SOME INTERESTING PHYSIOGRAPHIC FEATURES OF THE UPPER WABASH DRAINAGE BASIN IN INDIANA.

ROBERT R. SHROCK, Indiana University.

The writer* proposes to discuss a number of topographic features associated with valley development found in that portion of the Wabash drainage area in Indiana above Delphi. These features occur along the valleys of the Wabash, Salamonie, Mississinewa, Little and Eel rivers, Little Pipe and Pipe creeks, and numerous smaller tributaries of not only the Wabash River but also of the other above-mentioned major streams.

Except in a very few cases, the features to be discussed are found along or adjacent to the major stream valleys. Upon leaving the main drainage channels one comes onto a monotonously level till plain, the surface of which is in general little diversified. The area under discussion, however, is crossed by a number of lobate moraines, which give some diversity to the topography where they occur, and also determine to a large extent the regional direction of the streams.[1] The origin and character of these moraines have been discussed by Leverett, Mallot[2] and others and hence need not be given further attention here.

The subject of this discussion has to do with certain features which have been developed in and along valley ways set below the general level of the upland till plain.

To appreciate the position of these features it will be necessary to discuss briefly the conditions under which they were formed. In preglacial times the relief of northern Indiana was probably comparable to that of southern Indiana at the present time. With the advent of the Pleistocene glacier, however, the surface configuration underwent a profound change. Although the moving ice undoubtedly performed some erosion, its great work in this region was of a depositional character. Located in close proximity to the terminus of the glacier in its retreating stages, this region was greatly modified by the thick mantle of glacial drift that was deposited. Here was an upland bed-rock plain, with a relief of from 100 to 300 feet due to valley development, which was completely buried beneath a mantle of drift. This upland plain

* The writer wishes to thank Dr. Clyde A. Malott, Professor of Geology at Indiana University, under whose supervision this paper was prepared, for his kind assistance and many helpful suggestions.

Contribution from the Waterman Institute, No. 32.

[1] Chas. R. Dryer, The Drift of the Wabash-Erie Region—A Summary of results. 18th Rept. Ind. Dept. Geol. and Nat. Res., 1894, pp. 83-90. Note the map.

[2] C. A. Malott, The Physiography of Indiana. Handbook of Indiana Geology, pt. ii, 1922, pp. 104-112, 149-154, 255-256.

surface, portions of which have been resurrected along the main valley of the Wabash, seems to have had an elevation of from 700 to 750 feet above sea level. Drift filled the valleys and spread over the bed-rock upland, completely mantling it. This condition largely prevails today.

As the glacier advanced over the region the pre-glacial erosion surface was buried beneath the drift. Then as the glacier retreated, depositing great amounts of debris, the floods of escaping waters first spread out over this newly constructed till plain, but later concentrated along certain lines of discharge. As soon as the waters became concentrated along definite channels erosion started, and soon the streams had cut deep valleys into the drift. These became superimposed streams, as they not only cut deeply into the drift but also cut their channels deeply into the much-diversified bed-rock surface beneath the mantle of drift, where this buried surface was not deeply covered. Examples will be cited later where these superimposed streams have cut narrow gorges through very resistant rock. We may, then, picture the Wabash Valley of glacial times as being very narrow at some places, where the waters rushed through a gorge, and quite wide at others where the stream crossed ancient buried valleys. In still others we may imagine it as a rock platform over which the torrents were sweeping, cleaning off not only the till but also weathered material which had been buried when the glacier first passed over the region.

The carving out of the valleys, the stripping off of the thick mantle of drift with the consequent resurrection of pre-glacial erosional features, and finally the alluviation of the valleys themselves were carried on by waters which escaped from the melting glacier and later from glacial Lake Maumee. These valleys have suffered but little alteration since, because the Wabash River of today is insignificant when compared with its great progenitor.

The topographic features to be discussed are of two classes: those features which owe their origin to the depositional work of the ice and the waters which escaped from the melting glacier, and those which owe their origin to the bed rock of which they are composed. The features of alluvial character are of either glacial or post-glacial origin, while the bed-rock features are pre-glacial or glacial. Some of the bed-rock features of pre-glacial times have been resurrected by the removal of glacial drift from off or around them, but many of them undoubtedly remain concealed by the mantle of drift. Some of these bed-rock features came into existence during the period of glaciation, resulting from the erosional work of the escaping waters, but it is believed that by far the greater number were in existence in pre-glacial times and have been merely resurrected and only slightly modified.

It is obvious that the Pleistocene glaciation has had a profound effect on the topographic expression of northern Indiana. The region as a whole is a great drift plain, but it is known that beneath the wide expanse of glacial drift occurs an ancient erosion surface, of which we are privileged to obtain only occasional glimpses where the heavy mantle of drift has been removed by stream action. It is from these occasional glimpses, especially of the bed rock, that we may hope to interpret the physiographic and geologic history of northern Indiana.

