STATE OF OHIO
C. WILLIAM O'NEILL, Governor
DEPARTMENT OF NATURAL RESOURCES
HERBERT B. EAGON, Director
DIVISION OF GEOLOGICAL SURVEY
RALPH J. BERNHAGEN, Chief

BULLETIN 56

GEOLOGY AND MINERAL RESOURCES OF MORGAN COUNTY

BY

DONALD L. NORLING

COLUMBUS
1958

Stratigraphic Sections

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ABSTRACT

Morgan County is located in southeastern Ohio, approximately 55 miles southeast of Columbus, 15 miles south of Zanesville, and 40 miles northwest of Marietta. The county is bisected by the southeasterly flowing Muskingum River, a major tributary of the Ohio River drainage system. McConnelsville, the county seat, is located near the center of the county on the Muskingum River. Morgan County is situated in the unglaciated portion of the state, and the topography is in a mature stage of development with moderate to strong relief. There is a topographic relief of 540 feet. The drainage pattern is dendritic.

This report is a study of the stratigraphy, structure, and economic resources of the outcropping rocks of the Allegheny, Conemaugh, and Monongahela series of the Pennsylvanian system, and the lower part of the Washington series of the Permian system, which were mapped as a part of the mapping program of the Geological Survey of Ohio. Included in the report are discussions of the general physiography and physiographic development, and of some of the subsurface mineral resources.

The surface rock section extends from the Middle Kittanning (No. 6) coal of the Allegheny series, exposed in the extreme northwestern corner of the county, to the Lower Marietta sandstone of the Washington series, exposed on ridge and hill tops in the eastern and southeastern portions of the county. Approximately 725 feet of Pennsylvanian strata is exposed, and consist of 111 feet of the Allegheny series, 365 feet of the Conemaugh series, and 247 feet of the Monongahela series. These Pennsylvanian rocks are overlain conformably by 110 feet of lower Permian strata. The rocks crop out in general northeast-southwest belts, and dip to the southeast at approximately 30 feet per mile.

The stratigraphic units are discussed in normal sequence beginning with the oldest. The strata consist of shales, sandstones, limestones, clays, and coals, with shales and sandstones comprising the major portion of the stratigraphic column. The sandstones and shales are subject to rapid and pronounced changes in facies. Many of the thin coals, clays, and limestones are non-persistent, while others are identifiable over large areas. The limestones are more prevalent and in thicker bodies in the upper part of the Conemaugh and in the Monongahela series, and in the latter, comprise thick sequences. The limestones in the Allegheny series and in the lower half of the Conemaugh series are marine in origin. Those in the upper Conemaugh, Monongahela, and Washington series are of questionable non-marine origin. Highly colored red shales appear in thick sections in the upper part of the Conemaugh, and become prevalent in the younger strata. The rock column is illustrated by a network of stratigraphic cross sections.

Persistent strata of stratigraphic and/or economic importance depicted on the geologic map include the Middle Kittanning (No. 6) and Upper Freeport (No. 7) coals of the Allegheny, the Ames limestone of the Conemaugh, and the Pittsburgh (No. 8), Meigs Creek (No. 9), and Waynesburg (No. 11) coals of the Monongahela series.

The structural position of the rocks is shown on maps contoured on the top of the Ames limestone, on the base of the Pittsburgh coal, and on the base of the Meigs Creek coal.

Economic resources of coal, clay, sandstone, limestone, water, salt (brine), and petroleum and natural gas are discussed. The Pittsburgh (No. 8) and Meigs Creek (No. 9) coals are of major economic importance in the county.

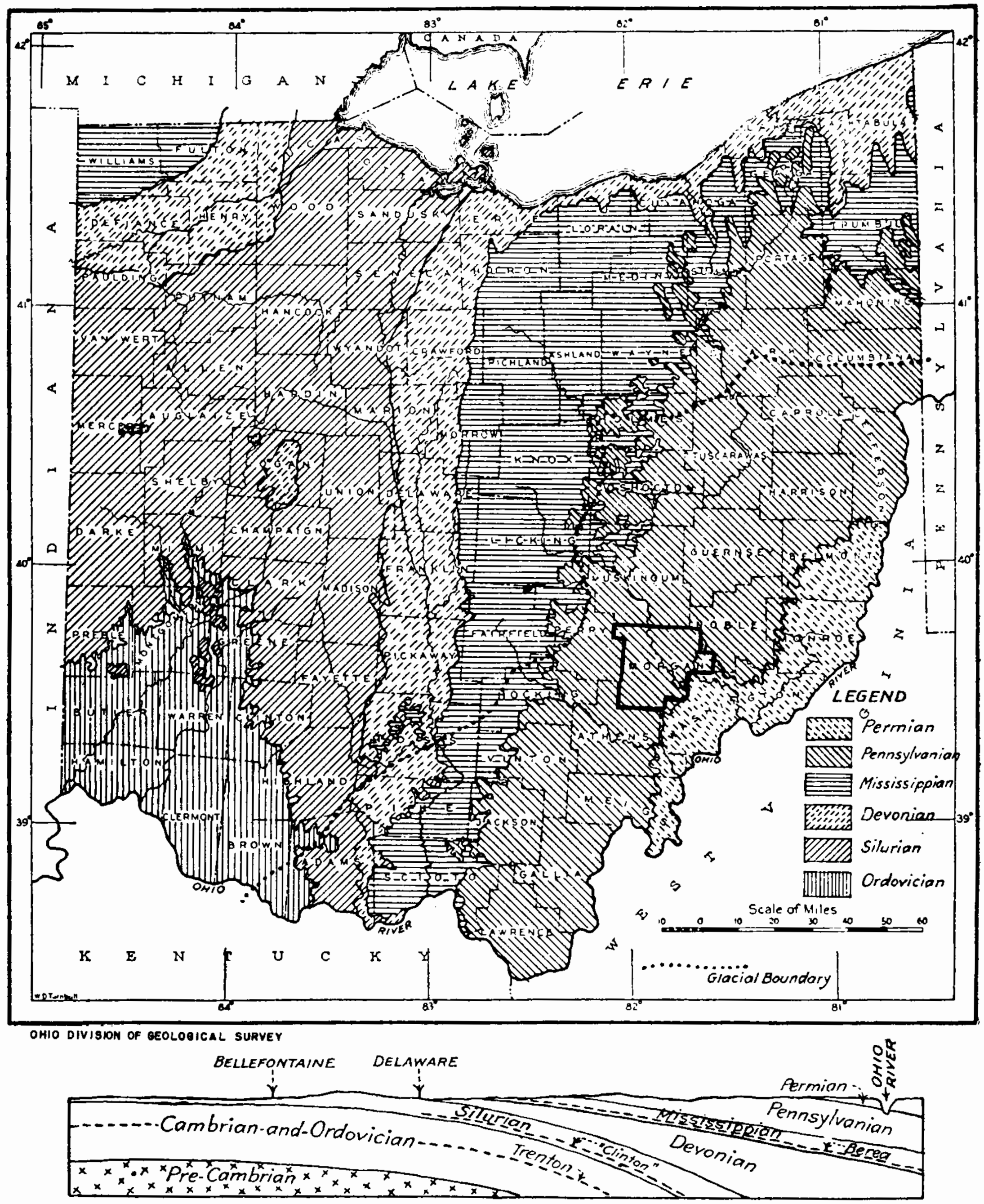


Figure 1. - Index and generalized geologic map of Ohio.

CHAPTER 1

INTRODUCTION

LOCATION

Morgan County is located in southeastern Ohio, approximately 55 miles southeast of Columbus, 15 miles south of Zanesville, and 40 miles northwest of Marietta. It is bounded on the north by Muskingum County, on the east by Noble and Washington Counties, on the south by Washington and Athens Counties, and on the west by Athens and Perry Counties (figure 1). It lies between longitude 81 degrees 35 minutes and 82 degrees 05 minutes west, and latitude 39 degrees 27 minutes and 39 degrees 46 minutes north. The county embraces a land area of 420.79 square miles (Sherman, 1933, table, p. 49).

Most of the county has been subdivided according to the Congressional System of Land Survey. The irregularly shaped county is included within portions of three surveys and includes Townships 6 and 7 North, Ranges 10 and 11 West; Townships 8 to 11 North, Ranges 11 and 12 West; and Townships 7 to 10 North, Ranges 13 and 14 West. It has been mapped topographically on the United States Geological Survey McConnelsville quadrangle, and on adjoining portions of the New Lexington, Zanesville, Philo, Cumberland, Caldwell, Parkersburg, Chesterhill, and Athens quadrangles (figure 2).

Morgan County includes the political townships of York, Deerfield, Union, Homer, Bloom, Morgan, Malta, Penn, Marion, Bristol, Meigsville, Windsor, Manchester, and Center (figure 2).

ACKNOWLEDGMENTS

The writer gratefully acknowledges the assistance and advice of those who have given their time so willingly during the course of the field work and in the preparation of this report. Special thanks are due to John H. Melvin, former State Geologist, and the Geological Survey of Ohio for financial assistance during the summer field seasons of 1948 and 1949; to Ralph J. Bernhagen, State Geologist; to Dr. J. Osborn Fuller of the Department of Geology, The Ohio State University, who served as adviser and who furnished valuable suggestions during the preparation of this report; to Charles M. Chapman, now with the Mohawk Petroleum Company in Casper, Wyoming, who served as a competent assistant during the field season of 1949; and to John D. Bartlett, now with the Texas Company in Wichita, Kansas, who worked his Master of Science thesis on Union Township, and whose work is incorporated in this report.

Thanks are due also to Robert L. Alkire, Consulting Geologist in Columbus, Ohio, formerly with the Oil and Gas Division of the Geological Survey of Ohio, for aid in acquiring information on wells drilled for petroleum and natural gas in the county; to L. Morgenstern, for field assistance for several weeks during 1948; and to Henry Trapp, now with the Atlantic Refining Company in Casper, Wyoming, for field assistance during part of the 1948 season.

Much basic information was acquired from the files and publications of the Geological Survey of Ohio. For this the writer is indebted to the many geologists who contributed to those

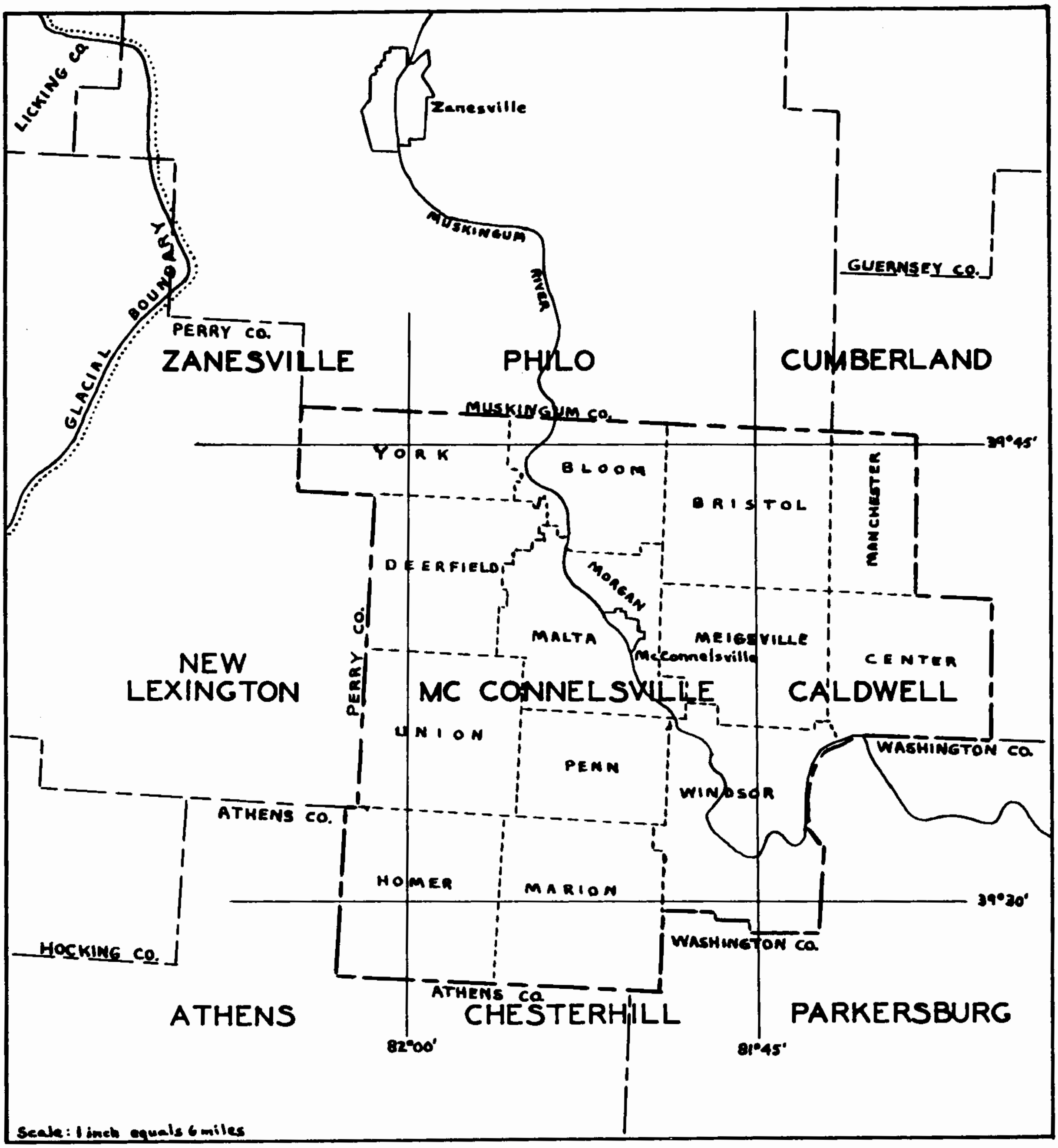


Figure 2. - Map of Morgan County showing boundaries of political townships and of U. S. G. S. topographic quadrangles.

files and reports. The work of Wilber Stout and of George W. White, former State Geologists, was particularly valuable.

Appreciation is extended to Dr. Daniel A. Busch, Consulting Geologist in Tulsa, Oklahoma, and to Roger R. Patton, Senior Geologist for Murphy Oil Company of Oklahoma, Inc., also of Tulsa, for suggestions and criticisms made during the preparation of the manuscript.

Special gratitude is extended to Eileen Norling for assistance in editing this report.

PURPOSE AND SCOPE

This report is essentially a study of the stratigraphy, structure, and economic resources of the outcropping Pennsylvanian and lower Permian rocks in Morgan County. Also included are discussions of the general physiography and physiographic development, and of some of the subsurface mineral resources. Field work was done during the summers of 1948 and 1949 as a part of the mapping program of the Geological Survey of Ohio. United States Geological Survey topographic quadrangles were used as field maps, as the base for the Geologic Map of Morgan County (plate I), and for the base of the special map of the county drafted for illustrations in this report.

Approximately 500 field sections were measured and described. These were supplemented by 268 sections from the files of the Geological Survey of Ohio, and a number of sections plotted from published reports of that survey. The sections were measured by the use of field staff and hand level. Elevation control was based on United States Geological Survey bench marks and Ohio Highway Department elevations on bridges. Elevations were carried to the measured sections by use of a hand level or an aneroid barometer. For correlation study the measured sections were plotted on log strips to the scale of 1 inch equals 10 feet.

The surface rock column extends from the Middle Kittanning (No. 6) coal of the Allegheny series of the Pennsylvanian to the Lower Marietta sandstone of the Washington series of the Permian (fig. 3). Key Pennsylvanian stratigraphic beds used in mapping were the Middle Kittanning (No. 6) and Upper Freeport (No. 7) coals of the Allegheny, the Brush Creek and Ames limestones of the Conemaugh, and the Pittsburgh (No. 8), Meigs Creek (No. 9), Uniontown (No. 10), and Waynesburg (No. 11) coals of the Monongahela. The outcrop lines of these beds, with the exception of the Brush Creek limestone and Uniontown coal, are shown on the Geologic Map (plate I).

The stratigraphic units recognized in Morgan County are discussed in normal sequence from the oldest to the youngest unit. A series of stratigraphic cross sections shows the main correlations and lithologic variations between representative measured sections.

The structure of the Ames limestone, the Pittsburgh (No. 8) coal, and the Meigs Creek (No. 9) coal is shown on figures 16, 17, and 18, respectively.

Economic resources of coal, clay, sandstone, limestone, water, salt (brines), and petroleum and natural gas are discussed. The occurrence and the development of the main coal beds are illustrated on isopach maps.

PREVIOUS WORK

Comments concerning the general geology of Morgan County were included in the report by Hildreth in the First Annual Report of the Geological Survey of the State of Ohio in 1837. A more detailed discussion of the geology of the county was given by Andrews in 1873 in the first volume to be published by the Second Geological Survey of Ohio. The work of Andrews was essentially a report of the occurrence of the Pomeroy (now Pittsburgh) and Cumberland (now Meigs Creek) coals in the several townships in Morgan County. Representative surface sections were given for each township and the report was accompanied by a map of 22 grouped sections (Map 9 of that report). Brief comments were made concerning salt production from brines, and concerning oil and gas production. This report was written before the advent of railraods into the coal fields of Morgan, Perry, and Athens Counties.

Subsequent to the above publication Morgan County geology has been mentioned or discussed briefly in reports of the Geological Survey of Ohio, and of the United States Geological Survey, but there has been no comprehensive treatment. Most of the discussions have been in reports on specific geological units such as the Conemaugh (Condit, 1912), and the Dunkard (Stauffer and

Schroyer, 1920), or in reports on economic products such as coal (Brown, 1884; Lovejoy, 1888; Bownocker, Lord, and Somermeier, 1908; Bownocker and Dean, 1929; and Dean, 1948), coal formation clays (Stout, Stull, McCaughey, and Demorest, 1923), oil and gas (Bownocker, 1903; Alkire, 1948), and salt (brines) (Bownocker, 1906). Since 1951 the Geological Survey of Ohio has published a series of short works on economic geology. Pertinent to Morgan County are the reports on oil and gas by Magbee and Alkire (1954), and on coal by Brant (1954 and 1956), DeLong (1955 and 1957), and Smith (1952).

Manuscript sections of surface rocks in Morgan County measured by several field geologists are in the files of the Geological Survey of Ohio. These include numerous sections by Stout and Meyers in 1927, Stout and Morgan in 1928, White in 1945, and a few by Brown in 1883. Lovejoy in 1888, Baird in 1916, and Lamborn in 1926. The report of Bartlett (1950) on Union Township included 36 new measured sections. Bartlett's sections and text have been used freely in the present report.

CHAPTER 2

PHYSIOGRAPHY

GENERAL

Morgan County lies within the western portion of the Kanawha section of the Allegheny Plateaus province of the Appalachian Highlands physiographic division (Fenneman and Johnson, 1946). It is described as a "mature plateau of fine texture with moderate to strong relief."

The county is situated in the unglaciated portion of the state about 10 miles east of the glacial boundary, which trends in a general northeast-southwest direction across southern and east central Ohio (figure 2). The chief effects in Morgan County of the several glacial advances from the northwest and north are found, first, in the outwash material and, second, in the modification of drainage systems. Outwash material partially fills the valleys of the Muskingum River and its major tributary streams, and is evident in the locally terraced flood plain of the Muskingum River. The present Muskingum River in Morgan County flows in a channel which is the result of a series of drainage modifications brought about by the melt waters of the several ice sheets.

The physiographic development of unglaciated southeastern Ohio is the result of a rather complex series of erosional periods and of regional rejuvenations. Stout and Lamb (1939, pp. 1-2) list the prominent physiographic factors in southeastern Ohio in the following order, beginning with the oldest:

1. Monadnock hills and ridges, representing possible remnants of the original surface.

2. Harrisburg peneplain, the oldest well defined erosional surface.
   A. Uplift and rejuvenation.

3. Lexington peneplain.
   B. Uplift and rejuvenation.

4. Parker strath with Teays, Pittsburgh and Dover drainage systems developed.
   C. Flooding and filling of valleys through damming by early drift sheet.
   D. Uplift and rejuvenation.

5. Deep Stage drainage with Cincinnati, Newark, and Pomeroy drainage developed.
   E. Cutting of valleys much below that of the older systems.
   F. Advance of Illinoian ice with consequent changes.

6.. Post-Illinoian drainage with the development of the New Martinsville, Post-Illinoian Muskingum, and Post-Illinoian Hocking Rivers.
   G. Cutting of cols and formation of new valleys.
   H. Advance of Wisconsin ice with again a shift of drainage.

7. Present drainage system of Ohio, Tuscarawas, Muskingum, Hocking, and Scioto Rivers.
   I. Removal of outwash, formation of terraces, new channels, etc.

For rather complete discussion of the various evidences for the above outline the reader is referred to the text of the paper by Stout and Lamb, and also that by Stout, Ver Steeg, and Lamb (1943), wherein the old drainage systems of the entire state of Ohio are discussed. The latter work treats the physiographic development in much the same manner as in the earlier work but with modification of Post-Illinoian drainage (Factor 6 as listed on the previous page). In the earlier writing Stout and Lamb concluded that the Muskingum River system was formed following the Illinoian glacial advance. In the later work it is considered that the divide or col across northwestern Morgan County was not breached until Post-Wisconsin time. Both of these works are comprehensive treatments accompanied by maps of the several drainage systems and by bibliographies.

The development of such physiographic features, as outlined, is necessarily regional. Near the close of the Paleozoic era regional crustal movements resulted in the formation of the Appalachian Mountains and the uplift of adjoining territories, such as the Appalachian Highlands. Erosion during the Mesozoic era brought these land areas to a base leveled condition. Monadnock hills and ridges representing remnants of this surface of erosion are well distributed throughout southeastern Ohio. The higher knob-like hills prevalent in the western part of Morgan County may be remnants of such monadnocks.

The topography of Morgan County is that of an upland which is comparatively uniform in elevation, and which subsequently has been deeply dissected by streams of relatively recent origin. Detailed physiographic analysis of the topography of the county was not made during this study; hence, the following comments are general.

The oldest well-defined erosional surface, the Harrisburg peneplain, in Morgan County is believed to be represented by the higher ridges in the western part of the county at an elevation of 1,100 to 1,140 feet. Following rejuvenation and erosion, generally attributed to Tertiary time, the Lexington (Worthington) peneplain was developed. This erosional surface is best defined to the southwest of Morgan County. In Morgan County the general elevation of 1,000 to 1,080 feet is believed to represent the Lexington (Worthington) peneplain. The Parker strath of possible late Tertiary development is not discernible in Morgan County. It represents an incomplete peneplanation along the major stream systems just prior to the invasion of the early ice sheets of the Pleistocene. The dominant stream system in southern Ohio at that time was the Teays, a major stream which flowed toward the northwest. One of the smaller streams tributary to the Teays system was Barlow Creek, which flowed to the southeast through central and southern Morgan County. Apparently there was a divide or col in the northwestern portion of the county at that time (Stout and Lamb, 1939, p. 11; and Stout, Ver Steeg, and Lamb, 1943, facing p. 50, Map of Teays Drainage).

With the invasion of the early ice sheets, Jerseyan (Kansan) of Stout and Lamb (1939, p. 12), and early Illinoian of other workers, striking modifications of drainage systems were brought about along the ice front. These streams dissected deeply during the interglacial period resulting in the Deep Stage Drainage System (Stout and Lamb, 1939, p. 23 ; and Stout, Ver Steeg, and Lamb, 1943, facing p. 78, Map of Deep Stage Drainage). The divide in northwestern Morgan County continued to be a barrier, and the drainage through the county was toward the southeast by means of the Lowell Creek system, which apparently occupied essentially the same headwater channels as the ancestral Barlow Creek system.

The invasion of the Illinoian glacial sheet into east central and southern Ohio, to a line about 10 miles west of Morgan County, resulted in further stream modifications and a burial of much of the Deep Stage Drainage systems across central Ohio. The divide across northwestern Morgan County continued to act as a barrier, so that the county still drained to the southeast through the Beverly Creek system, which occupied essentially the headwater channels developed by the previous Lowell and Barlow Creek systems (Stout, Ver Steeg, and Lamb, 1943, facing p. 86, Map of Post-Illinoian Drainage).

Subsequent to the advance of the Wisconsin glacial sheet, ponding of streams along the ice front is believed to have occurred to such a height that the cols were breached, thus establishing southeasterly flowing streams which are in existence today. The Muskingum River was formed by the breaching of the divide across the northwestern part of Morgan County, near the village of Eagleport, with the water then flowing southeasterly through a headwater channel of the Beverly Creek system (Stout, Ver Steeg, and Lamb, 1943, facing p. 94, Map of Post-Wisconsin Drainage). The narrow channel with little or no flood plain, in northern Morgan County, is considered evidence of this stream diversion. Outwash waters from the melting Wisconsin glacial sheet filled the early Muskingum River channel with debris. As the present Muskingum River cuts its own channel in the glacial outwash material it develops small terraces in that material. These can be observed locally in central and southern Morgan County where the river channel is broader than in the northern part of the county.

DRAINAGE

The Muskingum River is the dominant stream in Morgan County. It flows southeastward through the middle portion of the county and receives the major part of the drainage. Other main lines of drainage in the county are roughly parallel to the Muskingum, and are separated from it by prominent ridges.

The eastern part of the county is drained by Meigs and Olive Green Creeks, which join the Muskingum River near the Washington County line. West of the Muskingum River the area is drained chiefly by Wolf Creek, which unites with the Muskingum at Waterford in Washington County. The southwestern corner of the county is drained by branches of Federal and Sunday Creeks, which are tributaries of the Hocking River.

The drainage pattern is dendritic because of the lack of structural control by the gently dipping bedrock. This pattern is well illustrated by the tributaries of Meigs, Olive Green, and Wolf Creeks.

RELIEF

The land surface of Morgan County is comparatively rugged with steep hills and ridges throughout the county. The region is in an early mature stage of dissection with more of the area in slope than on the ridge tops. Many of the ridges are quite narrow. Because of the post-glacial breaching of the col in the northwestern portion of the county with the resulting over-deepening of the early Muskingum River Valley by the glacial melt waters, the tributaries of the present Muskingum River flow in narrow ravines with steep gradients, which are characteristic of a youthful stage of stream development.

The main divides trend northwest-southeast. Branching from these are numerous ridges separated by deep ravines and hollows. The most gentle topography is west of the Muskingum River in the west central part of the county, where Wolf Creek and its tributaries flow in valleys with more gentle slopes.

The highest hills occur in the northwestern portion of the county, in the northern part of eastern York Township, and have an altitude from 1,120 to 1,160 feet above sea level. Few hills in the northeastern part of the county reach an altitude of 1,080 feet. The highest point in this portion of the county is in section 9 of Manchester Township near the Noble County line, where a small hill has an altitude of 1,140 feet. In the central and southern parts of the county, there are few ridges over 1,040 to 1,060 feet. In the southeastern part of the county, in southern Windsor Township, they seldom reach an altitude of 960 to 980 feet.

The lowest elevation along the Muskingum River in Morgan County is about 620 feet. This results in a topographic relief of 540 feet for the county.

The Muskingum River enters the county at an altitude of 680 feet, and leaves the county at about 620 feet. The average gradient is a little less than 2 feet per mile throughout its winding course of 32.5 miles across the county in the glacial outwash filled valley.

In the northern part of the county, in Bristol Township, the Meigs Creek channel has an altitude of 720 feet. At its junction with the Muskingum River at the Washington County line the altitude is about 620 feet. Hence, the stream has a drop of 100 feet in 15 miles or a gradient of 6.6 feet per mile. Little Olive Green Creek has an headwater altitude of 980 feet in eastern Manchester Township, and an altitude of 760 feet where it joins Olive Green Creek in southern Center Township. This stream has a drop of 120 feet in 10 miles or a gradient of 12 feet per mile.

West of the Muskingum River the headwaters of Wolf Creek, in western Deerfield Township, are at an altitude of 960 feet. In a distance of 16 miles to the point where it leaves the southern part of the county this stream has a gradient of 16.2 feet per mile. In the extreme western part of the county East Branch of Sunday Creek has a gradient of 26.6 feet per mile with a drop in altitude from 940 to 700 feet.

The tributaries of the Muskingum River in Malta, Morgan, eastern Deerfield, and York Townships have relatively short courses through steep ravines with near cliff-like valley slopes. Salt Run, on the eastern side of the Muskingum River about 2 miles north of McConnelsville, has a course of about 1.5 miles in length and a gradient of 26.6 feet per mile. On the western side of the Muskingum River, north of McConnelsville, the tributary streams are more numerous. The following tabulation shows the steepness of these streams:

Tributaries to Muskingum River, west of the river and north of McConnelsville

Stream and Distance From McConnelsville	Headwater Altitude	Mouth Altitude	Length	Gradient
Miller's Run (1 mile)	900	670	2.5 miles	92.0 feet
Havener's Run (3 miles)	800	670	1.0 miles	130.0 feet
Oil Spring Run (3.5 miles)	980	670	4.0 miles	77.5 feet
Island Run (6 miles)	920	670	6.0 miles	41.6 feet
Opossum Hollow (7 miles)	800	670	1.0 miles	130.0 feet
Big Bottom Run (8.5 miles)	1,000	675	2.5 miles	130.0 feet

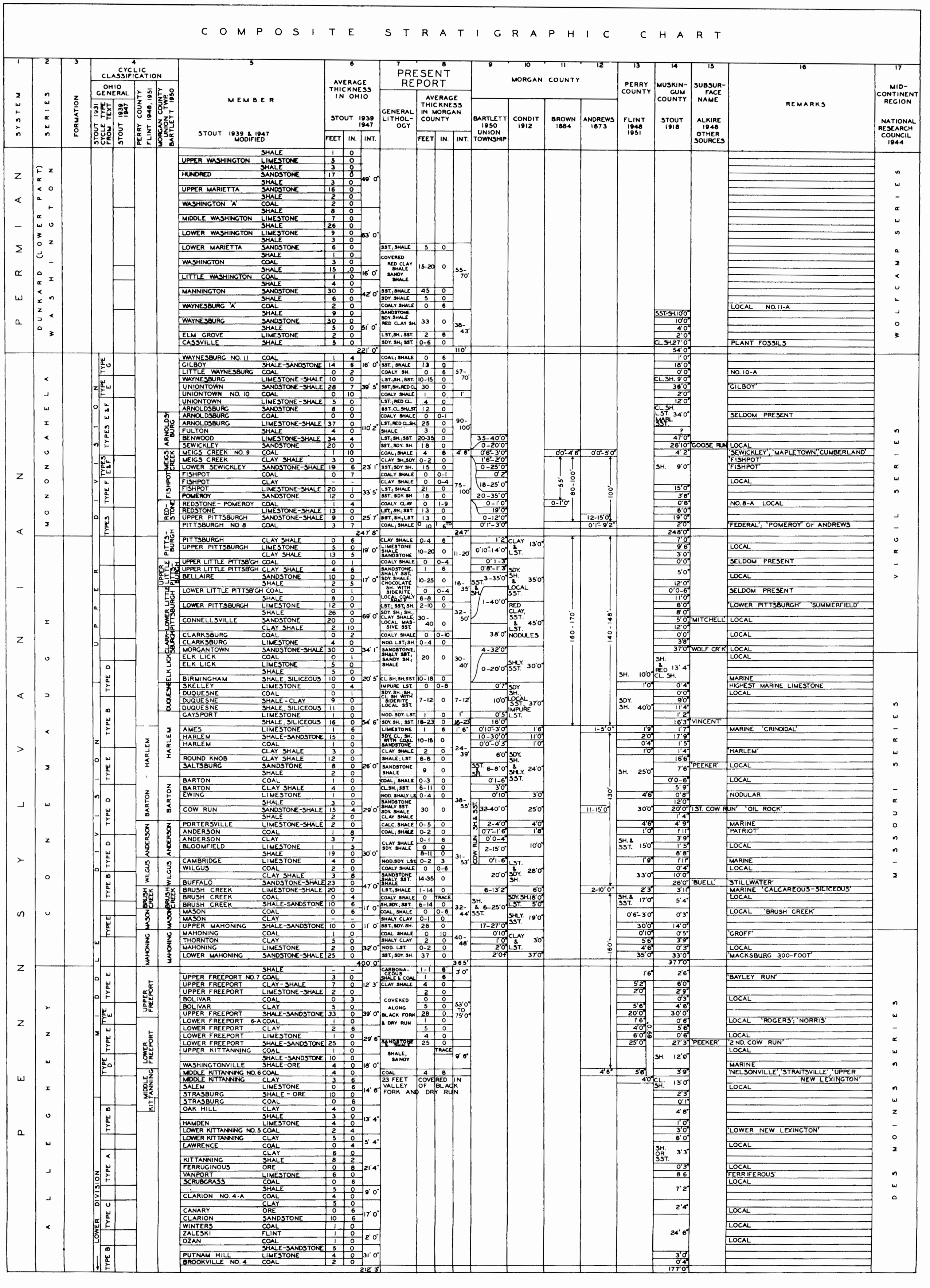

COMPOSITE STRATIGRAPHIC CHART
1 SYSTEM
2 SERIES
3 FORMATION
4 CYCLIC CLASSIFICATION
OHIO GENERAL
STOUT 1931 CYCLE TYPE FROM TEXT
STOUT 1939 1947
PERRY COUNTY FLINT 1948, 1951
MORGAN COUNTY UNION TWP. BARTLETT 1950
5 MEMBER
STOUT 1939 & 1947 MODIFIED
6 AVERAGE THICKNESS IN OHIO
STOUT 1939 1947
FEET IN. INT.
7 8 PRESENT REPORT
GENERAL LITHOLOGY
AVERAGE THICKNESS IN MORGAN COUNTY
FEET IN. INT.
9 10 11 12 MORGAN COUNTY
BARTLETT 1950 UNION TOWNSHIP
CONDIT 1912
BROWN 1884
ANDREWS 1873
13 PERRY COUNTY FLINT 1948 1951
14 MUSKINGUM COUNTY STOUT 1918
15 SUBSURFACE NAME ALKIRE 1948 OTHER SOURCES
16 REMARKS
17 MID-CONTINENT REGION NATIONAL RESEARCH COUNCIL 1944
PERMIAN
DUNKARD (LOWER PART) WASHINGTON
WOLFCAMP SERIES
PENNSYLVANIAN
MONONGAHELA
VIRGIL SERIES
CONEMAUGH
MISSOURI SERIES
ALLEGHENY
DES MOINES SERIES
SHALE 1 0
UPPER WASHINGTON LIMESTONE 5 0
SHALE 3 0
HUNDRED SANDSTONE 17 0
SHALE 3 0 49' 0"
UPPER MARIETTA SANDSTONE 16 0
SHALE 2 0
WASHINGTON 'A' COAL 2 0
SHALE 8 0
MIDDLE WASHINGTON LIMESTONE 7 0
SHALE 26 0
LOWER WASHINGTON LIMESTONE 9 0 63' 0"
SHALE 3 0
LOWER MARIETTA SANDSTONE 6 0
SHALE 1 0
WASHINGTON COAL 3 0
SHALE 15 0 16' 0"
LITTLE WASHINGTON COAL 1 0
SHALE 4 0
MANNINGTON SANDSTONE 30 0 42' 0"
SHALE 6 0
WAYNESBURG 'A' COAL 2 0
SHALE 9 0
WAYNESBURG SANDSTONE 30 0
SHALE 5 0 51' 0"
ELM GROVE LIMESTONE 2 0
CASSVILLE SHALE 5 0
221' 0"
WAYNESBURG NO. 11 COAL 1 4
GILBOY SHALE-SANDSTONE 14 6 16' 0"
LITTLE WAYNESBURG COAL 0 2
WAYNESBURG LIMESTONE-SHALE 10 0
UNIONTOWN SANDSTONE-SHALE 28 7 39' 5"
UNIONTOWN NO. 10 COAL 0 10
UNIONTOWN LIMESTONE-SHALE 5 0
ARNOLDSBURG SANDSTONE 8 0
ARNOLDSBURG COAL 0 0
ARNOLDSBURG LIMESTONE-SHALE 37 0 110' 2"
FULTON SHALE 4 0
BENWOOD LIMESTONE-SHALE 34 4
SEWICKLEY SANDSTONE 20 0
MEIGS CREEK NO. 9 COAL 1 10
MEIGS CREEK CLAY SHALE 3 0
LOWER SEWICKLEY SANDSTONE-SHALE 19 6 23' 1"
FISHPOT COAL 0 7
FISHPOT CLAY - -
FISHPOT LIMESTONE-SHALE 20 1 33' 5"
POMEROY SANDSTONE 12 0
REDSTONE-POMEROY COAL 1 4
REDSTONE LIMESTONE-SHALE 13 0
UPPER PITTSBURGH SANDSTONE-SHALE 9 0 25' 7"
PITTSBURGH NO 8 COAL 3 7
247' 8"
PITTSBURGH CLAY SHALE 0 6
UPPER PITTSBURGH LIMESTONE 5 0 19' 0"
CLAY SHALE 13 5
UPPER LITTLE PITTSB'GH COAL 0 1
UPPER LITTLE PITTSB'GH CLAY SHALE 4 6
BELLAIRE SANDSTONE 10 0 17' 0"
SHALE 2 5
LOWER LITTLE PITTSB'GH COAL 0 1
SHALE 8 0
LOWER PITTSBURGH LIMESTONE 12 0
SHALE 26 0 69' 0"
CONNELLSVILLE SANDSTONE 20 0
CLAY SHALE 2 10
CLARKSBURG COAL 0 2
CLARKSBURG LIMESTONE 4 0
MORGANTOWN SANDSTONE-SHALE 30 0 34' 1"
ELK LICK COAL 0 1
ELK LICK LIMESTONE 5 0
SHALE 5 0
BIRMINGHAM SHALE, SILICEOUS 10 0 20' 5"
SKELLEY LIMESTONE 0 4
DUQUESNE COAL 0 1
DUQUESNE SHALE-CLAY 9 0
DUQUESNE SHALE, SILICEOUS 11 0
GAYSPORT LIMESTONE 1 0
SHALE, SILICEOUS 16 0 54' 6"
AMES LIMESTONE 1 6
HARLEM SHALE-SANDSTONE 15 0
HARLEM COAL 1 0
CLAY SHALE 3 0
ROUND KNOB CLAY SHALE 12 0
SALTSBURG SANDSTONE 8 0 26' 0"
SHALE 2 0
BARTON COAL 1 0
BARTON CLAY SHALE 4 0
EWING LIMESTONE 1 0
SHALE 3 0
COW RUN SANDSTONE-SHALE 15 4 29' 0"
SHALE 2 0
PORTERSVILLE LIMESTONE-SHALE 2 0
ANDERSON COAL 1 8
ANDERSON CLAY 3 7
BLOOMFIELD LIMESTONE 1 5
SHALE 19 0 30' 0"
CAMBRIDGE LIMESTONE 4 0
WILGUS COAL 2 0
CLAY SHALE 3 8
BUFFALO SANDSTONE-SHALE 23 0 47' 0"
BRUSH CREEK LIMESTONE-SHALE 20 0
BRUSH CREEK COAL 0 4
BRUSH CREEK SHALE-SANDSTONE 10 6 11' 0"
MASON COAL 0 6
MASON CLAY - -
UPPER MAHONING SHALE-SANDSTONE 10 0 11' 0"
MAHONING COAL 1 0
THORNTON CLAY 5 0
MAHONING LIMESTONE 2 0 32' 0"
LOWER MAHONING SANDSTONE-SHALE 25 0
400' 0"
SHALE - -
UPPER FREEPORT NO. 7 COAL 3 0
UPPER FREEPORT CLAY-SHALE 7 0 12' 3"
UPPER FREEPORT LIMESTONE-SHALE 2 0
BOLIVAR COAL 0 3
BOLIVAR CLAY 5 0
UPPER FREEPORT SHALE-SANDSTONE 33 0 39' 0"
LOWER FREEPORT 6-A COAL 1 0
LOWER FREEPORT CLAY 2 6
LOWER FREEPORT LIMESTONE 1 0 29' 6"
LOWER FREEPORT SHALE-SANDSTONE 25 0
UPPER KITTANNING COAL 1 0
SHALE-SANDSTONE 10 0
WASHINGTONVILLE SHALE-ORE 4 0 18' 0"
MIDDLE KITTANNING NO. 6 COAL 4 0
MIDDLE KITTANNING CLAY 3 6
SALEM LIMESTONE 0 6 14' 6"
STRASBURG SHALE-ORE 10 0
STRASBURG COAL 0 6
OAK HILL CLAY 4 0
SHALE 3 0 13' 4"
HAMDEN LIMESTONE 4 0
LOWER KITTANNING NO. 5 COAL 2 4
LOWER KITTANNING CLAY 5 0 5' 4"
LAWRENCE COAL 0 4
CLAY 6 0
KITTANNING SHALE 8 2
FERRUGINOUS ORE 0 8 21' 4"
VANPORT LIMESTONE 6 0
SCRUBGRASS COAL 0 6
SHALE 5 0 9' 0"
CLARION NO. 4-A COAL 4 0
CLAY 5 0
CANARY ORE 0 6
CLARION SANDSTONE 10 6 17' 0"
WINTERS COAL 1 0
ZALESKI FLINT 1 0 2' 0"
OZAN COAL 1 0
SHALE-SANDSTONE 5 0
PUTNAM HILL LIMESTONE 4 0 31' 0"
BROOKVILLE NO. 4 COAL 2 0
212' 3"

Figure 3

CHAPTER 3

STRATIGRAPHY

PENNSYLVANIAN SYSTEM

GENERAL

During the geological investigations at the time of the First (1837-1838), Second (1869-1888), and Third (1889-1894) organizations of the Geological Survey of Ohio, the term Carboniferous System was in general usage to include all of the strata above recognizable Devonian rocks. This system was subdivided into Lower Carboniferous and Upper Carboniferous or Coal Measures. For discussion of early stratigraphic nomenclature the reader is directed to such works as Newberry, 1874, The Carboniferous System, and Orton, 1884, The Stratigraphical Order of the Lower Coal Measures of Ohio, both of which were published by the Geological Survey of Ohio. The term "Coal Measures" included, in descending order, the following subdivisions: "Upper Barren Measures," "Upper Productive Measures," "Lower Barren Measures," "Lower Productive Measures," and Pottsville conglomerate. According to Wilmarth (1925, pp. 72-73), the "Upper Barren Measures" were the Dunkard group, and were assigned to the Permian on the basis of plant fossils by Fontaine and White in 1880. The other descriptive terms were replaced subsequently by geographic names. In general, the "Upper Productive Measures" is equivalent to the Monongahela (Rogers, 1840), the "Lower Barren Measures" to the Conemaugh (Platt, 1875), and the "Lower Productive Measures" to the Allegheny (Rogers, 1840).

In 1891, Williams introduced the term Pennsylvanian to replace "Coal Measures" series in a chart accompanying a report on Washington County, Arkansas (Wilmarth, 1925, p. 72). This new term was discussed at length by the same author in a bulletin published by the United States Geological Survey (Williams, 1891). The introduction of the term Pennsylvanian has been attributed by other writers to Rogers in 1838 (Stout, 1943, p. 140). The Pennsylvanian included, in descending order, the subdivisions of Monongahela, Conemaugh, Allegheny, and Pottsville. These terms have been given series rank by many authors and formation rank by other writers. In the publications of the Geological Survey of Ohio both ranks have been used. In the present report these subdivisions will be treated as of series rank, in accordance with the usage by the National Research Council Committee on Stratigraphy (1944). The relationship of these subdivisions to those used in the Mid-Continent Region is shown on figure 3, column 17.

The Pennsylvanian rocks in Ohio are a part of the great Appalachian Basin strata. These rocks crop out in broad bands, which trend in a southsouthwest-northnortheast direction across the state (figure 1). The rocks have a gentle dip to the southeast, so that the older rocks crop out on the western side of the Pennsylvanian outcrop belt. In Morgan County approximately 725 feet of Pennsylvanian strata are exposed, and consist of 111 feet of the Allegheny series, 365 feet of the Conemaugh series, and 247 feet of the Monongahela series.

The Pennsylvanian rocks in Ohio consist mainly of shales and sandstones, with varying amounts of limestones, thin coals, and clays. The shales and sandstones show pronounced regional and local facies variations. Stout (1943, pp. 143-148) has computed the percentage of sandstones and shales in the Pennsylvanian of Ohio as follows: Allegheny series, 40 per cent sandstone and 60 per cent shales and clays; Conemaugh series, 30 per cent sandstone; and Monongahela series, 15 per cent sandstone.

The limestones are more prevalent and in thicker bodies in the upper part of the Conemaugh and in the Monongahela series, and in the latter, comprise thick sequences. The limestones in the Allegheny series and in the lower half of the Conemaugh series are marine in origin. The Skelley limestone of middle Conemaugh has always been regarded as the youngest marine limestone in Ohio. The marine limestones are relatively thin and persistent beds, and usually are quite fossiliferous. The limestones above the Skelley in the upper Conemaugh and in the Monongahela have been considered non-marine in origin because of the presence of Spirorbis. There is now some question concerning the non-marine environment assigned to this fossil. These limestones are in thick sequences, are subject to rapid lithologic variations, and are characterized by a "conglomeratic" or "brecciated" appearance. Because of this appearance, some workers have referred to them as "desiccation conglomerates".

The coals and clays are usually in thin beds, some of which are regionally persistent and many of which are developed only locally. The coals of the Allegheny and of the Monongahela are the most important commercially.

The Pennsylvanian rocks are characterized by repetitive sequences of beds, with each sequence associated with a coal. The concept of cyclic deposition originated in Illinois, with the recognition of repetitive sequences by Udden in his study of the Peoria Quadrangle (1912). The concept was not enlarged until Weller's work in 1930 and 1931, in which a typical succession of 9 lithologic types, with coal in the middle, was proposed to represent sedimentation during a sea invasion and subsequent withdrawal:

Marine:
9. Shale with ironstone and thin limestones
8. Limestone
7. Calcareous shale
6. Black shale

Continental:
5. Coal
4. Underclay
3. Limestone
2. Sandy shale
1. Sandstone

The base of this typical succession, termed a "cyclothem," was placed at an unconformable base of a sandstone.

The cyclothem concept was advanced vigorously in Illinois by Wanless (1931) and by Weller and Wanless (1932), and applied to the regional Eastern Interior and Appalachian Coal Fields by Wanless (1939). A symposium on Pennsylvanian Problems (Wanless et al., 1947) summarizes the application of cyclothems.

Other "typical" sequences of strata have been proposed by various workers for other coal-bearing areas. Stout (1931, pp. 195-216) discussed the Pennsylvanian of Ohio, and, after commenting on the importance of distance from source areas in any resulting succession of strata, divided the Pennsylvanian of Ohio into 3 major divisions:

3. Upper Division. - Strata from top of Skelley limestone to top of Waynesburg coal; beds appear to be entirely of fresh-water origin. (Includes upper Conemaugh and Monongahela series.)

2. Middle Division. - Strata from top of Strasburg coal to top of Skelley limestone; both marine and fresh-water strata are prominent. (Includes upper Allegheny and lower Conemaugh series.)

1. Lower Division - Strata from Harrison ore to top of Strasburg coal; marine deposits are very prominent. (Includes Pottsville and lower Allegheny series.)

Stout (1931, pp. 198-202) outlined 7 types of cycles present in the Pennsylvanian of Ohio with the base of each cycle at the base of a coal bed:

Lower Division. -

A. Clay, fresh-water origin
Shale and sandstone, largely marine
Iron ore, marine
Limestone, marine
Coal, fresh-water

B. Clay, fresh-water
Shale and sandstone, mainly marine
Limestone, marine
Coal, fresh-water

This type is distinctive of the Lower Division.

C. Clay, fresh-water
Shale and sandstone, brackish-water or marine
Shale, fossiliferous, brackish-water
Coal, fresh-water

"These three types of cycles may all be repeated in the Middle Division..... but none of them is present in the Upper Division. They all depend on either a marine or a brackish-water condition during a part of the cycle."

Middle Division. -

"Represents a transition stage between predominant marine conditions in the lower part of the system and truly fresh-water conditions in the upper part. On this account the Middle Division contains cycles peculiar to itself, some typical of the Lower Division and others characteristic of the Upper Division."

D. Clay, thin, impure, fresh-water
Limestone, fresh-water
Shale and sandstone, partially marine
Limestone, marine
Coal, fresh-water

This type is distinctive of the Middle Division.

C. As in the Lower Division.

E. Clay, fresh-water
Limestone, fresh-water
Shale and sandstone, fresh-water
Coal, fresh-water

Upper Division. -

Strata entirely of continental or fresh-water origin.

E. As in the Middle Division.

F. Clay, thin, fresh-water
Limestone and calcareous shale, fresh-water

Coal, fresh-water

This type is distinctive of the Upper Division.

G. Clay, fresh-water, thin
Shale and sandstone, fresh-water
Coal, fresh-water

Stout (1931, p. 203) states, "No regional disconformities are evident at any position in the Pennsylvanian system in Ohio." Thus, his cycle types, at the base, have coal beds which correspond to the middle of the cycles or cyclothems of Weller and Wanless, and of other workers. As in other areas in which cyclic classification has been applied, few successions of rock strata form complete cycles or cyclothems. Stout's cycle types are indicated on figure 3, column 4.

During the current mapping program of the Geological Survey of Ohio some workers have revived classification of the Pennsylvanian strata according to cyclothems (Flint, 1948 and 1951; Merrill, 1948; and Bartlett, 1950). These workers included coal as the top member of their cyclothems. Sturgeon and Merrill (1949, p. 2) state: "In Ohio only two cyclothems, one associated with the Middle Kittanning coal in the Allegheny formation and another associated with the Anderson coal in the Conemaugh formation..... are recognized as more or less complete. Inspection of Stout's stratigraphic charts (1939 and 1947) shows that all other Ohio cyclothems are incomplete and that several may consists of as few as two members." Sturgeon and Merrill found marine fossils in a shale superjacent to the Lower Freeport (No. 6-A) coal in the upper part of the Allegheny series, and proposed this cyclothem as the third nearly complete cyclothem in the Pennsylvanian of Ohio. The cyclothems of Flint, Merrill, Bartlett, and Sturgeon have been named from the contained coals (fig. 3, column 4).

