11-1952

PLEISTOCENE EVOLUTION OF THE OHIO AND WABASH VALLEYS

William J. Wayne
University of Nebraska-Lincoln, wwayne3@unl.edu

The Journal of Geology, Vol. 60, No. 6 (Nov., 1952), pp. 575-585.

PLEISTOCENE EVOLUTION OF THE OHIO AND WABASH VALLEYS[1]

WILLIAM J. WAYNE
Indiana University

ABSTRACT

Studies of drift thickness and character currently in progress in Indiana indicate changes in drainage that have occurred in Indiana and some adjoining states since the beginning of the Pleistocene epoch. After late Tertiary (Lexington) peneplanation the master-drainage line, the Mahomet-Teays Valley system, became entrenched about 200 feet below its former level before it was ponded by Nebraskan ice and diverted into a new course. During the Parker cycle, which was interrupted by glaciation, the present physiographic features of southern Indiana and their now buried extensions to the north became recognizable. Static rejuvenation then was a major factor in erosion of the "Deep stage" of the Ohio Valley. Reversal of the pre-Illinoian Miami Valley probably resulted from this glaciation also. Further ponding of the Mahomet by Kansan ice and diversion of its drainage down the Wabash Valley is suggested as the origin of the "Deep stage" along that stream. Present drainage in central Indiana is a result of modifications produced by Tazewell and Cary glaciers.

INTRODUCTION

Differences of opinion concerning preglacial and interglacial stream courses in the states drained by the Ohio River and its tributaries from the north have long existed. Recently, a report on the bedrock topography of Illinois has been published, in which the evolution of present drainage is discussed and figured (Horberg, 1950, fig. 21). A similar study for Indiana currently in progress by the writer shows the existence of many previously unrecorded buried valleys and supplies additional data for interpretation of the erosional history of the region.

This report presents the writer's views of the sequence of changes in the drainage basins of the Ohio and Wabash valleys that resulted from Pleistocene glaciation. Approximately 4,000 water- and oil-well records in central Indiana have been collected and studied, the thickness of glacial drift plotted on county maps, and isopachous contours drawn from these data and outcrop information. Refraction seismograph data and well logs for the northern fourth of Indiana have not been studied.

This investigation is part of a survey of the mineral resources of Indiana and is being made under the direction of W. D. Thornbury, chief of the Glacial Geology section of the Indiana Department of Conservation, Geological Survey.

PREGLACIAL DRAINAGE

MAHOMET-TEAYS VALLEY

The main preglacial river of Indiana was the Mahomet-Teays, which probably headed in the Piedmont of North Carolina (Stout and Schaaf, 1931, p. 671) and flowed across West Virginia, Ohio, Indiana, and Illinois (fig. 1). An early ice sheet caused the first derangement of the river by severing the part called the Teays Valley (Tight, 1903, pp. 50–57, pl. 9) from that downstream.

Thornbury (1948, p. 1359) suggested using the name "Kanawha Valley" for this preglacial drainage line. In the opinion of the writer the name "Mahomet," proposed by Horberg (1945, p. 349) for the lower part of the valley which crosses Illinois to its discharge point on the preglacial Mississippi, could appropriately

[1] Published with the permission of the state geologist, Indiana Department of Conservation, Geological Survey. Manuscript received October 19, 1951.

be used for the valley across Indiana as well (fig. 1). The entire preglacial river valley might well be designated as the "Mahomet-Teays system," but the shortened interglacial valley of Illinois, Indiana, and western Ohio (fig. 2) should be called the "Mahomet" to distinguish it from its longer pre-Pleistocene ancestor.

One of the major tributaries of the Mahomet-Teays system in Indiana appears to have headed in southeastern Indiana and flowed northwestward to join the Mahomet Valley near Lafayette (fig. 1). The name "Anderson Valley" is suggested for the course of this preglacial river, as Anderson, Indiana, is situated on the till plain above it.

OHIO VALLEY

The pre-Pleistocene Ohio River was a relatively insignificant stream, which probably headed on the Silurian limestones[2] that underlie the area of the Muscatatuck regional slope (fig. 3) southwest of Madison, Indiana. Leverett (1902, pp. 116–118), Fenneman (1916, pp. 118–119), Ver Steeg (1938, pp. 657–659), and others thought that the Ohio headed upstream from Cincinnati. They based their conclusions mainly on the fact that the Miami Valley bedrock floor has a southwest gradient, whereas it should have a northeast gradient if it flowed toward the Mahomet-Teays. Malott (1922, pp. 136–138) and Fowke (1925, p. 87) favored the view that the Ohio headed near Madison, Indiana, and that the Kentucky River flowed northeastward through the old Miami Valley, which emptied into the Mahomet-Teays.

