STATE OF OHIO
FRANK J. LAUSCHE, Governor
DEPARTMENT OF NATURAL RESOURCES
A. W. MARION, Director
DIVISION OF GEOLOGICAL SURVEY
JOHN H. MELVIN, Chief

BULLETIN 53

GEOLOGY OF COSHOCTON COUNTY

BY

RAYMOND E. LAMBORN

COLUMBUS
1954

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DEPARTMENT OF NATURAL RESOURCES

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INTRODUCTION

LOCATION AND GENERAL RELATIONS

Coshocton County embraces an area of 567.48 square miles[1] surrounding the confluence of the Tuscarawas, Walhonding, and Muskingum rivers in the east central part of Ohio. It is roughly rectangular in outline and lies between 81° and 37' and 82° 12' west longitude and between 40° 8' and 40° 28' north latitude. It is bounded on the north by Holmes and Tuscarawas counties, on the east by Tuscarawas and Guernsey counties, on the south by Guernsey and Muskingum counties, and on the west by Licking and Knox counties. Coshocton County is divided into townships of somewhat unequal size as follows: Tiverton, Newcastle, Perry, Pike, Washington, Bedford, Jefferson, Monroe, Clark, Bethlehem, Jackson, Virginia, Linton, Franklin, Tuscarawas, Lafayette, Keene, Mill Creek, Crawford, White Eyes, Adams, and Oxford. Coshocton, a town of some 12,000 inhabitants located at the junction of the Tuscarawas and Walhonding rivers, is the county seat and largest city. Smaller towns and villages include West Lafayette, Conesville, Warsaw, Nellie, Walhonding, Newcastle, West Carlisle, Blissfield, Fresno, and Roscoe. Rail transportation facilities are provided by the Wheeling and Lake Erie Railroad and the Pennsylvania Lines which cross the eastern third of the county. Improved highways extend through every village and township, providing safe year-around avenues for travel and for the transportation of the products of industry. The productive life of the people is directed chiefly to agriculture and mining. The broad flood plains of the Muskingum, Tuscarawas, Walhonding, and Killbuck valleys are well adapted to specialized or general farming, the rolling uplands to general farming and grazing, and the steep slopes to forestry and lumbering. The mining of coal has long been an important industry in the southeastern part of the county where the Middle Kittanning bed is of good thickness and continuity. Manufacturing has never been important in Coshocton County, although many factory sites can be found having good transportation facilities by either rail or highway and with copious supplies of water.

PURPOSE OF REPORT

The first report by the Geological Survey dealing specifically with the geology of Coshocton County was prepared by J. T. Hodge in 1872 and with revisions by M. C. Read was published in 1878 in Vol. III of the Survey reports. At this early date only the most conspicuous elements in the geology of the county were described and some of these were incorrectly identified. No specific attention was given to rock structure or attitude of the strata, a phase of geologic investigations which has gained prominence in recent years through its relation to oil and gas accumulations. As a result the writer began early in the thirties as time and funds permitted

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[1] Sherman, C. E., Ohio Topog. Survey, Vol. IV, p. 49, 1933.

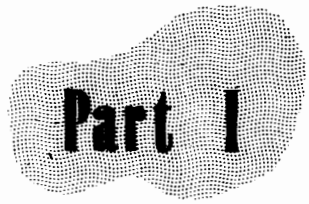
to map the structure in the Lower Tuscarawas Valley including not only Coshocton but also Tuscarawas, Guernsey, and Carroll counties. In the pursuit of this task it seemed necessary to section rock exposures wherever possible to avoid or reduce possible errors in identification of members. A fund of data on the geology of Coshocton County was thus accumulated which with some small amount of additional investigation formed the basis for this report.

The report on the geology of Coshocton County has been prepared with the following objectives in view: to give some meaning to physiographic features and to state the probable succession of events in their development; to portray the detailed stratigraphic succession of strata exposed within the county; to describe the different series and members, giving distribution, character, and economic use, and showing the most important elements on maps; to describe the subsurface succession within the present range of drilling; give the probable correlation of various units recognized; and show on maps the degree of development of the oil and gas industry. A geologic map of Coshocton County showing the structure of the area, the distribution of Mississippian system and series of Pennsylvanian beds exposed, and the extent of the Middle Kittanning coal was published by the Division of Geological Survey in 1948. The present report is designed to supplement this map. The writer believes that it will constitute a distinct addition to the published information on the geology of Coshocton County.

FIELD WORK AND ACKNOWLEDGMENTS

The field studies upon which the report and geologic map of Coshocton County are based was carried on at various times during the summer seasons of 1935-1940 and 1945-1946 as time and means permitted. In the preparation of the manuscript, much of which has been written since the publication of the Geologic Map in 1948, the writer has had access to field sections and measurements secured by T. R. Meyers in 1928 in Bedford and Jefferson townships. To Mr. Meyers the author expresses his appreciation. Some exposures recorded at that time are no longer visible for measurement.

In the preparation of the review on oil and gas development within the County much information in the form of drillers' logs and well locations has been secured from the Division of Mines, Department of Industrial Relations, and from the Geological Department of the Ohio Fuel Gas Company. To all who have aided the project by supplying information necessary for this report as well as those who have aided materially in typing the manuscript for publication the author is duly grateful.