The writer does not argue against cyclic deposition; however, in view of the wide divergence of opinion as to the position of the boundaries of the cyclothems (and hence, the basic significance of cyclothems), the major change in lithologies from the marine beds of the Allegheny to the questionably non-marine beds of the upper Conemaugh and Monongahela, and the awkwardness of current cyclothem terminology, the stratigraphy of the Pennsylvanian in this report on Morgan County will be treated without recourse to cyclothem classification. The nomenclature indicated in Stout's Generalized Section of Rocks of Ohio (1947) will be followed in this report (fig. 3, column 5).

Stratigraphic sections, measured in Morgan County by the writer and his associates, are on file at the office of the Ohio Division of Geological Survey. Figure 4 shows the location of the stratigraphic cross sections on Morgan County presented in this report.

ALLEGHENY SERIES

General

Nomenclator: H. D. Rogers, 1840,(Pennsylvania Geological Survey 5th Annual Report, p. 150).

Original Description: Wilmarth, 1938, p. 33.

H. D. Rogers, 1840, Allegheny series (Lower Coal Measures). Developed in valley of Allegheny River. Underlies Monongahela Series, the boundary between the two series being marked by final outcrop of the shales exposed just above Ohio River at Pittsburgh, and overlies formation XII - coarse, massive, white sandstone about 100 feet thick, which constitutes bottom of Productive Coal Measures, and which appears to include at base the sandstone on Tionesta Creek (Homewood sandstone member of Pottsville formation). (The above definition includes Allegheny and Conemaugh formations of present nomenclature.)

J. J. Stevenson, 1873, (American Philosophical Society, Transactions, Volume 15, new series, p. 16). Lower Coal Group (Allegheny River Series) - extends from the great conglomerate (Pottsville formation) (350 feet thick) up to Mahoning sandstone. (This definition accords with current definition of Allegheny formation, the shorter name.)

The present Pennsylvania Geological Survey classifies the Allegheny as a group; the United States Geological Survey classifies it as a formation.

The Allegheny is considered as a series in this report, in accordance with the National Research Council Committee on Stratigraphy (1944, chart No. 6). The strata included within the series in Ohio extend from the base of the Brookville (No. 4) coal to the top of the Upper Freeport (No. 7) coal.

In Morgan County the outcropping Allegheny strata range from the Middle Kittanning (No. 6) coal to the top of the series, or approximately the top third of the Allegheny strata present in Ohio (fig. 3). Several units below the Middle Kittanning (No. 6) coal undoubtedly are present in a covered interval of 23 feet, but were not identified definitely during the course of the field work. The Allegheny rocks in Morgan County have a total thickness of 111 feet, including the covered interval.

The Allegheny crops out along stream channels in western York Township (plate I). The rocks consist of shales and sandstones, with thin limestones, clays, and coals. Two coals, the Middle Kittanning (No. 6) and the Upper Freeport (No. 7), are of sufficient thickness and quality for local commercial mining by the drift method.

Middle Kittanning Clay Member

Description: Wilmarth, 1938, p. 1,362. A clay bed, 3 to 15 feet thick, underlying Middle Kittanning coal, in western Pennsylvania.

The Middle Kittanning clay was not recognized during field mapping in Morgan County. In the limited area of possible outcrop the ravines have been filled and the lower valley slopes covered by refuse from the mining of the overlying Middle Kittanning (No. 6) coal. Approximately 23 feet of section is covered from the base of the coal to the stream levels of Black Fork and Dry Run, in western York Township. The Middle Kittanning clay should occur near the top of the covered interval.

Flint (1951, p. 49) recognized a thickness of 4 feet of this clay in Perry County.

Middle Kittanning (No. 6) Coal Member

Nomenclators: J. P. Lesley and I. C. White, 1876, (Second Pennsylvania Geological Survey, Map of Southern Butler County).

Original Description: Wilmarth, 1938, p. 1,107.

J. P. Lesley and I. C. White, 1876, (The block beneath Darlington coal reads (descending) "Kittanning group, Kittanning coal.")

J. P. Lesley, 1877, (Second Pennsylvania Geological Survey Report H-3, p. xxiii). Divided Lower Productive Coal Measures (Allegheny formation) into (descending) Freeport coal group, Kittanning coal group, and Clarion coal group.

I. C. White, 1878, (Second Pennsylvania Geological Survey Report Q). Kittanning group extends from top of Upper Kittanning coal to top of the Buhrstone iron ore overlying the Ferriferous (Vanport) limestone.

G. H. Ashley, 1926, (Pennsylvania Topographic and Geological Survey Atlas, Number 65, Punxsutawney Quadrangle, pl. 4, p. 28). Kittanning formation includes beds from top of Upper Kittanning coal to top of Vanport limestone member.

Kittanning coal group is treated by United States Geological Survey as an economic member in middle of Allegheny formation. In Maryland it includes Upper, Middle, and Lower Kittanning coals and, at base, Split-Six coal.

Outcrops of the Middle Kittanning (No. 6) coal in Morgan County are limited to the valleys of Black Fork and Dry Run in the western part of York Township, in the northwestern corner of the county (plate I and fig. 19). Good visible outcrop sections are sparse at the present time due to extensive mining and the resulting filling of the valleys with mine refuse. Most of the drift mines have been abandoned for years, and the coal faces cannot be reached for study. When visited in 1949, the last operating mine, the New York Coal Company Mine No. 52, in section 26, T 14 N, R 14 W, was being abandoned.

Some of the measured sections of this coal are illustrated on Stratigraphic Cross Section A - A' (fig. 5). The thickest section observed is in the northern part of section 27, where the following section was measured near the collapsed entry of an old mine.

York Township; SW$\frac{1}{4}$, NE$\frac{1}{4}$, section 27, T 14 N, R 14 W. Mouth of D. S. Thomas Coal Company drift mine. G. S. O. File No. 8051. Norling and Chapman.

		Ft.	In.
Shale, sandy, tan to gray, thin-bedded		8	0
Clay shale, dark gray, thin-bedded	Middle Kittanning coal	0	4
Coal, black, bony to bright, blocky	Middle Kittanning coal	0	8
Shale, black, thin-bedded; in part bony	Middle Kittanning coal	0	4
Coal, black, bright, blocky; with thin irregular partings	Middle Kittanning coal	1	4
Shale, black, bony	Middle Kittanning coal	0	1$\frac{1}{2}$
Coal, black, bright, blocky	Middle Kittanning coal	1	4
Shale, black; and coal, bony	Middle Kittanning coal	0	0$\frac{1}{2}$
Coal, black, bright, blocky	Middle Kittanning coal	0	6
Covered	Middle Kittanning coal	-	-
Total coal section		4	8

The following subsurface coal section was obtained from a mine company map at the New York Coal Company Mine No. 52 in section 26:

York Township; E. Cen. NW$\frac{1}{4}$ section 26, T 14 N, R 14 W. New York Coal Company Mine No. 52. Mine Map. G. S. O. File No. 8073. Norling and Chapman

			Ft.	In.
Bone coal	Middle Kittanning coal	. . .	0	3
Draw slate		. . .	0	1
Tear		. . .	0	2
Coal, good		. . .	1	3
Middle slate		. . .	0	1½
Bottom coal, poor		. . .	1	0
Bottom coal, very poor		. . .	1	3
Total section reported			4	1½

This coal was reported by a mine employee to be approximately 60 feet beneath the valley floor.

The Middle Kittanning (No. 6) coal is present in the subsurface to the east and southeast under progressively thicker cover, and is undoubtedly one of the coals which are shown on some of the logs of wells drilled for petroleum and natural gas. Core drilling in Homer Township, in the southwestern part of the county, has revealed the presence of a thin coal bed under 150 to 175 feet of cover. This area is discussed more fully in the section of this report on Economic Resources.

Representative coal analyses from mines in adjoining parts of Muskingum, Perry, and Athens Counties are presented in Appendix A.

Washingtonville Shale Member

Nomenclators: W. Stout and R. E. Lamborn, 1924,(Geological Survey of Ohio, 4th Series, Bulletin 28, pp. 175-181).

Original Description: Wilmarth, 1938, pp. 2,281-2,282

W. Stout and R. E. Lamborn, 1924, Washingtonville member of Allegheny formation - bony carbonaceous shale of dark slaty-gray to nearly black color, hard, tough, resistant. Carries marine fauna. Occurs in Allegheny formation. In places lies on and in other places as much as 10 feet above Middle Kittanning coal, the average interval being 4 feet 4 inches of dark fissile shale or gray siliceous shale. Thickness of Washingtonville shale varies from 6 inches to 6 feet; average 2 feet 2 inches. Extends from Muskingum County, Ohio, to Beaver County, Pennsylvania, and from Mahoning County, Ohio, to Panhandle of West Virginia.

Named for exposures at Washingtonville, Columbiana County, Ohio.

The Washingtonville shale is poorly exposed along its limited areal extent on valley slopes in western York Township, Morgan County. It was measured in three localities in section 27, T 14 N, R 14 W, where its thickness varies from 5 feet to 9 feet 6 inches (Stratigraphic Cross Section A - A', fig. 5). The strata consist of gray to tan, thin bedded, sandy shale and clay shale with thin to platy layers of shaly sandstone and thin layers of small siderite nodules. In other counties, where the siderite is more abundant, this unit has been termed the "Yellow Kidney Ore." Several very thin carbonaceous shale streaks near the top, observed in one outcrop, may represent the Upper Kittanning coal.

Upper Kittanning Coal Member

Nomenclators: J. P. Lesley and I. C. White, 1876,(Second Pennsylvania Geological Survey, Map of Southern Butler County).

Original Description: See under Middle Kittanning (No. 6) coal.

The Upper Kittanning coal is important in Pennsylvania, but is thin and of no value in Ohio (Bownocker and Dean, 1929, p. 124). The coal was not recognized definitely in Morgan County. Thin carbonaceous shale streaks within the top portion of the Washingtonville shale, observed in one outcrop in section 27, T 14 N, R 14 W, York Township, may represent this coal.

Lower Freeport Sandstone and Shale Member

Nomenclator: J. J. Stevenson, 1878, (Second Pennsylvania Geological Survey Report K).

Original Description: Wilmarth, 1938, p. 1,227.

J. J. Stevenson, 1878. Lower Freeport sandstone, 50 feet thick, underlies Lower Freeport limestone and overlies Upper Kittanning coal.

I. C. White,1878, (Second Pennsylvania Geological Survey Report Q), and 1879 (ibid. Report Q-2). Lower Freeport sandstone is same as Freeport sandstone of earlier reports.

I. C. White, 1891, (United States Geological Survey Bulletin 65, pp. 163-164). Lower Freeport sandstone - grayish white sandstone, sometimes double and contains a coal bed. Thickness 30 to 300 feet. Is thickest in West Virginia. Underlies Lower Freeport limestone and overlies Upper Kittanning coal.

The Lower Freeport sandstone and shale is reported to be 25 feet thick in Perry County, and 27 feet thick in Muskingum County (fig. 3, columns 13 and 14, respectively). In western York Township, Morgan County, the unit was measured in section 27, T 14 N, R 14 W (Stratigraphic Cross Section A - A', fig. 5), where it consists of 15 feet of tan to gray, micaceous, medium to coarse-grained sandstone with layers of thin to platy bedded, shaly sandstone and sandy shale. The grains in the thicker sandstone beds are subrounded to subangular. The bedding of the sandstone layers ranges from 3 inches to 1 foot 6 inches, with some development of cross-bedding. The observed sandstone was overlain by a covered interval, but it is estimated that the true thickness of this unit is approximately 25 feet.

Lower Freeport Limestone Member

Nomenclator: F. Platt, 1877, (Second Pennsylvania Geological Survey Report H-2, p. xxviii).

Original Description: Wilmarth, 1938, p. 778, and p. 1,227.

F. Platt, 1877. Applied Freeport limestone to a limestone between the Upper and Middle Freeport coals, and applied Middle Freeport limestone to a limestone between Lower and Middle Freeport coals in Cambria County, Pennsylvania, but with statement that so-called

Middle Freeport coal would probably in future be called Lower Freeport, that so-called Middle Freeport limestone would be called Lower Freeport limestone, and that so-called Lower Freeport coal would be called Kittanning coal.

F. and W. G. Platt, 1877, (Second Pennsylvania Geological Survey Report H-3, p. 316). Changed Freeport limestone of previous reports to Upper Freeport limestone, Middle Freeport limestone to Lower Freeport limestone, Middle Freeport coal to Lower Freeport coal, and Lower Freeport coal to Upper Kittanning coal. These are names that have been in common use for many years.

I. C. White, 1878, (Second Pennsylvania Geological Survey Report Q, p. 49). Butler (Lower Freeport) limestone - lies 3 feet below Lower Freeport coal and 15 feet above Freeport (Lower Freeport) sandstone in Beaver County. Thickness 2 to 5 feet. Was called Middle Freeport limestone in Reports H-2 and H-3 (Cambria and Somerset Counties). Does not occur at Freeport, but is present at Butler (Butler County), in cut near railroad station, hence name.

I. C. White, 1879, (Second Pennsylvania Geological Survey Report Q-2). Lower Freeport (Butler) limestone was called Butler limestone in Report Q, but Professor Lesley suggests it be named Lower Freeport limestone.

The stratigraphic section from the top of the Lower Freeport sandstone to within the Upper Freeport clay member or nearly to the base of the Upper Freeport (No. 7) coal is covered to very poorly exposed in the limited area of possible outcrop in western York Township. The Lower Freeport limestone member was not recognized during field study. The thickness of the unit in Perry County is 6 feet (fig. 3, column 13), and in Muskingum County ranges from 6 inches to 1 foot 8 inches (Stout, 1918, p. 211). Stout reports that the member varies from a light gray, well-defined limestone to a yellow, nodular and limonitic limestone.

Stout (1944, p. 174) states that the "Yellow Kidney Ore" belongs to the horizon of the Lower Freeport limestone, sometimes replacing it and sometimes accompanying it. It thus appears that the mining term "Yellow Kidney Ore" has little stratigraphic value (see this report, p. 17).

It is anticipated that the limestone should be present in limited areas in York Township, Morgan County. A probable thickness of 4 feet has been assigned to the zone.

Lower Freeport Clay Member

Description: Wilmarth, 1938, p. 1,227. - A clay bed, 5 feet thick, underlying Lower Freeport coal in Appalachian region.

The Lower Freeport clay member is covered in Morgan County. The area of possible outcrop is on valley slopes in western York Township. The member has been recognized in both Perry and Muskingum Counties (fig. 3, columns 13 and 14). It is reported to be about 4 feet thick in Perry County, and about 5 feet 6 inches in Muskingum County. The zone may be as much as 5 feet thick in Morgan County. Stout (1918, p. 211) reports that the Lower Freeport clay is everywhere siliceous and of an inferior quality in Muskingum County.

Lower Freeport (No. 6-A) Coal Member

Description: A thin coal of local development at or near the base of Upper Freeport sandstone.

The Lower Freeport (No. 6-A) coal member in Morgan County is situated within the covered interval below the Upper Freeport (No. 7) coal. The area of possible outcrop is limited to valley slopes in western York Township.

The coal is of little value in Ohio, except in Jefferson County (Bownocker and Dean, 1929, pp. 124-125). Stout (1918, p. 241) reports that the coal is very thin and inconspicuous over much of Muskingum County, and that its thickness ranges from a few inches to about one foot. In places in Muskingum County the coal is absent where the overlying Upper Freeport sandstone coalesces with the Lower Freeport sandstone member (Stout, 1918, p. 213). Flint (1951, p. 54) reports an average thickness of 1 foot 6 inches for this coal in Perry County. A thin interval of this coal can be expected in Morgan County, but none was observed.

Dorr Run Shale Member

Nomenclators: M. T. Sturgeon and W. M. Merrill, 1949, (Ohio Journal of Science Volume XLIX, No. 1, pp. 5-9; Reprinted by Geological Survey of Ohio, 1949, as Information Circular 5).

Original Description: Shale, gray to black, argillaceous and/or carbonaceous, fossiliferous, marine, locally present. Thickness 1 foot 6 inches. Type locality - Section 31, Ward Township, Hocking County, Ohio.

During field mapping in Hocking County in 1948, Sturgeon and Merrill found marine or brackish-water fossils in a thin shale overlying the Lower Freeport (No. 6-A) coal, and subsequently named the unit the Dorr Run shale.

This member is not recognized in Morgan County. The area of possible outcrop is mainly covered.

Upper Freeport Sandstone and Shale Member

Nomenclator: I. C. White, 1878, (Second Pennsylvania Geological Survey Report Q, pp. 40-71, 130).
Original Description: Wilmarth, 1938, p. 304, p. 2,220.

I. C. White, 1878. Butler (Lower Freeport) sandstone - massive sandstone. Lies 35 feet below Upper Freeport limestone and overlies Lower Freeport coal. Thickness 30 feet. Type locality is in town of Butler, Butler County, Pennsylvania..... where it has been quarried.

The United States Geological Survey and the Pennsylvania Topographic and Geologic Survey have adopted the name Butler for this member. In Ohio, the term Upper Freeport sandstone and shale has been used, and is established firmly in the literature.

In Morgan County the area of possible outcrop is limited to valley slopes in western York

Township. During the course of field study, several zones of very poorly exposed shaly sandstone and sandy shale were observed but were not described. The unit falls within the thick, essentially covered interval below the Upper Freeport (No. 7) coal. A thickness of approximately 28 feet has been assigned to the member in Morgan County. In one outcrop section in the northwestern corner of section 23, T 14 N, R 14 W, a thin interval of medium-grained, platy, cross-bedded sandstone only 6 inches below the Upper Freeport (No. 7) coal may be the top portion of the Upper Freeport sandstone. Too few outcrop sections are available to establish this correlation with certainty.

Flint reports a thickness of 20 feet for the sandstone in Perry County (fig. 3). Stout (1918, pp. 213-214) describes this unit as a micaceous, rather coarse grained, poorly cemented sandstone with sandy shale layers, and ranging in thickness from 30 to 46 feet. Stout states that locally the Upper Freeport often coalesces with the Lower Freeport sandstone.

Bolivar Clay Member

Nomenclator: I. C. White, 1891, (United States Geological Survey Bulletin 65, pp. 159-160.

Original Description: Wilmarth, 1938, p. 229.

I. C. White, 1891. Bolivar fire clay - where Upper Freeport limestone is absent or only slightly developed, there usually comes into the section at this horizon a bed of excellent fire clay, which from having long been mined near Bolivar, Westmoreland County, Pennsylvania, is generally known as Bolivar clay

E. V. d'Invilliers, 1895, (Second Pennsylvania Geological Survey Volume 3, pt. 2). The Freeport upper fire clay occurring a short distance below Freeport upper limestone is known as "Bolivar fire clay."

G. H. Ashley, 1908, (Pennsylvania Topographic and Geologic Survey). Bolivar fire clay lies short distance below Upper Freeport limestone.

B. L. Miller, 1925, (Pennsylvania Topographic and Geologic Survey, 4th Series, Bulletin M-7, pp. 261 and 316). Bolivar fire clay underlies Upper Freeport limestone.

The Bolivar fire clay member should be near the top portion of the poorly exposed and covered interval which extends over nearly all of the section from the Lower Freeport sandstone to within the Upper Freeport clay in the limited area of possible outcrop of Allegheny series in the western part of York Township. This member is reported to be from 4 feet to 5 feet 6 inches thick in Perry and Muskingum Counties (fig. 3), and it is expected that a similar thickness is present in Morgan County. The member consists of light colored, plastic clay with local flinty content, and often with small nodules of marly limestone and impure siderite (Stout, 1918, pp. 214-215). The clay has little value for ceramic use, but has been used locally in Muskingum County for bonding material in brick manufacture.

Bolivar Coal Member

Description: A thin coal which overlies the Bolivar clay. Named for occurrence above this clay, which has long been mined commercially near Bolivar, Westmoreland County, Pennsylvania.

The Bolivar coal is usually absent or represented in Ohio by only a few inches of carbonaceous shale or bony coal. It was not recognized in Morgan County. Stout (1918, p. 214) stated, "In many places a smut streak or a thin bed of shaly coal is found just above the clay." The Bolivar coal is not reported in Perry County by Flint (1951, p. 55).

Upper Freeport Limestone Member

Nomenclators: F. and W. G. Platt, 1877, (Second Pennsylvania Geological Survey Report H-3, p. 316).

Original Description: Wilmarth, 1938, p. 2,220.

F. and W. G. Platt, 1877. Upper Freeport limestone, substituted for Freeport limestone of previous reports, Lower Freeport coal substituted for Middle Freeport coal, Lower Freeport limestone substituted for Middle Freeport limestone, and Upper Kittanning coal substituted for Lower Freeport coal.

J. P. Lesley, 1879, (Second Pennsylvania Geological Survey Report Q-2). Freeport Upper limestone, formerly called Freeport limestone, consists of 8 feet of very hard, compact, grayish or white limestone in 3 layers separated by fire clay. Underlies Freeport Upper coal and lies higher in section than Freeport (Upper or Butler) sandstone.

The Upper Freeport limestone was not recognized definitely in Morgan County. It should occur near the top of the long covered interval below the Upper Freeport (No. 7) coal in western York Township. In Muskingum County, Stout (1918, pp. 215-216) reports that this member varies from a thin zone of nodular, marly limestone to a hard, compact limestone about 3 feet 6 inches thick. The zone is given an average thickness of 2 feet 6 inches in Muskingum County, and 2 feet in Perry County (fig. 3). A thickness of 2 feet has been assigned to the member in Morgan County.

Upper Freeport Clay Member

Nomenclator: J. J. Stevenson, 1878, (Second Pennsylvania Geological Survey Report K-3).

Original Description: Wilmarth, 1938, p. 2,220.

J. J. Stevenson, 1878. Upper Freeport clay, 2 to 12 feet thick underlies Upper Freeport limestone and is separated from underlying Lower Freeport coal by 25 feet of sandstone and shale. (The 3 to 5 feet of clay separating Upper Freeport coal from underlying Upper Freeport limestone was not given a name in this report, but in subsequent reports the name Upper Freeport has been applied to the clay above and to the clay below the Upper Freeport limestone.)

J. P. Lesley, 1878, (Second Pennsylvania Geological Survey Report Q, pp. 308-316). Upper Freeport fire clay underlies Upper Freeport coal and overlies Upper Freeport limestone.

The Upper Freeport clay was measured in sections 23 and 34, T 14 N, R 14 W, in western York Township, Morgan County. In section 34 the Upper Freeport (No. 7) coal is underlain by

4 feet of poorly exposed gray to dark gray clay shale with some sandy material near the base. In the northwestern corner of section 23 the coal is underlain by about 6 inches of dark gray clay and by 1 foot 6 inches of cross-bedded sandstone, which may be the top portion of the Upper Freeport sandstone, or may represent a more sandy phase of the Upper Freeport clay member. Insufficient outcrop sections are available to establish a reliable correlation. Baird in 1916 measured 2 feet of dark, siliceous clay beneath the Upper Freeport (No. 7) coal in south central section 23. These three measured outcrop sections are shown on Stratigraphic Cross Section A - A' (fig. 5).

The clay member is reported to be 5 feet 2 inches thick in Perry County, and 6 feet thick in Muskingum County (fig. 3). Stout (1918, p. 228) reports that in Muskingum County the clay was used to a limited extent near Zanesville in the manufacture of paving blocks.

Upper Freeport (No. 7) Coal Member

Nomenclator: H. D. Rogers, 1858, (Pennsylvania Geological Survey Volume 2, pt. 1, pp. 474-492).

Original Description: Wilmarth, 1938, pp. 777-778.

H. D. Rogers, 1858. Freeport group, 100 to 250 feet thick, underlies Mahoning massive bed of sandstone and overlies Freeport or contorted sandstone. Includes Upper Freeport coal, Freeport limestone, and Lower Freeport coal.

J. P. Lesley, 1877, (Second Pennsylvania Geological Survey Report H-3, p. xxiii). Lower Productive Coal Measures (Allegheny formation) divided into (descending) Freeport coal group, Kittanning coal group, and Clarion coal group.

I. C. White, also J. P. Lesley, 1878, (Second Pennsylvania Geological Survey Report Q). Freeport group extends from top of Upper Freeport coal to top of Upper Kittanning coal.

G. H. Ashley, 1926, (Pennsylvania Topographic and Geologic Survey Atlas 65, Punxsutawney Quadrangle, pl. 4, p. 28). Freeport formation extends from top of Upper Freeport coal to top of Upper Kittanning coal.

Freeport coal group is treated by United States Geological Survey as an economic member in the upper part of the Allegheny formation, extending from top of Upper Freeport coal down to top of Upper Kittanning coal.

The Upper Freeport (No. 7) coal marks the top boundary of the Allegheny series in Ohio. The coal zone is somewhat erratic in distribution, and varies in composition from a well-developed bituminous coal to a zone of bituminous and cannel coal or to a zone of impure coal and carbonaceous shales. Its thickness ranges from a few inches to approximately 6 feet locally. The thickest interval in the vicinity of Morgan County occurs to the north near Cannelville, in the northern part of Brush Creek Township, Muskingum County, where a section of 2 feet of cannel coal underlain by 4 feet 1 inch of bituminous coal is reported (Stout, 1918, p. 218). The average thickness of the member is reported to be 2 feet 6 inches in Muskingum County, and 1 foot 6 inches in Perry County (fig. 3). In Morgan County the zone consists of 6 inches to 1 foot 6 inches of shaly to bony bituminous coal overlain by as much as 1 foot 6 inches of carbonaceous to coaly clay shale.

The area of outcrop in Morgan County is limited to valley slopes in the western part of York Township (plate I). The thickest section of coal measured is located in the southwestern part of section 34, T 14 N, R 14 W, in the extreme southwestern corner of the township, south of the village of Tropic Station. The section at this location was rather poorly exposed:

York Township; SW$\frac{1}{4}$, section 34, T 14 N, R 14 W. Roadside south of Tropic Station. G. S. O. File No. 8049. Norling and Chapman.

		Ft.	In.
Clay shale, gray, sandy, thin bedded		2	8
Covered		0	11
Clay shale, dark gray to gray, thin bedded; basal part coaly	Upper Freeport coal	1	6
Coal, black, sooty	Upper Freeport coal	0	1
Coal, black, bright, somewhat bony	Upper Freeport coal	1	5
Covered		1	2
Clay shale, dark gray, in part carbonaceous, thin bedded		0	6
Total coal section exposed		3	0

Approximately a mile to the northeast, in section 26, the top clay shale bed is 7 to 8 inches thick, and the coal bed is 9 to 11 inches thick. The cannel coal section present in Muskingum County was not found in Morgan County. In some counties, such as Perry and Tuscarawas, the "Blackband Ore" is developed locally just above the Upper Freeport coal or is part of that zone. No evidence of this ore was found in Morgan County.

Measured sections of the Upper Freeport (No. 7) coal are shown on Stratigraphic Cross Sections A - A', and B - B' (fig. 5). Plate I and figure 21 indicate the area of outcrop of this coal in Morgan County.

The Upper Freeport coal has been mined extensively in Perry, Muskingum, and western Morgan Counties in the Crooksville coal field. Several representative analyses of the coal from nearby mines in Muskingum County are given in Appendix B.

CONEMAUGH SERIES

General

Nomenclator: F. Platt, 1875, (Second Pennsylvania Geological Survey Report H, p. 8).

Original Description: Wilmarth, 1938, p. 503.

F. Platt, 1875. Conemaugh series underlies Pittsburgh coal bed, basal bed of Monongahela series, and overlies Allegheny series, which includes Upper Freeport coal at top. The Conemaugh includes Middle Barren Measures and underlying Mahoning sandstone. (This definition accords with current definition of Conemaugh formation except that the thin clay underlying the Pittsburgh coal has for many years been included in Monongahela formation.)

Named for exposures along Conemaugh River, Pennsylvania.

The present Pennsylvania Geological Survey classifies Conemaugh as a group; the United States Geological Survey classifies it as a formation.

The Conemaugh is considered as a series in this report, in accordance with the National Research Council Committee on Stratigraphy (1944, chart No. 6). The strata included within the series extend from the top of the Upper Freeport (No. 7) coal to the base of the Pittsburgh (No. 8) coal (fig. 3).

The boundaries of the series are based essentially on coal development, and not on prominent changes in life forms, on changes in general lithology, or on regional crustal movements. There is no evidence of regional unconformity anywhere in the Pennsylvanian or lower Permian rock sequence of Ohio. The coals of the Conemaugh are thin and of comparatively little economic importance, whereas those in the underlying Allegheny series and in the overlying Monongahela series are thicker and of great economic value. The Conemaugh is the "Lower Barren Measures" of the old classification of Pennsylvanian rocks.

There is a general two-fold division of the lithology of the rocks in the Conemaugh series of Ohio. The lower half is characterized by gray shales, often sandy; thick sandstones and shaly sandstones; and relatively thin fossiliferous marine limestones. The upper half is characterized by variegated and highly colored shales and clay shales; marly limestones; and thick sequences of dense limestones of questionable non-marine origin.. The upper Conemaugh rocks are more closely allied to those of the Monongahela than to the rocks of the lower Conemaugh.

In the lower half of the series the limestones are thin and contain definite marine fossils. Mark (1912, pp. 261-326) has described the fauna of the Conemaugh. Marine fossils were found in five distinct limestones in the lower part of the Conemaugh. These are, in descending order, Skelley, Ames, Portersville, Cambridge, and Brush Creek limestones. Marine fossils have been found also in the Gaysport limestone, between the Ames and Skelley members, and locally in the Birmingham shale, which overlies the Skelley limestone.

Mark (1912, p. 295) summarized the faunal content of the Conemaugh as follows:

Skelley	10 species
Ames	90 species
Portersville	107 species
Cambridge	74 species
Brush Creek	57 species

The Skelley is the youngest known limestone of definite marine origin in the Pennsylvanian of Ohio.

The limestones of the upper Conemaugh have always been considered non-marine in origin. Condit (1912, p. 15) and Bownocker (1917, p. 61) state: "All..... strata lack forms of undoubted marine origin, their fossils being mostly plant remains and certain minute fossils, such as Spirorbis, ostracods, and gastropods, generally regarded as fresh-water, together with occasional fish, amphibian, and reptilian bones. Insect remains are sometimes found well preserved in the shales." During recent years there has been some question concerning the non-marine environment previously assigned to Spirorbis (personal communication from J. Osborn Fuller quoting Aurele LaRocque of The Ohio State University). The questionably non-marine limestones vary greatly in thickness and continuity within relatively short distances.

The sandstones of the Conemaugh are subject to rapid changes in facies from massive sandstones to shaly sandstones and to sandy shale sequences. In some instances the sandstones are conglomeratic. Many of the sandstones carry abundant accessory minerals, such as feldspar, chlorite, zircon, sericite, muscovite, hornblende, tourmaline, apatite, rutile, magnetite, limonite, and others (Condit, 1912, pp. 250-252). It has been suggested by Condit (1912, p. 250) that "many of the coarse-grained sandstones of the Conemaugh appear to be the result of river deposition."

The shales in the lower part of the Conemaugh are usually some shade of gray or tan. Variegated shales and reddish colored shales and clay shales in thick sequences are characteristic of the upper part of the Conemaugh. These shales and clay shales appear first in thin sections in the Upper Mahoning sandstone interval and in thick bodies at about the position of the

Ewing nodular and conglomeratic limestone, and then extend at intervals upward into the Permian. Associated with these highly colored beds is much concretionary limonite and hematite, which is uncommon in the lower portion of the Conemaugh.

For thoughts concerning regional sedimentation during Conemaugh time the reader is referred to Condit's work, which presents the results of a widespread areal study of the Conemaugh rocks in Ohio (Condit, 1912, pp. 249-260).

Conemaugh rocks crop out in Morgan County in a broad band extending through the western and north central portions of the county with a southwest-northeast trend (plate I). Because of the southeastward dip of the strata, the older rocks are exposed on the western side of the outcrop band. The entire Conemaugh is present in the county in a total thickness of 365 feet (fig. 3, column 8). A total thickness of 377 feet is present in Muskingum County (fig. 3, column 14). The outcrop line of the Ames limestone is shown on the Geologic Map (plate I).

Lower Mahoning Sandstone and Shale Member

Nomenclator: J. P. Lesley, 1856, (Manual of Coal, pp. 94, 97-98).

Original Description: Wilmarth, 1938, pp. 1,269, 2,221.

J. P. Lesley, 1856. Mahoning sandstone - underlies coal F of Barren Measures and overlies the Lower Series, which includes coal E (Upper Freeport) about 50 feet beneath top. The Mahoning consists of two sandstones each 35 feet thick, separated by 25 feet of shale. Rests on 2 to 50 feet of brown and blackish shale.

H. D. Rogers, 1858, (Geology of Pennsylvania Volume 2, pt. 1, pp. 477, 493). Mahoning massive bed of sandstone, 50 to 75 feet thick, underlies Lower Barren Measures and overlies Freeport group. Becomes a true conglomerate along the Mahoning Creeks.

F. Platt, 1876, (Second Pennsylvania Geological Survey Report L). Divided Mahoning sandstone into Upper Mahoning sandstone, 34 feet thick; shale, 25 feet thick; and Lower Mahoning sandstone, 35 to 40 feet thick.

I. C. White, 1878, (Second Pennsylvania Geological Survey Report Q, p. 33). The Mahoning sandstone of Rogers extended from top of Buffalo sandstone to base of Lower Mahoning sandstone. Name here restricted to lower sandstone, which is 40 to 80 feet thick, and consists of (descending) flaggy sandstone, 28 feet; fire clay and argillaceous shale, 35 feet; limestone, 5 feet; shaly sandstone, 10 feet. When massive it is usually a coarse-grained yellowish white rock and frequently contains small pebbles of quartz. The term Mahoning has always been applied to this lower sandstone. The Buffalo sandstone and Mahoning sandstone never merge. Both sandstones are present on Mahoning Creek (Indiana and Jefferson Counties, Pennsylvania). Lies lower than Brush Creek coal and rests on Upper Freeport coal.

W. G. Platt, 1880, (Second Pennsylvania Geological Survey Report H-3). Recognized in Armstrong County, Pennsylvania: 1) Upper Mahoning sandstone, 160 feet thick (which J. P. Lesley on p. 312 proposed to change to Saltsburg sandstone); 2) Middle Mahoning sandstone, 15 feet thick (probably Buffalo sandstone), overlying the Gallitzin coal; and 3) Lower Mahoning sandstone, 20 feet thick, separated by a short interval from underlying Upper Freeport coal.

I. C. White, 1891, (United States Geological Survey Bulletin 65, pp. 95-98). Mahoning sandstone - in places one rock; in other places it subdivides, is complex, and 100 to 150 feet thick, consisting of (descending) Upper Mahoning sandstone, 40 to 50 feet thick; Mahoning coal, 0 to 17 feet; Mahoning limestone, 0 to 20 feet; Upper Cannelton coal, 0 to 5 feet; thin red or variegated shale; Middle Cannelton coal, 0 to 3 feet; thin red or variegated shale; Lower Mahoning sandstone, 30 to 100 feet (generally bluish gray sandstones and shales).

C. Butts, 1906, (United States Geological Survey Bulletin 279, pp. 39-40). For reasons fully stated in Kittanning Folio (No. 115, 1904) writer has decided to apply Mahoning sandstone to only sandstones lying between Upper Freeport and Brush Creek coals, an interval of 70 to 100 feet. This sandstone usually lies at base of Conemaugh formation and closely overlies Upper Freeport coal. It may, however, occupy a higher position and be separated from the coal by a shale bed of variable thickness. (This is definition followed by United States Geological Survey.)

The United States Geological Survey does not use "Upper Mahoning sandstone" and "Lower Mahoning sandstone," but treats the Mahoning as a unit, composed of an upper sandstone, a lower sandstone, and a middle shale. The use of Upper Mahoning sandstone and Lower Mahoning sandstone is especially undesirable because the Buffalo sandstone was called "Upper Mahoning" in early reports.

The terms Lower Mahoning and Upper Mahoning have been established firmly in the geological literature of Ohio. The Lower Mahoning is the basal member of the Conemaugh series, and includes the shale and sandstone section extending from the top of the Upper Freeport (No. 7) coal to the base of the Mahoning limestone (fig. 3). In places where the Mahoning limestone is absent, the sandstone member extends upward into the Thornton clay or to the base of the Mahoning coal. In a few areas it merges with the Upper Mahoning sandstone, thus completely occupying the interval of the Mahoning coal and the Thornton clay.

The Lower Mahoning has a thickness of 37 feet in Morgan County. It varies in lithology from a medium-to coarse-grained, cross-bedded, massive sandstone to a fine-grained, shaly sandstone or to sandy shale. Even in the massive phase, zones of shaly sandstone to sandy shale are present in varying thicknesses. The sandstone is best developed in the northwestern portion of the county, in York Township (fig. 5). . In sections 23 and 34, T 14 N, R 14 W, in this township, there is a basal gray to dark gray shale or clay shale between the massive sandstone and the Upper Freeport (No. 7) coal. In most of the township the sandstone rests on the Upper Freeport coal.

In southwestern Morgan County, a series of sections measured by Bartlett in Union Township show a few feet of sandy shale, which represents the top portion of the Lower Mahoning member, immediately underlying the Mahoning coal or separated from it by 6 inches to 1 foot of Thornton clay (fig. 6).

Mahoning Limestone Member

Nomenclator: I. C. White, 1891, (United States Geological Survey Bulletin 65, pp. 95-98).

Original Description: Wilmarth, 1938, p. 1,269.

I. C. White, 1891. Recognized Mahoning limestone as a bed in the midst of Mahoning sandstone member. (See references under Lower Mahoning sandstone.

The term Mahoning limestone was originally applied to a limestone in the Pottsville series by Rogers in 1858. I. C. White in 1879 renamed this lower Pennsylvanian bed the Upper Mercer limestone. In 1891, White reapplied the term Mahoning to the limestone overlying the lower part of the massive Mahoning sandstone of Pennsylvania. Thus, in Ohio, it is the limestone overlying the Lower Mahoning sandstone and shale member (fig. 3).

The Mahoning limestone is absent or inconspicuous in Morgan County. It was recognized by Bartlett in section 31, T 8 N, R 13 W, Union Township, and described as 2 feet of slightly sandy clay shale with concretionary limestone nodules up to 1 inch in diameter (figures 6 and 14). The limestone member is poorly developed in Muskingum County, but locally in Perry County attains a thickness of 4 feet 6 inches (fig. 3, columns 13 and 14). Stout (1944, p. 206) states that the "Mountain Ore" is associated with the Mahoning limestone, and has been worked locally in Perry and Athens Counties. No evidence of this ferruginous section was observed in Morgan County.

Thornton Clay Member

Nomenclator: I. C. White, 1903, (West Virginia Geological Survey Volume 2, p. 322).

Original Description: Wilmarth, 1938, p. 2,141.

I. C. White, 1903. Thornton fire clay - lies just under Mahoning coal and occasionally replaces it; overlies Mahoning limestone. Thickness 0 to 6 feet. Named for Thornton, Taylor County, West Virginia. (In places he shows 19 feet of fire clay overlying Lower Mahoning sandstone, and calls it Mahoning fire clay.)

The Thornton clay occurs between the Mahoning limestone and the Mahoning coal (fig. 3). As previously mentioned, the clay rests on the Lower Mahoning sandstone and shale member in areas where the limestone member is absent. In areas where the limestone, clay, and the overlying Mahoning coal are not developed, there is a coalescence of the Lower and Upper Mahoning sandstone sections.

In Morgan County the Thornton clay is most easily recognized in Union and York Townships, where the overlying Mahoning coal is developed. In section 6, Union Township, along the western side of the county, the Thornton varies from 6 inches to 1 foot 3 inches of gray to dark gray, subplastic clay or clay shale with abundant plant remains near the contact with the Mahoning coal (figures 6 and 14). In one measured outcrop in this section no clay was present, and the coal rested on sandy shales of the Lower Mahoning sandstone member.

In the northern part of the county in York Township, the Thornton clay is thicker. The following section reveals the maximum thickness:

York Township; NW$\frac{1}{4}$ section 23, T 14 N, R 14 W. G. S. O. File No. 8052. Norling and Chapman.

		Ft.	In.
Coaly clay, weathered.	Mahoning coal	0	11
Clay, red, weathered	Thornton clay	0	1$\frac{1}{2}$
Clay shale, light gray, weathered	Thornton clay	2	5
Covered		11	0

The Thornton is better developed to the north in Muskingum County, where Stout (1918, p. 233) reports from 3 to 10 feet of gray to dark gray, plastic, siliceous clay in Clay and Brush Creek Townships, just north of the Morgan County line.

In general the clay is of inferior quality, and has little value for ceramic purposes.

Mahoning Coal Member

Nomenclator: I. C. White, 1891, (United States Geological Survey Bulletin 65, pp. 95-98).

Original Description: Wilmarth, 1938, p. 1,269.

I. C. White, 1891. See description under Lower Mahoning sandstone member.

The Mahoning coal is thin and poorly developed in Morgan County. It is less than a foot thick in most of the exposures in York and Union Townships, and consists of 6 to 8 inches of coal overlain by a few inches of carbonaceous shales. The coal is rather persistent but thin in southwestern Muskingum County (Stout, 1918, p. 232).

In some areas in sections 23, 26, and 35, T 14 N, R 14 W, York Township, the interval of the coal is occupied by the coalescence of the Upper and Lower Mahoning sandstone members. This is a similar condition to that reported by Stout (1918, p. 232) for northern Muskingum County.

The coal has no economic value in Morgan County. It attains its best development in Columbiana, Carroll, and Jefferson Counties (Condit, 1912, p. 58). It was known as the Brush Creek coal in early geological reports, and has been given the trade names of "Groff" and "Strip Vein."

Upper Mahoning Sandstone and Shale Member

Nomenclator: F. Platt, 1876, (Second Pennsylvania Geological Survey Report L).

Original Description: Wilmarth, 1938, p. 2,221.

F. Platt, 1876. Divided Mahoning sandstone into Upper Mahoning sandstone, 34 feet thick; shale 25 feet thick; and Lower Mahoning sandstone, 35 to 40 feet thick.

(See additional references under Lower Mahoning sandstone and shale member.)

In Ohio, the Upper Mahoning sandstone and shale member occupies the interval between the Mahoning coal and the Mason clay or Mason coal (fig. 3). It is an erratic zone of sandstone development, which varies rapidly from a massive sandstone to shaly sandstone or to a sandy shale sequence. Beds of shale with nodular siderite often are present, especially in the lower part. In some areas the sandstone coalesces with the Lower Mahoning sandstone, thus occupying the position of the Mahoning coal and Thornton clay. In many areas the Mason clay and coal members are absent or inconspicuous; hence, the top boundary of the Upper Mahoning likewise is indefinite. Sandstone and shale development in other areas occupies the entire interval between the Mahoning coal and Brush Creek limestone. Correlation of the several members is made more difficult by the presence of coal beds at different intervals below the base of the Brush Creek limestone. It is difficult to determine the true position of the Mason coal and the top of the Upper Mahoning member.

In Morgan County, lower Conemaugh strata below the Brush Creek limestone crop out in two areas. One of these is in the southwestern and western part of the county in western Homer and Union Townships. The other area is in York Township in the northwestern part of the county.

In the southern area, recognition of the top boundary of the Upper Mahoning sandstone is difficult because of the general absence of the Mason clay and coal. The sandstone and shale development is so discontinuous that demarcation into zones is purely arbitrary. The erratic character of the strata is illustrated on figure 6 . In the massive phase the sandstone is a tan to buff colored, medium-to fine-grained, micaceous sandstone, which often includes siderite nodules and concretions up to 4 or 5 inches in diameter. Many of the sandstone sections contain beds of shaly sandstone and sandy shale. In the shaly phase, the Upper Mahoning member consists of beds of sandy shale with zones of shaly, thin-bedded sandstones, and often contains small nodules of siderite, both in thin layers and disseminated throughout the unit. The presence of these siderite nodules was used by Bartlett in his thesis on Union Township to differentiate the Upper Mahoning sandstones and shales from the shales and sandstones just below the Brush Creek limestone. The writer does not believe that this is a good criterion because siderite nodules and concretions are present in some sandy shales which extend from the Mahoning coal horizon to the base of the Brush Creek limestone. In other measured sections the siderite nodules are not present even in undoubted Upper Mahoning strata. In Homer and Union Townships the Upper Mahoning member is probably from 20 to 28 feet thick.

In the northern area, in York Township, the thickness of the Upper Mahoning member varies from 23 to 30 feet. It is somewhat indefinite because of the thin and non-persistent development of the Mason clay and coal members. In this area the Upper Mahoning is mostly sandy shale or shaly sandstone. Local massive sandstone sections are not so well developed as in the southern area (figures 5, 7, and 12). Siderite nodules have been found locally in shales below and above the Mason coal horizon in this northern area.

Condit (1912, p. 58) states, "The lowest red beds of the Conemaugh appear in the Upper Mahoning a few feet below the Mason coal." This occurrence was noted by the writer in one exposure in section 26, T 10 N, R 13 W, York Township, where 13 feet of chocolate red to gray clay shale occurs just below the Mason clay and coal (fig. 7, section 8053). Similarly colored clay shales were measured in two exposures of the shales underneath the Brush Creek limestone in section 35 in Homer Township (fig. 6, section 7868).

Mason Clay Member

Description: Wilmarth, 1938, p. 1,316. A name applied to the light gray to drab, brown, or pink clay, 1 to 10 feet thick, underlying Mason coal in Ohio.

In the preceding discussion of the Upper Mahoning member, it was pointed out that in many areas in Morgan County the interval of the Mason clay is occupied by sandstones and shales, which extend to the base of the Brush Creek limestone.

In the northern part of the county Mason clay and coal were identified in scattered sections in eastern York Township. The coal section is so impure that it is difficult to demarcate the clay interval. In section 27 at the falls in Big Bottom Run a thin streak of coal is underlain by 4 feet of gray clay shale. In section 23 in a small gully near the headwaters of Big Bottom Run a thin coal rests on 1 foot of dark gray, carbonaceous clay shale. A third interval of Mason clay was measured in sections 25 and 26 in a tributary to Big Bottom Run, where the thin coal is underlain by 1 inch of dark gray clay and 9 inches of gray, slightly sandy clay (fig. 7).

Mason Coal Member

Nomenclator: I. C. White, 1903, (W. Va. Geological Survey, Volume 2, pp. 285-305).

Description: In Ohio, a thin coal bed which occurs from 5 to 20 feet below the Brush Creek limestone.

Mason coal is developed locally in eastern York Township in northwestern Morgan County. The member consists of 2 to 6 inches of blocky to bony coal overlain, in most cases, by 3 to 10 inches of dark gray, carbonaceous to coaly shale. The coal occurs from 6 to 15 feet below the base of the Brush Creek limestone.

In section 20 of Union Township, a coal exposure near the level of Sunday Creek is considered by Bartlett to be the Mahoning coal. The writer believes that this zone of 3 feet of dark shale and bony coal is the Mason member (fig. 6, section 8854). The bed occurs just 14 feet below the base of the Brush Creek limestone, which is too short an interval for the Mahoning coal.

Brush Creek Shale and Sandstone Member

Nomenclators: R. V. Hennen and D. B. Reger, 1913, (West Virginia Geological Survey Report on Marion, Monongalia, and Taylor Counties, p. 309).

Original Description: Wilmarth, 1938, p. 280.

R. V. Hennen and D. B. Reger, 1913. Brush Creek shale - dark gray or black shale, 3 to 10 feet thick, containing marine fossils in upper half and fossil plants in basal part. Underlies Brush Creek limestone and overlies Brush Creek coal.

C. K. Swartz, 1922, (Maryland Geological Survey Volume II, pl. 6). Applied Brush Creek shale to a shale lying a short distance below Brush Creek limestone and resting on Brush Creek coal in Upper Youghiogheny Valley, Maryland.

The Brush Creek shale and sandstone member occupies the interval between the base of the Brush Creek limestone and the top of the Mason coal (fig. 3). In early geological reports on Ohio the Mason coal was one of the beds to which the name Brush Creek coal was applied, as in the original description. The thickness of the Brush Creek shale and sandstone varies from 6 to 14 feet in eastern York Township, Morgan County, where the Mason coal is best developed. In some exposures the member consists of gray to dark gray shales. In most of the area the lithology varies from a sandy shale with small siderite nodules to a shaly, thin-bedded sandstone or to a more massive sandstone phase. Lithologic changes from shale to sandstone are rapid.

In the discussion of the Upper Mahoning sandstone member it was mentioned that the sandstone and shale development in many exposures extends to or nearly to the base of the Brush Creek limestone. In these cases the separation of the beds into Upper Mahoning or Brush Creek members is arbitrary. This condition is particularly prevalent in western and southwestern Morgan County, in western Union and Homer Townships.

Chocolate red shales, previously mentioned in the discussion of the Upper Mahoning sandstone member, comprise most of the interval of the Brush Creek shale and sandstone in section 35 of Homer Township.

