STATE OF OHIO
Richard F. Celeste, Governor
DEPARTMENT OF NATURAL RESOURCES
Joseph J. Sommer, Director
DIVISION OF GEOLOGICAL SURVEY

Report of Investigations No. 140

GLACIAL GEOLOGY OF GEAUGA COUNTY, OHIO

by

Stanley M. Totten

Columbus
1988

ODNR
OHIO DEPARTMENT OF NATURAL RESOURCES

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GLACIAL GEOLOGY OF GEAUGA COUNTY, OHIO

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ABSTRACT

Geauga County is located within the glaciated portion of the Allegheny Plateau in northeastern Ohio. The Plateau in Geauga County is a maturely dissected resistant sandstone upland that ranges in elevation from 1,220 to 1,370 feet. The relief between upland and lowland commonly is greater than 200 feet. The major streams in Geauga County are the Cuyahoga, Grand, and Chagrin Rivers, which flow into Lake Erie.

Glaciation in Geauga County resulted from the southwestward expansion of ice in the Grand River sublobe and the southeastward expansion of ice in the Cuyahoga sublobe of the Erie lobe. Several ice sheets invaded the county during the Wisconsinan Stage, and an unknown number of advances occurred in earlier Pleistocene time.

The Mogadore Till (early Wisconsinan-Altonian) of the Cuyahoga sublobe and its correlative, the Titusville Till of the Grand River sublobe, are the oldest tills identified in Geauga County. The Mogadore-Titusville Tills typically are hard, compact, sandy, and silty and contain abundant pebbles, cobbles, and boulders. Unaltered Mogadore-Titusville till is dark or drab gray, whereas the oxidized till is dark yellowish brown, commonly with an olive cast. The till has prominent vertical joints, and oxidized till is characterized by angular blocks which are stained reddish brown to black by iron and manganese. Mogadore-Titusville Tills range from thin (less than 10 feet) on uplands to very thick (greater than 150 feet) in buried valleys; 115 feet of Titusville Till is exposed in the Grand River valley near Parkman. The Mogadore-Titusville Tills are complex stratigraphic units consisting of at least three subunits in places separated by layers of sand.

The Kent Till, the oldest of three Woodfordian (late Wisconsinan) tills deposited in Geauga County, overlies Mogadore or Titusville Till and generally is present over the entire county. Kent Till is the surface material in the south-central part of the county and is overlain by the Lavery and/or Hiram Till elsewhere in the county. Kent Till is silty, sandy, moderately pebbly, and crumbly and contains numerous sand lenses that tend to slump when wet, so that the Kent Till commonly appears as a wet zone in a road cut. Oxidized Kent Till is dark yellow brown, in contrast to the overlying chocolate-brown tills; its average thickness is 4.1 feet.

Lavery Till of Woodfordian age overlies Kent Till and is present over all except the south-central part of Geauga County. Lavery Till is silty, clayey, and sparingly pebbly and oxidizes to a dark chocolate brown, in contrast to the underlying yellow-brown tills. Its average thickness is 2.5 feet except in Thompson Township, where the till is absent in most places.

Hiram Till of Woodfordian age is the youngest till in Geauga County and overlies Lavery Till. Hiram Till is the surface till over all of the county except the south-central part. The Hiram Till boundary generally coincides with the Lavery Till boundary in Geauga County. Hiram Till is silty and clayey and contains so few pebbles that it is sometimes mistaken for lacustrine silt or clay. Hiram Till oxidizes to a dark chocolate brown similar to the Lavery Till. Hiram Till can be distinguished from the underlying Lavery Till by its slightly darker brown color, its higher clay content, and its very sparse pebble content. In most places Hiram Till is 2 to 4 feet thick; average thickness is 2.8 feet.

The Defiance Moraine, a more or less continuous belt of hummocky topography typically 1 to 2 miles wide with 10 to 30 feet of relief, nearly encircles Geauga County on the west, north, and east. In Geauga County the Defiance Moraine commonly consists of three to six elements separated in places by valleys or tracts of ground moraine; in other places the moraine elements are closely bunched to form a single hummocky tract.

A very wide belt of hummocky topography in south-central Geauga County is mainly a hummocky mass of sand and gravel and till in the form of a kame moraine. This kame moraine, known as the Kent Moraine, covers an area about 5 miles wide and 10 miles long in an interlobate position between the Cuyahoga and Grand River sublobes.

Kame terraces are present along one or both sides of the valleys of the Grand River west of Parkman, the Cuyahoga River and its tributaries East Branch and Tare Creek, and Bridge Creek. Valley-train remnants are preserved as terraces along the valley sides of the Chagrin River, West Branch Cuyahoga River, the Grand River, and Swine Creek.

Remnants of alluvial terraces are preserved along the valley sides of Aurora Branch and East Branch Chagrin River. These terraces represent floodplains of northward-flowing streams which had base levels higher than at present.

An extensive late-glacial lake, known as Lake Grove, is recorded by lacustrine deposits in the Cuyahoga River valley and its tributaries between Burton Station and the Geauga-Portage County line. Extensive areas of lacustrine sediment are present in large valley depressions that remained after other parts of the valley had been plugged with drift. These areas include the Chagrin River valley east and south of Chardon, the West Branch Cuyahoga River valley southeast of Chardon, and the East Branch Cuyahoga River valley in Montville and Huntsburg Townships.

Sand and gravel deposits are present in many places in Geauga County. Commercial exploitation of glacial sand and gravel in the county has occurred mainly within the interlobate kame moraine (Kent Moraine). Most of the sand and gravel deposits are of Mogadore-Titusville age and generally have a covering of till which may reach many feet in thickness.

Glacial sands and gravels are important aquifers in several buried valleys in the county. Yields up to 1,000 gallons per minute are possible from wells in permeable sands and gravels in the buried Cuyahoga Valley between Burton and LaDue Reservoir.

INTRODUCTION

Geauga County is located in northeastern Ohio (fig. 1) about 20 miles east of Cleveland. It is bounded on the north by Lake County, on the east by Ashtabula and Trumbull Counties, on the south by Portage County, and on the west by highly urbanized Cuyahoga County. Geauga County lies between 81°00′12″ and 81°23′30″ west longitude and 41°20′52″ and 41°42′53″ north latitude. The entire county lies within the Connecticut Western Reserve and has an area of about 412 square miles. The population of the county, according to the 1980 Federal Census, was 74,474, which represents an increase of 18.3 percent over 1970. The county seat and largest village in the county is Chardon. Other villages include South Russell, Middlefield, Burton, and Aquilla. Historically, the county has been a rural, agricultural area sprinkled with small villages. In recent times, eastward expansion of the Cleveland/Cuyahoga County urban complex into Geauga County has resulted in significant nonagricultural development, particularly in the western part of the county.

FIGURE 1.—Location of Geauga County, Ohio.

PURPOSE AND SCOPE

This report describes the glacial drift—the surface material overlying the bedrock—in Geauga County (pl. 1). The morphology of the landforms and the stratigraphy of the deposits are described and correlated with deposits and surface features in adjacent counties. Economic resources of the deposits are considered, and suggestions are made for resource utilization and conservation.

This report will be of interest to various groups and individuals: geologists, highway engineers, builders, sand and gravel pit operators, well drillers, architects, city planners, soil scientists, and landowners. Citizens who are or will be responsible for planning and shaping the future of Geauga County for agriculture, urbanization, recreation, and industrialization will find this report useful for making their decisions.

ACKNOWLEDGMENTS

This report is based primarily on field study by the author in the summer of 1981, aided by the study of aerial photographs, soil maps, and water-well records. These data were supplemented by numerous field observations made in the county during the previous decade accompanied at various times by George W. White and by Jack Baker, who made available their field notes of earlier years. Horace R. Collins, former State Geologist, provided valuable support and encouragement in the development of this report.

PREVIOUS INVESTIGATIONS

Some of the earliest investigations of the geology of northern Ohio, including Geauga County, were made by Charles Whittlesey (1838, 1848, 1850, 1866, 1869). He (1838, p. 55-56) described the unconsolidated material (till) which mantles the bedrock and attributed its formation to transportation by water. He also noted the impressive knob-and-kettle topography which characterizes much of the south-central part of the county.

J. S. Newberry (1874, p. 1-80) recognized the glacial origin of the surficial deposits and summarized the glacial geology of Ohio and neighboring states. Among his significant contributions was the interpretation of glacial striations on bedrock. T. C. Chamberlin (1883, p. 291-402) mapped several end moraines in northeastern Ohio and from their distribution noted and named the major ice lobes. Leverett (1902), in his Erie Basin monograph, described the topographic features and the materials of the county. Baker (1957) made a comprehensive study of the glacial deposits of Geauga County and included considerable information on the buried drift and its contained ground-water resources. White (1960, 1982) mapped and described the glacial deposits of northeastern Ohio, including Geauga County. Heath (1963) studied the mineralogy of till samples from northeastern Ohio.

Economic products in the rocks and overlying surficial deposits of Geauga County have been reported in various publications. Smith (1949) described sand and gravel resources and Dachnowski (1912) described peat deposits. The Ohio Division of Geological Survey annually publishes a *Report on Ohio mineral industries.* The report by Stout, Ver Steeg, and Lamb (1943, p. 307-315) contains valuable information about water resources. Ground-water resources of the bedrock have been described by Rau (1969) and Sedam (1973). Walker (1978) has prepared a generalized map of the ground-water resources in Geauga County. The detailed soil survey of Geauga County (Williams and McCleary, 1982) is a useful reference in the study of the surficial materials, including their engineering properties.

Reports on adjacent counties have provided information on glacial deposits in Geauga County, although compilers of the older reports did not have the benefit of 1:24,000-scale topographic maps or detailed soil surveys. Published reports include Portage County (Winslow and White, 1966) to the south, Trumbull (White, 1971) and Ashtabula (White and Totten, 1979) Counties to the east, Lake County (White, 1980) to the north, and Cuyahoga County (Ford, 1987) to the west.

PHYSIOGRAPHY AND DRAINAGE

TOPOGRAPHY

Geauga County has a varied topography that ranges from gently rolling to rolling to steeply sloping. The only surfaces that could be called flat are former lake bottoms in portions of partially buried preglacial valleys. An area along the eastern margin of the county is very gently rolling and is characterized by numerous swampy areas. The steepest topography is along valley walls, where steep cliffs may be 100 feet high or more.

The topography of Geauga County is controlled by the bedrock, with some modification by deposition of glacial drift. Dominating the topography are numerous sandstone knobs and ridges of varied shapes and sizes. Deep, narrow valleys surround many of the knobs. These valleys were cut as much as 350 feet below the uplands in several places during preglacial and interglacial times and then were partially filled with drift during and following glaciation. The modern valleys have been entrenched into these earlier deposits to depths of 100 feet or more.

The highest point in Geauga County, at an elevation of 1,396 feet, is Sugarloaf Mountain, which rises about 100 feet above the adjacent upland in Troy Township in the southeastern part of the county.

The lowest elevation in the county is 770 feet, where East Branch Chagrin River flows northwestward from Chardon Township into Lake County. The relief at the Geauga-Lake County line is 310 feet in ½ mile. The sandstone uplands range in elevation from 1,220 to 1,370 feet; elevations are generally higher in the northern part of the county and lower in the west and south. However, the highest elevation in the county is in an area of relatively low overall elevations, whereas the lowest elevation occurs near the higher overall elevations. The relief between upland and lowland commonly is greater than 200 feet.

Most villages in the county are located on high bedrock knobs, and from these villages scenic views overlook relatively deep and steep valleys. The high elevations, coupled with its nearness to Lake Erie, provide Geauga County with greater than normal precipitation. Williams and McCleary (1982) report an annual precipitation of 46 inches, an average seasonal snowfall of 113 inches, an average winter temperature of 27°F, and an average summer temperature of 69°F.

BEDROCK GEOLOGY

The bedrock beneath the glacial drift in Geauga County consists primarily of sandstones, conglomerates, and shales of the Devonian, Mississippian, and Pennsylvanian Systems (fig. 2). The bedrock has influenced strongly the physiography, drainage, and glacial features. The oldest rocks in the county are the Ohio and Bedford Shales (Devonian-Mississippian), which are the surface rocks along the flank of the Portage Escarpment in northern Thompson Township. Devonian-Mississippian shales also form the bedrock in the deeply incised valleys in the county.

Overlying the Devonian-Mississippian shales is the Berea Sandstone (Mississippian). The Berea, a fine-grained sandstone, ranges from 40 to 70 feet in thickness (Rau, 1969) and forms the high plateau platform. The Berea is the most widely outcropping rock in Geauga County. The Berea Sandstone is overlain by shales and sandstones of the Cuyahoga Formation (Mississippian).

The youngest rocks in Geauga County are conglomerates, sandstones, and shales of the Pottsville Group, of early Pennsylvanian age. The basal Pottsville unit is the Sharon sandstone/conglomerate, which forms most of the high knobs and ridges in the county. The Sharon is quarried in several places for coarse aggregate for construction and other industrial uses. Some dimension sandstone is also produced (Ohio Division of Geological Survey, 1987). The largest quarries are in central Thompson Township, where the drift cover averages only a few feet in thickness. The youngest Pottsville unit in Geauga County, the Homewood sandstone, caps Sugarloaf Mountain, northeast of Welshfield in Troy Township.

The sandstones in Geauga County have been interpreted as lenticular channel sands associated with deltaic development (Rau, 1969; Sedam, 1973). The configuration of the channels and the lateral variability of the units no doubt strongly influenced the drainage development in the county.

GLACIAL EROSION

Because the topography of Geauga County is dominated by resistant sandstone knobs which have the highest elevations in northeastern Ohio, the landscape presented a formidable obstacle to glacial advances. Thus the main ice flow, and the most likely areas for erosion, tended to be down the Grand River and Cuyahoga River lowlands on either side of the county. The sandstone knobs undoubtedly were smoothed repeatedly by abrasion during several glacial advances, but the overall effect probably was negligible.

The ice was thicker in the valleys than on the adjacent uplands, and the greatest erosion potential was in the valleys aligned parallel to ice movement. It is probable that some valleys were deepened and widened, but the position and configuration of the bedrock floor of the many buried valleys in the county (see fig. 4) are so poorly known that it is not possible to determine the amount of erosion.

The bedrock surfaces exposed beneath glacial drift have been scoured by ice, and any preglacial soil that might have been developed in rock was removed. However, there is little if any evidence to indicate that glacial erosion was responsible for eroding more than the thin layer of weathered bedrock, or regolith.

An unknown amount of older glacial deposits may have been eroded during later ice advances. The lack of pre-Wisconsinan till in the county, except in a few protected buried valleys, may be the result of erosion by the early Wisconsinan (Altonian) Mogadore-Titusville ice advance. Very little erosion by ice in the county is attributed to the later Wisconsinan (Woodfordian) ice advances.

PHYSIOGRAPHIC DIVISIONS

Geauga County lies within the glaciated Allegheny Plateau section of the Appalachian Plateaus physiographic province (Fenneman, 1928, 1938). The Allegheny Plateau is hereafter referred to as the Plateau. A short distance north of the county in Lake County is the steep Portage Escarpment, which rises 470 feet in 2 miles and separates the Plateau from the Lake Plain to the north. The Plateau in Geauga County is essentially a maturely dissected resistant sandstone upland that attains several of the highest elevations in northeastern Ohio. Glaciation has sufficiently modified the Plateau so that four physiographic divisions may be recognized: drift-mantled upland, morainic upland, interlobate kame moraine, and valley bottoms (fig. 3).

Drift-mantled upland

Most of Geauga County is characterized by thin drift which covers but does not obscure the underlying bedrock topography. This surface mainly is that of a plateau, underlain by sandstone and dissected considerably by stream erosion. The upland surface differs considerably in appearance from one place to another. East of the Defiance Moraine in Montville, Huntsburg, and Middlefield Townships the surface is relatively flat, poorly drained, and slopes eastward from an elevation of about 1,200 feet at the moraine to 1,100 feet near the eastern boundary of the county. Nearly all of Thompson Township is an upland in the shape of a broad dome, with a central horseshoe-shaped sandstone ledge. The Thompson Ledges, as this central area is known, are a scenic outcropping of Sharon sandstone (Pennsylvanian) and the site of a township park. The thickness of till covering the bedrock in Thompson Township is the least of any in Geauga County, being 5 feet or less in most places.

The drift-mantled upland in the remainder of the county

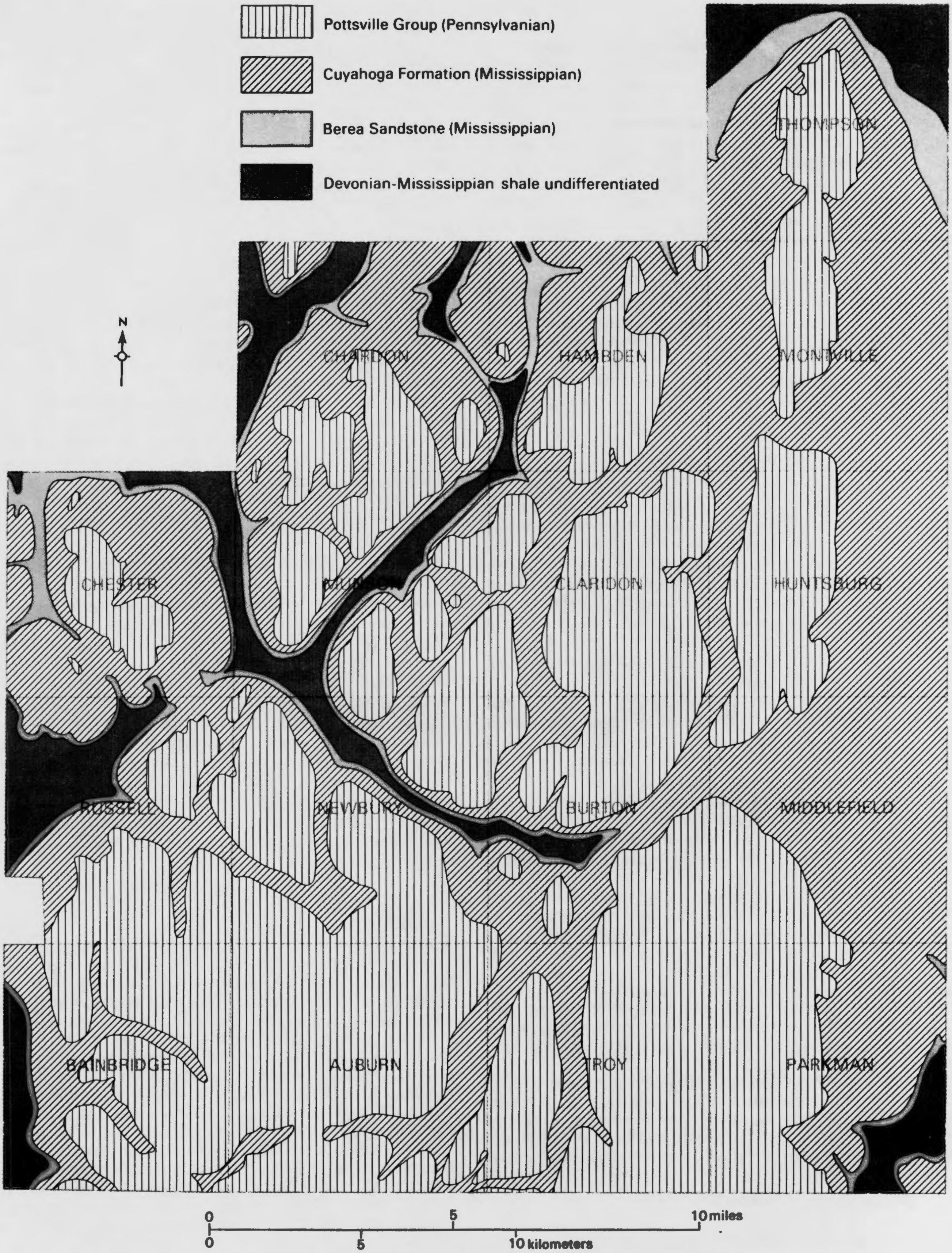


FIGURE 2.—Generalized bedrock geology of Geauga County (from manuscript map by M. C. Hansen on file at the Ohio Division of Geological Survey).

