Glacial Stratigraphy of the Fort Wayne Area and the Draining of Glacial Lake Maumee[1]

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Abstract

Two major glacial till sequences are present in the Fort Wayne area. The upper sequence consists of the clayey tills of the Lagro Formation and the lower consists of extremely hard loam tills that are correlated with the Trafalgar Formation. Both are Wisconsinan in age.

The morphology and development of the Fort Wayne Outlet, the Six Mile Creek channel, and the Wabash-Erie Channel were controlled by a combination of bedrock topography, early glacial discharge routes, the lithology and thickness of glacial materials, and the most recent ice-controlled drainage.

The morphology of the lake floor and the morphology and postglacial stratigraphy of the outlets of glacial Lake Maumee suggest that all three of the classic lake levels could have discharged at Fort Wayne and that the classical 800-foot, 760-foot, and 780-foot sequential order is without foundation. The lower hard tills could have slowed temporarily the downcutting of the Fort Wayne Outlet and stabilized the intermediate lake level.

Introduction

An ongoing study of the environmental geology of the Fort Wayne area, Allen County, Indiana, has required that we develop much more detailed knowledge of the glacial stratigraphy than has been known heretofore. Therefore, we have accumulated a considerable amount of data in the form of water well records, engineering boring logs, shallow refraction seismic records, measured sections of natural and artifical exposures, and logs of our own power augering. Our synthesis of these data is just beginning, but we wish here to outline some of the new information by giving a basic stratigraphic framework for the area and a more detailed description of the outlets of glacial Lake Maumee and then to point out some of the ramifications regarding accepted concepts of glacial and glacial lacustrine history.

Past Work

Until the present study, the most recent geologic work in the Fort Wayne area was done as a part of the Indiana Geological Survey's regional geologic mapping program. The surficial geology shown on the "Geologic Map of the 1° x 2° Fort Wayne Quadrangle . . ." (G. H. Johnson and S. J. Keller, in preparation) does not differ significantly from that mapped by earlier workers (Fig. 1).

The first comprehensive work in this area, the "Report upon the Geology of Allen County," by C. R. Dryer, M.D. (3), has gone virtually unchallenged to this day. And even it, in part, summarized work by

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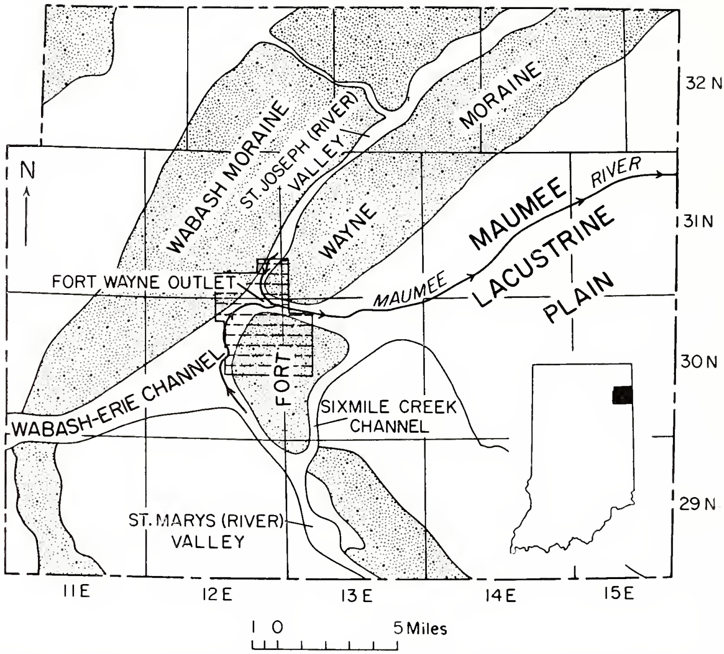

FIGURE 1. *Primary geologic features, Allen County, Indiana. Unlabeled areas are till plain. City of Fort Wayne is outlined. Generalized from Johnson and Keller (in preparation).*

N. H. Winchell and G. K. Gilbert on "the moraines of the Maumee Valley [that] were among the first to be recognized upon this continent" (4). A report on "The Roads and Road Materials of Allen County," by J. A. Price (10), included a colored 1:250,000-scale surficial geologic map, which is still a valuable tool. The synthesis of this geology into the regional interpretation of glacial history was done by Leverett (8) and Leverett and Taylor (9). There are very few areas in the Midwest whose glacial geology was better known before 1915 than was the glacial geology of this area. And as is true for so many other areas, virtually no morphologic or stratigraphic work has been done since the time of Leverett and Taylor.

Bedrock Topography and Preglacial Drainage

Situated on the northeast flank of the Cincinnati Arch, just within the Michigan Basin, the bedrock surface in Allen County is one of physiographic transition. The dolomite, limestone, and shale bedrock of Silurian to Mississippian age dips very slightly to the north and east. To the north the average bedrock elevation becomes less where valleys are cut into the softer shales. A carbonate rock plateau occupies the south half of the county, and a persistent escarpment separates it from the lowlands in the northern two tiers of townships (Fig. 2) (2). Glaciers from the Erie basin entered Indiana by riding obliquely up the slope of this escarpment.

