STATE OF OHIO
John J. Gilligan, Governor
DEPARTMENT OF NATURAL RESOURCES
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Horace R. Collins, Chief

Report of Investigations No. 88

GLACIAL GEOLOGY OF RICHLAND COUNTY, OHIO

by

Stanley M. Totten

Columbus
1973

SCIENTIFIC AND TECHNICAL STAFF
OF THE
OHIO DIVISION OF GEOLOGICAL SURVEY

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GEOLOGY SERVES OHIO

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ABSTRACT

Continental ice sheets spread into Richland County as the Killbuck and Scioto lobes of the major Erie lobe. The ice advanced at least four times during the Wisconsinan Stage and at least once during the Illinoian Stage; it may have advanced also during the Kansan and Nebraskan Stages. The Wisconsinan Killbuck-lobe tills, Millbrook, Navarre, Hayesville, and Hiram, from oldest to youngest, correlate with the Jelloway, Knox Lake, Mt. Liberty, and Centerburg Tills, respectively, of the Scioto lobe. The Illinoian Butler Till is found at the surface in the southeastern part of the county. Lower, older tills are exposed too poorly to allow tracing over a considerable area.

Ground moraine topography is drift controlled in the north and west and bedrock controlled in the south. A series of end moraines bunched closely together in northern Richland County form an east-west belt of hummocky topography about 10 miles wide. The extensive bed of proglacial Lake Shelby is located in the northeastern portion of the county.

Substantial deposits of sand and gravel occur in kame terraces and valley trains. Coarse gravels provide much of the filling of Black, Rocky, Clear, and Cedar Fork valleys in the southern part of the county and yield moderate to large quantities of water.

INTRODUCTION

LOCATION

Richland County is located in the glaciated area of north-central Ohio (fig. 1). The county seat and largest city is Mansfield, an important industrial center and a rapidly expanding urban district. Other important municipalities are Shelby, Plymouth, Butler, and Bellville. The county is bounded on the north by Huron County, on the east by Ashland County, on the south by Knox and Morrow Counties, and on the west by Crawford County.

Richland County is rectangular, elongated north-south, and lies between 82°20' and 82°45' west longitude and 40°33' and 41° north latitude. U.S. Geological Survey topographic quadrangle maps cover the county: the out-of-print 15-minute maps (1:62,500), Ashland, Crestline, Perrysville, and Shauck, and the 7½-minute maps (1:24,000), Bellville, Blooming Grove, Butler, Crestline, Jelloway, Lucas, Mansfield North, Mansfield South, Olivesburg, Pavonia, Perrysville, Shauck, Shelby, and Shiloh.

PURPOSE AND SCOPE

This report describes the glacial drift (pl. 1), the surface material overlying the bedrock in Richland County. Stratigraphy of the deposits and morphology of the land forms are described and correlated with deposits and morphologic features of bordering counties for a more complete regional picture of geologic history during the Pleistocene Epoch. Economic resources of glacial drift are considered, and suggestions are made for their utilization and conservation.

The bedrock underlying the glacial drift is described in general as it pertains to glacial history.

This report will be of interest to various groups and individuals: highway engineers, construction firms, architects, city planners, and soil scientists. Citizens who are, or will be, responsible for planning and shaping the future of Richland County for agriculture, urbanization, recreation, and industrialization, will find this report useful in making their decisions.

PREVIOUS INVESTIGATIONS

Early reports on the glacial geology of northern Ohio and of Richland County were presented by Read (1878), who described the glacial drift, by Wright (1884, 1890), who mapped the glacial boundary, and by Leverett (1902), who made a study of the glacial geology of the entire Erie Basin. White (1934a) studied the reentrant angle in the glacial boundary and later studied the end moraines (1935, 1939b) and the Illinoian drift (1937) of north-central Ohio. Richland County was included by Goldthwait and others (1965) in a review of the glacial geology of the Erie lobe. Lacustrine deposits in Richland County were described by Hubbard and Rockwood (1942), and buried valleys in glacial drift in the county by White (Norris and White, 1961). Drainage changes affecting Richland County were studied by Todd (1900), Coffey (1914, 1930, 1958, 1961), Ver Steeg (1934, 1936, 1946), and White (1934b).

Studies of the glacial geology of counties adjacent to Richland County include those of Campbell (1955) in Huron and Erie Counties, Gregory (1956) in Crawford County, Forsyth (1961) in Knox County, and White (1961) in Ashland County.

ACKNOWLEDGMENTS

This report is an outgrowth of a Ph.D. dissertation submitted to the faculty of the University of Illinois (Totten, 1962). The writer wishes to give special recognition to Professor George W. White for his invaluable aid as dissertation advisor. Professor White kindly provided data which he and the writer collected during the construction of Interstate 71 in 1959. Dr. Jane Forsyth and Mr. Marvin Bureau accompanied the writer in the field on several occasions and offered valuable suggestions, particularly concerning soils.

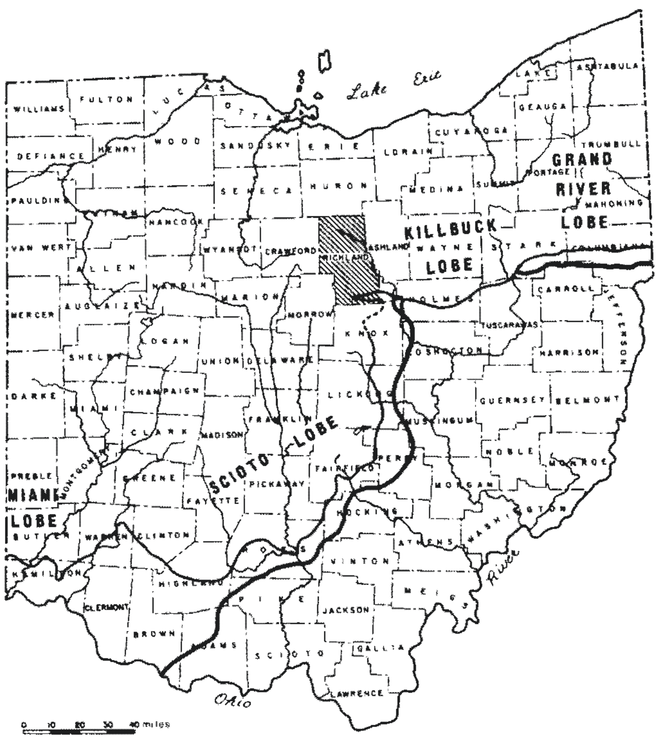


FIGURE 1.–Index map of Ohio showing the location of Richland County, Late Wisconsinan drift border (light line), Illinoian drift border (heavy line), and glacial lobes. (Modified from *Glacial Map of Ohio*, Goldthwait, White, and Forsyth, 1961.)

Financial support for this project was provided by several sources. Funds from the University of Illinois Research Board, the National Science Foundation, and the Ohio Division of Geological Survey supported field studies and laboratory work in 1961 and 1962. A research grant from Hanover College provided support for additional field work in 1970.

PHYSIOGRAPHY

PHYSIOGRAPHIC PROVINCES

Richland County lies at the western edge of the Allegheny Plateau physiographic province of Fenneman (1928). White (1943b) has modified Fenneman's interpretation by recognizing a Low Plateau province in the northwestern portion of the county (fig. 2). Two escarpments, the Berea and Black Hand, formed by differential erosion of alternating sandstones and shales, mark the boundaries between provinces. Preglacial erosion of the resistant Berea Sandstone formed a northwestward-facing escarpment 50 to 100 feet high (White, 1934b, p. 368) in the northwestern corner of the county near Plymouth (fig. 2). Glaciation extensively modified the preglacial topography in this area, obliterating much of the escarpment. The lowland in front of the escarpment, now mantled with Lake Willard deposits, belongs to the Till Plain province.

The Black Hand Escarpment, which is a part of the Allegheny Escarpment of Stout and others (1943, p. 48), is a relatively prominent northwestward-facing

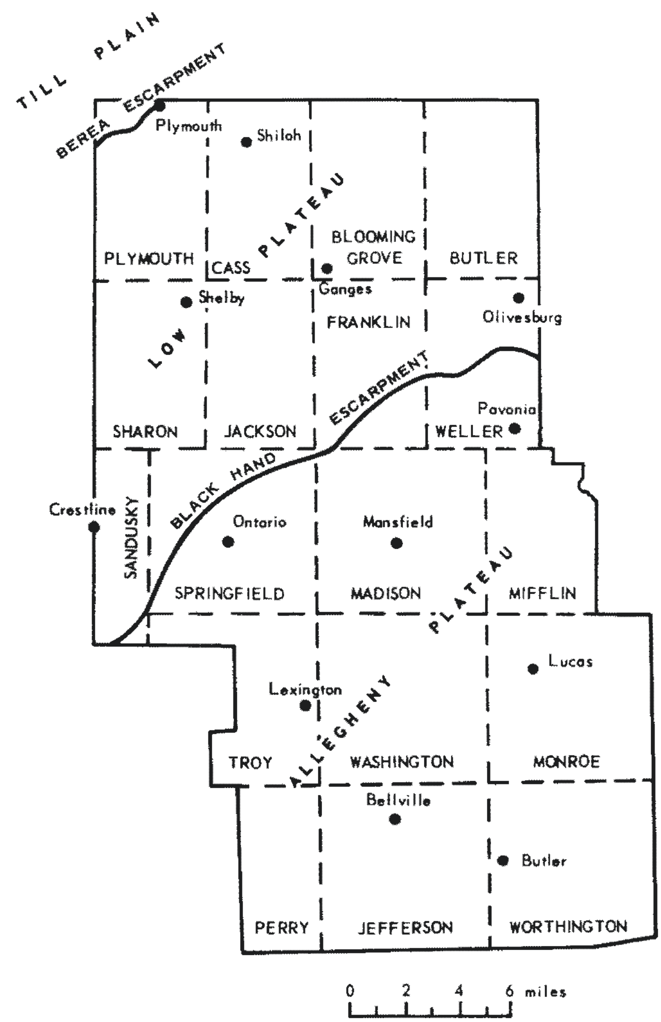


FIGURE 2.–Map of Richland County showing escarpments, physiographic provinces, township names, and principal municipalities.

feature marking the boundary between the Low Plateau and the Allegheny Plateau. This escarpment, in places reaching 200 to 300 feet above the Low Plateau, enters the county near Olivesburg and extends southwestward in a broad irregular arc to the common corner of Richland, Morrow, and Crawford Counties. The escarpment front has been extensively dissected by stream erosion, and several outliers, such as the 200-foot high knob northwest of Pavonia, have resulted.

TOPOGRAPHY

Richland County is an area of topographic contrasts. In the northern and western portions the surface ranges in elevation from 1,000 to 1,200 feet, with local relief of more than 40 to 50 feet in only a few places. Much of this area is flat or gently rolling, primarily because of a thick covering of glacial drift, which buried pre-existing valleys and smoothed out the land surface. Most irregularities on this surface are due to local thickening in the drift where the deposits have been concentrated in ridges to form end moraines.

In the central and southern portions of the county, surface elevations range from 1,000 to more than 1,500 feet. The highest elevation in the county is west-southwest of Mansfield, where an elevation between 1,510 and 1,520 feet is reached on the Lexington Ontario Road in the southern part of sec. 34, Springfield Township. Several other hills near Mansfield reach elevations between 1,450 and 1,510 feet and collectively are known as the Mansfield Highland. This highland, the second highest in Ohio, has played an important part in the glacial history of the county.

The southern half of the county is in the maturely dissected Allegheny Plateau and is characterized by valleys cut deeply into resistant sandstone-capped uplands. In this region the covering of glacial drift is generally of insufficient thickness to fill the valleys and much of the preglacial and interglacial relief of the Plateau is preserved.

DRAINAGE

The major divide in Ohio separating Ohio River drainage from Lake Erie drainage runs east-west through northern Richland County 1 to 2 miles south of the Richland-Huron County line. The small amount of northward drainage is by way of the Vermilion and Huron Rivers and their tributaries to Lake Erie and then by way of Lake Ontario and the St. Lawrence River to the Atlantic Ocean.

Nearly all of Richland County drains south by way of Black Fork, Clear Fork, Rocky Fork, and Cedar Fork of the Mohican River, which then finds its way to the Ohio River via the Walhonding and Muskingum Rivers. Other southward-flowing streams that head in Richland County are the East Branch of the Kokosing River, Paramour Creek, and the Olentangy River.

EARLY DRAINAGE SYSTEMS

GENERAL STATEMENT

The advent of glaciation in northern Ohio during the Pleistocene Epoch profoundly disrupted drainage, damming streams, filling valleys with drift, and diverting waters into other drainage basins. Each glacial advance led to new diversions, and the modern drainage is a composite of these successive diversions. This history of drainage changes in Richland County is pieced together by a study of well records, bedrock topographic contours, existing topography, anomalous drainage lines, and partially buried valleys.

TEAYS SYSTEM

The cycle of erosion and the drainage network that preceded Pleistocene glaciation is referred to as the Teays (fig. 3). This name was applied by Tight (1903) to the preglacial stream of the Teays Valley in West Virginia; the stream has since been traced through southern Ohio, Indiana, and Illinois, where it entered the Mississippi River. The Teays drained much of the area now drained by the Ohio River, and the vast Teays tributary system extended northward into Richland County. Just how far north the tributaries extended has been a point of conjecture. Stout and others (1943) interpreted the Black Hand Escarpment to be the preglacial divide, and they show the Groveport River, the largest tributary of the Teays System in Ohio, flowing southwestward from Perrysville, Ashland County, to Butler and then to Ankenytown, Knox County. This reconstruction seems doubtful in that two narrow constricted former divides known as cols are present in Richland County along that route.

The more generally accepted reconstruction of the Teays System is the product of studies by White (1934b), Ver Steeg (1934, 1936), and Coffey (1961), who agree that a preglacial divide extended east-west across the southern end of the county and that the preglacial drainage of most of Richland County was toward the north.

The highest elevations in Richland County are along the front of the Black Hand Escarpment, and it may appear logical for this to be the preglacial divide. Escarpment fronts, however, rarely mark drainage divides because master streams flowing away from the escarpment and eroding in less resistant strata are able to extend their valleys some distance into the upland. In Richland County, three streams, Black Fork, Clear Fork, and Rocky Fork, were responsible for shifting the divide southward by headward erosion and stream piracy. These streams were closely spaced and had relatively short tributaries, leaving high narrow divides between deep valleys. The major preglacial divide (fig. 3) is placed 1 to 2 miles north of the Richland-Knox County line along a chain of bedrock hills

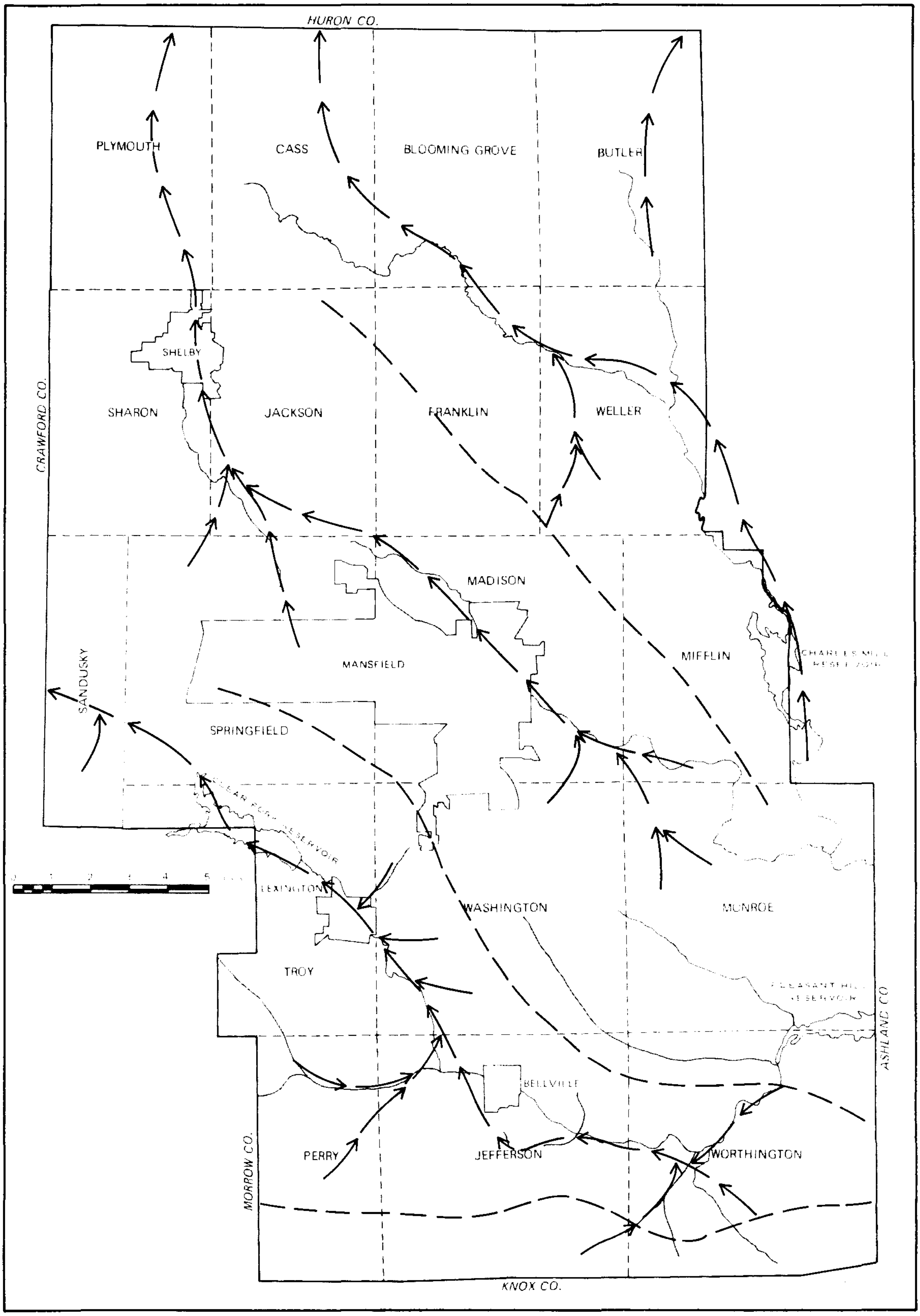


FIGURE 3.—Preglacial drainage lines (arrows) and major preglacial divides (dashed lines) of the Teays System.

having elevations in excess of 1,300 feet.

The bedrock elevations of preglacial valley bottoms in the northern and western parts of the county suggest that these early streams flowed at higher elevations than do present streams in southern Richland County. For example, a large preglacial valley south of Crestline has an elevation of about 1,100 feet; allowing for a normal gradient, valley bottom elevations must have been at least 1,200 feet or more in the southern part of the county, compared to 1,070 feet for the valley bottom at Butler today. Bedrock contour elevations of 1,200 feet at cols through the divide support this conclusion. The preglacial bedrock topography of northern Richland County is still imperfectly known, and the reconstruction of preglacial drainage lines extending north through Plymouth and Shiloh is conjectural.

DEEP STAGE DRAINAGE

With the first advance of an ice sheet into north-central Ohio in Nebraskan(?) or Kansan(?) time, northward and westward drainage was ponded, and preglacial valleys were at least partially filled with drift. Ponded waters were backed up in their headwaters by the damming effect of ice until water overflowed the divides, cutting deep notches or cols. Preglacial Clear Fork overflowed the divide at Newville northeast of Butler; preglacial Rocky Fork overflowed the divide 1 mile east of Lucas and joined with Black Fork, which overflowed a similar divide at Perrysville, Ashland County (fig. 4). All three major streams joined at Perrysville and flowed eastward through Ashland County to Holmes County, where Richland County drainage joined the Holmes River (White, 1949) and then flowed southward through central Holmes and Coshocton Counties.

Elevations of the valley bottoms of these diverted streams are considerably lower than elevations proposed for preglacial drainage. Such deep valleys are common in Ohio, leading to the use of the term "Deep Stage" for valleys of this period. Bedrock contour elevations for Deep Stage valleys are near or below 900 feet for the partially buried Clear Fork valley west of Butler and are near or below 800 feet for the partially buried Black Fork valley between Pavonia and Olivesburg. These Deep Stage valleys had few and relatively short tributaries and very steep valley walls.

Three anomalous-appearing bedrock "islands" probably developed as a part of Deep Stage diversion. These islands, actually resistant sandstone and siltstone upland remnants surrounded by deep drainage channels, are located northwest of Lucas, southeast of Bellville, and northwest of Pavonia.

ILLINOIAN AND WISCONSINAN DRAINAGE

The Deep Stage drainage system strongly influenced later drainage in Richland County. This system was not drastically changed by Illinoian and Wisconsinan ice: the major effect of these later ice advances was to fill the Deep Stage valleys with drift. This filling was largely completed in the northern part of the county, resulting in Black Fork wandering in all directions before entering its former valley east of Ganges.

The most significant post-Deep Stage drainage change took place near Perrysville, Ashland County, where Clear Fork was blocked by Illinoian and/or Wisconsinan drift and was diverted southward and eastward to cut a deep gorge through the upland of Hanover Township, Ashland County. A similar though smaller gorge has been cut a short distance to the south by Pine Run.

The Deep Stage valleys in southern Richland County are only partially filled with drift and relatively few subsequent diversions have taken place. One anomalous drainage feature is the intersection of drainage lines at right angles at Butler. Slater Run, southeast of Butler, apparently was the headwater for preglacial Clear Fork, which flowed northwestward past Butler, Bellville, and Lexington. Tributary to preglacial Clear Fork were Smoky Run, southwest of Butler, and the segment of Clear Fork northeast of Butler as far as the col at Newville. Smoky Run and Slater Run, as well as Robinson Run and Honey Creek, south of Bellville, were important meltwater channels for Scioto lobe ice during the Wisconsinan. Present drainage remains practically as the Wisconsinan glaciation left it.

BEDROCK

GENERAL STATEMENT

A brief introduction to the rock strata underlying the glacial drift is included to give the reader an appreciation of how the various rock units have influenced topographic variation, drainage, and glaciation in Richland County. The study of the bedrock of the county is still in progress and the map (fig. 5) should be considered preliminary, particularly for the northern portion of the county, where the rocks are buried beneath thick drift and exposures are sparse. In the southern part of the county, where the drift generally is thinner, the bedrock has been studied extensively in numerous stream valleys and road cuts.

The rocks exposed at the surface (the bedrock surface beneath the surficial glacial deposits, pl. 2) are of Mississippian and Pennsylvanian ages and dip east-southeast 15 to 20 feet per mile. The oldest rocks are found in the northwestern corner of the county, and the youngest strata cap the tops of several high hills in the southeastern corner of the county near Butler.

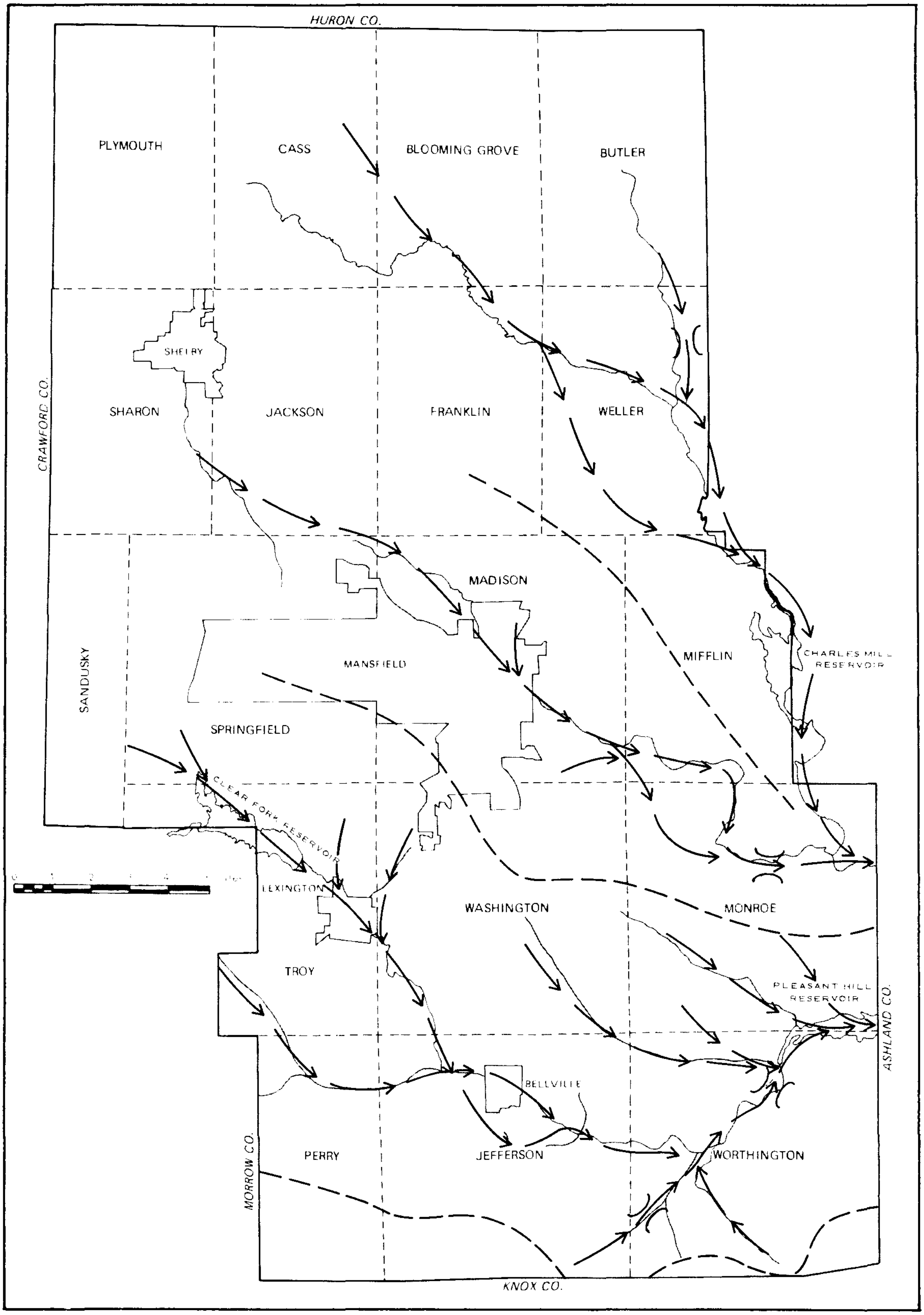


FIGURE 4.—Deep Stage drainage lines (arrows), major divides (dashed lines), and cols.

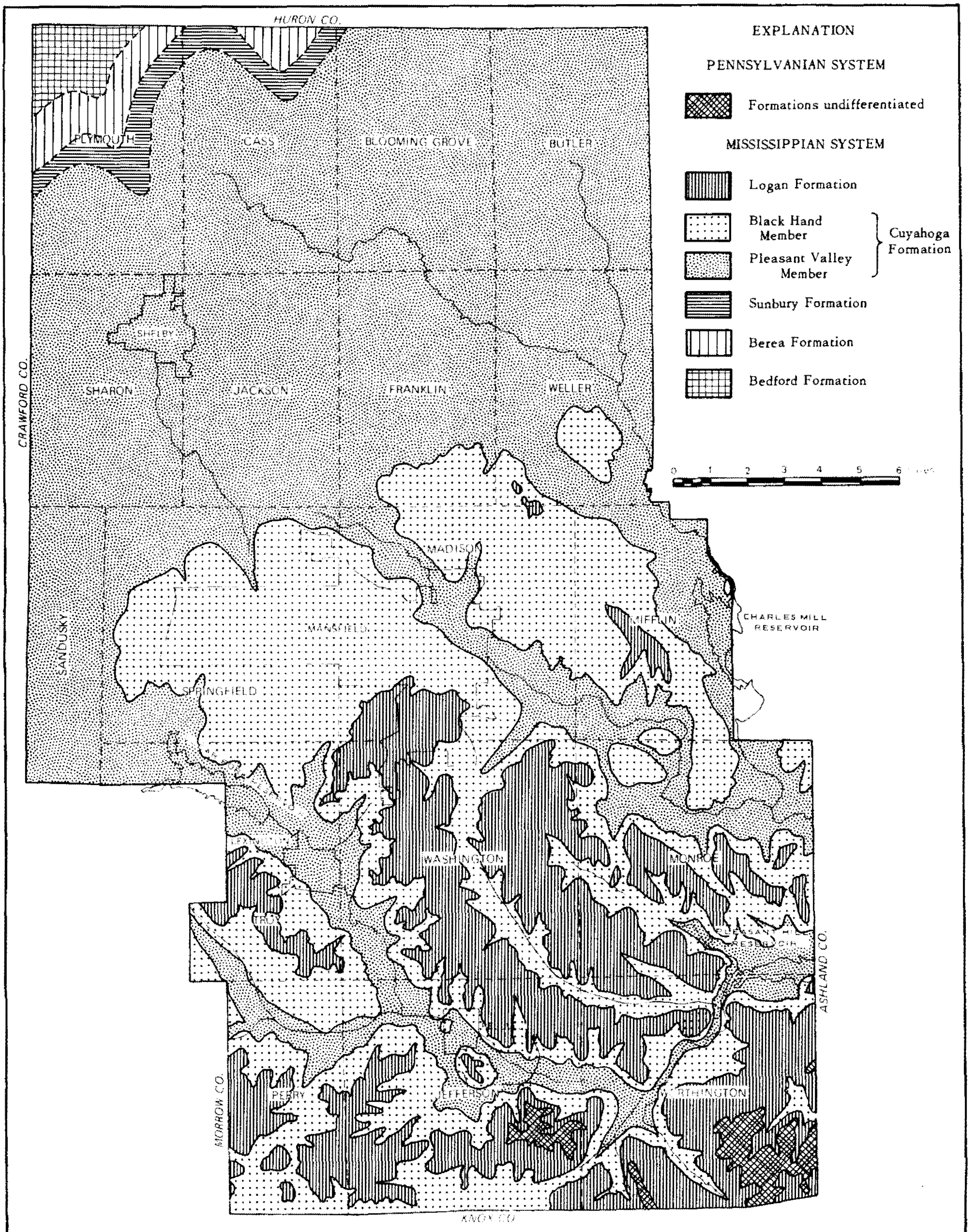


FIGURE 5.—Preliminary bedrock map of Richland County showing outcrop beneath the drift.

MISSISSIPPIAN SYSTEM

The Mississippian System in Richland County is represented by a sequence of alternating sandstones and shales known as the "Waverly group." The Waverly group has been divided into five formations which are, from oldest to youngest, the Bedford Shale, Berea Sandstone, Sunbury Shale, Cuyahoga Formation, and Logan Formation. The first three are thin units found in the northwestern corner of the county; their distribution is known only imperfectly from well records.

The Bedford Shale is red and gray in northern Ohio (Pepper and others, 1954) and has an estimated thickness of 90 feet. It is not exposed anywhere in the county.

The Berea Sandstone was formerly quarried in Plymouth along the tributary to the West Branch of the Huron River (Stout and others, 1943, p. 547) and 3 miles southwest of Plymouth (Read, 1878, p. 317). These quarries have been inactive for many years. The Berea was deposited in channels on an eroded Bedford surface (Holden, 1942, p. 39) and is therefore quite irregular in thickness, ranging from only a few feet to more than 80 feet. Due to its resistant nature and position between easily eroded shale strata, the Berea Sandstone forms a ridge or escarpment along its line of outcrop, but this escarpment, originally 50 or more feet high, has been highly modified by a covering of glacial drift. The Berea is noted for its gas and oil production in many parts of Ohio, but water is all that occurs in the formation in Richland County.

