GLACIAL GEOLOGY OF WABASH COUNTY, INDIANA

by

WILLIAM J. WAYNE AND WILLIAM D. THORNBURY

Indiana Department of Conservation

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GLACIAL GEOLOGY OF WABASH COUNTY, INDIANA

BY WILLIAM J. WAYNE AND WILLIAM D. THORNBURY

ABSTRACT

Most of the topographic features of Wabash County are of glacial origin or are glacial deposits eroded by postglacial streams. Shales, limestones, and dolomites, all Silurian, are exposed only along some of the deeper valleys.

Four major rivers and six smaller streams in Wabash County flow in glacial sluiceways. Only the Eel and Wabash sluiceways carried large quantities of melt-water. The Eel River valley train occupies an interlobate position, and the Wabash Valley bears evidence of its roles as a sluiceway and as an outlet for glacial Lake Maumee in late Cary time. Three topographic areas comprise the upland part of Wabash County: the Tipton till plain, the Mississinewa terminal moraine, and the Packerton interlobate moraine.

The buried bedrock surface of the county, as revealed by well records, suggests an old age topography which is correlated with the Lexington peneplain of Kentucky and southern Indiana. The preglacial and interglacial Teays River was the main stream across the county, and its associated "deep stage" was intrenched more than 300 feet below the upland. Where the "deep stage" is crossed by the Mississinewa moraine, the maximum thickness of drift is 410 feet. The present course of the Wabash River originated in late Tazewell time.

Till of the Cary substage is heavier, blockier, and more clayey than till of the Tazewell substage, which locally contains more quartz sand. A few exposures of weathered material, the thickness of the buried leached zone beneath Cary till, and the difference in depth of leaching of the surficial Tazewell and Cary tills suggest that the Tazewell-Cary interglacial sub-age lasted 10,000 to 12,500 years. A high percentage of spruce and fir pollen in a buried muck deposit indicates a cool, humid climate during the sub-age.

Economic resources within the drift consist of marl, gravel, sand, and ground water. Marl is restricted to the area of the Packerton moraine. Sand and gravel occur in the Packerton moraine, in abundance along the Eel and Mississinewa valley trains, and along the Wabash and Salamonie Valleys where they cross preglacial and interglacial valleys. Buried valleys, particularly the Teays and Eel, contain large potential supplies of ground water.

INTRODUCTION

Wabash County is located in north-central Indiana about 80 miles northeast of Indianapolis. Latitude 40°45′ north and longitude 85°45′ west intersect near the center of the county. Wabash County is bounded on the east by Huntington and Whitley Counties, on the south by Grant and Miami Counties, on the west by Miami and Fulton Counties, and on the north by Kosciusko County (Pl. 1). The county is 27 miles long and 16 miles wide and has an area of 426 square miles.

Exploitation of sand and gravel from the glacial deposits along the upper Wabash River and its tributaries and the production of agricultural lime from marl beds are important local industries. Since four railroad lines cross and serve the county, a producer could ship gravel by either rail or highway if more distant markets develop.

This report presents the results of an areal survey of the glacial and glacio-fluviatile deposits of Wabash County, many of which developed because of its position between the Saginaw and Huron-Erie lobes of Wisconsin age, interprets them for possible mineral resources, and brings together available information on drift thickness and bedrock topography. The field work was done mainly during the summer of 1948.

Little detailed mapping has been done in the glaciated part of Indiana, and, with the exception of soil maps of some of the counties, no detailed mapping has ever been done in the northern part of the state. Leverett and Taylor (1915, pl. 6) published a glacial map of Indiana which has been used as a basis for the study of glacial features since that time, but extensive road building and the opening of many new gravel pits have exposed sections which were not available to the early workers. Aerial photographs provided a method of rapid reconnaissance of the area, and many features which might otherwise have been missed were selected for particular observation in the field.

ACKNOWLEDGMENTS

The investigations were made under the direction of Dr. William D. Thornbury, Geology Department, Indiana University. The writers express their appreciation to Dr. Charles F. Deiss, State Geologist and Chairman of the Indiana University Department of Geology, for his critical reading of the manuscript and to Professor T. M. Bushnell, Purdue University Agricultural Experiment Station; Professor K. B. Woods, Purdue University Engineering Experiment Station; and the late Dr. C. A. Malott, Bloomington, Indiana, for the suggestions and material they gave for the preparation of this work. The writers also thank the well drillers in Wabash County, G. K. Stremmel and W. L. Stands of La Fontaine, Willard Mauser of Roann, Jack Smith of Lagro, and Ralph Klutz of Servia for the information on the thickness and

character of drift which they provided from their records. G. K. Guennel, paleobotanist for the Geological Survey, identified the fossil pollen.

TOPOGRAPHY

EXPLANATORY STATEMENT

Wabash County is located in north-central Indiana in the Eastern Lake and Till Plains section of the Central Lowland province of the Interior Plains division of the United States (Fenneman, 1938, pl. 4). Two physiographic regions of Indiana (Malott, 1922, pl. 2) are represented within its boundaries. The section of the county south of the Wabash River, approximately 170 square miles, is a part of the Tipton till plain, and the area north of the Wabash River, about 240 square miles, is called the Steuben morainal lake section (Malott, 1922, p. 116) and is a part of the Northern moraine and lake region. An area of typical till plain between the Wabash and Eel Rivers in Wabash County should be included in the Tipton till plain region. It has the physiographic characteristics of the till plain farther south and undoubtedly was formed under similar conditions.

RIVERS

The major streams of the area are the Wabash, Eel, Mississinewa, and Salamonie Rivers. Many smaller streams, such as Poney, Treaty, and Bear Grass Creeks rise and flow all or most of their courses within the county. Lake and swamp areas are common only in the northern part of the county. Most streams have not had time to intrench themselves and still flow sluggishly through swamps or meander across the nearly flat till plain. Dissection has made little progress except along the major streams and a short way up their tributaries.

Wabash River.—The master stream, the Wabash River, flows nearly straight southwest across the center of Wabash County. The river enters the county at an altitude of 669 feet and leaves it at an altitude of 634 feet, a drop of 35 feet in 18 3/4 miles and an average gradient of 1.9 feet per mile. The valley of the Wabash varies from a narrow gorge cut in bedrock to a wide, alluviated valley where it is cut in unconsolidated glacial drift.

Eel River.—The Eel River enters northern Wabash County at an altitude of 750 feet, flows southwestward, and leaves the county

1 mile west of the town of Roann at an altitude of 705 feet. The average gradient is 2.1 feet per mile. At no place is the river channel cut in bedrock.

Mississinewa River.—The Mississinewa River crosses the southwest part of Wabash County and flows northwestward; it has an average gradient of 3.8 feet per mile. The western edge of the massive Mississinewa moraine controls its course until it enters Wabash County, where it flows westward across the till plain to its junction with the Wabash River near Peru in Miami County. The valley is being widened, and its walls exhibit many good exposures of glacial materials and bedrock. The tributaries of the Mississinewa and Wabash Rivers, where they flow on bedrock, have developed cascades or falls which are receding upstream. Only those flowing on glacial deposits have flood plains.

Salamonie River.—The Salamonie River enters Wabash County from the east at the northern edge of sec. 20, T. 27 N., R. 8 E., and flows northwestward to the Wabash River at Lagro. Its average gradient is 5.9 feet per mile. The river is intrenched as much as 75 feet, and the valley walls are vertical bluffs in bedrock and glacial drift.

UPLAND AREAS

Till plain.—The most extensive topographic feature in Wabash County is the till plain that lies south of the Eel River. Except for the Mississinewa terminal moraine and the Wabash Valley, the topography is gently rolling to flat ground moraine. The till plain west of the Mississinewa moraine is extremely flat and has a general altitude of 790 feet. On the east side of the Mississinewa moraine, the altitude is about 815 feet, and the relief is somewhat greater.

Much of the till plain lacks valleys, and drainage is internal or by sheetwash, except in areas adjacent to the major streams. Only where the drift is shallow have the smaller creeks reached bedrock. Drainage has been established over much of the area by the use of tile and ditches.

Mississinewa moraine.—The broad, arcuate, morainic ridge which extends into Indiana and attains its westernmost extension in Wabash County is called the Mississinewa moraine (Dryer, 1889a, p. 124) after the river whose course it controls. The moraine can be traced through Noble and Whitley Counties to the northeastern corner of Wabash County, which it crosses as a sagittate

ridge, and then trends southeastward across Grant, Blackford, and Jay Counties into Ohio. Its average width in Wabash County is about 4 miles. The forward edge of the moraine has an altitude of about 800 feet, and the ridge rises gently eastward to more than 900 feet. The crest of the moraine averages 860 to 880 feet in altitude, and the eastern edge has an average altitude of 815 feet.

In Wabash County the morainal topography is gently rolling and has few distinct ridges or closed depressions. Its heavy clay lithology produced a rather fine drainage texture, and the "knob and kettle" topography often associated with end moraines is largely absent.

No large lakes exist within the Mississinewa moraine in Wabash County. A few small, shallow depressions hold enough water to be swampy, but vegetation and artificial drainage are gradually eliminating these fens. Erosion is noticeable on the heavy textured till.

Packerton moraine.—Leverett and Taylor (1915, pp. 158-160) described the massive series of morainic hills and ridges north of the Eel River, and Malott (1922, p. 117) named it the Packerton moraine from the village of Packerton in Kosciusko County, Indiana, which is situated on a typical part.

At its western end, near Delphi in Carroll County, the Packerton moraine is 2 to 3 miles wide. It lies north of the Wabash River as far east as Logansport, where it trends northeastward, north of and parallel to the Eel River. In Miami and Wabash Counties the moraine is much wider and is separated from the Eel River by a belt of outwash plain and valley train 1 mile to 3 miles wide. Its hummocky topography shows numerous kames, eskers and lakes (Pl. 2, A). The maximum altitude exceeds 830 feet, and local relief exceeds 100 feet. Only along the Wabash sluiceway is the local relief in Wabash County greater than that in the Packerton moraine.

