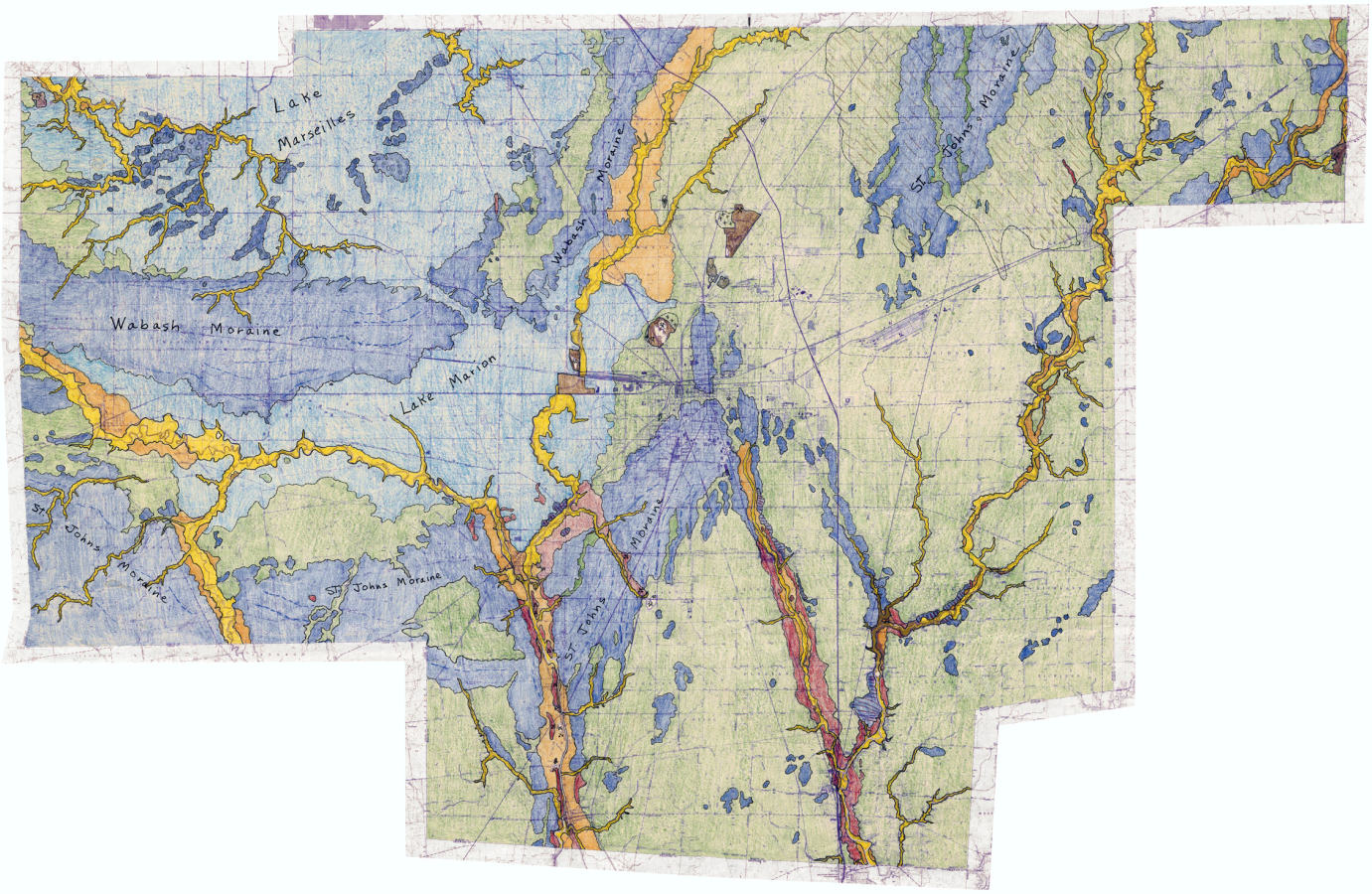
Glacial Geology of Marion County, Ohio

by
Stanley M. Totten



Open-File Report 86-1
Columbus 2017





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FOREWORD

Stan Totten worked on both his M.S. and Ph.D. with Dr. George White who was at the University of Illinois in Champaign-Urbana. Together, they spent every summer in the 1960s and early- to mid-1970s field mapping glacial geology in Ohio, one county at a time. As White's health declined during the late 1970s, Totten's role increased.

After graduation from the University of Illinois, Totten taught at Hanover College in southern Indiana. While teaching at Hanover College, he continued working summers for the Ohio Geological Survey mapping about one county each year. He conducted fieldwork each summer and then wrote the report and manuscript during the school year. Totten was dedicated, often working 12-hour days all summer to complete the fieldwork.

Lab analysis on samples collected in the field were conducted by either the Survey's sedimentology lab in Columbus, by John Szabo at the University of Akron, or by Totten's students at Hanover College.

Four mapping staff members joined the Survey during 1983–1984, along with a lab technician for the sedimentology lab, to form a Quaternary mapping subsection within the Regional Geology Section. Three of the new staff members, Rene Fernandez, Rick Pavey, and I, were assigned Seneca, Erie, and Sandusky Counties, respectively, in western north-central Ohio.

During the early 1980s, Totten was assigned to map several counties in eastern north-central Ohio, essentially an area between that previously mapped by White and Totten in northeastern Ohio and that being mapped by the newer staff members. Totten was tasked with extending westward the stratigraphic nomenclature used for the eastern Killbuck Lobe in Ashland, Medina, and Richland Counties, linking with mapping being done by the Quaternary mapping subsection. He mapped Crawford, Hardin, Huron, Lorain, Marion, and Morrow Counties during this period. Additional impetus for mapping in Morrow County was the result of research done for the field trip guidebook for the 1987 Midwest Friends of the Pleistocene Field Conference, which centered on Knox, Morrow, and Richland Counties.

Totten produced manuscript reports and draft maps (at a scale of 1:62,500) for each of these counties. The original goal was to publish a report of investigations for each county map and report that Totten produced, as well as the county maps and reports being produced by the Quaternary mapping subsection.

The maps and manuscripts were left unpublished for a number of reasons:

- The Survey encountered funding problems during the late 1980s, and the printing process was very expensive for both the maps and bound reports.
- The cartographic work for producing the maps was totally manual and involved an elaborate process of creating photographic negatives for base maps, peel-coats, scribing, type-setting and other steps that took a team almost a year to produce one map. And since there was inadequate cartographic staff to produce the maps and reports, this level of detail and completion was not provided for all the counties.
- Totten's ability to create tables, captions, and figures was very limited by the technology of that time, thus all this work fell on the editorial and graphics section.
- USGS funding supported reconnaissance-level mapping at a regional scale, and the concept of county-based maps and reports was abandoned by the Survey in favor of 30 x 60-minute quadrangle-based mapping initiatives. This was done to meet USGS standards being introduced nationally at that time.

It should be noted that these maps and reports are scanned as-is and may include typos, errors, editorial notes, and other marks. Maps are largely hand-colored and may represent the "final" of several versions. Legends accompanying the maps also may be hand-colored.

The Survey feels that these manuscripts may be of value to the public, academia, and perhaps consulting/geotechnical geologists. The reports contain a tremendous amount of particle size and mineralogical data and in-depth discussions of the materials and stratigraphy. The maps depict only the uppermost surficial materials and geomorphology, and they are very detailed. The maps and reports are of value to those who might need info on the background geology of a specific county, are doing detailed work in the county, or have a keen interest in the glacial geology of north-central Ohio.

Mike Angle
May 24, 2017

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Stanley M. Totten

1986

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Recent — Alluvium. Clay, silt, sand and gravel in stream channels and on modern floodplains. Thickness is highly variable.

Wisconsinan — Alluvial and Valley Train Deposits. Silt, sand and gravel deposited in valleys and preserved as terraces of one or two levels along valley sides.

Lake Deposits. Silt and clay deposited mainly in proglacial Lakes Marion and Marseilles dammed by end moraines and by ice.

Kames and Kame Terraces. Sand and gravel in knolls or in terraces; overlain by till in many places.

End Moraine. Hummocky topography having linear trend. Hiram Till at surface underlain by older tills.

End Moraine, drowned. Hummocky topography covered temporarily by glacial Lake Marseilles. Thin lake clay at surface underlain by till.

Valley-side Knolls. Linear belts or patches of knolls resembling kames and kame terraces. Till at surface; may contain slight to large amounts of gravel at depth.

Ground Moraine. Gently rolling to nearly flat topography. Hiram Till at surface underlain by older tills.

Ablation Deposits. Lake silt and clay deposited in crevasses or holes in wasting ice which deposited Hiram Till. Area consists of alternating patches of lake silt and clay and Hiram Till. Does not affect topography.

Bedrock within 5 feet of ground surface.

 Gravel Pit-Active

 Quarry-Active

 Gravel Pit-Abandoned

 Quarry-Abandoned

Crest of morainic ridge

CONTENTS

	Page
Introduction	1
Acknowledgments	4
Purpose and scope	5
Previous investigations	5
Physiography	7
Topography	7
Physiographic provinces	8
General statement	8
Till Plain	8
End Moraine	9
Lake Plain	10
Drainage	12
Modern drainage	12
General statement	12
Olentangy River Basin	12
Scioto River Basin	13
Tymochtee Creek Basin	15
Little Sandusky River Basin	16
Pleistocene drainage systems	17
Bedrock	18
Drift thickness	21
General erosion	22
Till deposits	24
Character and composition of the till	25
General statement	25

Texture 25
Mineral composition 25
Color 26
Weathering horizons 26
Millbrook Till 28
Navarre Till 33
Hayesville Till 36
Hiram Till 40
Loess 44
Geomorphology of the glacial drift 45
End moraines 46
General statement 46
Mississinewa moraine 47
St. Johns moraine 48
Wabash moraine 50
Valley-side hummocky topography 53
Ground moraine 55
Lake Marion 56
Lake Marseilles 62
Alluvial (outwash) deposits 66
Introduction 66
Kames 68
Little Scioto River valley kame terrace 69
Olentangy River valley kame terrace 70
Honey Creek valley kame terrace 71
Qu Qua Creek valley kame terrace 72

Scioto River valley esker 74
Scioto River valley train 75
Little Scioto River valley train 77
Olentangy River alluvial terrace 79
Mud Run and Flat Run alluvial terraces 80
Rush Creek alluvial terrace 81
Floodplains 82
Mineral Resources 83
General Statement 83
Sand and gravel 85
General statement 85
Scioto River valley train deposits 85
Scioto River valley esker 87
Other sand and gravel deposits 88
Water supply 90
Environmental and engineering geology 92
General statement 92
Till Plain 93
End Moraine 94
Lake Plain 95
Waste disposal 96
Solid waste 96
Septic tanks and tile fields 99
Recreation 100
References cited 101

Appendix A

Marion County till samples

Appendix B

Marion County till analyses

FIGURES

1. Map showing location of Marion County
2. Glacial map of Marion County showing physiographic divisions
3. Cross-section of Marion County
4. Modern drainage of Marion County
5. Geologic map of Marion County
6. Stratigraphic column of Marion County
7. Drift thickness map of Marion County
8. Average depth of leaching
9. Generalized soil map of Marion County
10. Marion County sample localities
11. Profile showing average thicknesses of drift units in Marion County
12. Plot of means and standard deviations of sand, silt, and clay percentages of Marion County till units.
13. Plot of means and standard deviations of carbonate percentages of Marion County till units.
14. Distribution of sand percentages of Millbrook Till A
15. Distribution of carbonate percentages of Millbrook Till A
16. Distribution of sand percentages of Navarre Till
17. Distribution of carbonate percentages of Navarre Till
18. Distribution of sand percentages of Hayesville Till
19. Distribution of carbonate percentages of Hayesville Till
20. Distribution of sand percentages of Hiram Till

TABLES

1. Classification of glacial deposits in Marion County

2. Statistical data of till and lacustrine sample analyses for Marion County

3. Relationship of soil associations to geology

PLATE

1. Glacial deposits of Marion County, Ohio

INTRODUCTION

Marion County is located in north-central Ohio about 30 miles north-northwest of Columbus and 67 miles south-southeast of Toledo. Marion County was formed in 1824, and was named for General Francis Marion of South Carolina who served in the Revolutionary War. The county is bounded on the north by Wyandot and Crawford counties, on the east by Morrow County, on the south by Delaware and Union counties, and on the west by Hardin County. The county lies between 82 51'30" and 83 25' 20" west longitude, and 40 26' and 40 42'15" north latitude. It is a medium sized county with maximum dimensions of 30 miles from east to west and 18 miles from north to south, for a total area of about 405 square miles and 259,200 acres. Marion County is largely rural and agricultural although a majority of its population lives in the city of Marion located near the center of the county. Of the total population of Marion County of 67,974 (1980 Census), 37,040 or 55 percent, live in the city of Marion. The population of Marion Township, which includes both the city of Marion and its suburbs, is 46,380 or 68 percent of the county population. The major villages include Prospect (pop. 1159), LaRue (pop. 861), Caledonia (pop. 759), Green Camp (pop. 475), and Morral (pop. 454). The city of Marion, perhaps best known as the home of Warren G. Harding, 29th president of the United States, prospered as a railroad and industrial center. The major highway linking Columbus with northwestern Ohio, State Route 23, passes through Marion.

About 83 percent of the acreage of Marion County is utilized for agriculture (Miller and Martin, in preparation), with the principle crops being soybeans, corn, and winter wheat. Wetness has been a major soil limitation with the predominantly clayey Marion County soils, but artificial drainage systems have made most areas highly productive for grain farming.

The Greenville Treaty Line extends diagonally in an east-west direction across the southern-most part of the county. The territory south of the treaty line, and the region south and west of the Scioto River including Bowling Green, Green Camp, Prospect, and Waldo townships, were not surveyed by the Township and Range system. An exception is the southeast corner of Waldo Township where all or part of 9 townships have been surveyed. The highest elevation in the county is about 1115 feet in Tully Township in the extreme northeastern corner of the county. The lowest elevation is about 855 feet in Grand Township in the northwestern corner of Marion County where Tymochtee Creek flows northward from Marion County into Wyandot County.

Topographic map coverage for Marion County is included on the following 7½ minute maps: Ashley, Caledonia, Denmark, Galion, LaRue, Marion East, Marion West, Marseilles, Meeker, Monnett, Morral, New Bloomington, Prospect, and Waldo.

Marion County lies on the axis of the Scioto sublobe (fig. 1) of the major Erie glacial lobe in which ice advanced southward into Ohio from the Laurentian ice center in eastern Canada. As ice advanced into the southwestern end of the Erie Basin beyond the confines of the Allegheny escarpment, ice was diverted



Figure 1. Map showing location of Marion County, glacial boundary (heavy line), Woodfordian drift boundary (light line), and glacial lobes.

southward along the Scioto Lobe axis into Marion County. A considerable amount of ice scour probably occurred in Marion County where ice flow was greatest.

ACKNOWLEDGMENTS

This report is based on a detailed field study conducted in 1985. Supplementary materials useful in preparing this report included air photos, water well records, and soil maps. Till samples were analyzed at the University of Akron under the supervision of John Szabo. Joel Vormelker of the Geological Survey provided the drift-thickness map based on water well records. Dennis Hull of the Geological Survey provided valuable support and encouragement in the development of this report.

Purpose and Scope

This report describes the glacial drift, the surface material overlying the bedrock. Stratigraphy of the deposits and the morphology of the land forms are described and correlated with deposits and surface features in adjacent counties in Ohio. Economic resources of the deposits are considered, and suggestions are made for their utilization and conservation.

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

PREVIOUS INVESTIGATIONS

The earliest report on the geology of Marion County was by Winchell in 1873 (p 639-645) and economic deposits. Leverett (1902) in his monograph on the Erie Glacial Lobe mentioned Marion County glacial features in briefest terms. Leverett's (1902, Plate 13) glacial map of the Scioto Lobe shows a distribution of moraines in Marion County that bears a close resemblance to the map (Plate 1) included with this report. Leverett's (1902) moraine mapping was revised by White (1935) and was incorporated in the Glacial Map of Ohio (Goldthwait and others, 1961). The drainage history of Marion County was included in reports by VerSteeg (1934, 1936, 1946), Coffey (1958, 1961), and Stout and others (1943). The principal sources of information regarding water supply are the report by Stout and others (1943) and the map by Crowell (1979). Oil and natural gas production in the county is shown on maps by Calvert (1964) and by Debrosse and Vohwinkel (1974). The economic geology of Marion County, including oil and gas, limestone and dolomite, and sand and gravel, was discussed by Hall and Alkire (1956). Lake beds in Marion County have been studied by Hubbard and Rockwood (1942), and a mastodon buried in these lake beds was reported by Hansen (1978). The detailed soil report by Miller and Martin (in preparation) is a useful reference in the study of the surficial materials.

Glacial reports on adjacent counties have been made by Gregory (1956) and Totten (in preparation) for Crawford County to the north, and by Totten (in manuscript) for Morrow County to the east.

PHYSIOGRAPHY

Topography

Most of Marion County has a gently undulating to nearly flat topography that is prone to poor drainage. The glacial topography varies from flat in the lake plain to hummocky and moderately sloping in the end moraines. The glacial drift is sufficiently thick to obscure most of the relief of the underlying bedrock. The only bedrock feature visible in Marion County is the limestone ridge which extends from Marion toward the north-northeast for a distance of about 5 miles. This broad ridge is the site of most of the stone quarrying in the county.

The highest elevations in Marion County are in the eastern and northeastern parts of the county whereas the lowest elevations are in the northwestern and southern parts of the county. The highest elevation is approximately 1115 feet in the northeastern corner and the lowest elevation is approximately 855 feet in the northwestern corner, for a total topographic relief of 260 feet.

Although only one stream, the Little Sandusky River, actually heads in Marion County, the major drainage lines in the county - Scioto River, Olentangy River, and Tymochtee Creek, head in nearby areas of adjoining counties. Consequently, the stream courses in Marion County have small valleys and low discharges. In only a few places have the streams cut valleys more than 10 or 15 feet below the surrounding area.

Physiographic Provinces

General Statement

Marion County lies entirely within the Till Plain section of the Central Lowland province of Fenneman (1928, 1938). In order to emphasize local differences, three physiographic types or divisions of the Till Plain section may be recognized in Marion County - lake plain, till plain, and end moraine (fig. 2). About half of the county, primarily the eastern half, is composed of till plain. End moraine and lake plain each comprise about one-fourth of the area of the county.

Till Plain

The Till Plain of eastern Marion County is a relatively featureless plain marked by a few low knolls of end moraines and by several relatively small valleys. Two of the streams, Olentangy River and Qu Qua Creek, have entrenched their valleys 15 to 30 feet below the Till Plain surface in the southern part of the county near Waldo. The western margin of the Till Plain is marked by the westward facing Columbus Limestone escarpment (fig. 3). The escarpment, about 100 feet high, trends north-south through the center of the county, and it significantly affected the style of glaciation. A segment of the St. Johns moraine between Prospect and Marion, and a segment of the Wabash moraine north of Big Island mantle the escarpment. However, in many places along the crest of the escarpment, Columbus Limestone occurs within a few feet of the surface.

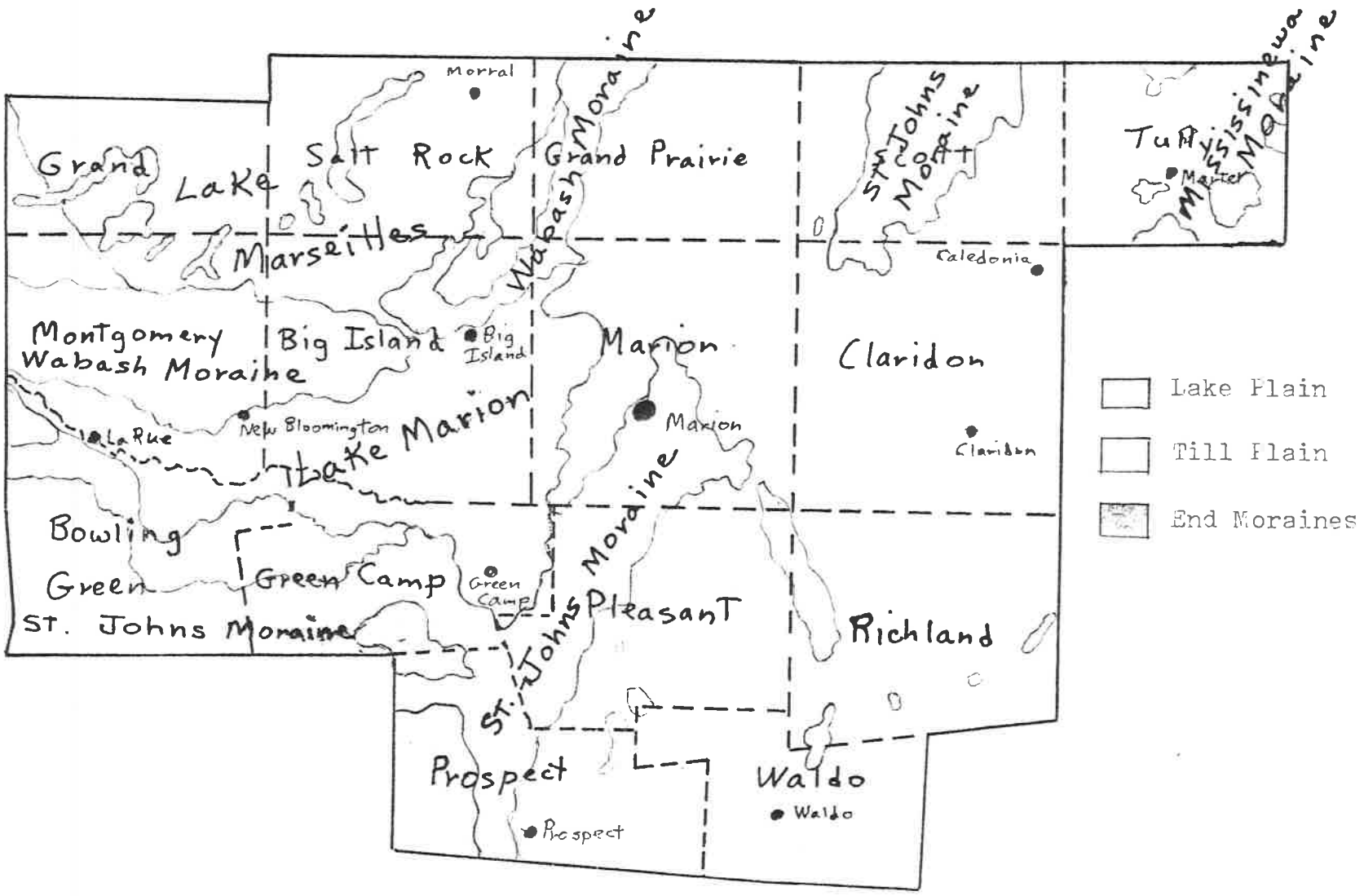


Figure 2 . Generalized glacial map of Marion County showing three major physiographic divisions. Modern valleys are not shown.

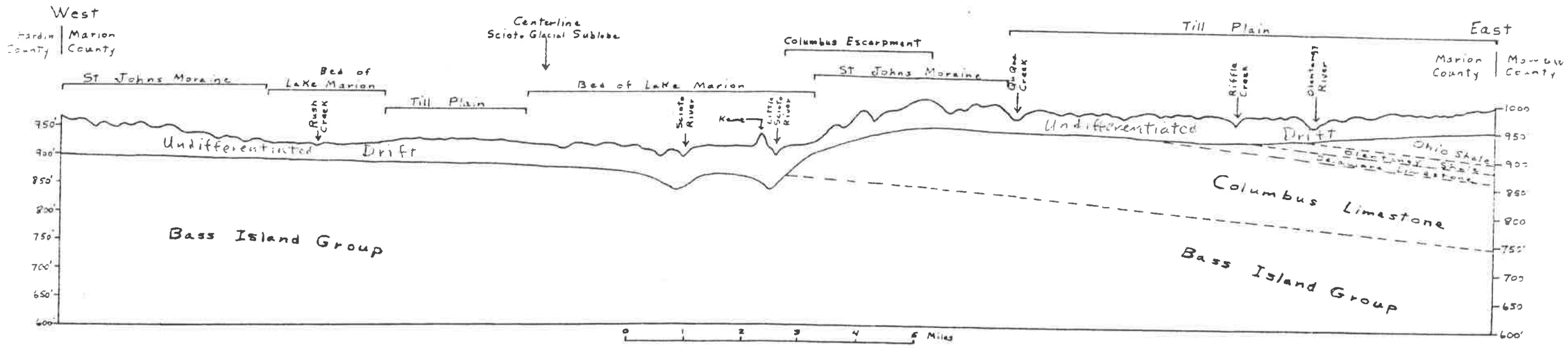


Figure 3. Cross-section of Marion County at 40°33' North Latitude

End Moraine

Two large tracts (belts) and numerous small segments of end moraines occur in Marion County (fig. 2). The largest tracts occur in the western part of the county, though at least small morainic tracts occur in every township. The two major morainic belts, known as the St. Johns and Wabash moraines, have an east-west trend in the center of the Scioto glacial sublobe in western Marion County, and both moraines bend toward the northeast in the central part of the county. These two moraines are responsible for the greatest relief and many of the steepest slopes in the county, though the highest elevations are on the low knolls of the Mississinewa moraine in the northeastern part of the county. The greatest relief is near LaRue in Montgomery Township where the Scioto River has an elevation of 915 feet and the crest of the bordering Wabash moraine has an elevation of 990 feet, a rise of 75 feet in a distance of 1.25 miles. Typically the major morainic ridges rise only about 25 to 30 feet above the surrounding lake plain and till plain, and the discontinuous knolls characteristic of the Mississinewa moraine and others (fig. 2) rise only 5 to 15 feet above their surroundings. Within the more extensive morainic tracts, the topography varies from moderately hummocky to gently rolling to smooth gentle slopes. The morainic ridge tops typically are smooth much like the till plain, presumably because the hummocks have been smoothed by overriding ice.

Lake Plain

Two large areas of lake plain, separated from each other by the Wabash moraine, occur in western Marion County (fig. 2). The lake plain north of the Wabash moraine is the bed of glacial Lake Marseilles which covered a major portion of Grand and Salt Rock Townships and smaller parts of Montgomery, Big Island, and Grand Prairie Townships. The central part of the lake bed in Salt Rock Township and northern Grand Township is a nearly featureless plain. This broad flat lake plain extends northward to include a portion of southern Wyandot County. The flat surface is interrupted by numerous shallow depressions, a few low knolls, and a few small stream courses. In Grand and northern Salt Rock Townships, the lake bed has been dissected by drainage of Tymochtee Creek and Little Sandusky River. Low knolls occur on the lake plain near the margin of the Wabash moraine (fig. 2) and a discontinuous belt of knolls, possibly representing a small unnamed moraine, also occurs on the plain a short distance north of the Wabash moraine. The lake bed slopes toward the northwest and has elevations ranging from about 918 or 919 feet at its margin to 912 feet at Morral, 890 feet at Meeker, and about 885 feet along the Marion-Wyandot County line.

The lake plain south of the Wabash moraine is the bed of glacial Lake Marion which covered a major portion of Big Island Township and smaller portions of Montgomery, Bowling Green, Green Camp, and Marion Townships. The lake bed extends westward nearly to the Marion-Hardin County line. The lowest part of the lake bed is followed by the valley of the Scioto River

which flows east-southeast to Green Camp where the river has cut a narrow trench through the St. Johns moraine, thereby draining the major portion of the lake. The valley of the Little Scioto River dissects the eastern portion of the lake plain from north to south and joins the Scioto River at Green Camp. Much of the bed of glacial Lake Marion appears featureless although numerous shallow depressions 1 to 3 feet deep and as much as 0.5 mile wide are present in many places. A portion of the flat plain north of the Scioto River has been diked and flooded to provide an aquatic habitat for the Big Island Wildlife Area.

