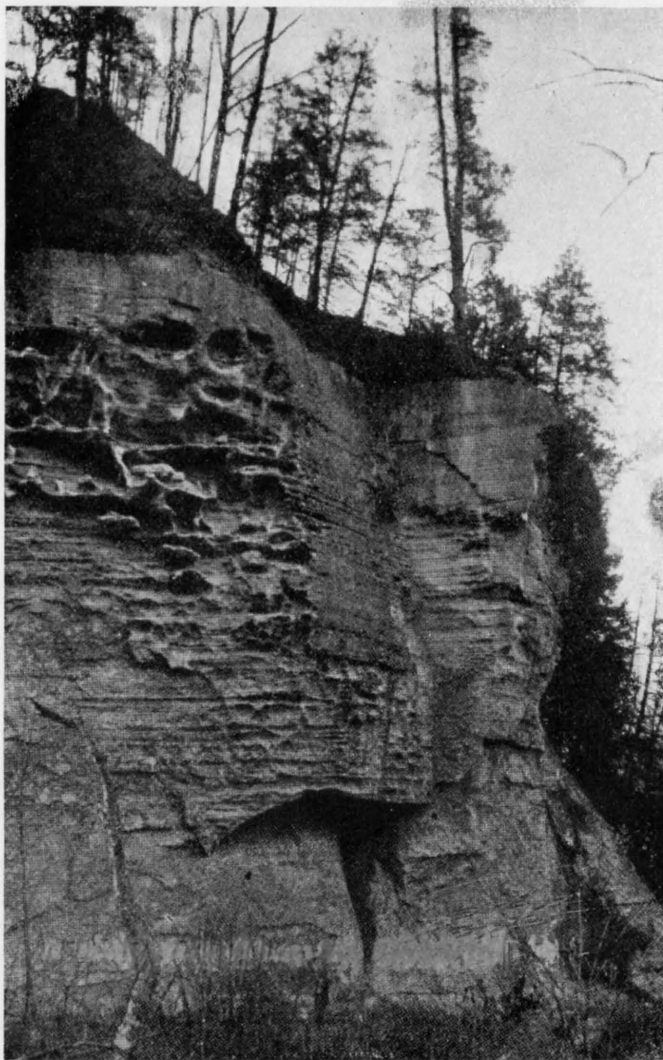
The starting point for a tour of the Shades is the hotel on a



"Bridal Veil Falls" at foot of canyon near Sugar Creek at "Shades."

round wooded eminence within easy walking distance of the main features of the region. Starting from the hotel, a path leads to the old rustic wooden bridge, one hundred feet in length, crossing

the feature known as the Canyon, just at its head. Gazing down from the bridge one is looking into the feature known as the Devil's Punch Bowl, one hundred feet below, a huge bowl-shaped



Weathered sand stone cliff, showing "Box" erosion, at "Shades."

cavity that has been formed in the Mansfield sandstone by weathering and stream erosion. A rough, steep path hard by the bridge leads down to the Bowl. Once in the Canyon the tour is toward Sugar Creek.

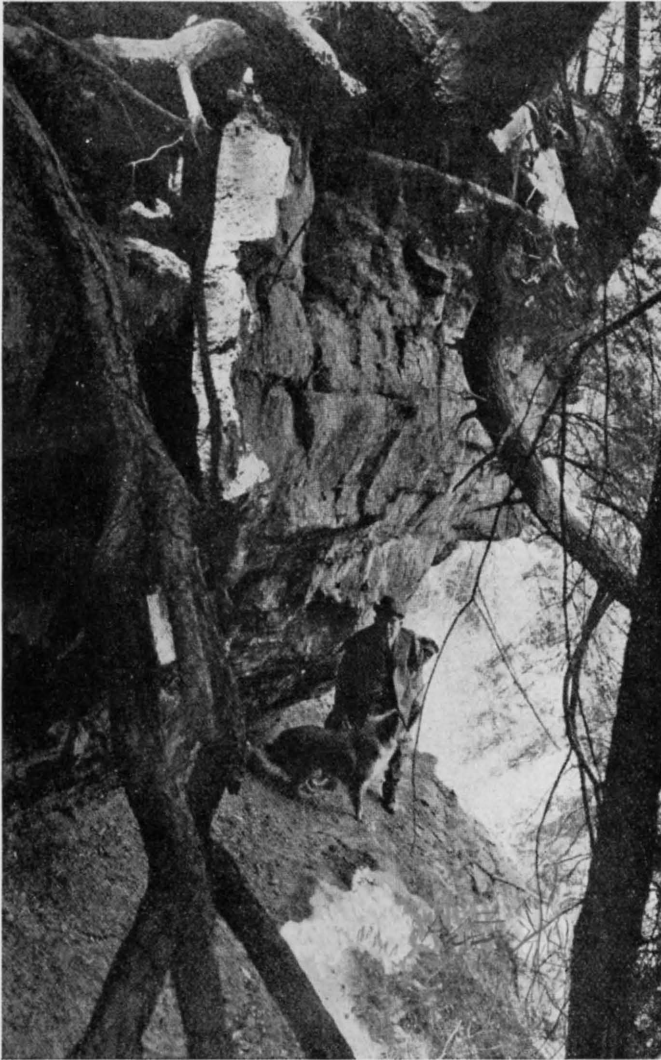
Going down the Canyon from the Punch Bowl a few hundred yards, the Mineral Springs are reached. One of these springs gives up fifteen gallons of pure, sparkling water per minute, an-



Massive wall of sand stone near Sugar Creek at "Shades."

other fifty gallons and a third ninety gallons. The scenery about the Springs is extremely beautiful, and rugged walls reaching up more than a hundred feet, and the dense shadows of the walls

and overhanging vegetation shrouds the place in a twilight even at midday.



Narrow path known as "Fat Man's Misery." Sand stone cliff extending 70 feet above and 140 feet below. Total height of cliff from Sugar Creek, 210 feet. At "Shades."

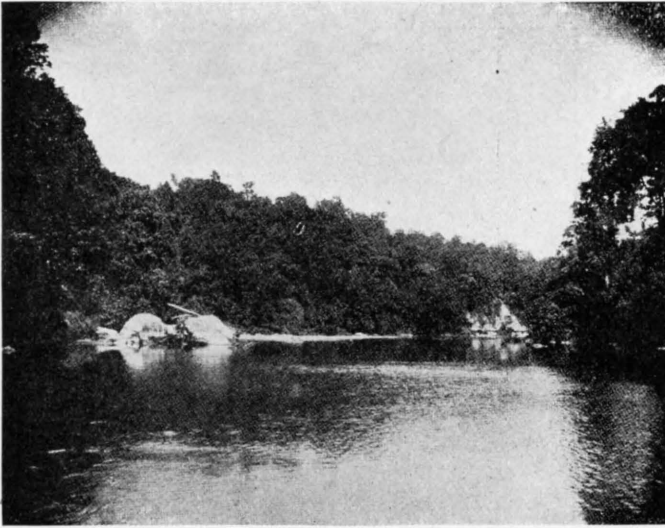
Continuing down the Canyon from the Springs, the perpendicular walls go higher and higher, until, at the point known as the Falls, they reach upward nearly two hundred feet.



View of Sugar Creek near mouth of canyon at "Shades."

