THE GEOLOGY OF MIAMI COUNTY, INDIANA

by

WILLIAM D. THORNBURY AND HAROLD L. DEANE

Indiana Department of Conservation
GEOLOGICAL SURVEY
Bulletin No. 8

1955

STATE OF INDIANA
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GEOLOGICAL SURVEY
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BLOOMINGTON

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PRINTED BY AUTHORITY OF THE STATE OF INDIANA
BLOOMINGTON, INDIANA
July 1955

For sale by Geological Survey, Indiana Department of Conservation, Bloomington, Indiana
Price $1.00

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THE GEOLOGY OF MIAMI COUNTY, INDIANA

BY WILLIAM D. THORNBURY AND HAROLD L. DEANE

ABSTRACT

Most of the geomorphic features of Miami County are of glacial origin or are glacial deposits that were modified by postglacial erosion. Three major and nine smaller valleys were sluiceways for glacial melt waters. The Wabash and Eel Valleys carried glacial outwash during both the Tazewell and Cary subages of the Wisconsin. As a result, thick and extensive valley trains were developed down these valleys. During part of the Cary subage the Wabash sluiceway was the outlet for Lake Maumee.

Glacial deposits older than Wisconsin have not been recognized positively in Miami County. Wisconsin deposits consist of till, outwash, lake silts and clays, and undifferentiated sands of the Tazewell substage and outwash and wind-blown sands of the Cary substage.

The upland area of the county has within it parts of three distinct units: parts of the Tipton till plain and the Packerton and Union City moraines. The till of the Packerton moraine is more sandy than that of the ground moraine of the Tipton till plain to the south and has associated with it extensive sand deposits of uncertain origin. Devonian limestones of Hamilton age and the Silurian Kokomo limestone, Liston Creek limestone, Mississinewa shale, and associated Niagaran bioherms constitute the exposed bedrock.

An old-age topographic surface, correlated with the late Tertiary Lexington peneplain of Kentucky and southern Indiana, is buried beneath a glacial cover. Another erosional level, which probably is of the same age as the Parker strath, is developed at an altitude of 400 feet along the buried Teays and Metea (preglacial Eel) Valleys. The "deep stage" was not recognized in Miami County. The greatest determined drift thickness is 451 feet and is at the place where the Packerton moraine crosses the Metea Valley. The average thickness of drift, however, is approximately 125 feet.

Economic resources are oil and gas, limestone, sand and gravel, ground water, marl, and peat. Oil and gas are produced from rocks of Trenton (Middle Ordovician) age. Quarries formerly were operated in the Kokomo limestone and Niagaran bioherms. Sand and gravel are obtained from terraces along the Wabash, Eel, and minor sluiceways, from outwash gravels beneath Recent alluvium, from outwash that was buried beneath till, and from kames and eskers. Thick beds of gravel in buried valleys and local lenses of gravel within till provide a large potential water supply. Marl and peat have been mined from depressions in the Packerton moraine and the floodplain of the Wabash River.

INTRODUCTION

LOCATION OF AREA

Miami County is in north-central Indiana about 70 miles north of Indianapolis. Latitude 40° north and longitude 86° west intersect about 4 miles northeast of Peru. Miami County is bounded on the west by Cass and Fulton Counties, on the north by Fulton County, on the east by Wabash and Grant Counties, and on the south by Howard County (pl. 1). The county is 30 miles long and 12 miles wide except in the extreme southern part, where it is 16 miles wide. It has an area of 384 square miles.

Peru, which has a population of about 16,000, is the only corporate city in Miami County. Incorporated villages in the county are Amboy, Bunker Hill, Converse, Denver, Macy, and North Grove.

Miami County is served by four railroads. Two branches of the Pennsylvania Railroad and one of the Wabash Railroad cross the county in a general east-west direction. The New York, Chicago and St. Louis and the Chesapeake and Ohio Railroads extend in a general north-south direction. U. S. Highway 24 and Indiana Highways 16, 18, and 218 have general east-west and U. S. Highway 31 and Indiana Highways 19 and 21 north-south directions across the county.

SCOPE OF INVESTIGATION

An isopachous map showing the thickness of drift (pl. 7), a map showing bedrock topography (pl. 6), and three cross sections (pl. 8, A, B, and C) were prepared from information which had been gathered from water well drilling, oil well drilling, and seismic-refraction shooting. The field work was done during the summer of 1949 by William D. Thornbury and Jacob P. Hamilton and during the summer of 1950 by the writers. Many sections in active and abandoned gravel pits and limestone quarries were studied. Much of the information pertaining to thickness of drift and subsurface geology of the northern one-third of the county, where few water wells are in bedrock, was obtained by seismic-refraction shooting. Surface altitudes were obtained from U. S. Geological Survey maps, from oil well altitudes, and by aneroid barometer traverses. A detailed soil map of Miami County (Tharp and Kunkel, 1927) and a glacial map of Indiana (Leverett and Taylor, 1915, pl. 6), along with aerial photographs of the county, served as guides in the study of the areal geology. The results of this areal survey are shown on the geologic map (pl. 1).

ACKNOWLEDGMENTS

The writers wish to express their appreciation to Dr. Charles F. Deiss, State Geologist and Chairman of the Department of Geology, Indiana University, for his many suggestions and critical reading of the manuscript, and to Professor T. M. Bushnell, of the Purdue University Agricultural Experiment Station, and to Dr. William J. Wayne, Head of the Glacial Geology Section, Indiana Geological Survey, for information and suggestions which they gave in the preparation of this report. The writers also thank Dr. Judson Mead, of the Department of Geology, Indiana University, and Maurice E. Biggs, Head of the Geophysics Section, Indiana Geological Survey, for the interpretation of geophysical data. Dr. John B. Patton and Thomas A. Dawson, of the Indiana Geological Survey, aided in the interpretation of the subsurface geology. The writers also thank the water well drillers in Cass, Fulton, Howard, Miami, and Wabash Counties: Jesse Snyder of Onward, Cecil Miller of Royal Center, Guy Amos of Galveston, Richard Henderson of Fletcher's Lake, Virgil Baker and G. R. McGrew of Fulton, J. B. Ortmann of Kokomo, J. W. Mills of Peru, Everett Zehring of Bennett's Switch, Frank Eaber of Macy, Willard Mauser of Roann, W. L. Stands and G. K. Stremmel of LaFontaine, and Jack Smith of Lagro for information on the thickness and character of drift which they provided from their records.

PHYSIOGRAPHY

Parts of two sections of the Central Lowland province of the Interior Plains division of the United States are found within Miami County. The part of the county north of the Wabash River, approximately 190 square miles, is in the Great Lakes section, and the area south of the Wabash River, likewise approximately 190 square miles, is in the Till Plains section. Malott (1922, pl. 2) shows parts of two physiographic regions of Indiana within the boundaries of the county. The area north of the Wabash River he considered as belonging to the Steuben morainal lake part of the Northern Moraine and Lake region; on the other hand, the area south of the Wabash River was mapped as part of the Tipton till plain region. The area between the Wabash and Eel Rivers, however, should be included in the Tipton till plain because it has physiographic characteristics similar to the till plain farther south and undoubtedly was formed under comparable conditions (Wayne and Thornbury, 1951, p. 7).

The hummocky topography of the northern one-third of the county is largely end moraine which was deposited by ice of the Erie and Saginaw ice lobes. The southern two-thirds of the county is gently rolling to extremely flat ground moraine which was laid down by the Erie lobe. Terraces which are underlain by outwash deposits and bedrock are found along the major streams and some of their tributaries.

STREAMS AND VALLEYS

The major streams of the area are the Wabash, Eel, and Mississinewa Rivers and Big Pipe, Deer, and Mill Creeks. The master stream is the Wabash, and all other streams except Mill Creek, which flows northwestward into the Tippecanoe River, are its tributaries. Lakes and swamps are common only in the area of the Packerton moraine. North of Eel River, stream dissection of the upland areas has made little progress except along major streams and for a short distance up their tributaries.

WABASH RIVER

The Wabash River flows almost directly westward across the center of Miami County. It enters the county at an altitude of 634 feet and leaves it at an altitude of 610 feet, a drop of 24 feet in 13 miles and an average gradient of 1.85 feet per mile. Its valley is cut in both unconsolidated drift and bedrock and is wide and alluviated along its entire course across the county.

EEL RIVER

The Eel River enters Miami County from the east about 6 miles south of the northern boundary, flows southwestward across the county, and joins the Wabash River at Logansport in Cass County. The river enters Miami County at an altitude of 710 feet and leaves it at an altitude of 649 feet, a drop of 61 feet in 21 miles and an average gradient of 2.9 feet per mile. Its valley is wide and alluviated throughout the county and at no place is it cut in bedrock.

MISSISSINEWA RIVER

The Mississinewa River flows northwestward across the east-central part of Miami County to its junction with the Wabash River about 1 mile east of Peru. It enters the county at an altitude of 675 feet and joins the Wabash River at an altitude of 633 feet, a drop of 42 feet in 8 miles and an average gradient of 5.2 feet per mile. Its valley is wide and alluviated where it enters the county and continues so for about 1¼ miles. It thereupon becomes a narrow gorge cut partly in bedrock which is overlain by a thin cover of drift. The east side of the valley is cut in bedrock and the west side in unconsolidated till to a point about 1 mile south of its junction with the Wabash. The remainder of the course of the Mississinewa is in glacial deposits.

BIG PIPE CREEK

Big Pipe Creek enters Miami County from the east at the north edge of sec. 29, T. 25 N., R. 6 E., flows northwestward, and leaves the county at the south edge of sec. 7, T. 26 N., R. 3 E. It joins the Wabash River about 2½ miles west of the Miami-Cass county line. Big Pipe Creek enters the county at an altitude of 791 feet and leaves it at an altitude of 727 feet, a drop of 64 feet in 20.1 miles and an average gradient of 3.2 feet per mile. Its valley is narrow and is alluviated throughout its entire length. It is cut in glacial drift except for the part between the SE¼ sec. 29, T. 26 N., R. 4 E., and the NE¼ sec. 24, T. 26 N., R. 3 E., which is in bedrock.

MILL CREEK

Mill Creek heads in Miami County in sec. 17, T. 29 N., R. 4 E., and flows northward to leave the county in the north-central part of sec. 5, T. 29 N., R. 4 E. The valley is gently sloping, not alluviated, contains areas of muck and peat, and is cut entirely in unconsolidated drift.

INTERSTREAM AREAS

TILL PLAIN

The most extensive physiographic area of Miami County is the till plain that lies mainly south of Eel River but also includes two small areas on the north side of that river (pl. 1). Malott (1922, p. 104) proposed for it the name Tipton till plain because of its excellent representation in Tipton County.

The till plain south of the Wabash River is extremely flat and has an average altitude of 800 feet. North of the river, the topography is gently rolling, the relief is somewhat greater, and the altitude averages about 780 feet. A maximum relief of 90 feet is found near the Wabash Valley. Tributaries of Wabash and Eel Rivers have dissected parts of the till plain adjacent to them. Drainage is mainly by sheetwash or is internal, except near the larger streams. Bedrock is reached only by the major streams and has limited lateral and vertical exposure.

PACKERTON MORAINE

Except for the two small areas of till plain north of Eel River, the topography of the northern one-third of the county is that of an interlobate moraine. Dryer (1892, p. 168) called it the Saginaw-Erie interlobate moraine. Malott (1922, p. 117) named it the Packerton moraine from the village of Packerton in southern Kosciusko County.

At its west end, near Delphi in Carroll County, the Packerton moraine has a width of 2 to 3 miles. It borders the Wabash River on the north (fig. 1) until it reaches Logansport in Cass County, where it turns northeastward and follows a course north of and parallel to Eel River through Miami and Wabash Counties. The moraine is overlapped by the Mississinewa morainic system 8 miles northeast of Columbia City in Whitley County (Leverett and Taylor, 1915, p. 158). In some places the altitude of the moraine exceeds 860 feet, and the maximum local relief is 100 feet, an amount comparable to that found along the Wabash Valley. The topography of the moraine is hummocky and the drainage is deranged. Morainic hills and ridges, kames, eskers, outwash fans, and intramorainal lakes are characteristic topographic features.

