STATE OF OHIO
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL SURVEY
Horace R. Collins, Chief

Report of Investigations No. 117

GLACIAL GEOLOGY OF LAKE COUNTY, OHIO

by

George W. White

Columbus

1980

DEPARTMENT OF NATURAL RESOURCES

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GEOLOGY SERVES OHIO

Photocopy composers: Beverly A. Leffler and Jean M. Lesher
Cartographer: James A. Brown

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GLACIAL GEOLOGY OF LAKE COUNTY, OHIO

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ABSTRACT

Lake County consists of three physiographic units–a 2- to 5-mile-wide Lake Plain adjacent to Lake Erie, an approximately 2-mile-wide Escarpment south of the Lake Plain, and the Allegheny Plateau south of the Escarpment.

Continental ice sheets spread into Lake County from the Erie basin at least five times during the Wisconsinan Stage and an unknown number of times in earlier stages. All of these incursions, except the last, extended far beyond Lake County. The last invasion extended only into the northern part of the county. The ice advances deposited tills, unsorted mixtures of clay, silt, sand, and pebbles, in identifiable sheets. Pre-Wisconsinan tills are present in only a few places and are very poorly known; however, the Wisconsinan tills are widespread and well known. From oldest to youngest the Wisconsinan tills are: Titusville, Kent, Lavery, Hiram, and Ashtabula. Much of the Plateau is covered with one or more tills, rarely more than 20 feet thick. The Escarpment is the site of the prominent Euclid and Painesville Moraines, in which the till is as much as 100 feet thick. The Lake Plain is covered by silt and sand deposits of late-glacial and postglacial lakes, the highest of which was about 200 feet higher than the level of present Lake Erie (571 feet). Four of the most long-lived lakes left beach deposits at their margins; the highest, the Maumee beach deposits, are discontinuous and meager, but the Whittlesey (South Ridge), Arkona (Middle Ridge), and Warren (North Ridge) beach deposits are conspicuous elements of the Lake Plain.

The sand and gravel of the beach ridges have been of economic importance, but are now mostly exhausted or built upon and thus no longer available for exploitation. Kames and kame terraces in southeastern Kirtland Township may contain considerable amounts of sand and gravel. Solid- and liquid-waste disposal capabilities in Lake County are varied and depend on till composition and position of the water table. Ground-water resources are not great in much of the county; these resources are most promising in a part of Kirtland Township. Areas of unstable slopes are present along some deep valley sides where till deposits are thick.

INTRODUCTION

LOCATION

Lake County, the smallest county in Ohio, with an area of approximately 231 square miles, lies on the southern shore of Lake Erie between 81° and 81° 29' west longitude and is 25 miles west of the Ohio-Pennsylvania state line. Lake County is bordered on the west and southwest by Cuyahoga County, on the south by Geauga County, and on the east by Ashtabula County (fig. 1).

PURPOSE

This report, with its accompanying map (pl. 1), describes the surface material overlying the bedrock in Lake County and is concerned with the surface form (geomorphology) of the land and the stratigraphy of the deposits. Economic resources of the deposits are considered, with special attention to use of the surface and subsurface for human occupation. The information presented contributes to a more complete regional history of the Pleistocene and Recent (Holocene), the latest epochs of earth history.

PREVIOUS INVESTIGATIONS

Although some incidental notices of topographic features in what is now Lake County were made very early in the past century, the first specific description of geologic features was by Charles Whittlesey (1838, p. 50-55). He discussed changes in water levels in Lake Erie, the amount of shore erosion in 40 years, the contrast between the upland and the Lake Plain, and the sandy ridges on that plain, ridges now known to be deposits of earlier, higher stages of Lake Erie. Later, Whittlesey (1869) recorded further observations on a part of Ohio including Lake County.

The only specific report on Lake County to the present is that of Read (1873), who gave a brief but perceptive report on the bedrock, topography, glacial drift, and "lake ridges." His diagrammatic section across the county from Lake Erie to Little Mountain is of such interest that it is reproduced here (fig. 2), along with his profile of the beach ridges from Lake Erie to Grand River (fig. 3). He identified the northernmost end moraine–the Painesville Moraine–as a beach ridge, a mistake made by other observers in northwestern Pennsylvania in the early part of the last century. Read's major interests were in bedrock stratigraphy, so it is

FIGURE 1.–Location of Lake County, Ohio.

understandable for him to have recorded and illustrated sections of the Painesville Moraine at Painesville (his "south ridge east of Painesville") and of gravel in the "south ridge at Painesville" (p. 517). These are some of the earliest printed sections of Pleistocene material in Ohio. Lake County is included in the maps and discussions in the great monograph by Leverett (1902), who named the end moraines along "the face of the Lake Erie escarpment" the "Lake Escarpment system" (p. 651-652, 660, 667-669) and showed them on a map (pl. 15). He named two moraines in Lake County the Euclid Moraine and the Painesville Moraine. He also described early Lake Erie raised beaches (p. 735-736).

The water supply and associated geology of some of the municipalities of the county are dealt with by Stout (1943, p. 394-399). The glacial geology of Lake County is shown in a general way on the Glacial map of Ohio (Goldthwait and others, 1961).

ACKNOWLEDGMENTS

This report is based on data from many sources. Some of the data were secured at various times from 1954 to 1961 in an investigation of the glacial geology and water resources of northeastern Ohio by the U.S. Geological Survey in cooperation with the Ohio Department of Natural Resources, Division of Water. An air photo geology study was made during this investigation. Preliminary copies of soil maps (Ohio Division of Lands and Soil) at a scale of 1 inch equals 1,000 feet provided essential information for many parts of the county. D. S. Fullerton and G. H. Groenewold provided detailed measured sections of glacial deposits; these sections have been most useful. C. H. Carter provided detailed sections of the lake bluffs; his stimulating discussions at various times are appreciated. M. L. Couchot provided information on the raised beaches. Data on surface of the bedrock beneath the drift have been provided by J. D. Vormelker. H. R. Collins, State Geologist, has taken a continued interest in the development of this map and report and has provided valuable direction and encouragement.

PHYSIOGRAPHY

Lake County is of great topographic contrast because it lies in two markedly different physiographic provinces, which in turn have subdivisions. The northern end of the glaciated Southern New York Section of the Appalachian Plateaus Province, conveniently referred to here as the Allegheny Plateau or the Plateau, extends into the southern and southeastern parts of the county. The Eastern Lake Section of the Central Lowland Province, conveniently referred to here as the Lake Plain, occupies a belt about 3 to

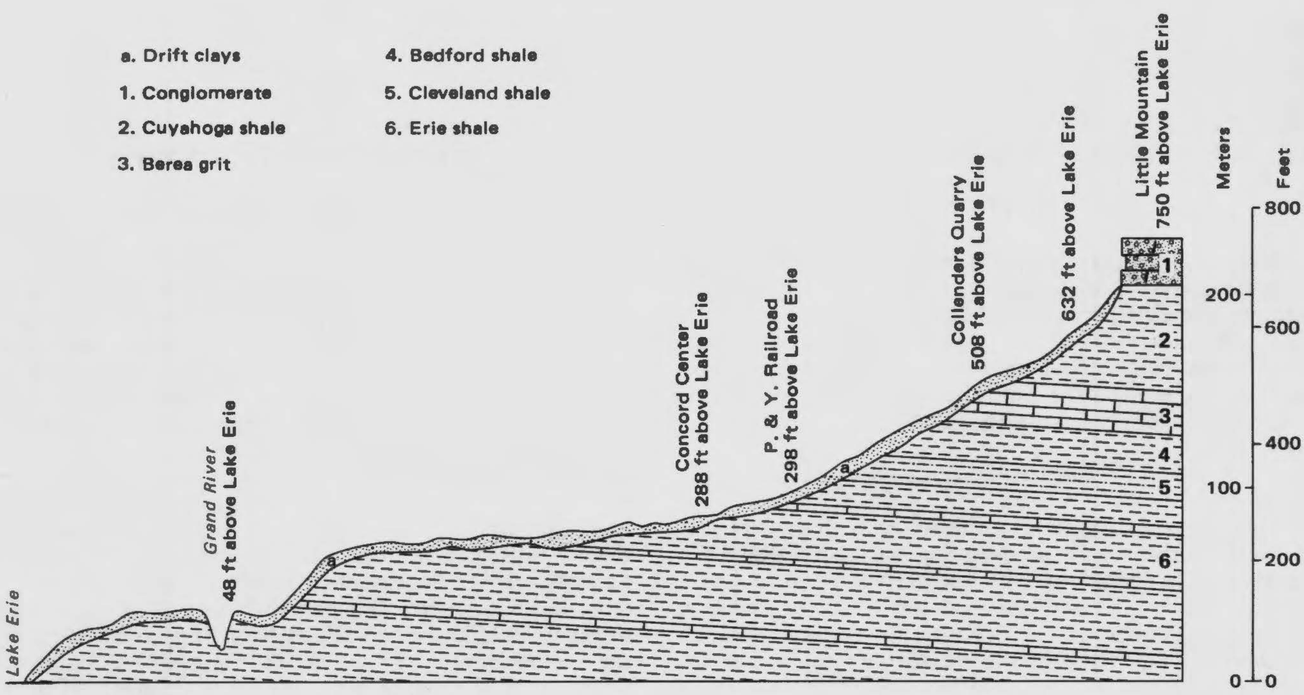


FIGURE 2.–Profile of Lake County from Lake Erie to Little Mountain (modified from Read, 1873).

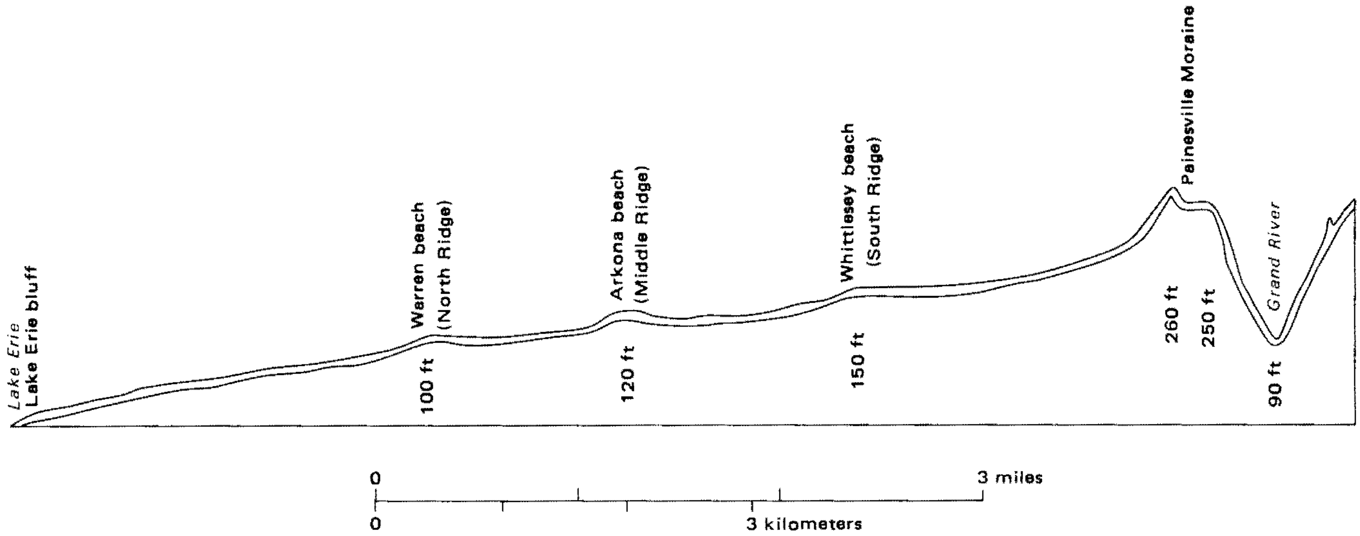


FIGURE 3.–Profile of Lake Plain from Lake Erie to the Grand River, Madison Township, Lake County (modified from Read, 1873). Elevations in feet above Lake Erie level. Features labelled in modern nomenclature.

5 miles wide paralleling the lake shore. The Plateau rises above the Lake Plain in a marked Escarpment. The Lake Plain is bounded at the shore of Lake Erie by a cliff ranging from 30 to 70 feet or more in height. The mean lake level is 571 feet, and the Lake Plain rises very gradually and almost imperceptibly from 600 or 620 feet at the top of the cliff above the lake to a little more than 700 feet at the base of the Escarpment. The Escarpment, a belt 1 to 3 miles wide, rises from the southern margin of the Lake Plain to 900 feet or more at the top of the Escarpment. The Plateau rises from the top of the Escarpment to 1,240 feet at the extreme southeastern corner of Leroy Township and continues to rise to over 1,300 feet farther south and southeast in Geauga County. The physiographic divisions are shown in figure 4, and a profile across the county is shown in figure 5.