At the foot of the Canyon, where it drops over into Sugar creek there is a beautiful cataract known as Bridal Veil Falls, which has a sheer drop of more than sixty feet. At this point we have a fine example of a hanging valley. The stream in the Canyon has not yet cut its channel down to a level with the larger stream (Sugar creek) and presents a fine example of the geologic feature mentioned above.

Turning to the left of the mouth of the Canyon, the first feature noticeable is the Devil's Fireplace, a little room that has been eroded out from the side of the wall, and presenting the appear-



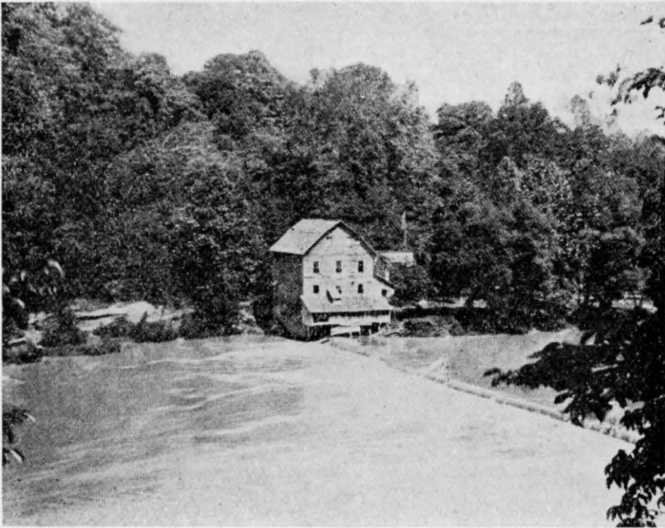
"Tumbling Rock". At "Shades."

ance of an old-fashioned fireplace. The Fireplace is large enough for two or three persons to get into at one time.

Following the narrow path to the left around the cliff, one finds himself looking down to Sugar creek, one hundred and forty feet below, and looking up to the brow of the cliff, seventy feet above, a total distance of two hundred and ten feet. A portion of the path is so narrow and precipitous that a person of large size can scarcely pass. This point is known as Fat Man's Misery.

From the top of the cliff above Fat Man's Misery a beautiful view of the valley of Sugar creek up stream may be had. The visitor to the Shades should not fail to go up Sugar creek about a mile and a half to the feature known as the Devil's Backbone,

which is simply a natural bridge. The scenery in the valley of Sugar creek alone would pay well for the trip, but a view of the natural bridge makes a fitting and wonderful climax to the journey. The Backbone was formed in a similar manner to the other features of the Shades region. It is simply a case of stream cutting or stream erosion. There is a stream on either side of the Backbone. Each of these streams has been cutting away the sandstone between them for ages, until finally all that is left at this point is a long, narrow backbone or natural bridge. The length of this bridge is about three hundred and fifty feet from extreme points. The width of the bridge in the narrowest place is six feet,



Pleasant view up Sugar Creek. Old moss-covered mill. At "Shades."

and the perpendicular distance down to the level of the streams from the top of the bridge is about one hundred feet. This Devil's Backbone, or natural bridge, is alone worth a trip to the Shades.

The Shades region abounds in other canyons besides the one mentioned at the first of this article. A day's visit to the Shades serves only to give a meager insight to its exquisite beauties, and one leaves the region with a feeling of regret and with a mental reservation that he will return again at the first opportunity.

The premises around the hotel are cool, shady and restful, and the proprietor, Mr. J. W. Frisz, is a genial, whole-souled gentleman, always ready to inform his visitors as to the features

and routes about the Shades, and to make people glad that they have made a visit to the region. Last, but not least, chicken dinners are a feature at the hotel conducted by Mr. Frisz, which



Top of "Devil's Back Bone" or natural bridge. 350 feet long, 100 feet above ravine.
At "Shades."

is the only hotel at the Shades. There is no extortion, or desire to extort, from visitors, and the price for meals and luncheons are very reasonable.

The Canyon of McCormick's Creek.

The government agents and engineers, in the selection of areas, which the Federal Government has set aside as national parks or natural recreation grounds, have kept in mind one underlying principle and that principle is that each area selected shall have distinctive features of its own. In other words, that it shall have an individuality or a personality of its own.

People who make pilgrimages to regions of beautiful, natural scenery are attracted always by the rugged and the picturesque. There is not an area in Indiana, with the possible exception of Turkey Run, that is more marked in its distinctive features than the canyon of McCormick's creek, two and one-half miles east of Spencer, Owen county, Indiana. Geologists, who have made a study of the region, have conceived a unique theory as to the formation of the canyon.

A few miles to the west of Spencer is a region known as the Flat Woods, lying partly in Owen and partly in Monroe counties. The underlying rock formation of the Flat Woods is the Mitchell limestone, which is known to be the cavernous limestone of Indiana. The entire area of Mitchell limestone, reaching from Montgomery county on the north to the Ohio river on the south, is a region of sink holes and subterranean drainage. The Flat Woods is supposed to be the bed of an ancient glacial lake. When the ice sheet moved down over the Flat Woods, the glacial debris choked up the sink holes leading to the subterranean caverns and the result was the formation of a lake in the area known as the Flat Woods. The Flat Woods itself is well worth a trip to Owen county. There is a distinct shore line or ridge entirely encircling the area, and a road follows the top of this ridge almost entirely around Flat Woods. In driving over this road one is looking continuously down into the basin-shaped area that was once a large glacial lake, though later the area was covered with forests and is now an area of cultivated farms. After the ice sheet retreated, drainage, what is now McCormick creek, began.

McCormick's creek started at White river northwest of the Flat Woods and gradually cut its way back toward the ancient lake until it tapped it on the northwest corner. The volume of



View on White River approaching canyon of "McCormick's Creek," near Spencer, Indiana.



Head of "McCormicks' Creek" canyon, known as "Hell's Half Acre."



The cascade near head of canyon of "McCormick's Creek."



Massive wall of Mitchell lime stone. 75 feet high. Canyon "McCormick's Creek."

water from the lake, which was increased by the drainage on either side of McCormick's creek, cut and eroded the channel down almost to its present depth before the lake was fully drained. The



"The Mirror." Wall of Mitchell lime stone 100 feet high. "McCormick's Creek" canyon.

canyon has cut through the Mitchell limestone, one of the hardest formations in Indiana, indicating that the volume of water must have been considerable to have done the work of carving out this canyon. The canyon itself is beautiful in the



Wall of massive lime stone, showing undercutting of stream. Canyon "McCormick's Creek."



Massive lime stone wall near old quarry. "McCormick's Creek," canyon.



Old quarry of Bedford lime stone from which was taken stone for the construction of present State Capitol Building at Indianapolis.
"McCormick's Creek" Canyon.

extreme. The gray walls of Mitchell limestone, rugged and angular, reach up from forty to one hundred feet in height, for a distance of a mile and a half. Mosses and lichens cover the walls of the canyon in places, and over-hanging vines, that droop in festoons from the brow of the cliffs, give portions of the canyon the appearance of vine-clad castles and turrets. Two beautiful cataracts occur in the canyon and they add to the picturesqueness and the ruggedness of the region.