Considerable evidence has been offered to support the hypothesis of a former divide near Madison, Indiana. The Ohio River Valley is extremely narrow there, and the adjacent upland is undissected (Fowke, 1925, p. 87). The upland on the Muscatatuck regional slope near Madison shows a lack of beveling toward the Ohio River, but beveling does occur along the Kentucky River and its supposed continuation northeast from Madison (Fowke, 1925, p. 89). Beveling toward the Ohio does occur below Madison (Malott, 1922, p. 138). Many of the streams which join the Ohio above Madison exhibit a barbed pattern, but those that enter the Ohio below the old divide show normal relationships (Malott, 1922, p. 138). "Lafayette" gravels are present in quantity along the Kentucky River and along the Ohio downstream from New Amsterdam at the mouth of Indian Creek in Harrison County (Leverett, 1902, pp. 111–112). The upland is so well preserved in the Madison area that it is remarkable that they are not now present there, if they ever were deposited (Malott, 1922, p. 138). The presumed southwesterly slope does not take into account the possibility of uplift to the north following glacial unloading (Malott, 1922, p. 138) or the possibility of interglacial reversal of drainage in southern Ohio.

In view of the fact that the Mahomet-Teays Valley system apparently skirted the Cincinnati uplift on the north instead of flowing directly across it, as does the present Ohio River, it would seem likely that other drainage also would have become adjusted to that structure. The parts of Kentucky, Ohio, and Indiana underlain by Ordovician limestones and shales constitute essentially a shallow topographic basin. The lower part of the Kentucky River lies entirely within this basin and enters the Ohio River above the probable old divide at

[2] J. B. Patton (personal communication) indicates that the formation which generally forms the divide is the Laurel limestone.

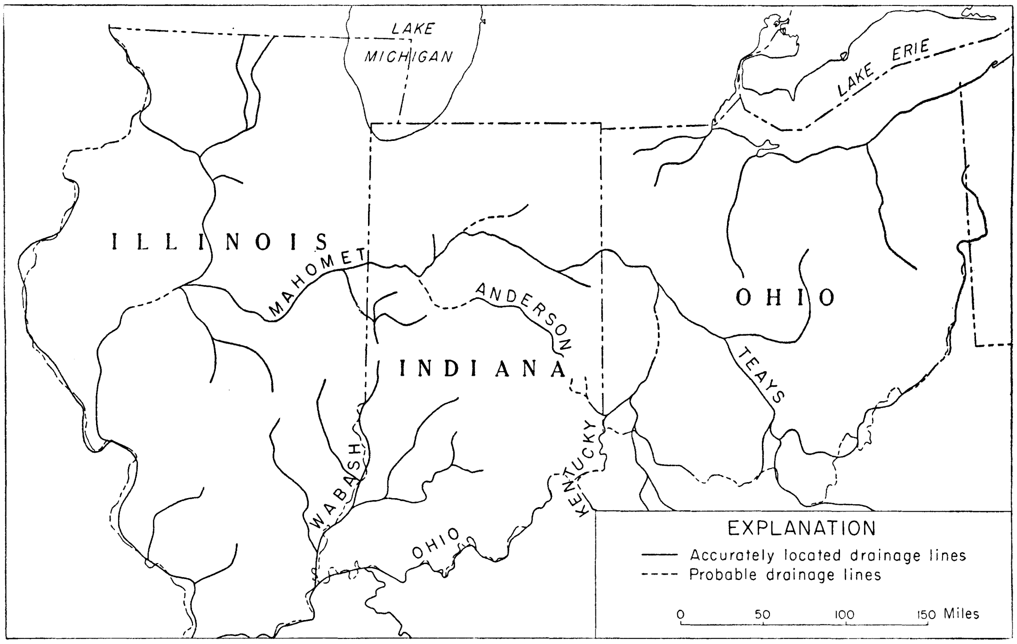

FIG. 1.—Principal preglacial drainage systems of Indiana and adjoining states. Compiled from studies by Leverett (1915, 1929), Malott (1922), Stout, Ver Steeg, and Lamb (1943), Fidlar (1948), McGrain (1949, 1951), Horberg (1950), and others.