ALLEGHENY PLATEAU

The Allegheny Plateau in Lake County is composed of Pennsylvanian sandstone near the south margin of the county and Mississippian sandstone, siltstone, and shale farther north. The Plateau declines from an elevation of 1,247 feet at the top of Little Mountain in southwestern Concord Township to about 900 feet at the northern edge of the Plateau at the top of the Escarpment. Except at a few places, especially in southern and southeastern Kirtland Township, the bedrock in the Plateau has only a thin cover of glacial till. In places the till is so thin that bedrock crops out in road ditches and cellar excavations. The streams have cut to bedrock, and bedrock is exposed along the valleys. In some places the valley walls are very steep and clifflike. At Little Mountain and at prominent hills in Chapin State Forest and south of Holden Arboretum in Kirtland Township very coarse basal Pennsylvanian sandstone crops out in picturesque cliffs.

END MORAINE BELT

Along the Escarpment is a belt from 1 to 3 miles in width trending from southwest to northeast across the county. In this belt thick till in the form of two ridges, the Euclid and Painesville Moraines, covers the bedrock to thicknesses of as much as 100 feet or more. The highest points on the crests of the ridges range from 775 to 940 feet. Streams have dissected the moraines in deep sharp valleys and cut through the till to expose bedrock in some places. The north margin of the end moraine belt is sharply delineated at 760 feet, where an earlier, high stage of glacial Lake Erie eroded a shore cliff or deposited beach sands.

INTERMORAINE LOWLAND

Associated with the end moraine belt is a lowland, in part dissected, lying between the Painesville and Euclid Moraines. The first part of this lowland extends from Willoughby Hills and Waite Hill northeast to the junction of Ellison Creek and Grand River in southern Painesville. This part is about 2 miles wide at Waite Hill, about a mile wide in Kirtland Hills, and less than ½ mile wide farther northeast. It has been dissected by the Chagrin River, East Branch Chagrin River, and their tributaries, but considerable original level surface remains. It is best preserved in the great flat in Waite Hill in the region of Waite Hill Road, Markell Road, Hobart Road, and to the southwest. The surface of this part of the lowland is a level expanse of silt and sand of various thickness that overlies till.

The second part of this lowland is in the valley of the Grand River from Ellison Creek northeast to the eastern border of Lake County. This part was originally a ½- to 1-mile-wide flat area of coarse sand and gravel within the valley and was built to the same level as that of the lowland to the southwest. This area is depicted as outwash on plate 1. After the lowering of the level of early Lake Erie, to which this deposit was graded, the Grand River cut down to its present position, leaving the remnants of the valley fill as terraces.

LAKE PLAIN

The Lake Plain is a level surface 3 to 5 miles wide and poorly drained in most places. The plain declines from an elevation of 760 feet at the base of the Painesville Moraine to 600-620 feet at the top of the cliff rising above Lake Erie. The surface is marked by several sand ridges, which contain some gravel and which mark the locations of shores of former higher levels of late-glacial Lake Erie. These ridges, which rise from 10 to 30 feet above the Lake Plain, are well drained, and from the earliest days main highways were located along North Ridge, South Ridge, and, at places, Middle Ridge.

LAKE BLUFFS

The north margin of the Lake Plain is an almost continuous cliff, broken only by valleys of streams entering Lake Erie: the Chagrin River, Marsh Creek (Mentor Marsh), the Grand River, and a few much smaller streams east of the Grand River. The bluff ranges in height from 20 to 50 feet above the waters of the lake and is everywhere composed of glacial material, in most places of two till units separated by silt, clay, and fine sand. At the top is a few feet to many feet of silt or sand. The bluff ranges from an almost vertical cliff to a more irregular steep slope where landsliding has occurred. The geology of the shore and its changing character is the subject of a report by Carter (1976).

VALLEYS

The Plateau and the Lake Plain are transected by the wide valleys of the Grand River and its tributary Big Creek and by the Chagrin River and its East Branch. Some of the tributaries themselves have tributaries of various lengths and depths of dissection. The floodplains of the rivers range in width from less than ¼ mile to more than ½ mile. These floodplains, ranging from a very few feet above stream level to second bottoms 20 feet or more above the stream, are composed of silt and some sand of various thickness, with bedrock or till below. The tributaries to the major streams have cut headward from a fraction of a mile to several miles. The largest of these have low gradients and narrow floodplains in their lower courses, but most have steep gradients and V-shaped valleys throughout most of their extent.

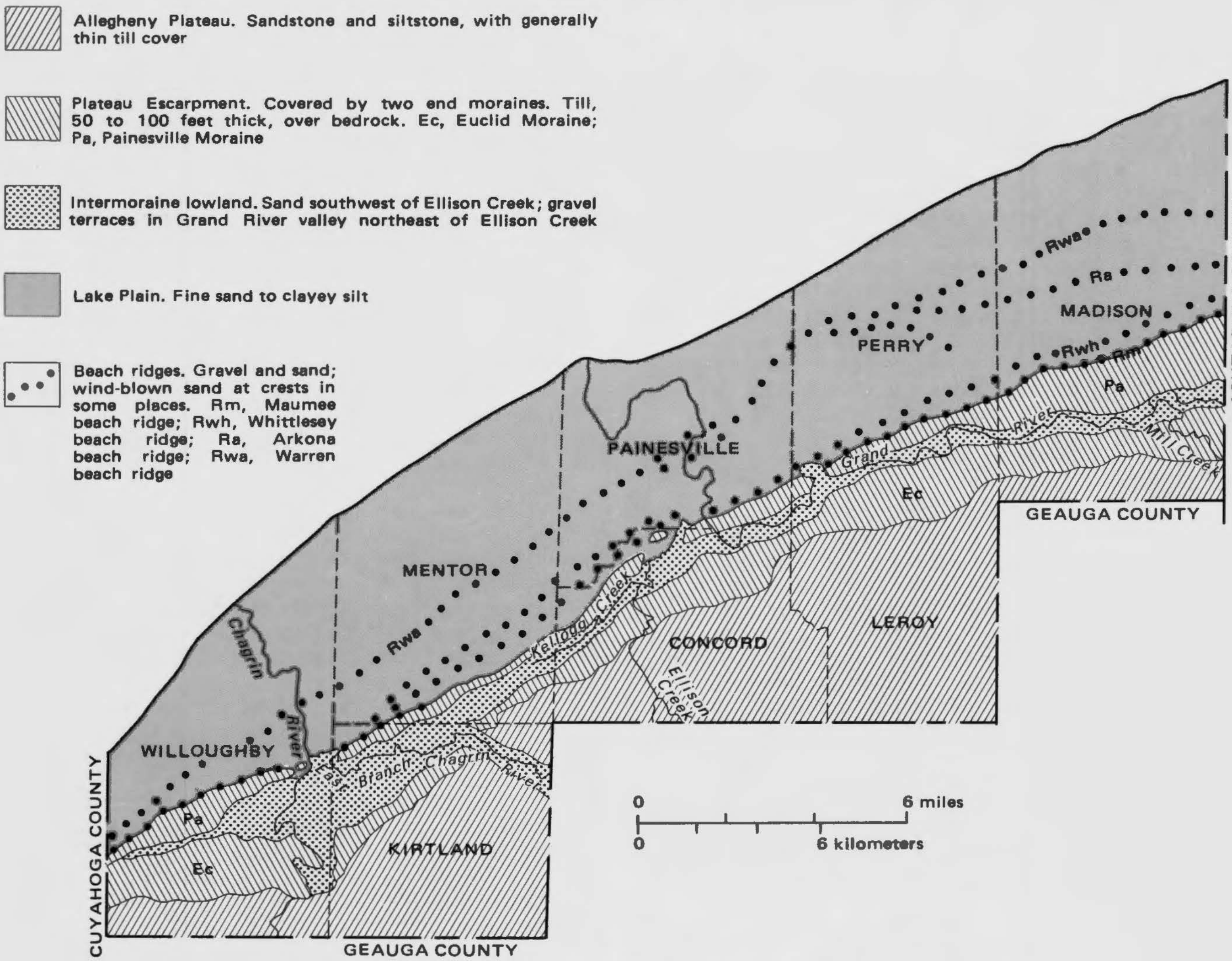


FIGURE 4.–Physiographic divisions of Lake County.

The walls of the major valleys above the floodplains are steep and clifflike, with bedrock (shale, except in the extreme southern part of the county) cropping out below a cover of glacial drift of various thickness. These deep valleys, with their steep sides, are considerable barriers to roads.

GEOMORPHOLOGY OF THE SURFICIAL MATERIAL

The surficial material overlying the bedrock in Lake County consists of glacial deposits, which in the northern half of the county have been more or less modified by erosion and deposition by the waters of the late-glacial predecessors of Lake Erie. These lakes stood at levels as much as 200 feet higher than Lake Erie does today. Later deposits of windblown sand occur at places upon and near the old beaches. Alluvial deposits are present along the major streams, in some places high above the present streams. This combination provides an unusual diversity of material and surfaces in Lake County.

GROUND MORAINE

Much of the surface of the Allegheny Plateau consists of bedrock-controlled ground moraine. In extreme southern Madison Township, in much of Leroy Township, in southern and southeastern Concord Township, in southernmost Willoughby Township, and in a belt about 2 miles wide in Kirtland Township south of East Branch Chagrin River, the northward-sloping bedrock is covered with a veneer of till, which at places may be less than 5 feet thick, so that the drift surface reflects the underlying bedrock surface. Sandstone crops out in some of the prominent high knobs. At places where the drift is somewhat thicker, the surface is very gently undulating. The fairly smooth ground moraine surface is cut by numerous narrow valleys and ravines, as shown on the glacial map (pl. 1). The walls of these valleys provide excellent exhibits of the bedrock with its very thin till cover.

The surface till is of Hiram age, but in places that till may be missing because of erosion or nondeposition, and earlier tills—Lavery, or even Kent—may be at the surface.

HUMMOCKY MORAINE

Strongly expressed constructional topography, commonly called "morainic topography," presents an irregular and hummocky appearance, with knolls or swells of 1 or 2 acres to 10 acres or more rising 10 to 20 feet above their bases. The till in these areas is markedly thicker than in the ground moraine areas and may reach thicknesses of more than 100 feet. Two kinds of hummocky moraine exist in Lake County—linear end moraines and irregular areas without linear trend.

END MORAINES

Two linear ridges of the end moraine belt are present all along the Escarpment at the north margin of the Plateau. They are separated by the Grand River valley east of Painesville and west of that city by the intermoraine lowland except in Wickliffe, where the ridges are separated by the valley of a stream tributary to the Chagrin River (fig. 5).

Euclid Moraine

A ridge which extends from Euclid in eastern Cuyahoga County northeast across Lake County has been named the Euclid Moraine (Leverett, 1902, p. 652). The southern border of this moraine is the northern boundary of the Allegheny Plateau proper. The moraine in Willoughby Township is about 1 mile wide except where it has been eroded by the Chagrin River in the eastern margin of the township. Across this township the southern margin of the moraine is marked by a small westward-flowing stream in a shallow valley and by an eastward-flowing stream which is tributary to the Chagrin River and which has cut a deep ravine. Chardon Road follows the crest of the moraine, which ranges from 850 to 890 feet in elevation, rising about 50 feet above the base at the south and 100 to 120 feet above the base at the north. The northern margin in Willoughby Township is marked by a linear depression, which is occupied for a short distance in the extreme western part by a small westerly-flowing stream. The eastern part is occupied by a stream flowing in a generally easterly direction, then northeasterly to the eastern margin of Willoughby Township, where it joins the Chagrin River. I-90 follows this depression from just northeast of the I-271 interchange to the Chagrin River valley. In this stretch the north margin of the Euclid Moraine is dissected by deep ravines tributary to the east-flowing Chagrin River tributary. The ridges with their preserved hummocky topography between the steep-sided ravines provide picturesque settings for houses and for a golf course. The moraine has been completely eroded by the Chagrin River where that stream crosses the moraine in eastern Willoughby Township and western Kirtland Township.

Across Kirtland and Mentor Townships the Euclid Moraine is only about ½ mile wide or even a little less. Its crest is somewhat lower than to the east, reaching 850 feet in only a few places. The moraine in some of its course across these townships is weakly developed and entirely cut through by deep ravines tributary to East Branch or by East Branch itself. The southern margin of the moraine is against the ground moraine of the Plateau or the earlier nonlinear hummocky moraine. The northern margin makes a distinct break in slope at about 800 feet at the sand and silt plain of the intermoraine lowland.

Across Concord Township the crest of the Euclid Moraine ranges from 840 to 870 feet in elevation and from less than ½ mile to somewhat over a mile in width. The moraine is cut entirely through by the valleys of Ellison Creek and Big Creek. The southern edge is marked along much of its course by marginal streams. The northern margin is marked distinctly by the intermoraine lowland in the western part of the township and by the valley of the Grand River in the eastern part.

