The History of Indiana During the Glacial Period.

CHAPTER I.

PREGLACIAL INDIANA.

To reconstruct the history of Indiana during the glacial period we must first glance at the INDIANA of late Tertiary times.

Newsom—Proc. Ind. Acad. Sc. 1897. pp. 250-3.

The *general topography* of the state would have shown us various physiographic provinces distinguished from one and another by characteristics.

Leverett—U. S. G. S. Mon. No. 41, p. 77.

The southeast section we might have called the *Cincinnati Island.* The soil of the hills and valleys was underlain by limestones and shales of the Ordivician and Silurian age and due to a Paleozoic uplift this province stood higher than the regions to the west and northwest of it.

Note—In this region at the headwaters of the White and Whitewater Rivers in Randolph and Wayne counties, we still find the highest elevations in the state.

To the west of the Cincinnati Island is a broad north and south valley, which at first glance might seem the valley of a mighty glacier draining stream, but which closer investigation shows is a valley formed by many subaerial degradation agencies in the soft underlying shales of Devonian age. This region with next to be mentioned we might call the Devonian Valley.

Note—Newsom calls this the Eastern Lowland, a term which does not describe it clearly enough it seems.

Proc. Ind. Acad. Sc. 1897, pp. 250-3.
Leverett, No. 41, p. 76.

Running southwest across the central part of the state, just north of the *Cincinnati Island,* was another wide valley, 50 miles or more in breadth. This valley included most of north eastern Indiana up to where the Mississippi limestones began to outcrop in northeast Indiana and Benton and Fulton counties. The soil of this *Northern Devonian Valley,* as we might name it, was underlain principally by shales of the Devonian age, as in the case of the previous valley, with which it communicated on the south.

The western boundary of the Devonian Valley was a distinct escarpment of sandstone knobs of Mississippian age. West of these was the *Western Upland* which the streams were reducing to a base level by carving out their valleys in the Mississippian and lower Pennsylvanian limestones, shales and sandstones. This upland was limited in the north by the Northern Devonian Valley, although there was a remnant of it found in a water divide extending southwest and northeast in Benton County.

From the Western Upland and extending over into Illinois, was the *Western Lowland,* gradually sloping to the west. This had been cut out of the shales ofthe Upper Pennsylvania age.

Leverett, U. S. G. S. Mon. No. 38, p. 460.

This sketch of Pre-pleistocene Indiana, in the region covered by the glaciers, is only a reconstruction, due to the fact that most of the bedrock of the state is covered by 25 to 300 feet of glacial drift which hides the original topography.

General Lines of Drainage.

Since we have reconstructed the various physiographic regions of late Pliocene Indiana, let us get a general idea of the drainage of those days.

The drainage lines of the driftless region can be fairly easily located for Pliocene times. But when we remember that with the exception of the lower courses of the Wabash, White and Ohio Rivers, most of the other drainage lies on the glacial deposits, 25 to 300 feet thick, over the old pre-glacial courses, we can see the difficulty in trying to locate pre-glacial lines of drainage.

However, from well borings, we have traced the courses of some pre-glacial streams, and have determined the dip of the bed-rock, and from these data we can get a general idea of the drainage of those days before the coming of the glaciers.

Leverett, No. 38, pp. 529-30.

The Northern Devonian Valley with its dip of 20 feet to the mile, must have had a pre-glacial Wabash running down its axis, we find its continuation, in a valley from about Lafayette south, and certainly from Covington south. At Terre Haute the present Wabash River is flowing over 100 feet of glacial gravel while the pre-glacial bluffs show in each valley face 5 miles apart. The head of the pre-glacial Wabash may have been up in Lake Michigan but more likely it wandered down the steeper northwest, dipping limestones of the Cincinnati Island where a pre-glacial valley has been traced under the glacial drift by well logs, from Shelby County, Ohio, to Blackford County, Indiana. This pre-glacial Wabash was a larger stream than its present successor as shown by the width of its valley, which the present stream has not cleared out much above Terre Haute in its meanderings. After making a great bend above Covington it swung to the south down the Western Lowland where its valley widened to 15 miles at its junction with the Ohio River.

Leverett—No. 38, pp. 532-3.

Joining the Wabash River near its mouth is the White River, which from Worthington southwest meanders around in its pre-glacial valley, across the Western Lowlands. From Worthington northeast to Martinsville the West White River lies in its pre-glacial valley in a number of places. From Martinsville its course is so drift covered that it is at present impossible to say just what its pre-glacial course was. However, judging from the size of its pre-glacial valley below Martinsville, it must have headed above Indianapolis on the Cincinnati Island and flowed down the Devonian Valley, through the Knobstone escarpment, across the Western Upland to the Western Lowland. This course must have been carved out before the slow Tertiary uplift. The course above Martinsville will have to be shown by well logs, to the bedrock.

Note—A study of the well logs in Indianapolis would show something about the rock surface and probably determine whether the pre-glacial White River passed through there.

The greater part of the course of East White River was not affected to a great extent by the glacial drift and an analogy it shows something of the pre-glacial course of its neighbor, the West White River. With its tributaries, the Muscatatuck, the Flat Rock, etc., it heads up on the Cincinnati Island and wanders down the Devonian Valley, showing considerable reluctance to crossing the Knobstone escarpment. Then it gets across the Western Upland fairly quickly and joins the West White River down in the Western Lowland. As I have said above there is little drift in this river's valley and so a study of its course would show many of the characteristics of a pre-glacial stream.

Note—Proc. Ind. Acad. Sc. 1901, pp. 222-237. A study of Beanblossom Creek valley made some years since by Profs. Marstera, Cumings and Beede is valuable on this point.

Leverett, No. 38, pp. 97-101; 532.

On the western edge of the Western Upland three northward flowing streams joined the East White River in valleys which later were covered with glacial lucustrine deposits. These we will speak of later as Lake Patoka.

Leverett, No. 41, pp. 185; 323-4.

Flowing down the strike of the limestone beds of the Cincinnati Island was a stream heading about in its present place and finally emptying into a pre-glacial Ohio. The pre-glacial Whitewater valley must have been about the size of the present valley, as shown by well borings and was at least 100 feet below the present drift, which covers the valley floor, the tributary valleys and some of the slopes.

Leverett, No. 41, pp. 109-111.

Heading above Cincinnati and flowing through much of it present valley was a smaller Ohio. This valley was old as a trip from Vevay to Louisville will show, the bluffs in most cases standing quite a distance back from the river valley with their slopes soil covered. In Indiana, this pre-glacial Ohio came the dip of the Cincinnati Island uplift, wandered through the Devonian Valley which is narrow from east to west here, crossed the Western Upland in a southwest direction and was finally joined by the pre-glacial Wabash in the Western lowlands.

The upland of the Mississippian limestones in Benton County and east, which here formed the northern Devonian valley's northwest boundary, must have been a pre-glacial water divide. On the northwest side must have headed streams flowing into the Illinois River. However, as the drift is thick here and well borings are not numerous in the old lake Kankakee bottoms, we have not determined the course of any pre-glacial stream here.

