

RESULTS OF GLACIATION IN INDIANA.

BY CHARLES W. SHANNON.

During the past five or six years my field work has been in both the glaciated and unglaciated parts of Indiana. The work has been chiefly concerning the surface features, such as drainage, soils, clays, gravel and sand deposits, and stone outcrops. A study of these surface features has revealed many contrasts between the two areas. Some of these are very marked, others are not so prominent at first consideration. It is the purpose of this paper to show some of these results of glaciation within the State.

For the general information concerning the ice sheets which have invaded the State, and their influence upon drainage and other physical features, I have drawn upon the works of Prof. T. C. Chamberlin, Mr. Frank Leverett, Dr. Charles R. Dwyer, and others who have made special studies and investigations in glaciation within the State.

The work of the glaciers in Indiana has been attracting the attention of geologists and other investigators for a number of years. Both the State and the United States Surveys, as well as individuals, have done a great amount of work and are at present engaged in the investigation. A careful study of the glacial deposits in Indiana will throw much light upon the conditions present in adjoining States, and on the results of glaciation in general. According to Mr. Leverett, the glacial deposits and scorings of the State have been recognized from the earliest days of settlement. "It is in Indiana that we find about the first recognition in America of the boulders as erratics and of striæ as products of ice action. So long ago as 1828, granite and other rocks of distant derivation were observed by geologists near New Harmony, in the southwestern part of the State; at nearly as early a date (1842), striæ were noted near Richmond, in the eastern part of the State." But even with these observations, very little attention was given to the deposits until within the past twenty-five or thirty years.

About four-fifths of the State lies in the glaciated area. In the south central part of the State is a driftless area comprising all or a part of twenty counties,



Topography outside of influence of Glaciers. Knobstone area in Brown County.



Topography just outside the Glacial Boundary, but influenced slightly by outwash. Coal Measure area, Dubois County.

Two distinct periods of glaciation are recognized and in addition much material derived from a third, in which the advance of the ice sheet did not reach the limits of Indiana, but produced many important features by the action of wind and water upon the outwash material.

The various stages producing glacial deposits are spoken of as (1) The First Ice Invasion, chiefly that of the Illinoian ice sheet and probably an eastern lobe which reached the eastern side of Indiana. (2) The Main Loess Depositing Stage, the Iowan drift. (3) The Wisconsin Stage of Glaciation.

First Ice Invasion.—The State was invaded by ice which had its center of dispersion in the elevated districts to the east and south of Hudson Bay. From the region to the north of Lake Huron there was a movement to the west or south over the Lake Michigan Basin, Illinois and western Indiana. From a part of this sheet the part known as the Illinoian lobe was formed. The deposit left by this invasion constitutes the surface (aside from the thin covering of loess) over southwestern Indiana and an area of almost equal size in southeastern part—that is, it covers the entire area between the glacial boundary and the line of the Wisconsin drift. Many wells and drillings have shown that this drift is also present farther to the north underlying the Wisconsin. The thickness of this drift over the area of its exposure is in general about twenty-five feet except in filled valleys. In places the ridges carry but a thin coating, while adjoining valleys may be filled 100 feet or more. At the southern limit the coating of material is very thin in most places, and while the boundary is not marked by a well defined ridge, the character of the soil and the natural vegetation mark approximately the limits of the drift.

In general, the material is of a yellowish brown color to a depth of fifteen feet or more, beneath which the color is a gray or blue gray. There is every transition from the brown to the gray; it is therefore probable that the brown is an altered gray till, the oxidation of the iron having produced the color. In the filled valleys sand and gravel are often found, and in the northern part of the area the drift becomes more variable. The underlying rock formations in most of the area appear to have contributed largely to the material of the till. Where the underlying rocks are of a friable nature the material has been reduced to sand or clay and few if any pebbles remain in the till, the coarse and pebbly constituents of the

till thus varies with the character of the underlying rocks. The locally formed pebbles and rock fragments are chiefly sandstone, but numerous foreign rocks and boulders of large size are occasionally found near the limit of the drift. The region presents a fairly even topography. In places, knolls and ridges with undulating surfaces occur, but in no place do they become of great height.

Striae are found in several places. They occur in Sullivan, Vigo, Clay, Greene and Owen counties. The markings are chiefly upon sandstone exposure. The drainage of the area covered by the Illinoian Invasion was in many respects greatly modified. In attempting to work out the history of an area whose drainage has been assisted by the invasion of the ice sheet, the life resolves itself into four fundamental parts. First. What were the topographic characteristics of the area during the preglacial history? Second. What changes took place during the glacial history? Third. What has happened since the disappearance of the ice sheet; its post glacial history? Fourth. What was the effect produced on the unglaciated parts of this area? The drainage is discussed to some extent under the heading of "Rivers and Lakes."