Across Leroy and Madison Townships the crest of the Euclid Moraine rises from about 880 feet in the southwest to 940 feet in the northeast. Across these townships the width ranges from ½ to 1 mile. The moraine is completely transected by many steep-sided valleys, some of which, owing to piracy of former marginal streams, have sharp doglegs at the moraine margin. The southern edge is marked by a series of marginal valleys. The northern margin is marked by the valley of the Grand River. In eastern Madison Township the moraine appears to consist of two parallel ridges, between which are east-west valleys occupied by

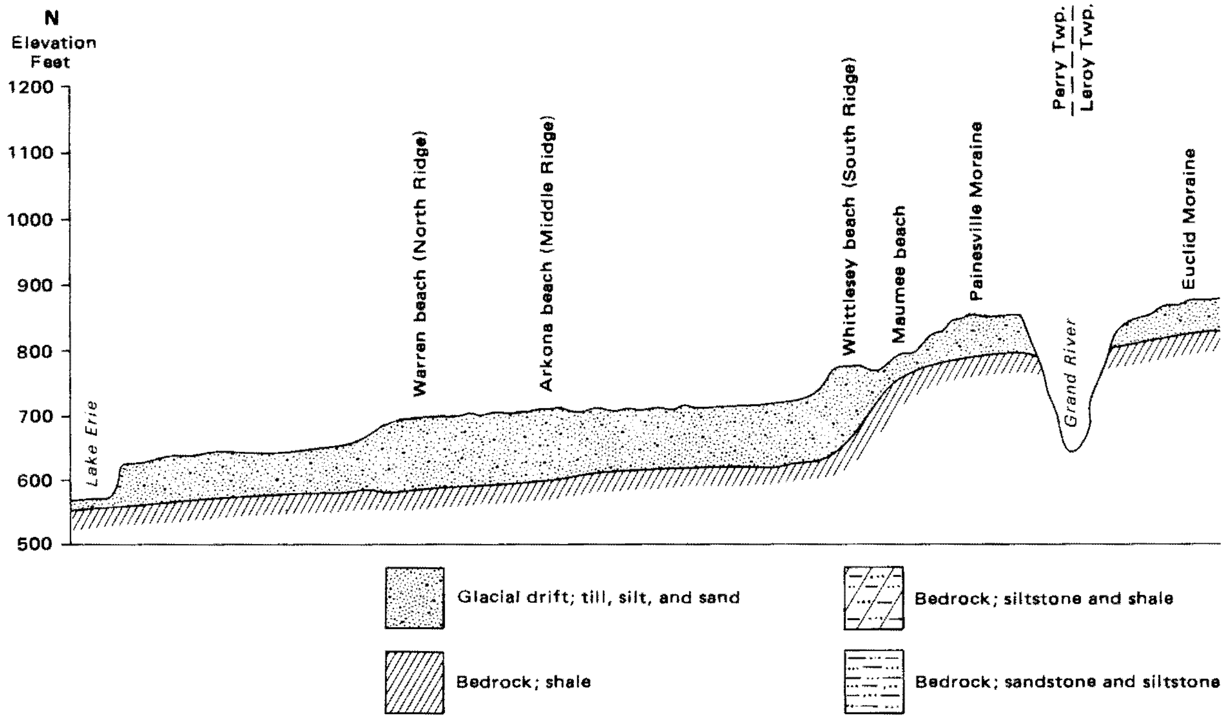


FIGURE 5.—North-south cross section through

lower Griswold Creek, part of Mill Creek, and an easterly flowing tributary to Mill Creek.

The surface material of the Euclid Moraine is the Ashtabula Till, here in its southernmost extent. This till is very thin in some places, and earlier till is close to, or even at, the surface. The bulk of the moraine is made up of several pre-Ashtabula tills.

Painesville Moraine

The Painesville Moraine, named by Leverett (1902, p. 651), extends from the Lake-Cuyahoga County line northeast across Lake and Ashtabula Counties and across Pennsylvania to New York. This moraine is north of the Euclid Moraine and parallel to it; the two are separated by a depression (the intermoraine lowland) as much as 2 miles wide in part of Kirtland Township, but elsewhere much narrower. This depression in the northeast half of its course is occupied by the Grand River, which has cut a gorgelike valley.

That part of the Painesville Moraine from the Lake-Cuyahoga County line to Painesville ranges from less than ¼ mile to about ½ mile in width. In places erosion has removed the moraine or reduced it to mere fragments. It has been reduced in width by wave erosion on the north side at the high level of glacial Lake Erie (glacial Lakes Maumee II and Whittlesey) and on the south by cutting of meanders by the Chagrin River, East Branch Chagrin River, and Ellison Creek and by ravines tributary to East Branch.

From Painesville northeast to the Lake-Ashtabula County line the Painesville Moraine ranges from ½ to about 2 miles in width. Two miles east of Painesville a northward-migrating incised meander of the Grand River has entirely removed the moraine for ¾ mile. The northern margin from Painesville northeast has been trimmed at 760 feet by wave erosion of glacial Lake Maumee; along part of this margin a gravel or sand beach, quite similar to the narrow beach along parts of the present Lake Erie shore, is present.

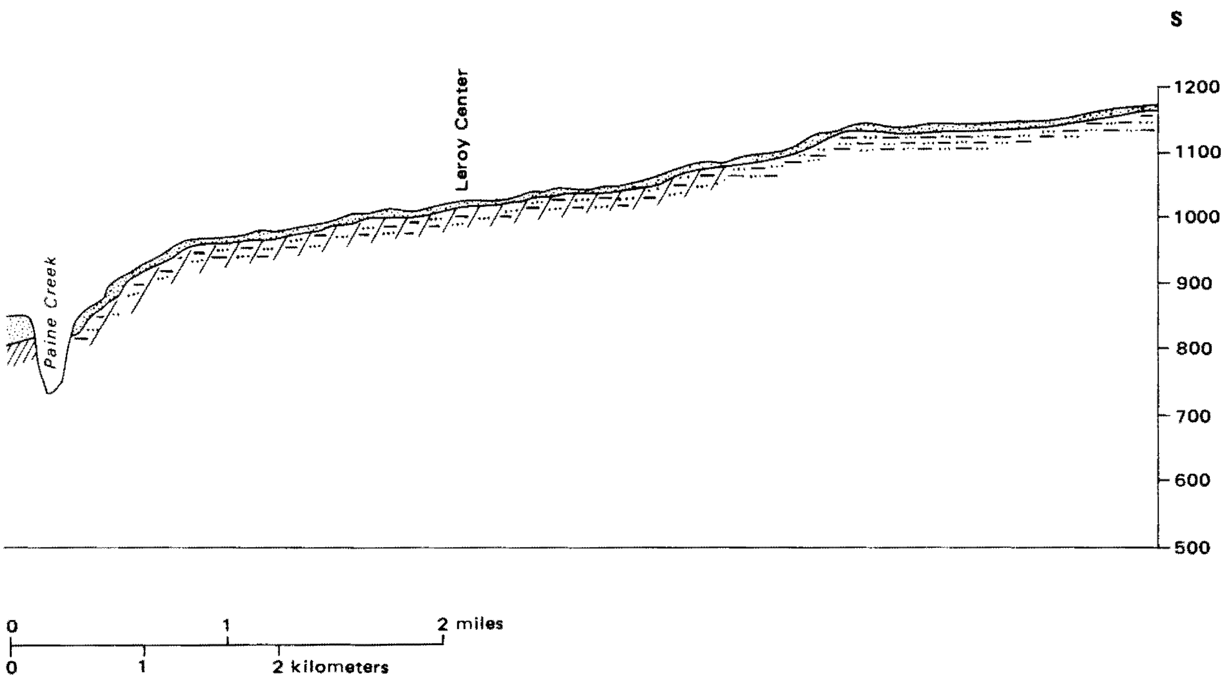
The Painesville Moraine ranges in elevation from about 780 feet on the southwest to 800 feet at the Wickliffe-Willoughby Hills boundary and in Kirtland Township. Its elevation is less than 800 feet across Mentor Township and western Painesville Township, probably because of washing and erosion at the time of deposition, when water stood at 760-770 feet in the intermoraine lowland. Across eastern Painesville, Perry, and Madison Townships the crest of the Painesville Moraine rises from 800 feet to 860 feet at the Lake-Ashtabula County line.

The moraine has a hummocky surface throughout its course, quite weak in Kirtland Hills and most prominent in Perry and Madison Townships, where knolls as high as 20 feet are present. Only a few generally shallow kettle holes are present in this moraine, partly because they have been cut into by headward erosion of streams flowing in ravines down the north and south sides of the moraine.

The material at the surface of the Painesville Moraine is Ashtabula Till and ranges in thickness from a very few feet to 20 feet or more. Below the Ashtabula Till are earlier tills, which make up the bulk of the moraine.

HUMMOCKY TOPOGRAPHY WITHOUT LINEAR TREND

Areas of hummocky topography that do not have the linear trend of the end moraines are found on the Plateau south of the Euclid Moraine. This topography was formed



Perry and Leroy Townships, Lake County.

by irregular deposits upon and adjacent to masses of stagnant ice in the waning stages of glaciation and is generally related to depressions, mainly ancient valleys, now more or less buried by drift. The drift of these hummocky areas is thicker than that of the ground moraine and is composed of deposits made at different times. In places till can be seen to overlie kame gravel; at other places drilling reveals kame gravel at greater depths below a thicker till cover.

The major area of hummocky topography without linear trend is in Kirtland Township south and southeast of the Euclid Moraine. This tract, with its undulating to sharply hummocky topography, contrasts with the smooth ground moraine surface of the other parts of the Plateau. The sharpest knolls, some of them 30 feet or more high, are along the valley of East Branch Chagrin River, where they are associated with gravel knolls–kames. Kettle holes–depressions left by the melting of detached ice blocks of the disappearing glacier–are between the knolls; some of the kettle holes contain bodies of water.

Smooth bedrock knobs rise through the drift of this area of hummocky topography. The most prominent of these are the conical knob ½ mile southeast of Parks Corners, the dumbbell-shaped hill crossed by Sperry Road 1¼ miles northwest of the southeast corner of Kirtland Township, and the elongate hill in Chapin State Forest.

This area is in part dissected by deep ravines. Between the ravines the undulating to sharply hummocky surface superimposed upon the northward and northwestward slope of the Plateau provides some of the most picturesque settings in Lake County. The combination of slope and somewhat more pervious drift of this tract provides fair to excellent drainage of specific sites.

A smaller area of hummocky topography is found in a narrow tract in extreme southwestern Willoughby Township, just south of the Euclid Moraine. Here the hummocks are so weak that they are merely undulations, and the drift is not nearly as thick as in the large tract in Kirtland Township. A similar narrow tract, parallel to I-90, lies on either side of Ellison Creek in Concord Township, extending from the west line of the township to the interchange of I-90 and Ohio Route 44. The topography in this tract is weakly constructional and the drift rather thin, but more constructional than that of the ground moraine to the south.

The surface material of these areas is generally Hiram Till, but because this till is thin and at some places lacking, the material at or very near the surface may be Lavery Till. At places the still older Kent Till is close to the surface.

KAMES AND KAME TERRACES

Kames are separate knolls of gravel. The southern part of Kirtland Township, through which U.S. Route 6 passes, contains some kames, but these have more or less till over them, and their exact extent cannot be determined. Kames are near the surface in the region of the cemetery on U.S. Route 6, about $^{2}/_{3}$ mile east of County Line Road. Some buried kames may underlie till at a few places in the Painesville Moraine; gravel knolls are present in that moraine in Madison Township $^{1}/_{2}$ mile west of Ledge Road (Ohio Route 528), $^{3}/_{8}$ mile north of the Grand River.

Kame terraces are terraces with generally irregular surfaces made up of interspersed kames and kettle holes. The terraces, which rise from a few feet to more than 100 feet above valley floors, were formed by meltwater flowing over and along linear ice masses persisting in the valleys after the uplands became free of ice. The central depression in the valleys is the linear hole left by the melting of the last ice mass. Present-day streams flow through these depressions, but some of the depressions are yet undrained and are the sites of lakes or swamps.

Kame terraces on either side of East Branch Chagrin River in Kirtland Township rise 50 feet to almost 100 feet above the floodplain. The terraces, which are extensive in Geauga County on the south and extend northward into Lake County for about 2 miles, are more than ½ mile wide at the county line, but become much narrower to the north. Northward in Kirtland Township from the point where East Branch leaves the county to the southern corporation boundary of Kirtland Hills, the form of the kame terrace on the west side of the valley continues, but the original gravel terrace is covered by till, and the gravel is concealed. The basins of Corning Lake and Hourglass, Heath, Blueberry, and Foster Ponds are kettle holes, deep enough to extend below the water table, and hence partly filled by water. These ponds are probably spring fed by water emerging from the gravel beneath the till cover.

LACUSTRINE DEPOSITS

Deposits of the succession of glacial lakes which had levels as much as 200 feet higher than present Lake Erie cover the Lake Plain and intermoraine lowland, the locations of which have already been described in the section on physiography.

INTERMORAINE LOWLAND

The deposits of the intermoraine lowland area have a level surface, except where dissected by stream erosion. The largest undissected areas are in Waite Hill and northeast from Kirtland Hills for 3 miles. The level surface is formed by deposits of sand and silt, which may reach a thickness of 20 feet or more. This material was deposited in waters of an early Lake Maumee, which formed a large bay between the Euclid and Painesville Moraines. The Chagrin River and East Branch Chagrin River flowed through the Euclid Moraine into this bay, and thence to early Lake Maumee at the Painesville Moraine. The sand and silt deposits in this bay are partly beach material at the mouth of the bay and partly sediment brought into the bay by the streams entering it.

LAKE PLAIN

The Lake Plain proper is a surface that slopes very gently from an elevation of 760 feet at the base of the Painesville Moraine northward to the present lake bluff. This poorly drained surface is very smooth, except for ancient beach ridges and some windblown mounds. The surface is silt and sand, which are the bottom deposits of a series of late-glacial lakes. The silt and sand range in thickness from only a very few feet to 20 feet or more and rest upon till which was eroded to a smooth surface by the waves of the earlier lakes.