PHYSIOGRAPHY

GENERAL DEVELOPMENT AND RELATIONSHIP

The bedrocks which are exposed at the surface in Coshocton County are all of sedimentary origin. They consist for the most part of sandstone and shale with minor amounts of coal, clay, and limestone. The materials composing this series were laid down in or through the action of water. During the deposition of the sediments the region was generally sinking below sea level. Sediments were washed by water from nearby shores and deposited as essentially horizontal beds either in shallow seas or in bordering bodies of fresh or brackish waters. Deposits of organic matter and calcium carbonate, promoted on the one hand by the growth of plants in swamps and marshes, and on the other by chemical precipitation, the action of algae, and the accumulation of shells of marine organisms, increased the variety of sediments and added to the depth of the deposits. With burial the materials became solidified by pressure and chemical action. These processes of rock formation continued with interruptions until the end of the coal-bearing period. Hundreds of feet of sedimentary deposits were laid down including all those now exposed at the surface in Coshocton County. At the end of the Paleozoic era much of the eastern part of the United States was elevated above the sea. The various agents of weathering and erosion began their work of wearing away and degrading the new land surface. Valleys formed by surface runoff were deepened, lengthened, and broadened, tending to lower divides and reduce the surface to essential flatness. A peneplain was thus developed by Cretaceous time, the level of which was not far above tide. Later crustal movements led to the uplift of this peneplain to form the Allegheny Plateau. Uplift rejuvenated the streams and marked the beginning of a new cycle in the degradation of the land surface. Stream erosion again carved the surface into high hills and deep valleys, the process being punctuated now and then by minor crustal movements. During Pleistocene time the ice advance from the north which just touched the western edge of Coshocton County introduced a new factor in the modification of the land surface by modifying the contour of the hills over which it passed, by filling old valleys; and by diverting streams so that new valleys and new drainage systems were formed in regions untouched by glacial ice.

The various features which characterize the land topography in Coshocton County are similar to those developed over large areas of the unglaciated portion of the Allegheny Plateau of eastern Ohio of which it is a part. Here the dominant modifying agent has been stream erosion acting for long periods of time in a region of moderate elevation composed of gently-dipping sedimentary rock strata of varying resistance to stream erosion. The topography which has been thus formed is rough and rugged. The streams have so deepened their valleys and lengthened their courses that much of the land surface is reduced to a condition of hillside and slope. The divides are in places ridgelike in character and at other localities they are marked by small intermittent areas of rolling uplands. In parts of the area they have been carved into isolated hills. The valley flats are generally narrow, being confined in their distribution to the large valleys and to the lower courses of their major tributaries. In the extreme western part of the county the topography has been slightly modified by the Illinoian ice sheet which by its erosive action tended to subdue the bold features developed by stream erosion.

DRAINAGE

MUSKINGUM RIVER AND ITS TRIBUTARIES

The surface waters of Coshocton County flow either directly or indirectly into the Muskingum River, the master stream in this area. This river is formed at Coshocton in the south central part of the county by the union of the Tuscarawas River from the east and the Walhonding River from the west. From the junction of these rivers the Muskingum follows a meandering course through an open flat-bottomed valley a mile or more in width which extends in a southern direction through western Tuscarawas, eastern Jackson, western Franklin, and southwestern Virginia townships to the south border of the county. The average gradient of the river which flows entirely on sands and gravels in this county is a little less than 2 feet per mile to the south. From the outer edge of the river flats, the valley walls rise rather steeply to a height of approximately 200 feet. Tributary streams are in general not well developed in this county as they are generally short and immature and receive the drainage from only small areas. Wills Creek which enters the Muskingum near the southwest corner of Franklin Township is a notable exception, however, in that it enters the county in the southeast part of Linton Township, follows a very devious course in a flat-bottomed valley through Linton, southern Oxford, and southern Franklin townships and receives the drainage from Linton, southern Oxford, southeastern Lafayette, and southeastern Franklin townships. The length of the channel in this county is approximately 22 miles, and the average gradient of the stream, as determined from a topographic map, is about 15 inches per mile.

The southwestern part of Coshocton County is drained by a number of small streams, having a general southern direction of flow, all tributary to Wakatomika Creek, which in turn empties into the Muskingum River near Dresden some 2 miles south of the southern border. The most important tributaries are Mill Creek, Little Wakatomika Creek, Fivemile Run, Nickel Valley Run, and Winding Fork. These streams have their headwaters just south of the high divide extending westward from Coshocton and drain an area in Coshocton County estimated at 100 square miles, including the northwest half of Virginia Township, Washington Township, the southern half of Bedford Township, all of Pike Township, and the southwest two-thirds of Perry Township. In general the streams flow in narrow steep-sided valleys with thin ribbon-like valley flats in their lower courses. For greater detail see maps accompanying this report.