Loess Depositing Stage.—The Iowan Drift.—Prior to the invasion by the Illinoian ice lobe there was a marked interval of deglaciation and a similar interval occurred at the close of the Illinoian period. These intervals were marked by leaching and oxidation of the drift, the accumulation of peat and soil, and the processes of erosion. The interglacial interval following the Illinoian invasion is known as the Sangamon Stage.

The surface of the Illinoian drift outside the limits of the Wisconsin drift is covered with a fine grained yellowish silt or loam, to which the term loess has been applied. Loess is a deposit which, like sand or gravel, may be laid down whenever conditions are favorable, but since the great bulk appears to have been deposited at a definite stage in the glacial period, the time of deposition may be referred to as the Loess Stage. This loess may be of different ages, but since the materials contained are such as occur in glacial drift it must have been derived from the drift. The source is supposed to be from the Iowan drift, and the distribution due to the combined action of wind and water. The loess of Indiana varies from a fine silt of a loose floury texture to compact masses, held firmly by a calcareous cement. In some places small pebbles are found imbedded, also fossil remains of fresh water mollusks, and some insects and bones

of mammals are found. The color varies from yellow to almost white, due probably to modified forms of the same material. The thickness varies from a thin coating to twenty-five feet or more. Where exposures of the loess material occur the faces are vertical and compact, and any markings upon the face remains well preserved indefinitely. (See photograph of exposures along Wabash River north of Old Fort Knox, Knox County.) How far the material from the Iowan drift extends under the Wisconsin is not known.

The Wisconsin Stage.—Considerable time elapsed between the main deposition of loess and the invasion of the Wisconsin ice sheet. This time is designated as the Peorian Stage. Erosion produced many changes in the surface of the loess and the underlying drift. In places extensive deposits of muck and peat have been found. Following the Peorian Stage there occurred one of the most important stages of glaciation in the entire glacial period. "It is marked by heavier deposits of drift than those made at any other invasion. Throughout much of its southern boundary in the United States, a prominent ridge of drift is to be seen rising in places to a height of 100 feet or more above the outlying districts on the south, and merging into plains of drift on the north, which are nearly as elevated as its crest.

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

Thickness of the Drift.—"There are surprising differences in the thickness of the drift within the State. The portion of the older drift exposed to view has, as already noted, an average of about thirty feet. The additional 100 feet of the newer drift is, however, deposited very

irregularly. In the belt of thick drift which leads from Benton County southeast to Marion County, and thence east into Ohio, the thickness is probably 200 feet. The portion of the newer drift area to the south of this belt has an average of about fifty to seventy-five feet. A still larger tract extending north from this belt of thick drift as far as Allen County and the west flowing portion of the Wabash, has only fifty to seventy-five feet, with limited areas where its thickness is but twenty to thirty feet. In northwestern White, southwestern Pulaski, and southern Jasper counties there are several townships in which scarcely any drift appears excepting boulders and sandy deposits. In northern Indiana the drift is very thick. Its average thickness for fifty miles south of the north boundary of the State is probably not less than 250 feet and may exceed 300 feet. At Kendallville it is 485 feet, and at several cities on the moraine which leads northeast from Fulton County to Steuben County, its thickness has been shown by gas borings to exceed 300 feet. The rock is seldom reached in that region at less than 200 feet. Were the drift to be stripped from the northern portion of Indiana its altitude would be about as low as the surface of Lake Michigan, though much of the present surface is 200 to 300 feet above the lake¹

TOPOGRAPHY.

The surface of Indiana presents no great diversity of topographic features. The elevation above sea level ranges from 313 feet at the junction of the Ohio and Wabash rivers to about 1,285 feet, in the southern part of Randolph County. It is on this height of land that both the east and west forks of White River have their source. The average elevation of the State is about 700 feet. The greater part of the State is a plain of accumulation. North of the glacial boundary much of the area has a comparatively level surface, or only gently undulating. In the northeastern part of the State are some considerable hills and ridges, formed from the coarser materials and large boulders of the drift. These morainic ridges, some of which reach a height of 200 feet, stand out in sharp contrast to the level area of old Lake Maumee on the south, and to the sand covered area to the west. Here on the west, the Kankakee Marsh with an area of 1,000 square miles is very flat, and the area to

¹ See U. S. G. S. Monograph XXXVIII, Leverett. Also "Studies in Indiana Geography," Dryer, pp. 29-40.