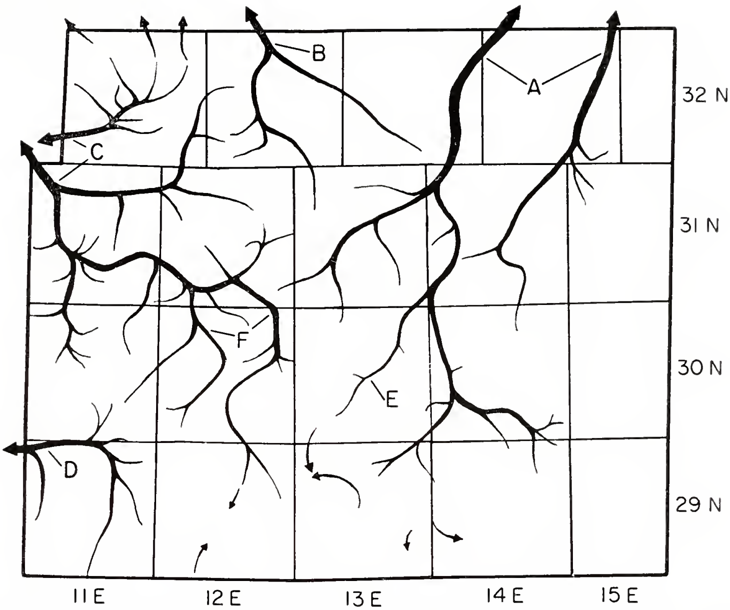

FIGURE 2. *Generalized drainage pattern on the bedrock surface, Allen County, Indiana. Generalized from large-scale bedrock topographic map (M. C. Moore, unpublished) compiled from more than 1,000 well, boring, and seismic records.*

All bedrock valleys in Allen County are tributary to the Teays Valley, about 50 miles to the southwest (2). The headwaters of the Valley F-C (Fig. 2), which are much steeper than those of Valley E-A, perhaps were deepened by proglacial waters of one of the pre-Wisconsinan ice advances that undoubtedly covered the area.

Glacial Stratigraphy

Two major drift sequences are present in the Fort Wayne area (Fig. 3). A dense sand is commonly present at the base of the lower sequence, and its distribution appears to be partly controlled by topography on the bedrock surface, the thicker deposits commonly occupying lows. The lower drift sequence is composed of loam-textured glacial tills (C and D, Fig. 3), having in places abundant interstratified sand, silt, and flowtill-type deposits, particularly near the top of the unit, and a persistent sand at about mid-depth. The tills typically contain 35 to 45% sand and 15 to 20% clay (grain-size analysis by American Association of State Highway Officials Designation T-88; Wentworth size grades). They are overconsolidated and are hard in the engineering sense of the word, having unconfined compressive strengths far in excess of 4 tons/ft^2. Moisture contents are typically well below 10% and, correspondingly, dry densities commonly exceed 140 lb/ft^3. The top of the lower till sequence rises from an elevation of about 735 feet in the axis of the Maumee Lake basin in easternmost Allen County to an elevation of more than 800 feet beneath the moraines in western Allen County. Between the upper and