TUSCARAWAS RIVER AND ITS TRIBUTARIES

Only the lower course of the Tuscarawas River occurs in Coshocton County. Having its headwaters near Akron in southern Summit County and in northwestern Stark County, the Tuscarawas follows a very crooked course in a southeastern direction through Summit, Stark, and Tuscarawas counties to Uhrichsville where it assumes a southwestern direction of flow, entering the east central edge of Coshocton County at Newcomerstown. The total area drained by the Tuscarawas River and its tributaries is 2,589.7 square miles.[1]

In Coshocton County the Tuscarawas River follows a meandering course in a broad open valley extending westward from Newcomerstown to Coshocton. Here the length of the channel approximates 19.5 miles over a line distance of about 13.5 miles. Here also the stream bed, which is composed entirely of silt, sand, and gravel of alluvial origin, has an average gradient along its course of about 27 inches per mile. The valley flats, which are conspicuously developed, vary from one to two miles in width furnishing some of the best agricultural lands in the county. These flats are flanked on both sides by valley walls which rise to a height of 200 to 250 feet and are broken here and there by deep notches, through which enter tributary streams. Those which enter from the south draining parts of Lafayette and Oxford townships are generally

[1]Sherman, C. E., Miscellaneous data, Ohio Topographic Survey, Vol. IV, p. 218, 1933.

small and flow through short steep-walled valleys. Morgan Run which enters the Tuscarawas from the south in the western part of Lafayette Township has a length of about 3 miles and is the largest of these tributaries.

Streams tributary to the Tuscarawas from the north in Coshocton County include as most important Evans Creek to the east and White Eyes Creek to the west. Both streams have their headwaters in the highlands extending in a southeast-northwest direction through central Bucks Township, Tuscarawas County, and northeastern Crawford Township, Coshocton County, and flow in a direction south of west in essentially parallel courses through moderately incised valleys. Except along their lower courses, valley flats bordering these streams are generally narrow and inconspicuous. Streams tributary to the Tuscarawas from the north receive the surface run-off from all of Adams Township, the east three-fourths of Crawford Township, and all of White Eyes Township except the northwest edge. The total area drained by the Tuscarawas River and its tributaries in Coshocton County is estimated at about 130 square miles.

In the east central part of Lafayette Township the Tuscarawas is joined from the south by a broad open valley containing in Lafayette Township a small intermittent stream, which is not commensurate in size with the valley it occupies. This valley was formed in preglacial times, was deepened during early interglacial substages, and later aggraded and abandoned through drainage changes described in later pages of this report.

WALHONDING RIVER AND ITS TRIBUTARIES

The Walhonding River is formed near Walhonding, Newcastle Township, Coshocton County, by the union of the Kokosing River from the west and the Mohican River from the north. From its source to its junction with the Tuscarawas at Coshocton to form the Muskingum River, the Walhonding follows a crooked meandering course across valley flats one-half to three-fourths of a mile in width. The average gradient of the river as determined from the topographic map is about 45 inches per mile. The hills bordering the flood plain rise rather steeply to heights of 200 to 250 feet. The tributaries which enter the Walhonding from the south are generally short and receive the surface waters from comparatively small areas, all of which occur in Coshocton County. Chief among these tributaries are Crooked Creek which drains the northeastern part of Jackson Township; Simmons Run which receives the runoff from northwestern Jackson, northeastern Bedford, and southeastern Jefferson townships; and Mohawk Creek which drains southwestern Jefferson, northwestern Bedford, northeastern Perry, and southeastern Newcastle townships.

Much of Coshocton County which lies north and northeast of the Walhonding River is drained by tributaries flowing into that river. The most important of these streams are Dutch Run, Beaver Run, Killbuck Creek, and Mill Creek. Mill Creek, the most eastern one, rises in the southwestern part of Clark Township, Holmes County, flows southwest across Mill Creek and Keene townships, and meets the Walhonding in the northwestern part of Tuscarawas Township. Mill Creek and its tributaries receive the drainage from western Crawford Township and nearly all of the surface waters from Keene and Mill Creek townships. The southeastern quarter of Tiverton Township contains the headwaters of Dutch Run which flows to the southeast and reaches the Walhonding near the northeast corner of Newcastle Township, and of Beaver Run which flows to the southeast receiving the drainage of southeastern Monroe Township and northern Jefferson Township and reaching the Walhonding at Warsaw, Jefferson Township. The valley of Beaver Run has all the aspects of early maturity with narrow valley flats throughout much of its course.

Killbuck Creek

Killbuck Creek, the largest stream tributary to the Walhonding, rises in the southwestern part of Medina County. From its source it flows south through western Wayne County, central Holmes County, into north central Coshocton County, reaching the Walhonding River in south central Bethlehem Township. In Coshocton County the Killbuck is a stream of low gradient,

flowing on sands and gravels, with well developed valley flats which, unlike the open flood plains of the Tuscarawas, Walhonding, and Muskingum rivers, take a very winding or meandering course. The gradient of Killbuck Creek in Coshocton County as determined from topographic maps is slightly more than 20 inches per mile. The valley flats vary from three-tenths to eight-tenths of a mile in width in this county, being broadest on the meander-like curves of the valley. In Bethlehem Township and the southern half of Clark Township streams tributary to the Killbuck are short and flow in steep gorge-like valleys of small drainage area. In the northern half of Clark Township the Killbuck is met by two large tributaries, Doughty Creek from the east and Big Run from the west. Doughty Creek, which has its headwaters in the northeastern part of Mechanic Township, Holmes County, enters Coshocton County at Bloomfield near the northeast corner of Clark Township. It flows in a southwestern direction in Clark Township in an open valley with well developed valley flats and receives the drainage of northeastern Clark Township and the northwest corner of Mill Creek Township. Big Run enters the Killbuck from the west and has its headwaters in northwestern Monroe Township. It has a general eastern direction of flow and receives much of the drainage from the northern half of Monroe Township and the northwestern part of Clark Township. Wolf Creek, a tributary to the Killbuck in Killbuck Township, Holmes County, receives the run-off from the northeast quarter of Tiverton Township. The total area of Coshocton County drained by Killbuck Creek and its tributaries is estimated at 67 square miles.