Raised beaches

Upon the Lake Plain are linear sand and gravel deposits which mark the shores of late-glacial lakes. These beaches have been the subject of extensive study for over 100 years by Whittlesey (1869), Leverett (1902, 1931), Carney (1916 and references therein), and Forsyth (1959 and references therein), but none of these studies dealt in great detail with the beaches in Lake County. The various levels of the glacial lakes which preceded the present lake have been dealt with in detail by Leverett (1931, p. 96-103). More recently, detailed study by Totten (*in* White and Totten, 1979, p. 27-40) in adjacent areas is applicable to Lake County. Totten's work, based on study of recent topographic maps (scale 1:24,000), air photos, and recent detailed soil maps (Ritchie and Reeder, 1979), on field observations, and on subsurface study, indicates that the cliffs are older than the beaches, which are ridges built upon the older terraces in front of the cliffs. The successive levels of the beach ridges are shown in figure 6. Plate 1 shows these beaches and their forms and locations, so only a general description is needed here. These beaches (fig. 5) are well-known geographic features in Lake County and from the earliest times have been the sites of roads and settlements.

Maumee II beach.–The highest lake in Lake County had an elevation of about 760 feet. The waters of this lake, Lake Maumee II, cut a small cliff along the base of the Painesville Moraine at some places, and a narrow discontinuous beach was deposited, as shown on plate 1. The beach in Madison Township is large enough to have been a limited source of sand and gravel at a few places. The beach can be traced southwest across Perry Township, but becomes obscure in Painesville Township east of the Grand River. West of the Grand River this beach continues southwest at an elevation of about 760 feet, but its tracing in Mentor and Willoughby Townships is uncertain. At the Lake-Cuyahoga County line it is probable that the 760-foot beach has been cut into by the waters of the next lower lake.

Whittlesey beach.–One of the most prominent beaches in Lake County is South Ridge, the beach of glacial Lake Whittlesey. As shown on plate 1, this sand and gravel ridge extends from Unionville at the Lake-Ashtabula County line through Madison and thence to Painesville. Across Madison and Perry Townships, this beach lies about ½ mile north of the base of the Painesville Moraine and of the discontinuous Maumee II beach. Across eastern Painesville Township, the beach lies against the Painesville Moraine, and at places the waters of the lake cut a cliff in the moraine. West and southwest of the Grand River the beach continues across Painesville, Mentor, and Willoughby Townships, where it is about ½ mile north of the Painesville Moraine, except west of the Chagrin River, where the beach is at the base of the Painesville Moraine; at places in Willoughby Township there is a small beach at the base of a distinct cliff. The beach rises to an elevation of as much as 740 feet along its course, but in many places sand dunes on the beach reach elevations of 750 feet or even a little more. Across southwestern Painesville Township and Mentor Township the beach is made up of two ridges separated by a narrow sand flat. The beach ranges from less than ⅛ to as much as ¼ mile wide, but the greater width is unusual.

The material of the beach is sand and gravel, ranging in thickness from a few feet to more than 20 feet. There are gravel pits along its course, as shown on plate 1, but none of these is active at present.

Arkona beach.–The Arkona beach, which is Middle Ridge, is discontinuous in Madison Township, where it is the site of Middle Ridge Road; in Perry Township, where it is the site of Narrows Road; in Painesville and eastern Mentor

Townships, where it is occupied by several streets; and in western Mentor Township, where it is occupied by Johnnycake Ridge Road. The Arkona beach is not as continuous nor as prominent in Lake County as the Whittlesey or Warren beaches. The diffuse gravel deposit at elevation 690 feet south of North Ridge in Painesville, east of the Grand River, probably represents Arkona sands and gravels spread out along the Arkona lake shore and partly derived from the Grand River of that time.

Elevation of the Arkona beach ranges from 680 to 720 feet. It is younger than the Whittlesey beach and lower than that beach. This is at variance with the earlier assumption that the Arkona beach is older and was later submerged; this assumption cannot now be substantiated in adjacent Ashtabula County (Totten, *in* White and Totten, 1979, p. 39).

Warren beach.—Another prominent beach in Lake County is North Ridge, the beach of glacial Lake Warren. As shown on plate 1, this sand and gravel ridge extends across Madison Township through North Madison and North Perry and thence to Painesville. For over 2 miles, in the vicinity of the Grand River at Painesville, the beach is very diffuse; although much sand and gravel was deposited in the lake at this stage, a single ridge was not formed. From Painesville, North Ridge extends across Mentor Township and through Willoughby to Wickliffe. From the earliest days it was the location of an important highway, which is now Euclid Avenue at the Lake-Cuyahoga County line and U.S. Route 20 all the way across Lake County.

The Warren beach ranges in width from about 1/8 mile to almost 1/4 mile, and is somewhat wider than 1/4 mile east of the Grand River. The crest of the beach reaches an elevation in some places of 685 feet. Where sand dunes are located along the beach crest, as in Madison Township, the elevation of the crest is higher than in other areas.

The Warren beach is composed of sand and gravel. It is the site of the only active gravel pit in Lake County at the present time; this pit is located just east of the Grand River and north of Casement Airport in Painesville. Thicknesses of sand and gravel of as much as 20 feet are known, especially where windblown sand rests upon sand and gravel of the beach.

Elkton beach.—The lowest in the series of beaches on the Lake Plain is the Elkton beach. In western Lake County this beach extends from the Lake Erie shore in northern Willoughby Township across western Mentor Township, where Lake Shore Boulevard follows the crest of the beach. The beach has an elevation at the crest of about 625 feet and rises 20 feet or more above the Lake Plain on either side. The beach is as much as 1/2 mile in width east of Marsh Creek in Mentor. Farther east, in Painesville, this beach becomes much wider and more diffuse, and the ridgelike form is not evident, and is not shown on plate 1. The beach

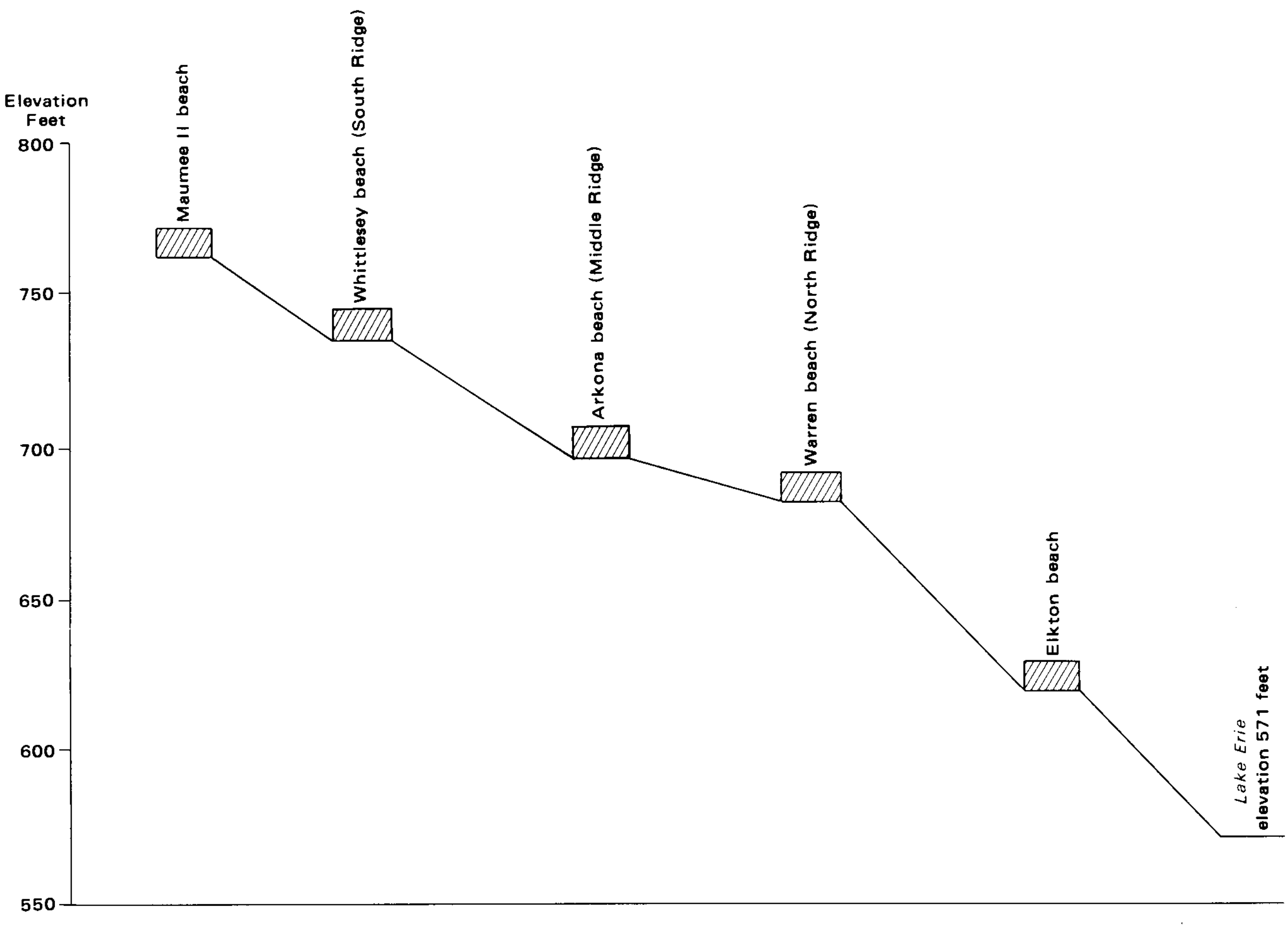


FIGURE 6.—Beaches of glacial Lake Erie in Lake County (compare with Leverett, 1931, fig. 9).

consists rather of broad expanses of sand and silt. The material of the Elkton beach is mainly sand with a few pebbles; as much as 10 feet of sand has been observed.

Sandy material extending to the lake shore in northwestern Madison Township on the north side of an east-west stream just south of Chapel Road may have been deposited along the shore of glacial Lake Elkton, but the ridgelike form of this feature is not evident.

ALLUVIAL AND TERRACE DEPOSITS

FLOODPLAINS

The floodplains of the streams are low, level, poorly drained belts subject to frequent inundation by flood waters. The streams, as they have changed course in the bottom of their valleys, have cut the floodplains, and the surfaces have been covered by silt and sand deposited by the flood waters. In the bends of meanders, successive bars (point bars) have been deposited as the stream migrated to form a larger meander loop and cut into the opposite bank to form a cliff. These deposits range in thickness from a thin veneer over bedrock to many feet. The different materials—silt, sand, and some gravel—are differentiated in great detail on the soil maps of the county (Ritchie and Reeder, 1979).

A few feet above the floodplains of some of the streams are slightly older floodplains, the second bottoms, which are now partly removed by erosion and are better drained than the first bottoms adjacent to the streams. The second bottoms form low terraces of sand or silt and are inundated in the highest floods. These low terraces are shown in detail on the soil maps.

HIGH TERRACES

At much higher levels above the larger streams are terraces which are remnants of ancient floodplains, formed when the streams were flowing at that elevation. Later the streams cut down, removing most of the older floodplain, leaving only terrace remnants. These terraces are present at levels which seem to have been controlled by the level of the late-glacial lakes into which the major streams flowed. The detailed study and analysis of these terraces would be an interesting project, but does not come within the scope of this report.

These high terraces generally slope gently toward the stream, because they were formed as slip-off slopes on the floodplain across which the stream that formed them was migrating. The material is quite varied, ranging from silt through sand to gravel. Some terraces have been cut upon bedrock and have only a thin veneer of sediment, but others are composed of many feet of sediment.

Prominent terraces are present along the Grand River. In Madison Township, a particularly fine series, the highest of which is at an elevation of about 800 feet, may be seen east and west of Ledge Road (Ohio Route 528) and in the valley of Mill Creek. Excellent terraces are present along the valley in Perry and Concord Townships, where the elevation of the highest one is about 750 feet, apparently correlating with the 800-foot terrace farther upstream.

Extensive high terraces are present in the valleys of the Chagrin River and of East Branch Chagrin River. The highest terraces along East Branch, in Kirtland Hills, are at an elevation of 820-830 feet; elevations decline downstream to the intermoraine lowland surface at about 800 feet. Below the highest terrace are one or more lower terraces cut below the intermoraine lowland surface. The terraces are a veneer of sand and silt of various thickness over bedrock.

High terraces are present at several levels in the Chagrin River valley (fig. 7). The highest terraces, at 740-730 and 690 feet, were cut when the Chagrin River flowed into a controlling late-glacial lake. The Chagrin River valley terraces have surfaces of silt, sand, and gravel. As much as 10 feet of gravel was exposed in a pit above the river near Rogers Road at the south boundary of the county.