Leverett and Taylor (1915, pp. 158-159) believed that most of this morainic mass was deposited by the northern limb of the Huron-Erie lobe. Malott (1922, p. 117) stated that it was more probably formed as a joint product of the southern edge of the rapidly retreating Saginaw lobe and the northern edge of the Huron-Erie lobe.

The interlobate position of the Packerton moraine gave rise to a great variety of glacial deposits. Till and water-laid sands and gravels occur together in rather complex relationships, and a few short eskers are associated with the moraine in the northern part

of the county. The largest, in secs. 32 and 33, T. 30 N., R. 6 E., has a maximum height of 40 feet and forms a discontinuous east-west ridge for about 2 1/2 miles. Four other groups of small eskers were found in the Wabash County part of the moraine. Two pits expose a large kame north of the village of Disko in SW1/4 sec. 35, T. 30 N., R. 5 E., along the Wabash-Fulton county line. Low esker-like ridges extend toward this kame from the east.

How much of the Packerton moraine was built by the Huron-Erie lobe and how much by the Saginaw lobe is difficult to determine. Some inferences may be made from the trend of eskers in the northwest part of the county. The eskers south of Disko have a generally southeast-northwest trend, but north of there the trend is northeast-southwest, suggesting that the part of the Packerton moraine south of Disko was built by the Huron-Erie lobe and the portion north of Disko by the Saginaw lobe.

The surface drainage of the Packerton moraine has a deranged pattern. The small lakes and ponds within the moraine may be called intramorainal lakes and are the results of irregular deposition of the drift. Luken's Lake is the largest of this origin in Wabash County. Extensive outwash deposits down the sluiceways ponded the water in tributary valleys to form lakes. Long Lake is the remains of such a lake back of the Eel River valley train.

CLASSIFICATION OF THE PLEISTOCENE OF NORTH AMERICA

Since 1839, when Lyell applied the name Pleistocene to rocks older than Recent and younger than Pliocene, the series and its subdivisions have been under almost constant revision. In its present usage the term Pleistocene includes all deposits of the Ice Age and all contemporaneous deposits of marine, lacustrine, fluviatile, and volcanic origin. The writers have used the cessation of glacial or proglacial deposition and the beginning of intrenchment by non-ice fed streams as the break between the Pleistocene and the Recent.

The following table, modified from Flint (1947, p. 210), is the most recent classification of the Pleistocene glacial deposits in North America.

Period (System)	Epoch (Series)	Age (Stage)	Sub-age (Substage)
Quaternary	Recent (postglacial)		
	Pleistocene	Wisconsin	Mankato
			Cary
			Tazewell
			Iowan
		Sangamon interglacial	
		Illinoian glacial	
		Yarmouth interglacial	
		Kansan glacial	
		Aftonian interglacial	
		Nebraskan glacial	
	Pliocene		

PLEISTOCENE OF INDIANA

The earliest comprehensive studies of the glacial deposits in Indiana were made by Leverett and Taylor (1915, pl. 6), who mapped the moraines and boundaries of the several drift sheets. Since then few workers have studied the glacial geology of the state. Malott (1922, pl. 3) presented a refined version of Leverett and Taylor's map, and a paper by Thornbury (1937) covered the glacial geology of southern and south-central Indiana from the Bloomington morainic system southward. No recent detailed work has been published on the glacial geology of northern Indiana.

The ice did not reach Indiana during the Mankato sub-age. Two lobes of the Laurentide Ice Sheet reached Indiana in Cary time and built the Valparaiso and Mississinewa terminal moraines. The Shelbyville moraine of central Indiana marks the farthest advance of the Wisconsin glaciers during the Tazewell sub-age. No deposits of the earliest of the Wisconsin substages, the Iowan, have been

recognized in Indiana. The greatest ice advance in Indiana occurred during the Illinoian age. Malott (1922, p. 79) estimated that about 30,100 square miles, or five-sixths of the state, was glaciated at that time (Fig. 1).

No drift earlier than Illinoian has been recognized in outcrop in Indiana, but parts of the state probably were glaciated during the Kansan and Nebraskan ages. The approximate position of the Kansan ice front across the state has been inferred by Flint (1947, p. 281). Some of the buried organic beds reported in well records in Wabash and surrounding counties may be of Yarmouth age.

WISCONSIN GLACIATION OF WABASH COUNTY

TAZEWELL SUBSTAGE

The surficial glacial deposits in Wabash County (Pl. 1) belong to the Cary and Tazewell substages of the Wisconsin stage. The Mississinewa moraine and associated outwash and the ground moraine east of the Mississinewa moraine belong to the Cary substage. The Packerton moraine and the till plain in the western part of the county are of Tazewell age.

The oldest drift that crops out in the region is of Tazewell age and consists of till, outwash, and lake deposits. Sections exceeding 60 feet in thickness have been measured, and the average thickness of this drift may be about 100 feet. Separation of Tazewell and Cary drifts can be made on the bases of differences in local lithology and in depth of leaching, although the time interval between the two advances was so short that locations must be selected carefully in order to obtain significant results.

Till.—The unweathered Tazewell till is pale gray, bouldery, calcareous, clayey, and generally contains a large amount of quartz sand which appears to decrease in quantity southward. Heavier textured and less sandy till which is generally somewhat loose and contains many thin lenses of sand and silt in the upper 15 to 20 feet occurs along the Mississinewa River. The lower part is much more compact, may be jointed, and contains less water assorted material. A decided break occurs between the upper and lower parts in exposures where both can be examined, and the lower till stands in more nearly vertical bluffs because of its greater compactness. The difference in structure of these two layers of till indicates that the upper part was superglacial and englacial material deposited when the ice melted and that the lower, compact layer was plastered down

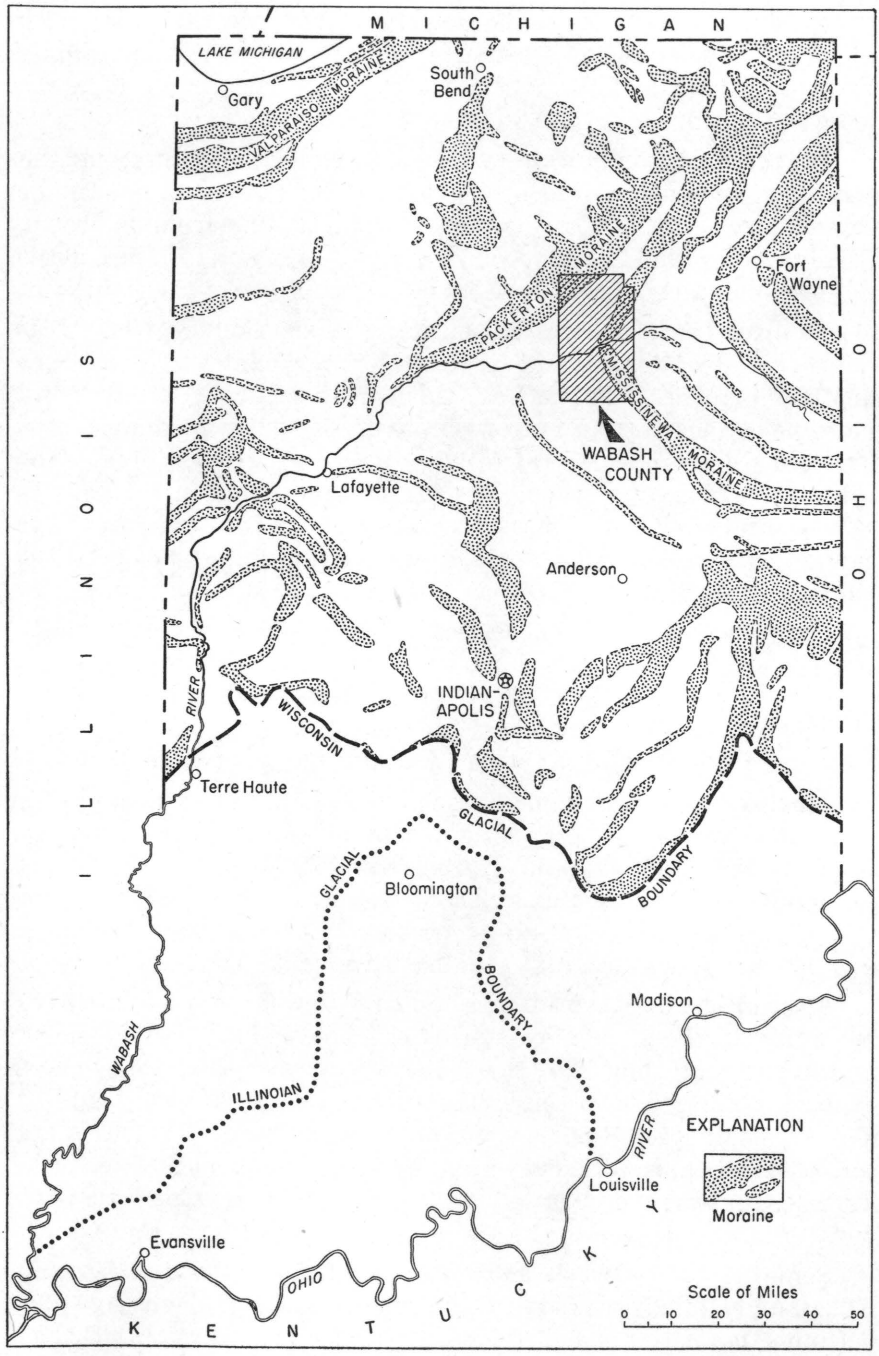


Figure 1. *Map of Indiana showing moraines and glacial boundaries. Modified after Leverett.*

at the base of the glacier as the ice sheet moved over the area. Such differences in deposition account for the presence of pseudo-bedding in the basal till and for the lenses of water laid material in the loose upper till.