The Sunbury Shale is a carbonaceous black shale which overlies the Berea Sandstone. Exposures of the Sunbury are not known in the county. According to Holden (1942, p. 40), the formation ranges from about 15 to 30 feet in thickness.

The Cuyahoga Formation, which overlies the Sunbury Shale, is widespread across Richland County. The formation consists of a sandstone facies, the Black Hand Sandstone, along with a partly contemporaneous, partly older shale facies known as the Pleasant Valley Member (Holden, 1942). The Black Hand, a lens-shaped sand body in the upper part of the otherwise finer grained Cuyahoga Formation, is a coarse-grained sparsely fossiliferous sandstone that is conglomeratic in many places and is highly resistant to weathering. Consequently, it is a ledge and cliff former, and exposures are common in the Mansfield region and along many of the streams in the southern part of the county. The sandstone is commonly brown to buff in color, but varied shades of orange and red due to iron oxide concentration and coloration are seen in many places. These colorful layers are especially well exposed in several deep road cuts along Interstate 71 and U.S. 30 near Mansfield. In these road cuts and also close to Lucas, the sandstone strata dip from 5° to 10° toward the north-northeast. Preglacial erosion of the Black Hand formed a prominent escarpment, the Allegheny Escarpment, that was to play an important role in determining the direction and distance of ice movement in Richland County. Nearly 200 feet of Black Hand Sandstone is exposed at several places south of Mansfield, and Root (1961, p. 11) reports 275 feet of Black Hand in a well north of Butler. The Black Hand has been quarried for building stone at several localities (Bownocker, 1915, p. 142), but these quarries have closed; it is unlikely that future demands for building stone will be sufficient to reopen them.

The Pleasant Valley Member is a thin-bedded gray siltstone and shale which is exposed beneath Black Hand Sandstone along valleys in widely scattered localities from Lexington to Shenandoah. About 80 feet of Pleasant Valley shale is exposed north of Mansfield in a quarry of the Mansfield Shale Brick Company, which uses the shale in manufacturing clay products. Even though the Pleasant Valley Member is the surface rock over most of the northern half of the county, exposures are rare due to the covering of drift.

Shale of the Cuyahoga Formation is present in the lower 70 feet of an excellent section of Mississippian rocks exposed 1 mile east of the Richland County line at Lyons Falls in Mohican State Forest, Ashland County (section first described by Herrick, 1888, p. 101-102; reprinted with modern stratigraphic names by White, 1949, p. 42-43). A similar section of Mississippian strata in Holmes County 6 miles east of Richland County has been described by White (1949, p. 43-44).

The overlying Logan Formation consists, in ascending order, of the Berne, Byer, Allensville, and Vinton Members, which cap the ridges in the southern portion of the county. The formation is composed predominantly of thin-bedded slabby siltstone which is resistant to weathering and is exposed along numerous road ditches which cut across the ridges.

The basal Berne Member is a conglomerate which disconformably overlies slightly truncated Black Hand strata. The Berne is thin but persistent, ranging in thickness from 1 to 8 feet. Exposures of the Berne are relatively common, though it is easily overlooked because of its thinness.

The Byer Member is a fossiliferous light-brown siltstone which weathers into large slabs that impart a rubbly appearance to the outcrop in many places. These slabs contribute a large portion of the colluvium that mantles the steep hillsides in the southern part of the county.

The Allensville Member is a conglomerate which thins rapidly northward and disappears in Richland County. The only exposure of the Allensville known to the writer is in the large roadcut along State Route 13 north of Bellville.

The Vinton member is a siltstone similar to, and not differentiated from, the Byer siltstone. Thicknesses of siltstone in excess of 100 feet are found near Butler. The Vinton siltstone is the youngest Mississippian stratum remaining in Richland County, but at least one younger Mississippian formation, the Maxville Limestone, was deposited above the Vinton in this region. The evidence for this is large angular Maxville blocks incorporated in the basal Pennsylvanian strata, as is also the case in Wayne County (Conrey, 1921, p. 88-89) and in Holmes County (White, 1949, p. 51, 55).

MISSISSIPPIAN-PENNSYLVANIAN CONTACT

Near the end of the Mississippian period, epeirogenic uplift of Ohio resulted in an episode of subaerial erosion, at which time the Richland County area was eroded to a ridge-and-valley surface having a relief of 100 feet or more and littered with blocks of Maxville Limestone. Basal deposits of the Pennsylvanian System first filled in the valleys and the Maxville blocks were incorporated in these rubbly coarse valley-fill deposits.

PENNSYLVANIAN SYSTEM

Rocks of the Pottsville Group, at the base of the Pennsylvanian System, cap the ridges in the southeastern corner of the county. Pottsville strata were once much more extensive, but erosion has reduced greatly their areal extent. The Pottsville beds in the county consist of the Harrison conglomerate and sandstone, the Massillon sandstone, and one or more poorly exposed thin units, including a coal.

The Harrison, the basal Pennsylvanian stratum, is a highly variable conglomerate and conglomeratic sandstone stained red and cemented by iron oxide; in places the unit resembles an iron ore. The Harrison in places is a breccia composed of angular to subrounded weathered fragments of fossiliferous Maxville Limestone up to 11 inches in diameter. An extraordinary thickness of 40 feet of Harrison conglomerate and breccia is exposed southeast of Butler, though much thinner intervals are generally recorded.

The Massillon sandstone is a coarse-grained to conglomeratic gray to reddish-brown sandstone which overlies the Harrison bed. It is poorly exposed along the ridge tops where thicknesses range from 10 to 40 feet. A few tree trunk impressions are found in the sandstone.

A thin carboniferous unit, probably a coal, and associated shale are found in at least one locality, but exposures are poor. None of these Pennsylvanian deposits are sufficiently thick or extensive in Richland County to be economically important.

PLEISTOCENE STRATIGRAPHY

GLACIAL LOBES

The glacial deposits of Ohio are a result of several ice advances during the Pleistocene 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 southeastward into the Lake Erie basin as a major tongue known as the Erie lobe. As the Erie lobe advanced into northern Ohio, it spread southward into lowlands and subdivided, from east to west, into the Grand River, Killbuck, Scioto, and Miami lobes (fig. 1).

Glaciation of Richland County resulted from a general southward expansion of the Killbuck lobe and an eastward expansion of the Scioto lobe. The line of junction between the two lobes was not a sharp one and was in different places during succeeding ice advances (fig. 6). The rather transitional nature of the change from one lobe to the other was pointed out by Leverett (1902), who considered the Killbuck lobe as a "shoulder" of the Scioto lobe. The Mansfield Highland, the apparent natural boundary between lobes, was

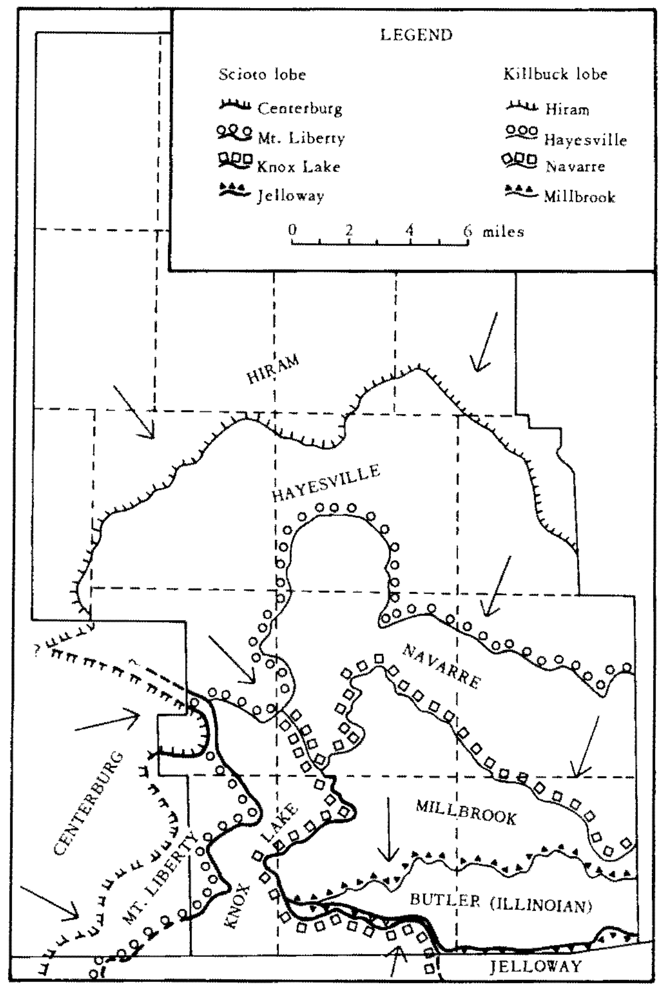


FIGURE 6.–Drift sheet margins showing junctions of intersection of Killbuck lobe tills (light lines) with tills of the Scioto lobe (heavy lines). Arrows indicate direction of ice movement.

a major influence in the lobate pattern, but was not, in fact, the actual boundary. Ice of the Killbuck lobe was able to override the escarpment nearly as far south as the preglacial divide near the southern border of the county.

CLASSIFICATION

Four major glacial stages of the Pleistocene Epoch, separated by warmer interglacial intervals, are generally recognized in the central United States (table 1). Ice moved into Richland County several times during at least two glacial stages, the Illinoian and Wisconsinan, and may have advanced into the county also during one or both of the earlier glacial stages. Conclusive proof of age of the older deposits in the form of direct interregional correlation is not yet possible.

TABLE 1.—*Classification of Pleistocene deposits in the central United States*

Glacial stages	Interglacial stages
Wisconsinan Illinoian Kansan Nebraskan	Sangamonian Yarmouthian Aftonian

As ice moved over Richland County, it deposited unsorted unstratified material called till. Meltwater flowing on, within, beneath, and away from the ice deposited sorted and stratified sand and gravel called outwash. Deposits of silt and clay collected in glacial lakes, and windblown silt and fine sand, called loess, mantled the slopes and uplands after ice retreat. During longer periods of ice retreat, known as interglacials and interstadials, the climate ameliorated, vegetation flourished, the deposits weathered, and soils were formed.

Each major ice advance into northern Ohio carried material of slightly different texture and composition from that of the preceding advance. It is possible therefore to differentiate tills and to trace them for several hundreds of square miles through parts of several counties. It is now the practice of investigators to treat these tills as rock-stratigraphic units or formations and to assign names to them for purposes of mapping and discussion (table 2). Separate classifications are used for the Scioto and Killbuck lobes because deposits differ from one lobe to the other in many instances. In this investigation, Killbuck-lobe tills were traced from type localities in the Killbuck lobe (White, 1961) westward into Richland County, and the Scioto-lobe tills of Knox County (Forsyth, 1961) were traced northward into southern Richland County.

CRITERIA FOR IDENTIFYING AND CORRELATING TILLS

Identification and correlation of tills are based upon field criteria and laboratory analyses. Factors considered were (1) weathering characteristics, (2) texture, (3) mineral composition, (4) color, (5) structure, (6) topography and drainage, and (7) areal and stratigraphic position of the till with respect to other tills.

Weathering characteristics

The weathering of till produces a soil profile that may be subdivided vertically into several horizons (White, 1963; 1967).

Horizon 5 is the unaltered till, which is some shade of dark gray. This horizon is typically 10 to 15 feet below the surface; many exposures are too shallow to reveal gray till.

Horizon 4 is calcareous till, which differs from horizon 5 primarily in that the gray till has been oxidized to a shade of brown that is different for each till and is a useful field identification criterion. Gray veins of secondary carbonate enrichment are found in some places in the upper part of this horizon.

Horizon 3 is composed of brown till from which the carbonate minerals have been leached by the percolation of ground water. Dark-rusty-brown and black stains of iron and manganese oxides may occur along joint and fracture surfaces, particularly in the sandy tills. The contact between horizons 3 and 4 is known as the depth of leaching, which ranges from as little as 2 feet below the surface in the youngest tills to over 12 feet in the oldest tills. This depth, which is easily determined in the field by use of dilute hydrochloric acid, is an aid in distinguishing different tills. The depth of leaching is dependent on many variables, including age of the till, topography, drainage, and parent material. Within a single till sheet of sufficient thickness these variables are at a minimum, and depth-of-leaching measurements are generally consistent enough to be of value.

One of the biggest problems concerning the depth of leaching, and one that has been often overlooked, is correct interpretation of leaching depths when till sheets are thin and discontinuous. Depth-of-leaching values may be significant only for till deposited by the last ice sheet to cover a particular area and only then if the till is sufficiently thick that leaching has not proceeded into, or has not been influenced by, material underlying the till. There are many places in Richland County where an older till is at or near the surface in an area of a younger till. In some places the older till has been partially eroded, exposing fresh calcareous till. In such places the amount of leaching of the older till cannot be expected to be greater than the amount of leaching of the till deposited by the

TABLE 2.—*Classification of glacial deposits in Richland County*

Epoch	Stage	Substage	Killbuck lobe		Scioto lobe		Approximate dates (years B.P.)
			Unit or interval	Material	Unit or interval	Material	
Pleistocene	Wisconsinan	Woodfordian	Postglacial Late glacial	Alluvium, peat, loess, lacustrine silt and clay	Postglacial Late glacial	Alluvium, peat, loess lacustrine silt and clay	Present 14,300
〃	〃	〃	Hiram Till	Dark-brown clayey till	Centerburg Till	Dark-brown silty till	14,500
〃	〃	〃	Ice retreat	Loess	Ice retreat	Loess	14,700
〃	〃	〃	Hayesville Till	Dark-brown silty till	Mt. Liberty Till	Dark-yellow-brown silty till	15,000
〃	〃	〃	Erie Interval	Loess	Erie Interval	Loess	18,000
〃	〃	〃	Navarre Till	Yellow-brown sandy till	Knox Lake Till	Yellow-brown sandy till	24,000
〃	〃	Farmdalian	Ice retreat	Paleosol, loess	Ice retreat	Paleosol, loess	28,000
〃	〃	Altonian	Millbrook Till (two sheets?)	Olive-brown sandy till	Jelloway Till	Olive-brown sandy till	75,000(?)
〃	Sangamonian (?)		Prolonged ice retreat	Paleosol	Prolonged ice retreat	Paleosol	
〃	Illinoian		Butler Till	Yellow-brown silty till	Butler Till	Yellow-brown silty till	(?)
〃	〃		Ice retreat	Loess(?)	No lobe distinction made in older deposits; units and material probably similar in both lobes		
〃	〃		Unnamed till	Silty, sandy till			
〃	〃		Ice retreat	Loess(?)			
〃	〃		Unnamed till	Silty, sandy till			
〃	Pre-Illinoian(?)		Weathered till and gravel				

last ice advance.

Horizon 2 is composed of thoroughly weathered till in which some pebbles and cobbles have decomposed. Clay coatings are present, and dark stains of iron oxide and manganese are found along joints in many places.

Horizon 1 is the soil of pedologists, and generally is divisible into an upper gray-brown to dark-brown topsoil (A) and a lower yellow-brown subsoil (B).

There is good evidence that different tills give rise to different soil types. In addition to the length of time a till has been weathered, till texture and mineralogy also influence soil types. A generalized soil map is included (fig. 7) to show soil associations and their regional distribution. The figure is from a map published in 1972 by the Ohio Division of Lands and Soil and based on a detailed soil-mapping project completed during 1970 by the U.S. Soil Conservation Service. The various soils are discussed in detail as they apply to the tills described.

Texture

The texture or size of the grains composing a till has been an important criterion in till identification in northeastern Ohio and northwestern Pennsylvania (White, 1963; 1967; Shepps and others, 1959; White and others, 1969). Texture was determined by using Shepps' (1953) method of size analysis and was calculated as percentages of sand, silt, and clay. Textural data are shown in table 3 and in several figures illustrating cuts; in the columnar sections these data are given opposite sampled till horizons.

Mineral composition

Till in Richland County consists of a large variety

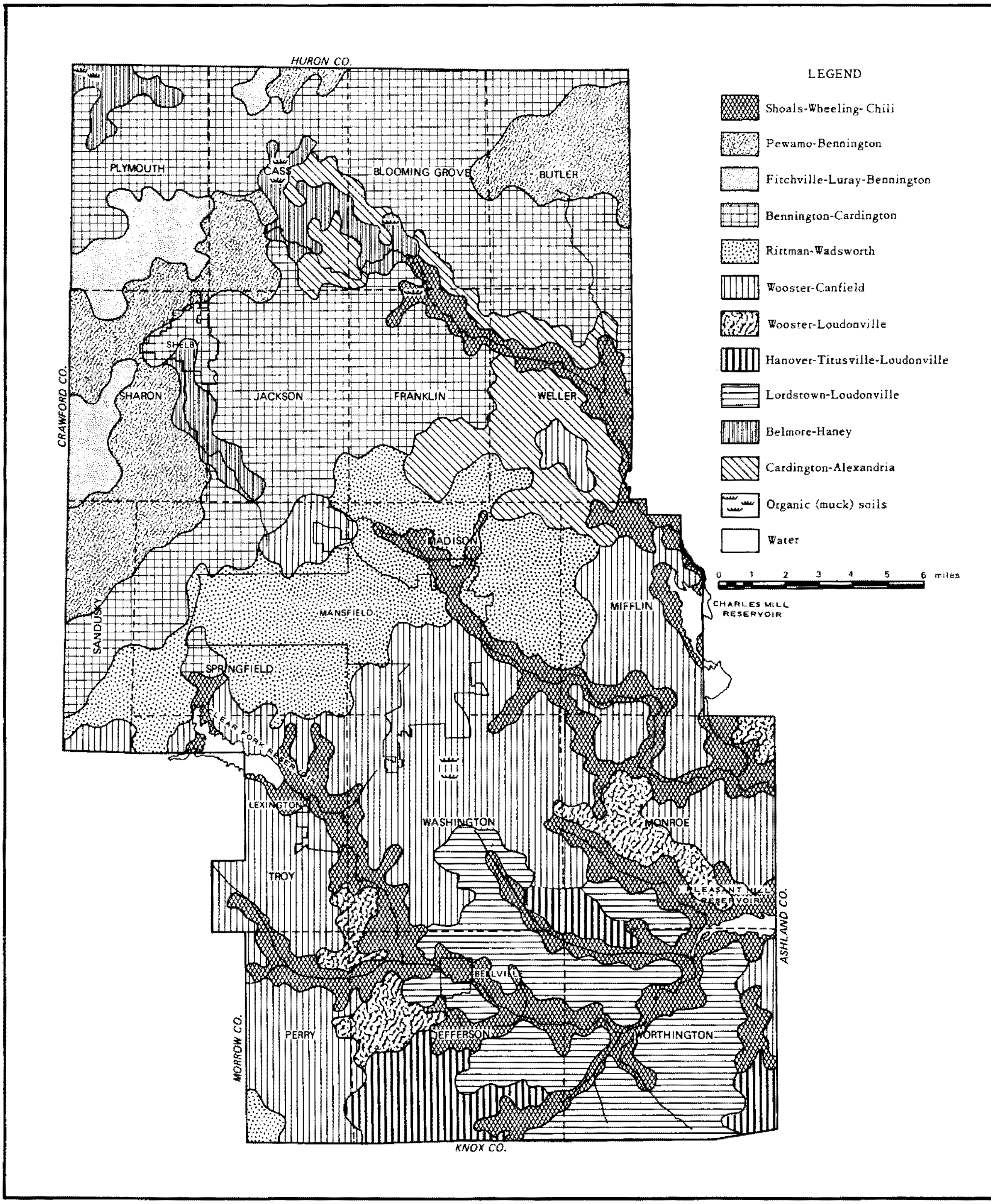


FIGURE 7.—Generalized soil map for Richland County (from General soil map of Richland County, published in 1972 by Ohio Division of Lands and Soil).

TABLE 3.—*Average percentage compositions of tills in Richland County*

Lobe	Till	No. of samples	Sand	Silt	Clay	Sand/clay	Quartz	Orthoclase	Plagioclase	Quartz/feldspar	Carbonate	Illite	Chlorite	Kaolinite
Killbuck lobe	Hiram	62	23	47	30	.77	53	9	22	1.7	17	86	7	7
	Hayesville	102	25	48	27	.93	66	6	17	2.9	12	83	6	11
	Navarre	48	36	44	20	1.80	66	7	16	2.9	13	82	6	12
	Millbrook	29	41	42	17	2.41	68	6	16	3.1	9	79	7	14
Scioto lobe	Centerburg	6	34	43	23	1.48	67	7	18	2.7	18	89	3	8
	Mt. Liberty	20	37	42	21	1.76	64	8	16	2.7	12	80	5	15
	Knox Lake	13	40	41	19	2.11	70	6	19	2.8	9	79	5	16
	Jelloway	4	42	39	19	2.21	71	8	15	3.1	14			

of minerals, the most abundant of which are quartz, feldspar, clay minerals (illite, chlorite, kaolinite), and carbonate minerals (calcite, dolomite). Studies of till samples from northeastern Ohio (Totten, 1960; Heath, 1963) indicate that tills vary in mineral content; accordingly, the relative abundances of each of these minerals were determined in order to characterize the mineralogy of Richland County tills (table 3).

Color

The color of till is a subtle but very useful physical characteristic in till identification. With practice and experience, these subtle color differences can be distinguished by use of the standard Munsell Soil Color Chart (1954). All tills, where sufficiently thick, display two dominant colors: gray where unaltered and brown where oxidized, the boundary in Richland County being commonly 5 to 15 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.

Structure

Structure refers to the size and shape of the individual units that result when till fractures or breaks. Unweathered till commonly appears structureless, but weathered till may exhibit a variety of fracture patterns. It is not known how these patterns are produced, but they are of use in distinguishing tills.

Topography and drainage

The surfaces of different till sheets in many cases show differences in topography and drainage that aid in distinguishing one till from another. Sometimes these differences can be detected in the field, but they are most evident on aerial photographs. These are relative differences and must be considered with care. In general, slopes tend to become smoothed and rounded with increasing age, and drainage becomes more extensive and integrated.

Areal and stratigraphic position of till

The approximate areal and stratigraphic positions of the tills in neighboring counties have been established by White (1961, 1963, 1967) and Forsyth (1961), who have demonstrated that the older tills extend farther toward the glacial boundary than the younger tills.

Stratigraphic sections showing more than one till are of importance in determining the sequence of deposits, and the relative age relationships between tills in a sequence may be inferred by intercalated paleosols and other deposits. Numerous multiple-till stratigraphic sections have been studied in Richland County (Totten, 1965; White, in Norris and White, 1961); many of the sections are illustrated in this report, either by sketches or by columnar presentation.

PRE-WISCONSINAN DEPOSITS

GENERAL STATEMENT

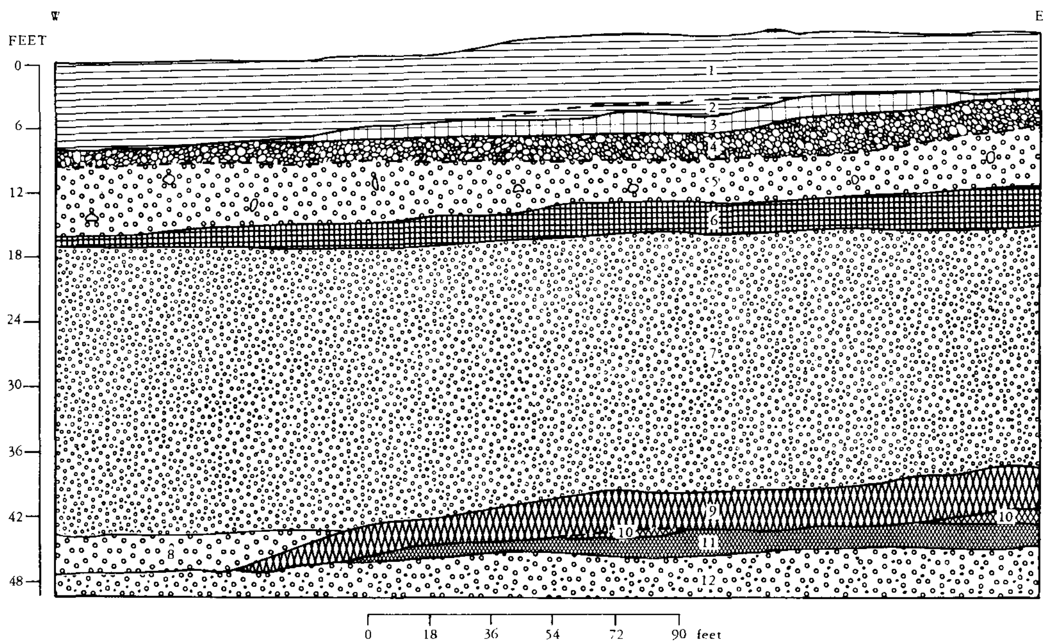
In Richland County, Wisconsinan-age drift is present at the surface in all except the southeastern corner of the county, where a very thin and deeply weathered earlier drift is present (pl. 1). Earlier drift is exposed also beneath Wisconsinan deposits in numerous stream cuts and excavations, allowing identification of several pre-Wisconsinan till units and associated deposits.

A wide fringe of deeply weathered drift in the Scioto lobe (shown on the Glacial Map of Ohio, Goldthwait and others, 1961) extends southward from southeastern Richland County and was assigned an Illinoian age by Leverett (1902). White (1937) modified Leverett's mapping and substantiated stratigraphically (1937, 1939a) the difference between the older drift of the fringe in the Scioto lobe and the younger drift at the margin of the Killbuck lobe. Forsyth (1961) followed White's (1937) usage of Illinoian for the drift of eastern Knox County.

Recent studies in Pennsylvania (White and others, 1969) and eastern Ohio (White, 1963, 1967; Moran, 1967) have revealed the presence of widespread and relatively thick early Wisconsinan drift and, in a few places, pre-Wisconsinan drift beneath the "classical" Wisconsinan drift of Leverett. The early Wisconsinan till, which in Pennsylvania has been named the Titusville Till by White and Totten (1965), has been traced westward into Ohio, where it becomes the Mogodore Till in the Grand River lobe and the Millbrook Till in the Killbuck lobe. The Millbrook Till is similar to almost all of the Scioto-lobe Illinoian Till of Knox County of Leverett (1902) and White (1937) in terms of texture, composition, weathering characteristics, and stratigraphic position, and I believe they should be considered correlatives. Therefore only a small portion of this fringe in Richland County is regarded as pre-Wisconsinan.

PRE-ILLINOIAN(?) DEPOSITS

Evidence for a pre-Illinoian glaciation in Richland County has come largely from a study of drainage changes described previously. Additional evidence for an early glaciation was uncovered in 1970 in a deep excavation at the Derwacter gravel pit a mile and a half northwest of Bellville (fig. 8). Exposures in this pit have revealed, over a period of 10 years, a thick and complex sequence of deposits which have been protected from erosion by bedrock spurs along the east side of Clear Fork. At the Derwacter pit, weathered gravel and till are found beneath a thick sequence of calcareous gravel and three tills considered to be of Illinoian age. The lowermost unit, exposed at water level, is sandy gravel, which is weathered to a dark-reddish-brown color and is leached of carbonates for



1. Till, olive-brown, deeply weathered, pebbly. MILLBROOK
2. Till, olive-brown, calcareous. MILLBROOK
3. Till, dark-reddish-brown, much weathered. BUTLER
4. Gravel, strong-reddish-brown, coarse, cobbly, much-weathered; few boulders
5. Gravel, gray-brown, calcareous; as above
6. Till, gray, hard, pebbly, calcareous. ILLINOIAN
7. Gravel, gray-brown, sandy, even-bedded, calcareous. ILLINOIAN outwash
8. Gravel, gray-brown, coarse, calcareous
9. Till, dark-yellow-brown, pebbly, hard, calcareous (sample no. 534, 39 percent sand, 21 percent clay). ILLINOIAN
10. Till, gray brown as above
11. Till, strong-olive-brown, very pebbly, weathered; limestones thoroughly rotted. Pre-ILLINOIAN(?)
12. Gravel, dark-reddish-brown, sandy, weathered; limestone ghosts. Pre-ILLINOIAN(?) outwash

FIGURE 8.—Sketch of glacial deposits exposed in deep pit of the Derwacter Sand and Gravel Co., NW¼NE¼ sec. 5, T. 19 W., R. 18 W., Jefferson Township, Richland County, 1½ miles northwest of Bellville.

the exposed thickness of 4 feet. Thirty feet of this gravel deposit were excavated below the water table by dragline, giving a minimum thickness of 34 feet for this ancient outwash material. Above the gravel, lying beneath calcareous gray-brown Illinoian till, is a truncated highly weathered till and paleosol up to 2 feet thick. The till is strong olive brown in color, and intense black manganese stains coat pebbles and till partings. Limestone pebbles are ghosts in the upper part and are soft and powdery in the lower part. This weathered till and gravel is sharply defined beneath the relatively unaltered deposits directly above, and the undulatory contact can be followed on all sides of the excavation.

The presence of these deeply buried and intensely weathered deposits lends support for an early pre-Illinoian(?) glaciation in Richland County. It is probable that the lower deposits in the partially filled Deep Stage valleys of the county are of this type. Only under the most fortuitous circumstances are such deposits exposed above the water table, their ages cannot be precisely determined. It is clear only that they are considerably older than the till and gravel directly above. They may be correlative with similar deposits in western Pennsylvania called by White and others (1969) Slippery Rock Till and regarded as pre-Illinoian.

ILLINOIAN DEPOSITS

The hilly upland surface south of Clear Fork valley in southernmost Richland County is characterized by extremely sparse drift. Leverett (1902) regarded this area as driftless, but White (1937) reported the presence of erratics and thin till, confirming that glaciation had taken place. On the hillsides and hilltops only a few crystalline erratics can be found amid colluviated siltstone slabs, but thicker till occurs in the valleys. This patchy till, named the Butler Till and considered to be of Illinoian age, can be traced beneath younger till over much of Richland County. Tills situated beneath the Butler Till at several exposures are tentatively assigned an Illinoian age also, although they may be older.