PLEISTOCENE STRATIGRAPHY

The glacial deposits of Ohio resulted from several ice

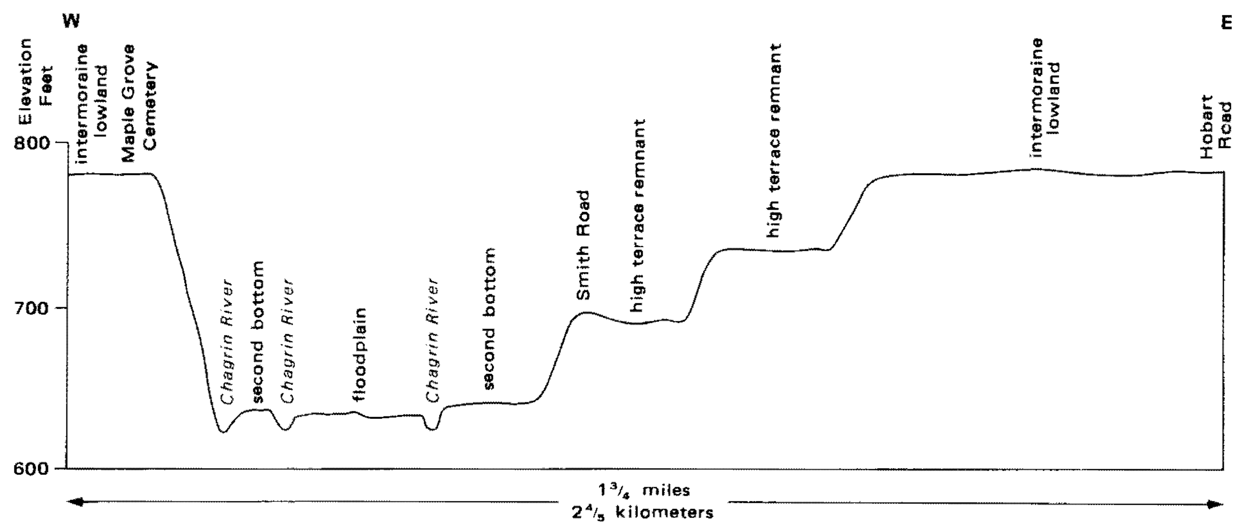


FIGURE 7.—Profile of terraces across the Chagrin River valley from Maple Grove Cemetery in Willoughby Hills, Willoughby Township, eastward to Hobart Road in Waite Hill, Kirtland Township, Lake County. Profile is across two bends of the river.

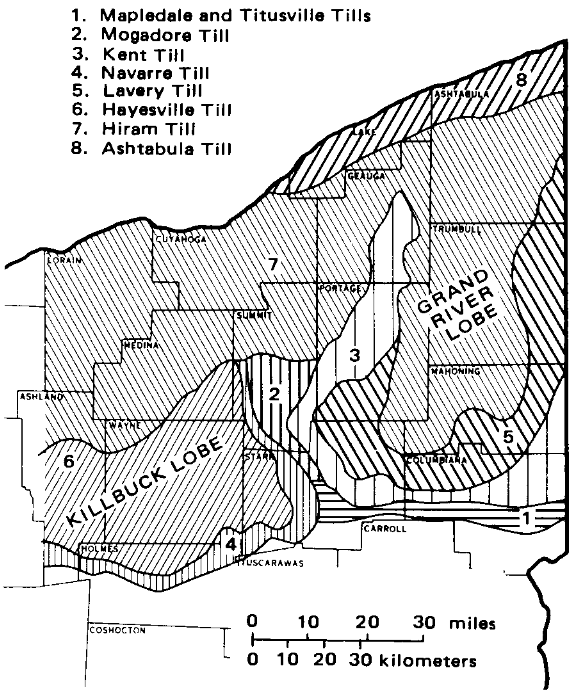


FIGURE 8.–Glacial lobes and tills in northeastern Ohio.

advances during the Pleistocene Epoch. The ice flowed southwest through the Erie basin, from which sublobes of ice extended into the lowlands south of Lake Erie (fig. 8): the Grand River lobe in the Grand River Lowland, the Killbuck lobe in the lowland west of the Grand River Lowland, and the Scioto lobe in the great lowland in central and western Ohio; other lobes existed farther west. The glacial deposits of Lake County are those of the main Erie lobe, from the center of which the ice advanced into Lake County in a general southerly direction.

CLASSIFICATION

Four major glacial stages of the Pleistocene Epoch, separated by warmer interglacial intervals, are generally recognized in the central United States. These divisions, their representation in Lake County, and the postglacial episode are shown in table 1.

Evidence for the advance into northern Ohio of the ice of the Nebraskan and Kansan glacial stages is indirect; no deposits of these early ages can be positively identified in Lake County, although Nebraskan and Kansan deposits have been identified much farther south in the Cincinnati region. Deposits of Illinoian age are known in adjacent counties, and very thin deposits of much weathered drift found in a very few places in Lake County may be of Illinoian age. It is possible that lower deposits in the southern part of the county in the deep buried valleys now occupied by the Chagrin River and East Branch Chagrin River may be of Illinoian age, but direct evidence of this is not now at hand. The great bulk of the drift in Lake County is Wisconsinan in age, deposited at five different times by separate ice advances, as shown in table 2.

COMPOSITION AND CHARACTERISTICS OF TILLS

The various tills in northeastern Ohio differ among themselves in texture, mineral and lithologic composition, color, and weathering horizons. These characters are dealt with in more or less detail in several publications describing the glacial geology of Ashland (White, 1977), Ashtabula (White and Totten, 1979), Cuyahoga (White, 1953a), Geauga (Baker, 1957), Portage (Winslow and White, 1966), Richland (Totten, 1973), Stark (White, 1963), Summit (White, 1953b), Trumbull (White, 1971), and Wayne (White, 1967) Counties, and of the Allegheny Plateau in general (White, 1969). In Lake County the area of each till exposed at the surface is relatively small. The till of the northern half of the county has been partly eroded by the waves of the glacial lakes that preceded present Lake

TABLE 1.–*Glacial stages*

Epoch	Stage	Remarks
Holocene (Recent)		Windblown sand Stream deposits
Pleistocene	Wisconsinan Glaciation	Most drift of Lake County; several divisions, see table 2
	Sangamonian Interglaciation	Period of weathering and erosion; rare buried soils (paleosols) may be of this age
	Illinoian Glaciation	Possibly rare much weathered material
	Yarmouthian Interglaciation	
	Kansan Glaciation	Not known in Lake County
	Aftonian Interglaciation	
	Nebraskan Glaciation	Not known in Lake County

TABLE 2.–*Ice-laid deposits*

Epoch	Stage	Substage	Unit	Color (oxidized)	Color (unoxidized)	Texture
Pleistocene	Wisconsinan	Woodfordian	Ashtabula Till	Brown	Gray	Silty, clayey
			Hiram Till	Dark brown	Gray	Clayey, few pebbles
			Lavery Till	Brown	Gray	Silty, clayey, moderate number of pebbles
			Kent Till	Yellow brown	Gray	Sandy, coarse
			Paleosol			
		Altonian	Titusville Till	Olive brown	Gray	Sandy, stony, hard
			Paleosol			
	Pre-Wisconsinan		Rare weathered till			

Erie. The thickest drift is present in the relatively narrow end moraine belt. The till of the Allegheny Plateau is thin in most places. For these reasons stratigraphy and characteristics of the tills in Lake County are not simple and must be confirmed from adjacent regions where the tills are more extensively displayed.

TEXTURE

Tills in northern Ohio range from quite sandy tills with a quite low clay content to clayey tills with a low sand content. The texture of each till is reasonably constant over a large area. Most of the tills of Lake County are clayey or silty, but some sandy till is found in southern Kirtland Township.

MINERAL COMPOSITION

Tills differ in content of quartz, feldspar, and carbonate minerals. The quartz and feldspar contents of Lake County tills have not been investigated, but some assumptions can be made on the basis of the percentages of these minerals in the tills of adjacent areas, where quartz ranges from 72 to 82 percent, being greater in the older tills, and feldspar ranges from 8 to 28 percent, being greatest in the youngest tills. The carbonate content of Lake County tills ranges from less than 5 percent to more than 15 percent, and is composed of calcite and dolomite.

COLOR

Unaltered tills are various shades of gray, and color variations are subtle. Exposures of unoxidized till may be seen along steep valley walls, along the Lake Erie bluff, and in deep excavations. The oxidized tills are brown, ranging from dark brown to dark yellow brown to yellowish brown. The oxidized tills of most of Lake County are generally dark brown, tending toward chocolate brown, except for the rarely exposed older tills, which are yellow brown or olive brown.

WEATHERING HORIZONS

Where the upper part of a till has not been removed by erosion or the work of man, tills can be divided vertically into five distinct horizons, based on degree of weathering, as shown in figure 9. In the weathering of till the first minerals to be attacked are the iron-bearing minerals, especially pyrite. These are oxidized, furnishing the brown color to the weathered till. Carbonates are leached, and the most resistant minerals, the silicates, are degraded.

Horizon 5 is the unaltered till; the iron-bearing minerals have not been oxidized, and the carbonates have not been leached. This horizon is sometimes called "blue clay with stones," but the color is actually some shade of gray, rather than blue. Its top is 10 feet or more below the surface. In Lake County unweathered gray till may be seen in the upper parts of the cliff sections along the major streams and in the bluffs of the Lake Erie shore.

Horizon 4 is calcareous till similar to that of horizon 5, except oxidized to a brown color. The top of horizon 4 is also the depth of leaching, which ranges from less than 2½ feet below the surface to as much as 5 feet in some places.

Horizon 3 is similar to horizon 4, except that in horizon 3 the carbonates have been leached. Iron oxide and manganese stains may be present along joints.

Horizon 2 (essentially the B3 horizon of soil scientists) is the zone of decomposed till underlying the main part of the true soil. This horizon is not only oxidized and leached, but is also considerably weathered, and some of the pebbles and cobbles may have been decomposed. Some clay material has accumulated in the joints, and soil-forming processes are

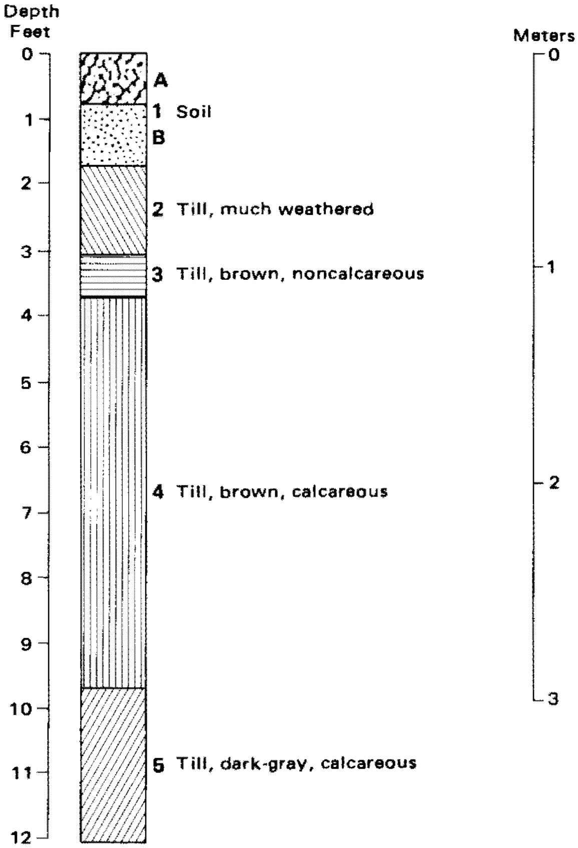


FIGURE 9.–Weathering horizons of Ashtabula Till in cut through the Euclid Moraine for I-90 at the east bluff of Big Creek, 3 miles southeast of Painesville.

advanced. The material is not so completely weathered, however, that it cannot be identified as once having been till. The color of the upper part is generally a mixture of buff, gray, and brown. The lower part may have dark stains along the joints.

Horizon 1 is the soil, divided into the A and upper B soil horizons of soil scientists. The characteristics of the soil differ with drainage and slope, as well as with parent material.

Well-preserved and complete weathering horizons are found along the Euclid and Painesville Moraines and at places in the Plateau. In the Lake Plain, wave erosion has removed the upper part of the till and then covered it with silt or sand, so that a normal weathering profile is not present in the till. On the Plateau the till is generally thin, and on slopes erosion has removed some of the weathered material.

TILL DEPOSITS

Except for very rare, thin, much weathered till found on bedrock below later, fresher tills, all the glacial deposits of Lake County are of the Wisconsinan Stage, the latest stage in glacial history (table 2). Deposits of several advances of the Wisconsinan ice are sufficiently distinctive to be separated in the exposures where they may be seen (figs. 10, 11, and 12). It is to be expected that, in any very large exposure showing considerable thickness of glacial material, the glacial material will have been deposited by more than one ice advance and will differ more or less in character. Lake County is a county of limited north-south extent and consists of a narrow Lake Plain and a narrow extent of Plateau, so that clearly defined successive belts of several different tills do not occur, as they do in counties with a greater north-south extent (fig. 8). The original surface till of the Lake Plain has been eroded, so that in some places beneath the silt or sand cover the till is not the last one deposited. In the Plateau, the drift is generally very thin; the last ice sheet to invade the Plateau–the Hiram ice–may have deposited little or no till in some places, so that the surface till is not Hiram, but the earlier Lavery Till.

