The Reversal of Racoon Creek at Atherton Island, West-Central Indiana[1]

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Atherton Island in southwestern Parke County and northern Vigo County is one of the more intriguing features of stream reversal and circumalluviation along the Wabash Valley (fig. 1). Several ideas have been advanced for the cause of the derangement of drainage that produced it, particularly Hobbs' (9) suggestion that diastrophic forces had diverted the stream, the ice-dam hypothesis of Dryer (2), and the proposals of Bartle (1) and Fidlar (3) that sand dunes blocked and reversed the drainage. None of them has seemed fully convincing to some geomorphologists who have examined the area.

Dryer (2) observed that the river that cut the bedrock valley of Raccoon Creek between Mansfield and Terre Haute had been a much larger stream than present Raccoon Creek. The upper reaches of the bedrock valley of Raccoon Creek headed north of Indianapolis (11). Dryer suggested that an ice dam probably blocked the mouth of Raccoon Creek valley south of Atherton during Illinoian time, creating a lake that drained to the north past Mecca. Further cutting, he reasoned, took place during Sangamon time. During the Wisconsin glaciation he thought the Raccoon drainage temporarily reused its old valley below Rosedale, but that after the glacier had melted, the stream returned to the northern route.

Bartle (1) reviewed previous suggestions on the reversal of Raccoon Creek and then proposed that the diversion was entirely postglacial. He thought Dryer's ice-dam hypothesis unlikely, because if the glacier melted from south to north, the ice would have opened the southern route first while the valley was still blocked with ice at Montezuma. To account for a postglacial deflection, Bartle (1) proposed that an accumulation of dunes southeast of Atherton Island blocked the mouth of Raccoon Creek and diverted the stream northward through a tributary and across a low divide near Coxville into a tributary of the Wabash. In a footnote, he (1) added a suggestion by Tucker that the outwash accumulation at the mouth of Raccoon Creek along the Wabash could have contributed to the damming and reversal of drainage.

The currently accepted explanation is Fidlar's (3) modification of Bartle's sand dune-deflection hypothesis. Fidlar suggested that the present trough north of Coxville was cut by glacial meltwater through enlargement of a tributary of Raccoon Creek, and that the diversion and reversal of drainage were accomplished when the accumulation of sand dunes in the valley below Rosedale blocked southwestward flow of the stream after the ice had melted from the area.

Dune sand is loose, and it is readily moved by running water, especially by streams in flood; therefore an accumulation of dune sand is

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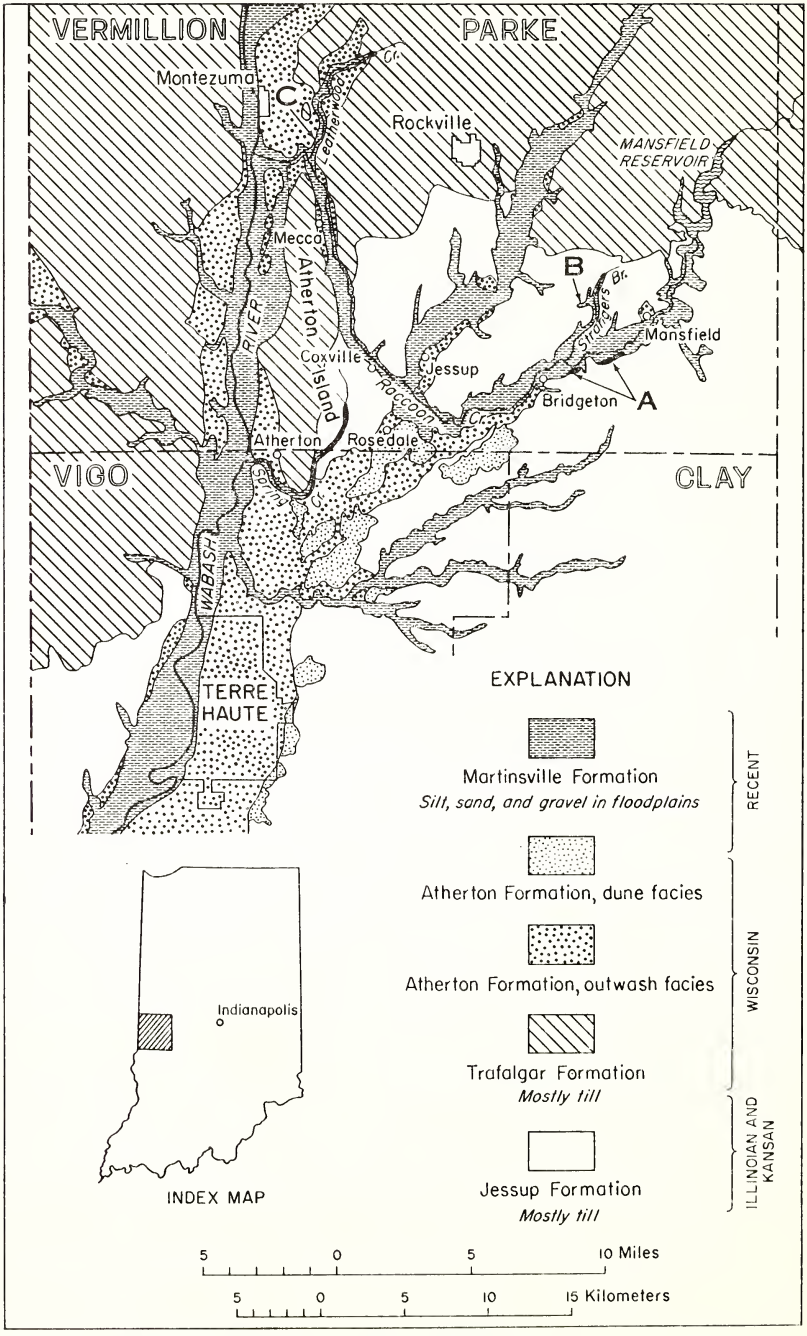