Conclusion.

The main lines of pre-glacial drainage seem to have been, (1) down the northern Devonian valley and the western lowland, through a pre-glacial Wabash; (2) across the various physiographic provinces of Indiana through a pre-glacial Ohio; (3) midway between these a pre-glacial White River across the provinces.

THE GENERAL SURFACE.

In an attempt to reconstruct the general surface of Indiana, before the coming of the Pleistocene glaciers, we would be helped much be recalling the general surface of the present driftless region of Indiana.

A trip through southwestern Indiana shows even an amateur observer, certain general characteristics which are observable over quite an extensive area. One of these which is quite common is the fact that the hill slopes are usually covered with a thin mantel of residual soil. Erosion here is at a maximum for the state. Another fact observable almost anywhere is that the valley bottoms are filled with alluvium brought down from higher levels.

Going across the various physiographic regions from east to west, one finds himself in a succession of narrow and wide valleys. A little investigation shows that this is determined by the kind of rock underlying the surface. The same kind of rock always produces the same kind of valleys.

The strike of the rock outcrops is generally north and south. The major streams seem to follow these strike lines, whi.e the minor streams come in at right angles to the strike, following the dip to the southwest.

In the upper courses of many of the streams we find clean, rock-ribbed valleys, showing the youth of the valley, while in their lower courses we find flood plains and meanders, showing the maturity of the stream.

Along the valley sides we usually find springs at the contact line of overlying pervious strata with underlying impervious strata.

All the above characteristics mark the present driftless region of the state.

Now let us see what the general surface of the present drift covered region in the late Pliocene times.

In tracing the various physiographic provinces of Indiana, we saw how the underlying rock in central, northern and eastern Indiana is the same as in southern and southwestern Indiana. The Devonian valley of the driftless region being continuous with northern Devonian valley of the drift covered region. The Cincinnati Island being so thinly covered that its rock basement outcrops continually. And the western upland only being covered at its northern end. We have other evidence of the continuity of the rock basement in well logs which are especially full in the case of gas and oil wells. Also the drift has in it bowlders dragged from the underlying rock which shows the constitution of the underlying rock. Likewise, we have, in numerous places throughout northern Indiana, shown by well borings the presence of deep river valleys under the drift. So all this evidence of the continuity of the rock surface in both the drift covered and the driftless region, the presence of buried drainage channels, etc., convince us that before the glaciers came, drift covered Indiana must have looked considerably driftless.

That is, there was thin soil on the valley slopes. This is shown in the region of the Illinoian drift. There the drift is thin on the slopes where the thin soil allowed the ice to move fast and thick in the valley bottoms where the residual soil impeded the ice and added to the moraine deposits.

In the valley bottoms were alluvium flood plains. In the valleys having the same kind of rock we would find the same general kind of valleys. The tracing of buried channels as the one from Shelby County, Ohio, to Blackford County, Indiana, has shown this. The main streams followed the strike of the outcrops and their tributaries the dip. In the upper courses the streams were young and in the lower courses older. While the presence of the water table far up in the drift might show a contrary fact, still in getting good wells in the drift region as in Indianapolis, the driller goes below the drift, below the black shales, almost to the bottom of the pervious limestone, showing practically the same occurence of water conditions in the drift region as in the driftless, a pervious strata underlain by an impervious one.

Conclusion.

To conclude this review of Pre-glacial Indiana, I will quote the words of an observer of a section of the drift region as to what he thought Indiana looked like just before the coming of the ice fields.

Capps, U. S., Water Supply Paper No. 254, p. 24.

"The land surface was cut into ridges and valleys and the streams established well developed drainage lines. This was the condition at the beginning of the glacial period."

CHAPTER II.

THE COMING OF THE GLACIAL LOBES.

During the late Pliocene times of the Indiana which we have just reconstructed, a gradual change was taking place in the climate.

Chamberlin and Salisbury, Vol. III, p. 320.

It was becoming cooler as evidenced by the plant and animal life. It was less humid. With this cooling, slowly there advanced from the north and northeast great ice lobes which covered Indiana at times almost completely, and at other times retreated to the north and northeast to return again and again.

THE CAUSE OF PLEISTOCENE GLACIATION.

Now to account for this cooling of the atmosphere and the advance of the ice lobes from the north, many of the world's best physicists, physical chemists, astronomers and geologists have applied themselves with the result that we have a number of hypothesis which we will review.

THE ELEVATION HYPOTHESIS.

Chamberlin and Salisbury, III. pp. 424-6.

As today we find most of the glaciers on elevated tracts of the earth, so many geologists think that to produce the enormous bodies of continental glaciers which must have existed in the Pleistocene times, we must have had great elevations in that time on whose tops were produced the continental glaciers. Now this sounded very reasonable until we began to learn more concerning glaciation in earlier periods of the world's history. We learned that there was extensive continental glaciation of Australia, South Africa, and India, not more than 23 degrees north or south of the equator in Permian times. Also we found out that Australia and South Africa were not elevated tracts at that time. So the elevation theory of the origin of Pleistocene glaciers is not borne out by the Permian glaciation facts. Likewise, why should not the greatest elevated tract of the world, India, be glaciated today as it was in Permian times before it was elevated? Another objection to this hypothesis comes from its inability to account for the successive advances and retreats of the various ice fields within a comparatively short time. Altogether the objections to this hypothesis have caused it to be dropped as a theory to entirely account for Pleistocene glaciation.

The Crollian Hypothesis.

Chamberlin and Salisbury, III. pp. 426-31.

At the present time due to the inclination of the earth's axis and the ellipticity of its orbit, at the time that the northern hemisphere is closer to the sun, we receive the less direct sunlight and vice versa when we are the farther away. But in 10,500 years the conditions will be reversed. Then when the northern hemisphere is the closer to the sun it will receive the greater amount of direct rays of the sun during a short summer and during a long winter it will receive the less amount of rays. According to the Crollian hypothesis this will produce conditions which will bring about glaciation in the northern hemisphere in 10,500 years and glaciation in the southern hemisphere 21,000 years hence. This theory would be workable were the facts of Pleistocene glaciation in accordance with it. But they are not. For instance, we know that the Labradorean ice fields advanced at least 1,500 miles from its gathering ground. Now if we allow 365 days in each year for it to advance, giving it one foot advance each day, it would take it 21,698 years to advance 1,500 miles, as long as the hypothesis allows for both the advance and retreat. This objection seems to invalidate the hypothesis to wholly account for the Pleistocene glaciation.

The Wandering of the Poles.

Chamberlin and Salisbury, III. pp. 431-2.