PRE-WISCONSINAN TILLS

A calcareous very silty very sparingly pebbly till, of which the uppermost 3½ feet was seen in a cut on the north side of I-90, just west of the overpass of Chillicothe Road, Mentor Township, may be a pre-Wisconsinan till. The till lies below silt and gravel, the uppermost 5 feet of which is weathered; the silt and gravel in turn lie below 4 feet or more of Hiram and Kent Tills. This till resembles no early Wisconsinan till, but also is not like the Illinoian till seen at several places in Cuyahoga County (White, 1953a, p. 36).

Much weathered colluvium, which includes decomposed crystalline fragments, underlies calcareous tills at the south margin of the Euclid Moraine ⅜ mile east of the west line and ⅞ mile north of the south line of Madison Township. The weathered fragments may be the remains of an early pre-Wisconsinan till.

These much weathered materials, rarely present in the section, are remnants of deposits of an ice sheet earlier than Wisconsinan. It is not possible to determine their age more closely.

TITUSVILLE TILL

The oldest till of Wisconsinan age exposed in the county is the Titusville Till, named for Titusville, Pennsylvania (White and Totten, 1968; White, Totten, and Gross, 1969, p. 23). The Titusville Till has been traced from Titusville into Ohio. In Ohio the Titusville Till is present at the surface in a narrow belt in Columbiana and Stark Counties and has been traced beneath later tills throughout the Grand River lobe and into Lake County. It is seen in Lake County only in cuts deep enough to penetrate the overlying tills. The Titusville Till is exposed in a cut on the north side of Seeley Road, ¼ mile northeast of the bridge over Paine Creek at Indian Point, Leroy Township, where 20 inches of Titusville Till overlies shale, and is capped by a pavement of boulders up to 22 inches in diameter (fig. 10, section 35). This till may be present in considerable thickness beneath later tills in southern Kirtland Township, where the total drift thickness may exceed 100 feet.

The Titusville Till is very sandy, coarse, and pebbly. It is very compact and dark gray where unoxidized; where oxidized, it is a distinctive olive-brown color with dark manganese stains on joint surfaces, in contrast with the younger Kent Till, which is yellow brown, and Lavery, Hiram, and Ashtabula Tills, which are darker brown, with a chocolate-brown tint.

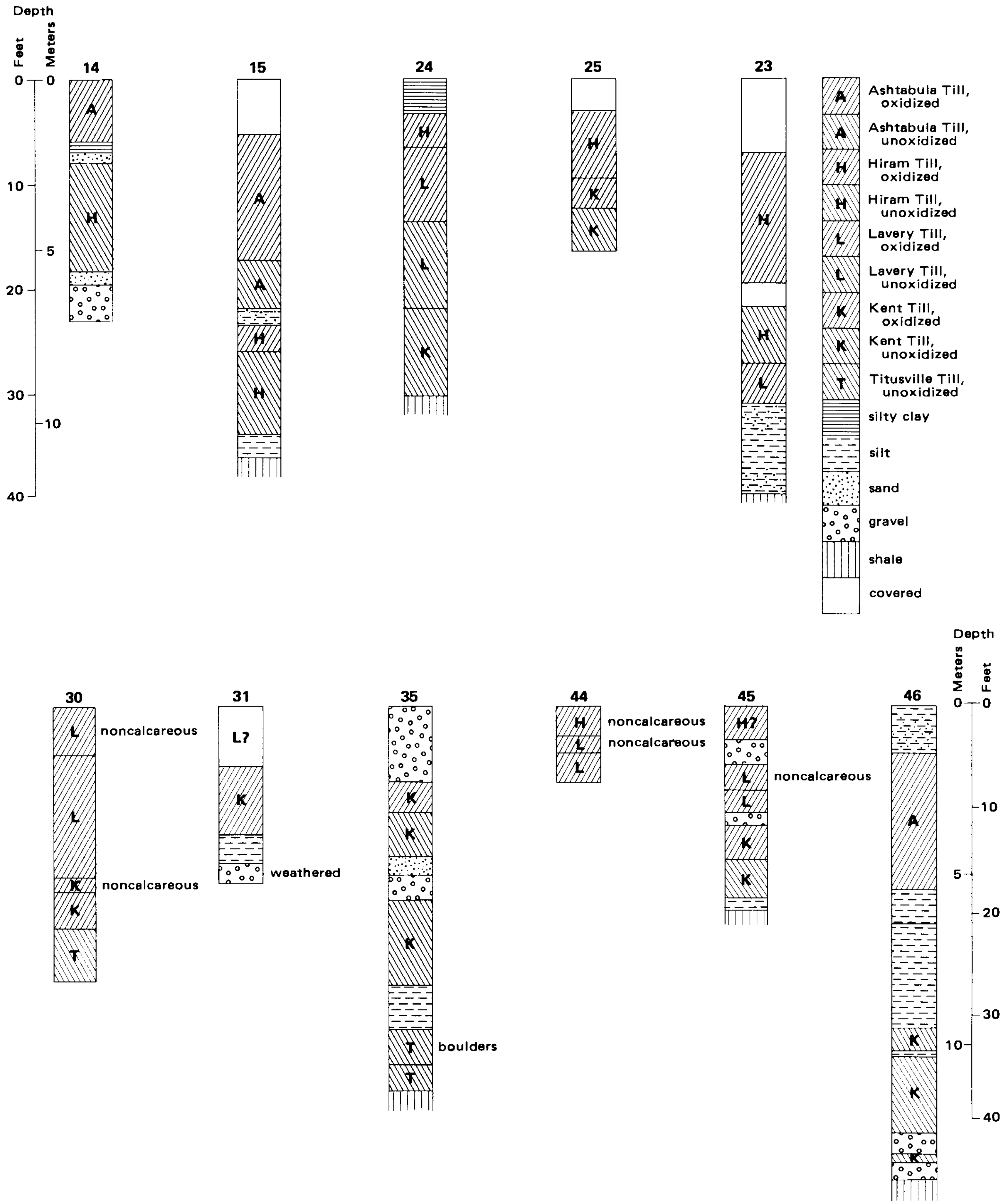
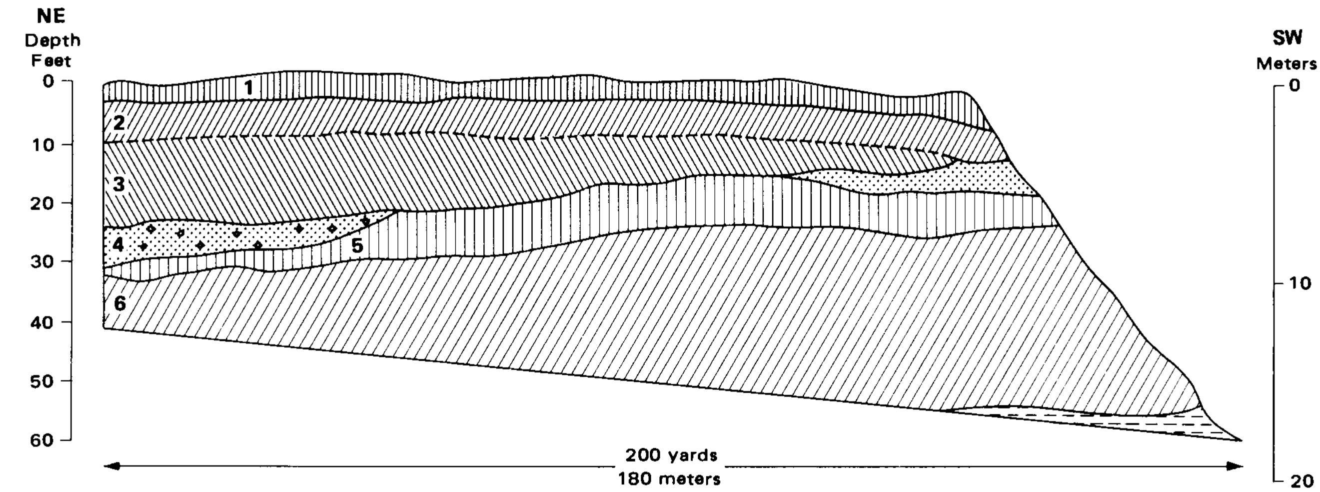


FIGURE 10.–Columnar sections of tills and associated material in Lake County. Numbers are Ohio Geological Survey file numbers. Section locations: **14**, I-90, 0.2 mi SW of Ohio Rte. 86, Concord Twp.; **15**, I-90, 0.9 mi E of Ohio Rte. 283, Concord Twp.; **24**, Ohio Rte. 2 at Lost Nation Rd., Willoughby Twp.; **25**, Ohio Rte. 2, 0.1 mi SW of Stevens Blvd., Willoughby Twp.; **23**, Ohio Rte. 2, 0.6 mi NE of Ohio Rte. 306, Mentor Twp.; **30**, ravine W of Tibbetts Rd., 0.5 mi S of U.S. Rte. 6, Kirtland Twp.; **31**, U.S. Rte. 6 at Sperry Rd., Kirtland Twp.; **35**, Indian Point, Seeley Rd., Leroy Twp.; **44**, Callow Rd., 0.2 mi N of Radcliffe Rd., Leroy Twp.; **45**, composite section on Callow Rd., N of Aylworth Creek, Leroy Twp.; **46**, Ohio Rte. 615, 0.25 mi E of East Branch, Kirtland Twp.



1. Till, brown; leached 43 inches

2. Till, dark-brown, silty, moderately pebbly, calcareous; 31% sand, 20% clay. ASHTABULA

3. Till, dark-gray, moderately pebbly; more massive than till below; 24% sand, 25% clay. HIRAM(?)

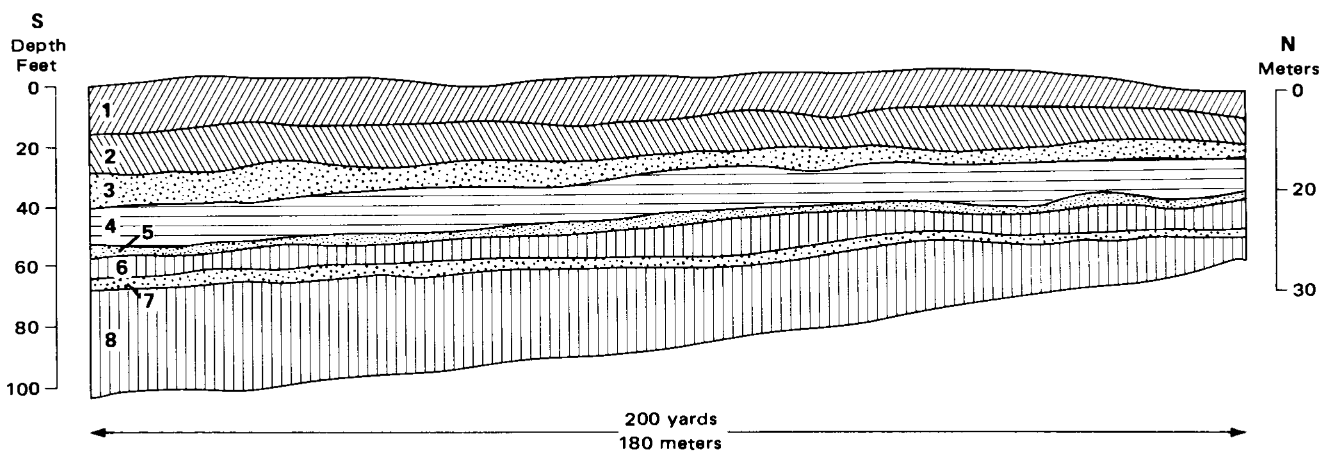
4. Silt, gray, sandy; with some gravel and sand (gravel strongly water bearing in lower part)

5. Till, dark-gray, moderately pebbly, calcareous; 28% sand, 28% clay. LAVERY(?)

6. Till, bright-gray; with much broken shale

7. Shale; gray

FIGURE 11.–Sketch of tills and other units in Euclid Moraine exposed in excavation for I-90 at the east bluff of Big Creek valley, 3 miles southeast of Painesville.



1. Till, brown; leached 48 inches. ASHTABULA

2. Till, gray, calcareous, silty, moderately pebbly; 17% sand, 36% clay. HIRAM(?)

3. Sand, brown, noncalcareous

4. Silty clay, gray, laminated, calcareous

5. Sand, yellow-brown, coarse, calcareous (5 feet thick farther north)

6. Till, gray, silty, pebbly; 33% sand, 24% clay. LAVERY(?)

7. Sand, brown, calcareous

8. Till, gray, silty, moderately pebbly; 31% sand, 26% clay. LAVERY(?)

FIGURE 12.–Sketch of tills and other units exposed in cut through Painesville Moraine for Ohio Rte. 44, ¼ mile south of Ohio Rte. 84 interchange near Painesville.

The Titusville Till was deposited by an ice advance about 40,000 years ago, as determined by C^{14} analysis of peat below Titusville deposits near Titusville, Pennsylvania (White, Totten, and Gross, 1969, p. 30). However, because Titusville is close to the margin of the Titusville Till, and Lake County is farther back from that margin (fig. 8), the Titusville ice reached Lake County earlier than it reached the farthest margin of advance, so that the Titusville Till in Lake County is older than Titusville Till farther south.