Figure 1. Map showing glacial geology of Raccoon Creek and vincinity (from Wier and Gray, 1961).

not likely to have been an effective dam that would have blocked and diverted a stream the size of Raccoon Creek. Recent studies of the glacial geology of Raccoon Creek valley between Mansfield and Terre Haute have provided data that permit the development of an additional hypothesis on the cause of the deflection.

Glacial Geology of Valley of Raccoon Creek

The bedrock valley of Raccoon Creek is filled with sands and gravels that are Kansan in age. Glacial sediments of the Cloverdale Till Member (Kansan Stage) of the Jessup Formation (12) are exposed in the lower parts of stream banks and road cuts in the Raccoon Creek valley. Flood-plain sediments of Yarmouth age are exposed in stream bluffs near Mansfield (Site A on fig. 1) at the present flood-plain level (10). Illinoian proglacial stratified clayey silts (part of the Atherton Formation, lacustrine facies) overlie the Yarmouth sediments and indicate that the valley was blocked at least temporarily, but the lacustrine sediments are overlain by thick outwash sands and gravels (Atherton Formation, outwash facies) as well as ice-laid sediments of the Butlerville Till Member (Illinoian Stage) of the Jessup Formation.

Significant enlargement of the gorge from Coxville north could have taken place during Illinoian or Kansan time. Part of the valley did exist as a tributary of Raccoon Creek, but the southern end of it has been filled with drift of Illinoian age that is being excavated by Spring Creek. The rock-walled narrow at Coxville is a diversion created during the retreatal phase of the Illinoian or an earlier glaciation, perhaps by meltwater of an ice-marignal stream.

The sediments of Wisconsin age that underlie the 2-mile-wide abandoned valley segment between Rosedale and Terre Haute are gravel and sand overlain by an uneven veneer of dune sand (fig. 1). This is the type area for these two facies of the Atherton Formation of Wayne (12). The surface is a plain that slopes gently from west to east and is covered with low dunes (13).

Upstream from Rosedale, progressively finer-grained sediments underlie terraces along Raccoon Creek. Silty sands and gravels of the Atherton Formation 2 miles below Bridgeton grade within a mile into sandy silt. Above Bridgeton few terraces are present, but fossiliferous shallow-water silts (Atherton Formation, lacustrine facies) underlie some low benches in small tributary valleys, and silt of either loessial or lacustrine origin caps low terraces underlain by Illinoian sand and gravel (Atherton Formation, outwash facies) in the main valley.

Although little can be said about the position of the Illinoian or Kansan ice margin in the vicinity of Raccoon Creek except by analogy, the extent of the ice during Wisconsin time can be rather readily determined. The Illinoian ice may have followed a similar pattern of lobation both during advance and retreat across this area.