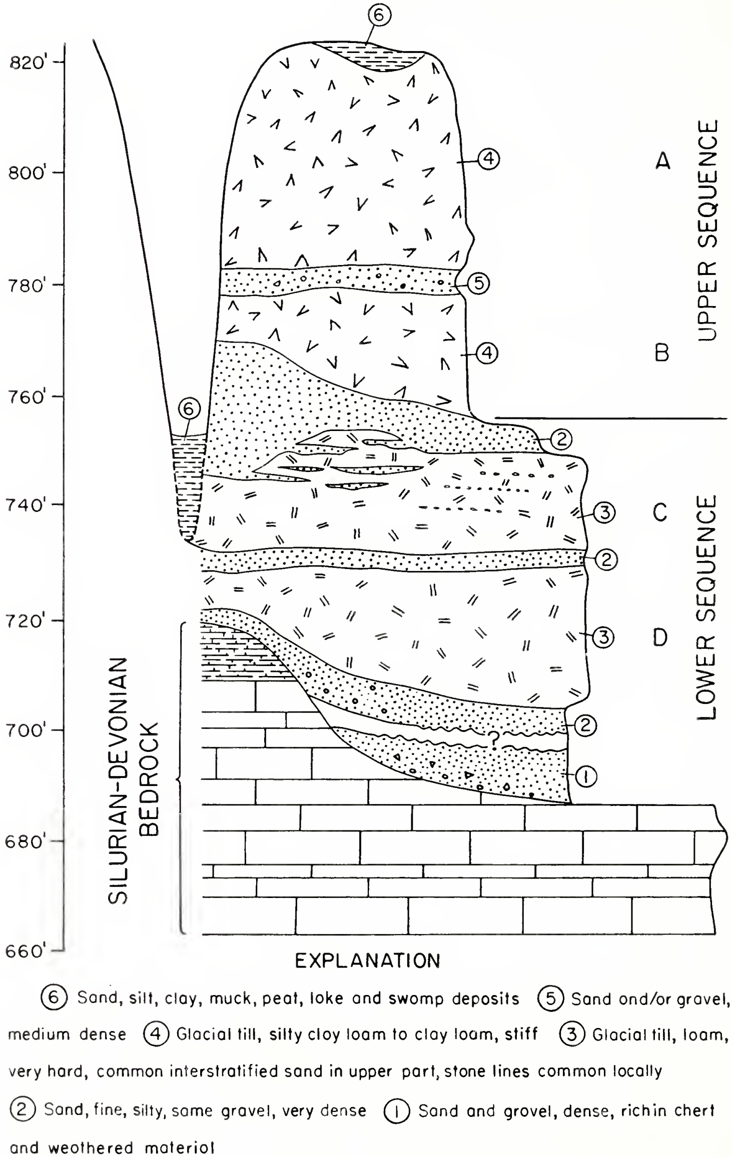

FIGURE 3. *Generalized geologic section, Allen County, Indiana, showing unconsolidated materials.*

lower till sequences there is usually a dense fine silty sand, which helps separate the drift sequences in water well and engineering boring records throughout the county.

The upper drift sequence is the series of clayey tills of the Erie Lobe (Fig. 3, A and B) that make up the concentric moraines of northeastern Indiana and northern Ohio. The upper tills are silty clay-loam to clay-loam textured, containing roughly 10% sand and 40 to 50% clay. They are stiff to very stiff in the engineering sense, having unconfined compressive strengths of 2 to 4 tons/ft^2. Their moisture content is typically between 15 and 20% with dry densities ranging from 115 to 125 lb/ft^3.

A. M. Gooding ("Characteristics of late Wisconsinan tills in eastern Indiana," in preparation) gives evidence for the glacial retreat and subsequent readvance of ice to the Wabash Moraine on the basis of a marked increase in clay content of surface tills within the Wabash Moraine. Although we have not as yet confirmed this in vertical section, numerous engineering boring and water well records and some measured sections indicate a distinct break marked by sand, gravel, or laminated clays within the upper till, which may represent the interval described by Gooding.

The sequential relationship is quite straightforward in most places, but in the Fort Wayne Outlet and the Wabash-Erie Channel areas, as discussed below, the lower drift sequence generally becomes much more complex and the basal sand, the intermediate sand of the lower sequence, and the intersequence sand in places increase greatly in thickness.

There is no evidence of any weathering interval between or within the till sequences, and thus we assume that both sequences record Wisconsinan glaciation. We believe that the lower sequence belongs to the Trafalgar Formation and the upper sequence to the Lagro Formation of Wayne (11). Wayne's plate 3 depicts a superposition of tills similar to that found in Allen County. Similar tills have also been described by Forsyth (5) near Defiance, Ohio.

The stratigraphically lowest and possibly the oldest unconsolidated materials yet examined in Allen County are exposed in the May Stone and Sand Company Ardmore Road quarry (NE¼, Sec. 29, T30N, R12E). This unit (Fig 3, Unit 1) consists of about 7 feet of medium to fine loamy sand to cobbly gravel, which, when moist, is dark gray, olive gray, and olive (5Y hue). Distinguishing characteristics of these lowest gravels are their high content of pebbles of angular chert and of igneous and metamorphic rocks, low content of shale, and lack of any carbonate except in a basal rubble layer. Clay mineral analyses show a significantly greater amount of mixed layered material than is present in samples of the area's oldest tills. The deposit rests upon Devonian limestone, possibly within a small bedrock valley, and is overlain by a generally clayey but variably textured till (correlation uncertain). It has the appearance of a weathered, reworked cherty lag deposit on an old erosion surface, but igneous and metamorphic pebbles indicate a previous or contemporaneous glaciation.

The Classic Glacial Lake Maumee Sequence

It has been supposed since 1915 that a lake level at about 800 feet was formed in the upper Maumee basin soon after the ice front retreated from the Fort Wayne Moraine (9). This lake was succeeded by another lake at 760 feet, after which the water rose again to 780 feet (790 feet according to some sources). The Maumee stages of the pro-Erie Lobe lakes ended once lower outlets were free to discharge into the Saginaw Bay area and into the Grand River valley.

For the sake of argument we will assume that three lakes existed at roughly these elevations. However, examination of 7½-minute topographic maps not available to earlier workers shows that gross miscorrelations of beaches were made and that many of the supposed beaches are probably near-shore features other than beaches. Thus, we feel that the nature and origin of these features and their correlation and sequential order should be restudied.

Knowledge of the basic glacial stratigraphy and of this classic lake sequence now provides the basis for a discussion of the morphology, stratigraphy, and developmental history of the outlets of the Maumee glacial lakes.