GENERAL DRAINAGE CHARACTERISTICS.

With its relatively low gradient and small volume, the Wabash River of today is but the vestige of a mighty river of the past which carried the waters from the receding glacier, and later those from glacial Lake Maumee, to the Mississippi. From Huntington* to Delphi the Wabash River flows in a valley which came into existence during the glacial period. In some places the valley is narrowly and deeply cut into the thick mantle of till; in others it is a broad, level flat, bounded on either side by high bluffs of drift, while in still others it is a rocky gorge. The lower portion of the valley is much older than the upper part, for as the glacier's concentric terminus receded to the northeast, the valley of the Wabash was as rapidly lengthened to furnish an avenue of escape for the waters from the melting ice. From the state line to Huntington, however, the Wabash flows in a post-glacial valley intrenched but slightly in the till, particularly in its upper reaches, and seldom reaching bed rock. When bed rock is exposed, as at a point two miles southeast of Huntington, in the vicinity of Markle both above and below the town, northwest of Bluffton, at Vera Cruz and near New Corydon, it is not due so much to the erosional work of the stream as it is to the fact that the bed rock lies very close to the surface.

From Huntington the old glacial valley of the Wabash continues to the northeast, but is now occupied by only a small stream, Little River, which is but little intrenched below the old valley floor. This stream strikes bed rock some six miles above its mouth and flows over it most of the way to its mouth. The original channel has been deepened somewhat by recent excavation. In the vicinity of Huntington there is an old erosion surface lying at or near the floor of the glacial valley as indicated by the numerous quarry openings and by the natural outcrops along the channel of Little River. This bed-rock surface has an altitude of about 735 feet above sea level,—an altitude approximated in many places along the Wabash River. Apparently it is an upland level of a peneplain character antedating the glacial period.

Just east of Lagro the Salamonie River joins the Wabash on what is probably a rock floor. Successively upstream one finds frequent rock cliffs and steep till bluffs. In the lower half of its course the Salamonie has intrenched itself from 50 to 75 feet below the upland level, while in its upper half the valley is wide and rather shallow, and reaches bed rock only at Montpelier and Portland. Notable examples of the steep till bluffs are to be found around Heiney's Bend[3] in southern Huntington County.

The Mississinewa River enters the Wabash about one mile east of Peru. Along this river from its mouth to its source are to be found frequent outcrops of rock, which may be in the form of vertical cliffs, rock floors or sloping bluffs. The Indians named it well when they called it Mississinewa,[4] meaning the "River of Much (or Great) Stones."

* For the location of the various places and features that will be mentioned in the following discussion, see figure 1.

[3] Wm. M. Heiney, River Bends and Bluffs. Proc. Ind. Acad. Sci. 1900 (1901), pp. 197-200.

[4] H. W. Beckwith, Indian Names of Water Courses in the State of Indiana. 12th Rept. Ind. Dept. Geol. and Nat. Hist., 1882 (1883), p. 39.

Like the Wabash, the Mississinewa flows through frequent rock gorges where the old stream has been superimposed on the ancient pre-glacial bed-rock surface. Its valley is always narrow and well intrenched below the upland.

Little Pipe Creek empties into the Wabash River just west of Peru. Although a small stream, it has been able to cut a gorge through one of the ancient bed-rock coral reefs[5] and also has cascades in its lower portions. The valley above Wallick's Mill where the gorge is present is broad and shallow.

Pipe Creek enters the Wabash River just below Lewisburg over bed rock of Kokomo age. Not far from its mouth a rock gorge begins and extends upstream to the present falls. The site of the present falls is over two miles from the Wabash, but the gorge is only about one-fourth of a mile long. Above the falls for a distance of a fourth of a mile the stream flows over a bed-rock floor of Devonian age. Except near Bunker Hill, Mier and Sweetsers where rock is found in the stream bed, the stream is in the drift.

Eel River enters the Wabash at Logansport over a rock bed. From Adamsboro to Logansport, a distance of some six miles, the stream flows over bed rock most of the way. Above Adamsboro no bed rock is seen.

The valleys of the smaller tributaries are always shallow and broad in their upper reaches and narrow and deep adjacent to the larger streams. Along the Wabash, Salamonie and Mississinewa, where rock is exposed, the small streams almost without exception flow through rocky gorges to reach the valley floor of the main stream. It is also a very common thing to find the streams tumbling over waterfalls near the river bluffs. If the stream is intermittent or very small the falls will be near the river bluff and an ampitheatre-shaped canyon head will be found, but if the stream is a fair sized one the falls may be back half a mile or more from the river bluff.