Showing topography in level till plains near Princeton, Gibson County.



Glacial boulders two miles northwest Bowling Green, southern limit of glacial boulders of large size, very rare even so far to the south.

the north has scarcely any significant ridges. When sand ridges occur on the area they are usually not more than 30-50 feet high. In the dune area some of the elevations will exceed 100 feet. The lower moraine of the Wisconsin sheet presents a distinct ridging in places, with a gently undulating surface, but the range in elevation is slight. The area lying between the Wisconsin drift boundary and the farthest advance of the early ice sheet is a flat to gently rolling surface.

Exposures, wells and borings show that the preglacial surface of the drift area was much eroded, and drainage lines well advanced. If the surface could be seen it would perhaps have much the same appearance as the surface of the driftless area.

The unglaciated region is a thoroughly dissected plateau. The elevation ranges from 350 feet at the southwest corner, along the Ohio, to 1,147 feet, at Weedpatch Hill in Brown County. The hills and ridges vary much in general characteristics, according to the geological formations. But the greater part of the area may be classed as very rugged, no level tracts of very large size occur, and much of the surface is too hilly for cultivation. In general the work of the glacier in Indiana has been to make the surface more level and of much greater value from an agricultural standpoint.

DRAINAGE.

The drainage has been greatly influenced by the glaciers which have invaded the State. Many of the preglacial valleys were filled with drift and have been able to cut out only a part of the material, or in many cases have followed new lines entirely. Glacial water streams have done much on the surface, but most of these lines are represented only by the old channels, or by streams which are insignificant as compared with the flow from the ice front. In the driftless area deep valleys, gorges and ravines, are characteristic of the drainage, some of the special drainage features will be considered under the heading of Rivers and Lakes.

Rivers.—All the rivers of the State have been more or less influenced by the glacial action. In the glaciated part there is no uniformity in the drainage lines; in the driftless area a section of drainage worked out in detail will present a perfect dendritic system.

The Ohio River forms the southern boundary of the State, and flows in a winding course for 352 miles. The valley of the Ohio is very nar-

row except for a few miles near Louisville where it has developed a valley several miles wide on the Devonian shales and again widens in the southwestern part of the State, in the area of the coal measures. There are a few places between Pittsburg and Louisville where the width of the valley exceeds two miles, and usually it is less than a mile wide. The narrows above Louisville range in depth from 300 to 450 feet, below Louisville the average is about 300 and in the wider parts the depth is from 100 to 150 feet. The lower Ohio appears to be a very old drainage line.

The course of the lower Ohio is almost parallel with the dip of the formations.

There has been almost a total disregard of topographic features; the part of the river as boundary which has been directly affected by the glaciation is between Louisville and the Indiana-Ohio line. The early history of the stream has been largely obliterated by glacial deposits. The entire part of the Ohio which has been influenced by the result of glaciation extends from Louisville to Maysville, Ky., a distance of 190 miles, and including the abandoned channel near Cincinnati the glacial extent is about 225 miles. The drift deposits are found to extend down to the rock floor at a lower level than the present bed of the river, and as the material is unmodified the full excavation of the valley precedes the stage of glaciation. This work was done during the Illinoian period.

White Water.—White Water River in the eastern part of the State drains an area of about 1,500 square miles, partly from Ohio. The source of the stream is in a moraine in southern Randolph County. The east and west forks unite near Brookville.

“The head water portion for 15-20 miles are flowing in channels cut in drift. The east fork, then, near Richmond enters the rock and has carved its course partly in rocks from that point to Brookville. The west fork encounters rock at only a few points. Below Connersville it is in a partially filled preglacial valley, with broad bottom and elevated uplands on either side.

“The west fork, with its head waters, constituted an important line of drainage for the waters from the ice sheet at the time the moraine above referred to was forming and probably also at earlier stages in the glacial epoch. It is in consequence a gravel-filled valley, and the work of the present stream has been merely a removal of a small portion of these

gravel deposits. Above Cambridge it has cut scarcely twenty feet into these deposits. The depth gradually increases toward Brookville. At Brookville and below that city it has formed a channel 60-75 feet in depth."—(Leverett.)

It is possible that the northern part of the river basin drained west to the Wabash, as would be indicated by channels encountered in oil and gas borings. However, the width and depth of the lower White Water valley would require a drainage area almost as large as the present.

Blue River has a drainage area of 450 square miles, which lies wholly in the unglaciated. The flow of the stream is greatly influenced by underground channels. The fall is estimated by Tucker to be 5.34 feet per mile.