Butler Till

The Butler Till is the surface material in extreme southern Richland County and in southern Worthington and Jefferson Townships. It was named (Totten, 1962) from exposures a short distance to the south of the village of Butler, where it is found at several places, primarily in lowlands beneath thick colluviated bedrock. The best exposure (section 519) was in a basement excavation on the south side of Cassel Road in the NW¼SW¼ sec. 19, 1 mile southwest of Butler:

	Ft	*In*
Silt loam, grayish-brown; some siltstone fragments	0	8
Silt loam, yellow-brown; numerous flat siltstone fragments	1	2
Till, much-weathered; thick clay flows and black manganese stains; numerous flat siltstone fragments	2	8
Till, yellow-brown, silty, sandy, weathered; clay coatings and manganese stains; rotted granite pebbles; hollow ghosts of carbonate(?) pebbles near base; sample no. 519 at base composed of 20 percent sand, 53 percent silt, 27 percent clay	1	0

Other exposures of the Butler Till are in Slater Run south of Butler, along Ankenytown Road south of Bellville, and along Smith Road from Ankenytown Road to State Route 13, where the exposures may be mistaken for bedrock because of a thick colluvium cover. The Smith Road exposures reveal up to 10 feet of deeply weathered stony yellow-brown till containing sparse crystallines, including weathered granites, and an abundance of angular siltstone and sandstone fragments. The top several feet are a colluviated mixture of bedrock, silt, and till. Calcareous till occurs in the road ditch at one place at a depth of about 10 feet, but a colluvial horizon at the surface indicates that the soil profile is truncated. The colluviated zone, of variable thickness and silt capped, may be the product of intense frost action during the Wisconsinan glacial stage. The Butler Till (fig. 9) is considerably more deeply weathered than the Millbrook Till and an Illinoian age is tentatively assigned. No distinction is made on the soil map (fig. 7) between the soils in the Millbrook and Butler Till areas; both tills, where

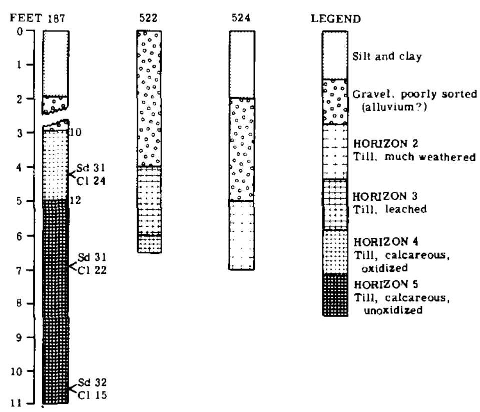


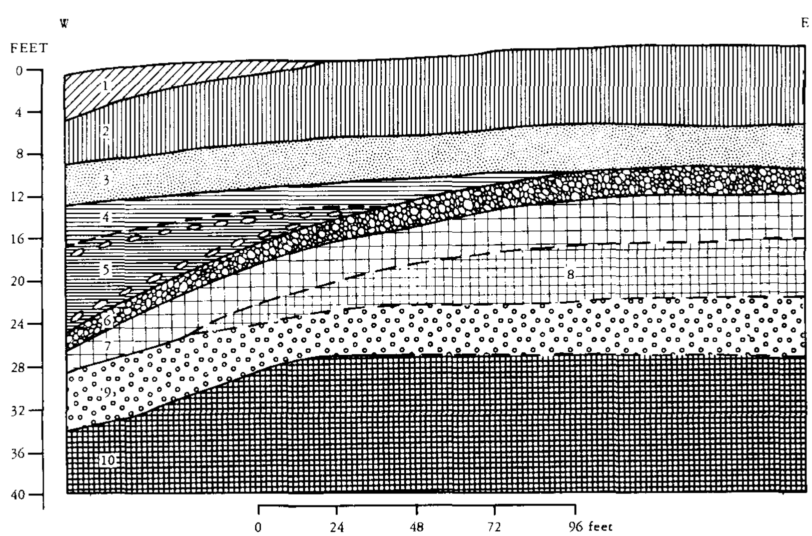
FIGURE 9.—Columnar sections showing weathering horizons of Butler Till. Percentages of sand (Sd) and clay (Cl) shown at points at which samples were collected.

TABLE 4.—*Characteristics of soils in till of the Killbuck lobe in Richland County*

Soil characteristics	Till unit				
	Hiram	Hayesville	Navarre	Millbrook	Butler
Silt cap thickness (in)	0-6	6-12	12	12-24	24
Structure	¼- to ½-inch cubes	½- to 1-inch cubes	Platy horizontal partings, few manganese stains	Large, irregular blocky; extensive manganese stains	Platy horizontal partings
Color (oxidized)	Dark brown 10*YR* 4/3	Dark brown 10*YR* 4/3	Yellow brown 10*YR* 4/4	Olive brown 2.5*Y* 4/4	Yellow brown 10*YR* 4/4
Depth of leaching (in)	20-32	35-60	50-70	84-96	At least 120
Depth of oxidation (ft)	5-7	7-9	10-12	Not known	Not known
Soil names	Cardington-Bennington	Cardington-Bennington Rittman-Wadsworth	Wooster-Canfield	Hanover-Loudonville	Loudonville

thin, give rise to Loudonville soils (table 4). Where the till is so thin that it does not influence soil development, as on steep hillslopes, Muskingum soils may be present.

The Butler Till occurs beneath Wisconsinan-age till at several localities, including Shenandoah (Totten, 1965), the railroad cut near Lucas (fig. 10), the Derwacter gravel pit near Bellville (figs. 8, 11), and Clear Fork Reservoir (fig. 12). At these localities the Butler Till is dark yellow brown (10*YR* 4/4) to dark brown (10*YR* 4/3) where oxidized, dark gray to gray brown where unweathered. The till is sandy, silty, pebbly, moderately calcareous, and generally rusty and compact. The few samples of calcareous Butler Till which have been analyzed average 32 percent sand, 47 percent silt, and 21 percent clay, and



1. Till and soil, dark-brown, weathered. HAYESVILLE
2. Till, yellow-brown, lower part calcareous (sample no. 166, 39 percent sand, 19 percent clay) NAVARRE
3. Sand, yellow-brown
4. Till, olive-brown, calcareous (sample no. 288). MILLBROOK
5. Till, olive-gray, calcareous (sample no. 289). MILLBROOK
6. Gravel, reddish-brown; cemented gravel and boulders. SANGAMONIAN(?)
7. Till, dark-yellowish-brown; lower part calcareous (sample no. 292). BUTLER
8. Till, dark-gray-brown, calcareous (sample no. 293). BUTLER
9. Gravel, brown, calcareous
10. Till, dark-gray, crumbly, calcareous (sample no. 296). ILLINOIAN(?)

FIGURE 10.—Sketch of glacial deposits exposed along the Pennsylvania Railroad cut in the SE¼SE¼ sec. 9, T. 22 N., R. 17 W., Monroe Township, Richland County, 1 mile east of Lucas.

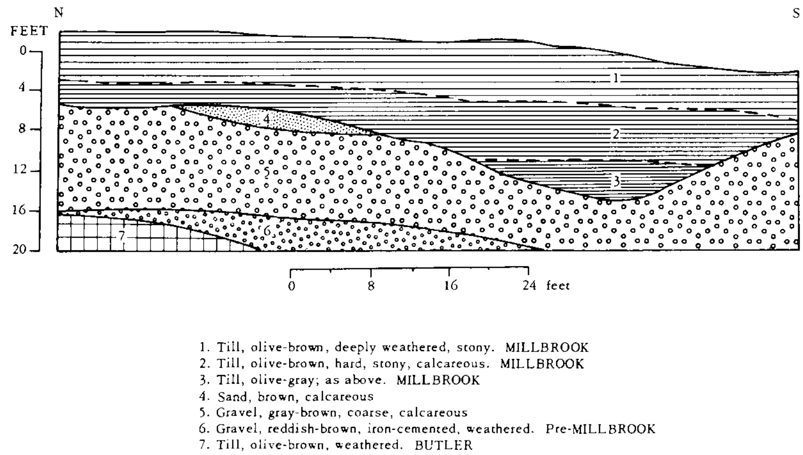


FIGURE 11.—Sketch of glacial deposits exposed in a small pit of the Derwacter Sand and Gravel Co. behind the barn in the SE¼SE¼ sec. 32, T. 20 N., R. 18 W., Washington Township, Richland County, 1½ miles northwest of Bellville.

have a 9 percent carbonate content. From its known distribution, the Butler Till appears to be present throughout the county in valleys and lowlands, but absent in the Interstate 71 road cuts and in other upland road cuts where it was particularly susceptible to stream and glacial erosion. No lobe distinction was made for the Butler and earlier tills.

Earlier Illinoian tills

At many of the same localities where Butler Till is exposed, additional till units are found beneath the Butler Till, separated from it by stone pavements or silt and sand layers (figs. 8, 10; see also fig. 13). These units can be grouped into two tills which are similar to, but older than, the Butler Till. However, they are not greatly older as no well-developed paleosol occurs between them and the Butler Till. These tills indicate that the Illinoian glacial stage was multiple, and that thick outwash sand and gravel deposits collected in the major valleys.

SANGAMONIAN(?) SOIL

A prominent weathering horizon is developed in the Butler Till where it is present beneath the Millbrook Till (fig. 14). This paleosol, which lends support to the contention that the Butler Till and underlying tills belong to an earlier glacial stage, is assigned to the Sangamonian Stage of Illinois, though

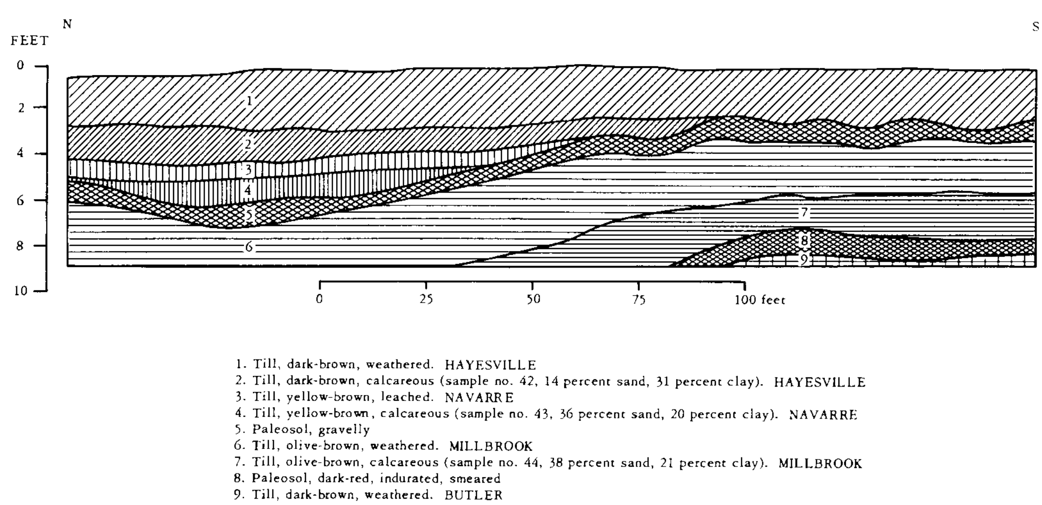
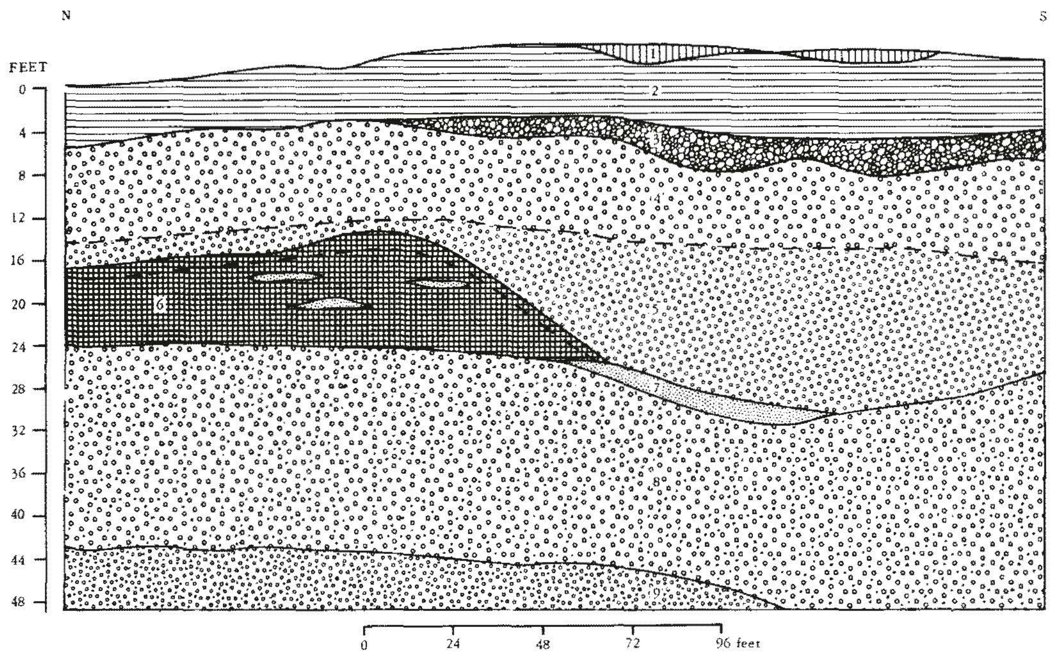


FIGURE 12.—Sketch of glacial deposits exposed along Clear Fork Reservoir in the NW¼SW¼ sec. 11, T. 20 N., R. 19 W., Troy Township, Richland County.



1. Till, yellow-brown, weathered; in pockets. NAVARRE
2. Till, olive-brown, weathered. MILLBROOK
3. Gravel, brown, very coarse; numerous cobbles and boulders
4. Gravel, brown, coarse
5. Gravel, gray-brown, coarse
6. Till, gray, tough, compact, calcareous; oxidized at the top; (sample no. 92, 43 percent sand, 18 percent clay). ILLINOIAN(?)
7. Sand
8. Gravel, gray, sandy, even-bedded
9. Gravel, brown, sandy

FIGURE 13.—Sketch of glacial deposits exposed in a pit of the Derwacter Sand and Gravel Co., south of Spayde Road, NW¼NE¼ sec. 5, T. 19 N., R. 18 W., Jefferson Township, Richland County, 1½ miles northwest of Bellville.

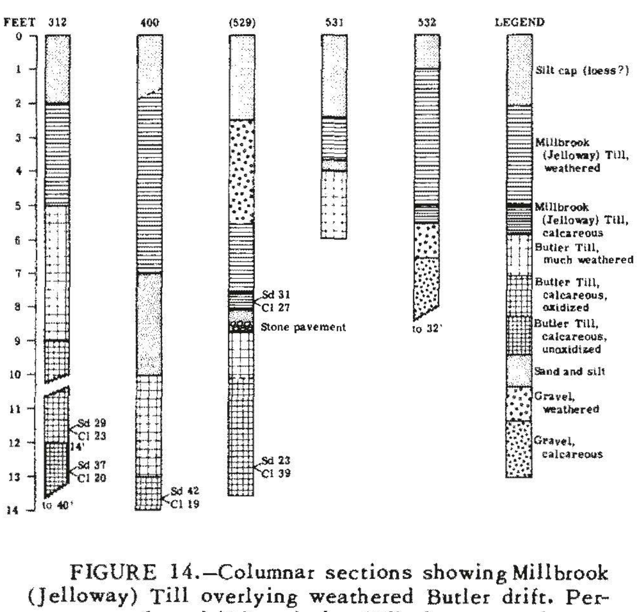


FIGURE 14.—Columnar sections showing Millbrook (Jelloway) Till overlying weathered Butler drift. Percentages of sand (Sd) and clay (Cl) shown at points at which samples were collected.

correlation by direct tracing cannot be claimed.

The Sangamonian(?) soil is developed in various materials. At Shenandoah (Totten, 1965) 4.5 feet of weathered sand is found in this position. At Clear Fork Reservoir, indurated dark-red paleosol is present beneath Millbrook Till. At the northeast edge of Bellville (section 400) one of the best exposures of the paleosol is in a kame, where 3 feet of weathered reddish-brown sand is present between weathered Butler and Millbrook Tills, and the combined depth of leaching is 13 feet. At the Derwacter gravel pit near Bellville, paleosol developed directly in Butler Till is exposed beneath calcareous Millbrook Till. Weathering has extended through the Butler Till into the underlying gravel, which contains completely rotted carbonates and weathered crystallines in the upper 3 feet. At the Pennsylvania Railroad cut near Lucas (fig. 10) the paleosol is developed in gravel which has been highly weathered and is cemented by iron oxide. Weathering extends into the underlying Butler Till, making a combined depth for the paleosol of 4 to 6 feet, a figure which is consistent with those for the other exposures. Wherever this soil exists beneath cal-

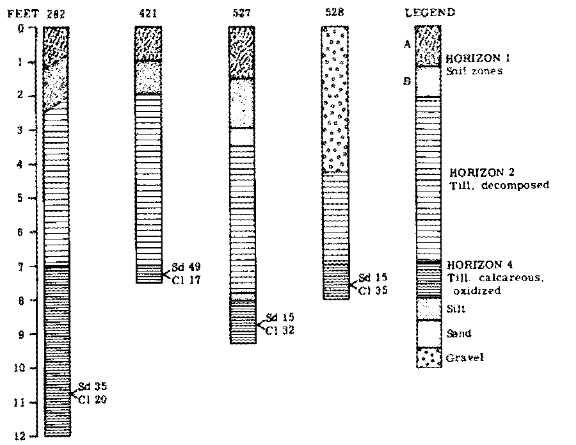


FIGURE 15.—Columnar sections showing weathering horizons of Millbrook Till (sections 282, 421) and Jelloway Till (sections 527, 528). Percentages of sand (Sd) and clay (Cl) shown at points at which samples were collected.

careous Millbrook Till, it is truncated and partially smeared by Millbrook ice; thus Sangamonian(?) weathering exceeded 6 feet and may have been considerably greater.

WISCONSINAN DEPOSITS AND WEATHERING INTERVALS OF THE KILLBUCK LOBE

GENERAL STATEMENT

Glacial deposits covering approximately the northern four-fifths of Richland County belong to the Killbuck lobe (pl. 1). The tills of this lobe, in ascending order, are the Millbrook, Navarre, Hayesville, and Hiram Tills. Associated with these tills are outwash sands and gravels, lacustrine deposits, and eolian deposits. The tills of this lobe were named and described by White (1961), and his classification is used in this report.

MILLBROOK TILL

The Millbrook Till is the oldest till that is present in stratigraphic sections (figs. 14, 15, 16) over a wide geographic area. The till was named for a village in Wayne County by White (1961, p. 71-72), who traced the deposit across Stark, Wayne, Holmes, and Ashland Counties, mainly as a subsurface unit.

The Millbrook Till is present at the surface in parts of Worthington, Jefferson, Monroe, and Washington Townships. Its outer margin extends in a general east-west direction along the latitude of Butler about 3 miles north of the Richland-Knox County line, and follows in a general way a segment of Clear Fork and Honey Creek.

In southern Richland County and on uplands in the central part of the county (fig. 16) the Millbrook Till generally overlies bedrock, but in central and northern areas of the county, particularly in the lowlands, several tills may be present below the Millbrook. The Millbrook Till is commonly less than 10 feet thick on the uplands near its margin but is thicker in valleys and lowlands. No definite terminal moraine of this advance is present in Richland County. Thick Millbrook Till is present in northeastern Worthington Township in an elongate lowland called the Davis Basin by White (1937, p. 15), and thick Millbrook Till associated with kames is found 2 miles northeast of Butler.

The Millbrook Till is a hard compact sandy pebbly till that contains many cobbles and boulders. Analyses

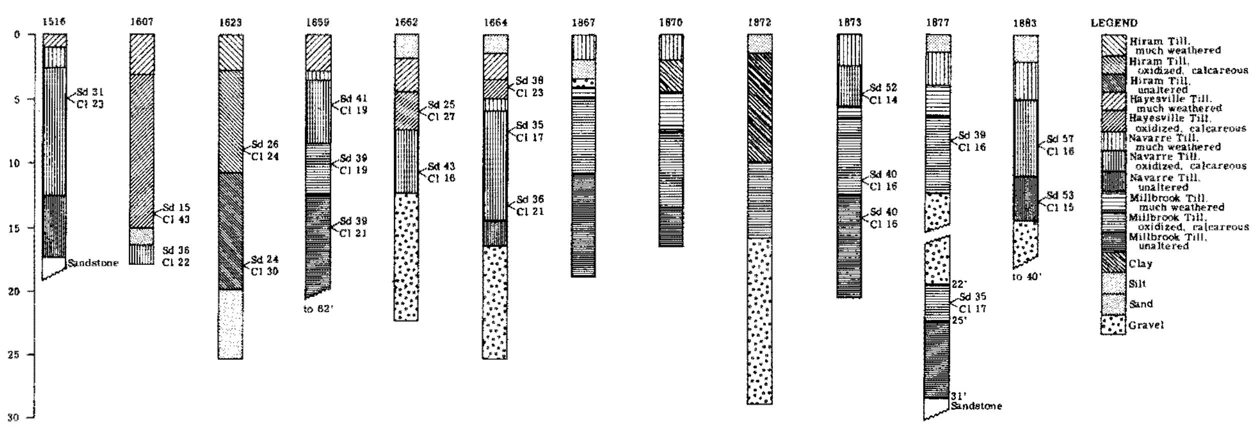


FIGURE 16.—Columnar sections showing glacial deposits of the Killbuck lobe exposed in Interstate 71 excavations. Percentages of sand (Sd) and clay (Cl) shown at points at which samples were collected.

average 41 percent sand, 42 percent silt, and 17 percent clay. The average carbonate content is 9 percent, the average quartz/feldspar ratio is 3.1, and the clay mineral composition is 79 percent illite, 7 percent chlorite, and 14 percent kaolinite.

Columnar sections of weathering horizons developed in Millbrook Till are shown in figure 15. Unaltered Millbrook Till (horizon 5) is dark olive gray, whereas the oxidized color of the till (horizon 4) is a characteristic distinct olive brown (2.5*Y* 4/4) which contrasts with the yellow-brown and dark-brown younger tills. The depth of oxidation cannot be determined precisely because of profile truncation and the influence of younger, overlying deposits. The depth of leaching, the top of horizon 4, is generally between 7 and 8 feet. Leached Millbrook Till (horizon 3) is characterized by a structure consisting of large angular blocks which are coated by clay skins and rusty iron and manganese stains. Rusty stains also coat most pebbles and, as pebbles are loosened from till, rusty molds remain where pebbles formerly were located. Horizon 2, about 3 feet thick, is characterized by thick clay flows and intense manganese staining. Many of the pebbles, particularly the granites, are either partially or completely rotted. The olive-brown till color is largely obscured by the abundant gray clay flows and intense brown iron stains. Horizon 1, about 2 feet thick, is a friable loam, gray brown at the top and yellow brown below. The loam is rich in silt and at many localities consists of 2 feet of pebble-free silt which grades abruptly downward into pebbly silt. This pebble-free silt, which is thinner and commonly mixed with colluviated bedrock on steep slopes, is mapped in many instances as a distinct unit, called a silt cap, and interpreted as wind-blown silt (loess).

Weathering of Millbrook Till, including the silt cap, yields a well-drained friable soil (table 4) mapped as Hanover (fig. 7) on drift-mantled slopes or as Loudonville on steep slopes where little drift remains. On gentle slopes covered with thick silt the soil may resemble the Wooster loam. These soils are light colored, strongly acid, and moderately productive. Because these soils occur most commonly on steep slopes, erosion is a serious problem, and land use should involve a minimum amount of soil tillage.

Thick Millbrook Till and associated outwash are present beneath younger deposits in many gravel pits and road cuts. With the possible exception of lower deposits in the deep drift-filled valleys, Millbrook drift apparently makes up the bulk of the drift in the Killbuck lobe of Richland County, a situation similar to that in Wayne County (White, 1967, p. 18). In places, the Millbrook drift appears to consist of more than one till, the units being separated by outwash gravel. This multiplicity of Millbrook Till units was seen at two localities near Lucas (figs. 10, 17) and at Shenandoah (Totten, 1965).

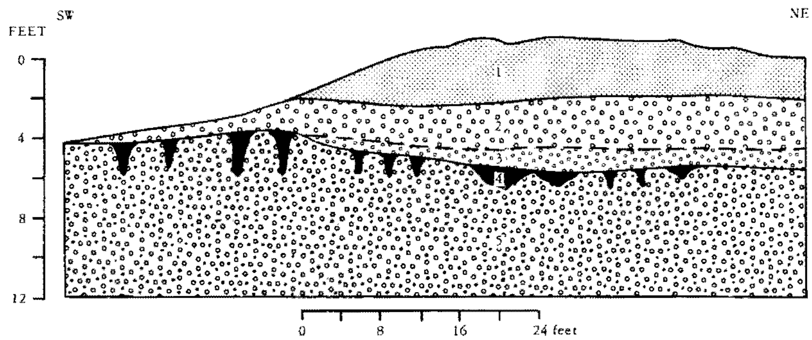
Typically associated with the Millbrook glaciation is outwash sand and gravel (figs. 18, 19) which may both underlie and overlie Millbrook Till, particularly in valleys, but not exclusively so. Where sufficiently thick and accessible, this good quality Millbrook gravel is a valuable economic resource and has been extensively quarried.

The Millbrook Till is correlative with the Mogodore Till of the Grand River lobe (White, 1967, p. 21) and with the Titusville Till of northwestern Pennsylvania (White and others, 1969); the latter has a radiocarbon date of approximately 40,000 years B.P. The Millbrook drift therefore is of early Wisconsinan (Altonian) age and possibly correlates with the Gahanna Till near Columbus, Ohio (Goldthwait, Forsyth, and White, 1965, p. 77).

FARMDALIAN SUBSTAGE

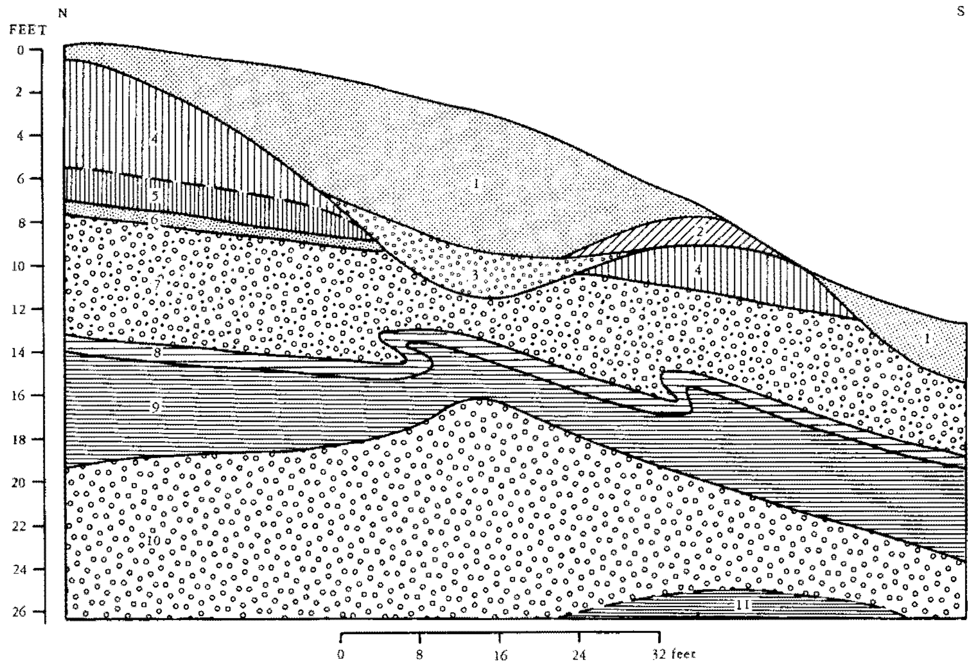
Where later till lies over Millbrook Till (figs. 16, 21, 23) a weathered zone or paleosol is found in many places upon the Millbrook Till. This weathered zone, which is present in similar stratigraphic position in the Scioto lobe, is up to 4 feet thick, including the zone of leaching, and commonly consists of several inches to 2 feet of mottled clay loam or reddish-brown clayey gravel, the latter of which may be in part a stone pavement. Some truncation of the weathered zone by the overriding glacier has evidently taken place and nowhere is a complete profile preserved. A typical example of the weathered zone is section 382 (fig. 21), located south of Mansfield. At this locality, beneath 3 feet of calcareous Navarre Till, there is 1 foot of hard compact clayey gravelly reddish-brown loam which contains stones (stone pavement?). Beneath the loam, 4 inches of leaching was recorded above calcareous Millbrook Till.

Characteristic of the paleosol developed in Millbrook outwash gravel in Clear Fork and Black Fork valleys are clay-filled wedges (figs. 18, 19) commonly 2 to 6 feet deep and 1 to 3 feet wide at the top. These wedges, or pendants as they are sometimes called, have two possible modes of origin: (1) from the movement of clay downward by ground water as part of soil-forming processes, or (2) from the filling of frost (ice) wedges which formed under conditions of permafrost. The closely spaced three-dimensional polygonal nature of the wedges at Lexington and Bellville supports a permafrost theory for their origin. However, frost wedges are generally filled with sand; Richland County wedges are filled with clayey paleosol, a difference that supports the soil pendant theory. Perhaps the wedges resulted from a composite of both processes: frost wedges may provide an avenue for the movement of clay during soil formation.



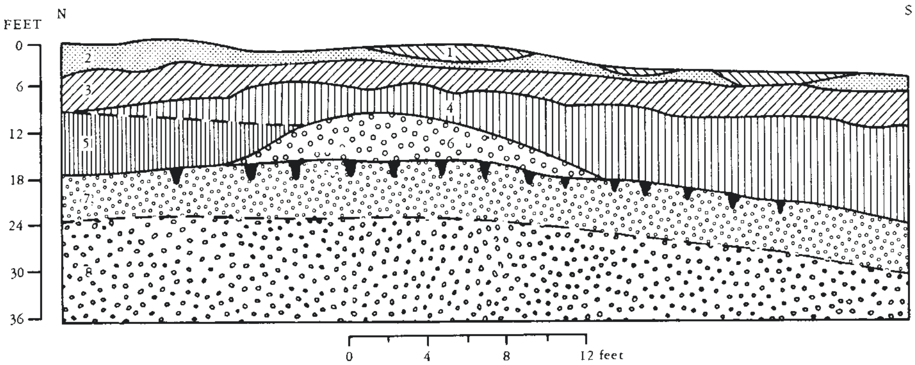
1. Silt, brown, weathered
2. Gravel, brown, clayey, weathered
3. Gravel as above, calcareous
4. Wedges, brown, clayey; up to 2 feet deep and 8 inches wide
5. Gravel, gray, sandy, poorly sorted, calcareous

FIGURE 18.—Sketch of glacial deposits exposed in a recently active gravel pit, NE¼SE¼ sec. 5, T. 23 N., R. 17 W., Mifflin Township, Richland County, 1½ miles north of the Interstate 71-U.S. 30 interchange.



1. Silt, yellow-brown; in pockets
2. Till, dark-brown, weathered. HAYESVILLE
3. Gravel, reddish-brown, poorly sorted
4. Till, yellow-brown, weathered. NAVARRE
5. Till, yellow-brown, calcareous (sample no. 177, 42 percent sand, 16 percent clay). NAVARRE
6. Sand, brown, calcareous
7. Gravel, sandy, poorly sorted; weathered in upper part
8. Till, purple-brown, stony, contorted (flotil?). MILLBROOK
9. Till, dark-gray, calcareous; as above (sample no. 178, 38 percent sand, 20 percent clay). MILLBROOK
10. Gravel, brown, calcareous, coarse
11. Till, dark-gray; poorly exposed in creek bed (sample no. 179, 30 percent sand, 25 percent clay). MILLBROOK

FIGURE 17.—Sketch of glacial deposits exposed in stream cut, SE¼SW¼ sec. 29, T. 23 N., R. 17 W., Mifflin Township, Richland County, 2½ miles north of Lucas.



1. Till, brown, weathered. HIRAM
2. Silt, brown, weathered
3. Till, brown, weathered. HAYESVILLE
4. Till, yellow-brown, sandy, leached. NAVARRE
5. Till, yellow-brown, calcareous. NAVARRE
6. Gravel, brown, weathered; ice-shove material
7. Gravel, brown; rusty brown paleosol in upper 4 feet containing clayey wedges. MILLBROOK outwash
8. Gravel, gray-brown, calcareous. MILLBROOK

FIGURE 19.—Sketch of glacial deposits exposed along the wall of an inactive gravel pit, NE¼SW¼ sec. 25, T. 23 N., R. 19 W., Cass Township, Richland County, 1½ miles northwest of Ganges.

The paleosol in Millbrook drift was developed during the interval between retreat of Millbrook ice and advance of Navarre ice. This interval of weathering and soil formation is of interstadial rank and is correlative with the Farmdalian Substage of Illinois, which has in that state a radiocarbon age of about 27,000 to 21,000 years B.P. (Willman and Frye, 1970, p. 87).