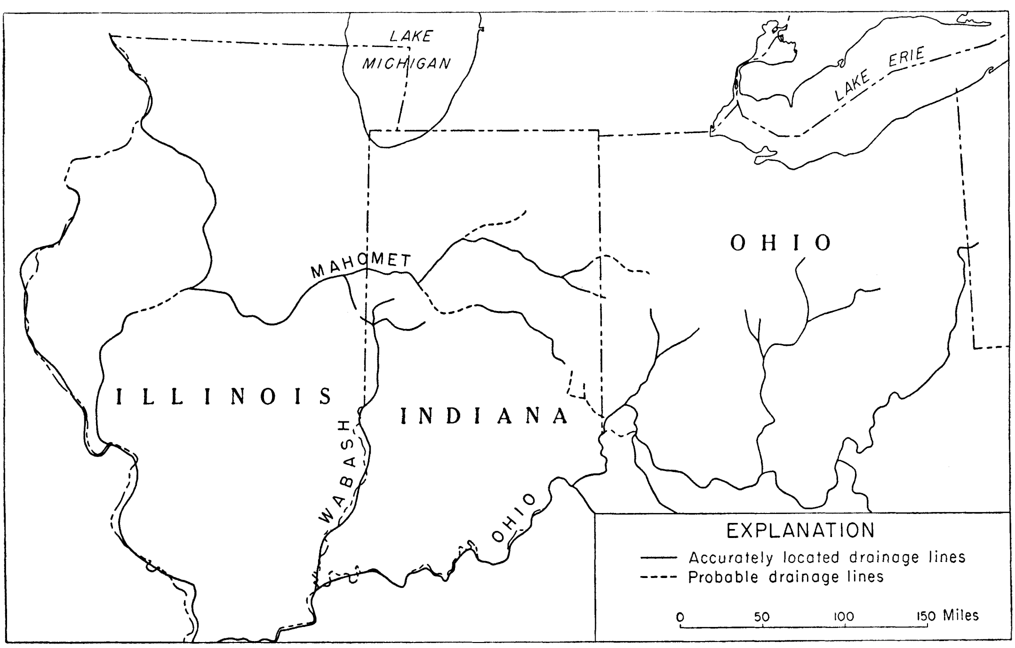

FIG. 2.—Drainage modifications that resulted from Nebraskan glaciation. Ohio data after Stout, Ver Steeg, and Lamb (1943); Illinois data after Horberg (1950).