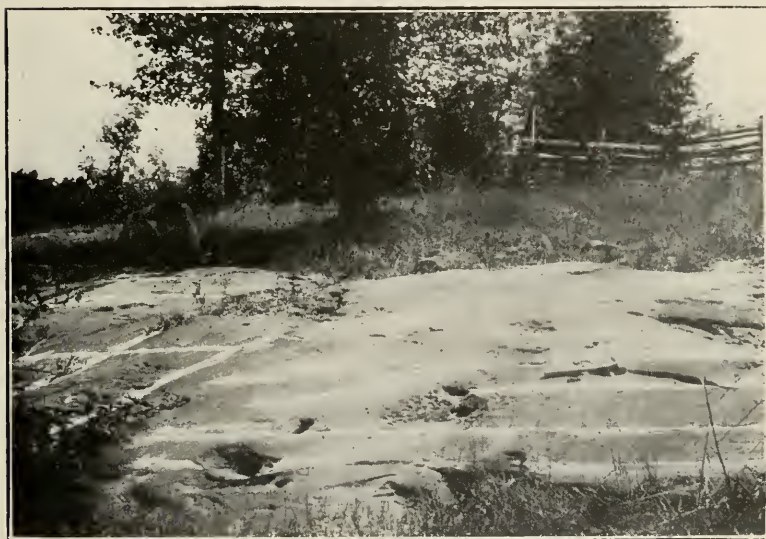
The White River System drains about one-third of the State. There are two main branches, the east and west forks, which unite at the southwest corner of Daviess County. Below the point of union the stream flows the entire distance to its junction with the Wabash through the lower part of the Illinoian drift. The west fork rises in Randolph County, where the maximum elevation is 1,285 feet; the elevation of the mouth is 375 feet. The total length of the stream is about 275 miles, with probably another 100 miles of windings. The average fall is nearly three feet per mile or more than twice that of the Wabash. The entire course is through the glacial area. The two main tributaries are Fall Creek having its source in a cascade ten feet in height at Pendleton, and Eel River which has a length of 100 miles; the source of the west fork is in southern Boone County. It flows over the edge of the Wisconsin drift in Putnam County. The eastern fork rises in Hendricks and flows through the limestone region in Owen County, where a series of falls are produced. Eel River is a very meandering stream with a sand-choked channel. The material is derived in part from glacial material but largely from the heavy sandstone formations exposed along the course, and especially on the tributaries.

The east fork of White River rises just below the southwest corner of Randolph County, a short distance from the head of west fork.

The main streams of these forks grow farther apart until they reach Shelby and Marion counties, where they approach each other then again turn from one another until the east fork reaches the southeast corner of Bartholomew County. This fork then turns in a southwest direction



Showing polished surface of sandstone. James Campbell farm north of Bowling Green.



Glacial Striae on Mansfield sandstone. James Campbell farm, north of Bowling Green. The marks to the left running at right angles to the scorings are cracks. Markings are filled with white sand to give contrast.

and crosses the glacial boundary near Brownstown, Jackson County. It cuts across the unglaciated area in a west-southwest direction, and is cut to a comparatively low gradient, although it has cut through many rock formations of great hardness. The valley has been filled to such an extent that the present stream is on the average about 100 feet above rock floor. The bluffs are 200 to 300 feet above the present valley floor, thus giving the preglacial valley a depth of 300 to 400 feet. In the unglaciated area the east fork receives only one important tributary from the north, that is Salt Creek. This creek lies wholly in unglaciated area but probably carried much water from the melting heads of glaciers which passed through the divides to the northeast, as is evidenced by the filling of sand and gravel in the upper course of the tributaries, as example Hubbard's Gap, Monroe County and eastern part of Brown County. The streams leading down from these gaps have strewn along their courses glacial boulders of considerable size.

In the Salt Creek basin the valleys are cut to great depth and a dendritic system of drainage has been developed which stands out in contrast to the irregular and unsymmetrical drainage system of the streams within the drift area to the north and east.

Lost River, an eastern tributary to east fork, is entirely out of drift limits area and for a distance of 12-15 miles flows through a subterranean channel. In flood times part of the water flows over the old surface bed.

The Muscatatuck, a large tributary from the east, has little fall compared with the neighboring part of the east fork. At the railway crossing south of Seymour the bed of the Muscatatuck is forty feet lower than at the crossing on the east fork to the north of Seymour. The difference is due to a filling of the east fork valley by deposits of gravel from the Wisconsin glacier. The Muscatatuck lies outside of the Wisconsin drift limits and the reach of its waters and the valley remains unfilled.