The major valleys of the Wabash, Salamonie and Mississinewa rivers were carved out in glacial times and have suffered little alteration since. The smaller tributary streams, however, have come into existence since the period of glaciation and hence have found themselves out of adjustment with the major streams. Where bed rock is present these post-glacial streams have not been able to adjust themselves very rapidly. In the till, however, they have cut down very rapidly. We may, therefore, expect to find tributary stream valleys of two kinds: (1) those which are developed entirely in the drift, having a broad, shallow poorly-defined upper portion, and a lower portion characterized by a narrow bottom with a high gradient, and steep valley sides; and (2) those developed partly in the drift and partly in the rock, having narrow, rocky defiles, with falls and cascades, in their lower portions, and broad, shallow depressions, developed in the glacial drift, in their upper reaches.

Stream valleys of the first class are well developed in the river bluffs and adjacent upland along the wider stretches of the Wabash Val-

[5] E. R. Cumings and R. R. Shrock, The Silurian Coral Reefs of Northern Indiana and Their Associated Strata. Proc. Ind. Acad. Sci. 1926 (1927), pp. 71-85.

ley as at "The Prairie" near the Wabash-Miami county line, and in the vicinity of Peru. Examples of streams having valleys of the second class are Liston, Lagro, Charley, Treaty, Enyert and Pipe creeks.

Topographic Features of the Valley Floor.

When the great floods were debouching from the melting ice, the Wabash River undoubtedly spread out over its entire valley flat, as we know it today, in the form of a much-braided stream. Numerous islands of bed rock and bars of sand, gravel and drift stood up above the water level. With the reduction in volume of the Wabash River, due to the withdrawal of the ice, the waters became confined to much smaller channels, and since that time have cut for themselves rather narrow channels set below this old valley floor. This old valley flat in places now forms alluvial terraces, above which rise low ridges of sand and gravel that represent the sand and gravel bars of the ancient braided river. In like manner there are to be found frequent isolated rock masses standing well above the present flood plain. Finally the old channels which the water once followed now appear as streamless stretches from 15 to 25 feet above the present bed of the Wabash River. During the 1913 flood many of the above-mentioned terraces and abandoned channels were inundated.

This old valley floor is usually broad in its stretches of alluvial and glacial materials and rather spectacularly narrow where it is confined within rock gorges. The rock which has been removed from the gorges apparently formed obstructions to the off-flowing glacial waters. It is probably because of these obstructions in the valley that wide stretches between them possess alluviated levels attained temporarily, and which are now above the present bed of the river. As soon as the rock barrier was removed the stream cut down through the fluvial deposit, leaving it as an alluvial terrace well above the stream channel. Some such condition as this may have been responsible for the formation of such a feature as "The Prairie" in Wabash County, about which more will be said later.

An excellent example of the bed-rock floor of the ancient Wabash River is found in the vicinity of Delphi, where the rock lies very near the surface over a considerable area. Again east of Logansport on the south side of the river the bed rock is seen exposed over a broad expanse. Above this flat rise small isolated masses of Devonian and Silurian rock, representing the unreduced portions of this water-swept surface—perhaps those portions which stood above the swiftly moving waters as small islands. Over this surface strewn with the larger glacial debris rushed the torrents which had issued from the melting glacier above. Thus we find here a unique physiographic feature, which Professor Malott, upon first seeing, described as "a torrent-swept floor, above which rise isolated masses of unreduced rock—a feature caused by fluvial erosion and subsequently modified by weathering." In the vicinity of Huntington the bed rock lies very near the surface in the old glacial sluiceway, indicating that a feature similar to the one just described was formed here also. These torrent-swept rock flats, with their