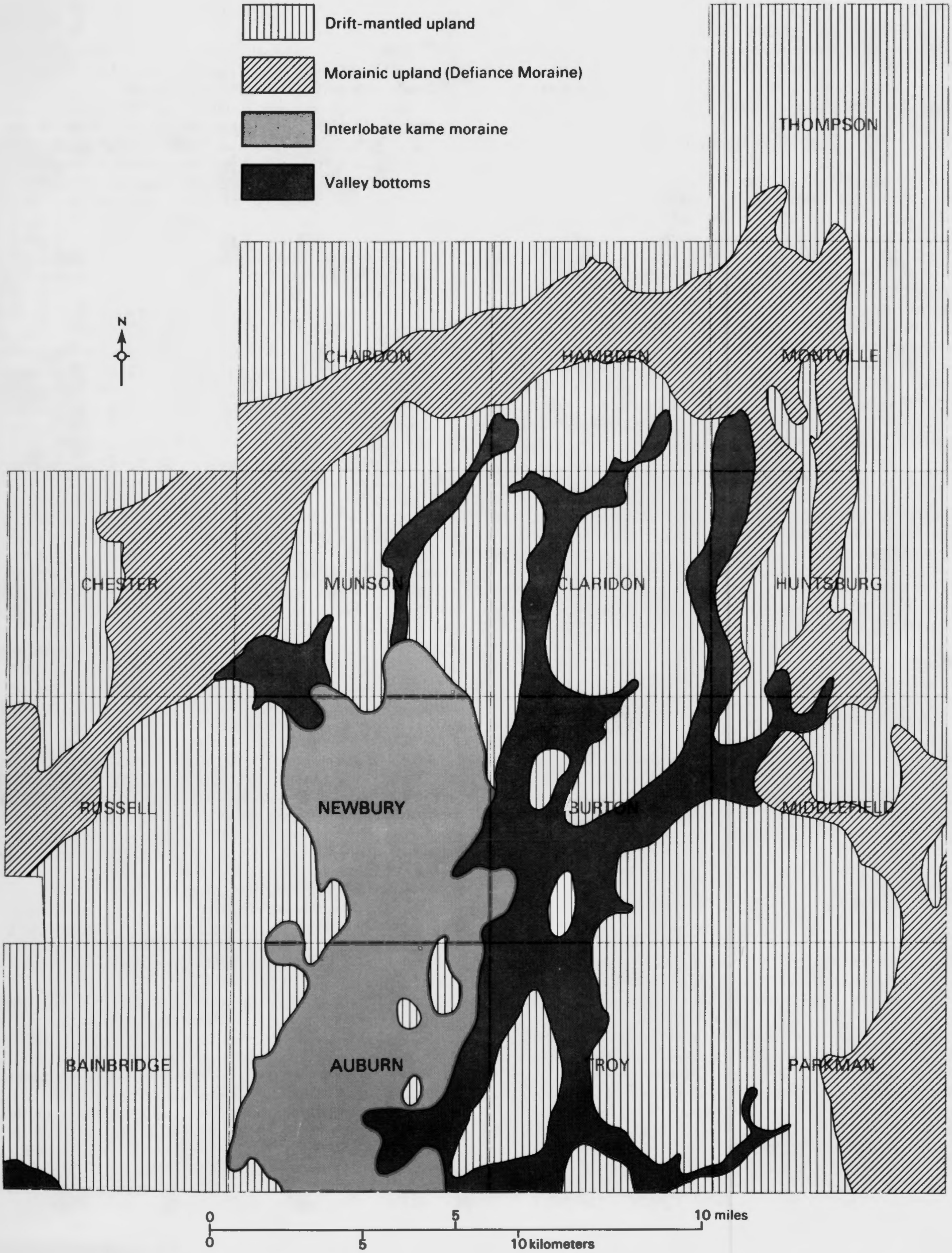


FIGURE 3.—Generalized physiographic divisions of Geauga County.

consists of broad smooth knobs and ridges with locally steep sides where bordered by entrenched streams. The ridgetops and steep slopes are mantled with very thin drift, the gentle slopes generally have a covering of drift more than 10 feet thick, and the valleys contain thick drift, in places 200 feet thick or more.

Morainic upland

A distinct 1- to 3-mile-wide end-moraine belt known as the Defiance Moraine surrounds Geauga County on three sides (fig. 3). This belt consists of multiple elements or ridges that are closely bunched, producing a hummocky topography. The morainic belt occupies the higher elevations in most places primarily because it is juxtaposed against higher bedrock ridges, which slowed and halted the glacial advance which formed the moraine. The actual height of the moraine above its surroundings is generally 25 to 50 feet. The morainic slopes are pleasing aesthetically yet are not so steep as to provide serious limitations on land use. The drainage in this area is influenced significantly by the Defiance Moraine, which marks much of the drainage boundary between the Grand River and Cuyahoga River drainage basins (compare figs. 3 and 4).

Interlobate kame moraine

The merging of the lateral margins of the Cuyahoga and Grand River lobes during the first Mogadore-Titusville (Altonian) ice advance (see figs. 9 and 10) produced a large volume of ice-contact deposits known as kames. These kames, together with intermixed and overlying till, have produced a large belt of pronounced knob-and-kettle topography, primarily in Newbury and Auburn Townships (fig. 3). Most of the valleys in these two townships were filled with drift, except for kettles, which mark the former position of buried ice blocks. Many of these kettles were, or are, the sites of irregularly shaped lakes, the largest of which is Punderson Lake in southeastern Newbury Township. Similarly formed lakes are Kiwanis Lake, Little Punderson Lake, Lake Kelso, Snow Lake, and Burton Lake. The kames occur as clusters of irregular well-developed knobs or hummocks which rise 10 to 50 feet above their surroundings. The excellent preservation of the kame topography is remarkable considering the kames have been overridden by one or more ice advances. The kame-moraine complex merges with kame terraces in several valleys peripheral to its margin.

Valley bottoms

A significant aspect of Geauga County physiography is the presence of numerous deeply cut valleys which form an intertwined network surrounding the bedrock knobs. Several of these valleys have been partially filled with drift, producing wide valley flats. These wide valleys were the sites of lakes at various times during the Pleistocene, and several lakes remain as vestigial remnants of earlier, more extensive lakes. Examples are Geauga Lake in the Chagrin River lowland in the southwestern corner of the county, Lake Aquilla in the valley of West Branch Cuyahoga River southeast of Chardon, and Bass Lake in the Chagrin River valley southwest of Chardon. One of the most extensive valley flats is where East Branch and Tare Creek join the Cuyahoga River midway between Middlefield and Burton. This flat extends southward for about 11 miles to the county line. In several places these valley bottoms are nearly 1 mile wide. Hummocky kames and kame terraces are common along the valley margins, and in places extend completely across the valley, forming a dam or plug.

DRIFT THICKNESS

Thickness of glacial deposits overlying the bedrock in Geauga County is highly variable, ranging from zero on the uplands to nearly 300 feet in several buried valleys. Areas of thin drift may be determined from field observations of actual bedrock or of soils derived from bedrock along streams, valley walls, and road cuts. Where the drift thickness is greater than a few feet, water-well drilling records (referred to as logs) represent the major source of subsurface information. A majority of the water wells in Geauga County have been drilled to bedrock, so the thickness of glacial drift is known in many places. In addition, most of these well logs contain information about the type of glacial drift recorded by the driller, so that the composition of the drift is known in a general way.

The thickness of drift in Geauga County is controlled by (1) the high elevation of sandstone knobs and ridges, (2) the depth of early Pleistocene valleys which have been filled or partially filled, (3) the formation of end moraines, and (4) postglacial erosion. The influence of the topographic and geomorphic landforms is evident in comparing figures 2, 3, 4, and 5.

The drift-thickness map (fig. 4) of Geauga County is dominated by an intertwining network of buried valleys, which generally trend northeast-southwest and northwest-southeast. Each of these valleys is characterized by drift thickness in excess of 150 feet. Nearly 400 feet of drift has been recorded in some places in the county.

Drift is thin—less than 10 feet thick—and bedrock is close to the surface at many places in Geauga County. Drift is thin on the tops and on the steeper flanks of most of the sandstone knobs and ridges, of which there are more than 100 in the county. The most extensive area of thin drift is in northern and central Thompson Township, where bedrock generally is within 2 to 5 feet of the surface. Bedrock also is exposed in some places where streams have cut deep valleys through thick drift. Examples are the Grand River near Parkman, the Chagrin River near Chagrin Falls, and East Branch Chagrin River northwest of Chardon.

Areas of 10-50 feet of drift are the most extensive and are widely distributed across the county (fig. 4). These areas are located primarily on the gentle slopes of broad uplands, where several till sheets are present and where moraines are not well developed. These broad uplands of relatively thin drift occur in every township and are most extensive in the eastern half of the county.

Areas of 51-150 feet of drift also are very extensive in Geauga County. These areas represent the Defiance Moraine in the western, northern, and eastern parts of the county, the kame moraine in the south-central part, the smaller buried valleys, and the upper slopes of the larger buried valleys.

Areas where drift is greater than 150 feet thick are limited to the central portion of large, deeply buried valleys and the downstream portion of a few of their tributaries. Although of limited extent, these areas are of great importance as possible locations of sand and gravel aquifers. Although Geauga County is considered a bedrock divide and is the headwaters region for the four major modern drainage basins in northeastern Ohio (see fig. 5), several deeply cut—and deeply buried—valleys occur in the county. These buried valleys are the ancestors of the modern Grand, Chagrin, and Cuyahoga Rivers, although the modern rivers have experienced some diversion from their former courses.

Most water wells in the buried valleys do not go all the way to bedrock but are completed in glacial sand and gravel aquifers, and thus do not reveal the true drift thickness. The deepest well penetration that did not reach

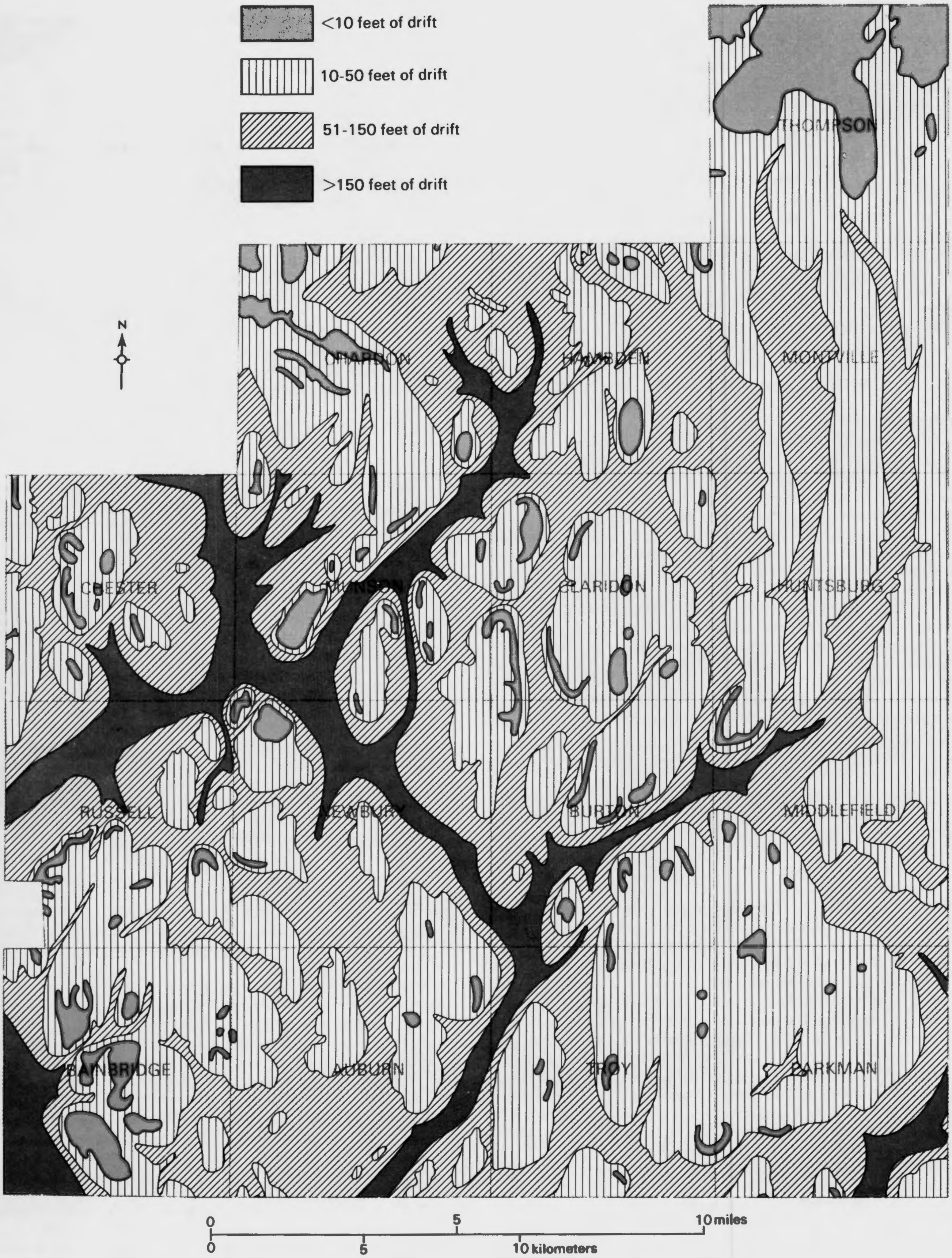


FIGURE 4.—Generalized thickness of drift in Geauga County.

bedrock is 383 feet in the buried Chagrin Valley 1 mile northwest of Geauga Lake. Other notable thicknesses of drift penetrated by wells include 323+ feet south of Chagrin Falls, 290+ feet in northern Newbury Township, 306 feet 2 miles east of Chesterland, 298 feet at the eastern edge of Chardon, and 258 feet southeast of Parkman.

DRAINAGE

Modern drainage

Geauga County has many of the highest elevations in northeastern Ohio, and the drainage flows away from the county in all directions (fig. 5). The modern drainage in the county is the product of a lengthy and complex erosional history, and the effect of glaciation on the drainage has been significant. The county contains the headwaters of four of northeastern Ohio's major drainage systems: the Cuyahoga, Grand, Chagrin, and Mahoning. The first three of these drain 99 percent of the county and flow into Lake Erie; the Mahoning drains the remaining 1 percent and flows into the Ohio River. The major drainage basins are described below.

Cuyahoga River basin.—The Cuyahoga River has its origin in the morainic upland in northeastern Geauga County a short distance west of Montville. East Branch Cuyahoga River flows generally southward in a shallow valley in western Montville and Huntsburg Townships to the vicinity of East Claridon, where the valley is plugged with kames. The valley has been artifically dammed in the southwest corner of Huntsburg Township to form East Branch Reservoir, which has a length of 2.3 miles. A short distance south of the reservoir, near Burton Station, East Branch and Tare Creek join to form the Cuyahoga River, which flows through a large swampy depression 0.5 mile wide and about 3 miles long. This swampy terrain also extends about 2 miles northeastward in the valley of Tare Creek, which flows southward in an intermorainic lowland in Huntsburg Township. The Cuyahoga River continues southward in a wide, swampy valley partially restricted in places by kames to the Geauga-Portage County line, for a total distance of 11 miles.

A short distance southwest of Burton, the Cuyahoga is joined by West Branch, a major southward-flowing tributary that originates in the upland of central Hambden Township and which drains a significant portion of Hambden, Claridon, and Burton Townships and a small portion of Munson Township. In western Claridon Township, West Branch flows southward in a large depression nearly 5 miles long and as much as 0.8 mile wide; this depression is a segment of an ancient valley plugged at both ends with kames. Lake Aquilla is the remnant of a once much more extensive lake which occupied this depression.

Most of the Cuyahoga tributaries in south-central Geauga County enter from the west, draining a large portion of the hummocky kame moraine. The valleys in the kame moraine, which covers a large area mainly in Newbury and Auburn Townships, have been filled with drift to such an extent that kettles are about all that remain of the valley depressions. The kettles are the sites of lakes, some of which are filled with sediment sufficient to turn them into swamps. The water in the kame-moraine area drains sluggishly from one kettle hole to the next, eventually reaching the Cuyahoga River.

Another major tributary of the Cuyahoga River is Bridge Creek, which drains nearly all of Auburn Township. The headwaters of Bridge Creek are in the kame moraine in southern Newbury Township, and the creek flows southward in Auburn Township nearly to the county line, then eastward a short distance, and finally northeastward to join the Cuyahoga River in northwestern Troy Township. Bridge Creek is artifically dammed at a wide part of the valley in Troy Township to form LaDue Reservoir, which is about 5.5 miles long and as much as 1 mile wide.

Geauga Lake, in the extreme southwestern corner of the county, drains southwestward into Aurora Pond. Aurora Pond in turn drains into the Cuyahoga River by way of Pond Brook and Tinkers Creek in northern Portage County.

Grand River basin.—The Grand River originates in the upland of northwestern Parkman Township, flows southward to Parkman, and then eastward into Trumbull County. A short distance east of Geauga County the Grand River bends northward. At Mechanicsville in Ashtabula County, the Grand River is diverted westward by a moraine, and the river flows westward into Lake County to enter Lake Erie about 10 miles northwest of Chardon. Along almost its entire course, the Grand River is fed by tributaries flowing eastward and northward from the Portage Escarpment. These tributaries drain much of eastern and northern Geauga County. The divide separating the Grand River and Cuyahoga River drainages is closely approximated by the Defiance Moraine (compare figs. 3 and 5). The weak and somewhat discontinuous nature of the Defiance morainic elements allows for some drainage lines to cut across the moraine.

The Grand River is deeply entrenched along most of its course, and many of its tributaries, particularly those cutting into relatively weak glacial sediments, likewise have entrenched their valleys. For example, the Grand River has cut a deep gorge 0.5 mile southeast of Parkman along which more than 130 feet of till is exposed. Swine Creek, a tributary which drains northern Parkman and southern Middlefield Townships, similarly is entrenched, and till nearly 100 feet thick is exposed 1 mile northwest of Bundysburg.

East of the Defiance Moraine in Middlefield, Huntsburg, and Montville Townships, numerous small tributaries flow eastward into Trumbull and Ashtabula Counties, eventually joining the Grand River. In Thompson Township many other tributaries flow eastward, northward, and westward away from the large sandstone upland of central Thompson Township. In the north-central part of the county, the area of Hambden and Chardon Townships north of the Defiance Moraine is drained northward by Bates Creek and Big Creek to the Grand River. In southwestern Hambden Township, Cutts Creek flows southwestward to Chardon between two elements of the Defiance Moraine. On the east side of Chardon, the large valley is blocked by glacial drift, which diverts Cutts Creek northward into Big Creek. Big Creek flows mainly northward from Chardon in a deeply entrenched valley along which glacial sediments about 100 feet thick are exposed.