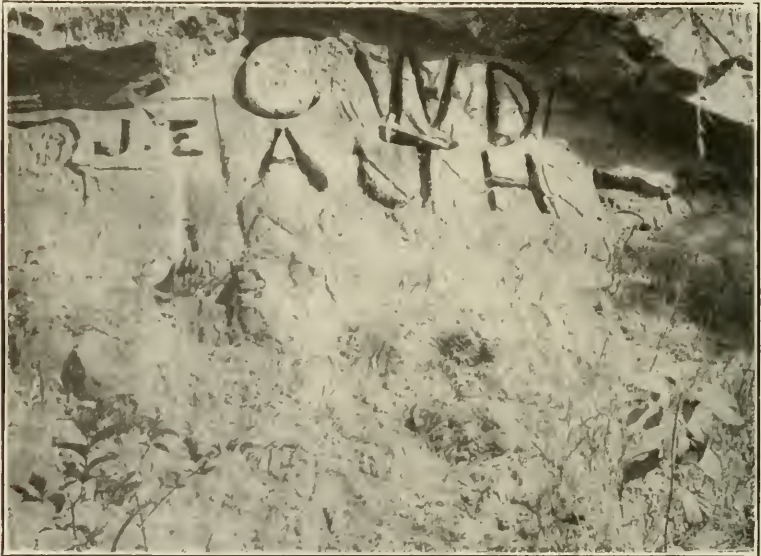
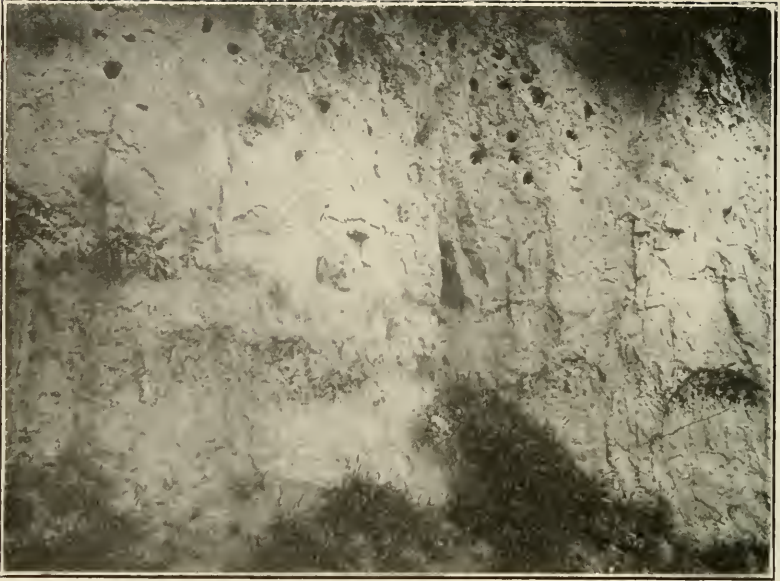
The principal tributaries of east fork to the northeast are Blue River and Little Flat Rock Creek. These tributaries have an average fall of about five feet per mile. From Columbus near the edge of the Wisconsin drift to the mouth of the Muscatatuck the fall is about twenty inches per mile. In the old preglacial valley through the driftless area the fall is about ten inches per mile. Riffles and rapids in this part of the course, however, increase the fall. The Hindostan Falls below Shoals give a

descent of about five feet; here the stream has cut off an old oxbow and is cutting down the rock in the ridge encircled by the oxbow.

The Patoka is a sluggish stream flowing along to the south of east fork of White River for a distance of about 100 miles, with a very narrow drainage basin, nowhere exceeding twenty miles in width. The river rises in the Huron Sandstone of southern Orange County, thus having its source in the driftless area, but in the vicinity of Jasper, Dubois County, it comes in contact with the drift. The present drainage system is made up of three small drainage systems which were formerly distinct and the waters of which flowed to the northwestward to west and east forks of White River. "The upper system embraced the portion above Jasper, the old divide being at the northeast border of that village. The middle system embraced the portion between Jasper and Velpen and the lower part from Velpen down to the vicinity of Princeton. The old drainage way there turned north to White River near Hazelton, but the present stream continues westward across a rock pass into the Wabash."—Leverett.

These streams which had then a northwestern discharge have been turned westward, just outside the glacial boundary to form the present Patoka River.