In the Packerton moraine, till is interbedded with outwash, and a complete picture of the lithology is difficult to obtain. In the several places where it has been examined, the till is medium brown, pebbly, clayey, and contains varying amounts of sand. The sand is not predominately quartz, as it is in the area south of the Eel River.

Tazewell till in the western part of Wabash County, where it is not covered by later deposits, is leached of carbonates to an average depth of 44 inches, whereas Cary till in and back of the Mississinewa moraine is leached to an average depth of 31 inches. Medium-brown oxidized till extends several feet below the zone of leaching. The rolling topography of the Packerton moraine made it difficult to select suitable sites for measuring the depth of leaching, and too few auger borings were made to attach any significance to the values obtained.

Outwash.—Outwash of the Tazewell substage in Wabash County consists of interbedded sand and gravel and commonly exhibits torrential cross-bedding (Pl. 2, B). Till belonging to the same substage overlies outwash in many places and indicates that the late Tazewell ice front fluctuated as it retreated across this part of Indiana.

Much of the sand and gravel of the Eel River valley train was deposited while the stream was an interlobate sluiceway between the Saginaw and Huron-Erie lobes. Outwash of the Cary substage overlies Tazewell sand and gravel, but the two cannot be differentiated. Outwash of probable Tazewell age lies along a creek that flows south into the Eel River near Roann.

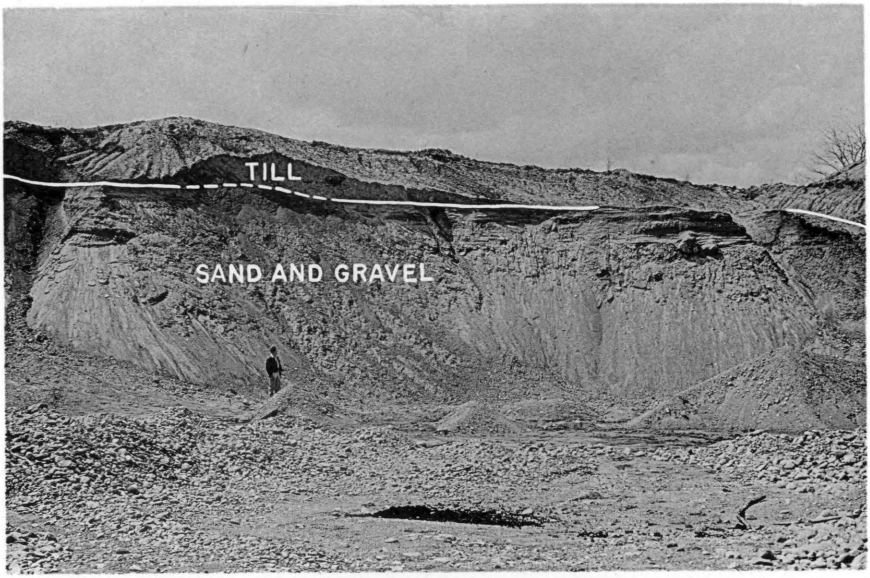
Most of the outwash interpreted as Tazewell is overlain by till belonging to the same substage. Gravel pits along Treaty Creek and in the south bluffs of the Wabash Valley at the west edge of Wabash County show this relationship well. Outwash exposed along a small creek 2 miles south of Wabash, in the NW1/4SW1/4 sec. 24, T. 27 N., R. 6 E., is overlain by sandy till about 20 feet thick. Tazewell outwash occurs as gravel terraces only along streams which did not serve later as Cary sluiceways, such as Mill Creek.

Some of the outwash along the Mississinewa and Salamonie Rivers undoubtedly was deposited during the Tazewell sub-age, but it cannot be distinguished from overlying Cary outwash. Gravel

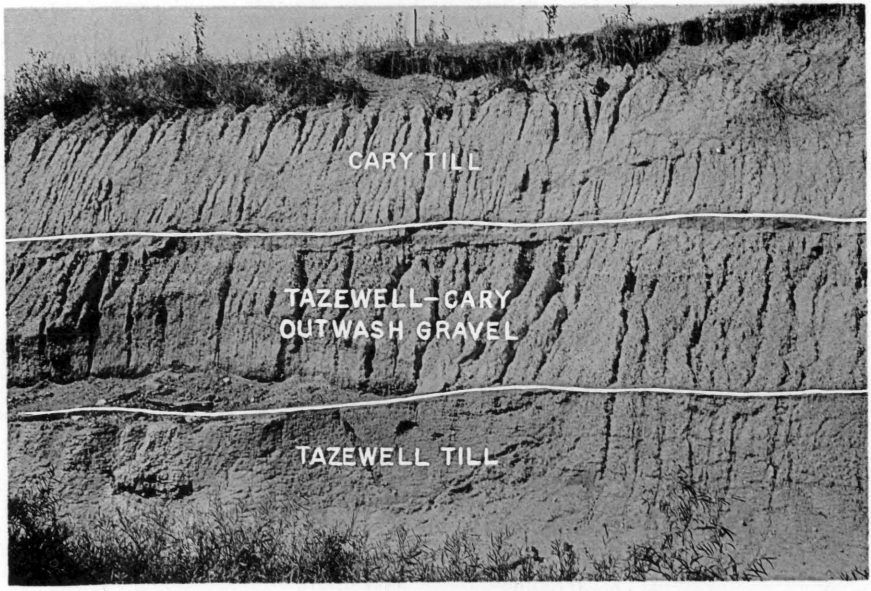
A. TYPICAL VIEW OF PACKERTON MORAINE, NORTH OF INDIANA HIGHWAY 114, SW1/4 SEC. 35, T. 30 N., R. 5 E.

B. CROSS-BEDDED SAND AND GRAVEL IN VALLEY TRAIN ALONG MISSISSINEWA VALLEY, 3 MILES WEST OF LA FONTAINE.

PACKERTON MORAINE AND SECTION OF VALLEY TRAIN.



A. TAZEWELL GRAVEL AND TILL IN GRAVEL PIT ON THE NORTH SIDE OF MISSISSINEWA RIVER, SE1/4NE1/4 SEC. 29, T. 26 N., R. 6 E.



B. STREAM BLUFF, SHOWING SEQUENCE OF TAZEWELL AND CARY DEPOSITS, SW1/4SW1/4 SEC. 9, T. 2 N., R. 8 E.

DEPOSITS OF TAZEWELL AND CARY SUBSTAGES.

pits near the junction of a small creek and the Mississinewa River, in the NE1/4 sec. 29, T. 26 N., R. 6 E., expose thick sand and gravel beneath 20 feet of till (Pl. 3, A). Tazewell and Cary outwash that ranges from 20 to 30 feet in thickness underlies Cary till along the Salamonie River and its tributaries at the eastern edge of the county. The following sections illustrate the character of the deposits in this area.

The first section was measured on the bluff along the south bank of a creek tributary to the Salamonie River, in the NE 1/4NE1/4 sec. 18, T. 27 N., R. 8 E.

Cary substage	Feet	inches
11. Clay till, brown, heavy textured. Some inwash present	4	0
10. Clay till, brown, heavy textured, calcareous	1	0
9. Sand and gravel, moderately well assorted, leached; eluviated clays below upper 6 inches of dark-brown sand	3	8
8. Sand and gravel, brown, calcareous	3	4
7. Till, tan, hard, calcareous, sandy	3	0
6. Clay till, dark gray, hard, compact, tough, calcareous; laminated limonitic layer 4 inches thick at base	2	0
5. Sand and gravel: Interbedded lenses and layers, upper part mostly sand, lower part sub-rounded, cross-bedded, well assorted gravel	13	0
4. Clay, brown, blocky, calcareous; no grit	0	6
3. Sand, buff, uniform, fine	3-5	0
2. Silt, tan, apparently cross-bedded, limonite stains along bedding	2	0
1. Till, hard, compact; upper 6 inches brown, remainder gray; quartz sand abundant throughout; shows compaction laminae	21	0
Total thickness of measured section	57	6

The following section was measured on the bluff along the east side of Rush Creek, in the NW1/4NE1/4 sec. 29, T. 27 N., R. 8 E.

Cary substage	Feet	inches
15. Soil and leached till	2	0
14. Clay till, calcareous, tan, blocky	11	0
13. Sand, leached, tan, fine, silty	1	0
12. Sand and clay: Leached, dark-brown, pebbly sand mixed with clay	0	8
11. Clay, leached, tan, plastic	0	2
10. Clay till, leached, tan, sandy	0	4
9. Clay till, calcareous, tan, sandy	3	0
8. Sand and gravel: Calcareous, cross-bedded gravel and coarse sand; smaller material toward top	4	0
7. Clay till, calcareous, brown, blocky, tough	1	6

6.	Clay till, calcareous, silty, sandy; upper 2 feet tan, lower 2 feet gray, 4 inches at base laminated with iron oxide.....	4	0
5.	Sand and gravel: Calcareous sand and fine gravel.....	2	6
4.	Clay till, calcareous, tan, silty.....	5	0
3.	Sand and gravel, calcareous, stratified.....	10	0
2.	Clay till, calcareous, brownish gray, hard; quartz sand abundant	18	0
1.	Unit covered (measured from creek).....	6	0
	Total thickness of measured section.....	69	2

Lacustrine deposits.—Several lake deposits of limited extent occur in Wabash County. Most of them probably were deposited in temporary lakes along the ice front or back of sand and gravel fills in the sluiceways. One such deposit occurs in a ditch crossing the center of the east edge of sec. 23, T. 30 N., R. 7 E., where 3 to 4 feet of stratified, calcareous, plastic, blue clay interbedded with thin, discontinuous layers of fine quartz sand is exposed. From 10 to 15 feet of sandy outwash overlies the clay.