NAVARRE TILL

The Navarre Till, the oldest of three Late Wisconsinan (Woodfordian) tills deposited in Richland County by the Killbuck lobe, was named by White (1961, p. 72) for the village of Navarre in southwestern Stark County. This till can be traced at the surface and in the subsurface (White, 1963, 1967) across western Stark County, Wayne County, northern Holmes County, and Ashland County into Richland County. The Navarre Till is at the surface in south-central Richland County, where it lies above the Millbrook Till, and can be traced northward to the Huron-Richland County line as a subsurface unit beneath Hayesville Till.

The outer margin of the Navarre Till can be traced northwestward from the Davis Basin near Newville across northern Worthington, the southwestern corner of Monroe, and the southeastern part of Washington Townships to sec. 15, Washington Township, where the margin bends abruptly southwestward in the direction of Clear Fork Valley and Bellville (pl. 1; fig. 6). Ice that flowed southeastward down Clear Fork Valley actually was intermediate in flow direction between the southward flow of Killbuck-lobe ice and the east-northeastward flow of Scioto-lobe ice into the southern portion of Richland County. As in the previous glaciation, Late Wisconsinan ice converged on southern Richland County from at least four directions—north, northwest, southwest, and south—and the junction between the Killbuck and Scioto lobes is not clear cut but transitional. The line of junction between Navarre Till and its Scioto lobe equivalent, Knox Lake, is the highland between Clear Fork and Cedar Fork south of Lexington. The outer margin is marked by a poorly developed end moraine—a wide fringe of hummocky topography and drift-filled tributaries—that contrasts markedly with the bordering Millbrook drift area. A broad area of hummocky topography near Kings Corners in southern Troy Township and extending westward into Morrow County may be the expression of an interlobate moraine formed between the Killbuck and Scioto lobes during this ice advance and now covered by later tills.

The Navarre Till is a silty sandy moderately pebbly till that contains scattered cobbles and boulders. Analyses average 36 percent sand, 44 percent silt, and 20 percent clay. The average carbonate content is 13 percent, the average quartz/feldspar ratio is 3.0, and the average clay mineral composition is 82 percent illite, 6 percent chlorite, and 12 percent kaolinite.

Columnar sections of weathering horizons developed in Navarre Till are shown in figure 20. Unaltered Navarre Till (horizon 5) is dark gray, whereas oxidized Navarre Till (horizon 4) is yellow brown (10*YR* 4/4) in contrast to the olive-brown Millbrook Till and the chocolate-brown tills above. The depth of oxidation is generally 10 to 12 feet, but Navarre Till is so thin in many places that it has been completely oxidized.

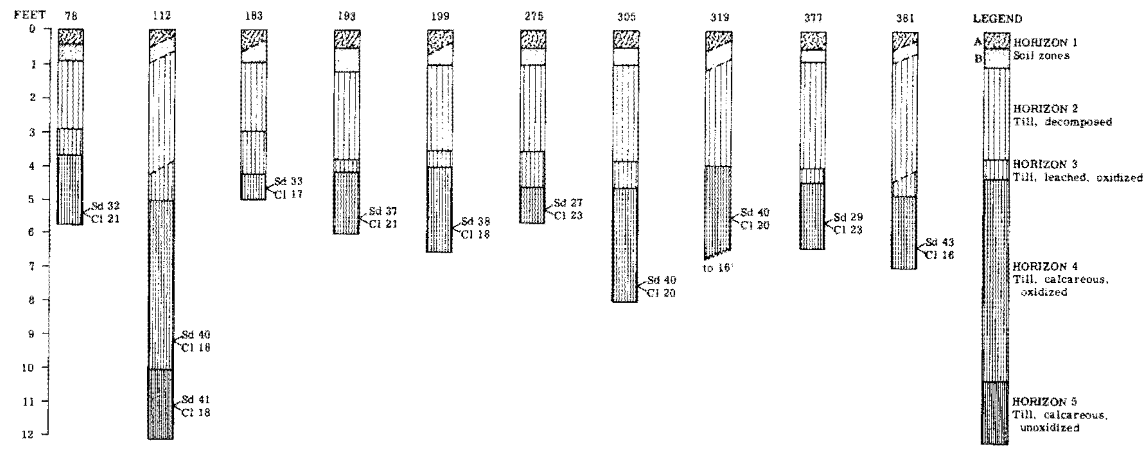


FIGURE 20.—Columnar sections showing weathering horizons of Navarre Till. Percentages of sand (Sd) and clay (Cl) shown at points at which samples were collected.

The thin but persistent nature of this till is evident in the columnar sections (figs. 20, 21). The till of horizon 4 is crumbly and flaky, and commonly contains well-developed horizontal partings that give the till a platy appearance. The top of horizon 4, the depth of leaching, ranges from 46 to 62 inches below the surface. Horizon 3, leached till, is stained along some joints, but is otherwise not greatly altered. Horizon 2 is characterized by relatively thick clay coatings and manganese and iron stains. The soils (table 4) developed in Navarre Till are mainly Wooster and Canfield silt loams, which are light colored, porous, and well drained and are well suited for general farm crops. About 1 foot of silt generally caps the Navarre Till where it is the surface till, but this silt is easily overlooked because it is incorporated in the soil. The silt cap may attain thicknesses of 3 to 4 feet in depressions on the till surface.

Outwash sands and gravels of Navarre age occur in terraces along major drainage lines, and several Navarre kames are present in the northern part of the county. These deposits generally are of too poor a quality and too thin to be of commercial use.

The Navarre Till is correlative with the Kent Till of the Grand River lobe in eastern Ohio and northwestern Pennsylvania (White, 1961, 1963, 1967; White and others, 1969). Driftwood in lacustrine material from Cleveland, Ohio, an area that was overridden by Na-

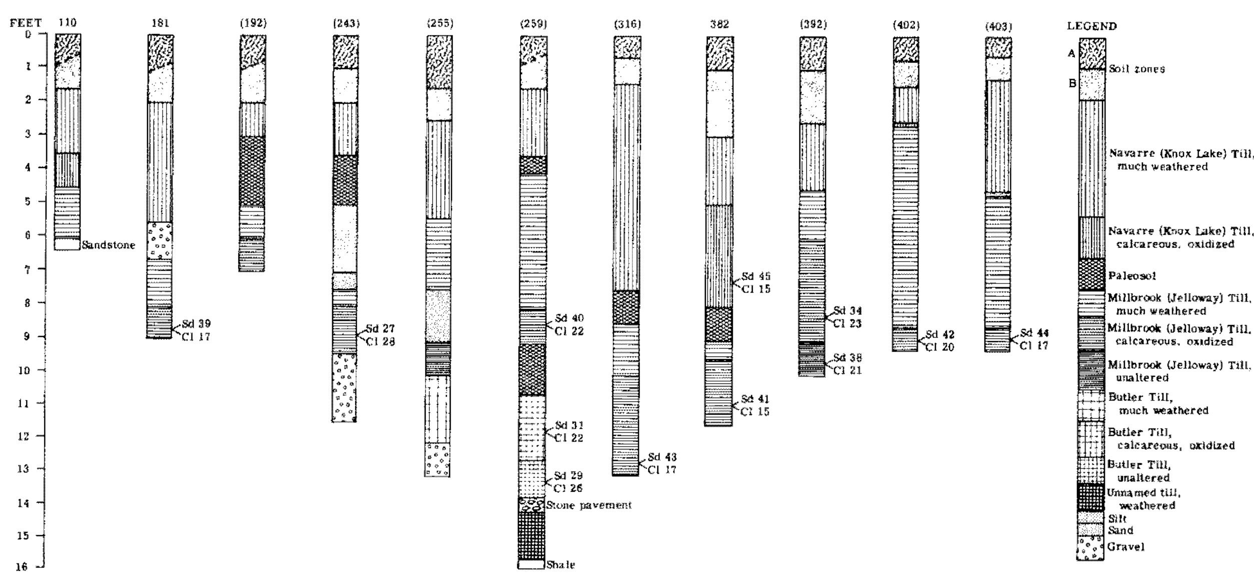


FIGURE 21.—Columnar sections showing thin Navarre (Knox Lake) Till overlying earlier drift. Percentages of sand (Sd) and clay (Cl) shown at points at which samples were collected.

varre ice, has a radiocarbon age of 24,000 years B.P. (White, 1968); the Navarre glacier probably reached Richland County between 22,000 and 20,000 years B.P.

ERIE INTERVAL

The retreat of Navarre ice from Richland County was followed by a short interval of climatic amelioration named the Erie Interval by Dreimanis (1958). According to Mörner and Dreimanis (1970), this interval probably corresponds to a worldwide warmer period that occurred about 15,500 years B.P. and separated two Late Wisconsinan glacial episodes. In Richland County, this warmer interval occurred between the Navarre and Hayesville ice advances and is represented by several inches to 1 foot of leaching beneath calcareous Hayesville Till (fig. 23, sections 62, 153, 330) and by thin sand or silt (fig. 23, sections 62, 142, 153, 505, 512).

The significantly greater depth of leaching on the Navarre Till where it is at the surface, compared with leaching depths on Hayesville Till, is regarded as additional evidence for an ice-free interval, though at least some of the difference in leaching depth must be due to the sandy nature of the Navarre Till. A withdrawal of Navarre ice back into, or beyond, the Lake Erie basin can be inferred also by the change in till composition from sandy (Navarre) to clayey (Hayesville). About the only source of abundant clay would have been proglacial lake clay deposited in the Lake Erie basin.

HAYESVILLE TILL

The Hayesville Till was named for the village of Hayesville in southern Ashland County by White (1961, p. 73), who traced the till across parts of Stark, Wayne, Holmes, Medina, and Ashland Counties into Richland County. The Hayesville Till, second youngest in the county, crops out in a broad curving band across the center of Richland County (pl. 1, fig. 6). The outer margin of the Hayesville Till follows Rocky Fork valley from the junction of Rocky Fork and Black Fork northwestward to Mansfield, then bends around the Mansfield Highland and extends southward to Lexington. A broad tongue of Hayesville ice extended into Clear Fork valley a short distance beyond Lexington; west of this area the Hayesville Till merges with its Scioto-lobe equivalent, the Mt. Liberty Till. The till is generally less than 10 feet thick, but is over 15 feet thick near its margin. Thicker Hayesville Till in the Mansfield region is associated with patches of hummocky moraine near the till margin.

The Hayesville Till is predominantly silty, sparingly pebbly, and contains nearly equal amounts of sand and clay. Analyses average 25 percent sand, 48 percent silt, and 27 percent clay. The average carbonate content is 12 percent, the average quartz/feldspar ratio is 3, and the average clay mineral composition is 83 percent illite, 6 percent chlorite, and 11 percent kaolinite. Averages, however, are misleading for Hayesville Till because the texture and composition change gradually in the direction of ice movement. The clay content increases toward the south and west. Quartz/feldspar ratios increase from 2.0 at the Huron-Richland County line to nearly 5.0 at the till margin near Mansfield. Carbonate content appears to decrease toward the south, but the higher values in the northern part of the county may be the result of secondary deposition of carbonates.

Columnar sections of weathering horizons developed in Hayesville Till are shown in figures 22 and 23. Unaltered till (horizon 5) is dark gray and is found 7 to 10 feet beneath the surface. Oxidized till (horizon 4) is dark chocolate brown (10*YR* 4/3) in contrast to the yellow-brown Navarre Till, which is commonly exposed beneath the Hayesville. The top of horizon 4, the depth of leaching, ranges from 35 to 66 inches and is a useful field criterion for distinguishing Hayesville Till from the similar Hiram Till. Hayesville Till is generally massive and compact where unweathered, but horizontal partings develop where the till has been exposed to weathering. These partings are commonly ½ to 1 inch apart, resulting in the till breaking into ½- to 1-inch cubes and prisms. Clay coatings are present along the joints and partings in horizon 2, but rusty stains are absent. A silt cap 6 inches to 1 foot thick overlies the Hayesville Till; thicker accumulations may be seen in hollows and depressions. The Rittman-Wadsworth and Cardington-Bennington soils (table 4) develop from Hayesville Till; where the silt cap is thickest or where Navarre Till is close to the surface, a soil resembling Wooster in character may develop. The soils developed in Hayesville Till are moderately well drained and moderately productive.

Construction in the Mansfield area has provided ample exposures of relatively thick Hayesville Till. Numerous cuts along U.S. 30 expose up to 12 feet of Hayesville Till. Behind Kingwood Center along Touby Run in the west part of Mansfield (section 511), 11.5 feet of Hayesville Till interbedded with 6 feet of sand and flotil[1] overlies 2.5 feet of alluvium, which in turn overlies 3.0 feet of Navarre Till. At the north edge of Mansfield along Bowman Street Road (fig. 24) both gravel and earlier tills underlie thin Hayesville Till. Very little sand and gravel is associated with the Hayesville Till, though abundant meltwater must have resulted from melting ice. Evidently insufficient pebbles were available for gravel formation, and most of the fines were washed down the valleys beyond the con-

[1]Flotil is till-like material that slumped or flowed as a mudflow away from the melting ice front.

fines of the county.

The Hayesville Till is correlative with the Lavery Till of the Grand River lobe (White, 1967, p. 27) and closely resembles it in texture and composition. According to Mörner (1970), the age for the Hayesville ice advance, at its maximum extent, is 14,800 years B.P.

DEFIANCE RECESSION

The Defiance Recession is the name used by Mörner (1970) for a brief ice retreat between the Hayesville ice advance of about 14,800 years B.P. and the Hiram ice advance of about 14,400 years B.P. The interval of time was not sufficient for soil-forming processes to become well established, but recession of ice from Richland County did allow windblown silt and sand to accumulate on the Hayesville Till surface (fig. 26). The large number of locations where thin sand is preserved between Hayesville and Hiram Tills seems remarkable and is evidence for widespread cover-sand formation of an arctic nature during this short cold recession.

HIRAM TILL

The Hiram Till, the youngest till of the Killbuck lobe of Richland County, was named for the village of Hiram in northeastern Portage County by White (1960), who traced it from its type locality in the Grand River lobe into the Killbuck lobe in northwestern Wayne and northern Ashland Counties (White, 1967, p. 27). The Hiram Till boundary follows closely the Black Hand escarpment, which proved to be too large a barrier for Hiram ice to override. A tongue of Hiram ice extended about 6 miles south of the main ice sheet in Black Fork valley, where irregular knolls of till resembling kames were deposited. These are well displayed on either side of Interstate 71 from the U.S. 30 interchange northeast to the Ashland County line. The bedrock outlier northwest of Pavonia may have existed as a nunatak surrounded by Hiram ice. West of Black

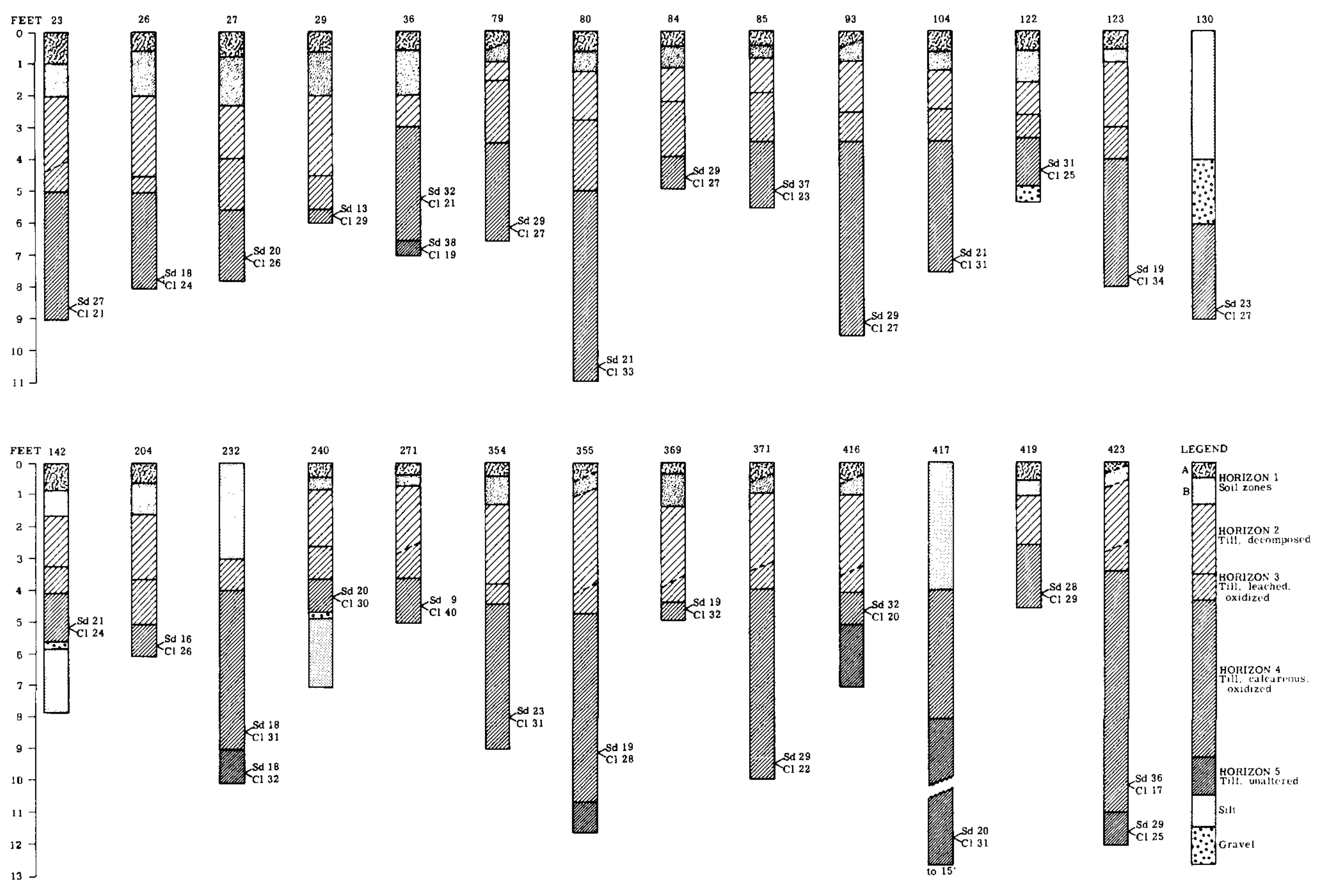


FIGURE 22.—Columnar sections showing weathering horizons of Hayesville Till. Percentages of sand (Sd) and clay (Cl) shown at points at which samples were collected.

Fork the till margin bends around the Mansfield Highland and extends in a southwesterly direction across parts of Franklin, Madison, Springfield, and Sandusky Townships; it can be traced into Morrow County where it joins with its Scioto-lobe equivalent, the Centerburg Till.

The Hiram Till is typically thin and discontinuous over northern Richland County, attaining a thickness in excess of 5 or 6 feet in only a few places; commonly soil-forming processes have continued downward into the Hayesville Till. The Hiram Till is silty, clayey, and sparingly pebbly, and has a relatively high carbonate content averaging 17 percent. Analyses average 23 percent sand, 47 percent silt, and 30 percent clay. The average quartz/feldspar ratio is 1.7, and the average clay mineral composition is 86 percent illite, 7 percent chlorite, and 7 percent kaolinite.

Columnar sections of weathering horizons developed in Hiram Till are shown in figures 25 and 26. The color of Hiram Till is almost the same as that of the Hayesville Till: dark gray in horizon 5, and dark brown in horizon 4. The Hiram Till is generally oxidized to a depth of 5 to 7 feet and leached to depths of 20 to 35 inches. The depth of leaching is a useful field criterion for distinguishing Hiram Till from Hayesville Till unless both tills occur in the section. Weathered Hiram Till is characterized by uneven horizontal partings generally ¼ to ½ inch apart, resulting in the till breaking into small cubes and prisms. In exposures where thin Hiram Till overlies Hayesville Till, the

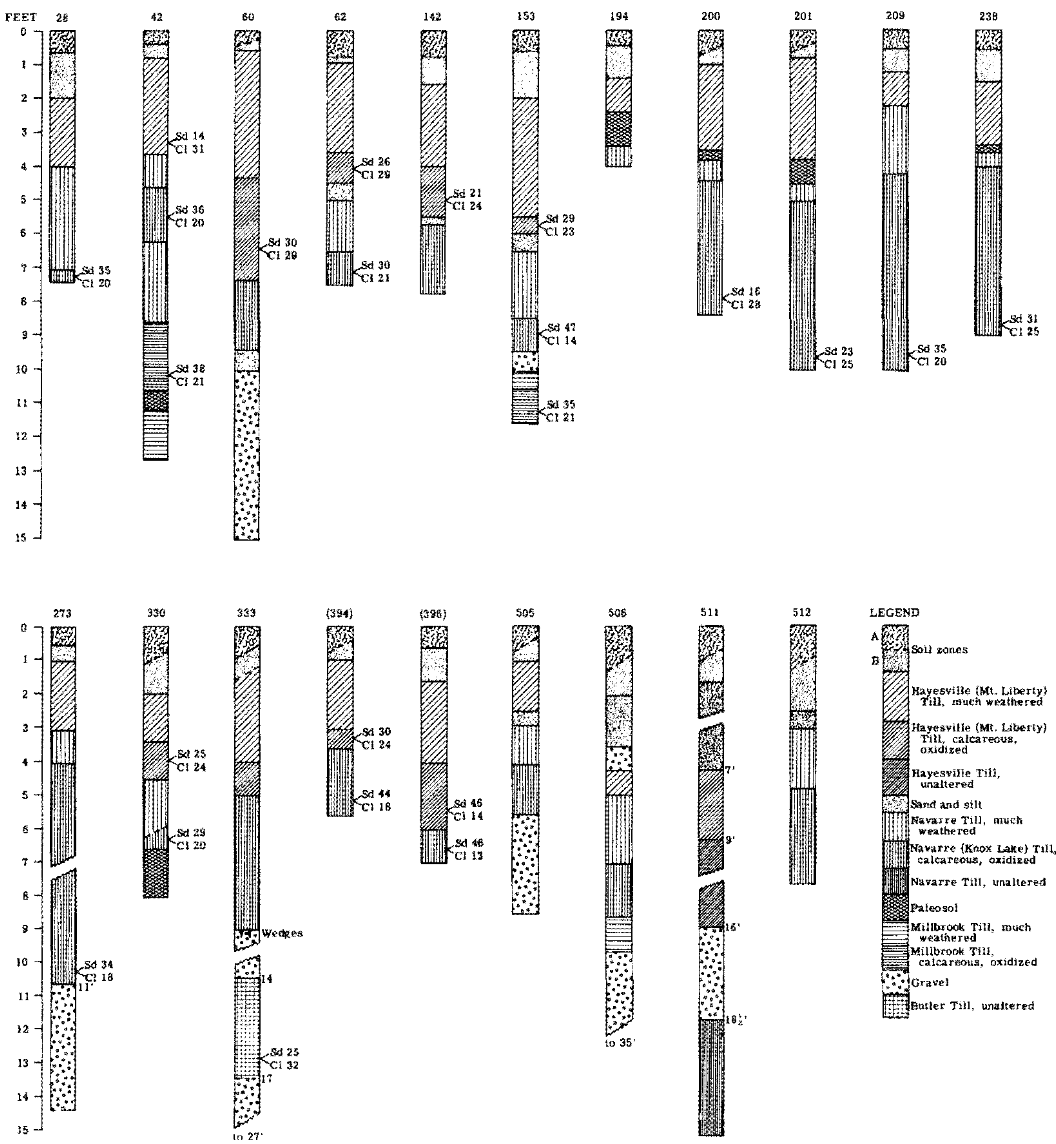
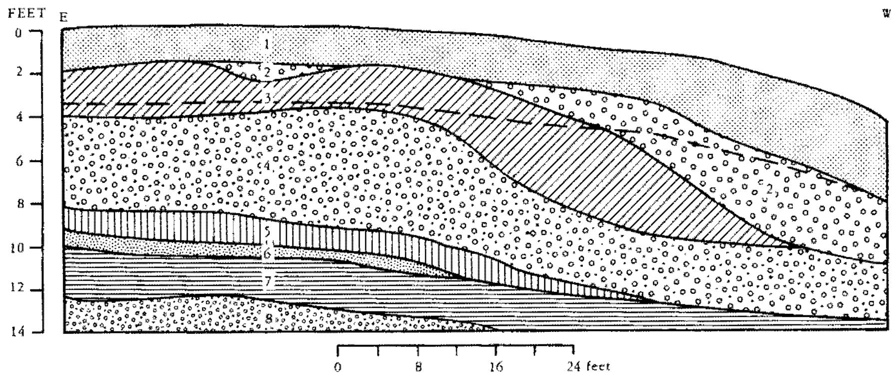


FIGURE 23.—Columnar sections showing thin Hayesville (Mt. Liberty) Till overlying earlier drift. Percentages of sand (Sd) and clay (Cl) shown at points at which samples were collected.



1. Weathered silt
2. Gravel, calcareous where thick
3. Till, dark-brown, leached to a depth of 42 inches (sample no. 229, 22 percent sand, 31 percent clay). HAYESVILLE
4. Gravel and sand, reddish-brown, calcareous
5. Till, yellow-brown (sample no. 230, 37 percent sand, 16 percent clay). NAVARRE
6. Sand, yellow-brown, pebbly
7. Till, olive-brown, pebbly, calcareous; rusty along joints (sample no. 231, 40 percent sand, 18 percent clay) MILLBROOK
8. Gravel, gray-brown, sandy, calcareous. MILLBROOK

FIGURE 24.–Sketch of glacial deposits exposed along a roadcut on Bowman Street Road, NW¼SW¼ sec. 9, T. 21 N., R. 18 W., Madison Township, Richland County, at the north edge of Mansfield.

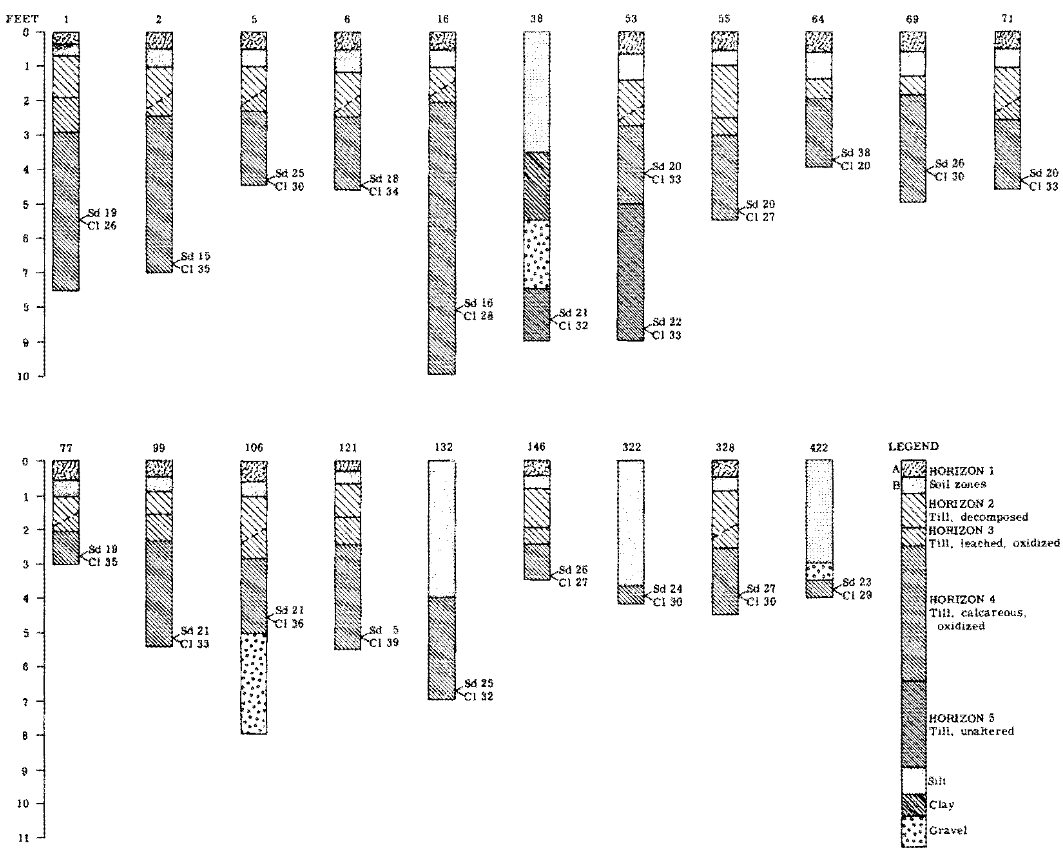


FIGURE 25.–Columnar sections showing weathering horizons of Hiram Till. Percentages of sand (Sd) and clay (Cl) shown at points at which samples were collected.

Hiram Till breaks into smaller prisms than does the Hayesville Till. The soil profile developed on Hiram Till is shallower than a Hayesville profile, and the clay coatings from a Hiram profile are thin, discontinuous, and occur within a narrow range vertically.

Soils (table 4) derived from Hiram till are generally poorly drained owing both to a clayey subsoil and to the presence of numerous undrained shallow depressions, detectable on aerial photographs. Cardington and Bennington soils are mapped in areas covered by Hiram ice, but these soils are commonly partially or wholly derived from Hayesville Till. A thin silt cap several inches thick occurs on top of Hiram Till, but the silt is generally so thin it is incorporated in the soil and is difficult to differentiate.

Sand and gravel deposits relatable to the Hiram ice advance are thin, sparse, and not economically important. Some fine-grained deposits in the lowest terrace of the major outwash valleys may be of Hiram age.

LATE GLACIAL AND POSTGLACIAL DEPOSITS

After the melting of the last ice sheet (Hiram) to invade Richland County at about 14,300 years B.P., a rather complex series of events including soil formation, lake filling or draining, reforestation, and animal repopulation began, leading up to the present. The Erie glacial lobe did not disappear immediately, but continued to fluctuate in the northern Lake Erie region until about 10,000 years B.P. (Mörner, 1970), a date which may be considered to mark the change from late glacial to postglacial in the Erie Basin.