Morphologic and Stratigraphic Relationships in the Wabash-Erie Channel and the Fort Wayne Outlet

Terminology

The entire valley through which glacial Lake Maumee drained, extending from just east of Fort Wayne to the Wabash Valley below Huntington, was called the Wabash-Erie Channel by Dryer (3). Leverett (8) preferred the term Fort Wayne Outlet for the same channel. Because

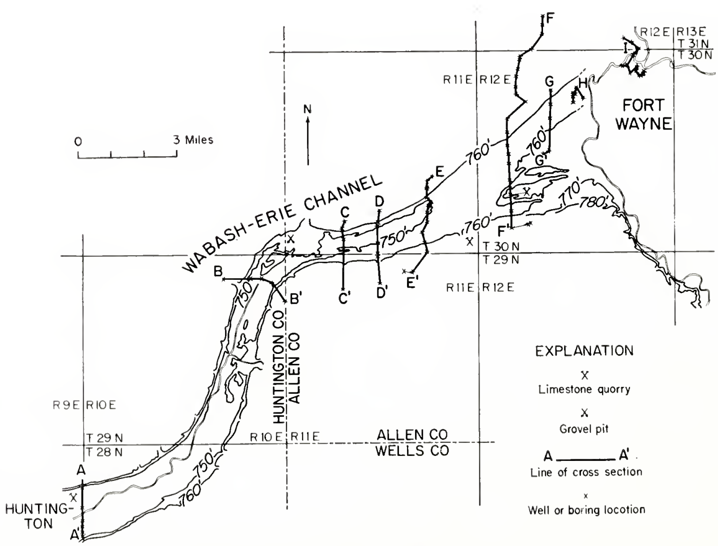

FIGURE 4. *Topography of the Wabash-Erie Channel floor, showing 10-foot contours and lines of cross section referred to in text. Maximum scoured elevation of Wabash-Erie Channel in Cross Section H, 742 feet; G, 740 feet; F, 743 feet; E, 739 feet; D, 735 feet; C, 735 feet; B, 745 feet; A, 735 feet (limestone bedrock). Cross sections H, E, D, and B show 10 to 25 feet of soft clay and/or loose sand below the uppermost unit of fine-grained fill.*

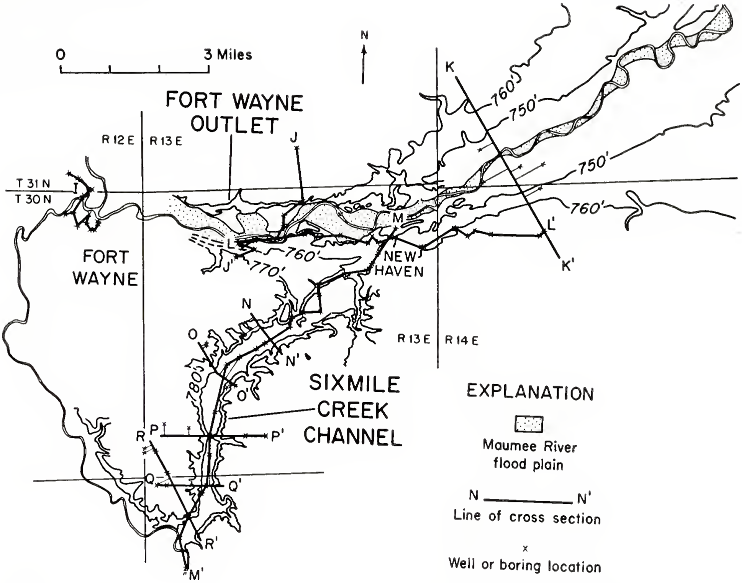

FIGURE 5. *Topography of the floor of westernmost glacial Lake Maumee and the Fort Wayne and Six Mile Creek outlets, showing 10-foot contours and lines of cross section referred to in text. Maximum scoured elevations of lake floor and Fort Wayne Outlet shown in Cross Section K, 750 feet; J, 750 feet.*

of their different although related origins we find it desirable to distinguish the mile-wide trough below Fort Wayne from that part of the valley that was cut through the Fort Wayne Moraine in Fort Wayne (Fig. 1). Therefore, we will use Dryer's term Wabash-Erie Channel for that single broad valley that is southwest of the city of Fort Wayne and that extends to Huntington. The head of this valley is the area of merging drainageways in the west half of T30N, R12E (Fig. 4). We will restrict the term Fort Wayne Outlet to that narrow valley extending from Sec. 4, T30N, R13E, the western point of the Maumee lake basin, westward through Fort Wayne to the point where the St. Mary's River turns east in Sec. 2, T30N, R12E to join the St. Joseph River (Fig. 5).