UNION CITY MORAINE

The Union City moraine (pl. 1) is poorly developed and only locally has the typical characteristics of a terminal moraine. It was named the Union moraine by Leverett (1902, p. 475) from the town of Union (Union City) in Randolph County. It was renamed the Union City moraine by Leverett and Taylor (1915, p. 30). This moraine extends from the Indiana-Ohio line northwestward through Randolph, Delaware, Madison, and Howard Counties and enters Miami County in secs. 34, 35, and 36, T. 25 N., R. 4 E. It continues northward to the village of Bunker Hill, beyond which it cannot be distinguished from the till plain. The recognizable part of the moraine in Miami County consists of smooth or gently undulating knolls and is comparatively free of sharp hills. A somewhat arbitrary altitude of 820 feet was used on the geologic map of the county to delimit its outer edge. The maximum local relief of the moraine above the till plain is 30 feet.

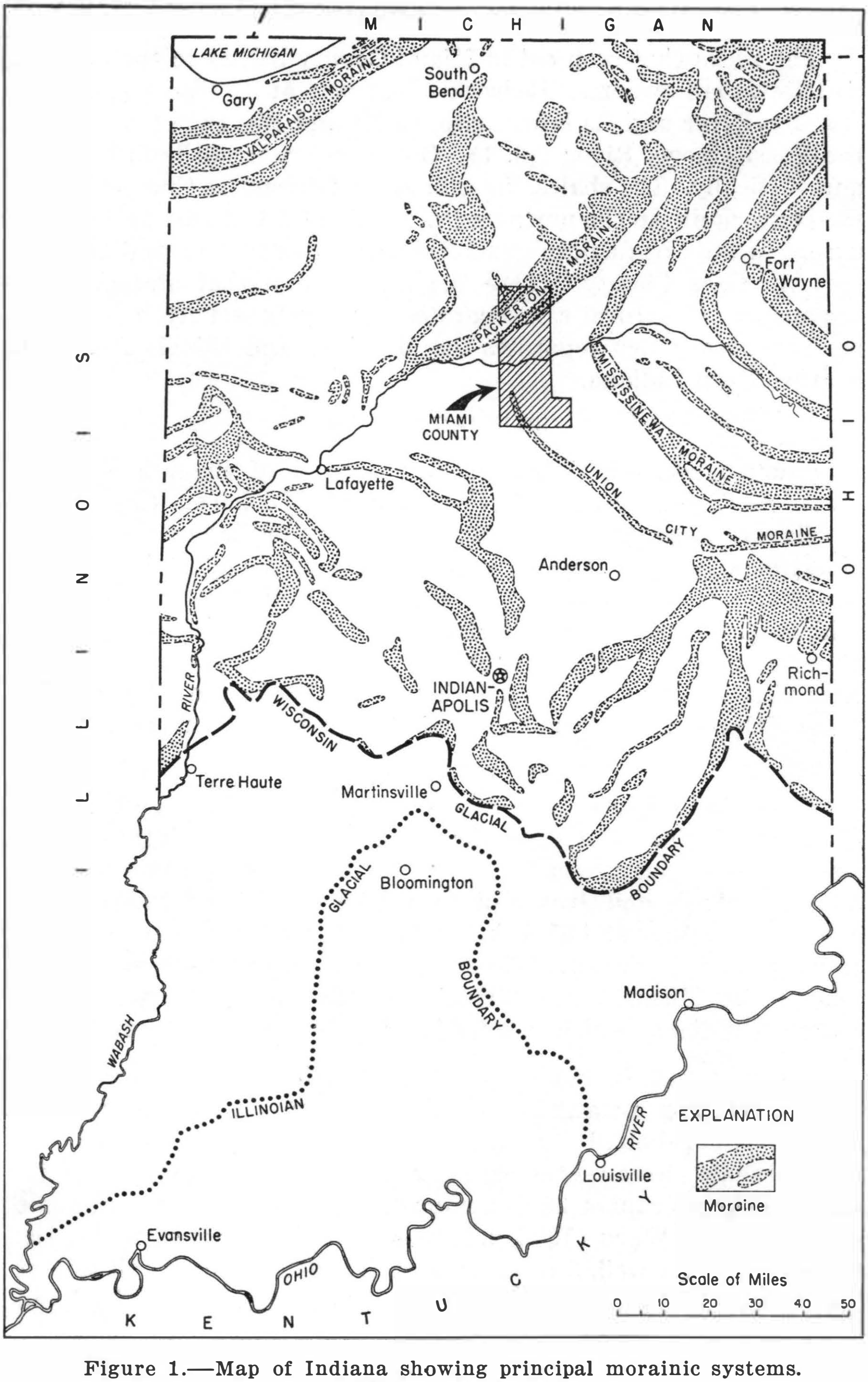

Figure 1.—Map of Indiana showing principal morainic systems. Modified after Leverett.

PALEOZOIC STRATIGRAPHY

The rocks that crop out in Miami County belong to the Silurian and Devonian systems. Bedrock is exposed at 31 places along the Wabash River and its tributaries, Little and Big Pipe Creeks, and the Mississinewa River (pl. 1). Outcrops are small both laterally and vertically. The shales, limestones, and dolomites that constitute the bedrock dip to the northwest at a rate of a few feet to the mile, except in the Logansport structural sag between Peru and Logansport, in Cass County, where the dip is somewhat steeper. The Logansport structural sag separates the Cincinnati Arch from the positive area which separates the Michigan and Illinois Basins in northwestern Indiana.

SILURIAN SYSTEM

Silurian rocks in Miami County consist of the Mississinewa shale, the Liston Creek formation, associated bioherms (see below) of Niagaran age, and the Kokomo limestone of Cayugan age. The oldest exposed rock, the Mississinewa shale, is underlain by limestones and dolomites, about 220 feet thick, of Niagaran age (Middle Silurian). Esarey and Bieberman (1949, pl. 2) indicated that about 10 feet of Brassfield limestone (Lower Silurian) underlies the Niagaran rocks in northern Indiana. Shales of the Cincinnatian series (Upper Ordovician) underlie the rocks of Silurian age.

MISSISSINEWA SHALE

The Mississinewa shale was named by Cumings and Shrock (1927, p. 72) from the Mississinewa River, along which the shale is well exposed and typically developed at or near water level in Miami, Wabash, and Grant Counties. The age of the formation was given by Cumings and Shrock (1928a, p. 63) as very late Rochester or very early Lockport. Esarey and Bieberman (1948, p. 7) correlated the Mississinewa formation with the Waldron shale of southern Indiana, which is considered to be late Rochester in age.

Patton (1949, p. 11) stated that the Mississinewa at most exposures is blue-gray, argillaceous, dolomitic, silty, massive limestone which has conchoidal fracture, but that in places it is gray calcareous shale. Because the base of the formation is not exposed, its exact thickness cannot be determined. At Wabash 75 feet of shale is exposed, and Ward (1906, p. 239) recorded 117 feet of blue shale, probably from a well, 3 miles west of Wabash on the north side of the Wabash River. All this shale may be Mississinewa. Elrod and

Benedict (1892, p. 202), on the basis of a well log, reported 114 feet of shale at Lagro, Wabash County, and indicated that the shale might be as much as 250 feet thick.

Evidence of the presence of the Mississinewa formation was found at one place in Miami County. Along Prairie Ditch about 1 mile northwest of Peru, in the SW¼ sec. 20, T. 27 N., R. 4 E., fragments of Mississinewa shale had been thrown out in the excavation of the ditch (pl. 1). Bedrock does not crop out because mud and silt deposited on the banks of the ditch have covered it. The formation there, as indicated by the excavated materials, is gray, thin-bedded, very calcareous shale.

LISTON CREEK FORMATION

The Liston Creek formation was named by Cumings and Shrock (1928a, p. 71) to include the same authors' former Liston Creek limestone (above) and Red Bridge limestone (below), both of which were thus reduced to member rank. The Liston Creek limestone member, according to the authors, was 28 feet thick at the type section and consisted of "a series of thin, slabby limestone beds with considerable associated chert." The Red Bridge limestone member was described as "the bed of reddish-yellow colored, impure, argillaceous limestone which occurs between the Liston Creek limestone and Mississinewa shale along the Mississinewa and Wabash rivers."

The Liston Creek formation was correlated (Esarey and Bieberman, 1948, fig. 4) with the Louisville limestone of southern Indiana. Its fauna resembles the typical Lockport fauna of New York and Ontario (Cumings and Shrock, 1928a, p. 84). Patton (1949, p. 12) described the Liston Creek formation as gray, thin-bedded, dolomitic, cherty limestone which contains intercalated beds of chert. The upper part is more cherty than the lower. The formation ranges from a few feet to as much as 60 feet in thickness. The maximum exposed thickness in Miami County is 28 feet.

The Liston Creek is exposed at 16 places in Miami County (pl. 1). The best outcrop of the formation is at the "Seven Pillars of the Mississinewa," about 6 miles southeast of Peru (pl. 4, A). There about 28 feet of gray, thin-bedded, well-jointed, cherty limestone is exposed. The Liston Creek crops out at four places along Big Pipe Creek: NW¼NE¼SE¼ and SW¼SE¼NE¼ sec. 24, T. 26 N., R. 3 E. Pieces of Liston Creek are found as dredgings in the

NW¼SE¼ sec. 30, T. 26 N., R. 4 E., and, as previously stated, it underlies the Devonian limestone in the NE¼ sec. 30, T. 26 N., R. 4 E. The Liston Creek also is found along the bluffs on the south side of the Wabash Valley near the east edge of the county. Normal Liston Creek limestone can be seen in the NW¼NE¼ sec. 33, T. 27 N., R. 5 E., and two exposures of Liston Creek can be found near the west line of sec. 33, T. 27 N., R. 5 E. In the southern part of the F. Godfroy Reserve No. 9, 28 feet of thin-bedded and extremely cherty limestone were measured. Two small exposures of Liston Creek can be seen in the SE¼SW¼ sec. 13, T. 27 N., R. 4 E., just east of the road which leads to the Mississinewa Country Club. The thickness there does not exceed 3 feet, and the limestone is thin-bedded, dolomitic, and somewhat shaly in th upper 1 foot. At Wallick's Mill, in the NW¼NE¼ sec. 5, T. 26 N., R. 4 E., normal Liston Creek limestone on the flank of a bioherm dips to the south at an angle of about 30 degrees. Several good exposures of Liston Creek appear along the Mississinewa River at the east edge of the county.

NIAGARAN BIOHERMS

The small dome-like structures that are found in the Silurian rocks of northern Indiana are called bioherms (organic mounds) or, less accurately, reefs. They are of Niagaran age and are associated intimately with the Mississinewa and the Liston Creek formations. The reefs are, in general, dome-shaped masses of dolomitic material which have massive, unstratified cores composed in part of the remains of stromatoporoids, corals, bryozoa, and algae. Because corals constitute only a small part of the total mass, the name coral reef, which so often is applied to them, is not especially appropriate (Cumings and Shrock, 1928b, p. 599).

The rock which composes the reef core is hard, gray to pink, ragged, porous dolomite that contains many pockets of calcite. Fossils that are found within the core are poorly preserved. The reef core is characterized by slickensides, many of which are inclined at angles of 45 to 65 degrees. Stylolites are developed along the slickensided surfaces and bedding planes and are the result of intraformational solution under the static pressure of the overlying rock after the solidification of the rock (Cumings and Shrock, 1927, p. 78). The visible parts of most of the reef cores do not exceed 75 feet in height and 300 feet in diameter. The core rock commonly is more resistant to erosion than is the surrounding rock.

The inclined beds which enclose the reef core constitute the fore-reef and often are referred to as the flank rock. The flank rock is typically yellowish-gray to pinkish limestone or dolomite. The dips in the fore-reef may be as much as 65 degrees at or near the reef core and decrease to 3 or 4 degrees or less on the periphery of the bioherm. Faults and slickensides are abundant in the beds of the fore-reef. Within a few hundred feet of the core, the beds of the fore-reef interfinger with normal Mississinewa shale or Liston Creek limestone (Cumings and Shrock, 1928a, p. 142-144).

Fourteen bioherms are exposed in Miami County (pl. 1). One in the "Prairie" about 1 mile northwest of Peru is flanked on the east by Mississinewa shale and on the west by Kokomo limestone (pl. 4, B). The Wabash Railroad Hospital on the north edge of Peru is on a large bioherm. Several small exposures of reef rock lie near the Fairlea Farms, in the SE¼NE¼ sec. 29, T. 27 N., R. 4 E. At Wallick's Mill on Little Pipe Creek, in the NW¼NE¼ sec. 29, T. 26 N., R. 4 E., a reef which is several hundred yards in diameter is flanked by Liston Creek limestone. Other bioherms are exposed at the following localities: NE¼ sec. 33 and NW¼ sec. 34, T. 27 N., R. 5 E.; NW¼NE¼ sec. 33, T. 27 N., R. 5 E.; NE¼NW¼ sec. 32, T. 27 N., R. 5 E., surrounded by Liston Creek limestone; NW¼SW¼ sec. 25, T. 27 N., R. 4 E., at the bridge over the Mississinewa River; NE¼SE¼ sec. 26, T. 27 N., R. 4 E., on the Ballard farm; SE¼ sec. 34, T. 27 N., R. 4 E., in a stream cut in the Peru city park; SW¼SW¼ sec. 33, T. 27 N., R. 4 E., in two abandoned quarries; on the north side of Mississinewa River in the north-central part of O-Sawdiah Reserve No. 10; on the south edge of the village of Peoria; and in the SE¼ sec. 34, T. 27 N., R. 5 E.