The east margin of the Wisconsin glacier trended almost due southward across Atherton Island at the time of the maximum advance of the ice (fig. 2A). Meltwater poured southward down the narrow gorge from Mecca to Coxville. Although the glacier was too thin to spread across

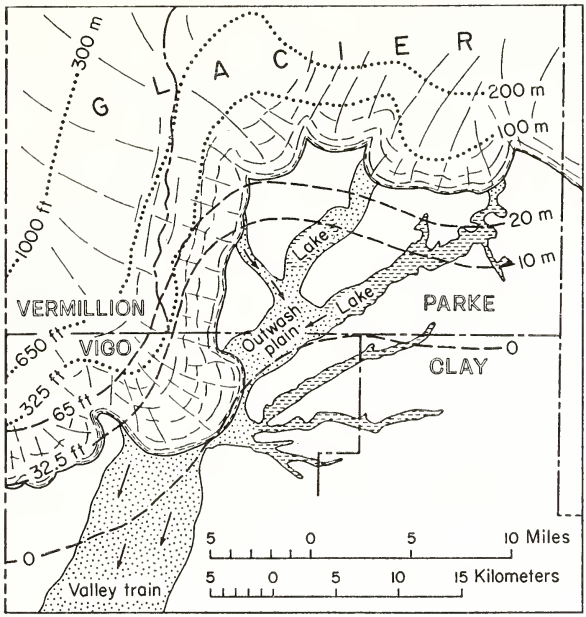
the upland, the ice margin extended southward down the Wabash Valley and into the mouth of Raccoon Creek along Spring Creek about 2 miles southeast of Atherton, where it built a broad outwash plain into the wide valley below Rosedale. The outwash plain extended toward Bridgeton as a delta into a lake that formed in Raccoon Creek valley upstream from the ice and outwash dam. Meltwater during both Illinoian and Wisconsin glaciations and perhaps normal erosion during Sangamon time had enlarged the valley of a former tributary of Raccoon Creek along the east side of Atherton Island. This trench is partly filled with crossbedded sand and gravel. Terraces along the lower valley of Raccoon Creek are 530 feet in altitude, as is the surface of the Shelbyville Terrace, the upper level of valley fill (Atherton Formation, outwash facies) along the Wabash and in the abandoned segment of Raccoon Creek. Upstream along Raccoon Creek, however, the surfaces of Wisconsin terraces on Atherton lacustrine silts rise to the northeast and, along Strangers Branch, are 600 feet above sea level (Site B on fig. 1).

Hypothesis to Explain Drainage Reversal

Probably no single hypothesis is adequate to account for the diversion of Raccoon Creek. The initial blocking of the mouth of the valley northeast of Terre Haute probably took place when ice from the Lake Michigan Lobe lay across it and dammed the valley (fig. 2A). Lake sediments attest to that during both the Illinoian and the Wisconsin glaciations. During the Illinoian Age, the lacustrine phase was followed by outwash deposition when the East White Sublobe of the Ontario-Erie Lobe of the ice reached the part of the valley near Mansfield and by till when ice covered Raccoon Creek. Similar events, the filling with outwash gravels and deposition of a till cover, did not take place during the Wisconsin Age because the ice stopped short of Raccoon Creek. During both glaciations it would be reasonable to assume that some stagnant ice may have remained in the mouth of the valley near Terre Haute after a route down the Wabash had opened between the ice margin and the west side of Atherton Island. If such a dam existed, lake water probably would have drained through the outlet to the north (fig. 2B).

Some bits of field evidence seem to indicate that the surface of northern and central Indiana may have been depressed isostatically during the Wisconsin glaciation from the weight of the overriding glacial mass. Harrison's (8) study of the ice thickness in central Indiana indicated that ice in the East White Sublobe thickened abruptly north of the margin. Because Wisconsin ice in the Wabash trough failed to spread eastward beyond the crest of Atherton Island, it may not have been more than 200 feet (60 meters) thick near the margin, but it probably would have increased in thickness to more than 1,000 feet (300 meters) about 10 miles upstream in the glacier (fig. 2A). Such ice thicknesses should have caused some isostatic depression during the few hundred years this area was covered by ice; rebound would not have been instantaneous but should also have required a few hundred years.