Morphology of the Outlet and Channel Floors

The general course of the channel between Fort Wayne and Huntington is of particular interest because of the possible indirect effect of bedrock topography upon the east-west segments (compare Valley D, Fig. 2, with Wabash-Erie Channel, Fig. 1) and because of the obvious effect of ice-controlled drainage upon the northeast-southwest segments of its course. As noted by Dryer (3), west of the outlet through the Fort Wayne Moraine "the channel turns to the southwest in a line which is a direct continuation of the valley of the St. Joseph River." Similarly, the valley also turns abruptly southwestward near the west Allen County line just west of where it bisects the Wabash Moraine and joins the continuation of Aboite Creek, which parallels the distal margin of the north limb of the moraine. The St. Joseph and Aboite Creek drainageways, like the nearby Mississinewa, Salamonie, upper Wabash, and St. Mary's Rivers, clearly have ice-marginal or otherwise ice-controlled trends.

Dryer (3) stated that "the present level of its bottom [the Wabash-Erie Channel] rises from 737 feet at the mouth of the St. Joseph to 756 feet at the summit 4 miles west, then falls to 744 feet at the margin of the Niagara outcrop, and to 699 feet at its junction with the Wabash," although Dryer recognized that those elevations did not record the scour depth of glacial lake outflow. He recorded about 4 feet of peat overlying blue clay underlying the Wabash-Erie Channel and 40 feet of silt over limestone at the outlet summit (discussed further below). Leverett (8), however, recorded the bed of the outlet in Fort Wayne as 755 feet (misquoted as 757 feet by Hough (7)) and noted that "parts of the bed are strewn with boulders and cobblestones, . . . indicating an old scourway. The northwest part of the city . . . stands on such a stony part of the bed." Leverett apparently considered the present floor at Fort Wayne to be the original scour depth, although he did recognize that below Fort Wayne "the bed is occupied by an extensive growth of peaty material, beneath which there is fine sand" and thus "had apparently been scoured out somewhat below its present level during the most vigorous stage of the excavation and was then filled in as the strength of the flow declined." The surface elevation in the northwest part of Fort Wayne, southwest of the confluence of the St. Joseph and St. Mary's Rivers, is, indeed, between 755 and 760 feet (Figs. 1 and 4). The configuration of the contours, of course, has been greatly affected by the building of the city, and for that reason they have not been shown on parts of Figures 4 and 5.

Of special interest, however, is the form of the outlet channel east of the city, where it is cut through the moraine. The outlet valley is for the most part occupied by the Maumee River floodplain at an elevation slightly greater than 740 feet, but in Secs. 3, 4, and 5, T30N, R13E, ter-

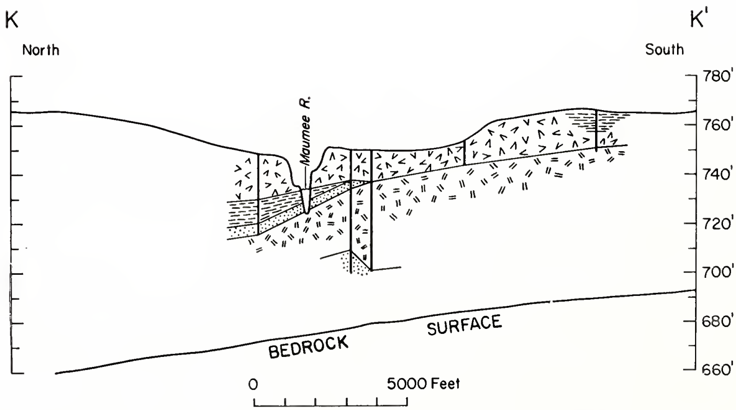

FIGURE 6. *Geologic Cross Section KK', showing geology beneath lake floor 2 miles east of New Haven. Bedrock surface interpreted from regional data. (See Fig. 5 for section location, Fig. 3 for explanation.)*

races at about 750 feet (along line of Cross Section JJ', Fig. 5) record the former scoured lake floor where it merges with the outlet.

The form of the westernmost lake bottom (along line of Cross Section KK', Figs. 5 and 6) clearly shows the constriction but also the continuation of the 750-foot contours into the outlet valley. It is clear from this geomorphic evidence that the original scoured depth in the outlet and channel downstream must have been even lower than 750 feet. In fact, this is exactly what the channel stratigraphy shows us.

Postglacial Stratigraphy within the Channel

Between 10 and 25 feet of silt, clay, and organic deposits (not yet radio-carbon dated) fill a scoured trough in the north half of the east-west part of the Wabash-Erie Channel (Fig. 7, Cross Section FF', as representative of Cross Sections CC' through H in Fig. 4). Even across the limestone sill at Huntington where Leverett (8) stated the elevation of the channel floor, and presumably the limestone surface, to be 744 feet, more than 7 feet of fine-grained fill is present over the limestone, which is at an elevation of about 735 feet in the center of the channel (along Cross Section AA', Fig. 4). Maximum elevations of the floors of the Fort Wayne Outlet and the Wabash-Erie Channel before the postlake infilling of the channel are given in the captions for Figures 4 and 5. It is clear that a significant buried trough, about the width of the valley of the Fort Wayne Outlet, occupies part of the larger Wabash-Erie Channel. The floor elevation of the buried trough, not the surface elevation, records the depth to which glacial Lake Maumee scoured. The buried channel floor appears to have broadly spaced highs and lows, whose origins are difficult to interpret. However, filling by at least the uppermost fine-grained unit must postdate the Lake Maumee discharge, and we interpret this to mean that the St. Marys and St. Joseph Rivers continued to flow sluggishly westward down the channel prior to the development of the Maumee River.