KOKOMO LIMESTONE

The Kokomo limestone was named by Foerste (1904, p. 33) from the city of Kokomo in Howard County. He recognized an eurypteroid zone in its lower part and a brachiopod zone in its upper part. Cumings and Shrock (1927, p. 76-77), however, restricted the name Kokomo to the eurypteroid zone and gave the name Kenneth limestone to the brachiopod zone. They considered the Kokomo formation as belonging to the Cayugan series of the Silurian system. Patton (1949, p. 13) described the Kokomo formation as gray to brown, banded dolomitic limestone, much of which is finely laminated. He observed that near Peru the upper beds are brecciated, crumpled, contorted, faulted, and recemented. The Kokomo limestone ranges from a few feet to as much as 60 feet in thickness. The maximum exposed thickness of the Kokomo in Miami County is 4½ feet.

The Kokomo limestone is exposed at eight places in Miami County (pl. 1). It is found in the excavations along Big Pipe Creek, in the SW¼NW¼SE¼ sec. 29, T. 26 N., R. 4 E., where it is covered by Devonian limestone of Hamilton age. A good exposure of 4 feet of gray, finely crystalline, thinly laminated limestone can be seen near the mouth of Little Pipe Creek, in the NE¼SW¼ sec. 32, T. 27 N., R. 4 E. (pl. 3, B). The Kokomo is exposed in two places along the banks of the Wabash River, in the SW¼SE¼ sec. 32, T. 27 N., R. 4 E., and in the NW¼NE¼ sec. 36, T. 27 N., R. 3 E. Normal Kokomo limestone was seen in the excavations from Prairie Ditch, in the NW¼SW¼ sec. 20, T. 27 N., R. 4 E.

The best exposures of the Kokomo are along the bluffs which form the south side of the Wabash Valley. In the NW¼NW¼SW¼ sec. 36, T. 27 N., R. 3 E., in a northward-flowing tributary of the Wabash, 3.2 feet of normal Kokomo limestone is exposed. In the SW¼SW¼NW¼ sec. 35, T. 27 N., R. 3 E., along a stream cut, 2½ feet of Kokomo is exposed. In a stream cut in the NW¼NW¼ SW¼ sec. 35, T. 27 N., R. 3 E., gray, finely crystalline, thinly laminated limestone 4½ feet thick crops out. The limestone continues upstream for about 1,100 feet. At some places the lower 2 feet are blue, finely crystalline, finely to nonlaminated limestone. About 800 feet upstream from the last-mentioned exposure, dips as steep as 90 degrees were observed. There the Kokomo consists of gray, thinly laminated, very dolomitic limestone. The limestone seems to have been derived from Silurian reef rock which was exposed at the time of deposition of the Kokomo. The thin laminations which are characteristic of the Kokomo persist even in this "reworked reef rock."

DEVONIAN SYSTEM

The Devonian rocks in Miami County are limestones of Hamilton age. Outcrops are confined to the western part of the county along the Wabash River and along Little and Big Pipe Creeks.

The Indiana Geological Survey has not adopted any official formation name for the Hamilton limestones of north-central Indiana. Kindle (1899, p. 136 and 148) introduced the name "Sellersburg beds," named for a village in Clark County, for the Hamilton limestones of southern Indiana but later (Kindle, 1901, p. 568) correlated Devonian limestone exposures along Big Pipe Creek, near Bunker Hill, with the Jeffersonville limestone (Ulsterian, Onondaga group) of southern Indiana. Cooper and Warthin (1941, p. 259) placed the beds in the Hamilton group, proposed the name "Logansport limestone" for them, and said that their closest faunal affinities are with the Four Mile Dam limestone of the Traverse group of Michigan. Campbell (1942, p. 1067-68) correlated the Devonian rocks of Miami County with the Beechwood member of the Sellersburg limestone. The subsurface lithology of the Devonian beds of the Miami County area bears closer resemblance to Traverse lithology than to southern Indiana and Illinois Basin Hamilton lithology (T. A. Dawson, personal communication, 1954).

In Miami County these beds consist of white to gray, coarsely crystalline, thin-bedded to massive limestone. Their maximum exposed thickness in the county is 6½ feet. The limestone is exposed at four places along Big Pipe Creek near the town of Bunker Hill (pl. 1). The following section was measured on the west bank of Big Pipe Creek, a quarter of a mile west of U. S. Highway 31, in the NW¼SE¼SE¼ sec. 24, T. 26 N., R. 3 E. (pl. 3, A).

	Feet
Devonian	
Hamilton group	
3. Limestone: Gray, coarsely crystalline, massive; contains many corals	2.5
2. Limestone: White, coarsely crystalline, very thin-bedded	4.0
Total exposed thickness of Hamilton group	6.5
Silurian	
Liston Creek	
1. Limestone: Brown, densely crystalline, massive, dolomitic (bioherm)	7.7
Total thickness of measured section	14.2

Approximately 500 feet downstream from the above section the Hamilton limestone is found again, but the lower thin-bedded limestone (unit 2) is lacking. Both units of the limestone are found in the excavations along Big Pipe Creek, in the SW¼NW¼SE¼ sec. 29, T. 26 N., R. 4 E.

The following section was measured just west of the bridge on U. S. Highway 31 over Big Pipe Creek, in the NE¼ sec. 30, T. 26 N., R. 4 E. This section was mentioned by Cumings and Shrock (1928a, p. 66).

Devonian	*Feet*
Hamilton group	
3. Limestone: Gray, coarsely crystalline, massive; contains many corals	3.0
2. Limestone: White, coarsely crystalline, very thin-bedded	3.0
Total exposed thickness of Hamilton group	6.0
Silurian	
Liston Creek limestone	
1. Limestone: Gray, moderately crystalline, thin-bedded, very cherty..	4.5
Total thickness of measured section	10.5

PLEISTOCENE STRATIGRAPHY

The classification of the Pleistocene of North America which is most generally accepted at present is as follows:

<table>
<tr><th>Period
(System)</th><th>Epoch
(Series)</th><th>Age
(Stage)</th><th>Subage
(Substage)</th></tr>
<tr><td rowspan="13">Quaternary</td><td colspan="3">Recent (postglacial)</td></tr>
<tr><td rowspan="12">Pleistocene</td><td rowspan="6">Wisconsin</td><td>Mankato</td></tr>
<tr><td>Two Creeks Interval</td></tr>
<tr><td>Cary</td></tr>
<tr><td>Brady Interval</td></tr>
<tr><td>Tazewell</td></tr>
<tr><td>Iowan</td></tr>
<tr><td>Sangamon interglacial</td><td rowspan="7"></td></tr>
<tr><td>Illinoian glacial</td></tr>
<tr><td>Yarmouth interglacial</td></tr>
<tr><td>Kansan glacial</td></tr>
<tr><td>Aftonian interglacial</td></tr>
<tr><td>Nebraskan glacial</td></tr>
<tr><td>Tertiary</td><td>Pliocene</td><td></td></tr>
</table>

PRE-WISCONSIN GLACIATION

In Miami County thick Wisconsin drift has buried glacial deposits of any older stages which may be present. Nowhere in the county has drift older than Wisconsin been identified positively.

Evidence suggests, however, that drift of all four glacial stages likely is present in northern Indiana. As mentioned below (see p. 33), Leverett considered scattered erratics in Kentucky as pre-Illinoian in age, and Thwaites (1946, pl. 3) later interpreted them as of Nebraskan age. Thwaites indicated that one lobe of Nebraskan ice may have extended to the Mississippi River southeast of St. Louis and another lobe across the Ohio River into northeastern Kentucky. If these interpretations are correct, northern Indiana was covered by the Nebraskan ice sheet.

Outcrops of Kansan glacial deposits were recognized by Bell and Leighton (1929, p. 485-486) in Illinois as far south as Winchester. Moreover, Horberg (1945, p. 353) recognized Kansan drift in Illinois from well cuttings; and according to MacClintock (1933, fig. 2), a lobe of the Kansan ice sheet extended into Illinois south of the latitude of Terre Haute, Ind. Several exposures of Kansan till have been discovered in southwestern Indiana recently (Wayne, 1954, p. 1320). It thus seems likely that Kansan ice covered Miami County.

Indiana was most extensively glaciated during the Illinoian glacial stage when the ice sheet reached the Ohio River. Because of the thickness of Wisconsin drift, however, no Illinoian deposits have been recognized positively in Miami County. Water well drillers occasionally report a brown till that lies directly above the bedrock which may be either Illinoian or earlier in age (Wayne and Thornbury, 1951, p. 24).

A till which may be older than Tazewell is evident at three places in Miami County. The following section was measured in a stream bluff along the Chesapeake and Ohio Railroad in the northwestern part of Richardville Reserve No. 6.

		Feet
Tazewell substage		
10.	Clay till: Reddish brown, leached	3.5
9.	Clay till: Reddish brown, calcareous, oxidized, compact	6.5
8.	Clay till: Gray, unweathered, very compact, somewhat less pebbly than lower till	6.4
7.	Sand and gravel: Gray, calcareous, poorly sorted, coarse	6.7
6.	Clay till: Reddish brown, calcareous, oxidized, very compact, pebbly	0.2
5.	Clay till: Gray, calcareous, very compact, pebbly	7.5
4.	Clay till: Dark gray to black, weathered, pebbly; contains fragments of wood	1.5
Sangamon (?)		
3.	Soil: Black, mucky	0.5
Illinoian stage (?)		
2.	Clay till: Greenish gray, oxidized and leached, compact	2.7
1.	Clay till: Gray, calcareous, very compact, pebbly	0.5
	Total thickness of measured section	36.0

The black soil at unit 3 is presumably a Sangamon soil, and the overlying clay till is interpreted as Wisconsin (Tazewell) till. The 32 inches of leached till could be either undisturbed Illinoian till or a mass of weathered Illinoian till which is incorporated in the Wisconsin till. The latter seems more likely because the leached till is underlain by unweathered till rather than the oxidized till which would be expected if the till were undisturbed. The lack of oxidized till beneath the leached might be explained as the result of a water table very near the surface. A greenish-blue till, similar to bed 2 above, crops out 500 feet north of the described exposure. A few twigs of wood were found above this till. The third possible outcrop of pre-Wisconsin till is that below the buried lacustrine deposit which is in the SW¼SW¼ sec. 15, T. 27 N., R. 4 E., and which is described in the section on page 28.

WISCONSIN GLACIAL DEPOSITS

Deposits of both the Tazewell and Cary substages have been recognized in Indiana. The surficial glacial materials in Miami County belong to these two substages of the Wisconsin. The Mississinewa moraine, which probably marks the maximum advance of the Erie lobe in northeastern Indiana during Cary time (Wayne and Thornbury, 1951, p. 18), does not extend into Miami County. Some question exists as to the age of the Packerton moraine. It has generally been considered to be Tazewell in age and it has been so mapped on plate 1. It is recognized, however, that the topography of the Packerton moraine has a freshness which certainly suggests an age younger than Tazewell. It will not be at all surprising if the Packerton moraine, like the Mississinewa moraine, proves to be Cary in age.[1] Outwash and wind-blown sands of Cary age are definitely present in the county.

TAZEWELL SUBSTAGE

The glacial drift in Miami County consists of till, outwash, lake silts and clays, and undifferentiated sands. The till plain, Packerton and Union City moraines, and most of the surficial and buried outwash are believed to be Tazewell in age. The average thickness of the drift in Miami County is about 125 feet. Probably the greater part of this drift is of Tazewell age.

Till.—Except in the area of the Packerton moraine, unweathered Tazewell till is pale gray, calcareous, pebbly and bouldery, and clayey, and it contains varying amounts of sand and gravel. Approximately 30 soil auger borings were made in the area of the Packerton moraine to determine the nature of the till. The till was found to be pebbly and extremely sandy in the upper part and to grade into a more clayey till in the lower part. Many small areas of well-sorted sand are associated with this till.

