

STATE OF INDIANA
HENRY F. SCHRICKER, GOVERNOR

DEPARTMENT OF CONSERVATION
KENNETH M. KUNKEL, DIRECTOR
INDIANAPOLIS

DIVISION OF GEOLOGY
CHARLES F. DEISS, STATE GEOLOGIST
BLOOMINGTON

BULLETIN NO. 4

GLACIAL SLUICEWAYS AND LACUSTRINE PLAINS
OF SOUTHERN INDIANA

BY
WILLIAM D. THORNBURY

PRINTED BY AUTHORITY OF THE STATE OF INDIANA

BLOOMINGTON, INDIANA
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CONTENTS

	Page
Abstract	3
Introduction	3
Alluviation associated with Illinoian glaciation	4
Illinoian sluiceways	4
Illinoian lakes and lacustrine plains	5
Glacial Lakes Quincy and Eminence	6
Alluviation associated with Wisconsin glaciation	8
Wisconsin sluiceways	10
Wisconsin lakes and lacustrine plains	14
Character of lake deposits	17
Relation of loess to sluiceways and lacustrine deposits	17
Partially buried bedrock hills	18
References cited	20

ILLUSTRATIONS

Plate	Facing page
1. Wisconsin deposits, Deer Creek Valley, Perry County, Indiana	8
2. Hill of circumalluviation and Illinoian lacustrine deposits	9

Figure	Page
1. Map of southern Indiana showing Illinoian glacial lakes and sluiceways	5
2. Map showing sites of glacial Lakes Quincy and Eminence	7
3. Map of southern Indiana showing Wisconsin glacial lakes and sluiceways	10

GLACIAL SLUICEWAYS AND LACUSTRINE PLAINS OF SOUTHERN INDIANA

BY WILLIAM D. THORNBURY

ABSTRACT

Lacustrine plains of two distinct ages and origins occur in southern Indiana. One system of lakes of Illinoian age developed as marginal lakes because of the ponding of the southwest drainage by the lobe of Illinoian ice which extended into southwestern Indiana.

Another and more extensive system of Wisconsin glacial lakes developed south of the Shelbyville moraine as a result of the ponding of the tributary valleys by the extensive valley trains built down the streams which acted as sluiceways for Wisconsin melt-waters. Lacustrine plains of this origin are extensively developed along the tributaries of the Wabash, Ohio, and White Rivers.

The lacustrine deposits are composed of calcareous clays and silts which generally are strongly laminated. Calcareous concretions are particularly abundant in the deposits adjacent to the sluiceways.

Sand dunes and loess are associated with the valley trains and lacustrine plains. The dunes are restricted to the sluiceways, but the loess mantles the uplands between the adjacent lacustrine flats.

INTRODUCTION

One of the most conspicuous features of the topography of southern Indiana is the widespread alluviation or valley filling, which in the main is associated directly or indirectly with the effects of Illinoian or Wisconsin glaciation. Valley filling in the major valleys resulted from the fact that they acted as sluiceways for glacial melt-waters during the Illinoian or Wisconsin glacial stages, with the consequent development of extensive valley trains down their courses.

Alluviation is not confined to the major valleys but also characterizes most of the tributary valleys in which lakes existed during either Illinoian or Wisconsin times. The lake sites are now marked by extensive lacustrine plains which have suffered relatively little stream dissection.

Illinoian glaciation did not result in widespread valley filling in southern Indiana, but in southwestern Indiana a series of marginal lakes developed against the ice front as a result of the damming by the ice of the westward and southwestward drainage of this area. Lacustrine plains, which exhibit varying degrees of dissection, mark the lake sites. They occur from Owen County in the north to Posey County in the south.

ALLUVIATION ASSOCIATED WITH ILLINOIAN GLACIATION

ILLINOIAN SLUICEWAYS

The Illinoian ice sheet extended into Indiana as two great lobes. The southeastern lobe reached as far south as the Ohio River at Louisville, Kentucky, and the southwestern lobe covered much of Indiana but came within only 7 miles of the Ohio in Posey County. Most of the early reports indicate that the western margin of the southeastern Illinoian lobe was at or near the foot of the prominent Knobstone escarpment (Leverett and Taylor, 1915, pl. 6; Malott, 1922, pp. 143-144; Malott, 1926, pp. 93-107) which extends south from southern Johnson County to the Ohio River. The escarpment, which derives its name from the old name of a group of rocks now known as the Borden group (Stockdale, 1931, pp. 3-5), is due in part to resistant sandstone members in this group and is probably the most striking topographic feature in Indiana, attaining a height of nearly 600 feet near the Ohio River and gradually decreasing in height northward. The escarpment everywhere presents a steep front overlooking the Scottsburg lowland to the east and undoubtedly was a formidable barrier to the westward progress of the Illinoian ice, which finally overrode it. Malott (1926, pp. 104-106) showed that the Illinoian ice overrode the escarpment nearly as far south as the East Fork of White River. Later field studies by the writer (Thornbury, 1932) showed that glacial drift exists west of the escarpment as far south as southeastern Washington County and that for a time the three forks of Blue River carried Illinoian outwash that resulted in a valley train which is partly preserved today as terraces along Blue River. Such terraces are well developed in the upper portion of the South Fork of Blue River. The ice probably did not long maintain its position west of the Knobstone escarpment because the valley train is not conspicuously developed in the lower part of Blue River Valley.