If the poles should be pulled further south and north of their present positions, according to another theory, we would have polar ice caps created in the new polar regions, which would be continental glacier centers from which would move out ice fields. The fields would then repeat the glaciation phenomena of the Pleistocene and Permian times, with its localization of ice fields. This theory has many advocates, especially among those who believe in a liquid interior of the earth. The rolling of this molten mass in the interior of the earth causes the shifting of the poles according to them. But as most of the geologists of today believe that the earth's interior is a rigid mass, there are few who can postulate a force great enough to cause the shifting of the poles 15 to 20 degrees which would be necessary to bring about the localization of the ice fields of the Pleistocene times, in North America and Europe. To back up this objection an intensive observation of the wandering of the north pole during the last twenty-five years discloses the fact that it has wandered in a very small circle during that time. So this theory, also, to wholly account for Pleistocene glaciation, is being dropped.

THE DEPLETION THEORY.

Chamberlin and Salisbury, III., pp. 432-445.

A more pretentious theory has been set out by Arrhenius and other European physical-chemists and broadened by personal studies and elucidated in this country by Chamberlin. The basic facts in this theory are that during Pliocene times we had a continuation of the Tertiary uplift movements, with the consequent increase of land surface. The result of these movements was the increased consumption of carbon dioxide by land vegetation. This, with the shifting of currents poleward, lead to the greater depletion of the atmosphere of its carbon dioxide both by the vegetation and the cooling waters. With the decrease of the CO_2 in the atmosphere more and more sunlight was radiated back into space with the consequent fall in the earth's temperature. With the fall of the earth's temperature snow fields commence to form with consequent glaciers which moved out from the centers. As the continental glaciers covered more and more of the earth's surface and the cooled waters of the ocean became super-carbonated, a reverse movement toward the repletion of the CO_2 in the atmosphere commenced with a consequent rise in temperature and the retreat of the glaciers. This pendulum-like swing repeated itself until we think it reached its lowest node and has finally died out; in this recent period at least. This theory seems to conform to most of the observed facts and is widely accepted throughout the geological world.

Annals Astro-physical Observatory, Vol. 2, 1908, p. 172, 175.

However, since Chamberlin stated his views on this theory, it has been discovered by later observers that it is water vapor rather than carbon dioxide which plays the part of blanketing the sun's rays. So if in the above we substitute water vapor in the place of carbon dioxide we may thus account for fluctuating temperatures and consequent glacial periods.

The Localization of the Ice Fields.

Chamberlin and Salisbury, III., pp. 330-333.

Whatever the cause of glaciation, we do know that at the beginning of Pleistocene times in North America that ice fields began to move out from certain definite forming centers.

The Cordilleran Field.

The one which still has remnants left is the Cordilleran field. This lay in the Canadian Cordilleran plateau of British Columbia, surrounded by mountains. This center was more of the Alpine type of merged glaciers than of the continental type of further east. The striations made by the ice field in moving over the bedrock show that it moved principally to the west through the passes of the coast range; also, it moved south but whether much beyond the United States border is undetermined.

Note—However, Stewart, (Journal of Geology, XXI, 1913, p. 430,) believes it moved further south than credited at present. There was also some movement east and some to the north-west. This icefield however played little part in the glaciation of the United States and absolutely none in that of Indiana.

The Keewatin Field.

West of Hudson Bay on an old Precambrian plain gathered another ice field which moved out from its center principally south and southwest 1,500 miles to Kansas and Missouri and west and northwest 800 to 1,000 miles to the foothills of the Rockies. This was a continental glacier with a probable level center and steep sloping fronts on its edges. As to its thickness, no intensive or accurate studies have been made, but the thickness of morainic deposits show that it must have been considerable. The deposits of this ice field lie thick in our western states.

The Labradorean Field.

East of Hudson Bay gathered another ice field which was of great importance to Pleistocene Indiana. Its greatest movement was to the southwest where it reached 37 degrees 30′, about 1,600 miles from its source. This field was responsible for the glaciation of New England, the East-central states, Ohio, and a great part of Indiana, as well as further west. Its traces are shown in the Archean bowlders of its parent area which are strewn throughout the drift of this region.

The Successive Ice Advances and Retreats.

Criteria.

The successive advances and retreats of the Keewatin and Labradorean ice fields have been worked out at their ice edges, where they made their last morainic deposits. By a careful field study of the drift, the till, the bowlders, the pebbles and the topography of the morainic hills over the drift covers region along with a study of the peat beds laid down between successive drifts, glacialists have been able to determine a series of criteria by which they identify the age of the various deposits they meet. To check these they also use the direction of the striae which are found on the bedrock over which the ice field passed. These criteria seem rather indefinite to a stragraphic and lithologic geologist but evidently field work with them makes them more certain tools to work with, in the hands of the glacialist.

The Succession in North America.

Chamberlin and Salisbury, III., pp. 383-405.

Chamberlin has worked out a succession which has been the standard section for a number of years. His succession with Leverett's identification of the Indiana section is as follows:

Chamberlin's North American section; bottom up.			Leverett's Indiana section (Dryer's). U.S.G.S. Mon. No. 38, 41.,
I.	Subaftonian	Earliest glaciation	Wanting
II.	Aftonian	1st interglacial	Wanting.
III.	Kansan	2nd glaciation	Wanting.
IV.	Yarmouth	2nd interglacial	Not identified.
V.	Illinoian	3rd glaciation	Illinoian of Southern Indiana.
VI.	Sangamon	3rd interglacial	Probably in patches.
VII.	Iowan	4th glaciation	Loess present in Southern Indiana. Dr. Beede finds edge of driftless region.
VIII.	Peorian	4th interglacial	Not identified.
IX.	Early Wisconsin	5th glacial	Early Wisoncsin.
X.	Unnamed interglacial	5th interglacial	Peat beds of Western Indiana.
XI.	Late Wisconsin	6th glacial	Late Wisconsin.
XII.	Lacustrine	Retreating	Lake Maumee etc.
XIII.	Champlain stage	Last submergence	Early present Wabash.

The European Succession.

Glacialists have been especially busy in Europe for a long time, working out the succession of the Pleistocene ice fields. A few years ago, one of our most noted field workers in glaciology, Mr. Frank Leverett, spent a year in the European field and in 1910 gave us this correlation of European and North American sections.

Leverett, Zeitscrift Gletscherkunde, 1910, pp. 241-336.

England.	Germany	Alps.	Alps foreland.	North America
....	Scånian..........	Gunz.......	Older Decken-scotter. ...	Subaftonian
Norfolkian....	Paludinenbank....	Gunz-Mindel................		Aftonian.
Old Drift....	Lower Diluvium.....	Mindel.....	Younger Decken scotter...	Kansan.
....	Rixdorf...........	Mindel-Riss................		Yarmouth.
....	Middle drift......	Riss........................		Illinoian.
....		Riss-Würm..................		Sangamon.
Younger drift	Upper Diluvium......	Würm......	Unterrassen.....	Wisconsin.

This is the first attempt of any importance at correlation by a field worker in both countries and will probably be improved upon by later students in both fields.

