STATE OF OHIO
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL SURVEY

REPORT OF INVESTIGATIONS NO. 28

The Economic Geology Of Crawford, Marion, Morrow and Wyandot Counties

By
JOHN F. HALL
and
ROBERT L. ALKIRE

COLUMBUS
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CHAPTER I

INTRODUCTION

LOCATION AND EXTENT OF AREA

This report covers the economic geology and general stratigraphy of Crawford, Marion, Morrow, and Wyandot Counties, which are located in the central and north-central part of the State, (see Fig. 1). Originally intended as an oil and gas study of the Trenton pools in Wyandot County and the Caledonia field in Marion County, it was later extended areally to cover Crawford and Morrow Counties, and in scope to other economic products.

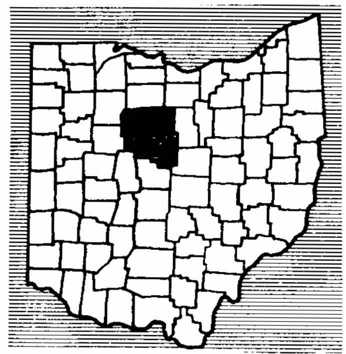


Fig. 1. Index map

The four counties encompass an area of approximately 1,622 square miles and are covered in entirety or in part by twelve 15-minute United States Geological Survey quadrangle maps.[1] The total population of the area is 125,650 (1950 census). The area, population, and rank in relation to other Ohio counties are shown in Table 1.

TABLE 1

County	Population	Population rank	Area sq. miles	Area rank
Crawford	38,738	43rd	402.54	81st
Marion	49,959	33rd	404.14	80th
Morrow	17,168	82nd	406.83	78th
Wyandot	19,785	77th	408.54	73rd

PREVIOUS INVESTIGATIONS

The first investigation of any of the counties covered by this report was by Briggs (1838), who made a very general survey of Crawford County. Winchell (1873) reported on the physiography, stratigraphy, and economic geology of Marion and Wyandot Counties. Similarly he covered Crawford and Morrow Counties a year later (Winchell 1874). These last two reports are the only nearly complete investigations available for the whole area. The economic aspects, particularly oil and gas, are mentioned briefly by Orton (1888 a, b); and Bownocker (1903). Smith (1949) barely mentions the sand and gravel deposits of Wyandot County. Stout et al (1943) covers the water supply for each county, town by town. Other reports, too numerous to mention,

[1] The twelve quadrangles are: Arlington, Bucyrus, Crestline, Delaware, Fredericktown, Larue, Marengo, Marion, Mt. Gilead, Shauck, Sycamore, Upper Sandusky. These maps can be purchased from the Ohio Division of Geological Survey, Orton Hall, Ohio State University, Columbus 10, Ohio.

particularly the various bulletins of the Ohio Geological Survey, 4th Series, occasionally refer to the individual counties, but they are for the most part very brief and usually very general. Some of these references will be listed under the chapters on stratigraphy and economic geology.

HISTORICAL INTEREST

Crawford County was formed in 1820 from old Indian Territory which was ceded to the United States by the Treaty of Maumee Rapids in 1817. It derives its name from Colonel William Crawford, a colonial soldier who was captured and burned to death by the Indians in 1772 along Tymochtee Creek, in the former limits of Crawford County, but now located in Wyandot County. Bucyrus (pop. 10,327) is the county seat. Other important towns are Galion (pop. 9,952) and Crestline (pop. 4,614).

Marion County was organized in 1824 and named for General Francis Marion of South Carolina, a Revolutionary War officer. Its county seat is Marion (pop. 33,817) and it is the only town of any appreciable size in the county.

One of the last counties to be formed in Ohio was Morrow, which was made up of portions of Richland, Knox, Marion, and Delaware Counties in 1848. The name is from Jeremiah Morrow, governor of Ohio from 1822 to 1826. Mt. Gilead (pop. 2,351) is the county seat and the only town of importance. When first founded it was known either as Whetson or Youngstown, but in 1832 the State Legislature changed it to Mt. Gilead.

Wyandot County, named after the Indians that lived there, was put together in 1845 by joining parts of Crawford, Marion, Hardin, and Hancock Counties. It contained the last Indian Reservation lands in the State. These lands were ceded in the Treaty of Upper Sandusky in 1842. The county seat is Upper Sandusky (pop. 4,397) and the other towns of importance are Carey (pop. 3,260) and Sycamore (pop. 935).

GEOGRAPHY

The topography of the area varies from gently rolling hills in Morrow and the eastern two-thirds of Crawford counties to a very flat and even till plain in Marion, Wyandot, and the remainder of Crawford County. In the west the only places of considerable relief are along stream channels. Though no major streams flow through the area, its centralized location in the State gives rise to drainage in many directions. Table 2 lists the drainage basins for the individual counties.

TABLE 2

County	Drainage basins
Crawford	Huron, Muskingum, Sandusky, Scioto
Marion	Sandusky, Scioto
Morrow	Muskingum, Scioto
Wyandot	Maumee, Sandusky

Due to the evenness of the land, the various divides between these basins are for the most part small and in many cases unnoticeable.

Originally covered with a hard wood forest of oak, beech, maple, and hickory and with few open prairies, the region is now predominantly devoted to agriculture. The rolling hills to the east are mainly areas of general farming and dairy cattle raising, whereas the flatter areas to the west belong to the cornbelt region.

The railway network, in general, is very good with all the counties except Morrow being crossed by both east-west and north-south railroad service. The main lines are the Akron, Cleveland, and Youngstown; Chesapeake and Ohio; Erie; New York Central; and Pennsylvania. The chief railway junctions are Marion, Bucyrus, Crestline, and Upper Sandusky, with Marion being the largest and serving as railway center for all the lines, except the Akron, Cleveland and Youngstown.

Highway transportation is also excellent with U. S. Highway 30N and 30S cutting across the area, and U. S. 23 and 42 providing north-south connections to both Columbus and Lake Erie area. Besides these main highways numerous Ohio routes and county roads furnish accessibility to all parts of the four counties.

ACKNOWLEDGMENTS

The writers are most grateful to Marcia Greve, Western Reserve University, Cleveland, Ohio, for her assistance in typing the manuscript. Much of the text was prepared by Dr. Hall after his departure from the Survey to become a member of the staff of Western Reserve. Also, our most sincere thanks to Miss Ethel Dean, Secretary of the Ohio Geological Survey, for her careful editing and helpful suggestions as to presentation of the assembled data.

CHAPTER II

GENERAL GEOLOGY

STRATIGRAPHY

In Crawford, Marion, Morrow, and Wyandot Counties, the exposed rocks range in age from the Niagaran series of the Silurian system to the Kinderhookian series of the Mississippian system. The Silurian and lower Devonian strata are dominantly limestone and dolomites, but the upper Devonian and Mississippian beds consist mainly of shale with a few important sandstone units.

The general dip of the beds is to the east, or a little south of east, with a magnitude ranging from 15 feet per mile in Marion County to almost 50 feet per mile in Wyandot County. This amount of dip is not too noticeable in a single outcrop where the beds appear rather horizontal, but upon tracing any particular formation for a considerable distance it becomes very evident. Due to this easterly dip, the Silurian rocks outcrop in the western part of the area, and the Mississippian rocks are found along the eastern margins of Morrow and Crawford Counties.

Figure 2 is a geologic map of the area, based mainly on the Geologic Map of Ohio as published by the Ohio Division of Geological Survey. No attempt has been made to subdivide the main divisions on the basis of their respective formations due to scarcity of outcrops. Figure 3 is a geologic column of the bedrock of the counties. In this column several of the thicknesses are questionable, again due to the lack of complete measurable stratigraphic sections.

Overlying the bedrock in the greater part of the area are glacial deposits, which obscure or completely cover all exposures, except in the two easternmost counties. Elsewhere good outcrops are confined to the valley floors of the main streams or the artificial outcrops of man-made quarries.

The discussions of the general stratigraphy and glacial geology in this report are based mainly upon the compilation of previously published sections and descriptions. Little actual field work was done in the area except for locating abandoned oil and gas wells and observing a few of the quarry sections.

SILURIAN SYSTEM

The oldest rocks exposed in the area belong to the Silurian system and are found in the central and western parts of Marion and Wyandot Counties (see Fig. 2). Both the Niagaran series and the overlying Cayugan series are present. The Silurian rocks are dominantly dolomite with a few shales or shaly dolomites.

Niagaran Series

The Niagaran group or series was named by Vanuxem in 1842 for the great thicknesses of rock so well exposed at Niagara Falls in New York. In 1871 Orton adopted the term for formations in Adams and Highland Counties. The term is now definitely established in Ohio nomenclature and has been divided by Ohio stratigraphers into various formations, with the youngest or Guelph formation being the only one present in the area under discussion.

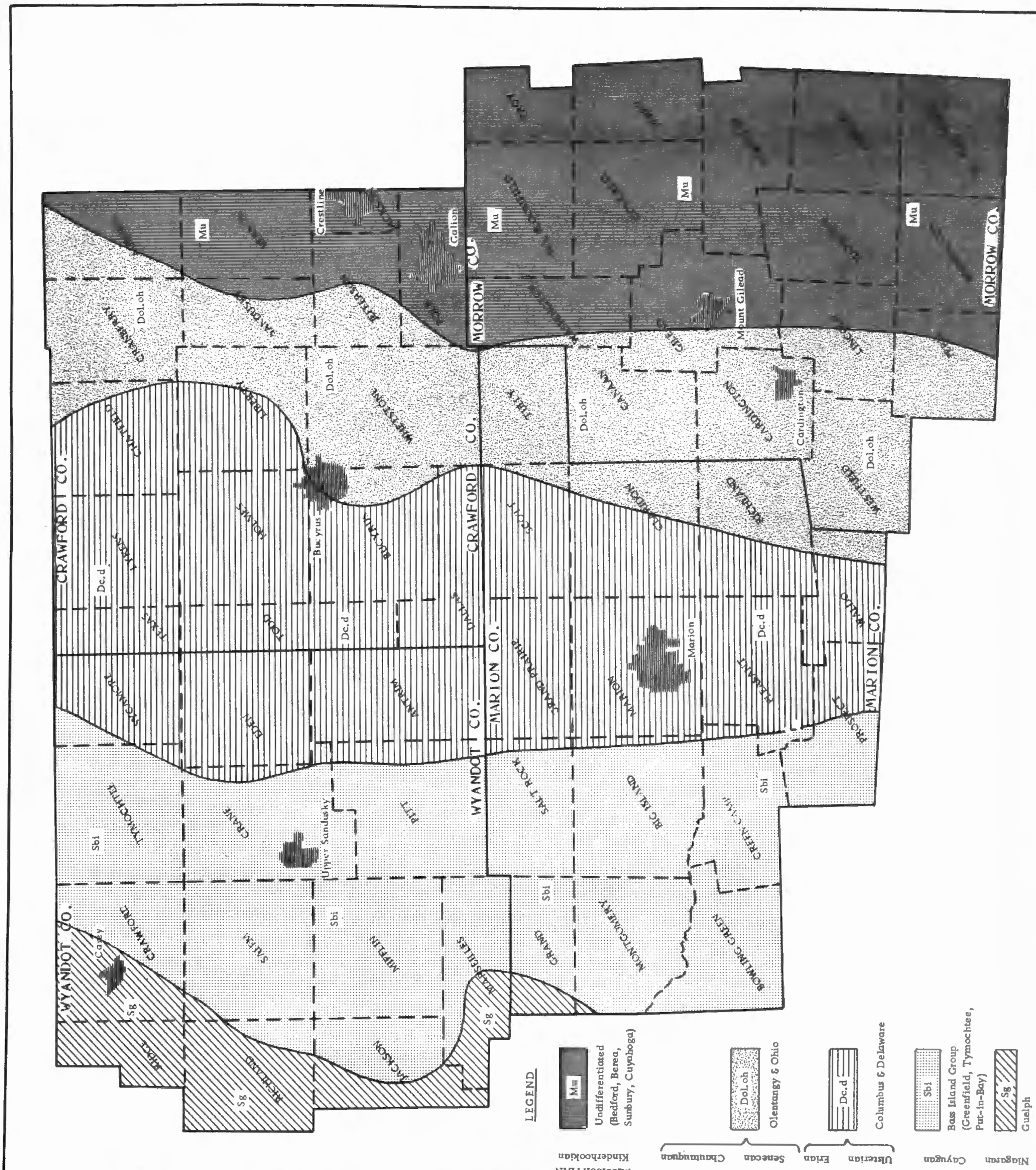


Figure 2. Geologic Map of Crawford, Morrow, Marion, and Wyandot Counties.