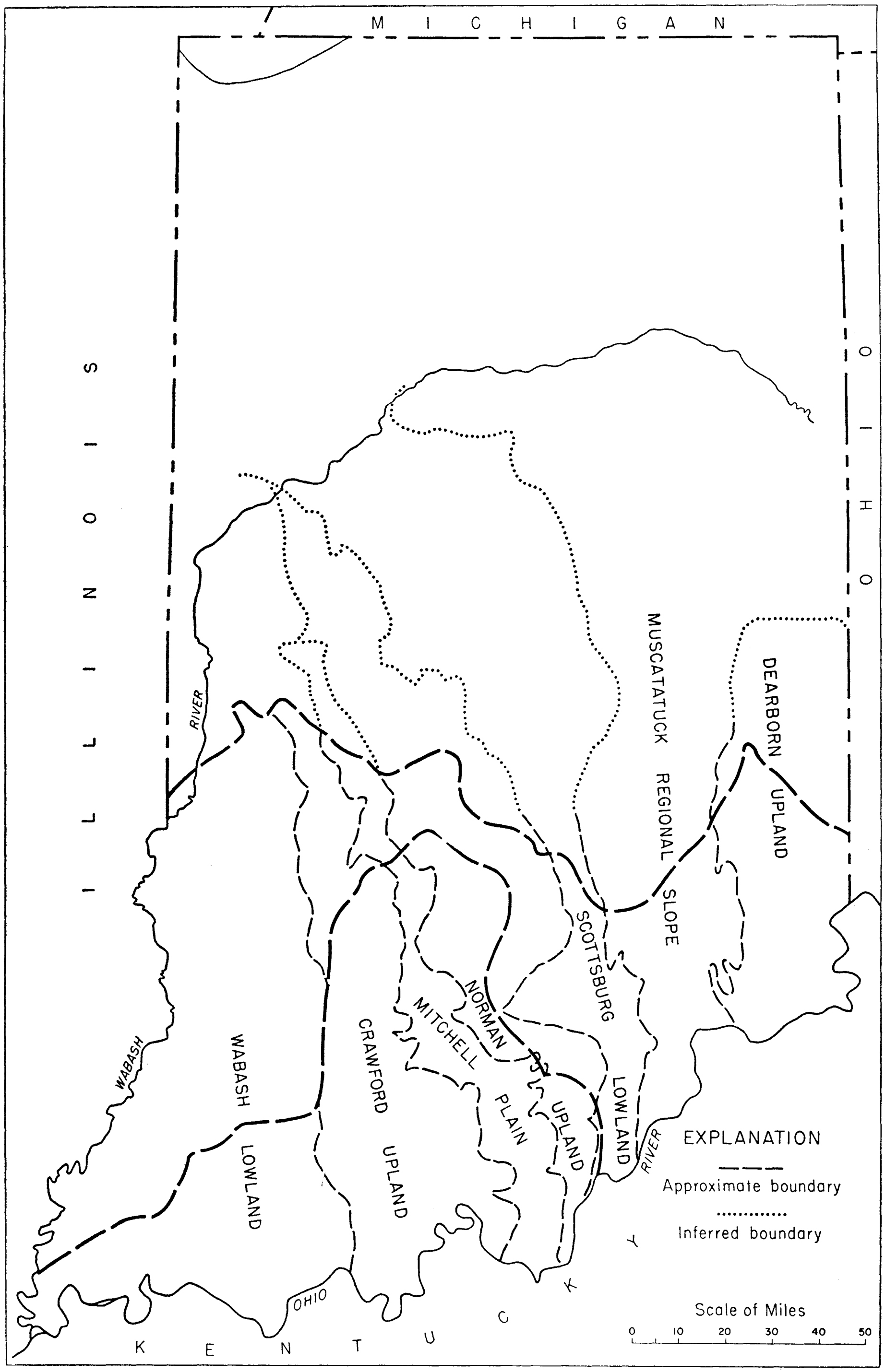

FIG. 3.—Physiographic units of southern Indiana, after Malott (1922), and their approximate boundaries where buried north of the Wisconsin glacial boundary.

Madison. Leverett (1929, p. 53) indicates that the south bluff of the Ohio River is composed of glacial till a short distance above the present mouth of the Kentucky River. On the northwest side, the basin developed on Ordovician rocks is rimmed by resistant Silurian limestones. Streams that flow westward from this scarp enter the Wabash drainage area; those, such as Laughery Creek and Tanner's Creek, which lie on the eastern side of the rim of limestone join the Ohio River above Madison (U.S. Geol. Survey, Aurora, Indiana, quadrangle). The writer thinks it highly unlikely that a small consequent river, such as the preglacial Ohio, could have accomplished the extensive headward erosion and the several piracies necessary to develop a river that crossed the Cincinnati Arch. For this reason, in addition to those listed above, the writer thinks that the preglacial Miami River probably flowed northeastward and that the Ohio River headed on the Muscatatuck regional slope.

WABASH VALLEY

Fidlar (1948, fig. 1) considered the preglacial Wabash River to have headed near Covington in Fountain County. Thornbury (1948, p. 1359) suggested that the Knobstone escarpment formed the preglacial divide in western Indiana between the basins of the Wabash and the Mahomet-Teays. The bedrock drainage pattern which exists in Fountain and Parke counties and the bedrock altitudes in the same area indicate that the divide was more likely about 15 miles south of Covington in northern Parke County and southern Fountain County. South of Parke County, the course of the bedrock Wabash Valley has been described in detail by Malott (1922), Fidlar (1948), Horberg (1950), and others.

LATE TERTIARY EROSION CYCLES

Indiana and the surrounding area were reduced to a gently rolling, old-age, topographic surface during the latter part of the Tertiary, probably in late Miocene or Pliocene time. This surface, the Lexington peneplain, is about 900–1,000 feet in altitude in the Dearborn upland (fig. 3) of southeastern Indiana, and the residual local relief is 100–200 feet. The Lexington peneplain sloped north and west toward the major drainage lines. It had an altitude of 700–800 feet in Wabash County in north-central Indiana (Wayne and Thornbury, 1951, p. 26). The peneplanation probably never was so complete that uplands and lowlands were unrecognizable. On the contrary, some structural and lithologic control of topography must have remained.

A new cycle of erosion called the "Parker" began with the late Tertiary rejuvenation, which caused the streams to entrench themselves 100–200 feet below the level of the peneplain and to develop broad floodplains. Lowlands were developed along the outcrop belts of weaker rocks, particularly those traversed by major streams. Degradation of the Scottsburg lowland of southern Indiana and its buried northward extension began during this period, as did that of the Pennsylvanian lowland (Horberg, 1950, pp. 35–37) of Illinois and Indiana. This cycle was interrupted by glaciation.

The present Scottsburg lowland is a result of degradation throughout the Pleistocene. Inasmuch as a major river system, the Mahomet-Teays, crossed north-central Indiana, the northern end of the lowland should have been eroded more than the southern end during preglacial times. Analysis of drift thickness indicates the existence of a former broad lowland along the outcrop of Devonian and Lower Mississippian shales in central Indiana, where they are deeply buried beneath Wisconsin glacial deposits. This part of the Scottsburg lowland was formed between the end of the Lexington cycle and the beginning of the Illinoian age, and probably the greater part of the development took place during Parker time. The southern part of the Scottsburg lowland has been further eroded and deepened since the enlargement of the Ohio River following Nebraskan glaciation.