An exposure in a bluff in the NE1/4NE1/4 sec. 18, T. 27 N., R. 8 E., shows 8 to 9 feet of stratified, tan, calcareous silt (See p. 15), apparently of lacustrine origin. This silt overlies calcareous till and is overlain by sand and gravel. A 3-foot thick deposit of calcareous gray silt overlies gravel beneath a terrace along a small stream in the NW1/4 sec. 13, T. 27 N., R. 5 E.

TAZEWELL-CARY INTERVAL

The time between the close of the Tazewell and the beginning of the Cary sub-ages is stratigraphically recorded by a buried immature soil profile or outwash gravels. A weathered zone that developed during this interval is preserved and exposed in whole or in part in only a few places along tributaries of the Salamonie River. An exposure along Rush Creek (See p. 15) shows a 26-inch leached zone between two beds of calcareous till. Another exposure (See p. 15) in the NE1/4NE1/4 sec. 18, T. 27 N., R. 8 E., shows 38 inches of noncalcareous material between calcareous till and calcareous outwash gravels. These weathered zones probably include some inwash of noncalcareous material and are thicker than if they were entirely due to leaching *in situ.* A weathered zone on till was found nearby in Huntington County along a small tributary of the Salamonie River. In this exposure 12 to 15 inches of leached till underlies unaltered till similar to that associated with the Mississinewa and later moraines of Cary age. The thickness of this

leached zone corresponds closely to the 13-inch difference in leaching referred to on page 14 and is a fair indication of the amount of leaching which occurred during the Tazewell-Cary interval. In most exposures Tazewell till is separated from younger (Cary) till by a layer of outwash gravel.

The following section was measured in a bluff along the west side of a small tributary of Silver Creek at the Wabash-Huntington county line, about 100 feet east of the road, SW1/4SW1/4 sec. 9, T. 28 N., R. 8 E., and is a good example of this type of exposure (Pl. 3, B).

	Feet	inches
Cary substage		
7. Soil and leached till	2	0
6. Clay till, tan, calcareous, heavy-textured	4	0
5. Clay till, gray, calcareous, heavy-textured	2	0
Tazewell-Cary outwash		
4. Sand, tan, calcareous, fine	0	6
3. Silt, tan, calcareous	0	6
2. Sand and gravel, stratified, well assorted, gray; thin cemented layer at top. Water seeps at base	6	0
Tazewell substage		
1. Clay till, hard, sandy, gray; showing compaction laminae; secondary limonite banding in top 4 inches; exposed	6	0
Total thickness measured	21	0

Mr. Gayle Ireland, operator of the Laketon Marl and Gravel Company, reported an interesting succession of beds from the base of a marl deposit in the SE1/4NE1/4 sec. 9, T. 29 N., R. 6 E. When the pit was opened the tiles carrying water into the area were blocked off, and a cut was made to the base of the marl. Below the thick surficial marl, a 1-foot bed of brownish-black, peaty material, underlain by another thin marl bed, was encountered. Smooth gray clay that contained fresh limbs of trees 2 to 3 inches in diameter lay beneath the lower thin marl layer and was the deepest deposit entered. No samples were preserved from this particular digging, but fragments of the black, peaty bed are brought out of the pits from time to time. The substance is dark brown to black, rubbery, compact when moist and readily cut with a knife, and contains fragments of partly decomposed plant fibers. The material, which is probably compressed muck, shrinks considerably when dry, becomes hard and brittle, and parts along thin compaction laminae. A pollen analysis made by Mr. G. K. Guennel, paleobotanist of the

Geological Survey, on a specimen collected from a horizon 6 inches below the top of the buried muck shows a spruce-fir association with a minor amount of oak, walnut, and tamarack present. A few fern spores occur, but not grass pollens. On the basis of this incomplete analysis, the pollen content indicates a boreal climate in the area at the time of its accumulation. Deposition probably occurred near the end of the Tazewell-Cary interglacial interval. The probable sequence of events is as follows: deposition first of clay and later, as conditions became suitable to the growth of Chara, of marl in a post-Tazewell pond; accumulation of muck on the low ground followed lake filling; outwash in the Eel River sluiceway during the Cary maximum apparently dammed the mouth of the small creek that drained the bog and formed another lake which, in post-Cary time, became filled with marl and peat.

An estimate of the length of the Tazewell-Cary interval is only approximate because the process of leaching presumably progresses more slowly as it extends downward. Kay (1931, p. 460) estimated that leaching proceeds at a rate of approximately 1 foot in 10,000 years. Because a 12- to 15-inch leached zone occurs between the Cary and Tazewell tills, this interval is estimated at 10,000 to 12,500 years.

CARY SUBSTAGE

The Mississinewa moraine probably marks the maximum advance of the Huron-Erie lobe in northeastern Indiana during the Cary sub-age. East of it lies the Salamonie, Wabash, and Fort Wayne moraines, which mark pauses or brief readvances during the withdrawal of this lobe.

Cary drift in Wabash County consists principally of till and outwash. Few lacustrine deposits occur. East of the Mississinewa moraine, the Cary ground moraine averages about 20 feet in thickness. If the Mississinewa moraine is interpreted as being composed wholly of Cary drift, the maximum thickness could be as great as 100 feet, since that is the difference in elevation between the highest part of the moraine and the till plain west of it. Actual measurements, however, show little more than 30 to 35 feet of Cary drift above the Tazewell deposits in the moraine. Part of the height of the Mississinewa moraine is due to a higher bedrock altitude.

Till.—The Cary till associated with the Mississinewa and later moraines is heavy-textured, dark gray, blocky, and clayey. It commonly breaks with a nearly cubic fracture and when moist is

much more plastic than the earlier till. Sand-size material is sparse throughout, and few cobbles and boulders are present. Differences in texture and color distinguish this till from the Tazewell till in the eastern part of Wabash County.

The Cary till is leached of carbonates to an average depth of 31 inches. At the rate previously suggested, assuming it to be a linear function, a minimum period of 26,000 years would be required to develop a leached zone of this depth.

Outwash.—Tazewell and Cary outwash are difficult to distinguish except where the later outwash overlies till of undisputed Cary age. The upper part of the valley-fill along each of the major sluiceways is probably Cary. Across much of Wabash County both the Wabash and Salamonie sluiceways were cut into bedrock, and the Cary outwash consists of a thin veneer of gravelly soil over a bedrock bench.

The Eel sluiceway carried large quantities of Cary melt-water, and the outwash of that substage may be as much as 20 feet thick in places. Most of the gravel consists of limestone and dolomite pebbles and small amounts of shale and crystalline rocks. The upper part of the extensive outwash along the Mississinewa Valley is also of Cary age and consists of calcareous, well-assorted, and cross-bedded gravel that contains a moderate amount of chert derived from the Liston Creek limestone.

Part of the gentle forward slope of the Mississinewa moraine is due to a narrow, thin outwash plain of sand and water-laid till which occurs at several places along the western edge of the moraine. The extent of the outwash apron is difficult to determine and for that reason is not shown on the geologic map (Pl. 1). It is best developed as a sandy apron northeast of Poney Creek, secs. 5, 6, and 7, T. 28 N., R. 7 E., and from State Highway 124 south to the county line. Another patch was noted south of Wabash along the east side of Treaty Creek.

Lacustrine deposits.—Few lake beds occur in the Cary drift in Wabash County. Deposition of the marl around Long Lake undoubtedly began during the Cary sub-age. Most of the deposit lies under water, and its detailed examination is difficult. The relationship of this marl bed to the Tazewell-Cary interval has already been discussed (See p. 17).

SLUICEWAY FEATURES

Mississinewa terrace.—The Wabash Valley was a major glacial sluiceway beginning with the Tazewell sub-age. It also acted as a sluiceway during the Cary sub-age, and most of the sluiceway features in Wabash County date from that time. The sluiceway varied from half a mile to 2 1/2 miles in width, and remnants of it are preserved as terraces 45 to 50 feet above the present floodplain of the Wabash River. In most of Wabash County the terrace that marks the former sluiceway level is developed on bedrock, but in the part of the sluiceway near the west edge of the county this level is developed on gravel. Hence it appears that the surface of the sluiceway was partly erosional and partly depositional in origin. The average gradient of this terrace surface between Lagro and the Miami-Wabash county line is 3.5 feet per mile. Because of its intimate association with the Mississinewa moraine and its excellent development along the Wabash River through and immediately west of that moraine, the term *Mississinewa terrace* is proposed for this surface. East of the Mississinewa moraine only small patches of a high level terrace are evident. The Mississinewa terrace is well preserved across Wabash County because it is largely developed on bedrock.

Melt-waters of the Cary maximum produced surfaces along the Eel and Mississinewa Rivers and some of their tributaries which are correlative in age with the Mississinewa terrace of the Wabash Valley. The Eel sluiceway was about 1 mile in width and had an average gradient between North Manchester and Roann of 3 feet per mile. The valley train built down this sluiceway is preserved as extensive terraces above the present floodplain. Small fluves on the terraces still show where the strongest currents were.

Many low mounds of wind-blown sand derived from the outwash are present along the sluiceway downstream from Long Lake. Most of these small dunes are variable in shape and are only a few feet in height. No dunes were recognized on the valley train above Long Lake, where the terrace is extremely flat.

Poney Creek, a small stream that joins the Eel River at North Manchester, carried melt-water for a short time while the ice stood at the Mississinewa moraine. Remnants of a valley train a quarter of a mile to half a mile wide occur as terraces along the creek and correspond in age to the valley train in the Eel Valley. Similar gravel terraces are present along a creek which heads at the Mis-

sissinewa moraine and joins the Eel River about midway between North Manchester and the north county line.