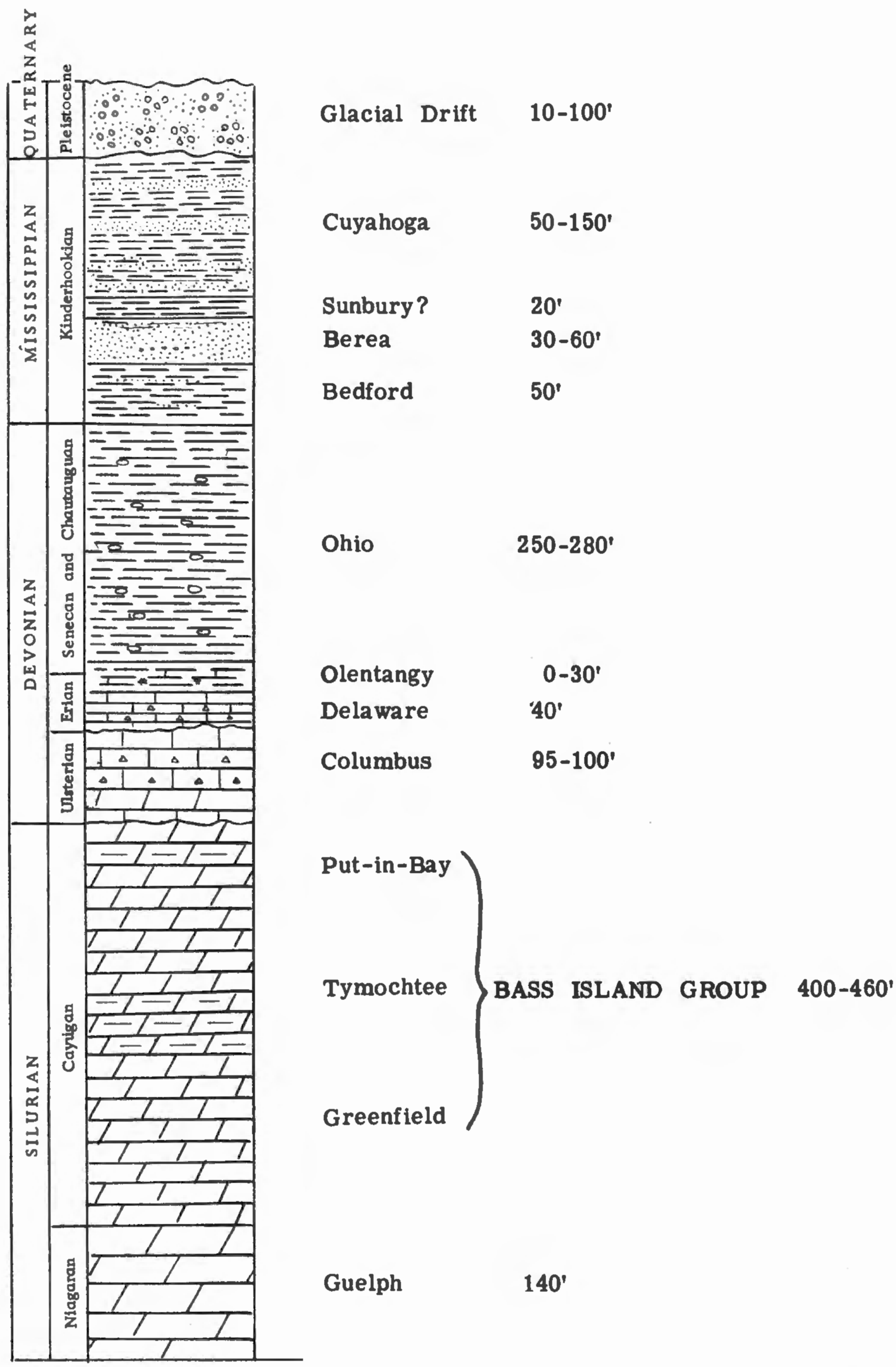


FIG. 3. GEOLOGIC COLUMN OF CRAWFORD, MARION, MORROW, AND WYANDOT COUNTIES

Guelph Formation

The Guelph where exposed is a true dolomite. It is massive in character, at few places shows distinct bedding, and is very porous. Some of the cavities exceed two inches in diameter. On unweathered surfaces it is light-gray to blue-gray in color, but where weathered it is usually drab to buff. Along certain zones fossils are common, but generally it is unfossiliferous. Inferred thickness, on the basis of drillings, is roughly 140 feet.

The Guelph covers all of Jackson, Richland, and Ridge Townships, and large areas of western Marseilles, Mifflin, Salem, and Crawford Townships in Wyandot County. In Marion County it is exposed in the western part of Grand Township (see Fig. 2).

At Carey, Crawford Township, Wyandot County, the Guelph is extensively quarried. The following section from Stout (1941, p. 294) is typical of this unit:

	FT.	IN.
Cayugan series		
Bass Island group		
Greenfield formation		
Dolomite, dense to somewhat open texture, layers 1 to 6 inches in thickness, light bluish gray, with papery partings of dark material, few fossils.	6	6
Dolomite, dense, bluish gray, banded, layers 1 to 10 inches.	5	6
Niagaran series		
Guelph formation		
Dolomite, light, open texture, crystalline, massive structure, locally stained with bitumen.	14	0
Dolomite, light, sugary texture, some dark oily spots, blotchy appearance, open structure, few fossils, high purity	18	0
Floor of quarry.		

Cayugan Series

In 1899 Clarke and Schuchert named the Cayugan series for the upper Silurian rocks at the north end of Cayuga Lake, New York. This was further subdivided into two stages, the Salina and Waterlime. In Ohio the underlying Salina beds do not outcrop, but are present in northeastern Ohio at considerable depth. Winchell (1873) reported and described the occurrence of the Waterlime in both Marion and Wyandot Counties. Later this term was abandoned in Ohio, and this series of rock was called the Lower Monroe. At present, though the term Monroe is still used in varying degrees by Ohio geologists, it is best to call the upper Silurian of central and northern Ohio the Bass Island group (Lane et al 1908). In Ohio, the Bass Island has been divided into the following formations: Greenfield, Tymochtee, Put-in-Bay, and Raisin River. Only the first three are present in the area covered by this report, since the Raisin River beds are found only west of Toledo and on Bass Islands. The Bass Island group covers all of Crane and Tymochtee Townships, most of Pitt, Crawford, and Sycamore, and parts of Eden, Marseilles, Mifflin, and Salem Townships in Wyandot County. In Marion County, the Bass Island underlies the glacial drift in all or most of Salt Rock, Big Island, Green Camp, Bowling Green, and Montgomery Townships, with small parts of Prospect, Pleasant, and Grand Townships also having outcrops of these groups. Since exposures of the Bass Island are very scarce, the Geologic Map (Fig. 2) and the columnar section (Fig. 3) do not subdivide it into its various formations. Estimated thickness in the area for the whole group is between 400 and 460 feet.

Greenfield Formation

The Greenfield was named by Orton (1871) from exposures near Greenfield, Highland County, Ohio. It was later assigned to the basal part of the Lower Monroe and finally to its present stratigraphic position as the basal formation of the Bass Island group.

The Greenfield formation is a fine-grained, dense dolomite occurring commonly in beds 2 to 6 inches thick. Carbonaceous partings are generally present and locally the rock becomes siliceous. In color it is generally drab, but in places it is found to be brownish or bluish gray. It is present at Carey in Western Wyandot County where it lies disconformably on the Guelph dolomite.

Tymochtee Formation

Winchell in 1873 named the second division of the Bass Island for exposures on Tymochtee Creek in Wyandot County. He restricted the term to only a small unit, but later it was expanded to comprise an entire formation.

Originally designated as a slate or a black shale, the Tymochtee does not differ much in composition from the other units of the Bass Island. It is mainly a pure dolomite, with clay material rarely exceeding 5 percent. The shelly or shaly layering is due to thin partings of organic or pyritic matter. Where this very thin bedding is not present, however, the Tymochtee may be massive and is a tough and coarsely crystalline rock. Its color ranges from dark bluish gray to brown, with the latter the more dominant shade. Near Upper Sandusky it exhibits a well defined joint pattern.

Stout (1941, p. 301) gives a typical Tymochtee section, as located in Crawford Township, Wyandot County.

	FT.	IN.
Bass Island group		
Tymochtee formation		
Dolomite, bluish gray, hard, dense, parts curly structure, 1 to 10 inch layers, few fossils.	11	0
Dolomite, bluish gray, very hard and dense, conchoidal fracture, thin bedded with papery partings, few fossils.	4	4

The Tymochtee is present in both Marion and Wyandot Counties along a zone running roughly from Tymochtee Township, Wyandot County, south through Upper Sandusky into Montgomery and Bowling Green Townships of Marion County. Few outcrops are present, with those along Tymochtee Creek and at Upper Sandusky being the best displayed.

Put-in-Bay Formation

The Put-in-Bay formation of the Bass Island group was named by Lane et al (1908, p. 553-56) from exposures near the small town of Put-in-Bay on South Bass Island in Lake Erie.

Best known in the lake region, its presence in central Ohio is questionable. However Stout et al (1943, p. 442-45) lists this unit as being the bedrock underlying the towns of Green Camp, Green Camp Township; Morral, Salt Rock Township; and Prospect, Prospect Township, all in Marion County. By inference the same formation should run north into Wyandot County through eastern Pitt, Crane, and Tymochtee Townships.

Lithologically, the Put-in-Bay is very similar to the other two formation of the Bass Island group. The exposure at Prospect Dam, Prospect Township, Marion County, as described by Stout (1941, p. 280), in the following measured section, probably best illustrates its lithologic nature.

	FT.	IN.
Bass Island group		
Put-in-Bay formation (?)		
Dolomite, thin layers, 1 to 4 inches, stone hard, dense, gray.	1	3
Shale, with a few thin layers of hard dolomite, gray to green, soft	1	10
Dolomite, thin layers, 1 to 4 inches, stone hard and dense	1	5
Shale, soft, greenish, calcareous	0	8
Dolomite, thin-bedded, with shale partings	1	3
Dolomite, thin-bedded, hard, dense	3	2
Dolomite, dark, thin-bedded, hard.	1	4

DEVONIAN SYSTEM

Disconformably above the Bass Island group of the Silurian system are the Devonian rocks. They cover the eastern half of Marion County, the eastern margin of Wyandot County, the western third of Morrow County, and almost all of Crawford County except for the easternmost townships.

The Devonian rocks range in age from the Ulsterian series to the Chatauquan series. The Upper Monroe or Detroit River group of lower Ulsterian age is missing in the four counties under consideration, hence resting directly upon the Bass Island group is the Columbus limestone, which is either late Ulsterian or very early Erian.

Winchell (1873, p. 625, 640) shows an outcrop line for the Oriskany sandstone in both Marion and Wyandot Counties. In his text he infers its presence though stating that no outcrops have been found. As shown by Hall (1952, p. 54), the Oriskany does not come that far west, and even if the Sylvania sandstone of northwestern Ohio is equivalent to the Oriskany, it is also not traceable to the south and east into either Marion or Wyandot Counties. Therefore, Winchell was in error for assuming that the Oriskany was present in this area.

Ulsterian Series

Columbus Formation

The Columbus formation, the earliest Devonian present in the area, was named by Winchell (1873, p. 143-44) from quarry exposures near Columbus, Ohio. In his early work in Crawford, Marion, and Wyandot Counties, he refers to this unit as the Lower Corniferous (Winchell, 1873, p. 636, 641; 1874, p. 245).

In general, the Columbus strata are massive in bedding, varying from 2 to 10 feet in thickness. The upper 50 feet or so is a light to blue-gray, hard and dense limestone, whereas the basal portion is usually a brownish gray, highly crystalline and porous dolomite or dolomitic limestone. Locally chert is present either in definite layers or as scattered nodules. The upper or limestone part is very fossiliferous, but the dolomitic layers contain only a few fossils. Other features of minor importance are stylolites along the bedding planes, ripple marks on some layers, and a more or less regular pattern of joints.

The Columbus formation in the area covered by this report is roughly 95 to 100 feet thick.

In Marion County, the formation extends in a north-south direction in a narrow belt, three to five miles wide, through Prospect, Pleasant, Marion, and Prairie Townships. In Crawford County, the Columbus is deeply buried beneath glacial drift in a small area along the western border in Dallas, Todd, Texas, and Lykens Townships. In Wyandot County, due to the glacial overburden, it is exposed only locally along Sycamore Creek in eastern Sycamore Township. By position it should also be present along the eastern borders of Antrim and Eden Townships (see Fig. 2).

In correlating, Cooper et al (1942) places the Columbus at the top of the Ulsterian and equivalent to the Onondaga limestone of the Appalachian and New York region.

Stauffer (1909, p. 94-95) gives a representative section of both the Columbus and overlying Delaware formations at Marion, Marion County.

	FT.	IN.
Devonian system		
Erian series		
13. Granular crinoidal blue limestone	3	0
12. Bluish brown limestone in rather thin even layers alternating with a great quantity of soft bluish white chert. The chert contains Bryozoans.	12	6
11. Rather massive layers of blue limestone, with pockets of fossiliferous white chert and thin shaly partings.	9	6
10. Soft shaly blue limestone.	0	6
9. Massive blue limestone with some chert and shaly partings.	5	6
Ulsterian series		
Columbus formation		
8. "Bone-bed".	0	0
7. Fossiliferous gray limestone	2	0
6. Layer of crinoidal gray limestone.	2	0
5. Massive gray limestone, somewhat crinoidal and very fossiliferous	10	0
4. Layer of hard gray chert alternating with gray limestone, both fossiliferous	4	0
3. Massive gray limestone at places crowded with specimens of Atrypa spinosa, and Atrypa reticularis	3	0
2. Massive layers of very fossiliferous, light gray limestone	12	6
1. Massive gray to light brown limestone, sparingly fossiliferous to bottom of quarry	8	6

Erian Series

Delaware Formation

Lying above the Columbus is the Delaware formation, named by Orton (1878) from exposures at Delaware, Ohio. In central and northern Ohio the two formations are separated by a thin bone bed or by a very slight disconformity. Farther to the east, where both units are deeply buried, a thin black shale, the Marcellus, is often present between them. As indicated by drilling records, this shale becomes thicker as you go towards Pennsylvania. The Delaware corresponds to Winchell's Upper Corniferous (1873, p. 636, 642; 1874, p. 244).

The Delaware is impure limestone of a darkish blue color, the shade dependent on inclosed impurities, such as organic matter or iron-bearing minerals. It is generally regularly bedded, the layers ranging from 1 inch to 2 feet in thickness but commonly measuring 4 to 12 inches. Chert is common, being found either as nodules or along definite bedding planes. The stone is fine-grained, hard and dense. Parts of the Delaware are very fossiliferous, but others are almost completely lacking in good well-preserved fossils. Due to the few exposures the thickness of this formation for this part of Ohio is questionable, but as calculated from well records and better exposures to the south, an approximate figure of 40 feet would be fairly accurate.

In Marion County the Delaware, like the Columbus, is confined to a narrow belt two to five miles in width northward through western Waldo, eastern Pleasant, southwestern Richland, eastern Marion, western Claridon, eastern Grand Prairie, and western Scott Townships. This same belt extends across western Crawford County through Dallas, Bucyrus, Holmes, and Lykens Townships.

According to Cooper et al (1942), the Delaware correlates with the Marcellus shale of the middle Appalachians and the Dundee limestone of northwestern Ohio and Michigan.

Stout (1941, p. 286) gives a representative section for the Delaware in Richland Township, Marion County.