Brush Creek Coal Member

In early geological reports in Ohio the term Brush Creek coal was applied to the lower Conemaugh coals now known as Mason and Mahoning. For this reason it is difficult to know from the literature whether or not there is a true Brush Creek coal. The term has been left in the stratigraphic column for Morgan County (fig. 3, columns 7 and 8) because of the presence of black, coaly to carbonaceous shales found immediately below the Brush Creek limestone in one exposure, located in section 24, T 14 N, R 14 W, York Township. These shales may represent the traces of a coal bed, or may be a local phase in the Brush Creek shale and sandstone member.

Brush Creek Limestone Member

Nomenclator: I. C. White, 1878, (Second Pennsylvania Geological Survey Report Q, p. 34).

Original Description: Wilmarth, 1938, p. 280.

> I. C. White, 1878. Brush Creek limestone - frequently seen along Brush Creek, Cranberry Township, Butler County, Pennsylvania, for which it is named. In places it is a black calcareous shale 4 to 5 feet thick; again, it is a very compact limestone 1 to 2 feet thick. Often has a peculiar slaty and arenaceous aspect, and sometimes contains so much iron as to be used as an ore. Underlies Buffalo sandstone from which it is separated by thin shale, and lies 10 to 15 feet above Brush Creek coal.

In the earlier years of geological work in tracing strata from Maryland, Pennsylvania, and West Virginia into Ohio there was considerable difference of opinion as to the correlation of the lower Conemaugh beds. The term Brush Creek was applied variously to the Cambridge limestone, to the true Brush Creek limestone, and to the Mahoning limestone. A large part of this miscorrelation resulted from the lack of knowledge that the well-established Cambridge limestone changed in character and became discontinuous westward in Ohio. As a result, the true Brush Creek was called Cambridge, and the term Brush Creek was applied to the still lower Mahoning limestone. The coals were involved also in the changes in terminology over the years. The regional changes in the lithology of the Brush Creek limestone member added further difficulty to correlations. Some of these difficulties of correlation were discussed by Condit (1912, pp. 49-55).

The Brush Creek member is a persistent limestone in Morgan County. There are two areas of outcrop in the county, one in the western part of Union Township and in the northwestern part of Homer Township, and the other in York, western Bloom, northern Deerfield, and northern Malta Townships. In the Union-Homer Township area the Brush Creek exhibits two types of development. In a number of locations within this area the member consists of two limestones, each from 6 inches to 1 foot 6 inches thick, separated by 4 to 8 feet of shale, clay shale, or sandstone. Other exposures have but the lower limestone bed, from 1 foot to 1 foot 6 inches thick. There is, in these latter exposures, no definite evidence of the former presence of an upper bed. When the sections are posted on a map, there is no apparent pattern to the development for the thin sections are interspersed among the thicker sections. A number of these measured sections are shown on the stratigraphic cross sections.

The lower, more persistent bed is characteristically a gray, somewhat mottled, medium to coarsely crystalline, resistant limestone, which oftens contains numerous small bright to dark green specks of glauconite. Locally the bed may be sandy or somewhat shaly. Crinoid stems are especially numerous, and usually stand out in relief on weathered surfaces. Other fossils are present and, in some exposures, are quite abundant.

The upper limestone bed is often similar in lithology to the lower bed, but varies locally to a more sandy or shaly bed, which is often ferruginous. Glauconite specks are not so plentiful as in the lower bed, and may be absent. The bed is fossiliferous with crinoid stems being most conspicuous. This upper limestone is non-persistent, apparently due to non-deposition.

The section between the two limestone beds varies from a buff to gray, micaceous, slightly sandy to sandy shale or clay shale, often with minute sideritic to limonitic nodules, to a fine-grained, thin-bedded sandstone. Locally the shale sections are calcareous, and may contain fossils similar to those in the limestone beds.

The Brush Creek is the oldest fossiliferous limestone in the Conemaugh in Morgan County. Mark (1912, pp. 262-268, 295) listed 57 species from the member. The fauna is strongly molluscan with 19 species of pelecypods, 16 of gastropods, and 13 of brachiopods. No diagnostic index fossils were designated by Mark. Of the 160 species of fossils collected from the Conemaugh in Ohio only 6 were found exclusively in the Brush Creek member. Of these, one has a restricted geographic distribution, and the other five are too uncommon to be useful in regional stratigraphic work.

The following sections are representative of the exposures of the Brush Creek member in the Union-Homer Township area:

Homer Township; NW$\frac{1}{4}$ section 34, T 7 N, R 13 W. G. S. O. File No. 7844. Norling and Chapman.

		Ft.	In.
Covered.		-	-
Limestone, gray, hard, medium crystalline, fossiliferous	Brush Creek	0	6
Sandstone, tan, medium-grained, micaceous	Brush Creek	0	6
Sandstone, tan, shaly, finely micaceous, thin to platy bedding	Brush Creek	3	6
Limestone, sandy, shaly, somewhat nodular, fossiliferous.	Brush Creek	1	0
Sandstone, tan, very shaly, finely micaceous, thin to platy bedding.		5	6

Homer Township; SW$\frac{1}{4}$ section 30, T 7 N, R 13 W. G. S. O. File No. 7840. Norling and Chapman.

		Ft.	In.
Covered.		-	-
Limestone, gray, sandy, shaly, nodular; replaced locally by sandstone, shaly	Brush Creek	1	0
Covered.	Brush Creek	6	6
Limestone, gray, hard, coarsely crystalline, glauconite specks, fossiliferous	Brush Creek	1	9
Sandstone, shaly, fine-grained, platy		6	0

Union Township, SW$\frac{1}{4}$, SE$\frac{1}{4}$ section 31, T 8 N, R 13 W. G. S. O. File No. 8851. Bartlett.

	Ft.	In.
Sandstone, tan, medium-grained, slightly micaceous, ferruginous, Buffalo	2	8
Clay shale, greenish tan, slightly sandy; siderite concretions near top, Buffalo	3	2

	Ft.	In.
Shale, tan, slightly sandy, thin-bedded; many limonitic specks, Buffalo	6	9
Limestone, gray, shaly, medium crystalline; fossiliferous, Brush Creek (lower)	1	6
Sandstone, gray, shaly, very micaceous, thin bedded	1	0

Union Township; NW¼ section 32, T 8 N, R 13 W. G. S. O. File No. 8852. Bartlett.

		Ft.	In.
Limestone, gray, finely crystalline, hard, fossiliferous	Brush Creek	0	7
Covered	Brush Creek	1	10
Clay shale, tan to brown, slightly sandy, thin bedded; many limonitic specks	Brush Creek	6	2
Limestones, brownish gray at top, pinkish at base, very hard, medium crystalline, fossiliferous	Brush Creek	2	3
Sandstone		2	0

Union Township; S. Cen. section 30, T 8 N, R 13 W. G. S. O. File No. 8853. Bartlett.

		Ft.	In.
Clay shale, tan to gray, slightly sandy, Buffalo		13	0
Limestone, gray to brownish pink, shaly	Brush Creek	0	8
Shale, brown, sandy, thin-bedded	Brush Creek	6	0
Limestone, gray, very hard, medium-crystalline; bright green glauconite specks	Brush Creek	1	11
Shale, greenish tan, slightly sandy, finely micaceous, thin-bedded		1	0
Sandstone, tan to buff, fine-to medium-grained, ferruginous, thin-bedded		4	0

Union Township; SW¼ section 6, T 8 N, R 13 W. G. S. O. File No. 8023. Norling, Chapman, and Bartlett.

	Ft.	In.
Covered	-	-
Shale, gray, sandy, iron-stained, thin to platy bedding; some leaf imprints, Buffalo	5	0
Limestone, medium to coarsely crystalline, gray to grayish tan; scattered glauconite specks; fossiliferous, Brush Creek (lower)	1	4
Interbedded sandstone and shale	25	0

In the northern part of the county the Brush Creek is a thicker limestone bed, and is usually very cherty. It is quite sandy locally. The thickness of the member ranges from 3 feet 6 inches to 14 feet. Some exposures consist of one limestone layer, others have two limestones separated by thinner calcareous shale or sandy shale intervals, often with nodular limestone layers. Fossils are present, but are not so numerous as in the Union-Homer Township area.

The thick, cherty limestone development is present to the east and southeast to the Muskingum River, where thicknesses up to 9 feet were measured in the northernmost part of Malta Township and in sections 16 and 17 of Bloom Township. Two miles north of these last outcrops, the Brush Creek is a series of thin, nodular and sandy limestones with interbedded shales and sandstones, in section 5 in northern Bloom Township, east of the Muskingum River. Some of these measured sections are shown on figure 7.

The following sections, arranged in a west-east order, are representative of the Brush Creek member in northwestern and northern Morgan County:

York Township; NE$\frac{1}{4}$, section 34, T 14 N, R 14 W. Along Ohio Highway 669, east of Tropic Station. G. S. O. File No. 8058. Norling and Trapp.

	Ft.	In.
Sandstone, gray, medium-grained, micaceous.	1	0
Shale and thin-bedded sandstone; and covered, Buffalo . .	3	0
Limestone, gray to tan to pink, finely crystalline to dense, cherty, fossiliferous, Brush Creek.	3	6
Shale, gray, clayey.	6	0

York Township; NE$\frac{1}{4}$ section 35, T 14 N, R 14 W. Along Ohio Highway 669, west of Deavertown. G. S. O. File No. 8055. Norling and Chapman.

		Ft.	In.
Covered.		-	-
Limestone, gray to tan, coarse to medium crystalline, hard, cherty, fossiliferous	Brush Creek	6	3
Shale, sandy, greenish gray, thin-bedded; with irregular layers nodular, cherty limestone	Brush Creek	3	0
Limestone, greenish gray, medium crystalline, in part cherty, in part sandy, slightly nodular; sparsely fossiliferous. . . . . . Note: In other exposures in this section this limestone is hard and cherty as in the upper bed	Brush Creek	4	9
Sandstone		7	11

York Township; W. Cen. section 31, T 10 N, R 13 W. Along road east of Deavertown. G. S. O. File No. 8063. Norling and Chapman.

	Ft.	In.
Shale, tan, sandy, micaceous, thin-bedded, Buffalo . . .	5	0
Limestone, tan to grayish tan, cherty, hard, medium to coarsely crystalline, Brush Creek . . .	7	0
Sandstone, tan, fine-grained, shaly, thin-bedded	2	6

York Township; SE¼ section 22, NE¼ section 27, T 10 N, R 13 W. Big Bottom Run Falls. G. S. O. File No. 8068. Norling and Chapman.

		Ft.	In.
Covered		5	0
Limestone, cherty as below	Brush Creek	1	6
Covered	Brush Creek	4	6
Limestone, gray, fine to medium crystalline, hard, cherty	Brush Creek	1	6
Limestone, gray, fine to medium crystalline, sandy, non-cherty, fossiliferous	Brush Creek	2	6
Shale, calcareous; limestone, gray, cherty	Brush Creek	2	0
Sandstone, gray to tan, fine-to medium-grained		4	0

York Township; NE¼ section 26, W. Cen. section 25, T 10 N, R 13 W. Tributary to Big Bottom Run. G. S. O. File No. 8053. Norling and Chapman.

		Ft.	In.
Covered		2	3
Sandstone, greenish gray, fine-grained, shaly		1	3
Limestone, gray to tan, fine-to medium-crystalline, sandy in part; thin calcareous shale beds; sparsely fossiliferous	Brush Creek	3	10
Shale, gray, calcareous	Brush Creek	0	4
Limestone, gray, medium crystalline, sandy	Brush Creek	0	2
Shale, sandy; plant impressions		12	1

Bloom Township; SE¼ section 5, T 11 N, R 12 W. Ravine east of Ohio Highway 77. G. S. O. File No. 7724. Norling and Chapman.

		Ft.	In.
Shale, bluish gray, very slightly sandy, thin-bedded, micaceous; more sandy toward top, Buffalo		15	0
Limestone, nodular, fossiliferous; weathered	Brush Creek	0	2
Shale, gray, sandy, with nodular limestone	Brush Creek	0	6
Limestone, dark gray, finely crystalline, nodular, fossiliferous	Brush Creek	0	6
Shale, greenish gray, slightly sandy	Brush Creek	1	0
Sandstone, gray to tan, fine-grained, very shaly, with much nodular limestone	Brush Creek	3	0
Limestone, dark gray, finely crystalline, hard, fossiliferous	Brush Creek	0	8
Shale, greenish gray, with limestone nodules	Brush Creek	0	7
Limestone, gray to tan, sandy, nodular, fine-to medium-crystalline; fossiliferous	Brush Creek	0	9

	Ft.	In.
Shale, gray to reddish gray, calcareous	0	6
Shale, bluish gray, slightly sandy, thin-bedded	5	0

The cherty Brush Creek limestone is persistent through southern Clay and Brush Creek Townships in Muskingum County, where the thickness varies from a few inches to 10 feet (Stout, 1918, pp. 234-236). The Brush Creek generally is absent in the northern part of Muskingum County. In the Muskingum Valley in Blue Rock Township, north of the Morgan County line, Stout (1918, p. 235) gives the following section, which is representative of the manner in which the thick, cherty phase of the Brush Creek limestone changes to a series of thin beds:

Muskingum County; Blue Rock Township; central section 29.

573

		Ft.	In.
Clay, gray, siliceous		16	0
Shale, with scattered limestone nodules	Brush Creek	4	6
Limestone	Brush Creek	0	4
Shale	Brush Creek	0	10
Limestone	Brush Creek	0	6
Shale	Brush Creek	0	7
Limestone	Brush Creek	0	3
Shale, gray, soft		1	0

The Brush Creek limestone has been quarried to some extent in the northern part of the county for local use as road material. The abundance of chert, however, makes this limestone a poor material for this purpose.

Buffalo Sandstone and Shale Member

Nomenclator: I. C. White, 1878, (Second Pennsylvania Geological Survey Report Q, p. 33).

Original Description: Wilmarth, 1938, pp. 286-287.

I. C. White, 1878. Buffalo (Upper Mahoning) sandstone - thickness 60 to 80 feet. Underlies Pine Creek limestone and is separated from underlying Brush Creek limestone by 0 to thin layer of shale. Attains maximum development along Buffalo Creek in Buffalo Township, Butler County, Pennsylvania. Was included in Mahoning sandstone of First Survey, but as there is a massive sandstone coming below this, to which the term Mahoning has always been applied, it is clear that one or the other should have a distinct name, for the two rocks are always distinct, and never merge into one mass. Both sandstones occur on Mahoning Creek. The name Mahoning is here restricted to the lower sandstone.

This sandstone is prominent along Big Stillwater Creek in Tuscarawas County, Ohio, and was named Stillwater sandstone by Newberry (1878, Geological Survey of Ohio Volume III, p. 74). This name, however, was dropped in favor of the name Buffalo.

In Ohio, the Buffalo sandstone and shale member occupies the interval between the top of the Brush Creek limestone and the base of the Wilgus coal, or, in the areas where that coal is not developed, the base of the Cambridge limestone (fig. 3). Condit (1912, p. 48) and Stout (1918, p. 236) state that in some areas the Buffalo member extends downward through the Brush Creek interval to coalesce with the Upper Mahoning sandstone. This is not the situation in Morgan County because of the widespread development of the Brush Creek limestone. The base of the Buffalo is considered at the top of the Brush Creek limestone whether that limestone is represented by a single bed or by the expanded double limestone section.

The summit boundary of the Buffalo member in Morgan County, however, is indefinite because of the absence of the Wilgus coal and the local occurrence of the Cambridge limestone. Where these beds are not present, the Buffalo member cannot be separated from the sandstones and shales considerably higher stratigraphically. In some areas there is an almost continuous sandstone and sandy shale development from the top of the Brush Creek limestone to the Ewing limestone or even to the Ames limestone.

In southwestern and western Morgan County, the Cambridge limestone has been recognized in a number of sections. The Buffalo member in this area consists mainly of shales of several types with some zones of sandstone. The shale types are (1) gray to tan, sandy, micaceous, thin-bedded; (2) buff to brown, sandy, thin-bedded, with zones of small siderite nodules; (3) variegated, sandy, clayey; and (4) pink to chocolate brown, with or without sandy content. Zones of sandy clay shale with siderite nodules also are present locally. The interbedded sandstone zones present in some sections are mainly fine-grained and shaly with thin to platy bedding. The thickness of the Buffalo member in this part of Morgan County varies from 19 to 30 feet.

In the central and northern parts of the county, the sandstone development becomes more prominent. Erratic zones of medium-to coarse-grained, micaceous, in part shaly sandstones interbedded with shales are present in thick sequences. In the massive sandstone phases cross-bedding is evident. Some of the sandstone and shale zones contain siderite nodules. Locally, where the Cambridge limestone is present, a thickness of 24 to 35 feet of Buffalo sandstone can be established. Elsewhere the sandstone and shale development continues upward to the Anderson coal and Portersville shale members, or in the absence of these members, even higher to coalesce with the Cow Run sandstone. Farther northward in southern Muskingum County the Buffalo again becomes quite shaly (Stout, 1918, p. 237). In northern Muskingum County the member changes once more to a coarse-grained massive phase.

The erratic lithology of the Buffalo sandstone and shale member is illustrated on the stratigraphic cross sections.

Little economic use has been made of the sandstones of the Buffalo member in Morgan County. The cementing material is argillaceous, which permits rapid weathering of the sandstone.

Wilgus Coal Member

Nomenclator: D. D. Condit, 1912, (Geological Survey of Ohio, 4th Series, Bulletin 17, p. 47-48).

Original Description: The best development of the coal is along Symmes Creek Valley in the southern part of Gallia County, and southward across Lawrence, where there are extensive areas underlain by coal 2 feet or more in thickness. The seam is generally known as the "limestone" coal, but this name would better be dropped and a geographic term substituted. Wilgus is proposed as appropriate, from the village of that name in Mason Township, Lawrence County, near which the coal is mined at several places for home use.

The position of the Wilgus coal is directly or a few feet below the Cambridge limestone. The presence of the coal in Morgan County has not been established firmly.

Sections of bony coal and carbonaceous shale, about 6 inches to 1 foot thick, found in section 33, T 11 N, R 12 W, Morgan Township, about $2\frac{1}{2}$ miles northwest of McConnelsville (fig. 12), and in section 5, T 11 N, R 12 W, Bloom Township, near the Muskingum County line, may represent the Wilgus coal. In neither instance is the Cambridge limestone present to aid in correlation.

Cambridge Limestone Member

Nomenclator: E. B. Andrews, 1873, (Geological Survey of Ohio Volume I, p. 262).

Original Description: Wilmarth, 1938, p. 322.

E. B. Andrews, 1873. Cambridge limestone - 0 to 2 feet thick, lies in Productive Coal Measures, about 225 feet below Pomeroy coal. Separated from higher Ames limestone by 85 to 90 feet of sandstones and shales.

Adopted as a member of Conemaugh formation for the limestone which in some reports has been called "Upper Cambridge limestone" and "Pine Creek limestone", and Brush Creek limestone member adopted for what in some reports has been called "Lower Cambridge limestone."

Named for exposures near Cambridge, Guernsey County, Ohio.

Condit (1912, pp. 43-44) discusses the early confusion in stratigraphic usage of the terms "Upper Cambridge," "Lower Cambridge," "Pine Creek," and Brush Creek. He further states (op. cit., p. 44), "Although present in every county where geologically due, the Cambridge limestone is very irregular, and is missing in numerous places..... Its general inconspicuous appearance or absence in Morgan, Athens, and other counties to the south has led to the Cambridge limestone being confused with the Brush Creek limestones, which lie 28 to 38 feet lower, and are as a rule much more prominent than the former limestone." The miscorrelation of the Cambridge for the Brush Creek limestone is evident in logs of wells drilled for oil and gas in the Joy area in Homer and Marion Townships.

The Cambridge limestone in Morgan County is developed locally as a thin limestone, gray to dark gray in color, medium to coarsely crystalline, usually shaly and sandy, and nearly always nodular or conglomeratic. The thickness ranges from 6 inches to a zone of 3 feet, with an average of about 1 foot. The member is represented in some areas by nodular limestone streaks or limestone nodules in a clay shale or shale interval. Fossils are present, but usually not in abundance.

The thickest exposures occur in the northern part of the county in sections 22 and 23, T 14 N, R 14 W, York Township, just south of the county line. In this area some 3 feet of dark gray nodular to conglomeratic limestone is exposed along a county road. This outcrop is more fossiliferous than the exposures in western Union Township, and contains numerous fusulinids as well as brachiopods and crinoid stems. Mark (1912, p. 295) lists 74 species from the Cambridge in Ohio. The discontinuous development of the Cambridge in Morgan County is shown on the stratigraphic cross sections (figs. 6, 7, and 12).

Unnamed Shale Member

A shale member between the Cambridge and Bloomfield limestones has been recognized in Muskingum County, and is demarcated on the stratigraphic column for Ohio (fig. 3). This shale interval of 8 to 11 feet was not named by Stout (1918, pp. 242-243) at the time he named and described the Bloomfield limestone. Bartlett (1950) applied the term Wilgus shale to the interval, but did not describe the strata. The writer doubts the wisdom of applying the term Wilgus to these shales, inasmuch as they are separated from the Wilgus coal by the Cambridge limestone. Too many of the Conemaugh members are poorly represented or absent in Morgan County to warrant the application of a new name for these strata.

In southwestern and western Morgan County the strata immediately above the Cambridge limestone consist of gray to tan, slightly sandy to sandy shales, with local development of thin sandstones. In the central and northern parts of the county the interval is occupied by a portion of the erratic sequence of sandstones and shales which extends from the Upper Mahoning member to the Ames limestone.

Bloomfield Limestone Member

Nomenclator: W. Stout, 1918, (Geological Survey of Ohio, 4th Series, Bulletin 21, pp. 242-243).

Original Description: Wilmarth, 1938, p. 213.

W. Stout, 1918. Nodular, hard, dense, non-fossiliferous, light gray limestone, in places stained with iron oxide. Of fresh-water origin. Thickness 0 to $2\frac{1}{2}$ feet. Lies 3 to 9 feet below Anderson coal and 8 feet 8 inches above Cambridge limestone in Muskingum County (Harrison, Blue Rock, Salem, and Highland Townships). Named for exposures west of Bloomfield, Highland Township.

The Bloomfield limestone was not recognized in Morgan County. The position of the member is within a sequence of shales and sandstones.

Anderson Clay Member

Description: Wilmarth, 1938, p. 51. A name applied to clay underlying Anderson coal in Jefferson County, Ohio. Lies in Conemaugh formation, 15 feet 2 inches above Cambridge limestone (see Lamborn, 1930, p. 134).

In Morgan County the Anderson clay is developed subjacent to the Anderson coal in some exposures. In other sections no recognizable clay beds are present. The beds range in thickness from 2 inches to a maximum of 1 foot 6 inches, and consist of gray to tan, subplastic to plastic clays and clay shales, which often are ferruginous. The thickest sections measured occur in the northwestern corner of Union Township. In areas where the underlying strata are sandstones there appears to be no development of recognizable clay.

The Anderson clay has little economic value in Ohio. It is high in fluxing material and is unsuitable for ceramic products. Locally it has been used with shales near Trimble in Athens County for the manufacture of paving brick (Stout, 1918, p. 456).

Anderson Coal Member

Nomenclator: Probably, E. B. Andrews, 1874, (Geological Survey of Ohio, Volume II, p. 539).

Description: A coal bed occurring about 12 to 15 feet above the Cambridge limestone in the Conemaugh.

Named for the owner of a coal "bank" in vicinity of Lore City, Guernsey County, Ohio (Lamborn, 1930, p. 134).

The Anderson coal in Morgan County varies from a few inches of coaly shale to a zone of 3 feet in thickness. Good coal beds are sporadic in development. In northwestern Union and southwestern Deerfield Townships the coal bed is 6 to 9 inches thick with some older reports of thicknesses up to 1 foot 10 inches. The best development of the coal occurs in northeastern Deerfield, eastern York, northwestern Malta, and western Bloom Townships. Along the bluffs of the Muskingum River in western Bloom Township the coal is exposed locally in good development:

Bloom Township; $NW\frac{1}{4}$, $SE\frac{1}{4}$ section 16, T 11 N, R 12 W. Ravine east of Ohio Highway 77. G. S. O. File No. 7720. Norling and Chapman.

		Ft.	In.
Sandstone, shaly, gray to greenish gray, fine-to medium-grained, platy-to thin-bedded, Lower Cow Run		8	0
Clay shale, black, thin-bedded; sparsely fossiliferous, Portersville		1	8
Shale, black, sandy, calcareous, fossiliferous, Portersville		0	10
Coal, black, bright, blocky; high in vitrain	Anderson coal	1	6
Shale, dark gray to black, carbonaceous to coaly	Anderson coal	0	4
Clay shale, gray, thin-bedded, Anderson clay		0	8

A zone of 3 feet of bright, blocky to bony coal and black shale underlain and overlain by massive, cliff-forming sandstones, in the Big Bottom Run Valley in eastern York Township, sections 25 and 26, T 10 N, R 13 W, may represent both the Portersville and Anderson members.

The Anderson is overlain locally by the Portersville calcareous, fossiliferous shales, which aid in identification. In other areas the Cow Run sandstone development starts just above the coal. The coal occurs from 7 to 19 feet above the Cambridge limestone, and from 31 to 53 feet above the base of the Brush Creek limestone. The coal was called "Patriot" by Lovejoy (1888, p. 634 ff.), and is known as the "Norwich" coal in Muskingum County.

Local mining of the Anderson coal is done in areas where the coal is a foot or more in thickness. In former years some areas were mined by stripping. The coal is high in ash and sulphur content, and has a relatively low heating value. The coal has been used mainly on local farms. Stout (1918, pp. 243-247) reports that the Anderson coal has been mined by stripping and in local drifts in the southern part of Muskingum County.

Portersville Shale and Limestone Member

Nomenclator: D. D. Condit, 1912,(Geological Survey of Ohio, 4th Series, Bulletin 17, pp. 41-42).

Original Description: From 12 to 30 feet above the Cambridge limestone is another fossiliferous horizon which is seldom more than a calcareous or pyritous shale, forming the roof of the Anderson coal. The name Portersville is chosen for this bed from the village of that name near the eastern edge of Perry County.

The type locality of the Portersville shale is located just west of the county line along the west central part of Deerfield Township. The member is recognized in almost every exposure in Morgan County where the Anderson coal is present. The strata consist of 3 to 5 feet of black, fissile, calcareous shale, with varying amounts of pyrite and abundant minute marine fossils. The pyrite is especially concentrated along the contact with the underlying coal, where the basal layers may be solid masses of pyritized fossils. In some areas in the county the member contains nodules or thin streaks of fossiliferous limestone. In one exposure in section 31 in Deerfield Township, the Portersville is represented by red clay shale.

Mark (1912, p. 295 ff.) lists 107 species of marine fossils from the Portersville. The fauna is the most strongly molluscan assemblage of the Conemaugh. The abundance of minute gastropods and pelecypods distinguishes the member from all other marine units in the series.. The gastropod and pelecypod assemblage contains both minute and dwarf forms. The brachiopods, however, are of ordinary size, though the forms present are small (Mark, op. cit.,pp. 281-282).

Cow Run Sandstone and Shale Member

Nomenclator: Unknown.

Description: Wilmarth, 1938, p. 535.

J. J. Stevenson, 1906, (Geological Society of America Bulletin, Volume 17, p. 154). Cow Run sandstone, 0 to 40 feet thick is equivalent to "Saltsburg" sandstone of West Virginia drillers.

D. D. Condit, 1912, (Geological Survey of Ohio, 4th Series, Bulletin 17, p. 39). Cow Run sandstone, 20 to 25 feet thick, consists of massive-to thin-bedded and shaly sandstone. Underlies Ewing limestone and overlies Portersville fossiliferous horizon. Named for stream in eastern Washington County, Ohio. Drillers apply name to almost any shallow sand, hence it is rather indefinite.

The name Cow Run has been applied to almost any massive sandstone in the middle portion of the Conemaugh series. The member, as defined by Condit, and as adopted by the Geological Survey of Ohio, includes an erratic sequence of sandstones and shales between the Portersville shale and the Ewing limestone (fig. 3). These latter two units are not developed in many areas; hence, the boundaries of the Cow Run member usually are indefinite.

The Cow Run has an established thickness of 30 feet in Morgan County. The following sections in different parts of the county give the thickness of the member in exposures in which both the superjacent Ewing limestone and the underlying Portersville shale are present:

Bloom Township; section 5, T 11 N, R 12 W. Along bluffs east of Muskingum River. Condit, 1912, p. 135.

10379

	Ft.	In.
Limestone, conglomeratic and impure in places; many minute fossils and fish bones, Ewing	2	0
Sandstone, coarse-grained, massive, with a conglomeratic base, Cow Run.	30	0
Shale, carbonaceous, with marine fossils preserved as pyrite, Portersville	3	0
Coal, Anderson	2	0

Union Township; SW$\frac{1}{4}$ section 6, T 8 N, R 13 W. Hillside southeast of Road Junction 838. G. S. O. File No. 8024. Norling, Chapman, and Bartlett.

	Ft.	In.
Limestone, reddish gray, mottled, slightly conglomeratic, Ewing	1	1
Sandstone, shaly, greenish gray, bedding 1 to 3 inches; and shale, sandy, greenish gray to tan, thin-bedded, Cow Run	27	7
Clay shale, chocolate, thin-bedded	3	3
Shale, black; weathered, Portersville	1	9

Few exposures in the county contain both the upper and lower limiting members. Where the Portersville shale is not present, the Cow Run may rest on the Anderson coal. In areas where that coal is not developed the sandstone section may extend downward to coalesce with stratigraphically lower sandstone members. The top boundary of the Cow Run member likewise is indefinite in areas where the Ewing limestone is not developed. In some portions of the county the interval from the top of the Brush Creek limestone to the base of the Harlem coal or the Ames limestone is a sequence of sandstones and shales, which is difficult to subdivide into its various members.

Lithologically the Cow Run varies from a massive sandstone to a series of sandstones and shales or to a sandy shale or clay shale section. The facies changes are rapid. The massive sandstone is usually gray to tan in color, medium-to coarse-grained, locally micaceous and may contain zones of shaly sandstone with bedding from 1 to 4 inches thick. Zones of conglomerate from several inches to several feet in thickness may be present, especially near the base. These conglomerates may consist almost entirely of quartz pebbles, or may be calcareous with nodules of limestone. The Cow Run sandstone usually has abundant accessory minerals. Condit (1912, pp. 251-252) lists the 15 most abundant minerals found in the member. These are listed in part earlier in the present report (page 25).

The Cow Run is developed in a massive, coarse-grained, cross-bedded phase in northern Morgan County, where it forms abrupt bluffs along the Muskingum River and its tributaries. This development extends southward from the county line in an area about 6$\frac{1}{2}$ miles long and about 3$\frac{1}{2}$ miles wide, which includes western Bloom, southeastern York, northeastern Deerfield, and northern Malta Townships. An example of massive sandstone beds developed in a thick sequence, which includes stratigraphically lower Buffalo sandstones, is that measured in Havener's Run in Malta Township, approximately 3 miles northwest of McConnelsville:

Malta Township; SE$\frac{1}{4}$ section 32, T 11 N, R 12 W. Havener's or Gillespie Run. G. S. O. File No. 7888. Norling and Chapman.

		Ft.	In.
Covered		-	-
Sandstone, shaly, gray to bluish gray, medium-to fine-grained; finely micaceous, thin-bedded; more shaly toward top	Cow Run	3	0
Sandstone, tan to grayish tan, fine- to medium-grained, finely micaceous, bedding $\frac{1}{2}$ to 5 inches; some cross-bedding	Cow Run	6	0
Sandstone, gray to tan, coarse-grained, micaceous; some cross-bedding; heavily oil-stained	Cow Run	18	0
Sandstone, tan to grayish tan, medium-grained, finely micaceous, hard, bedding $\frac{1}{2}$ inch to 2 feet; zones of massively bedded, coarse-grained sandstone up to 8 feet thick; some fine, conglomeratic zones	Cow Run	14	0
Clay shale, variegated greenish gray, tan and chocolate red; thin bedded		4	0
Sandstone, gray to tan, medium to coarse-grained, calcareous, cross-bedded; bedding 1 inch to massive 6 to 8 feet. Basal layers conglomeratic and calcareous with pebbles dominantly dense, dark gray limestone up to $1\frac{1}{2}$ inches in length	Buffalo	15	0
Covered	Buffalo	3	0
Sandstone, brown to greenish tan, medium to coarse-grained, micaceous, cross-bedded, iron-stained; thin layers shale, sandy, bluish gray, finely micaceous, especially near the top	Buffalo	3	0
Covered	Buffalo	7	0

The above section is interesting historically as well as stratigraphically, inasmuch as it is the site of the initial horizontal well in Morgan County. This well was drilled in 1937 by the Ohio Levelwell Company under the direction of Leo Ranney (Magbee and Alkire, 1954, pp. 47-50). The original pipe, set in the sandstone face in the oil-stained portion of the sandstone described above, was still in place when the writer visited the area in 1948 and 1949. Nearby upstream is the shaft of the attempt to produce oil commercially by drilling horizontally into the sandstone. Cores from some of the early holes were piled at the site, and were examined by the writer in 1948 and 1949. There was a remarkable variation in grain size in short sections of the cores, as well as marked differences in the amount of oil saturation and staining.

The massive sandstone development in western Bloom and northern Malta Townships loses character rapidly southward and eastward. In a distance of 1 to $1\frac{1}{2}$ miles the section changes to sandy shales and clay shales with only thin zones of sandstone. Exposures measured in sections 16, 21, and 28, Bloom Township, and in sections 34 and 3, Morgan Township, contain relatively little sandstone. Some of the clay shales in these exposures are of the highly colored type which is characteristic of the upper Conemaugh. On the western side of the area of massive sandstone development little sandstone is present in sections 22, 23, and 27, York Township, and in section 10, Deerfield Township.

The Cow Run member in western Deerfield, Union, and Homer Townships contains less massive sandstone beds than present in the north central part of the county. Some exposures consist of massive sandstones, but in most of the area the Cow Run is sandy shale or clay shale with zones of sandstone from 3 to 10 feet thick. The second horizontal drilling project in the Cow Run sandstone is located along Buck Run in section 2, Union Township.

Some of the Cow Run sandstone sections are shown on the stratigraphic cross sections; (figs. 6, 7, and 12).

The Cow Run sandstone in the massive phase was quarried in earlier years, especially in the northern part of the county along the Muskingum River. Stout (1918, p. 249) states that extensive quarrying was done in Harrison Township, Muskingum County, and that stone was shipped by boat and rail to local and outside markets. He reports that the chief uses of the quarried stone were for canal locks, bridge piers and abutments, road culverts, building foundations, and retaining walls. Some of the thinner bedded sandstones were quarried for use as flagstone for steps and walls, for caps and sills of buildings, and for chimneys and fireplaces. The Morgan County quarries undoubtedly served the same markets. All of these quarries have been abandoned for years.

Ewing Limestone Member

Nomenclator: E. Orton, 1878, (Geological Survey of Ohio, Volume III, pp. 889-890; p. 897, and plates opposite pp. 889, 900, and 912).

Original Description: Wilmarth, 1938, p. 711.

E. Orton, 1878. Ewing limestone - ferruginous limestone, 5 feet thick, in Coal Measures, about 80 feet above Cambridge limestone (Brush Creek) and 40 feet below Ames limestone. Extends from Sunday Creek Valley southward to Ohio River.

Named for Ewing Site, in Sunday Creek Valley, in Hocking or Perry County.

The Ewing limestone is a non-persistent bed in Morgan County. Stratigraphically it overlies the Cow Run member, and occurs from 6 to 11 feet below the Barton coal and 30 to 40 feet below the Ames limestone. The Ewing is a hard, crystalline limestone in a few exposures, but in most sections it is a ferruginous, nodular to conglomeratic zone, which is often sandy or shaly. Some exposures are shales or clay shales with interbedded thin nodular limestone layers. The Ewing generally is regarded as fresh-water in origin on the basis of the included Spirorbis, ostracods, occasional fish teeth, and the rare small reptilian bones (Mark, 1912, p. 283).

The thickness of the member ranges from 6 inches to a zone of 4 feet 9 inches. In Union Township, exposures in sections 6 and 30 consist of 1 foot 1 inch and 10 inches, respectively, of limestone, fine to medium crystalline, varying in color from bluish black to reddish gray. The limestone in section 6 contains scattered glauconite grains similar to those in the Ames limestone. In all other portions of the county the member is nodular to conglomeratic. In section 32, T 11 N, R 12 W, Malta Township, the zone changes within a half mile from 1 foot 6 inches of clayey shale with siderite nodules and small limestone nodules to 4 feet 9 inches of gray to dark gray, dense, nodular limestone layers separated by calcareous shales. In eastern York and western

Bloom Townships the Ewing is a definite, though non-persistent, bed of sandy conglomeratic limestone varying from 1 foot 6 inches to 3 feet in thickness.

Barton Clay Shale Member

Nomenclator: R. E. Lamborn, 1930, (Geological Survey of Ohio, 4th Series, Bulletin 35, pp. 137-138).

Original Description: Wilmarth, 1938, p. 122.

R. E. Lamborn, 1930. Barton clay, 3 feet 3 inches thick, underlies Barton coal, which in Jefferson County is represented by 2 inches of black, carbonaceous clay.

Named for association with Barton coal.

The Barton clay shale member includes the 6 to 11 feet of section between the Ewing limestone and the Barton coal members, both of which are represented only locally in Morgan County.

The following two exposures in section 32, T 11 N, R 12 W, Malta Township, contain both of the limiting members, and show the varying lithology of the Barton clay shale member within a distance of approximately a half mile:

Malta Township; Cen. $SW\frac{1}{4}$ section 32, T 11 N, R 12 W. Havener's or Gillespie Run. G. S. O. File No. 7908. Norling, Chapman, and Bartlett.

		Ft.	In.
Barton coal zone		3	6
Shale, sandy, tan to greenish gray, thin-bedded; zones of siderite nodules near base; thin sandstone near base	Barton clay shale	1	0
Sandstone, shaly, tan to gray, medium-grained, micaceous	Barton clay shale	0	3
Shale, gray to tan, sandy, thin-bedded, with siderite nodules	Barton clay shale	1	2
Clay shale, tan, nodular; numerous siderite nodules	Barton clay shale	1	0
Shale, dark gray, carbonaceous	Barton clay shale	0	$0\frac{1}{2}$
Clay shale, bluish gray, sandy, thin zones nodular siderite	Barton clay shale	2	2
Ewing limestone zone		4	9

Malta Township; $NW\frac{1}{4}$ section 32, T 11 N, R 12 W. Coopershop Hollow. G. S. O. File No. 7886. Norling and Chapman.

		Ft.	In.
Shale, black, coaly, fissile; and thin streaks coal, Barton coal		1	0
Clay shale, greenish buff, slightly sandy, thin-bedded; leaf imprints; thin coaly streaks near top	Barton clay shale	1	3

		Ft.	In.
Sandstone, shaly, finely micaceous, laminated to thin-bedded, iron stained; more shaly toward top	Barton clay shale	6	6
Shale, sandy, blocky; poorly exposed	Barton clay shale	2	3
Clay, gray to dark gray, semi-plastic, soft; streaks shale, dark gray, carbonaceous, to black, coaly, sooty	Barton clay shale	0	5
Ewing limestone zone		1	6

In some exposed sections the Barton clay shale consists mainly of clay shales with thin layers of small siderite nodules. In others, where the underlying Ewing is not present, the interval contains sandstones or sandy shales which cannot be differentiated from stratigraphically lower beds. In a number of exposures of this portion of the Conemaugh this interval is covered except for thin coaly streaks, which are termed Barton coal.

Barton Coal Member

Nomenclator: P. T. Tyson, ?

Description: Condit, (1912, p. 37) states, "The term Barton, proposed by P. T. Tyson, has priority over Bakerstown, and is regarded as the equivalent of the latter by J. J. Stevenson (1906, Geological Society of America, Volume XVII, p. 156). According to I. C. White,(1903, West Virginia Geological Survey Volume II, p. 265) the Bakerstown coal lies below the Saltzburg sandstone, and 60 to 100 feet below the Ames limestone."

The Barton coal is a thin, discontinuous bed in most of Morgan County. Correlations are difficult because of the thin coal beds or coaly streaks in intervals of dark shales, or within shale or sandstone sections with the coal occurring at variable distances from the base of the Ames limestone. The interval from the Ames limestone to the coal beds or coaly sections ranges from 24 to 39 feet. The writer strongly suspects that the coal sections designated as Barton are not stratigraphically the same, but are local developments of recognizable thin coals in a general coaly or dark carbonaceous shale zone. Such a long carbonaceous to coaly shale section was measured in the northern part of Bloom Township:

Bloom Township; SW$\frac{1}{4}$, SE$\frac{1}{4}$ section 5, T 11 N, R 12 W. Ravine east of Ohio Highway 77. G. S. O. File No. 7724. Norling and Chapman.

		Ft.	In.
Sandstone, very shaly, gray to bluish gray, thin to blocky bedding, Saltsburg		3	0
Clay shale, black, coaly, with basal 3-inch bony to bright coal	Barton coal?	3	0
Clay shale, gray to dark gray, thin-bedded	Barton coal?	1	6
Covered.	Barton coal?	2	6
Clay shale, black, thin-bedded; upper 3 inches coaly.	Barton coal?	6	7

		Ft.	In.
Clay shale, bluish gray, sandy, thin-bedded	Barton coal ? . . .	0	9
Coal, black, bright, blocky . . .	. . .	0	1½
Shale, clayey, dark gray to nearly black.	. . .	1	1
Sandstone, shaly	. . .	0	2
Clay shale, dark gray, carbonaceous	. . .	0	6
Shale, clayey, sandy, gray to dark gray, layers nodular siderite, Cow Run		15	6

The possibilities of miscorrelation in such a section are numerous, especially when the section is poorly exposed or almost entirely covered. Similar long dark shale sections, not as well exposed or as well developed, were measured in section 32, T 11 N, R 12 W, Malta Township, and in sections 31 and 32, T 9 N, R 13 W, Deerfield Township. Other exposures do not show such intervals of dark shale.

Differential compaction does not explain satisfactorily the variable interval between the Ames limestone and the beds designated as Barton coal. Some of the indicated thinner intervals occur where the section between the Ames limestone and the horizon of the Ewing limestone is mainly sandstone, and some of the longer intervals occur where the section is almost all shale or sandy shale. If differential compaction were the main cause of the variable interval, the thinner intervals would be the shale sections.

The best development of the Barton coal zone occurs in Malta Township, where the following strata were measured:

Malta Township, Cen. SE¼ section 32, T 11 N, R 12 W. Havener's or Gillespie Run. G. S. O. File No. 7908. Norling, Chapman, and Bartlett.

		Ft.	In.
Shale, sandy, greenish gray to gray, finely micaceous, thin-bedded; zones elongated nodular siderite. . . .		9	0
Coal, black, bright, blocky to sooty	Barton coal . . .	0	6
Shale, black, soft, coaly to sooty; thin-bedded; some bony, fissile	. . .	0	10
Coal, black, bright, blocky; bony in part.	. . .	0	5
Clay shale, dark gray, thin-bedded; thin coaly streaks; siderite nodules near base .	. . .	1	6
Shale, coaly, sooty to bony . . .	. . .	0	5
Shale, sandy, than to greenish gray, thin-bedded; zones siderite nodules near base; thin sandstone near base, Barton clay shale		1	0

In most of the county the coal bed termed Barton ranges in thickness from ½ inch to 1 foot. The general position of the Barton coal zone is shown on the stratigraphic cross sections (figs. 6, 7, and 12).

Saltsburg Sandstone and Shale Member

Nomenclator: J. J. Stevenson, 1878, (Second Pennsylvania Geological Survey Report K-3, p. 22).

Original Description: Wilmarth, 1938, p. 1,899.

J. J. Stevenson, 1878. Saltsburg sandstone - named for fine exposures along Conemaugh and Loyalhanna Rivers near Saltsburg (Indiana County, Pennsylvania). Thickness 25 and 40 feet. Underlies Berlin (?) (Maynardier (?)) coal in Fayette and Westmoreland Counties, and overlies Platt (?) (Upper Bakerstown (?)) coal. Lies 165 feet above Mahoning sandstone and 100 feet below Morgantown sandstone.

According to United States Geological Survey Folios, also G. H. Ashley, 1908 (Pennsylvania Topographic and Geologic Survey) the Saltsburg sandstone underlies Pittsburgh Reds and lies higher than Cambridge limestone member.

Condit, (1912, p. 37) reported, "Cross-bedded sandstone entirely replaces the clay and shale of the Round Knob horizon at Caldwell, Noble County, and also at numerous places in Harrison, Jefferson, and Carroll Counties. Locally, this rock also has replaced the underlying Barton coal and Ewing limestone, and may have a basal conglomerate made up largely of limestone pebbles. The name Saltzburg has been given to this sandstone by J. J. Stevenson, from Saltzburg in Westmoreland County, Pennsylvania, where it has a thickness of 100 feet."

From Condit's description it would appear that the Saltsburg sandstone and the Round Knob shale are contemporaneous units, or the names are applied to different facies of the same unit. Two ways of spelling the name, Saltsburg and Saltzburg, have appeared in the literature. The former is used in this report in accordance with the usage of the United States Geological Survey (Wilmarth, 1938, p. 1,899), and the Geological Survey of Ohio (Stout, 1947, and this report, (fig. 3). In the Geologic Column of Pennsylvanian Rocks in Ohio (fig. 3) the Saltsburg sandstone and the Round Knob shale are separate units, with the Round Knob superjacent to the Saltsburg. Stout and Lamborn (1924, p. 342) recognized that in Columbiana County the Round Knob shales occupy the same stratigraphic interval as the Saltsburg.

In Morgan County the interval between the Barton and Harlem coals, both of which are discontinuous, is 15 to 20 feet. The Saltsburg is represented in some parts of the county by sandstones or sandy shales, which change facies rapidly, and which may comprise the entire interval or may be present only in the lower half of the interval. In the thicker sandstone sections the rock is medium-to coarse-grained, with local pebbly to conglomeratic zones near the base.. Cross-bedding may be pronounced. Plant fossils are numerous locally, especially along shaly bedding planes near the base. The sandy shale facies often contains zones of elongated siderite nodules.

In some of the measured sections the sandstone phase is overlain by red to chocolate colored shales or clay shales, which may be sandy, and to which the name Round Knob has been applied.

In one area in section 30 of Union Township, the top portion of the Saltsburg is a buff to gray, sandy, ferruginous, micaceous limestone which has a thickness of 6 to 8 feet.

Round Knob Clay Shale Member

Nomenclator: D. D. Condit, 1912, (Geological Survey of Ohio, 4th Series, Bulletin 17, p. 35).

Original Description: Wilmarth, 1938, p. 1, 890.

D. D. Condit, 1912. Round Knob horizon - purple to red clay to deep red even-bedded shale, 34 feet thick designated "Pittsburgh red shale" by I. C. White. In many places entirely replaced by cross-bedded sandstones. The Saltsburg sandstone of Stevenson underlies Harlem coal and overlies Barton coal. A member of the Conemaugh formation.

W. Stout and R. E. Lamborn, 1924, (Geological Survey of Ohio, 4th Series, Bulletin 28, p. 342). Called these beds Round Knob shale member, and gave their thickness as 0 to 80 feet. Normal position is between Harlem and Barton coals, but locally it extends up to Ames limestone and down to Anderson coal. Is usually red, but also gray, yellow, and buff.

Named for Round Knob, a hill in Madison Township, Columbiana County, Ohio.

As discussed under the preceding member, the Round Knob member overlies the Saltsburg sandstone in some areas in Morgan County, and in others, occupies the same interval between the Barton and Harlem coals as does the Saltsburg. The term Round Knob is applied to the shaly phase of this interval where the strata are highly colored, and the term Saltsburg is applied to the sandy phase. Where developed, the Round Knob clay shales are pinkish to red or chocolate red, and often contain thin zones of small siderite nodules.

Harlem Coal and Harlem Shale Members

Nomenclator: Harlem coal - J. J. Newberry ?

Original Description: Harlem coal - Condit (1912, pp. 34-35), states, "The type locality of the Harlem coal is Harlem Springs, Carroll County, Ohio, from which locality it was named by Dr. Newberry. The term Friendsville has been applied to the coal in Maryland; Crinoidal is used in older reports of West Virginia; and in the county reports of Ohio it is designated the No. 7-B coal by J. J. Stevenson.

Condit gives also type section of 2 feet 4 inches of coal separated from the Ames limestone by 12 feet of sandy shale.

The Harlem coal member is difficult to define stratigraphically. Discontinuous thin coals or coaly shales occur at variable intervals below the base of the Ames limestone. The term Harlem has been applied to any recognizable coal or coaly bed from immediately below the Ames to as much as 18 feet below that bed. After correlating the plotted measured sections in which the "Harlem" coal appears, it is certain that there are several distinct coaly intervals, such as are shown in the exposure in Malta Township:

Malta Township; Cen. SE$\frac{1}{4}$ section 32, T 11 N, R 12 W. Havener's or Gillespie Run. G. S. O. File No. 7908. Norling, Chapman, and Bartlett.