As the visitor enters the head of the canyon, well up toward Flat Woods, there is but little to indicate the beauty of the canyon proper, but as one descends deeper and deeper, the canyon increases in depth and the walls in height, and the visitor scarcely realizes the change until he finds himself enclosed in the gray and white castellated walls. Geological agencies seem to have played hide-and-seek in this beautiful region. In places the sides have the appearance of a solid wall of masonry. In other places the stream has undercut the bluff for several feet and to a length of hundreds of feet. In the bottom of the canyon there are shady nooks, grass plots and giant trees. The tops of the cliffs above are fringed with native trees and vines that almost shroud the canyon in perpetual shade. Cool springs bubble up here and there, furnishing clear, sparkling water for the thirsty. The entire canyon is a riot of wild, rugged walls, cliffs, slopes, forests and over-hanging vines, making the region indescribably beautiful.

Structural Geology.

Nearly every oil field in the world occurs in close relationship to some earth curve or fold. Underground structure is one of the most important features of oil-field geology. So much depends on favorable structure that a careful study of the various types of oil-field structure is necessary. Below is a classification that is sufficient for all practical purposes:

- | | | | | |
|----|------------------------------------|---|----------|--------------|
| 1. | Anticlines..... | { | Single | Symmetrical |
| | | { | Compound | Asymmetrical |
| | | | | Overturned |
| | | | | Symmetrical |
| 2. | Synclines..... | { | Single | Asymmetrical |
| | | { | Compound | Overturned |
| 3. | Monoclines..... | | Terraces | |
| 4. | Combinations of 1, 2 and 3 | | | |
| 5. | Domes. | | | |
| | (a) Anticlinal | | | |
| | (b) Saline | | | |
| | (c) Volcanic | | | |
| 6. | Faulted forms of any of the above. | | | |

Every fold is part of an earth curve and must be considered as continually changing in dip or slope. The cause of folding is problematic. It is thought to be the result of the contraction of the earth's surface due to internal cooling. In places the crust of the earth is forced by folding into arches, and sags or basins. The results of such folding are structures called anticlines, synclines, domes and monoclines. Breaks or faults may affect all the above forms and make still more complicated structures.

Where masses of igneous rocks force the strata upwards, folds very similar to domes are formed. Volcanic necks or plugs may thus lift the formations around them, forming arched structures that are important factors in the accumulation of petroleum. Another form of arching such as the Saline domes of Texas and Louisiana is thought to be due to recrystallization of salt masses. The folds generally decrease with depth. Folding is near-surface phenomenon, as is often noticed the folds become more contracted toward the center and flatten with depth.

1. *Anticlines*.—The distinction between anticlines and domes is at present loosely drawn. In this book anticlines will be differentiated from domes as follows:

An anticline is a long, relatively narrow fold with the dips or slopes of its sides inclining away from a line of folding called an axis. Such a fold will eventually disappear due to gradual flattening or to faulting, merging with other folds, etc. When the fold flattens out, the ends of the fold plunge or dip along the line of the axis resulting in what is designated a plunging anticline. An anticline takes its type name from its cross-section. Folding is not only along a plane vertical or inclined to the horizon, but is also sinuous on the surface. Where folds curve sharply the beds on the inside of the curve are compressed; those on the outside are under tension. This results in localizing the oil at those portions of the fold which are opposite the point of greatest compression.

The simple anticline has but one high place or apex. If two or more high places form on the long fold such high places are designated anticlinal domes. The low places on the anticlines between such domes are called "saddles." Other names for anticlinal domes and saddles are "structural highs" and "structural lows" respectively. A fuller discussion of anticlinal domes is given later in this work. Two other types of domes are also found which will be discussed later.

Anticlines are of many forms or types: Symmetrical anticlines are those anticlines in which the inclinations or dips on both sides of the axis are equal.

Symmetrical or inclined anticlines occur when one of the limbs or flanks has a greater dip than the other. Symmetrical anticlines are the most common type of fold. Folds are overturned when the axes of the folds fall over.

Isoclines belong to a peculiar type of symmetrical anticlines. Such folds are not very common but occasionally occur.

Compound anticlines consist of a system of parallel anticlines which often cover a large area. The California and Pennsylvania oil fields clearly illustrate this condition.

2. *Synclines*. A syncline is a structure the reverse of an anticline, and receives its name because its beds incline toward a common central line.

Synclines are as varied as anticlines, and for every anticline one will nearly always find a similar syncline.

When the basins are filled with water, oil may be found on the flanks of synclines. When little or no water occurs in the basin, oil may be found close to the bottom of the depression.

3. *Monoclines.* A monocline is a structure with one slope or inclination. Its name comes from mono, one, and clino, sloping.

Monoclines are simple structures. They are often limbs of flanks of giant anticlinal folds or of giant domes, where but one side of the fold is apparent and that dipping in one direction. The northeastern Oklahoma oil-fields are located on minor folds that occur on a great northwestward dipping monocline.

Terrace structure is practically monoclinal as the major dip is in one direction. The famous Glen Pool of Oklahoma is on such a structure. Terrace structure is a combination of an anticline and a syncline for with such structures the fold has not been completed to the point where a well-defined reversal of dip has developed. Many times the oil accumulates in sand lenses. The peculiar relations here cause what are termed "oil pools."

4. *Combinations of Monoclines, Synclines and Anticlines.* The combination of a monocline, a syncline, and an anticline into one structure is a very common occurrence. Such fields are well illustrated by the Coalinga and the Simi valley oil fields of California, where one finds barren igneous, or metamorphic measures on one side, and a series of folds in the sedimentaries trending away from the igneous or metamorphic rocks. There is a monocline immediately on the flank of the igneous or metamorphic rocks. The next fold is a syncline and then comes the anticline, or a series of them.

5. *Domes.* A dome or quaquaversal is a structure in which the strata dips from a central point rather than from an axis or line. Domes are circular or elliptical and are divided into three main classes: (a) Anticlinal domes. (b) volcanic domes, and, (c) saline domes.

ANTICLINAL DOMES. Anticlinal domes are those high points or crests along the top of undulating anticlines. Such forms of domes are very common in California, Oklahoma, Wyoming, Pennsylvania and throughout the oil fields of India. In many places one main anticlinal fold may continue for 10 to 60 miles and undulate along its course, forming many anticlinal domes or quaquaversals that localize the accumulation of oil. In some cases anticlines intersect, and in other cases antelnes

merge into one another. The resulting structure in each case is generally an anticlinal dome.

Where such a quaquaversal structure stands alone it is simply called a dome. A knowledge of these domes is essential to intelligent prospecting as they make oil territory "spotted." Realization of this condition will save a great deal of money to oil operators who appreciate the value of structural geology.

IMPORTANCE IN RELATION TO PETROLEUM. The dome structure is the most favorable for the accumulation of petroleum, as the oil rises from a large area to the apex of the dome. The concentration of the oil must necessarily be localized as the tendency of the petroleum, where the oil strata are saturated with water, is to rise to the top of the dome, just as in an anticline the oil rise to an axis. As a result of doming, however, the oil is concentrated into a large reservoir around a central point on the axis instead of being concentrated along the line of the anticlinal axis.

IN GENERAL.

Of 267 wells drilled, only 29 were in the old Trenton Rock section of the field, and 238 were in the western section of the State. For several years back very little work was done in the old Trenton Rock fields, but the supposition is that the 1917 season will see much more accomplished than for a good many years. Late developments in parts of the field show some gas and the scarcity of gas has been all that kept work backward as there are many sections of the field that has only been scratched by the drill, and it is this territory that is bound to be drilled with prevailing prices of oil at the wells.