Chagrin River basin.—The Chagrin River, which drains the western third of Geauga County, has its origin in the kames and kame moraine in the large valley flat south of Chardon. The drainage from Chardon flows southwestward through the large lowland partially occupied by Bass Lake to Fowlers Mill, where the river has cut a small gorge. From Fowlers Mill, the Chagrin River meanders across a large valley flat which is plugged at either end by drift. From northwestern Newbury Township the Chagrin River has cut a sinuous gorge westward across the upland of northern Russell Township to Novelty. At Novelty, the Chagrin River bends southwestward and follows the outer boundary of the Defiance Moraine to Chagrin Falls. Between Novelty and Chagrin Falls, in western Russell Township, the river has cut a moderately sinuous gorge 80 feet deep through glacial sediments and into the underlying bedrock. At Chagrin Falls, the Chagrin River bends sharply northward and flows nearly due north in a deeply cut valley in eastern

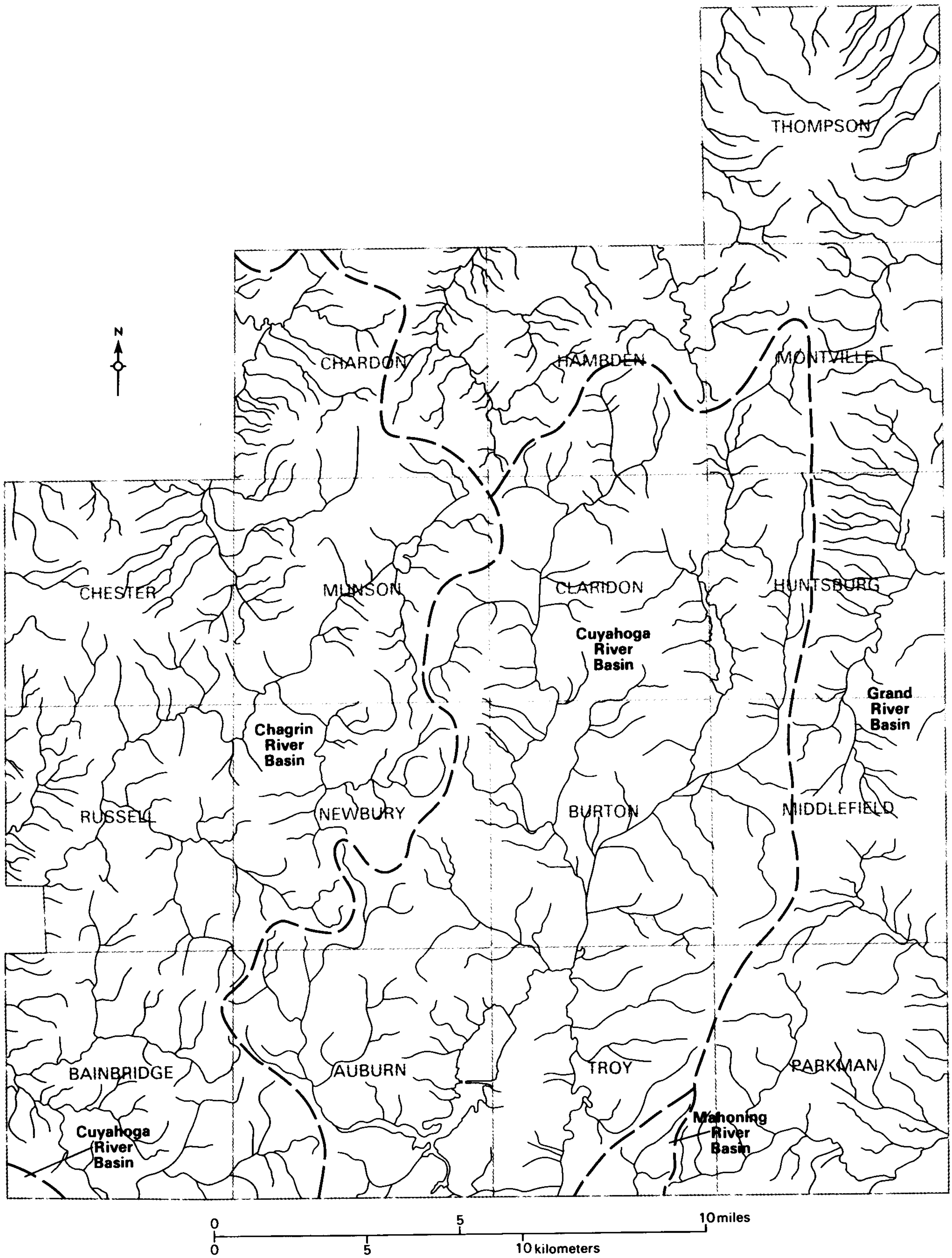


FIGURE 5.—Modern drainage lines in Geauga County. Drainage divides shown by dashed lines.

Cuyahoga County near the western border of Geauga County.

The Chagrin River has several major tributaries in Geauga County, the largest being East Branch and Aurora Branch. East Branch originates in the upland of northern Munson Township, flows southwest into Chester Township, and then bends sharply northward. East Branch follows a generally erratic course northward across the extreme southeastern corner of Kirtland Township, Lake County, into western Chardon Township for a distance of about 2.5 miles, and then back into Lake County, where it flows westward to join the Chagrin, and thence northward to Lake Erie. East Branch and its tributaries are deeply entrenched and have cut as much as 200 feet below the upland at the Lake-Geauga County line northwest of Chardon.

Aurora Branch and its tributaries, including McFarland Creek, drain all of Bainbridge Township except the southwestern corner, the southwestern corner of Auburn Township, and a small area of south-central Russell Township. Aurora Branch flows northwestward across the southwestern corner of the county in a narrow valley, which is entrenched about 70 feet below its surroundings. The valley is cut about 60 feet below the level of Geauga Lake, which is only about ½ mile from the valley. Headward erosion of the small tributaries through the soft glacial sediments eventually will lead to the draining of Geauga Lake and to the piracy of Pond Brook. Most of the tributaries of Aurora Branch follow circuitous routes around sandstone knobs and ridges which dominate Bainbridge Township. The narrow valleys have been dammed in several places to form manmade lakes, which are the sites of several scenic communities.

Mahoning River basin.—An area of slightly more than 1 square mile in southern Troy Township is drained by Silver Creek, a southward-flowing tributary of the Mahoning River, which flows into the Ohio River. A part of the headwaters of Silver Creek originates in a swamp that occupies an east-west-trending lowland that formerly connected the Cuyahoga River and Grand River drainage basins.

Pleistocene drainage systems

The drainage history of Geauga County immediately preceding glaciation and the drainage changes that occurred during the Pleistocene were complex, and many of the details are a matter of conjecture. Several reversals of drainage are thought to have occurred in Geauga County and elsewhere in northeastern Ohio during the Pleistocene. These reversals are associated with advance and retreat of ice coupled with the deposition of drift which blocked or impeded streamflow. The modern drainage (fig. 5) and the visible glacial landforms (pl. 1) are a product primarily of the latest (Wisconsinan) major glacial period. Earlier glaciations and their effect on the drainage of Geauga County are known primarily from water-well logs that record data pertaining to buried stream and lake deposits; these well logs can be used to determine the topography of the buried bedrock surface.

Two previous reconstructions of the Pleistocene drainage systems of Geauga County are by Stout and others (1943) and by Baker (1957). Stout and others (1943, map 4; fig. 6, this report) show the preglacial (Teays Stage) drainage in northern Ohio flowing north into the St. Lawrence drainage system. This interpretation is in accordance with the findings of White (1934), who presented evidence that the major preglacial divide in Ohio was located 50 miles southwest of Geauga County in Holmes County. White (1934) also concluded that the preglacial valleys were at higher elevations than at present.

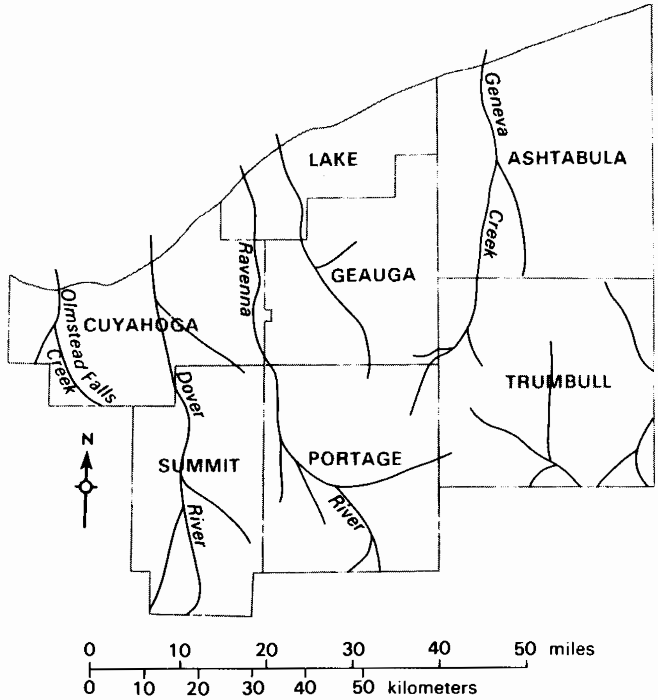


FIGURE 6.—Preglacial (Teays Stage) drainage in northeastern Ohio as interpreted by Stout and others (1943).

Stout and others (1943) show three northward-flowing preglacial streams draining Geauga County. The Ravenna River, the largest of the three, flowed northward across the southwestern corner of Geauga County and into Cuyahoga County a very short distance west of the Geauga-Cuyahoga County line in a valley occupied by a segment of the modern Chagrin River. Geneva Creek flowed northward across the southeastern corner of Geauga County and through Trumbull and Ashtabula Counties in a valley occupied by a segment of the modern Grand River. The smallest of the three streams was not named and flowed northward through west-central Geauga County. The existence of this unnamed valley was questioned by Baker (1957), who showed a somewhat different reconstruction of preglacial drainage. Baker (1957), using water-well logs, constructed a detailed bedrock-contour map of Geauga County which showed two major valleys. The larger valley trended northeastward in the northwest corner of the county from Russell Township through Chester, Munson, and Chardon Townships. This valley is traversed by a segment of the modern Chagrin River, which flows in the opposite direction. The smaller valley trended north from the southern edge of the county through Troy and Burton Townships to the vicinity of Burton. It changed course at Burton and trended northeastward through Middlefield and Huntsburg Townships to join Geneva Creek in Ashtabula County. This valley is followed by a segment of the modern Cuyahoga River. Although Baker's (1957) drainage reconstructions were based on considerable data, many more well logs were available in 1981 than in 1957, and it is possible to trace buried valleys with considerably greater confidence than was possible for Baker.

The drift-thickness map for Geauga County (fig. 4) indicates five major preglacial/early glacial valleys buried by drift more than 150 feet thick in Geauga County. Three of these valleys trend northeast-southwest, or parallel to the strike of the bedrock, and the other two trend northwest-southeast. These valleys are shown in figure 7 and

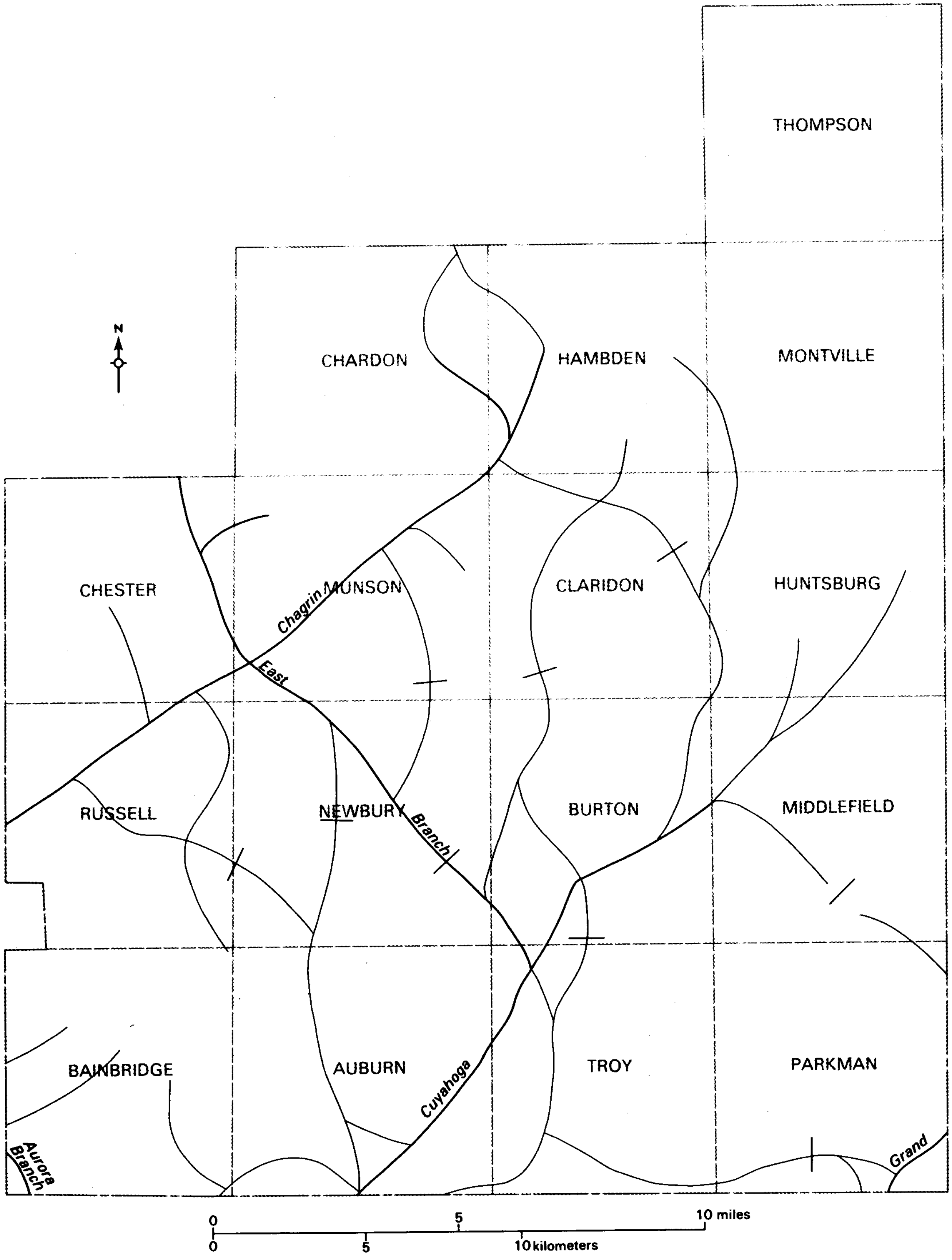


FIGURE 7.—Preglacial and early Pleistocene drainage in Geauga County. Valleys buried by over 200 feet of drift shown by heavy line; valleys buried by 100 to 200 feet of drift shown by light line. Local drainage divides shown by short bars.

each is described below with a name designation based on the modern stream that occupies the valley.

Chagrin.—A large buried valley originates in the highlands of northern Hambden Township and extends from Chardon southwestward past Fowlers Mill across Munson and Russell Townships into Cuyahoga County north of Chagrin Falls. This valley is followed in a general way by a segment of the modern Chagrin River and probably was tributary to the Ravenna River of Stout and others (1943), although it may have flowed at times into East Branch described below.

Cuyahoga.—A second large buried valley originates in the upland of Montville and Huntsburg Townships and trends southwestward south of Burton across southern Burton Township, across the northwestern corner of Troy Township, and across southeastern Auburn Township into Portage County. This valley is followed in its upper part by the modern Cuyahoga River and in the lower part by Bridge Creek. More data are needed to determine the trend of the valley near the Geauga-Portage County line, where there are several smaller east-west-trending buried valleys. It is probable that the buried Cuyahoga Valley also was tributary to the Ravenna River.

Grand.—A third large buried valley trends northeastward across the southeastern corner of Parkman Township. This buried valley can be traced northeastward through Trumbull County and into Ashtabula County, where it has been traced by White and Totten (1979). This valley is Geneva Creek of Stout and others (1943). In Geauga County, this buried valley is followed by a segment of the modern Grand River.

East Branch.—A fourth major valley trends northwestward across west-central Geauga County. This valley intersects the buried Cuyahoga Valley near Burton Lake, continues northwestward across Newbury Township, crosses the buried Chagrin Valley north of Fullertown, and bends northward near the Chester-Munson Township line into Lake County. This buried valley is followed by several small modern tributaries and in Chester Township is followed by modern East Branch Chagrin River. The buried East Branch Valley is eroded into the steep slope of the Portage Escarpment in Lake County and extended into Chester Township by headward erosion.

Aurora Branch.—A fifth major buried valley trends northwest across the southwestern corner of Bainbridge Township. It is a wide, deep valley that is now a wide lowland occupied by Geauga Lake and modern Aurora Branch. The buried Aurora Branch Valley has the lowest bottom elevation, 617 feet, recorded in the county and apparently was a portion or tributary of the Ravenna River.

In addition to the major buried valleys described above, numerous other, smaller tributary buried valleys (fig. 7) form a complex, intertwined drainage network. This complicated network obviously was produced when major drainage lines were dammed by ice of a glacial advance, or by deposition of glacial drift. The earliest glacier (Nebraskan?) to reach the Great Lakes area blocked the northward-flowing streams and diverted them southward into the Teays drainage basin of central and southern Ohio. Glaciers advanced more rapidly into the Grand River and Cuyahoga River lowlands, producing a lobate pattern, and surrounded Geauga County with ice on the north, east, and west sides. Lakes formed in the blocked valleys and ultimately spilled over divides to the south. Deep, narrow channels were eroded into the old drainage divides, and a new network of mainly southward-flowing streams was established. In many places the walls of the buried valleys are extremely steep and gorgelike and the narrow valley floors are incised 100 to 300 feet into bedrock. Some of the drainage reversals were permanent, while others were only temporary, with former drainage being reestablished after ice retreat. Drainage diversion and derangement occurred several times in Geauga County in response to multiple advances and retreats of the ice. Most valleys were not completely filled with drift during glaciation; after each glacial advance and retreat, drainage ultimately became reestablished, although at a different level and commonly in a different direction than previously. Most modern streams in the county flow in preglacial valleys which are partially buried by drift of varied composition and of several ages. A number of these buried valleys, such as the Grand River near Parkman, Swine Creek near Bundysburg, and East Branch Chagrin River in eastern Chester Township, have been exhumed by recent stream erosion.

GEOMORPHOLOGY OF THE GLACIAL DRIFT

Many of the surface features of Geauga County owe their formation directly or indirectly to glaciation. These features, which include ground moraine, end moraine, lacustrine plain, and glaciofluvial landforms, are the products of several ice advances. It is convenient to discuss these constructional geomorphic features separately from the stratigraphy of the deposits (discussed on p. 17) because many landforms did not result from deposition by the last glacier to cover the region, but are the result of deposition and modification by multiple glaciations.