			Ft.	In.
Limestone, Ames			1	2
Clay, light gray, soft	coaly (upper)	Harlem shale and Harlem coal	0	2$\frac{1}{2}$
Clay, dark gray to black, carbonaceous to coaly, thin-bedded	coaly (upper)	Harlem shale and Harlem coal	0	0$\frac{1}{2}$
Shale, clayey, dark gray to black, carbonaceous to coaly, thin-bedded	coaly (upper)	Harlem shale and Harlem coal	1	6
Shale, sandy, gray to bluish gray, finely micaceous, thin-bedded, with small elongated siderite nodules		Harlem shale and Harlem coal	3	0
Shale, dark gray to black, carbonaceous, thin-bedded	coaly (middle)	Harlem shale and Harlem coal	0	10
Coal, dull, bony, black	coaly (middle)	Harlem shale and Harlem coal	0	5
Clay shale, dark gray to black, carbonaceous	coaly (middle)	Harlem shale and Harlem coal	0	4
Coal, black, bony	coaly (middle)	Harlem shale and Harlem coal	0	4
Shale, clayey, sandy, hard, micaceous, thin-bedded; more sandy toward base		Harlem shale and Harlem coal	9	0
Sandstone, shaly, tan, fine-grained, irregular bedding $\frac{1}{2}$ to 3 inches; and interbedded shale, sandy with thin zones of siderite, Saltsburg			13	10
Coal, black; and shale, black, carbonaceous, Barton coal			3	8

Another exposure which shows two coaly zones is located in section 23, Deerfield Township:

Deerfield Township; E. Cen. section 23, T 9 N, R 13 W. G. S. O. File No. 7816. Norling and Chapman.

			Ft.	In.
Limestone, hard, gray, medium crystalline		Ames	1	4
Limestone, shaly, sandy, gray, fossiliferous		Ames	0	6
Clay, light gray, soft	coaly (upper)	Harlem shale and Harlem coal	0	0$\frac{1}{2}$
Clay, dark gray, coaly	coaly (upper)	Harlem shale and Harlem coal	0	0$\frac{1}{4}$
Clay, dark gray, carbonaceous	coaly (upper)	Harlem shale and Harlem coal	0	5
Clay, black, coaly, to coal, black, blocky	coaly (upper)	Harlem shale and Harlem coal	0	0$\frac{1}{4}$
Clay shale, medium gray, slightly sandy, thin-bedded		Harlem shale and Harlem coal	1	6
Shale, slightly calcareous, sandy, nodular		Harlem shale and Harlem coal	0	1
Clay shale, as above		Harlem shale and Harlem coal	1	2
Shale, nodular, slightly calcareous		Harlem shale and Harlem coal	0	1
Clay shale, as above		Harlem shale and Harlem coal	3	6
Covered		Harlem shale and Harlem coal	2	0
Clay, black, coaly to carbonaceous	coaly (middle)	Harlem shale and Harlem coal	0	4
Coal, black, bright, blocky; some bony	coaly (middle)	Harlem shale and Harlem coal	0	4

			Ft.	In.
Shale, black, carbonaceous to coaly	coaly (middle)	Harlem shale and Harlem coal	0	1
Shale, coaly, black, soft			0	0½
Shale, black, carbonaceous			0	3
Shale, gray, slightly sandy, thin-bedded			0	8
Covered			-	-

A third coaly zone is evident in some exposures, as in Bloom Township:

Bloom Township; E. Cen. section 5, T 11 N, R 12 W. Ravine east of Ohio Highway 77. G. S. O. File No. 7743. Norling and Chapman.

			Ft.	In.
Limestone, Ames			1	3
Shale, bluish gray, sandy; some nodules finely crystalline limestone in top foot		Harlem shale and Harlem coal	6	0
Shale, dark gray to black, carbonaceous, thin-bedded.			4	0
Coal, black, blocky, in part bony	coaly (lower)		0	6
Shale, black, coaly, thin-bedded			0	1½
Coal, black, blocky			0	2
Shale, black, coaly			0	1
Coal, black, in part bright to blocky			1	0
Shale, black, carbonaceous, thin-bedded			0	6
Covered			-	-

This third or lower coal zone is well exposed also in Morgan Township, along McConnel's Run in McConnelsville:

Morgan Township; SE¼ section 11, T 10 N, R 12 W. McConnel's Run in McConnelsville. G. S. O. File No. 7999. Norling.

			Ft.	In.
Limestone, Ames			1	9
Clay shale, gray to tan gray, thin-bedded		Harlem shale and Harlem coal	0	6
Sandstone, gray, fine-grained, thin-bedded, resistant			0	10
Sandstone, gray, shaly, micaceous, thin-bedded to laminated			4	0
Shale, gray, sandy, thin-bedded			3	0
Shale, dark gray, carbonaceous, fissile	coaly (middle)		0	3
Shale, black, carbonaceous to coaly; bone coal; nodules siderite and ~~marcasite~~			0	6

			Ft.	In.
Clay, dark gray to black, carbonaceous to coaly . . .	coaly (middle)	Harlem shale and Harlem coal	0	3
Clay and clay shale, gray. . .			0	7
Shale, black, coaly, sooty; grades upstream to bony coal			0	3
Clay, gray, soft, slightly sandy			0	2½
Sandstone, gray, fine-grained, slightly shaly.			4	9
Clay shale, gray to dark gray, hard, thin-bedded.	coaly (lower)		0	9½
Clay shale, dark gray, thin-bedded, iron-stained . . .			0	2½
Clay, dark gray to black, coaly; plant fossils.			0	0½
Clay shale, dark gray, slightly carbonaceous . . .			0	2
Clay shale, gray to dark gray, hard, thin-bedded			1	9
Covered			2	0
Barton coal probably 8 to 10 feet lower			-	-

In a number of exposures throughout central, northern, and western Morgan County discontinuous coal beds are found at each of the above indicated zones. The upper zone occurs from 0 to approximately 2 feet below the base of the Ames limestone, and ranges in thickness from a coal blossom to a zone of 1 foot of coal and carbonaceous shale. The middle zone occurs from 4 to 7 feet below the Ames, and ranges in thickness from a thin coal streak to a zone of 2 feet 6 inches of thin coals and shales. The third zone occurs from 9 to 12 feet below the Ames, and ranges in thickness from a thin coal to a zone of 3 feet of coal and shale.

The strata between the coaly zones are variable in character. In some areas dark carbonaceous shales make up most of the intervals; in others the shales are gray, sandy beds. In still other areas sandstones are predominant, and in a few cases such beds are massive and essentially continuous with the stratigraphically lower Saltsburg sandstone.

After study of numerous measured sections in Morgan County which exhibited the above described conditions, it is believed that the term Harlem coal is applied to a recognizable coal bed which may occur at any one of several intervals within a shale or sandstone section below the Ames limestone. In the Geologic Column for Ohio (Stout, 1947, and this report, fig. 3). there is an unnamed shale interval between the Harlem coal and the Ames limestone. It is here suggested that the term Harlem shale be applied to this interval of approximately 15 to 18 feet, and that the Harlem coal be considered a zone within that member. Such application of the term Harlem may have been made by earlier workers; however, the writer has been unable to locate any reference in the literature. The coal bed just beneath the Ames limestone undoubtedly has been named, at least locally, the Ames coal. The writer has included this in the Harlem shale and coal member because of the similarity to the lower beds.

The position of this member and the details of its lithology are illustrated on the stratigraphic cross sections (figs. 6, 7, and 12).

The Harlem coal has been stripped and mined by small drifts for local use. No mines were in operation when the area was studied in 1948 and 1949.

Ames Limestone Member

Nomenclator: E. B. Andrews, 1873, (Geological Survey of Ohio Volume I, pp. 235, 271, 296).

Original Description: Wilmarth, 1938, p. 46.

E. B. Andrews, 1873. Fossiliferous limestone, 1 to 5 feet thick, in Coal Measures of Morgan, Athens, and Gallia Counties, Ohio, about 140 feet below the horizon of Federal Creek or Pomeroy (Pittsburgh No. 8) coal.

Adopted as a member of Conemaugh formation. Replaces "Crinoidal" limestone of early reports.

Named for exposures near Amesville, in Ames Township, Athens County, Ohio.

The Ames limestone is the best stratigraphic marker in the entire Pennsylvanian and Permian rock column in Morgan County. It is almost an "ideal" bed for field use— thin distinct bed overlain and underlain by beds of different lithology, persistent over a wide area, resistant to weathering, lithologically quite constant, abundantly fossiliferous with crinoid stems weathering in relief, fairly constant in color and crystallinity, and with characteristic visible accessory mineral grains (glauconite). The outcrop of the member is shown on the Geologic Map (plate I).

The Ames is situated in about the middle of the Conemaugh series about 100 feet above the Brush Creek limestone, and from 140 to 160 feet below the Pittsburgh (No. 8) coal. It ranges in thickness from 10 inches to a maximum of 3 feet 6 inches, and averages about 1 foot 6 inches. Over much of its outcrop in western and north central Morgan County it retains a characteristic lithology. It is a gray to pinkish gray, hard, medium to coarsely crystalline limestone, usually in a single layer. Marine fossils are present, the most conspicuous of which are abundant crinoid stems, which stand out in relief on weathered surfaces. Bright to dark green grains of glauconite are common in most exposures, and are an aid to identification. Locally the limestone becomes slightly sandy to sandy, or somewhat shaly. In these impure phases the limestone is often ferruginous, and may be nodular in development.

Mark (1912, pp. 295 ff.) lists 90 species of marine fossils from the Ames in Ohio. In addition to the great abundance of crinoid stems, the fauna consists largely of brachiopods. Pelecypods and gastropods are usually scarce. Because of the conspicuous crinoid fragments this limestone was known as the "Crinoidal" in early geological reports. In local areas in the northern part of Morgan County the limestone contains numerous fusulinids. In exposures on Island Run in section 36, T 10 N, R 13 W, Bloom Township, the upper 4 inches of shaly limestone is a fusulinid coquina.

The Ames limestone is locally a chemically pure stone. Condit (1912, p. 31) gives the following analysis of a sample collected at Bishopville, in western Homer Township:

	Percent
Silica	2.95
Alumina	1.60
Ferric oxide	0.71
Calcium carbonate	92.80
Magnesium carbonate	0.82
Total	98.88

In Morgan County the limestone has not been used commercially because of the thinness of the bed.

Unnamed Shale and Sandstone Members

The interval of shale and sandstone between the Ames and Gaysport limestones has not been named in the Geologic Column of Ohio (fig. 3). The base of the member is well established at the top of the Ames limestone, one of the most persistent stratigraphic beds in the Conemaugh in Morgan County. The top boundary, however, is indefinite in many areas because of the absence of the thin Gaysport limestone, or because of the uncertain identification of poorly developed exposures of that bed.

Where the Gaysport member is present, the unnamed shale member ranges in thickness from 16 to 23 feet. The shales vary from gray to tan, micaceous, sandy beds to gray and reddish gray, sandy clay shales. There is a rapid lithologic change to shales with beds of shaly sandstone, and to thick sections of gray to tan, micaceous, shaly sandstones. In a few areas the sandstones are thick-bedded to massive. The thicker sandstones are not developed over wide areas, and, where developed, are usually continuous with stratigraphically higher sandstone beds. Many of the shale sections contain scattered small siderite nodules, and a few exposures contain thin layers of siderite.

In two local areas thin calcareous zones are present. In two exposures in section 5, T 11 N, R 12 W, Bloom Township, thin, nodular, sandy limestone layers occur from 6 feet 6 inches to 8 feet above the top of the Ames limestone. In sections 3 and 10, T 9 N, R 13 W, Deerfield Township, exposures of the shale section contain similar thin, sandy limestone layers from 4 to 8 feet above the Ames limestone. The lithology of these thin beds is distinctly different from that of the Ames, but is similar to that of the Gaysport limestone, which occurs from 10 to 12 feet higher in the geologic section.

Gaysport Limestone Member

Nomenclator: W. Stout, 1918, (Geological Survey of Ohio, 4th Series, Bulletin 21, p. 258).

Original Description: Wilmarth, 1938, p. 808.

W. Stout, 1918. Siliceous limestone or calcareous sandstone. Marine fossils. Thickness 0 to 2½ feet. Lies 20 feet 4 inches below horizon of Duquesne coal and 16 feet 3 inches above Ames. Occurs locally in Muskingum County. Best developed in vicinity of Gaysport, Blue Rock Township, Muskingum County, Ohio.

The Gaysport is a thin, sandy limestone, often nodular, which is discontinuous in Morgan County (figs. 6, 7, and 12). It occurs from 16 to 23 feet above the Ames limestone and approximately 10 to 15 feet below the Skelley limestone, another thin, non-persistent limestone. The Gaysport ranges in thickness from 3 inches to a maximum of 1 foot. The average thickness is about 4 inches. The limestone bed is always sandy and may be shaly. In some areas it is little more than a very calcareous sandstone bed, or a zone of limestone nodules. Marine fossils are present, but usually not in abundance. Brachiopods, crinoid stems, and a limited number of fusulinids were observed.

The Gaysport is best developed in Morgan County in Bloom, western York, and northern Malta Townships. In western Union and Homer Townships it is recognizable in only a few scattered exposures. In northern Bristol Township the member is represented by calcareous sandstone beds.

Duquesne Shale, Clay and Coal Members

The interval between the Gaysport and Skelley limestones is the position of the Duquesne shale, clay, and coal members of the Geologic Column of Ohio (fig. 3). The Duquesne clay and coal members are not present in Morgan County, and have little or no development in the adjoining Perry and Muskingum Counties.

In Morgan County an interval of 7 to 12 feet is established between the Gaysport and Skelley limestones in the limited number of scattered exposures in which both of these non-persistent members are present. The strata consist of two phases— a shale or clay shale phase, and a sandstone phase. The first phase varies from tan to buff colored shales or sandy shales to highly colored clay shales, which also may be sandy. Both the shales and clay shales locally contain small siderite nodules. These highly colored clay shales are usually red to chocolate brown in color, and comprise the bottom part of a thick section of clay shales, which may extend upward in the stratigraphic column for approximately 100 feet. The term "Pittsburgh Reds" was applied to these beds in other areas in early geologic reports. The provincial term "Big Red" has been applied to these beds in some areas. In most of Morgan County the Duquesne shales are tan to buff sandy beds.

The sandstone phase of the Duquesne members varies from a sequence of interbedded sandstones and sandy shales to a more massive sandstone section. The sandstones are usually shaly and micaceous and in thin to platy beds; however, the beds locally may be more massive and resistant.

Skelley Limestone Member

Nomenclator: D. D. Condit, 1912, (Geological Survey of Ohio, 4th Series, Bulletin 17, p. 27).

Original Description: Immediately over the Duquesne coal is a persistent fossiliferous limestone, which is named the Skelley, from exposures at Skelley Station on the Pennsylvania Railroad in Jefferson County, about 10 miles west of Mingo Junction. This bed is 25 to 40 feet above the Ames limestone and occurs nearly everywhere in eastern Ohio, excepting where replaced by massive sandstone.

The Skelley limestone is poorly represented in Morgan County. It is a non-persistent bed of gray to brownish gray, fine-to medium-crystalline limestone, which often is nodular to conglomeratic. Locally it is sandy or shaly. The bed, where present, averages 7 to 8 inches in thickness. It occurs from 7 to 12 feet above the Gaysport limestone and from 25 to 33 feet above the Ames limestone.

Marine fossils are common in most exposures. The presence of abundant crinoid stems in the purer type of limestone development has led to the application of the term "Upper Ames" in some areas. Mark (1912, p. 295) lists 10 species of marine fossils from the Skelley. This bed is regarded as the youngest marine limestone in the Pennsylvanian in Ohio, and as the approximate boundary between the series of dominantly gray shales and sandstones with interbedded marine limestones and thin coals of the lower half of the Conemaugh and the series of highly colored shales with thick sequences of dense limestones of supposed fresh-water origin, which are characteristic of the upper half of the Conemaugh and of the higher Pennsylvanian and Permian strata.

The Skelley limestone often is associated with red to chocolate brown clay shales, although exposures of the thin bed within sandstone and sandy shales also are found in Morgan County.

Birmingham Shale Member

Nomenclator: J. J. Stevenson, 1876, (Second Pennsylvania Geological Survey Report K, p. 79).

Original Description: Wilmarth, 1938, p. 193.

J. J. Stevenson, 1876. Birmingham shale - a dark thinly laminated shale nearly 50 feet thick, which occurs below Morgantown sandstone at Pittsburgh. Joints pass through the mass. Outcrops at Birmingham Station (just west of Pittsburgh).

P. E. Raymond, 1909, (Science, n. s., Volume 29, pp. 940-941). Base of Birmingham shale, of Conemaugh series of western Pennsylvania, lies 25 feet above top of Ames limestone.

E. W. Shaw and M. J. Munn, 1911, (United States Geological Survey, Burgettstown-Carnegie Folio, No. 177, p. 4). Birmingham shale member of Conemaugh, overlies Berlin coal and extends up to Elk Lick coal (or Elk Lick clay where present). Consists of shale, sandy shale and some sandstone. Thickness 50 to 60 feet.

The Birmingham shale is shown on the Geologic Column of Ohio (fig. 3) as the interval between the Skelley limestone and the Elk Lick members. Inasmuch as the latter members are not represented over much of Ohio, the Birmingham usually includes all strata between the Skelley limestone and the Morgantown sandstone. However, in many areas there is a development of thick sandstones throughout the interval from the Gaysport limestone, or the Ames limestone, to the top of the Morgantown sandstone, or even stratigraphically higher. This condition is not peculiar to Morgan County for similar situations were discussed by Stout (1918, p. 260) in Muskingum County, and by Condit (1912, pp. 25-58) on a regional basis. Thus, the stratigraphic position of the Birmingham shale member is indefinite. The shale probably was deposited in some areas contemporaneously with sandstone deposition in other areas. In Morgan County there is no definite evidence of the removal of the Birmingham shales by pre-Morgantown erosion.

In Morgan County in the limited areas where the underlying Skelley limestone is present the Birmingham consists of 10 to 18 feet of variegated gray to chocolate brown clay shale and shale, which is partly sandy and which, in some cases, contains small siderite nodules. The soft clay shales generally are poorly exposed. In most of the county where the Skelley is absent, the basal boundary of the Birmingham member is indefinite. The member consists essentially of shales and clay shales in the southwestern portion of the county, in Homer and Union Townships. In the northern part of the county the interval is occupied by gray to tan, fine-to medium-grained, shaly, thin-bedded sandstone, which is a part of the long sequence of sandstones mentioned above.

Mark (1912, pp. 291-293) reported that marine fossils were found in the Birmingham shale at Bishopville in western Homer Township, as well as in localities in Muskingum and Jefferson

Counties. It was from the latter area that the notable collection of fossil cockroaches was described in 1906 by Scudder and Handlirsch (Condit, 1912).

Elk Lick Shale and Limestone, and Elk Lick Coal Members

Nomenclator: Elk Lick limestone - F. Platt, 1877, (Second Pennsylvania Geological Survey Report H-3, p. 60).

Original Description: Wilmarth, 1938, p. 671.

Elk Lick limestone: -

F. Platt, 1877. Elk Lick (Upper Berlin) limestone, 6 to 12 feet thick, underlies Elk Lick coal in Somerset County Pennsylvania, and lies 210 to 220 feet below Pittsburgh coal.

I. C. White, 1891, (United States Geological Survey Bulletin 65, p. 90). Elk Lick limestone - light gray limestone, often tinged with buff. Thickness 0 to 12 feet. Lies a short distance below Elk Lick coal, from which it derives its name.

The Elk Lick members are not recognized over much of Ohio. In Morgan County the interval is occupied by sandstones, sandy shales, and red clay shales similar to those previously described under the Birmingham member, and for practical purposes are included within the Morgantown member.

In one exposure in section 22, Homer Township, there is an alternation of thin sandstones and thin sandy and shaly limestones, which occurs 49 feet above the Ames limestone and 29 feet above the Gaysport limestone. The thin layers of limestone occur in the middle of an exposure 3 feet 6 inches in thickness, which is overlain and underlain by covered intervals. The limestones could represent the Elk Lick limestone, or a calcareous phase in the bottom part of the Morgantown sandstone.

Morgantown Sandstone and Shale Member

Nomenclator: J. J. Stevenson, 1876, (Second Pennsylvania Geological Survey Report K).

Original Description: Wilmarth, 1938, p. 1,421.

J. J. Stevenson, 1876. Morgantown sandstone - named for Morgantown, West Virginia. Lies 140 to 160 feet below Pittsburgh coal, and 25 to 38 feet above Crinoidal (Ames) limestone. Thickness 30 to 70 feet.

W. G. Platt, 1878, (Second Pennsylvania Geological Survey Report H-4). Morgantown sandstone, 40 to 50 feet thick, overlies Elk Lick coal, and consists of an upper and a lower sandstone, each 10 to 15 feet thick, separated by 7 feet of red shale.

In his report on the Conemaugh in Ohio Condit (1912) wrote of the regional aspects of the Morgantown sandstone as follows: "Like all of the sandstones of the Conemaugh, this bed is very irregular in its occurrence, being conspicuous in one place and entirely wanting a short distance away. The rock varies from a fine grained, bluish gray freestone..... to a coarse grained, massive, yellowish gray bed 30 feet or more in thickness.

"Where present in the massive form, the Morgantown sandstone is seldom separated from the underlying Ames fossiliferous limestone by more than 25 feet of shale, and often the interval is only 10 or 15 feet. Less commonly, the sandstone reaches the Ames horizon and replaces that limestone over limited areas. In such instances there is a basal conglomerate consisting largely of fossiliferous limestone pebbles, intermixed with other material."

The Morgantown member in Morgan County includes the strata from the Birmingham shales to the base of the Clarksburg limestone (fig. 3). The basal boundary is indefinite because of the absence of the Elk Lick members, and the replacement, at least locally, of a portion or all of the Birmingham by sandstone. Because of the discontinuous distribution of the Clarksburg limestone, the Morgantown sandstone cannot be differentiated from the overlying Connellsville sandstone section in much of Morgan County.

The Morgantown member consists of gray to tan, fine-to medium-grained, shaly sandstones over most of the northern portion of the county. Condit (1912, p. 26) aptly stated, "Shaly, thin bedded sandstone is commonly found at the Morgantown horizon in Muskingum and Morgan Counties. This rock controls the extensive flat hilltops so prevalent in York, Deerfield and Bloom Townships of Morgan County." Locally, zones of medium-to coarse-grained, cross-bedded sandstones are developed, and occasionally zones of conglomerate are present. In a few exposures there are basal conglomerates which contain angular fragments of sandstone, limestone, and chert up to 4 or 5 inches in length.

In southwestern Morgan County there are some exposures of thick shaly Morgantown sandstone, but the member is represented usually in Union and Homer Townships by intervals of sandy shales with thin sandstone beds. In some localities in this portion of the county the interval is occupied by portions of the thick "Big Red" sequence of variegated clay shales.

When the limiting Clarksburg and Birmingham members are present, the Morgantown member is 15 to 20 feet thick. In the areas of sandstone development the thickness varies from 15 to 60 feet, depending upon how low stratigraphically the sandstone sequence begins.

The Morgantown sandstones are of little economic value because of the high argillaceous content. A few abandoned small quarries were observed. This rock was used for local farm stone.

Clarksburg Limestone Member

Nomenclator: I. C. White, 1891, (United States Geological Survey Bulletin 65, p. 88).

Original Description: Wilmarth, 1938, p. 453; p. 1,194.

I. C. White, 1891. Clarksburg limestone - upper part rather slaty; beneath this the layers are very compact and come out in rhomboidal blocks; some layers are very ferruginous. Thickess 20 to 30 feet. Directly underlies Little Clarksburg coal and is separated from underlying Morgantown sandstone by 25 to 40 feet of soft shales. Finely exposed in vicinity of Clarksburg (Harrison County), West Virginia, along bed of Elk and West Fork River.

B. L. Miller, 1925, (Pennsylvania Geological Survey, 4th Series, Bulletin M-7, p. 250). Applied name Little Clarksburg limestone to a limestone between Connellsville and Morgantown sandstone members which is position of Clarksburg limestone.

A thin limestone present in scattered localities in central and western Union Township in Morgan County has been correlated as the Clarksburg limestone member. It occurs about midway between the Ames limestone and the Pittsburgh (No. 8) coal. Most of the exposures are isolated limestone streaks within covered intervals. The limestone is buff to brown, sandy, ferruginous, and almost always nodular to conglomeratic. It ranges in thickness from 6 inches to 4 feet, but averages about 1 foot. Isolated exposures just east of McConnelsville in Morgan Township consist of 2 feet 6 inches to 3 feet of dark colored, nodular to conglomeratic limestone. The discontinuous development of the Clarksburg is shown on the stratigraphic cross sections.

Clarksburg Coal Member

The Clarksburg coal is recognized in only one exposure in Morgan County. In section 12, T 10 N, R 12 W, Morgan Township, northeast of McConnelsville, 10 inches of dark, carbonaceous to coaly shale overlies the nodular Clarksburg limestone.

Connellsville Sandstone and Shale Member

Nomenclator: F. Platt, 1876, (Second Pennsylvania Geological Survey Report L).

Original Description: Wilmarth, 1938, p. 507.

F. Platt, 1876. Connellsville sandstone - coarse, gray, diagonally bedded sandstone, 65 feet thick. (Also called Ligonier sandstone on pp. 17, 19, 20). Caps highest hills in Ligonier Valley, southwestern Pennsylvania, and town of Connellsville, Pennsylvania, is built on it. Lies about 25 feet below Pittsburgh limestone and about 40 feet above Pittsburgh (Morgantown ?) sandstone. (The Pittsburgh sandstone is a much younger bed than the Morgantown or Connellsville sandstone. The Morgantown is considerably older than the Connellsville according to generally accepted classifications).

Condit, (1912, p. 24) states, "Only a few feet below the Summerfield limestone (Lower Pittsburgh) there is often found a massive sandstone which was named the Connellsville by J. J. Stevenson, from exposures at Connellsville, Pennsylvania. Massive sandstone is uncommon at the horizon in eastern Ohio and the most easterly occurrence of such rock is in Athens County.. ... In Muskingum, Noble, and Morgan Counties are large areas where there is little besides sandy shale and clay at this horizon."

The Connellsville sandstone is another of the Conemaugh sections which is difficult to place stratigraphically. It occupies the interval between the Clarksburg coal and the Lower Pittsburgh limestone (fig. 3). It has been mentioned previously that the Clarksburg coal and the underlying Clarksburg limestone are known in Morgan County in only a few scattered exposures. In most of the county the base of the Connellsville sandstone member can be placed only approximately.

The top of the member, likewise, is indefinite because of the rapid changes in the character of the Lower Pittsburgh interval. The Connellsville member is mainly gray to tan, micaceous, sandy shales with beds of shaly, thin to platy bedded sandstones. Rapid facies changes occur in this interval so that local areas consist of erratic developments of thick sequences of sandstones separated by sandy shales.

The best development of the Connellsville sandstone occurs in the central part of the county in Malta, Morgan, and southwestern Bloom Townships. In this area fine-to medium-grained, thick-bedded to massive, cross-bedded sandstones are present in cliff-forming thickness ranging from 20 to 40 feet.

In other parts of the county the Connellsville consists mainly of sandy shales. In Homer, Union, and western Malta Townships the interval is occupied locally by the red clay shales of the "Big Red" sequence.

The changing character of the Connellsville is illustrated on the stratigraphic cross sections. In former years local quarrying was done on a small scale.

Lower Pittsburgh Limestone and Shale Member

Nomenclators: F. and W. G. Platt, 1877, (Second Pennsylvania Geological Survey Report H-3, p. 286).

Original Description: Wilmarth, 1938, p. 1,229.

F. and W. G. Platt, 1877. Lower Pittsburg limestone lies lower than Lower Pittsburg coal and higher than Morgantown sandstone.

I. C. White, 1878, (Second Pennsylvania Geological Survey, Report Q). Lower Pittsburg limestone, 5 feet thick in Allegheny County, Pennsylvania. Lies 65 feet below Upper Pittsburg limestone and 70 feet above Morgantown sandstone. It is generally in 2 or 3 layers. Is hard, dark gray in fresh fractures, but weathers dirty yellow.

(See references under Upper Pittsburgh limestone.)

The Lower Pittsburgh limestone was named the Summerfield limestone by Condit (1912, p. 23) for exposures in Noble County, Ohio; and the term was used widely in geological literature of the state. It has been pointed out to the writer (personal communication from Russell A. Brant of the Geological Survey of Ohio, April 8, 1957) that Condit later retracted the term Summerfield in favor of the older term Lower Pittsburgh limestone (1923, United States Geological Survey Bulletin 270, p. 17). The Geological Survey of Ohio recently has abandoned the term Summerfield.

The Lower Pittsburgh limestone is not well represented in Morgan County. It occupies the interval between the Connellsville and Bellaire sandstones (fig. 3). The best exposure in Morgan County is in section 33, T 9 N, R 13 W, Deerfield Township. At this locality there occurs 10 feet of yellowish brown, finely crystalline to dense, nodular limestone with interbedded calcareous shales. The limestone is separated from the overlying Bellaire sandstone by 7 feet 5 inches of sandy clay shales.

In a few other widely separated exposures in the county the Lower Pittsburgh is represented by thin streaks of nodular, finely crystalline limestone, or thin zones of limestone nodules imbedded in clay shales or sandy shales. The thickness of the Lower Pittsburgh member ranges from 2 to 10 feet.

Red clay shales occupy the interval of the Lower Pittsburgh in parts of Homer, Union, and western Malta Townships.

Mark (1912, p. 293) reported the presence of *Spirorbis*, ostracods, fish bones, and fish teeth in the Lower Pittsburgh limestone.

Lower Little Pittsburgh Coal Member

Description: A thin coal or coaly shale streak overlain by the Bellaire sandstone and underlain by the Lower Pittsburgh limestone.

The Lower Little Pittsburgh coal seldom is present in Morgan County. Dark gray to black, carbonaceous to coaly clays or clay shales occur as thin streaks, 1 to 4 inches thick, in four exposures located in sections 26 and 28, southern Malta Township; in section 32, northwestern Penn Township; and in section 28, south central Union Township. These coaly streaks range from 28 to 33 feet below the base of the Pittsburgh (No. 8) coal. The first three exposures are separated from the overlying Bellaire sandstone by shale intervals. The exposure in Union Township is overlain directly by the sandstone. All four exposures are underlain by a calcareous shale or sandy shale phase of the Lower Pittsburgh member.

Bellaire Sandstone and Shale Member

Nomenclator: D. D. Condit, 1912, (Geological Survey of Ohio, 4th Series, Bulletin 17, p. 22).

Original Description: In the eastern part of the state is a massive sandstone immediately beneath the Pittsburgh limestone, which locally is of some value as a building stone. It is also prominent in Pennsylvania, where it has been called the Lower Pittsburgh sandstone. The bed is a coarse-grained, massive rock, 20 feet thick in the vicinity of Bellaire, Belmont County, and the name Bellaire is proposed for it..... The sandstone is in most places less than 10 feet below the Pittsburgh coal, and has a thickness varying from 8 to 15 feet.

The Bellaire sandstone is well represented in Morgan County. It occurs between the Upper and Lower Little Pittsburgh coals when those thin beds are present (fig. 3). In the absence of the non-persistent coaly streaks the Bellaire comprises the interval between the Lower Pittsburgh and the Upper Pittsburgh limestones. The thickness of the Bellaire member ranges from 10 to 20 feet.

The strata consist of tan to buff, fine-to medium-grained, thin to platy bedded sandstone, which varies in the amount of included sandy shales. The Bellaire is exposed from the vicinity of McConnelsville southwestward to the county line. In much of this area the entire member consists of sandstone. In a number of exposures there is a fairly constant interval of 6 to 10 feet of sandy shale or sandy clay shale at the top of the member. In some localities in this portion of the county the Bellaire consists entirely of sandy clay shales, and in a few exposures, of calcareous shales with thin beds of limestone.

North and east of the vicinity of McConnelsville the Bellaire is poorly developed, and may be represented by sandy shales or calcareous shales. In some areas the interval is occupied by limestone beds representing an expanded development of the overlying Upper Pittsburgh limestone.

Upper Little Pittsburgh Clay Shale and Coal Members

In a few scattered localities in Union and Malta Townships in Morgan County there are exposures of thin streaks of coal or coaly shale underlain by thin clay or clay shale beds, between the Bellaire sandstone and shale member and the Upper Pittsburgh limestone member. These beds occur from 11 to 20 feet below the base of the Pittsburgh (No. 8) coal.

In sections 2, 3, 21, and 34 of Union Township the Upper Little Pittsburgh coal is represented by coal or coaly shale from $\frac{1}{2}$ to 3 inches in thickness. Gray to brown clay or clay shale beds below these coaly streaks range in thickness from 6 inches to 1 foot 3 inches, and represent the Upper Little Pittsburgh clay shale member. In section 15 of this township the coal streak was not found above 10 inches of brown sandy clay shale. In section 36, T 9 N, R 13 W, Malta Township, 4 inches of shaly coal is exposed in a limestone and calcareous shale interval.

Upper Pittsburgh Limestone Member

Nomenclator: H. D. Rogers, 1839, (Pennsylvania Geological Survey Third Annual Report, pp. 95-96).

H. D. Rogers, 1858, (Pennsylvania Geological Survey Volume 2, Part 1, pp. 628-635).

Original Description: Wilmarth, 1938, pp. 1,673-1,674; 2,222.

H. D. Rogers, 1858. Pittsburgh limestone is at top of Lower Barren Measures and immediately beneath Pittsburg coal. It consists of blue and black limestone, 25 feet thick, in 6 to 10 layers separated by shale. (As thus defined the term probably included both Upper Pittsburgh limestone member and Lower Pittsburgh limestone member of current classification. In subsequent reports, however, the name has by many geologists been restricted to Upper Pittsburgh limestone member.)

J. J. Stevenson, 1873, (American Philosophical Society Transactions, Volume 15, new series, pp. 20-21). Under term, Pittsburg limestone I include all of the limestone (of "Monongahela River Series") below the Waynesburg coal, although I am aware that it does not rightly cover so much. The total thickness of limestone is about 100 feet in 350 feet of strata. Color varies from light blue to almost black. Most of the strata are quite compact. (This usage of the name has not withstood the test of time.)

F. Platt, 1877, (Second Pennsylvania Geological Survey Report H-3, pp. 88, 100). Pittsburgh limestone group includes Uniontown limestone at top and Redstone limestone at base.

I. C. White, 1878, (Second Pennsylvania Geological Survey Report Q). Upper Pittsburgh limestone - light gray, compact limestone;

breaks with conchoidal fracture; weathered surface almost white; thickness 2 feet. In Allegheny County, Pennsylvania, it lies 65 feet above Lower Pittsburgh limestone, and 20 feet below Pittsburgh coal.

I. C. White, 1891, (United States Geological Survey Bulletin 65, p. 87). Lower Pittsburgh limestone lies a short distance above Connellsville sandstone. It is thicker and more persistent than Upper Pittsburgh limestone. The Little Pittsburgh coal lies a few feet above Lower Pittsburgh limestone, and is overlain by Upper Pittsburgh limestone, 3 to 5 feet thick. Both of these limestones are known under general name of Pittsburgh limestone.

In some United States Geological Survey reports the Upper Pittsburgh limestone member has been called Pittsburgh limestone member, but that usage is no longer followed.

Condit (1912, p. 20) quotes a definition of the Pittsburgh limestone by Rogers in 1839 as follows: "Immediately underlying the Pittsburgh coal seam is a bed of limestone of characteristic appearance, and remarkable for the regularity with which it accompanies the coal. It consists of blue and black limestone, in layers 6 to 10 in number, separated by shale..... The average thickness of the whole stratum is 25 feet."

In Morgan County the black color mentioned in the above descriptions is not evident. Some of the beds are dark gray in color but are not dark enough to be termed black. The unit consists of several limestone layers, interstratified with shale and clay shale, and with some nodular limestone. Condit's (1912, p. 21) description of the limestone in eastern Ohio is apt for the limestone in Morgan County, and is here reproduced as a comprehensive description of the unit:

"The limestone varies widely in lithologic and chemical character. It is usually somewhat dolomitic and has some silica and clayey material. A buff to brownish color is common in the more ferruginous beds, while others show a bluish..... color..... The rock has rarely any trace of crystalline texture and is more often entirely amorphous, and only shows its crystalline character when viewed in thin sections. There is usually considerable variation in even a small area, and individual beds may appear and disappear several times in a mile. There are almost invariably a few fossils present, all of which are minute forms, generally regarded as fresh-water. The most abundant are ostracod carapaces, which are especially plentiful along the bedding planes. Spirorbis anthracosia is locally so abundant that it constitutes the body of the rock. Less commonly, fish teeth and bones are found.

"It is not unusual to find the Pittsburg limestone with a conglomeratic structure. This consists of fragments of limestone cemented in a limestone matrix. Some outcrops show more or less rounded fragments, whereas others are made up of sharply angular pieces, cemented so as to have the appearance of a true breccia. Certain rounded, pebbly conglomerates are termed desiccation conglomerates by Hyde (1908), who regards them as having been formed in lime-mud flats exposed to the sun. The surface on drying became covered with sun cracks. Subsequent submergence, which produced a breaking and rolling into pebbles, is then supposed."

The variations in lithology and thickness of beds within the Upper Pittsburgh limestone, mentioned in the above statement, are evident in Morgan County. The limestone is mainly either bluish gray or tan in color, hard, compact, and dense. Some zones of finely crystalline limestone are found, but the bulk of the limestone is sub-lithographic in visual appearance. Characteristic of the limestone are numerous calcite veins which cut through the rock in all directions. Characteristic also is the white color of the weathered surfaces of the limestone. Most of the strata have a conglomeratic or brecciated appearance, although the rock is so compact that it has a conchoidal type of fracture. Some of the sections of the Upper Pittsburgh are nearly solid bodies of limestone, others are alternations of limestones and calcareous shales in beds of variable thickness, and still others are largely or wholly calcareous shales with varying amounts of nodular limestone. Facies changes are rapid. Some exposures contain sandy beds, both as sandy shales and/or as sandy limestones, and a few sections consist entirely of sandstones.

The Upper Pittsburgh member is widespread in all but the southeastern and northwestern corners of the county. Its position immediately subjacent to or close to the Pittsburgh (No. 8) coal makes the limestone a valuable stratigraphic marker in the location of thin exposures of the coal. The Upper Pittsburgh is generally 15 to 20 feet thick, but varies in limestone development from only a few feet to nearly 40 feet. In some exposures the limestone is separated from the Pittsburgh coal by a few inches or feet of Pittsburgh clay, but in other outcrops the coal rests on the limestone. In a number of localities the main limestone development is separated from the coal by 2 to 10 feet of calcareous shales with beds of nodular limestone.

When the exposures are plotted on a map, there appears to be no definite alignment or order to the several types of development. Outlines drawn around the areas where the limestone is near the Pittsburgh coal, around the areas where shale is at the top of the section, and around the few areas where sandstone is present instead of limestone, show only irregular enclosures of varying sizes. No pattern is apparent.

The Upper Pittsburgh limestone member is shown on a number of the stratigraphic cross sections.

The Upper Pittsburgh has been quarried on a small scale in a number of localities in Morgan County. Most of the rock is crushed for road material, but some is used for agricultural purposes.

Pittsburgh Clay Member

Subjacent to the Pittsburgh (No. 8) coal is a thin zone of clay or clay shale known as the Pittsburgh clay member. The top of this clay marks the top of the Conemaugh series in Ohio, according to the Geologic Column of Pennsylvanian Rocks in Ohio (fig. 3), published by the Geological Survey of Ohio (Stout, 1939 and 1947). The United States Geological Survey (Wilmarth, 1938, p. 503) regards the Pittsburgh clay as the basal member of the Monongahela series.

In Morgan County this clay zone is found beneath the Pittsburgh coal in many localities. Other exposures lack the clay beds. Where present, the clay ranges in thickness from 1 inch to a maximum of 4 feet 6 inches. The average thickness is 7 to 10 inches. The clay is best developed in Union Township, where Bartlett reported its presence in a number of exposures. The thickest body of clay is reported in section 20, Union Township, where Bartlett measured 4 feet 6 inches of gray to grayish brown, sub-plastic clay.

MONONGAHELA SERIES

General

Nomenclator: H. D. Rogers, 1840, (Pennsylvania Geological Survey Fourth Annual Report, p. 150).

Original Description: Wilmarth, 1938, p. 1,400.

H. D. Rogers, 1840. Monongahela series - the Upper Coal Measures. Exposed in valley of Monongahela River. Includes the beds entitled Pittsburgh series in my last annual report, and rests on Allegheny series, the boundary between the two being marked by final outcrop of the shales which are exposed just above Ohio River at Pittsburg.

J. J. Stevenson, 1873, (American Philosophical Society, Transactions, Volume 15, new series, pp. 15-22). Upper Coal Group (Monongahela River Series) extends from top of Waynesburg sandstone to base of the 3 feet of fire clay that underlies Pittsburg coal. (This definition corresponds with current definition of Monongahela formation (the shorter name) except that top of Waynesburg coal has for many years been accepted as top of Monongahela, the succeeding 1 to 15 feet of Cassville shale and overlying Waynesburg sandstone being included in Washington formation.)

The present Pennsylvania Geological Survey classifies the Monongahela as a group; the United States Geological Survey classifies it as a formation.

The Monongahela is considered as a series in this report, in accordance with the National Research Council Committee on Stratigraphy (1944, Chart No. 6). The strata included in the series in Ohio extend from the base of the Pittsburgh (No. 8) coal to the top of the Waynesburg (No. 11) coal (fig. 3). The Monongahela is the uppermost series in the Pennsylvanian system.

As in the case of the Conemaugh, the boundaries of the series are based on coal development, and not on prominent changes in life forms, on changes in general lithology, or on regional crustal movements. There is no evidence of regional unconformity between the strata of the Monongahela series and those of the superjacent Washington series of the Permian system. The Cassville shale and younger beds through the Waynesburg sandstone were included in the Monongahela series in early geological reports. These strata were assigned a Permian age by Fontaine and White (1880) on the basis of the similarity of fossilized plant forms from the Cassville shale to those in strata of Permian age in Russia.

The strata consist of variegated and highly colored shales and clay shales; marly limestones; thick sequences of dense limestones of questionable fresh-water origin; thick sandstones close to the major coals; and a series of coals, some of which are developed in rather thick seams. The clays are thin and impure. Highly colored shales become increasingly prevalent in the upper half of the series. The Monongahela strata are allied closely to those in the upper half of the Conemaugh. No strata of definite marine environment have been recognized in the Monongahela. The limestones are similar in character and faunal content to those in the upper Conemaugh, and have been regarded as of fresh-water origin. The sandstones are subject to rapid lithologic changes from massive sandstones to shale sandstones, and to sandy shale sequences.

The Monongahela is the "Upper Productive Measures" of the old classification of Pennsylvanian rocks. There are 7 rather persistent coals. These coals, in stratigraphic order, are:

Top - Waynesburg (No. 11)
Little Waynesburg (No. 10-A)
Uniontown (No. 10)
Meigs Creek (No. 9)
Fishpot (No. 8-B)
Redstone (Pomeroy) (No. 8-A)
Pittsburgh (No. 8)

Two coals, the Pittsburgh and the Meigs Creek, are well developed over wide areas in the county, and have been exploited commercially by stripping or by drift mining.

Monongahela rocks crop out over the entire county except in York Township in the northwestern corner (plate I). The entire Monongahela is present in the county in a total thickness of 247 feet (fig. 3). In Muskingum County a thickness of 248 feet has been reported (Stout, 1918, p. 266; and this report, fig. 3). The outcrop lines of the Pittsburgh, Meigs Creek, and Waynesburg coals are shown on the Geologic Map (plate I).

Pittsburgh (No. 8) Coal Member

Nomenclator: H. D. Rogers, 1839, (Pennsylvania Geological Survey Third Annual Report, p. 85.)

Original Description: Condit, 1912, p. 19.

H. D. Rogers, 1839. The Pittsburg seam presents itself, exhibiting a noble bed of coal, nine feet in thickness.

The Pittsburgh (No. 8) coal is the basal member of the Monongahela series in Ohio. In early geological reports of the state it was known as the Pomeroy coal (Lovejoy, 1888, pp. 650 ff.) and the Federal Creek or Federal coal (Bownocker, Lord, and Somermeier, 1908, pp. 68-69). The coal has been mined for many years in Pennsylvania, West Virginia, Maryland, and Ohio, and is regarded as the most valuable coal bed in the country. It is reported that the coal was mined in the Pittsburgh, Pennsylvania, area as early as 1760. Condit (1912, p. 19) states that the member was named by H. D. Rogers in 1839. Other workers state that it was named by J. P. Lesley in 1856 (Bartlett, 1950, p. 56).

In Morgan County the member ranges from a thin coal or coaly shale streak to a well-developed bed over 10 feet thick. The outcrop line of the coal is shown on the Geologic Map (plate I). Measured sections show the maximum development in Homer and Marion Townships. In subordinate coal basins in Union Township and in the Meigsville-Bristol Township area the seam has a maximum thickness of 2 feet 3 inches. In the other parts of the county the Pittsburgh coal is a thin streak of coal or coaly shale. Thickness changes are rapid. A pronounced change is evident in south central Homer Township, where the coal averages 8 to 9 feet in thickness in sections 9 and 15, but is absent in the center of section 14, a little more than a half mile away. Some of these changes in the Pittsburgh coal thickness are illustrated on the stratigraphic cross sections (figs. 6 and 8).

In Morgan County the coal has been mined commercially only in Homer and Marion Townships, which comprise a portion of the Federal Creek coal field. This coal field extends southward into Ames, Berne, and Rome Townships of Athens County. Mining in this area has been widespread for many years. The advent of the first railroad in 1885 resulted in large scale mining activity in the area. The coal crops out on the hills and ridges in Homer and Marion Townships, and much of the available minable coal has been removed by stripping. When the area was studied in 1949 one stripping operation and several drift mines were active. The coal sections in this area reveal the development of the two benches of coal which are characteristic of this coal field.

The following three measured sections are typical of the maximum development of the Pittsburgh (No. 8) coal in Morgan County:

Marion Township; SW$\frac{1}{4}$ section 31, T 8 N, R 12 W. G. S. O. File No. 3281. Stout and Morgan.

	Ft.	In.
Shale, gray	5	0

			Ft.	In.
Coal, good, with scattered pyrite nodules near base	Upper Bench	Pittsburgh coal	5	2
Bone shale, hard	Upper Bench	Pittsburgh coal	0	$6\frac{1}{4}$
Coal	Upper Bench	Pittsburgh coal	0	$5\frac{1}{2}$
Clay shale, soft, light		Pittsburgh coal	1	0
Shale, black, coaly	Lower Bench	Pittsburgh coal	0	1
Coal	Lower Bench	Pittsburgh coal	0	$10\frac{1}{2}$
Clay shale	Lower Bench	Pittsburgh coal	0	$0\frac{1}{2}$
Coal	Lower Bench	Pittsburgh coal	2	$5\frac{1}{2}$
Total coal section			10	$7\frac{1}{4}$

Homer Township; E. Cen. section 15, T 7 N, R 13 W. G. S. O.
File No. 7883. Norling.

			Ft.	In.
Shale, sandy, gray to tan, thin-bedded			4	0
Coal, black, bright, blocky; high in vitrain	Upper Bench	Pittsburgh coal	1	8
Shale, black, coaly; and coal, black, bony	Upper Bench	Pittsburgh coal	0	5
Coal, black, bright, blocky; high in vitrain	Upper Bench	Pittsburgh coal	2	6
Clay shale, gray, soft; locally partly dark gray; thin coaly streaks near top		Pittsburgh coal	1	0
Coal	Lower Bench	Pittsburgh coal	3	$9\frac{1}{2}$
Total coal section			9	$4\frac{1}{2}$

Homer Township; Cen. section 29, T 7 N, R 13 W. G. S. O.
File No. 7866. Norling.

			Ft.	In.
Shale, sandy, gray, finely micaceous, thin			10	0
Coal, black, bright, blocky; high in vitrain	Upper Bench	Pittsburgh coal	1	11
Shale, black, sooty; persistent	Upper Bench	Pittsburgh coal	0	$1\frac{1}{2}$
Coal, black, bright, blocky	Upper Bench	Pittsburgh coal	0	7
Shale, black, sooty; non-persistent	Upper Bench	Pittsburgh coal	0	1
Clay, dark gray to nearly black, soft		Pittsburgh coal	1	0
Coal, black, bright, blocky; in caved-in drift	Lower Bench	Pittsburgh coal	3	0
Clay, gray to tan; in caved-in drift			1	0
Total coal section			7	$8\frac{1}{2}$

Upper Pittsburgh Sandstone and Shale Member

Nomenclator: J. J. Stevenson, 1876, (Second Pennsylvania Geological Survey Report K).

Original Description: Wilmarth, 1938, p. 1,674.

J. J. Stevenson, 1876. Upper Pittsburgh sandstone - sandstone or sandy shale, 40 feet thick. Separated from overlying Redstone coal by 0 to 10 feet of limestone, and from underlying Pittsburg coal by 0 to 10 feet of shale.

The Upper Pittsburgh sandstone member occupies the interval between the top of the Pittsburgh (No. 8) coal and the Redstone limestone and shale members (fig. 3). The basal contact in Morgan County is well defined by the wide-spread occurrence of the Pittsburgh coal. The summit contact is indefinite because of the erratic development or absence of the Redstone limestone. In a number of areas the interval from the Pittsburgh coal to the Redstone (Pomeroy) (No. 8-A) coal is occupied by sandstones and sandy shales with no development of limestone. In other areas in the county, where the Redstone coal is missing, the sandstones of the Upper Pittsburgh member merge with those of the Pomeroy sandstone member. This latter situation is pronounced in Marion, southwestern Penn, and southeastern Union Townships, and in scattered localities in the north central part of the county.

The Upper Pittsburgh member in Morgan County is a sandstone and sandy shale sequence which varies considerably in the amount of sandstone present. The sandstone is tan to buff in color, usually fine-to medium-grained, micaceous, and shaly, and occurs in platy beds up to 8 inches in thickness. Locally the sandstone becomes coarser grained, and massive with a decrease in shale content. There is no apparent pattern to the development of the massive sandstone phase. The sandstone phase is usually separated from the Pittsburgh coal by 6 to 10 feet of sandy shales. Locally the basal 2 feet consists of clay shale. In many areas the entire interval of the Upper Pittsburgh member consists of sandy shale.