MOHICAN RIVER

The Mohican River is formed in the southern part of Ashland County by the union of Clear Fork and Black Fork. It flows through a deeply entrenched valley extending in a southern direction through western Holmes County and eastern Knox County into northwestern Coshocton County. Here it is joined from the west by the Kokosing River to form the Walhonding River. From its point of entry into Coshocton County near the northwest corner of Tiverton Township to its mouth in the northwest quarter of Newcastle Township this river flows on narrow valley flats in a deeply incised valley whose walls rise steeply to heights of 250 to 300 feet. The gradient of the stream as determined from maps is about 44 inches per mile. Tributary valleys are few in number and short in extent, and drain only a small area in Tiverton and Newcastle townships.

KOKOSING RIVER

The Kokosing River rising in eastern Morrow County, flowing across Knox County, and uniting with the Mohican to form the Walhonding River, is relatively unimportant in Coshocton County as only the lower 2 miles of its course is present in this area. The characteristics of the stream and the valley it occupies are similar to those of the Walhonding previously described.

RELIEF

The inequalities in the elevation of the land surface are quite marked in Coshocton County. The most conspicuous feature of the topography is the deeply incised valleys, often bottomed by narrow ribbon-shaped flats, traversing a region that consists in large part of steep hillside and slope. The plateau-like features typical of the Allegheny Plateau in its early stages have been in large part erased chiefly by stream erosion and to a much less extent by continental glaciation. From stream channels or the outer edges of the narrow valley flats the hillsides rise rather steeply for 100 feet or more, above which the slope becomes more gentle upwards

and generally ends in rounded hilltops or divides. Flatlands are not conspicuously developed in Coshocton County except as flood plains and terraces borderingthe major streams.

The divides in Coshocton County have in general their highest elevation in the northeastern and northwestern parts of the area surrounding the headwaters of the best developed tributary valleys. Sizable areas above the 1,200-foot elevation are found along the ridges between Little Mill Creek, West Fork of White Eyes Creek, and East Fork of White Eyes Creek in Crawford Township, surrounding the headwaters of Big Run in western Monroe Township; between Wolf Creek and the Mohican River in Tiverton Township; and south of Walhonding River in the vicinity of Newcastle, Newcastle Township. Isolated hills located in Section 12, Crawford Township, and in Section 5, Monroe Township, rise to the 1,300-foot contour and represent the highest altitudes in the county. Spur ridges extending to the south and southeast from these high lands tend to decrease in altitude in an irregular way in the general direction of drainage. Along the prominent ridges on either side of Evans Creek in Adams Township a few knobs rise above the 1,100 foot level. The prominent ridge west of White Eyes Creek descends from a maximum of about 1,280 feet in Section 6, Crawford Township, to about 1,100 feet near the Tuscarawas River in the south central part of Section 24, White Eyes Township. In like manner the high divide between the valleys of Mill Creek and Killbuck Creek descends from a maximum of 1,220 feet in Section 14, Mill Creek Township, to 1,140 feet near Helmick, Section 18, Clark Township. Similar features characterize the divides on both sides of Big Run and Dutch Run west of the Killbuck River.

The most prominent divide in Coshocton County west of the Muskingum River extends in a general western direction through central Jackson Township, central Bedford Township, and central Perry Township and separates the waters tributary to the Walhonding River from those flowing to the south to Wakatomika Creek. Summit elevations along this divide range from 1,000 feet to 1,160 feet, but variations from 1,040 feet to 1,140 feet are common. Summit areas above 1,100 feet are generally small, disconnected, and irregular in outline. Similar features characterize the spur ridges extending to the north between the valleys of Crooked Run, Simmons Run, and Mohawk Creek and to the south separating the various valleys tributary to Wakatomika Creek.

One of the most prominent divides east of the Muskingum River extends through east central Tuscarawas Township, southwestern Lafayette Township, and western Linton Township and separates the drainage to Wills Creek and the Tuscarawas River from that going directly to the Muskingum. Summit levels here range from 1,000 feet to 1,160 feet, but areas above 1,100 are small, scattered, and inconspicuous, Similar conditions prevail along the divide separating the valleys of Wills Creek and the Tuscarawas River in central Oxford Township.