END MORAINES

One of the most prominent glacial landforms in Geauga County is a series of end moraines, which are hummocky ridges of till with some gravel that were deposited at or near the ice margin wherever it fluctuated over a narrow belt for a period of time. These moraines are part of a large end-moraine sequence that trends southwest-northeast across the glaciated portion of Ohio (Goldthwait and others, 1961). Of the 27 morainic elements recognized in north-central Ohio (Totten, 1969), only five are recognizable in Geauga County. Several additional elements may be present in the kame-moraine complex in the south-central part of the county.

Several end moraines in Geauga County, collectively known as the Defiance Moraine, form an almost continuous border on three sides of the county—north, east, and west (pl. 1). The moraines, which mark former ice boundaries, are dramatic evidence of the way in which glacial lobes were influenced by the resistant upland of northern Geauga County. In many places the moraines have plugged major valleys, thereby causing derangement and reversal of drainage. The morainic elements tend to diverge on the uplands and converge in the valleys. Several elements may combine to form a single morainic ridge, whereas the same elements may diverge by a mile or more in a short distance.

The moraines do not project so high above their surroundings as to represent topographic barriers in the county. The major valleys and sandstone bedrock knobs are more imposing features. However, the moraines do represent a distinctly contrasting topography that is pleasantly rolling and not too steep to prohibit most agricultural uses.

The interlobate kame moraine in the south-central part of the county (fig. 3) is composed predominantly of kames which have been veneered with till of subsequent ice advances. These till-covered kames extend southward into Portage and Summit Counties, where they are known as the Kent Moraine.

Defiance Moraine

The Defiance Moraine is the northernmost of a series of end moraines that extends across all of Ohio (Goldthwait and others, 1961). The Defiance Moraine is not a single ridge but a multiple moraine consisting of as many as seven separate elements or ridges in north-central Ohio (Totten, 1969).

In Geauga County the Defiance Moraine is a more or less continuous belt of hummocky topography, typically 1 to 2 miles wide with 10 to 30 feet of relief, which nearly encircles the county on the west, north, and east sides (pl. 1). The Defiance Moraine in Geauga County commonly consists of three to six elements which in places are separated by valleys or tracts of ground moraine and which in other places are closely bunched to form a single hummocky tract.

In western Geauga County the moraine was formed by ice advancing southeastward in the Cuyahoga lobe (see figs. 9 and 10). The outer (distal) margin of the moraine is followed by the Chagrin River for 7 miles from Chagrin Falls northeastward into Munson Township north of Fullertown. The moraine exhibits a slight southeastward lobate trend where it crosses the valley of East Branch, and continues northeastward to Chardon, where it exhibits another small lobate trend in the valley of Big Creek. Both valleys were effectively plugged with drift where crossed by the moraine, which disrupted the drainage. The moraine north of Chardon has been breached by Big Creek, which has cut a narrow valley 40 feet deep through drift. From Chardon the moraine trends northeastward to Hambden, where it bends eastward and then southeastward in the Grand River lobe. The northernmost extent of the Defiance Moraine in Geauga County is in southern Thompson Township, where the moraine drapes around and over a prominent ridge of Sharon conglomerate.

In the Grand River lobe, westward-moving ice formed a north-south-trending moraine that extends for about 13 miles from Thompson Township due south to Middlefield. At the junction of the Cuyahoga and Grand River lobes in Hambden, Montville, and Thompson Townships, the Defiance Moraine consists of at least six poorly defined ridges or elements and several other broad, poorly defined areas of hummocky topography. South of Montville the elements merge to form two ridges, each about 1 mile wide and separated by a narrow tract of ground moraine. The eastern ridge, which is traversed by Madison Road (Ohio Rte. 528), is situated on the slope of the Sharon conglomerate escarpment and appears more prominent and higher than it really is; the morainic ridge projects only about 20 to 30 feet above its surroundings.

Near Middlefield the Defiance Moraine bends southeastward a short distance before bending southward once again near the Trumbull-Geauga County line in Parkman Township. From the southeastern corner of Geauga County, the Defiance Moraine may be traced southeastward across a corner of Portage County into Trumbull County (White, 1971).

The Defiance Moraine is believed to have formed during the latest (third?) advance of Mogadore-Titusville ice in the county. Exposures in the moraine reveal multiple till units, and Mogadore-Titusville Tills are exposed in the lower parts of deep excavations. These stratigraphic sections indicate the Defiance Moraine predates the Hiram, Lavery, and Kent ice advances, a situation which Baker (1957) recognized. The moraine was then overridden by the three later (Woodfordian) ice advances, which only slightly modified the morainic topography.

Other moraines

Several prominent end moraines between the glacial boundary and the Defiance Moraine in the Killbuck lobe (Totten, in preparation) are noticeably lacking in the Cuyahoga and Grand River lobes, where only sparse patches of hummocky topography occur between the Kent Moraine and the Defiance Moraine. A small discontinuous morainic ridge 10 to 20 feet high and 500 to 1,000 feet wide trends north-northeastward in Bainbridge and Russell Townships and appears to merge with the Defiance Moraine near the Russell-Chester Township line. A longer moraine segment occurs west of East Branch Reservoir in Claridon Township. Patches of morainic elements are present to the south in Middlefield and Parkman Townships and merge with the Defiance Moraine in eastern Parkman Township. These weakly developed morainic elements may have formed during the second Mogadore-Titusville ice advance a short time after the formation of the interlobate kame moraine.

HUMMOCKY TOPOGRAPHY WITHOUT LINEAR TREND

There are several areas of hummocky topography in Geauga County that do not have the linear trend of end moraines. The topography is the result of irregular deposition of drift adjacent to stagnant ice masses, mainly in ancient valleys. The drift of these hummocky areas is noticeably thicker than that of the ground moraine. Some of the hummocks may be till-covered kames, but most are thought to be thicker deposits of till.

In northern Chester Township along the Geauga-Lake County border, a large area of hummocky topography is gently undulating, with a few knolls rising 10 feet above their surroundings. Much of the area is dissected by deep ravines and the hummocky area appears almost flat by comparison. This hummocky area is an extension of a larger area in southern Kirtland Township, Lake County (White, 1980, p. 7).

Another relatively extensive area of hummocky topography is in western Newbury Township south and southeast of Fullertown. The hummocks are confined to a wide lowland surrounded on three sides by till-covered sandstone ridges. This area is adjacent to the interlobate kame moraine, and thus may contain buried kames. However, the hummocks are more gently undulating in comparison to the steeper knolls that characterize the kame moraine.

Several patches of hummocky topography occur in southern Bainbridge and Auburn Townships in lowland areas near the Geauga-Portage County line. Hummocks 10 to 20 feet high are concentrated near Spring Valley, Taborville, and west of Bainbridge.

GROUND MORAINE

Slightly more than half of the surface of Geauga County consists of ground moraine. The ground-moraine surface changes significantly from one place to another in the county. Along the eastern margin of the county the underlying bedrock is obscured beneath drift and the ground-moraine surface is a gently undulating plain that is swampy in places. Over much of the county the bedrock surface has considerable relief and the drift thickness is insufficient to obscure the topography of the bedrock surface. Consequently, the ground-moraine surface reflects the underlying bedrock surface, which ranges from nearly flat on the upland ridges to quite steep or hilly on the flanks of knobs and ridges. The surface till of the ground moraine over most of the county is the Hiram Till, in which somewhat poorly drained soils are developed. The older Kent Till is the surface till on the knobs and ridges in the south-central part of the county, where the soils are better drained.

GLACIOFLUVIAL DEPOSITS

A considerable amount of sorted and stratified sand and gravel was deposited by glacial meltwater streams in Geauga County. These sand and gravel deposits occur in several distinct landforms including kames, kame terraces, and outwash valley trains. Kames are conical hills formed when sand and gravel were washed into cavities in the ice or into reentrants along the edge of the melting glacier. Subsequent melting of the ice resulted in collapse and slumping of the bedded material to form kames. In places masses of unsorted debris (till) were deposited along with sand and gravel to form a kame moraine. Kame terraces consist of sand and gravel deposited along valley margins by meltwater streams flowing between the valley walls and stagnating ice remaining in the center of the valley. When the ice in the valleys melted, hummocky deposits resembling kames remained along the valley sides. Kame terraces may exhibit diverse topographical forms including chains of kames, kame deltas, valley-train segments, and kettles. Kettles are depressions, typically associated with glaciofluvial deposits, which formed when buried ice blocks melted. Valley-train deposits consist of outwash sand and gravel deposited in valley bottoms by meltwater streams flowing generally southward from the ice margin. The end moraines and kame moraines, deposited by Mogadore-Titusville ice, effectively blocked large segments of several valleys and ponded much of the drainage. Consequently, much outwash from the melting of Woodfordian ice was deposited in the broad valley depressions, and finer grained silts and clays were deposited as lacustrine sediments on top of coarser material in the ponded valleys. The stratigraphy in these buried valleys, as determined from water-well records, is extremely complex and varied, and the surface material may be thin and quite different from the material below. Postglacial stream erosion has removed much of the valley-train material; remnants of valley-train surfaces are terraces along valley sides. Valley-train terraces may be distinguished from kame terraces by their flat surfaces and by their position farther down the valley sides.

Distinctive soils are derived from the various types of glaciofluvial deposits, provided the deposit is not covered with more than a couple of feet of till. Chili, Oshtemo, Haskins, and Bogart soils are derived from sandy, gravelly parent material associated with kames, whereas Fitchville and Jimtown soils are derived from sandy, silty valley-train material (Williams and McCleary, 1982). Sebring, Damascus, and Carlisle soils are derived from silty, clayey lacustrine sediments. Figure 8 shows the general distribution of soil associations in Geauga County.

Kames and kame terraces

Interlobate kame moraine (Kent Moraine).—The Kent Moraine was named by Shepps and others (1959) for a belt of hummocky topography which characterized the marginal area of Kent Till in northwestern Pennsylvania. Goldthwait and others (1961) extended usage of the term Kent Moraine for hummocky topography in the outer margin of the Grand River lobe in Stark, Summit, and Portage Counties, Ohio, where Kent Till is the surface material. This very wide belt of hummocky topography can be traced northward from Portage County into south-central Geauga County, where it is mainly a hummocky mass of sand and gravel and till in the form of kames overlain by till. Unlike the situation south of Geauga County, where the Kent Till is the surface material of the moraine, in a major portion of the kame moraine in Geauga County the Lavery and Hiram Tills overlie the Kent Till.

The Kent Moraine in Geauga County actually is a large tract of kames deposited along the lateral margins of two neighboring lobes and overridden by two to four subsequent ice advances. The kames cover an area about 5 miles wide and 10 miles long in Auburn and Newbury Townships and small parts of Munson, Burton, and Troy Townships (fig. 3). Kames are not present everywhere within the tract, and several sandstone knobs project above the drift.

Kettle holes of all shapes and sizes are closely associated with the kames. Most kettles are elongate and are located in former valleys which are now buried with drift. Several kettles contain permanent bodies of water, the largest of which is Punderson Lake. Many former kettle lakes are filled with peat, silt, and clay. The drainage in the kame-moraine area is sluggish, and streams flow in and out of the kettles.

The kames occur in irregular clusters, each of which may be composed of 10 or more kames. The most spectacular kames are in the Punderson Lake area, where they rise 70 to 80 feet above lake level. The kame-and-kettle topography is well preserved, and the thin till covering deposited by overriding ice caused little modification of the topography in this area.

The internal structure and composition of the kames are displayed in numerous sand and gravel pits (see figs. 11-14). Most kames are composed of sandy gravel containing sand lenses and small pockets of till. The bedding is inclined and exhibits collapse structures typical of ice-contact deposits. The gravels generally are of good quality and may be suited for commercial operations.

The sandy gravel is thought to have been deposited during an early Mogadore-Titusville advance, and the hard, stony till that overlies the gravel is considered to be of a later Mogadore-Titusville advance. The gravel beneath the till is unweathered in many places, and does not appear to be appreciably older than the till. During the disintegration of the Mogadore-Titusville ice which formed the kames, large ice blocks were trapped and buried within the kame complex to later become kettles.

Grand River kame terraces.—Two levels of kame terraces occur in the valley of the Grand River west of Parkman. The terraces have a combined width of about 1 mile and a length of about 5 miles. The upper terrace is juxtaposed against bedrock knobs that border the valley and has elevations ranging from 1,130 feet to over 1,200 feet. The lower terrace, with a surface elevation of about 1,100 feet, is well developed on the west side of the Grand River and along an unnamed tributary. The terraces trend southwestward from Parkman to the vicinity of Maple Grove, where the upper terrace has an elevation of 1,110-1,120 feet. A pit in the upper terrace 1 mile west of Parkman exposes rubbly, very poorly sorted sand and gravel that contain till masses. The gravel is of poor quality and consists mostly of rounded sandstone fragments. Hiram Till, 11 feet thick, overlies the gravel in the pit. The upper terrace probably is Kent in age, and the lower terrace could be the same age or younger.

Cuyahoga River kame terraces.—The most extensive kame terraces in the county are along the Cuyahoga River valley and its tributaries. The terraces are narrow and are present only on the east side of the valley from the Geauga-Portage County line northward to Welshfield. Westward from the Cuyahoga River valley along the Geauga-Portage County line, kames and a kame terrace are present for 1.8 miles in the valley of Black Brook. Considerable amounts of till probably occur in the kames north of Black Brook.

North of Welshfield, two levels of kame terraces occur along the east side of the valley for a distance of 3.5 miles. The upper terrace, traversed by Ohio Rte. 700, is 0.7 mile wide and has an elevation ranging from 1,130 feet in the south to 1,160 to 1,180 feet in the north. The upper terrace is mantled with Kent Till, and its topographic appearance is that of low rounded knolls. The lower terrace is about 0.5

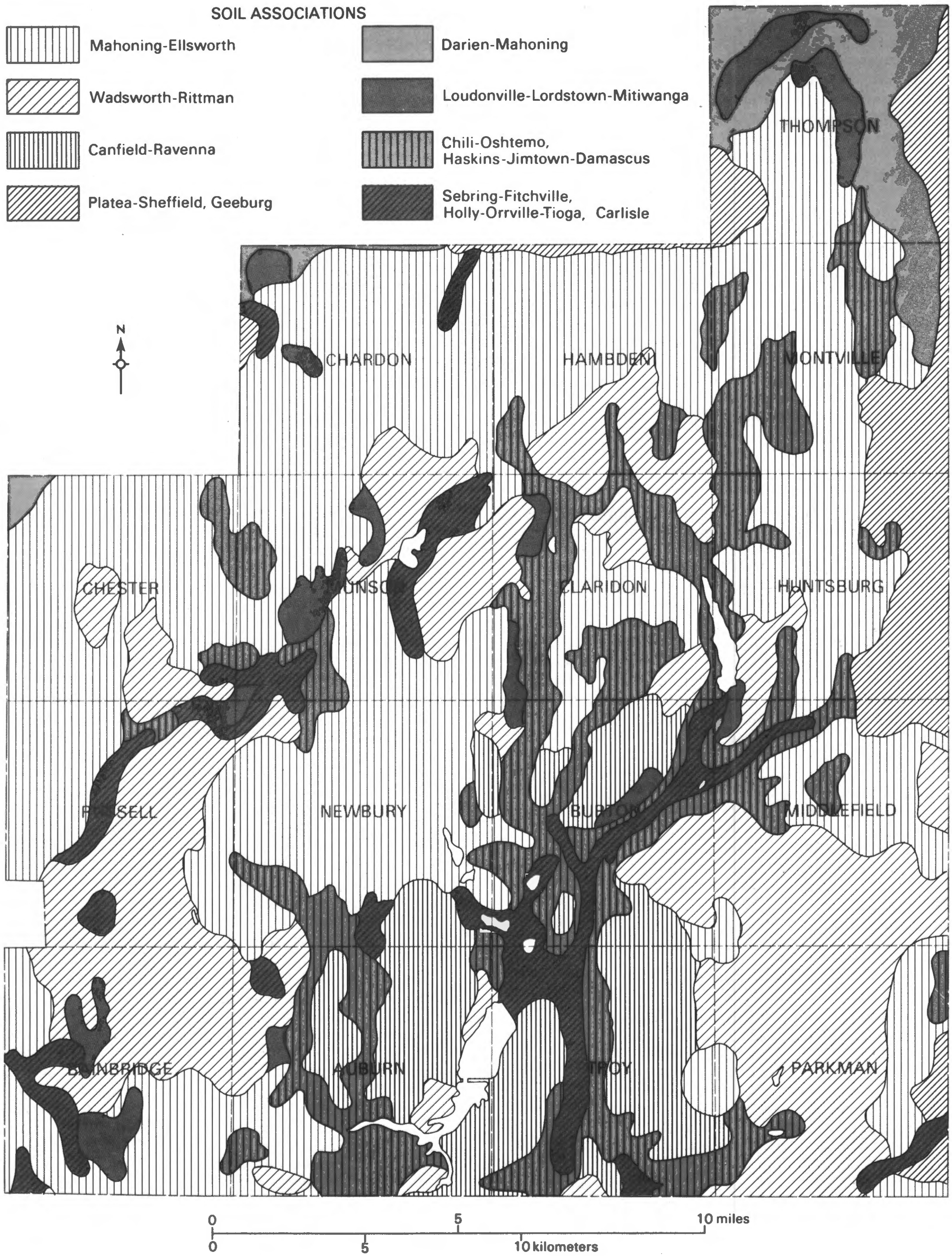


FIGURE 8.—Generalized distribution of soil associations in Geauga County (modified from Williams and McCleary, 1982). Soil associations may include many individual soils.

mile wide and has a surface elevation of about 1,110 feet. Its topographic expression is that of low irregular knolls. A narrow terrace is present on the west side of the valley and nearly encircles the sandstone knob 2 miles south of Burton.

From south of Burton northeastward the terraces continue upstream for 3 miles on both sides of the valley to the confluence of East Branch Cuyahoga River and Tare Creek. Smaller kame terraces are present along the valleys of both tributaries for several miles. The East Branch terrace, as much as 0.4 mile wide on either side of the valley, extends for 4.5 miles to the north end of East Branch Reservoir, which has drowned the lower part of the terrace. Near the north end on the east side of the reservoir two terrace levels are evident, the upper at an elevation of 1,260-1,270 feet, the lower at an elevation of 1,180-1,200 feet. At the north end of the upper terrace in northwestern Huntsburg Township, Hiram Till and in places Lavery Till overlie the sand and sandy gravel. Both terraces may be Kent in age, both may be Titusville, or the upper may be Titusville and the lower may be Kent. The Tare Creek kame terrace is about 4.5 miles long and is similar to, although smaller than, the East Branch terrace. Kent Till overlies the terrace, which apparently is Titusville in age. The elevation of the Tare Creek terrace is 1,130-1,150 feet at the south end and 1,220-1,240 feet at the north end, for a slope of about 20 feet per mile.

Bridge Creek kame terrace.—A small kame terrace extends for about 6 miles along the valley of Bridge Creek in southern Auburn Township. This terrace is best developed on the east and north sides of the valley and is overlain by sandy Kent Till in a few places. The terrace merges with kames of the interlobate kame moraine and appears to be the same age (Mogadore-Titusville) as the kame moraine.