The thickness of the member, where the Redstone limestone is present, ranges from 8 to 22 feet, and averages 13 feet.

In a few scattered localities there is a thin coaly shale streak from 1 to 4 inches thick, situated from 12 to 19 feet above the base of the Upper Pittsburgh member, and from 12 to 14 feet below the Redstone (No. 8-A) coal. This coaly streak occurs at or near the top of the Upper Pittsburgh sandstone member, and is known as the "Pittsburgh Rider." In these exposures the Redstone limestone is not developed, so the stratigraphic position of the coaly streak is not definite.

The sandstones of the Upper Pittsburgh member are shaly, and are usually too poorly cemented to have commercial value as construction stone.

Redstone Limestone and Shale Member

Nomenclators: F. and W. G. Platt, 1877, (Second Pennsylvania Geological Survey, Report H-3, pp. 55-104; p. 286).

Original Description: Wilmarth, 1938, pp. 1,788-1,789.

F. and W. G. Platt, 1877. Redstone limestone - 8 to 10 feet thick, is basal member of Pittsburg limestone group, and lies 30 feet above Pittsburg coal and below Redstone coal.

I. C. White, 1891, (United States Geological Survey Bulletin 65, pp. 62-63). Redstone limestone - 0 to 20 feet thick, so named because it occurs immediately below Redstone coal, which crops out along Redstone Creek, Fayette County, Pennsylvania.

The Redstone limestone and shale member occupies the interval between the Upper Pittsburgh sandstone and shale member and the Redstone (Pomeroy) (No. 8-A) coal (fig. 3). In Morgan County the Redstone limestone is represented only locally by limestone. The usual exposure consists of calcareous shales, whose boundaries are indefinite. It was mentioned under the preceding member that the interval of the Redstone limestone and shale member is occupied in many areas by the merging Upper Pittsburgh and Pomeroy sandstones. The superjacent Redstone (No. 8-A) coal is present only locally, hence the summit boundary is indefinite in those areas where the Pomeroy sandstone is not well developed, or where that unit is represented by thin limestones and shales.

Where the boundaries of the Redstone limestone and shale member can be determined, a thickness of 10 to 18 feet is indicated. The average thickness is 13 feet.

In the southwestern corner of the county, in section 31 of Homer Township, the Redstone member consists of 14 feet of limestone, and in a nearby exposure in section 26, it consists of 15 feet of limestone and calcareous shales. In a number of scattered localities in the county the Redstone is represented by calcareous shales with thin limestone streaks.

Redstone Clay Member

Description: Wilmarth, 1938, p. 1,789. A name applied to clay underlying Redstone coal in western Pennsylvania and eastern Ohio.

The Redstone clay was recognized in Morgan County in several exposures in Union Township. Bartlett (1950) measured an average of 1 foot of gray to dark gray, semi-plastic clay subjacent to thin sections of the Redstone (Pomeroy) (No. 8-A) coal. In other exposures in this and other townships in the county no definite clay has been found.

Redstone (Pomeroy) (No. 8-A) Coal Member

Nomenclator: H. D. Rogers, 1858, (Pennsylvania Geological Survey, according to Stout, 1918, p. 270).

Description: A thin coal exposed along Redstone Creek in Fayette County, Pennsylvania. Overlies Redstone limestone, and underlies Pomeroy sandstone.

The Redstone coal is of little value in Ohio except in Meigs and Gallia Counties, where it has been mined extensively in the Pomeroy coal field under the name of Pomeroy coal. Regional correlation during early geological work in the state suggested correlation with the Pittsburgh (No. 8) coal. This correlation was used in a number of early geological reports (Lovejoy, 1888). Subsequent work by Condit and other workers revealed a more proper correlation with the Redstone coal (Bownocker, Lord, and Somermeier, 1908, p. 156 ; and Bownocker, 1917, p. 71). This correlation is used at the present time. The term Redstone apparently has priority over Pomeroy.

In Morgan County the Redstone (No. 8-A) coal occurs as a thin streak of coal or coaly shale, 1 to 9 inches thick, situated from 25 to 35 feet above the Pittsburgh (No. 8) coal. Where the Redstone limestone is recognizable, the Redstone (No. 8-A) coal directly overlies that unit or is separated from the limestone by a few inches to a foot of Redstone clay. It is overlain by the sandstones and sandy shales of the Pomeroy sandstone member.

Exposures of the Redstone (No. 8-A) coal occur in six localities in central Union Township and in isolated localities in Homer, Morgan, and Meigsville Townships.

Pomeroy Sandstone Member

Nomenclator: E. Lovejoy, 1888, (Geological Survey of Ohio Volume VI, pp. 630, 631, 635).

Original Description: Wilmarth, 1938, p. 1,695.

E. Lovejoy, 1888. Pomeroy sandstone, 10 to 75 feet thick, overlies Pomeroy coal. Upper part of sandstone is in some areas replaced by red clay. In places sandstone replaces the limestone 45 feet above Pomeroy coal. Included in Upper Coal Measures.

Named for Pomeroy, Meigs County, Ohio.

The nomenclature of this unit has been a problem. The term Pomeroy, proposed by Lovejoy in 1888, has been applied to the sandstone overlying the Pomeroy coal. Hence, in the early geological reports when the Pomeroy coal was considered correlative of the Pittsburgh (No. 8) coal, the term Pomeroy sandstone was applied to the overlying sandstone, which is the Upper Pittsburgh sandstone. With the recognition of the equivalency of the Pomeroy coal and the Redstone (No. 8-A) coal, the term Pomeroy sandstone was applied in its present meaning.

The term Fishpot sandstone, as defined by Lamborn (1930, pp. 29, 32, 181, 234-236), was applied to a sandstone occurring between the Fishpot and Sewickley (Meigs Creek) coals. The probable correlation with the Lower Sewickley sandstone of West Virginia was recognized by Lamborn. Thus the term Fishpot as applied by Lamborn is stratigraphically higher than the Pomeroy sandstone of Lovejoy. However, on the Generalized Section of Rocks of Ohio, published by the Geological Survey of Ohio (Stout, 1939 and 1947), the sandstone above the Redstone (Pomeroy) (No. 8-A) coal is designated as the Fishpot or Pomeroy sandstone. A communication from the Geological Survey of Ohio, dated April 8, 1957, states that the Fishpot sandstone is not correlative with the Pomeroy sandstone, and consequently the term will be abandoned.

In Morgan County, the Pomeroy member is a well-developed sandstone unit in many areas, and a sequence of sandstones and shales in other areas. Sandy shales and variegated red and gray shales occupy part or all of the interval in some localities. Lithologic changes are rapid. The sandstone phase varies from a tan to buff, fine-to medium-grained, micaceous, platy bedded, shaly sandstone to a massive, medium-to coarse-grained, cross-bedded sandstone. The massive phase locally extends upward to coalesce with the stratigraphically higher Lower Sewickley sandstone in the areas where the Fishpot limestone, clay, and coal members are not present. The Pomeroy sandstone coalesces with the Upper Pittsburgh sandstone in the absence of the Redstone coal and limestone members as has been mentioned previously.

When the underlying Redstone (No. 8-A) coal and the overlying Fishpot limestone members are present, the interval of the Pomeroy sandstone ranges from 11 to 30 feet, and averages 18 feet.

Fishpot Limestone and Shale Member

Nomenclator: J. J. Stevenson, 1876, (Second Pennsylvania Geological Survey Report K).

Original Description: Wilmarth, 1938, p. 734.

J. J. Stevenson, 1876. Fishpot limestone - separated from overlying Sewickley coal by 10 feet of sandstone and from underlying Redstone coal by 25 feet of sandstone and sandy shale. Thickness at mouth of Fishpot Run, in southern Washington County, Pennsylvania, 30 feet; at West Virginia line, it is thin.

Also called Sewickley limestone - Wilmarth, 1938, p. 1,962.

F. and W. G. Platt, 1877, (Second Pennsylvania Geological Survey Report H-3, pp. 55-104). Sewickley limestone, 8 to 10 feet thick, is middle member of Pittsburg limestone group, and lies 90 feet above Pittsburg coal. It is lower than Sewickley coal and higher than Redstone coal.

J. J. Stevenson, 1877, (Second Pennsylvania Geological Survey Report K-2). Fishpot or Sewickley limestone, 25 feet thick, lies 30 feet below Sewickley coal and 20 feet above Redstone coal.

I. C. White, 1891, (United States Geological Survey Bulletin 65, pp. 61-62). I have deemed it preferable to apply the name Sewickley limestone to the whole limestone group, which lies between the Sewickley and Redstone coal beds.

The Sewickley limestone of Platt and Stevenson is same as Fishpot limestone member of Monongahela formation, the older name.

The Fishpot limestone and shale member occupies the interval between the Pomeroy sandstone and the Fishpot clay member (fig. 3). The boundaries of the member are indefinite. The basal contact is uncertain where the sandstone and shale development extends upward in thick sections. The Pomeroy sandstone occupies the entire interval of the Fishpot limestone member in three localities in east central Union Township in sections 11, 22, and 23. The limestone member is not recognizable in section 15 of Malta Township and in section 9 of Deerfield Township, where the interval is occupied by red and gray shales which are not particularly calcareous. In all other parts of the county the Fishpot limestone member is recognizable.

The summit boundary of the member is indefinite where the thin Fishpot clay and coal members are absent, and where the overlying Lower Sewickley sandstone is shaly. The Fishpot limestone extends to or near to the base of the Meigs Creek (No. 9) coal in Manchester, Bristol, western Morgan, and northern Meigsville Townships, and in scattered localities in Malta, Penn, and Union Townships. In these areas the Lower Sewickley sandstone is not developed.

The thickness of the Fishpot limestone member ranges from 15 to 33 feet, and averages 21 feet. It consists of an alternation of limestone and calcareous shale layers which vary rapidly in thickness and lateral extent. The limestone is yellowish gray to tan, dense to very finely crystalline, and breaks with a sub-conchoidal fracture. It usually contains an abundance of irregular calcite veins, and is often nodular to conglomeratic or brecciated in appearance. The surface of the outcrops often is covered with nearly flat, irregular fragments which shatter when struck with a hammer. The bedding of the limestone is irregular and ranges in thickness from 1 to 12 inches. Some exposures of massive limestone from 2 to 6 feet are present in some localities. The intervening calcareous shale beds vary in thickness from a few inches to 6 or 10 feet. In a few localities the member consists almost entirely of calcareous shales with but thin irregular beds of limestone.

Fishpot Clay and Fishpot (No. 8-B) Coal Members

The Fishpot clay and coal members occur stratigraphically between the Fishpot limestone and the Lower Sewickley sandstone (fig. 3). The term Fishpot coal is a "name proposed by Wilber Stout for the member in an unpublished report on the Monongahela series" (Bownocker and Dean, 1929, p. 247). The coal member is a persistent bed in Jefferson, Belmont, Harrison, Guernsey, and Nobles Counties, but is thin and inconspicuous in Morgan County.

The Fishpot coal is present as a thin, discontinuous shale to coaly shale streak from $\frac{1}{8}$ to 1 inch thick in scattered exposures in the county. It was recognized in Marion, Homer, Union, Penn, Malta, Meigsville, Bloom, and Bristol Townships, and occurs from 6 to 20 feet below the Meigs Creek coal.

The Fishpot clay is present in only a few of the exposures of the coal. It consists of 2 to 13 inches of dark gray clay or clay shale.

Lower Sewickley Sandstone and Shale Member

The Lower Sewickley sandstone and shale member, as accepted by the Geological Survey of Ohio, occupies the interval between the Fishpot coal and the Meigs Creek (No. 9) coal (fig. 3). The stratigraphic nomenclature of the unit is uncertain. The unit is not recognized as a distinct member by the United States Geological Survey (Wilmarth, 1938), and is the sandstone in the interval designated as Fishpot sandstone by Lamborn (1930). The subsequent application of the term Fishpot sandstone to the Pomeroy sandstone member was discussed under the latter member earlier in this report. In Lamborn's description of his Fishpot sandstone a probable correlation with the Lower Sewickley sandstone of West Virginia was recognized. The writer has not located the original source of this latter term in West Virginia geological literature. The term probably has resulted from the recognition of the position of the Sewickley (No. 9) coal within a long sandstone section, and the application of the terms Lower and Upper to portions of that sandstone below and above the coal, respectively. In the present report the name Lower Sewickley member is used in compliance with the accepted Ohio terminology.

The Lower Sewickley member in Morgan County is a sequence of sandstones and shales, which ranges from 10 to 20 feet in thickness, and which underlies the Meigs Creek (No. 9) coal. There is considerable variation in sandstone content in the exposures which range from sandy shale to massive sandstone sections. The sandstone is gray to tan, fine-to medium-grained, micaceous, and shaly. In the massive phase the grain size becomes coarser, and there is a decrease in shale content. A few conglomeratic zones are found occasionally, especially in the cross-bedded sections.

The member is absent in the northern part of the county, in Manchester, Bristol, western Morgan and northern Meigsville Townships, where the Fishpot limestone development reaches to or nearly to the base of the Meigs Creek coal. Similar conditions occur in small areas in Malta, Penn, and Union Townships. The sandstone section is thin in Bloom and southern Meigsville Townships, and thickens rapidly southward and southwestward. In scattered localities in Homer, Marion, Windsor, Union, Penn, and Malta Townships the Lower Sewickley sandstone coalesces with the Upper Sewickley sandstone to form a single massive section. In the vicinity of Hooksburg in northern Windsor Township the expanded sandstone sections are known as the "Hooksburg" sandstone.

Meigs Creek Clay Shale Member

The Meigs Creek clay and clay shale member is present in Morgan County between the Lower Sewickley sandstone and the Meigs Creek coal in a number of localities. In others, it is either absent or not recognized in the underlying shale sections of the Lower Sewickley sandstone and/or Fishpot limestone members. Where identifiable, it consists of 1 to 5 feet of gray to tan, semi-plastic clay or clay shale. The average thickness of the member is 2 feet.

Meigs Creek (No. 9) Coal Member

Nomenclator: C. N. Brown, 1884, (Geological Survey of Ohio Volume V, p. 1,059).

Original Description: Through Morgan, Noble, southeastern Muskingum, and northwestern Monroe Counties, the most important coal horizon is found about 250 to 260 feet above the Ames or Crinoidal limestone, or about 80 to 100 feet above the horizon of the Pittsburgh coal..... The seam appears to be the Sewickley coal of the Pennsylvanian series. In former reports this coal is known as the Upper Bellaire, Upper Barnesville, or Cumberland coal. The term Cumberland is already occupied as the name of a famous Maryland coal, and it will therefore be dropped, as a confusing synonym, and the coal will be designated the Meigs Creek coal from the name of the stream in Morgan County which drains a central portion of the field.

The Meigs Creek (No. 9) coal occurs between the Lower and Upper Sewickley sandstone members (fig. 3), and is stratigraphically the highest of the important coals in Ohio. It is correlative to the Sewickley coal of Pennsylvania and West Virginia. The occurrence of the coal in Morgan County and adjoining counties was discussed by Brown in 1884. The development of the coal in the several townships in Morgan County was discussed by Bownocker, Lord, and Somermeier in 1908. The coal was mapped in the Cumberland and Caldwell quadrangles by George White in 1947.

The coal has been mined commercially in Morgan County for many years by the drift method and by stripping. Many of the operations have been abandoned, but several large commercial mines and a number of small mines are active at the present time. The area in the vicinity of Reinersville in Manchester Township has been a mining center for over 80 years.

The line of outcrop of the Meigs Creek coal is shown on the Geologic Map (plate I). The measured sections show the development of commercial thicknesses of coal in the eastern part of the county and the consistent lack of development in the western and southern parts. As a generality, it can be said that all of the thick coal development occurs east and north of the Muskingum River.

The plotted coal sections show the variation in thickness from less than 1 inch of coaly shale to a maximum of 8 feet 5 inches of coal with some coaly shale in section 31, Manchester Township. The coal averages about 4 feet 6 inches through Manchester, Center, Meigsville, and eastern Bristol Townships. In some areas the coal is in nearly a solid section; in others, it is in two or three benches separated by shale partings. There is no apparent consistency to the position of the partings.

The following sections are typical of the development of the Meigs Creek coal in the eastern part of the county:

Manchester Township; NW$\frac{1}{4}$ section 31, T 7 N, R 10 W. Felix Angelo Strip Mine; Abandoned 1947. G. S. O. File No. 7944. Norling.

			Ft.	In.
Shale, clayey, sandy, dark gray, thin-bedded			3	0
Shale, black, bony to coaly	Upper Bench	Meigs Creek coal	0	$5\frac{1}{2}$
Coal, black, bright, blocky	Upper Bench	Meigs Creek coal	0	$2\frac{1}{2}$
Shale, clayey, dark gray, thin-bedded	Upper Bench	Meigs Creek coal	0	7
Shale, dark gray to black, coaly	Upper Bench	Meigs Creek coal	0	4
Shale, clayey, dark gray, soft, scattered siderite concretions		Meigs Creek coal	2	0
Shale, black, sooty to coaly	Middle Bench	Meigs Creek coal	0	$0\frac{1}{2}$
Coal, black, bright, blocky	Middle Bench	Meigs Creek coal	0	11
Shale, gray, soft	Middle Bench	Meigs Creek coal	0	$0\frac{1}{4}$
Coal, bony.	Middle Bench	Meigs Creek coal	0	$0\frac{1}{4}$
Shale, gray, soft	Middle Bench	Meigs Creek coal	0	$0\frac{1}{2}$
Coal, black, bony.	Middle Bench	Meigs Creek coal	0	$0\frac{1}{2}$
Shale, dark gray, soft.		Meigs Creek coal	0	11
Shale, black, sooty to coaly	Lower Bench	Meigs Creek coal	0	1
Clay, gray, soft.	Lower Bench	Meigs Creek coal	0	$0\frac{1}{2}$
Shale, black, sooty	Lower Bench	Meigs Creek coal	0	$0\frac{1}{2}$
Coal, black, bony.	Lower Bench	Meigs Creek coal	0	1
Coal, black, bright, blocky	Lower Bench	Meigs Creek coal	1	10
Shale, sooty to bony.	Lower Bench	Meigs Creek coal	0	$0\frac{1}{4}$
Coal, black, bright, blocky	Lower Bench	Meigs Creek coal	0	9
Total coal section.			8	$5\frac{1}{4}$

Meigsville Township; NE$\frac{1}{4}$ section 1, T 10 N, R 11 W. G. S. O. File No. 2942. Stout and Meyers.

		Ft.	In.
Shale, coaly	Meigs Creek coal	0	8
Coal	Meigs Creek coal	0	$6\frac{1}{2}$
Shale	Meigs Creek coal	0	4
Coal	Meigs Creek coal	0	5
Clay shale, dark	Meigs Creek coal	0	10
Coal	Meigs Creek coal	0	$6\frac{1}{2}$
Shale, dark	Meigs Creek coal	0	3
Coal	Meigs Creek coal	2	$0\frac{1}{2}$
Shale, gray, soft	Meigs Creek coal	0	$0\frac{1}{2}$
Coal	Meigs Creek coal	0	3
Shale, bony	Meigs Creek coal	0	$1\frac{1}{2}$
Coal	Meigs Creek coal	1	9
Limestone, Fishpot.		9	6
Total coal section		7	$9\frac{1}{2}$

Center Township; section 4, T 6 N, R 10 W. G. S. O. File No. 7030. George White.

		Ft.	In.
Shale, light gray, clayey to siliceous		1	7
Shale, coaly	Meigs Creek coal	0	2
Shale, dark, carbonaceous	Meigs Creek coal	1	1
Coal, bony	Meigs Creek coal	0	10
Shale, coaly	Meigs Creek coal	1	1
Coal, bright; paper thin shale partings	Meigs Creek coal	2	3
Shale, coaly	Meigs Creek coal	0	3
Coal, bright; somewhat shaly	Meigs Creek coal	1	1
Shale, black, bony	Meigs Creek coal	0	5
Clay shale, sandy, micaceous		5	0
Total coal section		7	2

Westward toward the Muskingum River the coal thins to 1 to 2 feet, but locally thicker sections are developed. The following section is the maximum thickness found in the central part of the county about 2 miles northeast of McConnelsville:

Morgan County; SE¼ section 36, T 11 N, R 12 W. Road Section along Ohio Highway 78 near Old Harmony School. G. S. O. File No. 8000. Norling.

		Ft.	In.
Clay, gray, soft		0	8
Clay shale, dark gray to black, coaly	Meigs Creek coal	0	6
Shale, black, coaly to bony	Meigs Creek coal	0	4
Coal, shaly; thin bony streaks	Meigs Creek coal	1	5
Shale, black, coaly, bony	Meigs Creek coal	1	0
Coal, black, bright; thin bony streaks	Meigs Creek coal	1	3
Covered		0	6
Clay, silty, gray		0	6
Covered		5	0
Total coal section		4	6

West of the Muskingum River in Morgan County the Meigs Creek coal is everywhere thin except in sections 21 and 33 of Union Township, where Bartlett (1950) measured a little over 3 feet of bony to shaly coal, and in section 29, Homer Township, where the following section was measured:

Homer Township; NE¼ section 29, T 7 N, R 13 W. Road Section along Ohio Highway 78. G. S. O. File No. 7865. Norling and Chapman.

		Ft.	In.
Shale, sandy, tan, thin-bedded; and sandstone, tan, fine-to medium-grained, shaly; bedding platy, Upper Sewickley		3	0
Clay shale, gray, thin-bedded		1	7
Shale, black, coaly; in part coal, bony	Meigs Creek coal	0	9
Clay shale, gray, thin-bedded	Meigs Creek coal	0	6

		Ft.	In.
Clay shale, dark gray to black, carbonaceous	Meigs Creek coal	0	2
Clay shale, gray, thin-bedded . . .	Meigs Creek coal	1	1
Shale, black, coaly; some coal, black, bony.	Meigs Creek coal	3	5
Sandstone, shaly, coarse to medium-grained, gray; thin coaly streaks.	Meigs Creek coal	0	6
Shale, black to dark gray, slightly sandy, thin-bedded	Meigs Creek coal	1	2
Coal, black, bony.	Meigs Creek coal	0	7
Shale, gray to black, carbonaceous, thin-bedded	Meigs Creek coal	1	0
Clay shale, gray to tan, Meigs Creek shale.		1	6
Total coaly section		9	2

This section is the thickest observed in the county, but consists largely of shale with no well-developed minable coal.

Some of the sections of the Meigs Creek coal are shown on the stratigraphic cross sections. Representative analyses of the coal are given in Appendix D.

Upper Sewickley Sandstone and Shale Member

Nomenclator: Sewickley sandstone - I. C. White, 1891, (United States Geological Survey Bulletin 65, p. 60).

Original Description: Wilmarth, 1938, p. 1,962.

I. C. White, 1891. Sewickley sandstone - flaggy, massive and even pebbly sandstone, 0 to 60 feet thick. Overlies Sewickley coal and underlies "Great" (Benwood) limestone, 160 feet thick. Its massive character is well shown along Monongahela River between Morgantown and Fairmont (West Virginia), in vicinity of Big Falls.

The Upper Sewickley sandstone and shale member in Ohio overlies the Meigs Creek coal and underlies the Benwood limestone and shale member (fig. 3). As described by White, this is the unit accepted as the Sewickley sandstone by the United States Geological Survey. That Survey does not recognize the term Lower Sewickley (Wilmarth, 1938), and inasmuch as that term is used in Ohio to designate the sandstone and shale subjacent to the Meigs Creek coal, it follows that the term Upper is necessary to designate the sandstone superjacent to that coal.

The Upper Sewickley member is developed in only part of Morgan County. The largest area of well-developed sandstone is in Manchester and eastern Bristol Townships, and in the adjoining corners of Center and Meigsville Townships. In this area the sandstone and sandy shale section varies from 4 to 34 feet in thickness, and consists of gray to tan, medium-to fine-grained sandstone, which changes rapidly from a massive phase to a platy or thin-bedded, shaly sandstone, or to a sandy shale section with beds of shaly sandstone. Within this area there are several localities where the sandstone is absent, and the limestones or calcareous shales of the Benwood member overlie the Meigs Creek coal.

Except for areas of small areal extent the Upper Sewickley is absent in most of Center, Meigsville, eastern Bristol, Bloom, Morgan, Malta, Homer, and Penn Townships. Where present, the sandstone and shale section varies from 10 to 23 feet in thickness.

There are localities of several miles extent in central Union, southern Marion, and western Windsor Townships where the Upper Sewickley sandstone is present from 10 to 28 feet in thickness. In small areas in central Homer, central Union, southeastern Marion, and western Windsor Townships, the Upper Sewickley coalesces with the Lower Sewickley sandstone.

Some of the sections of the Upper Sewickley sandstone and shale member are shown on the stratigraphic cross sections.

Benwood Limestone and Shale Member

Nomenclator: M. R. Campbell, 1903, (United States Geological Survey Brownsville-Connellsville Folio, No. 94, p. 10).

Original Description: Wilmarth, 1938, p. 165.

M. R. Campbell, 1903. Benwood limestone - geographic name (to replace inappropriate name "Great limestone") for the thick limestone, which occupies interval between Sewickley coal and Uniontown coal. Is generally composed of two members having a total thickness of about 140 feet. Lower member is entirely limestone and 70 to 80 feet thick. Upper member is considerably broken by sandstone and shale beds. Name Benwood suggested, in correspondence, by Dr. I. C. White, from town of Benwood, Marshall County, West Virginia. According to Dr. White the limestone is well exposed in river bluffs in that vicinity.

In 1907, the West Virginia Geological Survey (Reports on Ohio, Brooke, Hancock, Marshall, Wetzel, and Tyler counties) restricted Benwood limestone to lower division of "Great limestone," and applied Fulton green shale to the thin shale (0 to 5 feet) in places separating it from the overlying Uniontown limestone, or upper division of "Great limestone." This is present established definition of Benwood limestone.

The nomenclature of the thick sequence of limestones and shales between the Upper Sewickley and/or the Meigs Creek coal and the Uniontown coal has undergone several changes. The above notations give the original references accepted by the United States Geological Survey. Other workers give credit for the original subdivision of the older term "Great limestone" to J. J. Stevenson in 1876 (Stout, 1918, p. 279).

The Geological Survey of Ohio recognizes the Benwood member as that section of limestones and shales between the Upper Sewickley sandstone and the Fulton green shale member (fig. 3). The basal boundary is indefinite in many areas as the limestone development occurs just above the Meigs Creek coal when the Upper Sewickley sandstone is absent. It has been discusssd previously that this situation prevails over much of Morgan County. The summit boundary in Morgan and adjoining counties is uncertain because of the inconspicuous development or absence of the Fulton green shale. In the field the Fulton is seldom recognized. Thus, for all practicality, the thick limestone sequence must be termed the Benwood-Arnoldsburg limestone, or the Benwood-Arnoldsburg-Uniontown limestone, depending upon the local field separation of the upper strata. Many exposures consist of limestones and calcareous shales from 60 to 100 feet thick.

In Morgan County it is believed that the lower 25 to 35 feet of this limestone section represents the Benwood limestone member. The Benwood consists of thick sequences of limestones in many areas, and of alternations of limestone and calcareous shales in other localities. Still other exposures consist almost entirely of calcareous shales. The member is characterized by rapid lithologic and thickness changes of individual beds similar to those described for the Upper Pittsburgh limestone at the top of the Conemaugh series. The limestones in the Benwood member are of two types: a gray, dense to very finely crystalline limestone with a subconchoidal fracture and a softer, yellowish tan to buff, marly limestone. There often is interbedding of these two types of limestone, but, in general, the tan to buff limestone is more characteristic of the lower part of the member. Calcite veining is abundant throughout the limestone, especially in the gray phase. Much of the limestone has a brecciated or conglomeratic appearance similar to that of the Upper Pittsburgh limestone. Zones of nodular limestone are present locally. The strata have been regarded as of fresh-water origin.

In a few localities pink to red shales occur within the Benwood interval. This condition is present in the southeastern corner of Windsor Township, south of Brokaw; in section 9 of Deerfield Township; in section 22 of Center Township; and in sections 7 and 18 of Manchester Township. Sandstones occur within the member in a few areas, such as in section 4 of Center Township.

The following section of the Benwood member measured in a quarry is typical of the sections where the limestone beds are dominant:

Manchester Township; SW$\frac{1}{4}$ section 33, T 7 N, R 10 W. Limestone Quarry of Hall and Woodward, and in Stream. G. S. O. File No. 7930. Norling and Chapman.

		Ft.	In.
Covered		-	-
Shale, variegated greenish gray, chocolate, maroon; with thin layers nodular limestone; hard, gray, dense	Benwood	8	0
Limestone, tannish gray, hard, dense, somewhat nodular	Benwood	1	0
Shale, tan to gray, calcareous; with limestone as above	Benwood	1	6
Limestone, gray to tan, hard, dense, in layers 2 to 18 inches separated by shale layers 2 to 6 inches thick	Benwood	4	4
Shale, bluish gray to gray, calcareous, thin-bedded, irregular	Benwood	2	4
Limestone, gray to grayish tan, hard, dense, thin irregular bedding approximately 1 inch thick	Benwood	3	4
Shale, bluish gray to dark gray, calcareous; varies laterally to 2 inches thick	Benwood	1	0
Limestone, gray, hard, dense; varies laterally to 2 feet 6 inches thick	Benwood	3	6
Covered	Benwood	4	3
Limestone, gray to bluish gray, slightly shaly, bedding 2 to 6 inches; separated by shale layers 1 to 2 inches thick	Benwood	1	8
Clay shale, bluish gray, soft, slightly calcareous	Benwood	0	2
Limestone, gray, hard, dense; single layer which weathers to flat angular pieces	Benwood	1	10

	Member	Ft.	In.
Shale, bluish gray to greenish gray, calcareous; thin irregular bedding . .	Benwood	0	6
Limestone, gray, slightly shaly, dense, in layers 2 to 4 inches thick separated by calcareous shale layers 1 to 2 inches thick	Benwood	0	6
Sandstone, shaly, tan, micaceous, thin-bedded to platy.	Upper Sewickley	1	6
Shale, slightly sandy, bluish gray to tan, thin-bedded; thin layer nodular limestone in middle.	Upper Sewickley	5	4
Clay shale, bluish gray to gray, semi-plastic, thin-bedded	Upper Sewickley	2	10
Coal, black, bony; weathered	Meigs Creek	1	2
Shale, black, coaly, sooty; weathered. . .	Meigs Creek	0	3
Covered	Meigs Creek	-	-

The Benwood limestone has been quarried locally and on a commercial basis for road material and agricultural lime. A number of quarries were active during 1949.

Fulton Green Shale Member

Nomenclator: G. P. Grimsley, 1907, (West Virginia Geological Survey Report on Ohio, Brooke, and Hancock Counties, p. 92).

Original Description: Wilmarth, 1938, p. 786.

G. P. Grimsley, 1907. Fulton green shale, on fresh exposures is bright green, finely laminated shale, but weathers bluish green. Thickness 0 to 5 feet. Underlies Uniontown limestone and overlies Benwood limestone. Exposed at Fulton, Ohio County, West Virginia.

The Ohio and West Virginia Geological Surveys in 1931 applied Arnoldsburg limestone to lower part of Uniontown limestone of previous usage, and restricted Uniontown to younger beds.

The Fulton green shale member is stratigraphically a thin shale unit in the midst of a thick limestone sequence, and separated the Benwood limestone and shale member from the overlying Arnoldsburg limestone and shale member (fig. 3). The Fulton member is either absent or inconspicuous in Morgan County; the shales have not been identified positively in the county. Shales of the Benwood and of the overlying Arnoldsburg member weather easily and cover the exposures. Consequently, it is difficult to recognize a thin shale unit in a sequence of shales and limestones. Green sandy and calcareous shales, 3 feet thick, were recognized by George White in one exposure along Dyes Fork in section 20 of Manchester Township. These shales occur 26 feet above the Meigs Creek coal, and have been correlated tentatively with the Fulton green shale member.

Arnoldsburg Limestone and Shale Member

Nomenclator: W. Stout, 1929, (West Virginia Academy of Science Proceedings Volume 3, pp. 140, 143).

Original Description: Wilmarth, 1938, p. 76.

W. Stout, 1929. Arnoldsburg limestone (new) is a buff, hard stratum occupying most of the interval between Fulton green shale and Arnoldsburg sandstone in northern panhandle region of West Virginia, and belonging just below horizon of Lower Uniontown coal. Thickness 0 to 15 feet. Named for association with Arnoldsburg sandstone.

The Arnoldsburg limestone member is a portion of the thick sequence of limestones and shales occurring between the Meigs Creek (No. 9) coal and Uniontown (No. 10) coals, which was known as the "Great limestone" in early geological reports, and later as the Uniontown limestone. Stout, as noted above, restricted the term Uniontown to the upper portion of the limestone, and applied the term Arnoldsburg to the lower portion. The Geological Survey of Ohio recognizes the Arnoldsburg member as the limestone and shale sequence between the Fulton green shale member and the Arnoldsburg coal (fig. 3).

It has been discussed previously that the Fulton member is not recognized definitely in Morgan County, and that the Arnoldsburg limestones and shales cannot be differentiated from those of the Benwood member. In a number of localities the limestone and shale sequence extends upward to or near to the base of the Uniontown coal, and includes the Uniontown (restricted) limestone. In other areas the top of the Arnoldsburg limestone member is at the base of the Arnoldsburg sandstone inasmuch as the Arnoldsburg coal is absent over almost all of the county.

It is believed that the Arnoldsburg member includes 25 to 35 feet of strata in Morgan County. In a number of areas limestone is dominant; in others, the section consists largely of calcareous shales with beds of limestone of varying thicknesses. The lithology of the limestone is similar to that of the Benwood. The Arnoldsburg member generally contains more shale than does the Benwood. Some of the shales are gray, but in many localities pink and red shales are prevalent in sections ranging from 4 to 20 feet thick. The Arnoldsburg in some areas also includes sandstone or sandy shale sections from 2 to 14 feet thick. In a few widely separated areas the member consists entirely of sandstone and sandy shale.

Quarrying of Arnoldsburg limestone on a small scale is done in Morgan County. The product is used for local farm needs or for local road material.

Arnoldsburg Coal Member

The Arnoldsburg coal is present in Ohio only locally. It occurs between the Arnoldsburg limestone and the Arnoldsburg sandstone members (fig. 3). Thin, dark, carbonaceous to coaly shale streaks found in two exposures in Morgan County probably represent this coal member. In section 14 of Marion Township a $\frac{1}{8}$-inch streak overlies Arnoldsburg limestone and underlies a 15-foot section of sandy shales and sandstone of the Arnoldsburg sandstone member.

In section 28 of Center Township, 2 inches of carbonaceous shale is exposed in a shale and calcareous shale interval at the horizon where the Arnoldsburg coal should be situated.

Arnoldsburg Sandstone and Shale Member

Nomenclator: R. V. Hennen, 1911, (West Virginia Geological Survey Report on Wirt, Roane, and Calhoun Counties, pp. 57, 202, 505).

Original Description: Wilmarth, 1938, p. 76.

R. V. Hennen, 1911. Arnoldsburg sandstone - coarse, brown, and gray sandstone forming high pebbly cliffs. Thickness 25 to 45 feet. Lies 40 to 50 feet below Uniontown limestone and overlies Lower Uniontown coal. Named for Arnoldsburg, Calhoun County, West Virginia.

The Arnoldsburg sandstone and shale member in Ohio occupies a stratigraphic position between the overlying Uniontown limestone and the underlying Arnoldsburg coal and/or Arnoldsburg limestone (plate II). In Morgan County the member consists of an erratic development of sandstones and sandy shales ranging in thickness from 4 to 22 feet, and averaging about 12 feet. The sandstone is tan to buff, medium-to fine-grained, with some zones which are coarse-grained, micaceous, and shaly. There is a rapid variation from shaly sandstone sections to sequences of shales with sandstone layers and to sandy shale sections. There is no apparent pattern to the thicker sandstone development.

In many localities in the southern and eastern parts of the county the interval of the Arnoldsburg sandstone is occupied by gray, pink, or red shales, which are sandy in some cases and calcareous in others. Thin limestone layers are present locally in this interval. The amount of pink and red shales present is greater than in the underlying Arnoldsburg limestone member. These highly colored shales become increasingly prevalent in the overlying strata of the upper Monongahela and lower Permian.

Some of the rapid lithologic changes within the Arnoldsburg sandstone and shale member are illustrated on the stratigraphic cross sections.

Uniontown Limestone and Shale Member

Nomenclators: F. and W. G. Platt, 1877, (Second Pennsylvania Geological Survey, Report H-3, pp. 55-104, 286, 292).

Original Description: Wilmarth, 1938, p. 2,217.

F. and W. G. Platt, 1877. Uniontown limestone, 10 to 12 feet thick. Top member of Pittsburg group, and 160 feet above Pittsburg coal. Is older than Uniontown coal and younger than Sewickley coal. (In places, called Uniontown or Great limestone).

E. V. d'Invilliers, 1895, (Second Pennsylvania Geological Survey, Summary Final Report, Volume 3, Part 2, between pp. 2,153 and 2,588). Applied Uniontown limestone to upper 0 to 20 feet of Great limestone, immediately underlying Uniontown coal; and J. J. Stevenson, 1907, (Geological Society of America Bulletin, Vol. 18) also followed that usage. The definition adopted by the United States Geological Survey for Pennsylvania in 1919, and published in the Burgettstown-Carnegie folio (No. 177, 1911) and subsequent reports up to the present time, applied Uniontown limestone to beds in Pennsylvania, which underlie Uniontown coal, or in places occur a few feet below that coal, and which in places are separated from Benwood member by an interval of 5 to 20 feet of shale with lenses of limestone.

W. Stout, 1929, (West Virginia Academy of Science Proceedings Vol. 3, pp. 140, 143). Restricted Uniontown of Ohio and West Virginia to upper limestone of interval between Uniontown coal and Fulton shale, and introduced Arnoldsburg limestone for the lower limestone, lying on or close to Fulton shale.

Named for exposures at Uniontown, Fayette County, Pennsylvania.

The Uniontown member is present in southern and eastern Morgan County, and consists of 0 to 7 feet of limestone and calcareous shale or calcareous shale with limestone layers. The average thickness of the member is 4 feet. The limestone is gray, hard, and dense, and locally is shaly or sandy. Nodular limestone and limestone nodules are present in the more shaly sections. The limestone is developed only locally in the county. Adjoining exposures show a rapid change from limestone to calcareous shale. In much of the area of outcrop the interval of the Uniontown limestone is occupied by pink and red shales.

Uniontown (No. 10) Coal Member

The Uniontown (No. 10) coal member in Ohio overlies the Uniontown limestone and underlies the Uniontown sandstone (fig. 3). It is a fairly persistent bed in the eastern and southeastern portions of Morgan County, and consists of coal and coaly shale varying in thickness from less than an inch to a maximum of 2 feet 6 inches. The average thickness of the unit is less than 1 foot. The coal and coaly shale often are underlain by dark gray impure clays or clay shales from a few inches to 3 feet in thickness. A number of the sections are illustrated on the stratigraphic cross sections.

The following sections are representative of the best development of the Uniontown coal in Morgan County:

Windsor Township; SE part of township near abandoned Rose Hill School. G. S. O. File No. 8036. Norling and Chapman.

		Ft.	In.
Covered		8	9
Clay, black, coaly, soft	Uniontown coal	0	1
Clay, gray, in part coaly; thin coaly streaks near top	Uniontown coal	1	0
Shale, black, coaly to coal, black, bony	Uniontown coal	0	7
Clay, gray to dark gray, in part shaly	Uniontown coal	0	6
Shale, dark gray to black, carbonaceous	Uniontown coal	0	4
Clay shale, gray to dark gray, thin-bedded		2	2
Total coal section		2	6

Marion Township; SW$\frac{1}{4}$ section 16, T 8 N, R 12 W.
G. S. O. File No. 3017. Stout and Meyers.

		Ft.	In.
Shale, gray		20	0
Shale, bony	Uniontown coal	0	9½
Coal, rotten	Uniontown coal	0	7½
Clay shale and covered		5	0
Total coal section		1	5

The Uniontown coal has no economic value in Morgan County.

Uniontown Sandstone and Shale Member

Nomenclator: I. C. White, 1891, (United States Geological Survey Bulletin 65, pp. 55-59).

Original Description: Wilmarth, 1938, p. 2,217.

I. C. White, 1891. Uniontown sandstone - massive gray sandstone. Occurs immediately above Uniontown coal, hence its name, although it is not prominent at Uniontown, Fayette County, Pennsylvania. Lies 60 to 75 feet below Waynesburg coal and just below Waynesburg limestone.

The Uniontown sandstone and shale member occupies a stratigraphic position in Ohio between the Uniontown (No. 10) coal and the Waynesburg limestone members (fig. 3). The member in Morgan County consists of 20 to 40 feet of sandstones, sandy shales, and red shales. It varies from a well-developed gray to tan, fine-to medium-grained, micaceous, and shaly sandstone with platy to 6-inch bedding to sections of sandy shale with layers of sandstone from 2 to 15 feet thick. The sandstone is developed in thicker sections in Marion and Windsor Townships than in the townships to the northeast. The Uniontown in Manchester, eastern Bristol, Meigsville, and Center Townships contains thick sections of red shales, and gray to red sandy shales.

Throughout the area of outcrop in the county the basal portion of the member is a sandy shale, usually pink to red in color, which varies in thickness from 1 to 12 feet.

The Uniontown sandstone is usually shaly and rather loosely cemented, and has little economic value as construction stone.

Waynesburg Limestone and Shale Member

Nomenclator: J. J. Stevenson, 1877, (Second Pennsylvania Geological Survey Report K-2).

Original Description: Wilmarth, 1938, p. 2,290.

J. J. Stevenson, 1877. In Fayette and Westmoreland District of Pennsylvania, the Waynesburg limestone, 8 to 35 feet thick, underlies Little Waynesburg coal and is separated from underlying Uniontown coal by 50 to 80 feet of shale and shaly sandstone (the sandstone is Uniontown sandstone member).

Named for Waynesburg, Greene County, Pennsylvania.

The Waynesburg limestone and shale member occurs between the Uniontown sandstone and the Little Waynesburg (No. 10-A) coal in Ohio (fig. 3). The member is poorly developed in Morgan County. Limestone sections from 1 foot to 13 feet 3 inches occur in a few localities in Manchester and southern Meigsville Townships. The thicker limestone sections occur in Manchester Township (fig. 11). These limestones have little areal extent. In other localities in these townships and in Center, western Windsor, and Marion Townships the member is represented by gray, calcareous shales. The average thickness for the member is about 10 feet.

In many exposures of this interval no calcareous material is found, and the strata consist of red shales or sandstone. In a few instances such sandstones are continuous with the underlying Uniontown sandstone, but usually the sandstone of the Waynesburg limestone member is separated from the Uniontown sandstone by red shales or by covered intervals, which probably indicate soft shale sections.

Little Waynesburg (No. 10-A) Coal Member

The Little Waynesburg (No. 10-A) coal is a thin coal and coaly shale bed which occurs in Ohio between the Waynesburg limestone and the Gilboy sandstone members. In Morgan County the thin, discontinuous coaly streak occurs from 35 to 47 feet above the Uniontown (No. 10) coal, and from 13 to 20 feet below the Waynesburg (No. 11) coal at the top of the Monongahela series. The member is present in scattered localities in Marion, Windsor, Meigsville, Bristol, and Manchester Townships. The thickness of the coaly streak ranges from less than 1 inch to 2 feet 4 inches. The usual thickness is about 4 inches, with only one exposure in the county attaining the maximum thickness.

The thickest section was measured in Windsor Township:

Windsor Township; Southwestern corner. G. S. O. File No. 3010. Stout and Meyers.

		Ft.	In.
Shale, gray, siliceous; and shaly sandstone, Gilboy		13	3
Shale, coaly	Little Waynesburg coal	0	1
Shale	Little Waynesburg coal	0	2
Shale, coaly	Little Waynesburg coal	0	1½
Shale	Little Waynesburg coal	0	3½
Coal, rotten	Little Waynesburg coal	0	2½
Shale	Little Waynesburg coal	1	5
Coal, rotten	Little Waynesburg coal	0	1
Shale, pink		12	11
Total coal section		2	4½

Another exposure in Windsor Township contains streaks of better coal:

Windsor Township; East of Stockport. Section in Henry Hollow. G. S. O. File No. 2894. Stout and Meyers.

	Ft.	In.
Shale, gray, Gilboy interval	8	0

		Ft.	In.
Shale, coaly	Little Waynesburg coal	0	$1\frac{1}{2}$
Clay shale		0	2
Coal and bone shale		0	$4\frac{1}{2}$
Clay shale		0	$3\frac{1}{4}$
Coal		0	$1\frac{3}{4}$
Shale, calcareous, gray, Waynesburg limestone interval		5	0
Total coal section		1	1

Gilboy Sandstone and Shale Member

Nomenclator: I. C. White, 1891, (United States Geological Survey Bulletin 65, p. 58).

Original Description: Wilmarth, 1938, p. 277.

I. C. White, 1891. Browntown sandstone - hard, massive, gray sandstone, 0 to 35 feet thick. Lies 5 to 20 feet below Waynesburg coal and overlies Little Waynesburg coal. Finely exposed along bed and bluffs of Ten Mile Creek, at and below Browntown, Harrison County, West Virginia. Is sometimes called Gilboy sandstone from a rocky cut of that name near Mannington, Marion County, West Virginia.

I. C. White, 1903, (West Virginia Geological Survey Volume 3, p. 150). Gilboy sandstone - was formerly termed Browntown sandstone from a locality in Harrison County, but as there is a Brownstown sandstone from a locality in Kanawha County, West Virginia, it was concluded best to change the name of this sandstone to Gilboy.

The Gilboy sandstone and shale member occurs between the Little Waynesburg (No. 10-A) and Waynesburg (No. 11) coals (fig. 3). In Morgan County it consists of 13 to 20 feet of sandstone and sandy shales, with some gray to red shales. In some localities in the outcrop area in the southeastern and eastern parts of the county the member consists entirely of tan to buff, fine- to medium-grained, shaly, thin to platy bedded sandstone. In other areas the sandstone is more shaly, and the section is largely sandy shale with thin beds of sandstone. Where the overlying Waynesburg (No. 11) coal is not present, the sandstone section in some localities extends upward so that demarcation of the Pennsylvanian-Permian contact is not possible. This situation is more pronounced in Windsor and Marion Townships where the Gilboy sandstone is well developed.

In some areas the Gilboy interval is occupied by gray or red shales with little or no sandstone content. The highly colored shales are prevalent in the northeastern part of the county.

Waynesburg (No. 11) Coal Member

Nomenclator: H. D. Rogers, according to Stout, 1918, p. 283.

The Waynesburg (No. 11) coal is the top member of the Monongahela series of the Pennsylvanian. It is underlain by the Gilboy sandstone, and conformably overlain by the Cassville shale of the Washington series (Permian) (fig. 3). The line of outcrop is shown on the Geologic Map (plate I). The member crops out on the high ridges and hills in the eastern and southern parts of Morgan County. The Waynesburg coal occurs 57 feet above the Uniontown (No. 10) coal in the northeastern part of the county, and from 67 to 70 feet above that coal in the southern part.

In Morgan County the Waynesburg coal ranges in thickness from 1 inch to 1 foot, and averages about 6 inches. It usually consists of a thin streak of coal within a black coaly shale. It often is underlain by a thin section of clay or clay shale. In some localities, especially in eastern Marion and Windsor Townships, the coal is absent, and the interval is occupied by a thick sandstone section, which extends from the Gilboy sandstone up through the Waynesburg sandstone of the Washington series.

The Waynesburg coal has no economic value in Morgan County.

PERMIAN SYSTEM

GENERAL

The Permian system was named by R. I. Murchison in 1841 after study of an area in Russia. The name is derived from the ancient kingdom of Permia. In 1845 Murchison collaborated with de Verneuil and von Keyserling in a work entitled Geology of Russia in Europe and the Ural Mountains, in which the term Permian was established firmly in the geologic column. Synopses of these two original writings are given by Wilmarth (1925, pp. 70-72).

In the early geologic reports on Ohio the rocks under consideration were included in the "Upper Barren Measures" of the Pennsylvanian. Through the years subdivisions were made and new stratigraphic terms applied, of which some of the more important are discussed by Stauffer and Schroyer (1920, pp. 9-11). The subdivisions of Washington (Washington County Group) and Greene (Greene County Group) had been established in southwestern Pennsylvania by J. J. Stevenson in 1875 or 1876. These subdivisions were applied to Ohio terminology by J. S. Newberry, who included them in the "Upper Coal Measures." The beds were kept in this position in the works of E. B. Andrews and Edward Orton until about 1888.

Fontaine and White (1880) had established a Permian age for the strata of the "Upper Barren Measures" in West Virginia and Pennsylvania on the basis of the similarity of fossilized plants in the Cassville shale to those in the Permian strata of Russia and Europe. Through the work of I. C. White in 1891 the Permian age of these strata was established in southeastern Ohio through comparison of the Ohio sections with those in Pennsylvania and West Virginia. The term Dunkard (Dunkard Creek) was introduced into the literature by White. The Permian age of the Dunkard was accepted by the Geological Survey of Ohio by 1905 (Prosser, 1905, pp. 2, 5-7), and the term "Upper Coal Measures" was abandoned in favor of the term Dunkard. In subsequent years the Permian strata were studied in a number of areas in Ohio, and the subdivisions of Washington and Greene became established firmly in the geological literature of the state. A notable contribution was the regional work of Stauffer and Schroyer (1920).