The Mississinewa sluiceway was variable in character. Above the point where Indiana Highway 13 crosses the river, it was developed on a drift-filled preglacial valley and it was in places more than 1 1/2 miles wide. Below this place, where its course lay largely on bedrock, it narrowed to half a mile in width. Glacial retreat from the Mississinewa moraine caused abandonment of the sluiceway. Postglacial intrenchment has left much of the Cary sluiceway surface as terraces.

Terraces in the lower 2 miles of Treaty Creek Valley indicate that it was a small ice-marginal sluiceway during the Cary maximum. Remnants of other minor valley trains, developed in valleys tributary to the major sluiceway in the Wabash Valley, occur along Lagro Creek, secs. 26 and 27, T. 28 N., R. 7 E., and along a streamless trough north of the Wabash Valley midway between Wabash and Lagro.

During its recession, the Cary glacier built the weak Salamonie moraine a few miles east of the Mississinewa moraine. The Salamonie River originated at that time as an ice-marginal drainage line. In Wabash County most of this sluiceway was a bedrock-floored trough about a quarter of a mile wide. The terraces that resulted from dissection of this surface are slightly younger than the Mississinewa terrace, but, since the two are confluent surfaces and a Salamonie stage is not recognizable along the Wabash sluiceway, they have been mapped with the Mississinewa terrace (Pl. 1).

Maumee terrace.—After the ice retreated eastward beyond the present site of Fort Wayne, proglacial Lake Maumee came into existence. Because it acted as a settling basin for outwash, clear water passed through the spillway southeast of Fort Wayne and flowed southwest down the route now followed by the Little Wabash and Wabash Rivers. These overflow waters eroded a new trough below the level of the Mississinewa terrace. The name Maumee terrace was proposed by Fidlar (1936, p. 179) for the remains, in the lower Wabash Valley, of the degradational surface developed by the overflow waters from Lake Maumee.

In Wabash County a broad intermediate terrace, 20 to 25 feet below the level of the Mississinewa terrace and 15 to 20 feet above the present floodplain, is correlated with the Maumee surface. It is well preserved on both sides of the river east of Lagro and west

nearly to Wabash. Little evidence of the Maumee terrace remains through the rock gorge from Wabash to about 5 miles west of Wabash. It is better preserved above and below Lagro because the river was wider where it cut through shale and glacial drift instead of through limestone, as it did below Wabash. In the "prairie" at the west edge of the county, several flat-topped gravel terraces remain as unreduced portions of the Maumee surface (Pl. 4, A). This terrace surface has a gradient of 2.3 feet per mile across Wabash County, as compared with 3.5 feet per mile for the Mississinewa terrace above it.

The Cary sub-age ended with the uncovering of a lower outlet for Lake Maumee via the Grand River across Michigan and the resulting abandonment of the spillway near Fort Wayne.

Klintar.—The melt-water that carved the Wabash, Mississinewa, and Salamonie sluiceways uncovered many Silurian bioherms (Cumings and Shrock, 1927, pp. 77-84). The resistant dolomite of these reefs was more difficult to erode than the unconsolidated drift and the interreef rock, and the reefs stood out as islands in the sluiceways. Cumings and Shrock (1928, p. 44) applied the name klint (pl., klintar) to the exhumed remnant of an ancient bioherm. The Maumee terrace and the present floodplain are studded with klintar, but only a few stand above the Mississinewa terrace.

Several terrace remnants undoubtedly owe their preservation to the presence of klintar along the Wabash Valley. At the west edge of Lagro the resistant rock of the ancient reefs bulwarks both ends of a portion of Mississinewa terrace. Other reefs that performed a similar role can be found between Lagro and the eastern county line.

A few of the klintar have the topographic appearances of breached domes in which the steeply dipping flank strata form a small circle or oval that is higher than the center of the reef. The massive cores of the reefs commonly show what appears to be the beginning of sinkhole topography.

Where the glacial sluiceways cross buried valleys, they widen abruptly in the unconsolidated valley-fill. The most spectacular example occurs at the "prairie" west of Wabash, where the Wabash Valley crosses the buried Teays Valley (See p. 28). Above the "prairie" the Wabash River flows in a rock-walled valley from half a mile to 1 mile in width. At the point where the present Wabash Valley transects the buried Teays Valley, it abruptly becomes a

A. MAUMEE TERRACE, AND FLOODPLAIN OF WABASH RIVER, AT EAST EDGE OF RESERVE 12, 5 MILES SOUTHWEST OF WABASH.

B. MARL PITS AND STOCKPILES WEST OF LONG LAKE, SE1/4NE1/4 SEC. 9, T. 29 N., R. 6 E.

MAUMEE TERRACE, AND MARL PITS.

broad, open valley from 2 1/2 to 3 miles wide. Bedrock is lacking along the south wall but is exposed along the north side of the valley.

Plate 5 shows the relationships of the various topographic features along the Wabash sluiceway in Wabash County.

RECENT DEPOSITS

The Recent, or postglacial, age probably began with the withdrawal of the glacier from the region. As the process of deglaciation was slow, some of the deposits considered as Recent actually were formed while the Wisconsin ice sheet lay a few miles away. Such deposits, if not of glacial origin, should be considered postglacial.

ALLUVIUM

Along the streams of Wabash County small amounts of alluvial sand, silt, and clay have been deposited as floodplains. The most extensive alluvial deposits occur as a thin veneer over previously deposited outwash in that part of the Wabash sluiceway at the west edge of the county known as the "prairie."

MARL AND PEAT

The largest marl deposit in Wabash County that is open for examination surrounds Long Lake (See p. 17). The south edge of the old lake bed consists of calcareous white sand which grades laterally into a light-gray, slightly iron-stained, clayey lime that contains abundant gastropod shells and Chara remains and a few ostracods and pelecypods. Well preserved fragments of coniferous wood have also been recovered. In all but a few places 1 foot to 4 feet of muck overlies the marl. Peat replaces the marl toward the deeper parts of the lake basin. The marl around a pond in the NE1/4 sec. 9, T. 29 N., R. 6 E., may be as much as 20 feet thick.

A small deposit of marl beneath a few inches of muck was noted south of Eel River, in the NE1/4 sec. 21, T. 29 N., R. 6 E., in a small spring fed stream apparently ponded by the valley train along the Eel sluiceway. Auger borings indicate that some marl is present around most of the lake basins in Wabash County, but it does not appear to be extensive at any except those described.

Several theories have been advanced for the origin of fresh water lime deposits in lakes. The one most favored is that the calcium carbonate is precipitated as minute crystals of calcite by some of the algae of the Stonewort family, particularly Chara. The deposits generally form in shallow water (Hale, *et al.*, 1903, p. 55) and in depressions with porous substrata (Thiel, 1930, pp. 722-723).

PRE-WISCONSIN GLACIATION

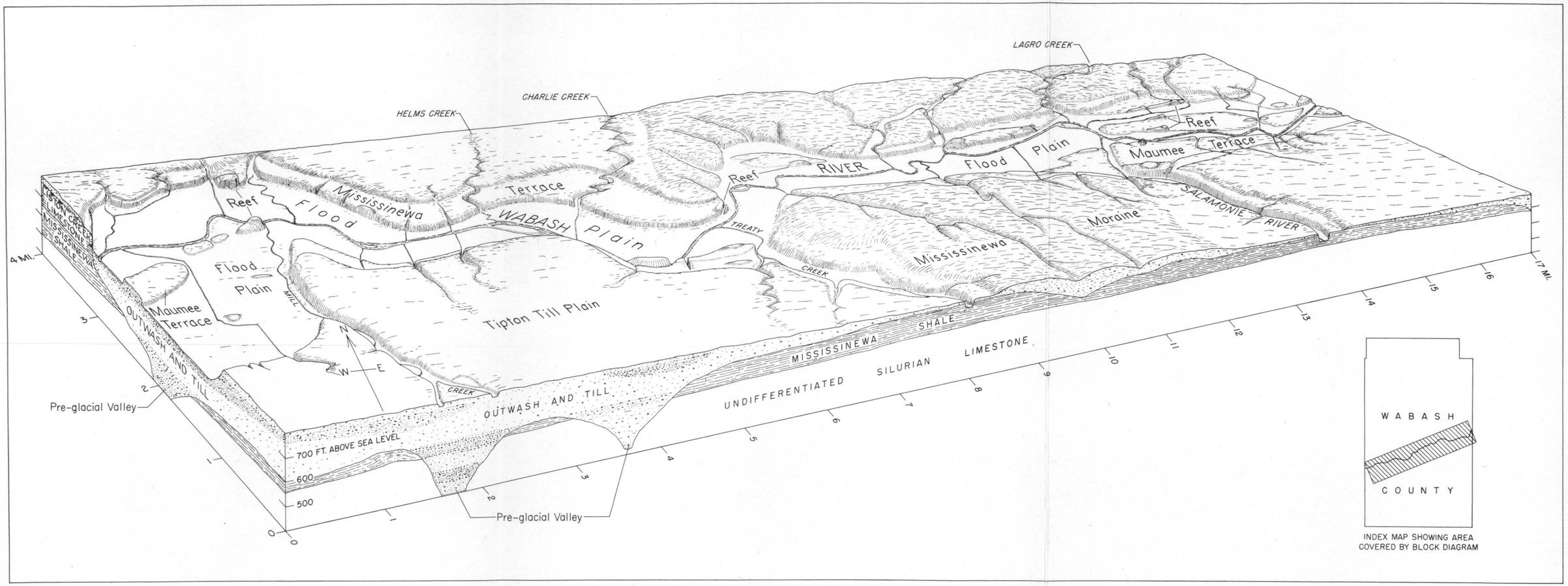
Wabash County undoubtedly was covered by ice during the Illinoian glacial age and possibly during one or more earlier ages, but evidence of earlier glaciation has been destroyed or deeply buried beneath Wisconsin deposits. Nowhere in the area has drift older than Wisconsin been recognized in outcrop.