Other kames.—A small terracelike grouping of kames along the west side of the Chagrin River near Novelty in northern Russell Township is mantled with thin Hiram Till and has a surface elevation of about 1,060 feet with very little slope. A small area of kames is present along the east side of the Chagrin River west of Novelty P O. Narrow kame-terrace segments occur on both sides of the small valley of West Branch Cuyahoga River 1 mile north of Lake Aquilla in northern Claridon Township. Two small tracts of kames are present in a small tributary of West Branch 1 mile southeast of Chardon. Several tracts of kames occur along the Chester-Munson Township line in the vicinity of the headwaters of East Branch Chagrin River. The largest of these tracts is 1.5 miles north of Fullertown and is nearly 1 mile wide. A line of kames about 1½ miles long trends northeast-southwest south of Bundysburg in eastern Parkman Township.

Valley-train outwash

Meltwater streams flowing generally southward away from melting ice sheets in Geauga County partially filled several valleys with outwash silt, sand, and gravel in the form of valley trains. Although nearly all of the Geauga County drainage ultimately flows northward into Lake Erie, most of the drainage in the county south of the Defiance Moraine is southward. At various times during the Pleistocene, and particularly during one or more of the Mogadore-Titusville ice advances, the southward-trending valleys became plugged with drift in several places. Consequently, meltwater flow was sluggish. During the retreat of Woodfordian ice, stagnant ice most likely remained in the valleys after ice had disappeared from the uplands. Meltwater flowed around and over this ice and deposited the thickest sediment in ice-free sections of the valleys. Subsequent melting of the valley ice resulted in the formation of shallow lake basins in the valleys (pl. 1).

The wide valley southwest of Chardon occupied by Bass Lake and the Chagrin River contains valley-train remnants on both sides of the valley. The valley train is continuous with the valley train of Beaver Creek. The terrace has an elevation of between 1,150 and 1,160 feet and has a very slight southward gradient in a distance of 3 miles. A large area of valley-train outwash about 2 miles southwest of Bass Lake in the Chagrin River valley in southwestern Munson Township and adjoining areas has an elevation of nearly 1,100 feet. Much outwash was ponded in the broad depression, now drained by the Chagrin River, between Fowlers Mill and Fullertown.

The wide valley southeast of Chardon occupied by Lake Aquilla and West Branch Cuyahoga River has valley-train remnants on both sides of the valley at an elevation of about 1,150 feet. It is believed that both of these wide valleys were protected by ice blocks which occupied the central valley and kept the valley free of drift. Sluggish meltwater flowed around and then over the blocks, depositing silty sandy outwash around and on the ice blocks. Finally, melting of the ice blocks allowed the outwash to sag in the central depression, forming a large lake. The outwash along the valley sides remained in place as narrow terraces which merge laterally with lacustrine deposits in the center of the valley.

A small valley train is present on both sides of the valley of the Grand River in the southeastern corner of the county. A few isolated remnants near Parkman have elevations of 970 to 990 feet. The valley train becomes more continuous downstream toward the Geauga-Trumbull County line, where the elevation is 870 feet. A few small segments also are present in the tributaries of the Grand River; the most extensive is along Swine Creek near Bundysburg about 5 miles northeast of Parkman. The Fitchville and Jimtown soils commonly develop on the silty sandy terrace sediments (Williams and McCleary, 1982).

Considerable amounts of valley-train outwash in the Bridge Creek valley originate in a narrow portion of the valley in northwestern Auburn Township and trend southeastward to LaDue Reservoir. A large tract of outwash south of the reservoir fills the wide buried valley to the Geauga-Portage County line.

A few small valley-train segments, at an elevation of 1,110 to 1,130 feet, are preserved in the valley of Tare Creek in northern Middlefield Township. Near Burton Station the Tare Creek valley train joins with a short valley-train segment in East Branch Cuyahoga River.

Alluvial terraces

The streams in Geauga County that flow northward into Lake Erie have entrenched their valleys to depths of more than 100 feet into drift and bedrock. The terraces developed in these valleys represent floodplains formed by streams that had base levels higher than present, determined by high levels of Lake Erie, probably during the Plum Point Interstade (see table 1). The present terrace surfaces are the result of modification of the original surface by both ice and water. Proglacial lakes occupied the valleys during retreat of the Woodfordian glaciers, and lacustrine silt and clay were deposited on the terraces. Postglacial streams flooded the terraces for a few hundred years during the high lake stages in the Erie Basin immediately following deglaciation. Lake levels in the Erie Basin dropped to below the present average lake level of 571 feet about 12,500 years ago, resulting in a new cycle of stream erosion. The modern streams flow in narrow valleys entrenched into the former floodplains, portions of which still remain as terraces.

Aurora Branch alluvial terrace.—Several remnants of an alluvial terrace are present along Aurora Branch and its tributary McFarland Creek in the southwestern corner of the county. The terrace elevation is 910 feet at the confluence of Aurora Branch and McFarland Creek, and 1,000 feet at the Geauga-Portage County line, for a slope of 20 feet per mile toward the northwest. On the north side of Aurora Branch a large terrace remnant traversed by Fields Road is mantled with Lavery Till, as evidenced by Wadsworth soil mapped on its surface (Williams and McCleary, 1982). During the Woodfordian ice advances till was deposited in the valley and on the terrace without obliterating the valley or the terrace. The modern floodplain has been cut about 10 feet below the level of the terrace.

East Branch Chagrin River alluvial terrace.—An alluvial terrace as much as 0.7 mile wide is present in the valley of East Branch Chagrin River in northeastern Chester Township. The terrace, which has an elevation of 920-950 feet, is about 20 feet higher than the floodplain and is underlain by silt, sand, and gravel at least 20 feet thick. Remnants of the terrace follow the stream as it trends northeastward into Lake County and then into western Chardon Township for about 2.5 miles before turning abruptly westward back into Lake County. The lowest elevation of the terrace remnants in Chardon Township is 840 feet. The slope of the terrace toward Lake Erie is about 17 feet per mile.

Other alluvial terraces.—Short, narrow remnants of alluvial terraces are preserved in the valleys of Big Creek north of Chardon and Bates Creek in northern Hambden Township (pl. 1). Small terrace segments are present in several places in the Big Creek valley, but are best preserved north of the Defiance Moraine and west of the creek. Terrace elevations north of the moraine range from 1,040 feet near the moraine to 930 feet at the Geauga-Lake County line, for a gradient of about 36 feet per mile.

LATE-GLACIAL AND POSTGLACIAL LAKES

Two types of glacially related lake basins formed upon disappearance of Hiram ice from the county. One type is the kettle lake, which formed when a buried ice block melted. The other type is the dammed valley, which was blocked or plugged by a variety of deposits and materials, including ice. Many lakes, of all shapes and sizes, existed in the county after deglaciation, and several still exist. As a rule, most lacustrine deposits are not well exposed because they accumulate below the water table; thus little is known of the details of the history of these lakes.

Lake Grove

An extensive lake, or perhaps a succession of lakes, is recorded by deposits and by topographic expression in the modern Cuyahoga River valley and its tributaries between Burton Station and the Geauga-Portage County line (pl. 1). Baker (1957) named this large body of water Lake Grove for the tiny hamlet of Maple Grove 2.5 miles southwest of Parkman. Maple Grove is within the Grand River drainage basin, but was probably inundated by the same lake that occupied the Cuyahoga River valley.

The lacustrine sediments form two types of topography—terraces and valley bottoms. Patchy irregular lacustrine terraces as much as 0.3 mile wide occur on both sides of the Cuyahoga River valley and extend a short distance up Bridge Creek and West Branch. These terraces extend for about 9 miles southward from the vicinity of Burton to the Geauga-Portage County line. The terraces have a surface elevation of 1,110 feet. The terrace sediment is mostly silt and silty clay with weakly developed lamination. Baker (1957) recorded a maximum thickness of 9 feet of lacustrine sediment south of Burton. The lacustrine material was deposited on and along the flanks of a low kame terrace; many kames still are recognizable beneath the lacustrine sediment. Soils derived from the silt and clay on the terraces are Fitchville, Sebring, and Glenford silt loams and Rawson and Haskins loams (Williams and McCleary, 1982).

After deposition of the sediments in the lake at 1,110 feet, the lake was drained and much of the sediment was eroded, leaving a few uneroded remnants as terraces. The relatively wide valley flat occupied by the sluggish-flowing Cuyahoga River also has the appearance of a lake bed and probably represents a later, lower level of Lake Grove at an elevation of 1,100 feet. The valley flat is featureless, swampy, and has a southward gradient of about 1 foot per mile, which is low for a stream in northeastern Ohio. The soils derived from the valley-bottom sediments are the Carlisle and Willette mucks and the Wabasha silty clay loam (ponded), which are indicative of lacustrine deposits (Williams and McCleary, 1982).

Lake Grove probably was initiated when Lavery ice of the Grand River lobe blocked the southward flow of the Cuyahoga River near Hiram Rapids, less than a mile south of the Geauga-Portage County line. The lake level rose a maximum of about 30 feet until it spilled over low divides in Portage County and drained into the Cuyahoga River south of Hiram Rapids. The lake was drained and the lacustrine sediment was eroded when Lavery ice retreated. The subsequent Hiram ice advance also may have dammed the Cuyahoga River for a short time to form the 1,100-foot lake, or perhaps the gradient was too low to permit adequate drainage of the valley bottom, imparting a ponded appearance to the floodplain. It is possible that the swamps within the Cuyahoga River valley are the remnants of nearly filled kettle holes.

Other lakes

Many other areas of lacustrine sediment occur in the county. Some of these areas are partially filled kettle holes; good examples are Snow Lake, Burton Lake, and Lake Kelso in Burton Township. These remnants of once considerably more extensive kettle lakes are rimmed by swamps which are being filled with a combination of silt, clay, and vegetation. The Carlisle muck soil (Williams and McCleary, 1982) is derived from the sediment filling these kettles. Other more extensive areas of lacustrine sediment are large valley depressions that remained after other parts of the valley had been plugged with drift. There are five major areas of valley lacustrine deposits, as well as several smaller tracts in the county (pl. 1): (1) Chagrin River valley east of Chardon, including Bass Lake, (2) West Branch Cuyahoga River valley southeast of Chardon, including Lake Aquilla, (3) East Branch Cuyahoga River valley in western Montville and western Huntsburg Townships, (4) a tributary of Bridge Creek in central Auburn Township, and (5) Chagrin River valley in southeastern Munson Township between Fowlers Mill and Fullertown.

PLEISTOCENE STRATIGRAPHY

The glacial deposits of Ohio are the result of several ice advances during the Pleistocene or Glacial Epoch. Ice accumulated far to the northeast in eastern Canada in the general area of Labrador and spread out laterally in all directions. A portion of this ice advanced southwestward into the Erie Basin as a major tongue known as the Erie

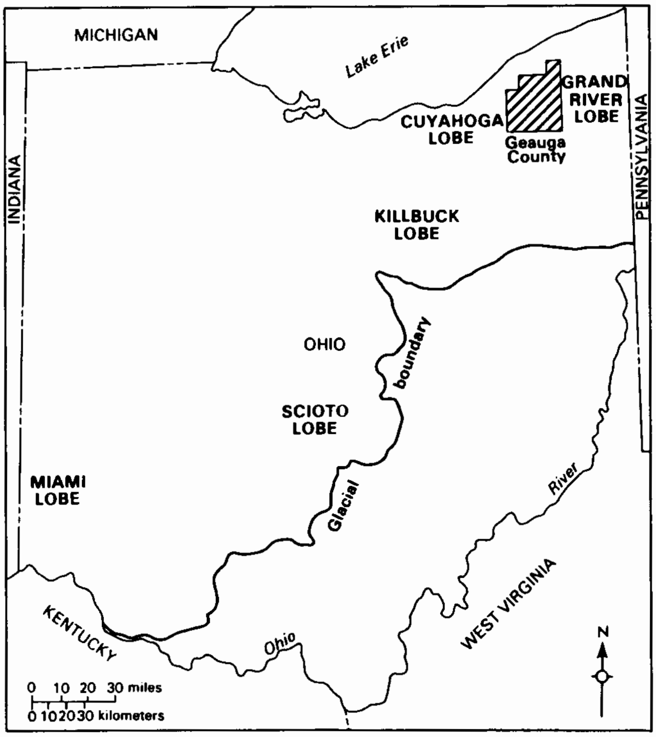


FIGURE 9.—Glacial boundary and glacial lobes in Ohio and position of Geauga County.

lobe. As the Erie lobe advanced into northern Ohio and northwestern Pennsylvania, it spread southward into lowlands and subdivided, from east to west, into the Grand River, Cuyahoga, Killbuck, Scioto, and Miami sublobes (fig. 9), hereafter referred to as lobes. Glaciation in Geauga County resulted from southward expansion of the Grand River and Cuyahoga lobes.

The glacial deposits at the surface and exposed in shallow cuts in Geauga County are of the Wisconsinan Stage, the latest stage in glacial history (table 1). Illinoian deposits are present beneath Wisconsinan deposits in buried valleys, and it is probable that pre-Illinoian deposits are present in deeply buried valleys accessible only to the drilling bit.

Deposits of the several advances of Wisconsinan ice are sufficiently distinctive to be separated in the exposures where they may be seen. It is to be expected that, in any exposure showing considerable thickness of glacial deposits, the material will have been deposited by more than one ice advance, and individual units will differ more or less in character. The till deposited by each ice advance commonly is very thin; the Hiram glacier, the last ice sheet to invade the county, may have deposited little or no till in some places, so that the surface till is not Hiram, but the earlier Lavery Till. Where the Lavery Till is very thin, Kent or even earlier till may be at or very close to the surface. Till is thickest in the belts of end moraine (pl. 1) and in buried valleys; till is thinnest or may even be absent on the sandstone knobs and ridges.

CRITERIA FOR IDENTIFICATION AND CORRELATION OF TILLS

The various tills in northern Ohio may be distinguished from one another by several criteria, including texture, mineral composition, color, and weathering characteristics. Till character is dealt with in more or less detail in several publications describing the glacial geology of northeastern Ohio counties, such as Ashtabula County (White and Totten, 1979), Richland County (Totten, 1973), and Wayne County (White, 1967), to cite a few.

TABLE 1.—*Glacial stages and deposits in Geauga County*

Epoch	Stage	Substage	Unit or interval	Deposit in Geauga County	Approximate dates (years B.P.)
PLEISTOCENE	Wisconsinan	Woodfordian	Late-glacial and postglacial	alluvium, peat, loess, lacustrine silt and clay	Present 15,000
			Hiram Till	dark-brown clayey silty till	16,000
			Lavery Till	dark-brown silty clayey till	17,500
			Kent Till	dark-yellow-brown silty sandy till	24,000
		Farmdalian	ice retreat (Plum Point Interstade)	stony paleosol	28,000
		Altonian	Mogadore-Titusville Tills (several units)	yellowish-olive-brown silty stony till	75,000(?)
	Sanga-monian		ice retreat	paleosol	125,000(?)
	Illinoian		Mapledale Till?	sandy pebbly till	(?)

Texture

The texture or grain size of a till is reasonably constant over a large area. Tills in northeastern Ohio range from silty sandy tills with relatively low clay content to silty clayey tills with low sand content. The tills at the surface in Geauga County are clayey or silty except for a small area in the south-central part of the county, where the surface till is sandy.

Mineral composition

Tills differ in content of quartz, feldspar, and carbonate minerals. The mineral composition of tills in northeastern Ohio, including Geauga County, has been the subject of earlier studies by Totten (1960) and Heath (1963). These studies indicate that the quartz content of tills ranges from 65 to 89 percent, being highest in the oldest tills; the feldspar content ranges from 11 to 35 percent, being highest in the youngest tills; and the carbonate (calcite and dolomite) content ranges from 5 to 21 percent.

Color

The color of a till is a subtle but very useful physical characteristic in till identification. At almost every thick till section, two dominant colors may be seen: brown where the till is oxidized and gray where the till is unaltered; the boundary is commonly 8 to 12 feet below the surface. The original gray color is due primarily to ferrous iron; oxidation to ferric iron gives the till a brown color, the shade of which is characteristic and consistent for each till. The oxidized younger Lavery and Hiram Tills in Geauga County are dark brown, tending toward "chocolate" brown, whereas the oxidized older tills are yellow brown (Kent) or olive brown (Titusville-Mogadore).

Weathering characteristics

In the weathering of till, among the first minerals to be altered are the iron-bearing minerals, especially pyrite. These minerals are oxidized, furnishing the brown color to the weathered till. In addition to the oxidation of pyrite, the carbonate minerals (calcite and dolomite) are leached, and the most resistant minerals, the silicates, are degraded. 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.

Horizon 5 is the unaltered till, which has changed little since it was deposited beneath or in front of the glacier. On drillers' and engineers' records, this horizon is sometimes called "blue clay with stones," but the color is a shade of gray rather than a shade of blue. The top of horizon 5 generally is 8 to 12 feet below the surface in Geauga County. The top of the gray till may be seen in deeper highway cuts, in gravel-pit excavations, and in cut banks along numerous streams.

Horizon 4 is calcareous till similar to that of horizon 5, except it has been oxidized to a brown color. The top of horizon 4 is also the depth of leaching, which ranges from as little as 2 feet below the surface in the Hiram Till to as much as 6 feet in Kent Till.

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 the joints or cracks in the till.

Horizon 2 (essentially the B_3 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 decomposed. Some clay material has accumulated in the joints, and soil-forming processes are 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 generally is a mixture of buff, gray, and brown. The lower part may have dark stains along the joints.

Horizon 1 is the soil of soil scientists and is divided into the A and upper B soil horizons. The characteristics of the soil differ with drainage and slope, as well as with parent material. The soils of Geauga County are described in great detail in the report and very detailed maps by Williams and McCleary (1982).

TILLS OLDER THAN MOGADORE-TITUSVILLE

There is very little evidence of tills older than the early Wisconsinan (Altonian) Mogadore-Titusville Tills at or near the surface in Geauga County. The Mogadore-Titusville Tills in many places contain small streaks and inclusions of red till which may be derived from the Keefus Till, which is known from exposures in Ashtabula County (White and Totten, 1979). The Keefus Till is older than the Titusville Till, but whether it is earliest Wisconsinan or older is uncertain. If the Keefus Till did extend as far south as Geauga County, it may have been completely eroded by Mogadore-Titusville ice. A firm, pebbly, stony till 68 feet thick exposed in a cut bank of Swine Creek (see section on p. 21) in southeastern Middlefield Township was assigned an Illinoian age by Baker (1957), who noted that 49 percent of the pebbles in the till were crystallines and carbonates. However, the physical characteristics and composition of the till along Swine Creek compare favorably with the Mogadore-Titusville Tills. Similar thick till along a cut bank of the Grand River southeast of Parkman (see section on p. 20) also is regarded as Titusville Till.

No other till earlier than Mogadore-Titusville is known in Geauga County. Till commonly is encountered in wells at depths exceeding 100 feet, particularly in buried valleys. It is possible that some of these deeply buried tills are of Illinoian or earlier age.