There is no regional unconformity between the Permian and Pennsylvanian strata in the Appalachian coal basin. The separation is based mainly on the above-mentioned study of plant fossils. Some workers during the years have proposed that the rocks as far down the stratigraphic column as the upper part of the Conemaugh have affinities which could justify their inclusion in the same stratigraphic grouping. This lengthy grouping could not be justified in the light of current knowledge of the Pennsylvanian rocks in the Eastern Interior Basin, and of the Pennsylvanian and Permian rocks in the Mid-Continent area.

In Ohio approximately 600 feet of Permian strata are known (Stauffer and Schroyer, 1920, p. 15). In the Generalized Section of Rocks of Ohio, published by the Geological Survey of Ohio (Stout, 1947), a total of 626 feet is given. In Morgan County the basal 110 feet of these strata is exposed (fig. 3). They extend from the base of the Cassville shale to the Lower Marietta sandstone, and comprise about the lower half of the Washington series. The strata consist of gray and highly colored shales and clay shales; erratic sections of sandstones and sandy shales; thin limestones; and thin coals. They are similar in character to those included in the underlying Monongahela series.

Permian strata crop out on the higher ridges and hills in the eastern and southeastern parts of Morgan County (plate I), and represent outlying tracts from the major belt which extends across southeastern Ohio through eastern Meigs, southeastern Athens, Washington, Monroe, eastern Morgan, eastern Noble, Belmont, and southern Jefferson Counties (fig. 1, p. 2). The exposures are generally poorly exposed, and are difficult to subdivide into members. The exposures usually reveal only the more resistant beds of sandstone and/or thin limestone. Some of the sections of the Permian strata in Morgan County are shown on the stratigraphic cross sections.

DUNKARD DIVISION

Nomenclator: I. C. White, 1891, (United States Geological Survey Bulletin 65, p. 22).

Original Description: Wilmarth, 1938, p. 642.

I. C. White, 1891. Dunkard Creek series - on Dunkard Creek, Greene County, Pennsylvania, includes 165 feet concealed beds above Gilmore sandstone and extends down to base of Cassville shale.

The above accords with present definition of Dunkard group, which is now divided into Greene formation (above), extending down to top of Upper Washington limestone member, and Washington formation (below). The United States Geological Survey classifies the Dunkard deposits as a group within the Permian series, but the present Pennsylvania Geological Survey classifies them as a series within the Permian system.

As previously mentioned, the Permian strata in Ohio are grouped under the term Dunkard, which has been given the rank of a group by the United States Geological Survey (Wilmarth, 1938, p. 642), and as a series by the Geological Survey of Ohio in earlier publications (Stauffer and Schroyer, 1920; Stout, 1939 and 1947). The Washington and Greene subdivisions of the Dunkard have been classified as formations. Recent trends in stratigraphic thought have been to raise the latter to series rank; thus, making the main subdivisions of the strata in the Permian the same stratigraphic rank as those in the Pennsylvanian. The Dunkard becomes a sort of super-series, and is superfluous. The term in Ohio is synonymous with the term Permian. In this report the general indeterminant term of Dunkard Division is used in order to keep the term under consideration until a decision is made as to its validity in current stratigraphic usage.

WASHINGTON SERIES

General

Nomenclator: J. J. Stevenson, 1876, (Second Pennsylvania Geological Survey Report K, pp. 44-56).

Original Description: Wilmarth, 1938, p. 2,200.

J. J. Stevenson, 1876. Washington County group - includes all beds between top of Upper Washington limestone and top of Waynesburg sandstone below. Thickness 150 to 450 feet. Is an important formation in Washington County, Pennsylvania. (For many years the Waynesburg sandstone and the underlying Cassville shale have been included in Washington formation (the shorter name), the base of which has been drawn at top of Waynesburg coal.)

Is lower formation of Dunkard group.

The present Pennsylvania Geological Survey classifies the Washington as a group and the Dunkard as a series.

Named for exposures in highlands of Washington County, Pennsylvania.

Stauffer and Schroyer (1920, p. 1) refer to an earlier writing by Stevenson in 1875 (American Philosophical Society Proceedings, Volume 15, p. 372) as well as to the reference listed above.

The lower subdivision of the Dunkard is the Washington series. As discussed previously, the Washington has been changed from its former rank of a formation in line with recent trends of stratigraphic thought.

The Washington series in Ohio includes the strata from the base of the Cassville shale to the top of the Upper Washington limestone and shale (fig. 3). Only the lower portion of these strata are present in Morgan County. These extend from the Cassville shale to within the Lower Marietta sandstone.

Cassville Shale Member

Nomenclator: I. C. White, 1891, (United States Geological Survey Bulletin 65, p. 41).

Original Description: Wilmarth, 1938, p. 364.

I. C. White, 1891. Cassville plant shale - dark gray shale, 5 to 15 feet thick, which very frequently separates Waynesburg sandstone from underlying Waynesburg coal. This shale is prolific in fossil plants, especially so in the vicinity of Cassville, Monongalia County, West Virginia. Is basal bed of Dunkard Creek series (Permian).

The lower formation of the Dunkard group has for many years been called Washington formation, and Cassville shale member of Washington formation is adopted name of United States Geological Survey.

The Cassville shale member is the basal unit of the Washington series of the Permian in Ohio. It rests conformably on the Waynesburg (No. 11) coal, the summit member of the Monongahela series of the Pennsylvanian. Fossils from this shale were used as the basis for assigning a Permian age to the strata above the Waynesburg (No. 11) coal (Fontaine and White, 1880). It is reported that some 107 species of plant forms were identified from the Cassville in West Virginia and Pennsylvania.

In Morgan County the exposures of possible Cassville shale are mostly covered, and recognition of the unit depends upon the presence of the underlying thin Waynesburg (No. 11) coal. In sections 28 and 29, Manchester Township, the Cassville is represented by 6 feet of reddish gray clay shales between the Waynesburg coal and the Elm Grove limestone. In section 6, Center Township, there are 3 feet 10 inches of poorly exposed shales between the Waynesburg coal and a very calcareous sandstone, which probably represents the Elm Grove member. The Cassville shale is 9 inches thick in section 26, Meigsville Township, in an exposure which contains both of the limiting beds.

In sections 5, 28, and 30, Center Township, the Cassville is represented by exposures of gray shales, in part sandy, from 3 feet 6 inches to 6 feet thick, between the Waynesburg coal and the base of the Waynesburg sandstone.

Elm Grove Limestone Member

Nomenclator: G. P. Grimsley, 1907, (West Virginia Geological Survey Report on Ohio, Brooke, and Hancock Counties, p. 68).

Original Description: Wilmarth, 1938, p. 679.

G. P. Grimsley, 1907. Elm Grove limestone - deep blue or black limestone, 2½ to 10 feet thick. Underlies Waynesburg sandstone and overlies Cassville plant shale. Exposed near Elm Grove and east from that town in Ohio County, West Virginia.

The Elm Grove limestone was recognized in but a few scattered exposures in Morgan County. The following section was measured by Stout south of Neelysville in Meigsville Township:

Meigsville Township; N. Cen. section 21, T 10 N, R 11 W.
G. S. O. File No 2890. Stout and Meyers.

		Ft.	In.
Shale, partly pink; and sandstone, shaly		35	0
Limestone, nodular, drab	Elm Grove	0	6
Shale and covered	Elm Grove	3	9
Limestone, dark gray to blue, hard, blocky	Elm Grove	0	4
Shale, gray, Cassville shale		0	9
Coal smut in clay, Waynesburg (No. 11)		0	3

In section 26 of the same township Stout measured a blue limestone, thickness not given, above 2 inches of Waynesburg coal. A third area of possible Elm Grove is located 1 mile south of Roxbury in southeastern Windsor Township, where 7 inches of dark calcareous shale overlies the Waynesburg coal. In section 26, Center Township, a bed of very calcareous sandstone, 1 foot 6 inches thick, occurs 3 feet 10 inches above the coal, and may represent the Elm Grove member. The Elm Grove is represented by nodular limestone in a 2-foot section of reddish brown clay shale in sections 28 and 29, Manchester Township.

In three exposures in Center Township several non-persistent limestones, from 1 foot to 1 foot 6 inches in thickness, occur widely spaced in a section of reddish gray clay shales. The base of this calcareous section is 15 to 18 feet above the Waynesburg (No. 11) coal. It is believed that this section represents a local development of limestone within the interval normally occupied by the Waynesburg sandstone and not the Elm Grove limestone.

Waynesburg Sandstone and Shale Member

Nomenclator: J. J. Stevenson, 1873, (American Philosophical Society Transactions Volume 15, new series, p. 16).

Original Description: Wilmarth, 1938, p. 2,290.

J. J. Stevenson, 1873. The "Upper Barren Group" (Dunkard group of present nomenclature) includes all above the Waynesburg sandstone, if I may so term it. This sandstone is separated from underlying Waynesburg coal by 1 to 15 feet of shale (later named Cassville shale member). (For many years the Waynesburg sandstone and Cassville shale have been included in Washington formation, the lower formation of the Dunkard group, although they were excluded in this original description. W. M. Fontaine and I. C. White transferred them to the higher formation in 1880 (Second Pennsylvania Geological Survey Report P-2).)

I. C. White, 1891, (United States Geological Survey Bulletin 65, pp. 40-41). Waynesburg sandstone - generally massive and conglomeratic, grayish white sandstone, but in places represented by sandy shales and flaggy sandstones with an occasional limestone stratum. Thickness 50 to 100 feet. Lies 2 to 5 feet below Mount Morris limestone, and lies on Cassville plant shale. Named for fine development near (on Ten Mile Creek just east of) Waynesburg, Greene County, Pennsylvania.

The Waynesburg sandstone and shale member includes the interval between the Elm Grove limestone and the Waynesburg "A" (No. 11-A) coal (fig. 3). As mentioned previously, the general absence of the Elm Grove limestone makes recognition of the base of the member indefinite. The Waynesburg "A" coal also is non-persistent; thus, in many areas, both the basal and summit boundaries of the member are arbitrary. The interval of the member ranges from 28 to 37 feet, and averages 33 feet. The strata consist of an erratic sequence of sandstones, sandy shales, and reddish brown clay shales. Facies changes are rapid within short distances.

In the thicker bodies the sandstone is gray to tan in color, fine-to medium-grained with some zones of coarser material, and thin to platy bedded. The sandstone usually contains beds of sandy shale, and in many areas is an alternation of sandstones and shales. Thick bodies of sandstone are prevalent in the southern part of the county in Marion and Windsor Townships, but also occur in local areas in Meigsville, Center, and Manchester Townships. Locally the sandstone coalesces with the Gilboy sandstone, which occurs below the Waynesburg (No. 11) coal, thus transgressing the systemic boundary. There also are some exposures where the sandstone is developed at the top of the interval and merges with the stratigraphically higher Mannington sandstone.

In the areas where the Waynesburg sandstone is not prominent, the strata consist of reddish brown and gray shales and clay shales, which are often sandy. Many of these sections are poorly exposed because of the soft nature of the beds. In several exposures in Center Township dominantly clay shale sections contain local development of thin limestones, which, as previously mentioned, might be confused with the Elm Grove member. This local limestone condition was recognized in White's definition.

Waynesburg "A" (No. 11-A) Coal Member

The Waynesburg "A" (No. 11-A) coal is non-persistent in Morgan County. It has been recognized on some of the high hills and ridges in local areas in Manchester, Center, and Windsor Townships. The thickest exposure occurs in Manchester Township, where the following was measured:

Manchester Township; C. SE section 9, T 7 N, R 10 W.
G. S. O. File 6997. George White.

		Ft.	In.
Shale, fine to silty, slightly ferruginous		4	0
Shale, dark gray, weathered		0	7
Coal blossom	Waynesburg "A"	1	1
Clay shale, gray, coaly	Waynesburg "A"	0	3½
Coal, weathered	Waynesburg "A"	1	2
Clay shale, gray		1	0
Total coal section		2	6½

In other scattered sections the Waynesburg "A" coal ranges in thickness from 1 to 9 inches, and averages 6 inches. The coal occurs from 38 to 43 feet above the Waynesburg (No. 11) coal. In some localities the coal is not recognized in the thick sandstone sections which result from the merging of the Waynesburg and Mannington sandstones.

In a few areas the Waynesburg "A" is of sufficient thickness to warrant mining for local consumption. The following section was measured along the mine face in the Clarence Walker drift (cut about 200 feet under a hill), near Brokaw:

Windsor Township; 1 mile east of Brokaw. Clarence Walker
Drift Mine. Reported by Dean (1948, p. 17).

		Ft.	In.
Shale, with thin sandstone layers		15	0
Shale, carbonaceous		0	2¼
Coal	Waynesburg "A"	0	6
Shale	Waynesburg "A"	0	1
Coal, bony	Waynesburg "A"	0	5¼
Coal	Waynesburg "A"	1	0½
Coal, bony	Waynesburg "A"	0	0¼
Coal	Waynesburg "A"	0	6¼
Clay, impure		-	-
Total coal section		2	7¼

An analysis from this coal seam is given in Appendix E.

Mannington Sandstone and Shale Member

Nomenclator: R. V. Hennen, 1909, (West Virginia Geological Survey Report on Marshall, Wetzel, and Tyler Counties, p. 226).

Original Description: Wilmarth, 1938, p. 1,287.

R. V. Hennen, 1909. Mannington sandstone - massive cliff-forming sandstone, 25 to 50 feet thick, underlying Litte Washington coal and overlying Waynesburg "A" coal. Named for Mannington, Marion County, West Virginia.

C. R. Stauffer and C. R. Schroyer, 1920, (Geological Survey of Ohio, 4th series, Bulletin 22), give 5 sections in Ohio showing 8 to 99 feet of Mannington sandstone lying 17 feet below Washington coal and 21 feet below Lower Marietta sandstone.

The Mannington sandstone and shale member in Morgan County is similar in character and development to the Waynesburg sandstone. The member is subject to considerable variation in the amount of sandstone, but, in general, is a more massive sandstone than the Waynesburg. The interval of the member is between the Waynesburg "A" (No. 11-A) coal and the Little Washington coal (fig. 3). The Waynesburg "A" is a non-persistent bed, and the Little Washington coal is not recognized in Morgan County. Thus, both the basal and top boundaries of the Mannington are indefinite.

In a number of localities the member is represented by a medium-to coarse-grained, platy to thick-bedded sandstone overlain and underlain by shales or sandy shales. The highly colored shales are not so prevalent as in the Waynesburg interval. The thickness of the Mannington sandstone and shale interval ranges from 30 to 45 feet. In much of the southern part of the county, in Marion and Windsor Townships, the Mannington coalesces with the stratigraphically lower Waynesburg sandstone to form a nearly solid sandstone section over 50 feet thick.

Interval From Mannington Sandstone and Shale Member to Lower Marietta Sandstone Member

Exposures of strata overlying the Mannington sandstone are scarce and very poorly exposed. Between the Mannington and the next higher recognizable unit, the Lower Marietta sandstone, there occurs a covered interval of 15 to 20 feet. The stratigraphic position of the Little Washington and the Washington coals is within this interval (fig. 3). These thin coals were not recognized in Morgan County.

Lower Marietta Sandstone Member

Nomenclator: Marietta sandstone - I. C. White, 1891, (United States Geological Survey Bulletin 65, p. 35).

Original Description: Marietta sandstone - Wilmarth, 1938, p. 1,299.

I. C. White, 1891. Marietta sandstone - In places two or three massive sandstones, each 25 to 40 feet thick, separated by thin shales; in other places one sandstone 100 feet thick. Overlies Washington coal in southeastern Ohio, western Pennsylvania, and West Virginia.

The Lower Marietta sandstone is the youngest stratigraphic unit recognized in Morgan County. The member is exposed only in a few isolated outcrops on the highest hills and ridges in the southeastern part of the county. Southwest and southward from Stony Creek in section 35, in the southwestern corner of Center Township, there is an exposure of approximately 6 feet of gray to tan, fine-to medium-grained, micaceous, shaly sandstone, which is separated from the Mannington sandstone by a covered interval of 41 feet. A few feet of similar sandstone is exposed poorly approximately a half mile northeast of the village of Dale in southern Windsor Township.

The exposures of the Permian strata are mostly covered due to the soft nature of the shales, and are generally unsatisfactory from a stratigraphic basis.

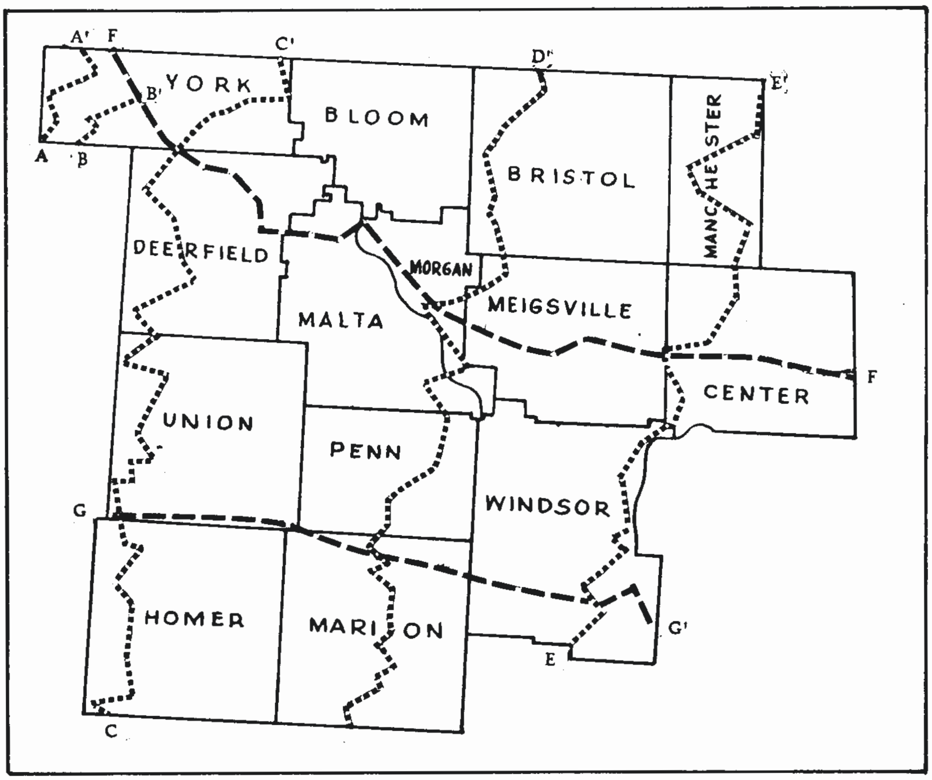
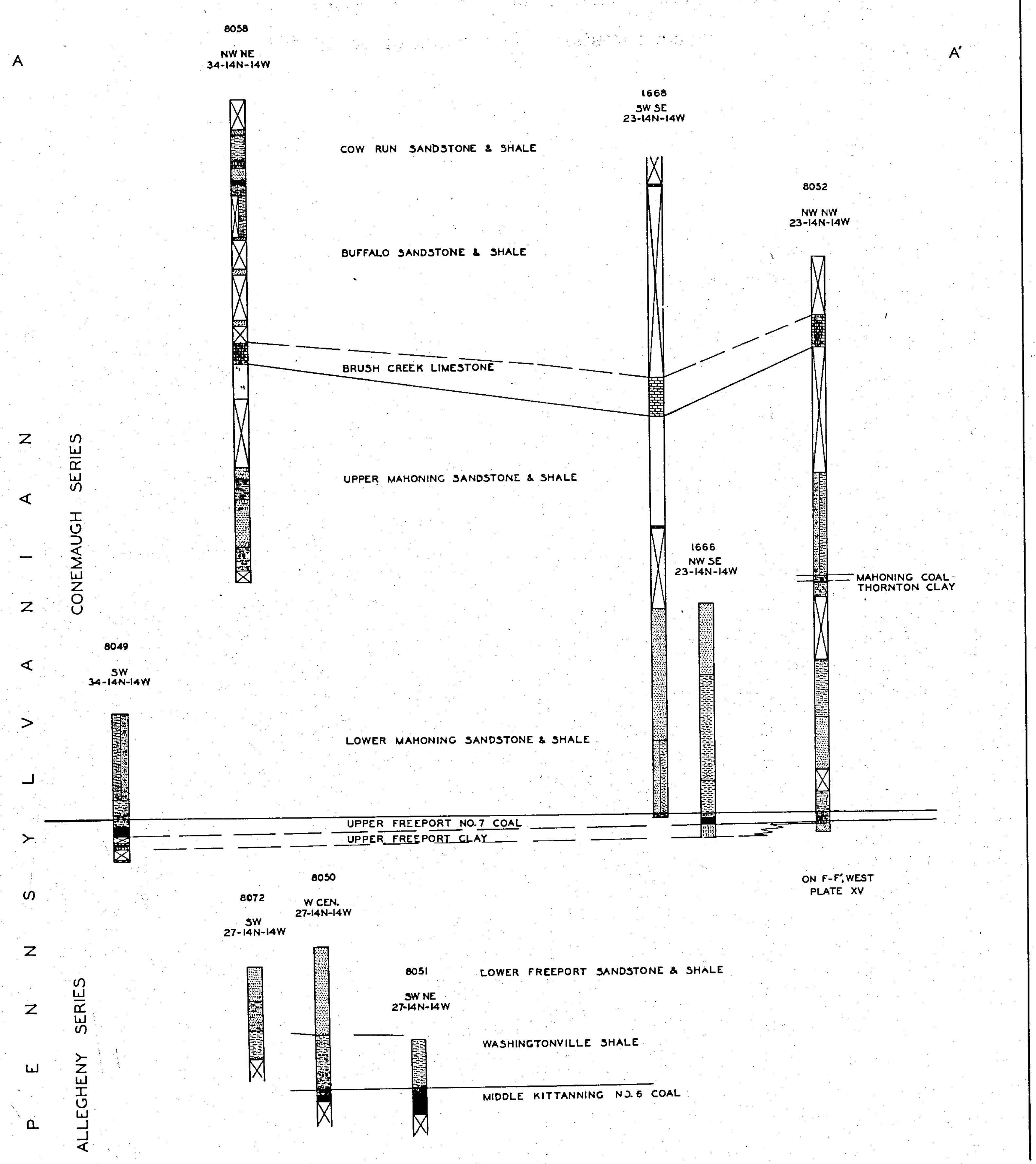


Figure 4. - Map showing location of stratigraphic cross sections.



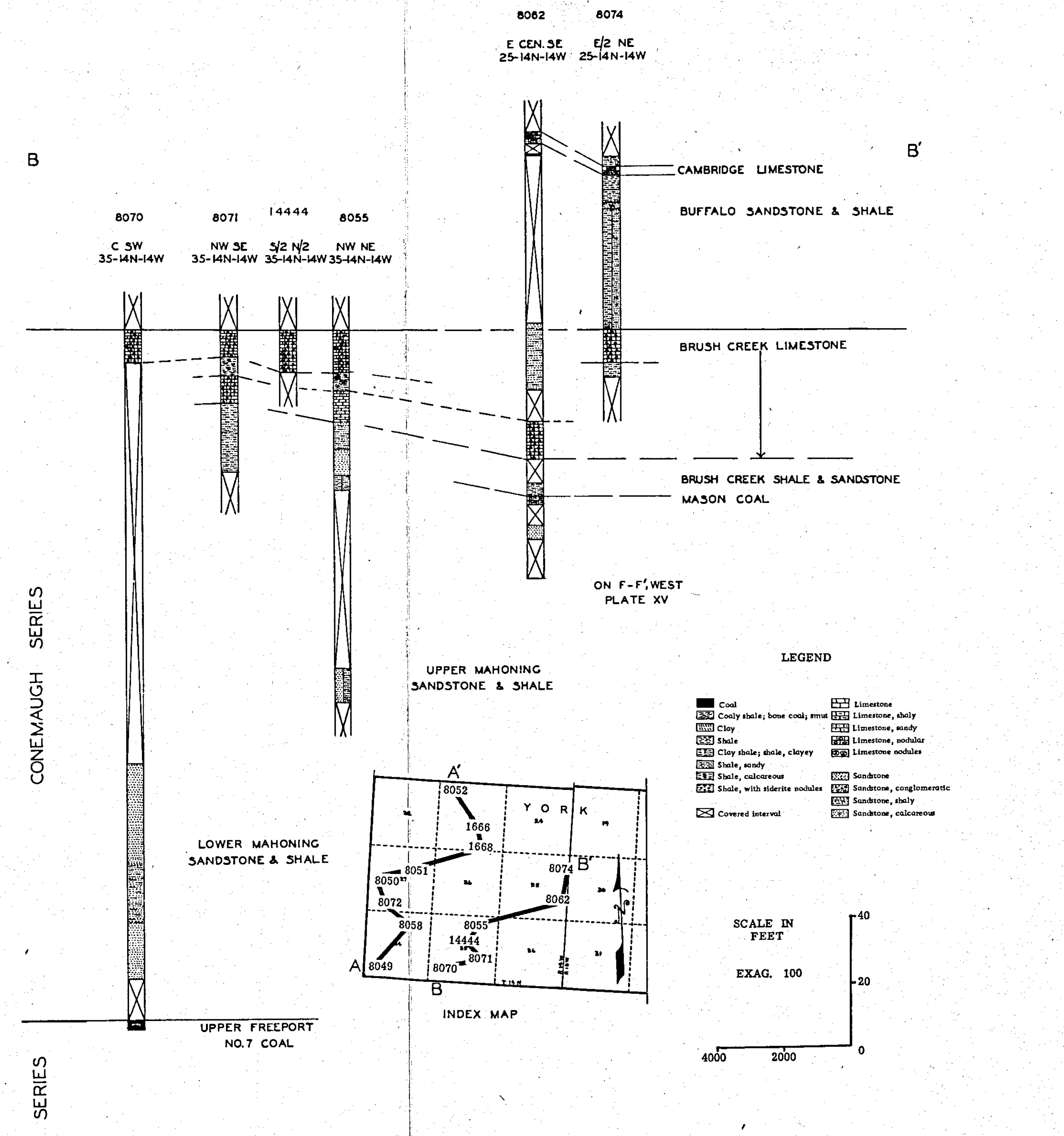


FIGURE 5

GEOLOGY OF MORGAN COUNTY, OHIO

Stratigraphic cross-sections A - A' and B - B', southwest-northeast through western York Township

FIGURE 6

GEOLOGY OF MORGAN COUNTY, OHIO

Stratigraphic cross-section C - C', south part, south-north through western Homer and Union Townships

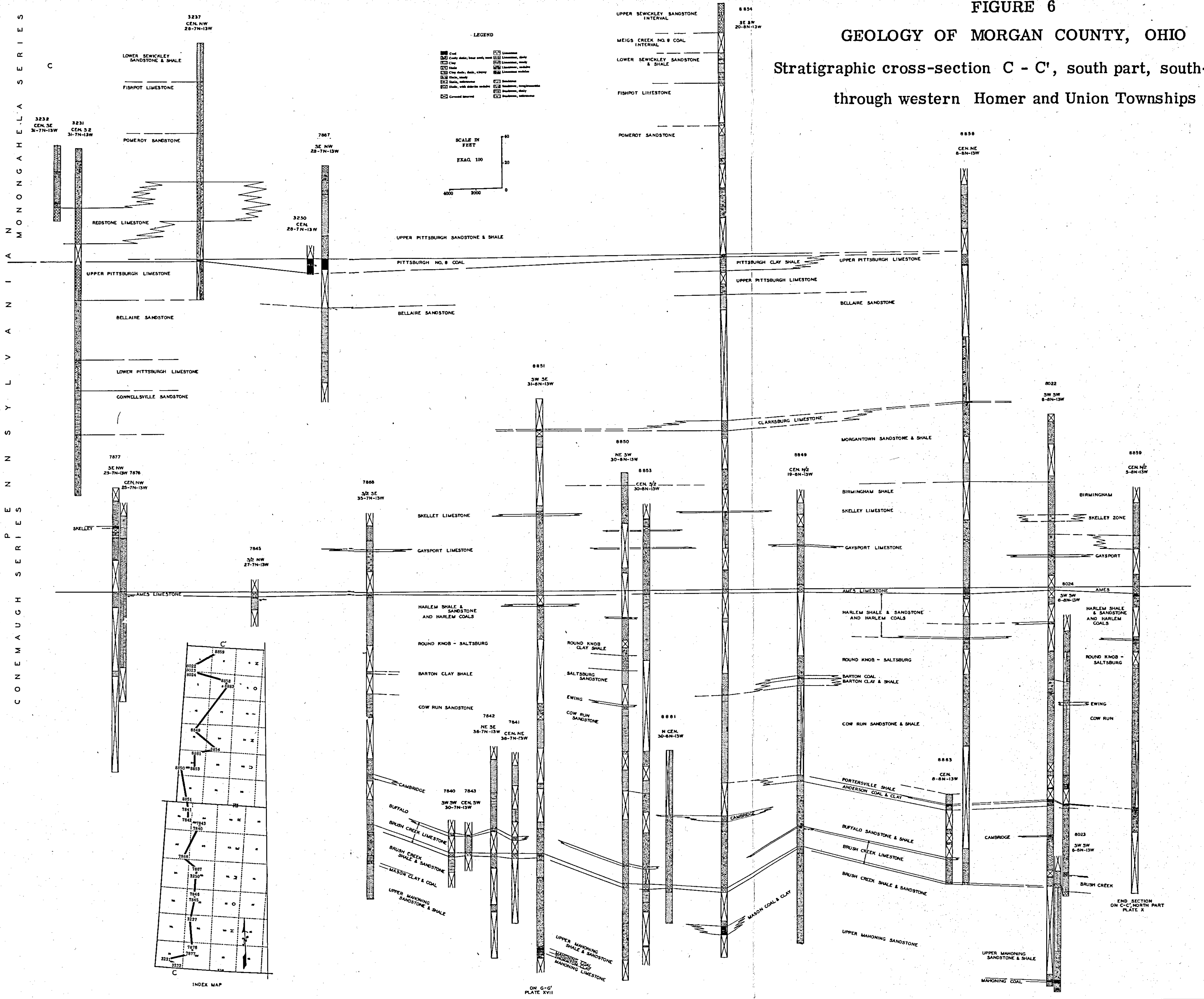
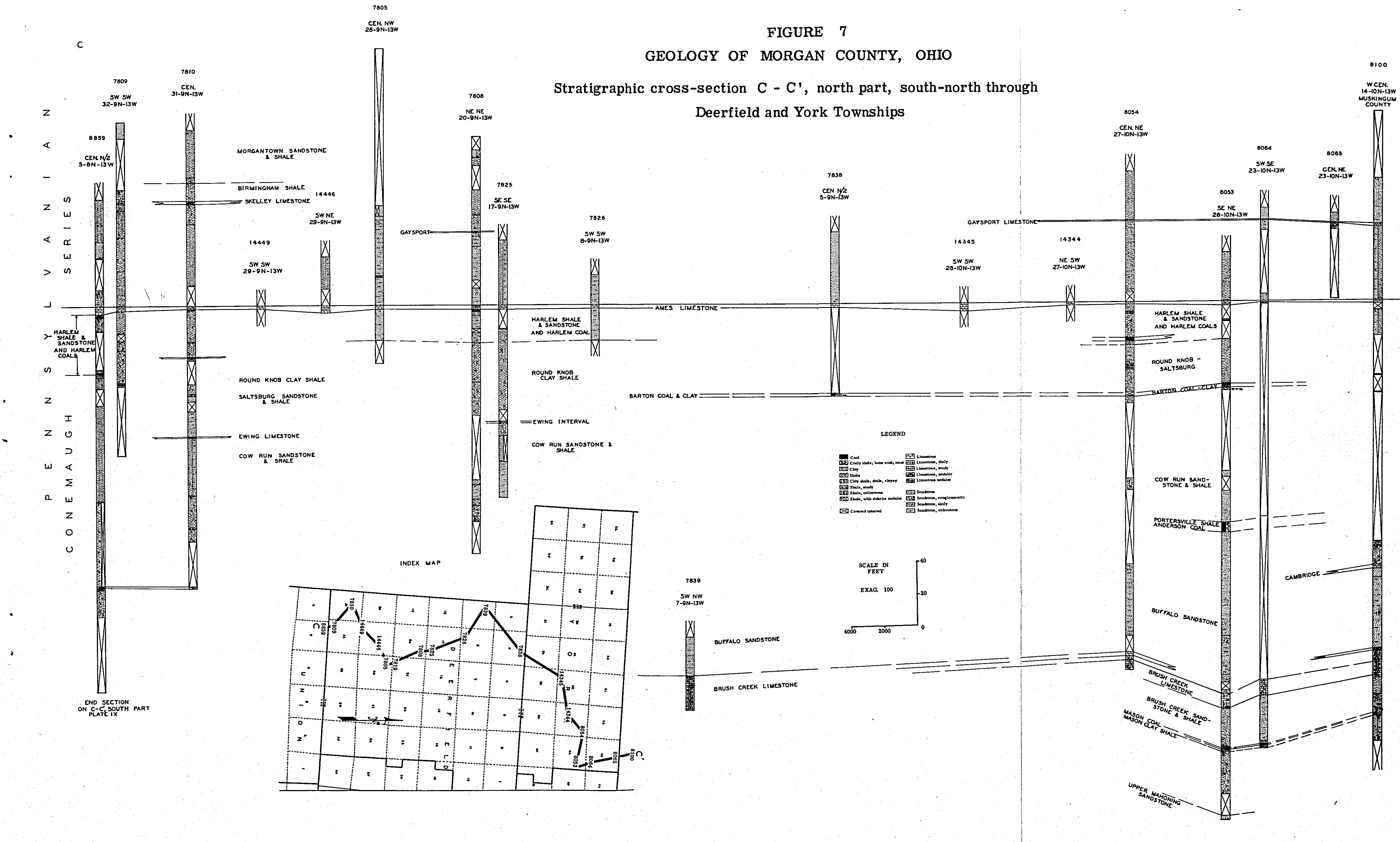


FIGURE 7

GEOLOGY OF MORGAN COUNTY, OHIO

Stratigraphic cross-section C - C', north part, south-north through Deerfield and York Townships



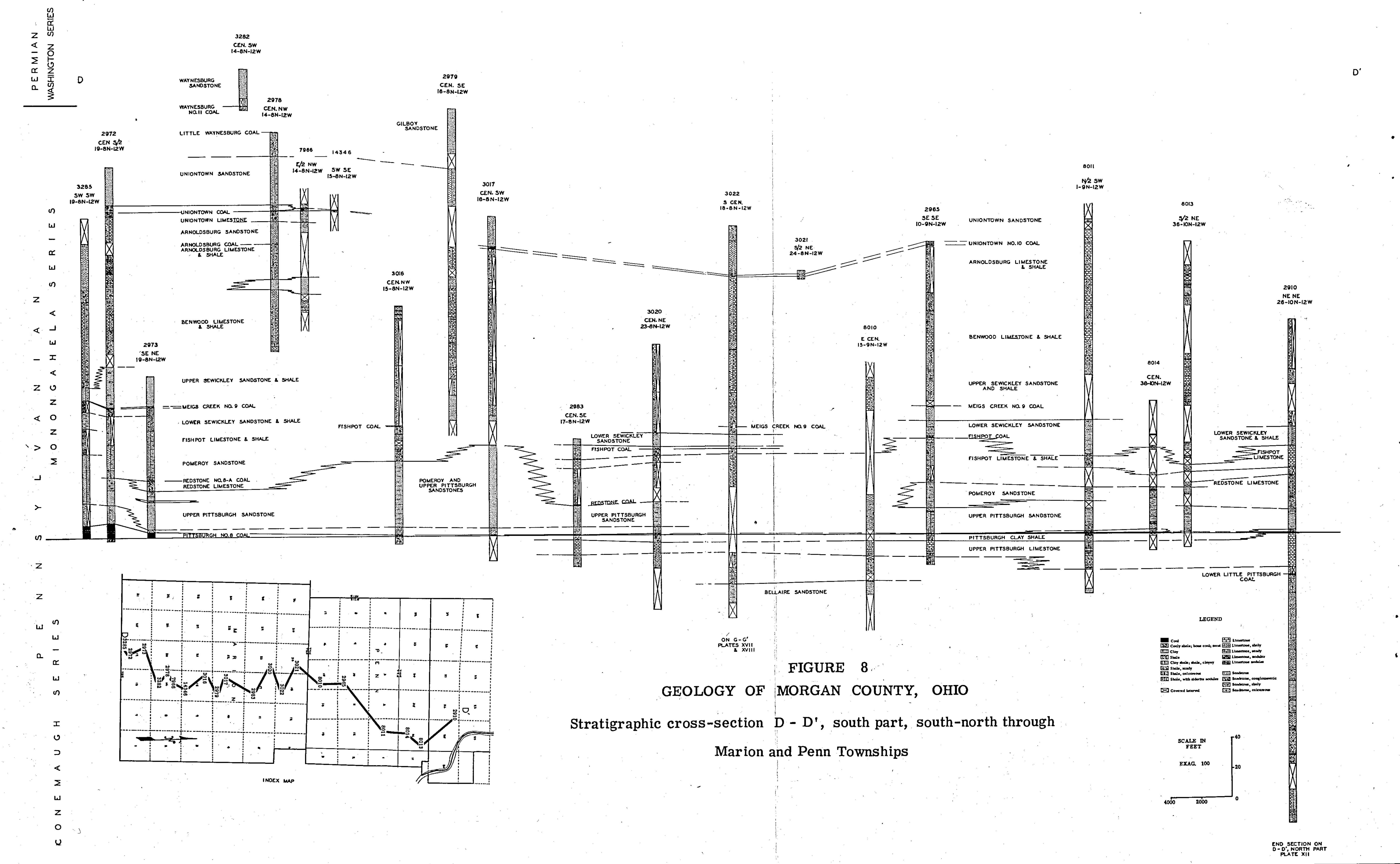


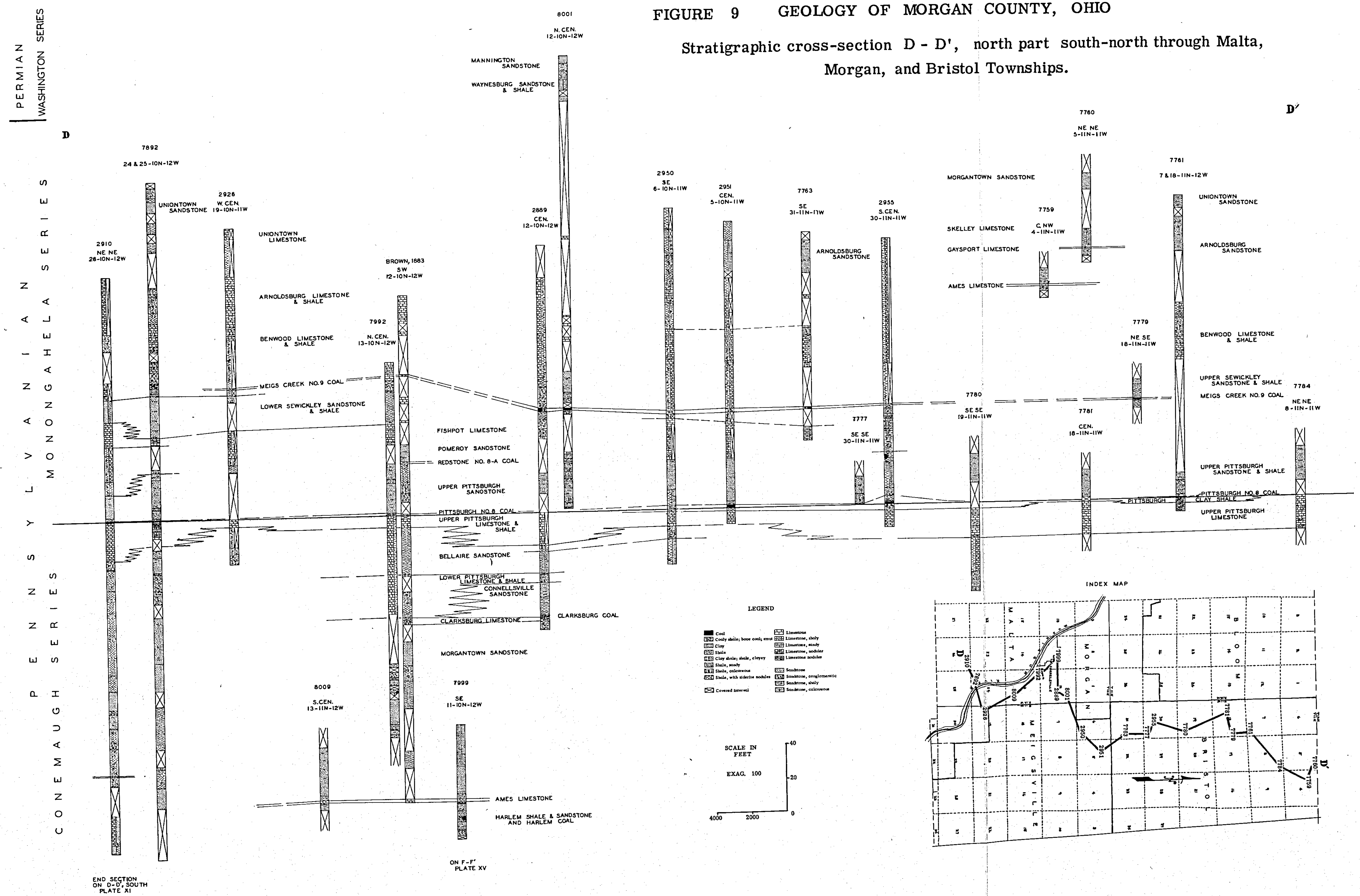
FIGURE 8

GEOLOGY OF MORGAN COUNTY, OHIO

Stratigraphic cross-section D - D', south part, south-north through Marion and Penn Townships

FIGURE 9 GEOLOGY OF MORGAN COUNTY, OHIO

Stratigraphic cross-section D - D', north part south-north through Malta, Morgan, and Bristol Townships.



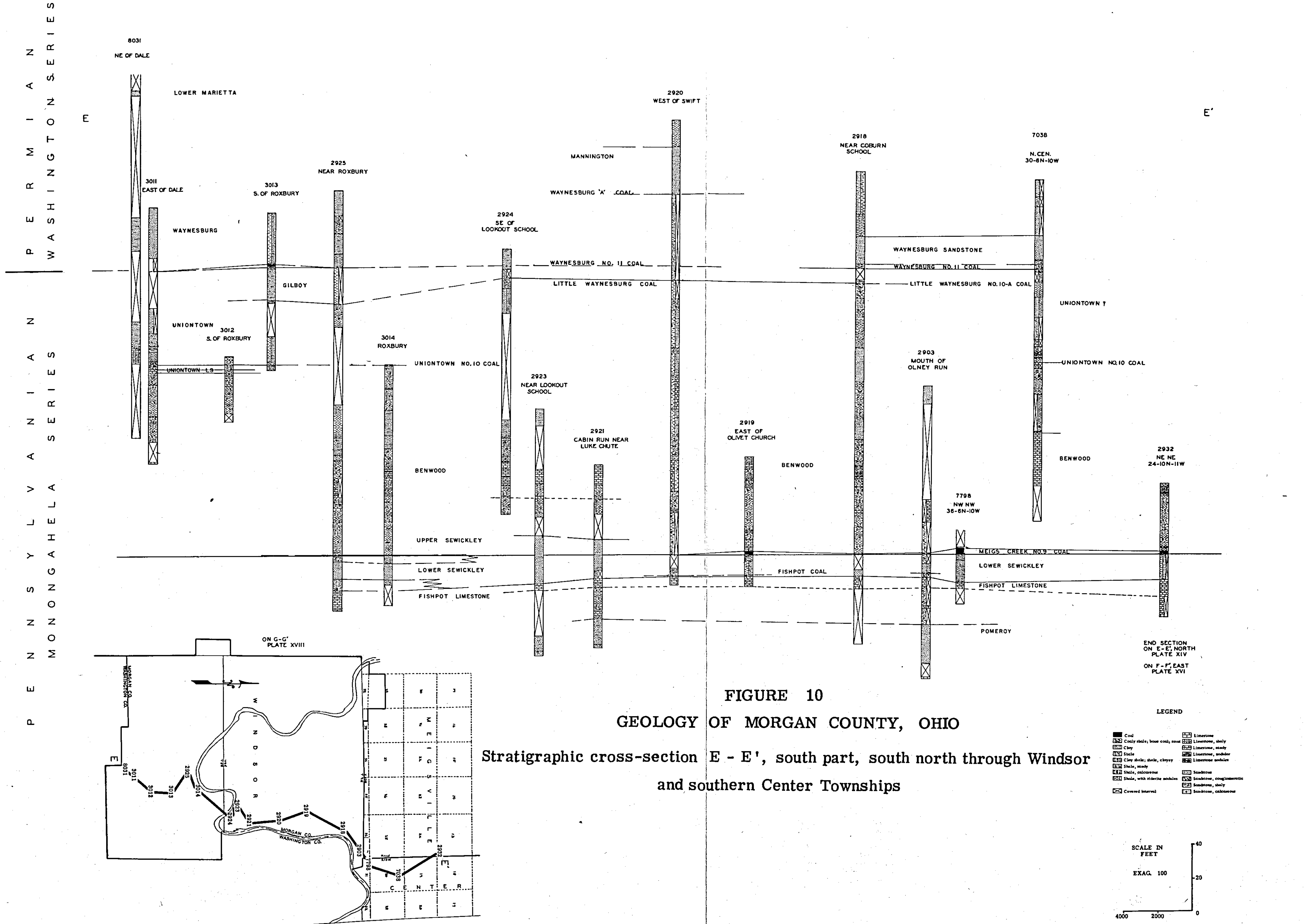


FIGURE 10

GEOLOGY OF MORGAN COUNTY, OHIO

Stratigraphic cross-section E - E', south part, south north through Windsor and southern Center Townships

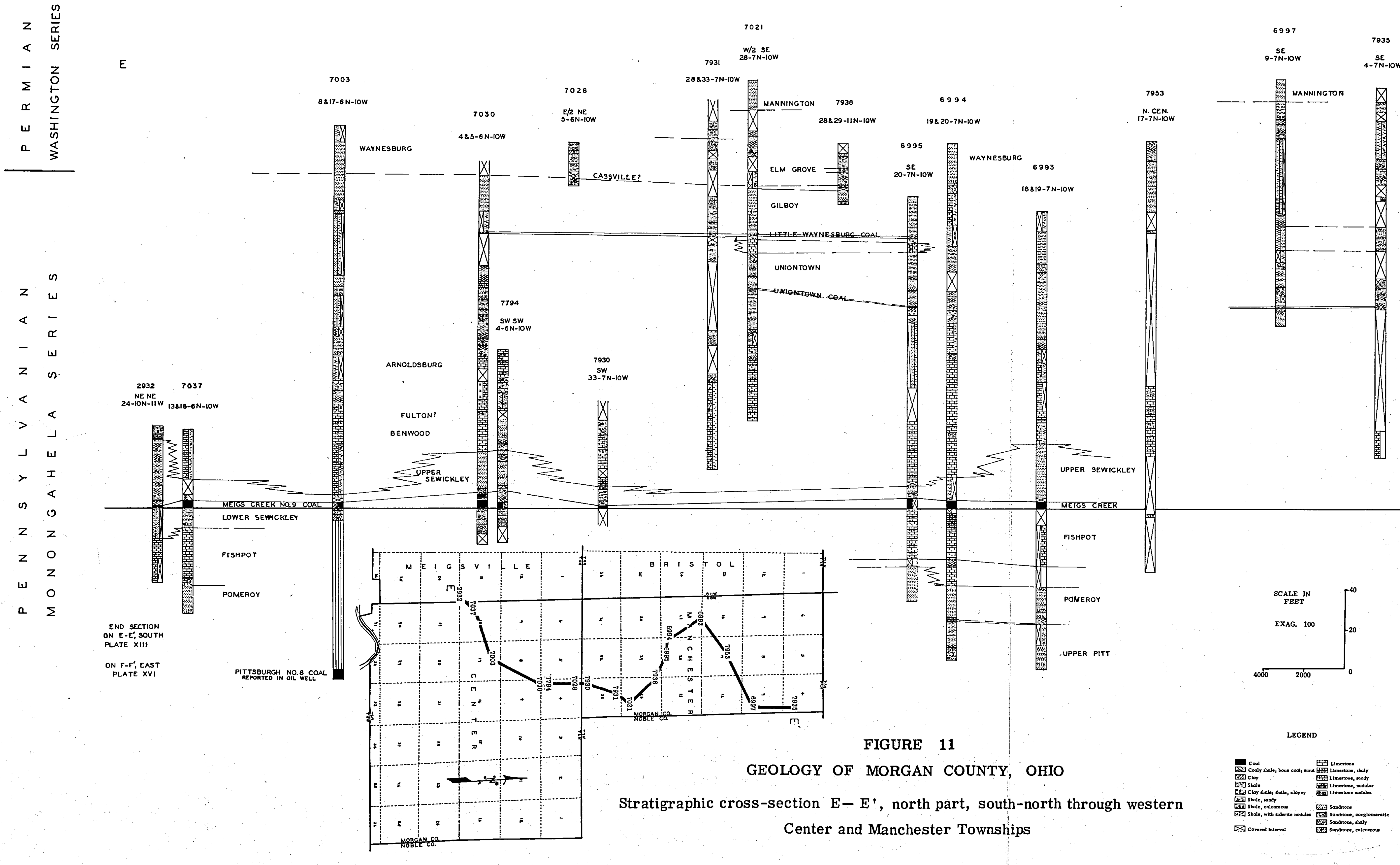


FIGURE 11

GEOLOGY OF MORGAN COUNTY, OHIO

Stratigraphic cross-section E— E', north part, south-north through western Center and Manchester Townships