KENT TILL

The Kent Till is named for Kent, Ohio (White, 1960, p. A-5). The till is exposed at the surface around the marginal part of the Grand River lobe (fig. 8) and thence extends discontinuously northward beneath later tills. The Kent Till is exposed in some of the deeper cuts in Lake County. One exposure is near Indian Point, Leroy Township (fig. 10, section 35).

The Kent Till is a sandy, stony till. It is gray to dark gray where unweathered; where oxidized it is yellow brown, in contrast with the olive-brown Titusville Till. The Kent Till is more mealy, and not as compact and dense as the Titusville Till.

Kent Till is more generally exposed in the extreme southern part of Kirtland Township and especially in the southeastern part, where the drift is more than 100 feet thick. The Kent Till is exposed in ravines and in excavations below a thin veneer of Hiram and Lavery Tills. In the southeastern part of Kirtland Township, gravel of considerable thickness underlies the Kent Till.

The Kent Till was deposited by an ice advance which reached the area of Cleveland about 23,250 years ago (White, 1968, p. 752). There is some indication that in Lake County the Kent Till exists in two distinct sheets, recording a retreat and readvance of Kent ice in at least part of the county.

LAVERY TILL

The Lavery Till is named for exposures in and near Lavery, Pennsylvania (Shepps and others, 1959, p. 38), and has been traced around the outer part of the Grand River lobe (fig. 8) and beneath the younger Hiram Till northward into Lake County. Lavery Till is generally present beneath younger tills in the Euclid and Painesville Moraines, where it may make up the bulk of the moraines. However, the Lavery is not present everywhere below later tills, as shown in figure 10, sections 25 and 46. Where the younger Hiram Till is missing through erosion or nondeposition, Lavery may be the surface till in the Plateau.

The Lavery Till is a clayey silty till, moderately pebbly, with only a few cobbles and boulders. It is markedly calcareous below the depth of leaching. The oxidized color of the Lavery Till is brown, resembling the color of Hiram Till, but of a very slightly darker tone. The Lavery Till contrasts sharply with the underlying yellow-brown Kent Till, which is much more sandy and pebbly.

HIRAM TILL

The Hiram Till, named for Hiram, Ohio (White, 1960, p. A-8), has been traced as the surface till northward to Lake County (fig. 8), where it is the surface till in much of the Plateau. However, Hiram Till is generally thin and not always present, so that Lavery Till may be at the surface in places. The Hiram Till occurs under the Ashtabula Till in the Euclid Moraine and, where Ashtabula Till is thin, may be very close to the surface.

The Hiram Till is a clayey to silty clayey till, generally very sparingly pebbly, with only a few boulders. It is markedly calcareous below the depth of leaching, which ranges from 24 to 36 inches. The oxidized Hiram Till is brown, generally tending toward chocolate brown. This till is slightly less compact than the Lavery Till, and very much less compact than the Kent Till; weathered zones break up into small prisms.

ASHTABULA TILL

The Ashtabula Till is named for exposures near Ashtabula, Ohio, east of Lake County (White, 1960, p. A-10), and has been traced from extreme northeastern Cuyahoga County, across Lake County and Ashtabula County, into Pennsylvania and on into New York (Shepps and others, 1959; White, Totten, and Gross, 1969, p. 41). Ashtabula Till is the youngest till deposit in Ohio and was deposited by the final advance of the Erie lobe, after which ice retreated from Ohio and did not reenter it. The Ashtabula Till is the surface till of the Painesville and Euclid Moraines and of the Lake Plain. In the Lake Plain the Ashtabula Till is generally covered by sand or silt of various thickness: more than 10 feet in Madison Township and generally thinning westward. The Ashtabula Till on the Lake Plain has been more or less wave washed, so that the upper part of the till has been partly eroded. The overlying silt has been at least partly derived from reworking of till.

The advance of the ice which deposited the Ashtabula Till took place after retreat from the Plateau to an unknown position in the Erie basin. The ice which deposited the Ashtabula Till then readvanced from the Erie basin to the margin of the Plateau, but not onto it. The core of the Euclid Moraine had been deposited by earlier ice advances—Hiram and Lavery, and perhaps even still earlier ones—so that the Ashtabula Till rests upon an earlier morainic surface.

The Ashtabula Till is a calcareous silty clay till, sparingly to moderately pebbly. Cobbles and boulders are present but not conspicuous. The composition of the matrix of 25 samples taken along the end moraines averages 25 percent sand, 46 percent silt, and 29 percent clay. The Ashtabula Till is a little coarser and contains more rock fragments than the Hiram Till. In this respect the Ashtabula Till resembles the Lavery Till farther south. The differences are seen where the three tills occur in one exposure. Along the Lake Erie bluffs Ashtabula Till 10 feet or more in thickness crops out. Here this till contains streaks, stringers, and pods of incorporated lacustrine silt and clay in the matrix of the till, but this characteristic has not been noticed farther inland.

The carbonate content ranges from 5 percent to 17 percent. There is a noticeable decrease in carbonate content, as measured along the Euclid and Painesville Moraines, from about 15 percent in the southwest to less than 10 percent in the northeastern part.

The Ashtabula Till in the end moraines is oxidized to a depth of about 10 feet (fig. 9). The depth of leaching ranges from 37 to 64 inches; the average of 23 measurements is 46 inches. The depth of leaching increases to the east; in

Madison Township on the Painesville Moraine the Ashtabula Till is leached from 53 to 64 inches.

The Ashtabula Till is underlain by Hiram Till or, where the Hiram Till is missing, by the Lavery Till. Generally a layer of silt or sand lies between the two tills (figs. 11 and 12).

No organic material for C^{14} assay has been discovered in the Ashtabula Till, but, based on age determinations of the highest lake beaches, the Ashtabula Till may have been deposited about 13,000 years ago. This till is probably only a few hundred years to not more than 2,000 years younger than the Hiram Till and records an episode of retreat of ice from the Plateau into the Erie basin, then an advance out of the basin to the Plateau margin as far west as Euclid in Cuyahoga County, where the ice margin appears to have turned to the north and ended in lake water near what is now Cleveland.

"COASTAL" TILL

At many places in the lower part of the bluffs along Lake Erie, a till is exposed which cannot at this time be definitely correlated with any of the tills farther inland. This till, informally called "coastal" till, lies below the Ashtabula Till, from which it is separated by a layer of silt and fine sand of various thickness.

This "coastal" till is massive, hard, and very tough. It is silty, but contains many cobbles and small boulders, and has a stony aspect. In contrast to the overlying Ashtabula Till, which has inclusions of lacustrine clay, the "coastal" till has no such inclusions. It is everywhere gray, indicating that a considerable, but unknown, thickness of weathered material has been removed by erosion before deposition of the overlying material.

Among the several possible correlations of this till, correlation with either Hiram or Lavery Till is unlikely, for the texture and composition are quite different from texture and composition of those tills. A possible correlation is with the Titusville Till, from which any overlying Kent, Lavery, and Hiram Tills were eroded by stream action or by wave action before the overlying silts and Ashtabula Till were deposited. A fortuitous lengthy north-south exposure or a line of drill holes south from the lake bluff may provide more data for settling this present uncertainty. The possible presence of this till in the subsurface of the Lake Plain should be considered in planning deep excavations.

LACUSTRINE DEPOSITS

The deposits on the Lake Plain consist of clay, silt, and sand laid down in the various glacial lakes that preceded present Lake Erie as well as beach materials deposited along the shores of these lakes.

LAKE PLAIN

The lake bottom deposits range in thickness from only a few inches to many feet. The best natural exposures are in the bluffs along Lake Erie and in the banks of streams tributary to the lake. Excavations also show the strata and their arrangement. The lacustrine deposits lie upon Ashtabula Till and at places the basal lacustrine material can be seen to be composed of washed till, grading downward into uneroded till. The stratigraphy is complex because deposits of the earlier lakes were eroded by the shallower water of succeeding lakes, so it is not possible at this time to separate in the subsurface the deposits of the various lakes. Details of the stratigraphy along the lake bluffs are given in the report by Carter (1976).

INTERMORAINE LOWLAND

In the intermoraine lowland, lacustrine deposits are discontinuous, and at some places till is at the surface. The thickness of lacustrine deposits, therefore, ranges from zero to several feet. The material is generally more silty or sandy than that of the Lake Plain proper. In the intermoraine lowland are sequences of lacustrine material overlain by till. These record deposits laid down earlier than those of the Lake Plain in lakes (or in a bay of those lakes) earlier than glacial Lake Maumee. These lacustrine deposits are pre-Ashtabula in age and range from silt through sand to gravel. This stratigraphy was well shown in excavations for I-90 at the crossings of Chillicothe Road and Little Mountain Road in Mentor Township. The surface of the intermoraine lowland consists of silt, ranging in thickness from a few inches to 10 feet or more, overlying till. The till ranges from 5 to 15 feet in thickness, below which is gravel at least 10 feet thick. The water-bearing gravel requires special drainage structures, because piping occurred along part of the outcrop. Throughout the intermoraine lowland similar complex sequences of strata may be expected in excavations and in drilling.

BEACHES

The locations and extents of the raised beaches on the Lake Plain have already been described in the section on geomorphology. The beach materials overlie Ashtabula Till, upon which they were deposited. In general, the beaches consist of 10 to 25 feet of gravel or gravelly sand overlying Ashtabula Till.

EOLIAN DEPOSITS

Windblown sand is associated with the beaches, but the most significant amount of eolian sand is that associated with the Warren beach (North Ridge) east of Painesville. Here as much as 15 feet of fine sand in the form of small dunes overlies the coarser beach material. The windblown sand continues north and south of the beach ridge as low swells and thinner sheets. In Madison Township north of North Ridge a more or less continuous sheet of eolian sand extends to Lake Erie. This fine-grained sand may overlie lacustrine silt and clay or may overlie Ashtabula Till. The sand differs in thickness because it is aggregated in low swells, which are probably the result of wind work on very low indistinct shore deposits of glacial Lake Elkton. A few sand dunes as much as 10 feet high are present on the Whittlesey beach in Madison Township.

MINERAL RESOURCES

The mineral resources of the glacial drift in Lake County are locally important, but do not equal in direct value those of the bedrock, from which at depth thick salt beds provide material for the great chemical industry adjacent to the mouth of the Grand River. (Bedrock mineral resources are not considered in this report.) The effects of the drift materials on the environment, however, are of great importance, and the water in the drift is of real importance in part of the county.

SAND AND GRAVEL

The sand and gravel of the raised beaches have been used since pioneer days. The locations of small pits along the beaches are shown on plate 1. Most of these are long since abandoned, either because of exhaustion of the material or because of encroachment of buildings. From a few pits a few loads of sand or gravel are still occasionally dug, but the only presently operating commercial pit is that in Painesville just east of the Grand River and north of Casement Airport. The sand and gravel of the beaches range in thickness from a few feet to as much as 30 feet.

Sand, with some pebbles, is found in the deposits of the intermoraine lowland; aside from very small excavations for a few loads of sand, the only excavations have been in the sandy plain in Waite Hill, south of the cemetery on Waite Hill Road. These pits are not now active.

Some sand and gravel are present on the high terraces along the major streams, but in general the thickness of such deposits is not great enough for commercial purposes. At one time considerable material was taken from a fairly large pit in Willoughby Township, just south of Chardon Road and just east of the Chagrin River. Another small pit was present at the Lake-Cuyahoga County line just east of the river.

Gravel of a different character exists in considerable quantities in the kame terraces on either side of East Branch Chagrin River in the extreme southeastern corner of Kirtland Township, as shown on plate 1. This body of gravel is a northward extension of a much larger deposit to the south in Geauga County (Baker, 1957), where several pits have worked this material. This gravel ranges from fine to very coarse, with irregular bedding, as is characteristic of kame gravel. Its thickness is more than 20 feet and may be much more at places. Generally the gravel has an overburden of till, which ranges in thickness from a foot or two to 10 feet or more; at the margins of the area the covering becomes so thick that the area is mapped as hummocky moraine, rather than kame terrace. It is probable that a large quantity of gravel exists below thick till cover considerably beyond the areas mapped as kame terraces on plate 1.

GROUND WATER

Although this report does not deal specifically with ground-water resources, a general statement will be included. Because Lake Erie forms the entire northern boundary of the county, lake water has long been used by municipalities along the lake, and ground water has not been important to them. Some smaller villages and settlements and many separate households inland, however, have used ground water.

The thick sand of the beach ridges has been an important ground-water source, but because the beach materials are of limited thickness (10 to 30 feet), the quantity of ground water is not great enough for major municipal use. North of North Ridge in Madison Township, the thick sand blanket provides a reservoir which should be investigated to determine amounts and quality of ground water available (McComas and Nacht, 1973, p. 14).

Because till has very low permeability, it is not a good source of water. It is now known that more water moves through joints in till than through intergranular spaces. Sand layers between tills may be water bearing, and some wells have found supplies in such water-bearing layers. At places upon the bedrock at the base of the till sequences is a zone of a few inches to 2 feet or more of more porous and permeable material in which ground water is present, generally in small amounts. Such porous layers in basal till are shown in figure 10, sections 14, 23, 31, 45, and 46. By drilling below this zone into the underlying shale, some storage may be provided so that a supply for a single house can be maintained by very careful and economical use.