Gutenberg (7) has suggested that the amount of isostatic depression to be expected under an ice cap should, at equilibrium, be one-third of the



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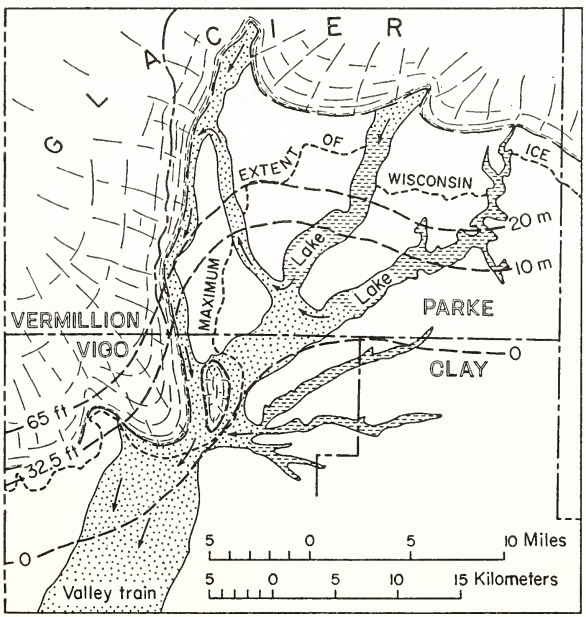

B

Figure 2. A. Depositional environments in Raccoon Creek area at time of maximum extent of Wisconsin glacier. Dashed contours show extent of crustal depression and dotted contours show estimated thickness of glacial ice.
B. Raccoon Creek area at time of drainage of proglacial lake and reversal of drainage, before isostatic rebound had taken place. Contours show extent of crustal depression.

thickness of the ice. The time required to reach equilibrium depends on the viscosity of materials in the zone of plastic flow, but it probably would be between 10,000 and 100,000 years. In another paper, he (6) suggested that the glacial boundary and the hinge line of subglacial crustal depression should be more or less coincident.

Atherton Island and the lower valley of Raccoon Creek lay within an interlobate re-entrant in the margin of the Wisconsin ice cap (13). It would have been logical for some subglacial depression to have existed beyond the margin of the glacier in such a place. Based on Gutenberg's formula the maximum amount of isostatic adjustment to the weight of the glacier at this place would have been about 100 feet (30 meters), but the ice probably remained in the area only about 1,000 to 2,000 years and melted before equilibrium was reached.

Evidence to support the hypothesis of ice loading depression and isostatic rebound, which has been called on to explain drainage anomalies in Illinois (4) and in Kansas (5), can be found in the present altitudes of terraces underlain by Wisconsin sediments in Raccoon Creek valley and its tributaries. The terrace remnants along the lower gorge of Raccoon Creek between Coxville and the mouth of Leatherwood Creek seem to have no gradient in either direction. If they were to preserve evidence of the southward flow of meltwater that evidently deposited the gravels and sands that underlie them, the surface of the terrace at Mecca should be several feet higher than the terraces at Rosedale, but they have the same altitude. The highest levels of outwash deposition at the junction of Leatherwood Creek and Raccoon Creek at Montezuma are 560 feet in altitude (Site C on fig. 1). The terraces along Raccoon Creek gorge would seem to represent a cut surface. If one allows a gradient of about 3 feet (1 meter) to the mile to the north for such a stream if it were the outlet of a lake, the depression of the north end of Atherton Island would have been 20 to 25 feet (6 to 8 meters) (fig. 2A). Isostatic rebound after the ice had melted would have destroyed the northward gradient of the surface that was cut while the lake drained northward.

Lacustrine sediments normally mark a water plane and should be nearly the same altitude everywhere in a lake. Although a slight variation could be dismissed readily, fossiliferous Wisconsin lake sands and silts along Strangers Branch (Site B on fig. 1), which is more than 8 miles upstream from the southwest end of the lake in Raccoon Creek Valley and only 2 miles from the Wisconsin ice margin in the interlobate re-entrant, lie beneath a terrace that now has an altitude of 600 feet, 60 to 70 feet (20 meters) higher than the dam at the downstream end of the valley. Such a difference in altitude can be explained most easily by sub-ice crustal depression, perhaps also an ice-marginal forebulge, followed by isostatic rebound after the ice had melted from the area.

Overflow waters from the lake in Raccoon Creek valley entered the Wabash by way of the lower outlet to the north, and once a lower outlet had been established, it was maintained even though spasmodic uplift through isostatic rebound was taking place. Dunes, which not only cover the outwash plain between Rosedale and Terre Haute but are found also

on the upland farther east, probably were blown from the Wabash Valley during the period when it was the outlet for glacial Lake Maumee. Dunes are abundant on the Maumee Terrace and all higher levels along the entire Wabash Valley. Most of them postdate the diversion and probably were completely incidental to it.

Summary

None of the existing hypotheses for the deflection of Raccoon Creek northward around the east side of Atherton Island in Parke and Vigo Counties, Indiana, have seemed wholly convincing to some geomorphologists. The ease with which loose sand can be eroded makes it seem unlikely that an accumulation of low dunes, as suggested by Bartle, could have been an effective barricade that would block a stream the size of Raccoon Creek. Field data suggest that two other hypotheses, Dryer's ice dam and Tucker's outwash barrier, may partly be valid, but that sub-ice crustal depression may have been of major importance in causing the reversal.