Glaciation caused complications in the Parker cycle, including drainage diversions, static rejuvenation, and alluviation in the major rivers. The present rivers in central Indiana follow largely the courses of Wisconsin or Illinoian sluiceways and in some places show little or no relation to the bedrock topography. Much of the post-Wisconsin drainage is superposed, so that streams now cross buried uplands and valleys with little relationship to either.

In north-central Indiana the main preglacial rivers appear to have been deeply entrenched below broad valleys that were about 100 feet below the level of the Lexington peneplain. The bedrock surface slopes gently toward these valleys, the dissected remnants of which have been interpreted as strath terraces representing the Parker cycle (Wayne and Thornbury, 1951, p. 29). The writer now thinks that these old-age valleys more likely are simply the broad troughs through which rivers flowed across the Lexington peneplain.

DEVELOPMENT OF THE DEEPLY INCISED VALLEYS

Several differences of opinion have arisen concerning the age of the deeply entrenched bedrock valleys. Ver Steeg (1936, pp. 935–936) suggested that the deep erosion along the major valleys ("Deep stage") took place after the disruption of the Mahomet-Teays drainage system and left the Parker strath as a terrace above the entrenched rivers. He states (1936, pp. 936–937): "The writer believes that the deep, comparatively narrow valleys buried beneath the glacial drift of western Ohio and incised below an old surface (Parker) were cut during Deep-stage time. . . . The Deep stage lasted from the flood stage of the Teays to the advent of the Illinoian glacier."

Horberg (1950, p. 70) recognized probable outwash below Aftonian soil in the bottom of the Mahomet Valley in Illinois, thus indicating that the erosion there may have been entirely pre-Pleistocene.

Thornbury (1948, p. 1359) interpreted the deep valley across north-central Indiana as part of the "Deep stage" of the Mahomet-Teays drainage system and suggested that it was eroded before Illinoian glaciation by an interglacial river that headed in western Ohio.

It is entirely possible that the "Deep stage" of the Mahomet-Teays Valley is pre-Pleistocene. Where the Teays disappears beneath glacial drift near Chillicothe, Ohio, its bedrock altitude is 620 feet (Stout and Schaaf, 1931, p. 665). The wide bench above the deep valley in Wabash County, Indiana, which has been interpreted as part of the same valley floor as that in southern Ohio (Wayne and Thornbury, 1951, p. 29) is about 600 feet above sea-level. The length of the valley between Chillicothe and the western edge of Wabash County is at least 210 miles, and the stream course probably was closer to 300 miles long. The middle reaches of this river, therefore, would seem to have had an average gradient of less than 2 inches per mile, a conclusion that is improbable. Differential rates of uplift could have caused such a gradient, but, if uplift occurred, its effects should be noticeable in steepened gradients of eastward-flowing streams and lessened gradients of other westflowing streams in Indiana. Such phenomena have not been observed. The deepest part of the Mahomet-Teays Valley in Wabash County, Indiana, is about 410 feet in altitude, or 210 feet lower than at Chillicothe, Ohio, which would provide a maximum average gradient of 12 inches per mile. Horberg (1945, p. 359) calculated the average gradient of the Teays-Mahomet Valley between Chillicothe, Ohio, and Tazewell County, Illinois, as 7 inches per mile; and Stout, Ver Steeg, and Lamb (1943, p. 53) calculated the gradient of the valley across Ohio as 12 inches per mile. For comparison, the average gradient of the present Ohio River from the mouth of the Miami River to its junction with the Wabash River is 4 inches per mile.

It seems rather unlikely that, after ponding and derangement of the Mahomet-Teays drainage system and diversion of the upper part over a divide into the Ohio Valley (fig. 2), the beheaded remains of the Mahomet River somewhere in west-central Ohio could have been capable of entrenching itself deeply below its former level. Instead, one would expect some aggradation by the underfit river after such a loss of volume. More likely, little or no deepening of the Mahomet Valley could have occurred after it was shortened.

The precise glaciation that caused the ponding of the Mahomet-Teays drainage system has not been determined. Leverett (1929, fig. 3), described partly decomposed erratics at various locations in Kentucky. As rafting by icebergs does not satisfactorily account for all the boulders, Leverett (1929, p. 33) postulated an extensive ice sheet of pre-Illinoian age. Thwaites (1947, pl. 3) interprets these boulders as Nebraskan in age.