In the southern and southeastern parts of Kirtland Township the kame terrace gravels and the gravels buried beneath till in adjacent areas are water bearing, and fair to good supplies have been obtained. The area along East Branch Chagrin River should be investigated because this stream would furnish recharge for any gravel that extends below the stream.

It should be noted that the bedrock of most of the county is not a favorable source for large supplies of ground water because the shale has very low permeability, except along joints. Sandstone layers in the shale may contain some ground water, but such occurrence is unpredictable.

GEOLOGICAL CONSTRAINTS ON PLANNING

Different geological materials influence suitability for various uses. Not only the material itself is important, but also its topographic position on floodplains, slopes, ridges, and flat areas and its position with respect to existing or projected human use (McComas and others, 1969).

MINERAL RESOURCES

The extraction of mineral resources, chiefly sand and gravel in Lake County, must be planned in relation to effect on adjacent territory and in relation to character and use of the area after extraction. Material—till, lake clay, or silt—used for fill is a mineral resource and should be treated as such.

GROUND WATER

The availability of water for individual or for cooperative (municipal or other) use must be taken into account in planning. Because ground-water supplies in Lake County are by no means widely distributed, it should be realized that certain areas are less promising than others.

WASTE DISPOSAL

Disposal of solid waste in landfills has special requirements for satisfactory sites (Hughes and others, 1971). These requirements include permeability and porosity of material and position of the water table. If other requirements are met, clayey or silty till, which is the major kind of till in Lake County, is quite satisfactory. However, it must be kept in mind that till is generally in more than one unit, and the units are separated by silt or sand layers of various thickness, as shown in figures 11 and 12. Even if a silt layer is so thin it is inconspicuous or even if such layers appear to be absent, the interface between the tills may allow water movement, and leachate from a landfill may travel along this interface, as well as along a more evident porous sand or silt layer (White, 1972, p. 80; Henning and others, 1975).

Liquid wastes are subject to somewhat similar geological constraints. Tile fields for septic tanks in the clayey and silty clayey till areas of Lake County are necessarily located in material of low permeability and very slow percolation. A large enough area for satisfactory performance must be provided. In some till areas the water table is high during part of the year, and serious problems may arise on this account. In spite of low intergranular permeability, some effluent may travel along joints or along interfaces between tills and contaminate ground water. In sand and gravel areas percolation may be rapid, and effluent may travel a considerable distance and contaminate ground water. It is evident that knowledge of the geology of a region and of the particular site is necessary for specification of proper equipment and installation.

EXCAVATIONS AND FOUNDATIONS

As larger and larger structures are built, foundation design becomes ever more important, and excavations become deeper and deeper. A detailed study of the surface materials (soils in engineering terminology) is necessary. This report contains a general map, descriptions, and diagrams to indicate what materials may be expected in various parts of Lake County. However, for project planning and specifications, a detailed geological engineering study of each site is necessary. In such a study, the multiple character of till deposits must be kept in mind in subsurface exploration. In any thick till deposit, conditions such as those shown in figures 10, 11, and 12 may be present. Not shown in these diagrams is a situation in which a sand layer is markedly thicker at a buried intertill valley (White, 1972, fig. 2). Such thick sand masses may present severe water problems and may also present problems of materials with different properties across the area of the foundation.

On cut slopes different tills may have different slope stability angles. Water escaping from interfaces may cause piping at the slope, and actual cavities may be produced at some distance from the slope.

In planning for fills it must be realized that the planned borrow pit may start in one material and at depth encounter quite a different material. In southern Kirtland Township excavations may start in till and encounter sand or gravel at depth. In the intermoraine lowland and on the Lake Plain excavations begun in surface silt, clay, or sand will encounter till at a depth of a very few feet to many feet. Even if the pit is entirely in till, the different tills may have different compacting characteristics.

SLOPES AND LANDSLIDES

Natural and manmade slopes have different slope stability angles in the different materials. Abundant examples of unstable natural slopes may be seen along the many miles of steep slopes along the major valleys. (The character of the lake bluff slopes and their stability problems are dealt with in the report by Carter, 1976.) Along most of the major valleys the upper part of the slope is on till, and the lower part is on shale (fig. 5). These materials have different stability angles, and at some places till is unstable and slides over the underlying bedrock. At places the slide is not along the base of the till, but at one of the interfaces between till sheets.

Along the Chagrin River valley from the Lake-Cuyahoga County line north for about 2 miles, slides along the valley walls are very conspicuous. Here the till is unusually thick and extends below stream level. The whole slope is till, of various character and with several interfaces, some of which are water bearing; this situation contributes to frequent sliding. The slope on the west side of the river, for about ½ mile north of Chardon Road (U.S. Route 6), shows many fine examples of landslides. It is obvious that slide-prone areas are hazardous places for buildings. Even slopes which show no indication of recent sliding may show on close examination in the field and of air photos that ancient slides have occurred and may be reactivated. Altering the slope will create hazards and initiate sliding unless very extensive engineering works, including subsurface drainage installations, are undertaken.

FLOODPLAINS

Floodplains present well-known constraints. By definition, a floodplain is covered by flood water of the stream. Low floodplains may be flooded more than once in some years, higher floodplains less often. The low terraces—second bottoms—along some streams are flooded only occasionally, sometimes not for several years. A false sense of security is engendered, but sooner or later a particularly high flood will inundate such areas. Topographic maps and soil maps will differentiate the floodplains and second bottoms. Detailed studies are now being made in many states of flood histories, flood heights, and flood frequencies in order to provide information for planning and zoning (Webber and Bartlett, 1977).

Floodplains have excellent potential for recreation. The park along the Chagrin River valley north and south of the Lake-Cuyahoga County line is an example of excellent floodplain use.

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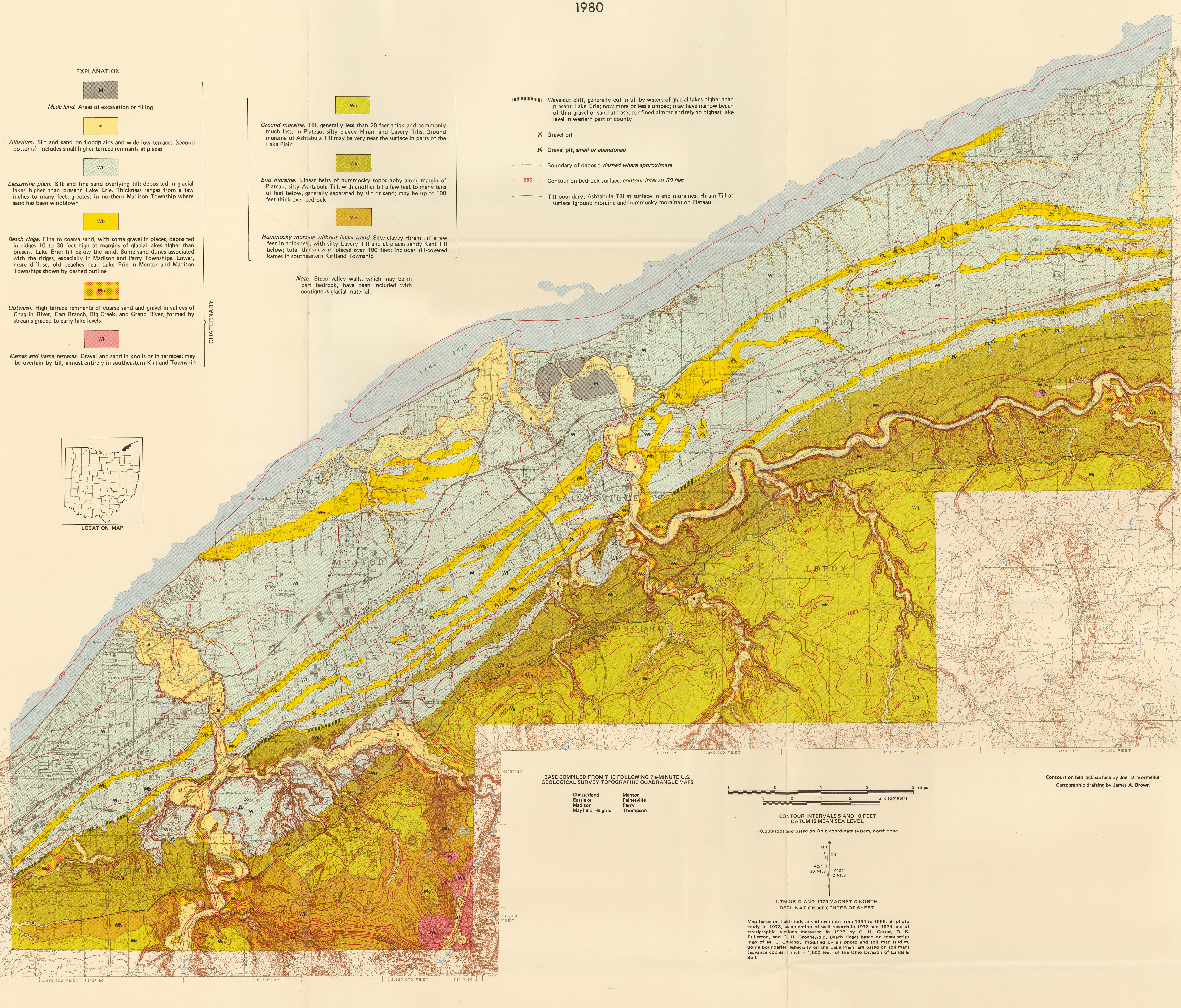
GLACIAL GEOLOGY OF LAKE COUNTY, OHIO

by George W. White

1980

REPORT OF INVESTIGATIONS NO. 117
PLATE 1



EXPLANATION

QUATERNARY

Recent

al — *Alluvium.* Silt and sand on floodplains and wide low terraces (second bottoms); includes small higher terrace remnants at places

M — *Made land.* Areas of excavation or filling

Pleistocene (Wisconsinan)

Wl — *Lacustrine plain.* Silt and fine sand overlying till; deposited in glacial lakes higher than present Lake Erie. Thickness ranges from a few inches to many feet; greatest in northern Madison Township where sand has been windblown

Wb — *Beach ridge.* Fine to coarse sand, with some gravel in places, deposited in ridges 10 to 30 feet high at margins of glacial lakes higher than present Lake Erie; till below the sand. Some sand dunes associated with the ridges, especially in Madison and Perry Townships. Lower, more diffuse, old beaches near Lake Erie in Mentor and Madison Townships shown by dashed outline

Wo — *Outwash.* High terrace remnants of coarse sand and gravel in valleys of Chagrin River, East Branch, Big Creek, and Grand River; formed by streams graded to early lake levels

Wk — *Kames and kame terraces.* Gravel and sand in knolls or in terraces; may be overlain by till; almost entirely in southeastern Kirtland Township

Wg — *Ground moraine.* Till, generally less than 20 feet thick and commonly much less, in Plateau; silty clayey Hiram and Lavery Tills. Ground moraine of Ashtabula Till may be very near the surface in parts of the Lake Plain

We — *End moraine.* Linear belts of hummocky topography along margin of Plateau; silty Ashtabula Till, with another till a few feet to many tens of feet below, generally separated by silt or sand; may be up to 100 feet thick over bedrock

Wh — *Hummocky moraine without linear trend.* Silty clayey Hiram Till a few feet in thickness, with silty Lavery Till and at places sandy Kent Till below; total thickness in places over 100 feet; includes till-covered kames in southeastern Kirtland Township

Note: Steep valley walls, which may be in part bedrock, have been included with contiguous glacial material.

Wave-cut cliff, generally cut in till by waters of glacial lakes higher than present Lake Erie; now more or less slumped; may have narrow beach of thin gravel or sand at base; confined almost entirely to highest lake level in western part of county

Gravel pit

Gravel pit, *small or abandoned*

Boundary of deposit, *dashed where approximate*

850 — Contour on bedrock surface, *contour interval 50 feet*

Till boundary; Ashtabula Till at surface in end moraines, Hiram Till at surface (ground moraine and hummocky moraine) on Plateau

LOCATION MAP

BASE COMPILED FROM THE FOLLOWING 7½-MINUTE U.S. GEOLOGICAL SURVEY TOPOGRAPHIC QUADRANGLE MAPS

Chesterland, Eastlake, Madison, Mayfield Heights, Mentor, Painesville, Perry, Thompson

1 0 1 2 3 miles
1 0 1 2 3 kilometers

CONTOUR INTERVALS 5 AND 10 FEET
DATUM IS MEAN SEA LEVEL

10,000-foot grid based on Ohio coordinate system, north zone

MN GN 4½° 80 MILS 0°07' 2 MILS

UTM GRID AND 1970 MAGNETIC NORTH
DECLINATION AT CENTER OF SHEET

Map based on field study at various times from 1954 to 1966, air photo study in 1973, examination of well records in 1973 and 1974 and of stratigraphic sections measured in 1973 by C. H. Carter, D. S. Fullerton, and G. H. Groenewold. Beach ridges based on manuscript map of M. L. Couchot, modified by air photo and soil map studies. Some boundaries, especially on the Lake Plain, are based on soil maps (advance copies, 1 inch = 1,000 feet) of the Ohio Division of Lands & Soil.

Contours on bedrock surface by Joel D. Vormelker
Cartographic drafting by James A. Brown