Elevations of the bed of Lake Marion range from a low of 910 feet along the Scioto valley near Green Camp to a high of about 935 feet north of La Rue. Along the east side of the lake the shoreline stood at about 919 feet, the same as the maximum elevation of Lake Marseilles. However, the ancient shoreline along the northern margin of Lake Marion as mapped exceeds 920 feet in elevation, and the elevation increases to 935 feet toward the west over a distance of about 10 miles. Most of the flat area is at an elevation of 914 to 916 feet. Although Lake Marion originally formed between the St. Johns moraine which blocked southward drainage and the retreating ice sheet which blocked drainage to the north, the elevation of the existing lake bed as mapped was controlled by the level of valley fill in the Scioto River valley near Green Camp and between Green Camp and Prospect. This outlet and possible reasons for the higher shoreline levels near LaRue will be discussed in a later section.

DRAINAGE

Modern Drainage

General Statement

Four major drainage basins containing six moderately sized streams occur in Marion County. These basins are the Olentangy River Basin in the eastern part of the county, the Scioto River Basin in the central and southwestern part of the county, and the smaller Tymochtee and Little Sandusky River Basins in the northwestern part of the county. Major drainage divides are the St. Johns moraine between the Olentangy and Scioto basins, and the Wabash moraine between the Scioto and Tymochtee-Little Sandusky basins. The headwaters of several small streams occur in the central part of the county, but the larger streams originate in areas adjacent to the county. Most of the drainage in Marion County is toward the south and is part of the Ohio River Basin. However the small part north of the Wabash moraine is toward the north and is part of the Lake Erie Basin. All of the drainage lines may be considered sluggish with mainly low discharges. Valley development has been minimal, and the maximum entrenchment by any stream into till and bedrock is about 30 feet.

Olentangy River Basin

The Olentangy River drains the eastern third of Marion County including much or all of Tully, Scott, Claridon, Ruhland, and Waldo Townships, and parts of Marion, Pleasant, and Prospect Townships (fig.4). Headwaters of the Olentangy River are in northern Morrow County, and the river flows a short distance

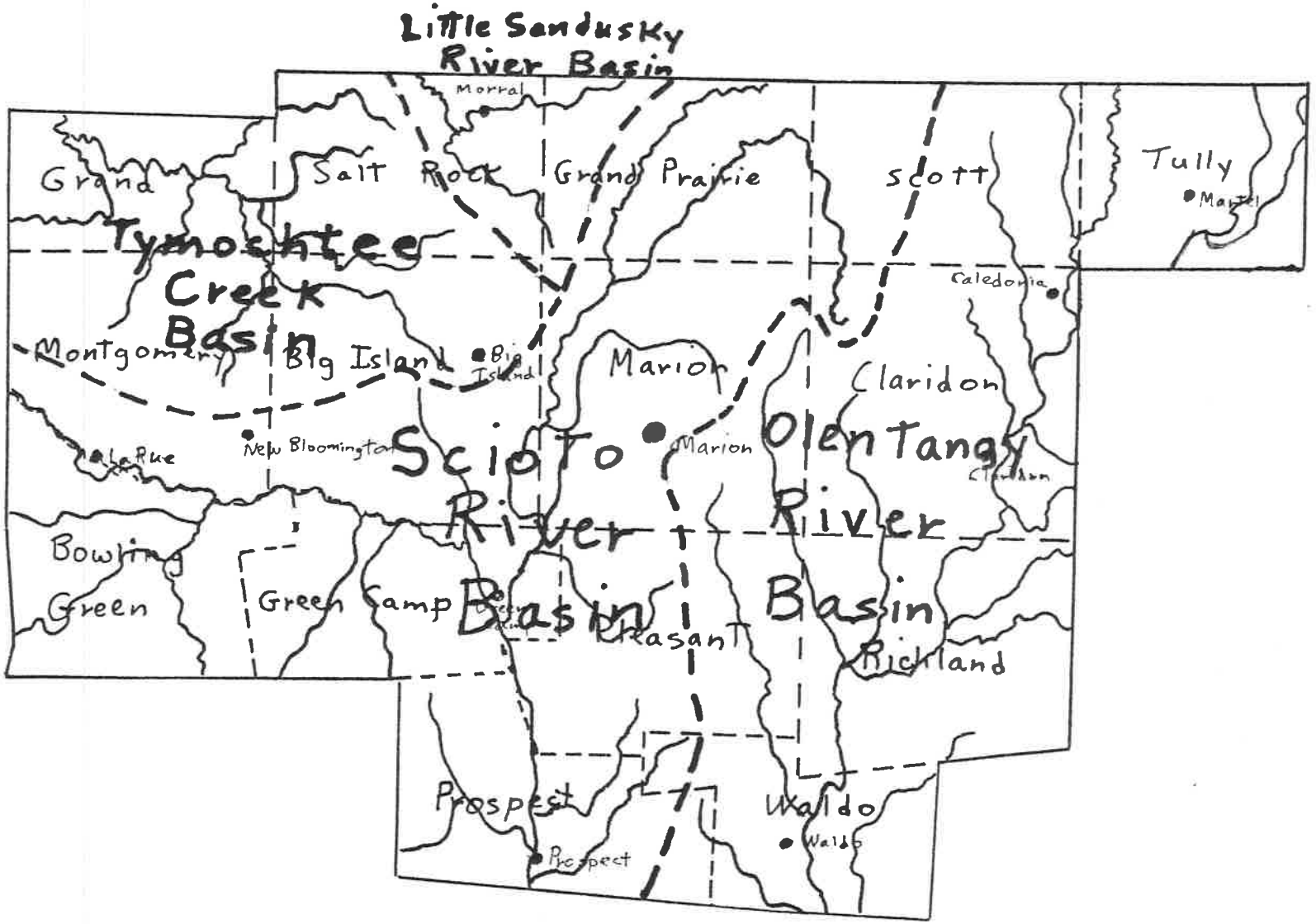


Figure 4 . Modern drainage of Marion County. Drainage divides shown by dashed lines.

north into Crawford County where it makes a sharp bend to the south. The Olentangy River enters Marion County near the Tully-Scott Township line and flows southward past Caledonia and Waldo into Delaware County. The Olentangy River meanders within a valley about 0.2 mile wide that trends southward across the till plain past Caledonia and Waldo into Delaware County. In central Richland Township the bed of the river is cut into shale. Elsewhere the bed is cut into drift.

Four major streams, Qu Qua Creek, Grave Creek, Riffle Creek, and Flat Run, are tributary to the Olentangy River in Marion County. Qu Qua Creek occupies a 0.25 mile wide valley which extends about 9 miles from Marion south-southeast to Waldo. Kame terraces on both sides of the valley increase the total valley width to 0.7 mile. Flat Run, another major tributary with a wide valley, drains eastern Tully Township and a part of northwestern Morrow County before entering the Olentangy River 0.8 mile south of Caledonia. The average gradient for the Olentangy River in the county is 3.1 feet per mile.

Scioto River Basin

The Scioto River Basin drains central and southwestern Marion County including all or part of 11 townships (fig. 4). Headwaters of the Scioto River are about 25 miles to the west of Marion County in Hardin and Auglaize counties, and the river flows eastward into Marion County where it serves as the boundary between Montgomery and Bowling Green Townships. The Scioto River meanders in a shallow valley 0.3 to 0.7 mile wide that trends eastward across the lowest part of the bed of glacial

Lake Marion. Near Green Camp the river bends southward and follows a relatively straight course into Delaware County. Between Green Camp and Prospect, a distance of 5 miles, the Scioto River is entrenched about 10 feet below the valley train outwash surface. Overall, the gradient of the Scioto River is about 1 foot per mile.

The major tributary to the Scioto River in Marion County is the Little Scioto River which drains the north-central part of the county. The Little Scioto River originates at Bucyrus in Crawford County and flows in a southwestward direction to enter Marion County near the common boundary of Grand Prairie and Scott Townships. It continues in a south-southwestward direction across central Grand Prairie and western Marion Townships where its valley follows the eastern margin of the Wabash moraine. Northwest of Marion the valley of the Little Scioto River enters the bed of glacial Lake Marion and trends generally southward near the Marion-Big Island Township line to Green Camp where it is tributary to the Scioto River. The Little Scioto River meanders within a valley that ranges in width from 0.2 to 0.4 mile, and it has a gradient of 2.6 feet per mile. In Grand Prairie Township, if the outwash terraces bordering the modern valley are considered, the total width of the valley is between 0.7 and 1 mile. Major tributaries of the Little Scioto River are Rock Fork which drains parts of Marion, Grand Prairie, Scott, and Claridon Townships north of Marion, and Honey Creek which drains northwestern Pleasant Township.

Another major tributary of the Scioto River is Rush Creek which originates southwest of Marion County in the morainic upland near Bellefontaine in Logan County. Rush Creek flows north and east from Bellefontaine across northeastern Logan County, the southeastern corner of Hardin County, and northern Union County for nearly 30 miles before it enters southwestern Marion County in Bowling Green Township. It flows northward across the St. Johns moraine for 4 miles in Marion County before it enters the Scioto River south of New Bloomington. In the short distance it flows in Bowling Green Township, it receives the tributary waters of McDonald Creek and Dudley Run, both of which originate in the St. Johns moraine in Hardin County. The other tributaries of the Scioto River in Marion County include Glade Run which drains a portion of Big Island Township, and Beaver Run, Patton Run, Davids Run, and Battle Run which drain Prospect Township.

Tymochtee Creek Basin

The Tymochtee Creek Basin drains northwestern Marion County including Grand Township and major portions of Salt Rock, Montgomery, and Big Island Townships (fig. 4). The southern boundary of the drainage basin is the Wabash moraine. Tymochtee Creek heads in the morainic knolls near Big Island and flows northwestward through the small "trench" cut through the moraine by a torrent that spilled over the morainic dam from glacial Lake Marseilles. Ironically, the direction of flow of modern drainage through the trench is opposite to the former flow of glacial floodwaters. Tymochtee Creek flows north-northwestward

past Meeker into Grand Township where it wanders rather aimlessly toward the northwest before entering Wyandot County near Marseilles. Tymochtee Creek is entrenched as much as 20 feet into till and thin lake deposits in Grand Township. Three sizable streams, Enoch Creek, Pawpaw Run, and Little Tymochtee Creek are tributary to Tymochtee Creek in Grand Township.

Little Sandusky River Basin

The Little Sandusky River Basin drains a small part of eastern Salt Rock Township and western Grand Prairie Township (fig. 4). From its headwaters along the west edge of the Wabash moraine, Little Sandusky River flows westward across the bed of glacial Lake Marseilles past Morral into Salt Rock Township. A short distance west of Morral the Little Sandusky River makes a sharp bend and flows northward into Wyandot County.

Pleistocene Drainage Systems

Relatively little evidence of pre-Pleistocene and Pleistocence drainage lines remains in the form of buried valleys in Marion County. It is almost certain that preglacial valleys in the county have been removed by glacial scour, and likewise some interglacial valleys may also have been obliterated by glacial erosion. White (1934) presented evidence for a major preglacial divide which extended in an east-west direction across north-central Ohio, but he was of the opinion that the preglacial valleys were at higher elevations than at present. White's (1934) interpretation suggests that the system of buried valleys present in north-central Ohio originated in the Pleistocene, and is not a preglacial system.

Water well records indicate the presence of two small buried valley systems in Marion County, both of which are closely followed by modern valleys. One buried valley system is followed by the Olentangy River in eastern Marion County. The other is followed by the Scioto River from Green Camp southward to the Marion-Delaware County line. Both buried valleys appear to be narrow and relatively shallow, and their courses are not well delineated by existing well records.

BEDROCK

The bedrock underlying the drift in Marion County is composed of dolomite, limestone, and shale of Silurian and Devonian ages (fig. 5). Older rocks of Ordovician age have been encountered in the subsurface during exploratory drilling for oil and gas (fig. 6). The rocks dip gently toward the east at approximately 15 feet per mile in the eastern part of the county and approximately 7 feet per mile or less in the western part of the county.

The oldest rock unit exposed in Marion County is the Guelph Dolomite which occurs along the western margin of Grand and Montgomery Townships in the northwestern part of the county (fig. 5). The Guelph Dolomite of Silurian age is light blue to blue gray in color, and is quarried for road gravel in northwestern Grand Township.

Overlying the Guelph Dolomite is the Bass Island Group which consists of the Greenfield, Tymochtee, and Put-in-Bay formations, all of which are composed of dolomite. These formations are undifferentiated in Marion County where they occur in the western part of the county (fig. 5). The Put-in-Bay Formation of Silurian age is encountered in shallow excavations in the village of Prospect, and Stout (1941) described a Put-in-Bay exposure of 11 feet of thin bedded dolomite and some thin shale at Prospect Dam on the Scioto River.

Lying unconformably above the Bass Island Group is the Columbus Limestone of Devonian age. The Columbus Limestone is a massive gray fossiliferous stone which was sufficiently

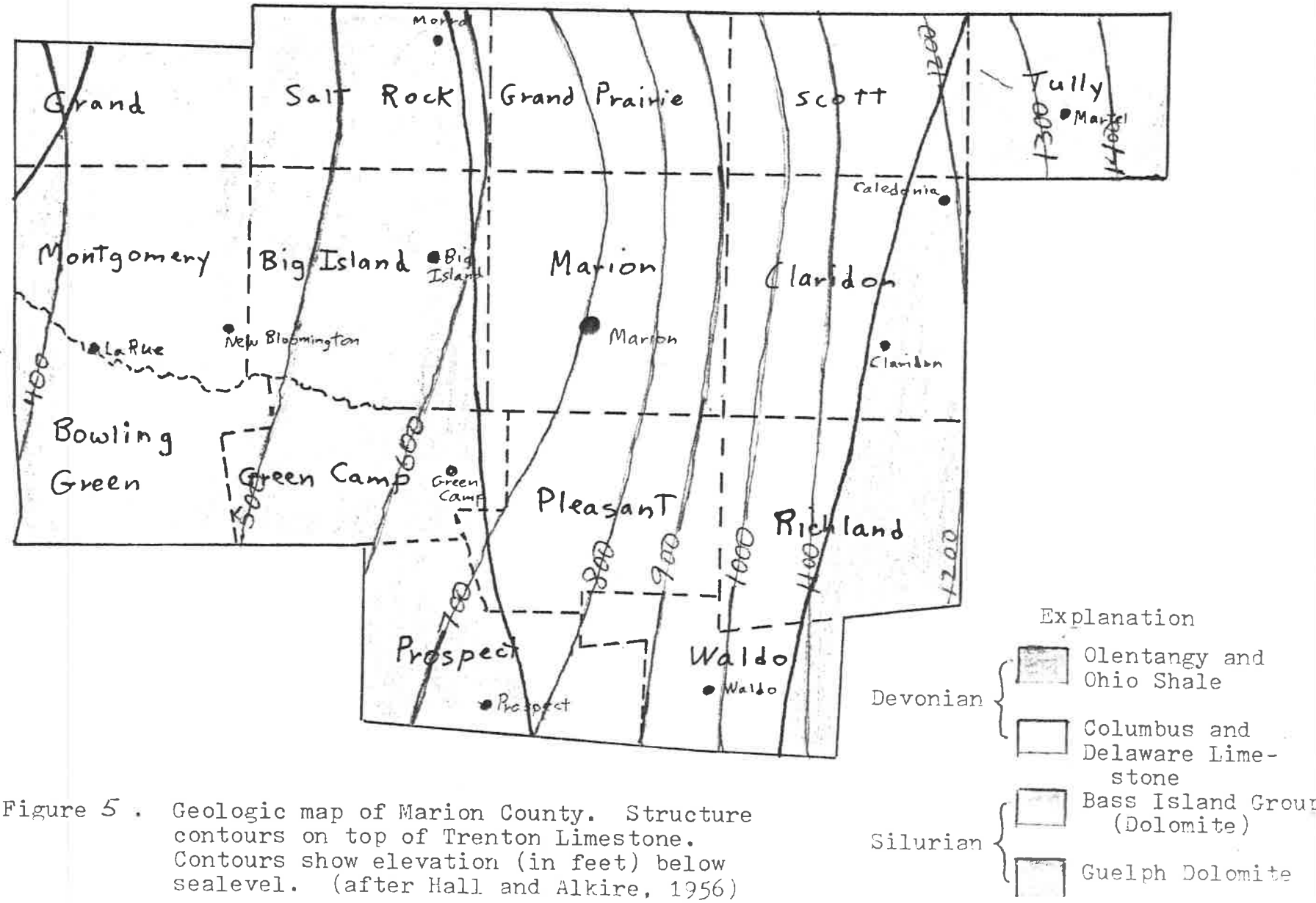


Figure 5 . Geologic map of Marion County. Structure contours on top of Trenton Limestone. Contours show elevation (in feet) below sealevel. (after Hall and Alkire, 1956)

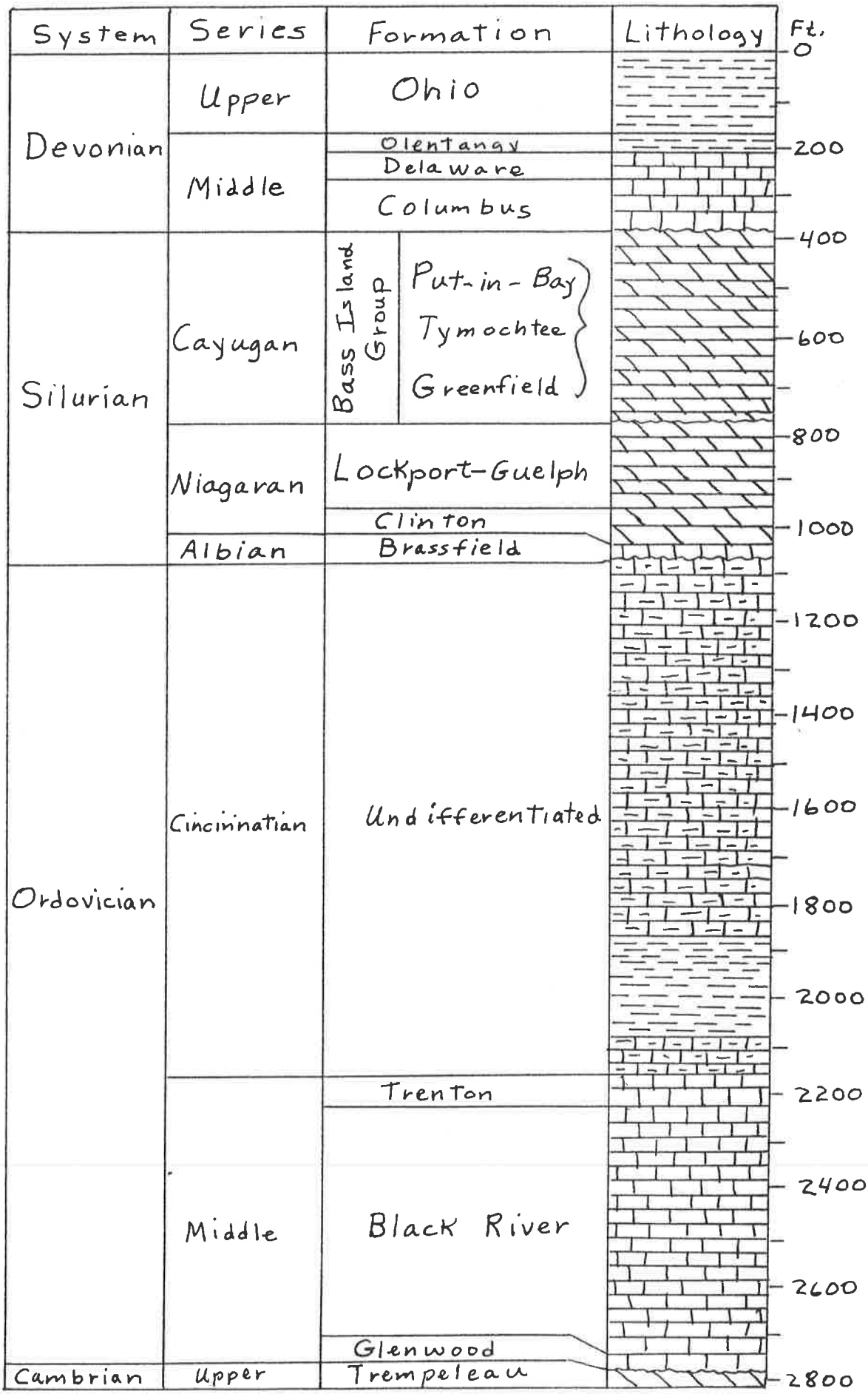


Figure 6. Stratigraphic column of Marion County (after Hall and Alkire, 1956; Shearrow, 1957)

resistant to glacial scour to form a prominent 100 foot escarpment (fig.3) which trends north-south through the center of the county. In Marion County the Columbus Limestone crops out (beneath a thin covering of drift) in a narrow 5 mile wide belt through Grand Prairie, Marion, Pleasant, and eastern Prospect townships. At least 8 quarries, two of which are still active, have operated in this limestone belt in Marion County.

Above the Columbus Limestone is the Delaware Limestone which crops out (beneath glacial drift) in a narrow 2 to 5 mile belt in Scott, Claridon, western Richland, eastern Pleasant, and Waldo townships (Hall and Alkire, 1956). Stout (1941) reported an occurrence of 24 feet of dark blue, hard, dense, cherty, fossiliferous Delaware Limestone in a quarry next to the Olentangy River in southwestern Richland Township. Stauffer (1909) reported the occurrence of 31 feet of blue Delaware Limestone overlying 42 feet of Columbus Limestone in one of the quarries near Marion. The maximum thickness of Delaware Limestone is estimated to be about 40 feet (Hall and Alkire, 1956).

Overlying the Delaware Limestone is the Olentangy Shale (fig. 6) which occurs in the eastern part of the county. The Olentangy Shale typically is a blue-gray silicious shale about 30 feet thick which is poorly exposed in Marion County. Shale exposed in the bed of the Olentangy River in central Richland Township constitutes the only known exposures of the Olentangy in the county.

The youngest rock unit in Marion County is the black to gray Ohio Shale which occurs along the eastern margin of the county. The best exposure of the Ohio Shale is in the large

shale quarry in southeastern Tully Township in the northeastern corner of the county where the shale is used in the manufacture of bricks. The total thickness of Ohio Shale in Marion County is estimated at about 160 feet.

Sedimentary rocks older than the Guelph Dolomite occur at depth in Marion County where thy have been encountered in drilling wells for oil and gas (fig. 6). These older rocks of Ordovician and Silurian age consist of limestone, shale, and dolomite and total about 1885 feet. The greatest thickness of rock penetrated in a well in Marion County is 2893 feet (Hall and Alkire, 1956), which probably represents nearly the maximum thickness of sedimentary rock overlying the Precambrian basement in the county.

DRIFT THICKNESS

The thickness of glacial materials (drift) overlying the bedrock in Marion County ranges from a couple of feet to over 100 feet (fig. 7), and the average drift thickness is 49 feet. In general, the thinnest drift in the county (< 20 feet thick) occurs in a north-south belt east of and along the top of the Columbus Limestone escarpment. Townships covered with thin drift include central Grand Prairie and central Marion, northwestern Waldo, and the eastern half of Prospect. Small patches of thin drift also occur in several other townships, primarily in Richland and Pleasant Townships where streams have removed some of the drift. Thin drift covers about 8 percent of the county.

The thickest drift in Marion County, 50 to 100 feet thick or more (fig. 7), occurs in the areas of end moraine and along the west edge of the escarpment. Every township contains at least small areas of thick drift with Scott and Montgomery townships having the largest concentrations of thick drift. Thick drift covers about 38 percent of the county.

Drift of moderate thickness (20 to 50 feet) occurs in all townships, and represents mainly areas of till plain and lake plain. Townships dominated by drift of moderate thickness include Richland, Waldo, and PLeasant. About 54 percent of the county is covered with drift of moderate thickness.

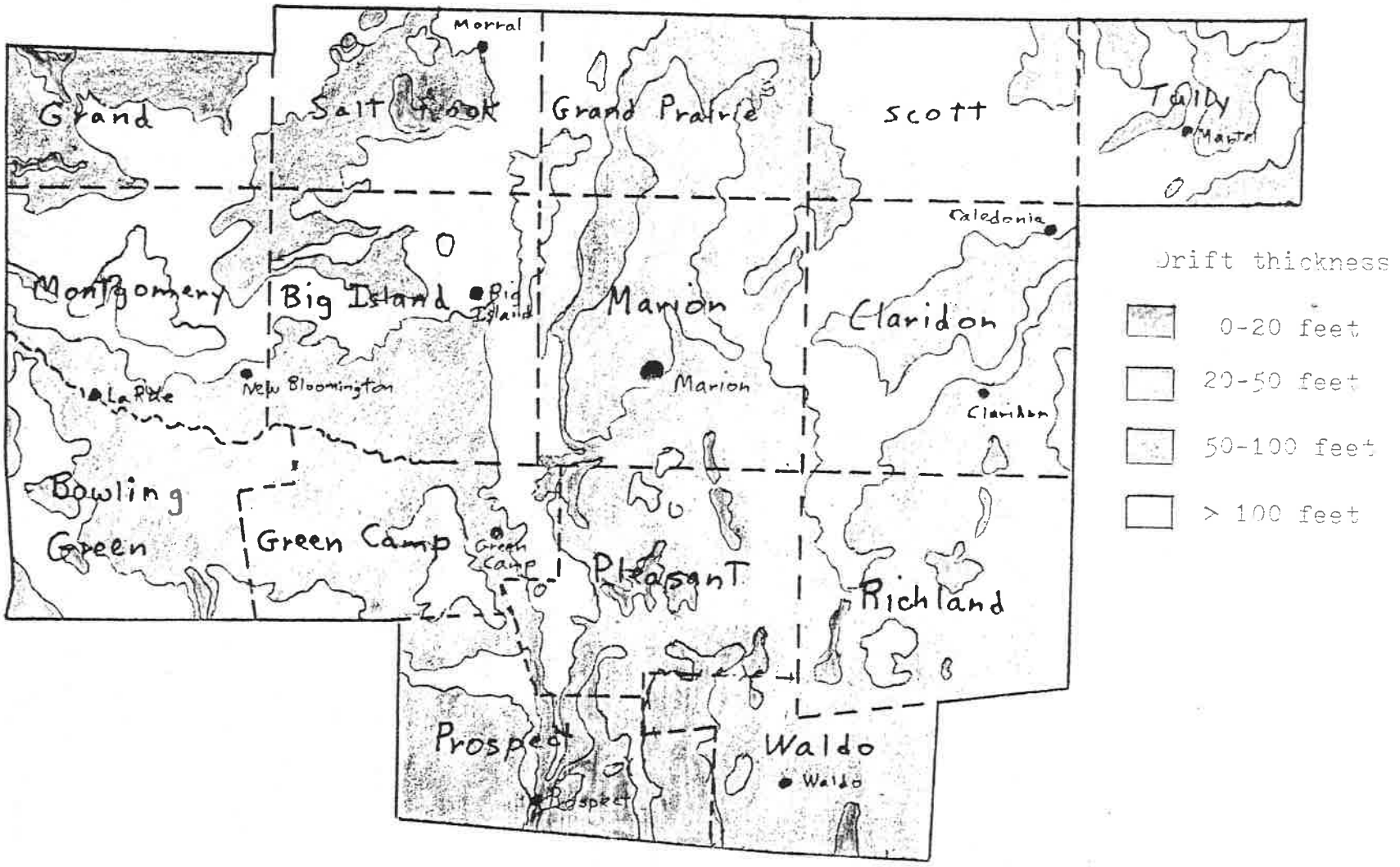


Figure 7. Drift thickness map of Marion County (based on map prepared by Joel Vormelker)

GLACIAL EROSION

Glaciers moving southward across Marion County most likely scoured the bedrock surface several times, removing an undetermined thickness of regolith and rock. Glacial erosion probably was at a maximum in western Marion County in the center of the Scioto lobe (fig. 3) where ice was thickest and the rate of flow was greatest. The lower elevation of the present bedrock surface in western Marion County compared with higher elevations of bedrock in eastern Morrow County (fig. 3) seem to support this conclusion.