Up to the close of 1916 there have been 36,259 wells completed in the Indiana field, of which 7,723 were either dry holes or gas wells, 18,403 wells have been pulled out and abandoned.

The wells completed in the Indiana field for 1916, by months, were as follows:

MONTH	Comp.	Prod.	Dry.	Gas.	Abd.
January.....	16	296	6	1	13
February.....	17	182	7	1	28
March.....	26	292	11	2	24
April.....	22	148	13	0	5
May.....	37	488	14	1	7
June.....	32	524	10	0	106
July.....	26	282	10	0	27
August.....	21	217	7	0	15
September.....	21	536	5	1	54
October.....	18	271	2	0	159
November.....	18	205	8	1	80
December.....	13	113	5	1	0
Total.....	267	3,554	98	8	518
For 1915.....	192	2,521	87	8	721
Difference.....	75	1,033	11	0	203

The above wells were distributed by counties as follows:

COUNTY.	Comp.	Prod.	Dry.	Gas.	Abd.
Wells.....	2	18	0	0	64
Blackford.....	6	35	3	0	26
Jay.....	4	145	2	0	49
Adams.....	0	0	0	0	131
Grant.....	3	23	0	0	77
Huntington.....	0	0	0	0	72
Delaware.....	1	5	0	0	80
Randolph.....	3	150	2	0	6
Gibson.....	19	155	5	0	6
Pike.....	70	872	28	3	7
Sullivan.....	132	1,862	49	4	0
Vigo.....	11	168	3	0	0
Miami.....	10	87	4	0	0
Daviess.....	2	30	0	0	0
Decatur.....	1	0	0	1	0

PIKE COUNTY.

In the western part of Indiana, in Monroe township, Pike county, Michael Murphy's test on the Mary McGregor farm, section 27, and 1,320 feet from the south line and 250 from the east line of the farm, pumped two barrels at 1,171 feet. The Emery Petroleum Co.'s test on the northeast corner of the E. T. Fowler farm, section 30, pumped 20 barrels at 1,321 feet. This well is in Madison township. In the same township, McNamara & Donnelly's test on the southwest corner of the M. L. Reded heirs farm, section 20, was dry at a depth of 1,253 feet. At that depth

the hole filled up with Blue Lick water. When this water makes its appearance a well might as well be given up, for no one has been able to cope with it, as has been done with salt water.

In Madison township, Pike county, the Emery Petroleum Co.'s well on the Sarah I. Thomas farm, section 30, and 700 feet from the south line and 190 from the east line of the farm, is among the best of the wells completed in that part of the field, having pumped 50 barrels from a depth of 1,280 feet.

Petersburg gets a good well in a new part of the territory which may open up a new pool. This well is the Bement Oil & Gas Co.'s No. 1 on the L. C. Thomas farm, the southwest quarter of the southwest quarter of section 32, Washington township, about four miles southeast of Petersburg. The well is estimated at 50 to 100 bbls. Whenever the fluid is agitated the well flows over the top of the mast. It stands nearly full of oil and certainly looks good for 50 bbls. The depth is 1,170 feet.

The well is 1,200 feet north of the one drilled some time ago by W. J. Rodgers, of Evansville, and which showed considerable oil. It is west of the well drilled by Rodgers on the Chew farm, which also had some oil and considerable gas. There is some hustling for leases, but there is very little loose, the owners of the well having secured most of it before starting the test.

The Ohio Oil Co. is starting a test in section 15, Ohio township, Warrick county, Indiana, where the geologists have mapped out an anticline.

In Washington township, Pike county, the well of Bement and others on the L. C. Thomas farm, section 32, is making a nice showing and looks like the best well yet drilled in the Petersburg end of the field.

Madison—A. L. Fowler, Michael Murphy, 1.....	5
E. T. Towler, Emery Pet., 2.....	dry
Washington—W. M. Chew, Emery Pet., 1.....	dry
L. C. Thomas, Bement & Co., 1.....	47
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Wells completed.....	4
Production.....	52
Dry.....	2

The Oakland City field was hard hit of late, for out of six wells drilled, four were dry and the other two were mere strippers. In Madison township, Pike county, The Emery Petroleum Co.'s No. 4 on the H. A. Sutton farm, section 29, was dry at 1,362 feet. No. 5 same farm, is drilling. Michael Murphy's second well

on the Eliza D. Tame farm, section 30, pumped five bbls. at 1,303 feet. William Soles is drilling a test on his own farm, section 30. In Patoka township, the Ohio Oil Co.'s No. 16 Alf. Hurt farm, section 14, pumped five bbls. and No. 10 Harlan L. Kays farm section 14, is drilling.

Madison—H. A. Sutton, Emery Pet., 4.....	dry
Eliza D. Tame, Michael Murphy, 2.....	5
Washington—Thomas, Bement & Co., 2.....	dry
L. C. Thomas, Bement & Co., 4.....	dry
J. R. Chew, Ohio Oil, 2.....	dry
Patoka-Alf. Hurt, Ohio Oil, 16.....	5
<hr/>	
Wells completed.....	6
Production.....	10
Dry.....	4
Madison—H. A. Sutton, Emery Pet., 5.....	dry
Wm. Soles, Wm. Soles, 1.....	dry
Washington—Holland, Bement & Co., 1.....	dry
Patoka—Harlin L. Kays, Ohio Oil, 10.....	dry
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Wells drilling.....	4

In Madison township, Pike county, the Emery Petroleum Co.'s test on the Laura C. Stewart farm, section 30, pumped 23 bbls. at 1,287 feet deep. The well is in the northeast corner of the farm.

Madison—H. A. Sutton, Emery, Pet., 5.....	dry
L. C. Stewart, Emery Pet., 1.....	15
L. B. Soles, Lillie B. Soles, 1.....	16
Washington—Holland, Bement & Co., 1.....	dry
L. C. Thomas, Ohio Oil, 2.....	dry
Patoka—Harlan L. Kays, Ohio Oil, 10.....	dry
Patoka—Harlan L. Kays, Ohio Oil, 10.....	5
<hr/>	
Wells completed.....	6
Production.....	36
Dry.....	3

One well was reported for the week from the Indiana field and that was so small that it is hardly worth mentioning. It is the Ohio Oil Co.'s No. 11 on the Harland L. Kays farm, section 14, Patoka township, Pike county and pumped but one bbl. The hole was drilled to 1,285 feet deep and filled back to 1,236 feet where the oil was found.

A large deal is reported from the Petersburg district, in Pike county, but has not been confirmed. The deal is the sale of the

Emery Petroleum Co.'s property, with leases on about 3,000 acres and at least 10 wells, to the Ohio Oil Co., for a consideration reported as \$126,000. The field is practically a new one and the Ohio Oil Co., will start a number of new wells upon the property as fast as drilling tools and material can be assembled. The sale took place shortly after the Emery Co., drilled in its 25 bbl. well on the J. E. Brady farm, section 30, Madison township, Pike county, and near Petersburg. In the same township, the Forest Oil Co., is drilling a test on the E. J. Whitebook farm, section 29, and Henne and others a test on the H. H. Smith farm, section 24. Michael Murphy is drilling No. 3 on the Eliza D. Tame farm, section 30. In Washington township, same county, A. B. Bement is drilling a test on the M. M. Byers farm, section 28, and in Monroe township, closer to Oakland City, J. C. Heydrick and others are drilling close to the sand with a second well on the I. Spellman and others farm, section 35.