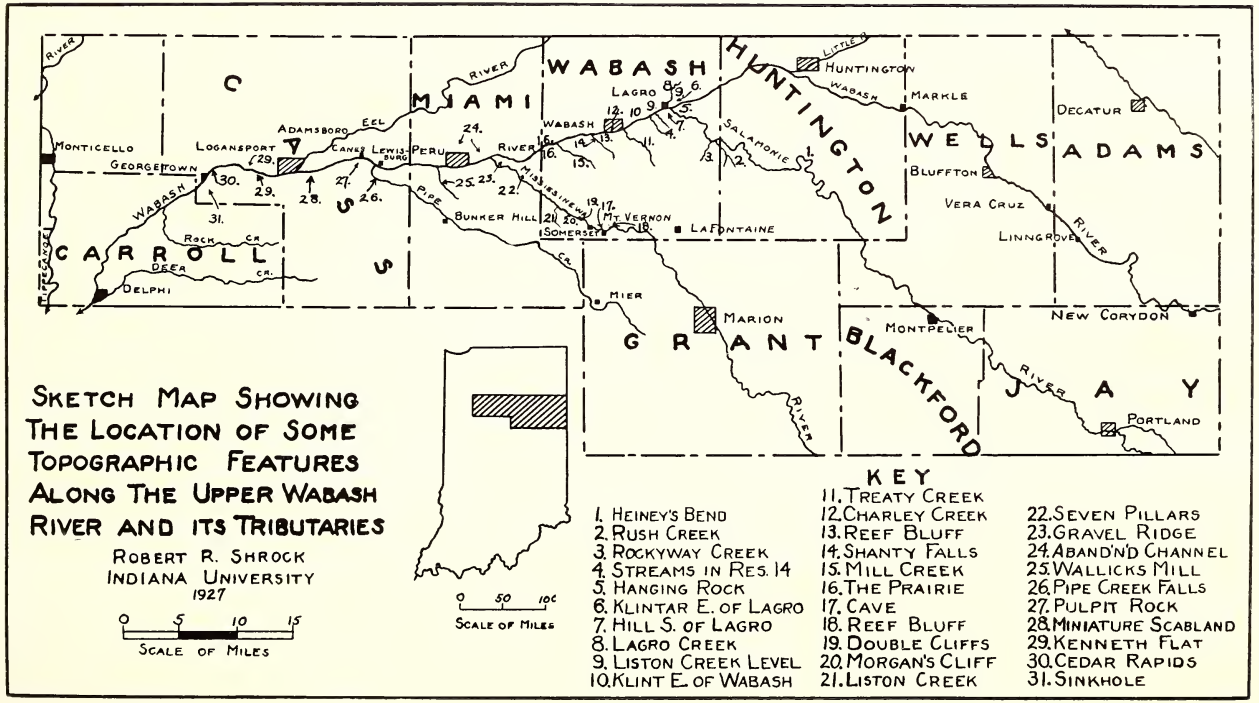

Fig. 1—Sketch map showing the location of some topographic features along the upper Wabash River and its tributaries.

interlacing channels and mound-like masses of unreduced rock, bear considerable resemblance to what Bretz[6],[7] has called "Scablands" in the Columbia Plateau. Their origin seems to have been much the same. The meager exposures of this torrent-swept flat in northern Indiana indicate, however, that even in its largest aspects it can be little more than a miniature "scabland."

Usually the unreduced portions of this miniature "scabland" appear merely as irregular piles of rock, but in reality they are actually bed-rock features which are weathered and broken only on the outside—a condition subsequently attained. One of these erosion remnants, located

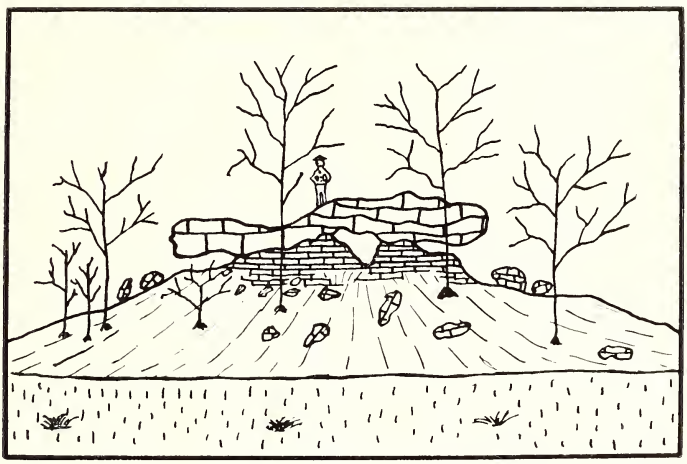

Fig. 2—Sketch from a photograph of "Pulpit Rock," near Danes (Cass County), Indiana. This erosion remnant stands about 20 feet above the surrounding valley flat. The man standing on the feature is six feet tall.

just south of Cass Station (Danes) some five miles east of Logansport, is of particular interest. On this bed-rock surface of fluvial erosion we find a feature which is thought of as characterizing a driftless area instead of a glaciated area. This feature, known locally as "Pulpit Rock," consists of a large mass of Devonian limestone perched on a narrow base of Kokomo limestone. Numerous holes are present at the contact, causing the large overlying mass to rest on a number of small pillars of Kokomo limestone. "Pulpit Rock" stands about 20 feet above the surrounding flat and is about 60 feet across the base and 30 feet across the top. It is elongate in the direction of stream flow. The figures given above are for the length of the feature. Its width is about half its length. The accompanying sketch (fig. 2) indicates the unique character of this unexpected feature.

[6] J Harlen Bretz, Glacial Drainage on the Columbia Plateau. Geol. Soc. Amer., Bull., vol. 34, 1923, pp. 573-608.

[7] J Harlen Bretz, The Channeled Scablands of the Columbia Plateau. Jour. Geol., vol. 31, 1923, pp. 617-649.

In the vicinity of Lagro two pronounced flats are present. The upper one represents a pre-glacial rock upland, which may be correlated with that revealed in the vicinity of Huntington. The lower level represents the torrent-swept flat developed by the discharged glacial waters at the expense of the pre-glacial rock upland. Rising above the lower flat, sometimes to the level of the bed-rock upland, are numerous irregular-shaped mounds of rock which are the unreduced portions of the upland.