Along the Mississinewa River is a fairly compact, pebbly clay till which contain lenses of sand and silt in the upper 20 to 25 feet. The lower part has many joints, is more compact, and contains less water-deposited material than that above. The difference in the structure of these two layers of till suggests that the upper layer probably was superglacial and englacial material which was dropped as the ice melted, whereas the lower, compact part was plastered down at the base of the glacier as the sheet moved over the area (Wayne and Thornbury, 1951, p. 12 and 14). The following section was measured along the west side of the Mississinewa River near the center of the south line of sec. 5, T. 26 N., R. 5 E.

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[1] While this bulletin was in preparation for publication radiocarbon dating of some gytta from beneath 12 to 13 feet of marl in a pit at the southeast edge of the Packerton moraine near the village of Laketon in Wabash County gave an age for the gytta of 13,140 $\pm$ 400 years. This indicates a probable late Cary age for the material and further suggests that the Packerton moraine is Cary in age.

Tazewell substage	Feet
7. Clay till: Reddish brown, oxidized and leached, compact	5.0
6. Clay till: Reddish brown, oxidized but unleached, compact, pebbly. Shows banding which suggests that it may have been deposited in water	11.0
5. Silt: Light brown; contains lime concretions; stratified	0.5
4. Clay till: Reddish brown, oxidized but unleached, compact, pebbly	2.0
3. Clay till: Gray, calcareous, unweathered, compact, pebbly	7.5
2. Sand: Brownish, calcareous, medium-grained, well sorted	1.5
1. Clay till: Gray, calcareous, unweathered, very compact, pebbly	96.5
Total thickness of measured section	124.0

Outwash.—Outwash in Miami County consists of mixed sand and gravel. A gravel pit owned by the J. C. O'Connor Company, just west of Peru, exposes more than 21 feet of well-sorted, cross-bedded sand and gravel which contains many large boulders, both igneous and metamorphic. The following section was measured in an abandoned gravel pit on the east side of the Mississinewa River, in the SE¼NW¼NW¼ sec. 10, T. 26 N., R. 4 E.

Tazewell substage	Feet
5. Sand: Brownish, leached, medium-grained, well sorted	3.2
4. Sand and gravel: Reddish brown, weathered, well sorted	2.7
3. Sand: Brownish, weathered, medium-grained, well sorted	0.8
2. Sand: Tan, weathered, very fine-grained, well sorted	1.1
1. Sand and gravel: Gray, unweathered, well sorted	15.5
Total thickness of measured section	23.3

Outwash along Mill, Big Pipe, Little Pipe, Deer Creeks, an eastward-flowing tributary of Squirrel Creek, and the southward-flowing tributaries of Eel River has been interpreted as being entirely of Tazewell age. The composition of the outwash is shown in the following section which was measured in an abandoned gravel pit along Big Pipe Creek, in the NE¼SE¼NW¼ sec. 24, T. 26 N., R. 3 E.

Tazewell substage	Feet
2. Sand and gravel: Reddish brown, weathered, poorly sorted	4.0
1. Sand and gravel: Gray, unweathered, coarse, poorly sorted in the upper part	14.5
Total thickness of measured section	18.5

Except along the valley trains, Tazewell till overlies much of the outwash that has been interpreted as Tazewell in age. Intertill gravels, which crop out along the bluffs of the Wabash and Mississinewa Rivers and Little Pipe, Big Pipe, and Deer Creeks, provide excellent evidence of the extensive burial of outwash gravel beneath till. In the SE¼SE¼ sec 10, T. 26 N., R. 5 E., along the south bank of the Mississinewa River, 27 feet of coarse, moderately well-sorted sand and gravel are overlain by 9½ feet of till. A gravel pit just west of Little Pipe Creek, in the SE¼SE¼ sec. 5, T. 26 N., R. 4 E., exposes 31 feet of coarse, poorly sorted sand and gravel which are overlain by 4 to 8 feet of not very compact, pebbly, reddish-brown clay till of Tazewell age. This clay till is oxidized but unleached in its lower part. An exposure of 16 feet of sand and gravel overlain by 5 feet of Tazewell till may be seen in a gravel pit in the NE¼NE¼NE¼ sec. 23, T. 27 N., R. 4 E. (pl. 2, A). The following sections show the lithology of the intertill sand and gravel in detail.

The first section was measured in a ravine in the southeast corner of the F. Godfroy Reserve No. 8.

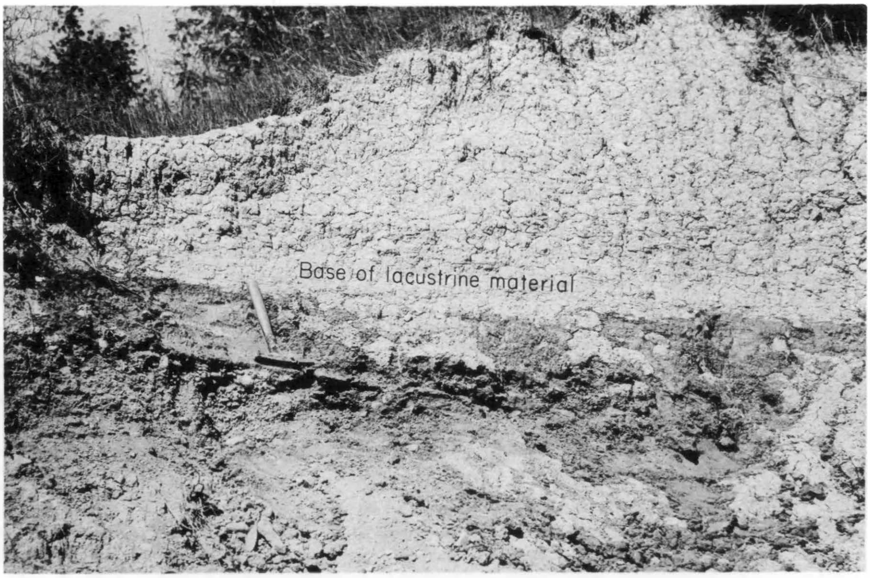
Tazewell substage	*Feet*
4. Clay till: Brown, calcareous, oxidized, weathered	3.5
3. Sand: Brown, calcareous, medium-grained, well sorted	4.0
2. Sand and gravel: Gray, unweathered, well sorted	13.5
1. Clay till: Gray; upper 3 to 4 inches oxidized but unleached; pebbly	15.0
Total thickness of measured section	36.0

The following section was measured in an abandoned gravel pit along a tributary of Deer Creek, in the NE¼SW¼ sec. 36, T. 25 N., R. 3 E.

Tazewell substage	*Feet*
4. Clay till: Reddish brown, leached, not very compact	5.7
3. Sand: Brownish, calcareous, medium-grained, poorly sorted	11.7
2. Clay till: Reddish brown, oxidized but unleached, not very compact	6.5
1. Sand and gravel: Brownish, oxidized, poorly sorted	4.7
Total thickness of measured section	28.6

The following section was measured in an active gravel pit on the south side of the Wabash River, in the NW¼NW¼SW¼ sec. 31, T. 27 N., R. 4 E.

A. INTERTILL GRAVEL ALONG THE NORTH SIDE OF THE WABASH RIVER, IN THE NE¼NE¼NE¼ SEC. 23, T. 27 N., R. 4 E.



B. INTERTILL LACUSTRINE DEPOSIT, JUST EAST OF U.S. HIGHWAY 31, IN THE SW¼NE¼ SEC. 21, T. 27 N., R. 4 E.

DEPOSITS OF TAZEWELL SUBSTAGE.

A. DEVONIAN LIMESTONE-LISTON CREEK REEF ROCK CONTACT ALONG BIG PIPE CREEK, A QUARTER OF A MILE WEST OF U.S. HIGHWAY 31, IN THE NW¼SE¼SE¼ SEC. 24, T. 26 N., R. 3 E.

B. KOKOMO LIMESTONE OVERLAIN BY TILL AND STRATIFIED SAND AND GRAVEL NEAR THE MOUTH OF LITTLE PIPE CREEK, 1 MILE WEST OF PERU, IN THE NE¼SW¼ SEC. 32, T. 27 N., R. 4 E.

DEVONIAN AND KOKOMO LIMESTONES.

Tazewell substage	Feet
9. Clay till: Brown, leached	4.5
8. Clay till: Oxidized, calcareous, heavy, blocky, pebbly	7.5
7. Sand: Brown, oxidized, calcareous, fine-grained	0.2
6. Sand and gravel: Gray, calcareous, well sorted, stratified	4.5
5. Sand: Gray, calcareous, medium-grained	0.5
4. Silt and clay: Red, oxidized, calcareous	0.3
3. Sand and gravel: Gray, calcareous, well sorted	1.5
2. Sand: Gray, calcareous, medium-grained	1.5
1. Sand and gravel: Gray, calcareous, well sorted, stratified	12.1
Total thickness of measured section	32.6

That these intertill gravels have a large areal extent is shown by their exposure beneath till at the following localities: NW¼NW¼NW¼ sec. 14, T. 26 N., R. 3 E.; NE¼NE¼ sec. 3, T. 27 N., R. 3 E.; SW¼SW¼ sec. 24, T. 27 N., R. 3 E.; SE¼NE¼NW¼ sec. 25, T. 27 N., R. 3 E.; SW¼SE¼NE¼ sec. 36, T. 27 N., R. 3 E.; NW¼NE¼ sec. 23, T. 27 N., R. 4 E.; SW¼NW¼SW¼ sec. 31, T. 27 N., R. 4 E.; SE¼NW¼SE¼ sec. 31, T. 27 N., R. 4 E.; NE¼SE¼SE¼ sec. 31, T. 27 N., R. 4 E.; NW¼SE¼ sec. 21, T. 27 N., R. 5 E.; SE¼NW¼ sec. 21, T. 27 N., R. 5 E.; NE¼NE¼ sec. 22, T. 27 N., R. 5 E.; NE¼SW¼NE¼ sec. 34, T. 27 N., R. 5 E.; SE¼NW¼ sec 35, T. 27 N., R. 5 E.; NE¼SW¼NE¼ sec 35, T. 27 N., R. 5 E.; SW part of the F. Godfroy Reserve No. 8; west line of the F. Godfroy Reserve No. 8; NW corner of Richardville Reserve No. 6; NW part of Richardville Reserve No. 13; and NE¼SE¼NW¼ sec. 20, T. 28 N., R. 4 E.

In the area of the Packerton moraine, 13 complex kames and eskers were found. The outwash contained therein was poorly sorted sand and gravel with lenses of clay.

Lake silts and clays.—Lacustrine deposits of Tazewell age in Miami County are exposed at several places along the till bluffs which form the north wall of the Wabash Valley just north of Peru. In the SE¼SW¼ sec. 14, T. 27 N., R. 4 E., is an outcrop of 9 feet of heavy, blocky clay which has many lime concretions in it. Beneath the concretionary clay is an undetermined thickness of sand and gravel and overlying it are 14 feet of sand and gravel. In the SW¼NE¼ sec. 21, T. 27 N., R. 4 E., in a road cut on U. S. Highway 31, 12 to 14 feet of heavy, blocky clay which has abundant calcareous concretions is exposed (pl. 2, B). The lake silts and clays are underlain by 9 to 10 feet of sand and gravel which in turn overlie 16 feet of till. Above the lacustrine clays are 4 feet of Tazewell till.

The following section was measured along a Nickel Plate Railroad cut in the SW¼SW¼ sec. 15, T. 27 N., R. 4 E.

Tazewell substage	*Feet*
5. Clay till: Brown, weathered, upper half leached, pebbly	10.0
4. Clay: Brown to buff, oxidized but unleached in the lower part, heavy, blocky; has scattered lime concretions	13.5
3. Clay: Blue gray, unweathered, heavy, blocky; has scattered lime concretions	2.5
2. Silty till: Yellowish brown, oxidized, loose, pebbly	4.5
1. Clay till: Yellowish brown, oxidized, heavy; may be much older than overlying till	3.0
Total thickness of measured section	33.5

The altitude of the base of the section is 704 feet.

The lake silts and clays were deposited in a lake which was formed after a temporary withdrawal of the ice sheet. Till afterwards was laid down over the lacustrine deposits during a readvance of the ice.

Undifferentiated sands.—The till in the area of the Packerton moraine is much more sandy than that in the area south of it. Associated with the sandy till are many areas of well-sorted sand. The sand, which ranges from 1 foot to 20 feet in thickness, is yellowish brown, unstratified, round to subround, fine- to medium-grained, well sorted, and, in many places, contains a few pebbles.