In Washington township, Pike county, A. B. Bement's No. 10 on the L. C. Thomas farm, section 32, pumped 20 bbls. from the Brown sand. The top of the sand was struck at 1,123 feet and drilled to a total depth of 1,138 feet. (October).

In Madison township, Pike county, the Ohio Oil Co.'s No. 3 on the southeast corner of the J. C. Brady farm, section 30, pumped 37 bbls. from the Brown sand, which was found at 1,287 feet and drilled four feet in and given a shot of 50 quarts. In Monroe township J. C. Heydrick and others test on the northeast corner of the Hulda Curter farm, section 35, was drilled to a depth of 1,223 feet in the Oakland City sand and produced less than a bbl. a day.

The well of Michael Murphy on the northeast corner of the Dave W. Gladish farm, in section 30, Madison township, Pike county, Indiana, that was reported as doing about a barrel a week ago, has been abandoned as too small to pump. In Washington township, same county, A. B. Bement drilled in his No. 11 on the L. C. Thomas farm, section 32, and located 800 feet from the north line and 400 from the east line of the farm, and it is a dry hole at a depth of 1,162 feet.

PETERSBURG OIL FIELD.

Several years ago a strong gas well, known locally as the "Jumbo" well, was drilled west of Petersburg, and during the last two years The Emory Oil Company, acting on the theory that gas comes from oil, started operations in sections 29 and 30 in

Township 1 North, Range 8 West in Pike county. Since that time sixteen wells have been drilled in the above sections that started to producing oil at the rate of from sixty to one hundred barrels per day and pump down to a settled production of about twenty barrels.

The oil is produced from the lower members of the Huron group of sandstones and shales at a depth of about 1,300 feet.

At the same time the above operations have been going on some other operators have been developing another small field east of Petersburg in Section 5, Township 1 South, Range 7 West, and Section 32, Township 1 North, Range 7 West, and up to the present time twenty producing wells have been drilled. The wells compare in production and depth to the wells west of town and are finished in the same formation, but the two fields belong to two separate domes or anticlines.

SULLIVAN COUNTY.

In Sullivan county, Indiana, and in Turman township, A. T. Osborn drilled a test on his farm, section 12, and located 200 feet from the south line and 570 from the east line of the farm, and secured a 25 bbl. pumper. The Ohio Oil Co.'s No. 2, Elwood Brown farm, section 28, and 600 feet from the north line and 200 from the east line of the farm, pumped five bbls. Same company's No. 8 on the southwest corner of the C. H. Walters farm, section 3, produced 75 bbls., and No. 4 on the southwest corner of the Francis Connor farm, section 4, pumped 78 bbls.

In Hamilton township, Sullivan county, E. R. Riggs drilled a test on the F. C. Springer farm, section 7, and 1,320 feet from the north line and 150 from the west line of the farm and secured a gas well that produced 1,500,000 cubic feet.

In Fairbanks township, in this county, the Ohio Oil Co.'s second well on the Alva DeBaum farm, section 35, and 200 feet from the north line and 660 from the east line of the farm, pumped 27 bbls. In Gill township Paul Kuhn's No. 3 on the A. Brokaw farm, section 1, and 300 feet from the north line and 600 from the east line of the farm, was a dry hole, while in Turman township, the Ohio Oil Co.'s No. 10 on the J. and C. Dodd farm, section 9, and 200 feet from the north line and 660 from the east line of the farm, pumped but one barrel.

In the Sullivan county field of Indiana, in Hamilton township, E. R. Riggs drilled a 1,000,000 cubic foot gas well in No. 3 on the F. C. Springer farm, section 7, 200 feet from the north line and

1,120 from the west line of the farm. In Curry township Hammil and others drilled a dry hole in a test in the southeast corner of the H. J. Douglas farm, section 30.

In Turman township, same county, Alexander McKnight and others' test on the W. W. Ladd estate, section 16, 660 feet from the north line and 100 from the west line of the farm, was a dry hole. The Ohio Oil Co.'s No. 3 on the J. F. Houpt No. 1 farm, section 28, 660 feet from the north line and 200 from the west line of the farm, pumped 35 bbls. No. 11 of the same company on the H. E. Bland farm, section 3, 240 feet from the north line and 640 from the east line of the farm, pumped but one barrel, and No. 11 on the M. B. Bland farm, section 36, 960 feet from the north line and 200 from the west line of the farm, pumped 8 bbls., while No. 11 on the W. E. Hardy farm, section 4, 660 feet from the south line and 200 from the west line of the farm, pumped 70 bbls.

Fairbanks—Alva DeBaum, Ohio Oil 3.....	dry
P. A. Poorman, Ohio Oil 1.....	dry
A V. Carrithers, Ohio Oil 1.....	dry
Gill—Oscar Hunt, Ohio Oil 2.....	dry
Turman—J. & C. Todd, Ohio Oil 12.....	dry
W. E. Hardy, Ohio Oil 12.....	60
C. H. Walters, Ohio Oil 9.....	1
Mary G. Gushman, Ohio Oil 2.....	7
J. & C. Dodd, Ohio Oil 13.....	dry
E. H. Ransford, Ohio Oil 1.....	dry
Clyde Alkire, Steele & Co. 3.....	30
A. Poe, Hien & Co. 1.....	25
W. W. Harris, Brawley & Co. 2.....	dry
Wells completed.....	13
Production.....	123
Dry.....	8
Fairbanks—J. V. Merrill, Ohio Oil 11.....	drg
C. E. Harrison, Ohio Oil 2.....	drg
Alva DeBaum, Ohio Oil 4.....	drg
Gill—P. Huck, McKnight & Co. 1.....	drg
A Morris, McKnight & Co. 1.....	drg
Curry—E. Martz, J. Mohlenhour & Co. 3.....	drg
Turman—Josephine Dix, Ohio Oil 16.....	drg
Mary A. Coffman, Ohio Oil 13.....	drg
J. W. Wier, Ohio Oil 1.....	drg
Francis Connor, Ohio Oil 5.....	drg
Joel C. Barnes, Ohio Oil 4.....	drg
Jane McGrew, Ohio Oil 5.....	drg
C. Brown, Ohio Oil 8.....	drg
M. H. Dix, Terre Haute Oil 1.....	drg
Wells drilling.....	14

A few completions are being made in the fields of the western part of Indiana, especially in Sullivan county, where the drill has been more or less active in the shallow sand for the past couple of years. The latest completions of prominence in that county was located in Fairbanks township, and was the Ohio Oil Co.'s No. 5 on the Alva DeBaum farm, section 35, and 660 feet from the north line and 200 from the east line of the farm. The well produced 120 bbls.

In Gill township, same county, McKnight and others test on the A. Morris farm, section 22, and 200 feet from the north line and 1,120 from the east line of the farm, was a dry hole. In Hamilton township, E. R. Riggs drilled a 1,000,000 cubic foot gas well in a test on the S. Springer farm, section 6, and 500 feet from the south line and 200 from the east line of the farm.

SULLIVAN COUNTY.