The Wabash River has a large drainage area within the State. The river rises in the western part of Ohio, flows across central Indiana then turns south and from a point a few miles below Terre Haute forms the Indiana-Illinois boundary to its junction with the Ohio. The main stream lies entirely within the glaciated area and practically all the waters from the system come from the drift surface. The river enters a preglacial valley just north of Lafayette, and after following this valley for a few miles, turns southwestward across a rock point, while the preglacial valley takes a longer route to the west and south, joining the river at the bend near Covington. From this point southwest the river follows the preglacial valley to the Ohio. Above Terre Haute the present stream has cut out only a part of the old valley, while to the south the river bottoms extend from bluff to bluff of the old valley. At Terre Haute the valley is five miles wide, to the north from 2-4 miles, and increases to the south to about fifteen miles near the mouth of the river. In the upper part of its course at Huntington the river enters the old outlet of glacial Lake Maumee. The old valley here is several times



Vertical face of loess along the Wabash north of Old Fort Knox. Withstands weathering—letters which have been cut in face for long time remain unchanged.

as wide as that occupied by the river above this point. From Huntington it flows in a westward course and has opened up a post glacial line as far as Lafayette, where it joins a preglacial channel as mentioned above.

Big Raccoon Creek and its main tributary *Little Raccoon Creek* drain an area of about 500 square miles. At the southern edge of Parke County the stream enters an old channel of the Wabash and follows this channel for about fifteen miles northward before entering the Wabash.

Busscron Creek, a tributary of the Wabash, has its source near the Clay and Vigo line. The general direction of the stream is southwest across Sullivan County into the Wabash. For a few miles near the mouth the stream probably occupies a preglacial channel, otherwise it is not influenced by preglacial drainage.

There are two Eel rivers within the State. One a tributary of the Wabash entering at Logansport and the other a tributary of White River entering just above Worthington.

Along the latter and its tributaries are some of the best rock exposures in southern Indiana. These exposures are chiefly in the Mansfield sandstone. It is a very meandering stream and at present the question of the drainage of some of the bottom lands which are subject to overflow is receiving serious consideration in Clay, Vigo and Greene counties. From the great bend westward to the Wabash there is a continuous strip of almost level country.

The Salamonie River enters the Wabash from the southeast near the city of Wabash. The river is about seventy-five miles in length and flows along a plain along the south side of a moraine. The Mississinewa enters near Peru. It has a length of about 100 miles and its channel is cut mainly in drift, but in a few places down to solid rock. *The Tippecanoe River* is the main tributary from the northwest. Its source is in the moraines in the northeast part of the State. Its course is controlled by the moraines. From the moraines it passes through a sand plain of "Old Lake Kankakee" then again follows the course of a moraine along the northwest side of the Wabash, and enters it a few miles below Delphi.

The Kankakee River is a very sluggish stream, flowing a distance of about seventy-five miles in Indiana by a very meandering course in which the river is said to make 2,000 bends.



Washes in Glacial till, eastern Gibson County. Thickness about 50 feet.



Glacial till intermingled with large fragments of sandstone from local formations. Gibson County.

In Illinois the Kankakee unites with the DesPlaines to form the Illinois. The river drains an area of about 3,040 square miles in Indiana. The general trend of the watershed is from east to west with an entire length of 200 miles and a north and south width of seventy miles. All the north tributaries have their source in the Valparaiso morainic system. The southern limit of the watershed is in the Iroquois and Marseilles moraines. There is no well defined ridge separating the watershed of the Kankakee from that of the Wabash. The river rises in a marsh near South Bend in the edge of a moraine. The Kankakee marshes comprise the most extensive body of swamp land in Indiana. In the seven counties drained by the river the original area of the marsh was almost a half million acres. In many places wild rice, rushes, water-lilies and grasses grow so abundantly in the channel as to cause the flooding of the marshes even during a summer freshet. In former years the river could scarcely be approached but now more than a dozen railways cross the stream and numerous highways bridge its waters. The surface of the marsh land is for the most part a treeless plain except along the immediate border of the river, where some trees are found. The soil is in general a dark, sandy clay soil, rich in organic matter. The sand content varies, and presents a number of soil types. According to situation the soils would be classed as swamp, marsh, island, peat and muck.

The St. Joseph River, now tributary to Lake Michigan, formerly discharged through the Kankakee. It has a drainage area of about 4,000 square miles. *Papaaw River* which joins it near the mouth is the chief tributary. It has its source in the swampy region to the east of Valparaiso Moraine. *Pipestone Creek* and *Dowagiac River* are other tributaries.

Yellow River drains an area of about 700 square miles lying to the east of the moraine in which the Kankakee also has its source.

About 800 miles of the Iroquois watershed lies in Indiana. In most of its course the stream is sluggish and the drainage imperfect. The soil of the area is a sandy loam and is largely under cultivation. The natural waterways have been greatly assisted in drainage by systems of ditching.