Nebraskan drift has not yet been recognized in Indiana, but scattered erratics in northeastern Kentucky and southern Ohio, interpreted as Nebraskan in age, have been described (Leverett, 1929, pp. 33-47). If these boulders were ice-deposited, the ice sheet must have crossed part of Indiana. Bell and Leighton (1929, pp. 485-486) identified Nebraskan till in outcrops in southwestern Illinois. Thwaites (1946, pl. 3) interpreted data as indicating that one lobe of the Nebraskan ice extended to the Mississippi River southeast of St. Louis, and another lobe extended across the Ohio River into northeastern Kentucky. A lobe of Nebraskan ice probably crossed the upper Wabash Valley region at one time.

MacClintock (1933, p. 717) gave a generalized boundary for a lobe of the Kansan glacier which once extended into Illinois. It can be inferred from his map that during the Kansan maximum the ice front across Indiana approximately paralleled the position later occupied by the Wisconsin glacier at its greatest advance. Deposits of the Kansan stage have been recognized both in outcrop (Bell and Leighton, 1929, pp. 485-486) and in well records in Illinois (Horberg, 1945, p. 351), but as yet none has been positively identified in Indiana.

The most extensive glacial deposits in Indiana belong to the Illinoian stage. In Wabash County Wisconsin deposits are extremely thick (See p. 12), and no exposures of Illinoian or earlier drift have been recognized. Water well drillers occasionally report hard brown till immediately above bedrock which may represent oxidized till of either Illinoian or earlier age.

Well drillers in Wabash County have reported encountering pieces of wood and other organic material at varying depths. One such record, obtained from Mr. W. L. Stands, indicated that his bit passed through 2 feet of peaty material at a depth of about 100 feet in a well located in the NE1/4NW1/4 sec. 4, T. 28 N., R. 7 E. Whether the entire deposit that overlies the peat is of Wisconsin age or includes both Wisconsin and Illinoian deposits over older drift could not be determined. Similar records from Huntington



BLOCK DIAGRAM OF WABASH SLUICEWAY ACROSS WABASH COUNTY, INDIANA

and Miami Counties show the presence of buried trees and peat beds, most of them of probable Sangamon age, at varying depths. The great thickness of the Wisconsin drift, along with the lack of detailed well records, makes impossible an accurate estimate of the extent of pre-Wisconsin glacial materials in northern Indiana.

BEDROCK TOPOGRAPHY

The bedrock that underlies the glacial drift in Wabash County County belongs to the Niagaran series of the Silurian system. Two formations are exposed in outcrops along the Wabash, Mississinewa, and Salamonie Rivers and many of their tributaries. The uppermost of these is the Liston Creek limestone (Cumings and Shrock, 1928, pp. 71-94), which is generally thin-bedded, cherty, and rather resistant to erosion. Its maximum thickness is about 60 feet. The Mississinewa shale (Cumings and Shrock, 1928, pp. 56-71) lies beneath the Liston Creek limestone and is comparatively weak, calcareous, becomes more limy in its lower part, and attains a maximum thickness of 110 feet. The Silurian strata that underlie the Mississinewa shale consist mainly of limestone and dolomite about 220 feet thick (Indiana Division of Geology, 1949, pl. 2) and are known only from well cuttings. Upper Ordovician (Cincinnatian) shales underlie the rocks of Silurian age. The county lies on the crest and west flank of the Wabash arch, and the regional dip is a few feet per mile to the northwest.

A topography generally similar to that found in the unglaciated part of Indiana developed in the area during the long period of erosion that preceded the Pleistocene. The old-age erosion surfaces of the southern part of the state undoubtedly had their counterparts in northern Indiana. During the Tertiary period, peneplains and straths were formed and dissected. Accordant hilltops in southern Indiana at altitudes of 900 to 1,000 feet have been correlated with the Lexington peneplain of Kentucky (Malott, 1922, p. 130), which is believed to be of late Tertiary age. The bedrock surface on the Silurian formations of northern Indiana probably correlates with this peneplain, which is known to have sloped to the west and north. A similar surface which developed at about 900 to 1,100 feet above sea level in northern Illinois has been called the Lancaster peneplain (Grant and Burchard, 1907, p. 2), and Horberg (1946, p. 189) correlated a buried peneplain at an altitude of 600 to 650 feet in central Illinois with it. Another correlation (Fenneman, 1938,

p. 504) links the Lancaster surface with the Highland Rim or Lexington peneplain of Kentucky.

The buried upland in Wabash County is characteristic of an old-age surface with a few residual mounds rising above it (Pl. 6). Relief is generally less than 50 feet and slopes are gentle. South of the present Wabash Valley the average altitude of the buried upland is about 750 feet, with some high areas exceeding 800 feet. North of the Wabash the buried upland plain is slightly lower and is most typically developed at about 720 feet above sea level. Several hills are present on the bedrock surface. The most likely explanation of these buried monadnocks is that they are the remains of the Silurian bioherms which, due to the more resistant material of which they are composed, were not as easily eroded as the surrounding strata.

The highest altitude of the buried bedrock surface occurs beneath the Mississinewa moraine south of the Wabash River and appears to be partly attributable to the presence of a preglacial divide. North of the Wabash River the drift is thicker, and the bedrock surface below the moraine stands only slightly higher than that under the till plain to the west.

Glacial erosion took place over the bedrock floor, but it is doubtful whether it did much more than reshape to a minor extent some of the hills and valleys. At least it did not destroy the major preglacial topographic features.

The possibility of a structural plain on the Liston Creek limestone must not be overlooked since the highest known bedrock altitudes occur along the axis of the Wabash arch. The bedrock upland slopes westward across Wabash County about 10 feet per mile, and the regional dip westward from the Wabash arch is approximately 8 feet per mile (Cumings and Shrock, 1928, fig. 36). The abundance of chert in the Liston Creek limestone makes it a resistant formation which might allow the development of a structurally-controlled erosion surface. For such a small area as that covered in this report, however, it is difficult to determine whether this correspondence between regional dip and the slope of the bedrock surface is merely coincidence or is actually due to structural control. The general flatness of the buried upland area suggests that near peneplain conditions existed toward the end of the Tertiary period in northern Indiana.

TEAYS VALLEY

A preglacial trunk stream which headed in the Blue Ridge or Piedmont of Virginia (Stout and Schaaf, 1931, pp. 671-672) and flowed generally northwestward across the states of West Virginia and Ohio (Ver Steeg, 1936, fig. 1) entered Indiana in southern Adams County. From there it flowed across northern Jay County into Blackford County, where it turned northwestward through Grant and Wabash Counties. The name Teays has been applied to this preglacial river and its associated valley from the silt-filled Teays Valley in West Virginia, which is an abandoned section of its former course.

The name Teays is associated so intimately with this buried valley that it would be difficult to supplant, but a more logical term is preglacial Kanawha Valley, which in fact it was. The preglacial Kanawha River flowed across Ohio, Indiana, and Illinois to the Mississippi River. As a result of glaciation, its upper drainage was diverted to the present Ohio River, and the lower part of its course was buried. The term Teays as now used applies mainly to the abandoned part of the former Kanawha River.

From Wabash County the course of the Teays roughly paralleled that of the present Wabash River as far as Tippecanoe County, where it continued westward through southern Benton County and into Illinois (Fidlar, 1948, pp. 12-15). The same valley, there called the Mahomet, has been traced through Illinois to its junction with the bedrock valley of the present Illinois River (Horberg, 1945, pp. 349-350).

The "deep stage" is not limited to the Teays Valley but is characteristic of every major valley in the group of states around the Great Lakes. It is recognized along the Ohio Valley, which probably headed near Madison, Indiana, before the Pleistocene (Malott, 1922, p. 137); along the Wabash Valley; and along the Mississippi Valley. Apparently the upper Kanawha (Teays) drainage system was diverted to the Ohio prior to the completion of "deep stage" erosion. The floor of the Teays Valley in West Virginia stands 200 feet above the intrenched Kanawha and Ohio valley floors, and its bedrock floor is at least 15 feet above them. The "deep stage" apparently was cut mainly after the diversion of the upper Kanawha (Teays) drainage to the Ohio River (Stout, Ver Steeg, and Lamb, 1943, pp. 78-79).

The only satisfactory explanation which has been offered for the diversion of such a large river as the Kanawha (Teays) across a major divide is damming by a continental ice sheet. The diversion probably occurred during the Nebraskan glaciation. The fact that drift interpreted as Kansan in age has been recognized in "deep stage" valleys of Illinois (Horberg, 1945, p. 353) indicates that the gorge was cut in pre-Kansan time.

The Teays Valley enters the southeastern corner of Wabash County and extends westward a mile north of the county line for about 7 miles. The buried valley turns northwest 3 miles west of La Fontaine and crosses into Miami County about half a mile south of the present channel of the Wabash River. About 18 miles of its course lie within Wabash County (Pl. 6). Available well data make possible a fairly accurate location except in the area 2 to 4 miles west of La Fontaine, where wells which penetrate to the deepest part of the valley are lacking.

The lowest bedrock altitude obtained along the course of the Teays Valley across Wabash County was 410 feet above sea level in the vicinity of La Fontaine. Two wells here are near the deepest part of the buried valley. Horberg (1945, p. 359) stated that the average gradient of the Mahomet Valley above Beardstown, Illinois, is about 7 inches per mile. The altitude of the valley floor where it occurs beneath the present floodplain of the Wabash River should be about 400 feet.

The cross profile of the Teays exhibits a distinct gorge-like valley intrenched within a broad, old-age valley. Steep walls as much as 200 feet high can be recognized along the buried trench where control is closely spaced. The inner valley has been called the "deep stage" and is either preglacial or interglacial in age. Horberg (1945, p. 355) considered the "deep stage" an entirely preglacial development, since he tentatively identified gravels overlying the bedrock in the Mahomet Valley in Illinois as Nebraskan outwash, but the authors believe that it is interglacial in age.