In Turman township, same county, the Ohio Oil Co.'s No. 16 on the Josephine Dix farm, section 1, and 1,120 feet from the south line and 660 from the east line of the farm, pumped five bbls. No. 13 on the Mary A. Coffman farm, section 36, and 200 feet from the north line and 660 from the east line of the farm, pumped five bbls. No. 1 on the southeast corner of the J. M. Weir farm, section 28, is a dry hole. No. 5 on the Francis Conover farm, section 4, and 200 feet from the south line and 900 from the west line of the farm, pumped 15 bbls.; No. 4 on the northeast corner of the Joel C. Barnes farm, section 4, pumped five bbls. No. 8 on the C. Brown farm, section 4, and 200 feet from the north line and 660 from the west line of the farm, pumped 60 bbls., while No. 7 on the northwest corner of the same farm, pumped 30 bbls. The Clyde Alkire Oil Co.'s No. 4 on the Clyde Alkire farm, section 12 and 550 feet from the north line and 200 from the west line of the farm, pumped but two bbls.

In Sullivan county, in Fairbanks township, the Ohio Oil Co.'s No. 1 on the Northeast corner of the C. E. Harrison farm, section 17, was a dry at 1,080 feet deep.

Fairbanks—Alva DeBaum, Ohio Oil 4	100
Alva DeBaum, Ohio Oil 5	100
J. V. Merrill, Ohio Oil 11	25
C. E. Harrison, Ohio Oil 1	dry
Gill—A. Morris, McKnight & Co. 1	dry
Hamilton—Springer, E. R. Riggs 1	gas
Buckholder, Riggs & Co. 1	dry
Graham hrs. Dome Gas L	dry

Curry—Martz, J. Mohlenhour & Co. 3.....	dry
Turman—Josephine Dix, Ohio Oil 16.....	5
Mary A. Coffman, Ohio Oil 13.....	5
J. W. Weir, Ohio Oil 1.....	dry
Francis Connor, Ohio Oil 5.....	15
Joel C. Barnes, Ohio Oil 4.....	5
Jane McGrew, Ohio Oil 5.....	2
C. Brown, Ohio Oil 8.....	60
C. Brown, Ohio Oil 7.....	30
W. A. Burton, Ohio Oil 1.....	dry
W. E. Hardy, Ohio Oil 13.....	1
E. T. Osborn, Ohio Oil 7.....	15
C. Brown, Ohio Oil 9.....	15
Francis Connor, Ohio Oil 6.....	7
Francis Connor, Ohio Oil 7.....	25
Alex. Raley, Ohio Oil 17.....	dry
J. G. Wilson, Sullivan 1.....	dry
Clyde Alkire, C. Alkire O. & G. 4.....	2
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Wells completed.....	26
Production.....	412
Dry.....	9
Gas.....	1

Only two completions are reported from the Sullivan county field, October. In Turman township, the Ohio Oil Co.'s No. 4 Woodward farm, section 4, pumped five bbls. and in Fairbanks township, the same company's No. 9 on the southwest corner of the S. A. Merrell farm, section 36 was the same size.

In Fairbanks township, Sullivan county, the Ohio Oil Co.'s No. 10 S. A. Merrill farm, section 36, pumped 40 bbls. and the Bays Oil Co.'s No. 19 M. J. Beard farm, section 36, pumped six bbls. In Gill township, McKnight and others' test on the P. Houk farm, section 27, was a dry hole. In Turman township, the Ohio Oil Co.'s No. 14 C. H. Walters farm, section 4, pumped five bbls.

GIBSON COUNTY.

The only well reported from Indiana during the week was the Farmer's Oil Co.'s No. 35 on the C. T. Emerson farm, section 10, Patoka township, Gibson county, and located 1,840 feet from the south line and 400 from the west line of the farm. A heavy dose of salt was struck at 836 feet and the hole was abandoned as worthless.

In the Princeton field in Patoka township, Gibson county, the Farmer's Oil Co.'s test on the A. McLean farm, section 32, is

a dry hole, and this company is now drilling No. 36 on the C. T. Emerson farm, section 10. The Ohio Oil Co.'s No. 31 on the I. Kendall farm, section 9, pumped 10 bbls., and No. 32 is now drilling.

In the Princeton field, Patoka township, Gibson county, western Indiana, the Ohio Oil Co.'s No. 32 on the I. Kendel farm, section 9, and 300 feet from the north line and 1,300 from the west line of the farm, pumped five bbls. at a depth of 856 feet.

Patoka—I. Kendal, Ohio Oil 32.....	5
Patoka—Miller, Hoosier Prospecting 6.....	drg
T. C. Emerson, Farmers Oil 36.....	drg
Patoka—Emerson, Farmers Oil 37.....	5
I. Kendel, Ohio Oil 33.....	5
<hr/>	
Wells completed.....	2
Production.....	10

In the Princeton field, Patoka township, Gibson county, the Patoka Valley Oil & Gas Co.'s No. 13 on the northeast corner of the Harris & Barr farm, section 2, pumped 6 bbls. from the Princeton sand at 871 feet.

LOGOOTEER OIL FIELD.

In 1913 there were three light oil wells drilled just outside the corporation line of the town of Loogootee which started producing at about ten barrels each, but have at present pumped down to about five barrels each. The wells are about 500 feet deep and are located on the east slope of the anticline and in the same sand that has for so many years furnished Loogootee with gas for fuel and lights. However, the gas at the present time is getting very low.

OFFICE OF STATE SUPERVISOR OF NATURAL GAS.
INDIANAPOLIS, IND., December 31, 1916

*Hon. Edward Barrett, State Geologist,
Indianapolis, Ind.*

Dear Sir:

I am sending you today the manuscript of the Annual Report for the 41st Annual Report of the Department of Geology.

Thanking you for the valuable suggestions and assistance I have received from you, I am,

Very truly yours.

FLOYD E. WRIGHT,
State Supervisor of Natural Gas.

Oil and Gas

By FLOYD E. WRIGHT.

THAYER OIL AND GAS FIELD.

Thayer is in the northeastern part of Newton county on the Monon Railroad about one mile south of the Kankakee river, which forms the northern boundary of Newton county.

About fifteen years ago there was a well drilled about one mile west of the town of Thayer in section thirty-two, township thirty-two, north of Range eight east, which is said to have had a good flow of gas and would have pumped fifty barrels of oil per day had it not been spoiled in shooting.

Seven years later a well was drilled about 400 feet west of Thayer, on the land now owned by Grant Brothers in section thirty-three, township thirty-two, range eight, in which there was a good flow of gas and some oil. The well stood open until the fall of 1915, at which time the oil sand was plugged in the bottom of the hole and the gas closed in.

In the fall of 1916 the Thayer Oil and Gas Company drilled a well three hundred feet west of well Number 1 on the Grant farm. At 655 feet deep they struck a flow of gas which would make about 75,000 cubic feet per day, and at 850 feet they struck some oil, but the quantity is yet to be determined. The gas is produced from a stratum of limestone about 40 feet thick, which belongs to the Hudson river shales and is just above the Utica shale. It seems to have a good steady flow and will prove valuable in that vicinity for domestic use.

The oil was struck in Trenton rock at 850 feet, but on account of the gas pressure on the oil they have been unable, up to date, to pump enough oil to determine what the well will make. The same company a little later drilled a well about 600 feet southeast of the Grant well Number 2 and got a very small flow of gas and no oil, which shows that the best possibilities for future developments are west of the Grant wells.