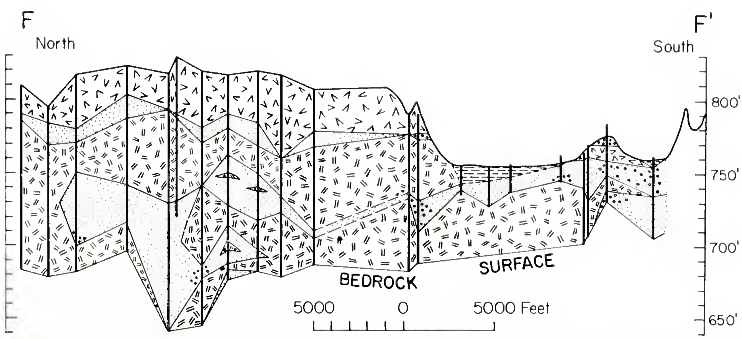

FIGURE 7. *Geologic Cross Section FF', showing representative geology of Wabash-Erie Channel and surroundings. (See Fig. 4 for section location, Fig. 3 for explanation.)*

The geology of the channel area is particularly complex. Intersequence sand and silt or lower sequence sand is present beneath the latest channel filling in many sections across the channel, the outlet, and the westernmost lake bottom (Fig. 7 and as along Cross Sections JJ' and

LL', Fig. 5). Because of this, it is almost impossible to assign position and age to many such deposits that occur immediately below the latest fine-grained fill. Often, only engineering data can give any clue as to whether sediments are exhumed or postglacial. Furthermore, there are several very deep holes in the channel filled with as much as 25 feet of soft (not overconsolidated) sediments to well below even the elevation of the bedrock sill at Huntington (see captions, Figs. 4 and 5).

Stratigraphic Evidence Bearing upon the Early Development of the Channel

Preliminary study of subsurface data suggests that the route of the present channel in and just west of Fort Wayne is roughly parallel to the route of drainage associated with lower sequence ice. Furthermore, two upper sequence tills, possibly representing the advance of the Erie Lobe to the Wabash Moraine and an earlier Erie Lobe advance, are separated in one major exposure on the south wall of the present channel (Midwest Aggregates quarry, Sec. 36, T30N, R11E) by a thick gravel that contains armored till balls derived from the lower till. This outwash may have been concentrated, before formation of the Wabash Moraine, along the present trend of the Wabash-Erie Channel, just as earlier meltwaters had been concentrated there.

During later development of the channel, high level outwash was deposited west of the confluence of the St. Joseph and St. Mary's valleys in continuation of the terraces in those valleys. Outwash as much as 25 feet thick is present as high as 785 feet in the west half of T30N, R12E (Figs. 1 and 4). Thus, a precursor of the present Wabash-Erie Channel was also in existence while the Fort Wayne Moraine was forming and discharging outwash through the St. Joseph and St. Marys valleys.

The lows in the channel floor that are filled with soft sediment in some way relate to the overall development of the channel. Were they cut by waters under considerable head flowing off or through ice? Do they represent plunge pools that consecutively developed as the channel lengthened? Or is there another explanation? We do not know.

But as a generalization, we can say that the Wabash-Erie Channel had a long, perhaps in part repetitive history of drainage and that most of the route as we see it today was an already established drainageway before the Fort Wayne Moraine and thus also before the Maumee glacial lakes came into existence. As noted above, the course of the main east-west segment of the channel may have been indirectly bedrock controlled, and the northeast-southwest courses were determined by ice.

Six Mile Creek Channel

Morphology

The only other incised breach in the Fort Wayne Moraine, the Trier Ditch, or the Six Mile Creek Channel as it was called by Dryer (Figs. 1 and 5) (3), connects the St. Marys River at 750 feet elevation with the Maumee River 8½ miles away at an elevation of 740 feet (Figs. 1 and 5). In the northern one-third of its length the channel broadens considerably and the 780-foot scarp swings into the embayment. The course of this

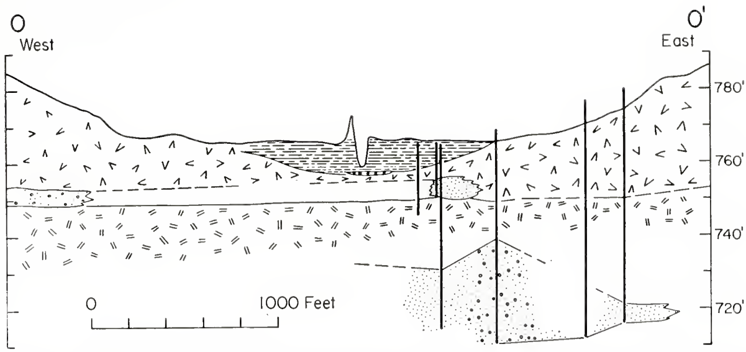

FIGURE 8. *Geologic Cross Section OO', showing representative geology across Six Mile Creek Channel. (See Fig. 5 for section location, Fig. 3 for explanation.)*

channel may have been indirectly determined by a minor bedrock valley Fig. 2 E), which was tributary to one of the major north-flowing preglacial streams.