Scattered erratics found in northeastern Kentucky and southern Ohio by Leverett (1929, pp. 33-47) are interpreted as pre-Kansan in age. Since only one glacial stage, the Nebraskan, is recognized as earlier than Kansan, these have been designated as remnants of deposits left by the Nebraskan glacier (Thwaites, 1946, pl. 3). This indicates that a lobe of that glacier overrode the course of the preglacial Kanawha (Teays), ponded it, and diverted the upper

part to the preglacial Ohio. Thus the "deep stage" more likely is post-Nebraskan and pre-Kansan in age rather than preglacial, as suggested by Horberg. With the withdrawal of the Nebraskan glacier, which caused integration of the upper Kanawha (Teays) with the preglacial Ohio, a vastly shortened, unnamed descendant of the Teays apparently headed somewhere in west-central Ohio and cut the "deep stage" across Ohio, Indiana, and Illinois during the long Aftonian interglacial stage, which followed.

The "deep stage" of the Teays Valley in Indiana is narrow, and, because of the scarcity of recorded wells that extend to bedrock, its exact location is not always determinable. Water well drillers have reported sudden and surprising drops in the altitude of the bedrock surface within a quarter of a mile. These probably represent steep bluffs, some of which could have been buttressed by Silurian bioherms, along incised meanders. These massive rock features, which dot the terraces and floodplains of the present rivers, undoubtedly are equally abundant on the buried surface.

If the sequence of bedrock formations of northern Indiana were exposed, the extensive cliffs along the "deep stage" of the Teays and its tributaries would provide a clearer understanding of the stratigraphy of northern Indiana. The entire Silurian section below the Liston Creek limestone (Indiana Division of Geology, 1949, pl. 2) and a few feet of the upper Ordovician probably would be visible in the vicinity of La Fontaine. Most of these beds are known only from well cuttings.

In Wabash County the part of the Teays Valley above the "deep stage" consists of broad terraces at an altitude of about 600 feet. From this terrace level the bedrock rises gradually to the 700-foot level of the slightly rolling Lexington peneplain surface. These terraces probably correspond in age to an erosional surface in the unglaciated areas known as the Parker strath, which has been interpreted as the product of a partial erosion cycle that ended sometime prior to Kansan glaciation (Fenneman, 1938, p. 443). More recent correlation (Thornbury, 1948, p. 1359) places its age as pre-Nebraskan. The Parker strath probably represents an erosional level existent at the beginning of the Pleistocene before the rejuvenation associated with, and following, the Nebraskan glaciation. The general appearance and width of the strath terrace along the Teays Valley in Indiana indicates that it represents only a slight rejuvenation following the Lexington cycle.

Intrenchment of the "deep stage" took place so rapidly that the smaller tributary streams of the major valley could hardly have maintained accordant junctions. For this reason either a falls or rapids was present at varying distances from the main valley along each of the tributaries of the Teays. The positions of these knickpunkte could not be located even with the closely spaced data in southern Wabash County. On Plate 6, therefore, the lower part of each tributary valley shows a steepened gradient rather than a falls.

PREGLACIAL EEL VALLEY

The Eel Valley across Wabash County follows the course of a preglacial tributary of the Teays which probably entered the trunk valley in Miami County (Horberg, 1945, p. 357). The presence of this tributary has long been recognized because old gas borings penetrate its filled valley in the vicinity of North Manchester. Besides the wells at North Manchester, a well in the vicinity of South Whitley in Whitley County penetrated 250 feet of glacial drift and entered bedrock slightly below 600 feet above sea level.

Most of the water wells along the region crossed by the buried Eel Valley are completed in gravel at varying depths, and few reach bedrock. Hence, exact delineation of the valley is difficult. Abundant water is nearly always reached at comparatively shallow depths. Scanty information has resulted in a highly generalized interpretation of the valley of this ancient river.

The "deep stage" must have developed along the ancient Eel River. Its junction with the "deep stage" of the Teays Valley occurs at an altitude slightly under 400 feet, and its floor probably does not rise above 500 feet within Wabash County.

No detailed work has been done on the thickness of drift in northeastern Indiana, and, although the presence of a divide between the Mississippi and preglacial St. Lawrence drainage system can be inferred, its location is still unknown.

THICKNESS OF DRIFT

A thickness of drift map (Pl. 7) correlates closely with a map of the bedrock topography. Drift is thickest where the Mississinewa moraine crosses the buried "deep stage" of the Teays east of La Fontaine. Here four wells penetrated 410 feet of drift. At the southeast edge of the county, where many wells have entered bedrock, more than 300 feet of drift frequently is encountered. Except

where present streams have incised their valleys, depths to bedrock of 375 feet may be expected over the most deeply buried portion of the Teays, but where the present floodplain of the Wabash River crosses it, the depth to bedrock is about 275 feet.

The thickness of drift over the buried upland varies from about 100 feet near the Teays Valley to little or nothing along the present Wabash, Salamonie, and Mississinewa Rivers. The glacial cover thickens abruptly from the high terraces along these streams toward the upland, where it is characteristically about 75 feet. Many interglacial ravines were cut into the upland and cause considerable variation in drift thickness, especially near buried trunk valleys.

The preglacial divide between the Teays and Eel Valleys was in the vicinity of the present Wabash River, and the bedrock surface descends gently northward from there. In the east part of the county, the massive Mississinewa moraine stands between 50 and 100 feet above the flat till plain to the west. Drift thickness increases in the area of the moraine but not as much as the differences in surface elevation indicate because bedrock stands about 25 feet higher beneath the moraine than on either side. Drift in this region ranges from 80 to 160 feet in thickness, and many wells penetrate about 100 feet.

Information is sparse on the thickness of the glacial cover in the Eel bedrock valley and in the region north of it, but more than 300 feet of drift may be present in the deeper parts of the valley. The only wells in this area which reach bedrock are oil and gas wells because water usually is obtained from gravel. One water well record north of the Eel River showed a drift thickness of 146 feet, and several other wells have been completed in gravel at depths exceeding 100 feet. The general thickness of drift in the area of the Packerton moraine, disregarding the hills and depressions, is 150 to 175 feet.

BURIED GRAVEL BEDS AND MAJOR INTERGLACIAL DRAINAGE LINES

Sand and gravel beds encountered in oil, gas, and water wells aid in the recognition of buried valley trains. Many of the sluiceways that carried melt-waters of the earlier glaciers were used by interglacial streams which intrenched themselves in the glacial valley-fill but did not remove all of the outwash before it was covered by subsequent glacial deposits. Many of the thicker gravel

beds encountered by well drillers in Wabash County undoubtedly originated in this way.

Erosion of the "deep stage" presumably ceased with the advent of Kansan glaciation. Available information is insufficient to determine whether Kansan drift is present in Indiana. A fairly persistent ground water aquifer which occurs between altitudes of 475 and 560 feet suggests the presence of either Kansan or Illinoian outwash gravels.

Many wells obtain water in the buried Teays Valley from an aquifer between 610 and 670 feet above sea level which may represent Illinoian or Wisconsin outwash. The depth of this gravel is in accord with that of a buried peat bed near Urbana that is tentatively interpreted as Sangamon in age.

Some preglacial drainage lines were still active as sluiceways well into Wisconsin time or remained as topographic sags until the close of the Tazewell substage. Thick gravel beds overlain by till crop out along the Wabash River 1 mile east of Wabash and along Treaty Creek in Reserve 19. Outwash gravels beneath till at an altitude of 700 feet along the south bluff of the Wabash River south of Rich Valley indicate that part of the Teays Valley was still in use as late as Tazewell time. Similar deposits of gravel overlain by till are present along the Mississinewa River in the NE1/4 sec. 29, T. 26 N., R. 6 E. (Pl. 3, A).

Each glaciation, beginning with the Kansan, or even Nebraskan, contributed to the fill in the buried valleys. During Yarmouth and Sangamon interglacial times, the unnamed descendant of the Teays was probably an underfit stream with floodplain characteristics of superposed old age due to valley filling, similar to the present lower Wabash Valley. During the fluctuating retreat of the Tazewell ice, the till surface contained sags that reflected the buried valleys and were followed by many of the sluiceways. The final readvance of the Tazewell ice sheet deposited another layer of till over the valley trains. The superposed courses of the present Wabash River and its tributaries came into existence with the final Tazewell retreat.

ECONOMIC GEOLOGY

SAND AND GRAVEL

The many gravel roads throughout Wabash County reflect the abundance of deposits within easy hauling distance and the relative scarcity of limestone suitable for road metal. About 80 gravel pits,

active and abandoned, are scattered over the county. Several deposits in the area could be screened and washed for use as concrete aggregate if the market warranted.

Deposits of gravel in Wabash County occur both above and beneath the water table. Because layers of sand commonly occur separately from layers of gravel, the sand lenses in dry pits often are worked separately for plaster and cement sand, and the gravel is used for road metal and fill. A dragline generally is used to operate the wet pits, and the gravel is stockpiled on the banks until needed. Front end loaders or other portable loading equipment are used in most of the pits, both wet and dry. None of the pits in Wabash County produces washed and sorted sand and gravel at the present time, although the operators of a few pits have crude equipment to remove boulders.

Intramorainal deposits.—Intramorainal deposits are associated with ground or end moraines and were dropped by melt-water below or within the glacier at or near its edge. They include eskers, kames, and deposits of poorly-assorted, water laid materials which interfinger with till in many morainic knolls. Intramorainal deposits may have limited extent and, except for eskers, generally show wide variations in size of materials and degree of sorting. One active gravel pit in the SW1/4 sec. 35, T. 30 N., R. 5 E., is located in a kame. Several other pits have been opened in intramorainal deposits but at the present time are either inactive or abandoned.