The Indiana Lobes.

As will be noted from the above, there is present in Indiana, deposits from the Illinoian to the late Wisconsin times and it might be well to point out some facts concerning the lobes of the ice fields which made these deposits.

The Illinoian Lobe.

Leverett, No. 38, pp. 22-31.

This lobe pushed down from the Labradorean region and occupied all of Indiana with the exception of a triangle of counties east of the Wabash and White Rivers, south of Morgan County and west of Columbus, Seymour, Brownstown and New Albany.

The Saginaw Lobe.

Dryer, 17th Ind. Geol. Report, pp. 131-32; 18th Ind. Geol. Report, pp. 28, 227.

Advancing down Saginaw Bay, a narrow tongue of ice was thrust out in front of the ice field and although not very heavy, as evidenced by its smaller moraines, it advanced from the northeast into Indiana as far as Fulton County. However, it was soon pressed back on both the northwest and the southeast by two larger and heavier glaciers, the Erie and Michigan Lobes and depositing its load of drift, retreated to the northeast forever.

The Erie Lobe.

This large and heavy lobe bringing with it bowlders and pebbles from the Canadian highlands came into Indiana from Lake Erie, occupied the great northern Devonian valley, and after awhile retreated slowly to the north, leaving great crescentic moraines behind along the Wabash drainage and interlobate moraines piled on the smaller Saginaw moraines through Kosciusko, Whitley, Noble, Lagrange, and Steuben Counties.

The Michigan Lobe.

This lobe coming from the Canadian highlands was forced to the west by either the Erie lobe or the easy slope of the Michigan valley. It covered northwestern Indiana down past the Kankakee at least. When it retreated, it left behind the rolling Valparaiso moraine and long remained in the Michigan lake bottom supplying the water from its ice front which made glacial Lake Chicago.

The Length of Time.

As we almost touch the Pleistocene time, it is of great importance to us to estimate its length and the time which has elapsed since.

The Time Elements.

To judge correctly the length of Pleistocene times, there are many elements to consider First, there is the time of the gathering ice fields, a mazy period. Second, there is the time of advance of the ice field, an estimate based on moving ice fields today. Third, the time of retreat, an estimate based on present glaciers, present ice fields, and the field study of weathered drift, and weathered peat beds. Fourth, there is the time of rest and interglacial periods. Lastly, there is the time since the last retreat up to now, a fairly accurate estimate of which is being made by the study of Niagara Fall's rate of cutting its gorge. Now all of these vary in the case of the successive sheets, and so only general estimates have been made.

Some Time Computations.

Chamberlin and Salisbury, III., pp. 413-421.

Chamberlin has given the following estimate of the length of Pleistocene times.

1 time unit—Climax of Late Wisconsin to present day.

1 unit	Climax of Late Wisconsin	20,000—	60,000 years ago.
2-2½ units	Climax of early Wisconsin	40,000—	150,000 years ago.
3-5 units	Climax of Iowan	60,000—	300,000 years ago.
7-9 units	Climax of Illinoian	140,000—	540,000 years ago.
15-17 units	Climax of Kansan	300,000—	1,020,000 years ago.
X units	Climax of Subaftonian	x	y....years ago.

Penck and Brückner after an intensive study of Alpine glaciation extending over many years, give us the following estimate of European Pleistocene time extension:

Penck and Bruckner, Die Alpen im Eiszeitalter, Vol. III.

1 time unit...Würm to present time.

1 unit	Würm (Wisconsin)	16,000—	24,000 years ago.
3 units	Riss (Illinoian)		60,000 years ago.
12 units	Mindel (Kansan)		240,000 years ago.
18 units	Gunz (Subaftonian)		360,000 years ago.

It will be noted that the North American Pleistocene is some longer than the European Pleistocene, provided they were contemporaneous. However, these figures are not to be taken literally, but instead they represent more or less varying periods of relative time.

The Time Since.

Glacialists have been more successful in their estimate of the time elapsing since the lacustrine stage of the Pleistocene. G. K. Gilbert and Frank Taylor have taken the rate at which Niagara cuts its gorge back each year and after getting a mean, they have laid this foot rule down and measured the valley of the Niagara from the falls to the escarpment at Kingston. The latest results of Mr. Taylor's study gives an estimate of 20,000 to 30,000 years, since the last ice left the Erie basin. This estimate coincides fairly well with Penck and Brückner's estimate of time since the last stage of Alpine glaciation, the Würm.

Conclusion.

We have seen something concerning the cause of the glacial period, something concerning the immense ice fields, and the way in which they followed one another. We have also estimated the length of time of this work. Now let us study what these glacial lobes left behind them.

CHAPTER III.

THE GLACIAL DEPOSITS.

When the ice lobes, which we have just described, were advancing into resting on, and retreating from the surface of Indiana, they were doing physiographic work which was to change the face of Indiana radically. This work was that of cleaning off the rotten rock from the decayed rock surface and filling the valleys and hilltops with masses of clay, sand, gravel, pebbles and bowlders. This drift was pushed on under and in the mass of the ice lobe and was left on the land when the ice lobe melted and retreated. Some of it was washed out from under the edges of the lobes and in stratified beds it lies down the river valleys or as great outwash plains on the uplands. But, in the great part of the drift was left inextricably mixed, clay, bowlders, sand, gravel, and pebbles, either as morainic hills when the ice paused in its retreat for awhile or as a gently undulating ground moraine plain, which the ice left behind in its steady retreat northeast and north.

The Moraines.

As the most prominent feature of glacial deposits are the moraines, let us look at some Indiana moraines for a time.

Method of Deposit.

Early glacialists in studying continental glaciation discovered the remarkable resemblance between certain continental deposits and the terminal moraines of mountain glaciers. So by a careful study of mountain glaciers they have come to the conclusion that the large morainic ridges running in many directions over central and northern Indiana were formed from the rotten rock pushed forward by the ice lobes. When the ice stood still for a time, at its edge accumulated a greater load which rested as a ridge along the ice front. Often in front of this ridge, the glacier draining streams made outwash aprons and kames of stratified gravel and sand. Then when the ice commences to retreat again, these ice front deposits were left as ridges, knolls, etc., on whose surface the weathering agents commenced to work, making them still more diversified. This is the moraine of today.

The Appearance of the Moraines.

Leverett, No. 38, p. 195; Ibid., No. 41, pp. 512, 539, 570.

The general characteristics of moraines which one notices as he rides from Indianapolis to Richmond or from Indianapolis to Fort Wayne or Chicago, is that they are ridges. Often these are single ridges as in the case of several of the late Wisconsin moraines southwest of Indianapolis. At other places they are parallel ridges, as in the case of the Valparaiso moraine in places. Still, again they may be a broad rise covered with knolls standing 10 to 20 feet above the drift with hollows irregularly occurring between them. This kind of topography Dryer found in Whitley County, especially. In these hollows are where the beautiful Indiana lakes of kettle hole origin in Noble, Steuben, Lagrange and Kosciusko Counties occur. However, the ice may have stood at this moraine edge such a short time that these knolls, hollows and undulations are conspicuous by their absence. And it is only as in the case of the Illinoian moraines, by viewing the front relief of 30 feet to 50 feet that we see that we are on a morainic ridge. In fact it only after long field identification of glacial deposits that one can make a general classification of morainic ridges. On this point Dryer has shown the great extremes in the same kind of morainic ridges.