The amount of bedrock removed by glacial erosion in Marion County is unknown, but it may be on the order of 10 feet to several tens of feet based on several lines of evidence. First, the preglacial regolith (soil) which may have been quite thick, has been stripped in its entirety, presumably by glaciers. Another line of evidence for erosion is the complete lack of karst and other solutional features in the Columbus Limestone. At several places along the top of the escarpment the Columbus Limestone is exposed in extensive quarry sections beneath a thin covering of till. At no place was any evidence of solutioning seen in the limestone which has most of the characteristics required for optimum development of karst. A third line of evidence for erosion is topographic. Most likely the preglacial topography was moderately rolling to hilly with considerable valley development. The present bedrock surface in Marion County exhibits only slight relief and has the appearance of a glacially scoured

surface (fig. 3). The fourth line of evidence favoring extensive glacial erosion is the lack of glacial deposits older than Millbrook in the county. Evidently any pre-Wisconsinan drift deposited in the county was removed during subsequent glacial advances.

TILL DEPOSITS

All of the glacial deposits at the surface and in shallow to deep cuts in Marion County are of the Wisconsinan Stage, the latest stage in glacial history (table 1). It is possible that pre-Wisconsin deposits occur buried beneath Wisconsinan deposits, primarily in buried valleys. Buried Pre-Wisconsinan drift may also occur in favorable areas at the base of the Columbus Limestone escarpment, particularly in those places where drift thickness exceeds 100 feet.

Deposits of several advances of Wisconsinan ice are sufficiently distinctive to be separated in the exposures where they may be seen. It is to be expected that, in any large exposure showing considerable thickness of glacial material, the glacial material will have been deposited by more than one ice advance and will differ more or less in character. The till deposited by each ice advance often is very thin. The last ice advance into Marion County, ice that deposited the Hiram Till, covered all of the county. Yet the Hiram Till is thin or non-existent at many places so that the uppermost recognizable till is not Hiram, but the earlier Hayesville Till. At places where the Hayesville Till is very thin, even earlier till may be evident at or very close to the surface. The thickest till is found in the belts of end moraine and the thinnest till occurs in the ground moraine areas of the Till Plain (Plate 1).

Table I. Classification of glacial deposits in Marion County

	Stage	Substage	Unit or Interval		Material	Approximate dates (Years BP)
Pleistocene	Wisconsinan	Woodfordian	Postglacial		Alluvium, loess, peat, lacustrine silt and clay	
			Late glacial			15,200
			Hiram Till		Dark brown clayey silty till	17,000
			Hayesville Till		Dark brown and yellowish brown silty clayey till	19,500
			Navarre Till		Yellow brown silty till	23,000
		Farmdalian	Ice retreat		Stones and gravel	33,000(?)
		Altonian	Millbrook Till (several units)	A	Yellow brown, olive brown, and very dark gray brown compact, firm stony till; sand and gravel lenses	
				B I		
				B II		
				B III		40,000
	Pre-Wisconsinan		Lower units unknown		No Pre-Wisconsinan material known. Possible till, outwash and alluvium in buried valleys	(75,000?)

Character and Composition of the Till

General Statement

The various tills in north-central Ohio may be distinguished from one another by using several criteria including texture, composition, color, and weathering horizons. These characters are dealt with in more or less detail in several publications describing the glacial geology of Richland County (Totten, 1973), Wayne County (White, 1967), and Ashland County (White, 1977) to name just a few.

Texture

Tills in north-central Ohio range from silty sandy tills with relatively low clay content to clayey, silty tills with a low sand content. The texture (grain size) of each till is reasonable constant. The tills at the surface in Marion County are clayey or silty, but some relatively sandy till occurs in places in the subsurface below the fine grained tills.

Mineral Composition

Tills differ in content of quartz, feldspar, carbonate, and clay minerals. The carbonate content, including the calcite/dolomite ratios, has proven useful in identifying certain till units, particularly the Millbrook units. Mineral content of tills are included in Appendix A.

Color

The color of till is a subtle but useful physical characteristic in till identification. At every thick till section two dominant colors may be seen: brown where oxidized at the surface and gray where unaltered at depth, the boundary between the colors commonly being 6 to 10 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 relatively consistent. The oxidized tills at the surface of Marion County are generally dark brown, tending toward chocolate brown, whereas the older subsurface tills have weathered yellow brown or olive brown. In the till descriptions, colors are recorded according to hue, value, and chroma as shown on a standard Munsell color chart.

Weathering Horizons

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

Horizon 5 is the unaltered till in which the iron minerals have not been altered. On drillers' and engineers' records this horizon is sometimes called "blue clay with stones", but the color is some shade of gray rather than blue. Its top is usually 6 to 10 feet below the surface. In Marion

County gray till may be seen in the lower parts of deep highway cuts, in gravel pit excavations, and in the cliff sections along major streams.

Horizon 4 is calcareous till similar to that of Horizon 5 except it has been oxidized to a brown color. The top of horizon 4 is also the depth of leaching, which ranges from about 20 to 70 inches and averages 31 inches in Marion County (fig. 8). In places carbonates leached from horizon 3 are reprecipitated along joints and partings in this horizon to form gray zones of secondary carbonate.

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

Horizon 2 (essentially the B3 horizon of soil scientists) is the zone of decomposed till underlying the main part of the true soil. The horizon is not only oxidized and leached, but some of the pebbles and granules may have been decomposed. Some clay material has accumulated in the joints, and soil-forming processes are advanced. The material is not so completely weathered, however, that it cannot be identified as once having been till. The color of the upper part generally is a mixture of buff, gray, and brown. The lower part may have dark stains along the joints.

Horizon 1 is the soil, divided into the A and upper B soil horizons of pedologists. The characteristics of the soil differ with drainage and slope, as well as with parent material. The soils of Marion County are dealt with in great detail in a report containing detailed soils maps (Miller and Martin, in preparation)(fig. 9).

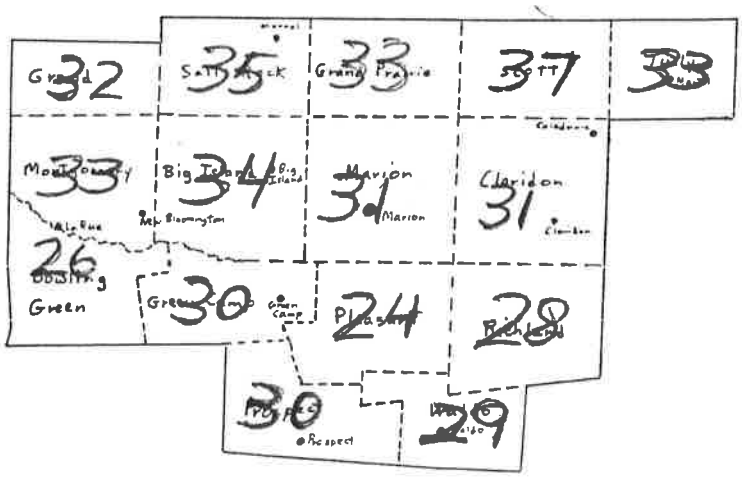


Figure 8. Average depth of leaching in inches (by township)

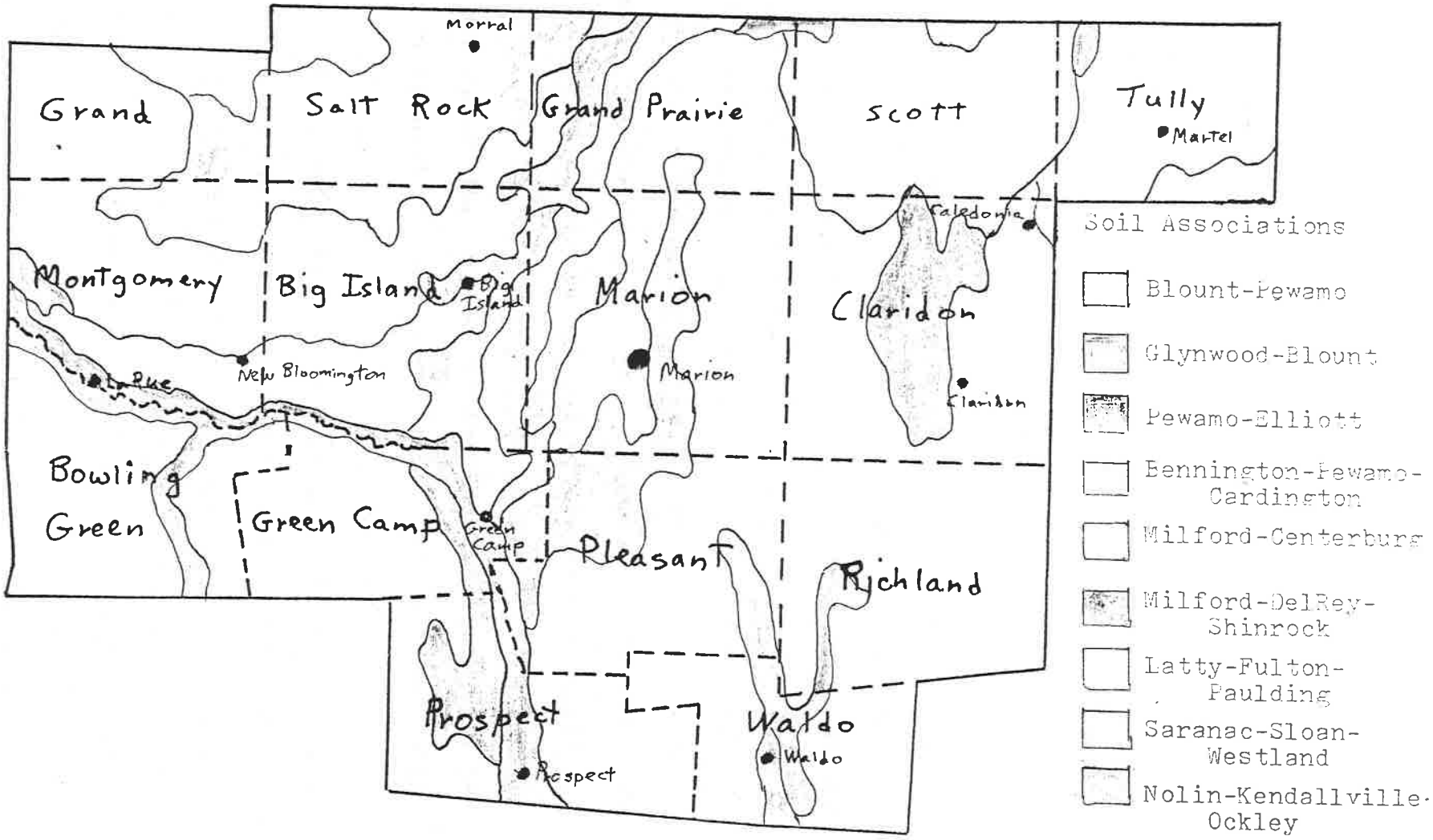


Figure 9. Generalized soil map of Marion County (after Miller and Martin, in preparation)

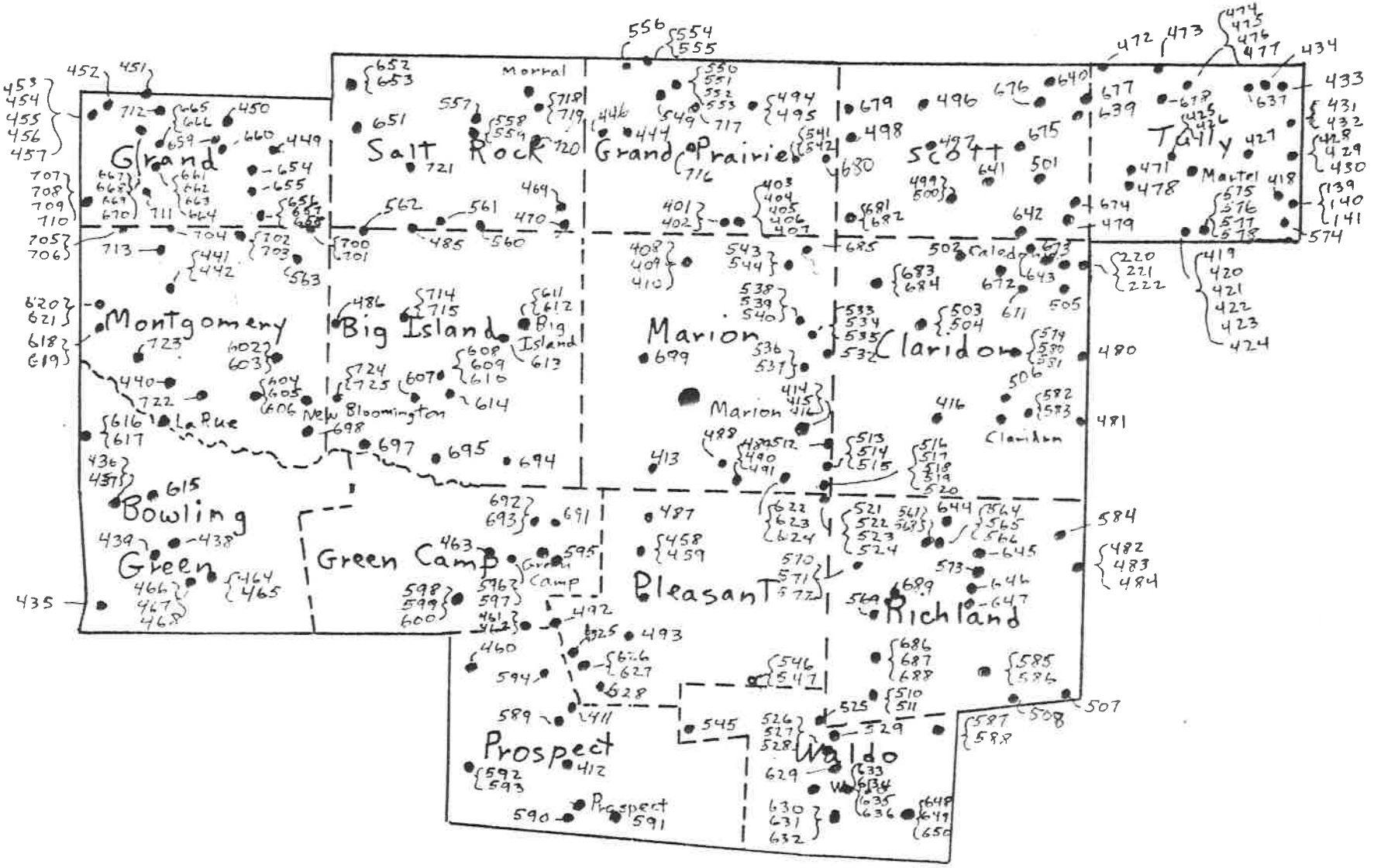


Figure 10 . Marion County sample localities

Millbrook Till

The Millbrook Till was named for a village in Wayne County by White (1961) who traced the deposit across Wayne and Ashland counties (White, 1967,1977) mainly as a subsurface unit. Totten traced the Millbrook Till across Richland County and named its correlative in the Scioto Lobe the Jelloway Till. The Killbuck Lobe tills of Richland County exhibit very similar physical properties and only subtle changes as they are traced southward and westward into the Scioto Lobe, Thus Killbuck Lobe terminology also is applied to the tills of Marion County in the Scioto Lobe. Totten has traced the Millbrook Till across Crawford and Morrow counties into Marion County where it occurs in the subsurface beneath Hiram, Hayesville, and Navarre Tills. Because of its stratigraphic position beneath the younger tills, the Millbrook Till is exposed only in deep excavations and in stream cuts. Still rarer are the places where a thick or complete Millbrook section can be seen. The thickest exposure of Millbrook Till in the county is 15 feet, and it is probable that Millbrook Till extends downward to bedrock in most places. The average thickness of Millbrook Till is estimated to be 39 feet, which is 10 feet less than the average drift thickness for the county. Where the Millbrook Till occurs in deep cuts, it occurs at an average depth of 7 feet. This depth is a minimum figure, and it is estimated that the average depth to the Millbrook Till (and the average thickness of Woodfordian drift) is nearer to 10 feet in Marion County.

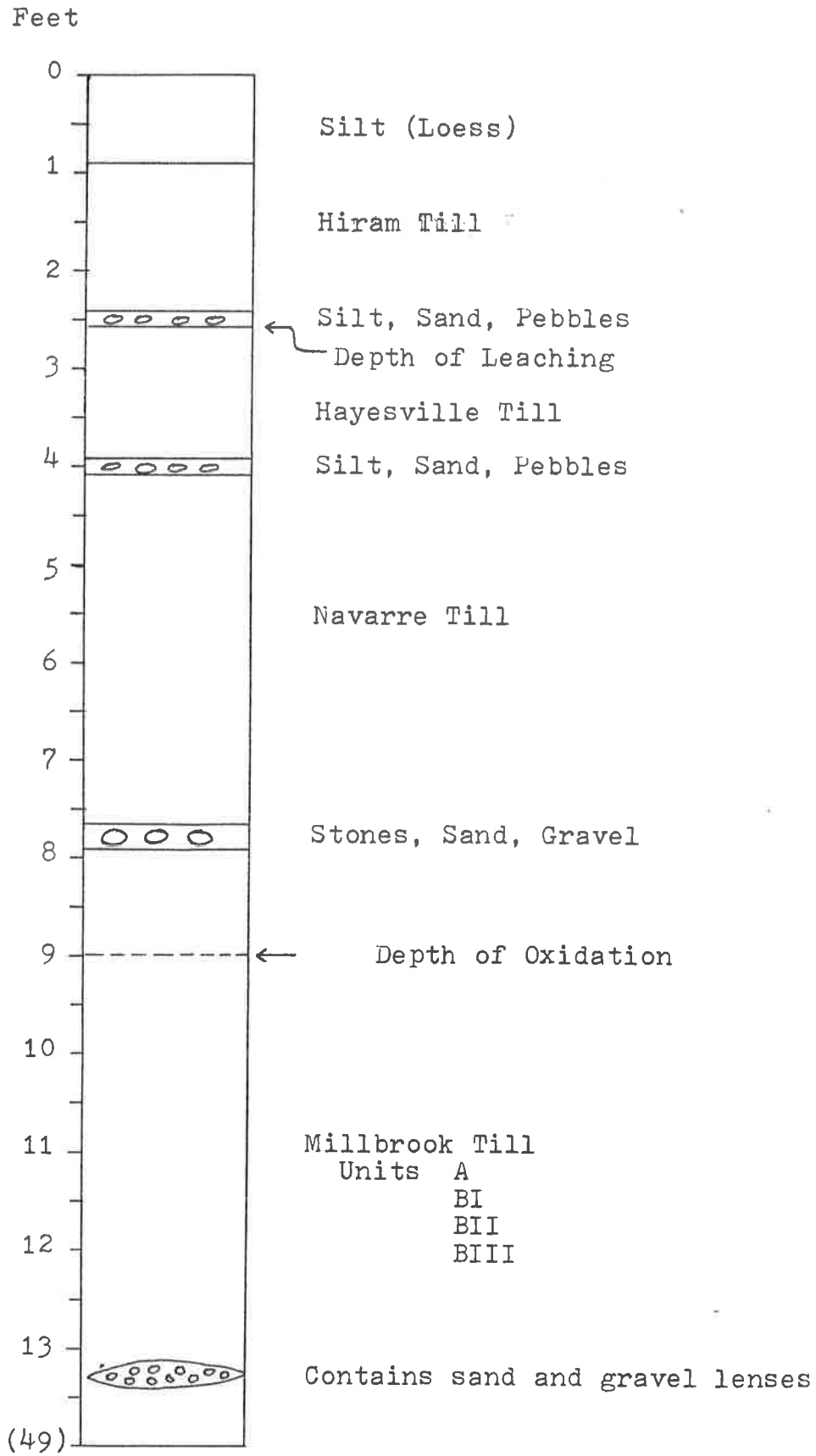


Figure 11 . Profile showing average thickness of drift units in Marion County

Millbrook Till may be recognized by its dense, firm, compact habit and its pebbly, stony texture. Typical Millbrook Till is considerably more dense and compact than the overlying Woodfordian tills. Millbrook Till commonly exhibits gray, reddish brown, or black stains along prominent joints and in pebble molds. These rusty joints commonly extend downward a short distance below the zone of oxidation into the gray unoxidized till. The firm Millbrook Till may be broken with difficulty, and the till breaks around pebbles and stones in such a way to preserve perfectly the pebble shapes as molds.

Millbrook Till oxidizes to various shades of brown, generally olive brown (2.54 4/4) or yellow brown (10YR 4/4). Unoxidized Millbrook Till exhibits a gray brown color, most frequently very dark gray brown (10YR 3/2).

In Marion County Millbrook Till is divided into four units based on carbonate composition, stratigraphic position, and the occurrence of stones, sand, and gravel between units. These four units, designated from top to bottom A, BI, BII, and BIII, have similar physical characteristics and are not reliably distinguished from each other in the field. They are best subdivided by carbonate composition.

The lowermost Millbrook unit, BIII, is characterized by a low calcite content which averages 2.2 percent and a moderately high carbonate content which averages 15.7 percent (Table 2). The calcite/dolomite ratio averages a low 0.16. Unit BIII is a silty till, with an average sand content of 30.9 percent and an average clay content of 22.5 percent (Table 2). This unit was recorded in only two places in the southeastern part of the county. The best exposure of BIII till is in an eroded drainage ditch on the east side of the

Table 2. Statistical data of till and lacustrine sample analyses for Marion County

Unit		No. of Samples	Sand Mean	Sand SD	Silt Mean	Silt SD	Clay Mean	Clay SD	Calcite Mean	Calcite SD	Dolomite Mean	Dolomite SD	Total Carbonate Mean	Total Carbonate SD	Calcite/Dolomite
Lacustrine		27	5.4	6.1	35.8	13.8	58.8	15.0	5.6	1.9	7.4	1.3	13.0	2.8	.76
Hiram		27	16.8	4.7	41.6	9.6	41.6	10.3	6.1	2.1	11.2	2.6	17.3	3.3	.54
Hayesville		94	20.5	4.7	41.6	6.5	37.9	7.1	5.5	2.1	11.7	3.0	17.2	3.9	.47
Navarre		100	24.9	5.0	43.2	6.8	31.9	7.7	5.3	2.5	13.3	3.6	18.6	5.2	.40
Millbrook	A	28	22.0	4.8	43.4	7.5	34.6	9.8	5.5	1.3	13.4	3.1	18.9	4.3	.41
	BI	15	31.9	6.7	38.4	7.0	29.7	8.0	0.3	0.6	8.3	2.0	9.6	2.0	.04
	BII	6	23.1	7.5	45.4	8.4	31.5	10.0	6.9	1.3	18.6	2.8	25.5	2.2	.37
	BIII	3	30.9	7.1	46.6	2.1	22.5	5.1	2.2	1.0	13.5	2.9	15.7	3.9	.16

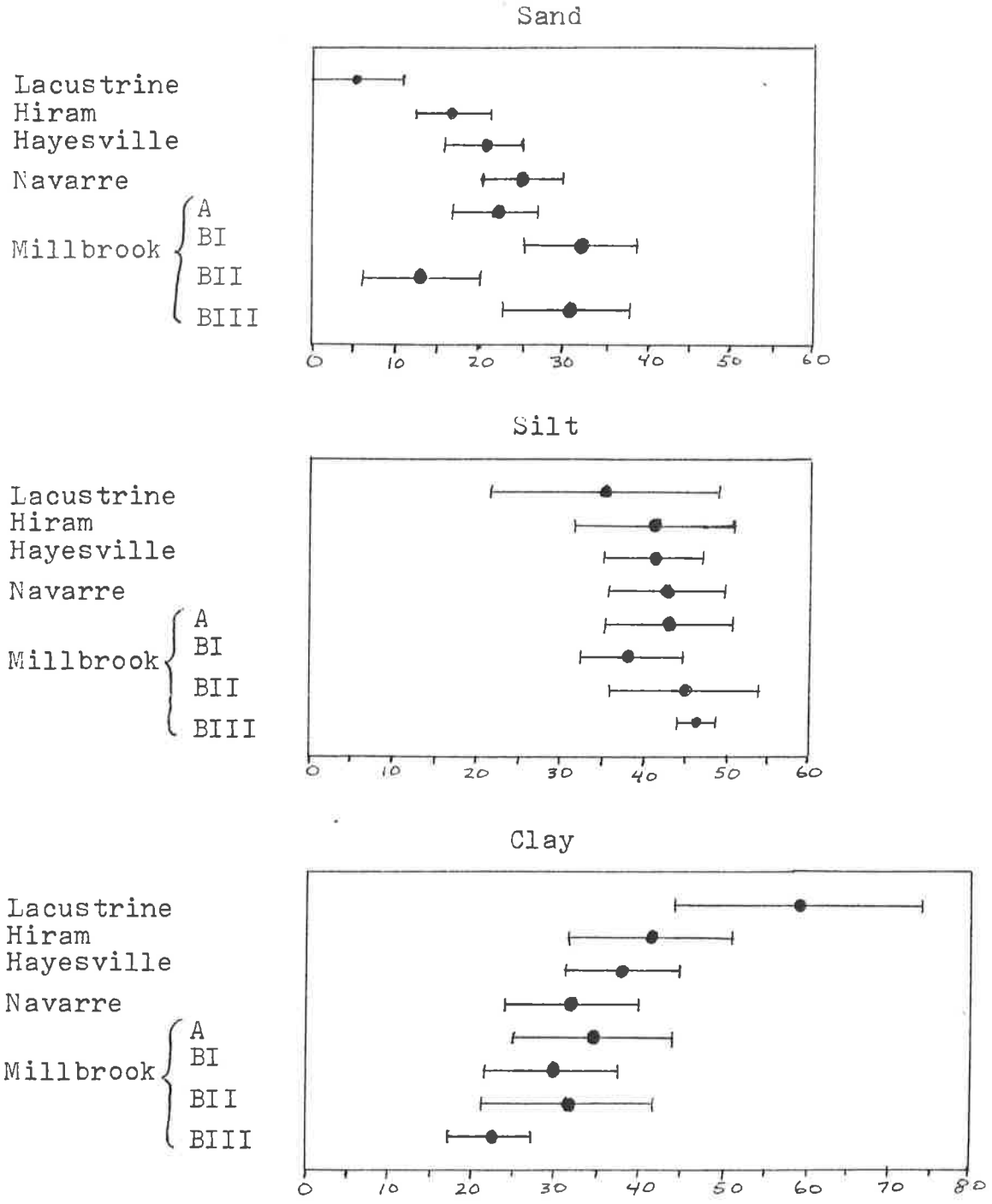


Figure 12.. Plot of means (solid circles) and standard deviations (solid lines) of sand, silt, and clay percentages of Marion County till units

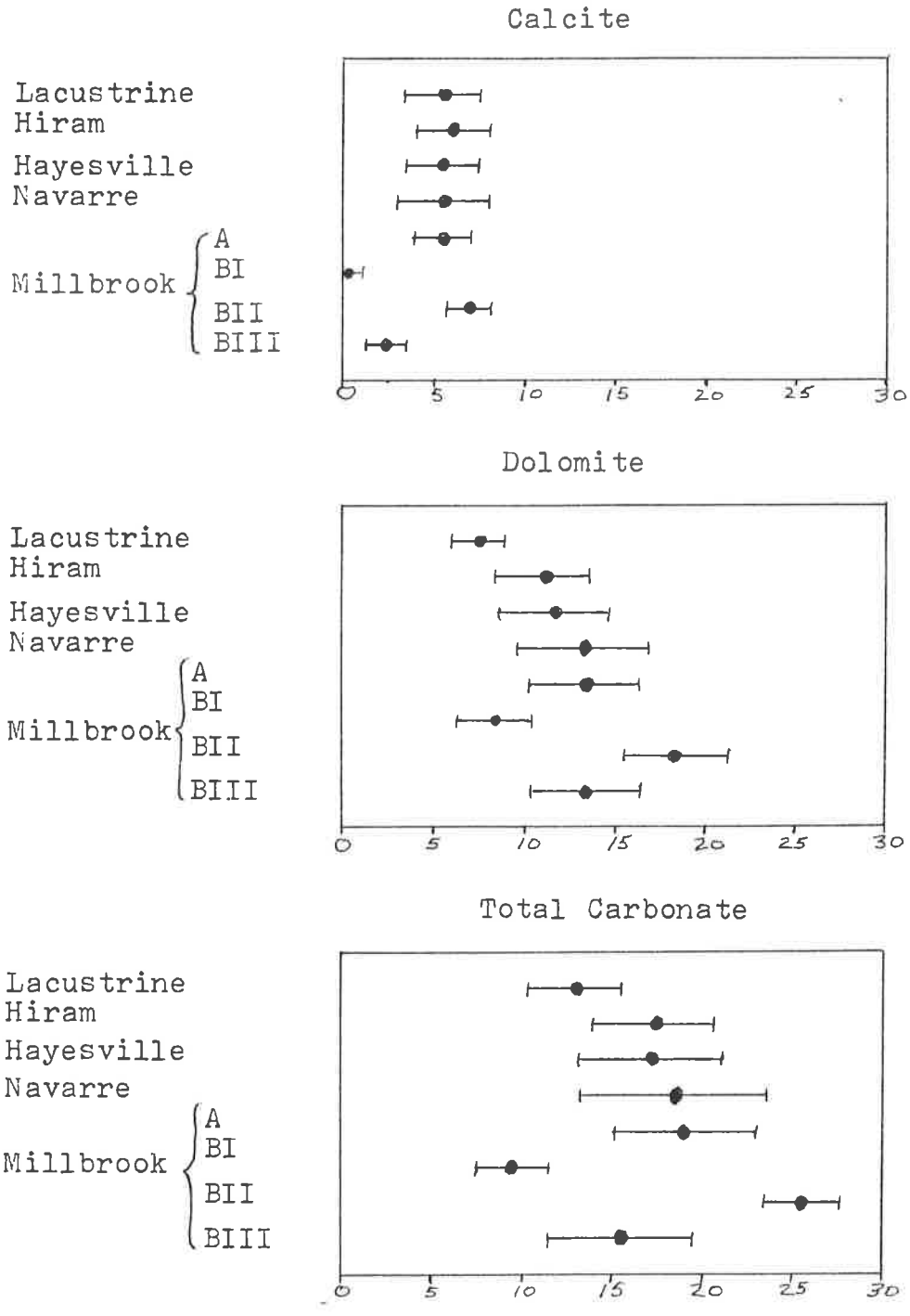


Figure 13. Plot of means (solid circles) and standard deviations (solid lines) of carbonate percentages of Marion County till units

Olentangy River east of Waldo. At this locality 10 feet of BIII till were exposed, and the 8 feet of covered drift below the exposure may also be part of unit BIII. Two slabs or sheets of BIII are present, separated by a distinct shear plane.