The Calumet River has its source in the Valparaiso morainic system south of Michigan City. All the tributaries enter from the south side. The course of the stream and tributaries are controlled to some extent by the sand dunes along the beaches of the old lake. The stream now

discharges at South Chicago in Illinois. The old discharge was in Lake County on the southeast border of the lake. Near the source the river flows in an almost straight line and has the appearance of an artificial ditch rather than a natural stream. After flowing across the counties of Porter and Lake it crosses the State line but three miles south of its entry into Porter County and almost due west of its source. From the State line it flows in a northwesterly direction, for about seven miles and then at Blue Island, Illinois, it makes a sharp curve, then flows northeast then southeast and again crosses into Lake County about three miles north of its first line then continuing eastward for fourteen miles to its old point of discharge, but two and a half miles from the point where it first entered Lake County. The area included in this meander consists of slightly elevated morainic tracts, sandy beaches and marshes.

LAKES.

In the northern part of the State are hundreds of lakes varying much in size. These lakes are chiefly confined to the four northern tiers of counties. These lakes are all due to the irregular deposition of glacial drift. They occupy basins within the morainic area. They may be divided into three classes. (1) Kettle Hole Lakes, those which have been formed by the melting of detached blocks of ice. (2) Channel Lakes, in which the basins are the abandoned channels of glacial streams. (3) Irregular lakes, those with no general form of outline but are due to the irregular depressions formed in the accumulated drift.

The abundant vegetation has produced considerable deposits of peat about the margins of many of the lakes, and many of the smaller ones have been completely filled. Good marl deposits also occur in many of the lakes and is being utilized for the manufacture of cement, brick and tile.

No lakes occur outside the limits of the Wisconsin drift, although many basins of extinct lakes occur over the southwestern border of the Illinoian. Some small ponded areas are found which take considerable proportions in wet seasons but are not permanent. In the driftless area numerous small ponds are found, which owe their origin chiefly to sink hole depressions in which the outlet has become clogged.

For description of Indiana Streams, see U. S. G. S. Monographs XXXVII and XLI.—Leverett.



Niagara limestone exposed in the Wabash Arch at Wabash



Niagara limestone exposed in the channel of the Wabash river at Logansport.

SOILS.

The soils of the State are of two general classes.

First. *Sedentary or Residual Soils.*—These are the soils in place, they have not been removed from the parent rock. Such soils occur throughout the driftless area. They vary much in color, texture structure and natural fertility, according to the nature of the formation of which they have been derived. The poor soils are those derived from the shales and the sandstones. Those from the limestones are rather fertile, but will not stand continuous cropping, but soon become depleted. The residual soils are as a rule not very deep and do not withstand drouth very well.

Another group of soils to be classed as sedentary are in cumulous deposits as peat, muck and swamp, since they result from the gradual accumulation of material "in situ." Though differening in both composition and origin from those just described such soils are common in the northern part of the State in the Wisconsin drift.

Peat occurs only in very limited areas outside of the Wisconsin drift boundary. Muck areas occur about the margins of the many lakes and thousands of acres are in the swamp areas of the lake region and the Kankakee basin.

Secoud. *Transported Soils.*—Those which have been transported by the power of water, wind and ice. These are known as colluvial, alluvial and glacial drift soils. The two latter classes are of most importance. All of the alluvial soils of the State are fertile both in the glaciated and driftless areas. A large part of the river bottom soils are low lying and difficult to drain. These soils vary from the sands and gravel to the stiffest clays, but in general they are a good clay loam. Corn is the principal crop.

The drift soils are composed of a great variety of types, and mostly of good to fair fertility. The black loam of the drift has made Indiana take first place among the States in the production of corn and other staple crops. The glacial drift is for the most part a very productive and permanent soil. The drift deposits are varied in the arrangement of clay, gravel and sand, so that what is true in one locality may be entirely different in another. But in general it consists of a confused mass of material derived from many sources and is usually rich in all the necessary plant foods.

The line between the residual types and the loess covered tracts is well defined as to differences of plant growth and crop production, but the line between the pale silt and the black soils of the Wisconsin drift is very conspicuous.

The loess soils are easily cultivated, much of the surface of a well filled field is frequently a loose floury dust, and when small clods occur they are easily broken. The soil may be plowed when wet and yet easily be worked to a loose pliable condition. There is a marked deficiency of organic matter in the virgin soil and as this amount becomes less the soils get in a poor physical condition and are sometimes difficult to manage. A systematic rotation of crops and good application of stable manure are necessary to keep the soils in good condition for cultivation. Much of the land is used for pasture, but when left uncultivated for a few years the ground becomes covered with a growth of briars.