The lowest levels in Coshocton County are found along its chief rivers where the altitude ranges from about 820 near the mouth of the Mohican to about 720 where the Muskingum River leaves the south boundary of the county. Along the Mohican River the land surface may rise from 300 to 350 feet in a horizontal distance of one-half mile. Much the same conditions of relief occur along the Walhonding and Kokosing valleys in Newcastle Township. In Jefferson Township where water level along the Walhonding ranges from 780 to 800 feet the local relief ranges in general from 250 to 300 feet. A similar condition prevails along the meandering valley of Killbuck Creek in Bethlehem and Clark townships where the elevation of the stream varies from about 785 feet at the north edge of the county to about 760 feet near its junction with the Walhonding River. In the Tuscarawas-Muskingum Valley the stream level ranges in altitude from 780 feet in eastern Oxford Township to about 720 feet in southwestern Franklin Township. The local relief along these valleys measured by the difference in altitude of valley bottom and adjacent hilltop generally ranges from 250 to 300 feet although locally, as in northeastern Tuscarawas Township, it reaches 350 feet. The maximum relief for Coshocton County as a whole is about 580 feet.

OLD EROSION SURFACES

HARRISBURG UPLAND

The high divide which in preglacial times separated the northern-flowing from the southern-flowing drainage in eastern Ohio extends in a general east-west direction through Holmes County a few miles north of Coshocton County. In the eastern part of Holmes County the directional trend of this highland is a little south of east into Tuscarawas County, reaching the Tuscarawas River near Port Washington. In Holmes County the summit of this divide is characterized by flat to rolling uplands with summits ranging in altitude from about 1,220 to 1,280 feet. Here and there isolated hills rise to 1,300 feet or even higher. From this high divide spur ridges extend to the south into the northwest and northeast parts of Coshocton County and are well represented in Monroe, Tiverton, Newcastle, and Crawford townships. Here the summits are represented by small flattened or rolling uplands having altitudes ranging from 1,220 to 1,260 feet. These uplands with scattered hills rising to the 1,300-foot level or even higher are here considered as remnants of the high part of the Harrisburg upland or peneplain so widely developed in eastern Ohio in Tertiary time.[1] From Newcastle Township high uplands extend to the southwest and are well represented in Jackson Township, Knox County, and Fallsbury Township, Licking County, by large areas above the 1,100-foot contour with many hills and ridges having altitudes of 1,200 to 1,240 feet. East of Newcastle Township, in Coshocton County, summits of the spur ridges descend to the south, reaching altitudes of 1,000 to 1,100 feet near the Walhonding-Tuscarawas rivers in Coshocton County.

In the southern half of Coshocton County, south of the Walhonding-Tuscarawas rivers and east of Newcastle Township the high ridges are capped at many places by several rounded hills or isolated knolls whose summit altitudes vary from approximately 1,100 to 1,160 feet. The rough accordance of these summit elevations suggests that such hills and knolls are remnants of an old erosion surface, the Harrisburg surface, which sloped southward from Holmes and northern Coshocton counties. An alternative view may consider these hills to be somewhat reduced below the Harrisburg surface by a post-Harrisburg erosion cycle of immature development. It is interesting to note in this connection that along the high ridge extending to the south from southwestern Linton Township, Coshocton County, through western Knox and Adams townships, Guernsey County, sizable summit areas occur above the 1,100-foot level but only occasional hills reach the 1,180-foot contours, and only two points reach the 1,200-foot level.

PARKER STRATH

The period of land degradation which led to the development of the Harrisburg erosion surface was brought to a close in late Tertiary time by regional uplift which rejuvenated the

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[1] See following references:

Stout, W., Physiographic Features of Southeastern Ohio, Ohio Jour. Sci., Vol. XXXVIII, pp. 49-83, 1938

Ver Steeg, Karl, Some Features of Appalachian Peneplains, Pan. Am. Geol. Vol. 53, pp. 359-364; Vol. 54, pp. 17-28, 1930.

————, Erosion Surfaces of Eastern Ohio, Pan Am. Geol. Vol. 55, pp. 93-102, 181-192, 1931.

————, Correlation of Appalachian Peneplains, Pan. Am. Geol. Vol. 73, pp. 203-210, 1940.

Cole, Storrs, Nomenclature of Appalachian Erosion Surfaces, Jour. Geol., Vol. 49, pp. 129-148, 1941.

————, Identification of Erosion Surfaces in Eastern and Southern Ohio, Jour. Geol. Vol. 42, pp. 285-294, 1934.

streams and inaugurated a new cycle of erosion. The streams which flowed on the Harrisburg erosion surface began to deepen their valleys; tributary valleys increased in number and length; the land surface became rougher; and in general the relief of the region increased. By the end of the Tertiary or the beginning of the glacial period, the major streams in east central Ohio had deepened their channels 100 to 400 feet below the Harrisburg surface, and had developed valley flats along their lower courses. During the glacial period which followed, these valley flats were in part destroyed by erosion and in part obscured by glacial debris. Remnants were preserved in places, however, in the form of rock terraces along the larger valleys, and as rock-bottomed valley flats along valleys abandoned through drainage changes. To the erosional stage represented by these terraces and valley bottoms the term Parker Strath is widely applied.[1]