One of these erosion remnants is of considerable interest. This hill, located about half a mile south of Lagro, is about 700 feet long, 300 feet wide, and rises 25 or 30 feet above the surrounding flat. It is elongate in the direction of stream flow in the Wabash River. The upstream end of this feature is rather abrupt but the downstream end is gently sloping. An examination showed this hill to be composed of Mississinewa shale[8] mantled with drift.

At the south side of the broad level expanse where the Mississinewa empties into the Wabash is an oblong hill, with the longer axis lying in the direction of stream flow in the Wabash, which is probably of gravel and represents a remnant of a former gravel bar in the glacial Wabash. Between this hill and the south bluff of the valley is a streamless channel some 500 feet wide connecting the broad valley flat of the Wabash directly with the present channel of the Mississinewa.

The abandoned channels already mentioned are intimately connected in physiographic history with the terraces and erosion remnants. These channels were at one time the avenues of escape for some of the glacial waters, but have long since been abandoned and now appear as streamless valleys. Such channels have been noted five miles west and five miles east of Logansport on the south side of the Wabash River; in the vicinity of Waverly, eastern Cass County[9]; on the north side of Peru; near the Winter Quarters and at Double Cliffs along the Mississinewa; and south of Lagro between the Wabash and Salamonie rivers. Careful topographic mapping would undoubtedly show many more. During the great 1913 flood the waters followed a number of these channels.

The Prairie. Reference has already been made in a general way to the alluvial features that characterize the floor of the Wabash River Valley. These terrace-like features have been very carefully mapped by Dryer,[10] but he neither described them nor offered any explanation of them or of numerous features associated with them.

A large area known locally as "The Prairie," located just east of the Miami-Wabash county line on both sides of the Wabash River, comprises one of these features. The main flat lies from 10 to 25 feet above the present stream level and is characterized by black fertile soil. It is mostly above the annual flood-water level, but in times of very high water, as in 1913, the greater portion may be inundated. Rising above

[8] Cumings and Shrock, *Ibid.*, p. 72.

[9] C. C. Beals, Soil Survey of Cass County, Proc. Ind. Acad. Sci. 1918 (1919), pp. 187-188. Note the map.

[10] Chas. R. Dryer, The Maumee-Wabash Waterway. Ann. Assoc. Amer. Geographers, vol. IX, 1920, pp. 41-51, Fig. 8.

the main flat are numerous mid-valley, terrace-like remnants or elongated, flat-topped ridges of sand and gravel. These features are often 25 feet above the main valley floor or "The Prairie" and upon them are located the farm buildings of the region. Dryer seems to have interpreted these ridges as being of rock instead of alluvium, for he has shown them as such on his map. These ridges, elongate in the direction of stream flow, were probably at first great sand and gravel bars when the flood waters from the receding glacier were sweeping over the level which now comprises "The Prairie." Later they became islands even as they are today in times of exceptional floods.

"The Prairie" is between four and five square miles in extent. The level of the tops of the isolated ridges may represent a temporary gradation plain the height of which was determined by an obstruction farther downstream. As the obstruction was being removed the stream was cutting down through the drift which had been deposited, and finally a second level was established over which the glacial flood waters poured. This level is now the main valley flat or "The Prairie." Then when the waters finally subsided to the present volume of the Wabash, they became concentrated along a rather narrow channel and this ancient valley floor was left high and dry.

This broad expanse of low lying land is bounded on both the north and south sides by high till bluffs. Bed rock is not exposed anywhere within the area. It is altogether likely that the glacial Wabash crossed an old pre-glacial valley at this point and not being restricted by rock on either side was able to laterally extend its valley to an exceptional width. It is this broad valley floor that is called "The Prairie."

Reef Hills and Reef Bluffs. Scattered throughout the Wabash Valley above the junction of the Wabash and Tippecanoe rivers are numerous dome-shaped rock hills which have elsewhere been shown to be the remnants of ancient coral reefs.[11] These reefs may be partly or entirely exposed as rock hills, or they may form bluffs along the streams. Reef hills or mounds of a similar character in Gotland are called "Klintar" (singular—"Klint").[12], [13]

One of the finest examples of these "klintar" occurs just south of where State Road 24 crosses the Wabash Railroad one mile east of Lagro. The north, east and south sides of the hill, which is elongate, slope with the inclined strata like the sides of an inverted bowl. The west side of the hill, which is the downstream or lee side, is concealed by a narrow tongue of drift which extends downstream from the rock hill. The reef mass has formed an obstruction in the path of the stream and consequently has protected the drift on the lee side from erosion. The rock mound or "klint" is about 450 feet in diameter and stands about 45 feet above the valley flat. The top of the hill is uneven. The tongue of drift extending downstream from the rock hill is 800 feet long. Nearby to the east are two similar "klintar," one of which has

[11] Cumings and Shrock, *Ibid.*, pp. 77-85.

[12] Carl Wiman, Ueber Silurische Korallenriffe in Gotland. Bull. Geol. Inst. Upsala, vol. 3, 1896-1897, pp. 311-326.