The principal alluvial soils of the State are those of the White River, Wabash and Ohio Valleys. The valleys of these streams and their tributaries are the results of stream erosion, and chiefly by the streams which now occupy them. During the glacial period they were largely choked with drift, only a small part of which has been removed; gorges and ravines exist in great numbers along the White Water, White and Ohio rivers and their tributaries. The eastern tributaries of the Wabash in Fountain and Parke counties flow through deep gorges cut in the sandstone. The streams flowing from the glacial area had their valleys flooded with glacial waters and choked with glacial debris. The effect of this is shown by the extensive terraces of sand and gravel which border their present channels. Between these terraces are the bottom lands, large areas of which contain very productive soils.

A larger percentage of the drift soils are suited for cultivation than those of the driftless area, but there are, however, large areas of the former which are either too rough for agricultural purposes, as in the boulder morainic belts, or too wet, as in the lake and marsh districts of the northern part of the State.

ROCK OUTCROPS.

In the northern part of the State rock outcrops are few. At Mokena, Illinois, occurs the first limestone outcrop along the Kankakee, and from that point to its junction with the Iroquois there is a solid



Oolitic limestone weathering into soil. Cleveland Quarry near Harrodsburg, Monroe County. Typical example of the source of the residual soils of the driftless area.

rock bed. At Momence some of the rock ledge has been blasted away in an effort to give a better flow to the Kankakee. The Wabash arch presents the best exposure in the central and northern part of the State. Following down the Wabash numerous outcrops occur, at Logansport, Covington, Merom, Vincennes and below New Harmony. The rock gorges along Sugar Creek below Crawfordsville afford some of the most picturesque scenery within the State. Above Crawfordsville the channel is shallow and touches rock only at a few places. Rocky Fork, in Parke County, also has many erosive features of similar appearance. In Vigo County many exposures occur along the tributaries of the Wabash. Along Eel River in Putnam County and Clay County are some excellent examples of erosion in the Mansfield Sandstone. Croy's Creek, a main tributary, is lined with gorges, undercut, vertical walls, and cliffs with steep slopes. The falls of the east fork of Eel River at Cataract in Owen County are over the limestone. In the eastern part of the State along Clifty Creek, Big Flat Rock and Little Flat Rock there are long stretches of rock bottom and bank exposures in the Devonian and Upper Silurian. Along the channel of White Water and at Madison is found some of the very best of scenery. The rock bluffs along the Muscatatuck, as at Vernon, and the shale in the beds of the streams to the south, as about Henryville, are also of prominence in the southeastern part of the State. In the southwest the bluffs of the Patoka are specially noted. These are only a part of the rock outcrops within the drift area, and in addition to the many exposures of natural ledges may also be mentioned the great deposits of conglomerate gravel which presents some rugged surfaces, as along the upper Wabash and along White River to the northeast of Noblesville.

In the driftless area the bare rock surfaces give all sorts of weathered forms. The sandstone areas have the most striking features, with the almost vertical cliffs, rising in some cases to 200 feet or more. The scenery of the driftless area is not excelled by any in the State, or along the Ohio Valley, or indeed, by any in the Middle West.

Most of the streams of the State would afford good water power; many examples of good power sites are present which could be utilized with little cost. Rock exposures in the bed of some of the streams afford greater fall and at the same time good solid bases for dams or other works to be constructed.

An accurate topographic map of the State would show the contrast in the physical features of the glaciated and the unglaciated portions better than any other description or illustration that could be given to a person who had not been over the area to investigate the contrast. In the glaciated area the lines would run in large regular curves and far apart, showing the smoothness and regularity of the surface. South of the drift limit the lines would be close together with a very winding course and sharp curves, showing a region of deep, narrow valleys, irregular divides and abrupt cliffs.

POPULATION AND LAND VALUES.

About four-fifths of Indiana is in the glaciated area.

Excluding Indianapolis, about one-eighth of the population of the State is in the unglaciated area. New Albion and Jeffersonville, although included in the unglaciated area, really do not belong in that class but are river valley towns and their population has been increased by the condition of the surrounding area.

The next largest towns in the unglaciated area are, Bloomington and Bedford, with populations of about 9,000 each, with no other towns coming up to this size by less than half.

In the unglaciated area the average per cent. of the land under cultivation is about 60 per cent. and is valued on the average at about \$40 per acre, while in the glaciated area over 75 per cent. is under cultivation and sells on the average at \$85 per acre. The average is lowered greatly by the sand hills of Lake County. In the central counties about 95 per cent. of the land is under cultivation, and much of it sells at prices ranging from \$100 to \$150 per acre, or even more where within a few miles of good market centers.