The origin of these sand deposits is debatable. Some of the deposits appear to have been reworked and deposited by wind. On the whole, however, they do not have the topographic form of dunes. Clay and boulders are so scarce in the sand deposits that it seems unlikely that they could be described correctly as sandy till. Perhaps the most logical interpretation is that they represent sand dumps which were made by water in, beneath, or against the ice. Evidence of stratification, however, rarely can be found. Because of the uncertainty as to the exact origin of these sands, they have been shown on the areal map (pl. 1) as undifferentiated sands.

CARY SUBSTAGE

Outwash.—Outwash of Cary age consists of valley-train deposits laid down along the sluiceways which carried glacial melt waters when the ice stood at and back of the Mississinewa moraine. In Miami County Cary outwash has not been distinguished from outwash of the Tazewell substage. It seems likely, however, that the upper part of the outwash along the Wabash, Eel, and Mississinewa Valleys probably is Cary in age, since these valleys were melt-water sluiceways during Cary time. This outwash forms sand and gravel terraces along these valleys. The outwash gravels along the Eel valley train consist mainly of limestone and dolomite pebbles, but small amounts of shale and crystalline rocks also are present. The upper part of the valley trains along the Wabash and Mississinewa Rivers consists of well-sorted, cross-bedded calcareous gravel and many lenses of sand. At some places the gravel contains much chert which was derived from the Liston Creek limestone.

Wind-blown sands.—Sand dunes are abundant on the terraces along the Eel Valley and small areas of wind-blown sand are found along the Wabash Valley, chiefly near the east edge of the county. The dunes range from indistinct mounds a few feet high to conspicuous dunal mounds as much as 40 feet high. Their average height, however, is about 20 feet. The sand is mainly well-rounded quartz sand. Cross bedding, although not prominent, is evident in some exposures. The sands were derived from the outwash of the valley trains. As soon as Cary melt water began to diminish, the prevailing westerly and northwesterly winds gathered the dry, loose sand and began the construction of the dunes. Undoubtedly, dune growth continued until vegetation had become established on the surfaces of the valley trains.

RECENT DEPOSITS

The youngest deposits in Miami County are of Recent (postglacial) age. They consist of alluvium along the valleys and muck and peat in many depressions in the Packerton moraine and at other scattered localities. Recent time began as the glaciers withdrew from the region. As soon as the ice sheet had with drawn beyond the head of a valley, glacial outwash ceased to be deposited in it and Recent alluvium began to accumulate. Large valleys, such as the Eel and Wabash, continued, however, to receive glacial outwash for a time after the lesser valleys had lost their connection with the ice front.

ALLUVIUM

Alluvium is present along all major streams and most of their tributaries. Except in steep-walled valleys, the exact contact between alluvium and the surrounding material, which in most places is till, is difficult to delimit exactly, because a strip of colluvium along the valley sides masks the contact between the alluvium and the material of the valley sides. The alluvium consists of flood-plain deposits of sand, silt, and clay; and it forms a thin veneer over the outwash, till, or bedrock which underlies the valley floors.

MUCK AND PEAT

Muck and peat deposits mark either the sites of former small lakes that existed in depressions on end or ground moraine or the sites of swampy areas along stream courses. The largest single area of muck and peat is just north of Peru in the part of the Wabash Valley known as the "Prairie." The major amount of muck and peat, however, is found in the many depressions on the Packerton moraine. In all but a few places, muck covers the small amounts of peat found.

GEOLOGIC HISTORY

The decipherable geologic history of Miami County begins with the deposition of sediments during the Paleozoic era. After the end of Paleozoic deposition, the area was subjected to the processes of mass wasting, weathering, and erosion until the beginning of the glacial epoch. Since the end of glacial times, sediments of Recent (postglacial) age have been deposited.

PALEOZOIC EVENTS

Miami County lies northwest of the Cincinnati Arch. It is situated in the Logansport structural sag, which probably connected the Michigan Basin and the Eastern Interior Basin during much of the Paleozoic. The oldest rocks that have been reached in drilling in Miami County are the limestones of the Trenton group (Middle Ordovician). Overlying the Trenton limestones are the rocks of the Cincinnatian series (Upper Ordovician). The Cincinnati Arch first appeared at the end of the Ordovician. In late Brassfield (Lower Silurian) time, the Cincinnati Arch was again covered by the sea.

No barrier existed between northern and southern Indiana during Silurian time (Esarey and Bieberman, 1948, p. 37). Evidence for this assertion is the fact that a thick sequence of unnamed limestones that are equivalent in age to the Osgood-Laurel group (early Rochester age) of southern Indiana underlies the Mississinewa shale in Miami County. The Cincinnati Arch was warped upward after deposition of the Laurel formation, and the Mississinewa shale, which is the equivalent of the Waldron of southern Indiana, was deposited upon the underlying limestone. According to Esarey and Bieberman (1948, fig. 4), the Mississinewa formation is late Rochester in age. As the sea deepened and the Cincinnati Arch again was submerged, the Liston Creek limestone, which overlies the Mississinewa conformably wherever it is present, was deposited.

During Niagaran time bioherms were built in the shallower parts of the sea by lime-secreting organisms. Reefs grew in southern, central, and northern Indiana. They began at any time or place that favorable conditions prevailed and continued to grow until the reef-building organisms were destroyed by environmental changes (Esarey and Bieberman, 1948, p. 36). The reefs were built up into more or less cylindrical masses which had many cavities. Cumings and Shrock (1928a, p. 143) stated that "if such a growing mass comes within the reach of waves of sufficient strength the coral sand and broken masses of various sizes will fall back around it in a steeply inclined talus, upon which corals and other organisms will gain a foothold and which, owing to the very rapid cementation of the material and the enmeshing growth of organism upon it, may assume angles far beyond the angle of repose of loose materials." The end result was a reef that had a core composed of porous dolomite surrounded by masses of steeply dipping limestones and dolomites which interfinger with normal Mississinewa and Liston Creek sediments.

At the end of Liston Creek time, the seas withdrew. The Kokomo and Devonian limestones unconformably overlie Niagaran sediments. Many Niagaran bioherms, however, persisted as topographic features in the seas upon which these formations were deposited. This fact is indicated by exposures at the places where Devonian and Kokomo limestones overlap the reefs.

The Devonian limestone is the youngest outcropping Paleozoic rock in Miami County. Evidence from seismic information, however, suggests that shale (probably New Albany) constitutes the bedrock directly beneath glacial drift in the northern one-third of the county. Mississippian and Pennsylvanian rocks may have been deposited in Miami County, but evidence of them is no longer present.

POST-PALEOZOIC EROSION

Little is known of the geologic history of Indiana during the Mesozoic era except that the region stood above sea level and was subject to erosion. Tertiary erosion presumably erased all evidence of any erosional surfaces that were formed during the Mesozoic.

During the Tertiary period, old-age surfaces that are similar to those visible in southern Indiana probably developed in northern Indiana. Accordant ridge sumits in southern Indiana that have altitudes between 900 and 1,000 feet were correlated by Malott (1922, p. 130) with the Lexington peneplain of Kentucky, which is believed to be of middle or late Tertiary age. In Miami County south of the Wabash River are extensive tracts of a buried upland that have altitudes close to 750 feet. This is an extension of a buried upland surface which was recognized by Wayne and Thornbury (1951, p. 25) in southern Wabash County and which was correlated with the Lexington peneplain. North of the Wabash River, the altitude of the buried bedrock surface is 660 to 680 feet. The lower altitude of the erosional surface here may be attributed to its development on shales.

Horberg (1946, p. 189-190) considered a buried peneplain at an altitude of 700 to 750 feet in western Illinois the equivalent of the Lancaster peneplain of Wisconsin, which commonly is considered to be of the same age as the Highland Rim or Lexington peneplain of Kentucky (Fenneman, 1938, p. 504). The altitude of this peneplain in Illinois indicates that it probably is the western continuation of the peneplain surface recognized in Miami County and adjacent Wabash County.

A partial cycle following that which produced the Lexington peneplain is indicated by an erosional surface along many valleys in Indiana. Malott (1922, p. 131-132) referred to this surface in southern Indiana as a "late Tertiary peneplain." It probably is better described, however, as a strath rather than as a peneplain. In the Appalachian Plateaus, a similar surface, which is either extremely late Tertiary or early Pleistocene in age, has been called the Parker strath (Fenneman, 1938, p. 301). Fenneman (1938, p. 443) placed the end of the Parker cycle as at some time preceding Kansan glaciation. Thornbury (1948, p. 1359), on the other hand, considered it as pre-Nebraskan. The broad floors of the Teays and Metea Valleys in Miami County (pl. 6), which are about 400 feet in altitude, may well correlate with the Parker strath of the Appalachian Plateaus and the Havana strath which Horberg (1946, p. 190) has recognized in Illinois.

The major drainage line of north-central Indiana during the Tertiary was the Teays Valley. As a result of glaciation, its upper drainage was diverted to the Ohio, and the lower part of its course was buried beneath glacial deposits (Tight, 1903, p. 75-76). The time of diversion is controversial. It may have taken place, however, during the Nebraskan glaciation. Horberg (1950, p. 71) indicated that the buried valleys of Illinois were cut in pre-Aftonian and probably pre-Nebraskan time. He based his assertion upon the deposits which were found in them and which were interpreted as Aftonian and possibly Nebraskan in age. Leverett (1929, p. 33-47) believed that scattered erratics which had been found in Kentucky were of pre-Illinoian age. Largely on the basis of Leverett's interpretation of these scattered glacial boulders, Thwaites (1946, pl. 3) indicated that a lobe of Nebraskan ice had extended into Kentucky. According to this interpretation, it would seem likely that the upper drainage of the Teays was diverted to the Ohio by this Nebraskan ice lobe.

The Nebraskan age of this glaciation is as yet questionable. It could very well have been a lobe of Kansan age. Information on the southern limits of Kansan and Nebraskan glaciations in Indiana is extremely meager, but such information as exists suggests that the ice reached farther south during the Kansan glaciation. Horberg (1945, p. 354) stated that the Mahomet (Teays) Valley in Illinois was an insignificant drainage line after the Kansan glacial stage. At least a part of the Teays must have continued as a drainage line for glacial melt waters until late Tazewell time, however, because an abundance of intertill sand and gravel exists along the Teays in Miami and Wabash Counties.

The "valley-in-valley" profile recognized in the Wabash and Ohio Valleys is not distinguishable in the part of the Teays which is found in Miami County. Wayne and Thornbury (1951, p. 28) thought that there was evidence of the "deep stage" within the Teays Valley in Wabash County. This conclusion, however, was based upon more meager well data than was available in Miami County. Later, Wayne (1952a, p. 580-582) stated that instead of there being a "deep stage" below a strath terrace along the Teays in western Ohio and in Wabash County, there may have been only one period of entrenchment. He thought that a stream which had been beheaded by glaciation likely would be incapable of further entrenching itself but more likely would aggrade its valley. The "deep stage" along the Ohio Valley seems to be post-Nebraskan and pre-Illinoian in age because Illinoian outwash is found in it (Leverett, 1902, p. 285-294). Much of the "deep stage" along the Wabash Valley may have been cut during Kansan and Yarmouth time as a result of an increase in the volume of the Wabash River through diversion of part of the Mahomet (Teays) drainage into it (Wayne, 1952a, p. 583).

OLD EROSIONAL SURFACES

A map of the buried bedrock surface in Miami County (pl. 6) shows topographic conditions generally similar to those found in the unglaciated part of Indiana. Three profiles (pl. 8) supplement the map showing the bedrock topography and give a more graphic picture of the buried topography.

Two major preglacial drainage lines cross the county and, with their tributaries, divide the county into four buried upland areas. The buried upland south of Big Pipe Creek has a general altitude of 760 feet and has a few hills that rise 30 feet above the surface. North of Big Pipe Creek and south of the Wabash River, the average altitude of the bedrock surface is about 700 feet. North of the Wabash River and south of Macy, the surface of the buried bedrock has a general altitude of 670 feet. North of Macy, the approximate altitude of the buried upland is 655 feet.

TEAYS VALLEY

The main preglacial drainage line in north-central Indiana was a river which probably headed in the Piedmont of North Carolina (Stout and Schaaf, 1931, p. 671) and flowed across West Virginia, Ohio, Indiana, and Illinois to join the preglacial Mississippi (Horberg, 1950, fig. 20). Tight (1903, p. 50-57) applied the name Teays Valley to the upper part of this preglacial river from the Teays Valley in West Virginia, an abandoned part of this former drainage system. Horberg (1945, p. 349) proposed the term "Mahomet" for a buried part of this preglacial valley in Illinois. Thornbury (1948, p. 1359) pointed out that the Teays Valley was essentially the preglacial Kanawha Valley. Because the name Teays has become associated intimately with this valley, it is used in this report.