[13] A. W. Grabau, Principles of Stratigraphy, 1913, pp. 420-430.

a tongue of normal stratified rock extending downstream for some distance from the reef mass. These hills form striking topographic features on the flat plain above which they rise.

Again about one mile east of Wabash, between the Wabash Railroad and State Road 24, is another of these "klintar." This hill is about the same size as the three already mentioned, but is not so high nor does it have such steep slopes except on the south side.

It is quite probable that the Cincinnati Arch in the regions under discussion was covered not only with Devonian and Silurian but also with Mississippian and Pennsylvanian formations, but through the long ages that elapsed between the close of the Paleozoic and the beginning of the Pleistocene, the forces of denudation had removed all the formations down to the upper Niagaran. Before the great continental glacier overrode northern Indiana there were undoubtedly many of the reef hills to be seen. It is quite likely that most of these now lie buried beneath the drift. We are privileged to see but a very few of them and these seldom in their entirety. Because of their great resistance to weathering and erosion, these reef masses have been able to exist not only through the long ages that preceded the glacial period, but even through the time that has passed since, and it is quite likely that except for some reshaping they have changed but little since the glacier passed over them.

The more spectacular of these "klintar" or reef hills are the four already mentioned, together with the ones at Hanging Rock near Lagro, and at the mouth of Mill Creek in western Wabash County. The accompanying sketch (fig. 3) shows the character of Hanging Rock, which rises over 75 feet above the level of the river.

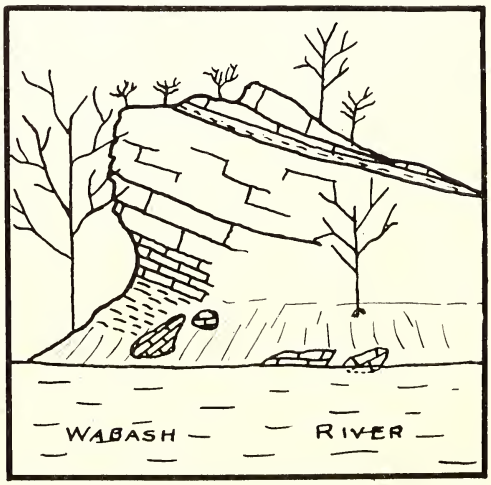

Fig. 3—Sketch from a photograph of Hanging Rock, one mile southeast of Lagro, Indiana. This rock remnant is over 75 feet high and represents a "klint" formed from the unreduced portion of an ancient coral reef. The core of the reef was to the left of the picture. The Wabash River flows at the base of this feature.

Many reefs are only partially exposed in the numerous stream bluffs. One very interesting one occurs near Mt. Vernon, Wabash County, on the south side of the Mississinewa River east of the bridge. The cliff here is nearly vertical and shows a tangential section of a reef. The erosion of the centuries seems to have had no appreciable effect on this gray, somber cliff. Another reef cliff of considerable interest is found one-eighth of a mile east of Shanty Falls and about a mile west of Wabash, on the south side of the Wabash River. Here a great cliff, over 40 feet high in places, extends for over 1,000 feet along the valley. The cliff is very effectively described by Elrod and Benedict[14] in the following words: "The massive wall of the outcrop rises in a sheer precipice forty feet high by one thousand feet in length. Its dark and frowning front, covered with gray lichens, looks as if only eternity could reduce it to dust." Numerous vacuities and large cave-like holes give a fantastic appearance to the ragged, towering cliff. Here and there along the bluff are small ravines down which the streams cascade in time of heavy rains. Accumulations of debris are found below them on the talus slope.

There are, in addition to the ones already mentioned, numerous other partially exposed reefs; but space does not permit a discussion of them here.

Some Features of the Pre-glacial Bed-rock Surface. Mention has already been made of a pre-glacial bed-rock surface. It remains to point out a few places where certain aspects of this surface may be studied. At the horizon of the Kenneth limestone[15] in Cass County west of Logansport there is a marked flat developed over a broad area. This same flat is also developed at the same elevation on several remnants of pre-Kenneth age, indicating that it is an old erosion plain rather than a structural plain. It is believed, however, that the Kenneth limestone by virtue of its rather resistant character has been responsible for the preservation of a considerable expanse of flat upland surface of pre-glacial age. The glacial drift has been cleared from it, making it rather conspicuous. This flat is well developed west of Logansport on both sides of the Wabash Valley. Numerous outcrops of the white Kenneth limestone mark it, giving prominence to it as a topographic feature. It is quite probable that this flat, like the miniature scabland east of Logansport, was swept clean of its glacial debris by the torrents which rushed over it in the early history of the Wabash Valley. The town of Kenneth, from which the limestone is named, is located on this plain. The general elevation of the plain is about 650 feet above sea level.