Diversion of so large a river as the upper part of the Mahomet-Teays into the Ohio Valley most certainly would have caused static rejuvenation to take place and rapid regrading to occur along that valley (Malott, 1922, p. 170). Glaciation of the duration necessary to derange the Mahomet-Teays system permanently could likewise have caused reversal of drainage in the preglacial Miami Valley of southwestern Ohio, which, in cutting in accordance with the deepened Ohio River, would have developed the observed southwesterly gradient of the Miami bedrock valley. A narrow but deep buried trench that is intersected by the present Whitewater River at Connersville, Indiana, may have been formed at the same time by overflow waters impounded in Anderson Valley. Well cuttings show that lacustrine clays more than 160 feet thick lie beneath Wisconsin till in Anderson Valley, but data are insufficient to determine whether this entire thickness represents one or more than one glacial stage. The relatively soft Ordovician shales in the Cincinnati area would have allowed fairly rapid reduction of interstream areas to conform to the new stream orientation. Thus the deep erosion ("Deep stage") of the Ohio River seems to be post-Nebraskan in age.

What appears to be a "valley-in-valley" profile along the Mahomet-Teays in western Ohio and in Wabash County, Indiana, may be a result of only one entrenchment rather than two. The rivers that crossed the gently rolling Lexington peneplain in late Tertiary time undoubtedly flowed through broad valleys and were somewhat below the level of the interstream areas. Following uplift, these rivers became deeply entrenched below their old floodplains.

The steep sides that occur along the bedrock valleys in east-central Indiana probably result from the greater resistance to erosion of the Niagaran limestones of the region as compared with shales both east and west of that part of the Cincinnati and Wabash arches. The valley floor had reached a stage of early maturity. Strath terraces have not been found along the upper reaches of the Anderson Valley (fig. 1). In its lower reaches, this valley passes through Devonian and Mississippian shales that underlie the Scottsburg lowland, and the river was able to erode a much wider valley than in limestone.

Horberg (1945, p. 354) drew generalized contours on the Sangamon interglacial surface of weathering in central Illinois. On the basis of this map and on the lithology of well cuttings along the Mahomet Valley, he concluded that the Mahomet River was insignificant as a drainage line across Illinois after Kansan glaciation. Outwash gravels and sands are extensive along the Mahomet Valley in Indiana and indicate that it was a sluiceway until late Tazewell time in this state. A possible explanation for the presence of abundant outwash in Indiana and its absence in Illinois is suggested by the deep erosion ("Deep stage") along the Wabash Valley that seems to extend north to the Mahomet Valley. At one time Fidlar (1943, p. 415) thought that the deep Mahomet-Teays Valley across Indiana was a continuation of the Wabash. Certainly the divide between the two drainage systems must have been low. Kansan ice may have impounded water in the Mahomet Valley above Warren County, Indiana, and diverted the drainage of the upper part of the basin into the Wabash Valley (fig. 4). A

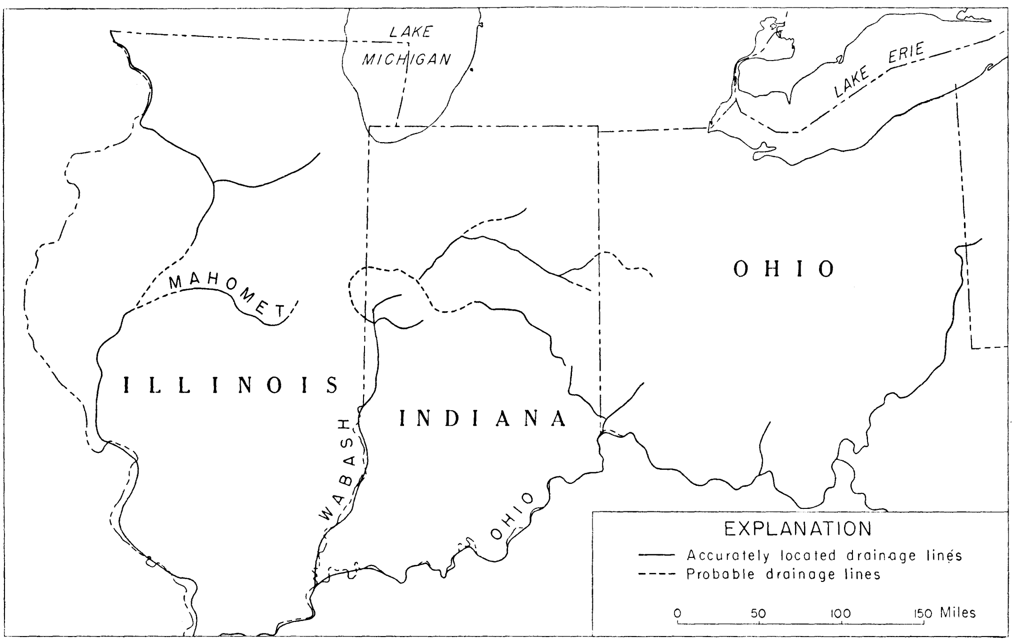

FIG. 4.—Drainage modifications that resulted from Kansas and Illinoian glaciations. Ohio data after Stout, Ver Steeg, and Lamb (1943); Illinois data after Horberg (1950).