Predominant among post-Hiram deposits are lacustrine sediments and stream alluvium. The cumulative effect of the Woodfordian ice advances was largely

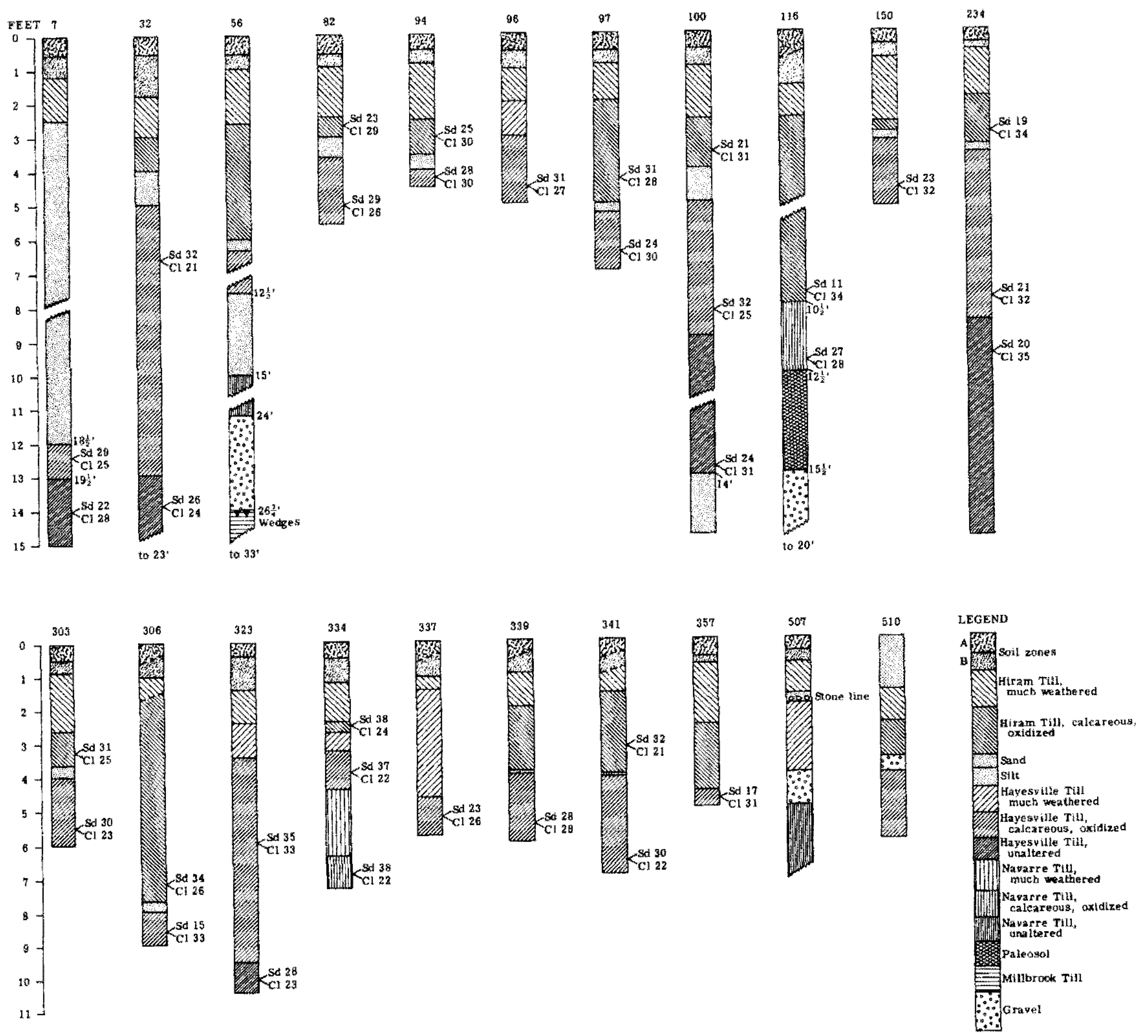


FIGURE 26.—Columnar sections showing thin Hiram Till overlying earlier drift. Percentages of sand (Sd) and clay (Cl) shown at points at which samples were collected.

disruption of the preexisting drainage in northern Richland County by filling or partial filling of the drainage lines. Numerous bogs, swamps, and kettles resulted from uneven and irregular deposition, in many cases in conjunction with buried or partially buried ice blocks. Ice-dammed lakes such as Lake Shelby (pl. 1) were drained as soon as the ice dam melted, but the smaller kettle lakes persisted much longer and some still exist. These lakes received fine silt or clay sediments more or less continuously until filled. Vegetation growing around or in lakes and swamps accumulated as peat in many of the lakes. The Pewamo soil is mapped in areas of silty clayey lake deposits. Pewamo soils are moderately productive, but drainage is a problem and tiling is a necessity. Many small kettle holes remain as swamps unsuitable for general farming, and such areas are usually relegated to pasture and woodland. The major valleys of southward-flowing Clear, Rocky, and Black Forks were only partially filled by Woodfordian deposits. After deglaciation, these streams, with some modification, were reestablished in their former valleys. With a decreased load and volume after meltwater runoff subsided, these postglacial streams now seem misfit and undersized for the large valleys they occupy: floodplains of present streams ordinarily occupy only a portion of the valley. These floodplains, which are a few feet below the lowest terrace levels, are underlain by highly variable silts, clays, sands, and gravel known as alluvium (pl. 1). These stream deposits, from a few inches to several feet thick, are in practically all valleys in the county which contain moving water at least a portion of the year. Shoals soils are mapped in these predominantly sandy gravelly valley bottoms and Wheeling-Chili soils are mapped in earlier, higher, floodplain levels (terraces of geologists, second bottoms of agronomists), which are present in

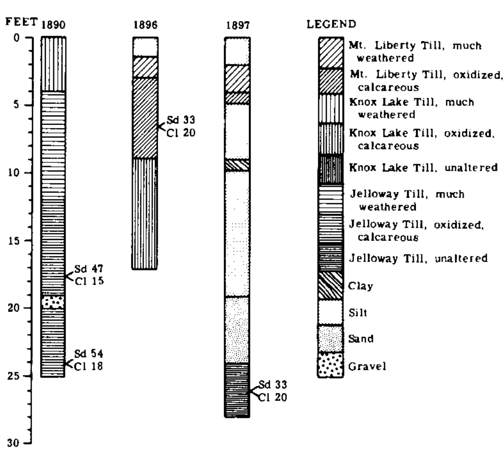


FIGURE 27.—Columnar sections showing glacial deposits of the Scioto lobe exposed in Interstate 71 excavations. Percentages of sand (Sd) and clay (Cl) shown at points at which samples were collected.

many places between the modern floodplains and the valley wall.

WISCONSINAN DEPOSITS OF THE SCIOTO LOBE

GENERAL STATEMENT

Wisconsinan-age glacial deposits covering the southern and southwestern areas of Richland County, including portions of Worthington, Jefferson, Perry, and Troy Townships, belong to the Scioto lobe (pl. 1; fig. 6). The tills of this lobe, in ascending order, are the Jelloway, Knox Lake, Mt. Liberty, and Centerburg. All except the Jelloway were named and described by Forsyth (1961), who applied the names specifically to soils, but also used the names to identify the till and the area in which the soil was developed; therefore these names are considered rock-stratigraphic names in this report.

Several exposures (figs. 14, 27, 28) of Scioto-lobe deposits show a multiple till sequence, and in a few instances paleosols occur between tills. Judging by these data, the Scioto-lobe deposits record numerous glacial advances and retreats similar to the fluctuations of the Killbuck lobe.

JELLOWAY TILL

The Jelloway Till is named in this report for exposures of till near the village of Jelloway, in northern Brown Township, northeastern Knox County, 2½ miles southeast of Richland County. The Jelloway Till is exposed along several roadcuts and ditches in the valley of Jelloway Creek and its tributaries. An exposure of calcareous till (section 527, fig. 15) in a till knoll on the west side of the valley floor of Jelloway Creek is selected as the type section. This section is located 1½ miles north of Jelloway in a cut along Ashland County Road 959 in the NW¼NE¼ sec. 32, Hanover Township, in the southwestern corner of Ashland County:

	Ft	*In*
Silt loam, dark-brown	1	6
Silt loam, yellow-brown	1	6
Silt, medium-brown		6
Till, light-reddish-orange, silty, much-weathered; irregular blocky structure; few pebbles; manganese stains along joints and between partings	1	4
Till, dark-yellowish-brown (10*YR* 4/4), silty, pebbly, much-weathered; few pebbles of sandstone and quartzite; abundant clay flows and manganese stains; thin sand streak near base	3	2

Till, dark-yellowish-brown (10*YR* 4/4), silty, pebbly; soft and crumbly when wet; calcareous horizontal partings common; thin sand streaks (sample no. 527: 15 percent sand, 53 percent silt, 32 percent clay)	1	0

The till near Jelloway has a higher clay content than elsewhere, yet does not appear clayey or sticky owing to its high silt content. At this section, as well as others, thin wet sand streaks were present. The depth of leaching measured along 100 feet of section ranged from 7 to 8 feet. A silt cap 1½ to 3 feet thick is characteristic of the Jelloway Till.

In southeastern Richland County, the Jelloway Till boundary extends in an east-west direction across Worthington Township just north of the Knox-Richland County line. At this position along the eastern side of the Scioto lobe, Jelloway ice actually flowed northward into Richland County and just failed, by a matter of about 3 miles, to meet Millbrook ice advancing southward. The Jelloway margin extends farther north in Jefferson Township and joins the Millbrook margin of the Killbuck lobe along the upland south of Bellville.

Southwest of Bellville, the Jelloway Till still retains the diagnostic color, texture, and structure of its Killbuck-lobe equivalent, the Millbrook Till, but near the Richland-Knox County line the till grades into a silty yellowish-brown till that has only a hint of olive-brown coloration remaining. Significantly, the till character is quite uniform throughout the Jelloway area, and the leaching depths of 7 to 8 feet likewise are consistent. Till thickness is highly variable, depending upon topographic position, and ranges from scattered boulders on steep hillsides to possibly several tens of feet in the valleys.

Analyses of Jelloway Till samples from Richland County average 42 percent sand, 39 percent silt, and 19 percent clay. The average carbonate content is 14 percent, and the average quartz/feldspar ratio is 3.1. These averages, except for the carbonate figure, which is higher, are nearly identical to the averages for the Millbrook Till of the Killbuck lobe.

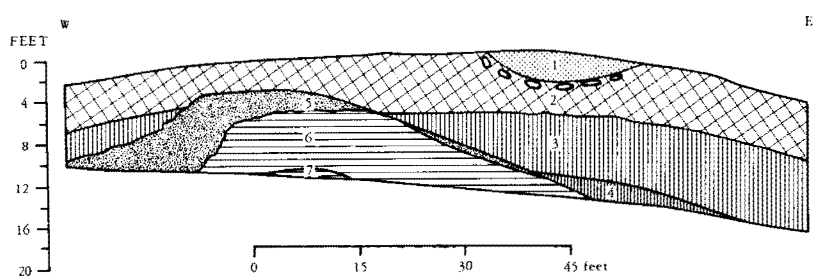
The Jelloway Till can be traced beneath younger Wisconsinan deposits in the southwest corner of the county. At an exposure along Painter Road (section 259) in Lost Run Valley, NW¼ sec. 35, southern Perry Township, the Jelloway Till is sandwiched between paleosols and tills. Weathered Knox Lake Till overlies the Jelloway Till, separated from it by 6 inches of clayey reddish-brown gravel. Weathering on the Jelloway Till is more intense than on the Knox Lake and is assigned to the Farmdalian Substage.

Beneath calcareous Jelloway Till at this locality at a depth of 9 feet is 1 to 2 feet of clayey gravelly loam, probably a paleosol, which has been smeared beneath Jelloway ice. The smear zone rests on brown till which is regarded as Butler Till. Several other nearby sections show similar stratigraphic sequences.

The texture, composition, and stratigraphic position of the Jelloway Till of southern Richland County and the Millbrook Till of the Killbuck lobe are similar, and the tills are considered to be correlatives.

The Jelloway Till, more deeply weathered than the Late Wisconsinan tills which overlie it, is assigned an Early Wisconsinan (Altonian) age. The arguments for this age assignment are the same as those given for the Millbrook Till.

The Jelloway Till area of the Scioto lobe was originally mapped as Illinoian by Leverett (1902). Later studies by White (1937) accepted and used the designation of Illinoian for this till and included in the Illinoian the deeply leached till of east-central Knox County that Leverett (1902, pl. 13) had mapped as



1. Silt, stones at base
2. Till, yellow-brown, pebbly, weathered
3. Till, dark-yellow-brown, calcareous; prominent limestone pebbles (sample no. 1892, 46 percent sand, 15 percent clay). KNOX LAKE
4. Till, olive-gray (sample no. 1893, 43 percent sand, 18 percent clay). KNOX LAKE
5. Ice-shove material and colluvium
6. Till, olive-brown, weathered. JELLOWAY
7. Till, olive-brown, calcareous (sample no. 1894, 46 percent sand, 14 percent clay). JELLOWAY

FIGURE 28.—Sketch of glacial deposits exposed along Interstate 71, NE¼ SE¼ sec. 14, T. 19 N., R. 19 W., Perry Township, Richland County.

Wisconsin (presumably his "early Wisconsin") and which he had reaffirmed as Wisconsin in 1939 (p. 835). In more recent studies, Forsyth (1961) followed White's (1937) usage of Illinoian for a wide expanse of till in eastern Knox County, which includes the area of Jelloway. Much of northeastern Knox County lies within the area of the Jelloway Till, which is considered by the writer to be early Wisconsinan, and not Illinoian, in age. In Knox County east of Jelloway the relationships may be similar to those in northwestern Pennsylvania (White and others, 1969), and the outer fringe of thin drift may be of older Illinoian age. Further study is needed to establish the glacial sequence along the Scioto-lobe margin in this region.

KNOX LAKE TILL

The Knox Lake Till was named by Forsyth (1961, p. 126) for exposures near Knox Lake in northern Knox County. The Knox Lake Till is at the surface in southwestern Richland County in parts of Jefferson, Perry, Washington, and Troy Townships and joins its Killbuck-lobe equivalent along the divide between Cedar Fork and Clear Fork south of Lexington. Forsyth (1961, pl. 5) traced the Knox Lake margin northward into Richland County to the valley of East Branch, a tributary of the North Branch of the Kokosing River. The margin bends westward a short distance north of the Knox-Richland County line and follows the divide to Bangorville. From Bangorville the margin extends northward to a junction with the Killbuck-lobe deposits near Bellville. Hummocky topography is present near the till margin, giving the impression of a broad weakly developed end morainal system. Forsyth (1961, pl. 5) mapped a similar expanse of hummocky topography near the Knox Lake margin in Knox County.

The Knox Lake Till is silty and sandy, moderately pebbly, and contains some cobbles and boulders. Analyses of Knox Lake Till samples average 40 percent sand, 41 percent silt, 19 percent clay, and 9 percent carbonate. The clay mineral composition is 79 percent illite, 5 percent chlorite, and 16 percent kaolinite, and the quartz/feldspar ratio is 2.8. The Knox Lake Till contains slightly more sand and less silt, has a lower carbonate content, and has a slightly lower quartz/feldspar ratio than its Killbuck-lobe equivalent, the Navarre Till.

Columnar sections of weathering horizons developed in Knox Lake Till are shown in figure 29. Unaltered Knox Lake Till (horizon 5) is dark gray; where oxidized (horizon 4) it is yellow brown (10*YR* 4/4). The depth of oxidation is about 12 feet, whereas the depth of leaching is 4 to 5½ feet. The soil profile is characterized by moderately thick clay coatings and extensive manganese stains. A layer of silt 1 to 2 feet thick is found capping the till in many places. Wooster soils are derived from Knox Lake Till (Forsyth, 1961, p. 124) and are well drained, strongly acid, and moderately high in productivity.

The Knox Lake Till margin has been traced to the margin of the Killbuck lobe where it joins with and becomes the Navarre Till margin; these tills are considered to be correlatives. In terms of color, texture, composition, and soil profile development, the Knox Lake and Navarre Tills are markedly similar. Forsyth (1961, p. 137) assigned an Early Wisconsinan age to Knox Lake Till. In present terminology this till is correlated with the Navarre Till and is thus early Woodfordian in age. Its moderate depth of weathering, wide distribution even on hillslopes, and lack of paleosol development beneath younger tills all confirm this age assignment.

MT. LIBERTY TILL

The Mt. Liberty Till, the second youngest Scioto-lobe till present in Richland County, was named by Forsyth (1961, p. 125) for the village of Mt. Liberty in southwestern Knox County. This till is present at the surface in southwestern Richland County in western Perry and southwestern Troy Townships. The Mt. Liberty Till margin enters Richland County from Morrow County near the common corner of Richland, Morrow, and Knox Counties and extends northward to near Lexington, where the Mt. Liberty Till joins with its Killbuck-lobe equivalent, the Hayesville Till (pl. 1; fig. 6). A broad area of hummocky topography near the till margin is attributable in part to the Mt. Liberty Till and is probably in part pre-Mt. Liberty in age.

The Mt. Liberty Till is silty, sandy, and moderately pebbly. Analyses of Mt. Liberty Till samples average 37 percent sand, 42 percent silt, and 21 percent clay, a more sandy composition than that of the Hayesville Till. The average carbonate content is 12 percent, and the average quartz/feldspar ratio is 2.7. The clay mineral composition is 80 percent illite, 5 percent chlorite, and 15 percent kaolinite.

Columnar sections of weathering horizons developed in Mt. Liberty Till are shown in figure 30. The till is dark brown to yellow brown (10*YR* 4/3, 4/4, 5/4) where oxidized (horizon 4) and dark gray where unoxidized (horizon 5). Oxidation has reached a depth of about 9 feet and leaching a depth of 38 to 60 inches. Irregular horizontal partings are common in the oxidized till. The soil profile contains some manganese stains and thin clay coatings, but they are not as extensive as in the older Knox Lake Till. A layer of silt about 1 foot thick is generally present, capping the till. Alexandria soils are mapped on the moderately steep slopes of the Mt. Liberty Till area in Richland County (fig. 7). In Knox County, according to Forsyth (1961, p. 125), Alexandria soils are derived from Mt. Liberty Till, although Wooster soils have been mapped in some areas of Mt. Liberty Till. Wooster soils, however, probably are derived from Knox Lake Till, occurring as surface material where Mt. Liberty Till is absent.

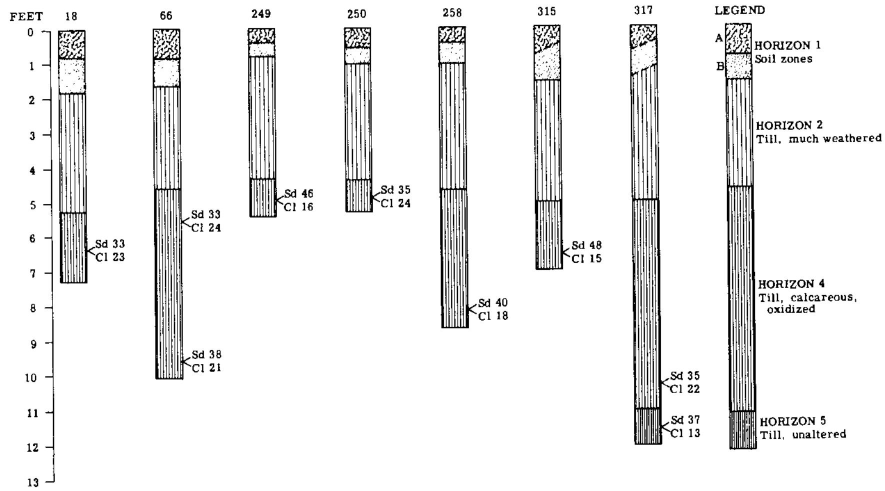


FIGURE 29.—Columnar sections showing weathering horizons of Knox Lake Till. Percentages of sand (Sd) and clay (Cl) shown at points at which samples were collected.

Forsyth (1961, p. 136) assigned an "older Wisconsin" age to the Mt. Liberty Till in Knox County. This age was relative to the younger Centerburg Till; both tills are included in the Late Wisconsinan of this report. The age assignment of the Mt. Liberty Till in the Scioto lobe is in close agreement with the age assignment of its Killbuck-lobe correlative, the Hayesville Till.

CENTERBURG TILL

The Centerburg Till, named for the village of Centerburg in southwestern Knox County by Forsyth (1961, p. 123), is the youngest Scioto-lobe till present in Richland County. The Centerburg Till occurs in southwestern Richland County only in an area of less than 3 square miles near Kings Corners (pl. 1). The margin can be traced northwestward into Morrow County, where the Centerburg Till joins its Killbuck-lobe equivalent, the Hiram Till. The Centerburg margin can also be traced southward into Morrow County, where it connects with the Centerburg margin extended northward from Knox County by Forsyth (personal communication).

The Centerburg Till is silty, sandy, and slightly pebbly, but appears clayey because the weathered till is very sticky when moist. Analyses of Centerburg Till samples average 34 percent sand, 43 percent silt, and 23 percent clay. The average carbonate content is 18 percent, and the average quartz/feldspar ratio is 2.7. The clay mineral composition is 89 percent illite, 3 percent chlorite, and 8 percent kaolinite. The Centerburg Till has a higher sand/clay ratio and a higher quartz/feldspar ratio than its Killbuck-lobe equivalent, the Hiram Till. The carbonate content and clay mineral composition of the two tills are about the same.

Columnar sections of weathering horizons developed

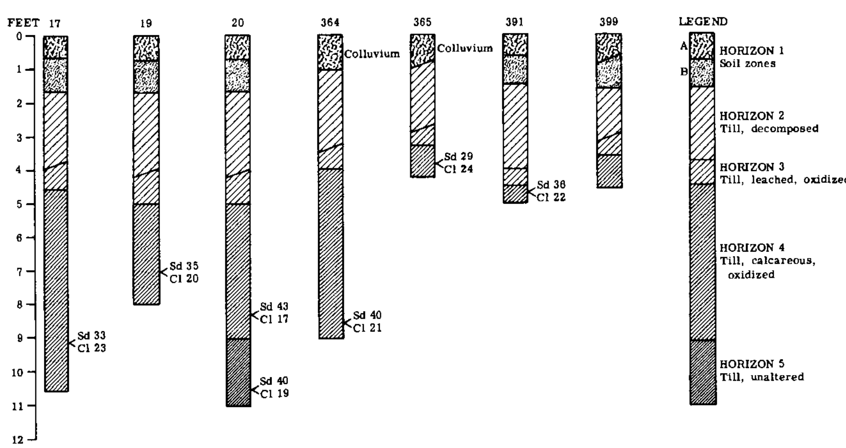


FIGURE 30.—Columnar sections showing weathering horizons of Mt. Liberty Till. Percentages of sand (Sd) and clay (Cl) shown at points at which samples were collected.

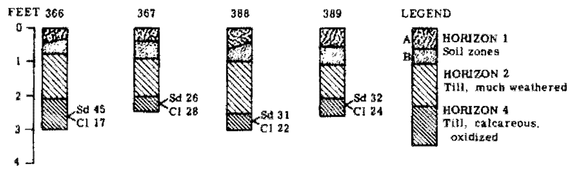


FIGURE 31.—Columnar sections showing weathering horizons of Centerburg Till. Percentages of sand (Sd) and clay (Cl) shown at points at which samples were collected.

in Centerburg Till are shown in figure 31. The till is dark brown (10*YR* 4/3) where oxidized (horizon 4) and tends to break into small prisms and cubes. Unaltered Centerburg Till (horizon 5) was not found in the shallow excavations where the till was exposed. The depth of leaching ranges from 24 to 32 inches, and the soil is correspondingly thin and not strongly developed. A thin silt cap is present on the surface of the till in places. The thickness of the Centerburg Till in Richland County has not been determined, but farther west in Morrow County in the many miles of exposures made during the construction of Interstate 71, G. W. White (personal communication) observed thicknesses of this till ranging from less than 2 feet to 4 or 5 feet. Generally the younger till was separated from the underlying till by an inch or two of silt or fine sand.

GLACIOFLUVIAL DEPOSITS

GENERAL STATEMENT

Glaciofluvial deposits consist of sorted and stratified sand and gravel that have been separated from the silt and clay till matrix and deposited by glacial meltwater streams. There is a large volume of these deposits in Richland County, nearly all of it in large valleys.

Many gravel pits, large and small, old and new, provide an excellent opportunity to study the stratigraphy of the sand and gravel deposits. In most instances the gravel is veneered by later deposits of silt or till, a situation which creates quarrying problems for gravel pit operators, but which often facilitates stratigraphic dating by the geologist. Dating or age assignment of valley deposits has commonly been made on the appearance or position of the geomorphic feature containing the gravel, and little attention has been given to stratigraphic principles. Many of the criteria used to date tills apply also to gravel. In general, recent stratigraphic studies of gravel in Richland County and in the Allegheny Plateau of Ohio and northwestern Pennsylvania have indicated that these gravels are older than previously thought.

Gravel deposits make up several distinct kinds of landforms, such as kames, kame terraces, eskers, crevasse fillings, and valley trains, the morphology of which will be described in a later section. Representative columnar sections of some of these deposits are shown in figure 32, and many sketches illustrate the relationship of gravel deposits to associated material.

KAMES

Kames are conical hills of gravel that were laid down in contact with an ice margin and have undergone modification by slumping subsequent to melting of the ice. Kame gravels typically are poorly sorted and may contain large boulders. The kames 1.5 miles west of Plymouth along the Richland-Huron County line consist of poorly bedded sand and fine gravel 10 or more feet thick associated with slumped masses of flotil of Hiram or Hayesville type. These kames represent one of the few deposits of Hiram or Hayesville age. Several small kames (shown on pl. 1 as a unit) are present in secs. 7 and 18, about 2½ miles south of Plymouth. The kames are mantled by Hiram and Hayesville Till, suggesting a Navarre age for the underlying gravel. Similar small isolated kames are found at several places in northern Richland County.

The kames along Black Fork 2 miles south of Shelby consist of 18 feet of sand and fine-grained gravel weathered reddish brown in the upper part and overlain by 1 to 3 feet of silt. In places Hiram or Hayesville Till overlies the gravel; in one small pit Hayesville Till may occur beneath sand. The bulk of the gravel in these kames appears to be of Navarre age.

A large kame of Navarre(?) age situated along State Route 603 is 2 miles east of Lucas and half a mile north of Pinhook. Thirty feet of poorly sorted gravel leached to a depth of 2½ to 3 feet is exposed in a large pit in the kame, and in a few places brown Hayesville-type till overlies the gravel.

Another large kame dissected by a gravel pit is situated in the SW¼ sec. 8, 2 miles west of Bellville. In this pit an exposure of 25 feet of grayish-brown gravel contains the typical collapse bedding structures of kames. Cemented gravel layers are present in the upper portion of the exposure. The uppermost 1 foot of gravel is weathered reddish brown and is overlain everywhere by 4 to 5 feet of olive Jelloway Till. Apparently this is an Illinoian-age Butler kame. About 10 feet of sandy gravel leached 4 to 5 feet is exposed in a pit in a kame located in the NE¼ sec. 7, Worthington Township, two miles northwest of Butler. This kame is within the area of thin Millbrook drift and is probably a Millbrook kame. Another Millbrook kame is located nearby in the NE¼ sec. 5, 2 miles west of Newville.

Numerous kames or kamelike features are found elsewhere in Richland County. The vast majority of these kames are arranged in stringlike fashion along

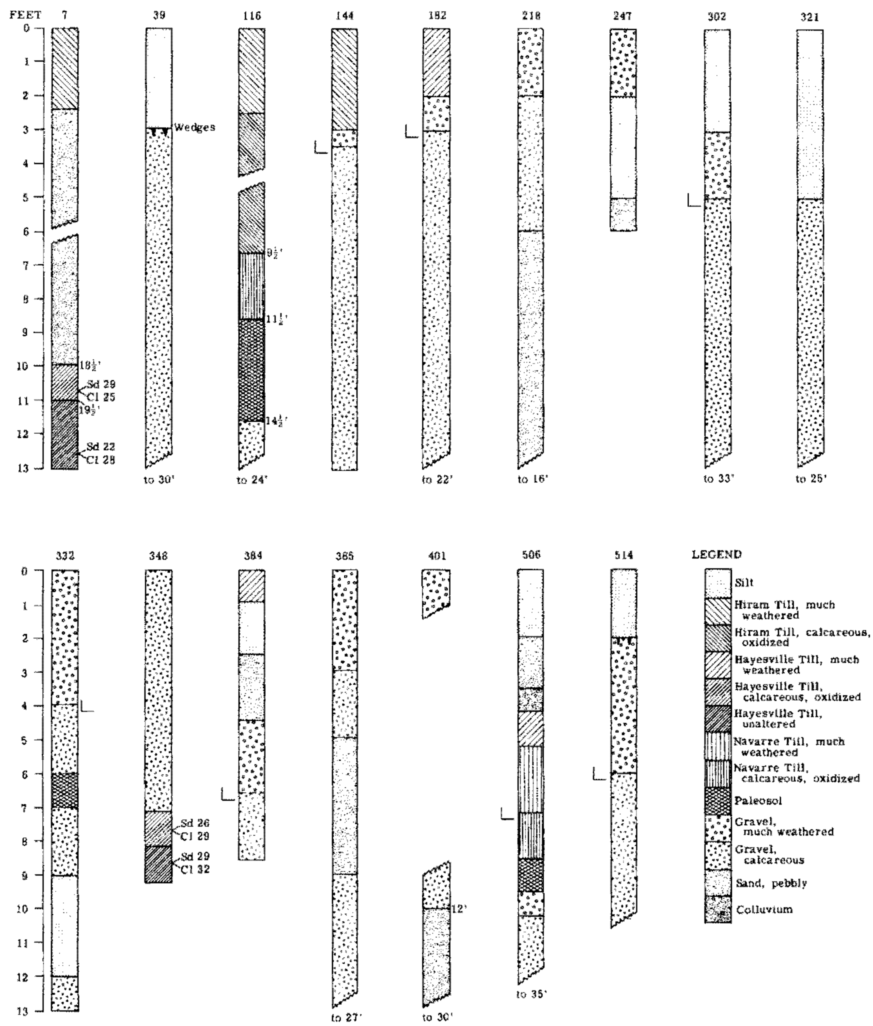


FIGURE 32.—Columnar sections showing sand and gravel deposits. Percentages of sand (Sd) and clay (Cl) shown at points at which samples were collected. L is depth of leaching.

major drainage lines or their tributaries and are considered to constitute kame terraces. These features are particularly characteristic of Black Fork valley, which is nearly filled with kamelike masses at several places. Numerous pits in these hummocks along Black Fork attest to the gravel composition of many of these features. However, exposures along Interstate 71 and U.S. 30 on the west side of Black Fork are in clay-rich brown till. These till knolls, which look like kames, nearly fill Black Fork in secs. 9 and 10, are as much as 50 feet high, and appear to be of Hayesville age. Silt and gravel are found higher up the valley sides.

KAME TERRACES

Kame terrace deposits were laid down along the valley sides in contact with melting ice blocks which lingered in the central portion of the valley. These terraces are composed of sand and gravel and in character are intermediate between valley trains and kames. Kame terrace deposits are found along the sides of the major valleys and several of their tributaries.

Black Fork valley

The glaciofluvial deposits of Black Fork valley are very complex both geomorphically and stratigraphically. Gravel deposits are common and widespread, but overburden of till and silt, among other problems, has discouraged extensive quarrying operations at most places. Gravel attributable to several Wisconsinan ice advances can be found in Black Fork valley. Complicating the picture are the changes in drainage of Black Fork and the overriding of earlier deposits by later ice sheets.

One of the best exposures of gravel in the northern part of the county is located 1.5 miles northwest of Ganges (fig. 19), where 25 feet of good quality Millbrook gravel is exposed beneath a blanket of silt and till. A similar exposure of good quality Millbrook gravel (fig. 32, section 506) is in the gravel pits operated by Purdy's Mohican Sand and Gravel, Inc., in the SE¼ sec. 11, Weller Township, where 25 feet of sandy gravel is overlain by paleosol and calcareous Navarre Till. Thin pockets of Millbrook Till directly overlie the gravel and are incorporated in the paleosol. This same gravel is also exposed in two gravel pits along Adams Road.

The largest single deposit of Millbrook gravel exposed along Black Fork is in a large kame terrace segment near the confluence of Black Fork and Rocky Fork. In several pits of Purdy's Mohican Sand and Gravel, Inc., SW¼ sec. 12, as much as 45 feet of Millbrook gravel is exposed. The uppermost 10 feet is very coarse, but the gravel becomes finer below. Collapse structures and cross bedding are common features, cemented zones up to 6 feet thick are found in places, and abundant wedges are present in the top 3 feet of gravel. The gravel is capped with silt and is leached about 6 feet.

Kame terrace gravel of probable Navarre age is exposed in most of the smaller borrow pits in many parts of Black Fork valley. This sandy gravel is covered with silt and brown Hayesville or Hiram Till at most places. The depth of leaching is relatively shallow, generally between 3 and 4 feet, and the exposed thickness exceeds 15 or 20 feet in only a few places.