	FT.	IN.
Erian series		
Delaware formation		
Limestone, dark blue, practically no flint present, layers 2 to 3 inches in thickness	12	10
Limestone, blue, layers 3 to 6 inches in thickness, with occasional nodules of white flint	1	8
Flint, white, prominent layer, with some limestone	0	3
Limestone, deep blue, hard, layers up to 6 inches in thickness	3	10
Limestone, shaly	0	3
Limestone, dark blue, hard, layers 1 inch or more in thickness	5	0

Olentangy Formation

The Olentangy formation lies above the Delaware formation and was named by Winchell (1874, p. 287) from excellent exposures along the Olentangy River at Delaware, Ohio.

The Olentangy is bluish-gray, siliceous clay shale, with a few minor beds of impure limestone. At places the shale is carbonaceous and pyrite is a consistent impurity. The formation is very poorly fossiliferous.

Though deeply buried by glacial drift, the Olentangy is inferred to be present in a roughly north-south belt extending from western Marion County into Crawford County. Its thickness in this area is not well known, but Stauffer (1916, p. 486), on the basis of well records in Crawford County, lists a variable thickness from 0 to 30 feet. Winchell (1874, p. 243) gives it a questionable thickness of 30 feet, though he mentions not seeing any outcrops.

Cooper et al (1942) correlates the Olentangy as both Erian and Senecan, with at least the basal portion being equivalent to the Tully limestone of the Appalachian area.

Senecan-Chatauquan Series

Ohio Formation

The thick series of shales in the upper part of the Devonian system was called the Ohio by Andrews in 1870. It is composed of three members: Huron, Chagrin, and Cleveland. The Huron and Cleveland are typically black or brownish black fissile shales with a high content of carbonaceous matter. The Chagrin, or middle unit, is typically a gray siliceous shale with a definite lack of carbonaceous material. The separation of the Ohio into these various members is possible only in northern Ohio, where they are well exposed and show these characteristics. Therefore, no attempt has been made in the four-county area under consideration to subdivide this formation. Winchell (1874, p. 263, 264) attempted a more rigid classification, but on the basis of the very poor exposure it seems doubtful that his subdivision is valid.

Locally the Ohio formation is present in eastern Marion County (part of Waldo, Richland, Claridon, and Tully Townships); western Morrow (roughly along a north-south belt, with its eastern boundary just west of Mt. Gilead), and in east central Crawford County (see Fig. 2). In this area it is typically a black fissile shale with varying amounts of pyrite and locally contains large concretionary masses up to four feet in diameter. The light gray middle portion seems to be lacking. Due to poor exposures a true thickness of this unit is hard to determine. However, on basis of well records and meager outcrops, a tentative thickness of roughly 250 to 280 feet is assigned to the Ohio formation for this four-county area.

In correlation, Cooper et al (1942) places the Ohio formation as both Senecan and Chautauquan, being equivalent to the Portage, Chemung, and Catskill beds of eastern United States.

MISSISSIPPIAN SYSTEM

The youngest bedrocks in the four-county area belong to the Mississippian system. In contrast to the rocks of the two older systems, all the Mississippian strata are clastic either sandstone or shale, with the latter being the dominant type.

Four formations, the Bedford, Berea, Sunbury (?), and Cuyahoga, are present in this area. These are the original members of the older classification or "Waverly group." On the geologic map (Fig. 2) no attempt has been made to list the individual formations. All the Mississippian rocks are listed as "Mississippian undifferentiated." Also in Fig. 3, only approximate thickness for the combined formation is given. This figure is probably in error 25 to 50 feet either way.

The bottom three formations are, according to Weller et al (1948), Kinderhookian in age. The Cuyahoga formation is considered by him to be both Kinderhookian and Osagean.

However, since only the basal part of this formation is present in the area all the Mississippian rocks are considered by the authors to be lower Mississippian or Kinderhookian in age.

Mississippian strata outcrop in only Crawford and Morrow Counties, roughly east of a line drawn north-south through Mt. Gilead (see Fig. 2). Exposures are rare except for local quarries and along some of the deeper stream channels.

Kinderhookian Series

Bedford Formation

The Bedford shale was named by Newberry (1870, p. 188) from the outcrops at Bedford, southeast of Cleveland. It is the oldest Mississippian formation and conformably overlies the Ohio shale.

At or near its type locality the Bedford is either a dull pink or light bluish-gray shale. In central Ohio the soft pink shale is absent, and the unit is composed entirely of light-blue, soft shale, with a few hard sandstone layers. Though marine in origin, few if any fossils are present.

In Crawford and Morrow Counties, the Bedford for the most part is completely covered, hence little is known either of its true character or thickness. At Mt. Gilead, at the bottom of old quarries in the Berea, a dull blue siliceous shale is present, which because of its color is inferred to be Bedford. Winchell (1874, p. 240, 256) lists thicknesses of 40 and 75 feet for Crawford and Morrow Counties respectively. These are guesses, as no complete section is available. On the basis of exposures to the south and north, an approximate thickness of 50 feet is perhaps a better figure.

Berea Formation

The Berea, named by Newberry (1870, p. 21, 29) from exposures at Berea, Ohio, is typically a fine to medium grained sandstone.

The Berea in Crawford and Morrow Counties is a buff to blue-gray sandstone, which due to iron impurities turns a brownish-yellow upon weathering. The sandstone varies from being medium fine-grained to places where it could actually be called pebbly. The upper five to ten feet in all known quarries is usually very shaly or thin bedded, while the basal portions are more massive bedded, with some layers reaching 3 feet in thickness. In this lower part, definite bedding planes are very uneven and often lacking. Iron concretions and peculiar rounded sandstone pebbles are often present in the stone. Vertical joints, so helpful in quarrying procedures, are generally missing.

The thickness of the Berea for the two counties is estimated to be from 30 to 60 feet. It is better exposed than most of the units in the area. Good outcrops are present in Lincoln and Gilead Townships of Morrow County and in Polk, Vernon, Jefferson, and Auburn Townships of Crawford County.

Bownocker (1915, p. 101) gives the following Berea section, six miles south of Mt. Gilead, at Fulton in Lincoln Township, Morrow County.

	FT.
Kinderhookian series	
Berea sandstone	
Shell rock. Uneven beds that range in thickness from an inch to two feet or more. Used for foundations.	6 - 12
Massive rock. Without real bedding planes. Sawed for flagging, curbing, and building stone.	27
Bedford shale.	

The Berea sandstone probably correlates (Weller et al, 1948) with the basal Pocono sandstone of eastern United States.

Sunbury Formation

The Sunbury shale was named by Hicks (1878, p. 216) for exposures just east of Sunbury in Delaware County. It lies directly above the Berea sandstone and is a fairly persistent brown to black shale, often fissile in nature.

No known outcrops of this shale are present in either Crawford or Morrow Counties. However, due to its persistent nature, it is thought to underlie parts of the eastern area of these counties. If present, it probably follows its usual average of being about 20 feet thick.

Cuyahoga Formation

The Cuyahoga formation, named by Newberry (1870, p. 21), overlies the Sunbury shale and consists of a series of interbedded sandstones and shales.

This formation underlies parts of Vernon, Jackson, and Polk Townships in Crawford County and probably under the eastern third of Morrow County. Again, due to scattered and poor outcrops, little is known of this unit in this particular area.

Where exposed, as along stream beds in Troy Township, Morrow County, it is usually a series of alternating thin-bedded sandstones and gray-blue shales. The sandstone, averaging 1 to 3 inches in thickness, is fine-grained and often very micaceous. The shales are fissile, micaceous and very soft. In a few places the sandstone layers have reached a thickness of 12 to 14 inches and hence have been locally quarried for foundation use.

Based on well records, the Cuyahoga formation ranges in thickness from 50 to 150 feet (?) in Morrow County. Thicknesses for Crawford County are unreliable.

GLACIAL GEOLOGY

Overlying the bedrock of this four-county area are deposits of glacial drift. This drift, except in the parts of Crawford and Morrow Counties, completely masks the true nature of the underlying bedrock. As the glacial geology has been worked in detail only in Crawford County, a very general review of the known glacial deposits is all that will be presented here.

During the Pleistocene epoch of the Cenozoic this area was covered by large continental glaciers. At different times, two, perhaps three, of these ice sheets advanced from the north over the area. The first of these glacial advances was probably the Kansan which occurred roughly 750,000 to 675,000 years ago. Actually the presence of this glacier in this part of Ohio is still in the doubtful category. Stout et al (1944, p. 24) mentions this glacier covering that area north of the Kansan or pre-Kansan limits as shown in Fig. 4. His evidence is not based on known glacial deposits, but rather on drainage changes due to very early glacial action.

The second glacial mass to advance over the area was the Illinoian (370,000 to 275,000 years ago). This ice sheet covered the entire area and left deposits of glacial debris, now covered by later drift. As a result, little is known about this glacial stage.

The third or last glacier to cover the area was the Wisconsin (125,000 to 12,000 years ago). The Wisconsin completely covered all the Illinoian deposits and the surface drift is all of Wisconsin age.

The glacial drift of the region is composed of unsorted rock debris, or till, and deposits of stratified sand and gravel. Most of the material is till, which is a dull blue-gray, changing to yellowish brown upon oxidation. The depth of oxidation varies from 10 to 20 feet for the area. The till is composed of a mixture of clay, silt, and sand, plus erratic boulders of varying size. Some of these boulders reach three feet in diameter. Locally the glacial drift has been stratified by the action of running water, which has provided good deposits of sand and gravel. These areas are very minor when compared to the till regions. The till, absent in some areas, locally reaches a thickness of 100 feet or more. Representative drift thicknesses are shown on Fig. 4. No attempt has been made to classify the drift into the tills belonging to individual glacial stages or substages. The given thicknesses include deposits of both the Illinoian and Wisconsin glaciers.

Physiographically the area is traversed by various end moraines, as shown in Fig. 4. These end moraines represent periods when the glacial fronts were stationary for a considerable length of time, allowing thick masses of debris to be formed at the ice front edge. They are usually expressed topographically by a very definite ridge or series of low hummocky mounds. Between the end moraines are flatter areas called ground moraine. Most of the known sorted deposits are found along the drainage ways.

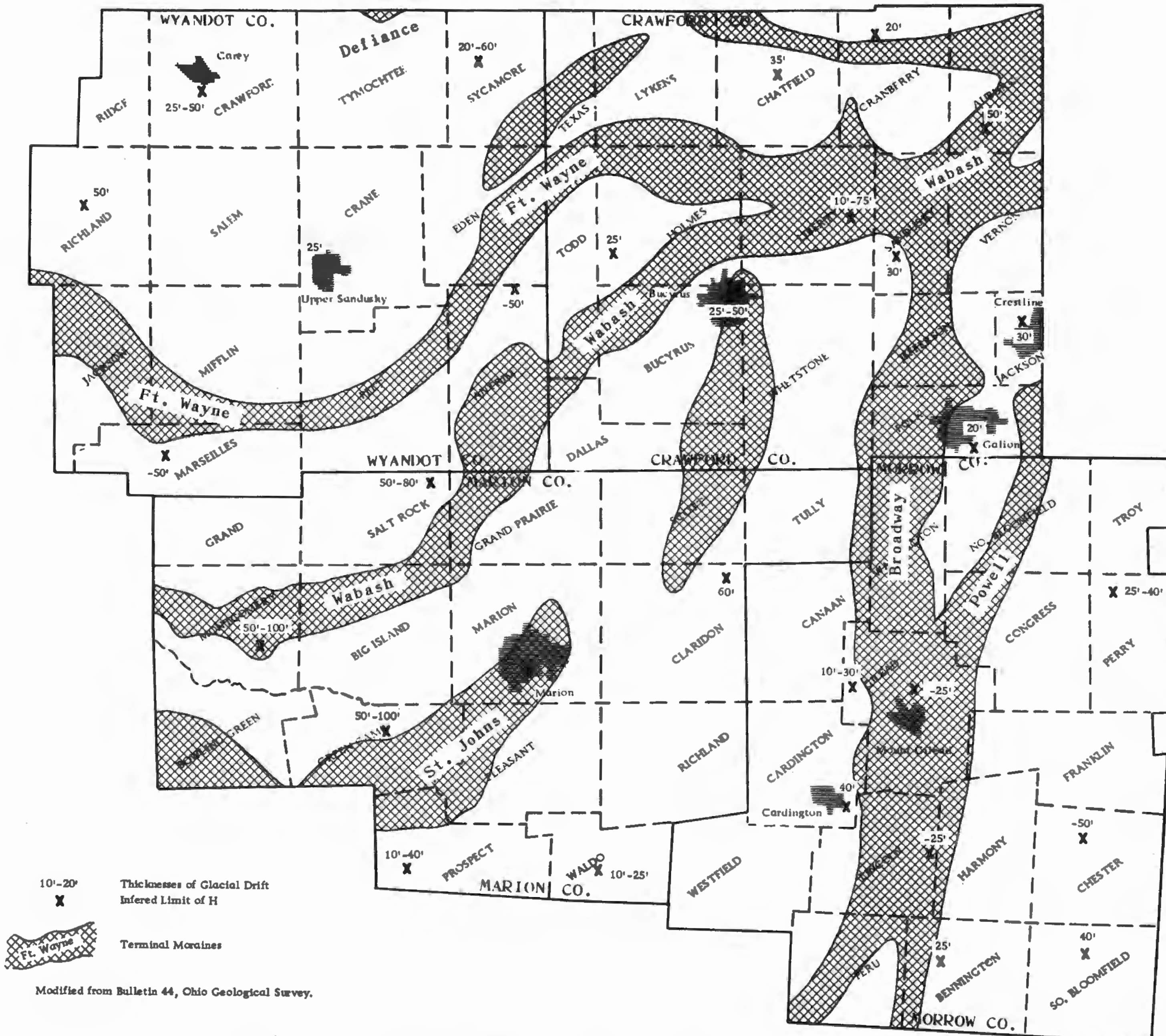


Figure 4. Location of Terminal Moraines.