Course-grained sediments (Atherton Formation, Wisconsin Stage) fill the abandoned segment of the valley from Rosedale to Terre Haute. Between Rosedale and Bridgeton the deposits that underlie the terraces change from gravel to sandy silt; few terraces exist upstream from Bridgeton. This distribution of sediments suggests that the fill in the lower part of the valley is a large outwash plain and delta built into a proglacial lake in Raccoon Creek valley when the Wisconsin glacier margin trended in a north-south direction along the west edge of Atherton Island and blocked the mouth of Raccoon Creek north of Terre Haute. The weight of the glacier undoubtedly caused some depression of the surface beneath it, the effects of which should have extended a short distance beyond the ice margin. Altitudes of lake and outwash terraces in Raccoon Creek suggest that the crustal depression there may have been about 60 feet (20 meters), adequate to reverse the drainage as soon as the glacial ice melted from the area.

After the ice had melted far enough westward to open the outlet north of Mecca that was partly filled with outwash gravel, overflow water from the lake swept through the gorge from Coxville northward. Outwash and perhaps stagnant ice blocked the wide valley south of Rosedale. The glacier still covered the west bluffs of the Wabash Valley, and the east side of the valley became an ice-marginal sluiceway. While the gorge served as a spillway for the lake, the overflow waters cut it lower than the channels in the outwash plain southwest of Rosedale. This drainage reversal, once established, continued to exist because postglacial rebound was slow enough to permit erosion to keep pace with uplift. Although this explanation is based on the Wisconsin glaciation, a similar set of events also could have taken place during the Illinoian glaciation and the original diversion might date from that time. The dunes that now cover the outwash plain between Rosedale and Terre Haute probably date from the time the Wabash River served as the outlet for Lake Maumee and are completely incidental to the diversion of Raccoon Creek.

Literature Cited

1. BARTLE, G. G. 1924. A change of drainage of Raccoon Creek, Parke County, Indiana: Indiana Acad. Sci., Proc., **34**:63-68.
2. DRYER, C. R. 1913. Wabash studies: Indiana Acad. Sci., Proc. for **1912**: 199-213, 15 figs.
3. FIDLAR, M. M. 1948. Physiography of the lower Wabash Valley: Indiana Div. Geology, Bull. **2**: 112 p., 5 pls., 3 figs.
4. FRYE, J. C. 1963. Problems of interpreting the bedrock surface of Illinois: Illinois Acad. Sci., Trans., **56**:(1)3-11.
5. FRYE, J. C., and LEONARD, A. B. 1952. Pleistocene geology of Kansas: Kansas Geol. Survey, Bull. **99**: 230 p., 19 pls., 17 figs.
6. GUTENBERG, BENO. 1941. Changes in sea level, post-glacial uplift, and mobility of the earth's interior: Geol. Soc. America, Bull., **52**:721-772.
7. ————. 1951. Internal constitution of the earth: Dover Publications, Inc., N. Y.: 439 p., 43 figs., 85 tables.
8. HARRISON, WYMAN. 1958. Marginal zones of vanished glaciers reconstructed from the preconsolidation-pressure values of overriden silts: Jour. Geology, **66**:72-95, 8 figs., 1 table.
9. HOBBS, B. C. 1872. Geological survey of Parke County: Indiana Geol. Survey, 3rd and 4th Ann. Repts.: 341-384, 1 fig.
10. THORNBURY, W. D., and WAYNE, W. J. 1957. Kansan, Illinoian, and early Tazewell tills, loesses, and associated faunas in south-central Indiana: Midwest Friends of the Pleistocene, 8th Ann. Field Conf. Guidebook: 27 p.
11. WAYNE, W. J. 1956. Thickness of drift and bedrock physiography of Indiana north of the Wisconsin glacial boundary: Indiana Geol. Survey, Rept. Prog. **7**: 70 p., 1 pl., 10 figs.
12. ————. 1963. Pleistocene formations in Indiana: Indiana Geol. Survey, Bull. 25: 85 p., 4 pls., 8 figs., 2 tables.
13. WIER, C. E., and GRAY, H. H. 1961. Geologic map of the Indianapolis 1° x 2° Quadrangle, Indiana and Illinois, showing bedrock and unconsolidated deposits: Indiana Geol. Survey, Regional Geologic Map, Indianapolis Sheet.