In Coshocton County the level of the Parker stage is not in great evidence owing to the complicated drainage changes which resulted from continental glaciation. During the earliest interglacial stage the large valleys in Coshocton County were deepened much below the Parker level. Later under the influence of glaciation these valleys were aggraded above the Parker level, obliterating evidence of the early drainage stage. From the position of the Parker Strath in counties bordering on the south its level is expected along the Tuscarawas-Muskingum Valley in central Coshocton County at altitudes of 800 to 830 feet. This level corresponds rather closely to the present level of alluvial flats near the mouth of the old valley extending south from West Lafayette, although deposits comprising such flats are without question of later age. The Parker level is believed to be represented along the Tuscarawas Valley above West Lafayette by narrow rock terraces having altitudes ranging from 810 to 830 feet and occurring near the mouth of White Eyes Creek, above the Blue Hole, at the mouth of Evans Creek, and at a few points farther east. Below Coshocton a few rock hills flanked by outwash gravels occur in the Muskingum Valley near Franklin Station and Conesville. The summits of these low hills, having altitudes ranging from 800 to 820 feet, are believed to represent remnants of the Parker level in this part of the present Muskingum Valley

LATE TERTIARY (PRE-GLACIAL) DRAINAGE

At the end of the Tertiary or the beginning of the Glacial Period the high divide in eastern Ohio which separated the northern-flowing streams from those flowing in a southerly direction extended in a general northwest-southeast direction through Holmes and southwestern Tuscarawas counties. It crossed the present Tuscarawas Valley between Port Washington and Gnadenhutten, the Killbuck Valley midway between Killbuck and Millersburg, and the present Mohican Valley near the northeast corner of Knox County.[2] Along this divide in western Tuscarawas County and in Holmes County sizable areas occur above the 1,200-foot contour and many hills rise to the 1,300-foot level. Spur ridges which extend in a southerly direction into northern Coshocton County with slightly diminishing altitude separate small drainage areas which enlarge and open out in a general southerly direction. The most prominent of these secondary divides extends through west central Knox and central Richland townships, Holmes County, into north central Tiverton Township, Coshocton County. When traced farther south this old highland apparently crossed the site of the present deep channel of the Mohican River in southwestern Tiverton Township and the Kokosing River at the west edge of Newcastle Township. Its southern extension can be traced near Newcastle, Newcastle Township, and through northwestern Perry Township into eastern Jackson Township, Knox County. From New Guilford, Perry Township, a secondary spur ridge extends with diminishing height southeast into southwestern Bedford Township and then south along Graham Ridge to the northeast corner of Jackson Township, Muskingum County.

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[1] Butts, Charles, Kittanning Pa., U. S. Geol. Survey Folio 115, p. 3, 1904.

[2] Coffee, G. N., Preglacial, interglacial and postglacial changes of drainage in northeastern Ohio with special reference to the upper Muskingum drainage basin, Ohio Jour. Sci., Vol. XXX, pp. 373-384, 1930; Stout, Wilber, et al., Geology of Water in Ohio, Geol. Survey Ohio, Bull. 44, Map opposite p. 50, 1943.