In addition to Blue River, the Ohio and Wabash Rivers, the East and West Forks of White River, Salt Creek, and Bean Blossom Creek acted as Illinoian sluiceways (Fig. 1). Recognizable remnants of the valley trains that developed down these sluiceways are present as terraces in the valleys of Blue River, Salt Creek, and Bean Blossom Creek, which did not later act as Wisconsin sluiceways. Illinoian outwash cannot definitely be recog-

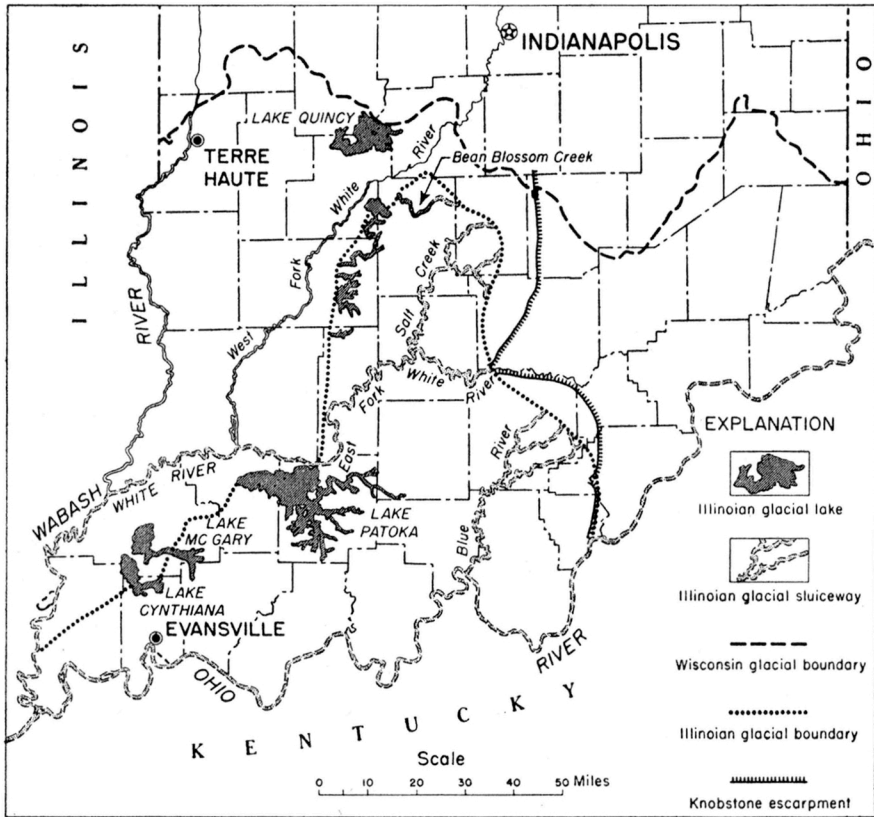


Figure 1. Map of southern Indiana showing Illinoian glacial lakes and sluiceways.

nized along the Ohio, Wabash, or White Rivers because these valleys later carried large volumes of Wisconsin melt-water, and the previously deposited Illinoian outwash was either removed, buried, or incorporated in the Wisconsin outwash. The best preserved Illinoian gravels occur along the various forks of Salt Creek, where they cap prominent terraces. Post-Illinoian streams have cut through these gravels into bedrock. Outwash occurs in the upper part of Bean Blossom Valley and grades into or inter-fingers with lacustrine deposits in the lower part. Bean Blossom Creek was ponded in its lower course by the Illinoian lobe.

ILLINOIAN LAKES AND LACUSTRINE PLAINS

While drainage from the Illinoian lobe in southeastern Indiana developed valley trains down the sluiceways, a series of lakes came

into existence along the margin of the southwestern glacial lobe as a result of the ponding of the southwest drainage by the ice front. Most of these lakes have been previously described (Fuller and Ashley, 1902, p. 4; Fuller and Clapp, 1904, p. 4; Malott, 1922, pp. 233-247) and will not be discussed here except to show that their origin was different from the more extensive system of Wisconsin lakes (pp. 14-17).

Included in this Illinoian lake system were Lake Cynthiana in Posey, Gibson, and Vanderburgh Counties, Lake Patoka in Pike and Dubois Counties, the so-called American Bottoms region in eastern Greene County (Malott, 1922, pp. 233-247), the Flatwoods region of Monroe and Owen Counties (Malott, 1922, pp. 211-215), and several smaller lacustrine areas. These lakes disappeared with the withdrawal of the ice sheet from across the valleys in which they existed (Fig. 1). Several of the sites are still well preserved as lacustrine plains. In the smaller valleys, remnants of the lake flats are preserved as terraces along the valley sides.

In general the altitudes of the lake flats decrease toward the south in relation to the thinning of the ice sheet in that direction. From north to south, the Flatwoods lake plain is developed at an altitude of approximately 740 feet, the American Bottoms region at 660 feet, Lake Patoka still farther south at 490 feet, and Lake Cynthiana near the extreme southern end of the ice margin at 450 feet.

Glacial Lakes Quincy and Eminence.—The existence of an extensive lacustrine plain occupying portions of Owen, Morgan, Putnam, and Hendricks Counties was recognized by early geologists, but most observers assumed that this lacustrine area was of one age and origin (Collett, 1875, pp. 306-307; Brown, 1883, p. 80; Edmondson, 1911, p. 84; Malott, 1922, pp. 210-211; Addington, 1927, pp. 115-116). Field studies (Thornbury, 1940) suggested that two lakes, one of Illinoian age (Lake Quincy) and another of Wisconsin age (Lake Eminence), developed so close to each other and at so nearly the same altitude that they appear to be one lake plain (Fig. 2).