MOGADORE AND TITUSVILLE TILLS

The Mogadore Till of the Cuyahoga lobe and its correlative, the Titusville Till of the Grand River lobe (table 2), are the oldest tills present in stratigraphic sections over a wide geographic area. The Mogadore Till, named by White (1960) for a village in Summit County, Ohio, is a sandy pebbly till of the Cuyahoga lobe. The Titusville Till, named by White and Totten (1965) for a city in northwestern Pennsylvania, is a similar till in the Grand River lobe. The Mogadore Till is the surface till of southern Summit County and occurs beneath Kent Till over most of the Cuyahoga lobe. The Titusville Till is the surface till along a narrow fringe at or near the glacial boundary of the Grand River lobe in northeastern Pennsylvania (White and others, 1969) and eastern Ohio (White and Totten, 1985), and occurs beneath the Kent Till elsewhere in the Grand River lobe. The Mogadore and Titusville Tills are nearly identical in their physical properties and were deposited by the same (Altonian) ice advance, although in different lobes, which merged or coalesced along a north-south line bisecting Geauga County (fig. 10). The Altonian-age till in western Geauga County is the Mogadore Till; its correlative in the eastern part of the county is the Titusville Till. The Mogadore-Titusville Tills occur only in the subsurface in Geauga County, and extend generally over the entire county, although they vary widely in thickness and may be absent on some uplands.

Mogadore-Titusville till is hard, compact, sandy, and silty and contains abundant pebbles, cobbles, and boulders.

TABLE 2.—*Correlation of tills in northeastern Ohio*[1]

WISCONSINAN	WOODFORDIAN		*Erie lobe:* Ashtabula Till	
		Killbuck lobe	*Cuyahoga lobe*	*Grand River lobe*
		Hiram Till Hayesville Till Navarre Till	Hiram Till Lavery Till Kent Till	Hiram Till Lavery Till Kent Till
	FARMDALIAN (Plum Point Interstade)		paleosol	
	ALTONIAN	Millbrook Till	Mogadore Till	Titusville Till Keefus Till
SANGAMONIAN			paleosol	
ILLINOIAN		unnamed till	unnamed till	Mapledale Till? (subsurface only)
KANSAN		unnamed till	unnamed till	Slippery Rock Till? (subsurface only)

[1]Modified from White (1982).

Unaltered Mogadore-Titusville till (horizon 5) is dark or drab gray, whereas the oxidized till is dark yellowish brown, commonly with an olive cast. The depth of oxidation generally is 12 to 14 feet below the surface. The till contains prominent vertical joints along which oxidation extends downward for several inches into the unoxidized till. These joints generally are filled with clay and secondary calcium carbonate. Leached Mogadore-Titusville till is characterized by angular blocks which are stained reddish brown to black by iron and manganese. Rusty stains also coat most pebbles; as the pebbles are loosened from the till, rusty molds remain. In a few places, the till contains inclusions of red till eroded from an earlier deposit. The red-till inclusions probably were derived from the Keefus Till, which is known from exposures in Ashtabula County (White and Totten, 1979) and which presumably was the surface material along much of the south shore of Lake Erie prior to the Mogadore-Titusville advance.

Mogadore-Titusville till samples from several northeastern Ohio counties average 47 percent sand, 37 percent silt, and 16 percent clay (Totten, 1960). The till contains carbonates, although reaction to acid is noticeably less than that of the younger Woodfordian tills.

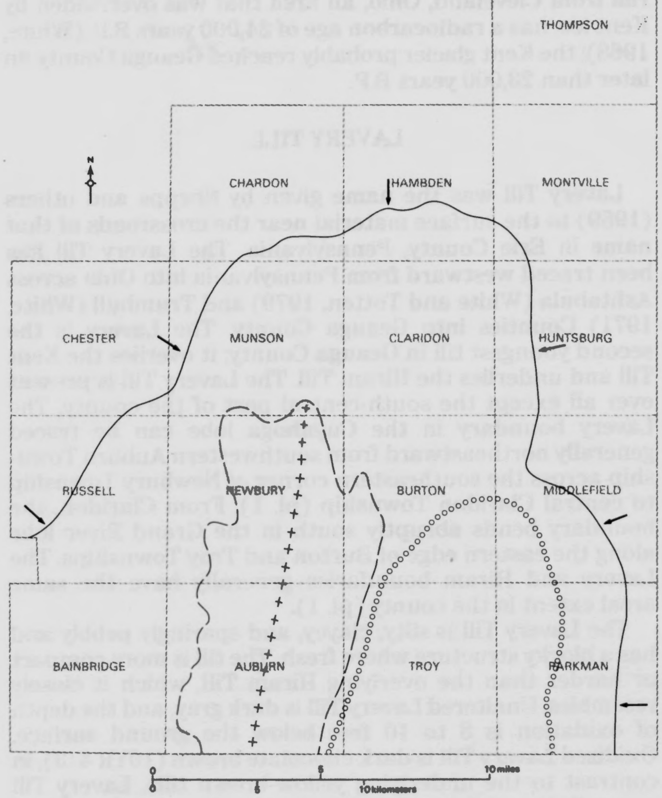
The Mogadore-Titusville Tills are the product of more than one ice advance (White and others, 1969; White, 1982) and are closely associated with thick, high-quality gravel deposits in several areas of the county. Evidence exists in Geauga County for at least three separate Mogadore-Titusville advances (fig. 10). The earliest advance covered all of the county; where the Cuyahoga and Grand River lobes joined in Newbury and Auburn Townships a complex assemblage of kames and gravelly moraine was deposited (pl. 1; fig. 3).

The second Mogadore-Titusville ice advance covered all but a small area in the southeastern part of the county (fig. 10) and deposited a layer of till generally 3-6 feet thick over the gravels deposited during the earlier advance. A few till knolls and ridges resembling end moraines were formed during the second advance, but end-moraine development was much weaker than in the adjacent Killbuck lobe (Totten, 1969, 1973).

The limit of the third Mogadore-Titusville ice advance is marked by the outer margin of the Defiance Moraine, which encircles the county on three sides (pl. 1; fig. 3). The Defiance Moraine, which consists of several partially overlapping elements or ridges, was formed during this third advance.

The thickness of Mogadore-Titusville till is difficult to measure because the base of the till is rarely exposed. Most thickness determinations of Mogadore-Titusville till are in upland areas of shallow bedrock; consequently, a statistical study of till thickness would yield a figure less than the true thickness. The Mogadore-Titusville Tills make up the bulk and framework of the moraines in other counties in northeastern Ohio (White, 1982), and it is projected that this till comprises the bulk of the Defiance Moraine in Geauga County. The thickest Mogadore-Titusville till exposures in Geauga County are associated with buried valleys that have been partially exhumed by modern drainage. The thickest section is along a cut bank of the Grand River southeast of Parkman, where 115 feet of Titusville Till is exposed. Analyses of Titusville Till samples from the Parkman section indicate a till composition of 42 to 48 percent sand, 38 to 45 percent silt, and 12 to 19 percent clay. Calcite is absent in all Titusville Till samples and the dolomite content is 2.8 to 3.6 percent.

Cut bank, Grand River	*ft*	*in*
Silt loam, gray-brown and yellow-brown	0	7
Till, dark-brown, clayey, weathered. HIRAM	2	3
Till, dark-brown, silty, clayey, blocky, calcareous, 18% sand, 47% silt, 35% clay, 2.5% calcite, 3.8% dolomite. LAVERY	1	2
Silt, yellow	0	2
Till, yellow-brown, sandy, silty, friable, calcareous, 53% sand, 35% silt, 12% clay, 1.7% dolomite. KENT	9	3



+ + + Approximate boundary between Grand River and Cuyahoga lobes during first Mogadore-Titusville ice advance

— — — Mogadore-Titusville interlobate kame moraine

oooooo Approximate limit of second Mogadore-Titusville advance

Outer boundary of Defiance Moraine and limit of third Mogadore-Titusville advance; arrows indicate direction of ice movement

FIGURE 10.—Boundaries of Mogadore-Titusville ice advances in Geauga County.

Boulder zone, large angular blocks of Sharon sandstone	3	0
Till, yellow-brown, sandy, silty, very firm, weakly calcareous, iron stained along fracture surfaces, 50% sand, 39% silt, 11% clay, 2.1% dolomite. TITUSVILLE	7	9
Till, as above, gray, with sand lenses 2-10 inches thick; average of 9 samples = 43% sand, 41% silt, 16% clay, 3.3% dolomite. TITUSVILLE	91	0
Sand, brown, calcareous	2	5
Till, drab-gray, silty, sandy, weakly calcareous, firm, platy to irregularly blocky, pebbly; red streaks; 41% sand, 45% silt, 14% clay, 2.9% dolomite. TITUSVILLE	16	6
TOTAL SECTION	134	1

An equally spectacular, although not as thick, exposure of Titusville Till occurs in a cut bank on Swine Creek in southeastern Middlefield Township. Several sand layers are present within the Titusville Till sequence, and a very stony till occurs near stream level beneath a layer of sand and gravel. Analyses of Titusville Till samples from the Swine Creek section indicate the till is composed of about 45 to 50 percent silt and about 35 to 40 percent sand. Calcite is absent in all till samples and the dolomite content averages 3.5 percent.

Cut bank, Swine Creek (thicknesses are approximate)	*ft*	*in*
Silt loam, gray-brown and yellow-brown	1	2
Till, dark-brown, clayey, weathered. HIRAM?	1	0
Till, dark-brown, clayey, weathered; concentration of pebbles at base. LAVERY?	1	0
Till, yellow-brown, not calcareous, sandy, silty, moderately pebbly. KENT	1	10
Till, as above, yellow-brown, calcareous. KENT	6	0
Till, as above, gray, calcareous, pebbly; contains sand stringers; 26% sand, 55% silt, 19% clay, 3% dolomite. KENT	6	0
Sand, brown, calcareous	1	6
Till, dark-gray, calcareous, firm, pebbly; interbedded with sand layers; 42% sand, 51% silt, 7% clay, 4.5% dolomite. KENT	3	6
Sand, as above, lenticular	0	6
Till, dark-gray, calcareous, very firm, pebbly; contains rusty stains along fractures; 29% sand, 53% silt, 18% clay, 3.1% dolomite. TITUSVILLE?	4	0
Sand, as above	2	0
Till, dark-gray, very firm, calcareous, pebbly, 40% sand, 47% silt, 13% clay, 3.3% dolomite. TITUSVILLE	5	0
Till, as above, 52% sand, 45% silt, 3% clay, 3.8% dolomite. TITUSVILLE	7	0
Sand, as above	2	0
Till, as above, 34% sand, 50% silt, 16% clay, 4% dolomite. TITUSVILLE	6	0
Sand, as above, lenticular	0	6
Till, as above, 39% sand, 46% silt, 15% clay, 3.8% dolomite. TITUSVILLE	6	0
Sand, as above	2	0
Till, as above, 36% sand, 47% silt, 17% clay, 3.8% dolomite. TITUSVILLE	4	0
Sand and gravel	2	6
Till, dark-gray, very stony, calcareous, very compact, platy; contains coal and dolostone clasts; 36% sand, 44% silt, 20% clay, 3.6% dolomite. TITUSVILLE	3	6
Till, dark-gray, slowly calcareous, very firm, 39% sand, 48% silt, 13% clay, 2.6% dolomite. TITUSVILLE	4	0
TOTAL SECTION	71	0

The Mogadore-Titusville Tills are correlative with the Millbrook Till of the Killbuck lobe (White, 1982) and with the Titusville Till of northwestern Pennsylvania (White and others, 1969) and northeastern Ohio (White, 1982). Considering the multiple nature of the Mogadore-Titusville till-gravel-moraine complex, it is likely that the sequence formed over a considerable expanse of time. One advance of Titusville ice in northwestern Pennsylvania was dated at about 40,000 years before present (B.P.) (White and others, 1969) on the basis of radiocarbon dates on peat and wood underlying gravel. However, the relationship of the dated organics to the Titusville Till was not firmly established, and the age of the till must be regarded as uncertain. A thermoluminescence date of about 125,000 years B.P. (Totten and Szabo, 1987) on loess overlying lower units of Millbrook Till (Titusville correlative in Killbuck lobe) suggests at least some Titusville Till may be Illinoian. No paleosol or other evidence of extensive weathering occurs within the Mogadore-Titusville sequence in Geauga County. Any paleosol that may have developed within this sequence has been removed by erosion. Only a concentration of stones, in places associated with rusty-colored sand and gravel or in a clay matrix, is common between the Mogadore-Titusville Tills and the overlying Kent Till. Some of the stones may be the result of frost heaving, and some stones probably were transported at least a short distance by Kent ice.

KENT TILL

The Kent Till, the oldest of three late Wisconsinan (Woodfordian) tills deposited in Geauga County, was named by White (1960) for the city of Kent, in western Portage County. The till can be traced at the surface from Kent northward into Geauga County, where it is the surface material in the south-central part of the county. Elsewhere in the county, the Kent Till is overlain by the Lavery and/or Hiram Tills. The Kent Till is essentially identical in the Cuyahoga and Grand River lobes.

The Kent Till is silty, relatively sandy, moderately pebbly, and tends to be crumbly or "mealy." It contains numerous sand lenses that tend to slump when wet, so that the Kent Till commonly appears as a wet zone in a road cut. Kent Till samples average 37 percent sand, 47 percent silt, and 20 percent clay (Totten, 1960).

Unaltered Kent Till is dark gray, although in Geauga County the till rarely is thick enough or exposed at sufficient depth to exhibit a gray color. Oxidized Kent Till is dark yellow brown (10YR 4/4 to 4/3), in contrast to the overlying chocolate-brown tills. Its color is similar to the underlying Mogadore-Titusville Tills; however, the Kent Till may be distinguished by its crumbly nature. A fresh exposure of oxidized Kent Till, when struck by a pick or mattock, exhibits numerous orange spots, which are cross sections of broken, strongly oxidized sandstone pebbles.

The depth of leaching in the Kent Till in its area of outcrop (pl. 1) commonly is greater than the till thickness, which ranges generally from 2 to 5 feet. Calcareous Kent Till occurs in several places beneath younger tills, which protected the sandy till from leaching.

The mineralogic composition of the Kent Till was studied by Heath (1963), who determined that the quartz content of the sand fraction increased from north to south, whereas the plagioclase feldspar content decreased over the same area. From north to south in the county the percentage of quartz (relative to feldspar) increased from 76.6 percent to 82.2 percent, while plagioclase feldspar decreased from 15 percent to 7 percent. Orthoclase feldspar, which decreased from east to west, averaged 10 percent in the Grand River lobe and 5 percent in the Cuyahoga lobe. Moderately drained to well-drained Canfield-Wooster-Ravenna soils (Williams and McCleary, 1982) are developed in Kent Till (see fig. 8).

The Kent Till was deposited as a relatively thin, nearly continuous layer. The average thickness measured in Geauga County is 4.1 feet. Complete sections of Kent Till are rarely exposed; the true thickness may be greater. Kent Till is thickest in the south-central part of the county; the thickest section measured was 10 feet in southeastern Burton Township.

Minor amounts of outwash sands and gravels are associated with Kent Till in major valleys. These glaciofluvial deposits are discussed in another section of this report (p. 14-17).

The contact between the Kent Till and the underlying Mogadore-Titusville Tills generally is marked by either a stone line or a moist gravelly zone. In places, where cobbles or other coarse materials are lacking, the contact is marked by a distinct increase in the compactness or hardness of the underlying Mogadore-Titusville Tills.

The Kent Till is correlative with the Navarre Till of the Killbuck lobe (White, 1961). Driftwood in lacustrine material from Cleveland, Ohio, an area that was overridden by Kent ice, has a radiocarbon age of 24,000 years B.P. (White, 1968); the Kent glacier probably reached Geauga County no later than 23,000 years B.P.

LAVERY TILL

Lavery Till was the name given by Shepps and others (1959) to the surface material near the crossroads of that name in Erie County, Pennsylvania. The Lavery Till has been traced westward from Pennsylvania into Ohio across Ashtabula (White and Totten, 1979) and Trumbull (White, 1971) Counties into Geauga County. The Lavery is the second youngest till in Geauga County; it overlies the Kent Till and underlies the Hiram Till. The Lavery Till is present over all except the south-central part of the county. The Lavery boundary in the Cuyahoga lobe can be traced generally northeastward from southwestern Auburn Township across the southeastern corner of Newbury Township to central Claridon Township (pl. 1). From Claridon, the boundary bends abruptly south in the Grand River lobe along the eastern edge of Burton and Troy Townships. The Lavery and Hiram boundaries generally have the same areal extent in the county (pl. 1).

The Lavery Till is silty, clayey, and sparingly pebbly and has a blocky structure where fresh. The till is more compact or harder than the overlying Hiram Till, which it closely resembles. Unaltered Lavery Till is dark gray, and the depth of oxidation is 8 to 10 feet below the ground surface. Oxidized Lavery Till is dark chocolate brown (10YR 4/3), in contrast to the underlying yellow-brown tills. Lavery Till generally is massive and compact where fresh and relatively unweathered, but horizontal partings develop where the till has been exposed to weathering. These partings commonly are ½ to 1 inch apart, and the till breaks into ½- to 1-inch cubes and prisms. A concentration of secondary calcium carbonate may be present along the partings just below the zone of leaching. Heath (1963) analyzed the sand fraction of Lavery Till samples and reported an average of 80 percent quartz, 12 percent plagioclase feldspar, and 8 percent orthoclase feldspar.

Wadsworth-Rittman soils, ranging from moderately well drained to somewhat poorly drained, develop in Lavery Till in those areas where the overlying Hiram Till is thin or absent. These soils are dominant in Parkman Township and occur over wide areas of Middlefield, Bainbridge, and Russell Townships (Williams and McCleary, 1982) (see fig. 8). Very little sand and gravel is associated with the Lavery Till, probably owing to relatively clean ice and an insufficient quantity of coarse material in the till.

Lavery Till averages 2.5 feet in thickness in Geauga County, except in Thompson Township, where the till is absent in most places. The till is slightly thicker in the Cuyahoga lobe than in the Grand River lobe, attaining a thickness of 5 to 8 feet in several places.

The contact of the Lavery Till with the underlying Kent Till typically is marked by the presence of stones, boulders, gravel, or sand. The sand and gravel are in thin lenses 1 to several inches thick, and the zone in places is marked by small springs. In an earlier study of Geauga County, Baker (1957) included the Lavery Till with the Hiram Till and gave them the designation "Late Cary." The Lavery Till is correlative with the Hayesville Till of the Killbuck lobe (White, 1967).

The time of advance of Lavery ice into Geauga County is not known. Estimates of the age of the Lavery Till differ widely; approximate dates of 17,500-16,000 years (table 1) are used for Geauga County in this report. Ice that deposited the Lavery Till may have advanced rapidly as a surge, and thus a relatively short amount of time may be represented by the Lavery Till.

HIRAM TILL

The Hiram Till, the youngest till in Geauga County, was named for the village of Hiram, in northeastern Portage County, by White (1960), who traced the till from its type locality northward into Geauga County. Hiram Till is the surface till over all of the county except the south-central part. The Hiram Till boundary in Geauga County generally coincides with the Lavery Till boundary (pl. 1). At the height of Hiram glaciation, a narrow peninsula of Kent Till, extending southward from Burton into Portage County, was surrounded by Hiram ice.

Hiram Till is silty and clayey and contains so few pebbles that it is sometimes mistaken for lacustrine clay or silt. Hiram Till samples average 33 percent clay, 42 percent silt, and 25 percent sand (Totten, 1960). The till is very calcareous, and secondary calcite concretions sometimes form a short distance below the leached zone. The till is sticky when wet and very hard when dry.

The color of unaltered Hiram Till is dark gray, whereas the color of oxidized till is dark chocolate brown (10YR 4/3). Hiram Till can be distinguished from the underlying Lavery Till by its slightly darker brown color, its higher clay content, and its very sparse pebble content.