Unit BII is characterized by a high calcite content averaging 6.9 percent and a very high dolomite content averaging 18.6 percent (Table 2). Its average carbonate content of 25.5 percent is the highest by far of any till in the county. It is a silty till with an average clay content of 31.5 percent and an average sand content of 23.1 percent (Table 2). Unit BII was recorded at 5 localities in the eastern and northwestern parts of Marion County where it is overlain by younger Millbrook or Navarre Till. The thickest exposure of BII drift, 15 feet, is near Waldo, where the till is associated with boulders and gravel.

Unit BI is characterized by a virtual absence of calcite and a low dolomite content averaging 8.3 percent (Table 2). It has an average carbonate content of 9.6 percent which is much lower than all other till units in the county. It is a loomy till, with an average silt content of 38.4 percent, an average sand content of 31.9 percent, and an average clay content in eastern Marion County where it occurs beneath Navarre Till. This unit generally is less than 5 feet thick where present except along Flat Run in Tully Township where 15 feet of Millbrook BI Till are exposed. Two sand lenses occur within the thick exposure.

Unit A is characterized by a high calcite content averaging 5.5 percent (Table 2) and a high carbonate content averaging 18.9 percent. It is a silty till with a fairly high clay content which averages 34.6 percent and sand content which averages 22 percent. (fig. 14) The carbonate content is high in east central Marion Co. east of the Columbus escarpment, and is high in the northwestern corner of the county (fig. 15). Its sand content varies from a low of 18 in Grand Township in the northwestern corner of the county to a high of 25 percent in Richland Township in the southeastern corner of the county. Unit A is widely distributed over the county and it occurs beneath Navarre Till at most deep exposures. The depth to unoxidized Unit A till ranges from 5 to 10 feet, and averages 8 feet. Unit A is variable in thickness, ranging from 0 to more than 5 feet thick. Although deep exposures in morainic areas are lacking, it is thought that Unit A makes up the cores of the end moraines in Marion County based on exposures in nearby counties (Totten, Morrow County manuscript).

The interface between Millbrook Till and the overlying Navarre Till is marked by stones as much as 3 feet in diameter and by gravel. In places this zone resembles colluvium but no paleosol or other evidence of chemical weathering was observed in the county. Millbrook Till is the oldest till observed in Marion County. It occurs on unweathered bedrock in several places in the county; however the base of the Millbrook Till is exposed at only a few places and it is possible that older till may be present at depth.

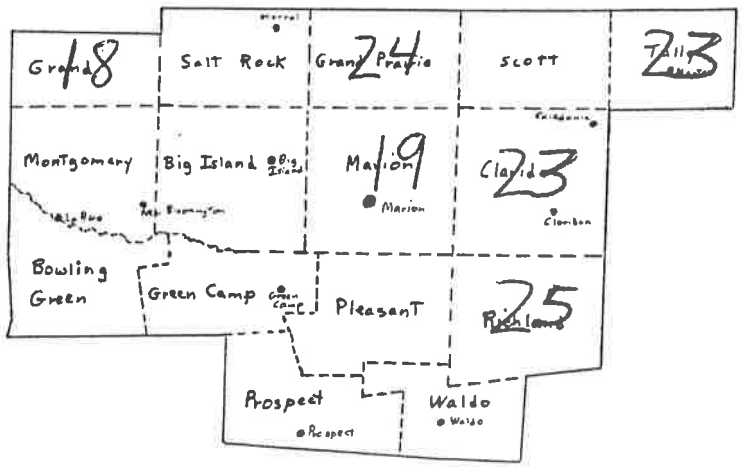


Figure 14. Distribution of sand percentages of Millbrook A Till (by township)

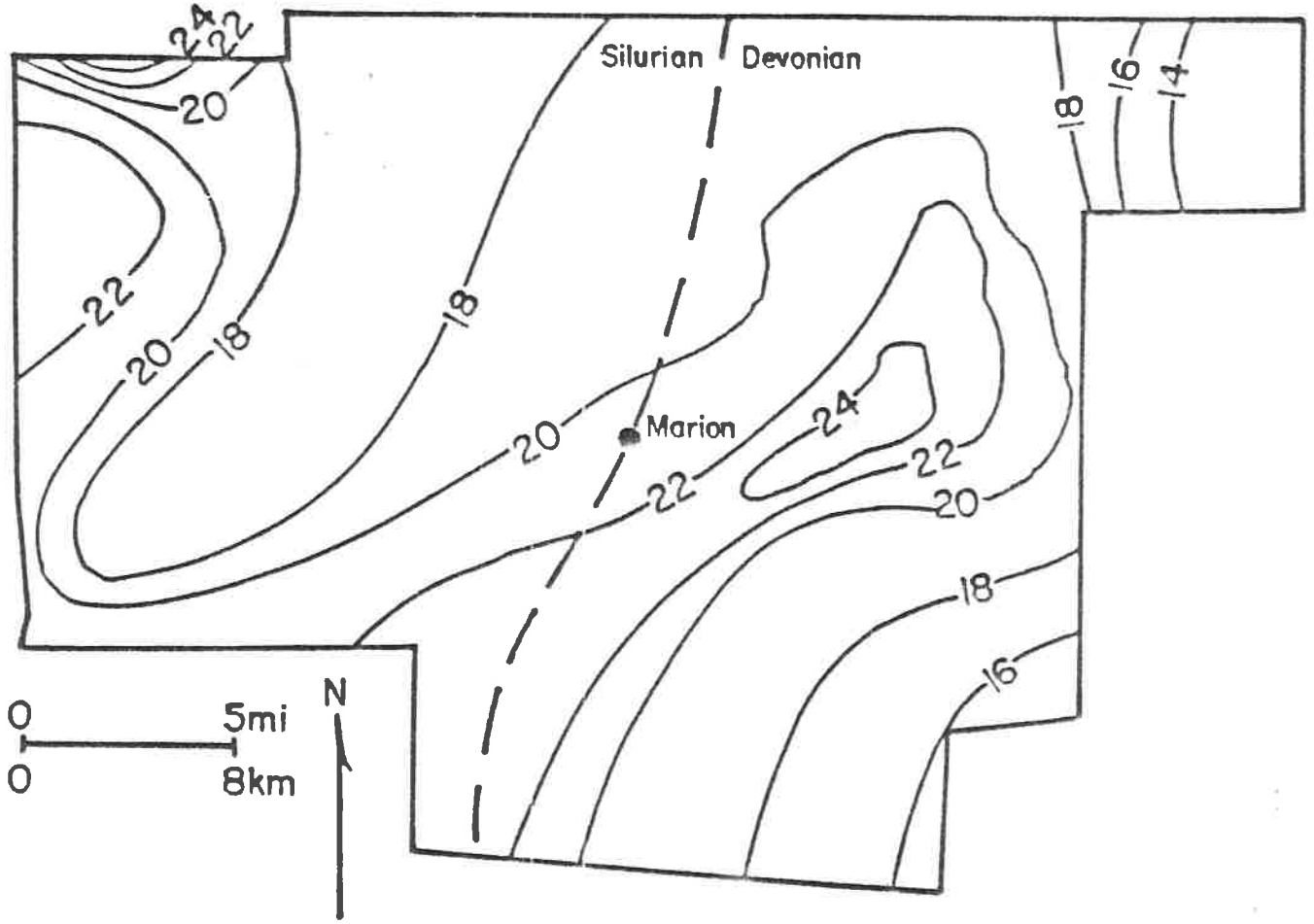


Figure 15. Distribution of carbonate percentages of Millbrook Till A

The top of the Millbrook Till in many places is characterized by a concentration of stones, silt, sand, and gravel usually 6 inches or less in thickness. The Millbrook Till and its correlatives form the bulk of the till in the moraines of north—central Ohio (Totten, 1969; White, 1982). The multiple units of Millbrook Till indicate a complex depositional history which probably includes both minor readvances during ice retreat, and thrusting of the ice near its outer margin. The Millbrook Till and its correlatives are closely associated with thick, high quality gravel deposits in many places in north—central and northeastern Ohio (White, 1982; Totten, 1973). Much of the gravel in Marion County apparently was deposited by meltwater from melting Millbrook ice.

Millbrook Till is correlative with Mogodore Till of the Cuyahoga Lobe and with Titusville Till of the Grand River Lobe (White, 1982). It is also correlative with the Jelloway Till (Totten, 1973) of the eastern margin of the Scioto Lobe. In this report, Jelloway and the younger Woodfordian till unit names formerly assigned to the Scioto Lobe have been dropped in favor of retaining the names assigned tills in the Killbuck Lobe. White, Totten, and Gross (1969) have assigned an Altonian (Middle Wisconsinan) age for Titusville Till based on several radiocarbon dates of about 40,000 years. The Millbrook Till probably is no older than 40,000 years, and it may be considerably younger.

Navarre Till

The Navarre Till, the oldest of three closely related Late Wisconsinan (Woodfordian) tills deposited in Marion County, was named by White (1961) for the village of Navarre in southwestern Stark County. This till has been traced by White (1967, 1977) at the surface and in the subsurface westward across Wayne and Ashland Counties, and by Totten (1973) who traced the till across Richland, Crawford, and Morrow Counties into Marion County.

Navarre Till is present in the subsurface beneath Hiram and Hayesville Till in all parts of Marion County. Navarre Till ranges in thickness from 24 inches to more than 108 inches and has an average thickness, where it could be measured, of 43 inches. The base of the Navarre is not seen in most roadcuts and thus the till thickness was measured in relatively few places.

Navarre Till is silty, somewhat clayey, though less clayey than most other tills in the county, and has a loose crumbly or friable structure. The till is moderately pebbly, contains a few stones, and in places contains thin silt and sand lenses which may appear as wet zones in road cuts and stream banks. The oxidized color of the till typically is dark yellow brown (10YR 4/4). In a few places where the Navarre Till is thick, unoxidized dark gray to very dark gray brown (10YR 3/1—3/2)

till occurs about 9 to 9½ feet below the surface. Weathering of the till produces distinct horizontal partings and a platy surface. A freshly broken surface usually reveals several orange "spots" which are the remains of smeared iron-rich sandstone pebbles. Bare slopes exposed to sheet wash develop a pebbly and stony surface, though not as stony as a Millbrook surface.

Analyses of Navarre Till samples (Table 2 , Appendix B) average 24.9 percent sand, 43.2 percent silt, and 31.9 percent clay. The carbonate content of Navarre Till samples averages 5.3 percent calcite, 13.3 percent dolomite, and 18.6 percent total carbonate for a calcite/dolomite ratio of 0.40. The sand content (fig. 16) generally is 20 percent or higher in the western and southern portions of the county, and is below 20 percent in the northeast.

The interface between the Navarre and the overlying Hayesville Till in most places is marked by a variable zone 1 to 8 inches thick consisting of silt, sand, gravel, and stones sufficiently numerous to be labelled a stone line.

In Tully Township in the northeastern corner of Marion County, the Navarre Till is sufficiently near to the surface to affect soil development. The Bennington-Perwamo-Cardington soil association (fig. 9) is mapped in Tully Township where the Navarre Till has a low 11 percent carbonate content (fig. 17).

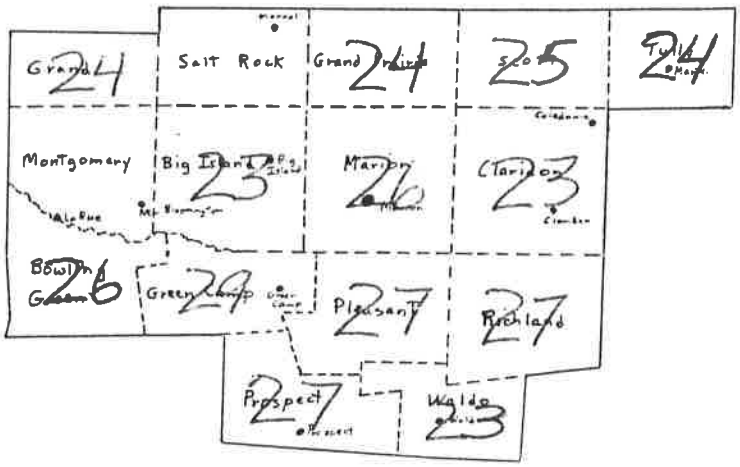


Figure 16. Distribution of sand percentages of Navarre Till (by township)

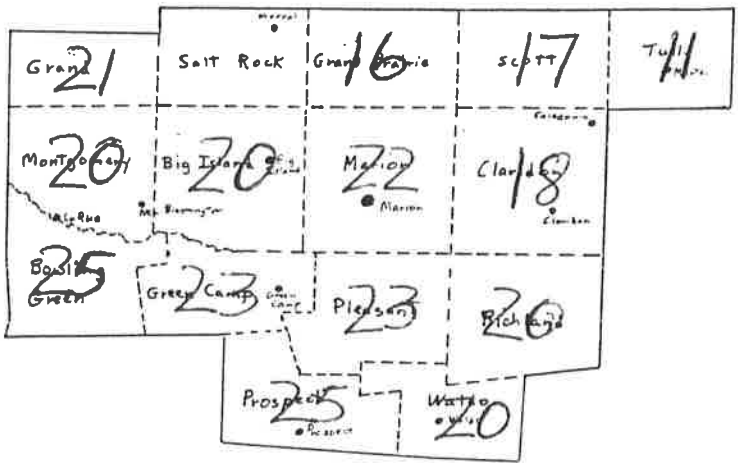


Figure 17. Distribution of carbonate percentages of Navarre Till (by township)

The Navarre Till is correlated with the Kent Till of the Grand River Lobe of northeastern Ohio which has a radiocarbon age of about 23,000 YBP (White, 1968), a date accepted as earliest Woodfordian in northern Ohio. The Navarre Till also is equivalent to the Knox Lake Till (Forsyth, 1961; Totten, 1973) of the eastern margin of the Scioto Lobe. The term "Knox Lake Till" has been dropped in favor of "Navarre Till".

Hayesville Till

The Hayesville Till was named for the village of Hayesville in southern Ashland County by White (1961) who traced the till westward and southward across Richland, Crawford, and Morrow Counties into Marion County where the till occurs widespread over the entire county beneath a thin covering of Hiram Till.

Hayesville Till ranges in thickness from 0 to at least 60 inches and has an average thickness of 16 inches. It is less than 2 feet thick nearly everywhere in the county, and is absent in several places in the eastern part of the county.

Hayesville Till is oxidized a dark brown to yellow brown (10YR 4/3—4/4), a color intermediate between the overlying Hiram Till and the Underlying *Navarre* Till. These color differences are very subtle and should be employed for till identification only with caution. Unoxidized Hayesville Till, observed at only one locality, is dark gray brown (10YR 3/3--3/2).

Hayesville Till has a silty clayey texture and is intermediate in sand, silt, and clay percentages between the Hiram and Navarre Tills. Hayesville Till samples (Table 2, Appendix B) average 20.5 percent sand, 41.6 percent silt, and 37.9 percent clay. Till samples average 5.5 percent calcite, 11.7 percent dolomite, and 17.2 percent carbonate, for a calcite/dolomite ratio of 0.47. Sand percentages of Hayesville Till (fig. 18) show slight variation across Marion County, with the highest percentages occurring in the southern part of the county. Carbonate percentages generally are highest in

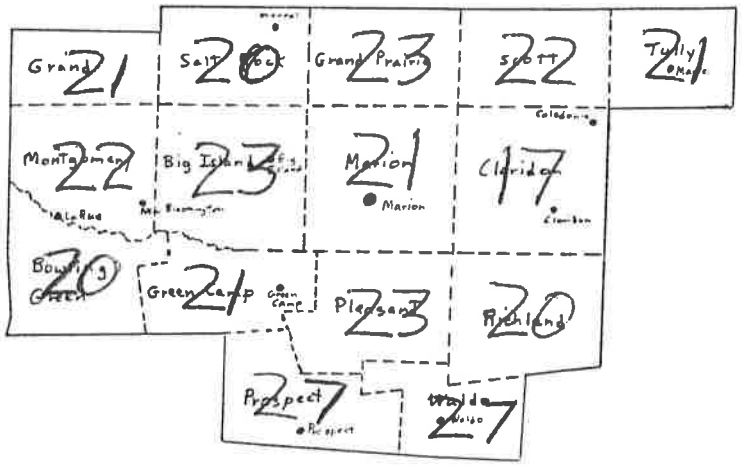


Figure 18. Distribution of sand percentages of Hayesville Till (by township)

southern Marion County and are lowest in the northeastern part of the county (fig. 19).

Hayesville Till breaks into large square to rectangular blocks on a freshly exposed surface, and a short period of exposure causes horizontal partings about ½ inch thick to develop, resulting in a platy structure and smaller blocks. The till contains a small to moderate amount of pebbles and granules which are predominately sedimentary in origin—mostly shale. The presence of granule—sized particles in nearly every small piece of Hayesville Till is one of the best ways to distinguish between Hayesville Till and the overlying Hiram Till which is almost devoid of any granular material.

Secondary carbonate in the form of small irregular calcite concretions, thin gray veining along cracks, and gray mottling is concentrated directly beneath the leached zone in Hayesville Till in many places. Leaching of carbonates from the Hayesville Till is influenced by the thickness and composition of the overlying material which may be Hiram Till, loess, and/or lacustrine silt and clay. The depth of leaching may reach 50 or more inches where material overlying Hayesville Till is thin, permeable, or absent. The average depth of leaching in the county is about 31 inches, which usually is sufficiently deep to penetrate the top of the Hayesville Till. In general, leaching depths exceed 30 inches in the northern part of the county, and are less than 30 inches in the southern part

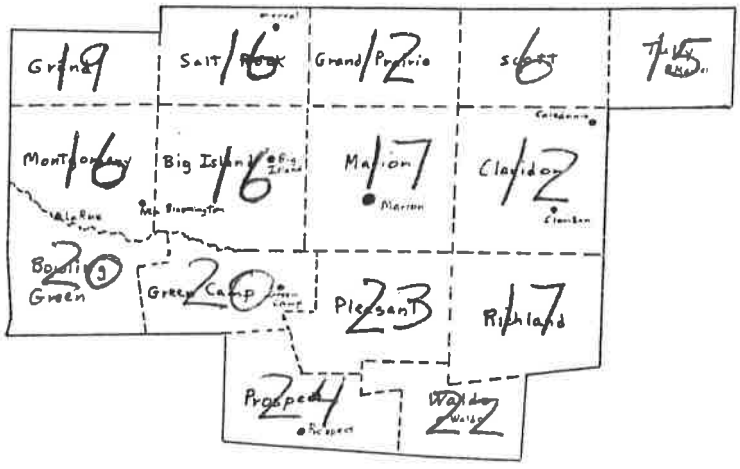


Figure 19. Distribution of carbonate percentages of Hayesville Till (by township)

(fig. 8).

The contact or interface between the Hayesville Till and the overlying Hiram Till is the most difficult till contact to detect because little if any foreign material occurs between the two tills. At most places, the contact is marked by a line of small pebbles, and in a few places, stones as large as 8 inches in diameter are present. Rarely are silt and sand layers present along this contact. In places where the two tills are in direct contact with each other, the contact may be detected by a distinct increase downward in the granule and pebble content.

Hayesville Till is sufficiently near the surface in many places to influence the development of the soil profile. The Pewamo, Blount, and Glynwood soils usually have their lower part developed in this till. The Bennington, Cardington, and Centerburg soils also are derived, wholly or in part, from Hayesville Till (Table 3).

The Hayesville Till was deposited during the Woodfordian glacial stade, and is intermediate in age between the older Navarre Till and the younger Hiram Till. Its exact age in radiocarbon years has not been determined because of the lack of datable organic material associated with the till; its estimated age is about 18,500 YBP based on its relationship to deposits of known age. The Hayesville Till is correlated with the Lavery Till of the Grand River Lobe in northeastern Ohio (White, 1982).

Hayesville Till is equivalent to the Mt. Liberty Till of the eastern margin of the Scioto Lobe (Forsyth, 1961; Totten, 1973).

Table 3 . Relationship of Soil Associations to geology

Soil Association	General Characteristics	Dominant parent materials
Blount-Pewamo	Lev l to gently sloping Poorly drained	Hiram Till Hayesville Till
Glynwood-Blount	Gentle slopes Somewhat poorly drained	Hiram Till Hayesville Till
Pewamo-Elliott	Level Very poorly drained	Hiram Till
Bennington-Pewamo-Cardington	Level to gently sloping Somewhat poorly drained	Thin Hiram and Hayesville Till Navarre Till
Milford-Centerburg	Level to gently sloping Poorly drained	Hiram ablation till Lacustrine silt and clay
Milford-Del Rey-Shinrock	Level to gently sloping Poorly drained	lacustrine silt and clay
Latty-Fulton-Paulding	Level Very poorly drained	Lacustrine clay and silt
Saranac-Sloan-Westland	Level Poorly drained	Outwash silt and clay Recent alluvium
Nolin-Kendallville-Ockley	Level to sloping Well-drained	Recent alluvium Outwash sand and gravel

Hiram Till

The Hiram Till, the youngest till in Marion County, was named for the village of Hiram in northeastern Portage County by White (1960). The Hiram Till has been traced across a wide area of northern Ohio by White (1982) into Richland County. Totten (1973) traced the Hiram Till southward and westward across Richland, Morrow, and Crawford counties into Marion County where it is at or near the surface in most places. In the lake plain regions (fig. 2) of the western part of the county, lake clay and silt as much as 11 feet thick are the near surface materials. A layer of wind—blown silt (loess) averaging 11 inches in thickness is the surface material throughout the county, but it is not particularly noticeable because soil forming processes have modified the loess and obscurred its contact with the underlying materials.

The thickness of Hiram Till ranges from 0 to more than 45 inches and averages 18 inches. The till thickness is quite consistent as over 75 percent of the 88 recorded measurements are between 12 and 22 inches.

Hiram Till is oxidized to a dark brown (10YR4/3) color, and normally is a slightly different shade of dark brown as compared to the underlying Hayesville Till. The difference in color between the Hiram and Hayesville tills is so slight as to not be a reliable criterion for distinguishing between them. Hiram Till is rich in silt and clay, has a blocky or

prismatic structure, and where calcareous has a relatively high carbonate content. Hiram Till is very sparsely pebbly, contains almost no granules, and in places may be mistaken for lacustrine clay which it closely resembles. Most of the granular material in Hiram Till consists of small chips of shale. In the subsoil, weathering of Hiram Till develops horizontal partings and a fine prismatic structure.

The depth of leaching is partly dependent on the thickness of Hiram Till. In places where leaching has not progressed through the entire thickness of Hiram Till, the leaching depth averages 26 inches. In places where Hiram Till is thin or absent, the depth of leaching in the underlying tills exceeds 30 inches.

Analyses of Hiram Till samples (Table 2, Appendix B) indicate the till averages 16.8 percent sand, 41.6 percent silt, and 41.6 percent clay. Thus Hiram Till has the lowest sand content and the highest clay content of any till in Marion County. Hiram Till samples average 6.1 percent calcite, 11.2 percent dolomite, and 17.3 percent carbonate for a calcite/dolomite ratio of 0.54. It is likely that many of the Hiram Till samples had experienced some leaching, and thus the original carbonate content probably was higher, though not necessarily much higher than measured.

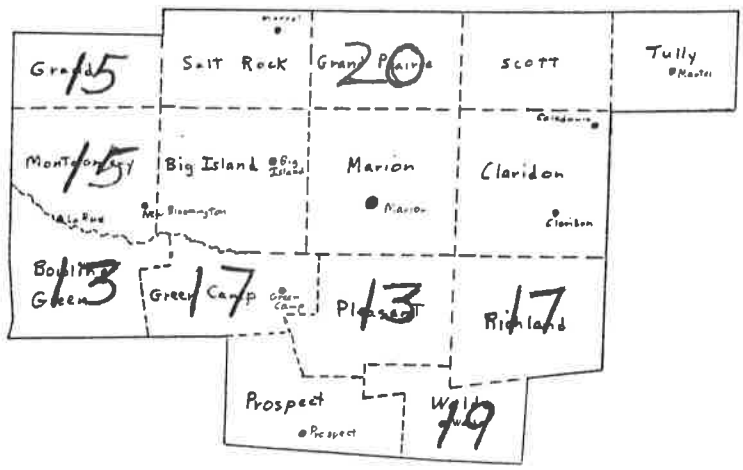


Figure 20. Distribution of sand percentages of Hiram Till (by township)

The major soil association developed in Hiram Till is the Blount—Pewamo association (fig. 9) which is very widespread across most of the county. Blount soils are somewhat poorly drained soils developed in high lime till that occur in gently sloping areas. Pewamo soils are poorly drained soils developed in high lime till that occur on nearly flat areas. A third soil commonly developed in Hiram Till is the Glynwood soil. Glynwood soils are moderately well drained soils developed in high lime tills that occur on end moraines and gentle slopes. An area including nearly all of Scott Township and the northern edge of Claridon Township has been mapped as the Milford—Centerburg soil association (fig. 9). This area consists of thin lacustrine sediment as much as 3 feet thick which was deposited in crevasses and other low areas on ablating, stagnant Hiram ice. Milford soils are developed in the lacustrine materials, which make up slightly more than 50 percent of the area, and Centerburg soils are developed in the Hiram and underlying tills. The thick, widespread glacial lake sediments deposited on top of Hiram Till in the western part of the county are described in another section. At many places in the county not mentioned above, numerous shallow depressions existed on the Hiram Till surface following deglaciation, and many are wholly or partially filled with lacustrine sediments such as clay, silt, and peat. Wind blown silt (loess) forms a silt cap averaging 11 inches on top of the Hiram Till in most places.