The Teays Valley enters Indiana in southern Adams County and extends across northern Jay County into Blackford County, where it turns northwestward through Grant, Wabash, and Miami Counties. From Miami County, the course of the Teays roughly parallels that of the present Wabash River as far as Tippecanoe County. There it turns northwestward through northeastern Warren County and southern Benton County into Illinois (Horberg, 1945, fig. 4; McGrain, 1950).

The Teays Valley enters Miami County in the east-central part of secs. 22 and 27, T. 27 N., R. 5 E. The valley runs westward for about 9 miles, turns northwestward, and leaves the county in parts of secs. 2 and 11, T. 27 N., R. 3 E. (pl. 6). The major tributaries of the Teays in Miami County were the preglacial Mississinewa River and a stream whose position now is approximated by Little Pipe Creek.

The lowest bedrock altitude which the writers obtained along the Teays Valley in Miami County is 419 feet above sea level. This bedrock altitude was recorded in a well in the NW¼SE¼ sec. 19, T. 27 N., R. 4 E., about 2 miles west of Peru. Wayne and Thornbury (1951, p. 28) reported two wells which reached bedrock at altitudes of 410 feet in the vicinity of LaFontaine in Wabash County. Horberg (1945, p. 359) stated that the average gradient of the Mahomet (Teays) Valley between Chillicothe, Ohio, and Beardstown, Ill., is 7 inches per mile. If this gradient is assumed for the valley across Wabash County, the altitude of the floor of the Teays should be approximately 400 feet in Miami County.

The Teays Valley is deeply incised in the limestones, dolomites, and shales of Silurian and Devonian age (pl. 8, A and C). At some places the valley walls are steep, and relief as great as 250 feet exists (pl. 6). The valley in most places is broad enough to be considered mature.

Two isolated bedrock hills in the Teays Valley are shown on plate 6. They are in secs. 16, 21, and 22, T. 27 N., R. 4 E., and in secs. 21, 22, and 28, T. 27 N., R. 5 E. Cuttings from the Weisell J. Baber No. 1 well, which is in the NE¼SW¼ sec. 21, T. 27 N., R. 4 E., and which penetrated one of these hills, indicate that it consists of light-gray, dense, vuggy dolomite. A dark-gray, medium-crystalline dolomite was encountered in the Edwards No. 3 well, which is in the SE¼ sec. 21, T. 27 N., R. 4 E., and which is on the edge of the Teays Valley rather than on one of the hills in the valley.

The bedrock hills stand at altitudes of 420 to 480 feet and are 20 to 80 feet above the floor of the Teays Valley. They probably owe their existence to resistant Niagaran bioherms. Dredgings from Prairie Ditch, which is about 2 miles northwest of these bedrock hills, indicate the presence of Mississinewa shale at an altitude of 640 feet. These buried reefs, if they are such, are at least 160 to 220 feet below the top of the Mississinewa formation. Cumings and Shrock (1928a, p. 62) stated that the bioherms had their roots in the upper 100 feet of the Mississinewa formation. The above evidence, however, suggests that they may extend at least 200 feet below the top of the Mississinewa formation.

METEA VALLEY

The present Eel River roughly parallels the course of a preglacial tributary of the Teays. Wayne and Thornbury (1951, p. 30) recognized the existence of this buried valley and proposed the name preglacial Eel Valley for it, although scanty information necessitated a none too accurate interpretation of its location. Seismic-refraction data, however, have made possible more accurate location of this valley in Miami County. As these data show that the present Eel Valley does not follow the course of this preglacial tributary of the Teays, the designation preglacial Eel is inappropriate. It has thus been renamed the Metea Valley from the village of Metea in northern Cass County near which this valley joins the Teays (Wayne, 1952b, p. 44). According to Wayne (1952b, p. 44-45), Metea Valley heads in southern Noble County.

Metea Valley enters Miami County in sec. 10, T. 29 N., R. 5 E., and extends southwestward across the county. It leaves the county in secs. 23, 26, and 35, T. 29 N., R. 3 E. The average gradient of this valley in Miami County is about 2 feet per mile. The valley is deeply incised below the surrounding uplands, and the altitude of the valley floor is about 400 feet above sea level (pl. 8, C). The valley is wide throughout and probably is cut in the New Albany shale. The divide between Teays and Metea Valleys is narrow and has a general altitude of 670 feet. The present Eel River flows about 6 miles south of Metea Valley.

BEDROCK MISSISSINEWA VALLEY

The third major buried valley in Miami County was named the Bedrock Mississinewa Valley because the present Mississinewa River follows it throughout most of its course. This valley heads in northern Grant County, extends northwestward across Wabash County, and enters Miami County in secs. 10 and 15, T. 26 N., R. 5 E., at an approximate altitude of 600 feet (pl. 6). It continues northwestward and joins the Teays in sec. 25, T. 27 N., R. 4 E., at an altitude of about 400 feet. Its gradient across Miami County is about 25 feet per mile. The valley is incised as much as 250 feet below the upland surface and is typically about half a mile wide. It probably is cut in Liston Creek limestone, Mississinewa shale, and the underlying Niagaran limestones and dolomites.

THICKNESS OF DRIFT

An isopachous map of the glacial drift of Miami County (pl. 7) shows that the variations in drift thickness are controlled mainly by the buried bedrock topography. The maximum known thickness of drift, as indicated by a seismic record, is 451 feet and is found in the NE¼NW¼ sec. 13, T. 29 N., R. 4 E., where the Packerton moraine crosses Metea Valley. Seismic records in the northern one-third of the county indicate that the thickness of drift exceeds 350 feet at many localities. At a few places along the Teays Valley, wells penetrated 320 feet or more of glacial drift before they reached bedrock. The average thickness of drift along this preglacial stream and the present Wabash floodplain, however, is 240 feet.

Information obtained from 605 water well, oil well, and seismic records provided the data on thicknesses of drift in this report. In general, the drift thickness over buried upland areas increases from south to north. Over the upland tract south of Bip Pipe Creek, the drift averages 85 feet in thickness. The preglacial upland there is extremely flat and there is a suggestion of a few sinkholes in the underlying limestone. Between Big Pipe Creek and the Wabash Valley, the average drift thickness is 93 feet, whereas the cover of drift over the buried upland north of the Wabash River and south of the Eel River averages 126 feet. Tributaries of the Metea and Teays Rivers had dissected this upland tract into a maze of sharp ridges and deep valleys prior to its burial. North of Eel River, in the area of the Packerton moraine, drift averages 202 feet in thickness. The average drift thickness in Miami County, however, is about 125 feet.

PRE-WISCONSIN GLACIATIONS

As indicated on page 22, there is no question that Miami County was covered by the Illinoian ice sheet, and very probably it also was covered during Kansan glaciation. There is even the possibility that the Nebraskan ice sheet reached this part of Indiana. Glacial deposits that may be pre-Wisconsin in age were found, however, in only three places. Undoubtedly these earlier glaciations had important effects upon the drainage lines in northern Indiana, and it is likely that the Teays Valley ceased to function as a through drainage line after Kansan glaciation (Horberg, 1945, p. 354), although portions of the valley in Miami County seem to have been used as late as Tazewell time.

WISCONSIN GLACIATION

The surficial till of all or most of Miami County belongs to the Tazewell substage. As noted on page 24, there is a strong probability that the drift in the Packerton moraine is of Cary age. Two lobes of the Laurentide ice sheet reached Miami County. The easternmost was a part of what has been called the Erie lobe because the ice extended from the main sheet through the Erie Basin. The other lobe, the Saginaw, lay to the west of the Erie and extended through Saginaw Bay into north-central Indiana.

TAZEWELL SUBAGE

The ice of the Erie lobe covered most of the county during the Tazwell subage. Leverett and Taylor (1915, p. 30) thought that the Union City moraine marked the outermost advance of the Erie lobe during late Wisconsin time. They considered it a part of a system of moraines which includes the Mississinewa, Salamonie, Wabash, and Fort Wayne moraines. Because recent work (Wayne and Thornbury, 1951, p. 18) indicated that the Mississinewa moraine is the oldest of the Cary moraines in north-central Indiana, the Union City moraine (fig. 1) is interpreted as a recessional moraine of the Erie lobe during late Tazewell time.

A retreat of the ice that was followed by a readvance during late Tazewell time is indicated by many exposures of buried outwash deposits in bluffs of the Wabash, Mississinewa, Big Pipe, Little Pipe, and Deer Creek Valleys. The presence of these outwash deposits along the Wabash Valley suggests that the Teays Valley had topographic expression as late as the Tazewell substage. Many exposures of buried lacustrine materials (see p. 27) along the north wall of the Wabash Valley indicate that during this retreat a lake which was at least 6 miles wide and of unknown length existed just north of Peru. This may have been an ice marginal lake, but more likely it resulted from the damming of a tributary valley by deposition of outwash along the Teays. Readvance of the ice resulted in the burial of the lacustrine and outwash deposits beneath till. Moreover, this readvance brought about the obliteration of the Teays Valley in Miami County.

The Packerton moraine in north-central Indiana (fig. 1) has been considered by most persons who have studied it to be a large interlobate moraine. Dryer (1892, p. 168) indicated that it was interlobate between the Saginaw and the Erie lobes. Leverett and Taylor (1915, p. 158-159), however, thought that it was deposited largely by the Erie lobe. Malott (1922, p. 118) stated that it was formed at the south edge of the rapidly retreating Saginaw lobe and the north edge of the Erie lobe. Wayne and Thornbury (1951, p. 10) pointed out that the northeast-southwest direction of the eskers north of Disko, Wabash County, and the southeast-northwest trend south of there indicated that the part of the Packerton moraine south of Disko was built by the Erie lobe and the part north of Disko by the Saginaw lobe. Eskers which have been observed in Miami County substantiate this belief. Except in the western part of Miami County, eskers exhibit a southeast-northwest trend. One esker, in the NE¼NW¼ sec. 26, T. 29 N., R. 3 E., shows a northeast-southwest alignment. Thus most of the Packerton moraine in Miami County probably was built by the Erie lobe, but a small area in the northwestern part of the county probably was deposited by the Saginaw lobe.

Because of its interlobate position, the Packerton moraine is complex in composition. Thirteen kame and esker complexes, the largest in secs. 23 and 26, T. 29 N., R. 3 E., were mapped. Till is intimately mixed with sand and gravel. The till is much sandier, especially in the part deposited by the Saginaw lobe, than in the ground moraine south of the Packerton moraine. This indicates that the Saginaw lobe passed over some source of sand, possibly previously deposited outwash or dunes, whereas the Erie lobe did not. Water-laid or wind-blown sands are found throughout the Packerton moraine. As mentioned previously (see p. 28), these are shown as undifferentiated sands on plate 1 because it is not always possible to be certain of their origin. The bulk of the sand seems to have been water-deposited, but locally the sand appears to have been reworked by the wind. Few of the sand deposits exhibit dunal forms.

During the Tazewell subage, the Wabash, Eel, and Mississinewa Rivers and their major tributaries served as sluiceways for the Saginaw or Erie lobes. Outwash that was deposited along the major valleys has not been distinguished from that laid down later during the Cary substage. Tazewell outwash is exposed, however, along such minor sluiceways as Mill, Big and Little Pipe, and Deer Creeks and three southward-flowing tributaries of the Eel River, none of which served as sluiceways during the Cary substage.

BRADY (SUBAGE) INTERVAL

The interstadial that followed the melting of the Tazewell ice and preceded Cary glaciation has come to be called the Brady interval (Frye and Leonard, 1951, p. 301) from the soil which developed during this interval to which the name Brady was given (Schultz and Stout, 1948, p. 570). No evidence of this soil has been found in Miami County, but Wayne and Thornbury (1951, p. 16) described sections in Wabash and Huntington Counties in which Tazwell drift leached to a depth of 12 to 15 inches is immediately overlain by unweathered Cary till. If the drift of the Packerton moraine is Cary in age, one can expect that some time evidence of the Brady interval may be found in the northern part of the county.