Glacial and Postglacial Stratigraphy

As elsewhere in the Fort Wayne Moraine, the stratigraphy is relatively simple and is described by the basic sequence shown in Figure 3. In the southern part of the channel a thick basal sand is overlain by hard sandy till of the lower sequence (Cross Section 00', Fig. 8, as representative of Sections NN' through RR'). This in turn is overlain by a thin dense fine sand or silt of the intersequence unit. The upper clayey till sequence lies above. All glacial stratigraphic units, as shown on Cross Section MM' (Fig. 9), drop in elevation northward as they approach the lacustrine plain and the axis of the Erie Lobe. The upper part of the lower sequence here and near the main Fort Wayne Outlet becomes much more varied where it is topographically low, containing abundant intercalated sand and silt. Lacustrine and fluvial materials associated with glacial lakes

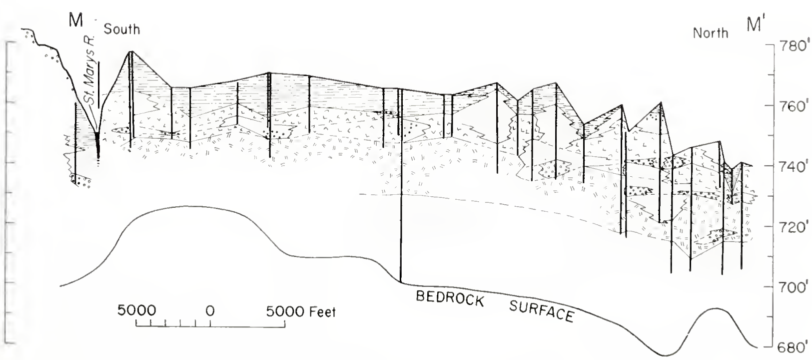

FIGURE 9. *Geologic Cross Section MM' along the Six Mile Creek Channel. Bedrock surface interpreted from regional data. (See Fig. 5 for section location, Fig. 3 for explanation.)*

and recent alluviation rest on both upper and lower sequence units along the channel, depending upon the depth of erosion.

Although there may have been a bedrock-determined initial sag, there is no indication that the Six Mile Creek Channel was active prior to deposition of the upper clayey till sequence. It appears that the contact of the upper and lower sequences may be lower there than it is a few miles to either side, but the data are insufficient to tell whether this indicates a valley or a local, closed low. The scoured floor of the present channel was cut in upper sequence clayey till at an elevation of 755 feet and, as would be expected, does seem to drop in elevation at both ends. The slope to the St. Mary's is very short and can be attributed to the more recent drainage. The slope to the north begins nearly half way along the length of the channel, is very gentle, parallels the boundary between the lower sequence till and the basal sand, and becomes difficult to trace as the stratigraphy becomes complex near the lake border. Leverett (8) pointed out that current bedding in gravels exposed southwest of New Haven shows a southward transport, which he attributed to drainage from glacial Lake Maumee. Cross beds could, of course, be related to storm deposits or longshore drift. Furthermore, it is obvious (Cross Section MM', Fig. 9) that no coarse sediment is found in the base of the channel in its southern half and that there is no appreciable buildup of such material opposite its south end. Thus, there is no clearcut reflection in morphology or general stratigraphy of the lake drainage that must have passed southward in the Six Mile Creek Channel.

As suggested by Dryer (3), the St. Mary's River used the channel as a flood stage outlet after lake levels had dropped. As recently as 1913, a flood of water 5 feet deep flowed through it. Leverett and Taylor (9) made reference to this event, and Dryer suggested that it was a frequent occurrence before the advent of modern drainage controls.

Dryer (3) defined a large sandy area in and just east of New Haven as the delta of the St. Mary's-Six Mile Creek Channel. However, the topographically prominent sand at the east end of the supposed delta appears to us to be dunal rather than deltaic, the dune sands lying upon coarse sands on the lake floor. The broadest expanse of the so-called "delta" is found in the city of New Haven where the elevation is about 760 feet, but most of the town is underlain by hard loam till.