buried valley that contains considerable outwash crosses the bedrock valley of the Wabash in northern Vermillion County. This valley is relatively narrow and is a continuation of buried Danville Valley in Illinois (Horberg, 1951, p. 71). Static rejuvenation would have caused the overfit river to begin cutting its course to grade immediately. Such a history could explain the peculiarity of the deeply entrenched bedrock valley that appears to head so close to a major preglacial river. Presence (reported by well-drillers) of silt and fine sand in the Mahomet Valley in Tippecanoe, White, and Carroll counties, Indiana, and exposures of thick outwash deposits overlain by till in Fountain and Warren counties, Indiana, support this interpretation, but data are admittedly inconclusive. Much of the "Deep stage" of the Wabash Valley, according to this interpretation, would have been cut during Kansan and Yarmouth time as a result of an increase in volume from diversion of part of the Mahomet River.

LATE PLEISTOCENE VALLEY-FILLING

The extent of Illinoian glaciation in Indiana has been discussed thoroughly by Leverett and Taylor (1915), Malott (1922), Thornbury (1937), and others. Some of the more important events that took place during this glacial age were the beginning of extensive deposition along the Ohio River and many of its tributaries, and continued filling of the Mahomet and its tributaries with till and glaciofluviatile deposits. As much as 160 feet of calcareous lacustrine clay was deposited in Anderson Valley, most of it probably during Illinoian time. Malott (1922, pp. 140–141) suggested that the great volume of Illinoian and Wisconsin outwash enlarged the Mississippi delta and thereby forced the Mississippi River

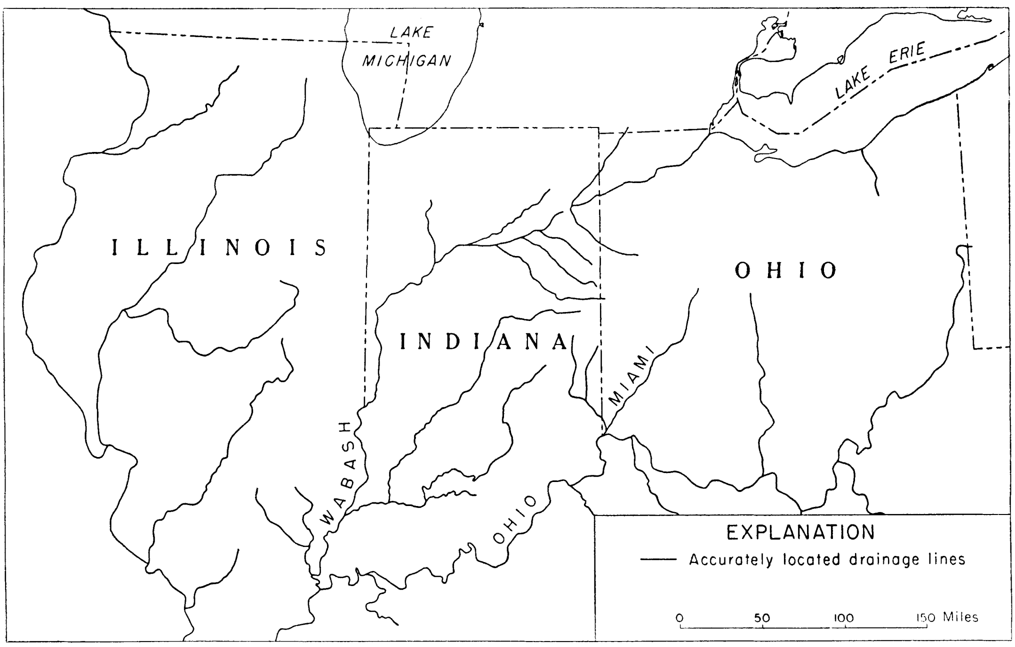

FIG. 5.—Principal post-Wisconsin drainage systems of Indiana and adjoining states

and its tributaries to aggrade their valleys. This may have been a contributing factor, along with the rising sea-level during deglaciation (Turnbull, Krinitzsky, and Johnson, in: Trask, 1950, p. 210).

Early Wisconsin (Tazewell) ice provided great quantities of outwash, which aggraded major sluiceways, such as the Ohio and Wabash rivers (Fidlar, 1948, pl. 3). The upper Wabash apparently still followed the course of the ancient Mahomet as far as Lafayette. A readvance of the ice covered the thick outwash with till, and, when the ice melted, the upper course of the present Wabash was established (fig. 5; Wayne and Thornbury, 1951, p. 32).