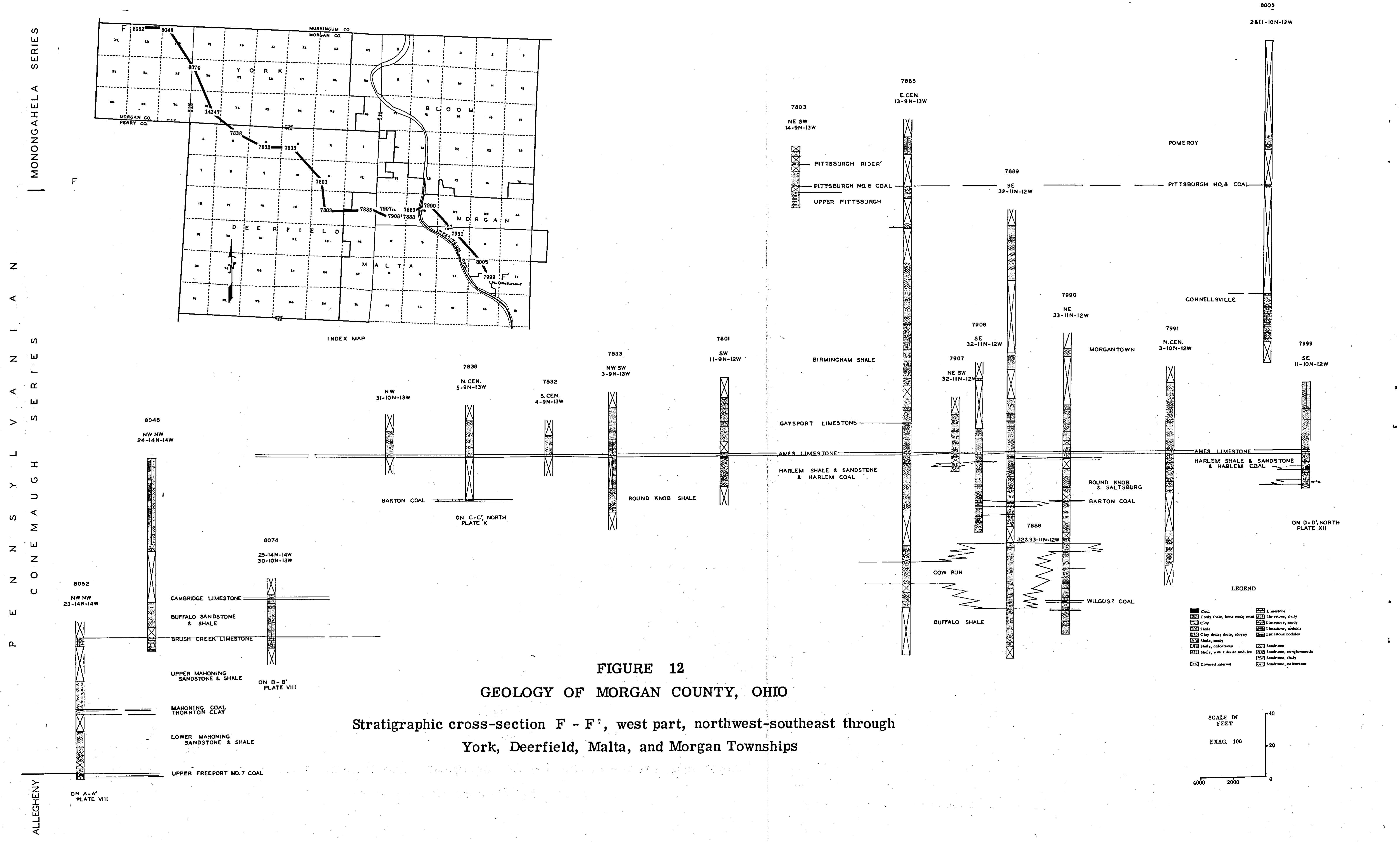


FIGURE 12

GEOLOGY OF MORGAN COUNTY, OHIO

Stratigraphic cross-section F - F', west part, northwest-southeast through York, Deerfield, Malta, and Morgan Townships

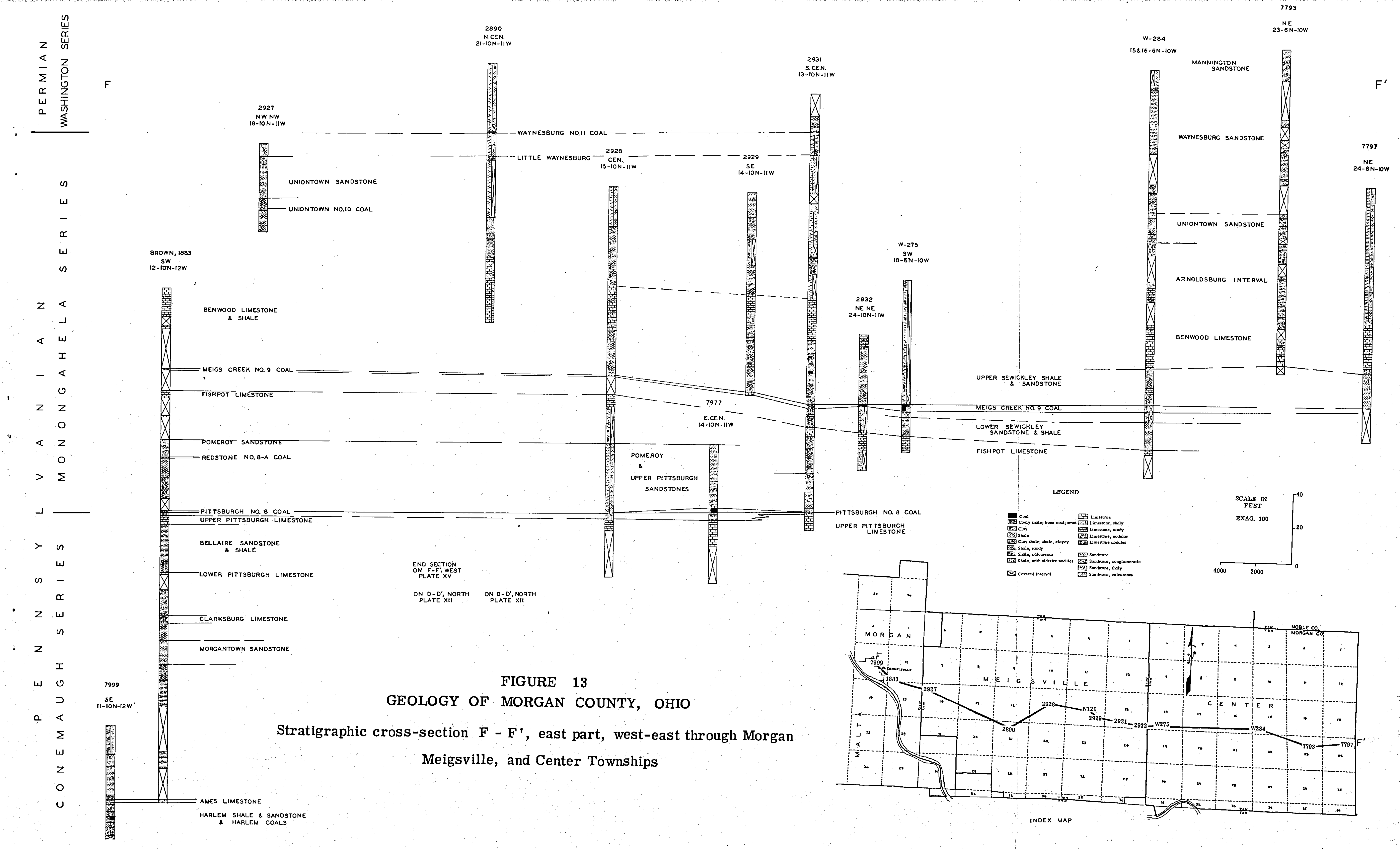


FIGURE 13

GEOLOGY OF MORGAN COUNTY, OHIO

Stratigraphic cross-section F - F', east part, west-east through Morgan Meigsville, and Center Townships

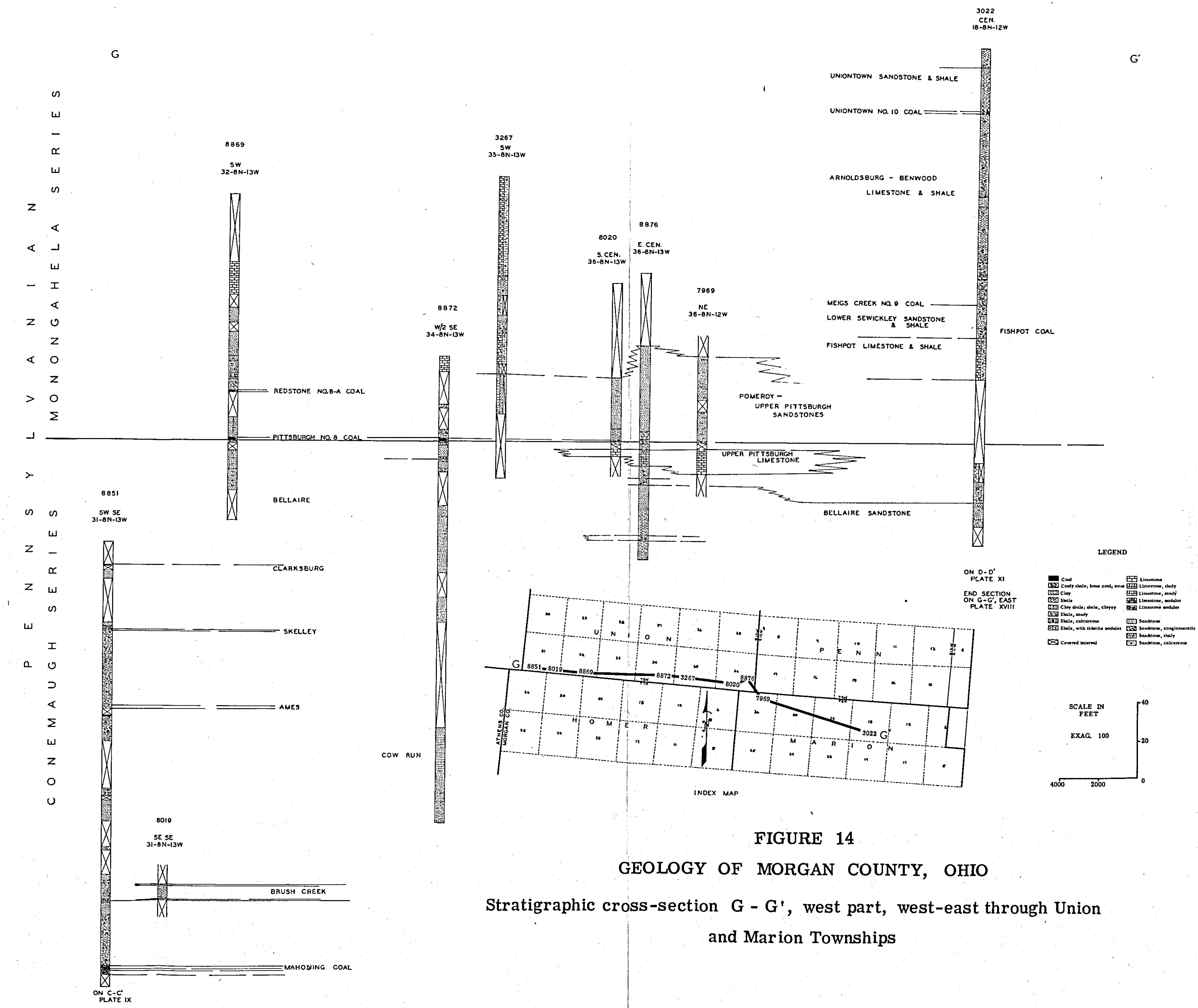


FIGURE 14

GEOLOGY OF MORGAN COUNTY, OHIO

Stratigraphic cross-section G - G', west part, west-east through Union and Marion Townships

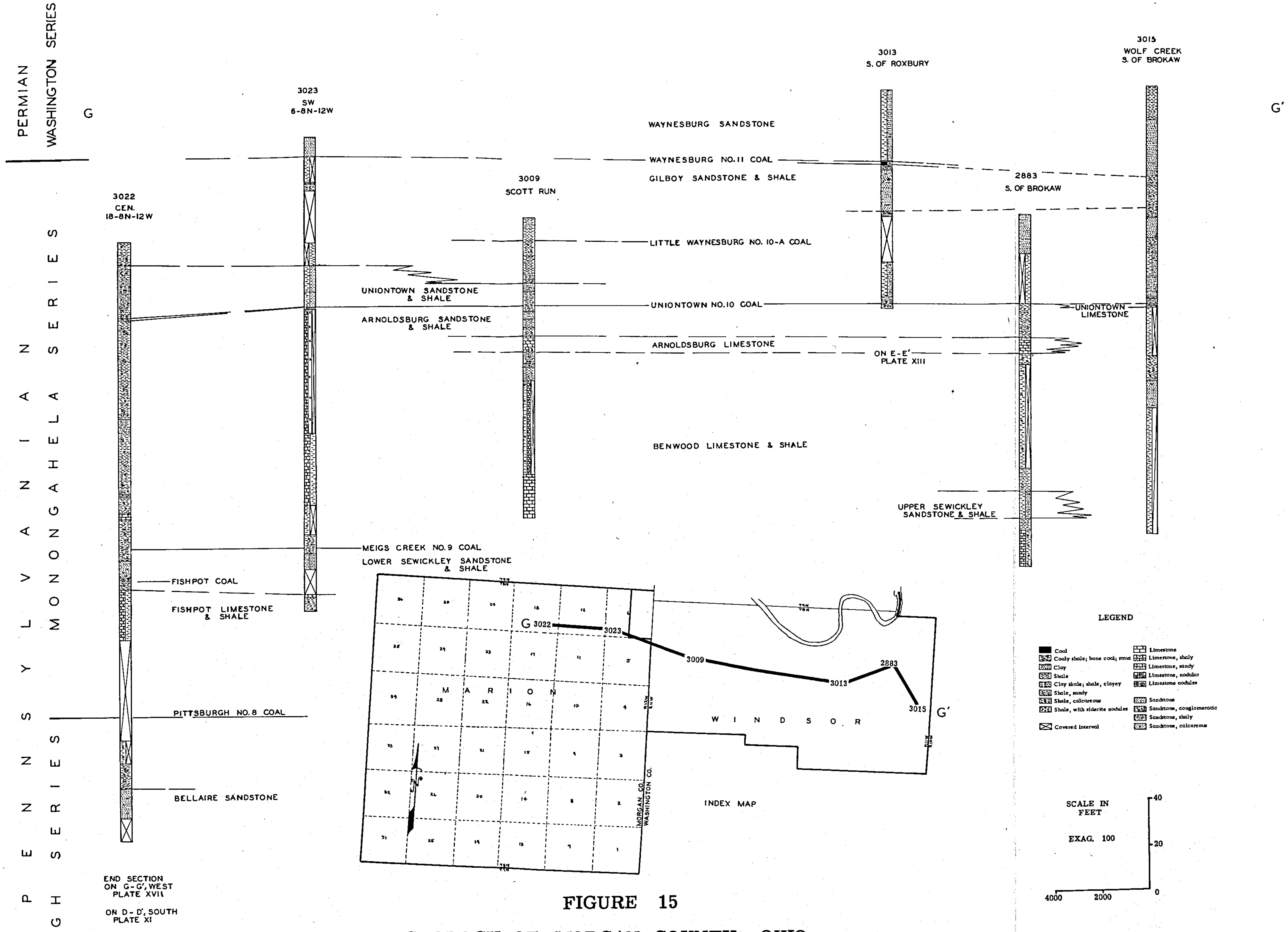


FIGURE 15

GEOLOGY OF MORGAN COUNTY, OHIO

Stratigraphic cross-section G - G', east part, west-east through Marion and Windsor Townships

CHAPTER 4

STRUCTURE

GENERAL

The principal structural feature in eastern Ohio is the Parkersburg-Lorain syncline (Magbee and Alkire, 1954, p. 7). This syncline enters the state between Marietta, Ohio, and Parkersburg, West Virginia, and extends northward through the state to the vicinity of Lorain on Lake Erie. This major structural feature plunges toward the south. The axis of the syncline, as delineated by middle and upper Pennsylvanian stratigraphic markers, trends through the eastern part of Morgan County. Structural interpretations based on subsurface data from wells drilled for oil and gas have been presented by Magbee and Alkire (1954).

The structural position of the surface Pennsylvanian rocks in Morgan County is portrayed on maps contoured on the top of the Ames limestone, on the base of the Pittsburgh (No. 8) coal, and on the base of the Meigs Creek (No. 9) coal. The data for these maps were computed from the measured sections, or were taken from manuscript maps in the files of the Geological Survey of Ohio. The regional structural interpretations are supported by numerous control points. Local irregularities may represent true structure or may be due to inaccuracies in barometer readings and calculations. It is suggested, therefore, that before commercial use is made of any indicated local structure, accurate surveys be done by plane table or transit. Most of the elevations used to compute the data for these maps were taken with an aneroid barometer.

Ames Limestone Member

Control points for the Ames limestone are numerous throughout western Morgan County (fig. 16). The contours show regional dip to the southeast at an average rate of 33 feet per mile. The greatest rate of dip occurs in the northern part of the county where 40 feet per mile can be measured. The Ames limestone dips at about 28 feet per mile in the southwestern corner of the county.

In the vicinity of McConnelsville a small synclinal area is indicated. This is an irregularity on the western flank of the Parkersburg-Lorain syncline, which is shown in more detail by the use of the subsurface well data in the interpretation by Magbee and Alkire (1954, figure 4, p. 6). This subsurface interpretation is similar in the western part of the county to that on the map accompanying this report (fig. 16) except in several local areas. Magbee and Alkire show pronounced closed structural "lows" in central York and northern Deerfield Townships, which are not so interpreted on the structural map of the outcropping Ames limestone. The control points for the subsurface interpretation are not shown.

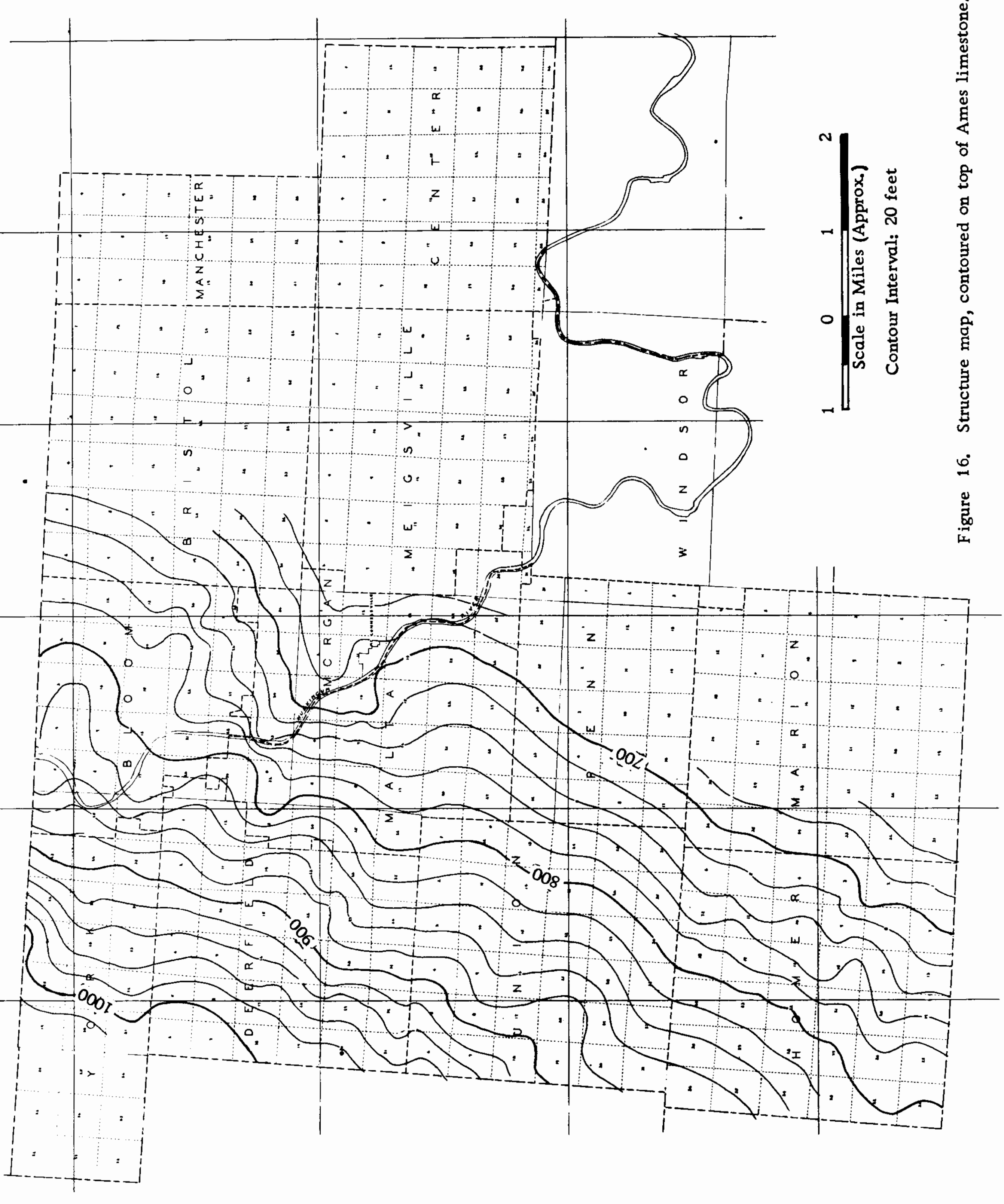


Figure 16. Structure map, contoured on top of Ames limestone.

Pittsburgh (No. 8) Coal Member

The Pittsburgh (No. 8) coal in Morgan County (fig. 17) varies from a thin coaly streak to a well-developed bed as thick as 9 feet. The base of the coal was selected as the contour datum because that horizon is believed to represent a time datum.

Control points for the Pittsburgh coal are available over most of the county. The contours show regional southeastward dip at an average rate of 30 feet per mile. In contrast with the structure on the Ames limestone, the Pittsburgh coal dips a little more steeply in the southwestern part of the county, with an average of 33 feet per mile, than in the northern part, where the dip averages 28 feet per mile. The slight steepening of structural dip in the southwestern part of the county appears to be the result of a thinning of the Ames-Pittsburgh interval in that portion of the county.

The general pattern of the contours on the base of the Pittsburgh coal is one of numerous local irregularities of small magnitude. The contour interpretation in Union Township is somewhat different from that presented by Bartlett (1950) in his thesis on that township. Most of the difference is due to the addition of more control points in the township.

Meigs Creek (No. 9) Coal Member

The Meigs Creek (No. 9) coal in Morgan County (fig. 18) varies from an inconspicuous bed in the western part of the county to a well-developed bed in the eastern part. Numerous control points are available in the latter area, and only a relatively few in the western part of the county. Data for the control points in Noble County were taken from maps in the files of the Geological Survey of Ohio, and have been added to this map to give a more complete interpretation.

The Meigs Creek coal dips southeastward across Morgan County at an average rate of 24 feet per mile. The contour interpretation shows the plunge of the Parkersburg-Lorain synclinal area to the southeast and south.

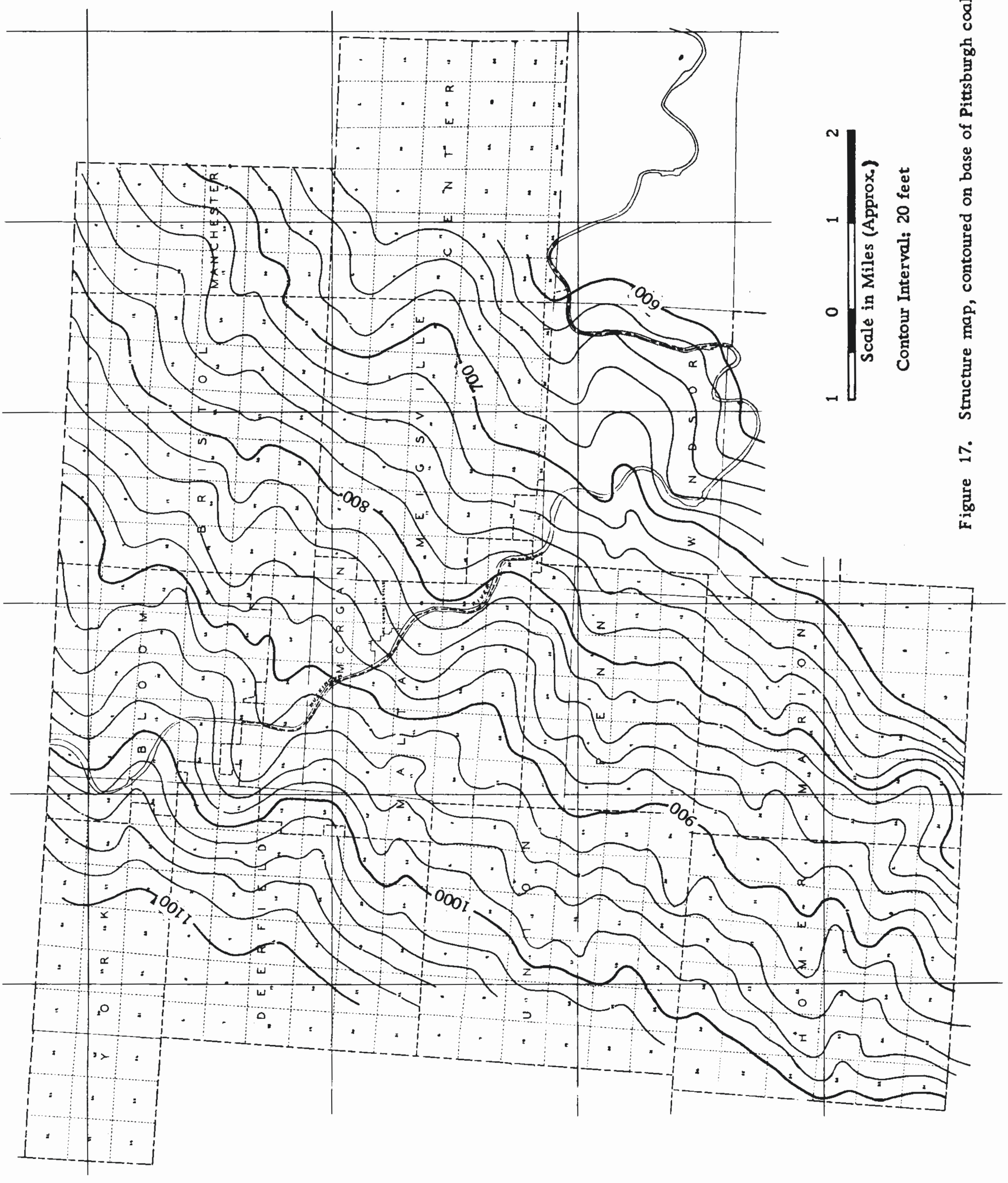


Figure 17. Structure map, contoured on base of Pittsburgh coal.

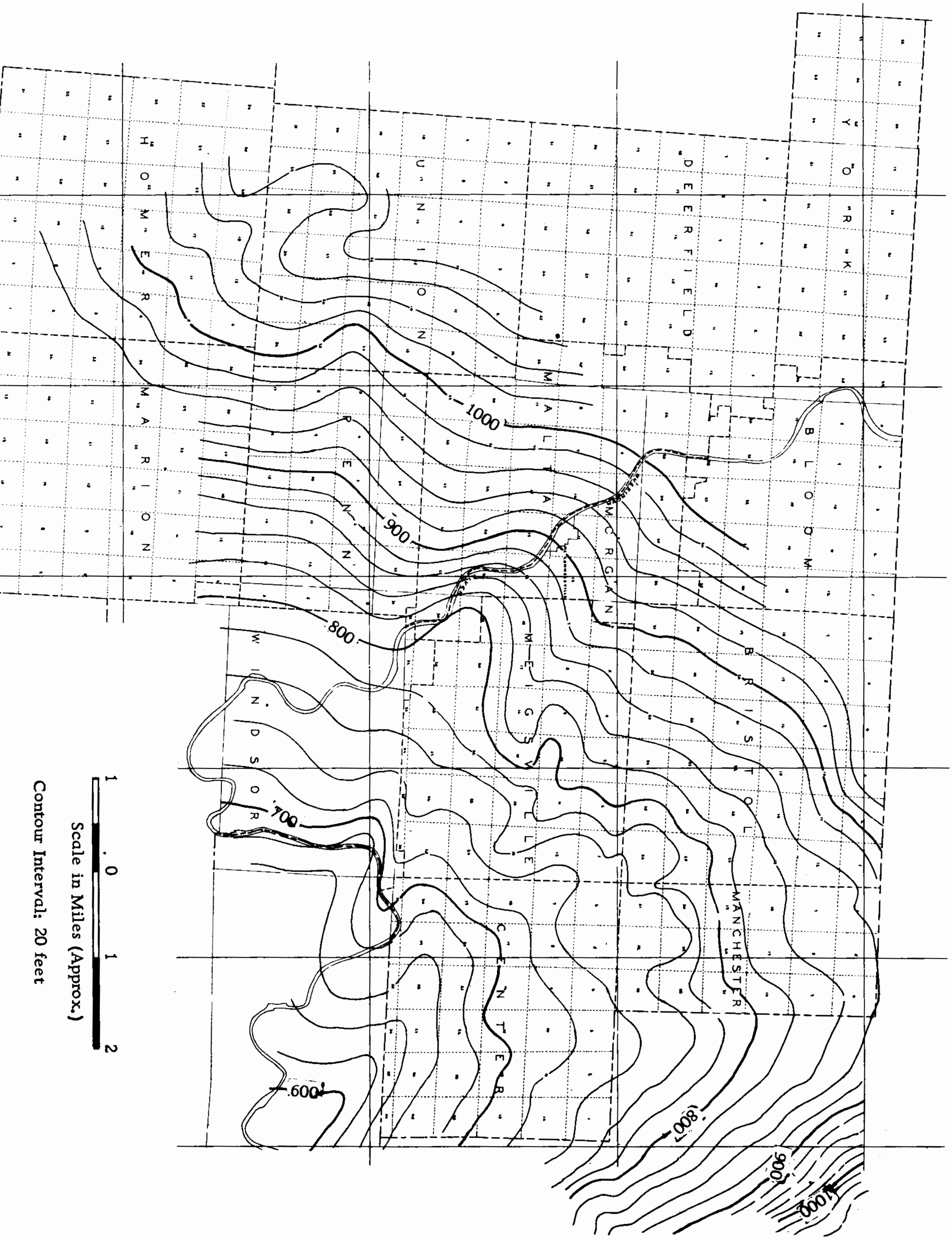


Figure 18. Structure map, contoured on base of Meigs Creek coal.

CHAPTER 5

ECONOMIC RESOURCES

GENERAL

The surface rocks in Morgan County are important mainly for the layers of coal, some of which are sufficiently thick and persistent locally to warrant commercial mining by stripping or by drifts. Some sections of sandstone and limestone have been quarried for local building stone and for road material. The clays are thin and impure and have not been used for ceramic purposes.

Some of the subsurface rocks yield commercial petroleum and natural gas, and, in former years, yielded the brines for the salt industry.

In general, Morgan County has not been as important industrially as some of the adjoining counties.

COAL

General

The coal members in the Pennsylvanian and Permian rock section in Morgan County, in ascending order, are:

Pennsylvanian System
- Allegheny Series
  - Lower Kittanning (No. 5)
  - Middle Kittanning (No. 6)
  - Upper Kittanning
  - Lower Freeport (No. 6-A)
  - Bolivar
  - Upper Freeport (No. 7)
- Conemaugh Series
  - Mahoning
  - Mason
  - Brush Creek ?
  - Wilgus
  - Anderson
  - Barton
  - Harlem
  - Duquesne
  - Elk Lick
  - Clarksburg

Lower Little Pittsburgh
Upper Little Pittsburgh

Monongahela Series
Pittsburgh (No. 8)
Redstone (Pomeroy) (No. 8-A)
Fishpot (No. 8-B)
Meigs Creek (No. 9)
Arnoldsburg
Uniontown (No. 10)
Little Waynesburg (No. 10-A)
Waynesburg (No. 11)

Permian System
Washington Series
Waynesburg "A" (No. 11-A)
Little Washington
Washington

Only four of these coals are important commercially in Morgan County: the Middle Kittanning (No. 6) and Upper Freeport (No. 7) coals of the Allegheny series; the Pittsburgh (No. 8) and Meigs Creek (No. 9) coals of the Monongahela. All of the other coals are either absent locally, poorly developed, or too thin to be important industrially. A few of these beds, i. e., the Anderson, Harlem, Barton, Uniontown, and Waynesburg "A", are mined locally for farm use.

The Upper Freeport, Lower Freeport, Middle Kittanning, and Lower Kittanning coals are mined in the Crooksville coal field, which extends from Perry and Muskingum Counties into western York Township in the northwestern corner of Morgan County. The Lower Kittanning coal is not exposed in the county, but is reported to have been mined along with the higher coals in some mines. Commercial mining in Morgan County sector of the Crooksville field has been abandoned. The last mine was being abandoned when the area was studied in 1949.

The Pittsburgh (No. 8) coal in Homer and Marion Townships in the southwestern part of the county is a part of the Federal or Federal Creek coal field, which extends into Athens County. This field has been of major importance since the construction of the first railroad into the area in 1885. Much of the commercially available coal had been removed by stripping by the summer of 1949, although one stripping operation and several drift mines were still in operation at that time. In other parts of the county the Pittsburgh coal is mined for local farm use.

The Meigs Creek (No. 9) coal is present in commercial thickness throughout most of eastern Morgan County, and is mined on both a small-scale and a commercial basis.

Lower Kittanning (No. 5) Coal Member

The Lower Kittanning (No. 5) coal does not crop out in Morgan County. It should be present a short distance below the surface in the western part of York Township. It is reported that the coal was mined to a limited extent along with the overlying Middle Kittanning (No. 6) coal and the Upper Freeport (No. 7) coal in some mines in the Crooksville field.

Brant (1954, pp. 37-38) concludes that the Lower Kittanning coal, in thicknesses up to 28 inches or more, occurs in the subsurface in southern York and western Deerfield Townships in Morgan County. He estimates the original reserves of the coal in the county as 100,413,000 short tons (Brant, 1954, table 20, p. 36).

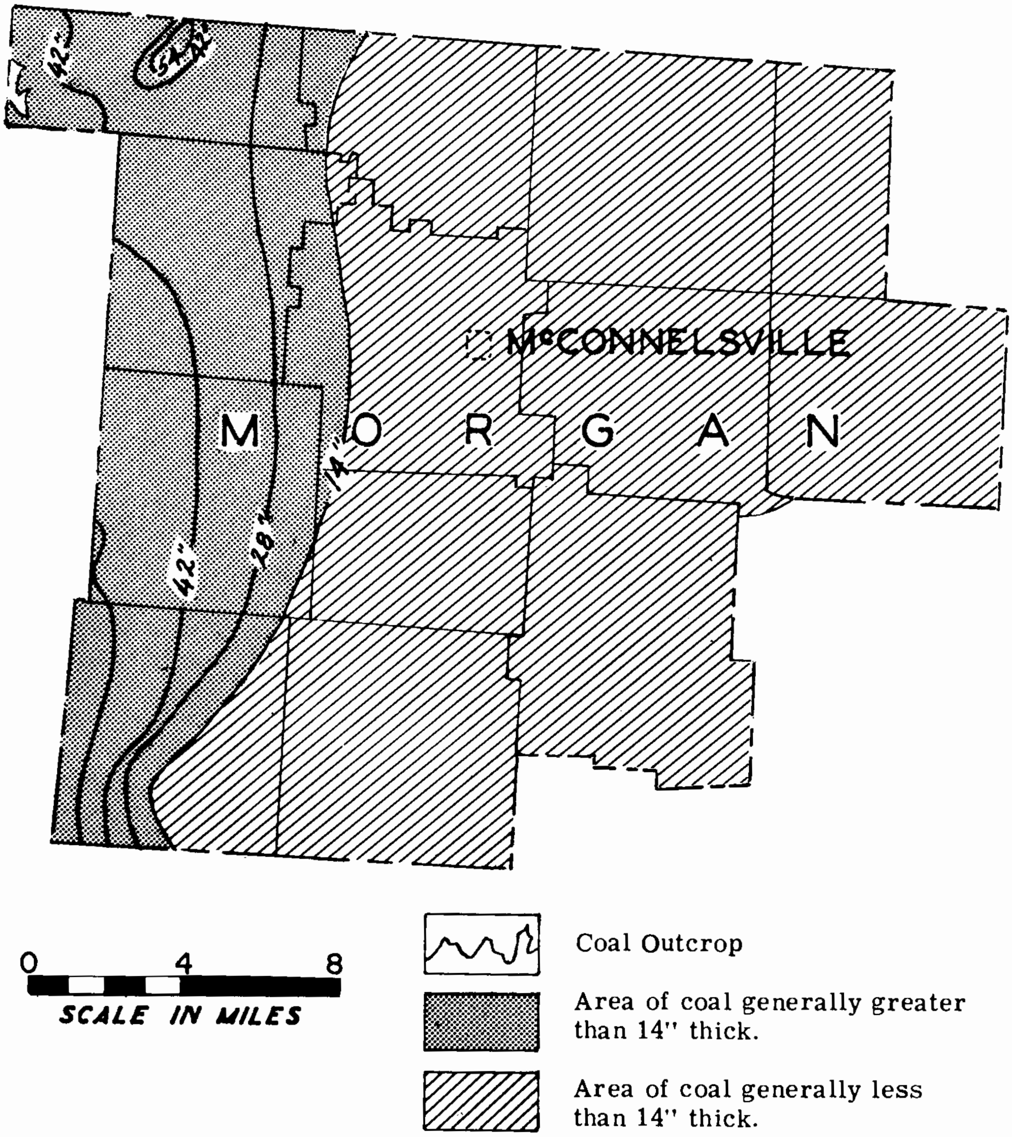


Figure 19. - Isopach map of the Middle Kittanning coal in Morgan County.

Middle Kittanning (No. 6) Coal Member

The Middle Kittanning (No. 6) coal is present in Morgan County in the valleys of Black Fork and Dry Run in western York Township, and represents the extension of the Crooksville coal field into the county. Outcrops are poorly exposed at the present time because of the extensive mining. The line of outcrop is shown on the Geologic Map (plate I). Figure 19 shows the interpretation of thickness variation of the Middle Kittanning coal in Morgan County. The eastern boundary of minable coal (14" line) is, in part, arbitrary and reflects lack of data rather than known thinning of the coal. The thickest section measured totaled 4 feet 8 inches. Brant (1956, p. 50) reports the presence of 5 feet 6 inches of coal in a core hole in York Township. The coal is present to the south and southeast under progressively thicker cover, but has not been mined. It is reported in some of the logs of wells drilled for petroleum and natural gas.

In the southwestern part of the county, in western Homer and Union Townships, the Middle Kittanning coal has been reported in a number of core holes. This coal has been mined extensively in the Hocking Valley coal field of eastern Perry County, where the coal averages approximately 5 feet in thickness. Maps of this coal field by F. A. Ray are shown by Bownocker (1917, pl. III, p. 52), and Bownocker and Dean (1929, map 3, facing p. 72). The Middle Kittanning coal in Morgan County is separated from the main coal field by an area of no coal development commonly known as the "Jumbo fault" area. Bownocker (1917, p. 52) stated, "The map by F. A. Ray shows for the first time the Jumbo 'fault,' which is not a fault at all in the technical sense, but an area where the coal is cut out by sandstone or other rock. The cutting appears to have been the work of streams whose current swept away the accumulated vegetal material and deposited in its place sand and mud." Bownocker (1917, p. 52) further stated, "The coal comes in again just east of the fault in Homer, Union, and Marion townships, but is thin...."

Bartlett (1950, p. 77) reported that the Middle Kittanning coal occurs about 175 to 200 feet below the surface in the Sunday Creek Valley in Union Township.

Brant (1956, table 38, p. 50) summarizes the estimated original reserves of the Middle Kittanning (No. 6) coal under several reliability categories for different thickness groupings. He computes a total of 446,291,000 short tons of original coal in Morgan County. The coal occurrence is shown on a map in Brant's report (1956, p. 47) and in the present report by figure 19.

Representative analyses of the Middle Kittanning coal from mines in adjoining portions of Athens, Perry, and Muskingum Counties are presented in Appendix A.

Upper Freeport (No. 7) Coal Member

The Upper Freeport (No. 7) coal is exposed in a few localities in western York Township in Morgan County. The line of outcrop is shown on the Geologic Map (plate I) and figure 20 shows the interpretation of thickness variation of the Upper Freeport coal in Morgan County. The eastern boundary of minable coal (14" line) is, in part, arbitrary and reflects lack of data rather than known thinning of the coal. The thickest section measured totals 3 feet of coal and carbonaceous shale.

Bartlett (1950, p. 77) states that the coal occurs from 10 to 30 feet below the surface in the Sunday Creek Valley in Union Township, and gives an approximate thickness of 3 feet for the zone.

Brant (1956, fig. 16, p. 49) shows a map of coal occurrence which reveals a thickness of over 54 inches of Upper Freeport coal in the southwestern corner of Union Township (see also fig. 20 of the present report). Brant computes the total estimated original reserves of the coal in Morgan County at 41,202,000 short tons (1956, table 39, p. 50).

Representative analyses of the Upper Freeport coal from mines in the adjoining portion of Muskingum County are given in Appendix B.

Pittsburgh (No. 8) Coal Member

The Pittsburgh (No. 8) coal has been one of the most important economic products of Morgan County. The line of outcrop is shown on the Geologic Map (plate 1) and figure 21 shows the interpretation of thickness variation of the Pittsburgh coal in Morgan County. The eastern boundary of minable coal (14" line) is, in part, arbitrary and reflects lack of data rather than known thinning of the coal. Coal thicknesses from 5 to 9 feet occur in the Federal Creek coal

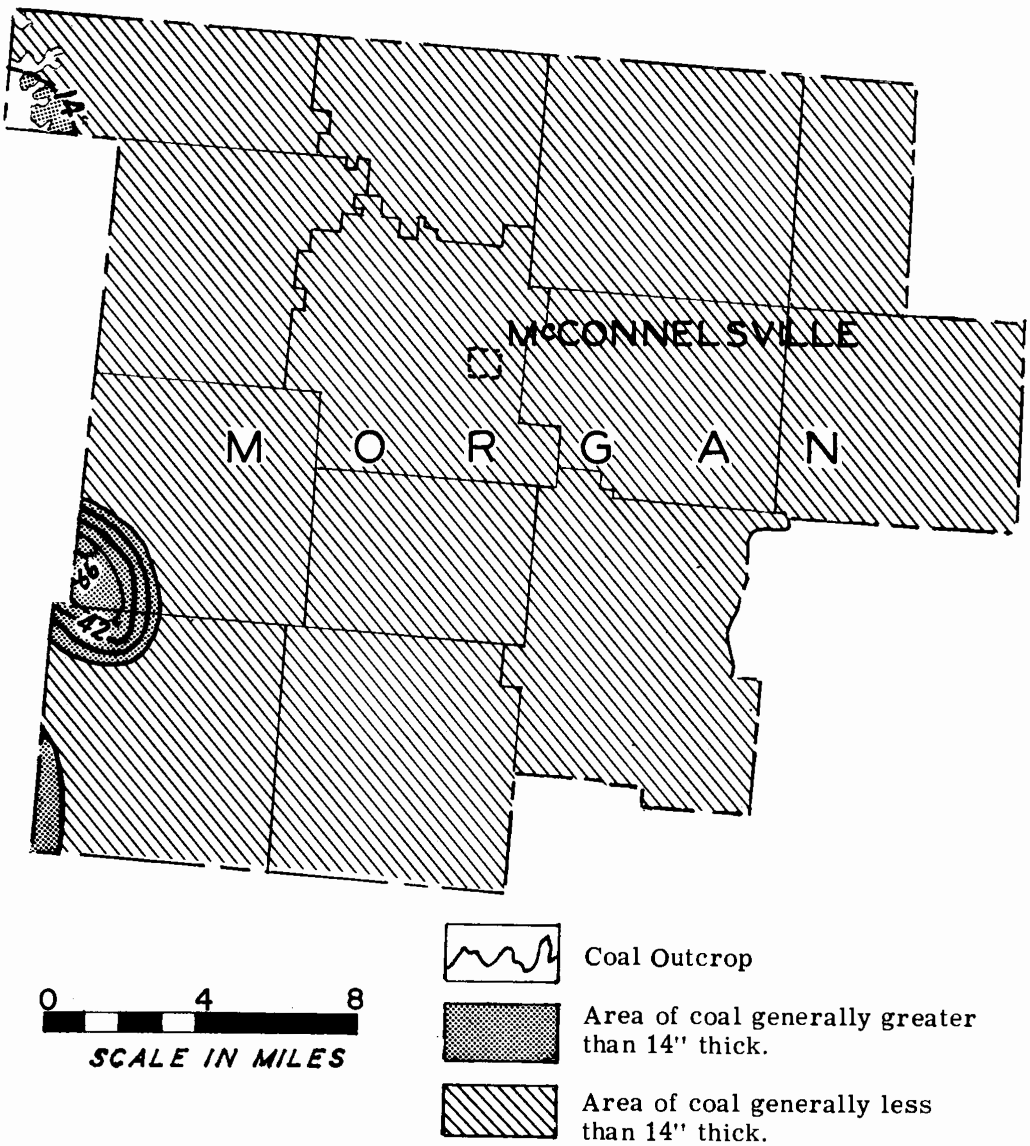


Figure 20. - Isopach map of the Upper Freeport coal in Morgan County.

field in Homer and Marion Townships, and the occurrence of thicknesses of 1 foot 6 inches to 2 feet 6 inches in Union, Meigsville, and Bristol Townships. In most of the county the coal is represented only by thin streaks of coal and coaly streaks.

The change from thick coal bodies to thin streaks is rapid. A notable change is that from mined seams of 8 to 9 feet thick in sections 9 and 15 in Homer Township to no coal in the center of section 14 of the same township. This rapid change occurs within a distance of a little more than a half mile. Some of these changes are portrayed on the stratigraphic cross sections (figs. 6 and 8).

In the Morgan County sector of the Federal Creek coal field the Pittsburgh coal is present usually in the two benches which are characteristic of that field. The coal in this area occurs high in the hills and ridges, and has been stripped extensively. At the time the area was being studied in 1949 there were in operation one commercial strip and several drift mines. In other parts of the county mining was being done locally for farm use.

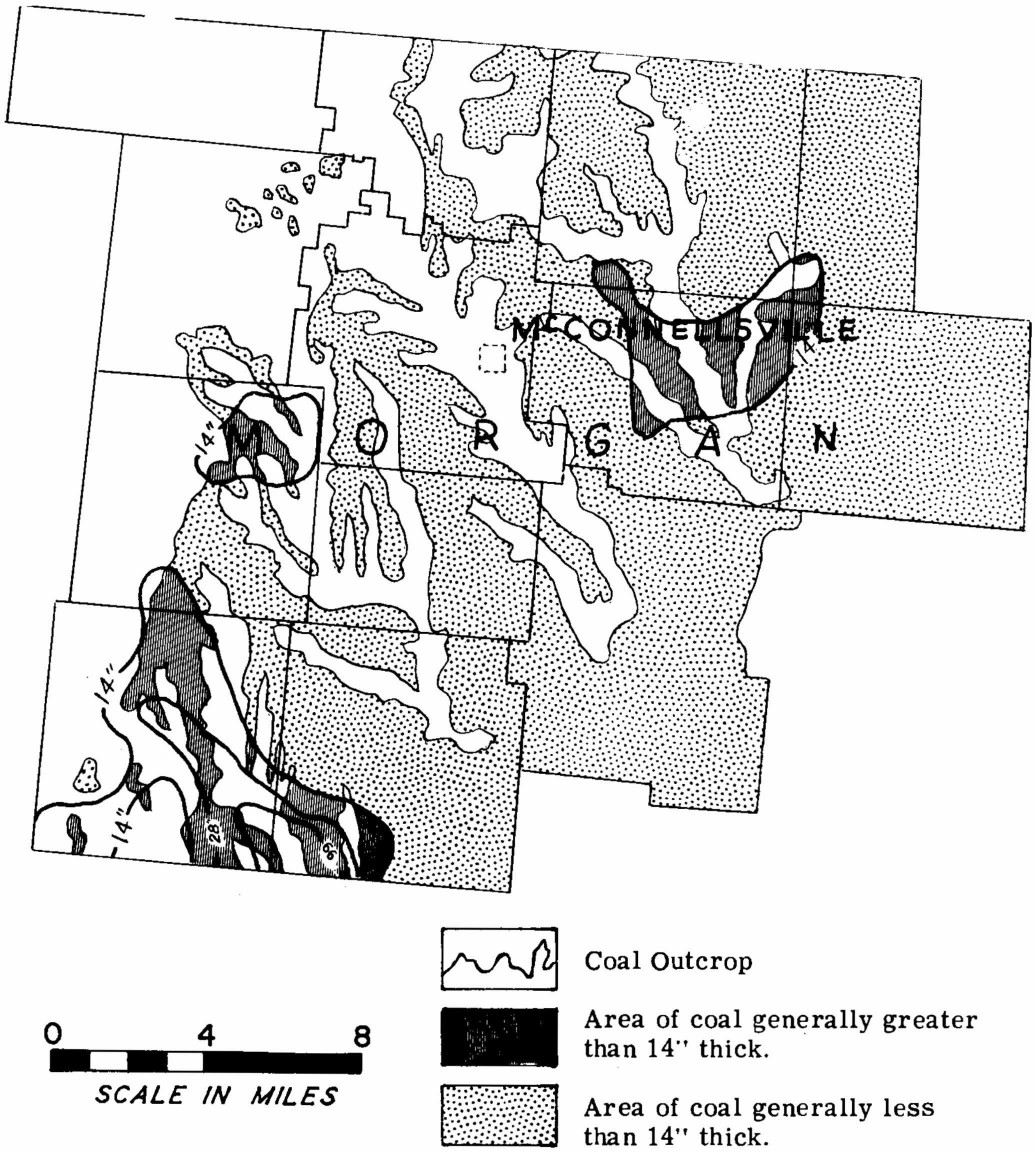


Figure 21. - Isopach map of the Pittsburgh coal in Morgan County.