OIL AND GAS

INTRODUCTION

With the discovery of oil and gas at Findlay, Hancock County, in 1885 and 1886, nearly every town in central and western Ohio proceeded to sink wells in the hope that they too might share in the rewards afforded by the recovery of these two minerals. Their efforts proved fruitless except for the few fortunately situated within the productive limits of the great Trenton field. In Wyandot County wells were sunk at Carey, Nevada, and Upper Sandusky; in Marion County, at Prospect and Marion; and in Crawford County, at Bucyrus and Crestline. Those at Carey and Upper Sandusky were moderately successful and led to the development of a relatively narrow productive area between the two towns. The wells at Nevada, Marion, Prospect, Bucyrus, and Crestline were failures.

One of the investigators of the Trenton field was Edward Orton (1888), State Geologist of Ohio. His reports of early developments and conclusions as to the origin and accumulation of the oil and gas are now among the classical writings of petroleum geology. He recognized porosity resulting from ground water circulation, but its relationship to the unconformity at the top of the Trenton and accumulation was not fully appreciated until 1929 when Ver Wiebe stated that the highly productive "crevice" wells, found in nearly every county in the field, tapped honey-comb zones due to solution action of circulating water rather than areas of porosity due to dolomitization as suggested by Orton.

The conditions for oil and gas accumulations in the Trenton field were summarized by Edward Orton (1888 b, p. 307-310) as follows:

> "1. In fourteen of the northwestern counties of Ohio (and like conditions prevail in contiguous territory in Indiana), the upper beds of the Trenton limestone, which lie from 1,000 and 2,000 feet below the surface, have a chemical composition different from that which generally characterizes this great stratum. They are here found as dolomite or magnesium limestone instead of being, as usual, true carbonate of lime. Their percentage of lime, in other words, ranges between 50 and 60 percent instead of between 80 and 90 percent, as in the formation at large. These dolomites of northwestern Ohio are mainly quite free from siliceous impurities. The dolomitic composition seems to have resulted from an alteration of a true limestone. At least occasional masses of true limestone charged with fossils that are found on the horizon of and surrounded by the dolomite are best explained on this supposition. In the change which it has undergone the fossils which the original limestone contained appear to have been for the most part discharged or rendered obscure, as is usual in this metamorphosis. The crystalline character of the dolomite is often very marked, and there results from it a peculiar open or porous structure. Its storage capacity is much greater than that of ordinary oil sandstones or conglomerates, so far at least as pores visible to the unaided eye are concerned. The change usually extends for ten to thirty feet below the surface of the formation. In some cases, however, sheets of porous dolomite are found as low as fifty feet and very rarely as low as 100 feet below the surface....

"2. A porous rock, buried 1,000 to 2,000 feet below the surface of northwestern Ohio, will not be found empty. Nature abhors a vacuum. With what will its pores be filled? Mainly with salt-water of peculiar composition, possibly representing the brine of the ancient seas in which the limestone was laid down. Ninety-nine-hundredths, or perhaps nine hundred and ninety-nine-thousandths of the limestone will be thus occupied. The remaining hundredth or thousandth will be filled with petroleum and gas which have, in the long course of the ages that have passed, been gathered from a wide and general distribution through the water into certain favored portions of the great limestone sheet.

"3. This salt-water will be held under artesian pressure. The porous limestone containing it rises today in Michigan and Illinois, communicating there with surface waters. The pressure of this head of water will be felt through every portion of the porous rock, and when the stratum is pierced by the drill in the areas that are thus occupied, the salt-water will rise with more or less promptness, depending on the varying degrees of porosity in the rock. The height to which the water will rise will vary in some wells, by reason of the different elevations of the locations at which they are drilled, but with reference to sea-level, the water columns will be found to closely agree. The same artesian pressure accounts for the force with which oil and gas escape when their limited reservoirs in the porous rock are tapped by the drill.

"4. The accumulation of oil and gas in the porous rock depends altogether upon the attraction of gravitation. The lighter portions of the contents of the porous rock, viz., oil and gas, are forced by gravitation into the highest levels that are open to them. Everything turns on the relief of the Trenton limestone. The gas and oil are gathered in the arches of the limestone, if such there are. In default of arches, the high-lying terraces are made to serve the same purpose, but the one indispensable element and condition of all accumulation is relief. A uniform and monotonous descent of the strata is fatal to accumulation of oil and gas where everything else is favorable. The sharper the boundaries of the relief, the more efficient does it become. Absolute elevation is not essential; all that is required is a change of level in the porous rock.... The large accumulations are derived from the large terraces. The Findlay terrace, for example, consists of a very flat-lying tract, ten or twelve miles across in an east and west line, from which the connected areas of the Trenton limestone slope on every side, and to which, therefore, they are necessarily tributary. The gas terrace of Indiana is, by far, the largest of these several subdivisions of the field. The minor elevations of Oak Harbor, Tiffin, and Bryan, for example, give rise to the local supplies of gas or oil in these districts respectively.

"It is certain that all the considerable areas of productive dolomite, that is, of the porous phase of the Trenton limestone lying relatively high enough to accumulate gas and oil, have already been discovered.... Nor does there seem room for many minor arches of importance. The productive field as now defined can be well enough extended by a few square miles on this side or that, but these additions can scarcely change its proportions. Some scanty production can be obtained outside the dolomitic limits laid down, but it will be remembered that there is more or less magnesia in the limestone around the borders of the true field, and is quite possible that this production is in proportion to the amount of dolomite in the rock."

In 1929 Ver Wiebe stated: "Differential porosity induced by solution seems to explain the localization of the oil in the district, although the influence of the doming of the strata on the axis of the arch has also undoubtedly been of great importance....This implies an unconformity at the top of the Trenton and the basis for this assumption may be set forth briefly as follows: (1) The experienced drillers in this district soon found out that the good territory was characterized by what they called "crevices." Holes or openings were encountered by the drill which were in places only a foot or less in depth, but in places dropped 6 or 8 feet, indicating cavities made by circulating underground water. (2) Many fragments blown from the wells by torpedoes showed honey-comb structure and examination of the walls of the cavities showed that they were produced by solution. (3) The depth at which production was encountered is suggestive. As a rule production is not found at the top of the limestone, but ordinarily at varying depths down to approximately 50 feet and only exceptionally below that depth. The producing level was not uniform, but varied greatly from well to well, as much as 50 feet in some offset locations. (4) The fact that gushers were found adjacent to small wells or dry holes also indicates that the cavities in which the oil existed were more comparable with channels and openings produced by ground water than with openings produced by any other agency. (5) The distribution of oil and gas territory looks very much like a map of the underground caverns and channels in a region where we may now see the effects of ground water in thick limestone, for example, in the Mammoth Cave area of Kentucky."

Carman and Stout (1934) concluded "The Trenton reservoir contains salt water, oil, and gas, and so far as porosity and dip are adequate these substances are arranged in the order of their gravity with the gas at the top of the structure, followed in order downward by oil and salt water. However the degree of porosity varies from place to place or fails entirely and the dips are very low over large areas. As a result the Cincinnati geanticline is not a simple oil and gas structure with gas everywhere beneath the crest, oil on the limbs, and salt water farther down. Most of the production of oil and gas is related to monoclines, terraces, faults, et cetera, which locally modify the simple gentle dips of the geanticline as a whole. Within these structures the normal relative positions of the gas, oil and salt water hold, in so far as they are present.... As the field is exhausted the salt water level rises, progressively narrowing the producing belt."

DEVELOPMENT BY COUNTY

Of the four counties concerned in this report only Wyandot and Marion have produced oil and gas in commercial quantities. In Wyandot County the production occurred in the top of the Trenton along a sharply dipping terrace which enters the county near the northwest corner and gradually dies out southeast of Upper Sandusky. Wells to the east, or down dip from the terrace, usually encounter salt water. Those to the west fail to find porosity. Near Caledonia in Marion County, four wells produced oil from the St. Peter horizon for a number of years.

WYANDOT COUNTY

In reviewing the early activities in this county, Orton (1888) reports at Upper Sandusky "A deep well which was drilled 472 feet into the Trenton limestone, early in 1886, proved a failure," and at Whartonsburg "In May 1887 .... a well was drilled without valuable result." In the same year "salt water was struck" in a well drilled at Nevada and "Eleven wells have been drilled at Carey and its immediate vicinity up to the present time."

Bownocker (1903) relates that the productive area in Crawford Township in 1902 was limited to Sections 20, 27, and 35, but it was formerly considerably larger. Also that development in the area began in 1888 when a 500-barrel oil well was discovered on the Kinley farm in Section 1, Salem Township. The largest well discovered in the county was on the Krebs farm, Salem Township, completed in 1890. Bownocker reports that "It began flowing at the rate of 1,200 barrels of oil per day...." By 1902 the productive area of Salem Township was confined to Sections 1, 2 and 12, and the daily production of the 1,200-barrel well had declined to 2 barrels. In adjoining Crane Township, Sections 6, 7, and 19 comprised the productive area in 1902 (see Fig. 5).

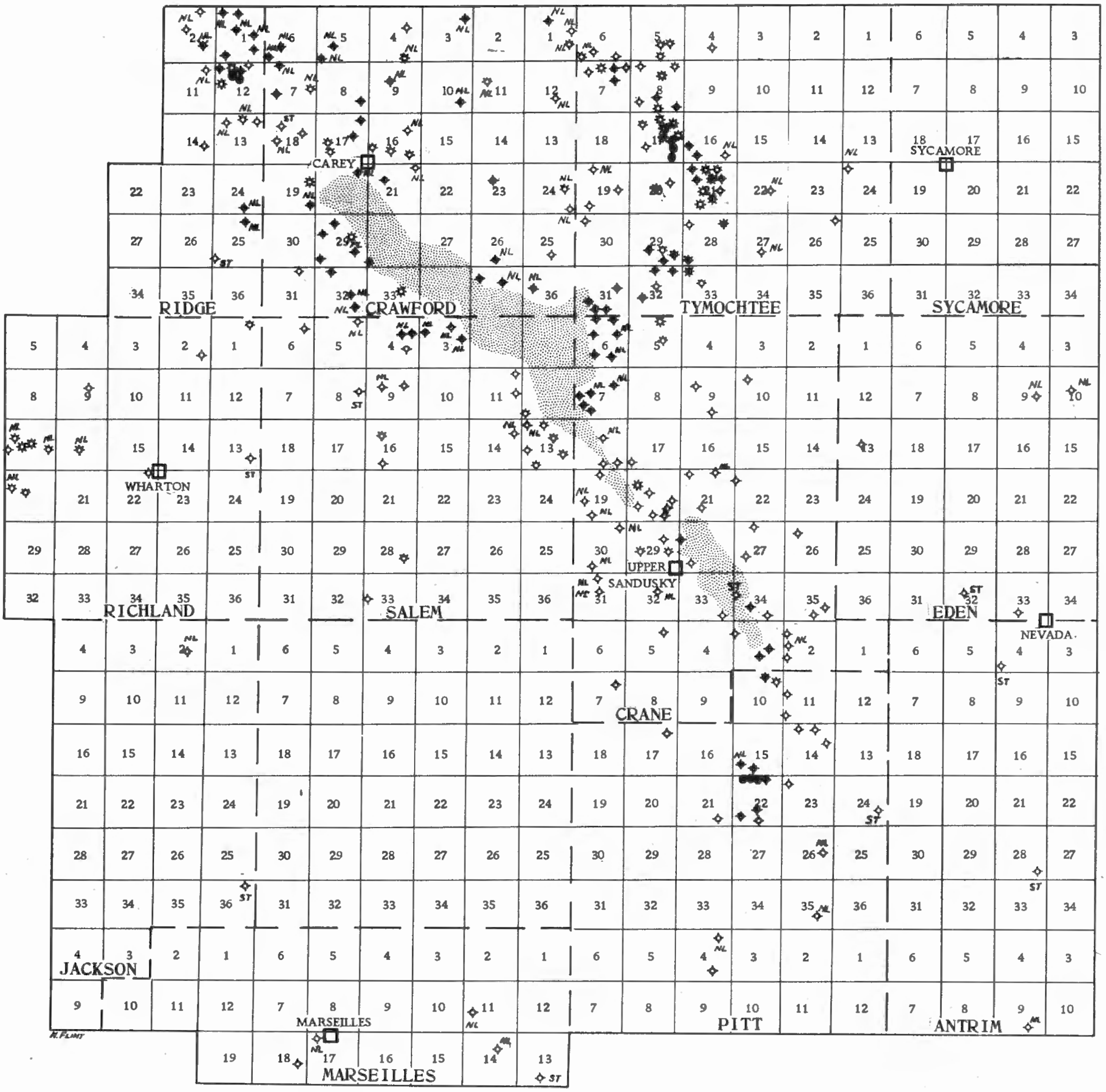
Exploratory drilling in Wyandot County has been carried on almost continuously through the years, but for the most part the rewards have been either small producers or dry holes. In the middle 1930's a number of gas wells were discovered in Sections 5, 8, 17, 29, and 31, Tymochtee Township, and a number of good oil wells were completed in Sections 28, 33, and 34, Crane Township. Activity subsided until 1948 when Homer Lininger, son of an earlier driller, cleaned out an old well on the Hildebrand farm in Section 33, Crane Township, and treated it with 500 gallons of acid. It responded by producing 13 barrels of oil per day. A second treatment, using 1,400 gallons of acid, increased the oil production to 10 barrels per hour. Although this production declined very rapidly, drilling activity again resumed. By 1953 the limits of the new development were defined and recent wells have been located primarily within the pool boundaries.

MARION COUNTY

The first oil and gas test well drilled in this county was located just west of the city of Marion near the Columbus and Toledo Railroad (see Fig. 6). It was completed in 1885 to a total depth of 1,790 feet. The top of the Trenton limestone occurred at 1,678 feet and drilling was halted 112 feet deeper when salt water was encountered. No oil or gas was found. A well at Prospect in 1887 also failed to find production.