Two places were noted where the Hiram Till was sufficiently thick to preserve unaltered gray till—northwest of Parkman and north of Lake Punderson. At both places the depth of oxidation was about 9 feet below the surface. The depth of leaching in the area covered by Hiram Till ranges from 24 to 48 inches and averages 33 inches. In general, the greater depths of leaching are associated with very thin Hiram Till and/or with shallow bedrock. Weathered Hiram Till is characterized by uneven horizontal partings generally ⅛ to ½ inch apart; as a result the till breaks into small chunks, cubes, or prisms. Heath (1963) determined that the sand fraction of Hiram Till samples from Geauga County averages about 74 percent quartz, 16 percent plagioclase feldspar, and 10 percent orthoclase feldspar.

The Hiram Till in Geauga County ranges from 0 to 20 feet in thickness and averages 2.8 feet. In most places the till is 2 to 4 feet thick. Hiram Till is thickest in and near the valley occupied by Lake Punderson and is thinnest on the uplands in the eastern and western portions of the county.

The most common soils developed on Hiram Till are the somewhat poorly drained Mahoning and Ellsworth soils (see fig. 8). Other soils developed in Hiram Till include the Platea and Sheffield soils, which are somewhat poorly drained and poorly drained soils that have a fragipan (an extremely compact soil layer), and the Geeburg, which is a moderately well drained soil. Platea and Sheffield soils occur primarily along the eastern border of the county adjacent to Ashtabula and Trumbull Counties. Geeburg soil is mapped on gently sloping morainic topography in the southeastern corner of the county.

The contact between the Hiram Till and the underlying Lavery Till is the least evident of any till contact in the county. At a majority of exposures, small amounts of silt, sand, gravel, or cobbles mark the contact. However, at many places, distinctive material is lacking at the contact and the only differences noted across the contact are subtle changes in color, texture, and pebble content.

The time of advance of Hiram ice into Geauga County is not known. A minimum radiocarbon age for the Hiram advance in Medina County is 14,500 ± 150 years (ISGS 402), determined from organic matter overlying Hiram Till (Totten, in preparation). Ice that deposited the Hiram Till also may have advanced rapidly as a surge; approximate dates of 16,000-15,000 years (table 1) are used for Geauga County in this report.

BOULDER PAVEMENT

A zone or layer of large boulders is encountered several feet below the surface in numerous road cuts, ditches, and other excavations. Evidence of large concentrations of boulders can be seen in housing developments, where boulders excavated during construction are prized landscape materials. Drilling records also indicate boulder concentrations.

Boulders are concentrated at the contact between the Mogadore-Titusville Tills and the overlying Kent Till. A few boulders also are encountered in the overlying tills, mainly in the Kent Till. These subsurface boulder zones are composed of well-rounded to angular boulders of all sizes; many are several feet in diameter. Newberry (1874, p. 38) estimated the exposed part of one boulder to weigh 150 tons. The boulders are of sufficient size and concentration to attract attention wherever moderately deep excavations occur. A majority of the boulders are Precambrian igneous and metamorphic rocks that are native to Canada. Most others are angular sandstone blocks that are native to northeastern Ohio.

It is postulated that large concentrations of boulders littered the landscape south of Lake Erie just prior to the Kent advance. Frost action plus deflation and mass wasting could have produced a boulder pavement on the Mogadore-Titusville Tills. Erosion of the Mogadore-Titusville Tills by stream and wave action during the Farmdalian Substage could have produced a large concentration of rounded boulders in a zone peripheral to ancestral Lake Erie; some of these boulders then were incorporated into the Kent ice.

LATE-GLACIAL AND POSTGLACIAL DEPOSITS

Silt cap

Wind-blown silt, known as loess, was recognized at 10 localities in western Geauga County. Where present, this loess is the surface deposit and is slightly younger than the Hiram Till on which it rests. The loess was derived from silty floodplain deposits of valleys to the west of Geauga County, probably from the Chagrin and Cuyahoga River valleys. The loess, where recorded, ranges from 6 to 12 inches in thickness, with the thickest deposits recorded in Bainbridge Township. In places the loess likely has been washed from hillslopes into depressions, and in other places has been so disturbed that the contact between silt and till has been obliterated.

Made land

Made land consists of sandstone quarries, gravel pits, reclaimed land, graded areas, and areas of fill where the land surface has been modified by man. In Geauga County, a relatively small number of tracts of made land are of sufficient size to be mappable (pl. 1). Most of these tracts are active or abandoned gravel pits in which the surface materials most likely are sand and gravel. Two of the larger tracts of made land, one about 2 miles south of Chardon and the other about 1 mile southeast of Thompson, are quarries in the Sharon conglomerate; surface materials in these two quarries are sandy and permeable. Small tracts of made land in lowlands may contain fill of almost any material.

MINERAL RESOURCES

The mineral resources of the glacial drift in Geauga County consist of sand, gravel, ground water, peat, and clay. The resources of the bedrock do not form a part of this report, and only a brief summary is possible. Conglomerate and sandstone have been extensively quarried primarily for use as crushed aggregate in the production of concrete and other construction materials. Many abandoned rock quarries are present in the county. In 1986, quarries were operated in Bainbridge, Munson, and Thompson Townships (Ohio Division of Geological Survey, 1987). The chief rock unit that has been quarried is the Sharon conglomerate (Pennsylvanian), which is composed of a mixture of quartz sand, pebbles, and cobbles. The quartz grains are weakly cemented near the surface, and the Sharon is easily quarried and crushed to form a product similar to glacial sand and gravel.

Until the 1980's, oil and gas production in Geauga County was minor and was limited primarily to gas produced from Devonian shale (Janssens and de Witt, 1976). In 1983, drilling activity increased greatly; in 1985 the drilling of 323 producing wells ranked Geauga County third among all Ohio counties (Ohio Division of Geological Survey, 1986). Most of the production in the 1980's has been gas and oil from the "Clinton" sandstone of Silurian age.

SAND AND GRAVEL

The glacial drift of Geauga County includes large deposits of sand and gravel that have commercial potential. This potential has been tapped in relatively few places for several reasons. Historically, Geauga County has not been a high consumer of construction materials, which require large quantities of sand and gravel, and deposits in nearby counties such as Portage and Cuyahoga have been adequate to supply the needs of adjacent areas. The till cover has presented problems in both exploration and exploitation of the sand and gravel deposits.

The glacial sand and gravel and pits that have been operated in them (pl. 1) are associated with a variety of deposits in many places in the county. The sand and gravel occur in kames, kame terraces, valley trains, alluvial terraces, and floodplains. The principal deposits are discussed by region and by type.

Interlobate kame moraine

Most of the commercial exploitation of glacial sand and gravel in Geauga County has occurred within the large kame-moraine complex (pl. 1; fig. 3) in the south-central part of the county. The kames in this complex contain large quantities of good- to high-quality gravel that has been excavated in relatively few places. Several large pits in the kames reveal the stratigraphic nature of the deposits (figs. 11-14). The Haueter Sand & Gravel Co. has excavated large quantities of gravel from several kames east of Punderson Lake, in Newbury and Burton Townships. Gravel, sand, and pebbly sand about 40 feet thick in variable and dipping beds are exposed above the water table and are overlain by Titusville, Kent, and Hiram Tills, each about 6 to 8 feet thick (fig. 11). A dredging operation has removed additional gravel from below the water table, creating a lake. The gravel is gray, sandy, loose, fairly clean, and of good quality. The major problems are the variability of the deposits, the till cover which must be stripped off the gravel and discarded, and the added costs of dredging gravel below the water table.

The Teague Gravel Co., Inc., has made a major excavation in the kame moraine in central Newbury Township west of Newbury Center (fig. 12). The covering of till which must be stripped before the gravel is excavated generally ranges from 8 to 16 feet in thickness, although the cover is as little as 1 foot over the kame crests. Operators of the pit report the thickness of gravel beneath the floor of the pit to be as

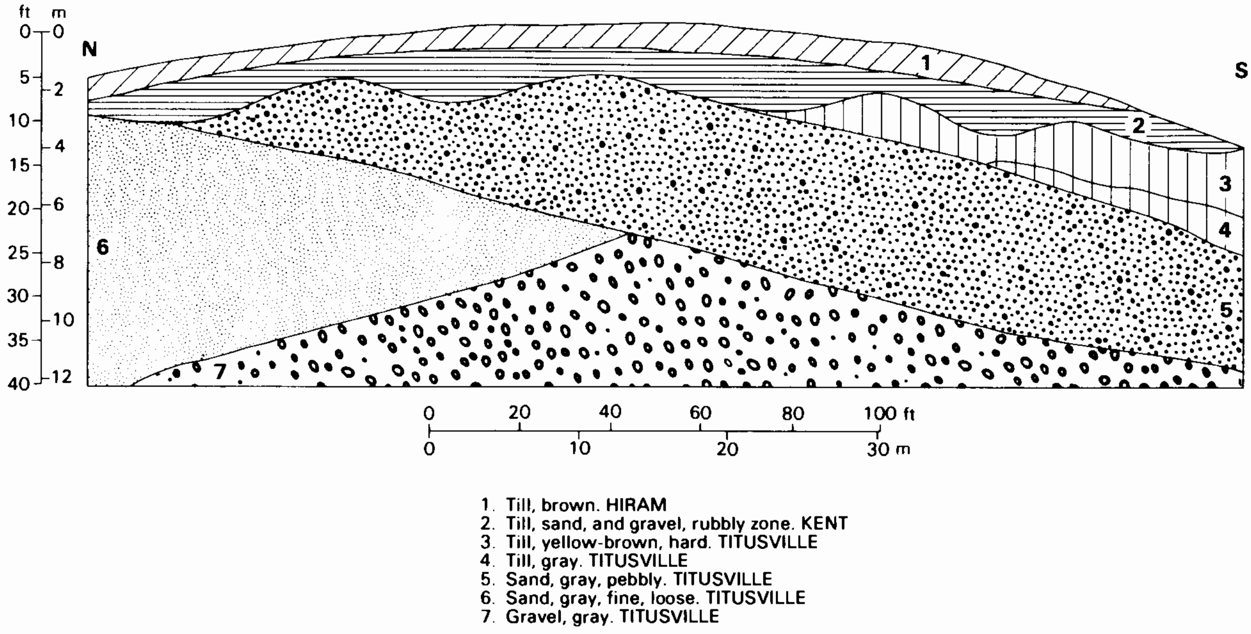
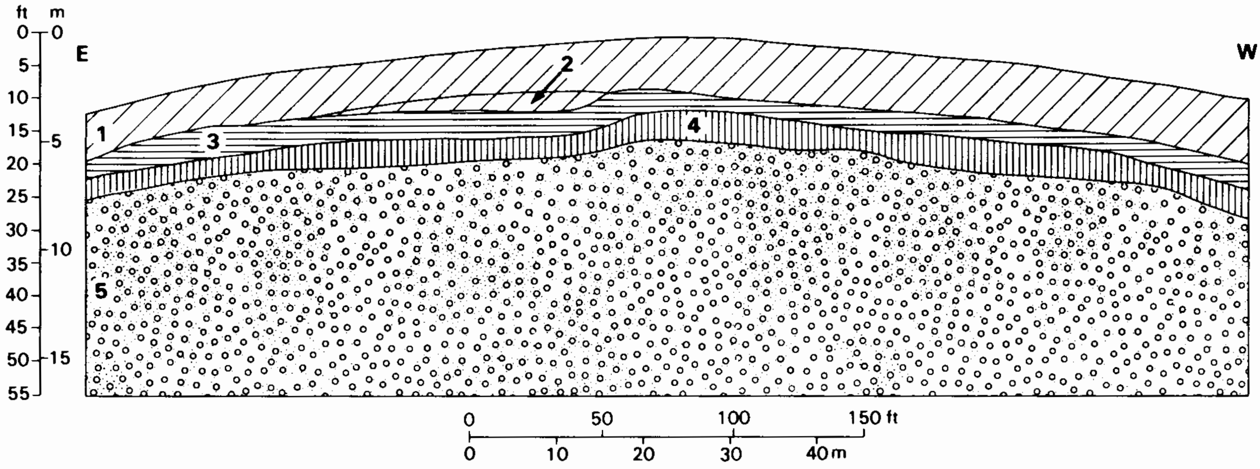


FIGURE 11.—Sketch of glacial deposits exposed in gravel pit of Haueter Sand & Gravel Co., 0.7 mile east of Punderson Lake and 0.4 mile north of Hotchkiss Rd., Burton Township.



1. Till, brown, clayey. HIRAM
2. Till, "lilac" gray. HIRAM
3. Till, yellow-brown, stony; gravel lenses. KENT
4. Till, yellow-brown very stony, hard; gray lenses. MOGADORE
5. Gravel, mostly gray, sandy. MOGADORE

FIGURE 12.—Sketch of glacial deposits exposed in gravel pit of Teague Gravel Co., Inc., 0.8 mile west of Newbury Center and 0.25 mile north of Ohio Rte. 87, Newbury Township.

much as 100 feet.

A pit in a large kame in southern Auburn Township (fig. 13) exposes Mogadore and Kent Tills, as much as 9 feet thick, overlying sand and gravelly sand at least 25 feet thick. The thickness of sand and gravel in this kame, as in the others, most likely is considerably greater than that exposed in the pit.

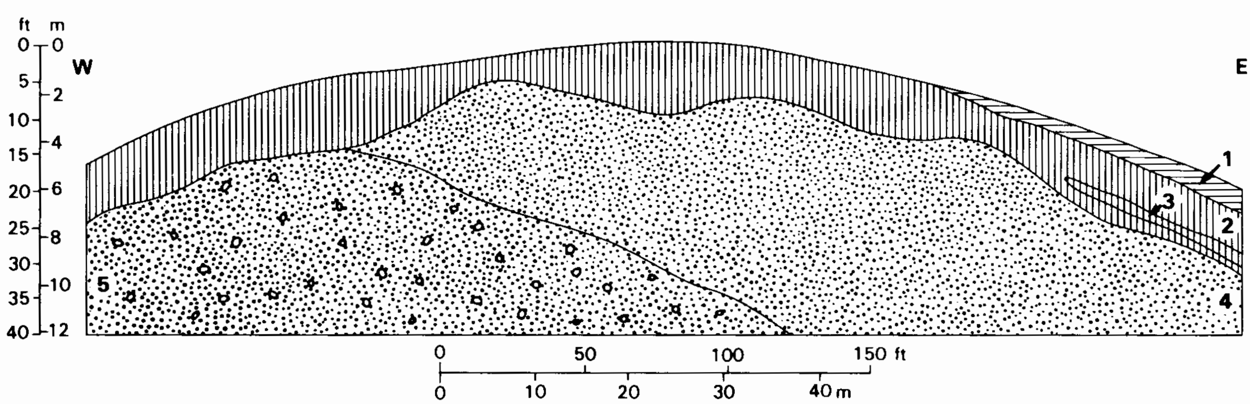
Large pits have been excavated in the kame moraine on both sides of U.S. Rte. 422 west of Auburn Center. These pits expose about 20 feet of sandy gravel overlain by thin Mogadore and Kent Tills. Many smaller borrow pits, most now abandoned, also are located in the kame moraine; the gravel in these small pits is used mostly for fill. Figure 14 illustrates the materials exposed in a borrow pit in Newbury Township.

East Branch Cuyahoga River kame terrace

The extensive kame terrace that borders East Branch Reservoir contains moderate amounts of sand and gravel. Gravel about 20 feet thick overlain by thin Hiram and Lavery Tills has been excavated in a pit northwest of the intersection of Princeton Road and U.S. Rte. 322. Several small exposures in the terrace reveal mostly sand near the surface, generally covered with thin till. The gravel probably is Kent in age, although a Titusville age cannot be ruled out.

Grand River kame terrace

The wide kame terrace bordering the Grand River west of Parkman has a moderate amount of gravel. The gravel



1. Till, gravelly, mostly boulders. KENT?
2. Till, yellow-brown, stony, mixed with gravel, very hard. MOGADORE
3. Till, gray. MOGADORE
4. Sand. MOGADORE
5. Sand, gravelly. MOGADORE

FIGURE 13.—Sketch of glacial deposits exposed in a gravel pit northeast of the intersection of Thorpe and Crackel Rds., Auburn Township.

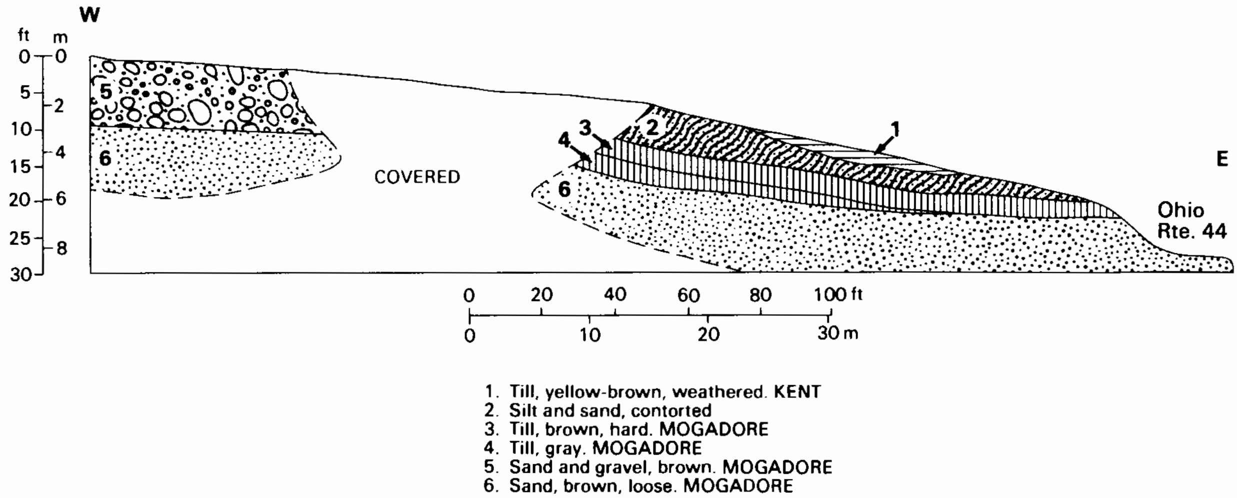


FIGURE 14.—Sketch of glacial deposits exposed in borrow pit southeast of the intersection of Ohio Rtes. 87 and 44, Newbury Township.

exposed in a large pit in the terrace north of U.S. Rte. 422 about 1 mile west of Parkman is very poorly sorted and rubbly and contains silt, sand, and till inclusions. The thickness of gravel exposed is about 20 feet, and the gravel is capped with Hiram Till as much as 11 feet thick. The thick till cover has presented considerable problems in excavating the gravel. The gravel is composed mainly of rounded sandstone fragments and probably is Kent in age.

East Branch Chagrin River kame terraces

Extensive kame terraces border both sides of East Branch Chagrin River and its tributaries in western Chardon Township, eastern Chester Township, and western Munson Township, but are buried beneath thick till. Consequently, no pits have been opened in the terraces. The south end of the terraces widens into a large mass of kames over 1 mile wide that plugs the valley of East Branch. The kames appear to be of more than one age. Hiram, Lavery, and Kent Tills overlie the kames in some places, whereas a few kames have only a very thin till covering. Most of the kames probably are of Mogadore age, a few appear to be of Kent age; one kame southeast of the intersection of Sherman and Heath Roads is composed of fine sand and silt 30 feet thick that appear to be of Hiram age.