Lake Quincy developed as a proglacial lake along the Illinoian ice front as a result of the ponding of the upper drainage of Mill Creek, which occurred after the Illinoian ice had receded somewhat from its southernmost position. The lake covered an area of between 40 and 50 square miles and during its early stages discharged through a spillway into Limestone Creek and thence into

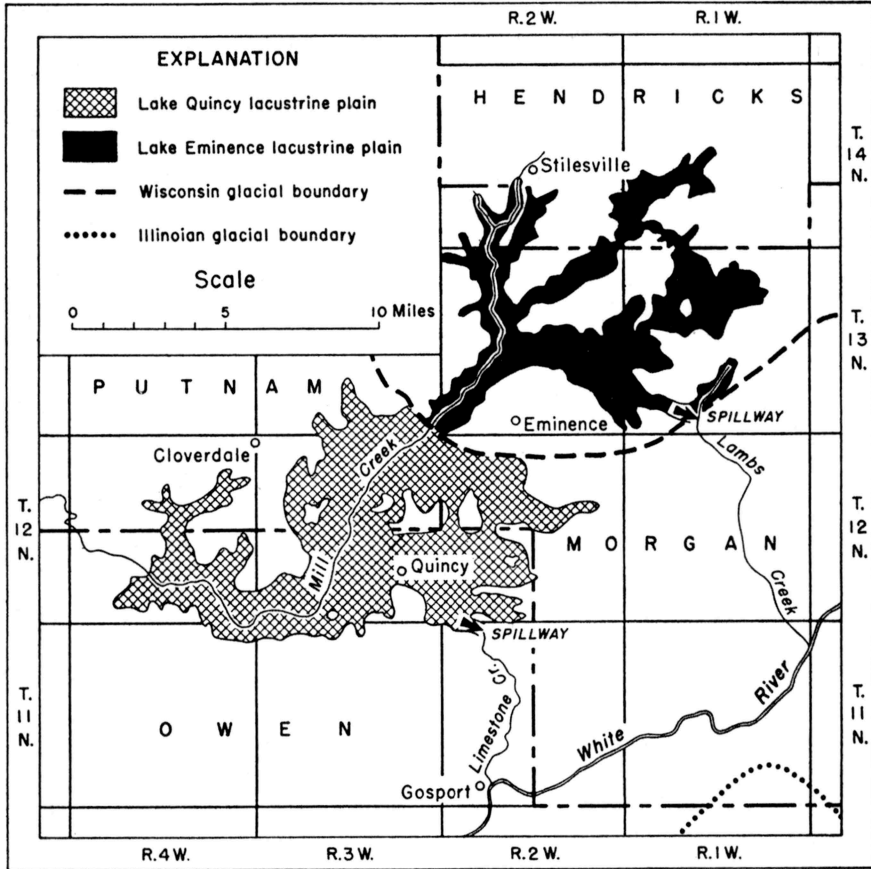


Figure 2. Map showing sites of glacial Lakes Quincy and Eminence.

the West Fork of White River. The lacustrine plain which marks the lake site rises gradually toward its head and is most typically developed between altitudes of 755 and 770 feet.

The deposits underlying the Lake Quincy lacustrine plain consist of gravels and sands at the bottom and silts and clays in the upper part (Pl. 2, *B*). They attained thicknesses of 30 to 40 feet in the lower end of the lake, where the silts and clays exhibit well developed lamination. Their Illinoian age is indicated by a leaching of carbonates to a depth of 12 to 13 feet, which is comparable to the depth of leaching of the Illinoian drift in southern Indiana.

After the drainage of Lake Quincy, Mill Creek reestablished its course across the lacustrine plain and since then has removed

a considerable portion of the lake deposits, particularly in the lower or west end of the plain. Prominent terraces along Mill Creek mark the level of the lake plain. The name of the lake was taken from the village of Quincy, which is located upon one of these terraces. In cutting through the lacustrine deposits at the west end of the area, Mill Creek encountered two buried bedrock hills and developed the two waterfalls now known as Cataract Falls. The falls are about half a mile apart and, with the rapids above them, have a total fall of over 80 feet. Mill Creek descends only 10 feet in its 12 mile course across the lacustrine plain, but the descent is nearly 100 feet in less than 2 miles from the upper falls.

Back of the Shelbyville moraine, immediately adjacent to and northeast of the Lake Quincy plain, is another lacustrine plain which was long considered a continuation of the Quincy plain. That it is of Wisconsin age, however, is shown by the facts that the materials comprising the lake plain are leached to a depth of only 5 to 5½ feet and that they have been much less eroded. The depth of leaching is comparable to the depth of leaching of the Tazewell drift in this part of Indiana. To the lake which developed here during Wisconsin time, the name Eminence has been given, from the town of Eminence near its western margin. The lake plain which marks its site covers an area of approximately 30 square miles and is most typically developed at an altitude of approximately 760 feet. There has been relatively little dissection of the Lake Eminence plain since its formation. During the early stages of its existence, Lake Eminence drained into White River through a spillway down Lamb's Creek. Later a breach was made in the Shelbyville moraine, and drainage was established across the Lake Quincy lacustrine plain to Eel River.

ALLUVIATION ASSOCIATED WITH WISCONSIN GLACIATION

Although some of the alluviation, which is so conspicuous a feature of southern Indiana, was caused by Illinoian glaciation, most of it occurred during the Wisconsin glacial age. The areas of valley filling to be described lie south of the Shelbyville moraine, and hence alluviation here is an indirect rather than a direct effect of glaciation.