Dryer, 17th. Ind. Geol. Report, p. 163.

In Whitley County in describing the Mississinewa moraine he says: "The country is entirely occupied by deep irregular, elongated valleys with narrow, sharp winding ridges between, all in inextricable, indescribable and almost unmappable confusion. It covers in all scarcely more than 40 square miles, and the greatest differences of level do not exceed 100 feet. The roads through it are very crooked in order to avoid the marshes, ... The ridges are composed of rather barren clay and the valleys occupied by marshes and tamarack swamps, ... Another strange peculiarity is that a country which so abounds in depressions is almost devoid of lakes."

Then in contrast he says: "The first and second moraines, (the Fort Wayne and the Wabash), are well defined ridges, but present only occasional evidences of the peculiar topography regarded as characteristic of terminal moraines. Hills, knobs, kames, kettle holes are chiefly conspicuous by their absence."

Dryer, 18th Ind. Geol. Report, p. 88.

The Composition of the Moraines.

In order to appreciate the economic importance of these moraines, a glance at their physical and chemical makeup is instructive. The sections are usually obtained in railroad cuts, stream banks and knolls which have been opened to obtain gravel.

The importance according to the occurence of the constituents in the morainic ridges are glacial till (glacial clay), sand, gravel, pebbles, and bowlders, all unstratified.

Capps, U. S. Water Supply Paper, No. 254, pp. 29-30.

This glacial till or rock rot as Chamberlin and Salisbury called it in 1885, is the usual matrix in which we find bowlders, pebbles, etc., as Capps says: "They consist of a heterogeneous mixture of glacial debris, composed of great bowlders, pebbles, and bl)cks of rock, mixed indiscriminately with sands and clays. The common matrix of this unstratified mass is a blue clay." This till is the Miami clay loam of the Indiana soil reports and although a heavy, cloddy soil makes extremely rich corn land.

The Sand and the Gravel.

The beds of sand and gravel vary in color and texture according to the nearness of the deposit to water courses and lakes. In the Valparaiso moraine we find much dune sand while the gravel pits around Indianapolis show rough angular brown to gray grains of sand gravel. These pockets of sand and gravel are what make the knolls of the moraines so valuable. The roads of the surrounding are always graded from this material. And as we use more and more concrete in our building operations, more of these sand and gravel deposits will have concrete block factories located near them.

The Bowlders.

Leverett, No. 38, pp. 66, 356-7. Ibid., No. 41, pp. 37, 261, 574-5.

Strewn on the surface in belts and mixed in the till are many large bowlders running from the size of one's fist to the size of a bushel basket or larger. These bowlders are granites, gneisses, schists, quartzites, greenstones and sandstones of the Canadian highlands and limestones of the Ordivician, Silurian and Devonian times of Indiana. These bowlders are interesting geologically as they tell us of the parentage of the deposits, but economically they are a hindrance to the cultivation of the farm lands. The early cultivators of northern Indiana not only had to clear the land of trees, but they had to clear the land of bowlders also. And today, even, they are ploughed up and must be stacked in the fence corner to accumulate weeds around them. The only economic use I ever noticed these have been put to, is to make cobble-stone porches, fire-places and fences.

Note—In a fence about a square long and 3 feet high in Irvington, I have found that the bowlders average 1 foot in diameter and are about 75 per cent of Algonquin and Archean origin. These bowlders were hauled in from the surrounding fields.

The Drumlins.

Undoubtedly these long ellitical hills composed of morainic material which accumulated under the lobes must be present in Indiana. But none of the observers whose reports I have read have described any and so I conclude that either the conditions for their formation were unfavorable or else they have not been identified yet.

Eskers.

These beds of sub-glacial streams which now show as smooth-sided ridges which wind across the ground moraine like snakes, have been found by Dryer in Noble County.

Dryer, Jour. Geol., IX., pp. 123 et seq.

There High Lake lies between two branches of one. Further west he found another esker, 2½ miles long, and 40 feet high, which makes an almost complete loop around Gordy Lake.

Leverett, No. 41, pp. 475-84.

Leverett found what he thought was an esker leading north from Muncie, almost connecting the Union and Mississinewa moraines. These deposits are made up of stratified beds of gravel and are valuable as a source of road metal.

Some of the Indiana Moraines.

Leverett, No. 38, pl. VI. Ibid., No. 41, pls. II., XI.

These ridges with their varied topography and varied composition wander over Indiana varying the surface and changing the preglacial drainage to a remarkable degree. Let us locate some of them.

THE ILLINOIAN MORAINE.

This moraine is difficult to trace as its edge is not marked by a definite ridge. We can only tell when we come to the border by the drift deposits dying out, the pre-glacial surface appearing with the pre-glacial drainage on it.

Leverett, U. S. W. S. P. pl. II.

The border of this moraine enters the state from Illinois at Mt. Vernon and runs northeast past Petersburg nearly to Shoals, then north along the western edge of Monroe County which it cuts on the north. After cutting east along Bean Blossom in Brown County, it drops south along the Bartholomew County line, west of Seymour and Brownstown. Then it strikes southeast to about Charlestown where it crosses the Ohio and parallels it on the south to the eastern border of the state.

Leverett, No. 41, pp. 271-2, 283-5.

This border region is characterized by a stony clay usually yellow for 5 or 6 feet down and then blue clay throughout the drift below. There are present some sand and gravel beds but no bowlder belts.

THE SHELBYVILLE MORAINE.

Leverett, No. 38, pp. 191, 193, 194, 195, 197, 198, 208.

This moraine of the early Wisconsin glaciation, (according to Leverett), is marked by a sharp rise of 20 to 50 feet in the relief at its border on the underlying Illinoian drift. However, there are a few ridges and knolls only on its surface. So it is difficult to trace as it comes into the state west of Terre Haute, then north along the Wabash River, where in northern Vigo County it crosses the Wabash River to Parke County and continues north on the divide between the Wabash and Big Racoon Creek to Montezuma. It then goes east across Parke County to Bainbridge, where it swings south to near Greencastle. From here it moves east and south through Putnam and Morgan Counties past Mooresville and from here on to the south of Franklin in Johnson County it becomes feebler and in the latter county is finally over-ridden by a later Miami lobe glacier. This moraine is made up of brownish yellow till for 6 to 8 feet down. Below this exidation line it comes a blue gray till. In the average, 40 feet of morainic deposits there are some sand and gravel beds.

The Union Moraine.

Leverett, N. 41, pp. 475-9; 480-4.