Outwash deposits.—Outwash deposits were laid down by melt-water as it flowed beyond the glacier in sheets to form outwash plains or as streams in sluiceways to form valley trains. Gravel in this type of deposit, which is the largest and most consistent, is somewhat rounded, fairly well sorted, and nearly free from silt and clay. Cross bedding is common (Pl. 2, B), and gravel lenses are generally large and homogeneous. Fifteen active or active on demand pits and many small inactive pits are located in outwash deposits in Wabash County.

Alluvial deposits.—Alluvial gravel deposits generally are found as bars in the larger streams, are composed of reworked glacial drift and a considerable amount of local bedrock, and generally contain a large quantity of silt. One small pit along the Salamonie River in Wabash County is located in an alluvial deposit.

Deposits along the Mississinewa River.—Some of the terraces along the Mississinewa River are bedrock benches and contain little outwash, but gravel and sand deposits lie beneath the terraces in many places. The material is coarse, well assorted, and contains a high percentage of limestone pebbles. Crystalline rocks are relatively rare. The overburden of weathered gravel is about 4 feet thick, and some of the deposits near the western edge of the county have till overburden of variable thickness. Three active or active on demand gravel pits are located in this area.

Deposits along the Salamonie River.—Most of the Salamonie Valley is cut in bedrock, with only a veneer of gravel over the terraces. Along the east edge of the county the present valley crosses a buried sluiceway and has exhumed a portion of its valley train. The largest and only active gravel pit in this area is in the SE1/4SE1/4 sec. 20, T. 27 N., R. 8 E. Other pits have been abandoned because of the thickness of till overburden.

Deposits along the Wabash River.—Gravel deposits are found in the bluffs along the Wabash River where it crosses buried sluiceways, but a thick till overburden has prevented extensive exploitation. An active gravel pit southeast of Wabash is in outwash along Treaty Creek and the western edge of the Mississinewa moraine. Flat terrace remnants above the Wabash Valley floodplain south of Rich Valley are potential gravel sources. Small deposits occur in the terraces along Mill Creek and similar tributaries.

Deposits along the Eel River.—The most extensive valley train in the region is along the Eel River and consists of rounded and well assorted outwash gravels. Most of the pebbles are limestone and dolomite, but some shale is present. The overburden is thin and consists of weathered gravel and sand. Due to a relatively high water table, many of the pits in this area are wet operations. Similar outwash occurs along Poney Creek, which joins the Eel River at North Manchester. Gravel along a small tributary of the Eel River half a mile west of the town of Roann contains a higher percentage of crystalline material than is present along the Eel River (D. R. Coates, personal communication).

Deposits within the Packerton moraine.—The principal sources of gravel in the Packerton moraine are kames and eskers. Crystalline rocks are more abundant in the northern part of this moraine than in the valley train deposits in the county. Such deleterious rocks as chert and shale are relatively scarce. The gravel makes

satisfactory material for surfacing roads. The pit in the SW1/4 sec. 35, T. 30 N., R. 5 E., exposes a deposit in a kame, and, as is typical of such deposits, the gravel is poorly assorted and contains many boulders and much silt and clay.

MARL

Marl or bog lime is used mainly for agricultural lime in Wabash County. Because of its finely divided character and high calcium carbonate content, it is a satisfactory material to correct the acidity of the soils of the area.

Marl occurs in small, fresh water glacial lakes and in the beds of former lakes. The only deposit in Wabash County that is operated at the present time is in the lake bed west of Long Lake. The marl is dug out and stockpiled (Pl. 4, B), then hauled and spread on fields by truck. When it comes from the pit, the marl is a light-gray plastic clay and contains as much as 50 percent water.

Small deposits of marl lie around some of the lakes in the northwest corner of the county but their extent was not determined. Before a pit is opened, test drilling of the area to determine the extent, thickness, and purity is advisable because individual marl deposits are seldom large and generally vary greatly in thickness and calcium carbonate content.

PEAT

Considerable peat, which could be developed commercially to improve the humus content of soils, occurs in the county. Peat was formerly marketed as a by-product of marl at one locality, but at the present time no peat is produced for commercial use. Peat deposits occur in the same type location as marl beds since it is one of the important products of the filling of small lakes.

GROUND WATER

Valleys of preglacial and interglacial sluiceways generally contain thick, extensive beds of gravel and sand. These coarse, porous, outwash deposits which lie buried beneath younger drift are excellent ground water reservoirs. Those that occur at the base of the drift in the "deep stage" Teays Valley and its tributaries are of particular importance in northern Indiana. The municipal water supply for the city of Wabash comes from several flowing wells south of Treaty Creek in Reserve 19 (Capps, 1910, p. 225). These wells tap an aquifer in coarse gravel within a comparatively small,

southward trending tributary of the Teays. The city of Peru in adjacent Miami County obtains its entire water supply from four 10-inch wells that are completed in gravel in the "deep stage" of the Teays Valley and have a total production potential of 3,000,000 gallons per day.

Not all buried valleys contain water-bearing sand and gravel. Those that flowed toward the ice sheets were ponded and partially filled with lacustrine silts and clays, as were many valleys tributary to sluiceways which were ponded by the valley trains built down them. Only valleys which were sluiceways are likely to contain coarse gravel (McGrain, 1949, p. 178). Outwash was deposited in the major valleys during each of the earlier glacial stages and later was overridden by ice; hence, several gravel beds may occur between layers of till in the deeper valleys. Knowledge of the thickness of glacial drift and of the bedrock topography can aid in locating and determining the size of the extensive ground water aquifers along former sluiceways.

The greatest potential ground water reservoirs in Wabash County, as yet largely unused except for domestic purposes, are in the buried Eel and Teays Valleys. At the present time water is obtained from shallow wells along the Eel Valley. The region is underlain by gravel, for it has been a drainage line since preglacial times. The possibilities of the Teays are indicated by the wells at Peru in Miami County. Gravel and sand are abundant throughout the Packerton moraine area, and few wells have to go to bedrock for water. Over the preglacial upland, ground water supplies sufficient for domestic use are obtained from wells in bedrock or sand and gravel. Sand and gravel beds in the drift here are generally local in extent and cannot be depended upon for large supplies of water.

Artesian conditions exist in a low area in the east part of sec. 35, T. 30 N., R. 5 E., where two flowing wells are reported, and in the area in Reserve 19, from which Wabash gets its water supply. In the latter area, the hydrostatic pressure has been lowered considerably since the first wells were drilled, and recent wells have required pumps.

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Wabash

Roann

La Fontaine

ERIE

PENNSYLVANIA

ST. LOUIS

CHICAGO CINCINNATI CLEVELAND

WABASH RIVER

EEL RIVER

SALAMONIE RIVER

MISSISSINEWA RIVER

LISTON CR.

LONG LAKE

LUKEN'S LAKE

PAWPAW CREEK

BEAR GRASS CREEK

ROSS RUN CREEK

BURR OAK CREEK

GRANT CREEK

MILL CREEK

LAGRO CREEK

PONEY CREEK

RES. 11 RES. 12 RES. 13 RES. 14 RES. 15 RES. 16 RES. 17 RES. 18 RES. 19 RES. 22 RES. 23 RES. 25 RES. 26 RES. 55

EXPLANATION

Recent

Muck and peat
(Decayed plants and varying amounts of clay and silt)

Marl
(Mixture of calcium carbonate, clay, and silt)

Alluvium
(Silt, sand, and gravel deposits of recent streams)

Pleistocene

Wisconsin

Cary

Maumee terrace
(Erosional surface cut by overflow waters of Lake Maumee)

Mississinewa terrace
(Upper level of valley trains underlain by well-assorted sand and gravel)

Ground moraine
(Mainly heavy, blocky, clay till)

Mississinewa moraine
(Mainly clay till)

Kame and esker
(Assorted sand and gravel)

Tazewell

Packerton moraine
(Till and varying amounts of sand and gravel)

Ground moraine
(Mainly clay till)

QUATERNARY

Klintar
(Exhumed bioherms, composed of massive, coarsely crystalline dolomite)

Bedrock
(Undifferentiated Liston Creek limestone and Mississinewa shale)

SILURIAN

Scale of Miles

1 ½ 0 1 2 3

INDEX MAP OF INDIANA SHOWING LOCATION OF WABASH COUNTY

AREAL GEOLOGIC MAP OF WABASH COUNTY, INDIANA

EXPLANATION

< 614 Bedrock elevation less than depth of hole

o 718 Well showing elevation of bedrock

x 700 Outcrop elevation

Contours shown solid where data closely spaced and broken where data incomplete

1 ½ 0 1 2 3 4 Miles

Contour interval 20 feet
Datum is mean sea level

MAP SHOWING BEDROCK TOPOGRAPHY IN WABASH COUNTY, INDIANA

KOSCIUSKO CO

R.5E. R.6E. R.7E. R.8E.

T. 30 N.

FULTON CO

WHITLEY CO

North Manchester

T. 29 N.

T. 28 N.

T. 27 N.

T. 26 N.

MIAMI CO

HUNTINGTON CO

GRANT CO

Roann

Wabash

Lagro

La Fontaine

SALAMONIE RIVER

EEL RIVER

WABASH RIVER

MISSISSINEWA RIVER

EXPLANATION

- 86 — Well showing thickness of glacial drift
- >130 — Drift thickness greater than well depth
- Bedrock terrace drift generally 5 feet or less
- Bedrock outcrop
- Contours shown solid where data closely spaced and broken where data incomplete

1 1/2 0 1 2 3 4 Miles

Isopachous contour interval 20 feet

MAP SHOWING THICKNESS OF GLACIAL DRIFT IN WABASH COUNTY, INDIANA