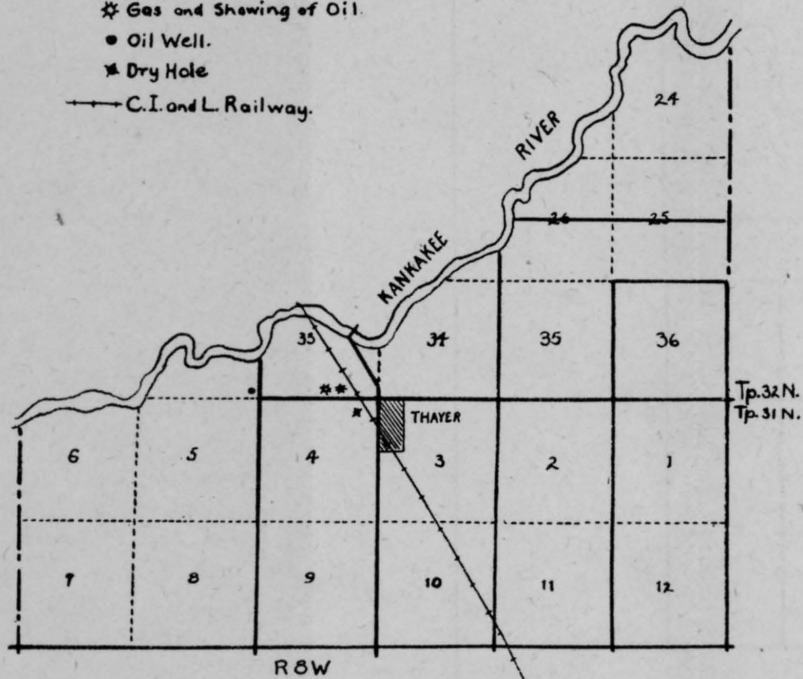
The following is a log of Grant well Number 2:

Log of well No. 2, drilled on Grant farm west of Thayer by the Thayer Oil and Gas Company.

OUTLINE MAP of THAYER OIL AND GAS FIELD.

LEGEND

- ☆ Gas and Showing of Oil.
- Oil Well.
- ✱ Dry Hole.
- C.I. and L. Railway.



Gas sand.....at.....	615
Thickness of gas sand.....	20
Salt water.....at.....	675
Trenton Rock.....	846
Oil.....at.....	850
Total depth.....	862

RANDOLPH COUNTY.

Monroe—D. McNabb, D. McNabb 1.....	abd
Monroe—M. F. Wood, M. F. Wood 5.....	drg
C. M. Congill, Condon & Co. 1.....	drg
T. F. Adams, T. F. Adams 1.....	drg
Wells drilling.....	3

During June in the Indiana fields 32 wells were completed, of which 10 were dry holes, the balance showing a daily production of 524 barrels, or an average per well per day of 23 9-11 barrels. This when compared with the May figures shows a decrease of 5 in completed wells and 5 fewer dry holes, but in new production there is a gain of 36 barrels. During the month the trade was busy pulling out old wells in the Trenton Rock end of the field, there being 106 abandoned and the pipe will be disposed of at good prices or utilized for the drilling of new wells. There is a great demand for second-hand pipe, owing to the excessive cost of new material.

In new work under way at the close of June there were one rig up and 21 wells drilling against 24 drilling wells and no rigs at the close of May. This is a net decrease in new work of only two, which is encouraging, as to heavy moving material throughout the producing sections.

Only one well of note was completed in the Indiana field during the month and that was a test drilled by T. F. Adams on his own farm, in section 21, Monroe township, Randolph county, and near Parker City. This well shows a production of 150 barrels a day and is the best find in the State for a long period. It will encourage further development work in the vicinity of the well and goes to show that there is still some prolific territory undrilled in the older fields on the eastern border of the State.

WASHINGTON COUNTY.

The Ohio Oil Co.'s wildcat well on the southeast corner of the J. W. Webb farm, section 15, Ohio township, Warrick county, and south of developments was dry hole at a depth of 1,450 feet, there being no showing of oil.

KNOX COUNTY.

In Washington township, Knox county, Bement and others drilled a dry hole in a test on the southeast corner of the Samuel Holland farm, section 30. The well was drilled through the pay sand at a depth of 1,252 feet.

VIGO COUNTY.

In Riley township, Vigo county, A. B. Bement's No. 7 on the Minnie McKinney farm, section 23, and 1,100 feet from the south line and 660 from the west line of the farm, pumped 25 bbls.

Riley—Wm. A. Clingerman, Bell Bros. & Barnes, 4..... drg

MIAMI COUNTY.

Only one completion is reported from the Indiana field and that is located in the Peru field, in Erie township, Miami county, and is the Jefferson Oil and Gas Co.'s No. 2 on the B. Harrison farm. This well like No. 1 pumped 10 barrels. The company is drilling a test on the D. M. Butt farm, section 19, also a test on the J. Tillett farm, section 23.

Erie—B. Harrison, Jefferson O. & G. 2..... 10

Erie—D. M. Butt, Jefferson O. & G. 1..... drg

J. Tillett, Jefferson O. & G. 1..... drg

Wells drilling..... 2

SUMMARY OF COMPLETED WORK.

	MARCH, '16			FEBRUARY, '16		
	Comp.	Prod.	Dry.	Comp.	Prod.	Dry.
Gibson.....	2	10	0	0	0	0
Pike.....	6	82	3	4	52	2
Sullivan.....	14	150	7	10	75	6
Vigo.....	3	50	1	2	45	0
Decatur.....	1	0	1	0	0	0
Miami.....	0	0	0	1	10	0
Total.....	26	292	13	17	182	8

Increase completed wells, 9.

Increase new production, 110 bbls.

Increase dry holes and gas wells, 5.

Abandoned, 24.

Average February, wells, 20 2-9 bbls.

Average March wells, 22 6-13 bbls.

SUMMARY OF COMPLETED WORK.

	APRIL, '16			MARCH, '16		
	Comp.	Prod.	Dry.	Comp.	Prod.	Dry.
Gibson.....	1	5	0	2	10	1
Pike.....	6	10	4	6	82	3
Sullivan.....	13	123	8	14	150	7
Vigo.....	0	0	0	3	50	1
Decatur.....	0	0	0	1	0	1
Miami.....	1	10	0	0	0	0
Warrick.....	1	0	1	0	0	0
Total.....	22	148	13	26	292	13

SUMMARY OF COMPLETED WORK.

	JUNE, '16			MAY, '16		
	Comp.	Prod.	Dry.	Comp.	Prod.	Dry.
Blackford.....	2	33	0	0	0	0
Randolph.....	3	150	2	0	0	0
Gibson.....	1	10	0	2	10	0
Pike.....	8	83	2	6	36	3
Sullivan.....	16	218	5	26	412	10
Vigo.....	1	30	0	1	30	0
Spencer.....	1	0	1	0	0	0
Miami.....	0	0	0	2	0	2
Total.....	32	524	10	37	488	15

Decrease completed wells, 5.

Increase new production, 36 bbls.

Decrease dry holes, 5.

Abandoned wells, 106

Average May wells, 22 2-11 bbls.

Average June wells, 23 9-11 bbls.

SUMMARY OF COMPLETED WORK.

	SEPTEMBER, '16			AUGUST, '16		
	Comp.	Prod.	Dry.	Comp.	Prod.	Dry.
Blackford.....	2	2	1	1	0	1
Jay.....	2	0	2	0	0	0
Grant.....	0	0	0	1	5	0
Gibson.....	4	60	1	3	13	1
Pike.....	6	255	1	6	80	2
Sullivan.....	6	209	1	10	119	3
Vigo.....	1	10	0	0	0	0
Total.....	21	536	6	21	217	7

Increase new production 319 bbls.