In the past, various theories have been proposed to account for the valley filling which characterizes the tributary valleys of the



A. LACUSTRINE SEDIMENTS UNDERLYING TERRACE.



B. CONCRETIONS OF CALCIUM CARBONATE IN LACUSTRINE DEPOSITS SHOWN IN A.

WISCONSIN DEPOSITS, DEER CREEK VALLEY, PERRY COUNTY, INDIANA.

Blue River was likewise ponded in its lower part by the valley train built down the Ohio.

WISCONSIN SLUICEWAYS

The major sluiceways during the Tazewell sub-age of the Wisconsin glaciation of Indiana were the valleys of the Ohio, White-water, Wabash, and Eel Rivers, the East and West Forks of White River, and Raccoon Creek (Fig. 3). The valley trains built down

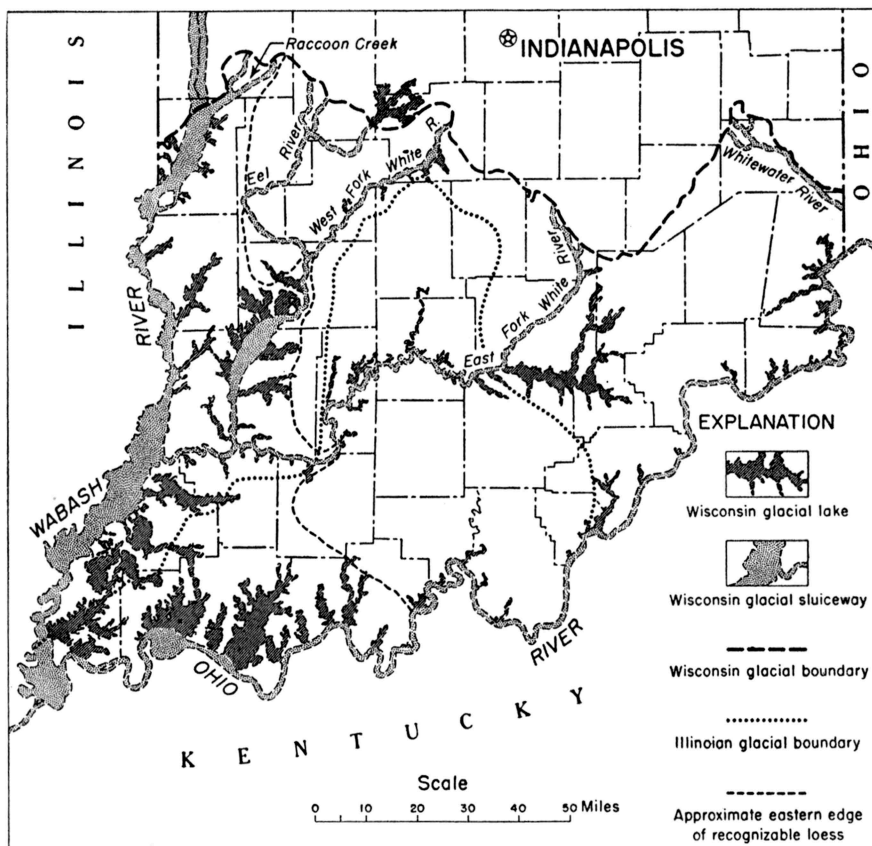


Figure 3. Map of southern Indiana showing Wisconsin glacial lakes and sluiceways.

these valleys are represented today by gravel terraces standing well above the present floodplains. The amount of outwash which they carried is indicated to some degree by the depth of valley filling. The two major sluiceways probably were the Wabash

and the Ohio Rivers, although the Whitewater and White Rivers were also important. Some data will be given to indicate the amount of valley filling in the Ohio and Wabash Valleys. It cannot be stated with certainty that all of the valley filling in these two valleys is to be attributed to Wisconsin outwash since they both acted as sluiceways during Illinoian time. Because very little Illinoian gravel has been recognized in either valley, however, it appears likely that most of the Illinoian outwash was cleaned out during the Sangamon interglacial age and that the present valley-fill is largely Wisconsin outwash.

The present valley floor of the Ohio is far above bedrock throughout most of its course, and the few places where bedrock is at or near the present stream level, as at the "falls of the Ohio" at Louisville, Kentucky, are due to lack of coincidence of the present stream channel with the buried bedrock channel.

It is not the purpose of this paper to undertake a discussion of the physiographic history of the Ohio River, but a few pertinent facts may be stated. Diversion and integration of the drainage of the upper Ohio River into a southwestward drainage line probably occurred during the Nebraskan glacial age. The "deep stage" of the Ohio, or the buried rock gorge below the present floodplain, was probably cut in the period between the Nebraskan and Illinoian glacial ages. Whether the Kansan glaciation affected the Ohio River directly is still not clear, but certainly the "deep stage" was developed prior to the Illinoian glaciation, for the Ohio River carried outwash during Illinoian time.