From Wabash nearly to Lagro on the north side of the Wabash River just north of the Wabash Railroad, and again east of Lagro on the same side of the river for several miles, extends a rock bench which is developed at the base of the Liston Creek limestone.[16] It is easily detected where the glacial drift has been removed. It is believed that this plain or bench is a representative of the same topographic level as

[14] Moses Elrod and A. C. Benedict, Geology of Wabash County. 17th Rept. Ind. Dept. Geol. and Nat. Res., 1892, p. 214.

[15] Cumings and Shrock, *Ibid.*, p. 77.

[16] Cumings and Shrock, *Ibid.*, p. 75.

the one in the vicinity of Huntington developed at the same horizon. Both form remnants of a once more extensive erosion surface, most of which lies buried beneath the drift. The elevation of the plain in the vicinity of Lagro is about 735 feet above sea level. Here again the preglacial upland surface, developed at a particular horizon, has been preserved because of the character of the rock. Here, also, it simulates a structural plain.

Topographic Features of the Valley Sides.

River Bluffs. Steep bluffs of both rock and till are frequently met with along the main streams. Mention has already been made of the reef bluffs, but there are also bluffs of normally stratified rocks. Some of the rock bluffs are precipitous, while others are gentle slopes. The till bluffs are in many instances remarkably steep. In fact, in a number of cases the writer had difficulty in ascending them after he had gone down them to the stream level. Around Heiney's Bend on the Salamonie and two and one-half miles west of LaFontaine and near "Seven Pillars" on the Mississinewa are to be found fine examples of these high, steep bluffs, often exceeding 65 feet in height.

Fig. 4—View of "The Cliffs" or "Seven Pillars", along the Mississinewa River, three miles southeast of Peru, Indiana. This beautiful cliff is carved out of the Liston Creek limestone and is about 20 feet high.

The rock cliffs form conspicuous features along some of the streams. It is not an uncommon thing along the main rivers to see a vertical cliff from 25 to 75 feet high surmounted with gnarled cedars which hang over the bluff by roots that have penetrated the openings and cracks in the strata.

Owing to the well developed jointing and bedding of the Liston Creek limestone, very interesting features are often carved from this

formation. At "The Cliffs" or "Seven Pillars," three miles southeast of Peru along the Mississinewa River, the north bluff of the river is carved into a series of beautiful buttresses and alcoves, nicely rounded and swept clean of unsightly talus accumulations by the flood waters of the river. The accompanying photograph (fig. 4) shows something of the spectacular beauty of this interesting bluff. Several beautiful columns were also noted at Shanty Falls in the weathered cliff of Liston Creek limestone.

Upon thorough examination there are found to be a surprisingly large number of rather high rock bluffs along the Wabash, Salamonie and Mississinewa rivers. Without these fine exposures the stratigraphy of northern Indiana would have to remain forever an unsolved problem. Some of the more spectacular of these bluffs occur near Lagro along both the Wabash and Salamonie, in the vicinity of Wabash, and along the Mississinewa, chiefly in southwestern Wabash County.

Mention should be made of several rock gorges along the routes of the larger streams. One mile east of Georgetown at "Cedar Rapids" the Wabash flows through a rocky gorge, which has been cut through the core of one of the ancient coral reefs. At Wabash the Wabash again flows through a very narrow valley confined within high rock bluffs. At Double Cliffs, Morgan's Cliff and Somerset the Mississinewa flows through rocky gorges. In these cases the glacial streams have been superimposed on the old pre-glacial erosion surface and have cut through the rock where it happened to obstruct their path.

Waterfalls and Cascades. Low waterfalls and cascades are of common occurrence in streams entering the rivers. Most of the falls noted were developed at the contact of the Mississinewa shale and the underlying formation, which may be either Red Bridge[17] or Liston Creek. The easily weathered Mississinewa shale overlain by the well-bedded Red Bridge or Liston Creek limestones gives rise to conditions favorable for the formation of waterfalls. These falls are of variable height, depending chiefly on the distance of the base of the Liston Creek above the valley flat of the major stream. Some of the better known falls of this type are Shanty Falls, 22 feet high, in a small stream one mile west of Wabash on the south side of the Wabash Valley; Liston Creek Falls, 5 feet high, in the bed of Liston Creek in southwestern Wabash County; and two beautiful falls, several feet high, in small streams one and one-half miles southwest of Lagro on the south side of the Wabash River in Reservation 14.

Several cases were noted where falls or rather cascades were present because of the presence of a coral reef in the stream channel. The streams have been unable to cut through the massive reef rock as rapidly as through the softer adjacent materials and cascades have been formed. Quite frequently the upturned edges of the inclined strata give rise to a series of beautiful cascades in the stream beds. Examples of this kind of cascade are found one mile north of Mt. Vernon, along the south bluff of the Mississinewa east of the bridge, where the water cascades about 20 feet along the steeply-inclined strata of a reef; at Rocky-

[17] Cumings and Shrock, *Ibid.*, p. 74.

way Falls along Rockyway Creek one mile south of Dora; at Wallick's Mill on Little Pipe Creek, one and one-half miles southwest of Peru; and along Treaty Creek two miles southeast of Wabash.