Decrease dry holes, 1.

Abandoned wells, 54.

Average August wells, 15½ bbls.

Average September wells, 35 11-15 bbls.

SUMMARY OF NEW WORK.

	SEPTEMBER, '16			AUGUST, '16		
	Rigs.	Drg.	Total	Rigs.	Drg.	Total.
Blackford.....	0	1	1	0	2	2
Jay.....	0	0	0	0	1	1
Delaware.....	0	2	2	0	1	1
Randolph.....	0	1	1	0	1	1
Gibson.....	1	1	2	0	4	4
Pike.....	3	7	10	3	7	10
Sullivan.....	0	3	3	0	5	5
Miami.....	0	2	2	0	2	2
Vigo.....	0	1	1	0	1	1
Total.....	4	18	22	3	24	27

Increase rigs, 1.

Decrease drilling wells, 6.

Net decrease new work, 5.

On account of the high price of oil during the past year there has been a number of wild cat wells drilled in various parts of the state in search of some new and undiscovered pool of oil.

At Gentryville, in Spencer county, there were two dry holes drilled near some old wells, which, at the time of their drilling, made some gas and had a good showing of oil.

Two wells were drilled south of Hall, Morgan county, on the lands owned by the McCarty heirs. The first one was drilled to a depth of about 860 feet and had a showing of oil in the corniferous limestone. The well was shot but the shot did not increase the showing of oil.

The same company then drilled a well 2,000 feet north of the first well, in which Trenton rock was penetrated at 1,240 feet deep, but had no gas or oil.

A well was drilled about due south of Spencer in Owen county, near the county line, in which there was a good showing of oil at 800 feet, which was cased off, and the well was still drilling at the end of the year.

A very strong gas well was drilled in about eight miles northwest of Princeton, in Gibson county, at a depth of 1,300 feet. The volume and pressure of the well indicates a well developed anticline, and should be a lead to a new oil field.

A well is being drilled on the Fox farm northwest of Oaklandon in the hope of getting oil or gas. The well is located toward the western edge of old Trenton Rock Gas Field.

Six miles south of Veedersburg, in Fountain county, there were two dry holes drilled to a depth of about 900 feet, which were finished in the Huron group of sandstones and shales.

At Milan, in Ripley county, a well was drilled to a depth of about 1,300 feet. A good showing of gas was struck in the top of Trenton rock at about 800 feet, and, at present, preparations are being made to take care of the gas and also use the mineral water from the bottom of Trenton rock.

A test well is now being drilled about two miles north of Fort Ritner, in Lawrence county, in which gas was struck at about 250 feet. An anticline has been traced out in that part of Lawrence county, which extends in a southeasterly and northwesterly direction from the western edge of Heltonville southeasterly and crosses the B. & O. Southwestern railroad at what is locally known as the Big Tunnel, which is about two miles east of the town of Tunnelton. The present well is being drilled near the crest of the anticline. The prospects for oil or gas look very good along the crest and on the west slope of the anticlines. The axis of the anticline is paralleled on the east, by about one mile, by a fault, which is the only known fault in the state.

The formation existing in this part of the state is the Knobstone shale. The Corniferous limestone will be reached from 700 to 800 feet and Trenton rock should be from 1,600 to 1,700 feet deep.

Early in the year four gas wells were drilled about two miles south of the Jamison pool in Sullivan county which showed a volume of 1,500,000 cubic feet of gas, each with a rock pressure of 257 pounds. The wells are now connected to the Sullivan gas plant, which was formerly supplied by some light wells in the Jamison pool, which are at present exhausted.

The service of natural gas from Oakland City Oil Field to Winslow and Oakland City has been discontinued on account of the failing supply of gas.

The oil production of the state shows an increase over the 1915 production of 215,612 barrels, which is largely due to the new developments in Pike county and extension of the Sullivan county field.

The following table shows the production by counties:

County.	Wells.	Production.
Sullivan.....	625	750,000
Pike.....	301	162,489
Lima—Ind.....	2138	273,701
Davies.....	5	18,000
Vigo.....	17	59,400
Total.....		<u>1,263,590</u>

The gas laws of Indiana were enacted several years ago when oil and gas developments in the State were new and the science and geology in connection with the oil and gas was largely unknown. Consequently they are deficient in many respects, and in view of these facts I wish to call the attention of some of these defects to the coming legislature and those interested in the gas and oil business.

The law provides that all fresh water shall be cased off in gas and oil wells. The damage to oil and gas, resulting from water coming from near the surface and leaking into the hole, is due to the fact that it creates a pressure in the oil or gas-bearing rock, which causes an inflow of the water and drifts the oil or gas from the near vicinity of that hole and in time ruins the well. When the Indiana laws were written they assumed that it was only fresh water that would do this damage, but they later found out that the damage is not caused by the kind of water that gets into the rock, but it is the pressure it creates, from the fact the source is so high that it overcomes the upper pressure of the water or oil in the oil-bearing rock. The law should read that all water above the oil-bearing rock shall be cased off and kept cased off.

In case there are more than one oil or gas-bearing sand, and in drilling through one sand water is penetrated in a lower formation, which will rise in the hole higher than the water from the first sand, the damage done by the water to the upper sand is just the same as if it was gotten from stratum near the surface and should be cased off or plugged off so as to protect the first sand penetrated. In case of abandoning a well and plugging it, while our laws require the oil or gas-bearing rock to be plugged in a manner which is well described in the present laws, I would suggest that each sand be plugged in the same manner, separately, so as to be protected from each other.

In the event that oil or gas operations are in your coal area of the state, I would suggest that for the protection of the coal, that oil and gas operators be required to file a map showing the

exact locations of their wells, so that in future coal operations there may be left a block of coal in the mine surrounding the oil or gas drilling. Then, in addition to this, I would suggest that the well be plugged above and below the coal either with wooden plugs, or that the hole be concreted through the coal so as to prevent the water, gas or oil, from the oil and gas-bearing sands from getting into the coal.

For the benefit of future operations, there should also be filed at the Central office a log of all wells drilled, so that the geologist in charge may classify the formations and greatly benefit future developments. It will also be convenient in finding the proper place to insert the plugs in case of plugging the wells in the future.

I find that the fee of \$5.00 very often does not cover the expense that the deputy is put to in getting to and from a well if he has to spend very much time in plugging it, and there are very few deputies who are making a living out of plugging wells. The only ones who are making a salary sufficient to justify them to devote their time to the job are those who live in the parts of the state that were developed many years ago and which now are being abandoned very rapidly where they can plug wells after three or four strings of tools. I would suggest that the fee be raised from \$5.00 to \$10.00.

CANNELBURG OIL FIELD.

During the last two years the Lynn Oil and Gas Company have drilled in nine producing wells in sections 8 and 17, township 2 north, range 5 west, in Daviess county.

The wells were finished in the lower sand of the Huron group of sandstones and shales at about 725 feet and started off at about 40 barrels and have pumped down to where all the wells are making 50 barrels steady.

Through advice to this office the first well was drilled in the northwest quarter of section 17 near a gas well drilled in 1912 to a depth of 380 feet.

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