CARY SUBAGE

Unless the Packerton moraine is Cary in age there is no Cary till in Miami County. However, the major Tazewell sluiceways, the Mississinewa, Eel, and Wabash Valleys, carried outwash of Cary age. Wayne and Thornbury (1951, p. 20) pointed out that in Wabash County the terrace that marked the sluiceway surface during Cary time is developed upon bedrock except near the west edge of the county, where it is on gravel. The upper surface of the terrace probably is both depositional and erosional in origin. Wayne and Thornbury (1951, p. 20) stated that "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." Along the Mississinewa Valley in Miami County, the Mississinewa terrace is preserved at five places at altitudes of 680 to 700 feet and stands 30 to 40 feet above the floodplain of the Mississinewa River. The terrace is developed mainly upon gravel, but at a few places along the east side of the river it is underlain by the Liston Creek limestone (pl. 1).

The Eel River sluiceway varies from three quarters of a mile to 2¼ miles in width. The Mississinewa terrace along that river has an altitude of 735 feet at the east edge of the county and 690 feet at the west edge. It stands about 20 feet above the floodplain of the Eel River and has an average gradient of 2½ feet per mile. The terrace is preserved extensively along the Eel Valley, and in that part of the Eel Valley in Miami County it is underlain by sand and gravel. The only important constriction of the Eel sluiceway is at Denver. Here the valley narrows to three quarters of a mile because it crosses a buried bedrock ridge (pls. 1 and 7). The wind-blown sands that are found on the Mississinewa terrace along the Eel River probably began to form as soon as Cary meltwater began to diminish.

In Miami County the width of the Wabash sluiceway ranges from 1¼ to 2½ miles. The Mississinewa terrace is preserved in three places (pl. 1) along the Wabash Valley at altitudes of 680 to 700 feet, which is 40 to 60 feet above the present floodplain, and has an average gradient of about 3 feet per mile. On Hospital Hill in the northern part of Peru, the terrace cuts across a bioherm over which is a thin veneer of gravel. Along the north edge of the Wabash Valley in the western part of the county, near the junction of the Wabash and Mississinewa Rivers, in the NE¼NW¼ sec. 19, T. 27 N., R. 5 E., and at the east edge of the county, the terrace is developed upon gravel.

As the ice of the Cary substage withdrew from the Fort Wayne moraine, melt waters were ponded to form Lake Maumee, of which present Lake Erie is a descendant. Clear water from the lake overflowed through a spillway southeast of Fort Wayne and flowed southwestward down the route of the present Little Wabash to the Wabash Valley at Huntington. Because the load of the overflow waters from Lake Maumee was much less than that of melt waters from the ice front which previously had built the valley train down the Wabash sluiceway, these waters began to excavate part of the unconsolidated valley fill. They cut a new valley flat some 20 to 25 feet below the surface of the valley fill which can be traced to the mouth of the Wabash. Remnants of this erosional surface have been called the Maumee terrace (Fidlar, 1936, p. 179). The Fort Wayne-Wabash River outlet of Lake Maumee was abandoned near the end of the Cary subage when the drainage of the lake had been established through the Grand River outlet across Michigan to Lake Chicago, the forerunner of Lake Michigan. Postglacial erosion by the Wabash River has developed a floodplain which is 20 to 40 feet below the surface that was eroded by the Lake Maumee waters and thus has left remnants of this surface as terraces along the valley.

As the Wabash River was the only stream to carry overflow waters from Lake Maumee, the Maumee level is confined to that sluiceway. In Miami County the Maumee terrace is preserved at altitudes of 660 to 680 feet, and its average gradient is 2 feet per mile. Except on Hospital Hill, the Maumee terrace is developed upon gravel. At seven places in the county (pl. 1) this terrace can be seen, but postglacial stream erosion has reduced the extent of these terrace tracts. An isolated remnant of the Maumee terrace can be found in secs. 30 and 31, T. 27 N., R. 5 E. (pl. 5, A).

Erosion has uncovered 14 Silurian bioherms in the Wabash sluiceway in Miami County. The name klint (pl., klintar) was applied to these exhumed bioherms by Shrock (1928, p. 133). Klintar are very resistant to erosion, and the one which forms Hospital Hill in Peru bulwarks an extensive terrace tract downstream from it. No klintar are found above the Mississinewa terrace; two are found above the Maumee terrace; and eight are exposed either on the floodplain of the Wabash River or along the bluffs of the Wabash Valley. A klint which projects above the floodplain of the Wabash River can be seen about 1 mile northwest of Peru (pl. 4, B).

RECENT EVENTS

As soon as the melt water ceased to flow down a valley, Recent alluvium began to accumulate. Muck and peat collected in the

A. LISTON CREEK LIMESTONE AT THE "SEVEN PILLARS OF THE MISSISSINEWA," ABOUT 6 MILES SOUTHEAST OF PERU.

B. KLINT ON THE FLOODPLAIN OF THE WABASH RIVER, ABOUT 1 MILE NORTHWEST OF PERU.

LISTON CREEK LIMESTONE, AND KLINT.

A. MAUMEE TERRACE REMNANT, JUST EAST OF THE MISSISSINEWA RIVER, IN SECS. 30 AND 31, T. 27 N., R. 5 E.

B. ACTIVE GRAVEL PIT IN THE MAUMEE TERRACE, ABOUT 1½ MILES WEST OF PERU, IN SECS. 20 AND 21, T. 27 N., R. 4 E

MAUMEE TERRACE, AND ACTIVE GRAVEL PIT.

closed basins in the Packerton moraine, on the floodplain of the Wabash River, and in depressions on the Mississinewa and Maumee terraces. Development of sand dunes continued into the Recent epoch in some areas.

ECONOMIC GEOLOGY

OIL AND GAS

Oil and gas have been produced from the rocks of Trenton age (Middle Ordovician) in Miami County since 1900. The early wells were abandoned, however, in the twenties and thirties. In 1947, two new pools, the Peru and Peru East, were discovered. Approximately 200 wells have been drilled in the county since that year. No production figures are available for the county except for 1951. During the first 11 months of 1951, about 60 wells produced 17,735 barrels of oil. The lowest monthly production, 1,320 barrels, was during February, and the highest production, 2,310 barrels, was in November.

LIMESTONE

No active limestone quarries exist in Miami County. However, at least four quarries, three in Niagaran bioherms and one in the Kokomo limestone, were active at one time. The quarry in the Kokomo is on the north bank of the Wabash River, opposite the mouth of Little Pipe Creek, in the SE¼NW¼ sec. 32, T. 27 N., R. 4 E. The stone from that quarry was burned for lime. Reef rock was quarried at Wallick's Mill, in the NW¼NE¼ sec. 5, T. 26 N., R. 4 E., and burned for use as agricultural lime. The other two abandoned quarries are in the SW¼SW¼ sec. 33, T. 27 N., R. 4 E.

SAND AND GRAVEL

The abundance of sand and gravel in Miami County is reflected by the many good gravel roads in the county. About 75 pits, of which 10 are active or active on demand and 65 are abandoned, are scattered throughout the county. The sand and gravel are obtained from Tazewell and Cary outwash and from kames and eskers.

Three sand and gravel pits in Miami County are active. Two large pits are owned by the J. C. O'Connor Company. The large pit that is on the Maumee terrace just west of Peru, in secs. 20 and 21, T. 27 N., R. 4 E., uses a dragline to load the sand and gravel (pl. 5, B). The overburden is removed by four large bulldozers. The raw product then is moved about 1½ miles over a railroad to a plant where it is washed, screened, and crushed. About 2 miles east of Peru, in the SW¼ sec. 19, T. 27 N., R. 5 E., outwash sands and gravels that are buried beneath alluvium are being stripped. There the same methods described above are used. The finished product is shipped by rail to various points. The third active pit in Miami County is owned by Mr. Riley Behny and is on the Mississinewa terrace south of the Mississinewa River, in the SW¼SE¼ sec. 10, T. 26 N., R. 5 E. A front-end loader is used in this pit. Seven pits have been stockpiled to furnish sand and gravel upon demand. Four of these pits are on the Mississinewa terrace along the Eel Valley, one pit on the Mississinewa terrace along the Mississinewa Valley, one pit along the bluffs of the Wabash Valley, and one pit of Tazewell outwash along Big Pipe Creek.

The sand and gravel are used for surfacing the county roads. The greatest problems encountered in this industry are concerned with the removal of large boulders, the presence of large lenses of sand, and the presence of an overburden too thick to remove economically. At many places in the county, however, gravel can be produced profitably.

GROUND WATER

The valleys of the buried preglacial drainage lines contain thick and extensive beds of sand and gravel which are good aquifers. The gravels in the Teays and Metea Valleys are particularly good aquifers in northern Indiana. C. E. Smith (personal communication), Manager of the Peru Waterworks, stated that the city of Peru has a potential water supply of 3,600,000 gallons per day from four wells at the northeast edge of Peru. Two of the wells are in gravel, and two are in bedrock. The Worthington well, in gravel at a depth of 76 feet, can produce 1,500,000 gallons daily, and the Harrison Street well, 3 blocks to the east of it and in gravel at a depth of 100 feet, can yield 700,000 gallons per day. One bedrock well has a capacity of 1,000,000 gallons, and the other will pump 900,000 gallons per day. The city uses about 2,000,000 gallons daily. The gravel wells tap a buried aquifer in the Teays Valley (pl. 8, C).

Many domestic wells derive their water from gravel in the Teays, Metea, Bedrock Mississinewa, and other buried valleys and from many local lenses of sand and gravel in the till beneath the end and ground moraines. Most of the latter aquifers are adequate for domestic purposes but could not meet large municipal or industrial needs.

MARL

Marl, an earthy, fresh-water lake deposit composed mainly of calcium carbonate, formerly was dug and used for agricultural lime in Miami County. Blatchley and Ashley (1901, p. 319) reported that marl pits were located 4 miles southwest and 1 mile northeast of Peru. These pits are abandoned now and the deposits are covered. Some of the areas of muck in the Packerton moraine may be underlain by marl, but whether or not any such deposits exist is not known.

PEAT

Peat formerly was mined in Miami County for use as a fuel and for the purpose of adding humus to the soil. Taylor (1907, p. 204-206) reported peat, 2 to 10 feet thick, in the following places: along the Wabash River in Peru; in the southern half of sec. 26, T. 29 N., R. 4 E.; in the north-central part of sec. 21, T. 29 N., R. 4 E.; in the SE¼ sec. 16, T. 29 N., R. 4 E.; and in secs. 2 and 3, T. 29 N., R. 3 E. The peat is found in association with muck and in most places is covered by it.