The Six Mile Creek gap, like the Fort Wayne Outlet, was very likely an original low in the Fort Wayne Moraine. When the ice of the Erie Lobe began to recede, there were surely isolated small lakes ponded in front of it which had their own outlets. Six Mile Creek, which is now of a magnitude equal to that of the channel of the Imlay Outlet, may have been one of these. Although a large quantity of meltwater may have been spilled through Six Mile Creek Channel after integration of the ice marginal lakes into Lake Maumee, the prevailing currents and sediment transport from the lake bed were through the larger Fort Wayne Outlet. After the lake was emptied and present drainage patterns established, the Six Mile Creek Channel acted as a floodwater route for the St. Marys River.

Evidences for the Lake Sequence

Since Leverett's (8) first description in 1902 of the high stand of glacial Lake Maumee, it has been assumed that that lake drained primarily through the Fort Wayne Outlet and the Six Mile Creek Channel. Although Taylor (9, 12) had traced the uplifted continuation of the highest beach to a point 6 miles north of Imlay, Michigan, well north along the west wall of the present channel at Imlay, neither author, for some reason, concluded that the high lake drained at Imlay. It has been always recognized that the intermediate lake level drained through the Imlay Outlet, but Hough (7) pointed out that that level, too, must have drained through the Fort Wayne Outlet. Leverett (8) originally accounted for the change in level from 800 feet to 780 feet by the opening of the Imlay Outlet. If the high lake drained at Imlay, however, the opening of the Imlay Outlet alone (at least to the extent of the channel presently visible) could not explain the lowering of the lake to the 780-foot level.

The "third beach" at 760 feet was recognized in 1908 by Leverett (11) and was placed last in the sequence, although Leverett suggested the possibility that the low level might actually be intermediate in age, based upon its "rather washed-down appearance." Leverett further stated that the third Maumee beach "appears to have been barely high enough to have opened into the Imlay Outlet if its northward rise is as rapid as that of the first and second beaches." Taylor (9), however, made no mention of this observation, and assumed that the floor of the Imlay Outlet visible today, like the floor of the Fort Wayne Outlet, was too high to have drained the low-level lake.

We believe that the overriding reason for Taylor's (9) placing the 760-foot lake level between the two higher levels in the lake sequence was not the washed look of the 760-foot beaches, rather it was that the presumed lack of an outlet for the lowest lake necessitated the postulated burial of the lake's outlet by a subsequent glacial advance that also raised the level of the lake. Taylor (9) felt that a "readvance of the ice did not [completely] close the [wider and deeper 760-foot] outlet [at Imlay] but pushed it [westward] up the slope to the place where the Imlay outlet channel is now found." The head of the Imlay channel visible today was thought to have drained only the last level, the 780-foot lake.

However, we have shown that the scoured floors of the Fort Wayne Outlet, the Wabash-Erie Channel, and the Six Mile Creek Channel are deeper than previously assumed. At least 10 feet of water from a 760-foot lake could have passed through the Fort Wayne Outlet, and concurrently 5 feet of water could have passed through the Six Mile Creek Channel. Furthermore, the important limiting elevation of the limestone sill at Huntington is nearly 10 feet less than indicated by Leverett, and thus discharge gradients of all lakes were considerably more than previously assumed. Preliminary study of modern 7½′ topographic maps seems to indicate that the two high beaches can indeed be traced into the Imlay channel and that taking into consideration about 50 feet of postglacial uplift, the 760-foot lake might also have barely discharged through the channel, just as Leverett (11) suggested.

The subdued or washed look of the 760-foot beaches has never been quantitatively documented in the literature. Many of the classic 760-foot beaches are far above that elevation, others can easily be explained as nonbeach features, and any truly subdued beach certainly can be explained in other ways than by the washing action of a higher lake. Therefore, we feel that there is no evidence for other than the simplest sequence of the classic Maumee Lake Levels, 800 feet, 780 feet, 760 feet.

Cause of Change in Level

An 800-foot lake level would have been controlled by the initial configuration of the surface of the Fort Wayne Moraine. Assuming a constant discharge rate, it is possible that the opening of a discharge route at Imlay in addition to the Fort Wayne and Six Mile Creek outlets could have balanced the lake level at a lower elevation, as Leverett (8) originally suggested. But backcutting in the Fort Wayne Outlet eventually would have cut through the moraine, perhaps in a "stoping" process of headward advance of a rapids or chute similar to that postulated for the outlet of glacial Lake Chicago by W. C. Alden (1) and modified by J. W. Goldthwait (6) in the early 1900's.

We suggest the possibility that a significant stratigraphic sill, the top of the lower hard till, could have temporarily slowed downcutting at Fort Wayne, perhaps causing a stabilization of the lake at the intermediate level. The Fort Wayne Outlet is cut into intrasequence sand and apparently into the lower hard till, which is encountered at 750 feet in borings in Fort Wayne just south of the outlet, and up to 780 feet just northwest of the city (Fig. 7). (The Six Mile Creek Channel is cut entirely in the upper clayey till.) The lowest lake level could have been initiated once erosional equilibrium was attained in the outlet and channel, or the lake could have been stabilized by a balance between glacial melting and lake discharge, perhaps due to partial opening of the drainage route that eventually lowered water to the glacial lake Arkona levels.

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