Scattered well records give some indication of the depth of the valley-fill along the Ohio River. Logan (1931, p. 97) reported a well at Lawrenceburg, Indiana, which penetrated 139 feet of valley-fill before encountering bedrock. Leverett (1902, p. 265) gave the record of a well at Madison, Indiana, on a terrace of Wisconsin age, which reached a depth of 120 feet without encountering bedrock, and also of a well at Carrollton, Kentucky, a few miles above Madison, which reached a depth of 107 feet without encountering bedrock. In another publication, Leverett (1929, p. 70) reported a well 4 miles below Madison which was sunk to a depth of 172 feet, or 110 feet below river level, entirely through sand and gravel. Siebenthal (1900, pp. 363-364) gave the record of a well at Utica, just above Jeffersonville, Indiana, which was sunk to 120 feet without encountering bedrock. Butts (1915, p. 203) estimated the thickness of valley-fill at Louisville, Kentucky,

at between 120 and 140 feet. Guyton (1946, pp. 645-646) estimated the thickness of outwash sands and gravels at Louisville to be 125 to 130 feet and the altitude of the buried bedrock floor to be 330 feet, as compared with an average surface altitude of 460 feet at Louisville.

Logan (1931, p. 127) gave the record of a well below New Albany, Floyd County, Indiana, in the SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 28, T. 4 S., R. 6 W., which showed 150 feet of clay, sand, and gravel above the New Albany shale. Farther down the Ohio River in Harrison County (Logan, 1931, p. 344), a well penetrated at least 116 feet of sand and gravel. Another well in Harrison County (Indiana Division of Geology, 1944, p. 37), in the SW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 12, T. 6 S., R. 4 W., penetrated 143 feet of sand and gravel before reaching bedrock. A record of a well in Perry County (Logan, 1931, p. 468) 1 mile above Tobinsport, near the northeast corner of sec. 32, T. 7 S., R. 2 W., showed 150 feet of sand and gravel on green shale. Leverett (1929, pp. 62-63) gave logs of three test wells driven in connection with the building of a bridge over the Ohio River near Evansville, Indiana, which showed depths of 119, 118, and 107 feet to bedrock and corresponding bedrock altitudes of 242, 243, and 254 feet. A well in the SE $\frac{1}{4}$ sec. 20, T. 8 S., R. 14 W., approximately 1 mile above the junction of the Wabash and Ohio Rivers, showed 162 feet of valley-fill materials resting upon sandstone.

Thus it appears that along that portion of the Ohio Valley which crosses Indiana, the thickness of valley-fill everywhere exceeds 100 feet, and the maximum thickness may range between 150 and 170 feet. In general, gravels change in character and decrease in quantity going downstream, particularly in the upper 40 or 50 feet. Sand, silt, and clay are more common from Louisville down the valley, but, in the lower part of the valley-fill, gravels are quite common down the Ohio River as far as the junction with the Wabash.

The Wabash Valley was comparable to the Ohio Valley and even exceeded it in importance as a sluiceway. Physiographic evidence indicates that the Wabash sluiceway carried a larger volume of melt-water, or at least was far wider than the Ohio sluiceway, and was in places as much as 10 or 12 miles wide. During periods of maximum melting, the waters in this sluiceway attained depths of 15 to 20 feet in the narrower sections. The Wabash Valley is deeply alluviated throughout its length.

The average depth of valley-fill is probably between 90 and 100 feet, and in places the thickness may exceed 200 feet. Scovell (1896, pp. 520-524) gave the records for 10 wells in or near Terre Haute in which the depth of bedrock ranged between 84 and 130 feet. Three wells in the Wabash sluiceway in northern Knox County (Indiana Division of Geology, 1940, p. 29) penetrated 102, 114, and 132 feet before encountering bedrock. The altitude of the bedrock floor here ranges between 303 and 321 feet. Another well near the southwest corner of Knox County (Logan, 1931, p. 395) reached 100 feet before encountering shale at an altitude of 310 feet.

Numerous oil well records are available from Gibson County (Indiana Division of Geology, 1939; 1941). A well in the SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 13, T. 3 S., R. 14 W., penetrated 170 feet of sand and gravel. Two wells in section 23 of the same township encountered 175 and 190 feet of sand and gravel. Two wells in section 24 of the same township showed 160 and 185 feet of valley-fill above bedrock. A record of a well in the SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 28, T. 3 S., R. 14 W., indicated as much as 223 feet of sand and gravel. The surface at the well is 377 feet above sea level, and thus if the well log is correct the bedrock floor of the Wabash sluiceway is only 154 feet above sea level. Because the well record indicates a thickness of valley-fill somewhat in excess of any other well in the lower Wabash Valley or nearby Ohio Valley, there may be some question as to the driller's interpretation. From these scattered well records it is apparent that the amount of valley-fill in the Wabash Valley is comparable to if not slightly in excess of that in the Ohio Valley.

Valley trains occur in the valleys of Whitewater and Eel Rivers, the East and West Forks of White River, and Racoon Creek, which also carried Wisconsin outwash. Although well records from these valleys are scarce, those that are available indicate a depth of valley-fill comparable to that in the valleys of the Ohio and Wabash Rivers. Well records at Brookville in the Whitewater Valley indicate that the valley-fill is between 150 and 180 feet thick. The top of the valley-fill is represented by prominent gravel terraces which stand from 80 to 90 feet above the present stream bed. Wells at Martinsville in the valley of the West Fork of White River penetrated from 90 to 120 feet of drift before reaching bedrock. Records of three wells in Daviess County (Logan, 1931, pp. 74, 78, 81), one in the valley of Veales Creek

and two in the valley of Aikman's Creek, tributaries of the West Fork of White River, indicate depths of bedrock of 130, 115, and 122 feet, respectively.