Very little gravel, and none of commercial quality, can be attributed to a Hayesville or Hiram kame terrace.

Rocky Fork valley

Kame terrace deposits are not well exposed in Rocky Fork valley owing to the paucity of pits. A small pit in the center of sec. 35, Madison Township, southeast of Mansfield, revealed 10 feet of poorly sorted sand and gravel overlain by Navarre Till. Thick Millbrook(?) gravel is exposed nearby in the southwest corner of sec. 36 at the high elevation of 1,300 feet. Other pits in the Mansfield area along Rocky Fork are in secs. 9 and 24, Madison Township. Patchy kame terrace gravels are found near Lucas. These gravels appear to be thin and of relatively poor quality. Exposures in sec. 9, Monroe Township, near Lucas, reveal 10 feet of poorly sorted sand and gravel overlain by thin Navarre Till.

Clear Fork valley

The kame terrace gravels in Clear Fork valley are among the thickest and best gravel deposits in the county. Extensive quarrying of these gravels north of Lexington and near Bellville has exposed a complex sequence of gravel deposits overlain by one or more tills and silt.

A thick tongue of gravel is found north of Lexington on the north side of Clear Fork. Several large pits have been opened in these deposits and two of them are currently active. At the Mohican Materials pit, near the Mansfield Waterworks, NW¼ sec. 12, nearly 40 feet of calcareous sandy gravel overlies bedrock and Millbrook Till. The gravel has a thin truncated paleosol with wedges (frost wedges?) developed in the upper 3 to 6 feet and is overlain by calcareous Navarre and Hayesville Tills. The same section is repeated at the nearby Garber Materials pit in the SE¼ sec. 11. These gravels with the paleosol and wedges developed in the upper part are of Millbrook age and represent a major episode of melting and outwash deposition accompanying deglaciation of the Millbrook ice sheet. Down the valley at Bellville, in the D. H. Bowman and Sons pits, about 40 feet of Millbrook gravel is exposed in the high terrace on the north side of the valley. Wedges of clayey gravel are abundant in the top of the gravel, and 5 to 15 feet of silt overlies the gravel. The kame terrace is about half a mile wide in sec. 11. Several small shallow pits reveal gravel, in places cemented, overlain by silt. A few small kames continue up the tributary valley to Rhinehart Road. Of possible significance is the presence of this Millbrook kame terrace primarily on the northeast side of Clear Fork between Lexington and Butler. Gravel occurs on the southwest side of the valley, but rarely in commercial quantities, and it may be older.

Deeply weathered gravel capped by silt is found on the southwest side of the valley southeast from Bellville. In the SW¼ sec. 10, in a kame terrace remnant along the side of Schweitzer Hill, 20 feet of sandy gravel capped by 2 to 5 feet of silt is exposed in an old pit. Near the entrance to Templed Hills Camp, NE¼ sec. 15, sandy gravel is weathered to a minimum depth of 10 feet. Both deposits apparently are of Butler age and probably are related to older deposits at other localities, such as the Derwacter gravel pit (figs. 8, 11, 13) near Bellville. The Derwacter pit contains the thickest and most complete sequence of pre-Wisconsinan deposits in the county. The pit is actually several excavations along the valley wall on either side of Spayde Road. Millbrook gravel is thin or missing, and thin Butler Till is present near the top of the section. The uppermost gravel is coarse and contains numerous cobbles and boulders. In many places Illinoian-age till up to 12 feet thick separates the coarse gravel from the 25- to 35-foot thick fine sandy gravel below. At one place (fig. 8) there is a pre-Illinoian(?) gravel deposit which has a minimum thickness of 30 feet. The lowest old gravel deposit may actually be a valley train deposit; it is found mainly below the modern water table level.

One mile to the north, weathered coarse gravel and sand are exposed in an old pit in a kame terrace in a similar position along Kochheiser Road near its junction with Andrews Road. The small valley northwest of Bellville and west of State Route 13 apparently is filled with similar gravels. A small pit in the NE¼ SW¼ sec. 4 shows 15 feet of fine gravel overlain by 5 feet of coarse gravel and capped by olive Millbrook Till. From these exposures, it may be concluded that there is considerable gravel of Butler and Illinoian age near Bellville, though much of it may be covered by later deposits. The material of the kame terraces northeast of Butler is not as well known, but it appears to be of Millbrook age also. South of Clear Fork in secs. 10, 15, and 16, Worthington Township, three small pits reveal up to 20 feet of well-sorted medium gravel which is overlain in places by 7 feet of silt leached 4 to 5 feet. Till was absent in all these exposures.

The extensive kame terrace bordering Pleasant Hill Reservoir east of Newville has one exposure, a small borrow pit on the reservoir's south side in the NE¼ sec. 2. The gravel is poorly sorted and leached about 2 feet, indicating a Late Wisconsinan Navarre age for the deposit.

Small kame terrace deposits occur in several tributaries of Clear Fork. At the head of Possum Run in secs. 10 and 15 near Interstate 71 small quantities of gravel have been quarried in several small pits. Along the lower course of Switzer Creek valley, the kame terrace is narrow and only one small borrow pit was seen, in the NE¼ sec. 29. Gravel is exposed in at least three places in the kame terrace along Cedar Fork, 3 to 4 miles west of Bellville. Along Interstate 71 in the south-central part of sec. 12, kame gravel 20 feet thick is associated with flotil. The same thickness of gravel is exposed in the NW¼ sec. 11. A stream cut in the NE¼ sec. 10 exposed 10 to 15 feet of gravel capped by 2 to 4 feet of silt and overlain by gravelly gray till of probable Knox Lake age. It would appear that the tributary terraces to Clear Fork are all the same Navarre-Knox Lake age.

Other terraces

In the southeastern corner of the county in Worthington Township are two small kame terraces, one in sec. 13 along Pine Run at the south edge of the Davis Basin, the other in sec. 36 along a tributary of Jelloway Creek. The pits in these terraces are old and overgrown, and the nature of the gravel is only conjectural. Pits in a similar terrace half a mile east of the common corner of Richland, Ashland, and Knox Counties reveal 15 feet of calcareous poorly sorted sandy gray-brown gravel composed mostly of bedrock fragments and overlain by 3 feet of weathered rusty-brown sand capped by 1 to 2 feet of silt and colluviated gravel. This gravel resembles the Butler-type gravels near Bellville, but a Millbrook age cannot be ruled out.

ESKERS AND CREVASSE FILLINGS

A discontinuous esker which extends in Black Fork valley from Shiloh to south of Pavonia is composed of gravel which is nearly everywhere draped with brown till. At the northernmost exposure in Huron County, across the county line road from sec. 1, Cass Township, Richland County, 3 feet of weathered Hayesville Till overlies 10 feet of sand and fine-grained gravel. The total depth of leaching is 40 inches. Two exposures in the esker along Lamp Road, secs. 19 and 30, Blooming Grove Township, reveal a core of sand associated with stony olive-gray and brown Millbrook Till, which is overlain by Navarre and Hayesville Tills. Some Hiram Till may also be present in the section. An exposure along the Rome South road in the NE¼ sec. 32, Blooming Grove Township, reveals silt, sand, and gravel in excess of 20 feet thick and overlain by till. Two gravel pits are present in the esker on either side of State Route 13 in the SW¼ sec. 3, Franklin Township. On the northwest side of the highway, 20 feet of gravel is overlain by pockets of silt and by lenses of brown Hayesville(?) Till. The gravel is fine-grained and poorly sorted; cut-and-fill structure is well developed.

The southernmost exposure in Black Fork valley is southeast of Pavonia in a recently active gravel pit (fig. 18) where two ages of gravel are displayed. The lower gravel is probably Millbrook, with wedges and paleosol developed in the upper 2 feet. Above the paleosol is calcareous gravel, probably Navarre, leached to a depth of 5 feet and capped by 3 feet of silt. The stratigraphic relationship of the esker gravel to overlying deposits is indicative of a Millbrook age for the esker; such an age is in agreement with the age of the bulk of the kame terrace deposits along Black Fork.

A small esker or crevasse filling has been excavated for gravel in the SE¼NE¼ sec. 16, Worthington Township. The gravel is poorly sorted and is partially cemented.

VALLEY TRAINS

Because of the abundance and superior quality of kame terrace gravel in Richland County, very few borrow pits have been excavated in valley train deposits; consequently, exposures are few. An exposure in the lower Clear Fork valley train terrace near Gatton Rock between Bellville and Butler reveals 1.5 feet of sandy gravel overlain by 4.5 feet of sandy silt. No till was found overlying the terraces in Clear Fork valley, and stratigraphic data are insufficient for dating the terraces. They are no older than Millbrook and possibly no older than Navarre. The high-level kame terrace is Millbrook in age and it seems reasonable that the two lower valley train terraces are best dated as Navarre-Knox Lake and Hayesville-Mt. Liberty. The modern floodplain may represent a Hiram-Centerburg valley train level which was inherited by the present-day stream. According to one hypothesis, these valley train terraces are primarily cut terraces, incised into earlier gravels and covered with thin veneers of later outwash.

Valley train outwash deposits are found in the bottoms of many other valleys occupied by permanent streams such as Switzer Creek, Possum Run, Smoky Run, and Slater Run near Butler. These deposits are largely mantled by recent stream deposits or alluvium, which may be gravelly.

LAKE DEPOSITS

Lake deposits are common in many places in northern Richland County. These deposits have a wide range of character, and some of them contain abundant organic remains. They were deposited in numerous shallow depressions and in large ice-marginal lakes.

LAKE SHELBY

Lake Shelby refers to the lake bed in northwestern Richland County that was once the site of a proglacial lake (pl. 1); it was first named and described by Hubbard and Rockwood (1942, p. 242-243).

Lake Shelby was not a deep lake at any point of its history; the general absence of lacustrine deposits on the crests of the low end moraines within its confines suggest that these moraines were islands. Sediments within the remainder of the basin are considerably different from place to place, but consist chiefly of silts and clays. However, sand and even some pebbles may be included in places, and the sediments may be mistaken for till. The absence of beaches and other shoreline features indicates that the lake had a short life.

Few natural exposures exist on the lake plain, and augering was the only means of examining the deposits in most cases. Several sections of Lake Shelby deposits are shown in figure 33. Nearly everywhere, except at the lake margin, thicknesses of lacustrine silt and clay exceed 5 feet. Section 38 northeast of Crestline showed 6.5 feet of clay overlying 2 feet of gravel, which in turn overlies gray Hiram Till. It is probable that similar or greater thicknesses exist in other parts of the lake. The lake deposits become coarser northward to a point just south of the prominent moraine front, where gravel outwash lenses interfinger with silt. Several small deltas were built out into the lake south of the sharp morainic front which formed the north boundary of the lake.

LAKE WILLARD

Lake Willard is the name given by Hubbard and Rockwood (1942, p. 244) to a lake bed about 18 by 5 miles in extent and located in northwestern Richland, northeastern Crawford, and southern Huron Counties. This lake came into existence as Hiram ice disappeared from Richland County. The southern margin of the lake lay along the northwestern border of the New Washington Moraine, and only about half a square mile of flat lake plain is actually within the confines of the county. A detailed study of Lake Willard has been made by Campbell (1955, p. 60-63) for Huron County, where the lake was most extensive.

OTHER LAKE SEDIMENTS

Silts and clays that were probably deposited in small proglacial lakes are found at several places in

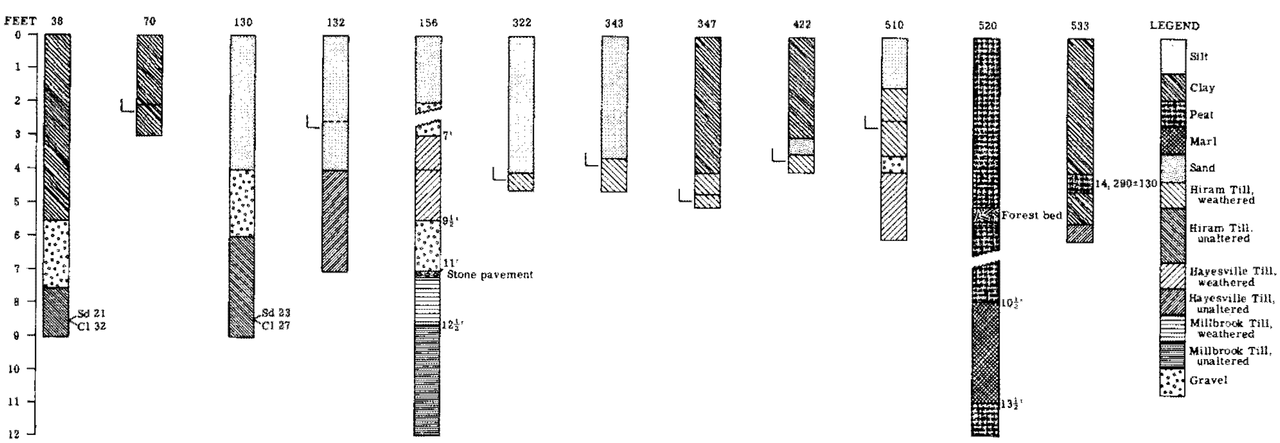


FIGURE 33.—Columnar sections showing lacustrine deposits. Percentages of sand (Sd) and clay (Cl) shown at points at which samples were collected; L is depth of leaching.

Richland County. These sediments are generally quite thin and cannot be traced away from a single outcrop. An exception is in the vicinity of Mansfield, where at three localities a deposit of calcareous laminated silt and sand up to 4 feet thick lies over calcareous Millbrook Till.

Many small lakes originated during the partial filling of Black Fork and its tributaries by Late Wisconsinan drift. Others resulted from the melting of partially buried ice blocks. Organic silt, peat, and clay have accumulated in these kettle-hole lakes since melting of the ice blocks after retreat of the last ice sheet. Because these deposits are at or near water table level, very few exposures of peat are available for study. The thickest peat deposit reported is one of 23 feet in sec. 30, Blooming Grove Township, north of Ganges. Greater thicknesses of peat may be present in some of the large kettle holes in Black Fork valley between Ganges and Pavonia. The most extensive exposure of lake sediments in the county may be seen along a drainage ditch in sec. 17, Blooming Grove Township, southeast of Shiloh (fig. 34). Organic silt, clay, peat, sand, and gravel 5 or more feet thick are found over till in the ditch for a distance of at least 1 mile. These thin organic-rich layers preserve a rich fauna and flora which inhabited Richland County shortly after the retreat of the Hiram glacier. The basal organic layer (fig. 34) has a carbon-14 age of 14,290± 130 years B.P. (ISGS-72).

GLACIAL GEOMORPHIC FEATURES

GENERAL STATEMENT

Many of the surface features of Richland County owe their formation directly or indirectly to glaciation. These features, which include ground moraine, end moraine, lake plain, and glaciofluvial land forms, are the products of several ice advances. It is convenient to discuss these geomorphic features as units separate from the stratigraphy of the deposits because many land forms are not results of deposition by the last glacier to cover the region.

GROUND MORAINE

Ground moraine has a relatively smooth or gently rolling surface that lacks appreciable knolls and ridges. In Richland County two forms of ground moraine topography can be recognized: drift-controlled plain in the north and west where drift is relatively thick and bedrock-controlled ground moraine in the south where drift is thin.

Drift-controlled plain

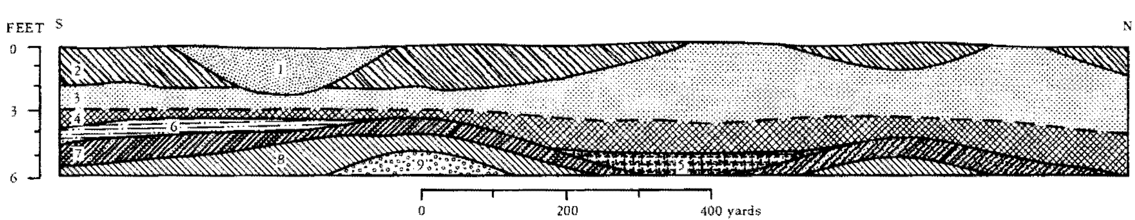
A till surface may or may not reflect irregularities that may be present on the underlying bedrock surface. Drift-controlled plain is ground moraine which does not reflect these irregularities, and is, therefore, more or less flat. Generally, such plains are gently rolling, with low and broad swells and a few undrained shallow depressions.

The largest areas of drift-controlled plain are found in the northern half of the county (pl. 1). One such area includes much of Sharon and parts of Plymouth, Cass, Jackson, Springfield, and Sandusky Townships. A part of this area has been covered with a thin veneer of lake sediments and is shown on plate 1 as lake plain.

Smaller areas of drift-controlled plain are found in central Blooming Grove and Butler, northwestern Franklin, and northern Weller Townships. All of these areas are rolling but only rarely do knolls rise more than 5 or 10 feet above the surrounding plain.

Bedrock-controlled ground moraine

Where the deposits of glacial drift are thin, or where the irregularities in the underlying bedrock



1. Sand, filling small valley
2. Clay, gray, silty, plastic
3. Silt, dark-gray; rich in organic matter; few mollusk shells
4. Marly silt, light-gray; mollusk shells extremely abundant
5. Peat, grayish-black
6. Peat and silt, gray-brown; spruce(?) wood; one spruce(?) cone; leaf litter; several large clam valves at the top; carbon-14 sample no. 533, dated 14,290±130 years B.P. (ISGS-72)
7. Silty clay, gray; grading downward to sand; no fossils or organic matter
8. Till, gray, silty, clayey, blocky, calcareous. HIRAM
9. Gravel, brown, sandy

FIGURE 34.—Sketch of glacial deposits exposed in a drainage ditch W½ sec. 17, T. 23 N., R. 18 W., Blooming Grove Township, Richland County, 3 miles southeast of Shiloh.

surface are great, or both, the bedrock irregularities may not be concealed. Such a surface is called bedrock-controlled ground moraine; it may be very irregular or may be level, depending on the nature of the preglacial surface.

The ground moraine surface in southern Richland County is largely bedrock controlled. The till is generally quite thin in this area and bedrock is exposed in many places on steep slopes. The largest such area includes much of Worthington, Jefferson, and Washington Townships, where (1) the area is near the glacial boundary and in a region of older drift; (2) the area is one of high relief, *i.e.*, steep slopes and deep valleys are common, making for greater difficulty in leveling existing bedrock surface irregularities by drift deposits. Postglacial erosion has removed some drift from this hilly region.

Smaller patches of bedrock-controlled ground moraine are found in Perry, Troy, Washington, Monroe, Mifflin, Madison, and Weller Townships. In some places valleys in these tracts have been wholly or partially filled, and all gradations between bedrock-controlled ground moraine and drift-controlled plain are present.

In some places elevated areas of bedrock-controlled ground moraine have nearly flat tops, as in the area northwest of Pavonia in southern Weller Township. This flat highland is a plateau remnant of resistant Black Hand Sandstone and is thinly mantled with till.

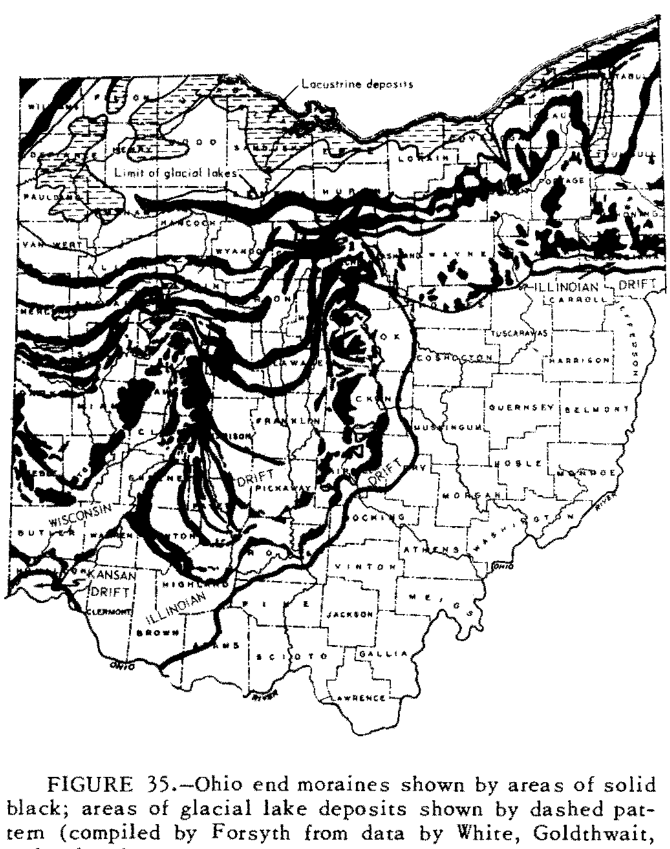


FIGURE 35.—Ohio end moraines shown by areas of solid black; areas of glacial lake deposits shown by dashed pattern (compiled by Forsyth from data by White, Goldthwait, and others).

END MORAINES

General statement

End moraines—more or less continuous hummocky ridges of till—were deposited at the ice margin whenever the margin remained stationary for a period of time. These moraines commonly are well-drained relative to the surrounding areas. A series of end moraines sweeps across Ohio in a general east-west direction (fig. 35), bending south into the major drainage basins to define the Miami, Scioto, Killbuck, and Grand River lobes. A regional study (Totten, 1969) indicates that end moraines are continuous from the Scioto lobe to the Killbuck lobe. Owing to Richland County's unique position at the edge of the Allegheny Plateau, all end moraines south of the Defiance Moraine (fig. 36) are compressed into a narrow band which passes through Richland County. This bunching effect has led to confusion in sorting out the various morainic elements.

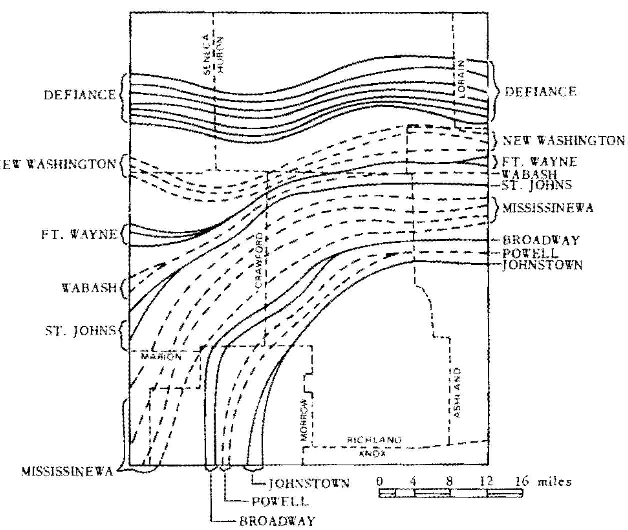


FIGURE 36.—Generalized traces of end moraine elements in north-central Ohio, showing the relationship of moraines in the Killbuck lobe to moraines in the Scioto lobe.

The end moraines of north-central Ohio were first systematically treated by Leverett (1902). White (1935, 1939b) combined field studies and projected profiles of 15-minute quadrangles for a detailed moraine description that has stood as the standard reference. Campbell (1955) and Gregory (1956) restudied portions of the area described by White (1939b), and their mapping closely followed his. The following presentation is condensed from Totten (1969), with special reference to Richland County.

In northern Richland, southern Huron, and northern Ashland Counties, a belt of hummocky topography more than 12 miles wide was formerly interpreted as formed by the junction of the Wabash and Fort Wayne Moraines (Leverett, 1902, pl. 13; White, 1939b; Campbell, 1955; White, *in* Goldthwait and others, 1961). It has been possible to separate elements of the morainic complex (pl. 1). Work in the field and study of aerial photographs and 7½-minute topographic maps have led to the conclusion that this belt is made up, not only of the Wabash and Fort Wayne Moraines, but also of elements of the Johnstown, Powell, Broadway, Mississinewa, and St. Johns Moraines. These moraines are separate in the Scioto lobe in the Till Plain, but tend to coalesce at the basin margin.

Stratigraphic studies of the morainic belts of Richland County indicate that the moraines consist mainly of Millbrook and/or earlier deposits veneered by thin Woodfordian till. Similar discoveries have been reported in northeastern Ohio, where White has recorded thin till over other tills in moraines in Wayne County (1967) and Stark County (1963). Similar sequences have been found extending eastward into Pennsylvania, as shown in scores of sections, many of which are illustrated by White and others (1969).

This stratigraphic evidence is construed to signify that the classic moraines of northern Richland County are most likely products of early Wisconsinan Millbrook glaciation and have been overridden and modified by Woodfordian glaciers.

Overriding and subsequent deglaciation may modify pre-existing moraines in several ways. The results may be (1) partial removal of the earlier moraine by scouring, (2) covering of the moraine with a layer of drift, (3) filling in of intermorainal tracts with drift, (4) deposition of new moraines beside or on top of older moraines, and (5) derangement of drainage with resulting dissection of moraines by meltwater streams.

The total effect is to produce a composite landscape consisting of elements of two or more separate glaciations. The elements of different ages may be distinguished by stratigraphic relations, trend directions, and sharpness of topography, because newer features have changed least. Overridden moraines have a subdued or drowned appearance; at many places only a chain of knolls remains to indicate their presence.

Johnstown Moraine

The moraine with continuity nearest the glacial boundary is the Johnstown Moraine, which is a northward-trending irregular poorly defined belt located along the eastern side of the Scioto basin. The mile-and-a-half-wide moraine enters Richland County in western Troy Township and begins a gradual bend around the Mansfield Highland. The moraine consists of broad hummocks 20 to 30 feet high and is much dissected by Clear, Rocky, and Black Forks drainage systems. The moraine bends eastward in the Killbuck lobe, where it consists of a distinct mile-wide belt of irregular 20- to 40-foot high knolls. The moraine contributes to the filling of the abandoned valley of Black Fork northwest of Pavonia and partially plugs the present Black Fork valley northeast of Pavonia.

Powell Moraine

The Powell Moraine in the Scioto basin consists of two northward-trending elements lying a short distance basinward of the Johnstown Moraine and mirroring its trend. This later moraine bends around the Mansfield Highland and has an eastward trend in the Killbuck basin, where the two morainic elements are closely juxtaposed to form a single unit.

The outer element is narrow, rarely exceeding a width of half a mile in the Scioto basin, and is ridgelike, with knolls reaching 40 to 50 feet high. The inner element is three quarters of a mile to a mile wide and consists of 20- to 30-foot high knolls. It is discontinuous at the common corner of Richland, Crawford, and Morrow Counties, and again north of Spring Mill, where the moraine crosses, and apparently sags down into, buried valleys. The two elements apparently join southeast of Crestline and remain joined northeastward into the Killbuck basin except for a short distance along a line between Mansfield and Shelby. This line extended to Plymouth is a line of discontinuity for many morainic elements in the northwestern part of the county.

The Powell Moraine is considered to represent the terminal moraine of a Late Wisconsinan ice advance into the Scioto basin (Goldthwait and others, 1965). In Richland County, however, no evidence has been seen to connect the moraine with any till boundary.

Broadway Moraine

Along the east side of the Scioto basin, the Broadway Moraine consists of two weakly developed closely spaced northward-trending elements which parallel the Powell Moraine. A short distance southwest of Crestline, the moraine begins its transition northeastward into the Killbuck basin, breaking up into a chain of irregular knolls that occupy an intermediate position between the Powell and Mississinewa Moraines. From Olivesburg, the moraine extends eastward through Ashland County as a mile-wide belt of continuous, though weak, hummocks.

Mississinewa Moraine

Four morainic elements between the Broadway and St. Johns Moraines in the Scioto and Killbuck basins are assigned to the Mississinewa Moraine. The moraine bends eastward through Shelby, where it passes from the Scioto basin to the Killbuck basin.

The transitional area in the northwestern part of the county has long puzzled glacial geologists confronted with the problems of tracing moraines from the western Ohio plains to the eastern Ohio plateaus. The more hummocky parts of this area were referred to by Campbell (1955, p. 31) as the Shiloh moraine knot. Leverett (1902) and White (1939b) show only the Wabash and Fort Wayne Moraines passing eastward through this knot into the Killbuck basin, and the most recent maps (Goldthwait and others, 1961) still show this correlation.

Gregory (1956, p. 23) detected hummocky topography in extreme eastern Crawford County extending eastward to Shelby and ascribed it to the Broadway Moraine. Gregory's (1956) mapping necessitates a highly improbable right-angle bend in the Broadway Moraine close to Sulphur Springs, near the center of Crawford County.

The outer element of the Mississinewa Moraine is lost for 8 miles southwest of Shelby and is patchy across the remainder of Richland County. West of Shelby the moraine consists of three inner elements, which are closely spaced (pl. 1). These elements are weak but distinct because they break the generally featureless lacustrine plain of Lake Shelby. The northernmost element is a classic example of a "drowned" moraine. Broad almost imperceptible knolls topped by prosperous homesteads and flanked by productive well-drained grain fields march in an east-west line across the countryside. Circles drawn on maps around the tops of these knolls and later expanded to include all elevated land outlined a distinct morainic element which served as a type example for detecting other weak morainic elements.

The Mississinewa Moraine has undergone considerable postdepositional modification. In addition to normal dissection by Black Fork and its tributaries, there are sharp valley-side knolls consisting of till and gravel kames, eskers, and crevasse fillings that clearly postdate the Mississinewa Moraine.

A sharp morainic ridge located 3 miles south of Plymouth is 3 miles long and half a mile wide and rises 50 to 60 feet above the bordering lacustrine plain. This morainic segment merges with the more subdued and apparently older Mississinewa Moraine on the east and terminates abruptly to the west. It is interpreted to be a product of a later (Woodfordian) glaciation. A similar short, but less sharp, morainic tract lies north of the St. Johns Moraine near Plymouth.

St. Johns Moraine

The St. Johns Moraine is a single nearly continuous belt of hummocky topography which extends across the northern part of the county. In northwestern Richland County the moraine rises 40 to 50 feet above the bordering Lake Shelby plain to the southeast. The St. Johns Moraine bends eastward into the Killbuck basin, passing through Shiloh and the sharp hummocky topography of a portion of the Shiloh knot. The moraine averages about 1 mile in width in the Killbuck basin and consists of low knolls 10 to 20 feet high, rising to 40 feet in a few places.

Wabash Moraine

The Wabash Moraine is a narrow morainic belt sandwiched between the St. Johns and Fort Wayne Moraines. Leverett (1902), White (1939), and Gregory (1956) show the Wabash merging with the more northerly Fort Wayne Moraine near Sulphur Springs in central Crawford County, forming another moraine knot. Moranic knolls characteristically rise 20 to 40 feet above intermorainal depressions, except in the Sulphur Springs moraine knot, where knolls rise to 60 feet. The unusually high knolls are interpreted as being formed by two combined Wabash morainic elements and possibly by superposition of the outer element of the Fort Wayne Moraine upon an earlier moraine having a north-northeast trend. A few subdued knolls north of Sulphur Springs record such a moraine.

East of Sulphur Springs the Wabash Moraine bends northeast along the east edge of the Scioto basin, which borders the Berea Escarpment. In the Killbuck basin the moraine widens eastward and consists of two partially overlapping elements; the boundary between them is approximated by the Huron-Richland County line.

Fort Wayne Moraine

The Fort Wayne Moraine is a narrow belt of hummocky topography in the northwestern corner of the county and is partially overridden and obscured by the New Washington Moraine. East of Plymouth in the Killbuck basin and about 1 mile north of the county line, the moraine is better defined and can be traced eastward into Ashland County.