Hiram Till is equivalent to the Centerburg Till of the eastern margin of the Scioto Lobe (Forsyth, 1961; Totten, 1973). Centerburg has been dropped as a till unit in preference to Hiram.

LOESS

At most places in Marion County a silt cap occurs on the surface of the lacustrine clay or the uppermost till. This silt, which comprises most if not all of the A horizon of the soil, is uniformly fine grained, is loose and friable, and is devoid or nearly devoid of pebbles and granules. Based on interpretations elsewhere in Ohio, this silt is believed to be loess, a wind blown deposit derived from floodplains of glacial meltwater valleys located west of Marion County.

The silt (loess) cap is recorded from nearly every described section in all parts of the county. Measurements of loess thickness range from 8 to 17 inches, with an average thickness of 11 inches. In general the loess thickness across the county is remarkably uniform.

GEOMORPHOLOGY OF THE GLACIAL DRIFT

The surface expression of the glacial drift in Marion County has been produced by several ice advances and, during some of the retreats, by outwash deposits laid down upon, within, or beyond the ice. In addition to ice-related deposits, two large lakes existed for an unknown length of time during and after ice retreat, and the beds of these lakes form distinctive features.

END MORAINES

General Statement

Two major end moraines, the St. Johns and Wabash, can be traced eastward into Marion County (fig. 2). A third moraine, the weakly developed Mississinewa, also occurs in the county. These moraines trend mainly east-west in western Marion County where they reach their southern-most extent in the central part of the Scioto Lobe. In central Marion County the moraines bend northeastward along the eastern flank of the Scioto Lobe. Each moraine is composed of more than one element or ridge (fig. 2, Plate 1).

Moraines were distinguished primarily on field recognition of hummocky topography. Moraine mapping was complicated by the fact that the moraines of Marion County predate the latest (Woodfordian) glaciation. These moraines have been overriden by three Woodfordian ice advances, smoothed, and in places nearly "wiped out".

The end moraines of Marion County were formed during the advance and retreat of one or more ice advances that deposited the Millbrook Till, probably about 40,000 — 35,000 RYBP during the Altonian Substage. Altonian ice advanced mainly southward in Marion County. Expansion of the ice eastward in eastern Marion County was slowed by the Columbus Limestone escarpment (fig. 3). Consequently both the St. Johns and Wabash moraines are deflected in a northward direction for a short distance where the moraines occur along the front of the escarpment.

Mississinewa Moraine

The Mississinewa moraine was named by Leverett (1902) for a morainic belt located a short distance north of the Mississinewa River in eastern Indiana. Leverett (1902) traced the moraine eastward across the Miami lobe of western Ohio. Goldthwait and others (1961) show the Mississinewa moraine as consisting of three elements in northern Darke and Shelby counties, the southern element of which was designated the Bloomer moraine. In the Miami Lobe the Mississinewa-Bloomer moraine is bounded on the south by the Union City moraine and on the north by the St. Johns moraine. In the Scioto lobe only a few unnamed morainic segments are shown by Goldthwait and others (1961), although the map by Leverett (1902, plate XIII) shows an unnamed ridge in Morrow County corresponding to the Mississinewa moraine of present usage. Three discontinuous elements of the Mississinewa moraine were mapped in Morrow County by Totten (Morrow County manuscript). In Marion County the Mississinewa moraine is represented by several low broad northeast-southwest trending hummocks located mainly in Tully Township. These hummocks which probably represent two elements of the moraine, rise only 10 to 15 feet above the till plain, and they are almost entirely lacking southwest of Caledonia in northeastern Claridon Township.

Several very small patches of hummocky topography occur over a wide area of southeastern Marion County, primarily in Richland, Waldo, and Prospect townships. These patches may be remnants of the Mississinewa moraine which was either poorly developed or was eroded by glacial scouring in the central part of the Scioto lobe.

St. Johns Moraine

The St. Johns moraine was named by Winchell (1872, 1874) for the village of St. Johns located on the ridge in Auglaize County. Winchell's mapping of the moraine was primarily in the Miami lobe where the St. Johns moraine is situated between the Mississinewa moraine to the south and the Wabash moraine to the north. Leverett (1902) mapped the Scioto lobe and named the ridge south of the Wabash moraine the Mt. Victory moraine for the village in Hardin County. White (1939) determined that the Mt. Victory moraine was a continuation of the St. Johns moraine and assigned the name St. Johns to both on the basis of priority. The St. Johns moraine extends in a general west to east direction across west-central and north-central Ohio and it makes gentle southward loops in both the Miami and Scioto lobes (Goldthwait and others, 1961). In southwestern Marion County, the St. Johns moraine typically is a broad belt of hummocky topography more than 4 miles wide which trends east-southeastward across Bowling Green and Green Camp Townships. Hummocks comprising the moraine rise about 10 to 15 feet above their surroundings. Several short crestlines 1 to 2 miles long can be identified within the morainic complex. Elevations on the moraine increase from about 935 feet along the north or proximal margin to about 995 feet to the south along the Marion-Union county line. The southern or distal margin of the moraine is south of Marion County in Union County.

At Green Camp about 4 miles southwest of Marion the St. Johns moraine bends rather sharply north-northeastward toward Marion.

Between Green Camp and Marion the moraine is a two mile wide hummocky belt within which as many as 6 ridge crests 10 to 20 feet high may be distinguished. This portion of the moraine was deposited on the Columbus Limestone escarpment (fig. 3), and limestone is close to the surface where the morainic deposits are thin. Near the center of Marion the St. Johns moraine breaks up into low discontinuous ridges which appear to merge with the crest of the escarpment in the northern part of Marion. Bedrock is very close to the surface from Marion north to the county line, and the low broad ridge in northern Marion and southern Grand Prairie Townships is composed of limestone which underlies the thin drift.

A gap about 4 miles long and a slight offset of about 2 miles eastward occurs in the trend of the St. Johns moraine northeast of Marion (fig. 2). This gap may either be the result of non-deposition or post-moraine ice scour. The eastward offset in the trend of the moraine coincides with the location where Millbrook ice that formed the moraine overrode the Columbus Limestone escarpment. Ice movement south of Marion was locally retarded by the westward facing escarpment. The St. Johns moraine can be traced from northern Claridon Township northward through the center of Scott Township to the Marion-Crawford county line, a distance of about 6 miles. Four distinct elements of the St. Johns moraine have been mapped in Scott Township (Plate 1). The elements range in width from 0.3 mile to 1.2 miles, and the combined width is as much as 3 miles. Distinct crestlines are lacking; instead the moraine is characterized

by weakly developed knolls mostly 10 to 15 feet high. Most of the material at the surface of the St. Johns moraine consists of Hiram Till associated with ablation ("dead ice") materials, mainly lacustrine silty clay. Till older than Hiram is exposed at shallow depths in the moraine. The St. Johns moraine probably formed during a temporary halt (or short readvance) of ice that deposited the Millbrook Till.

Wabash Moraine

The Wabash moraine was named by Winchell (1872) for the Wabash River in Indiana which flow along the southern margin of the moraine for a considerable distance. Winchell traced the Wabash moraine into the Miami Lobe of western Ohio where it trends generally eastward across Mercer, Auglaize, southeastern Allen, and Hardin counties. Leverett (1902) traced the moraine eastward into the Scioto Lobe across Hardin County to Marion County. In western Marion County the Wabash moraine trends eastward across Montgomery Township as a single belt of hummocky topography. Within this hummocky belt as many as 5 distinct though discontinuous ridge crests can be recognized. The southern or distal margin of the moraine is sharp and the contrast of topography between the hummocky moraine and the relatively flat lake plain to the south is striking. In places the southern-most ridge of the moraine towers 50 to 60 feet above the nearby lake plain. In eastern Hardin County the Scioto River is an ice marginal stream which follows the depression between the Wabash moraine to the north and the St. Johns moraine to the south. However, in Marion County the moraines diverge toward the center of the Scioto Lobe, and much of the intervening lowland is a

lake plain. The modern Scioto River occupies the lowest part of this lowland in Marion County.

As many as 6 distinct east-west trending ridge crests can be identified within the 1.5 to 3 mile wide morainic belt in west-central Marion County. The individual elements within the moraine are broad and the crests are smooth or flat in many places, probably a result of ice scour during subsequent glacial advances over the moraine. The northern or proximal margin of the moraine is marked by the strong topographic contrast between nearby flat lake plain on the north and the smooth hummocks of the moraine on the south.

Near the center of Big Island Township the Wabash moraine bends toward the northeast and bifurcates into two elements separated by a 1.2 mile wide expanse of till plain. Continuity of the moraine is interrupted by a spillover channel which was cut through the moraine by water draining glacial Lake Marseilles during one or more of the deglaciation phases in Marion County. The outer element of the Wabash moraine comprises the "island" at Big Island and extends as a hummocky belt 0.4 to 1.6 mile wide north-northeastward across northeastern Big Island, northwestern Marion, and western Grand Prairie Townships. The wider part of this element in Grand Prairie Township consists of two poorly defined ridge segments which generally have 20 to 30 feet of relief . Near the Grand Prairie-Marion Township line the outer (distal) element rises 40 feet above the adjacent outwash plain associated with the valley of Little Scioto River. Little Scioto River valley follows the eastern border of the moraine from Big Island north-northeastward to the Marion-

Wyandot county line.

The inner (proximal) element of the Wabash moraine is poorly developed and discontinuous in northeastern Big Island and southeastern Salt Rock Townships. This element appears to merge with the stronger outer element near the Marion-Wyandot county line.

North of the Wabash moraine in northwestern Marion County numerous patches of hummocky topography occur within the large lake bed of glacial Lake Marseilles (Plate 1). Individual ridge-like patches of knolls as much as 1.5 miles long and 0.6 miles wide are aligned in a northeast-southwest trend consistent with the trend of the Scioto lobe margin. These weakly-developed ridge segments may represent an unnamed moraine which was deposited in the Scioto lobe intermediate between the Wabash moraine and the Ft. Wayne moraine to the north in Wyandot County.

Valley-side Hummocky Topography

Hummocky topography apparently unrelated to the trends of end moraines occurs along the valley sides of Grave Creek, Olentangy River, and Qu Qua Creek southeast of Marion, and along both sides of the Scioto River valley in Prospect Township. Grave Creek follows a shallow depression within a nearby linear belt of low knolls which is about 4 miles long and as much as 0.6 mile wide. Most of the knolls rise only about 10 feet above their surroundings. The distribution of knolls resembles a kame terrace, but the only gravel known to occur in the knolls is at the confluence of Grave Creek, Riffle Creek, and Olentangy River in southwestern Richland Township.

Hummocky topography occurs as well-defined narrow belts of knolls on both sides of the valley of Qu Qua Creek. These knolls merge with knolls of the St. Johns moraine in the southern part of Marion. Much of the hummocky topography along Qu Qua Creek between Marion and Waldo is attributed to kame terraces (Plate 1). However, some hummocky areas, particularly in the northern portion of the valley, appear to contain little if any gravel and are mapped as moraine (or gravelly moraine). Similar hummocky topography, possibly of kame terrace origin, occurs along a 2.5 mile long portion of the valley of Olentangy River in Richland Township.

The valley of the Scioto River is bordered by belts of hummocky topography from Green Camp south to the Delaware-Marion County line. A portion of the hummocky topography may be related to the St. Johns moraine which crosses the Scioto River valley

at two places - Green Camp and 2 miles south of Green Camp. However the St. Johns moraine trend is nearly east-west where it crosses the valley, whereas other major hummocky belts trend north-south parallel to the valley south of Green Camp. The hummocky belt along the west side of the valley is about 6 miles long, as much as 0.8 mile wide, and it rises 10 to 30 feet above its surroundings. East of the valley the hummocky topography of the northeast trending St. Johns moraine is dominant, and only short, narrow hummocky segments extend southward parallel to the valley sides. It is possible that some of the hummocks on both sides of Scioto River valley contain gravel, and thus should be more properly related to kame terraces.

Ground Moraine

Slightly more than half of the surface of Marion County consists of ground moraine (Plate 1). The ground moraine surface, also known as till plain, is a gently undulating plain located mainly in the eastern half of the county which has undergone slight dissection by streams. In many places the surface may appear to be both flat and horizontal; however the ground moraine surface is composed mainly of gentle slopes. The ground moraine topography is very similar to the bordering lake plain topography, and the distinction between the two is made on the basis of material. The surface till of the ground moraine is mainly Hiram Till in which are developed the somewhat poorly drained Blount, Pewamo, and Glynwood soils. A layer of wind-blown silt or loess averaging 11 inches thick covers the Hiram Till and is the surface material of the ground moraine.

Lake Marion

Lake Marion is the name applied to a large lake bed about 12.5 miles long and 7 miles wide located in southwestern Marion County (Plate 1, fig. 2). Small portions of the lake bed also extend westward into Hardin County. Lake Marion came into existence during the retreat of Hiram ice and it existed for an unknown number of years until it was drained by the Scioto River which cut a trench through the St. Johns moraine. The lake bed, which was first recognized by Conrey (1916) during a soil survey of Marion County, is situated between the St. Johns moraine to the south and east, and the Wabash moraine to the north. Lake Marion covered parts of five townships: Montgomery, Bowling Green, Big Island, Green Camp, and Marion. The maximum extent of the lake is not marked by any shoreline features such as beach deposits, dunes, or wave cut cliffs. Mapping of the shoreline was based on the occurrence of lake clay and silt as determined from soils maps and by augering, and thus the lake margin (Plate 1) must be regarded as approximate.

The southern margin of Lake Marion can be traced from Green Camp northward along the margin of the St. Johns moraine for a distance of about 2 miles to north-central Green Camp Township where the shoreline trends generally westward around the edge of the moraine. The shoreline trends westward at an elevation of about 918 feet across northwestern Green Camp and northeastern Bowling Green Township. In northwestern Bowling

Green Township, the shoreline bends northwestward and follows in a general way the southern margin of the Scioto River Valley. The shoreline elevation increases to about 925 feet south of LaRue, and at its western extent near the Marion-Hardin County line the elevation reaches 935 feet. In southern Montgomery Township north of LaRue the lake width was constricted to 1.5 mile or less. It is in the constricted area that the lake level on the northern shore reached 935 feet. It is possible that the narrow part of the lake in southern Montgomery Township represents a slightly earlier lake dammed by a lobe of Hiram ice in the center of the Scioto Lobe.

The northern margin of Lake Marion across southern Montgomery and Big Island Township is located along the southern (distal) margin of the Wabash moraine. This northern shoreline is highly irregular and it declines in elevation eastward. At New Bloomington near the Montgomery-Big Island Township line the shoreline elevation is 925 feet, or 10 feet lower than near LaRue, and the 925 feet elevation is constant all along the northern lake margin eastward to Big Island. About 1 mile east of Big Island the shoreline bends northward for a short distance following the distal margin of the moraine.

The eastern margin of Lake Marion was located along the western edge of the Columbus Limestone escarpment in western Marion Township. The elevation of the shoreline decreases from about 925 feet in the northern part of Marion Township to about 918 feet southwest of Marion.

Much of the bed of Lake Marion is relatively flat, particularly in the Big Island Wildlife Area east of New Bloomington in Big Island Township. In a few places, particularly near the lake margin, low knolls about 5 feet high occur on the lake plain. Of particular note, and somewhat of an anomaly, are countless shallow depressions that are most visible on, but not necessarily restricted to the lake plain. These depressions, usually not more than 2 or 3 feet deep at most, range in size from a few feet to 1000 feet or more in diameter and usually are filled with water for 1 to several days after a heavy rain. One possibility is these depressions are kettle holes left by melting ice blocks trapped in drift. Another possibility, preferred by the writer, is the depressions are solution or collapse features resulting from solutioning of bedrock by groundwater.

The surface of the lake bed generally has an elevation of 913 to 915 feet. The lowest part of the lake bed is followed by the Scioto River and the Little Scioto River which join at Green Camp.

The typical sediment deposited in Lake Marion was silty clay which averages 65 percent clay, 32 percent silt, and 3 percent sand. The silty clay is oxidized to a dark brown to yellow brown color, free of pebbles, very stiff where dry, sticky and plastic where wet. Yellow and brown mottles have developed in the soil zones in response to a seasonally high water table and poor drainage. Gray stains and concretions of secondary carbonate are common directly below the leached surface zone which ranges from about 35 to 60 inches in thickness. Loess about 10 inches thick overlies the silty clay in many places. The total thickness of the clay and the nature of the material beneath the clay were

not determined because of insufficient deep exposures. The thickest lake clay exposed was 10 feet thick in south-central Big Island Township. The major portion of the lake bed, especially the flatest part, is characterized by the very poorly drained Latty—Fulton—Paulding soil association. The Milford—DelRey—Shinrock soil association is mapped in the more silty lake sediments near the margin of the lake bed.

The outlet of Lake Marion was southward through a notch cut into the St. Johns moraine by the Scioto River. A similar lake preceeded Lake Marion in the same location following retreat of Millbrook ice which formed the St. Johns moraine. A low section of the St. Johns moraine subsequently was breached by the Scioto River thereby draining the earlier Lake Marion. The Scioto River outlet was blocked with drift during the Woodfordian glacial advances and Lake Marion came into existence with at an elevation of about 918 feet following the retreat of Hiram ice. The narrowest place in the Scioto valley and the most likely location of the Woodfordian dam is located 2 miles south of Green Camp where the Scioto River makes an unusual S bend whereas the valley remains straight. No floodplain occurs along the river at this point and for 3½ miles south to Prospect where the river has downcut through the older alluvial deposits. It is probable that sluggish outwash flowed through the 0.5 mile wide Scioto River valley outlet of Lake Marion without causing erosion, thereby maintaining a relatively stable lake level. It is possible that the Scioto River drainage south

of Marion County also was sluggish which would have helped retard downcutting of the lake outlet. Ultimately the Scioto River established a channel which cut into the old channel fill material and Lake Marion was drained. The duration of the lake is unknown, but based on sediment accumulation, the lake may have lasted a few hundred years or more. Spruce wood (Hansen and others, 1978) buried in silty sand beneath 6½ feet of clay yielded a radiocarbon date of 10,340 YBP (OGS Mama 1). From the stratigraphic evidence presented by Hansen and others (1978) and the location in the floodplain of the Little Scioto River, it is possible the material which was dated was buried in alluvium which postdated Lake Marion. If the clay above the dated spruce wood was deposited in Lake Marion, the date would appear to be too young. Spruce forests disappeared from Ohio about 9,800 RYBP (Ogden, 1966), thus the 10,340 date on spruce may be too young. Additional dates are needed before a radiocarbon chronology of Marion County drift can be determined.

As mentioned previously, the lake shoreline is about 7 feet higher on the north side of the lake bed as compared to the south side. This elevation difference was first noticed by Hubbard and Rockwood (1942) who attributed the difference to differential glacial isostatic uplift similar to the uplift that has affected the late glacial shorelines bordering Lake Erie (Totten, 1985). It is possible that the elevation differences represent differential tilting of the bed of Lake Marion following retreat of Hiram ice. It is possible that the tilting initiated downcutting of the Scioto River outlet that drained the lake. This explanation of lake ele-

vations, however, does not account for the higher elevation of the western end of the lake bed near LaRue.

Lake Marseilles

Lake Marseilles is the name applied to a large lake bed about 13 miles long and nearly 13 miles wide located in northwestern Marion County and southern Wyandot County (Plate 1, fig. 2). Very small arms of the lake apparently extended into the extreme northeast corner of Hardin County. Lake Marseilles came into existence during the retreat of Hiram ice and it existed for an unknown number of years until it was drained by the opening of northward drainage into the Sandusky River Basin following ice retreat. The lake bed, which was first recognized by Hubbard and Rockwood (1942) during a study of Ohio lake beds, is situated between the Wabash moraine to the south and the Ft. Wayne moraine to the north. Lake Marseilles covered nearly all of Grand and Salt Rock Townships and small parts of Montgomery, Big Island, and Grand Prairie Townships. Because of the absence of shoreline features such as beaches or cliffs, the maximum extent of the lake was based on the occurrence of lake clay and silt as determined from soils maps and by augering. The lake bed margin as mapped (Plate 1) is significantly more extensive than the margin mapped by Hubbard and Rockwood (1942).

The eastern and southern margins of Lake Marseilles in Marion County follow the northern or proximal margin of the Wabash moraine which makes a southward loop in the county. The

lake shoreline is highly irregular everywhere in Marion County. Along the eastern lake margin in western Grand Prairie, southeastern Salt Rock, and northeastern Big Rock Townships the shoreline elevation is about 920 feet. Some of the knolls within the lake (Plate 1) near the margin were islands, whereas many other knolls, particularly those farther from shore, were submerged and in most places have a thin covering of lake clay and silt. Along the southern margin of the bed of Lake Marseilles in Big Island and Montgomery Townships the shoreline elevation is about 915 feet. Where the shoreline bends northwestward in northern Montgomery and southwestern Grand Townships, the elevation of the shoreline rises to about 918 feet adjacent to the till plain. The northern margin of the lake bed occurs in southern Wyandot County and was not mapped nor was the north shoreline elevation determined. From the evidence of shoreline elevations in Marion County, it is possible that the shoreline of Lake Marseilles is tilted, with elevations rising northward about 1 foot per mile similar to the tilt of Lake Marion.

Numerous hummocky morainic knolls 5 to 15 feet high occur within the lake bed in Grand and Salt Rock Townships. These maps, though mapped as moraine (Plate 1) were submerged beneath the waters of Lake Marseilles and typically have a covering of lake clay and silt 2 to 4 feet thick.

The flattest part of the lake bed occurs in northeastern Grand and northwestern Salt Rock Townships near the center of the lake. This extensive flat lake plain also is well-developed

in southern Wyandot County. It was this broad flat surface that Hubbard and Rockwood (1942) mapped as Lake Marseilles. The lake bed is drained by Little Sandusky River and Tymochtee Creek which flow northward toward Lake Erie.

The typical sediment deposited in Lake Marseilles was silty clay which averages 54 percent clay, 41 percent silt, and 5 percent sand. Near Morrall in northeastern Salt Rock Township the clay content reaches 84 percent and the thickness of the clay is 11.5 feet. The silty clay is dark brown to yellow brown in color, free of pebbles except for an occasional small dropstone, very stiff where dry, sticky and plastic where wet, and apparently free of laminations or banding. Loess about 11 inches thick caps the silty clay in many places. The Latty—Fulton—Paulding soil association is developed in the clay—rich lake sediments in the flat central portion of the lake bed. The Milford—Delroy—Shinrock soil association is developed in the silty clayey lake sediments which occur nearer the lake margin and on the hummocky or gently rolling portions of the bed of Lake Marseilles.

Two outlets, one to the south and another to the north, regulated lake levels in Lake Marseilles following retreat of Hiram ice from Marion County. The southern outlet was a narrow trench 0.2 mile wide cut through the Wabash moraine in central Big Island Township. This trench was first cut by floodwaters overflowing a low part of the moraine at an elevation of 925 to 930 feet following the retreat of Millbrook ice which

deposited the moraine. The outlet was cut down to an elevation of about 917 feet which is the elevation of the bed of Lake Marion south of the outlet. The modern drainage is reversed and a small area of the lake bed now drains northward through the trench. To what extent the southern outlet was modified by Woodfordian glaciation is unknown, but it is likely the 917 foot outlet was reestablished soon after the retreat of Hiram ice, and a 917 foot lake elevation would have remained relatively stable until the northern outlet was opened, thereby draining the lake. The earlier Lake Marseilles which came into existence following Millbrook ice retreat probably would have had a shoreline elevation of 925 feet to 930 feet for at least a short time. The northern outlet of Lake Marseilles is located in southern Wyandot County and was not included in this investigation.

The duration of Lake Marseilles is unknown, but an estimate of *a few hundred* years, similar to that for Lake Marion, is proposed based on sediment accumulation.

ALLUVIAL (OUTWASH) DEPOSITS

Introduction

Water from the melting ice sheets carried gravel, sand, silt, and clay away from the ice to greater or lesser distances. The deposits are sorted as to grain size, and generally the finer silt and clay are washed farthest downstream leaving sand and gravel nearest the source.

The outwash which was carried down the valleys that were free of ice was deposited as valley trains, which filled the valleys to a certain level. Later when sediment was no longer supplied by the melting ice, the streams began to erode and lower their channels below the valley train surface, leaving more or less extensive remnants as terraces along the valley sides.

In some places, water flowing from the ice deposited cones of material against the ice edge, or in holes or low places in or on the ice itself. When the ice disappeared, these became mounds called kames. As some of this material was deposited right at the ice edge, it incorporated masses of unsorted debris (till) in the sand and gravel, which in kames tend to be more poorly sorted and irregularly bedded than valley train deposits.

Some of the meltwater carved sinuous channels on top of the ice sheet. Sand and gravel representing the bedload of the stream were deposited in the channel. When the ice finally melted, the sand and gravel formed a sinuous ridge known as an esker.

During deglaciation, ice remained in some valleys after the uplands were free of ice, and meltwaters flowed on, around, or beneath the valley ice. Most commonly, meltwater streams deposited sand and gravel between the tongue of ice in the valley and the valley sides. When the ice in the valley melted, the outwash remained along the valley sides as kame terraces. Smaller ice masses which were buried in the outwash eventually melted and the sand and gravel over them collapsed to form kettle holes, some of which were deep enough to extend below the water table, and thus were the sites of lakes or swamps.

During the latter part of the Pleistocene, the major drainage mainly was to the east and south in Marion County, and moderate amounts of sand and gravel were deposited in the larger valleys. The prominent end moraines deposited by Millbrook ice blocked the Scioto River Basin drainage, thereby creating two large temporary lakes. Consequently, much outwash from melting Wisconsinan ice was ponded, and finer grained silts and clays were deposited on top of coarser material in the ponded valleys. The stratigraphy in these ponded valleys is complex, and the surface material often is quite different in age and composition from the material encountered in the subsurface.

Kames

The few kames that occur in Marion County are small and are closely associated with kame terraces. A few small kames occur along the Olentangy River valley in Richland Township and three small kames occur along the east side of Qu Qua valley in Pleasant Township. Several small kames 5 to 10 feet in height occur on the lake plain a short distance north of Green Camp. These kames have slight topographic expression and contain very minor amounts of sand and gravel.

Little Scioto River Valley Kame Terrace

A belt of kames 0.3 to 0.4 mile wide and 2.5 miles long occurs along the southeast side of the Little Scioto River valley northeast of Green Camp in Green Camp and Pleasant Townships (Plate 1). This belt may be composed of two generations of kame terraces, a higher hummocky belt farthest from the river, and a lower, less hummocky belt of low knolls nearest the river. Kames on the higher terrace are about 10 to 20 feet high and reach an elevation of 925 feet. Kames on the lower terrace are about 5 to 10 feet high and attain an elevation of 910 feet. The higher terrace has gravelly Fox and Kendallville soils developed in it, whereas the lower terrace has a combination of gravelly Fox and sandy silty Fitchville soils developed in it. Only one pit, now abandoned, has been opened in the kame terrace. This pit, which is located north of Green Camp Cemetery, has been restored and no exposure remains.

Several knolls which resemble kames in topographic appearance occur along the northwest side of the Little Scioto River valley northeast of Green Camp. These knolls, mapped as gravelly moraine (Plate 1), may be kames mantled with a thick layer of till.