In the fall of 1918 a Caledonia Oil Company test discovered oil in the "St. Peter sand" in Section 10, Claridon Township. The well, Ulsh No. 1, reached total depth of 2,731 feet and found the pay zone from 2,722 to 2,731 feet. It produced five barrels of oil per day after a 100-quart nitroglycerine shot. Three additional producing oil wells, the largest 45 barrels, and nine dry holes have been drilled in attempts to extend the productive area of this small pool. The most recent of these were completed during the summer of 1954, one to the northwest in Section 9 and the other to the south in Section 15. The first was completely dry and the latter found only a very small show of oil.

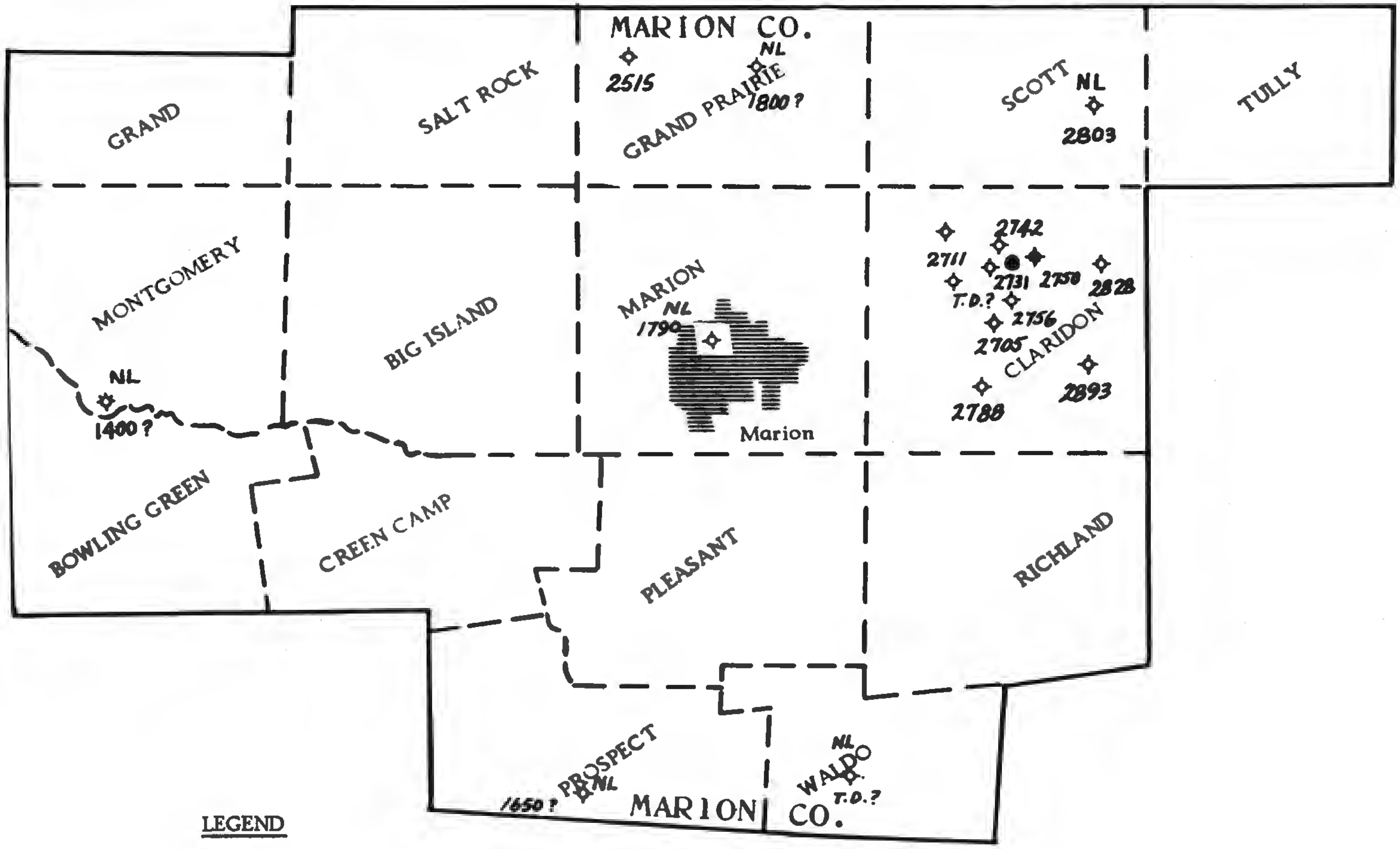
Cyrus Doyle, a resident of the village of Caledonia, founded the Caledonia Oil Company in 1918 to explore gas seeps which had been known to exist in the area for many years. The first well was begun during the winter of 1918-1919 approximately one mile west of the village and just south of U. S. Route 30. Mr. Doyle states that the prime consideration in making this location was nearness to the main road and nearby gas seepages. That later wells only a few hundred feet to the east or west should encounter salt water instead of oil makes his initial choice almost uncanny. Panyity (1921) found that the producing wells were located on a very



LEGEND

✲	Gas Well	ST	Sub-Trenton Test
●	Oil Well	✧	Dry Hole
✱	Oil & Gas Well	✲	Dry - Show Gas
NL	No Log Available	◆	Dry - Show Oil

FIG. 5. LOCATION OF PRODUCING AREAS AND TEST WELLS IN WYANDOT COUNTY.



LEGEND

NL	No log available
✧	Dry hole
2200	Total depth
✦	Dry - show oil
☼	Dry - show gas
✹	Gas well

Figure 6. Location and Depth of Test Wells in Marion County.

narrow ridge structure with salt water down dip from the oil. The four wells had produced approximately $135,000 worth of oil by 1924 when the company was dissolved. They were finally abandoned in 1926 because of encroaching salt water.

CRAWFORD COUNTY

In the early history of this county Orton (1888) relates "After an ineffectual effort to reach the Trenton limestone in a well begun in Bucyrus in 1885....a second well was begun in the summer of 1886, and was finished in November of that year at a depth of 2,264 feet. The Trenton was struck at 2,145 feet and the well was drilled 119 feet into it without any valuable results whatever....A well, drilled three years since in Crestline, reached a small supply of low-pressure gas at a depth of a few hundred feet in the great shale series, but there was not enough of it for anything more than the feeblest domestic supply. A deep well was sunk in the fall of 1886 which reached the Trenton limestone at a depth of 2,832 feet. It was carried down to a depth of 2,864 feet, where the tools became fast and all attempts to get them free proved unsuccessful. There is nothing in the experience of northwestern Ohio thus far to give any encouragement to see the Trenton limestone at these great depths."

In addition to the above early history of Crawford County it is reported that in 1862 a three-barrel oil well was discovered at a depth of 400 feet in the Ohio shale on the Mary Oldfield farm in Section 4, Jackson Township (see Fig. 7). Efforts to increase production by shooting brought in water and ruined the well. Six very close offset wells were dry. In 1916 a small gas pool was discovered in Section 28, Vernon Township, when, at 710 feet and 12 feet in the Devonian limestone, a reported flow of 300,000 cubic feet of gas was encountered. During the next three years fifteen wells were drilled in Sections 20, 21, 28, and 29, the majority of which were either dry or contained only small amounts of gas. Those which did produce soon were drowned out by water associated with the gas in the producing formation.

Fourteen deep tests are known to have been drilled in Crawford County. Eight recorded small shows of oil and gas in the Trenton and six were halted by salt water in the "St. Peter."

MORROW COUNTY

About 1870 a test well near an old salt lick along the bank of Alum Creek at West Liberty struck salt water at 330 feet and was abandoned (Winchell 1874). About 1900 two wells were drilled in North Bloomfield Township; one, located in Section 8, reached 1,100 feet and the other, in Section 15, stopped at 1,700 feet (see Fig. 8). Small quantities of gas, probably from the Ohio shale, were the only rewards. A well in Section 14, Washington Township, is reported to have halted at approximately 3,000 feet because of salt water. One in Section 29, Canaan Township, about 2,200 feet in depth, also failed to find production. The deepest test in the county was drilled on the Levering farm, two miles northeast of Chesterville, in 1931. The top of the Trenton was found at 3,320 feet and it was abandoned as a dry hole at 4,180 feet.

Several additional wells have been completed in the county through the years but all have been unsuccessful except for small quantities of gas in the shale. Most of these tests were efforts to extend the "St. Peter sand" oil pool in Claridon Township, Marion County, eastward into Canaan Township.

SUBSURFACE GEOLOGY

Several deep test wells have been drilled in this four-county area of which the most significant are shown on Table 9. One well which created some considerable interest during

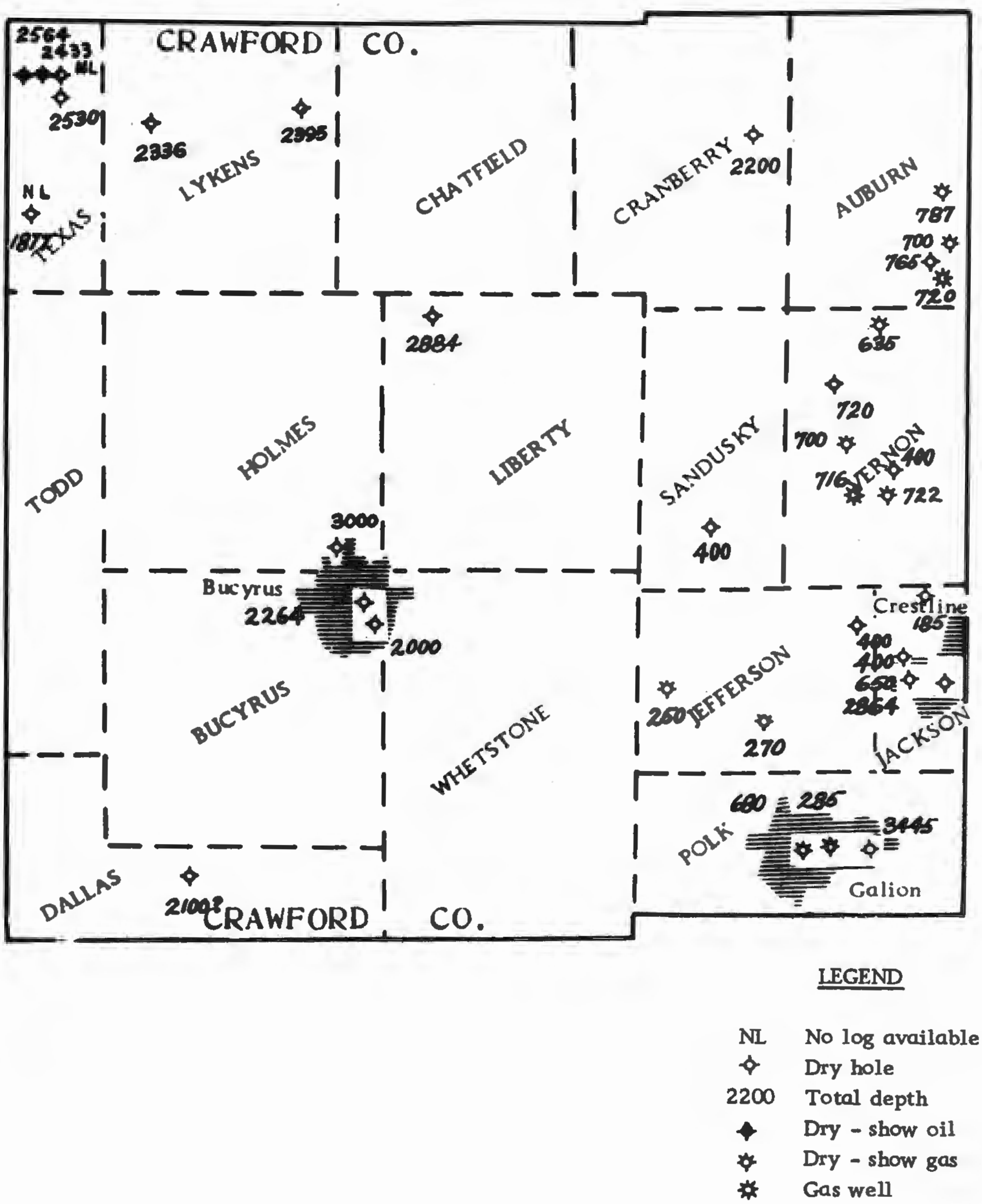


Figure 7. Location and Depth of Test Wells in Crawford County.