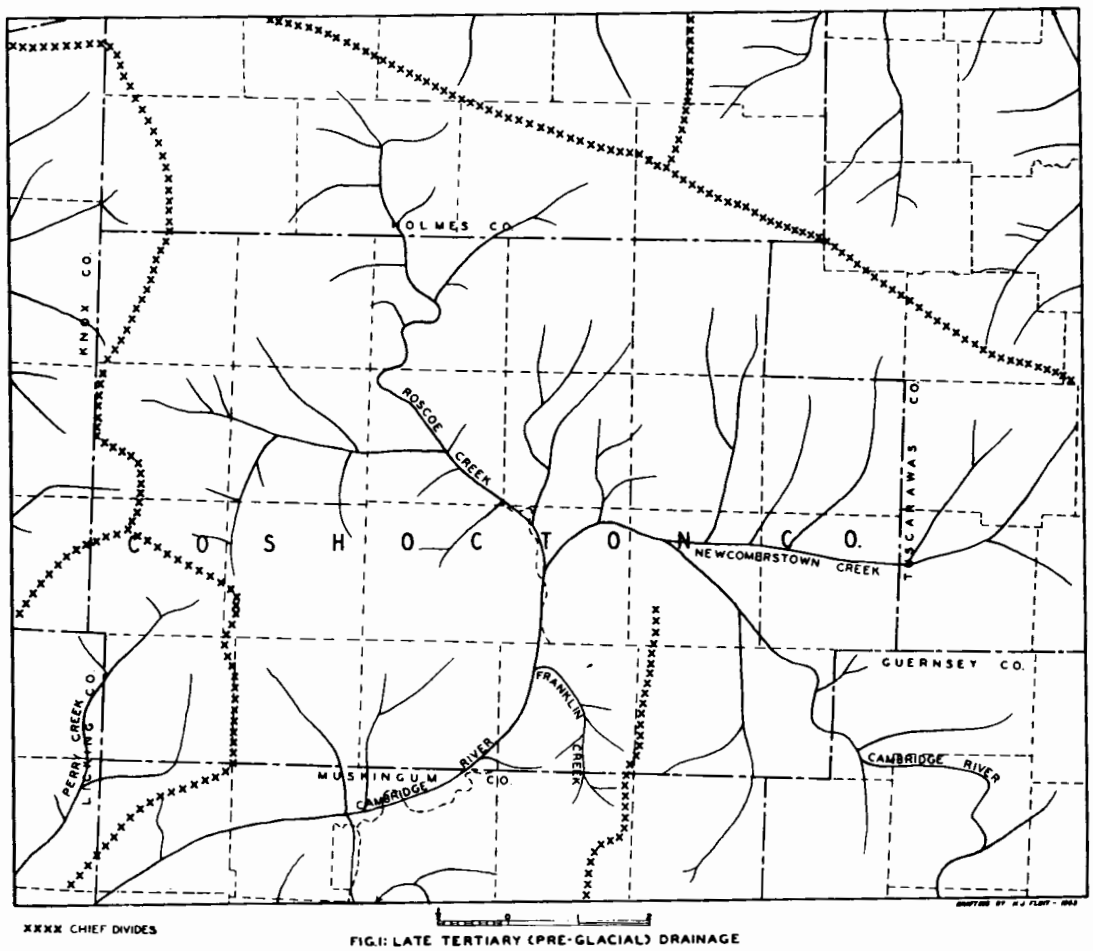

FIG.1: LATE TERTIARY (PRE-GLACIAL) DRAINAGE

The trend of this divide is to the southwest in Jackson Township, crossing the present site of Wakatomika Creek at the gorge-like narrows in its valley in the north central part.

In the southeastern part of Coshocton County another prominent divide in preglacial times extended from southwestern Lafayette Township south through western Linton Township and eastern Adams Township, Muskingum County. This divide apparently crossed the site of the present valley of Wills Creek in the northeast part of Adams Township, Muskingum County. Other watershed areas of secondary importance within the confines of Coshocton County are believed to have occupied much the same position in preglacial times as today, minor shifting resulting from differential head erosion of streams excepted.

The streams which drained Coshocton County just prior to the glacial period are shown in Figure 1. The axial stream receiving the drainage from this county had its headwaters to the southeast in northern Noble and Guernsey counties. It followed the course of the present valley of Wills Creek from Cambridge to Plainfield and thence northwest through an old valley, now abandoned, to West Lafayette. From West Lafayette the course was west near the site of the present Tuscarawas to Coshocton, south by way of the Muskingum to Trinway, and then southwest through a large open valley past Frazeysburg and Hanover to Newark. To this preglacial stream Stout and others have applied the name Cambridge River.[1] Beyond Newark the discharge of the Cambridge River was through an old valley extending to the southwest and west

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[1] Stout, Wilber, and Lamb, G. F., Physiographic Features of Southeastern Ohio, Ohio Jour. Sci., Vol. XXXVIII, p. 66-67, 1938; Stout, Wilber, VerSteeg, Karl, and Lamb, G. F., Geology of Water in Ohio, Geol. Survey Ohio, Bull. 44, pp. 64-65, 1943.

through southern Licking, northern Fairfield, southern Franklin, northwestern Pickaway, and eastern Madison counties to London, where it joined the northwestern-flowing Teays River.[1]

At West Lafayette the Newcomerstown Creek[2] entered from the east. It had its headwaters in southwestern Tuscarawas County and followed the site of the present Tuscarawas Valley, flowing to the west past the present town of Newcomerstown.

The preglacial drainage of the northwest part of Coshocton County was chiefly by way of Roscoe Creek and its tributaries. This stream had its headwaters in southern Holmes County and flowed south along the sites of Killbuck Creek and the Lower Walhonding to the Cambridge River at Coshocton. In central Bethlehem Township Roscoe Creek received a prominent tributary from the west which probably had its headwaters in Newcastle Township and flowed east along the site of the present Walhonding River. West of the high divide extending through Tiverton and Newcastle townships the preglacial drainage was apparently southwestward through channels now heavily choked with glacial drift.

In late Tertiary times the drainage of the southwestern part of Coshocton County was to the south and southwest through streams tributary to the Cambridge River. One such stream apparently occupied the site of Little Wakatomika Creek and another its chief eastern tributary Mill Fork. West of Graham Ridge the surface waters flowed in preglacial channels occupying the valleys of Fivemile Run and Winding Fork. These streams discharged to the southwest through Licking County by way of Perry Creek which followed an old valley now occupied by Wakatomika Creek in Fallsbury Township and by Brushy Fork in eastern and northeastern Perry Township, and now choked with glacial drift in southern Perry and northwestern Hanover townships.

GLACIATION

GENERAL CONSIDERATIONS

The cycle of land degradation represented by the Parker Strath stage was brought to a close by the advent of the Pleistocene or Glacial Period. During this period snow and ice accumulated in great thickness over central and eastern Canada. From regions of thickest accumulation the ice moved southward as a great continental ice sheet, covering a large area in the northern part of the United States. After each advance, the ice front retreated to the north by melting. From the nature, distribution, and degree of weathering of the rock debris left by the glaciers, at least four great ice advances and retreats separated by long interglacial stages have been recognized. The various ice advances and interglacial stages from youngest to oldest are usually designated as follows:

Recent
Wisconsin ice advance
Sangamon interglacial stage
Illinoian ice advance
Yarmouth interglacial stage
Kansan ice advance
Aftonian interglacial stage
Nebraskan ice advance (oldest)

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[1] Tight, G. W., Drainage modifications in southeastern Ohio and adjacent parts of West Virginia and Kentucky, U. S. Geol. Survey Prof. Paper 13, 1903; Bownocker, J. A., A deep preglacial channel in western Ohio and eastern Indiana, Am. Geologist, Vol. XXIII, 1899; VerSteeg, Karl, The buried topography of western Ohio, Jour. Geol. Vol. XLIV, pp. 918-939, 1936.