Olentangy River Valley Kame Terrace

Several segments of a kame terrace occur along both sides of the Olentangy River in Waldo and Richland Townships (Plate 1). The most extensive segments, about 1.5 miles long and 500 to 1000 feet wide, occur along both sides of the valley south of Waldo. Three similar but shorter segments occur in the valley north of Waldo. A large area of hummocky topography about 1 mile long also occurs along the west side of the valley north of Waldo. This tract of hummocks has the appearance of kames and may contain gravel beneath a covering of till. Similar but smaller tracts of hummocky topography occur along the Olentangy River northeast of its confluence with Grave Creek. Small amounts of gravel are known to occur in the hummocks along the valley sides, and more gravel may be encountered at depth.

Honey Creek Valley Kame Terrace

Honey Creek, a short tributary to the Little Scioto River in northwestern Pleasant Township, has a narrow kame terrace developed along the eastern margin of its narrow valley (Plate I). The major terrace segment is about 1 mile long, 500 feet wide, and has been exploited for gravel at both ends. One exposure revealed 10 feet of poorly sorted gravelly sand and sandy gravel which contained many cobbles up to 1 foot in diameter. Some till was observed which had been encountered during the operation of the pit, either within or on top of the gravel. The other pit in the terrace revealed 15 feet of poorly sorted gravel. Another segment of the Honey Creek kame terrace occurs about 0.5 mile north of the major segment where it merges with the northern end of the Little Scioto River kame terrace. Fox and Kendallville soils are developed in the gravelly materials of the Honey Creek terrace.

Qu Qua Creek Valley Kame Terrace

An extensive kame terrace occurs along both sides of Qu Qua Creek valley in Pleasant and Waldo Townships (Plate 1). The terrace is about 5.5 miles long and the segments on each side of the valley vary in width between 0.1 and 0.3 mile. The terrace surface is hummocky and kame-like knolls rise 10 to 20 feet above their surroundings. About 2 miles north of Waldo, two distinct kame terraces occur at different elevations along the east side of the valley. The low terrace, located next to the creek, is about 1,000 feet wide, is only slightly hummocky, and has a surface elevation of 950 feet. The high terrace, located farther from the creek, is about 1500 feet wide, is hummocky, and has a surface elevation of about 975 feet.

Gravel is exposed at 5 places north of Waldo in the kame terraces. In a pit in the low terrace 0.7 mile north of Waldo, 12 feet of sand and gravel are exposed beneath a thin covering of Navarre Till. Millbrook BI Till occurs within or beneath rubbly terrace gravel 0.4 mile north of Waldo. Millbrook A Till occurs beneath 10 feet of poorly sorted gravel in the high terrace east of Qu Qua Creek northeast of Waldo. Thus at least two and possibly three episodes of kame terraces were deposited in the valley during the various stages of Millbrook ice retreat. The major soil developed in the gravelly terraces is the well-drained Kendallville soil.

Kame-like belts of hummocky topography mapped as gravelly moraine (Plate 1) occur in several places along Qu Qua Creek valley between Waldo and Marion. These hummocky belts resemble kame terraces but no gravel was encountered in the hummocks.

Scioto River Valley Esker

Six narrow slightly curved linear ridge segments of a valley esker system occur within the Scioto River valley between Green Camp and Prospect (Plate 1). All of the segments are narrow, averaging 400 feet in width, and range in height from 5 to 20 feet. Individual ridge segments are as much as 1 mile long and they extend over a total distance of 5 miles. All but one of the segments have been exploited for gravel, and all segments are surrounded by finer grained sandy valley train material. The esker segments are composed primarily of coarse rubbly gravel about 10 feet thick. Sand, probably related to the older valley train outwash, occurs beneath the gravel. The esker probably is Pre--Hiram in age, but its exact age or relationship to the older Woodfordian ice advances is not known.

Scioto River Valley Train

The Scioto River valley train occurs as two widely separated segments—one leading into glacial Lake Marion in the western part of the county, and the other leading away from glacial Lake Marion in the southern part of the county (Plate I). The western segment, which occurs mainly north of the Scioto River in Montgomery Township, is 4.5 miles long and ranges in width from 0.2 to 0.9 mile. At the Marion-Hardin County line the elevation of the flat valley train surface is 930 feet; at LaRue where the train is most extensive the elevation is 925 feet, and east of LaRue the train surface south of the river has an elevation of about 920 feet, for a gradient of 2.2 feet per mile. The western valley train segment has an elevation lower than the narrow western bed of glacial Lake Marion, which indicates that the narrow western portion of Lake Marion was an earlier lake at a higher level which must have drained prior to the deposition of the valley train.

The southern segment of the Scioto River valley train originates at the south end of the bed of glacial Lake Marion 1.5 miles north of Green Camp, and it extends at least 7.8 miles southward to the Marion-Delaware County line. Remnants of the valley train occur along both sides of the Scioto River, and their combined widths range from 0.3 to 0.8 mile. The villages of Green Camp and Prospect are located on the flat surface of the train. The elevation of the valley train is 912

feet at its north end, 911 feet at Green Camp, and 910 feet at Prospect, for a very low gradient of 3 inches per mile.

Exposures in the western valley train segment indicate that 2 to 4 feet of silty sand overlies sand and gravel of undetermined thickness. Silt and sand 3 to 6 feet thick overlies sand and gravel in the southern valley train segment. The gravel thickness is variable, ranging from near zero to estimates of 40 to 70 feet based on drilling records. It is likely that the gravel is a pre—Woodfordian valley train deposit, and the silt and sand probably represent sediment deposited by slowly moving water draining from Lake Marion during retreat of the ice which deposited the Hiram Till. Fitchville soil is developed in the silty surface material of the valley train.

Small remnants of an alluvial terrace occur along the Scioto River within the confines of the bed of glacial Lake Marion. These low terrace remnants are the remains of a post-glacial, pre-modern floodplain surface developed at an elevation of 912 to 915 feet, which is 2 or 3 feet higher than the modern floodplain surface.

Little Scioto River Valley Train

During the waning stages of glaciation in Marion County following deposition of the Hiram Till, outwash from the stagnating ice margin located in Wyandot County to the north produced a valley train in the Little Scioto River valley in Grand Prairie and Marion Townships. The valley train is nearly 0.7 mile wide at the Marion—Wyandot County line and widens to 1.5 mile where it ends at the north end of the bed of Lake Marion a short distance northwest of Marion. The north end of the valley train is located north of Marion County in Wyandot County. At the Marion--Wyandot County line the valley train elevation is 936 feet, and the elevation 6 miles south at the southern extent of the train is 920 feet, for a gradient of 2.7 feet per mile. The valley train surface generally is flat and nearly level, although it has gentle slopes near the valley sides. Its broad surface has been dissected by the Little Scioto River which has cut a modern floodplain a few feet below the outwash surface. The wide southern part of the valley train ends in a broad delta where the river emptied into Lake Marion.

Exposures in the valley train deposit indicate 2 to 3 feet of silty clay which overlies sand. Apparently the silty clay is a thin surface covering which represents the last stages of train development when the ice margin had retreated a substantial distance northward so that only silt and clay were transported in suspension by the sluggish meltwater stream.

Sleeth and Westland soils have been developed in the mainly sandy outwash materials.

Olentangy River Alluvial Terrace

Numerous remnants of a once extensive terrace occur within the valley of the Olentangy River (Plate 1). The terrace begins north of Caledonia in northeastern Marion County and extends south-southwestward for about 13 miles nearly to Waldo near the Marion-Delaware County line. In most places the terrace is narrow, rarely exceeding 1,000 feet in width. The terrace elevation is 925 feet north of Caledonia, 975 feet near Claridon, and 945 feet north of Waldo, for a gradient of about 4 feet per mile. The material at the surface of the terrace mainly is silt except at the confluence of Grave Creek and Riffle Creek with the Olentangy River where 5 feet of poorly sorted sandy gravel was exposed in a small pit. Based on the high silt content, the terrace is thought to be the product of a postglacial stream unaffected by glacial meltwaters.

Mud Run and Flat Run Alluvial Terraces

Flat Run, a tributary of Olentangy River, and its tributary Mud Run, located in Tully Township in the northeastern corner of the county, contain remnants of alluvial terraces (Plate I). The Mud Run terrace is 600 to 1,000 feet wide, 3.5 miles long, and has undergone only slight modification by subsequent erosion. Flat Run terrace, which is 0.2 to 0.4 mile wide, has been considerably dissected by later stream erosion. Both terraces have surface elevations of 1,050 feet where they enter Marion County, and an elevation of about 1,010 feet 6 miles downstream, for a gradient of 6.7 feet per mile. The terrace materials are silty, similar to those of the Olentangy River, and they probably represent deposits of slow-moving postglacial streams.

Rush Creek Alluvial Terrace

Remnants of an alluvial terrace are preserved along both sides of northward flowing Rush Creek in Bowling Green Township in southwestern Marion County (Plate 1). This terrace represents a floodplain developed at the time when Rush Creek drained into Lake Marion at a lake elevation of about 918 feet. The terrace remnant along the west side of the valley is 3 miles in length and as much as 0.3 mile wide. Shorter remnants occur along the east side of the valley. Terrace surface elevations range from 930 feet at the Marion—Union County line to 918 feet at the north end, for a gradient of 4 feet per mile.

Floodplains

Modern floodplains are developed along all major streams and along many smaller streams (Plate 1) in Marion County. These floodplains are quite variable in width, and generally the larger the stream, the wider the floodplain. Floodplain surfaces range from flat to undulating, and vary from swampy to well-drained. Floodplain materials include variable amounts of clay, silt, sand, and gravel, usually interbedded. The sandy, well-drained floodplain surfaces are characterized by the development of the Nobin-Kendallville-Ockley soil association. The Saranac-Sloan-Westland soil association is developed in the silty clayey floodplain materials.

MINERAL RESOURCES

General Statement

The mineral resources of the glacial drift in Marion County consist of sand, gravel, and groundwater. These are discussed in detail below.

The resources of the bedrock do not form a part of this report, and only a brief summary is possible. Numerous quarries of all sizes have been operated in the Columbus and Delaware Limestone of Devonian age in the county near the crest of the Columbus escarpment (Plate 1, fig. 3). Two of these quarries still are active, and limestone ranging from 30 to 65 feet thick is being quarried and crushed for use as agricultural lime and as aggregate. Another active quarry occurs in extreme northwestern Marion County where the Bass Island dolostone of Silurian age occurs near the surface. Dolostone 35 to 40 feet in thickness is quarried and crushed for use as aggregate.

Shale is quarried a short distance west of the Marion—Morrow County line in the southeast corner of Tully Township. The shale is crushed and trucked a short distance to Caledonia where it is made into bricks. Company personnel indicate the dark gray non—calcareous shale is the Bedford Shale. Stratigraphic records (fig. 6) indicate the deposit more likely is the upper part of the Ohio Shale.

In past years, lake clay was utilized in the local production of brick and tile. At a pit near Morral, about 6 feet of silty

clay was quarried for the manufacture of tile at a large plant near the pit. The lake clay in Marion County contains too much carbonate to be used for commercial brick production.

Petroleum production in Marion County is negligible. Hall and Alkire (1956) recorded only one small field, near Caledonia, where oil has been produced in the county. According to their report, and from the maps of Calvert (1964) and Debrosse and Vohwinkle (1974), 4 wells, the first of which was drilled in 1918, produced small quantities of oil from the Knox Dolomite at total depths ranging from 2700 feet to 2900 feet. The largest well produced 45 barrels per day and the field was abandoned in 1926.

Sand and Gravel

General Statement

Sand and gravel have been excavated from several pits in southern Marion County for over 60 years. However, only two pits located in the Scioto River valley train north of Prospect currently are active on a commercial basis in the county. Two other large pits have been operated in the Scioto River valley esker in past years but are not active at the present time. Several smaller pits have been abandoned and some have been reclaimed.

Scioto River Valley Train Deposits

The largest commercial sand and gravel deposit in Marion County is the wide valley train in the Scioto River valley between Green Camp and Prospect. The two commercial sand and gravel operations in the valley train utilize dredges to excavate material from below the water table. At the Penry Stone Company pit 0.5 mile south of Newmans only 3 to 6 feet of coarse sand occurs above the water table. About 30 feet of sand and sandy gravel is dredged from below the water table, and drilling has indicated as much as 70 feet of gravel occurs in a buried valley a short distance west of the Scioto River. The deposit is about 80 percent sand and 20 percent gravel. The sand is used as mortar and concrete sand. At the Prospect Sand and Gravel pit located

1 mile north of Prospect, 10 to 12 feet of gravel occurs above the water table, and as much as 40 feet of gravelly sand are dredged from below the water table. The deposit is about 85 percent sand and 15 percent gravel. Relatively small areas of the valley train have been exploited for sand and gravel, and much commercial material still remains. In summary, the valley train deposit is primarily sand, is mostly below the water table, and has a widely variable thickness. It is likely that the valley train deposit (Plate 1) in many places such as the Prospect area is too thin to have commercial importance.

Scioto River Valley Esker

The Scioto River valley esker, located on the Scioto River valley train between Green Camp and Prospect, has produced significant amounts of sand and gravel in the recent past. Six segments of the esker, having a combined length of 4.3 miles, are located in the valley, and 4 of the segments have been exploited for sand and gravel. The pits tend to be long and narrow as they follow the trend of the esker ridge. In one large pit located 1 mile south of Green Camp, 10 feet of coarse cobbly gravel were exposed overlying 7 feet of finer grained well sorted sandy gravel. The coarse material is the major esker deposit, and the finer material below is part of the valley train deposit. At another pit in an esker segment 2 miles south of Green Camp, the same stratigraphic sequence is present. The coarse grained esker deposit, probably 15 feet thick at a maximum, has very limited dimensions, and both the esker and valley train materials must be utilized together in a commercial operation.

Other Sand and Gravel Deposits

Sand and gravel occur within and along the sides of many of the smaller drainage lines of Marion County. In most places and along most streams, the sand and gravel deposits are either too meager or too poor in quality to be of commercial quality. Relatively little exploration has occurred along the smaller valleys, and it is possible some of the promising areas contain moderate amounts of good quality material.

The Little Scioto River—Honey Creek kame terraces have produced small quantities of gravel from three pits. Poorly sorted cobbly gravel and gravelly sand 15 feet thick were exposed in the largest of the three pits. Moderate reserves of sand and gravel remain in the terraces, but the quality is questionable.

The Qu Qua Creek kame terraces north of Waldo, though extensive, have produced very little sand and gravel from one small pit. Sandy gravel 12 feet thick occurs in the terrace, and soils maps indicate similar gravel deposits in many places in the terraces. The quality of the gravel where exposed is variable, and the possibility that the gravel is more than one age could make commercial development of the deposit difficult.

Most of the smaller valley train deposits are composed mainly of sand with only small amounts of coarser material. Significant amounts of sand and gravelly sand occur in the western segment of the Scioto River valley train near LaRue. Sand and gravel also are extensive at depths below 2 or 3 feet in the Little Scioto River valley train northwest of Marion. This deposit, though widespread, probably is too thin and too silty in most places for a commercial operation. Most of the sand and gravel in this and other valley train deposits is below the water table. A dredging or dragline operation would be necessary for exploitation of valley train deposits.

Most floodplains in Marion County contain at least small amounts of sandy materials. These deposits are highly variable and are not considered to have economic potential.

Water Supply

This report does not deal with water supply in any detail but some suggestions can be made. An earlier report by Stout, Ver Steeg, and Lamb (1943, p.441—445) gives some information about water supplies of the major municipalities in the county, and a map by Crowell (1979) summarizes more recent information. A great deal more recent information is in the files of the Division of Water and the Division of Geological Survey in Columbus.

Historically, the water used in Marion County has come from three sources: wells in glacial drift, wells in limestone and dolostone bedrock, and surface runoff (streams). According to Crowell (1979) water supply from wells drilled into bedrock falls into two categories: very poor water possibilities (less than 3 gallons per minute) from Devonian shale in Tully Township and parts of Scott, Claridon, and Richland Townships in eastern Marion County, and good water possibilities (100 to 500 gallons per minute) from Devonian limestone and Silurian dolostone in central and western Marion County. Wells drilled into limestone have produced water yields exceeding 1000 gallons per minute at depths less than 300 feet (Crowell, 1979). Wells drilled deeper than 300 feet generally produce unuseable sulfur water.

Water supply from the glacial deposits is highly variable. Crowell (1979) states that yields of less than 4 gallons per minute are produced from till in water—poor eastern Marion County, and thus dry wells and cisterns are utilized to store rainwater. The highest yields from the drift may be obtained from coarse sand and gravel deposits in the Scioto River valley south of Green Camp. These gravel deposits have not been adequately explored or tested for exploitation as aquifers in Marion County.

Small amounts of ground water often may be obtained from sand and gravel lenses associated with till sheets. The thickest water-bearing sand and gravel lenses are associated with the Millbrook Till, and these gravelly lenses may offer the only hope for developing a ground water supply.

By far the greatest water user in Marion County is the city of Marion. Marion obtains its water from three sources—wells, limestone quarry, and Little Scioto River, which are located in close proximity to each other about 2 miles west of the city. The wells are 100 to 200 feet deep in the Columbus Limestone and Bass Island Group Dolostone. Water from all three sources is blended and treated at the Waterworks plant located north of the quarry and west of the river.

ENVIRONMENTAL AND ENGINEERING GEOLOGY

General Statement

The environment is influenced in general by the major physiographic divisions (fig. 2) and in detail by the glacial and post—glacial forms and materials that comprise or mantle them. The glacial drift is an important factor in performance of engineering structures built upon or in the drift. The thickness, composition, and surface configuration of the drift must be considered. Of great importance for large structures or those involving deep excavation is the vertical variation in the drift, because at most places the till or tills below are of different composition, texture, and engineering properties. Gravel and sand may underlie the upper tills at depths ranging from a few feet to 40 feet or more, and be water bearing.

Engineering interpretations of the surface soils of Marion County have been treated in the soil report by Miller and Martin (in preparation). That report should be consulted for specific engineering test data and classification both in the Unified and in the AASHTO systems. The test data recorded in the soil survey survey pertain primarily to the upper 60 inches of the soil. The present geological report deals not only with the surface material, but is also concerned with the whole column of glacial deposits. These reports therefore are complimentary to each other. This geological report cannot provide sufficient detail for planning at a specific site, but

it can point out features of the glacial stratigraphy that should be anticipated in detailed engineering investigations for a specific site.

The subsurface material becomes of increasingly greater importance as larger and larger structures and deeper and deeper excavations become more common. The parent materials of soils over 90 percent of Marion County are the relatively clay—rich lake deposits and Hiram and Hayesville tills. The material beneath the Hayesville till is slightly less clayey and therefore may have more desirable engineering properties. In some projects, it may be desirable to strip off and discard the clayey material to take advantage of the more permeable material below. Also, the "interfaces" between till units often are water—bearing and this must be taken into account in excavations because water seeping may cause piping and slumping.

Till Plain

The Till Plain represents a very gently rolling to nearly featureless surface in eastern Marion County (fig. 2). This surface is dissected by a few small stream channels which provide fair to moderate drainage for the relatively clayey surface. The drainage of the area has been improved considerably since pioneer days by dredging and tiling so that the soil has high productivity. Homesites and other construction projects should be carefully planned to provide adequate drainage.

Potential problems are wet basements and inoperative septic systems, particularly where homesites are closely spaced.

End Moraine

The steepest slopes and the most diverse topography occurs in the two large end moraine belts in western Marion County (fig. 2). Many small streams and rivulets head in the moraines and numerous valleys offer opportunities for the construction of lakes or ponds. The moraines tend to be somewhat better drained than the surrounding areas, and in many places offer favorable conditions for homesites in scenic surroundings. Caution should be used in the installation of septic waste disposal systems as the relatively clayey till at the surface over most of this area is very slowly permeable and will accept effluent with difficulty.

Lake Plain

The two large areas of lake plain in western Marion County are characterized by nearly featureless topography and poor drainage. Surface materials are mainly clay extending to depths of 5 to 10 feet in many places. The impermeable clay subsoil and the lack of slope have resulted in poor natural drainage and temporary ponding after heavy rainfall over much of the lake plain. Drainage in the area has been improved considerably by tiling and the construction of a network of deep drainage ditches, so that the artificially drained soil has high agricultural productivity. Homesites and other construction projects should be carefully planned to provide adequate drainage. Potential problems are wet basements and inoperative septic systems.

WASTE DISPOSAL

Solid Waste

The safe and prudent disposal of solid waste is becoming more important as the population increases, as the amount of waste multiplies, and as environmental regulations become more detailed. Open burning and dumping have been illegal in Ohio since 1969 and the sanitary landfill method has become the standard method of disposing of solid waste. Landfills should be located in areas of Marion County that have a thick till cover, have a low water table, have slight to gentle slope, and are not closely adjacent to urban centers. Areas where bedrock is closer than 25 feet of the surface should be avoided as should sand and gravel areas, valley bottoms, and steep hillsides. A comprehensive review of geologic considerations for selecting landfill sites is given by Groenewold (1974). The drift thickness map (fig. 7) is a most useful tool for preliminary selection of possible landfill sites in the county. Most of Marion County is underlain by drift at least 25 feet thick, and most of the drift is till, especially beyond the confines of the valleys. The till, actually a stratigraphic sequence composed of several till sheets, is suitable for most types of landfill operation. Two problems that may be encountered are the possibility of a high water table and the presence of water—bearing gravel between till sheets. Groenewald (1974) states that the minimum amount of till or similar material

between the solid waste and the water table should be 5 to 30 feet depending on the circumstances, and he advises 25 feet for Ohio. If other conditions are suitable, the water table may be lowered and kept low by pumping ground water from wells or by constructing deep drainage ditches to a nearby valley. The drainage operation should be monitored carefully to ensure that effluent does not contaminate the water being drained from the area.

In 1985 the Marion County landfill was located about 1.5 miles due west of Marion in the floodplain of the Little Scioto River valley and the adjoining bed of glacial Lake Marion. Hansen and others (1978) described a trench section in the landfill which exposed sandy clay at the base overlain by 8 inches of gravel, 2.5 feet of silty sand, and 6.5 feet of clay. A high water table limited deeper excavation and study. Landfill operations in 1985 were limited largely to burial of waste utilizing earth materials transported to the site.

Marion County has several areas that may be suitable for landfill sites pending detailed studies and the consideration of many factors. Areas of thick drift (fig. 7), especially till, should be given careful consideration as potential sites. The most promising areas appear to be along the eastern border of the county where thick drift overlies shale which is relatively impermeable and is not suitable as an aquifer. Over all except the eastern border of Marion County the limestone and dolostone bedrock is the principal ground water aquifer (Crowell, 1979).

Effluent escaping downward through drift could contaminate bedrock aquifers. Any future landfill in the county located in thick drift can be expected to have its lower part excavated in one or more units of Millbrook Till. The Millbrook Till is more compact than the overlying tills and is excavated with difficulty. Besides the compact nature of the till, other potential problems include gravel lenses and joints in the till. Both the gravel lenses and the joints could permit effluent to percolate toward aquifers if they are not properly sealed with an impermeable barrier. A careful engineering study should be made before a proposed landfill site is selected.

Septic Tanks And Tile Fields

The disposal of sewage effluent from septic tanks is a significant problem in many parts of the county that are not served by municipal sewers and and sewage treatment plants. The geologic factors which affect the operation of septic tanks include permeability of the soil, depth to bedrock, depth to the water table, slope, and drainage. Limitations affecting proper disposal are listed by Miller and Martin (in preparation) for each of the soil series for the county. In general, the soils over most of the county have severe limitations for septic tanks, mostly due to the low permeability of the Hiram and Hayesville tills which form the surface materials. Many localities are characterized by a seasonably high water table, and tile fields may be flooded by rising water levels in wet seasons.

Possible areas acceptable for disposal of effluent are the sandy terraces and kames (Plate 1). Another possible suitable area is Tully Township where Bennington and Cardington soils are developed partially in Navarre Till (fig. 9). Drainage of effluent from septic tanks and tile fields may percolate downward along joints in the underlying Millbrook Till until it reaches a shallow gravel aquifer in the Millbrook Till sequence. Shallow wells developed in the gravel lenses within the Millbrook sequence are subject to bacterial pollution, particularly in areas where several septic tanks occur in a limited area.

Recreation

Recreational opportunities provided by the natural landscape are limited in Marion County. However the natural and man-made features in nearby counties provide abundant and diverse opportunities for recreational fishing, boating, swimming, hiking, and camping. Within Marion County, canoeing, boating, and fishing are possible on portions of the major drainage lines including Scioto River, Little Scioto River, and Olentangy River. A portion of the Olentangy River valley in Waldo and Richland Townships has been designated part of the Delaware Reservoir wildlife area. Another area designated for the study and protection of wildlife is the Big Island wildlife area north of the Scioto River in southwestern Big Island Township.

Recreation areas near to Marion County include narrow, elongate, man-made Delaware Lake in the Olentangy River valley south of Waldo and Kildeer Plains wildlife area in southern Wyandot County.

Additions to Marion County report

Loess occurs on top of lacustrine silt and clay in the lake beds of both Lake Marion and Lake Marseilles. The loess thickness on the lake plain is very nearly as great as it is on the till plain and end moraine. It is concluded that these shallow lakes were short lived and were drained when loess was accumulating on the lake plain surface. The lack of fossils in the lacustrine deposits indicates lake water was very cold. If the lakes had existed long after disappearance of glacial ice, organic remains should have been preserved in the silt and clay.

Many shallow closed depressions occur on the flat topography in central marion County, most commonly in the outcrop area of the Delaware and Columbus limestones. These depressions tend to be elongate and have preferred orientation, with several closely grouped depressions all having the same direction of elongation. Evidently these depressions are solution features controlled by jointing in the limestone. The occurrence of several depressions on flat terrace surfaces indicates most of the depressions probably postdate glaciation.

Striations on bedrock were studied at two quarries where broad areas of glacial pavement were exposed during stripping of the overburden. At the National Lime and Stone Company quarry north of Marion, the most prominent set of striations is oriented S 10°W. An older set is oriented S 34°W to S 45°W. A third faint set of striations is oriented S 28°E. The most

prominent set probably was made by ice that deposited the Millbrook Till which occurs directly above the bedrock. The oldest set probably was made by pre-Millbrook ice, possibly by ice of an Illinoian glaciation originating in the Huron Lobe. Two sets of striations occur at the Tri-County Limestone Company quarry in the northwestern corner of the county. The most prominent set is oriented due south to S 18 W, whereas the less prominent set is oriented S 25 W. The most prominent set probably was made by ice which deposited the Millbrook Till whereas the secondary set may either be related to an earlier Millbrook advance or a pre-Millbrook advance.