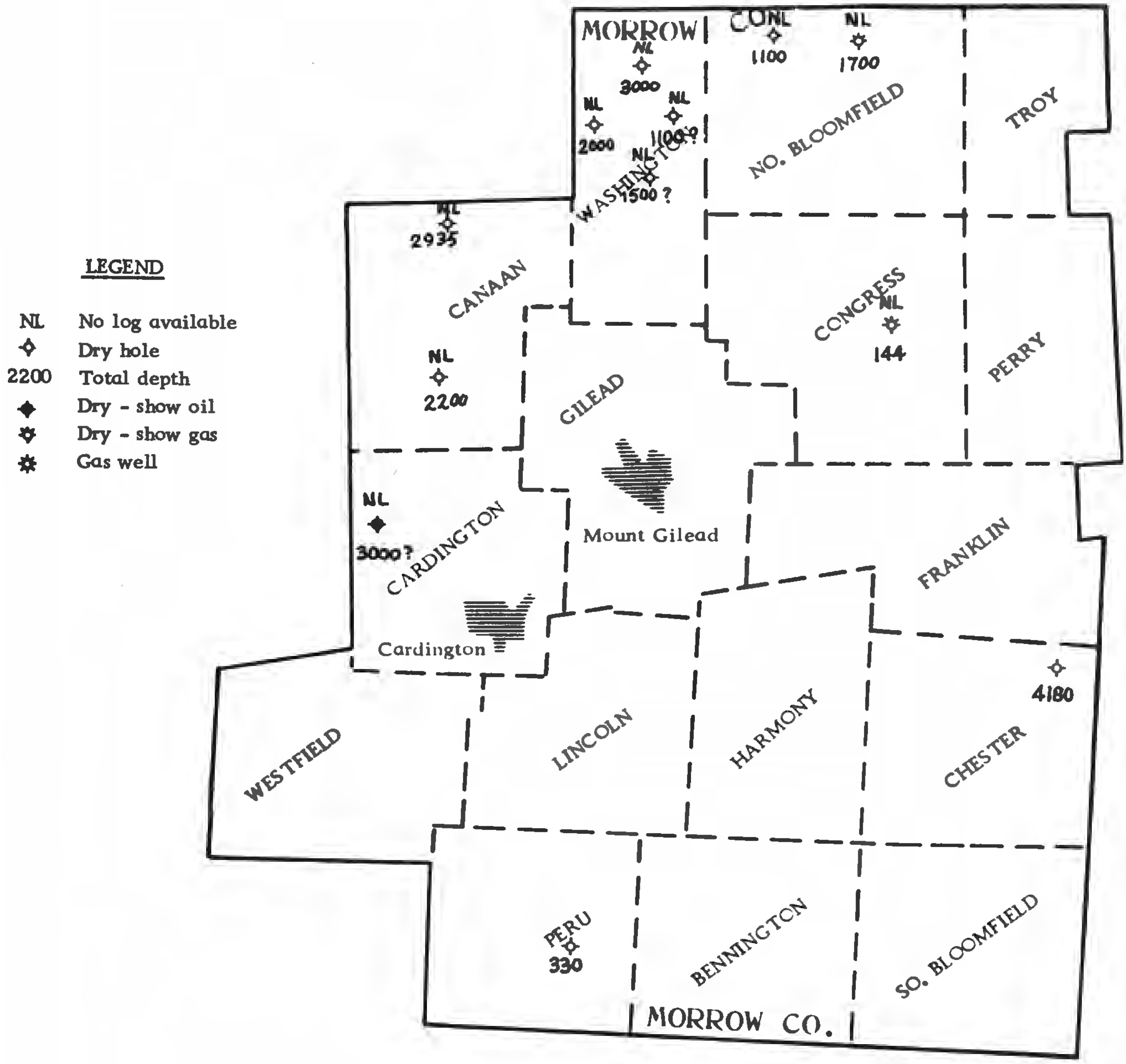


Figure 8. Location and Depth of Test Wells in Morrow County.

the six-year period required to drill it was located on the Parsell farm in Section 36, Jackson Township, Wyandot County. It was begun in June 1941 and drilled intermittently until March 1947 when a total depth of 5,632 feet was reached. The driller recorded Trenton limestone from 1,345 feet to 1,932 feet, granite wash from 3,040 to 3,475 feet, and granite from 3,475 to 5,632 feet. Unfortunately no drill cuttings were saved from this exceptional test. Much could have been learned of the basement rocks of Ohio had full advantage of this opportunity been taken. Another deep test in this area was completed in 1942 on the Heck farm in Section 18, Crawford Township, Wyandot County. It reached a total depth of 2,801 feet, approximately 880 feet below the St. Peter horizon. The driller recorded Trenton limestone from 1,321 to 1,890 feet, green shale 1,890 to 1,920 feet, "St. Peter sand" 1,920 to 1,934 feet, and sand and limestone to total depth. The shale is known as the "Lower Green" to the driller and is composed of green shale and gray to green dolomite. The "St. Peter sand" is usually green to gray dolomite with variable amounts of quartz grains. A small oil pool was developed in this horizon near Caledonia, Marion County, in 1918 (Fig. 8). It has also been productive at Tiffin and in several isolated wells in the central part of the State and along the shores of Lake Erie. The vast majority of the tests have either been dry, found "Blue Lick" salt water, or only small amounts of oil and gas. No production has been found in older formations in Ohio.

TRENTON SERIES

The term Trenton, as it is used by the driller, includes a series of limestones of Ordovician age which range in thickness from 450 feet in western Darke County to more than 800 feet in eastern Ohio. In depth it varies from outcrop along the Ohio river near Point Pleasant, Clermont County, to approximately 7,000 feet in eastern Washington County. In the west portion of Wyandot County it occurs about 1,300 feet below the surface and 560 feet thick and in eastern Morrow County 3,350 feet in depth and 700 feet thick (see Figs. 9, 10). Geologically these limestones are divided into two main units: the upper is known as the true Trenton and the lower as the Black River. The true Trenton is a medium dark gray to brown limestone or dolomite, partially dense and crystalline, with minor amounts of chert and dark shale. In the four-county area considered here it has an average thickness of 150 feet. The underlying Black River formation is a fine-grained gray to light brown, dense, limestone which sometimes contains thin discontinuous streaks of green shale and dolomite. The second and third oil pays, found in parts of the main Trenton field, probably occur in porous zones of these dolomitic streaks.

ORDOVICIAN SHALES

Above the Trenton occurs a series of shales which vary in thickness from approximately 600 feet in the south-western part of the State to more than 1,600 feet in the southeastern. The lowest member, the Utica, is easily recognizable because of its dark brown to black, carbonaceous, character. It is overlain by varicolored calcareous shales with some localized beds of nodular limestone. The top member, the Queenston, is known to the driller as the "Red Medina." Its persistence and distinctive red color make it an important stratigraphic marker in Ohio. Small quantities of gas are sometimes encountered in this great thickness of shales but at few places have they been of commercial value.

In the four-county area concerned in this report this series has an approximate average thickness of 1,050 feet. Drillers use the "Red Medina" as a casing point as the overlying limestones and dolomites usually contain water.

SILURIAN, DEVONIAN, AND MISSISSIPPIAN SYSTEMS

These rocks have produced only minor amounts of gas and oil in the Wyandot, Crawford, Marion, and Morrow County area. Gas in sufficient quantity for home use has been found in the

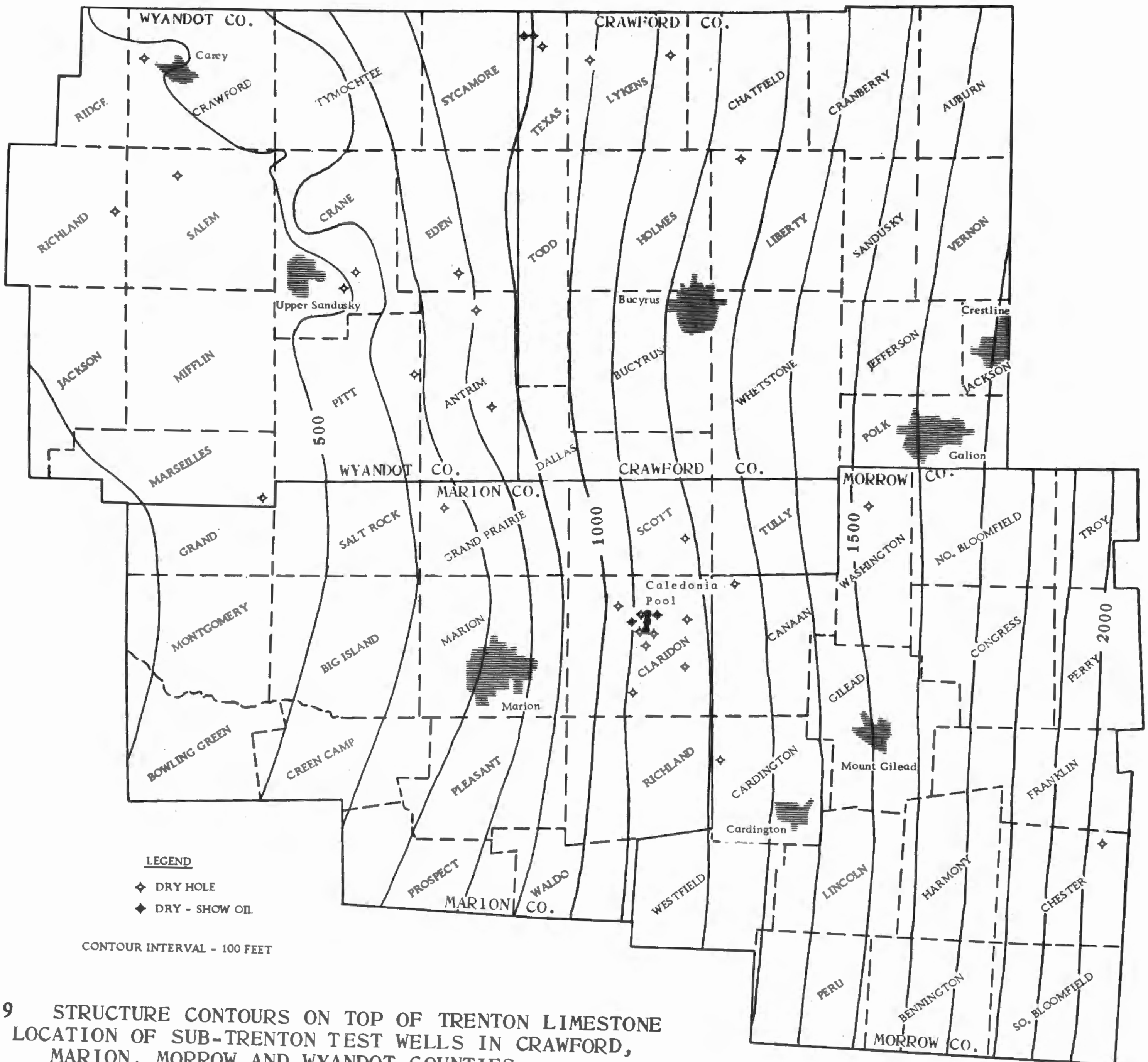


Fig. 9 STRUCTURE CONTOURS ON TOP OF TRENTON LIMESTONE AND LOCATION OF SUB-TRENTON TEST WELLS IN CRAWFORD, MARION, MORROW AND WYANDOT COUNTIES.

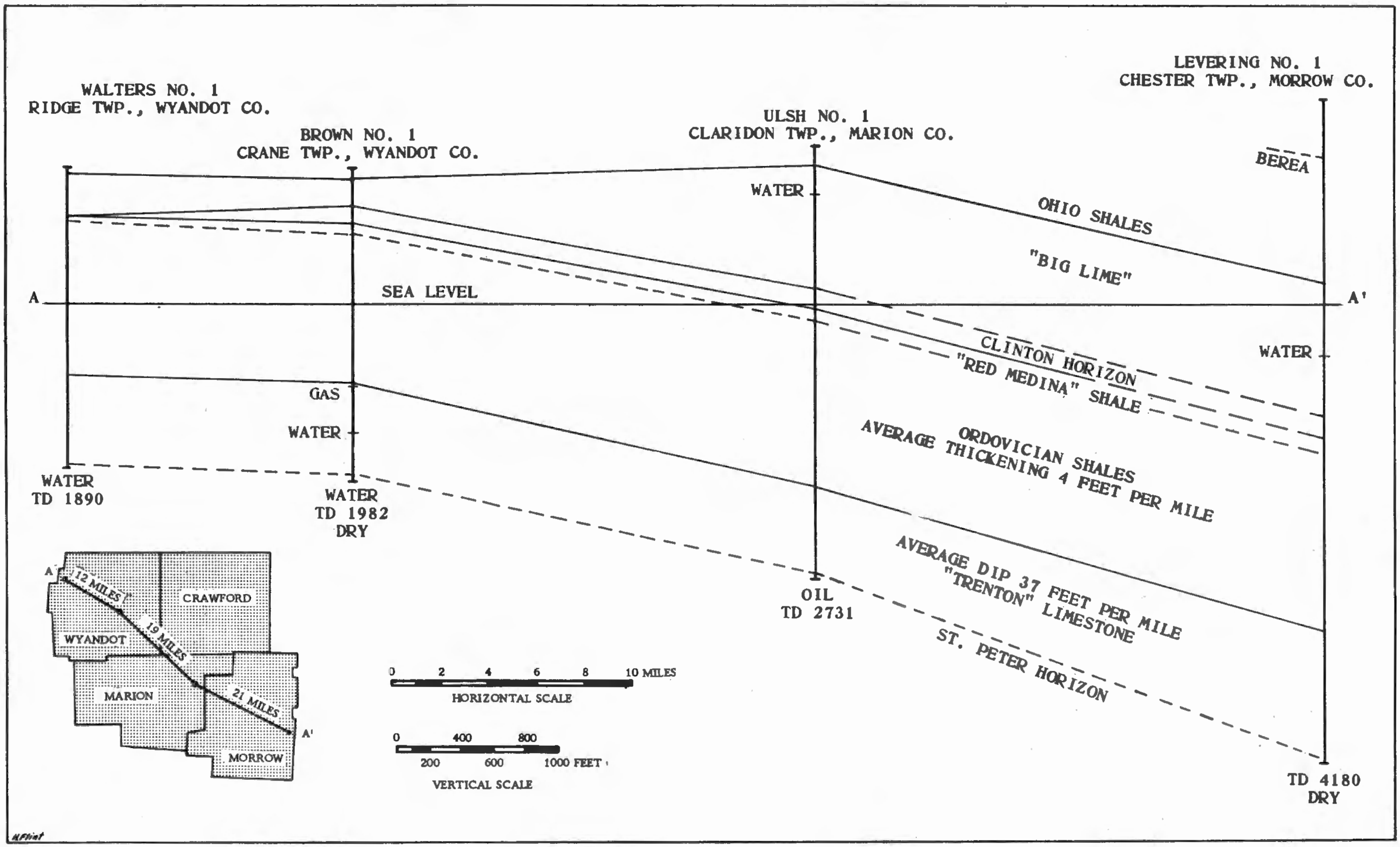


Fig. 10 CROSS SECTION SHOWING DIP AND THICKENING OF FORMATIONS FROM CINCINNATI ARCH TOWARD APPALACHIAN GEOSYNCLINE.

Berea sand and Ohio-Bedford shales in eastern Crawford County and in several wells in northeastern Morrow County. Small amounts have also been reported in the Niagara and Bass Island dolomites but they are usually associated with salt water, and soon drown out. The Clinton sand, which is so productive in central Ohio, occurs as gray to green shale and dolomite in this area. It pinches out as a sand a few miles east of the Morrow County line.

Below is a well log describing the materials penetrated by one of the deep wells in Wyandot County.

Sample Description

Drill cuttings from The Ohio Company well on the Bessie Chatlain farm, Section 28, Antrim Township, Wyandot County, completed in 1941.