Entering the state at Union, Indiana, and continuing west down the north side of West White River through Randolph County to Selma in Delaware County is a smooth gentle ridge with undulating surface. The swells on it rise 15 to 30 feet above the surrounding plain. A typical section of the morainic ridge would show:

4. Yellow till.
3. Gravel.
2. Sand.
1. Blue till.

The Mississinewa Moraine.

Leverett, No. 41, pp. 494-6, 498, 500, 505.

The Mississinewa moraine with its front covered by knolls and hollows, filled at places with lakes, rising 20 to 75 feet above the surrounding plain is a noticeable landmark as it comes into the state north of Ridgeville, continues west past Dunkirk and Hartford City; then parallels the Mississinewa for quite a distance and finally crosses the Wabash River above the city of Wabash. From here it strikes to the northeast past Columbia City and Albion and goes out of the state in Steuben County, merged with the Saginaw interlobate moraine. This moraine, of grayish yellow till for 10 feet down and grayish blue below, is 50 to 500 feet thick. Lying on its surface are many bowlder belts.

The Wabash Moraine.

Leverett, No. 41, pp. 545-8, 552-5.

This moraine, which is almost sagitate in outline has much the same topography as the Mississinewa, and was probably formed under about the same conditions of retreat of the Erie lobe. It has an abrupt bluff-like front. Its ridge is varied by knolls. The slope behind runs back a mile or more. It is about 20 feet in thickness. It is mostly glacial till with little gravel, showing poor drainage from the ice front at that time. Much of the ridge is covered by oaks. The moraine reaches from Geneva, northwest past Bluffton and crosses the Wabash River just west of Fort Wayne. Here it turns northeast past Auburn and Butler.

The Valparaiso Moraine.

Leverett, No. 38, pp. 339, 345-7,353, 356-7.

This massive moraine, encircling Lake Michigan in Lake, Porter and Laporte Counties, marks the site of the Michigan lobe when it was being drained south through Lake Kankakee and the Illinois River. It can hardly be separated into ridges and is mostly glacial till although there is more sand and gravel north of Valparaiso than there is to the south of that place. The moraine is marked by knolls, which make it a landmark.

Contrast of Moraines.

Dryer, 17th. Ind. Geol. Report, pp. 117-8.

Dryer has contrasted the Erie and Saginaw lobes' moraines in the following observation, "This valley, (west of the Mississinewa moraine) is an important feature in the topography, because it marks distinctly the dividing line between the Erie and the Saginaw drift.......On the east the hills and the dunes of the fourth Erie moraine are piled in indescribable confusion. The country on the west has about the same general elevation, and is distinctly morainic in character, but is very much more smoothed out. The slopes whether gentle or steep, are broad and plateau-like, their evenness being broken only by an occasional small kettle hole.

The Drift.

We now come to the most important, economically, of the glacial deposits, the drift. Under that heading we will include, not only the ground moraine, but also the outwash plains, the inner border deposits, and the old glacial lake bottoms.

The Method of Deposition.

As the ice lobes retreated, they deposited under the ice the glacial till which they made by crushing up the bowlders, pebbles, gravel, and sand gathered from the land they had moved over. The greater part of this till was a fine rock-flour which oxidized slowly when exposed to the weathering agents. This is evidenced by the fact that the drift is oxidized only to the distance of 5 or 6 feet down although it has been exposed for more than 20,000 to 60,000 years.

The Appearance of the Drift.

Leverett, No. 41, pp. 271-2.

Back from the moraine ridges the ground moraine is a flat, almost featureless plain. From north of Morgantown to nearly Indianapolis, the I. C. R. R. passes through considerable of this kind of country. A trip on any of the northern interurbans out of Indianapolis shows any number of these ground moraine plains, almost as level as a billiard table. The only undulations in the plains are made by the young creeks just beginning to cut into the plain. On these plains the roads run straight on the section lines, and the farms are quarter, half, and whole section size. This is also the country where the farmers grow rich from the yield of the Miami and other clay loams.

The Composition of the Drift.

Leverett, No. 41, pp. 222, 225-6, 254, 261.

The Illinoian drift of southern Indiana is a stony till. It is also thin, especially on the hill tops. Throughout it we find Canadian bowlders mixed with native rocks. A few sections may show its composition more clearly.

Leverett, No. 41, pp. 263-70.

Section in Beanblossom Valley near Needmore, Ind., 50 feet of brown, stony, almost gravelly till.

Section near Chestnut Ridge south of Seymour, Ind., 30-40 feet of fine clay and sand, yellow at surface, but blue at the depth of 16-18 feet.

Section in Ohio River bluff, (Split Rock), near Aurora, Ind., 5 feet silt, top of bluff; 50 feet gray to brown, fine to coarse sand, 50 feet rock outcrops 100 feet glacial conglomerate.

At the top where this drift is oxidized it is a brownish till, but farther down it is a bluish till. It is harder than the later Wisconsin till, due to the cementation of the lime flour in the till. The soil which comes from the breaking down of this till, is a harsh soil to work. It dries out easily and does not yield grains abundantly as does the Wisconsin drift covered region. In fact the whole range of Illinoian drift covered counties does not compare in agricultural wealth with the Wisconsin drift covered counties, according to the 13th census, (Vol. 6, Agriculture, pp. 460-1.)

The Wisconsin drift plain is also flat and undulating. Throughout it we find Canadian bowlders mixed with a few native rocks.

Leverett, No. 21, U. S. W. Paper, p. 10.

The sections show an average thickness of 130 feet with yellowish till the first 10 feet or so, followed by grayish blue till beds of unstratified gravel and sand. The soil of this Wisconsin drift covered region is heavy to work and requires a great deal of cultivation to keep it in shape. However, it yields abundantly, especially in the case of corn. The alternations of clay and sand usually give a soil which absorbs moisture fairly and yet not too fast to allow the roots of the growing crops to take it up as needed. The Wisconsin drift covered counties are the great farming counties of the state and give Indiana the rank she has among the agricultural states.

The Bowlders and Pebbles.

Leverett, No. 41, pp. 263-70.

The bowlders and pebbles of the drift are of the same general kind as are found on the surface of the moraines in the Bowlder Belts. Leverett gives this analysis of a gravel knoll of Illinoian age near Lancaster, Ohio.

Granite—2 per cent of total number of specimens.
Precambrian—9 per cent of total number of specimens.
Chert—2 per cent of total number of specimens.
Quartz—3 per cent of total number of specimens.
Ironstone—2 per cent of total number of specimens.
Sandstone—36 per cent of total number of specimens, (local.)
Limestone—46 per cent of total number of specimens, (local.)
Total 100 per cent.