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APPENDIX A

Marion County Till Samples

Till Sample M series	Depth Collected Inches	Age	Brown B or Gray G	Depth of Leaching Inches	Section	County	Township	Quadrangle Map
401	37	V	B	25	SW, SE, 34	Marion	Grand Prairie	Monnett
402	62	N	B	25	SW, SE, 34	Marion	Grand Prairie	Monnett
403	23	H	B	26	SW, SE, 34	Marion	Grand Prairie	Monnett
404	50	V	B	26	SW, SE, 34	Marion	Grand Prairie	Monnett
405	70	N	B	26	SW, SE, 34	Marion	Grand Prairie	Monnett
406	82	M BI	B	26	SW, SE, 34	Marion	Grand Prairie	Monnett
407	101	M BI	G	26	SW, SE, 34	Marion	Grand Prairie	Monnett
408	38	V	B	29	NW, NW, 10	Marion	Marion	Morral
409	40	V	B	24	NW, NW, 10	Marion	Marion	Morral
410	50	N	B	24	NW, NW, 10	Marion	Marion	Morral
413	42	N	B	36	NE, SW, 32	Marion	Marion	Marion W.
414-A	42	N	B	36	NW, SW, 25	Marion	Marion	Marion E.
414-B	82	N	B	36	NW, SW, 25	Marion	Marion	Marion E.
415	90	N	G	36	NW, SW, 25	Marion	Marion	Marion E
416	42	V	B	34	NE, NW, 28	Marion	Claridon	Marion E
418	56	V	B	—	NE, NW, 35	Marion	Tully	Galion
419	84	M BI	B	—	SW, SW, 33	Marion	Tully	Caledonia
420	120	M BI	G	—	SW, SW, 33	Marion	Tully	Caledonia
421	156	M BI	G	—	SW, SW, 33	Marion	Tully	Caledonia
422	192	M BI	G	—	SW, SW, 33	Marion	Tully	Caledonia
423	228	M BI	G	—	SW, SW, 33	Marion	Tully	Caledonia
424	264	M BI	G	—	SW, SW, 33	Marion	Tully	Caledonia
425	53	V	B	50	NE, NE, 29	Marion	Tully	Caledonia
426	59	V	B	50	NE, NE, 29	Marion	Tully	Caledonia
427	55	V	B	47	NE, NE, 27	Marion	Tully	Caledonia
428	38	V	B	26	NE, NE, 26	Marion	Tully	Galion
429	50	N	B	26	NE, NE, 26	Marion	Tully	Galion
430	84	N	B	26	NE, NE, 26	Marion	Tully	Galion

Till sample M series	Depth Collected Inches	Age	Brown B or Gray G	Depth of Leaching Inches	Section	County	Township	Quadrangle Map
431	48	N	B	–	SW, NW, 24	Marion	Tully	Galion
432	75	N	B	–	SW, NW, 24	Marion	Tully	Galion
433	52	V	B	–	NW, SE, 14	Marion	Tully	Galion
434	38	V	B	30	NW, SW, 14	Marion	Tully	Galion
435	~~33~~	H	B	25	–	Marion	Bowling Green	LaRue
436	28	H	B	25	–	Marion	Bowling Green	LaRue
437	37	V	B	25	–	Marion	Bowling Green	LaRue
438	68	MA	G	–	–	Marion	Bowling Green	LaRue
439	39	H	B	27	–	Marion	Bowling Green	LaRue
440	38	L	B	30	SW, SW, 21	Marion	Montgomery	LaRue
441	30	H	B	27	–	Marion	Montgomery	LaRue
442	34	V	B	27	–	Marion	Montgomery	LaRue
444	48	N	B	42	SE, SE, 19	Marion	Grand Prairie	Morral
446	25	N	B	23	SE, SW, 19	Marion	Grand Prairie	Morral
449	84	V	B	–	NE, NW, 26	Marion	Grand	Meeker
450	42	V	B	40	SE, SW, 22	Marion	Grand	Meeker
451	32	V	B	24	NE, NW, 20	Marion	Grand	Marseilles
452	46	V	B	28	SE, NW, 19	Marion	Grand	Marseilles
453	60	N	B	–	SW, NW, 19	Marion	Grand	Marseilles
454	96	MA	B	–	SW, NW, 19	Marion	Grand	Marseilles
455	120	MA	G	–	SW, NW, 19	Marion	Grand	Marseilles
456	41	V	B	24	SE, NW, 19	Marion	Grand	Marseilles
457	72	N	B	24	SE, NW, 19	Marion	Grand	Marseilles
458	40	H	B	–	SE, NW, 8	Marion	Pleasant	Marion W
459	54	V	B	–	SE, NW, 8	Marion	Pleasant	Marion W
461	38	H	B	–	–	Marion	Green Camp	Marion W
462	54	V	B	–	–	Marion	Green Camp	Marion W
463	31	V	B	29	–	Marion	Green Camp	Marion W

Till sample M series	Depth Collected Inches	Age	Brown B or Gray G	Depth of Leaching Inches	Section	County	Township	Quadrangle Map
464	36	V	B	26	-	Marion	Bowling Green	New Bloomington
465	42	V	B	26	-	Marion	Bowling Green	New Bloomington
466	29	H	B	27	-	Marion	Bowling Green	New Bloomington
467	48	V	B	27	-	Marion	Bowling Green	New Bloomington
468	64	N	B	27	-	Marion	Bowling Green	New Bloomington
469	34	V	B	32	SE, NE, 36	Marion	Salt Rock	Morral
470	29	V	B	26	SE, SW, 36	Marion	Salt Rock	Morral
471	36	N	B	33	NW, SW, 29	Marion	Tully	Caledonia
472	35	N	B	33	NW, NW, 18	Marion	Tully	Caledonia
473	38	V	B	36	NW, NE, 17	Marion	Tully	Caledonia
474	32	V	B	26	SE, NW, 16	Marion	Tully	Caledonia
475	52	N	B	26	SE, NW, 16	Marion	Tully	Caledonia
476	66	MA	B	26	SE, NW, 16	Marion	Tully	Caledonia
477	78	MA	G	26	SE, NW, 16	Marion	Tully	Caledonia
478	30	V	B	22	NW, SW, 29	Marion	Tully	Caledonia
479	37	V	B	25	SW, NE, 36	Marion	Scott	Caledonia
480	30	N	B	26	SW, SE, 13	Marion	Claridon	Denmark
481	31	N	B	28	SE, NE, 25	Marion	Claridon	Denmark
482	62	V	B	32	NE, SE, 12	Marion	Richland	Denmark
483	82	N	B	32	NE, SE, 12	Marion	Richland	Denmark
484	120	MA	G	32	NE, SE, 12	Marion	Richland	Denmark
485	35	V	B	28	NW, NE, 5	Marion	Big Island	Meeker
486	29	V	B	26	NW, NW, 18	Marion	Big Island	New Bloomington
487	30	V	B	22	SW, NE, 5	Marion	Pleasant	Marion W
488	72	V	B	—	NE, SW, 34	Marion	Marion	Marion E
489	30	V	B	24	SW, SE, 34	Marion	Marion	Marion E
490	72	N	B	24	SW, SE, 34	Marion	Marion	Marion E
491	96	MA	B	24	SW, SE, 34	Marion	Marion	Marion E

Till sample M series	Depth Collected Inches	Age	Brown B or Gray G	Depth of Leaching Inches	Section	County	Township	Quadrangle Map
493	30	V	B	25	SW,NW,20	Marion	Pleasant	Marion W
494	31	V	B	27	NE,NE,22	Marion	Grand Prairie	Monnett
495	36	N	B	27	NE,NE,22	Marion	Grand Prairie	Monnett
496	35	N	B	32	NE,NE,20	Marion	Scott	Monnett
497	36	N	B	32	NE,NW,28	Marion	Scott	Monnett
498	84	N	B	-	SW,SW,19	Marion	Scott	Monnett
499	60	N	B	24	NE,NE,33	Marion	Scott	Monnett
500	120	N	G	24	NE,NE,33	Marion	Scott	Monnett
501	32	N	B	24	SE,SE,26	Marion	Scott	Caledonia
502	46	N	B	42	SE,NE,4	Marion	Claridon	Monnett
503	42	N	B	32	NE,NE,17	Marion	Claridon	Marion E
504	66	N	B	32	NE,NE,17	Marion	Claridon	Marion E
505	60	N	B	-	NE,NW,12	Marion	Claridon	Caledonia
506	72	N	B	-	SW,SW,23	Marion	Claridon	Denmark
507	51	N	B	-	SE,SE,24	Marion	Richland	Ashley
508	39	V	B	24	SW,SW,23	Marion	Richland	Ashley
509	47	N	B	24	SW,SW,23	Marion	Richland	Ashley
510	40	N	B	36	NW,NW,32	Marion	Richland	Waldo
511	54	N	B	36	NW,NW,32	Marion	Richland	Waldo
512	84	N	B	-	SE,SE,25	Marion	Marion	Marion E
513	39	V	B	-	SE,NE,36	Marion	Marion	Marion E
514	60	N	B	-	SE,NE,36	Marion	Marion	Marion E
515	105	N	G	-	SE,NE,36	Marion	Marion	Marion E
516	40	N	B	31	SE,SE,36	Marion	Marion	Marion E
517	72	N	B	31	SE,SE,36	Marion	Marion	Marion E
518	96	N	B	31	SE,SE,36	Marion	Marion	Marion E
519	132	N	G	31	SE,SE,36	Marion	Marion	Marion E
520	147	N	G	31	SE,SE,36	Marion	Marion	Marion E

Till sample M series	Depth Collected Inches	Age	Brown B or Gray G	Depth of Leaching Inches	Section	County	Township	Quadrangle Map
521	48	N	B	–	NE, NE, 1	Marion	Pleasant	Marion E.
522	84	N	B	–	NE, NE, 1	Marion	Pleasant	Marion E
523	108	MA	G	–	NE, NE, 1	Marion	Pleasant	Marion E.
524	144	MA	G	–	NE, NE, 1	Marion	Pleasant	Marion E
526	36	N	B	34	NE, NE, 3	Marion	Waldo	Waldo
528	180	MBI	G	34	NE, NE, 3	Marion	Waldo	Waldo
529	144	MA	G	–	NE, NE, 3	Marion	Waldo	Waldo
530	30	H	B	32	NW, NE, 2	Delaware	Marlboro	Waldo
531	39	N	B	32	NW, NE, 2	Delaware	Marlboro	Waldo
532	30	N	B	26	SE, SE, 13	Marion	Marion	Marion E
533	48	N	B	24	SE, NW, 13	Marion	Marion	Marion E
534	90	MA	G	24	SE, NW, 13	Marion	Marion	Marion E
535	126	MA	G	24	SE, NW, 13	Marion	Marion	Marion E
536	40	V	B	28	SW, SE, 13	Marion	Marion	Marion E
537	48	N	B	28	SW, SE, 13	Marion	Marion	Marion E
538	44	V	B	–	NE, NE, 14	Marion	Marion	Marion E
539	84	N	B	–	NE, NE, 14	Marion	Marion	Marion E
540	108	MA	G	–	NE, NE, 14	Marion	Marion	Marion E
541	72	N	B	–	NW, NW, 25	Marion	Grand Prairie	Monnett
542	102	MA	B	–	NW, NW, 25	Marion	Grand Prairie	Monnett
543	48	V	B	30	SW, SW, 1	Marion	Marion	Monnett
544	84	MA	B	30	SW, SW, 1	Marion	Marion	Monnett
545	39	N	B	34	NW, SE, 33	Marion	Waldo	Prospect
546	22	H	B	24	SW, SW 23	Marion	Pleasant	Waldo
547	34	N	B	24	SW, SW, 23	Marion	Pleasant	Waldo
549	34	N	B	30	NE, NE, 20	Marion	Grand Prairie	Morral
550	56	N	B	–	NE, SE, 17	Marion	Grand Prairie	Morral
551	84	MA	B	–	NE, SE, 17	Marion	Grand Prairie	Morral

Till sample M series	Depth Collected Inches	Age	Brown B or Gray G	Depth of Leaching Inches	Section	County	Township	Quadrangle Map
552	108	MA	B	–	NE,SE,17	Marion	Grand Prairie	Morral
553	120	MA	G	–	NE,SE,17	Marion	Grand Prairie	Morral
554	66	N	B	–	NE,NW,17	Marion	Grand Prairie	Morral
555	96	MA	B	–	NE,NW,17	Marion	Grand Prairie	Morral
556	30	H	B	–	NW,NW,17	Marion	Grand Prairie	Morral
557	36	H	B	24	NW,SE,22	Marion	Salt Rock	Morral
558	44	L	B	–	SW,SE,22	Marion	Salt Rock	Morral
559	54	L	B	–	SW,SE,22	Marion	Salt Rock	Morral
560	38	L	B	–	SE,SW,34	Marion	Salt Rock	Morral
561	40	L	B	38	SE,SW,33	Marion	Salt Rock	Meeker
562	38	L	B	–	SW,SE,31	Marion	Salt Rock	Meeker
563	41	V	B	36	NW,SW,1	Marion	Montgomery	Meeker
564	132	N	G	–	NW,NE,9	Marion	Richland	Marion E
565	158	MBI	G	–	NW,NE,9	Marion	Richland	Marion E
566	200	MBI	G	–	NW,NE,9	Marion	Richland	Marion E
567	38°	V	B	26	NW,NE,9	Marion	Richland	Marion E
568	50	N	B	26	NW,NE,9	Marion	Richland	Marion E
570	55	N	G	–	NW,NE,18	Marion	Richland	Marion E
571	67	N	G	–	NW,NE,18	Marion	Richland	Marion E
572	104	MBIII	G	–	NW,NE,18	Marion	Richland	Marion E
573	122	N	G	–	SW,SW,10	Marion	Richland	Marion E
574	60	N	B	30	SE,NE,35	Marion	Tally	Galion
575	56	V	B	30	SE,SW,33	Marion	Tally	Caledonia
576	72	MA	B	30	SE,SW,33	Marion	Tally	Caledonia
577	93	MA	B	30	SE,SW,33	Marion	Tally	Caledonia
578	132	MBII	G	30	SE,SW,33	Marion	Tally	Caledonia
579	72	N	B	–	SE,SE,15	Marion	Claridon	Denmark
580	106	MA	B	–	SE,SE,15	Marion	Claridon	Denmark
581	110	MA	G	–	SE,SE,15	Marion	Claridon	Denmark

Till sample M series	Depth Collected Inches	Age	Brown B or Gray G	Depth of Leaching Inches	Section	County	Township	Quadrangle Map
582	42	V	B	–	NW, NE, 26	Marion	Claridon	Denmark
583	60	N	B	–	NW, NE, 26	Marion	Claridon	Denmark
584	37	V	B	25	SW, SW, 1	Marion	Richland	Denmark
585	30	H	B	28	NE, NE, 27	Marion	Richland	Waldo
586	35	V	B	28	NE, NE, 27	Marion	Richland	Waldo
587	20	H	B	22	NW, SE, 1	Marion	Waldo	Waldo
588	26	V	B	22	NW, SE, 1	Marion	Waldo	Waldo
591	38	N	B	30	–	Marion	Prospect	Prospect
592	27	H	B	29	–	Marion	Prospect	Prospect
593	34	V	B	29	–	Marion	Prospect	Prospect
594	44	N	B	–	–	Marion	Prospect	Prospect
595	120	V	G	–	–	Marion	Green Camp	Marion W
596	22	H	B	28	–	Marion	Green Camp	Marion W
597	32	N	B	28	–	Marion	Green Camp	Marion W
598	31	V	B	34	–	Marion	Green Camp	Marion W
599	54	N	B	34	–	Marion	Green Camp	Marion W
600	72	MA	B	34	–	Marion	Green Camp	Marion W
601	51	V	B	–	–	Marion	Bowling Green	N. Bloomingto
602	30	H	B	–	NW, NE, 23	Marion	Montgomery	N. Bloomingto
603	36	V	B	–	NW, NE, 23	Marion	Montgomery	N. Bloomingto
604	26	L	B	22	NW, NW, 26	Marion	Montgomery	N. Bloomingto
605	55	N	B	22	NW, NW, 26	Marion	Montgomery	N. Bloomingto
606	60	L	B	22	NW, NW, 26	Marion	Montgomery	N. Bloomingto
607	48	L	B	22	SW, SW, 21	Marion	Big Island	N. Bloomingto
608	36	L	B	30	NE, SW, 21	Marion	Big Island	N. Bloomingto
609	44	N	B	30	NE, SW, 21	Marion	Big Island	N Bloomington
610	56	L	B	30	NE, SW, 21	Marion	Big Island	N Bloomingto
611	40	V	B	26	NW, NE, 14	Marion	Big Island	Marion W
612	54	N	B	26	NW, NE, 14	Marion	Big Island	Marion W

Till sample M series	Depth Collected Inches	Age	Brown B or Gray G	Depth of Leaching Inches	Section	County	Township	Quadrangle Map
613	54	V	B	—	SE,NE,15	Marion	Big Island	Marion W
614	68	L	B	60	SE,SE,21	Marion	Big Island	Marion W
615	32	H	B	24	—	Marion	Bowling Green	LaRue
616	32	H	B	34	—	Hardin	Dudley	LaRue
617	38	V	B	34	—	Hardin	Dudley	LaRue
618	30	H	B	28	NW,SE,18	Marion	Montgomery	LaRue
619	37	V	B	28	NW,SE,18	Marion	Montgomery	LaRue
620	29	H	B	26	NW,NE,18	Marion	Montgomery	LaRue
621	40	V	B	26	NW,NE,18	Marion	Montgomery	LaRue
622	42	N	B	28	SE,NE,35	Marion	Marion	Marion E
623	54	N	B	28	SE,NE,35	Marion	Marion	Marion E
624	84	N	B	28	SE,NE,35	Marion	Marion	Marion E
626	43	V	B	25	SW,SW,19	Marion	Pleasant	Prospect
627	66	N	B	25	SW,SW,19	Marion	Pleasant	Prospect
629	84	M BII	G	—	—	Marion	Waldo	Waldo
630	42	N	B	—	—	Marion	Waldo	Waldo
631	84	M BI	B	—	—	Marion	Waldo	Waldo
632	96	M BI	G	—	—	Marion	Waldo	Waldo
633	50	M BI	B	—	SE,NW,18	Marion	Waldo	Waldo
634	75	M BI	G	—	SE,NW,18	Marion	Waldo	Waldo
635	120	M BIII	G	—	SE,NW,18	Marion	Waldo	Waldo
636	150	M BIII	G	—	SE,NW,18	Marion	Waldo	Waldo
640	57	V	B	54	NE,SE,14	Marion	Scott	Caledonia
641	27	V	B	24	SW,SW,27	Marion	Scott	Caledonia
642	57	N	B	54	SE,SE,34	Marion	Scott	Caledonia
643	126	M A	G	—	NW,SE,2	Marion	Claridon	Caledonia
644	34	V	B	28	SW,SE,4	Marion	Richland	Marion E
645	38	V	B	26	NW,NW,10	Marion	Richland	Marion E
646	33	V	B	25	NW,NW,15	Marion	Richland	Marion E

Till sample M series	Depth Collected Inches	Age	Brown B or Gray G	Depth of Leaching Inches	Section	County	Township	Quadrangle Map
647	80	N	B	—	SW, NW, 15	Marion	Richland	Marion E
648	23	H	B	25	NW, NE, 22	Marion	Waldo	Waldo
649	40	V	B	25	NW, NE, 22	Marion	Waldo	Waldo
650	55	N	B	25	NW, NE, 22	Marion	Waldo	Waldo
651	72	L	B	48	SE, SW, 19	Marion	Salt Rock	Meeker
652	60	L	B	—	NE, SW, 18	Marion	Salt Rock	Meeker
653	102	L	B	—	NE, SW, 18	Marion	Salt Rock	Meeker
654	46	N	B	43	NE, SE, 27	Marion	Grand	Meeker
655	76	N	B	—	NW, NW, 35	Marion	Grand	Meeker
656	32	V	B	24	NE, SE, 34	Marion	Grand	Meeker
657	50	N	B	24	NE, SE, 34	Marion	Grand	Meeker
658	60	MA	G	—	NW, SW, 35	Marion	Grand	Meeker
659	32	V	B	28	NE, NE, 28	Marion	Grand	Meeker
660	84	MA	G	—	NW, NW, 27	Marion	Grand	Meeker
661	48	V	B	25	SE, NE, 29	Marion	Grand	Marseilles
662	90	N	B	25	SE, NE, 29	Marion	Grand	Marseilles
663	132	MBII	G	25	SE, NE, 29	Marion	Grand	Marseilles
664	183	MBII	G	25	SE, NE, 29	Marion	Grand	Marseilles
665	72	V	B	45	NE, NE, 29	Marion	Grand	Marseilles
666	108	V	B	45	NE, NE, 29	Marion	Grand	Marseilles
667	30	H	B	23	SE, SW, 20	Marion	Grand	Marseilles
668	120	V	G	23	SE, SW, 20	Marion	Grand	Marseilles
669	150	N	G	23	SE, SW, 20	Marion	Grand	Marseilles
670	192	MBII	G	23	SE, SW, 20	Marion	Grand	Marseilles
671	90	MBII	G	—	NW, NE, 11	Marion	Claridon	Caledonia
672	60	V	B	—	SE, SE, 3	Marion	Claridon	Caledonia
673	40	V	B	31	NE, SE, 2	Marion	Claridon	Caledonia
674	49	N	B	46	NW, NE, 36	Marion	Scott	Caledonia

Till sample M series	Depth Collected Inches	Age	Brown B or Gray G	Depth of Leaching Inches	Section	County	Township	Quadrangle Map
675	50	N.	B	42	SE,SW,23	Marion	Scott	Caledonia
676	54	V	B	42	SE,SE,14	Marion	Scott	Caledonia
677	54	N	B	42	SE,SE,13	Marion	Scott	Caledonia
678	56	N	B	30	NW,NW,21	Marion	Tully	Caledonia
679	46	N	B	40	NW,NW,19	Marion	Scott	Monnett
680	66	N	B	58	NE,NE,25	Marion	Grand Prairie	Monnett
681	35	V	B	30	NE,SW,31	Marion	Scott	Monnett
682	43	N	B	30	NE,SW,31	Marion	Scott	Monnett
683	42	V	B	27	NE,NE,7	Marion	Claridon	Monnett
684	53	N	B	27	NE,NE,7	Marion	Claridon	Monnett
685	58	V	B	55	SE,NW,1	Marion	Marion	Monnett
686	24	H	B	27	NW,NW,29	Marion	Richland	Waldo
687	34	V	B	27	NW,NW,29	Marion	Richland	Waldo
688	48	N	B	27	NW,NW,29	Marion	Richland	Waldo
689	204	MA	B	—	SE,NW,17	Marion	Richland	Marion E
691	48	L	B	—	SW,SW,1	Marion	Green Camp	Marion W
692	38	V	B	30	SE,SE,2	Marion	Green Camp	Marion W
693	70	N	B	30	SE,SE,2	Marion	Green Camp	Marion W
694	58	V	B	33	NW,SW,35	Marion	Big Island	Marion W
695	48	L	B	35	SE,NW,33	Marion	Big Island	N. Bloomington
697	48	L	B	38	NE,NE,31	Marion	Big Island	N. Bloomington
698	48	L	B	—	SW,SE,25	Marion	Montgomery	N. Bloomington
699	40	V	B	33	NE,NW,20	Marion	Marion	Marion W
700	105	V	B	27	SE,SW,36	Marion	Grand	Meeker
701	111	V	G	27	SE,SW,36	Marion	Grand	Meeker
702	52	H	B	45	NE,NE,3	Marion	Montgomery	Meeker
703	58	V	B	45	NE,NE,3	Marion	Montgomery	Meeker
704	56	L	B	48	NW,NW,4	Marion	Montgomery	Marseilles

Till Sample M series	Depth Collected Inches	Age	Brown B or Gray G	Depth of Leaching Inches	Section	County	Township	Quadrangle Map
705	35	H	B	32	NE, NE, 6	Marion	Montgomery	Marseilles
706	52	V	B	32	NE, NE, 6	Marion	Montgomery	Marseilles
707	40	H	B	28	SE, NE, 36	Hardin	Goshen	Marseilles
708	50	V	B	28	SE, NE, 36	Hardin	Goshen	Marseilles
709	67	V	B	28	SE, NE, 36	Hardin	Goshen	Marseilles
710	108	V	G	—	SW, NW, 31	Marion	Grand	Marseilles
711	55	N	B	50	SE, SW, 29	Marion	Grand	Marseilles
712	40	N	B	35	SE, NE, 20	Marion	Grand	Marseilles
714	38	V	B	32	NE, SE, 8	Marion	Big Island	N. Bloomington
715	50	V	B	32	NE, SE, 8	Marion	Big Island	N. Bloomington
716	54	V	B	42	NE, NW, 28	Marion	Grand Prairie	Morral
718	54	L	B	—	NE, NE, 23	Marion	Salt Rock	Morral
719	96	L	B	—	NE, NE, 23	Marion	Salt Rock	Morral
720	96	V	B	—	NE, NE, 26	Marion	Salt Rock	Morral
721	55	L	B	40	SW, SE, 29	Marion	Salt Rock	Meeker
722	48	L	B	44	NE, NE, 28	Marion	Montgomery	N. Bloomington
723	33	L	B	24	NE, NW, 20	Marion	Montgomery	La Rue
724	44	L	B	48	SW, SW, 19	Marion	Big Island	N. Bloomington
725	56	L	B	48	SW, SW, 19	Marion	Big Island	N. Bloomington

APPENDIX B

Marion County Till Analyses

Sample No.	Township	Age Assignment	Depth collected Inches	Grain-size percentages			Carbonate Percentages		
				Sand	Silt	Clay	Calcite	Dolomite	Total
401	Grand Prairie	Hayesville	37	22.9	40.4	36.7	5.2	10.7	15.9
402	Grand Prairie	Navarre	62	23.7	54.4	21.9	1.3	9.8	11.1
403	Grand Prairie	Hiram	23	16.6	38.8	44.6	0	1.9	1.9
404	Grand Prairie	Hayesville	50	23.8	41.2	35.0	6.4	9.8	16.2
405	Grand Prairie	Navarre	70	26.9	36.3	36.8	2.2	10.2	12.4
406	Grand Prairie	Millbrook BI	82	21.8	41.8	36.4	0.7	7.5	8.2
407	Grand Prairie	Millbrook BI	101	24.0	33.1	42.9	0	10.5	10.5
408	Marion	Hayesville	38	24.0	38.7	37.3	5.0	10.7	15.7
409	Marion	Hayesville	40	23.4	41.3	35.3	5.5	10.7	16.2
410	Marion	Navarre	50	23.5	39.6	36.9	5.9	10.9	16.8
413	Marion	Navarre	42	40.5	39.9	19.6	6.2	21.0	27.2
414-A	Marion	Navarre	42	23.7	28.7	47.6	10.5	18.6	29.1
414-B	Marion	Navarre	82	26.2	41.7	32.1	6.5	16.9	23.4
415	Marion	Navarre	90	26.7	44.5	28.8	7.5	17.8	25.3
416	Claridon	Hayesville	42	20.8	38.0	41.2	5.9	11.0	16.9
418	Tully	Hayesville	56	22.0	43.8	34.2	3.5	13.4	16.9
419	Tully	Millbrook BI	84	26.8	42.0	31.2	0.9	8.1	9.0
420	Tully	Millbrook BI	120	24.7	39.4	35.9	1.9	6.5	8.4
421	Tully	Millbrook BI	156	33.5	28.9	37.6	0	5.5	5.5
422	Tully	Millbrook BI	192	44.7	35.1	20.2	0	7.5	7.5
423	Tully	Millbrook BI	228	24.4	49.6	26.0	0	8.2	8.2
424	Tully	Millbrook BI	264	34.5	20.9	44.6	0	10.1	10.1
425	Tully	Hayesville	53	24.4	49.9	25.7	3.6	16.3	19.9
426	Tully	Hayesville	59	21.8	43.3	34.9	7.7	15.7	23.4
427	Tully	Hayesville	55	24.9	39.1	36.0	4.7	11.6	16.3
428	Tully	Hayesville	38	17.9	39.6	42.5	2.5	8.3	10.8
429	Tully	Navarre	50	20.6	42.9	36.5	0	10.6	10.6
430	Tully	Navarre	84	35.2	41.5	23.3	0.3	8.6	8.9
431	Tully	Navarre	48	23.7	51.3	25.0	0	7.1	7.1
432	Tully	Navarre	75	24.8	49.9	25.3	0	1.4	1.4
433	Tully	Hayesville	52	18.0	40.2	41.8	4.7	11.5	16.2
434	Tully	Hayesville	38	20.8	40.1	34.1	5.9	9.8	15.7
435	Bowling Green	Hiram	33	11.4	35.1	53.5	11.2	13.9	24.1