	Top	Bottom
Devonian system		
Delaware-Columbus group		
Limestone, light brown to gray, dense	54	100
Limestone, light brown, dense, crystalline	100	110
Limestone and dolomite, gray to brown, some chert	110	160
Silurian system		
Bass Island and Niagara groups		
Dolomite, light brown to gray, dense	160	360
Dolomite and anhydrite, white to gray	360	380
Dolomite, light brown to gray, some anhydrite	380	425
Dolomite, white, crystalline	425	580
Dolomite, white, some pyrite	580	585
Osgood shale		
Shale, gray to green, clayey	585	630
Dayton-Brassfield limestone		
Dolomite, light brown to gray	630	695
Clinton sand		
Dolomite and gray to green shale	695	700
Ordovician system		
Cincinnati group		
Shale, red to brown	700	750
Shale, dark gray	750	810
Shale, dark gray to brown	810	1,485
Shale, dark brown to black	1,485	1,700
Limestone, dark brown to black, impure	1,700	1,755
Trenton limestone		
Limestone, gray to light brown, some chert	1,755	1,860
Dolomite, white to light brown, crystalline	1,860	1,870
Limestone, gray to light brown, some chert and shale	1,870	1,900

	Top	Bottom
Black River limestone		
Limestone, light brown	1,900	1,940
Limestone, gray to light brown, some shale	1,940	2,160
Limestone, gray to light brown, much green shale	2,160	2,170
Limestone, light brown, dense	2,170	2,335
Glenwood-St. Peter horizon		
Limestone, brown, green, impure dolomite	2,335	2,345
Dolomite, green, brown, impure	2,345	2,355
Dolomite, green to gray, impure	2,355	2,370
Dolomite, gray to green, much glauconite	2,370	2,380
Dolomite, gray to brown, crystalline	2,380	2,390
Total depth		2,390

CHAPTER IV

OTHER ECONOMIC MINERALS

LIMESTONE AND DOLOMITE

Limestone and dolomite have been quarried in the area since the early part of the last century. Used in the beginning as a local source of agricultural lime, the industry had progressed by 1850, so that the quarries were also supplying other parts of Ohio. All of the limestone or dolomite units in the geologic column, with exception of Raisin River, are being actively quarried at the present time. The respective geologic units will be discussed county by county as to their production and use. Fig. 11 shows the limestone and dolomite quarries in the area along with their operators.

WYANDOT COUNTY

In Wyandot County both the Niagaran (Guelph) and the various formations of the Bass Island group are being quarried. The only operations in the Guelph are at Carey, Ohio (see Fig. 11), where Guelph is a typically blue-gray, massive and extremely porous dolomite. A stratigraphic section at the Carey quarry is given on page 7. The stone is used dominantly for fluxing stone, road stone and ballast, concrete aggregate, and agricultural limestone.

Both at Carey and at the J. L. Foucht quarry in Pitt Township the Greenfield dolomite of the Bass Island group is being quarried (see Fig. 11). The deposits are worked mainly for road metal, railway ballast, and concrete aggregate. At the Kuenzli quarry in Crane Township, the Tymochtee formation produces considerable quantities of stone for crushed rock products use. Formerly it was used to some extent for lime burning. Sections and descriptions of both the Greenfield and Tymochtee are given in the general geology part of this report. Stout (1941, p. 294-301) gives representative chemical and mineral analyses for the Niagaran and Bass Island dolomites.

Though both the Raisin River formation of the Bass Island group and the Columbus formation of the Devonian outcrop in Wyandot County, there are no commercial operations in these units at the present time. Locally both have been used in the past as sources of lime and for foundation use.

The following production figures are broken up on the basis of use, and no attempt has been made to classify them as to geologic formation. Table 3 lists tonnage for the last five years as to crushed and broken stone. Table 4 lists for the same period of time the burned stone tonnage.

INDEX TO FIGURE 11

Crawford County
- Limestone
  1. National Lime and Stone Company: Holmes Township.
- Sandstone
  1. Leesville Quarry: Jefferson Township.

Marion County
- Limestone and Dolomite (Active)
  1. Tri-County Limestone Company: Grand Township.
  2. J. M. Hamilton & Sons: Marion Township.
  3. National Lime and Stone Company: Marion Township.
- Limestone and Dolomite (Abandoned)
  1. Ohio Blue Limestone Company: Marion Township.
  2. Marion Stone Company: Marion Township.
  3. France Stone Company (old Evans Quarry): Marion Township.
  4. S. M. Wooley Quarry: Grand Prairie Township.
  5. Laubis Stone Company: Grand Township.
  6. Irey Stone Company: Richland Township.
  7. Owen Station Quarry: Pleasant Township.
- Sand and Gravel
  1. Penry Sand and Gravel Company: Prospect Township.

Morrow County
- Sandstone
  1. Fulton Stone Quarry: Lincoln Township.
  2. Mt. Gilead Quarry: Gilead Township.
- Sand and Gravel
  1. Morrow County Commissioner's-Swartzentruber Quarry: Perry Township.
  2. Morrow County Commissioner's-Turner's Quarry: Chester Township.
  3. Chesterville Sand and Gravel Company: Chester Township.

Wyandot County
- Limestone and Dolomite
  1. National Lime and Stone Company-Carey Quarry: Crawford Township.
  2. Kuenzli Quarries Company Inc.: Crane Township.
  3. J. L. Foucht Quarry: Pitt Township.
  4. Wyandot Stone Company: Crawford Township.
- Sand and Gravel
  1. Corfman Gravel Company: Crane Township.
  2. H & W Sand Gravel Company: Eden Township.
  3. Kuenzli Quarries Company Inc.: Crane-Eden Townships.
- Clay
  1. Claycraft Company: Crane Township

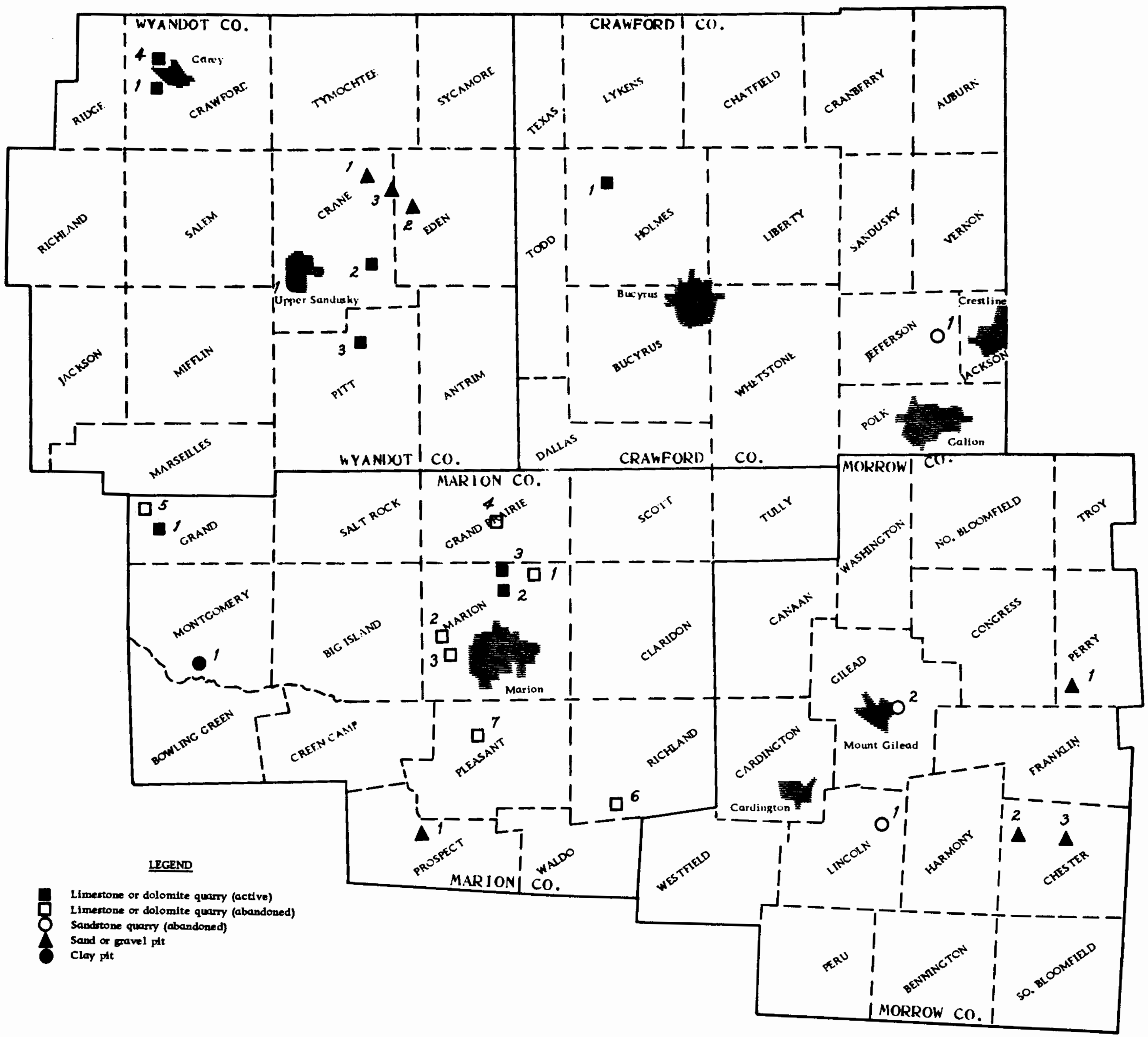


Figure 11. Map Showing Location of Principal Quarries and Gravel Pits in Crawford, Marion, Morrow and Wyandot Counties.

TABLE 3

Crushed and broken limestone and dolomite production
for Wyandot County 1950-1954
(figures in tons)

YEAR	FLUXING STONE	CONCRETE AND ROAD METAL	RAILROAD BALLAST	REFRACTORY	AGR. LIME	OTHER USES
1954	632,847	574,833	118,507	-	140,061	23,095
1953	874,466	661,783	252,699	-	152,792	37,092
1952	688,171	563,433	246,395	23,000	156,458	58,489
1951	738,855	515,828	110,980	-	102,044	19,956
1950	600,117	274,756	106,776	-	127,438	11,488

TABLE 4

Burned stone tonnage of limestone and dolomites
for Wyandot County 1950-1954

YEAR	AGR. LIME	BUILDING	CHEMICAL AND INDUSTRIAL
1954	13,845	3,667	106,352
1953	15,615	27,981	85,882
1952	17,233	27,544	75,564
1951	17,595	28,292	75,430
1950	7,648	10,274	91,207

MARION COUNTY

Limestone and dolomite from both the Niagaran series and the lower Devonian formations (Columbus and Delaware) are produced in Marion County. Fig. 11 lists both the active and the major abandoned quarries for the county.

The Guelph formation of the Niagaran series is quarried in Grand Township (Fig. 11) and is used mainly for concrete aggregate, road metal, and unburned agricultural lime. The Guelph here exhibits practically the same characteristics as the stone quarried at Carey in Wyandot County.

Though nearly 100,000 tons of Silurian (Guelph) dolomite was produced in 1952, the bulk of the limestone and dolomite production from Marion County comes from the Columbus and Delaware formations of lower Devonian age.

As early as 1850 lime was burned from quarries near Owen Station in southern Marion County (see Fig. 11). By 1910, the town of Marion was one of the most important quarrying centers in the State. At present two quarries are in full operation, whereas in the past at least two others were active near Marion (Fig. 11). Due to their geological relationship, both the Columbus and Delaware are usually quarried together, with the upper floors being Delware and the bottom levels or floor of the quarry being in the Columbus. The two stones are used extensively for caustic and hydrated lime, building stone, blast furnace flux, and crushed rock products. Several abandoned quarries in these same two formations are found in Richland, Pleasant, and Grand Prairie Townships.

Geologic sections and descriptions of several of the Columbus and Delaware quarries are given in Chapter 2, (General Geology, p. 4). Stout (1941, p. 280-91) gives quarry descriptions along with both chemical and mineral analyses for Marion County.

The western part of Marion County is dominantly underlain by the Bass Island group of Silurian age (see Fig. 2) but except for small individual quarries, there have been no major commercial operations in these formations. The depth of glacial drift has been a deterring factor in using these beds.

Table 5 gives tonnage figures for the last five years as to uses for limestone and dolomite in Marion County. As is the case with Wyandot County, no attempt is made here to divide these figures into either Columbus or Delaware production.

TABLE 5

Use and tonnage for limestone and dolomite production in Marion County 1950-1954

YEAR	RIPRAP	CONCRETE AND ROAD METAL	RAILROAD BALLAST	AGR. LIME UNBURNED	OTHER USES
1954	61	487,267	98,218	73,556	-
1953	18	491,531	213,918	86,517	-
1952	77	485,111	175,584	128,410	90,864
1951	112	476,251	59,979	120,228	-
1950	34	361,433	77,098	75,711	5,488

CRAWFORD COUNTY

At the present time there is only one active limestone quarry in Crawford County. This is located in Holmes Township (Fig. 11) and stone from both the Columbus and Delaware formations is being quarried. Originally the stone was produced for building purposes, but due to its irregular bedding and uneven thickness, the bulk of the raw material is now crushed for use as road metal, railway ballast, and concrete aggregate. Besides the one main quarry listed, several small pits are found in the same formations to allow for local consumption.

TABLE 6

Tonnage and use of limestone production in Crawford County 1950-1954

YEAR	CONCRETE AND ROAD METAL	RAILROAD BALLAST	AGR. LIME
1954	510,820	84,213	66,651
1953	518,401	183,623	74,159
1952[1]	410,376	187,710	76,764
1951	485,320	68,605	70,423
1950[2]	187,533	-	26,943

1. Another 52,997 tons was produced as burned stone, the bulk used for chemical and industrial industries.
2. An additional 19,923 tons was used as a flux.

SANDSTONE

Only two of the counties, Crawford and Morrow, are underlain by sandstones. However, at the present time there are no active quarries in the area. In the past the Mississippian sandstones (Berea and Cuyahoga) have been quarried to a large extent. The locations of several abandoned quarries are shown in Fig. 11.