WISCONSIN LAKES AND LACUSTRINE PLAINS

As valley trains were built down the individual sluiceways, the streams in the tributary valleys were ponded, and an extensive system of lakes was formed. The sites are now represented by partially dissected lacustrine plains whose levels coincide closely with the altitude of the top of the valley train in the adjacent sluiceway. Along each sluiceway the altitudes of the lacustrine plains in successive tributaries decrease downstream in accordance with the slope of the valley train in the sluiceway.

Along the Wabash Valley the lacustrine plains are about 500 feet in altitude just south of the Shelbyville moraine and descend to about 385 feet near the junction of the Wabash River with the Ohio River, a descent of 115 feet in 105 miles or slightly more than 1 foot per mile. In the Ohio Valley the lake flats descend from 515 feet near Lawrenceburg to 385 feet at the junction of the Wabash with the Ohio, a descent of 130 feet in about 350 miles or approximately four-tenths of a foot per mile. Along the West Fork of White River the lacustrine plains descend from 605 feet in altitude at Martinsville to 440 feet at the junction with the East Fork, a descent of 165 feet in 180 miles or nine-tenths of a foot per mile. Along the East Fork of White River the lake levels drop from 540 feet in the Muscatatuck Valley to 440 feet at the junction with the West Fork, a drop of 100 feet in about 110 miles or nine-tenths of a foot per mile.

Although a prominent valley train extends down the valley of the Whitewater, conspicuous lacustrine plains are absent in its tributary valleys. The effects of ponding did not extend very far up the tributaries of Whitewater, which was carrying glacial outwash, because they were so narrow and short. Materials similar to those that underly the lacustrine plains along the other sluiceways can be seen in one or two places, but they are not extensive enough to be conspicuous topographically. Although Eel River acted for a time as a Wisconsin sluiceway, no prominent lacustrine plains developed in its tributaries, apparently because it did not carry outwash long enough for a sizable valley train to form. Its headwaters are not far within the Shelbyville moraine, and shrinkage of the ice sheet soon terminated its connection with the meltwaters.

Most of the altitudes in the following table were determined with an aneroid barometer and are thus subject to error, but they do show the general descent of the plains along the sluiceways.

*Altitudes of lacustrine plains
in tributary valleys along the four major Wisconsin sluiceways*

	Altitude (feet)
Wabash River from north to south	
Honey Creek	500
Turman Creek	470
Busseron Creek	455
Maria Creek	449
Patoka River	420
Big Creek	385
Ohio River from east to west	
Tanners Creek	515
Hogan Creek	512
Laughery Creek	510
Goose Creek	500
Turtle Creek	490
Indian Creek	487
Indian-Kentuck Creek	480
Camp Creek	465
Fourteen Mile Creek	460
Silver Creek	455
Fall Run	455
Knob Creek	452
Mosquito Creek	450
Buck Creek	450
Big Indian Creek	444
Blue River	438
Little Oil Creek	434
Deer Creek	425
Anderson River	422
Crooked Creek	418
Little Pigeon Creek	398
Big Pigeon Creek	390
West Fork of White River from east to west	
Indian Creek	605
Fott Creek	595
Jack's Defeat Creek	575
Rattlesnake Creek	560
Raccoon Creek	530
Lemons Creek	515
Lattas Creek	509
Black Creek	480
Indian Creek	459
Veales Creek	447
Flat Creek	442
East fork of White River from east to west	
Muscatauck River	540
Buffalo Creek	535
Twin Creek	533
Guthrie Creek	513
Salt Creek	503
Crooked Creek	490
Indian Creek	487
Beaver Creek	475
Boggs Creek	464
Lost River	457
Mill Creek	510
Prides Creek	435
Conger Creek	429
Harvest Creek	428

As the ice sheet withdrew and the load carried by the sluiceway streams decreased, the streams began to reexcavate their valleys. The present floodplains are considerably below the tops of the valley trains but still well above the preglacial bedrock floors. Fidler (1948, pp. 20-24, 70-73) showed two distinct terrace levels along the Wabash Valley. To the upper terrace, which coincides with the top of the valley train, he applied the name Shelbyville because its construction was associated with the maximum advance of the ice during the Tazewell substage of glaciation and because it heads at the Shelbyville moraine. Another terrace, which is erosional instead of depositional in origin, occurs below the Shelbyville and above the present floodplain. Fidler applied the name Maumee to this terrace because he believed that it developed largely during the time that the Wabash Valley was the outlet for the overflow waters from Lake Maumee. Because these waters were relatively free from sediment, the Wabash was able to cut out much of the previously deposited valley-fill. South of the Shelbyville moraine the Maumee terrace occurs about 30 feet below the Shelbyville terrace, but in the lower Wabash Valley there is a difference of only 20 feet between the two levels.

Terraces contemporaneous with the Shelbyville terrace of the Wabash Valley occur along the Ohio, White, and Whitewater Valleys. Several terraces along the Ohio Valley have not been differentiated or correlated with those in other valleys and appear to be more complicated than the terraces of the Wabash Valley.

The Wisconsin age of the lacustrine plains is indicated by the facts that they are topographically related to the valley trains back of which they formed and that the materials comprising them are leached to a depth comparable to that of the Wisconsin drift in Indiana. Leaching extends to a depth of $4\frac{1}{2}$ to 5 feet, which is typical of the drift back of the Shelbyville moraine (Tazewell substage).