New Washington Moraine

The New Washington Moraine lies north of, and closely parallels, the Fort Wayne Moraine. The moraine consists of three elements, two of which are present in the extreme northwestern corner of Richland County. The moraine makes a conspicuous southward arc into Crawford County, but is otherwise little affected by the Scioto and Killbuck basins. The lowland responsible for the arc was later the site of Tabor School Lake south of the moraine and Lake Willard north of the moraine (Hubbard and Rockwood, 1942; Campbell, 1955).

Defiance Moraine

The Defiance Moraine is a broad belt of hummocky topography which lies to the north of, and closely parallels, the New Washington Moraine. This broad belt at its closest lies about 3 miles to the north of Richland County.

HUMMOCKY TOPOGRAPHY WITHOUT LINEAR TREND

Considerable tracts of hummocky topography are found south and east of the belt of arcuate end moraines. This hummocky topography generally is weakly developed on uplands, but in many places well developed in and along valleys.

Valley-controlled hummocky topography

In the larger valleys, particularly in those beyond the limit of the Late Wisconsinan ice advance, hummocky topography is present along the valley sides, and the hummocks may continue for a mile or more away from the valley walls. These hummocks, consisting of till or gravel or a combination of both, seem to owe their origin to the presence of large valleys that were parallel to ice movement and that influenced glacial flow and ice wastage.

Black Fork valley.—The largest tract of valley-controlled hummocky topography is in the partially buried preglacial and interglacial segments of the valley of Black Fork between Shiloh and Perrysville, Ashland County. The hummocky drift along the valley is 2 to 4 miles in width and some knolls rise 30 to 40 feet above their surroundings. The surface material of the knolls is mainly till, but in exposures gravel is commonly present below a till covering; it is believed that many knolls in this and other valleys are composed of gravel at depth. Kettle holes are numerous, representing ice blocks that were isolated from the downwasting stagnant ice and partially buried. These depressions became lakes after the ice melted, and the stream course is composed in part of interconnected kettle holes.

Rocky Fork valley.—Considerable hummocky topography is found along both sides of Rocky Fork and its tributaries from 3 miles southeast of Spring Mill to the junction of Rocky Fork with Black Fork east of Lucas. On the north side of the valley, hummocks are present mainly in small tributary valleys, whereas on the south side broad gravelly hummocks are continuous along the valley side and continue onto the uplands away from the valley.

Clear Fork valley.—Hummocky topography is present in Clear Fork valley from south of Ontario to Bellville and in the valley of Cedar Fork, tributary of Clear Fork, from the Crawford-Richland County line southeastward as far as Bellville. Knob-and-kettle topography predominates and much of the drift is gravelly. The margins of hummocky drift in the valley are marked by morainic and outwash deposits which nearly fill Clear Fork valley at the southwest edge of Bellville. The morainic drift apparently dammed the valley for a short time, forming a lake until meltwater managed to cut away a portion of the dam along the north valley wall.

Upland-controlled hummocky topography

A wide area of hummocky morainic topography occurs between the glacial boundary and the outermost mapped moraine, the Johnstown (pl. 1). This drift is the product of several Wisconsinan glaciations; a portion of it may belong to moraines of the same system as the named moraines, but any trends are now obscured, mainly because of postmorainic dissection in a hilly portion of the Allegheny Plateau.

Several of these hummocky areas may represent terminal moraines of Late Wisconsinan ice advances, though end moraine topography is lacking. Those upland areas shown as hummocky (pl. 1) consist mainly of drift-filled valleys and broad drift knolls on the hillslopes, topography in marked contrast to the thinly drift-covered ground moraine surfaces.

The largest area of hummocky topography is found on the Mansfield Highland south and west of Mansfield. This area is continuous with areas of hummocky topography on the uplands on the south sides of Rocky Fork and Switzer Creek valleys.

Hummocky topography is present also in the Davis Basin. This drift-filled lowland is hemmed in by high bedrock hills on three sides.

LAKE PLAIN

Lake plain refers to an area which has received sediment while it was covered by a body of standing water. Such areas have different degrees of flatness depending upon the duration of the lake, the amount of sediment deposited, and the relief of the surface upon which the lacustrine material was deposited.

Parts of the plains of two extensive lakes, Lake Shelby and Lake Willard, are present in Richland County, and both are associated with the retreat of the last ice sheet from the county. No water remains from either of these ancient lakes.

Lake Shelby

Hubbard and Rockwood (1942, p. 242-243) described Lake Shelby as an irregularly shaped tract of about 9 square miles located largely in southeastern Plymouth Township. The wide distribution of lacustrine sediment indicates that the lake or series of lakes occupied a much larger area in northwestern Richland County, including parts of Plymouth, Cass, Sharon, Jackson, and Sandusky Townships (pl. 1), and also covered a considerable area in eastern Crawford County. In general, the lake plain extends to the St. Johns Moraine on the north and west and nearly to the Broadway Moraine on the east and south.

In the northwestern portion of the county the regional slope is toward the north, and no deeply cut valley flowing southward exists. This water was impounded between Hiram-Centerburg ice and the divide, forming a temporary ice-marginal lake. As the ice retreated, lower outlets, probably toward the southwest, were uncovered, and the lake level continued to drop. The level of the final stage, which may have lasted for a time after the county became ice free, was determined by the lowest level of the basin, at around 1,085 feet, near Ganges. Water poured over this outlet, and a "gorge" was cut down to an elevation of 1,030 feet or lower west and north of Ganges, leading to the demise of the lake. It was during this time that the present anomalous-appearing Black Fork drainage was coordinated. The surface of the lake plain is nearly featureless, except for many small shallow kettles that dot the plain and for several narrow Mississinewa end moraine segments or "islands." The flat plain has poor natural drainage, but dredging and tiling have turned this lake plain into highly productive crop land.

Lake Willard

The extensive, nearly featureless plain of Lake Willard just touches the northwestern corner of Richland County (pl. 1). Most of this lake bed lies in Huron County and has been described by Campbell (1955, p. 60-63).

GLACIOFLUVIAL LAND FORMS

Materials deposited by meltwater streams flowing on, within, beneath, and beyond the glacier are classified under the broad heading "glaciofluvial deposits" and have been described previously. Glaciofluvial deposits give rise to land forms with characteristic features that distinguish them from other glacial forms. The land forms belonging to this class are kames, kame terraces, eskers, crevasse fillings, and valley trains. In many instances, these forms have been modified and wholly or partly obscured by overriding ice. Many of the original meltwater forms are veneered with one to three tills, and their original topographic expression has been somewhat subdued.

Kames

Kames are conical hills or mounds composed of poorly sorted sand and gravel. Kame gravel was deposited in contact with ice, either in a hole in the ice or at the ice front. Melting of the ice resulted in slumping of gravel and the development of collapse bedding structures.

Single kames and groups of kames or kame fields occur in several places in Richland County (pl. 1).

A kame field is located 2 miles west of Plymouth at the front of the Berea Escarpment along the Richland-Huron County line. The kames, which are clustered in a 1- by ½-mile area, are single knolls 10 to 30 feet high or knolls attached to each other to form an elongated ridge. Numerous small kettles are associated with the kames.

A small group of five kames, the tallest about 20 feet high, is mapped as a unit in the SE¼ sec. 7, Plymouth Township, 2 miles south of Plymouth.

Several isolated kames are located southwest of Ganges between Laser and Bowman Street Roads in northeastern Jackson Township. The largest of these kames, located in the SE¼ sec. 2, is 50 feet high and a quarter mile in diameter. A broad group of kames is located along the east side of Black Fork valley along Stiving Road in secs. 17 and 20, south of Shelby. Many kamelike knolls are found in the vicinity of Black Fork valley from Mifflin, Ashland County, about three quarters of a mile east of the county line, to Ganges and Rome, and in a buried portion of Black Fork valley north of those towns to the Huron County line. Associated with these knolls and kames are a multitude of kettles, in places arranged like beads on a string, so that Black Fork flows from one kettle to the next.

A large kame nearly 50 feet high is crossed by State Route 603 in sec. 14, Monroe Township, between Pinhook and Rocky Fork valley. This kame appears to be associated with kame terrace deposits on the south side of Rocky Fork.

A few small isolated kames are found in upland areas. The largest of these high-elevation kames is located a mile and a half southwest of Bellville in the SW¼ sec. 8, Jefferson Township. The kame nearly fills a small tributary valley in the hilly upland south of Clear Fork valley and has only slight topographic expression. Two similar kames having but slight topographic expression are situated north of Butler in sec. 5 and sec. 7, Worthington Township. The kames are very small and can be identified by their small moundlike shapes in contrast to the more steeply sloping till-mantled hillsides.

Kame terraces

Kame terraces are formed by sand and gravel deposited along valley sides by meltwater streams flowing between the valley walls and stagnating ice blocks remaining in the valley. Upon melting of the ice blocks, hummocky deposits resembling kames or valley trains remained along the valley sides and in many places kettles remained in the valley. Kame terraces may exhibit all gradations of morphology from high-level valley train segments to groups or chains of kames and kame deltas.

Many of the kame terraces in Richland County have been overridden by later ice sheets that deposited till over the terraces, partially altering their topography. Where the till covering is thick, the exact limits of the terrace deposits are not discernible.

Kame terraces are common in many of the larger valleys in the glaciated Allegheny Plateau. Richland County is no exception: kame terrace deposits are found in the valleys of Black Fork, Rocky Fork, Switzer Creek, Clear Fork, Cedar Fork, and several other streams.

Black Fork valley.—Extensive tracts of kame terraces, kames, kettles, and eskers are jumbled together in Black Fork valley (pl. 1). Much of the hummocky topography in the abandoned valley segments north and south of Shiloh to Ganges and Rome is probably kame terrace in origin. The wide terrace east of Ganges on the south side of Black Fork is nearly continuous, though narrow in places, from Ganges to Perrysville, Ashland County. A similar, though discontinuous, terrace is present on the opposite side of the valley. A large kame terrace on the valley floor 2 miles north of Pavonia measures a mile and a quarter by half a mile and in sec. 20, Weller Township, constricts the modern floodplain. Terraces are present also in an early abandoned portion of Black Fork valley west and northwest of Pavonia.

Southeast of Pavonia in Mifflin Township two levels of kame terraces with a combined width of a quarter to half a mile are present along the west side of Black Fork. The upper (Millbrook?) terrace is narrow and is generally till covered. The lower wider (Navarre?) terrace has a thick till cover as far south as sec. 22, Mifflin Township, beyond which the till covering is thin or absent. The lower terrace, part of which has been inundated by waters of Charles Mill Reservoir, is broad and extremely hummocky, with kamelike knolls rising 10 to 30 feet above the surrounding land. A large mass of kamelike knolls plugs Black Fork valley in secs. 9 and 10, Mifflin Township, and provides a natural fill where Interstate 71 and U.S. 30 cross the valley. These knolls, some of which rise 70 feet above the valley bottom, diverted Black Fork to the east valley wall, where it cut through a bedrock spur in the NW¼ sec. 14, Mifflin Township, Ashland County.

Rocky Fork valley.—Several kame terrace segments remain along the valley of Rocky Fork from the center of Mansfield southeast to the junction of Rocky Fork and Black Fork. Much of the terrace is obscured by a thick covering of till, and terrace margins are indistinct. Terrace segments on the northeast valley side are particularly narrow; the original terraces probably have been largely removed by stream erosion. The largest segment, on the south side of the valley southeast of Mansfield, is about 5 miles long and as much as half a mile wide.

Switzer Creek valley.—Short segments of a kame terrace are located along the valley of Switzer Creek in Monroe Township. These terrace segments begin in sec. 29 and continue downstream to Clear Fork valley. On the north side of Switzer Creek valley three narrow terrace segments have a total length of about 2 miles. The terrace broadens downstream and joins with a terrace on the north side of Clear Fork valley. The terrace has an elevation of about 1,170 feet at its head and an elevation of about 1,100 feet 3.5 miles downstream where it joins with Clear Fork, a slope of 20 feet per mile. A short terrace segment about 1 mile in length is present on the south side of the valley. Unlike the terraces mentioned previously, the terraces along Switzer Creek valley are fairly flat, with only a few knolls projecting above the almost level surface.

Clear Fork valley.—Extensive kame terraces are found along both sides of Clear Fork valley in the vicinity of Lexington and Clear Fork Reservoir and southeast to Bellville and beyond. Several kame terrace segments are also present in the valleys southeast of Bellville, northeast of Butler, and east of Newville.

Kames and kame terraces as much as 1 mile in width are found in Clear Fork valley northwest, north, and east of Lexington. A large tract of kamelike knolls nearby plugs the valley in secs. 11 and 14, Troy Township, 1 mile northwest of Lexington, at the site where the dam was constructed. Two levels of kame terraces, a higher terrace along the valley side, and a lower terrace near water level, are present on the south side of Clear Fork Reservoir. The terrace surfaces in the valley show good kame-and-kettle topography and have as much as 30 to 40 feet of relief. The kame terrace segments between Lexington and Bellville are small; on the east side of the valley, terraces extend some distance up tributary valleys between bedrock spurs. A delta kame fills a portion of a tributary valley in sec. 4 north of Clear Fork at the north edge of Bellville.

Several kame terrace segments are located on the northeast side of Clear Fork southeast from Bellville for about 2 miles. This terrace reaches an elevation of about 1,200 feet; a few small kames mapped as a unit are found in a tributary valley in sec. 11 north of the terrace. Much smaller terrace segments may be seen in the opposite valley wall, where erosion has removed nearly all evidence of a terrace.

A broad tract of kames and kame terraces is located northeast of Butler. In secs. 10, 15, and 16, Worthington Township, a large group of kames fills the valley, and Clear Fork was forced to cut a new valley north of its former course. Kame terraces extend into Ashland County on both sides of Clear Fork valley east of Newville. The terrace surface is broad and quite hummocky, and many small knolls rise 10 feet or more above the surrounding surface.

Cedar Fork valley.—Three kame terrace remnants are present on the south side of Cedar Fork valley. These terraces are very narrow and have a total length of about 3½ miles.

A more extensive tract of topography of kame terrace nature exists on both sides of a valley tributary to Cedar Fork in Perry and Troy Townships. This tract is about 3 miles long and half a mile wide. The terrace surface is quite hummocky and several knolls rise 10 to 20 feet above the surrounding land surface.

Other kame terraces.—Several small features resembling kame terraces are located at the heads of small tributary valleys. One tract is at the head of Possum Run in secs. 10 and 15 at the Interstate 71 and State Route 13 interchange. Two other tracts are in secs. 13 and 36, Worthington Township, in the southeastern corner of Richland County.

Eskers and crevasse fillings

Eskers are sinuous ridges composed of sand and gravel and representing fillings of stream channels on top of, within, or beneath marginal downwasting ice. Eskers are commonly discontinuous or segmented, and in many cases are associated with kames and kame terraces. Crevasse fillings are short linear ridges that may resemble eskers. Both features are found together in Black Fork valley, and no distinction is made between them in this report.

Black Fork esker.—An esker composed of many short segments extends almost the entire length of Black Fork valley, a distance of about 22 miles. The esker enters Richland County from Huron County in sec. 1, Cass Township, north of Shiloh, and trends southwestward to the kame complex in sec. 2. From the kame, the esker turns southward for 1 mile to Shiloh as a 20- to 30-foot high ridge. A short distance south of Shiloh, the esker bifurcates into eskers with parallel courses about 1 mile apart. One esker trends south from Shiloh and merges with the broad kame terraces west of Ganges. The other is more distinct and continuous southeast of Shiloh to the point where it enters the present Black Fork valley east of Ganges. The eskers join in sec. 4, Franklin Township, and continue as a single though discontinuous ridge 30 or more feet high down the center of the valley. In sec. 11, Weller Township, the esker divides again into two separate ridges that occupy valleys that circle the bedrock hill north of Pavonia. The more distinct ridge trends southward, passing west of Epworth, and then turns southeast toward Pavonia. Half a mile southwest of the village, it contributes to the filling of the abandoned valley. The other esker, which is poorly developed, follows Black Fork eastward to near the county line and then bends southward, where it merges with a complex of kames. About 2 miles southeast of Pavonia the eskers join with a large tract of hummocky drift that nearly fills Black Fork valley. Some of the elongate, ridgelike islands in Charles Mill Reservoir south of U.S. 30 may belong to this remarkable esker system. In addition to the eskers, numerous small crevasse-type fillings in Black Fork valley represent fillings of cavities between ice blocks.

Clear Fork esker.—A small esker in Clear Fork valley in the NW¼ sec. 15, Worthington Township, is associated with kames that fill Clear Fork valley and is mapped with them. The esker is about 1 mile long and from 10 to 15 feet high.

Valley trains

Large volumes of sediment-laden meltwater flowed southward or eastward down most of the valleys in Richland County. The sorting action of meltwater streams caused the clay and silt to be carried far down the valleys, but the sand and gravel were not carried as far and were deposited in the valleys as valley trains. Postglacial erosion removed much of these trains; their remnants, where present, are terraces along valley sides. Valley train terraces resemble, and may be mistaken for, kame terraces. The latter generally may be distinguished by their position farther up the valley sides, by a more hummocky surface, and by a more irregular inner margin.

Black Fork valley.—Black Fork valley has served as an important meltwater channel and contains outwash gravels at depth, yet few valley train terraces remain. A small flat-topped terrace remnant is located half a mile west of Rome in secs. 20 and 29. Another terrace segment about 2 miles long extends from sec. 2, Monroe Township, northward into Ashland County. Near the confluence with Rocky Fork east of Lucas, two small terrace segments remain. Elsewhere in the valley, valley train terraces have been eroded or obscured by kames, kame terraces, lacustrine sediments, and recent alluvium.

Rocky Fork valley.—A single broad partially dissected valley train as much as half a mile wide may be traced for about 13 miles along Rocky Fork from northwest of Spring Mill to Lucas. Terrace elevations are 1,185 at Spring Mill, 1,150 at Mansfield, and 1,100 near Lucas, a slope of about 7 feet per mile. The terrace narrows north of Lucas, and only a few remnants are seen between Lucas and the Ashland County line.

Clear Fork valley.—Remnants of two valley trains are present on either side of the modern floodplain in Clear Fork valley from a mile and a half southeast of Lexington downstream to Ashland County. The best exposure of both terraces superposed is along the north side of the valley between Bellville and Butler. The low terrace is only a few feet higher than the modern floodplain and 3 or 4 feet lower than the upper terrace. The upper terrace has elevations of 1,170 feet southeast of Lexington, 1,120 feet near Bellville, and about 1,080 feet near Butler, for a gradient of about 10 feet per mile. The lower terrace has slightly less slope and merges with the upper terrace west of Butler. East of Newville, the valley train is inundated by the water of Pleasant Hill Reservoir.

Several valleys tributary to Clear Fork, including Cedar Fork, Honey Creek, Smoky Run, Slater Run, Possum Run, and Switzer Creek, also contain valley trains with gradients steeper than those of the Clear Fork terraces. Alluviation by modern streams has contributed to the deposits in these valleys. South of the Clear Fork basin, a small valley train is present in the headwaters of Pine Run in the southeastern corner of the county.

PLEISTOCENE HISTORY

GENERAL STATEMENT

Pleistocene history in the midwestern United States is made up of four major glacial advances which are, from oldest to youngest, the Nebraskan, Kansan, Illinoian, and Wisconsinan Stages. These stages are separated by interglacial intervals of warmer climatic conditions which are, from oldest to youngest, the Aftonian, Yarmouthian, and Sangamonian Stages.

Continental ice sheets spread out of the Erie Basin into northern Ohio, and extended into Richland County as the Killbuck and Scioto lobes. The ice advanced to the edge of the Black Hand Escarpment and was slowed down and stopped. All of the ice advances that entered Richland County apparently were halted in this manner, but at different lines.

NEBRASKAN STAGE

A Nebraskan ice advance into northern Ohio is postulated from drainage changes discussed by various workers, most recently by Coffey (1961, p. 306-308). Deposits of the Nebraskan glacial stage have not been identified in Richland County; if they are present, they are most likely to be located in deep valleys and buried by younger drift.

AFTONIAN STAGE

Deposits of the Aftonian Stage are not known in Richland County. If present, these interglacial deposits are most likely to occur in deep valleys and to be buried by younger deposits.

KANSAN STAGE

Direct evidence for a Kansan(?) glaciation of most of Richland County is the occurrence of weathered till and gravel beneath a thick Illinoian sequence in the Derwacter gravel pit near Bellville (fig. 8). Additional evidence for an extensive Kansan(?) glaciation is the occurrence of Deep Stage drainage lines in the county. The northward-flowing drainage in Richland County was reversed by a Kansan or possibly Nebraskan ice advance, and deep valley cutting was an important development in Kansan(?) time.

YARMOUTHIAN STAGE

The weathering horizon developed in the Kansan(?) deposits in the Derwacter pit presumably represents interglacial weathering during the Yarmouthian Stage. No Yarmouthian deposits other than paleosol are known in Richland County; if present, they are likely to occur in deep valleys and to be buried by younger deposits.

ILLINOIAN STAGE

Ice advanced into Richland County as many as three times during the Illinoian Stage, as evidenced by the till and gravel deposits in the Derwacter pit, at Lucas and at Shenandoah, and at several other places. At least one of these advances, the Butler glacier, covered all of Richland County and stopped in the hilly upland in southwestern Ashland County. Meltwater from the Butler glacier flowed to the east and initiated or contributed to the cutting of the gorges of Pine Run and Clear Fork in Hanover Township, Ashland County. Abundant outwash deposits accumulated in Deep Stage valleys during deglaciation.

SANGAMONIAN(?) STAGE

A prolonged warmer climatic period known as the Sangamonian Stage followed retreat of Illinoian ice. The Sangamonian interglacial interval is represented primarily by weathering developed on the Butler Till and associated deposits and by erosion of till from the steep hillsides. Some of the weathered sand and gravel between the Butler Till and overlying Wisconsinan-age till may have been deposited during the interglacial but more likely was laid down at the end of the Illinoian. Interglacial deposits such as lacustrine silts and peat have not been discovered in Richland County.

WISCONSINAN STAGE

Altonian Substage, Millbrook-Jelloway advance

The Millbrook Till of the Killbuck lobe and the Jelloway Till of the Scioto lobe were deposited by ice that advanced into Richland County from the north in the Killbuck lobe and from the southwest in the Scioto lobe. The ice of the two lobes coalesced in the southwestern part of the county, but the southeastern part of the county, which earlier had been glaciated, remained free of ice during this advance. Hummocky drift along the margin may represent a broad diffuse terminal moraine. Much of the hummocky drift in southwestern Richland County and in eastern Morrow County may be the expression of an interlobate moraine formed during this advance and now covered by later drift. It is believed that the Millbrook-Jelloway ice margin retreated in a pulsating fashion and deposited the end moraines in the northern part of the county. As Millbrook-Jelloway ice retreated, drainage was resumed in the major valleys and outwash sand and gravel were deposited as kames, kame terraces, and valley trains. Deglaciation and glaciofluvial deposition were accompanied by deposition of windblown silt or loess on the newly uncovered surface.

The advent of Millbrook-Jelloway glaciation is thought to have occurred at least 40,000 years B.P., and may have begun as early as 75,000 years B.P. Ice may have persisted in Richland County for many thousands of years, and deglaciation of the Erie Basin may not have occurred until near the beginning of the Farmdalian interval.

Farmdalian Substage

After the retreat of the Millbrook-Jelloway ice sheet, a period of weathering and erosion of several thousand years duration followed. This warmer interval lasted from approximately 28,000 years B.P. to 24,000 years B.P., according to radiocarbon dates from several midwestern states. In Richland County no datable wood, organic silt, or peat from this interval has been discovered, although organic-rich deposits likely accumulated in Farmdalian lakes and ponds.

Woodfordian Substage

Navarre-Knox Lake advance.—The advance of ice south from the Erie Basin about 24,000 years ago (White, 1968) brought the Farmdalian Substage to a close. Late Wisconsinan ice advanced into Richland County as two separate lobes and deposited the Navarre Till of the Killbuck lobe and the Knox Lake Till of the Scioto lobe. This ice did not reach quite as far into Richland County as the preceding glacier, and the deposits of this advance are thin nearly everywhere. Hummocky topography near King's Corners, Troy Township, and at several places near the ice margin are the only morainic deposits attributed to this advance. Possibly some of the fresh-appearing hummocky drift near Shiloh is of this advance, also. At the time of maximum ice advance, major drainage lines were temporarily blocked with ice, and meltwater deposited minor amounts of sand and gravel in the form of kames, kame terraces, and valley trains. As Navarre-Knox Lake ice retreated into the Erie Basin a considerable distance to the north an estimated 18,000 years ago, thin deposits of loess accumulated on the surface deposits, and some weathering took place on the Navarre and Knox Lake Tills. This period of weathering is known as the Erie Interval and had a duration of about 3,000 years (Mörner, 1970).

Hayesville-Mt. Liberty advance.—The advance of Hayesville-Mt. Liberty ice into Richland County about 15,000 years ago brought the somewhat warmer Erie Interval to a close. Tongues of ice advanced into Black Fork and Clear Fork valleys and to a lesser extent into Cedar Fork valley. The ice stopped 1 to 4 miles short of the previous advance and deposited a thin layer of till which thickens near the margin at the north edge of Mansfield. Hayesville-Mt. Liberty ice stagnated and melted, but extensive gravel deposits were not formed at this time, probably because the till which would have supplied the gravel was not very pebbly. Following the melting of Hayesville-Mt. Liberty ice in Richland County, about 14,700 years ago, a thin blanket of loess accumulated on the surface deposits and very slight weathering in the form of leaching took place. This weathering interval was very short, perhaps no more than 200 years in duration.

Hiram-Centerburg advance.—After a short retreat northward, ice readvanced approximately 14,500 years ago and deposited the Hiram Till of the Killbuck lobe and the Centerburg Till of the Scioto lobe. As with the previous advance, tongues of ice advanced into valleys ahead of the main ice front, most noticeably in Black Fork valley. The Hiram-Centerburg advance deposited a thin discontinuous layer of till and stopped a fraction of a mile to several miles short of the previous advance.

Hiram-Centerburg ice stagnated and melted, and in northwestern Richland County, where the regional slope is northward, drainage of meltwater was ponded by ice and drift and a large proglacial lake, Lake Shelby, was formed. Lake Shelby was short-lived, however, and came to an end when ice blocks which formed a dam in Black Fork valley melted sufficiently to allow the water from Lake Shelby to escape down that valley. The narrow gorge at Ganges, now occupied by Black Fork, was cut by the sudden rush of water from Lake Shelby when the ice dam broke.

Hiram-Centerburg ice retreated from Richland County approximately 14,300 years ago, moving a short distance northward into the Erie Basin. Additional proglacial lakes were formed, including Lake Willard, which extended into the northwestern corner of the county. A minimum radiocarbon age for Hiram deglaciation is 14,290±130 years B.P. (ISGS-72), from wood embedded in organic silt overlying Hiram Till and Hiram outwash (fig. 34). The wood, probably a small spruce, is evidence of rapid plant migration back into a recently deglaciated area. Snails, clams, beetles, and several different kinds of plants also are preserved in this organic silt, which accumulated in a shallow lake or swamp. A thin covering of loess accumulated on the surface deposits after the retreat of ice from Richland County. Subsequent ice advances in the Erie Basin did not reach Richland County.

POSTGLACIAL HISTORY

Following the retreat of ice from Ohio about 10,000 years ago (Ogden, 1967), the climate in Ohio ameliorated. During the postglacial period, vegetation and animal life gradually migrated back into former habitats as the climatic and ecological conditions permitted. Alluvium, consisting mainly of silt and clay, was deposited in most of the valleys, and organic silt and peat collected in the numerous kettle holes. Postglacial erosion has removed some drift from hillsides, primarily in central and southern Richland County. Weathering and soil-forming processes have formed rich soils during the postglacial period.

MINERAL RESOURCES

GENERAL STATEMENT

The glaciation of Richland County has resulted in several valuable natural resources, of which sand and gravel deposits are among the most important. Gravel deposits not only provide industrial aggregate, but also are aquifers containing large supplies of ground water. Of no commercial value, but of interest, is the small amount of gold contained in some of the gravels. Peat moss, which has accumulated in kettle holes, is another potentially valuable resource, as are the rich soils, derived largely from glacial drift, which cover the county.

SAND AND GRAVEL

Sand and gravel deposits are plentiful in Richland County. Six large pits (table 5) were in operation in 1970, with a total yearly production (1969) of 738,000 tons. A number of smaller pits are operated intermittently, primarily for township road surfacing gravels and other local uses.

TABLE 5.—*Large gravel pits in operation in Richland County, 1970*

Name of operation	Location	1969 production (tons)	Years of operation
Purdy's Mohican	Sec. 12, Monroe Twp.	200,000	15
Mohican Materials	Sec. 12, Troy Twp.	160,000	6
Derwacter	Sec. 5, Jefferson Twp.	141,000	13
D. H. Bowman and Sons	Sec. 10, Jefferson Twp.	96,000	14
Garber Materials	Sec. 11, Troy Twp.	91,000	3
Purdy's Mohican	Sec. 11, Weller Twp.	50,000	0

Several techniques have been used in processing sand and gravel. General bank-run gravel need only be stripped of any overburden, then excavated by power shovel and marketed. Gravel or sand to be used in construction for concrete or asphalt requires additional treatment, which may include crushing, washing, and screening.

An important criterion for a large-scale gravel operation is that the gravel meet state requirements of hardness and durability. In general, Millbrook and earlier kame terrace deposits in the county meet or exceed these specifications and are among the best gravel deposits in the state. To ensure meeting state specifications, Purdy's Mohican Sand and Gravel Company has installed a magnetite separator which separates gravel particles according to their density. In this manner, the lighter undesirable gravel is floated and discarded.

An important consideration in any gravel operation is the amount of overburden of till or silt that must be removed. Several feet of overburden commonly is present on Richland County gravels, and in places the overburden exceeds 10 feet. In addition, in older deposits such as those at the Derwacter pit, till is intercalated between gravels and must also be discarded.

Weathering horizons and paleosols developed in gravel may increase its value for certain uses. Weathered clay-enriched paleosol or clay-filled wedges such as those associated with Millbrook gravels provide excellent bank-run gravel for roads because the small amount of clay acts as a binder. An undesirable character that may develop is secondary enrichment and cementation by calcium carbonate below the zone of leaching. Cemented gravel layers resemble concrete and must be discarded during quarrying operations. Fortunately few such cemented layers have been encountered in gravel operations in Richland County. In most quarrying operations, gravel is not removed below water table level, though excellent deposits of gravel may extend many feet below this level. A dragline operation was recently begun in the Derwacter pit to remove gravel to a depth of 32 feet below the water table, but such excavation is expensive and it is unlikely that dredging operations will become common until the easily accessible deposits are depleted.

UNDERGROUND WATER

Underground water is another extremely valuable natural resource of Richland County. Many municipalities, industries, and rural dwellers depend on wells for their water supply. Underground water is generally available everywhere, though in widely differing amounts and at various depths.

Underground water in Richland County may be obtained in moderate to large quantities from two contrasting types of aquifers, the Mississippian Black Hand Sandstone and the Pleistocene glaciofluvial sand and gravel deposits. The Black Hand Sandstone will generally yield moderate amounts of water: 25 to 250 gallons per minute according to Prée (1962).

Glacial deposits, particularly sand and gravel, are important aquifers where they have sufficient extent and thickness. Areas with the greatest potential yield of underground water are the preglacial and interglacial channels, which are now wholly or partially filled with glaciofluvial deposits 200 feet or more thick. The greatest yields are from coarse gravels which provide much of the filling of Black, Clear, Cedar, and Rocky Fork valleys in the southern part of the county. According to Prée (1962), yields as high as 1,000 gpm may be expected from Clear Fork valley gravels between Bellville and Lexington, and yields of 100 to 500 gpm are possible between Bellville and Butler in the same valley.