SUMMARY

The deep valley ("Deep stage") of the Mahomet-Teays across Illinois, Indiana, and western Ohio was eroded contemporaneously with the surfaces in the abandoned reaches of the Teays drainage system in Ohio and West Virginia and probably was preglacial. A lobe of the Nebraskan glacier ponded and diverted the upper Mahomet-Teays into the Ohio Basin, the Minford silts were deposited, and the direction of flow was reversed in some tributaries, such as the Miami. Erosion of the "Deep stage" of the Ohio Valley next occurred in post-Nebraskan time (Aftonian, possibly longer), when the Mahomet became an underfit stream that headed in western Ohio. Later the upper Mahomet probably was diverted into the Wabash Valley as a result of Kansan glaciation, and the "Deep stage" was cut along the lower Wabash in Yarmouth time. Extensive valley-filling in all the "Deep-stage" valleys of the Mississippi River and its tributaries began during the Illinoian age. The remains of the Mahomet drainage line in Indiana was obliterated by Wisconsin (Tazewell) glacial deposits, and many of the present valleys in north-central Indiana were eroded along melt-water drainage lines established during the Wisconsin glacial retreat.

ACKNOWLEDGMENTS.—The late C. A. Malott and John B. Patton, chief of the Industrial Minerals Section of the Survey, provided counsel as the work progressed. Preston McGrain, of the Kentucky Geological Survey, permitted access to a preliminary unpublished regional map which he had prepared of drift thickness in the upper Wabash Basin. Leland Horberg, University of Chicago, and Karl Ver Steeg, College of Wooster, kindly read and criticized the manuscript.

REFERENCES CITED

FIDLAR, M. M. (1943) The preglacial Teays Valley in Indiana: Jour. Geology, vol. 51, pp. 411–418.

——— (1948) Physiography of the lower Wabash Valley: Dept. Conservation, Indiana Div. Geology Bull. 2, 112 pp.

FOWKE, GERARD (1925) The genesis of the Ohio River: Indiana Acad. Sci. Proc., vol. 34, pp. 81–102.

HORBERG, LELAND (1945) A major buried valley in east-central Illinois and its regional relationships: Jour. Geology, vol. 53, pp. 349–359.

——— (1950) Bedrock topography of Illinois: Illinois Geol. Survey Bull. 73, 111 pp.

LEVERETT, FRANK (1902) Glacial formations and drainage features of the Erie and Ohio basins: U.S. Geol. Survey Mon. 41, 802 pp.

——— (1915) The Pleistocene of Indiana and Michigan and the history of the Great Lakes: *ibid.*, Mon. 53, 529 pp.

——— (1929) Pleistocene of northern Kentucky: Kentucky Geol. Survey, ser. 6, vol. 31, pp. 1-80.

MALOTT, C. A. (1922) The physiography of Indiana; in: Handbook of Indiana geology: Indiana Dept. Conservation, Div. Geology Pub. 21, pp. 59–256.

MCGRAIN, PRESTON (1949) Ground water resources of Henry County, Indiana: Indiana Acad. Sci. Proc., vol. 58, pp. 173–187.

——— (1951) Thickness of glacial drift in north central Indiana: Indiana Flood Control and Water Resources Comm. Circular No. 1.

STOUT, WILBUR, and SCHAAF, DOWNS (1931) Minford silts of southern Ohio: Geol. Soc. America Bull. 42, pp. 663–672.

———; Ver Steeg, Karl; and Lamb, G. F. (1943) Geology of water in Ohio: Ohio Geol. Survey Bull. 44, 4th ser., 694 pp.

Thornbury, W. D. (1937) Glacial geology of southern and south-central Indiana: Indiana Dept. Conservation, Div. Geology Pub., 138 pp.

——— (1948) Preglacial and interglacial drainage of Indiana (abstr.): Geol. Soc. America Bull. 59, p. 1359.

Thwaites, F. T. (1947) Outline of glacial geology, Ann Arbor, Edwards Bros., 119 pp.

Tight, W. G. (1903) Drainage modifications in southeastern Ohio and adjacent parts of West Virginia and Kentucky: U.S. Geol. Surv. Prof. Paper 13, 111 pp.

Ver Steeg, Karl (1936) The buried topography of western Ohio: Jour. Geology, vol. 44, pp. 918–939.

——— (1938) Thickness of the glacial drift in western Ohio: *ibid.*, vol. 46, pp. 654–659.

Wayne, W. J., and Thornbury, W. D. (1951) Glacial geology of Wabash County, Indiana: Dept. Conservation, Indiana Geol. Survey Bull. 5, 39 pp.