The lacustrine plains vary greatly in width and length. They have considerable areal extent (Fig. 3) and are conspicuous features of the landscape in the topographic divisions of the state known as the Wabash and Scottsburg lowlands (Malott, 1922, pp. 83-124). They are generally less extensively developed in the areas of the Norman upland, Mitchell plain, Muscatatuck regional slope, and the Dearborn and Crawford uplands. The lake plains attain their maximum expanse in those sections of southern Indiana where lowlands existed with wide open valleys at or near base

level at the time of the invasion of the Wisconsin ice sheet. In the Dearborn and Crawford uplands the lakes were very short and narrow. This is well illustrated along the Whitewater Valley, where no lacustrine plains of any consequence occur.

Topographically the former lake sites are now represented by partially dissected lacustrine plains. Near their junctions with the sluiceway valleys they commonly show a considerable degree of dissection and are represented only by terraces which stand as much as 30 to 40 feet above the present valley floors (Pl. 1, A). The amount of relief decreases headward in the tributary valleys, however, and in their upper parts they take on the characteristics of true lacustrine plains.

Character of lake deposits.—The materials underlying the lacustrine plains consist mainly of calcareous silts and clays which in some cases exhibit a degree of stratification resembling varved deposits. The percent of calcium carbonate is usually high in the lower end of the lake plain and generally decreases gradually toward its head, indicating that the calcium carbonate came from the sluiceway. In the larger lake plains the deposits may be highly calcareous for several miles from the sluiceway, probably due to the fact that these lakes were large enough for currents of water from the sluiceway to extend into the lake some distance and carry the lime with them. This is particularly noticeable in the case of the lacustrine plain in Little Pigeon Creek, where the lake deposits are highly calcareous for a distance of more than 15 miles from the Ohio River. Below the zone of leaching, the lime occurs in concretionary masses resembling, in many cases, loess kindchen (Pl. 1, B). In some places the amount of calcium carbonate is so high that slabs of cemented silt and clay several feet long are formed. The lake deposits are typically heavy, blocky clay and silt.

RELATION OF LOESS TO SLUICEWAYS AND LACUSTRINE DEPOSITS

In southwestern Indiana, particularly along the lower Wabash and Ohio Valleys, the lacustrine plains occur in intimate association with loessial deposits. Fuller and Clapp (1903, p. 154) proposed a two-fold classification for the silts of southwestern Indiana. They suggested the name "marl-loess" for those silts below an altitude of 500 feet and the term "common loess" for those silts above that altitude. They considered the marl-loess a fluvio-

lacustrine material deposited in a large lake but were rather vague as to the conditions responsible for the formation of the lake. Shaw (1915b) objected to calling the lower silts loess and pointed out that they were but part of a great system of valley fillings formed in the ponded tributaries of the Mississippi River.

The writer is in essential agreement with Shaw's contentions. Much of the silt of southwestern Indiana should be classed as a lacustrine deposit instead of true eolian loess. While the two resemble each other much in appearance, they can be distinguished without much difficulty because the lake silts are restricted to definite topographic levels, whereas the true loess is not. There is no sharp break between the lake silts and the loess of the uplands, however. In general the lake silts are more calcareous than the true loess, although immediately adjacent to the sluiceways and lacustrine plains the loess may be as calcareous as the lake deposits. Lime concretions occur in both, but they are commonly more abundant and much larger in the lacustrine deposits.

The major source of the loess was the sluiceways, as shown by its occurrence mainly along the lower Wabash and Ohio Valleys, but the lacustrine plains formed in the tributaries of the sluiceways probably contributed some of the material. Many of the lakes formed in the tributaries were shallow and somewhat seasonal. During the winter months, when little melt-water flowed down the sluiceways, some of the lakes undoubtedly dried up, and the silts and clays on their floors were exposed to the strong westerly winds. The fact that the loess is thickest and most extensive in southwestern Indiana is due partly to its position between the broad valley flats of the Wabash and Ohio Rivers and partly to the fact that the most expansive development of lacustrine plains was in this part of the state.

PARTIALLY BURIED BEDROCK HILLS

An interesting topographic effect of the widespread alluviation in southern Indiana has been the development of numerous partially buried bedrock hills which occur in the sluiceways and to a lesser degree in their tributaries. These hills have bedrock cores which are mantled in most cases with sand or loess derived from the sluiceways.

Shaw (1911, p. 489) called them "Island Hills" after the hill upon which the town of Island, Kentucky, is located. Fidler (1933, p. 135) suggested the term "valley braid core" for similar

features in the lower Wabash Valley since there they represent the unreduced upland areas between the anastomosing braided streams of the Wabash sluiceway.

"Island Hills" are most conspicuously developed in the lower Wabash Valley and are represented by Chimney Hills, Dicksburg Hills (Pl. 2, A), Fouts Pond Hills, Mumford Hills, and others and are excellently shown on the Patoka quadrangle. All of the hills in the lower Wabash Valley have a veneer of loess.

Some of the partially buried bedrock hills in southern Indiana are not braid cores but are meander cores which have been partially buried in recent alluvium or lacustrine deposits of Wisconsin age. An example of this type is Maxwell Hill, about 2 miles southwest of Martinsville in the valley of the West Fork of White River, which is partially buried in Wisconsin outwash and lacustrine materials. Another good example of a partially buried meander core occurs about 1 mile northeast of Mauckport and is shown on the Mauckport quadrangle. This isolated hill was formed by a meander cut-off of the Ohio River in pre-Wisconsin time, for it is almost surrounded by lacustrine deposits of Wisconsin age.