The partially buried channel of Black Fork, which extends the entire length of the county from Shiloh to Perrysville, Ashland County, also is an important aquifer. From Pavonia northwestward the valley fill consists of till, lacustrine silt and clay, and outwash sand and gravel, and in general has an underground water potential of 5 to 25 gpm (Prée, 1962), though in places yields may be much greater. The potential yield of wells in Black Fork valley from Pavonia southward and in Rocky Fork southeast of Mansfield is much greater, on the order of 100 to 500 gpm (Prée, 1962). In addition to the buried channels mentioned above, numerous smaller tributary channels may provide moderate supplies of underground water.

Till generally does not provide an adequate underground water supply for modern domestic needs. In localities where there is an absence of thick intervening sand and gravel layers, wells commonly are drilled into the underlying bedrock.

In Richland County, water pumped from the glacial drift is of good quality, though not as good as water from sandstone. Prée (1962) lists a total hardness range of 258 to 883 ppm and an iron content of 0.4 to 15 ppm for water from sand and gravel, while water from sandstone contains about 150 and 0.05 ppm total hardness and iron, respectively.

GOLD

A curiosity of no proven economic importance is the gold associated with glacial gravel in Clear Fork valley and its tributaries. Reed (1878) paid great attention to gold found in the drift near Bellville. According to Garber (1958), gold was first discovered in Deadman's Run near Bellville about 1853, and new discoveries were subsequently made in gravel along Gold Run near Butler and in Wildcat Hollow near Gatton Rock. An old picture in the possession of a Bellville resident shows several men shovelling gravel into a sluice in Steltz's Run north of Bellville at the site of the old "Gold Mine." Panning operations along Steltz's Run reportedly may net as much as $1.50 worth of gold per day, an indication of how futile the gold-mining operations in Richland County have been. The gold-bearing gravel in Steltz's Run overlies gray Butler Till of Illinoian age and is probably related to the high-level gravels in the Derwacter gravel pit.

Diamonds have been found with gold in drift in several midwestern states, but none have been found in the gravels of Richland County. The obvious source of these exotic minerals is the Precambrian shield crystalline rocks north of the Great Lakes, though the exact point of origin is still unknown.

PEAT

Peat, which in its commercial state is commonly known as peat moss, forms by the accumulation of plants in a swamp or bog. Numerous poorly drained depressions and deeper kettleholes were left by the wasting ice sheet, primarily in the northern portion of the county. These areas of standing water were sites of peat and silt accumulation until the bogs became filled or were drained. Nearly all the bogs in the county are filled, though a few large bogs in Black Fork valley still contain water. The known or projected peat localities are shown on plate 1 as lake plain deposits. Many other peat deposits probably exist in addition to those shown.

Only one locality currently produces peat in commerical quantities. The Reynolds Farms, Inc., have been producing a good quality sedge peat moss from a large bog area north of Ganges. The bog, first opened in 1943, is located in the SW¼NW¼ sec. 30, T. 23 N., R. 18 W., Blooming Grove Township, and produces about 6,000 yards of peat yearly. The peat deposit is in an elongated hollow, which is interpreted as a segment of a valley, blocked by drift. Mr. Robert Heyde, operator of the peat excavation, reports an average thickness of peat of 15 feet, with the greatest thickness being 23 feet. In one place a dragline excavation exposed 5 feet of sedge peat over a thin woody peat layer, which in turn was found to overlie 5 additional feet of sedge peat; beneath the sedge peat at a depth of 11 feet is 4 feet of peaty mud (gyttja) containing enormous numbers of small mollusk shells in the upper part; beneath the gyttja is sand, which was not reached in this particular excavation. Beetles are common in all layers in the bog.

The high water content and low bearing strength of peat makes it most difficult to excavate, a factor which anyone contemplating exploitation of such deposits must consider. In addition, before peat can be marketed, it must be dried and shredded. An analysis furnished by Mr. Heyde of Reynolds Farm peat showed organic content of 71.84 percent and ash content of 28.16 percent. The analysis gave a pH of 4.48 and a moisture absorption capacity of 405.5 percent.

It is likely that peat from several localities in the county has found local uses in farm gardens and in nurseries. For example, the nursey at Alta, southwest of Mansfield, is located beside a peat bog which formerly furnished peat moss for its operation. However, the peat remaining in the bog has burned, rendering it useless, and the Reynolds Farm peat is now used in the nursery.

All of the peat deposits examined in Richland County have accumulated since the disappearance of Hiram ice about 14,300 years ago. Wood and basal peat overlying Hiram Till 3 miles southeast of Shiloh (fig. 34) has a radiocarbon age of 14,290±130 years B.P. (ISGS-72). This date represents the time of the first accumulation of organic matter following deglaciation in northern Richland County.

PLANNING FOR THE FUTURE

GENERAL STATEMENT

The expansion of population and the growth of industry in Richland County have been accompanied by problems in land use. The realization that natural resources such as soil, water, minerals, forests, and even space for building sites are limited, exhaustible, and susceptible to pollution has led to increased emphasis on land-use planning.

Glacial deposits form the surficial materials nearly everywhere in the county, and this study provides the data concerning surficial deposits necessary for general recommendations for land-use planning.

Topics of concern include use of mineral and water resources, potential pollution hazards, and the competition of land for urban, agricultural, industrial, and recreational uses.

RESOURCES

Sand and gravel

The sand and gravel deposits of Richland County are among the best in the state, and are located near numerous potential markets. Conservation of sand and gravel resources should receive priority in planning: zoning regulations should permit the quarrying of these deposits, but at the same time should require that it be done wisely. In some parts of the county, particularly in the Lexington and Bellville areas, regulations may be needed to protect the kame terrace deposits from being engulfed by urban development. Areas underlain by gravel may be used for agriculture or woodland until needed. At that point, a planned excavation procedure is essential in order to extract the maximum amount of gravel possible with the minimum amount of disturbance. Plans are needed also to return worked-out pits to agricultural or recreational uses.

Peat

Peat moss deposits are a potentially valuable though virtually untapped resource. Some of the excavation problems must be overcome before the full potential of peat as a mineral resource can be realized. The undrained depressions or bogs in which peat deposits collect do not make suitable industrial or home sites, and conflicts in land use are likely to be less critical than for sand and gravel deposits.

Underground water

Underground sources provide water for the municipal, industrial, urban, domestic, and agricultural needs of most of Richland County. The major aquifers are the Black Hand Sandstone and the thick, extensive, and highly permeable sand and gravel deposits along the major drainage lines. These glacial deposits contain water in sufficient quantities to provide an ample supply for the county, but also, because of their permeability and accessibility, have a high susceptibility for pollution by waste-disposal practices and agricultural or urban activity.

WASTE DISPOSAL

In a populous area underlain by a variety of glacial materials, improper waste disposal may pose a serious pollution problem. Refuse disposal sites and sanitary land fills should be situated in dry impervious materials, particularly till, located considerably above the water table. Care should be taken that refuse is not dumped in valley bottoms, where the water table is near the surface, or in tributary valleys, where runoff will wash the waste into the streams.

Sewage effluent and liquid wastes present a more hazardous problem because these materials find their way quickly into the major drainage lines. Such streams contain too little water flowing too slowly to adequately dilute the waste to a "safe" concentration. A concerted effort by many will be required before the streams of Richland County can be considered natural resources rather than convenient sewers. Effluent from septic tanks presents a problem where the tanks are closely spaced, such as in subdivisions, in areas underlain by clayey soil, or in flat poorly drained areas. The portions of northern and western Richland County underlain by Hiram Till (and to a lesser degree by thick Hayesville Till) and the flat areas of lacustrine deposits such as Lake Shelby are poorly suited for septic tanks because these materials are impermeable.

LAND-USE RECOMMENDATIONS

Agriculture

Richland County has long been an important agricultural county, and its location convenient to the markets of heavily populated northern Ohio is certain to add to its importance in the future. Although nearly all parts of the county have contributed to agricultural production in the past, conditions of slope, drainage, and soil make certain areas more desirable than others for this purpose. The northern part of the county is particularly well suited for grain farming, especially since the problem of inadequate drainage has largely been solved by ditching and tiling. Restrictions on urban development in prime agricultural regions may be necessary to protect these valuable soil resources. General farming, including dairying and beef cattle raising, is important in southern parts of the county, but much of the area, particularly the southeast part, is too hilly for extensive cultivation. The steeper slopes should be kept in pasture, orchards, or woodland to protect the soil from serious erosion.

Urban development

Urban development is a most serious problem because it involves accelerated use of underground water, sand, gravel, and agricultural land, and because it pollutes or makes unusable the very resources on which growth depends. Urban development should be carefully planned with respect to other land uses. Development should not be allowed to take over prime farming land, nor should housing on a wide scale be permitted in heavily wooded land or on steep slopes. Probably the best area for urban development on a large scale is the Mansfield Highland area. A line drawn generally from Mansfield to Ontario, Lexington, Bellville, Lucas, and back to Mansfield, avoiding the valleys, encloses an area suggested for future housing development. Adequate supplies of underground water from either the Black Hand Sandstone or from gravel in buried valleys can be developed at reasonable cost. The topography is rolling and scenic, but not steep enough that erosion would be a serious problem. The most modern of sewage treatment plants should service all homes in this urban area to minimize pollution. Although individual septic tanks may work quite satisfactorily for rural homes in southern Richland County, these systems are unsuitable for urban developments.

Industrial development

The requirements for industrial development are similar to those for urban development. The availability of abundant ground water and construction materials, the nearness to major highways and railroads, a location near large urban markets, and the proximity of numerous cultural, educational, and recreational opportunities make Richland County an attractive site for industry. Waste disposal could present a major problem for those industries producing large quantities of solid or liquid wastes.

Recreation

Recreational uses of land are often considered last, and then only when land is unusable for other purposes. In the future, as the population of northern Ohio increases and as a proportionally greater expanse of land is used for urban development, recreational land is almost certain to become a high-priority item. With increased leisure time becoming available, facilities for camping, hiking, picnicking and other outdoor recreational activities will be required and should be provided by state, county, or municipal authorities. Such designated areas would also serve as nature and wildlife preserves, protecting the flora and fauna native to Richland County. The need may not be obvious at the present time because numerous and varied recreational facilities, both public and private, already exist in Richland and surrounding counties, but future development will demand additional facilities, and certain areas should be designated park or forest land before they are appropriated for other uses. Southeastern Richland County is particularly appropriate for recreational needs. The land is not suited for agriculture or urban development, the topography is as rugged, wooded, and scenic as any in northern Ohio, and the region is not densely settled. A similar scenic tract is located across the county line in southwestern Ashland County south of Perrysville.

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APPENDIX

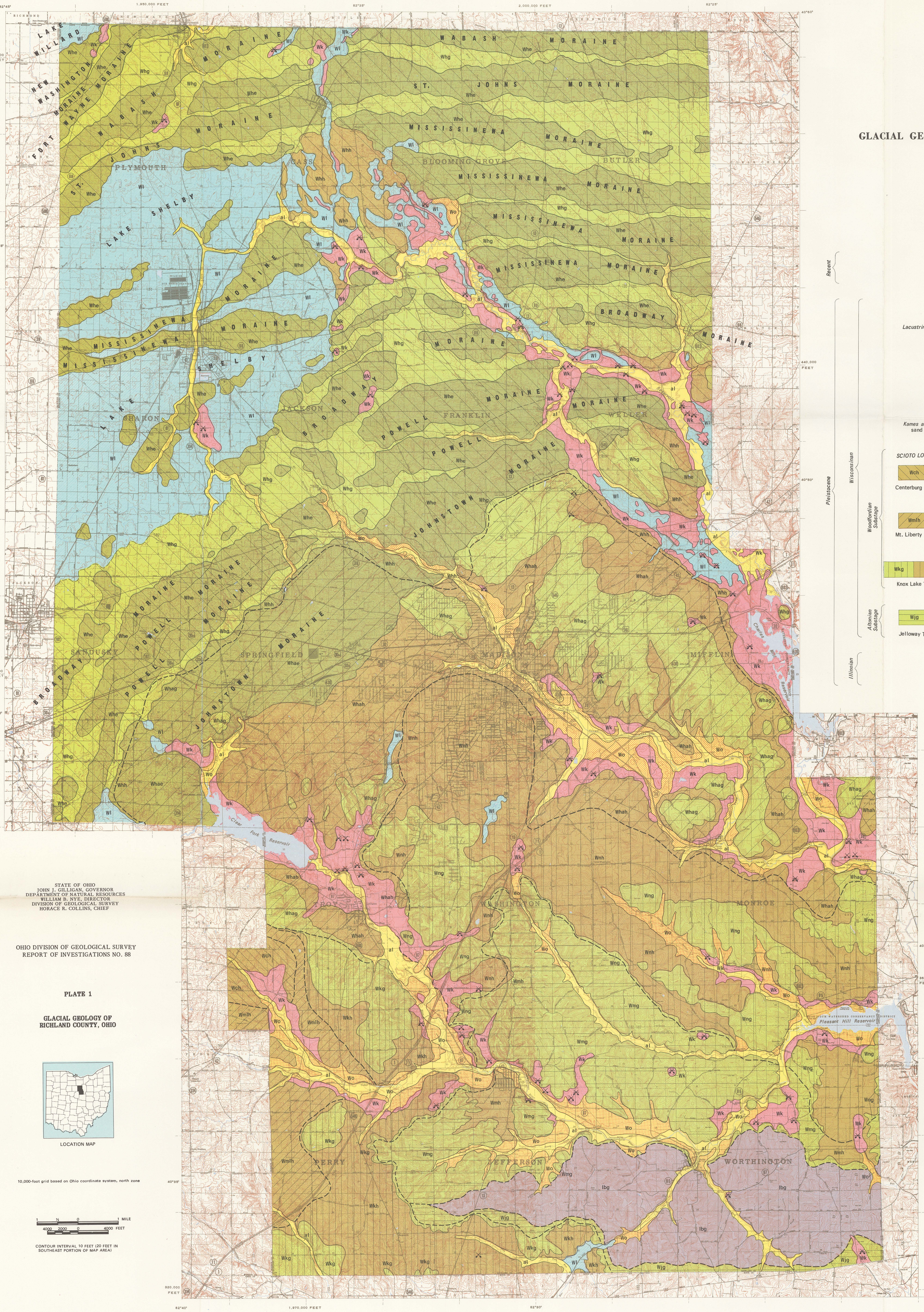
Locations of illustrated stratigraphic sections. Locations are according to townships in Richland County unless otherwise indicated.

No.	*Location*
1	New Haven Twp., Huron Co.
2	NW¼NE¼ sec. 23, Plymouth Twp.
5	NW¼NW¼ sec. 26, Butler Twp.
6	NW¼NE¼ sec. 8, Springfield Twp.
7	NE¼NW¼ sec. 20, Jackson Twp.
16	SE¼NW¼ sec. 17, Springfield Twp.
17	Middlebury Twp., Knox Co.
18	Middlebury Twp., Knox Co.
19	Middlebury Twp., Knox Co.
20	Middlebury Twp., Knox Co.
23	SW¼NE¼ sec. 23, Springfield Twp.
26	SW¼NE¼ sec. 25, Springfield Twp.
27	SW¼NE¼ sec. 34, Springfield Twp.
28	SW¼NW¼ sec. 3, Troy Twp.
29	SE¼NE¼ sec. 10, Troy Twp.
32	NW¼SE¼ sec. 3, Springfield Twp.
36	SE¼NW¼ sec. 30, Sharon Twp.
38	Jackson Twp., Crawford Co.
39	NE¼NE¼ sec. 14, Troy Twp.
42	NW¼SW¼ sec. 11, Troy Twp.
53	SE¼SE¼ sec. 6, Butler Twp.
55	Clear Creek Twp., Ashland Co.
56	Clear Creek Twp., Ashland Co.
60	NE¼NE¼ sec. 33, Jackson Twp.
62	NE¼SE¼ sec. 8, Weller Twp.
64	Clear Creek Twp., Ashland Co.
66	Chester Twp., Morrow Co.
69	NW¼SE¼ sec. 36, Sharon Twp.
70	Vernon Twp., Crawford Co.
71	NW¼SE¼ sec. 6, Plymouth Twp.
77	Vernon Twp., Crawford Co.
78	NE¼SW¼ sec. 7, Mifflin Twp.
79	NW¼SE¼ sec. 7, Mifflin Twp.
80	NW¼NE¼ sec. 18, Weller Twp.
82	NW¼NW¼ sec. 1, Weller Twp.
84	Greenwich Twp., Huron Co.
85	SE¼SE¼ sec. 6, Butler Twp.
93	Clear Creek Twp., Ashland Co.
94	Ruggles Twp., Ashland Co.
96	NW¼SE¼ sec. 18, Butler Twp.
97	Clear Creek Twp., Ashland Co.
99	NW¼NW¼ sec. 32, Butler Twp.
100	SE¼NE¼ sec. 31, Butler Twp.
104	NW¼SE¼ sec. 7, Weller Twp.
106	SW¼NW¼ sec. 12, Weller Twp.
110	NE¼NE¼ sec. 24, Monroe Twp.
112	NE¼SW¼ sec. 1, Washington Twp.
116	NW¼SE¼ sec. 5, Mifflin Twp.
121	SE¼SE¼ sec. 19, Weller Twp.
122	NW¼SE¼ sec. 26, Weller Twp.
123	NW¼SW¼ sec. 17, Madison
130	SE¼NE¼ sec. 33, Jackson Twp.
132	SE¼SW¼ sec. 21, Jackson Twp.
142	NE¼SE¼ sec. 6, Blooming Grove Twp.
144	Ripley Twp., Huron Co.

No.	*Location*
146	SE¼NE¼ sec. 34, Franklin Twp.
150	SW¼SW¼ sec. 27, Franklin Twp.
153	SW¼SE¼ sec. 18, Mifflin Twp.
156	NE¼SE¼ sec. 21, Franklin Twp.
181	SW¼SW¼ sec. 4, Monroe Twp.
182	SW¼NW¼ sec. 14, Monroe Twp.
183	SW¼SE¼ sec. 11, Washington Twp.
187	NW¼SW¼ sec. 34, Jefferson Twp.
192	NW¼SW¼ sec. 23, Perry Twp.
193	SE¼SW¼ sec. 8, Washington Twp.
194	NW¼NW¼ sec. 1, Troy Twp.
199	SW¼SW¼ sec. 28, Springfield Twp.
200	NW¼NW¼ sec. 33, Springfield Twp.
201	SE¼SW¼ sec. 28, Springfield Twp.
204	NW¼SE¼ sec. 33, Springfield Twp.
209	SW¼NE¼ sec. 4, Washington Twp.
218	NE¼NW¼ sec. 20, Weller Twp.
232	SE¼SE¼ sec. 5, Madison Twp.
234	NW¼NW¼ sec. 4, Madison Twp.
238	New Haven Twp., Huron Co.
239	SE¼NW¼ sec. 4, Cass Twp.
240	NW¼SE¼ sec. 4, Cass Twp.
243	NE¼NW¼ sec. 3, Perry Twp.
247	SW¼NW¼ sec. 34, Troy Twp.
249	NW¼SW¼ sec. 18, Jefferson Twp.
250	SE¼NE¼ sec. 24, Perry Twp.
255	SW¼SW¼ sec. 30, Jefferson Twp.
258	Middlebury Twp., Knox Co.
259	SW¼NW¼ sec. 35, Perry Twp.
271	SE¼SE¼ sec. 36, Jackson Twp.
273	NW¼SW¼ sec. 30, Madison Twp
275	NE¼SE¼ sec. 2, Madison Twp.
282	NW¼SW¼ sec. 24, Madison Twp.
302	Mifflin Twp., Ashland Co.
303	NW¼SW¼ sec. 5, Sharon Twp.
305	SW¼SW¼ sec. 16, Cass Twp.
306	Auburn Twp., Crawford Co.
312	SW¼SE¼ sec. 33, Washington Twp.
315	SE¼SE¼ sec. 11, Perry Twp.
316	SW¼NW¼ sec. 27, Perry Twp.
317	NW¼SW¼ sec. 27, Perry Twp.
319	SW¼SE¼ sec. 26, Jefferson Twp.
321	SE¼SW¼ sec. 10, Jefferson Twp.
322	Vernon Twp., Crawford Co.
323	Vernon Twp., Crawford Co.
328	SE¼NE¼ sec. 21, Blooming Grove Twp.
330	NE¼NW¼ sec. 10, Madison Twp.
332	NW¼NW¼ sec. 36, Cass Twp.
333	SE¼SE¼ sec. 26, Cass Twp.
334	NW¼SE¼ sec. 22, Cass Twp.
337	SE¼NW¼ sec. 10, Cass Twp.
339	NW¼NW¼ sec. 13, Cass Twp.
341	NE¼SW¼ sec. 13, Cass Twp.
343	NW¼SE¼ sec. 2, Sharon Twp.
347	NW¼SW¼ sec. 6, Franklin Twp.

No.	*Location*
348	SE¼SE¼ sec. 1, Franklin Twp.
354	NE¼SW¼ sec. 14, Madison Twp.
355	NW¼SW¼ sec. 18, Madison Twp.
357	SE¼NW¼ sec. 15, Springfield Twp.
364	Chester Twp., Morrow Co.
365	Franklin Twp., Morrow Co.
366	Franklin Twp., Morrow Co.
367	Perry Twp., Morrow Co.
369	NW¼SW¼ sec. 18, Madison Twp.
371	NW¼NW¼ sec. 18, Madison Twp.
377	SW¼NW¼ sec. 19, Mifflin Twp.
381	NW¼NW¼ sec. 6, Monroe Twp.
382	NW¼NW¼ sec. 34, Madison Twp.
384	NE¼SE¼ sec. 14, Troy Twp.
385	NE¼NE¼ sec. 14, Troy Twp.
388	Troy Twp., Morrow Co.
389	Troy Twp., Morrow Co.
391	Troy Twp., Morrow Co.
392	Perry Twp., Morrow Co.
394	Perry Twp., Morrow Co.
396	Perry Twp., Morrow Co.
399	SW¼NW¼ sec. 14, Perry Twp.
400	SW¼SW¼ sec. 3, Jefferson Twp.
401	SE¼NW¼ sec. 14, Perry Twp.
402	SW¼SW¼ sec. 36, Jefferson Twp.
403	Berlin Twp., Knox Co.
416	SW¼NE¼ sec. 22, Madison Twp.
417	NE¼SW¼ sec. 23, Madison Twp.
419	Milton Twp., Ashland Co.
421	SW¼SW¼ sec. 35, Washington Twp.
422	NW¼SW¼ sec. 1, Sharon Twp.
423	Perry Twp., Morrow Co.

No.	*Location*
505	SW¼SE¼ sec. 11, Weller Twp.
506	SW¼SE¼ sec. 11, Weller Twp.
507	NE¼SW¼ sec. 20, Jackson Twp.
510	NE¼NW¼ sec. 30, Sharon Twp.
511	SW¼NW¼ sec. 20, Madison Twp.
512	SE¼NW¼ sec. 16, Mifflin Twp.
514	SE¼SW¼ sec. 12, Monroe Twp.
520	SW¼NW¼ sec. 30, Blooming Grove Twp.
522	SE¼NE¼ sec. 4, Jefferson Twp.
524	SE¼NE¼ sec. 26, Worthington Twp.
527	Hanover Twp., Ashland Co.
528	Brown Twp., Knox Co.
529	Brown Twp., Knox Co.
531	NW¼SE¼ sec. 24, Perry Twp.
532	SW¼SW¼ sec. 8, Jefferson Twp.
533	SE¼NW¼ sec. 17, Blooming Grove Twp.
1516	SW¼SW¼ sec. 20, Mifflin Twp.
1607	NE¼NW¼ sec. 16, Mifflin Twp.
1623	SE¼NE¼ sec. 9, Mifflin Twp.
1659	SW¼NE¼ sec. 30, Mifflin Twp.
1662	NW¼SE¼ sec. 36, Madison Twp.
1664	NE¼NE¼ sec. 2, Washington Twp.
1867	NW¼SE¼ sec. 10, Washington Twp.
1870	NW¼SE¼ sec. 10, Washington Twp.
1872	SW¼NE¼ sec. 16, Washington Twp.
1873	SW¼NE¼ sec. 29, Washington Twp.
1877	NW¼NW¼ sec. 21, Washington Twp.
1883	NW¼SE¼ sec. 31, Washington Twp.
1890	NE¼SE¼ sec. 14, Perry Twp.
1896	SE¼NW¼ sec. 23, Perry Twp.
1897	Perry Twp., Morrow Co.



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JOHN J. GILLIGAN, GOVERNOR
DEPARTMENT OF NATURAL RESOURCES
WILLIAM B. NYE, DIRECTOR
DIVISION OF GEOLOGICAL SURVEY
HORACE R. COLLINS, CHIEF

PLATE 1

GLACIAL GEOLOGY OF RICHLAND COUNTY, OHIO

by Stanley M. Totten

1973

EXPLANATION

QUATERNARY

Recent

al — *Alluvium,* including peat and muck in some kettle holes

Pleistocene — Wisconsinan

Wl — *Lacustrine plain,* smooth level topography, mainly silt, clay, and peat

Wo — *Outwash,* valley trains and low terraces

Wk — *Kames and kame terraces,* including crevasse fillings and eskers; mainly sand and gravel in knolls; overlain by till or silt in many places

	SCIOTO LOBE	KILLBUCK LOBE
Woodfordian Substage	Wch — Centerburg Till	Whg, Whe, Whh — Hiram Till
	Wmlh — Mt. Liberty Till	Whag, Whae, Whah — Hayesville Till
	Wkg, Wkh — Knox Lake Till	Wng, Wnh — Navarre Till
Altonian Substage	Wjg — Jelloway Till	Wmg, Wmh — Millbrook Till

Illinoian

Ibg — Butler Till

g — *Ground moraine,* flat to rolling topography in north and west, drift-veneered bedrock hills in south; mainly till

e — *End moraine,* linear belts of hummocky topography, mainly till

h — *Hummocky topography,* without linear trend; mainly along valley sides or in hilly terrain; mainly till, but including some gravel

Boundary of deposit, *dashed where approximate*

Approximate till boundary

Gravel pit

Gravel pit, small or abandoned

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

Bellville	Mansfield South
Blooming Grove	Olivesburg
Butler	Pavonia
Crestline	Perrysville
Jelloway	Shauck
Lucas	Shelby
Mansfield North	Shiloh

Cartographic drafting by
Donald R. Camburn

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OHIO DIVISION OF GEOLOGICAL SURVEY
REPORT OF INVESTIGATIONS NO. 88

PLATE 1

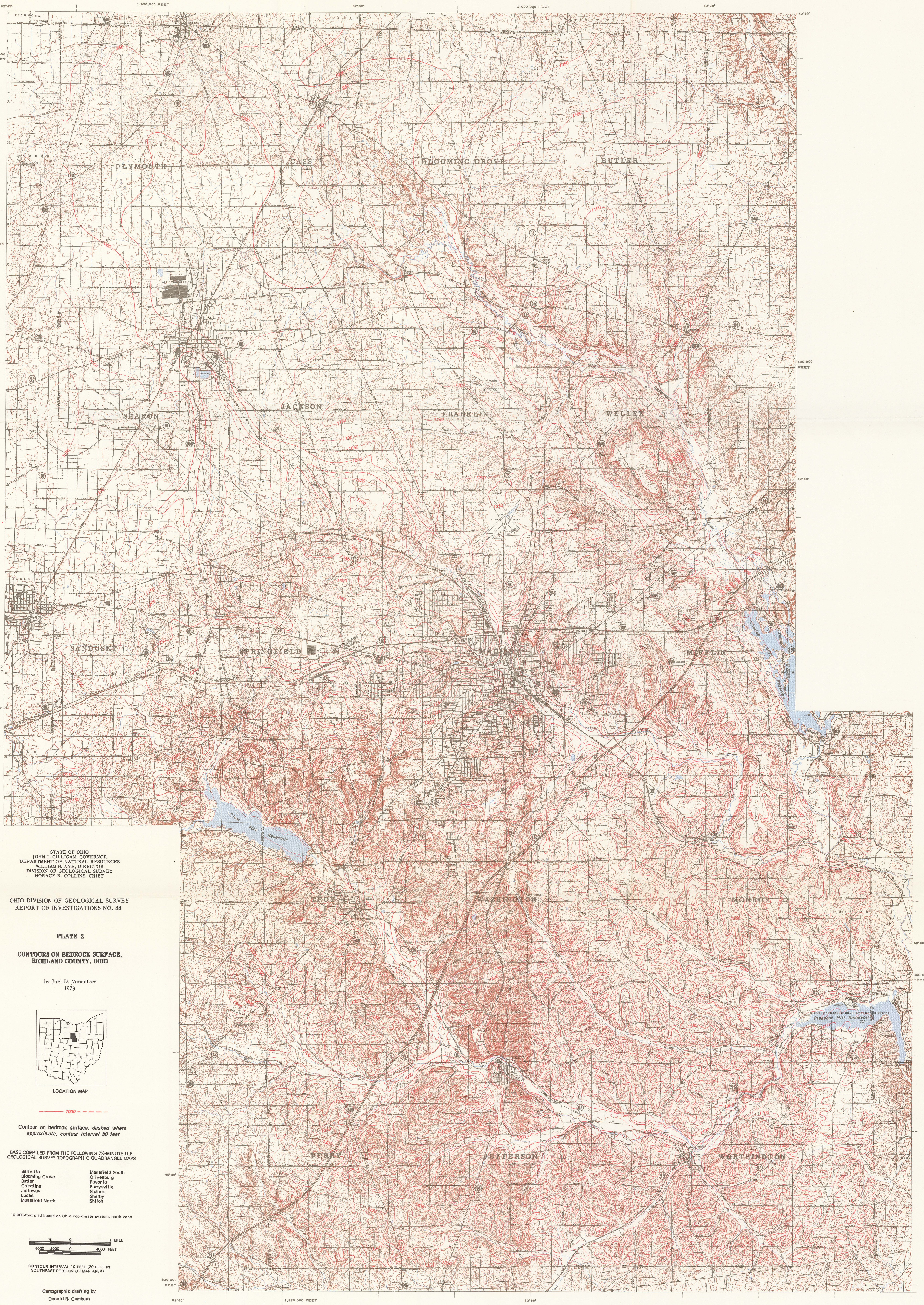
GLACIAL GEOLOGY OF RICHLAND COUNTY, OHIO

LOCATION MAP

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

1 ½ 0 1 MILE
4000 2000 0 4000 FEET

CONTOUR INTERVAL 10 FEET (20 FEET IN SOUTHEAST PORTION OF MAP AREA)



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REPORT OF INVESTIGATIONS NO. 88

PLATE 2

CONTOURS ON BEDROCK SURFACE, RICHLAND COUNTY, OHIO

by Joel D. Vormelker
1973

LOCATION MAP

1000

Contour on bedrock surface, *dashed where approximate, contour interval 50 feet*

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

Bellville	Mansfield South
Blooming Grove	Olivesburg
Butler	Pavonia
Crestline	Perrysville
Jelloway	Shauck
Lucas	Shelby
Mansfield North	Shiloh

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

1 ½ 0 1 MILE
4000 2000 0 4000 FEET

CONTOUR INTERVAL 10 FEET (20 FEET IN SOUTHEAST PORTION OF MAP AREA)

Cartographic drafting by
Donald R. Camburn