Valley trains

The valley-train deposits in Geauga County are located in or near swampy areas close to the water table. Most of these outwash deposits are below the modern drainage, and thus below the water table, which makes excavation more difficult. These deposits are relatively fine grained and become finer grained downstream. Relatively small amounts of valley-train sand and gravel have been exploited, and these deposits are not considered to have commercial value.

Alluvial terraces

The broad alluvial terrace of East Branch Chagrin River in northern Chester Township is underlain by sand and gravel, which are well exposed in several small borrow pits. The surface material consists of silt and sand about 5 feet thick overlying rusty, brown sandy gravel 2 to 3 feet thick. Beneath the rusty gravel is lenticular sandy silt that contains spruce cones and wood that have a radiocarbon date of 9,360 ± 100 years (ISGS-922). Beneath the wood-bearing silt is gravelly sand about 12 feet thick; this sand is the most desirable aggregate in the sequence and is composed mostly of sedimentary rock fragments. The radiocarbon date is suspected to be too young, partly because of the abundant spruce cones, which are common in sediments having radiocarbon dates of about 13,000-14,000 years B.P. elsewhere in northern Ohio, and partly because of groundwater alteration of the wood in the permeable sediments.

The sand and gravel in the alluvial terraces are of generally poor quality and are not extensive. These deposits will continue to be exploited for local needs, mainly for fill, but they are not considered to be important commercially.

Other sand and gravel deposits

Many other smaller areas in Geauga County not mentioned specifically contain some potentially commercial sand and gravel deposits. Nearly all pits in these relatively small deposits are old and abandoned (pl. 1). A few pits currently provide fill for local use.

Large quantities of sand and gravel occur at depth in buried valleys, as evidenced from water-well records. Gravels of probable Illinoian age were identified by White (1953, p. 37) in Griswold Creek at the eastern edge of Cuyahoga County near the Cuyahoga-Geauga County line. These gravels can be traced in the subsurface into Geauga County (Baker, 1957) in a buried valley that trends northeastward parallel to Griswold Creek. The gravels are covered by 60 to 70 feet of till and may be recognized as far as 1 mile northeast of Novelty. These gravels and similar deeply buried gravels elsewhere in the county are not considered to have commercial value as aggregate. Instead, the value of these gravels lies in the ground water which they contain.

WATER SUPPLY

Water is one of the most valuable natural resources of Geauga County. Springs were numerous and widely used in Geauga County in pioneer days. Historically, nearly all of the water used in the county has been from springs, from cisterns, and from wells completed both in bedrock and in glacial drift. East Branch and LaDue Reservoirs, in the Cuyahoga River basin in Geauga County, are owned by the city of Akron, 40 miles to the southwest in Summit County, and supply water for that city. An early report by Stout, Ver Steeg, and Lamb (1943, p. 309-315) gives some information about water supply for villages in the county. More recent data available for examination by citizens are on file at the Ohio Department of Natural Resources, Division of Water. These data are particularly useful as a basis for indicating areas of favorable ground-water supplies.

Ground water is available in most parts of Geauga County, although in widely differing amounts and at various depths. Ground water in the county may be obtained in moderate to large quantities from two contrasting types of aquifers, the sandstone bedrock (Rau, 1969; Sedam, 1973) and the Pleistocene glaciofluvial sand and gravel deposits (Walker, 1978).

Large quantities of ground water are produced from the bedrock. Sedam (1973) reports that 70 percent of the ground water pumped in the county is derived from bedrock; 40 percent is from the Pottsville sandstones and conglomerates of Pennsylvanian age and 15 percent is from Mississippian-age sandstones. Rau (1969) reports that individual wells in the Berea Sandstone produce as much as 50 gallons per minute (gpm).

The glacial drift provides 30 percent of the ground water pumped in Geauga County (Sedam, 1973). Considerable quantities of water are present in glacial gravels, which constitute significant aquifers, especially in the buried valleys (fig. 7). The major buried valleys appear to have good ground-water potential because they generally contain one or more layers of gravel and have some opportunity for recharge from the surface streams which tend to follow the buried valleys and from the permeable sandstones which discharge water along the valley walls.

The hydrogeologic character of the deposits filling the preglacial channels is very complex because the deposits consist of interbedded tills, clays, peat, sands, and gravels; detailed investigation would be necessary to establish the character and continuity of the aquifers. A common problem encountered in buried valleys is that thick clay or till may overlie the deeper gravels, thereby diminishing greatly the amount of water that may recharge the gravel aquifers. Satisfactory wells generally may be completed in the sands and gravels at various depths, particularly when proper installation and maintenance, including use of a well screen, are employed.

Walker (1978) indicates ground-water yields of 500 to 1,000 gpm are possible from permeable sands and gravels at depths of about 115 to 125 feet in the buried Cuyahoga Valley (fig. 7) between Burton and LaDue Reservoir. Yields of 100 to 300 gpm are possible in the same buried valley northeast of Burton in Burton and Middlefield Townships (Walker, 1978). According to Walker (1978), moderate ground-water yields of 25 to 100 gpm may be developed in widely scattered areas covering nearly half of Geauga County. Most areas of moderate yields are from Pennsylvanian-age sandstones and conglomerates, mainly on uplands. Buried valleys containing local deposits of sand and gravel that may yield 25 to 100 gpm (Walker, 1978) include the Chagrin Valley in Munson Township and East Branch Valley in Munson and Newbury Townships (fig. 7).

PEAT

Small amounts of peat have been produced from the swamp deposits north of Bass Lake southwest of Chardon, and from the small depression at the east end of Chardon. The extensive swamps in the county have potential for peat production, but have received little attention in recent years. Most of the areas containing peat in the county are defined on soils maps by the Carlisle muck soil (Williams and McCleary, 1982). Dachnowski (1912) mentions several areas that were sampled for peat, including Solon Bog and Geauga Lake in the extreme southwestern corner of the county and Bradley Pond (Lake Kelso), Everett Lake (Burton Lake), and South Pond (Snow Lake) in southwestern Burton Township. In most of these areas the peat thickness exceeded the available length (19 feet) of the sampling instrument. Dachnowski (1912) also reports that a mastodon skeleton was found in a shallow bog in Montville Township. Most of the swampy kettles in the kame-moraine complex are former lakes that are now filled with peat.

CLAY

An extensive area west of Hobart Road and north of Reynolds Road in the southeastern corner of the county has been stripped for clay. Exposures in the clay pits reveal 3 feet of Hiram Till at the surface underlain by several feet of silt and clay which appear to have a lacustrine origin. The lake in which the silt and clay were deposited formed when the Grand River was dammed by Woodfordian ice a short distance east in Trumbull County prior to the deposition of Hiram Till.

ENVIRONMENTAL AND ENGINEERING GEOLOGY

LAND USE

The environment is influenced in general by the major physiographic divisions (fig. 3) and in detail by the glacial and postglacial landforms and the materials that comprise or mantle them. The importance of constraints for structures and excavations built upon or within the glacial materials is a part of environmental geology referred to as engineering geology.

The glacial drift is an important factor in performance of engineering structures built upon or in the drift. The thickness, composition, and surface configuration of the drift must be considered. Of great importance for large structures or those involving deep excavation is the vertical variation in the drift, because at most places the till or tills below are of different composition, texture, and engineering properties (White, 1972, 1974). Gravel and sand may underlie the tills at depths ranging from a few feet to 50 feet or more, may be water bearing, and at depth may be under artesian pressure.

Engineering interpretations of the surface soils of Geauga County have been treated in great detail in the report by Williams and McCleary (1982). That report should be consulted for specific engineering test data and classifications in both the Unified and the AASHTO systems. The test data recorded in Williams and McCleary (1982) pertain to the upper 60 inches of the soil. This is the material in which vegetation grows and upon which many structures are built. The present geological report deals not only with the surface material, but also is concerned with the whole column of glacial deposits. These reports therefore complement each other. This geological report and map cannot provide sufficient detail for planning at a specific site, but can point out features of the glacial stratigraphy that should be anticipated in detailed engineering investigations for a specific site.

The subsurface material becomes of increasingly greater importance as larger and larger structures and deeper and deeper excavations become more common. The clayey Hiram Till is sufficiently thick over about 40 percent of the county to be the principal soil parent material; the soils derived from Hiram Till have such undesirable characteristics as slow permeability and seasonal wetness. Soils are developed from the silty clayey Lavery Till over about 20 percent of the county; these soils also have slow permeability, due mainly to the occurrence of a fragipan (extremely compact soil layer) in the subsoil. The material beneath the Hiram Till and the Lavery fragipan is more permeable, and therefore has more desirable engineering properties. In some projects, it may be desirable to strip off and discard the clayey till to take advantage of the more permeable material below. It should be noted also that the interfaces between till layers commonly are water bearing, and this factor must be taken into account in excavations because water seepage causes piping and slumping.

Drift-mantled upland

Nearly all of the villages in Geauga County are situated on sandstone uplands that are mantled with a thin layer of till. The pioneers who settled the county preferred the upland knobs and ridges as homesites for several reasons: the uplands were heavily wooded and provided good hardwood for homes and fuel, they were cool in summer, drainage was good, and good-quality spring water was abundant. Although the reasons may differ, these upland areas still provide attractive building sites. Some of the better agricultural land in the county is situated on the more gently rolling portions of the uplands where erosion is not a problem and permeable sandstone near the surface provides good drainage.

Morainic upland

The end moraines of Geauga County are areas of more or less rolling topography, scenically interesting, and suited for a wide variety of uses. In general, the end moraines are better drained than the surrounding lowlands. Flowing down the short front and back slopes of the end moraines are numerous small tributaries, many of which represent opportunities for constructing small lakes. The rolling hills coupled with the potential for lakes offer favorable conditions for homesites. Caution should be used in the installation of septic waste-disposal systems, as the clayey Hiram Till at the surface over most of this area is very slowly permeable and will accept effluent with difficulty.

Interlobate kame moraine

The kame moraine of south-central Geauga County consists primarily of two contrasting features: kames and kettles. Many of the kettles are lakes, and several of the lakes are bordered by gravelly kames which provide good access, suitable building sites, and sandy beaches. The kames in this area are composed of good-quality gravel, which has been exploited commercially in several places. Much of the area is suitable for recreation and wildlife, and where the kame topography is less steep it is suitable for agriculture. The kames north and south of Punderson Lake have been developed as attractive lake-oriented homesites. The kames are well drained and provide few construction problems. Septic tanks work well in the gravelly areas, but caution should be used in locating tanks so that effluent from the tanks does not contaminate shallow wells nearby.

Valley bottoms

The valley bottoms of segments of the larger valleys in Geauga County are surprisingly wide and contain three types of flat surfaces: floodplains, alluvial and outwash terraces, and lacustrine plains. Kame terraces, which have a gently rolling or hummocky surface along the valley walls, in many places provide a transition zone between the flat topography in the center of the valley and the valley wall sloping to the upland.

The floodplains are relatively narrow and occupy a relatively small portion of the total width of the valley. Floodplains are susceptible to annual flooding and should either remain in a natural wooded state or be utilized for agriculture. Floodplains are not suitable for homesites.

The alluvial and outwash (valley-train) terraces are relatively flat areas bordering modern floodplains at a higher elevation. The silty, sandy, gravelly terrace materials are more permeable than till, and terrace soils generally are better drained than other soils. The lower terraces may flood occasionally, but most terrace surfaces in the county are suitable for building sites. The water table may be high under the terrace surface, and excavations for basements or pipelines may encounter water, particularly during the spring.

Lacustrine plains, some of them quite extensive (pl. 1), occur in several major valleys and in segments of older buried valleys. The surface material generally is silt, clay, and/or peat; drainage generally is poor, and the water table is high. The lacustrine plains are swampy unless they have been artificially drained and generally are not suited for homesites. These areas, when drained, are suitable for agriculture; if undrained, they should remain as wetlands for wildlife.

WASTE DISPOSAL

Solid waste

The safe and prudent disposal of solid waste is becoming more and more important as the population increases, the amount of waste multiplies, and environmental regulations become more stringent. Open burning and dumping have been illegal in Ohio since 1969, and the sanitary landfill has become the standard method of disposing of solid waste. Landfills should be located in areas of Geauga County that have a thick till cover, a low water table, and a slight to gentle slope and that are not close to urban centers. Areas where bedrock is within 25 feet of the surface should be avoided, as should sand and gravel areas, valley bottoms, and steep hillsides. Groenewold (1974) gives a comprehensive review of geologic considerations for selecting landfill sites in Ohio. A drift-thickness map (see fig. 4) is a most useful tool for preliminary selection of possible landfill sites.

Most of Geauga County is underlain by drift at least 25 feet thick, and most of the drift is till, especially beyond the confines of the buried valleys. The till, which is actually a stratigraphic sequence of two, three, or more tills, may be suitable for some types of landfill operation. One major problem encountered in developing and operating landfills in till in the Allegheny Plateau is the presence of sand and gravel layers in nearly every thick till sequence. Many of the sand and gravel layers contain water or are potentially water bearing and thus may act as conduits for leachate to reach streams or the water table. In addition, leachate may percolate downward to the water table along joints or fractures in the tills. Another problem encountered is the possibility of a high water table. Groenewold (1974, p. 5) states that the minimum amount of till or similar material between the solid waste and the water table should be 5 to 30 feet depending on the circumstances, and he generally advises 25 feet. If other conditions are suitable, the water table may be lowered at a landfill site either by pumping ground water from wells or by constructing deep drainage ditches to a nearby valley. The drainage operation should be monitored carefully to ensure that effluent does not reach the water being drained from the area.

In general, the end-moraine areas (pl. 1) appear more suitable than any others for locating landfills in Geauga County; however, many areas of ground moraine also have sufficient till thickness to be considered for landfill sites.

Septic tanks and tile fields

The disposal of sewage effluent from septic tanks is a significant problem in those areas of the county not served by municipal sewers and sewage-treatment plants. The geologic factors which affect the operation of septic tanks include permeability of the soil, depth to bedrock, depth to the water table, slope, and drainage. Limitations affecting proper disposal are listed by Williams and McCleary (1982, p. 144-148) for each of the soil series in the county. In general, the soils of Geauga County have severe limitations, mostly due to the very low permeability of the Hiram and Lavery Tills, which are widely distributed at or near the surface in the county. Many localities are characterized by a seasonally high water table, and tile fields may be flooded by rising water levels in wet seasons.

Areas that may have permeable soils necessary for disposal of septic-tank effluent are the sandy alluvial terraces and gravelly kames (pl. 1). Other areas that may have suitable permeability are those at higher elevations, particularly the ridges and knobs covered with very thin till and underlain by permeable sandstone and conglomerate. However, the high percolation rates of the sands, gravels, sandstones, and conglomerates may allow effluent to travel some distance to wells and contaminate nearby groundwater supplies.

RECREATION

The great variety of topography, vegetation, and soils, together with an abundance of lakes, wetlands, and streams, makes Geauga County a prime recreational area. According to Williams and McCleary (1982), there are more than 120 recreational areas in the county, including 31 parks, 26 hunting and fishing areas, 23 camping areas, and 12 golf courses. Punderson State Park, which covers an area of 733 acres, is the largest park in the county. Punderson Lake, the focal point of the park, is surrounded by numerous wooded kames. Big Creek Park, operated by Geauga County, covers 635 acres about 2 miles north of Chardon and features a heavily wooded dissected upland which includes the gorge of Big Creek. Boating and fishing are permitted on East Branch Reservoir, LaDue Reservoir, and Punderson Lake. Geauga Lake in the southwestern corner of the county is one of the oldest and best known recreational areas in northeastern Ohio and currently is the site of a large amusement park and Sea World.

A portion of the Chagrin River, located mainly in Cuyahoga County a short distance west of Geauga County, but also including a segment of the river northeast of Chagrin Falls and a portion of Aurora Branch in Bainbridge Township, has been designated a State Scenic River.

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DIVISION OF GEOLOGICAL SURVEY

GLACIAL GEOLOGY OF GEAUGA COUNTY, OHIO

by Stanley M. Totten

1988

QUATERNARY

Recent

- cf — *Made land.* Areas of excavation or filling where original land surface has been modified by man
- al — *Alluvium.* Silt and sand on floodplains

Pleistocene (Wisconsinan) — WOODFORDIAN

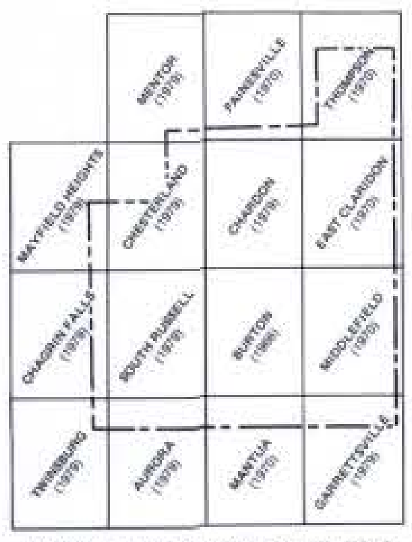
- Wl — *Lacustrine plain.* Silt, clay, peat, and muck in depressions
- Wlt — *Lacustrine terrace.* Silt and silty clay of Lake Grove, mainly in Cuyahoga River valley
- Wo, Wal — *Outwash.* Sand and gravel in valley trains (Wo), partly in terrace remnants; includes remnants of alluvial terraces (Wal) formed by streams graded to higher levels of Lake Erie, mainly in tributaries of Chagrin River
- Wk — *Kames and kame terraces.* Sand and gravel in knolls or in terraces with very thin or no till cover
- Wkt — *Till-covered kames and kame terraces.* Sand and gravel in knolls or terraces covered with thick till; sand and gravel may contain large till masses; includes interlobate kame moraine (Kent Moraine) in south-central Geauga County
- g — *Ground moraine.* Till in smooth to gently undulating surface on drift-veneered bedrock hills; till thickness generally less than 25 feet, and commonly much less
- e — *End moraine.* Till in linear belts of hummocky topography; till thickness generally greater than 25 feet; most end moraine in Geauga County is included in the Defiance Moraine
- h — *Hummocky topography.* Till in thicker accumulations (generally greater than 25 feet) but without linear trend

- Whg, Whe, Whh — *Hiram Till.* Silty clayey till
- Wlg, Wle — *Lavery Till.* Silty clayey till
- Wkg — *Kent Till.* Silty sandy till

- Boundary of deposit or landform, dashed where approximate
- Approximate boundary of Hiram Till
- Approximate boundary of Lavery Till, where it differs from Hiram boundary
- 800 — Contour on bedrock surface, contour interval 100 feet
- Gravel or clay pit, active
- Gravel or clay pit, small or abandoned
- Rock quarry

CONTOURS ON BEDROCK SURFACE BY JOEL D. VORMELKER

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



1:24,000 U.S. GEOLOGICAL SURVEY TOPOGRAPHIC QUADRANGLE MAPS COVERING GEAUGA COUNTY (DATES IN PARENTHESES INDICATE DATE OF NEGATIVES USED TO COMPILE BASE)

LOCATION MAP

UTM GRID AND 1979 MAGNETIC NORTH DECLINATION AT CENTER OF CHARDON QUADRANGLE

County lies within Connecticut Western Reserve

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

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

1927 North American datum

PHOTOTYPSETTING BY JEAN M. LESHER

CARTOGRAPHIC DRAFTING BY EDWARD V. KUEHNLE