REFERENCES CITED

- Addington, A.R. (1927) *Porter's Cave and recent drainage adjustments in its vicinity*, Indiana Acad. Sci., Proc. for 1926, vol. 36, pp. 107-116, 6 figs.
- Ashley, G. H., and Kindle, E. M. (1902) *The geology of the Lower Carboniferous area of southern Indiana*, Indiana Dept. Geol. and Nat. Res., 27th Ann. Rept., pp. 49-122, 13 pls., 3 figs., maps.
- Brown, R. T. (1883) *Geology of Morgan County*, Indiana Dept. Geol. and Nat. Hist., 13th Ann. Rept., pp. 71-85.
- Butts, Charles (1915) *Geology and mineral resources of Jefferson County, Kentucky*, Kentucky Geol. Survey, ser. 4, vol. 3, pt. 2, 270 pp., 65 pls., 3 figs.
- Collett, John (1875) *The geology of Owen County, Indiana*, Geol. Surv. of Indiana, 7th Ann. Rept., pp. 301-360, map.
- Edmondson, J. B. (1911) *Soil survey of Morgan County*, Indiana Dept. Geol. and Nat. Res., 36th Ann. Rept., pp. 83-109, 2 pls., map.
- Fidlar, M. M. (1933) *Some hills of circumalluviation in the lower Wabash Valley*, Indiana Acad. Sci., Proc. for 1932, vol. 42, pp. 135-140, 3 figs.
- (1948) *Physiography of the lower Wabash Valley*, Indiana Div. Geology, Bull. no. 2, 112 pp., 5 pls., 3 figs.
- Fuller, M. L., and Ashley, G. H. (1902) *Ditney Folio*, U. S. Geol. Survey, Geol. Atlas folio no. 84.
- , and Clapp, F. G. (1903) *Marl-loess of the lower Wabash Valley*, Geol. Soc. America, Bull., vol. 14, pp. 153-176, 5 figs.
- (1904) *Patoka Folio*, U. S. Geol. Survey, Geol. Atlas folio no. 105.
- Guyton, W. F. (1946) *Artificial recharge of glacial sand and gravel with filtered river water at Louisville, Kentucky*, Econ. Geology, vol. 41, pp. 644-658, 5 figs.
- Indiana Department of Conservation, Division of Geology (1939) *Gibson County*, 188 pp., mimeo. Supplement to Pub. no. 108, Sub-Surface Strata of Indiana.
- (1940) *Knox County*, 97 pp., mimeo. Supplement to Pub. no. 108, Sub-Surface Strata of Indiana.
- (1941) *Gibson County . . .*, 275 pp., mimeo. Supplement to Pub. no. 108, Sub-Surface Strata of Indiana.
- (1944) *Harrison County . . .*, 45 pp., mimeo. Supplement to Pub. no. 108, Sub-Surface Strata of Indiana.
- Leverett, Frank (1902) *Glacial formations and drainage features of the Erie and Ohio Basins*, U. S. Geol. Survey, Mon. 41, 802 pp., 26 pls., 8 figs.
- (1929) *Pleistocene of northern Kentucky*, Kentucky Geol. Survey, ser. 6, vol. 31, pp. 1-80, 15 figs.
- , and Taylor, F. B. (1915) *The Pleistocene of Indiana and Michigan and the history of the Great Lakes*, U. S. Geol. Survey, Mon. 53, 529 pp., 32 pls.

- Logan, W. N. (1931) *Sub-surface strata of Indiana*, Indiana Dept. Cons., Pub. no. 108, 790 pp., 16 figs.
- Malott, C. A. (1922) *The physiography of Indiana*, in Handbook of Indiana Geology, Indiana Dept. Cons., Pub. no. 21, pp. 59-256, 3 pls., 51 figs.
- (1926) *The glacial boundary in Indiana*, Indiana Acad. Sci., Proc. for 1925, vol. 35, pp. 93-107, 6 figs.
- Scovell, J. T. (1896) *Geology of Vigo County, Indiana*, Indiana Dept. Geol. and Nat. Res., 21st Ann. Rept., pp. 507-576, 1 fig., map.
- Shaw, E. W. (1911) *Preliminary statement concerning a new system of Quaternary lakes in the Mississippi Basin*, Jour. Geology, vol. 19, pp. 481-491, 4 figs.
- (1915a) *Newly discovered beds of extinct lakes in southern and western Illinois and adjacent states*, Illinois Geol. Survey, Bull. 20, pp. 139-157, 2 pls., 4 figs.
- (1915b) *On the origin of the loess of southwestern Indiana*, Science, new ser., vol. 41, pp. 104-108.
- Siebenthal, C. E. (1900) *The Silver Creek hydraulic limestone of southeastern Indiana*, Indiana Dept. Geol. and Nat. Res., 25th Ann. Rept., pp. 331-389, 1 pl., 2 figs., map.
- Stockdale, P. B. (1931) *The Borden (Knobstone) rocks of southern Indiana*, Indiana Dept. Cons., Pub. no. 98, 330 pp., 7 pls., 72 figs., maps.
- Thornbury, W. D. (1932) *Notes on the glacial boundary in southern Indiana*, Indiana Acad. Sci., Proc. for 1931, vol. 41, pp. 351-354, 1 fig.
- (1940) *Glacial Lakes Quincy and Eminence*, Indiana Acad. Sci., Proc. for 1939, vol. 49, pp. 131-144, 6 figs.
- Veatch, A. C. (1906) *Geology and underground water resources of northern Louisiana and southern Arkansas*, U. S. Geol. Survey, Prof. Paper 46, 422 pp., 51 pls., 33 figs.

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