BEREA FORMATION

Prior to 1920 very active operations in the Berea were to be found in both Crawford and Morrow Counties. In Jefferson Township, Crawford County, the Berea sandstone was quarried for flagging and building stone. This quarry, the Leesville, was abandoned in 1908.

In Morrow County, the Mt. Gilead and Fulton quarries (see Fig. 11) were active until about 1918 or 1919. The stone quarried at Mt. Gilead was unsuitable for building due to its uneven and very dirty appearance, but was used locally for foundation and ballast. The Fulton quarry (see p. 13) at one time employed 40 to 50 men, with an annual production at 75,000 cubic feet of sandstone. Though most of this was sold locally, some was shipped as far west as Iowa. It was sawed for flagging, curbing, and building stone. Work at this quarry was discontinued sometime after 1915 and before 1920.

Many other small quarries in the Berea are known to have existed along its outcrop in both counties. However, most of these were abandoned before the turn of the century. A few lasted until early 1920, but none was of large size and the material was used mostly for local bridge and foundation purposes.

CUYAHOGA FORMATION

Several of the thicker sandstone layers of the Cuyahoga formation in Morrow County were quarried in the latter part of the last century for local building and foundation uses. Winchell (1874, p. 258) lists several small quarries in Troy and North Bloomfield townships. These operations were all short-lived and no really true commercial quarries ever existed in this formation.

SAND AND GRAVEL

Though most of the area is covered by glacial drift, there are few important sand or gravel pits present. The bulk of the drift is a clayey boulder till, and only in isolated localities are good stratified deposits present, mainly as outwash gravels, in front of the terminal moraines (see Fig. 4 and 10). All the counties, with the exception of Crawford, have at least one sand or gravel pit in operation at the present time. The present operations are mentioned only as to generalities, because no detailed maps of the glacial geology in the area have been made, and hence it is impossible to determine the exact glacial history or extent of many of the deposits. Production figures and uses have been given where available.

CRAWFORD COUNTY

As stated above, there are no sand or gravel pits in operation at the present time. In the past, before the turn of the century, Crawford County had several very active pits. One of these was located near Leesville, Jefferson Township, where a gravel ridge, a little more than a half a mile long, was worked. According to Winchell (1874, p. 247), thousands of car loads of gravel had been removed. Popularly called a "hog's back," it has often been referred to as the Leesville esker.

MARION COUNTY

The only sand and gravel pit active today is located in Prospect Township (see Fig. 11) and produces both sand and gravel. Table 7 shows the production and use of materials from this pit for the period covering 1950-1954. This pit lies on or near the eastern extension of the St. Johns terminal moraine. In general the southern part of the county contains more stratified material than the northern.

TABLE 7

Tonnage and use of sand and gravel in Marion County
1950-1954

YEAR	TOTAL SAND AND GRAVEL	SAND BUILDING	GRAVEL BUILDING	GRAVEL PAVING
1954	48,975	33,185	6,909	8,881
1953	44,161	42,661	1,500	-
1952	38,540	38,540	-	-
1951	23,617	20,117	3,500	-
1950	20,345	20,345	-	-

MORROW COUNTY

Sand and gravel from the glacial drift are abundant in the eastern portion of the county. At the present time there are three pits in operation in this area (Fig. 11). Two are Morrow County workings supplying material for the county roads. These deposits are closely related to the terminal moraines of the area and probably represent outwash formed simultaneously with the moraines.

In 1953, 53,963 tons was produced, 29,700 tons of which was gravel and used in road work. The remaining tonnage, all sand, was used both for building and road material.

WYANDOT COUNTY

In Eden Township, closely bordering the Fort Wayne moraine (Fig. 4), are located the sand and gravel pits of Wyandot County (Fig. 11). The Corfman pit produces mainly gravel, and the two workings farther to the south produce mainly sand. Smith (1949, p. 19) mentions that the depth of sand here is approximately 100 feet thick and that, due to the good quality of the material, it is trucked distances up to 40 miles from the pits.

Reference to Table 8 shows that sand and gravel production in this county has been increasing steadily for the past five years.

TABLE 8

Production of sand and gravel for Wyandot County
1950-1954

YEAR	TOTAL PRODUCTION	SAND BUILDING	GRAVEL BUILDING	GRAVEL PAVING	OTHER USES
1954	119,559	95,947	872	12,071	10,669
1953	107,789	87,218	781	13,784	6,015
1952	82,897	65,059	75	14,972	2,791
1951	80,605	66,312	102	11,977	2,214
1950	76,224	60,538	3,864	11,290	532

CLAY

At the present time there are only two active clay pits located in the area, one in Montgomery Township, Marion County, and the other in Crane Township, Wyandot County (see Fig. 11). Both are using glacial tills as their source material.

The Marion County operations are small, with the production of raw material in 1953 amounting to only 3,700 tons.

The clay in Wyandot County is more extensive and drain tile, face brick, and building block are produced from the glacial drift. According to Lamborn et al (1938, p. 256), two pits are used, one supplying good plastic clay and the other a more sandy material. The two when mixed together form a good blend for the above mentioned products. The same reference (Lamborn et al, 1938, p. 256-57) lists a chemical analysis and the firing properties for the glacial material.

Winchell (1873, p. 639, 644; 1874, p. 252, 269) mentions the production of brick, tile, and red pottery from various localities in the four counties. All the raw materials were derived from the glacial debris and were all short-lived, since they could not compete with the larger clay plants in other parts of the State.

MISCELLANEOUS RESOURCES

In the area under discussion various minor products have been utilized on a small scale in the past, particularly during the last century. None of these economic minerals or rocks is being used today, but are mentioned mainly for their historical interest.

Winchell (1874, p. 270) mentions several brine wells having been drilled near West Liberty, in Peru Township of Morrow County. The dates of these wells are between 1818 and 1820, truly some of the earliest wells in Ohio. The depth of the wells was around 330 feet and the salt brine was probably from the Columbus formation.

Dachnowski (1912, p. 45-47; 139-144) mentions several tracts of peat land in both Crawford and Wyandot Counties. The total area for both counties originally covered by peat bogs is roughly 4,000 to 5,000 acres. Most of this has long since been either drained or burned over to make it available for cultivation. The thickness of the peat varies from 4 to 8 feet. Descriptions of the material, chemical analyses, and botanical information concerning these areas can be found in the references cited above. During the early settlement of these counties, some of this material was undoubtedly used for fuel.

Briggs (1838, p. 65) and Stout (1940, p. 35) mention several large deposits of "calcareous tufa" in Crawford County near Bucyrus. Briggs indicated it could be or was being used for quick lime purposes.

Stout (1940, p. 49-50) summarizes several earlier references (Briggs 1835, Winchell 1874) concerning the presence of bog-iron ore in Crawford and Morrow Counties. Though the earliest references indicate sufficient amounts of the ore being present to warrant small furnaces, there is no record that these deposits were ever utilized.

FUTURE DEVELOPMENT OF MINERAL RESOURCES

The supply of dolomite and limestone in the four-county area is more than sufficient for many years to come. Vast areas of Wyandot, Crawford, and Marion Counties are underlain by the Bass Island, Columbus, and Delaware, which to date have not been opened to quarrying operations (see Fig. 11). A notable example is the Bass Island group which underlies nearly one-half of Marion County, but there is not a single quarry operation at the present time.

Once the glacial geology of the various counties has been worked out in some detail, numerous sand and gravel localities will be available for exploitation. In fact, all four counties probably contain vast reserves of good sand and gravel deposits.

The future of the sandstone industry in the area seems very poor as the Berea (the only thick sandstone present) does not exhibit either the great thicknesses nor the attractiveness of the same stone farther to the north.

The Devonian and Mississippian shales in Crawford, Marion, and Morrow Counties have not been put to any economic use, though at the present time they are being used both north and south of this area for the manufacture of building stone and clay products. In the future the shales of this area may be so utilized.

To date only the Trenton limestone has proved commercially productive of oil and gas in this four-county area. Small amounts of oil have been recovered from the St. Peter horizon in Marion County and minor amounts of gas obtained from the shale in Crawford and Morrow Counties. The Trenton producing area in Wyandot County is now defined. Potential future production from these counties must come from deeper and as yet untested formations.

Table 9. Summary of Deep Wells Drilled in Crawford, Marion, Morrow and Wyandot Counties, Ohio

Location			Year drill-ed	Surface elevation by barometer (ft.)	Depth (ft.)						Remarks
County and Township	Sec-tion	Farm name and well number			Big Lime Top	Big Lime Bottom	Trenton Top	Trenton Bottom	St. Peter reached	Total	
Crawford											
Bucyrus	1	At Bucyrus	1885	910	320	-	2145	-	-	2264	Dry
Cranberry	13	-	1885	-	-	-	-	-	-	2200	Dry-No log
Dallas	5	-	1902	-	-	-	-	-	-	2100*	Dry-Lost tools-No log
Holmes	36	At Bucyrus	1885	-	-	-	-	-	-	3000	Dry-No log
Jackson	15	At Crestline	1885	1155	768	1624	2832	-	-	2864	Dry-Lost tools
Liberty	6	Walters No.1	1929	1022	185	1075	2280	-	Probable	2884	Salt water at 2884
Lykens	14	A.Fox No. 1	1920	956	-	-	-	-	-	2395*	Dry-No log
"	18	P.Shellhorne No.1	-	948	-	-	1896	-	Probable	2336	Dry-No log
Polk	-	At Galion	-	1182	740	1558	2822	-	Probable	3445	Dry
Texas	11	W.Riedel No.1	1924	907	-	-	1804	-	2410	2433	Dry-Oil at 2410, water at 2425
"	11	W.Riedel No.2	1925	910	-	-	1825	-	2446	2530	Dry-Water at 2500
"	11	C.Oder No.1	1924	894	-	-	1784	-	2389	2564	Dry-Water at 2429
"	26	D.McGrath	-	879	-	-	-	-	-	1877	Dry-No log
Marion											
Claridon	9	Foos No.1	-	990	-	-	2087	-	Yes	-	Dry-No log
"	9	S.Baker No.1	1954	990	90	-	2070	-	2666	2711	Dry-Water at 2711
"	10	Ulsh No.1	1919	992	130	908	2140	-	2722	2756	St.Peter 4 Bbl. oil well
"	10	Ulsh No.2	1919	992	-	-	-	-	-	-	St.Peter 8 Bbl. oil well
"	10	Ulsh No.3	1919	992	130	906	2123	-	2727	2742	Dry-Water at 2740
"	10	Ulsh No.4	1919	992	125	900	2112	-	2703	2718	St.Peter 20 Bbl. oil well
"	10	Ulsh No.5	1919	992	115	914	2115	-	2706	-	St.Peter 45 Bbl. oil well
"	10	L.Irey No.1	-	993	100	908	2126	-	2706	-	St.Peter gas well
"	10	G.Lafferty No.1	1919	992	175	912	2132	-	2732	2762	Dry
"	10	C.Norris No.1	1921	992	120	900	2115	-	2741	2750	Dry-Oil at 2746
"	10	Irey Hrs. No.1	-	993	106	970	2141	-	2746	2780	Dry-Water at 2780
"	11	Barnhart No.1	1924	990	190	956	2120	-	Yes	2828	Dry-Water at 2828
"	15	J.Kennedy No.1	-	991	110	900	2130	-	Yes	2705	Dry-Water at 2705
"	15	W.Brocklesby No.1	1954	995	145	977	2134	2716	2730	2756	Dry
"	23	H.Haley No.1	1919	980	190	920	2120	2760	Yes	2893	Dry-Water at 2875
"	28	C.Miller No.1	-	985	120	885	2104	-	Yes	2788	Dry-Water at 2765
Grand Prairie	20	E.Brown No.1	1933	-	95	500	1625	-	Yes	2515	Dry-Water at 2245
Marion	-	At Marion	1885	970	18	633	1678	-	-	1790	Dry
Prospect	-	At Prospect	1887	-	-	-	1650	-	-	*	Dry-No log
Scott	26	C.Coulter No.1	1905	-	173	948	2170	-	Probable	*	Dry-Water at 2803
Morrow											
Canaan	6	E.Lyon No.1	-	1005	-	-	2235	-	Probable	2935*	Dry-Water at 2935-No log
"	29	M.Shaw No.1	1900*	-	-	-	-	-	-	2200*	Dry-No log
Cardington	17	-	1930*	1002	-	-	-	-	Probable	*	Dry-Reported show oil in St.Peter-No log
Chester Lot	9,NE¼	C.Levering No.1	1931	1280	1142	-	3320	-	Probable	4180	Dry
Washington	14	J.Green No.1	1900*	-	-	-	2900	-	-	3000*	Dry-Water-No log
Wyandot											
Antrim	4*	G.Martin No.1	1919	900	53	620	1780	2405	Yes	2435	Dry-Water at 2435
"	28	B. Chatlain	1941	910	-	590	1750	-	2370	2390	Dry-Water at 2390
Crane	33	J.Brown No.8	1953	-	65	248	1340	-	1918	1982	Dry-Water at 1666 & 1982
"	34	L.Brandt No.1	1921	855	-	-	1381	-	1961	2001	Dry-Water
Crawford	18	N.Heck No.1	1942	860	1	235	1321	1890	1920	2801	Dry-Water at 1928 & 1975
Eden	32	J.Williams No.1	1937	945	190	345	1714	2333	Probable	2361*	Dry
"	33	At Nevada	1887	933	1	600	1763	-	-	2000	Dry-Water at 2000
Jackson	36	P.Parsell No.1	1947	910	89	220	1345	1932	Yes	5632	Dry-Water at 1995 & 2335
Marseilles	13	W.Morral No.1	1939	882	50	228	1328	1905	1920	1920	Dry-Water at 1920
Pitt	24	A.Reber No.1	1933	870	40	420	1428	-	Probable	1913	Dry
Richland	13	R.Kear No.1	1941	860	51	220	1305	1880	1895	1928	Dry-Water at 1895
Ridge	25	W.Walters No.1	1935	850	45	310	1310	1870	1870	1890	Dry-Water
Salem	8	E.Creamer No.1	1951	820	55	245	1286	1864	1867	1893	Dry-Water at 1893

* Not definite

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