Sample No.	Township	Age Assignment	Depth Collected Inches	Grain-size percentages			Carbonate Percentages		
				Sand	Silt	Clay	Calcite	Dolomite	To
436	Bowling Green	Hiram	28	15.7	41.2	43.1	4.0	12.1	16.
437	Bowling Green	Hayesville	37	15.1	37.3	47.6	6.6	11.1	17.
438	Bowling Green	Millbrook A	68	7.4	32.3	60.3	6.5	10.9	17.4
439	Bowling Green	Hiram	39	7.5	57.0	35.5	6.7	15.4	22.
440	Montgomery	Lacustrine	33	0.3	25.2	74.5	7.9	7.3	15.
441	Montgomery	Hiram	30	14.5	42.5	43.0	4.8	9.8	14.
442	Montgomery	Hayesville	34	23.7	45.1	31.2	5.4	11.2	16.
444	Grand Prairie	Navarre	48	14.0	56.7	29.3	7.1	9.3	16.4
446	Grand Prairie	Navarre	25	22.3	37.0	40.7	4.9	9.1	14.
449	Grand	Hayesville	84	23.0	44.7	32.3	6.0	12.5	18.5
450	Grand	Hayesville	42	24.2	44.3	31.5	4.8	10.4	15.
451	Grand	Hayesville	32	22.8	46.0	31.2	6.6	11.4	18.
452	Grand	Hayesville	46	20.8	51.3	27.9	6.3	11.4	17.7
453	Grand	Navarre	60	19.2	45.2	35.6	6.4	10.9	17.3
454	Grand	Millbrook A	96	19.5	40.6	39.9	2.2	4.4	6.
455	Grand	Millbrook A	120	14.6	35.2	50.2	4.7	15.3	20.
456	Grand	Hayesville	41	18.1	40.8	41.1	6.1	10.9	17.
457	Grand	Navarre	72	20.8	46.1	33.1	8.0	10.7	18.7
458	Pleasant	Hiram	40	13.4	44.9	41.7	5.8	12.3	18.1
459	Pleasant	Hayesville	54	25.4	36.4	38.2	6.9	15.6	22.
461	Green Camp	Hiram	38	16.8	44.7	38.5	2.6	15.4	18.
462	Green Camp	Hayesville	54	17.6	47.2	35.2	5.8	16.9	22.
463	Green Camp	Hayesville	31	21.6	41.1	37.3	4.9	18.2	23.
464	Bowling Green	Hayesville	36	18.9	45.9	35.2	7.8	11.9	19.
465	Bowling Green	Hayesville	42	17.7	40.9	41.4	5.8	12.2	18.
466	Bowling Green	Hiram	29	17.1	45.0	37.9	4.3	12.6	16.9
467	Bowling Green	Hayesville	48	26.1	36.9	37.0	10.0	12.5	22.
468	Bowling Green	Navarre	64	25.8	46.0	28.2	7.5	17.3	24.8
469	Salt Rock	Hayesville	34	13.0	45.0	42.0	6.0	8.9	14.9
470	Salt Rock	Hayesville	29	20.1	41.8	38.1	7.1	9.3	16.4
471	Tully	Navarre	36	21.4	45.2	33.4	2.5	9.0	11.5
472	Tully	Navarre	35	20.7	42.2	37.1	0.4	8.1	8.5
473	Tully	Hayesville	38	22.0	46.5	31.5	1.4	5.5	6.9

Sample No.	Township	Age Assignment	Depth Collected Inches	Grain-size percentages			Carbonate Percentages		
				Sand	Silt	Clay	Calcite	Dolomite	Total
474	Tally	Hayesville	32	20.5	37.9	41.6	6.1	6.9	13.0
475	Tully	Navarre	52	21.5	36.1	42.4	3.5	8.6	12.1
476	Tully	Millbrook A	66	22.4	38.3	39.3	5.3	8.5	13.8
477	Tully	Millbrook A	78	21.7	36.6	41.7	4.8	10.6	15.4
478	Tully	Hayesville	30	20.2	44.8	35.0	5.4	8.1	14.0
479	Scott	Hayesville	37	27.5	39.9	32.6	2.1	13.1	15.2
480	Claridon	Navarre	30	24.0	35.3	40.7	1.9	11.6	13.5
481	Claridon	Navarre	31	24.9	26.3	48.8	1.9	13.2	15.1
482	Richland	Hayesville	62	21.4	42.5	36.1	7.2	11.7	18.9
483	Richland	Navarre	82	22.4	42.5	35.1	6.2	12.1	18.3
484	Richland	Millbrook A	120	21.9	34.2	43.9	3.7	14.6	18.3
485	Big Island	Hayesville	35	24.9	48.3	26.8	7.0	11.4	21.4
486	Big Island	Hayesville	29	22.2	56.2	21.6	8.5	10.3	18.8
487	Pleasant	Hayesville	30	26.5	25.3	48.2	6.7	15.6	22.3
488	Marion	Hayesville	72	22.2	32.4	45.4	6.2	15.9	22.1
489	Marion	Hayesville	30	19.0	36.7	44.3	7.1	13.6	20.7
490	Marion	Navarre	72	20.9	46.5	32.6	6.0	15.9	21.9
491	Marion	Millbrook A	96	19.3	42.4	38.3	7.2	14.6	21.8
493	Pleasant	Hayesville	30	16.2	33.4	50.4	5.1	16.5	21.6
494	Grand Prairie	Hayesville	31	21.4	42.4	36.2	0	6.8	6.8
495	Grand Prairie	Navarre	36	21.1	41.4	37.5	4.7	9.5	14.2
496	Scott	Navarre	35	31.9	50.1	18.0	5.9	15.1	21.0
497	Scott	Navarre	36	27.0	43.7	29.3	7.6	13.1	20.7
498	Scott	Navarre	84	22.9	42.1	35.0	1.9	10.9	12.8
499	Scott	Navarre	60	27.2	49.1	23.7	5.3	13.4	18.7
500	Scott	Navarre	120	22.7	46.4	30.9	3.6	18.5	22.1
501	Scott	Navarre	32	23.5	46.7	29.8	3.6	10.4	14.0
502	Claridon	Navarre	46	25.3	41.4	33.3	3.2	16.0	19.2
503	Claridon	Navarre	42	20.8	11.7	67.5	6.0	11.1	17.1
504	Claridon	Navarre	66	17.6	42.0	40.4	7.8	11.8	19.6
505	Claridon	Navarre	60	25.9	44.7	29.4	6.9	8.7	15.6
506	Claridon	Navarre	72	24.1	43.6	32.3	4.1	12.5	16.6
507	Richland	Navarre	51	21.2	37.8	41.0	3.9	12.2	16.1

Sample No.	Township	Age Assignment	Depth Collected Inches	Grain-size percentages			Carbonate Percentages		
				Sand	Silt	Clay	Calcite	Dolomite	Total
508	Richland	Hayesville	39	17.9	38.4	43.7	4.0	10.0	14.0
509	Richland	Navarre	47	21.3	35.2	43.5	8.0	12.0	20.0
510	Richland	Navarre	40	34.5	43.5	22.0	5.6	18.3	23.9
511	Richland	Navarre	54	23.5	48.9	27.6	0.7	12.2	12.9
512	Marion	Navarre	84	23.6	43.7	32.7	6.5	13.1	19.6
513	Marion	Hayesville	39	21.2	39.7	39.2	3.5	12.7	16.2
514	Marion	Navarre	60	26.1	42.8	31.1	5.7	14.4	20.1
515	Marion	Navarre	105	32.1	41.5	26.4	7.4	18.3	25.7
516	Marion	Navarre	40	23.5	52.2	24.3	8.0	13.1	21.1
517	Marion	Navarre	72	25.6	40.0	34.4	6.5	12.9	19.4
518	Marion	Navarre	96	24.9	44.3	30.8	5.0	15.8	20.8
519	Marion	Navarre	132	29.3	38.4	32.3	6.8	17.6	24.4
520	Marion	Navarre	147	28.5	39.1	32.4	6.3	18.9	25.2
521	Pleasant	Navarre	48	31.0	51.6	17.4	7.1	16.6	23.7
522	Pleasant	Navarre	84	22.8	50.3	26.9	5.5	14.0	19.5
523	Pleasant	Millbrook A	108	22.9	40.7	36.4	5.4	14.2	19.6
524	Pleasant	Millbrook A	144	25.7	30.1	44.2	4.6	16.2	20.8
526	Waldo	Navarre	36	24.1	48.1	27.8	5.3	13.6	18.9
528	Waldo	Millbrook B.I	180	30.9	41.5	27.6	1.2	10.7	11.9
529	Waldo	Millbrook A	144	32.0	39.5	28.5	3.6	15.5	19.1
530	Delaware Co Marlboro	Hiram	30	23.1	37.8	39.1	0	0	0
531	Delaware Co Marlboro	Navarre	39	29.0	41.9	29.1	7.1	15.8	22.9
532	Marion	Navarre	30	24.4	45.0	30.6	7.5	10.9	18.4
533	Marion	Navarre	48	19.2	54.1	26.7	5.0	15.0	20.0
534	Marion	Millbrook A	90	20.5	40.3	39.2	6.5	15.3	21.8
535	Marion	Millbrook A	126	17.7	41.1	41.2	5.6	15.6	21.2
536	Marion	Hayesville	40	21.2	42.8	36.0	4.6	15.3	19.9
537	Marion	Navarre	48	16.5	50.3	33.2	3.9	14.8	18.7
538	Marion	Hayesville	44	21.3	43.9	34.8	6.2	10.3	16.5
539	Marion	Navarre	84	25.5	38.1	36.4	1.5	15.1	16.6
540	Marion	Millbrook A	108	18.9	39.5	41.6	3.7	15.8	19.5
541	Grand Prairie	Navarre	72	25.1	45.6	29.3	3.0	17.2	20.2
542	Grand Prairie	Millbrook A	102	24.9	48.2	26.9	4.1	16.5	20.6

Sample No.	Township	Age Assignment	Depth Collected Inches	Grain-size percentages			Carbonate Percentages		
				Sand	Silt	Clay	Calcite	Dolomite	Total
543	Marion	Hayesville	48	20.5	47.4	32.1	5.1	9.5	14.6
544	Marion	Millbrook A	84	18.6	50.6	30.8	6.6	13.3	19.9
545	Waldo	Navarre	39	22.1	42.8	35.1	5.7	16.8	22.5
546	Pleasant	Hiram	22	20.1	25.5	54.4	0	2.4	2.4
547	Pleasant	Navarre	34	27.7	40.3	32.0	6.4	15.3	21.7
549	Grand Prairie	Navarre	34	20.8	49.6	29.6	3.6	9.3	12.9
550	Grand Prairie	Navarre	56	22.2	44.5	33.3	8.0	10.2	18.2
551	Grand Prairie	Millbrook A	84	24.1	60.1	15.8	6.2	10.8	17.0
552	Grand Prairie	Millbrook A	108	22.2	54.4	23.4	5.7	10.8	16.5
553	Grand Prairie	Millbrook A	120	24.0	47.0	29.0	5.7	11.2	16.9
554	Grand Prairie	Navarre	66	20.1	47.3	32.6	6.6	10.0	16.6
555	Grand Prairie	Millbrook A	96	23.7	43.5	32.8	6.7	11.2	17.9
556	Grand Prairie	Hiram	30	22.3	24.4	53.3	0	0	0
557	Salt Rock	Hiram	36	2.6	49.6	47.8	5.1	7.0	12.1
558	Salt Rock	Lacustrine	44	3.2	61.8	35.0	4.9	8.1	13.0
559	Salt Rock	Lacustrine	54	3.7	64.5	31.8	4.9	6.9	11.8
560	Salt Rock	Lacustrine	38	3.2	46.7	50.1	0	1.4	1.4
561	Salt Rock	Lacustrine	40	19.5	25.2	55.3	0.8	3.5	4.3
562	Salt Rock	Lacustrine	38	19.7	51.1	29.2	0	0	0
563	Montgomery	Hayesville	41	23.1	39.3	37.6	1.6	7.4	9.5
564	Richland	Navarre	132	30.3	29.8	39.9	0	0	0
565	Richland	Millbrook BI	158	36.5	43.6	19.9	0	11.7	11.7
566	Richland	Millbrook BI	200	40.2	36.8	23.0	0	5.8	5.8
567	Richland	Hayesville	38	20.1	40.3	39.6	5.0	11.9	16.9
568	Richland	Navarre	50	21.1	43.9	35.0	5.6	14.9	20.5
570	Richland	Navarre	55	27.6	43.3	29.1	4.9	15.7	20.6
571	Richland	Navarre	67	30.3	47.2	22.5	8.2	14.9	23.1
572	Richland	Millbrook BIII	104	22.9	48.7	28.4	1.9	11.5	13.4
573	Richland	Navarre	122	33.0	42.7	19.3	5.9	18.2	24.1
574	Tully	Navarre	60	23.7	50.5	25.8	5.4	13.1	19.0
575	Tully	Hayesville	56	20.3	45.3	34.4	5.2	8.3	13.5
576	Tully	Millbrook A	72	21.4	47.1	31.5	6.0	10.4	16.4
577	Tully	Millbrook A	93	26.3	43.6	30.1	5.7	12.2	17.9

Sample No.	Township	Age Assignment	Depth collected Inches	Grain-size percentages			Carbonate Percentages		
				Sand	Silt	Clay	Calcite	Dolomite	To
578	Tully	Millbrook B.II	132	26.6	50.3	23.1	5.4	14.6	20
579	Claridon	Navarre	72	24.0	43.0	33.0	11.3	15.2	26.
580	Claridon	Millbrook A	106	25.0	37.8	37.2	8.7	13.7	22.
581	Claridon	Millbrook A	110	25.0	41.2	33.8	5.6	16.2	21.
582	Claridon	Hayesville	42	21.5	30.5	48.0	6.1	11.3	17.
583	Claridon	Navarre	60	25.5	38.6	35.9	6.5	15.4	21.
584	Richland	Hayesville	37	20.6	40.6	38.8	5.8	10.7	16.
585	Richland	Hiram	30	14.9	48.2	36.9	0.9	6.5	7.4
586	Richland	Hayesville	35	11.6	37.4	51.0	0.6	13.6	14.
587	Waldo	Hiram	20	14.6	36.1	49.3	0	1.9	1.
588	Waldo	Hayesville	26	22.5	40.9	36.6	6.6	16.0	22.
591	Prospect	Navarre	38	33.8	47.5	18.7	3.0	19.9	22.
592	Prospect	Hiram	27	22.9	39.6	37.5	0	0	0
593	Prospect	Hayesville	34	26.6	31.3	42.1	7.3	16.7	24.
594	Prospect	Navarre	44	18.9	48.6	32.5	9.0	17.6	26.
595	Green Camp	Hayesville	120	10.6	39.2	50.2	8.2	11.6	19.
596	Green Camp	Hiram	22	22.6	38.4	39.0	0	0	0
597	Green Camp	Navarre	32	29.5	40.8	29.7	5.4	15.3	20.
598	Green Camp	Hayesville	31	20.7	40.0	39.3	0.2	12.5	12.
599	Green Camp	Navarre	54	36.9	43.4	19.7	9.5	16.3	25.
600	Green Camp	Millbrook A	72	25.7	46.3	28.0	5.4	17.8	23.
601	Bowling Green	Hayesville	51	23.5	38.2	38.3	0	0	0
602	Montgomery	Hiram	30	17.7	41.6	40.7	0	0	0
603	Montgomery	Hayesville	36	19.7	48.1	32.2	4.8	11.6	16.
604	Montgomery	Lacustrine	26	2.5	39.0	58.5	8.3	7.9	16.
605	Montgomery	Navarre	55	23.5	43.7	32.8	6.7	12.8	19.
606	Montgomery	Lacustrine	60	10.0	35.8	54.2	5.6	8.3	13.
607	Big Island	Lacustrine	48	2.4	23.2	74.4	9.2	7.6	16.
608	Big Island	Lacustrine	36	3.6	18.2	78.2	8.7	9.8	18.
609	Big Island	Navarre	44	25.8	41.9	32.3	7.0	9.5	16.
610	Big Island	Lacustrine	56	3.6	32.8	63.6	5.7	6.7	12.
611	Big Island	Hayesville	40	7.4	35.9	56.7	7.6	7.2	14.
612	Big Island	Navarre	54	19.0	41.5	39.5	9.8	12.2	22.

Sample No.	Township	Age Assignment	Depth collected Inches	Grain-size percentages			Carbonate Percentages		
				Sand	Silt	Clay	Calcite	Dolomite	T.
613	Big Island	Hayesville	54	23.4	39.2	36.4	0	0	0
614	Big Island	Lacustrine	68	2.2	33.2	64.6	5.1	6.1	11.2
615	Bowling Green	Hiram	32	10.9	38.8	50.3	7.3	10.2	17.
616	Dudley Hardin Co	Hiram	32	12.5	26.8	60.7	0	5.2	5.
617	Dudley Hardin Co.	Hayesville	38	15.4	36.6	48.0	8.7	10.0	18.
618	Montgomery	Hiram	30	21.1	52.9	26.0	5.0	7.9	12.
619	Montgomery	Hayesville	37	20.7	49.3	30.0	7.5	9.8	17.
620	Montgomery	Hiram	29	18.6	50.9	30.5	8.5	10.5	19.
621	Montgomery	Hayesville	40	17.5	49.1	33.4	7.4	12.8	20.
622	Marion	Navarre	42	23.5	48.3	28.2	5.6	11.2	16.
623	Marion	Navarre	54	24.6	45.4	30.0	6.0	12.5	18.
624	Marion	Navarre	84	27.1	49.5	23.4	6.6	16.0	22.
626	Pleasant	Hayesville	43	30.4	34.0	35.6	8.1	16.3	24.
627	Pleasant	Navarre	66	18.4	46.9	34.7	6.7	17.9	24.
629	Waldo	Millbrook B II	84	32.5	50.4	17.1	6.4	22.9	29.
630	Waldo	Navarre	42	22.2	34.2	43.6	2.8	13.2	16.
631	Waldo	Millbrook B I	84	32.1	39.6	28.3	0	10.1	10.1
632	Waldo	Millbrook B I	96	31.2	41.9	26.9	0	6.0	6.0
633	Waldo	Millbrook B I	50	39.8	36.2	24.0	0	6.7	6.7
634	Waldo	Millbrook B I	75	33.4	45.1	21.5	0	9.4	9.4
635	Waldo	Millbrook B III	120	33.7	46.5	19.8	1.4	12.2	13.
636	Waldo	Millbrook B III	150	36.2	44.6	19.2	3.4	16.8	20.
640	Scott	Hayesville	57	21.7	47.8	30.5	0	2.2	2.2
641	Scott	Hayesville	27	14.8	59.1	26.1	0	8.0	8.0
642	Scott	Navarre	57	23.8	47.7	28.5	5.0	12.5	17.5
643	Claridon	Millbrook A	126	25.0	41.3	33.7	5.2	13.5	18.7
644	Richland	Hayesville	34	15.3	54.6	30.1	6.9	11.5	17.4
645	Richland	Hayesville	38	23.1	43.1	33.8	5.5	13.0	18.
646	Richland	Hayesville	33	20.6	40.8	38.6	5.7	11.3	17.
647	Richland	Navarre	80	24.4	53.5	22.1	5.1	14.8	19.
648	Waldo	Hiram	23	21.7	41.6	36.7	0	0	0
649	Waldo	Hayesville	40	26.5	43.1	30.4	5.9	14.9	20.
650	Waldo	Navarre	55	24.4	49.4	26.2	4.0	14.3	18.

Sample No.	Township	Age Assignment	Depth Collected Inches	Grain-size percentages			Carbonate Percent		
				Sand	Silt	Clay	Calcite	Dolomite	T
651	Salt Rock	Lacustrine	72	4.2	47.3	48.5	7.1	8.4	15
652	Salt Rock	Lacustrine	60	2.1	30.3	67.6	4.4	5.1	9.
653	Salt Rock	Lacustrine	102	1.2	40.4	58.4	5.9	8.1	14.
654	Grand	Navarre	46	24.8	47.3	27.9	7.4	16.1	23.
655	Grand	Navarre	76	25.4	46.3	28.3	7.1	12.5	19.
656	Grand	Hayesville	32	26.0	37.6	36.4	7.6	14.2	21.
657	Grand	Navarre	50	26.1	44.9	29.0	7.3	19.1	26.
658	Grand	Millbrook A	60	16.7	53.7	29.6	6.6	12.9	19.
659	Grand	Hayesville	32	17.5	49.8	32.7	8.5	9.8	18.
660	Grand	Millbrook A	84	19.1	53.1	27.8	6.3	19.6	25.
661	Grand	Hayesville	48	16.9	52.1	31.0	7.9	11.2	19.
662	Grand	Navarre	90	28.6	55.5	15.9	5.8	21.6	26.
663	Grand	Millbrook B II	132	17.8	50.2	32.0	7.3	15.0	22.
664	Grand	Millbrook B II	183	12.2	46.6	41.2	9.4	15.4	25.
665	Grand	Hayesville	72	20.1	56.1	23.8	7.7	16.1	23.
666	Grand	Hayesville	108	18.8	55.8	25.4	7.7	15.4	23.
667	Grand	Hiram	30	15.3	49.3	35.4	7.1	11.5	18.
668	Grand	Hayesville	120	14.6	38.3	47.1	5.3	14.7	20.
669	Grand	Navarre	150	28.6	46.2	25.2	8.0	14.5	22.
670	Grand	Millbrook B II	192	20.8	46.3	32.9	6.3	19.1	25.
671	Claridon	Millbrook B II	90	28.7	28.6	42.7	6.1	18.9	25
672	Claridon	Hayesville	60	12.4	41.7	45.9	1.2	6.7	7.
673	Claridon	Hayesville	40	23.6	39.8	36.6	1.8	7.5	9.
674	Scott	Navarre	49	20.9	45.9	33.2	0	7.2	7.
675	Scott	Navarre	50	24.0	40.8	35.2	4.4	12.8	17.
676	Scott	Hayesville	54	20.4	39.4	40.2	0	3.0	3.
677	Scott	Navarre	54	42.3	24.1	33.6	0	4.0	4.
678	Tully	Navarre	56	20.4	51.3	28.3	4.1	8.5	12.
679	Scott	Navarre	46	20.5	41.3	38.2	0.7	12.1	12.
680	Grand Prairie	Navarre	66	38.7	32.5	28.8	5.0	15.6	20.
681	Scott	Hayesville	35	18.7	38.4	42.9	0.5	10.7	11.
682	Scott	Navarre	43	24.1	36.6	39.3	3.9	9.9	13.
683	Claridon	Hayesville	42	11.0	33.0	55.0	0.4	4.4	4.7

Sample No.	Township	Age Assignment	Depth collected Inches	Grain-size percentages			Carbonate Percentages		
				Sand	Silt	Clay	Calcite	Dolomite	To
684	Claridon	Navarre	53	23.4	35.7	40.4	4.1	15.7	19.
685	Marion	Hayesville	58	17.8	41.2	41.0	0.6	2.6	3.
686	Richland	Hiram	24	18.7	65.6	15.7	0	0	
687	Richland	Hayesville	34	27.4	39.7	32.9	6.6	14.3	20.
688	Richland	Navarre	48	28.2	35.9	35.9	8.2	13.2	21.
689	Richland	Millbrook A	204	29.7	57.6	12.7	5.7	12.2	17.
691	Green Camp	Lacustrine	48	4.9	57.4	37.7	0	0	
692	Green Camp	Hayesville	38	28.7	33.0	38.3	5.1	14.5	19.
693	Green Camp	Navarre	70	18.5	29.9	51.6	9.5	13.8	23.
694	Big Island	Hayesville	58	28.9	26.2	44.9	3.4	16.6	20.
695	Big Island	Lacustrine	48	5.6	27.4	67.0	5.4	7.4	12.
697	Big Island	Lacustrine	48	24.2	30.9	44.9	6.6	9.1	15.
698	Montgomery	Lacustrine	48	0	44.3	55.7	0	2.2	2.
699	Marion	Hayesville	40	14.7	43.7	41.6	0	12.4	12.
700	Grand	Hayesville	105	26.2	42.3	31.5	6.1	12.9	19.
701	Grand	Hayesville	111	25.7	47.9	26.4	7.1	13.6	20.
702	Montgomery	Hiram	52	9.1	26.7	64.2	0	4.9	4.
703	Montgomery	Hayesville	58	17.6	50.3	32.1	5.5	10.2	15.
704	Montgomery	Lacustrine	56	2.0	58.0	40.0	4.5	7.4	11.
705	Montgomery	Hiram	35	9.7	49.8	40.5	6.1	8.1	14.
706	Montgomery	Hayesville	52	16.7	43.8	39.5	6.7	9.9	16.
707	Goshen Hardin Co	Hiram	40	21.4	36.0	42.6	7.0	10.4	17.
708	Goshen Hardin Co	Hayesville	50	19.9	22.1	58.0	6.9	10.6	17.
709	Goshen Hardin Co	Hayesville	67	19.7	36.5	43.8	7.5	10.1	17.
710	Grand	Hayesville	108	21.3	41.1	37.6	6.2	10.9	17.
711	Grand	Navarre	55	20.2	45.1	34.7	5.9	10.5	16.
712	Grand	Navarre	40	21.4	39.8	38.8	8.9	10.1	19.
714	Big Island	Hayesville	38	18.9	36.0	45.1	2.5	7.9	10.
715	Big Island	Hayesville	50	22.2	37.2	40.6	4.3	10.1	14.
716	Grand Prairie	Hayesville	54	24.7	34.7	40.6	0.9	6.3	7.
718	Salt Rock	Lacustrine	54	1.2	25.6	73.2	3.9	5.1	9.
719	Salt Rock	Lacustrine	96	0.7	15.4	83.9	4.7	8.8	13.
720	Salt Rock	Hayesville	96	21.6	41.1	37.3	5.7	11.6	17.

Sample No.	Township	Age Assignment	Depth Collected Inches	Grain-size percentages			Carbonate Percents		
				Sand	Silt	Clay	Calcite	Dolomite	To-
721	Salt Rock	Lacustrine	55	4.3	33.4	62.3	6.7	7.0	13.
722	Montgomery	Lacustrine	48	6.7	28.2	65.1	4.4	5.5	9.
723	Montgomery	Lacustrine	33	2.7	28.4	68.9	2.7	8.6	11.
724	Big Island	Lacustrine	44	6.3	20.5	73.2	0	1.2	1.
725	Big Island	Lacustrine	56	6.7	21.6	71.7	1.9	5.7	7.

Lake Marseilles

Wabash Moraine

Wabash Moraine

Lake Marion

St. Johns Moraine

St. Johns Moraine

St. Johns Moraine

ST Johns Moraine

Moraine

Glacial Geology of Marion County, Ohio ± 1986

Stanley M. Totten

Recent	Alluvium. Clay, silt, sand and gravel in stream channels and on modern floodplains. Thickness is highly variable.
Wisconsinan	Alluvial and Valley Train Deposits. Silt, sand and gravel deposited in valleys and preserved as terraces of one or two levels along valley sides.
	Lake Deposits. Silt and clay deposited mainly in proglacial Lakes Marion and Marseilles dammed by end moraines and by ice.
	Kames and Kame Terraces. Sand and gravel in knolls or in terraces; overlain by till in many places.
	End Moraine. Hummocky topography having linear trend. Hiram Till at surface underlain by older tills.
	End Moraine, drowned. Hummocky topography covered temporarily by glacial Lake Marseilles. Thin lake clay at surface underlain by till.
	Valley-side Knolls. Linear belts or patches of knolls resembling kames and kame terraces. Till at surface; may contain slight to large amounts of gravel at depth.
	Ground Moraine. Gently rolling to nearly flat topography. Hiram Till at surface underlain by older tills.
	Ablation Deposits. Lake silt and clay deposited in crevasses or holes in wasting ice which deposited Hiram Till. Area consists of alternating patches of lake silt and clay and Hiram Till. Does not affect topography.
	Bedrock within 5 feet of ground surface.
	Disturbed land. Quarries and landfill.
	Gravel Pit-Active / Quarry-Active
	Gravel Pit-Abandoned / Quarry-Abandoned
	Crest of morainic ridge

MARION CO.

MARION #1



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