Subterranean Drainage Features. Associated with the hanging valleys already described are features which owe their origin to subterranean drainage development. At Liston Creek Falls two small sinkholes were noted. The larger one was about 20 feet in diameter and at least 10 feet deep. The other was more like a swallow-hole. It had a small ravine extending out from the main sink. These sinks were located near the canyon a short distance above the falls. Just north of Mt. Vernon on the north side of the Mississinewa River west of the bridge a short distance is a small cave about fifteen feet long, seven feet wide and seven feet high. A smaller channel runs farther in from the room but it was too small for exploration. There is no water in this channel but nearby and about seven feet below, a good-sized spring comes out of the rock near the Liston Creek-Mississinewa contact. Just northeast of the spring in a small quarry the water can be heard flowing through the rock. This development, like that at Liston Creek Falls, is in the Liston Creek limestone. The formation is well bedded and has well-developed joint planes, both of which are favorable for subterranean drainage development. Small solution channels were noted in the bluff northeast of Somerset on the north side of the Misissinewa. Here again the development was confined to the Liston Creek limestone.

Two miles east of Georgetown, on the south side of the Wabash River, a farmer reported a large sinkhole about half a mile back from the river. He stated that in time of heavy rain considerable water goes into this sink. He also stated that under similar conditions water boils up vigorously at a much lower level in the flat along the river. It would seem very likely that the water which enters the sink comes out in the form of a spring on the flat adjoining the river. This development appears to be in the Kokomo limestone.

A very interesting case of subterranean diversion was noted along a small stream near the center of Reservation 14 east of Wabash. The stream formerly flowed over the surface in a well-defined but shallow valley to a falls where the water tumbled over to the canyon floor below. At the present time, however, the stream bed is dry from the falls upstream. About five feet below the crest of the falls, which are over the Liston Creek limestone, a large spring comes out at the contact of the Mississinewa and Red Bridge formations. The water seems to have found an underground route which is shorter than the surface route, and hence has abandoned the latter except in time of heavy rain when the subterranean channel can not accommodate all of the water.

It might be stated at this point that where conditions are favorable, springs are common at the contact of the Mississinewa shale and overlying formation. Because of the impervious character of the shale, the water, since it can not penetrate the shale, flows along horizontally until it can find an opening to the surface. In the Markland Avenue quarry at Kokomo and in the Erie Stone Company quarry at Huntington, large streams of water issue from the rock at the top of the Mississinewa shale.

Summary.

The outstanding topographic feature of northern Indiana is the great till plain beneath which is buried an ancient pre-glacial erosion surface developed on a normal stratigraphic sequence which is interrupted at frequent intervals by complicated structures known to be ancient coral reefs. Crossing this broad till plain in a general westerly direction is the Wabash Valley with its major stream valleys of the Salamonie, Mississinewa and Eel rivers.

The Wabash Valley is a great sluiceway which came into existence during Pleistocene glaciation by the erosive work of the debris-laden flood waters which debouched from the melting glacier. Not only the Wabash, but also the Salamonie, Mississinewa, Eel and Little rivers are superimposed streams which have cut down into and in some cases through the drift from 50 to 100 feet below the upland till plain. Their valleys may follow or cross pre-glacial drainage lines or they may be entirely a result of the erosive work of the glacial streams. The numerous topographic features which characterize the valley floor and sides may have been in existence previous to the glacial period, or they may have come into existence during glaciation. With the decrease in volume of the streams, due to the withdrawal of the ice, they confined themselves to rather narrow channels and have since cut down below the old flood plain level, leaving portions of it as alluvial terraces. The tribuary streams found themselves out of adjustment with these main streams so that they were forced to tumble over falls to reach the valley floor of the major streams.

Thus in northern Indiana today we find set into the till plain a glacial sluiceway which was once filled with a great rushing torrent of debris-laden waters but which is now occupied by a rather insignificant stream that covers but a fractional part of the flood plain of its mighty progenitor. Along this sluiceway we are privileged to catch only occasional glimpses of the old buried pre-glacial erosion surface, pre-glacial erosional features, and features which came into existence during glaciation. With the aid of these few glimpses it is our problem to interpret, so far as we can with such a limited amount of knowledge, the physiographic history of this most complicated yet interesting region.

The writer has attempted to describe some of the more outstanding topographic features of the great Wabash sluiceway and also to interpret the physiographic history of some of them. Suffice it to say that the physiographic history of the Wabash Valley is not simple; in fact it is extremely difficult, and many features can not be satisfactorily explained until careful topographic maps are available. Finally, in this region lies one of the most interesting physiographic areas to be found anywhere in Indiana, and the solution of its many individual problems, an almost hopeless task with present facilities, will mark an important advance in the knowledge of the physiographic development of our state.