In Union County, Indiana, he found in a Wisconsin drift region, that only 5 per cent of the pebbles were Canadian in origin. Also in the Salamonie ground moraine he found many fossils of the local Ordivician, Silurian and Devonian limestones. The above shows fairly clearly that while the larger bowlders are mostly Canadian, the smaller ones and pebbles are mostly native rock. This can be accounted for on the ground that the Canadian rocks being of higher specific gravity gradually road higher in the ice lobe and were subjected to less wear and so were deposited last in the morainic ridges or in the top layers of the drift.

The Old Glacial Lake Bottoms.

Leverett, No. 38, pp. 334-8, 424-59.

As the ice lobes retreated, the water from the melting ice front often ponded there and formed glacial lakes. The topography of these old glacial lake bottoms is always easily recognized. The level flat stretches, with not a break in them, is usually bounded by a ridge marking an old beach line. The old glacial lake bottoms are numerous in Indiana, reaching from old Lake Patoka and Lake Flatwoods in southern Indiana to Lake Maumee and its successors and Lake Kankakee in the northern part of the state. When the mucky soil, made up of decayed vegetation, is thoroughly drained, either artificially or naturally, the old lake bottoms become rich farm lands.

The Outwash Plains.

Leverett, No. 38, pp. 208, 375. Ibid., No. 41, pp. 329, 379, 578-9.

Beyond the moraines, stretching down the Whitewater, the Wabash and the Kankakee Rivers are level plains of sandy and gravelly loams. Again on the divides between these streams lay plains of the same kind. At other places, as in the case of the Shelbyville moraine, this plain is almost entirely silt. These outwash plains were formed by the drainage away from the ice front. As the current varied from strong to sluggish, so the deposits vary from coarse gravel to fine silt. These bottom lands are also desirable from an agricultural standpoint.

The Inner Border Plains.

Leverett, No. 38, p. 213. Ibid., No. 41, pp. 561-2.

Close behind the morainic ridges and the ice front, as in the case of the Erie lobe, there was poor drainage and here were swamps and here today we find much black soil, suitable for truck farming.

Conclusion.

In this chapter we have briefly reviewed the moraines and the underlying drift. We have seen something concerning their composition and appearance. We have located some of the chief ones also. Now let us see something concerning the changes in topography brought about by these deposits and the ice lobes which formed them.

CHAPTER IV.

THE TOPOGRAPHIC WORK OF THE ICE LOBES AND THEIR DEPOSITS.

Introduction.

In speaking of the topographic work of the ice lobes and their deposits on the surface of Indiana, let us see what one observer has to say concerning this phase of the Pleistocene history of Indiana.

Capps, U. S. W. Paper, No. 254, (1910), p. 26.

He says, "The ice, moving slowly south, first removed all the soil and loose materials, and then with its base shod with fragments of rock frozen into the ice, gradually wore down the hills and smoothed off the most prominent irregularities. Great quantities of rock debris were picked up and carried by this ice sheet.....The materials which the ice gathered in its southward journey were deposited toward the south or melting edge of the glacier. Much was deposited beneath the thinning edge of the glacier as till, filling depressions and grading over worn rock surfaces."

The Soil.

When the ice withdrew, it left behind drift till, moraines and lakes and with the help of glacial and post-glacial streams these have been spread over glaciated Indiana giving us many different kinds of soil provinces. They are:

(1) Till plains, from the ground moraine deposits especially. These are the rich farms, adapted to grain raising and general farming.

(2) Outwash plains and aprons, stream deposits from the terminal moraines. They have on them orchards suited to the sandy subsoil.

(3) Old lake bottoms, from vegetation accumulating in ice front lakes and inter-morainic ridge lakes. When the soil is properly drained and sweetened they make magnificent truck farms, suitable for raising onions, celery, etc.

(4) Morainic ridges, ice edge deposits on which can be planted orchards and from whose subsoil can be procured any amount of clean gravel for building and road purposes.

Leverett has made a classification of glacial soils according to their composition, which is useful along with my table above.

Leverett, No. 41, pp. 778-81.

His table, as paraphrased by the writer, follows:

Name.	Origin.	Distribution.	Remarks.
Residuary.	Bedrock.	Driftless Indiana.	....
Stony clay.	Glacial till.	On most of the moraines, most of till plains of Wisconsin age. On valley slope of Illinoian age.	Very productive; porous; the good farm land of greater part of Indiana.
Gravelly or stony.	Glacial outwash; old lake beaches.	On interlobat moraines of Wisconsin age; on some Wisconsin moraines; on some Illinoian drift; on glacial outwash; on stream deposits; on deltas in glacial lakes; old glacial lake beaches.	
Sandy.	Glacial drainage; glacial streams; glacial lake beaches.	On beaches of glacial lakes; on lake bottoms; in valleys.	Least productive.
Silty or Clayey.	In part from slowly moving waters; some by winds; also from glacial lakes.	In Maumee region; in Illinoian region.	
Peaty.	Vegetal accumulation and shells..	In regions of imperfect drainage; old lake bottoms.......	Yield large returns in truck farming.

Note—It is interesting to get Leverett's point of view on the formation of various kin ds of glacial deposit soils.

Leverett, No. 41, p. 776.

He says, "The soils of the glaciated portion of the Ohio River basin are largely derived from the glacial drift and the loess and lacustrine silts that cover the drift. . . . . The great agencies involved in producing the soils of the glaciated district, the ice sheet, the glacial lakes, the glacial streams, have long ceased to operate, but modern streams are still at work spreading alluvium over valley bottoms in their flood stages. The small lakes that remain in the depressions of the drift are precipating marl deposits and when drained will give a rich soil."

These two above tables, when used together, one to identify the general region, the other to identify the special region, will give pretty clear field identification criteria for glacial soil.

THE HILLS.

Jour. Geol. XXI. (1913), pp. 422 et seq., 748 et seq.

As the ice lobes stood without advancing or retreating for long periods, as do the mountain glaciers of today, in front of them was carried out the gravel by sub-glacial streams and left there. These stratified deposits of gravel and sand Dryer has found in Northern Indiana and the author has also observed just south of Indianapolis on the I. C. R. R. These are kames and are a source of much good road metal. The I. C. R. R. has used the above deposit for much of its ballast from Indianapolis south for some distance.

While the ice lobe was retreating, some obstruction in its bed caused the accumulation of long, narrow, ellipitical, hills which now arise above the drift plains and furnish ideal locations for healthful homes. As noted above, none of these deposits have been identified in Indiana as yet.

If it were not for the morainic ridges crossing the sky line above the undulating till plains, glaciated Indiana would be rather dreary from an aesthetic point of view. But these ridges dimpled at places by knolls, 20 to 30 feet high, with clear lakelets or green dales between them, furnish variety to the scenery of northern Indiana and give Dryer some backing in his calling some of this region the "Switzerland of Indiana."

THE LAKES.

Leverett, U. S. W. Paper. No. 182, p. 6. Ibid., No. 38, pp. 334-8, 427-59.