DeLong (1955, fig. 8, p. 29) presents a coal development map of the county, and in a table of estimated original coal reserves, arranged in several thickness groupings according to the reliability categories, computes the total coal reserves as 82,463,000 short tons (1955, table 14, p. 30).

Representative analyses of the Pittsburgh coal in Homer Township are given in Appendix C.

Meigs Creek (No. 9) Coal Member

The Meigs Creek (No. 9) coal has been an important economic product of Morgan County. The line of outcrop is shown on the Geologic Map (plate I) and figure 22 shows the interpretation of the thickness variation of the Meigs Creek coal in Morgan County. The area of coal depicted

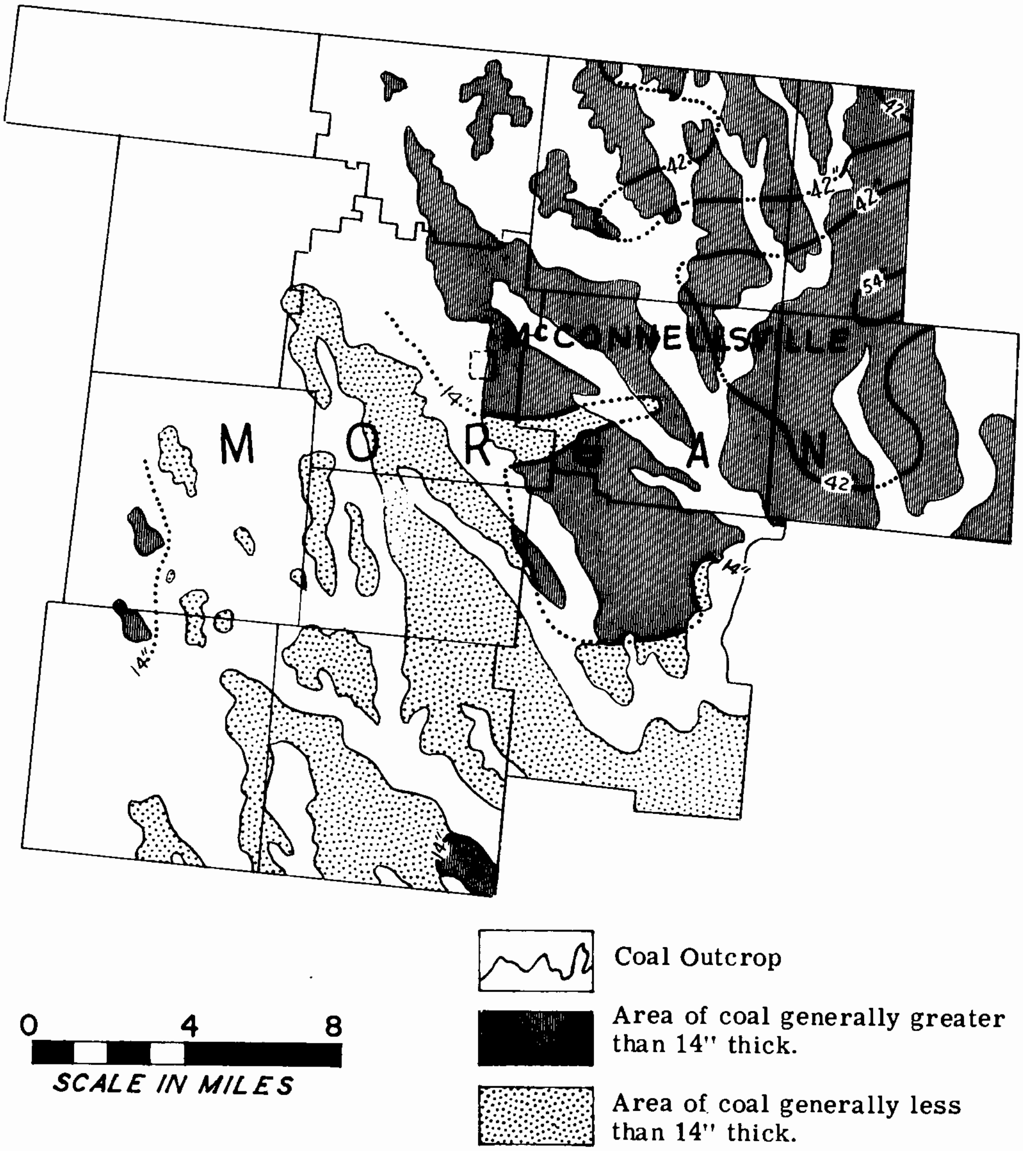


Figure 22. - Isopach map of the Meigs Creek coal in Morgan County.

as being generally less than 14 inches thick is, in part, arbitrary and reflects lack of data rather than known thinning of the coal. Minable coal thickness, to a maximum of 8 feet 5 inches, occurs in Manchester, eastern Bristol, Meigsville, and Center Townships, and the general thinness of the coal is to the west, south, and southwest of those townships. The Meigs Creek coal is developed locally in fairly thick sections in central Union and northwestern Homer Townships, but contains much more shale than in the northeastern part of the county.

Mining of the Meigs Creek coal by drift and stripping operations has continued in Morgan County for many years. The Reinersville area in Manchester Township has been a mining center for over 80 years. A number of small-scale and a few commercial mines were active in the county when the area was studied in 1949.

There is an estimated original reserve of 330,342,000 short tons of Meigs Creek coal in Morgan County (Smith, Brant, and Amos, 1952, p. 20). Representative analyses of the Meigs Creek coal are given in Appendix D.

CLAY

The clays of Morgan County have little economic value. Most of the clays are thin and impure. They are high in iron content, mainly in finely divided state, and are often quite calcareous or sandy. Stout (1923) has described the coal formation clays and their uses in Ohio, and stated that although some clays are developed in Morgan County, they have not been utilized because of their impurities and thinness. In a table in Stout's report (1923, p. 15) there is a reference to the listing in the Federal Government Sixth Census in 1840 of one pottery in Morgan County. The source of the clay was not given. Stout (1931, p. 197) stated, "Clay of some kind and of some thickness is found below every coal throughout the entire system. The high-grade coal formation clays, those of best economic value, are in the Pottsville and Allegheny series, or that portion of the Pennsylvanian section between the Sharon and Strasburg coals. This part is below the first fresh-water limestone, which occurs at the base of the Middle Kittanning coal. In this portion is found not only the purest plastic clays but also the most refractory flint and semi-flint clays. Clays of somewhat less ceramic value are present in the upper Allegheny and lower Conemaugh series, or between the Strasburg coal and the Ames limestone. Throughout this part of the section, where both marine and fresh-water limestones are present, the clays are generally contaminated with more or less calcareous matter. In Ohio, no clays above the Ames limestone are worked. This part of the Pennsylvanian system is entirely of fresh-water origin, and the clays are calcareous and in many cases only a few inches thick."

SANDSTONE

The Pennsylvanian and Permian rocks in Morgan County contain thick bodies of sandstone. Most of the sandstones are shaly, and are not particularly suitable for construction stone as they do not withstand continued weathering. Some of the more massive sandstones are more firmly cemented, and in local areas have been quarried on a small scale. Small quarries, which have been abandoned for many years, are to be found locally along the outcrop of many of the sandstones. Most of the stone has been used for general farm purposes in the construction of flagstone walks, steps, and walls; for small farm buildings, and occasionally for farm homes. Some of the larger blocks have been used for local bridge abutments and road culverts.

Commercial quarrying has not been of importance, except in the case of the Cow Run sandstone, which was quarried extensively years ago along the Muskingum River in southern Muskingum County and northern Morgan County. Stone from these quarries was used in the construction of canal locks, bridge piers and abutments, building foundations, and retaining walls. When the canal was in operation, the stone was shipped by boat to outside markets in eastern Ohio.

In the subsurface the Cow Run sandstone has been of importance as an oil reservoir. The subsurface Cow Run undoubtedly includes, at least locally, the Saltsburg and Buffalo sandstones.

LIMESTONE

The limestones in Morgan County are important economically mainly as sources of road material and agricultural lime. Commercial quarries in the thick limestones of the upper Conemaugh and the Monongahela have yielded much crushed stone for road construction. Some limestone beds, which are chemically suitable, are crushed for agricultural lime. One quarry operator stated that a small amount of crushed product was used locally for cement manufacture.

Small abandoned quarries are to be found along the outcrops of many of the thick limestones.

The stone was used mainly for farm purposes, but some local stone can be seen in bridge abutments and retaining walls, and in building foundations.

Some of the more chemically pure limestones could be used for industrial purposes, but have not been so used because of their thinness and the availability of thicker bodies elsewhere. An analysis of the Ames limestone from the Bishopville area is given earlier in this report (p. 54).

WATER

Potable water has not been a serious problem in Morgan County. The county is traversed by a network of permanent streams which serve as water sources for many farms. Other farms derive their supply from springs, which are fairly abundant in the county and which maintain a small but constant flow. Many farms are supplied through shallow wells. The construction of two reservoirs in the Wolf Creek and Sunday Creek valleys in southwestern Morgan County will afford adequate future industrial and domestic supplies in that portion of the county.

Farms and villages along the Muskingum River derive their supply from shallow wells in the valley fill.

Stout (1943, pp. 478-480) gives the water sources of the following villages and towns in Morgan County as follows:

Chesterhill	-	Small wells in Waynesburg sandstone. Brines at depth of 300 feet.
Malta	-	Ground water; untreated in 1941. Brines at depth of 300 feet or less.
McConnelsville	-	Wells in flood plain of Muskingum River, 42 feet deep; in gravel below layer of "hard pan." Untreated in 1941. Brines at depth of 300 feet. Water supply established in 1899.
Pennsville	-	Common wells. Brines at depth of 300 feet.
Stockport	-	Wells in flood plain of Muskingum River. Brines at depth of 300 feet.

SALT (BRINES)

The recovery of salt from brines was once a main industry in Morgan County, but today is of interest only from an historical viewpoint. Some of the aspects and color of the once flourishing industry can be presented best by quotations from some of the early publications of the Geological Survey of Ohio:

Andrews (1873, p. 295) states, "Salt is now one of the most important of the products of the county.....on Duck Creek in Washington and Noble counties, good brine is obtained in sand rocks interstratified with the Coal Measures, and consequently nearer the surface; and it is highly probable that the same is true in Morgan County."

Root (1888, p. 655) wrote of the salt industry, "The salt industry in Morgan County is centered along the Muskingum River, in the vicinity of Eagleport, about 10 miles above McConnelsville. There is one furnace active below McConnelsville. The valley of the Muskingum River is the pioneer territory in Ohio in the production of salt.

"Thirty-seven (37) furnaces once flourished along the river. Of this number but four remain. The most of these furnaces were built to burn the wood from the native forests, and they remain as they were built, the industry in later years not warranting further investment. They are kettle furnaces throughout, and of small capacity, the four furnaces representing a total daily capacity of 80 or 90 barrels only. The wells at Eagleport average about 700 feet in depth. The brine stands at about 7½ degrees Baume as it comes from the wells. The brines grow stronger and the wells deeper in descending the river. The brines at Eagleport are quite pure, yielding a small quantity of bitter water. A small percentage of iron is present, and is eliminated by a process peculiar to this locality, called the blood process of settling.....

"The Middle Kittanning coal furnishes fuel for the industry. The seam is worked above Eagleport near Zanesville, and the coal transported to the furnaces by boat. Slack coal is used when possible to secure it. At other times the furnaces use "mine Run." They consume from 6 to 8 tons daily each, and realize about three barrels (280 pounds per barrel, DLN) of salt to the ton of coal. With the source of fuel so far removed, the weak brines and primitive process of manufacture, it is only a question of time until the salt industry will be a thing of the past in this valley. The salt produced is of fair quality, but lacking somewhat in uniformity. The product finds a market mainly in Zanesville, and in small towns along the river."

Nearly twenty years later, Bownocker (1906, pp. 13-15) wrote, "The valley of the Muskingum..... is one of the oldest producers in the state. It appears that several furnaces were in operation as early as 1825. The brines, however, were weak, having a density of only 7½ degrees Baume.. Moreover, when the supply of wood became inadequate and coal was necessary, the furnaces were at a further disadvantage because the coal had to be transported some distance, thus adding to the expense. Since the Civil War the industry has declined until at present (1905) one furnace alone remains. This is located at Durant on the Muskingum River in the extreme northern part of the county. As late as the summer of 1903 the furnace was of the type of that of a half century ago, and was known as the Big Bloom Salt Works. The brine was evaporated in iron kettles, 31 in number, each holding 90 gallons. Beef's blood was the clarifying agent, and in other respects the process was similar to that of the pioneer days of the salt industry. The capacity of the plant was reported at 30 barrels of salt per day.

"When this locality was revisited in August, 1904, the old plant had disappeared, but a new one stood nearby. It was operated by the Muskingum River Salt and Coal Company, the capacity being 20 barrels per day. The plant had two vats, each 60 x 20 x 6 feet, and two grainers, each 16 x 10 x 2½ feet. The brine is evaporated by live steam, the fuel being coal. Beef's blood is still used as the clarifying agent, this being the only plant in Ohio retaining this primitive method. The brine which is obtained in the Salt sand is supplied by two wells having depths approximately 670 feet. The well heads are about 50 feet above the Middle Kittanning coal."

Several pictures of the interior and exterior of this salt plant at Durant are included in the work of Bownocker.

During the summers of 1948 and 1949, the writer found no evidence of the early salt plants, and did not find any county resident who had first-hand knowledge of the plants.

PETROLEUM AND NATURAL GAS

Oil was discovered in Morgan County shortly after the pioneer well of the industry was completed in 1859 by Drake at Titusville, Pennsylvania. Oil and gas showings had been encountered in early brine wells in a number of areas in southeastern Ohio, and there was a lively trade in "Seneka" or "Seneca" oil for medicinal purposes as early as 1847. Stout (1918, pp. 4-5) refers to oil and gas showings in a brine well as early as 1814 at Olive, just east of Caldwell in Noble County. A number of oil seeps were known, including those in Oil Spring Run, in Havener's or Gillespie Run, in Buck Run, and along Wolf Creek in Morgan County.

Thus attention was centered in Washington, Morgan, and Noble Counties as soon as the news of the Titusville discovery was available. The first commercial drilling for oil in Ohio was in 1860 in the Macksburg area in Washington County (Minshall, 1888). This was followed by the discovery of production in June 1861 near Joy in southeastern Homer Township, Morgan County. Early exploitation efforts and methods were discussed by Andrews (1873, pp. 297-304), Lovejoy (1888, p. 635), and Orton (1888, pp. 311-409). Magbee and Alkire (1954) have summarized the oil and gas industry in Morgan County in a comprehensive report, complete with discussions of the individual producing zones and of the exploitation in each township.

The early development of the Chesterhill and Buck Run fields of Homer, Marion, Windsor, and Union Townships in Morgan County was discussed at some length by Bownocker (1903, pp. 126-144), and by Magbee and Alkire (1954). Maps of some of the early fields are included in Bownocker's work. The Chesterhill and Buck Run fields produce from shallow depths in the Cow Run sandstone, which in the subsurface must include, at least locally, the Saltsburg and Buffalo sandstone sections. The term Cow Run was applied by drillers to almost any shallow sandstone which was oil or gas bearing.

During the years 1861 to 1864 the drilling of shallow wells spread over most of western and southern Morgan County with the discovery of a number of producing areas. The yield from most of these wells was small, although some wells apparently were quite prolific. Many of the wells were productive for relatively short periods, while others have had a long productive history. The writer was informed in 1949 by local residents that several wells in Oil Spring Run were still producing small amounts of oil after 75 years. No record was kept of the location or production history of most of these shallow wells.

The Cow Run sandstone is of interest also as the zone in which the pioneer attempts of producing oil by horizontal drilling were made. In Havener's or Gillespie Run in section 32, T 11 N, R 12 W, Malta Township, northwest of McConnelsville, oil-stained Cow Run sandstone crops out in a small cliff face. The stratigraphic section at this locality is given earlier in this report (p. 44). Into this old seep the Ohio Levelwell Company and Leo Ranney drilled horizontally in the experimental stages of the development of the new technique in 1937. A short distance upstream the first commercial attempt was made to apply the new drilling technique. Ranney constructed a circular shaft about 30 feet in diameter and about 30 feet deep. This shaft was lined with concrete. The drilling equipment was installed in the bottom of the shaft, and four wells were drilled horizontally into the Cow Run sandstone. The first two wells were cored. When the writer visited the area in 1948 and again in 1949 piles of core fragments were near the shaft. The core pieces revealed a remarkable variation in grain size, and in the amount and extent of oil staining.

The "longest" or "deepest" well was reported by residents in the area to be 1,734 feet into the Cow Run sandstone. The end of the hole was approximately five inches higher than the well head in the shaft. Thus, the oil would drain by gravity into a sump pin beneath a wooden floor in the shaft. The procedure was designed so that when the sump contained a sufficient amount of oil it was pumped to the surface into barrels for marketing. The quantity of oil produced naturally by gravity was small. When the shaft was visited by the writer in 1948 two of the original wells were producing a small amount of oil under vacuum. When revisited a year later, the project had been abandoned, and the shaft was filled partially with water. This horizontal drilling project was discussed by Magbee and Alkire (1954, pp. 47-50).

A second attempt to produce oil by horizontal drilling is located along Buck Run in south central section 2 in Union Township, where a bell-shaped shaft was constructed to the base of the Cow Run sandstone at a depth of 110 feet. This project is situated in the old Buck Run field Six horizontal wells are reported to have been drilled at this site, and were producing a small amount of oil by gravity drainage when the area was visited by Bartlett and the writer in 1949.

Bartlett (1950, p. 81) reports that the construction of this shaft was preceded by the drilling of a horizontal well 1,070 feet into the Cow Run sandstone in an exposure in a small ravine in section 16, Union Township.

As the Cow Run production was being developed in Morgan County, some wells were drilled deeper into sandstones of Mississippian age. Orton (1888, pp. 389-390) reported wells drilled in 1885 to 1887 to the Logan sandstone near Malta, and to the Berea sandstone near Joy, Homer Township, and on Island Run in Deerfield Township. Bownocker (1903, pp. 144-148) reported on the early development of gas from the Berea in the McConnelsville area. Areas of production of gas and oil from the First and Second Berea sandstone sections are demarcated on the oil and gas map of the state (Alkire, 1948), and are discussed in some detail by Magbee and Alkire (1954).

Drilling in Morgan County during the years has resulted in the discovery of oil or gas production in 16 to 18 different zones ranging in age from middle Pennsylvanian to lower Silurian. Numerous subsurface names have been applied to these productive zones, and the terminology has been a problem for years. Magbee and Alkire (1954) have shown the correlation of some of these subsurface names with the geologic terminology. Ten of these productive zones are Pennsylvanian in age, and include such subsurface sandstones as the Peeker, Cow Run, Macksburg, Salt, Brill, and Maxton. Four other zones are Mississippian in age, and include the subsurface Keener, Big Injun, and Berea sandstones. The Oriskany sandstone of Devonian age and the Newburg zone of Silurian age have yielded showings of gas in Morgan County. The Clinton and Medina sandstones of lower Silurian age are the lowest producing zones in the county. The Clinton sandstone, a subsurface unit and stratigraphically lower than the outcropping Clinton of New York state, is a major gas-producing zone in Ohio. Production in the Clinton has been found in York and Bloom Townships, Morgan County. The producing zones in Morgan County are listed and discussed by Magbee and Alkire (1954, chapter 2).

BIBLIOGRAPHY

Andrews, E. B., 1873, Geology of Morgan County, Ohio: Geol. Survey of Ohio vol. I, pt. I, Geology, chpt. XI, p. 294-313.

Alkire, Robert L., 1948, Oil and gas fields of Ohio: Map published by Geol. Survey of Ohio.

Bartlett, John D., 1950, The geology of Union Township, Morgan County, Ohio: The Ohio State University, unpublished Master of Science Thesis.

Bownocker, J. A., 1903, The occurrence and exploitation of petroleum and natural gas in Ohio: Geol. Survey of Ohio, 4th series, Bull. 1.

______________, 1906, Salt deposits and the salt industry in Ohio: Geol. Survey of Ohio, 4th series, Bull. 8.

______________, 1915, Building stones of Ohio: Geol. Survey of Ohio, 4th series, Bull. 18.

______________, 1917, The coal fields of Ohio: U. S. Geol. Survey Prof. Paper 100-B.

Bownocker, J. A. and Dean, Ethel S., 1929, Analyses of the coals of Ohio: Geol. Survey of Ohio, 4th series, Bull. 34.

Bownocker, J. A. and Lord, N. W., and Somermeier, E. E., 1908, Coal: Geol. Survey of Ohio, 4th series, Bull. 9.

Brant, Russell A., 1954, The Lower Kittanning No. 5 coal bed in Ohio: Geol. Survey of Ohio Rept. Inves. No. 21.

______________, 1956, Coal resources of the upper part of the Allegheny formation in Ohio: Geol. Survey of Ohio Rept. Inves. No. 29.

Brown, C. Newton, 1884, The Meigs Creek coal seam in Morgan, Muskingum, Guernsey, and Noble Counties: Geol. Survey of Ohio vol. V, Economic Geology, chpt. XIX, p. 1059-1085.

Condit, D. Dale, 1912, Conemaugh formation in Ohio: Geol. Survey of Ohio, 4th series, Bull. 17.

Dean, Ethel S., compiler, 1948, Additional analyses of coals in Ohio: Geol. Survey of Ohio Rept. Inves. No. 4.

DeLong, Richard M., 1955, The Pittsburgh No. 8 and Redstone No. 8-A coal beds in Ohio: Geol. Survey of Ohio Rept. Inves. No. 26.

______________, 1957, Coal resources of the lower part of the Allegheny formation in Ohio: Geol. Survey of Ohio Rept. Inves. No. 31.

Fenneman, N. M., and Johnson, D. W., 1946, Physical divisions of the United States: Map prepared in cooperation with the Physiographic Committee of the Geological Survey.

Flint, Norman K., 1948, Geologic map of Perry County, Ohio: Geol. Survey of Ohio.

_______________, 1951, Geology of Perry County, Ohio: Geol. Survey of Ohio, Bull. 48.

Fontaine, W. M., and White, I. C., 1880, The Permian or Upper Carboniferous flora of West Virginia and southwestern Pennsylvania: Second Pennsylvania Geol. Survey Rept. P-2.

Hildreth, S. P., 1837, Report of First Assistant Geologist: First Ann. Rept. of the Geol. Survey of Ohio, p. 25-54.

Lamborn, R. E., 1930, Geology of Jefferson County: Geol. Survey of Ohio, 4th series, Bull. 35.

Lovejoy, Ellis, 1888, The Pomeroy and Federal Creek coal field: Geol. Survey of Ohio vol. VI, chpt. XI, p. 627-652.

Magbee, Byron D., and Alkire, Robert L., 1954, Oil and gas in Morgan County, Ohio: Geol. Survey of Ohio Rept. Inves. No. 22, Petrol. and Nat. Gas Series No. 6.

Mark, Clara Gould, 1912, The fossils of the Conemaugh formation in Ohio: Geol. Survey of Ohio, 4th series, Bull. 17, chpt. V, p. 261-326.

Merrill, William M., 19[illegible], The geology of Green and Ward Townships, Hocking County, Ohio: The Ohio State University, unpublished Master of Arts thesis.

___________________, 1950, The geology of northern Hocking County, Ohio: The Ohio State University, unpublished Doctorate dissertation.

Minshall, F. W., 1888, The history and development of the Macksburg oil field: Geol. Survey of Ohio vol. VI, chpt. VI, p. 443-475.

National Research Council Committee on Stratigraphy, The Pennsylvanian Subcommittee, R. C. Moore, chairman, 1944, Correlation of Pennsylvanian formations of North America: Geol. Soc. Am. Bull., vol. 55, p. 657-706, June, chart 6.

Newberry, J. S., 1874, The Carboniferous system: Geol. Survey of Ohio vol. II, Geology and Paleontology, chpt. XXXI, p. 81-180.

Orton, Edward, 1884, The stratigraphical order of the Lower Coal Measures of Ohio: Geol. Survey of Ohio vol. V, chpt. 1, Economic Geology.

______________, 1888, Berea grit as a source of oil and gas in Ohio: Geol. Survey of Ohio vol. VI, p. 311-409.

Prosser, C. S., 1901, Names for the formations of the Ohio Coal Measures: Am. Jour. Sci., 4th series, vol. II, p. 199.

_______________, 1905, Revised nomenclature of the Ohio geological formations: Geol. Survey of Ohio, 4th series, Bull. 7.

Root, W. J., 1888, The manufacture of salt and bromine: Geol. Survey of Ohio vol. VI, chpt. XII, p. 655.

Sherman, C. E., 1925, Ohio Cooperative Topographic Survey Final Report, Vol. 3.

________________, 1933, Ohio Cooperative Topographic Survey Final Report, Vol. 4.

Smith, G. E., 1952, The Pittsburgh coal of the Federal Creek field: Geol. Survey of Ohio Rept. Inves. No. 14.

Smith, W. H., Brant, R. A., and Amos, F., 1952, The Meigs Creek No. 9 coal bed in Ohio: Geol. Survey of Ohio Rept. Inves. No. 17.

Stauffer, C. R., and Schroyer, C. R., 1920, The Dunkard series of Ohio: Geol. Survey of Ohio, 4th series, Bull. 22.

Stout, Wilber, 1918, Geology of Muskingum County: Geol. Survey of Ohio, 4th series, Bull. 21.

____________, 1931, Pennsylvanian cycles in Ohio: Illinois State Geol. Survey Bull. 60, p. 195-216.

____________, 1938, Mineral resources of Ohio: Geol. Survey of Ohio, 4th series, Infor. Circ. No. 1; Revised and enlarged, 1946.

____________, 1939, Generalized section of coal-bearing rocks of Ohio: Geol. Survey of Ohio, 4th series, Infor. Circ. No. 2; Reprinted from Bull. 34.

____________, 1943, Geology of water in Ohio: Geol. Survey of Ohio, 4th series, Bull. 44.

____________, 1944, The iron ore bearing formations of Ohio: Geol. Survey of Ohio, 4th series, Bull. 45.

____________, 1947, Generalized section of rocks in Ohio: Geol. Survey of Ohio, 4th series, Infor. Circ. No. 4; Reprinted from Bull. 44.

Stout, Wilber, and Lamb G. F., 1938, Physiographic features of southeastern Ohio: Ohio Jour. Sci. vol. XXXVIII, no. 2; Reprinted by Geol. Survey of Ohio as Reprint Series No. 1.

Stout, Wilber, and Lamborn, R. E., 1924, Geology of Columbiana County: Geol. Survey of Ohio, 4th series, Bull. 28.

Stout, Wilber, Stull, R. T., McCaughey, W. J., and Demorest, D. J., 1923, Coal formation clays of Ohio: Geol. Survey of Ohio, 4th series, Bull. 26.

Stout, Wilber, Ver Steeg, Karl, and Lamb, G. F., 1943, Old drainage systems: Geol. Survey of Ohio, 4th series, Bull. 44, chpt. II, p. 51-106.

Sturgeon, M. T., and Merrill, W. M., 1949, An additional fossiliferous member of the Allegheny formation (Pennsylvanian) of Ohio: Ohio Jour. Sci. vol. XLIX, no. 1; Reprinted by Geol. Survey of Ohio as Infor. Circ. No. 5.

Udden, J. A., 1912, Geology and mineral resources of the Peoria quadrangle, Illinois: U. S. Geol. Survey Bull. 506.

Wanless, Harold R., 1931, Pennsylvanian cycles in western Illinois: Illinois State Geol. Survey Bull. 60, p. 179-193.

________________, 1939, Pennsylvanian correlations in the eastern interior and Appalachian coal fields: Geol. Soc. Am. Sp. Paper 17.

Wanless, Harold R., et al., 1947, Symposium on Pennsylvanian problems: Jour. Geol. vol. 55, no. 3, pt. II, p. 183-308.

Wanless, Harold R., and Weller, J. Marvin, 1932, Correlation and extent of Pennsylvanian cyclothems: Geol. Soc. Am. Bull. vol. 43, p. 1003-1016.

Weller, J. Marvin, 1930, Cyclical sedimentation of the Pennsylvanian period and its significance: Jour. Geol. vol. 38, no. 2, p. 97-135.

Weller, J. Marvin, 1931, The conception of cyclical sedimentation during the Pennsylvanian period: Illinois State Geol. Survey Bull. 60, p. 163-177.

White, George W., 1947, Map of Meigs Creek coal in Caldwell quadrangle, Ohio: Geol. Survey of Ohio.

________________, 1947, Map of Meigs Creek coal in Cumberland quadrangle, Ohio: Geol. Survey of Ohio.

________________, 1947, Sections of Meigs Creek coal in Cumberland and Caldwell quadrangles, Ohio: Geol. Survey of Ohio.

Williams, H. S., 1891, Arkansas Geological Survey Ann. Rept., vol. 4, p. xiii.

______________, 1891, The Coal Measures or Pennsylvania(n) series: U. S. Geol. Survey Bull. 80, chpt. IV, p. 83-108.

Wilmarth M. Grace, 1925, The geologic time classification of the United States Geological Survey compared with other classifications, accompanied by the original definitions of era, period, and epoch terms: U. S. Geol. Survey Bull. 769.

_________________, 1938, Lexicon of geologic names of the United States: U. S. Geol. Survey Bull. 896, 2 vol.

APPENDIX A

REPRESENTATIVE ANALYSES OF MIDDLE KITTANNING (NO. 6) COAL

Published analyses of the Middle Kittanning (No. 6) coal in Morgan County were not located by the writer. The following analyses from mines in nearby townships in adjoining counties are presented here to serve as representative of the coal in the vicinity of Morgan County.

1. Muskingum County; Harrison Township, section 30 or 31. Wesley Wells Mine. Approximately along center of southern boundary of county, about a mile north of Morgan County line.

Proximate Analysis		Ultimate Analysis	
Moisture	4.67	Carbon	67.71
Volatile Matter	40.32	Hydrogen	5.38
Fixed Carbon	45.18	Oxygen	11.82
Ash	9.83	Nitrogen	1.16
		Sulphur	4.10
		Ash	9.83

Heating Value: Calories 6,873
B. t. u. 12,371

Source: Bownocker, Lord, and Somermeier, 1908, p. 221.
Stout, 1918, p. 203.
Sample taken by B. A. Eisenlohr, August 1902.

2. Perry County; Harrison Township; sections 20 and 29. Keystone Mine No. 1; Shaft Mine.

Proximate Analysis		Ultimate Analysis	
Moisture	7.21	Carbon	69.77
Volatile Matter	37.60	Hydrogen	5.60
Fixed Carbon	49.93	Oxygen	15.77
Ash	5.26	Nitrogen	1.26
		Sulphur	2.34
		Ash	5.26

Heating Value: Calories 7,008

Source: Bownocker, Lord, and Somermeier, 1908, p. 216.
Sample taken by B. A. Eisenlohr, July 1902.

3. Perry County; Bearfield Township, section 3. National Fuel Company, Mine 34, Shaft Mine.

Proximate Analysis		Ultimate Analysis	
Moisture	5.90	Carbon	65.43
Volatile Matter	36.58	Hydrogen	5.26

Proximate Analysis		Ultimate Analysis	
Fixed Carbon	47.42	Oxygen	13.03
Ash	10.10	Nitrogen	1.22
		Sulphur	4.96
		Ash	10.10

Heating Value: Calories 6,686

Source: Bownocker, Lord, and Somermeier, 1908, p. 215.
Sample taken by B. A. Eisenlohr, July 1902.

4. Perry County; Monroe Township, section 9.
S. C. C. Company Mine 8, Shaft Mine.

Proximate Analysis		Ultimate Analysis	
Moisture	6.69	Carbon	70.30
Volatile Matter	35.45	Hydrogen	5.49
Fixed Carbon	51.85	Oxygen	16.00
Ash	5.91	Nitrogen	1.30
		Sulphur	1.00
		Ash	5.91

Heating Value: Calories 6,983

Source: Bownocker, Lord, and Somermeier, 1908, p. 213.
Sample taken by B. A. Eisenlohr, July 1902.

5. Athens County; Trimble Township, section 8.
Continental Coal Company, Mine 4, Shaft 135 feet deep.

Proximate Analysis		Ultimate Analysis	
Moisture	7.28	Carbon	69.46
Volatile Matter	32.38	Hydrogen	5.45
Fixed Carbon	53.61	Oxygen	16.16
Ash	6.73	Nitrogen	1.34
		Sulphur	0.86
		Ash	6.73

Heating Value: Calories 6,894

Source: Bownocker, Lord, and Somermeier, 1908, p. 212.
Sample taken by B. A. Eisenlohr, July 1902.

6. Athens County; Dover Township, section 27.
Continental Coal Company Mine. Shaft 117 feet deep.

Proximate Analysis		Ultimate Analysis	
Moisture	7.14	Carbon	69.32
Volatile Matter	34.22	Hydrogen	5.56
Fixed Carbon	51.92	Oxygen	15.45
Ash	6.74	Nitrogen	1.30
		Sulphur	1.65
		Ash	6.74

Heating Value: Calories 6,863

Source: Bownocker, Lord, and Somermeier, 1908, p. 210.
Sample taken by B. A. Eisenlohr, July 1902.

APPENDIX B

REPRESENTATIVE ANALYSES OF UPPER FREEPORT (NO. 7) COAL

The writer did not locate any published analyses of the Upper Freeport (No. 7) coal in Morgan County. Two analyses of that coal in adjoining portions of Muskingum County are presented here as representative analyses.

1. Muskingum County; Brush Creek Township.
   Maynard Brothers' Mine.

Proximate Analysis		Ultimate Analysis	
Moisture	4.72	Carbon	68.27
Volatile Matter	43.47	Hydrogen	5.55
Fixed Carbon	44.25	Oxygen	12.30
Ash	7.56	Nitrogen	1.32
		Sulphur	5.00
		Ash	7.56

Heating Value: Calories 7,046

Source: Bownocker, Lord, and Somermeier, 1908, p. 258.
Sample taken by B. A. Eisenlohr, August 1902.

2. Muskingum County; Harrison Township.
   Blue Rock Coal Company Mine.

Proximate Analysis		Ultimate Analysis	
Moisture	4.89	Carbon	67.74
Volatile Matter	42.35	Hydrogen	5.53
Fixed Carbon	44.98	Oxygen	13.42
Ash	7.78	Nitrogen	1.17
		Sulphur	4.36
		Ash	7.78

Heating Value: Calories 6,944

Source: Bownocker, Lord, and Somermeier, 1908, p. 257.
Sample taken by B. A. Eisenlohr, July 1902

APPENDIX C

REPRESENTATIVE ANALYSES OF PITTSBURGH (NO. 8) COAL

1. Homer Township; W. Cen. section 2.
   Alfred Waymer Bank, west side of Sharp's Fork; near village of Joy.

Proximate Analysis		Ultimate Analysis	
Moisture	6.87	Carbon	67.39
Volatile Matter	40.55	Hydrogen	5.32
Fixed Carbon	44.39	Oxygen	13.98
Ash	8.19	Nitrogen	0.90
		Sulphur	4.22
		Ash	8.19

Heating Value: Calories 6,722

Source: Bownocker, Lord, and Somermeier, 1908, p. 69.
Bownocker and Dean, 1929, p. 228.
Sample taken by B. A. Eisenlohr, 1907.
Analysis by Lord and Somermeier.

2. Homer Township; $NW\frac{1}{4}$ section 2.
   Mansfield Petroleum Company Land. Analysis of lower bench.

Proximate Analysis	
Moisture	4.55
Volatile Matter	39.99
Fixed Carbon	45.46
Ash	10.00
Sulphur	4.89

Runs unusually high in ash and sulphur; low in fixed carbon.

Source: Lovejoy, 1888, p. 650.

3. Homer Township; Fractional section 6.
   Hogshead Bank.

Proximate Analysis	
Moisture	5.30
Volatile Matter	40.18
Fixed Carbon	48.50
Ash	6.02
Sulphur	2.87

Source: Lovejoy, 1888, p. 651.

4. Homer Township; Near center section 28.
E. M. Blower Mine on D. E. Carr property.

Proximate Analysis

		As Received	Moisture Free
	Moisture	4.80	0.00
	Volatile Matter	42.22	44.35
	Fixed Carbon	43.03	45.20
	Ash	9.95	10.45
	Sulphur	5.19	5.45
Heating Value:	Calories	6,600	6,933
	B. t. u.	11,880	12,479

Source: Bownocker and Dean, 1929, p. 228; Table p. 321.
Sample taken by E. S. Bonnet, May 1929.
Analysis by D. J. Demorest.

5. Homer Township; section 29.
J. Steffy's Bank.

Proximate Analysis

Moisture	5.39
Volatile Matter	41.18
Fixed Carbon	46.32
Ash	7.11
Sulphur	4.16

Source: Lovejoy, 1888, p. 652.

APPENDIX D

REPRESENTATIVE ANALYSES OF MEIGS CREEK (NO. 9) COAL

1. Bristol Township; NE¼ section 21.
   D. C. Lawrence Farm.

Proximate Analysis

	As Received	Moisture Free
Moisture	5.05	0.00
Volatile Matter	37.83	39.84
Fixed Carbon	46.75	49.24
Ash	10.37	10.92

Ultimate Analysis

	As Received	Moisture Free
Carbon	67.04	70.61
Hydrogen	5.14	4.82
Oxygen	12.26	8.18
Nitrogen	0.89	0.94
Sulphur	4.30	4.53
Ash	10.37	10.92

Heating Value:		As Received	Moisture Free
	Calories	6,730	7,088
	B. t. u.	12,114	12,758

Source: Bownocker, Lord, and Somermeier, 1908, p. 154.
Bownocker and Dean, 1929, p. 271.

2. Center Township; SW¼ section 27.
   C. M. Noyes Mine; 1 mile east of Ludlow. Drift mine, cut 150 feet under hill.

Proximate Analysis

		As Received	Moisture Free
	Moisture	2.53	0.00
	Volatile Matter	41.22	42.29
	Fixed Carbon	42.40	43.40
	Ash	13.85	14.21
	Sulphur	5.66	5.81
Heating Value:	Calories	6,680	6,853
	B. t. u.	12,024	12,336
Fusion of Ash:	Incipient	2,444 degrees F.	
	Complete	2,516 degrees F.	

Source: Dean, 1948, p. 13.
Sample taken by A. W. Seabright and I. Vaughn, August 1924.

3. Manchester Township; SW¼ section 29.
Louis H. Grandstaff Mine.

Proximate Analysis	As Received	Moisture Free	Ultimate Analysis	As Received	Moisture Free
Moisture	4.07	0.00	Carbon	66.19	69.00
Volatile Matter	37.61	39.21	Hydrogen	5.10	4.84
Fixed Carbon	47.66	49.68	Oxygen	12.11	8.85
Ash	10.66	11.11	Nitrogen	0.87	0.91
			Sulphur	5.07	5.29
			Ash	10.66	11.11

Heating Value:		As Received	Moisture Free
	Calories	6,770	7,067
	B. t. u.	12,202	12,720

Source: Bownocker, Lord, and Somermeier, 1908, p. 155.
Bownocker and Dean, 1929, p. 271.
Sample taken by J. E. Hyde, 1907.
Analysis by Lord and Somermeier.

4. Meigsville Township; NE¼ section 1.
F. S. Murray Farm.

Proximate Analysis	As Received	Moisture Free	Ultimate Analysis	As Received	Moisture Free
Moisture	5.13	0.00	Carbon	64.77	68.27
Volatile Matter	36.07	38.02	Hydrogen	5.06	4.73
Fixed Carbon	47.06	49.60	Oxygen	12.67	8.55
Ash	11.74	12.38	Nitrogen	0.87	0.92
			Sulphur	4.89	5.15
			Ash	11.74	12.38

Heating Value:		As Received	Moisture Free
	Calories	6,625	6,983
	B. t. u.	11,925	12,569

Source: Bownocker, Lord, and Somermeier, 1908, p. 156.
Bownocker and Dean, 1929, p. 272.

APPENDIX E

REPRESENTATIVE ANALYSIS OF WAYNESBURG "A" COAL

1. Windsor Township; 1 mile east of Brokaw.
   Clarence Walker Mine; Drift Cut 200 feet under hill.

Proximate Analysis			Ultimate Analysis		
	As Received	Moisture Free		As Received	Moisture Free
Moisture	4.08	0.00	Carbon	58.40	60.88
Volatile Matter	38.54	40.18	Hydrogen	6.30	6.10
Fixed Carbon	50.26	52.40	Oxygen	27.65	19.83
Ash	7.12	7.42	Nitrogen	1.08	1.13
			Sulphur	4.45	4.64
			Ash	7.12	7.42

		As Received	Moisture Free
Heating Value:	Calories	6,196	6,460
	B. t. u.	11,154	11,628

Fusion of Ash: Incipient, 2,435 degrees F.
Complete, 2,515 degrees F.

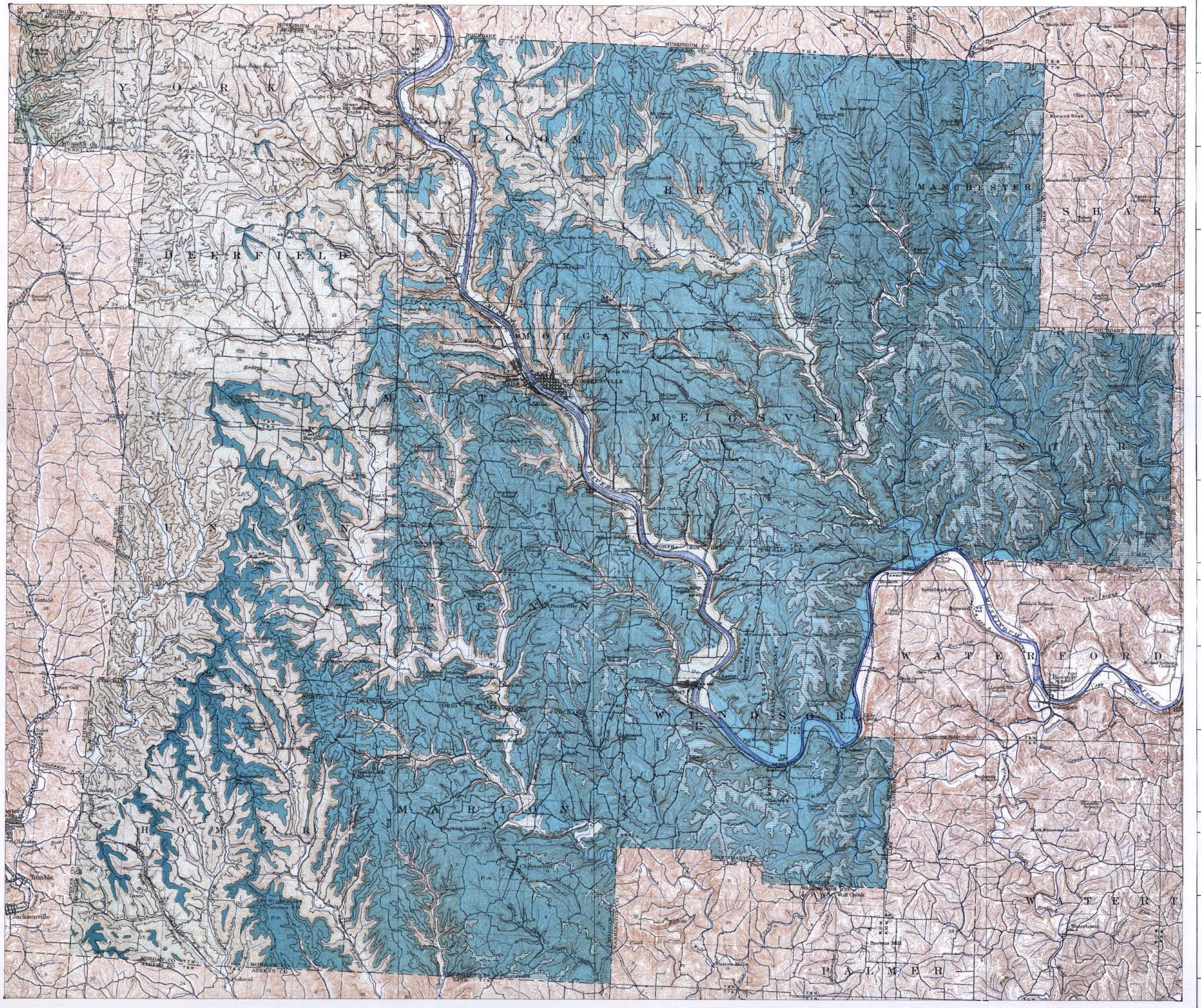
Source: Dean, 1948, p. 17.
Sample taken by A. W. Seabright and I. Vaughn, August 1929.

INDEX

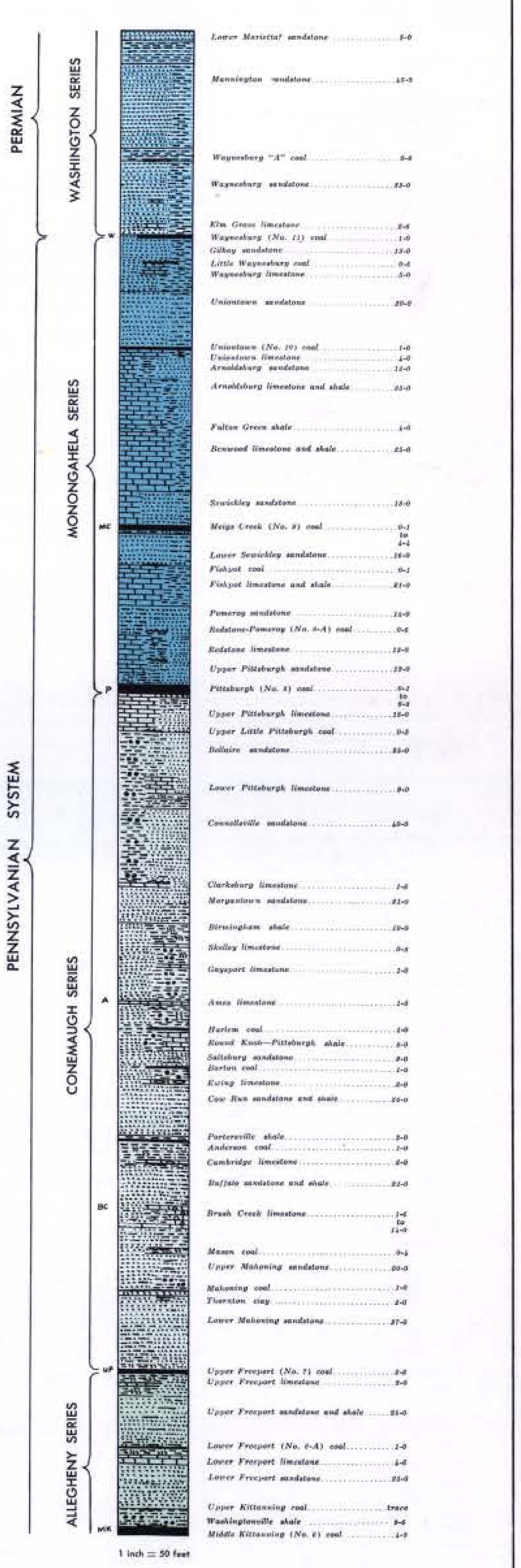
M

O

P



GENERALIZED COLUMNAR SECTION



1 inch = 50 feet

EXPLANATION

PERMIAN SYSTEM

Pdw	Dunkard Group Washington Series

PENNSYLVANIAN SYSTEM

Pm	Monongahela Series
Pc	Conemaugh Series
Pa	Allegheny Series

LOCATION OF MORGAN COUNTY, OHIO

STATE OF OHIO
C. WILLIAM O'NEILL, GOVERNOR
DEPARTMENT OF NATURAL RESOURCES
HERBERT B. EAGON, DIRECTOR
DIVISION OF GEOLOGICAL SURVEY
RALPH J. BERNHAGEN, CHIEF

Base compiled from U. S. Geological Survey Topographic quadrangles:

Athens	New Lexington
Caldwell	Parkersburg
Chesterhill	Philo
Cumberland	Zanesville
McConnelsville	

GEOLOGIC MAP OF MORGAN COUNTY, OHIO

GEOLOGY BY
DONALD L. NORLING

1957

Scale

Contour interval 20 feet
Datum is mean sea level

DRAFTING BY HAROLD J. FLINT

10,000 FOOT GRID BASED ON
OHIO COORDINATE SYSTEM

Field Assistants: Charles M. Chapman (1949), Henry Trapp (1948),

Map incorporates work of: J. D. Bartlett (1950, Union Township)
G. W. White (1945)
Wilber Stout and Richard Morgan (1928)
Wilber Stout and Theodore Myers (1927)
D. D. Condit (1912)
C. N. Brown (1884)
E. B. Andrews (1873)