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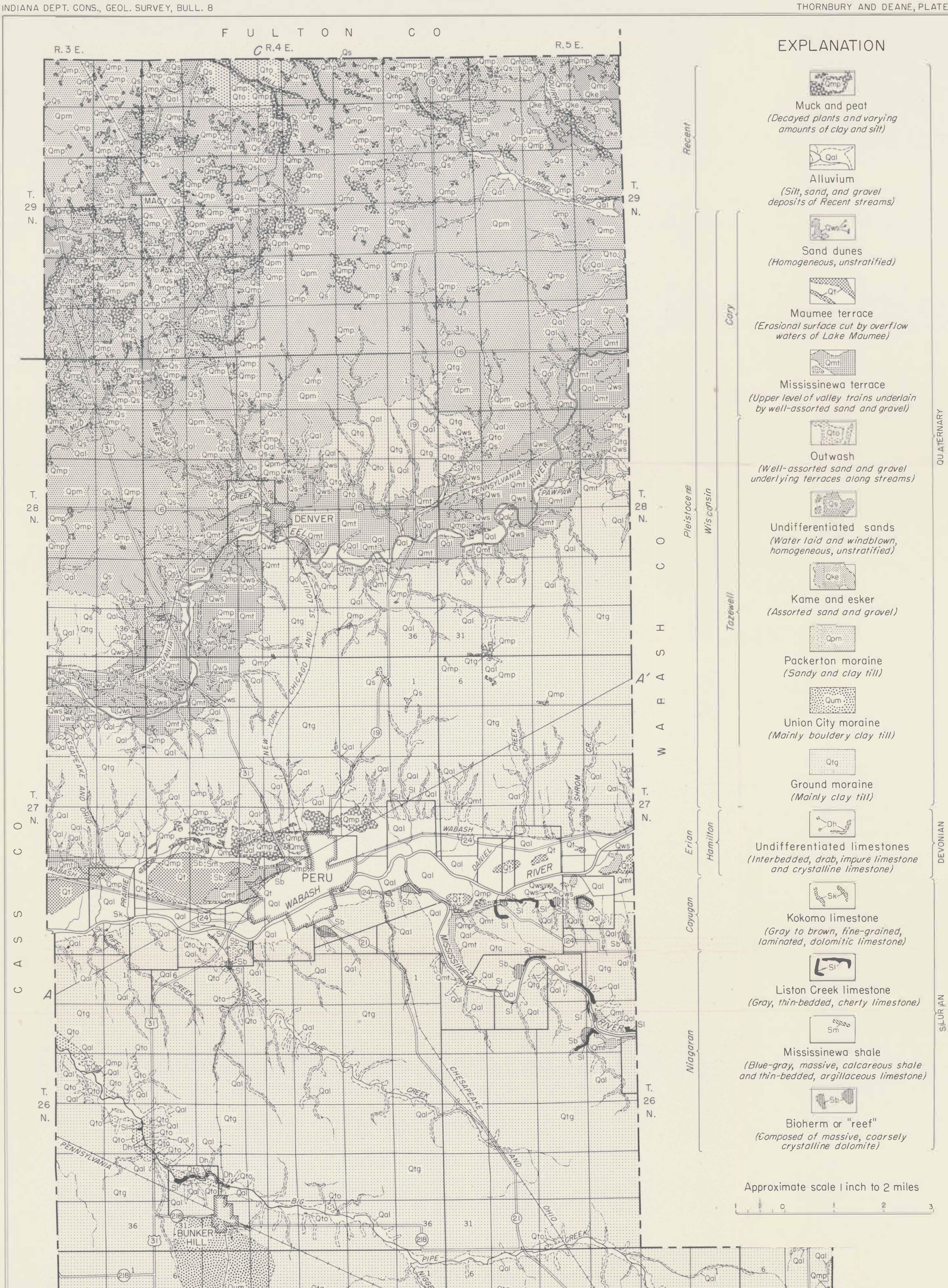
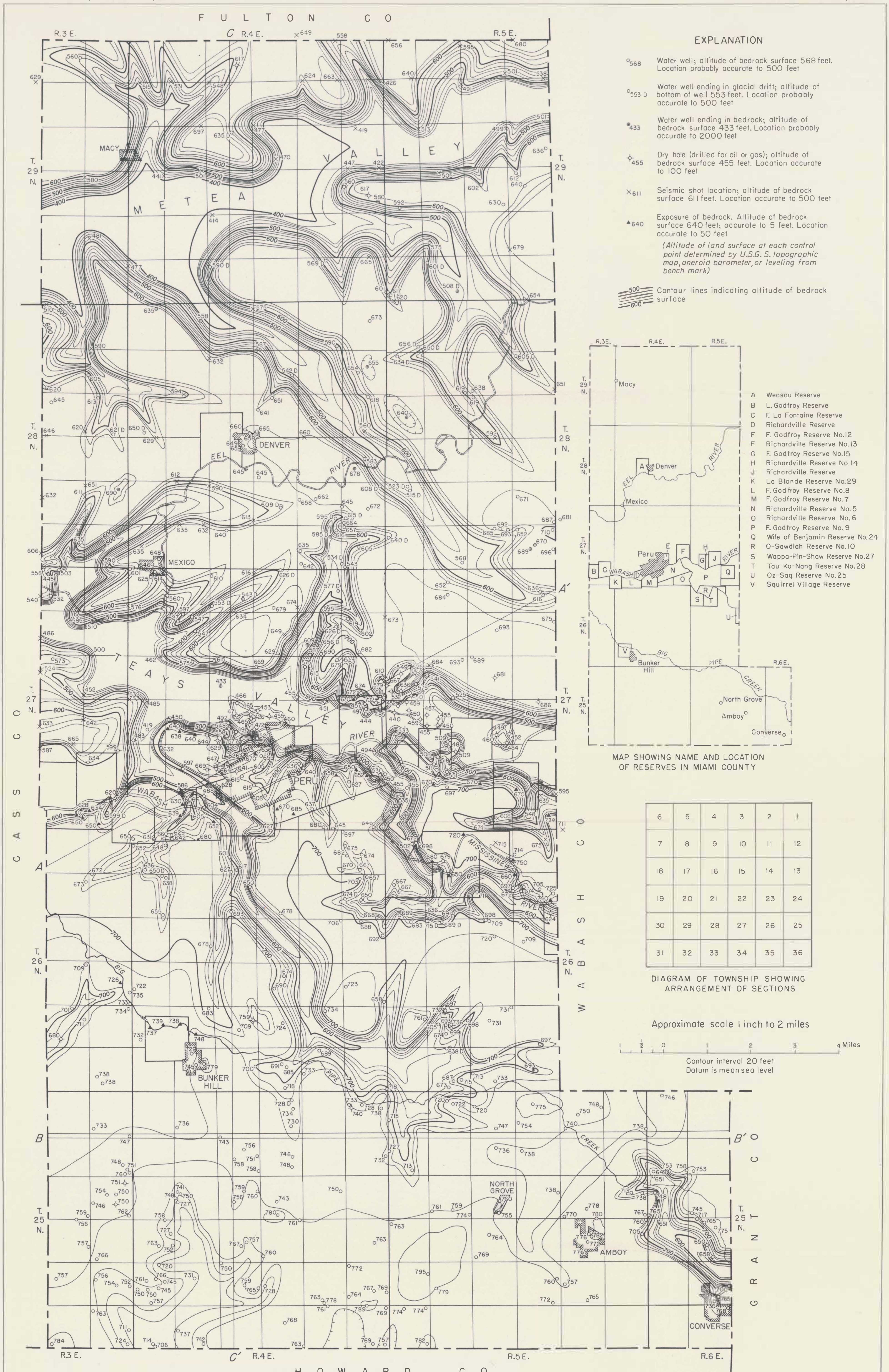


Base from Base Map of Miami County, Indiana (1952) by Indiana Department of Conservation, Geological Survey.

AREAL GEOLOGIC MAP OF MIAMI COUNTY, INDIANA

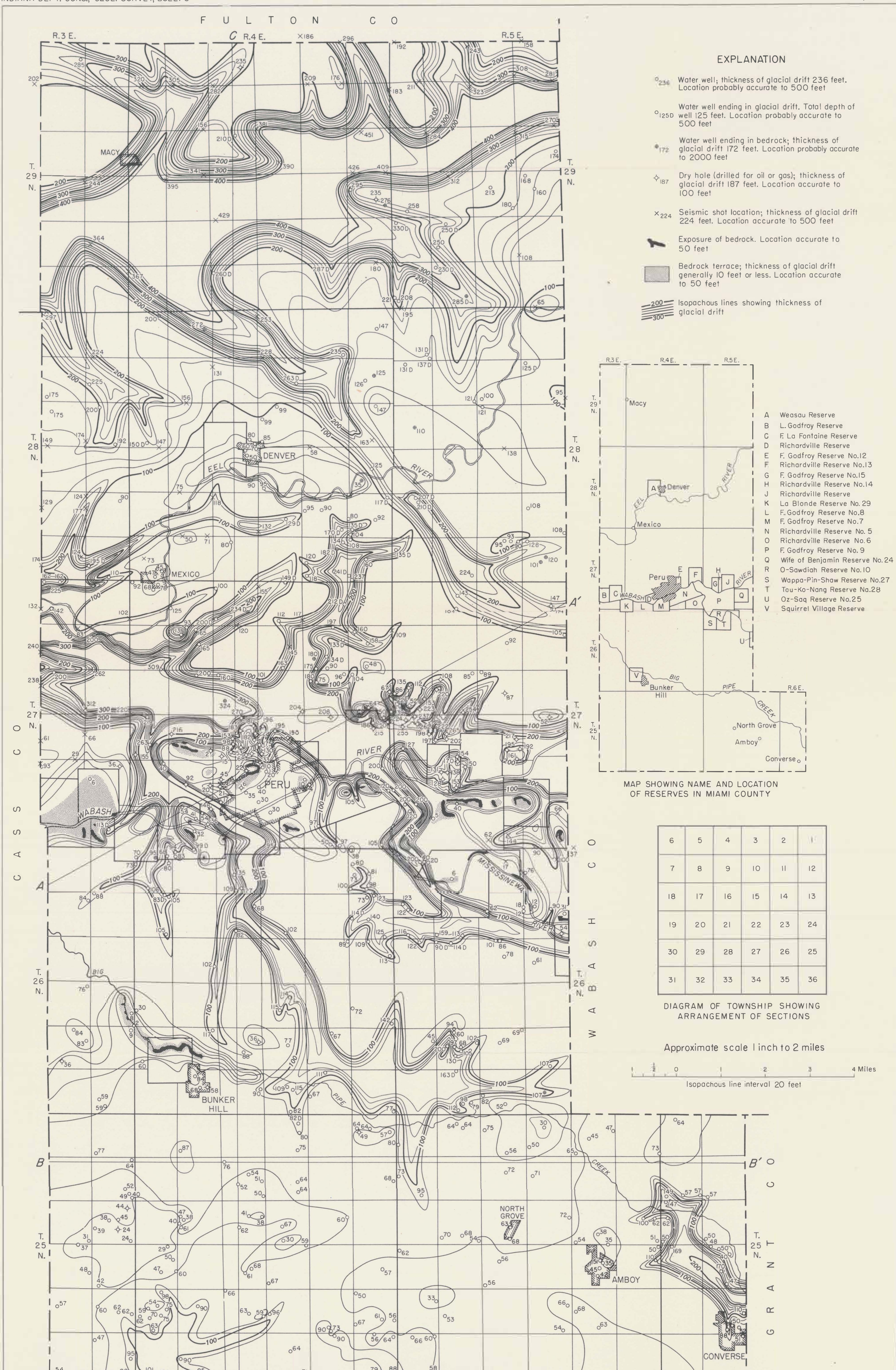
Geology by H. L. Deane and W. D. Thornbury. Minor revisions by W. J. Wayne. 1954



Base from Base Map of Miami County, Indiana (1952) by Indiana Department of Conservation, Geological Survey.

MAP SHOWING BEDROCK TOPOGRAPHY OF MIAMI COUNTY, INDIANA

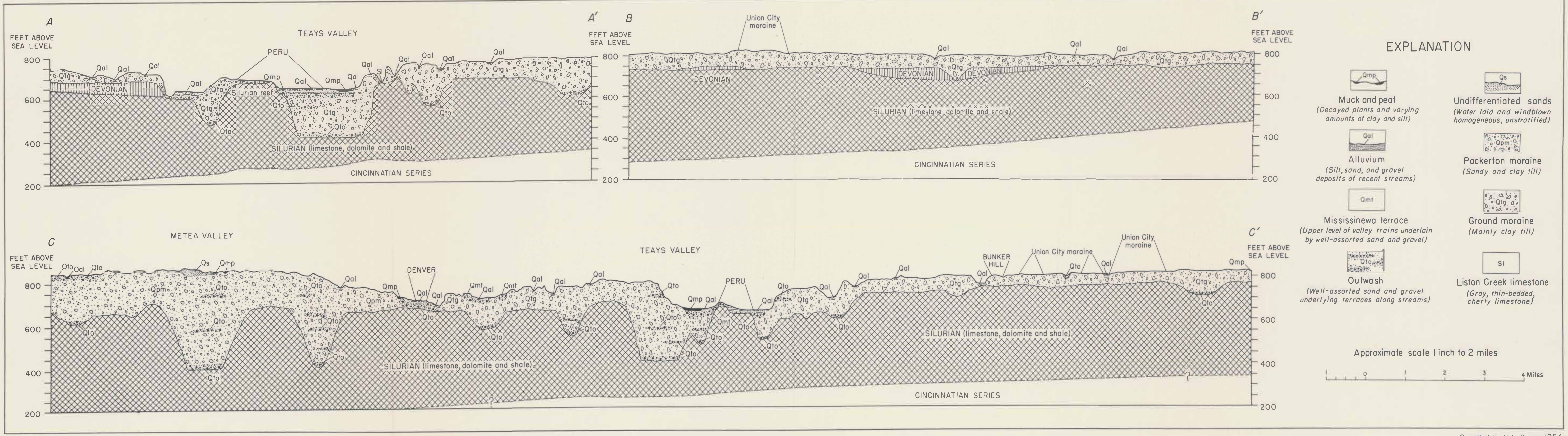
Compiled by H.L. Deane. 1954



Base from Base Map of Miami County, Indiana (1952) by Indiana Department of Conservation, Geological Survey.

ISOPACHOUS MAP SHOWING GLACIAL DRIFT IN MIAMI COUNTY, INDIANA

Compiled by H.L. Deane. 1954



PROFILES ACROSS MIAMI COUNTY, INDIANA, SHOWING BEDROCK TOPOGRAPHY AND THICKNESS OF DRIFT

Compiled by H. L. Deane. 1954