In front of the slowly retreating ice lobes, accumulated the melting ice which could not be drained away by the outlet as fast as it changed from glacial ice to ice-cold water. In front of the Erie lobe, in the Maumee basin, was such a glacial lake and as the lobe retreated, exposing lower outlets, its basin outline changed and it built up a succession of lower beach lines. To this glacial lake has been given various names, according to the position of its beaches, such as Lake Maumee, Lake Whittlesey, Lake Warren, Lake Algonquin, Lake Nipissing, etc. In front of the Michigan lobe was a series of lakes, shallow and marsh-like, called Lake Kankakee. Later when the Michigan lobe retreated to Lake Michigan basin and the outlet wss shifted west, the ice front lake was called Lake Chicago. Scattered through Indiana were a number of lakes which were formed by the ice lobes backing up streams and ponding them. Such lakes were Lake Patoka, made by the ponding of the upper, middle and lower Patoka by the Illinoian lobe; Lake Beanblossom, formed by the ponding of Beanblossom Creek at Gosport and Lake Flatwoods in Monroe County. The effects of the presence of these lakes, all of which are known by the level stretches of rich farm land and the bluff-like beaches, was to change the drainage of pre-glacial times to that of the present day. These lakes also left behind rich farm lands, whose price is above that of the surrounding country. Also, a fact which is not of so great importance today as it will be a hundred years hence, they left behind them immense deposits of peat, almost lignitic today, an immensely valuable fuel asset to northeastern Indiana.

The Present Day Lakes.

Dryer, 17th. Ind. Geol. Report, pp. 123-7. Ibid., 18th. Ind. Geol. Report, pp. 73, 121-3.

As the present drainage began to establish itself, much of the water along the morainic ridges, especially in Steuben, Lagrange, Noble, Whitley, Fulton, Kosciusko and Elkhart Counties found itself compelled to wander back and forth through the dales scattered haphazard along the ridges. Finally most of them found an outlet to Lake Michigan or Lake Erie. The diversity of the valleys of these kettle hole lakes is what makes them so beautiful. For instance, Lake George (Steuben County) has low bowldery shores, while James Lake (Steuben County), is divided into five basins and one half mile further on is Jimerson Lake, shaped like a St. Andrews Cross. All of these lakes, which furnish ten miles of boating, are connected by Crooked Creek as an outlet. At places the lakes have high bluff banks, as Lake Gage (Steuben County), or sandy beaches as Lake Tamarack (Steuben

County), or it may be a wash bowl in shape as Clear Lake (Lagrange County), or only the expansion of a river as Mud Lake on the Kankakee. All of these lakes will gradually drain away and be replaced by marshes, which in turn will be drained by man and become farms, but before that, they will have done their work. At present they furnish for the people of Indiana, the most pleasant and safe boating grounds that I can think of. The beaches, sandy in most cases, invite one to take a plunge while down in the clear water you can see 150 species of fish which beckon to your line. Beside, many of the cities of this region use these lakes for reservoirs where can be collected clean, potable supplies of drinking water. Their psychological effect should not be forgotten, as there seems to be something in the nearness to these lakes which gives a certain "go" to the inhabitants, while making them genuine followers of Izaak Walton.

Dryer, 17th. Ind. Geol. Report, p. 134.

The present lakes have economic values which must not be forgotten, also. Dryer gives a classification of the Indiana lakes, based on the bottom of the lakes, which is valuable in pointing out their economic importance. He calls them, first, peat lakes, which will become covered up and bogged the soonest. Second, he has the lime lake, on whose bottom is accumulating the marl deposits which are so valuable in making cement. These will next be filled and disappear. And last, there are the sand lakes with bottoms of sand which will drain away the last and leave their sand to form the porous subsoil of a rich bottom farm.

Altogether I believe the lakes of the glacial deposits make the greatest appeal to me of any of the topographic work of theice lobes and their deposits.

River Valleys.

Leverett, No. 38, pp. 538-9.
Ibid., No. 41, pl. II.
Dryer, 17th. Ind. Geol. Report, pp. 167-8.
Ibid., 18th. Ind. Geol. Report, p. 88.

The morainic deposits lie in more or less parallel lines, marking successive stages in the retreat of the ice lobes. The result is that over northern Indiana was established new river valleys, through which flow post-glacial streams. For instance, the Mississinewa, the Salamonie, the St. Mary's and the St. Joseph, all flow northwest and southeast between the Mississinewa, the

Salamonie, the Wabash, the Fort Wayne and the Interlobate moraines. Their pre-glacial drainage was not at all like this we have tried to show in the first chapter. Beside this profound topographic work of creating new post-glacial river valleys, the ice lobes created post-glacial valleys in another way. The till plains, with their undulating or almost flat surface, invited the post-glacial streams to cut new valleys across them, as in the case of the upper West White River, the Elkhart and many others. However, this work was dwarfed in its importance by the number of drainage changes affected by the ice lobes and the drift.

Drainage Changes.

Leverett, No. 38, p. 460, 97-100, 230-1.
Ibid., U. S. G. S. Report, 1897, pt. 4., p. 439.
Dryer, 18th. Ind. Geol. Report, pp. 25-6.

Leverett has summed up the changes which ice lobes effect in the following way:

(1) New drainage systems.
(2) Major streams deflected.
(3) Minor streams deflected.
(4) Re-established or non-deflected drainage.

The first of these we have treated, and the others we will note in our discussion of this point. Beside creating new river valleys in Iudiana, the glacial deposits were laid across many drainage lines as a low flat till plain. This plain became the prairie country of northern Indiana today.

Not only did the glacial deposits produce well drained prairie lands as we have said, but often they left behind them, low, flat, sometimes hummocky, swamp lands in the place of the previously well drained country as in the interlobate counties of northeastern Indiana and the Kankakee valley.

In the matter of major stream deflections, we have already seen the post-glacial Wabash cutting to the east of its old valley near Covington. Also, at Louisville, the post-glacial Ohio pursues a different course from that of the pre-glacial Ohio. The upper Whitewater was probably reversed and the St. Joseph sent west to Lake Michigan instead of southwest to the Gulf by an ice dam and moraine below South Bend. To mention the reversed courses of the St. Mary's and the St. Joseph at Fort Wayne, shows another case or morainal deflection of major streams.

The cases of minor stream deflections are very numerous. We could speak of the new Patoka River, the deflected Coal Creek, in Fountain County, the changed McCormack's Creek, in Monroe County and many others. But that would give us material for another long and interesting study. So we will drop this question of topographic work of the ice lobes and their deposits after having shown something about the soil, the hills, the lakes, and the changed drainage left behind, to our present day.

General Conclusion.

In this short history of Indiana during the glacial period, we have seen how the pre-glacial Indiana must have appeared before the coming of the Pleistocene ice fields. Then we tried to account for the coming of the ice fields and particularly the ones which reached Indiana. The deposits which these ice lobes left behind, then studied in detail. And finally in order to see the importance to us of this glacial history, we saw the changes which were made on the surface of Indiana by these deposits, which made the Indiana that we know today.

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