[2] Stout, Wilber et al., Op. cit. Oppo. p. 50, 1943.

No accurate measure exists for determining the time duration of the glacial period. Estimates of time elapsed since the advance of the Nebraskan ice sheet range from 750,000 to 1,000,000 years. Similar estimates place the length of time since the last ice sheet (Wisconsin) melted from the Erie-Ontario basin at 20,000 to 40,000 years.

The glacial drift deposits recognized in Ohio were laid down during the Illinoian and Wisconsin stages. During the Illinoian ice advance the glacier apparently moved to the southwest from eastern Canada and covered much of Illinois, Indiana, and the northern and western parts of Ohio, advancing a few miles into northern Kentucky below Cincinnati. As it melted back well within the borders of Canada it left deposits of glacial drift of variable character and thickness widely distributed over the area formerly covered by the ice. During the Wisconsin stage the ice again moved from the north and covered much of western and northern Ohio, that had formerly been blanketed by the Illinoian ice sheet. The earlier drift sheet was in part eroded away and in part buried by Wisconsin drift. As the Wisconsin glacier did not extend as far south in western Ohio as the Illinoian, a fringe of older drift is found margining the deposits of Wisconsin age in that part of the State. In parts of northeastern Ohio the Wisconsin ice moved so far to the south that it over-rode the outer margin of possible earlier ice advances. The southern border of glaciation in northeastern Ohio can be represented by a general east-west line extending near St. Clair, Lisbon, and Kensington, Columbiana County, Minerva, North Industry, and Beach City, Stark County, and Winesburg and Millersburg, Holmes County, to eastern Butler Township, southeastern Richland County. At the last locality the border line turns abruptly to the southward, passing near Brinkhaven in northeastern Knox County, Newcastle in western Coshocton County, Hanover in eastern Licking County, Fultonham in southwestern Muskingum County, Junction City in west central Perry County, Lancaster in central Fairfield County, South Perry in western Hocking County, and crosses the Scioto River about 6 miles below Chillicothe in Ross County. West of the Scioto River the border extends more uniformly to the southwest near Cynthiana, Pike County, Sinking Springs, Highland County, Seaman, in Adams County, and Ripley on the Ohio River in southern Brown County. All parts of Ohio north and west of this border line were covered by one or more of the ice invasions during the Pleistocene Period.

In Ohio south and west of Richland County the Wisconsin drift border lies wholly within the area covered by the Illinoian ice invasion. From Perry County north to Richland County the Wisconsin drift is margined on the east by a continuous belt of Illinoian drift varying in width from six to fifteen miles. This belt is narrowest just east of Newark in east central Licking County, but widens to the south through northern Perry and western Muskingum counties, and to the north through eastern Knox and western Coshocton counties.[1]

From the foregoing paragraphs it is apparent that Coshocton County was little affected by the direct action of the glaciers during Pleistocene time. The Wisconsin ice covered parts of Holmes and Knox counties adjoining Coshocton on the north and west respectively, but failed to reach Coshocton County. During the Illinoian stage the ice apparently advanced from a northwesterly direction and blanketed only small areas in western Perry and western Newcastle townships. Here neither the erosional effect of the ice nor the topographic expression of its drift deposits is very conspicuous. The various ice advances during the Pleistocene, however, supplied enormous quantities of drift material to streams leading from the ice and by blocking pre-existing drainage lines, led to a series of drainage changes which affected much of the unglaciated part of Ohio.

THE ILLINOIAN DRIFT

The line representing the eastern border of the Illinoian drift sheet enters Coshocton County near the northwest corner of Newcastle Township. The border line trends to the southeast in Newcastle Township, crossing the Kokosing River near the mouth of the Mohican River

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[1] White, G. W., Illinoian drift of eastern Ohio, Am. Jour. Sci., Vol. 237, pp. 161-174, 1939.

and passing about one mile east of Newcastle. In Section 23 it turns to the south and extends in a north-south direction one and one-fourth miles east of New Guilford to the northwest quarter of Section 12, Perry Township. Here the borderline takes a southwesterly course passing through sections 13, 18, 23, 24, and 25, and leaves the county near the northwest corner of Pike Township.

The edge of the drift sheet is indistinct in Coshocton County as marginal moraines having characteristic topographic expression are lacking. The line representing the outer margins and shown in Figure 3 has been determined chiefly by the distribution of glacial pebbles and erratics on the ridges and uplands. From the northwest corner of Newcastle Township southeast across the Kokosing River to the hills north of Newcastle, border evidence has been largely removed by erosion. The margin of glacial deposits can be determined with some assurance from Newcastle south to Section 12, Perry Township, but it again became vague and uncertain where it crosses the narrow divide between Winding Fork and its tributaries to the northwest corner of Pike Township. The boundary as thus determined is in essential conformity with previous determinations by G. W. White.[1]

The materials deposited by the Illinoian ice consist chiefly of unassorted mixtures of clay and silt with minor amounts of sand, pebbles, and cobbles, the last chiefly of foreign origin, all collectively known as till. Till of Illinoian age, on fresh exposure, generally possesses a gray to bluish gray color. On prolonged exposure to the weather the soluble constituents, such as calcium carbonate, are leached from the upper layers and the iron compounds are changed to the oxide form yielding a porous mass having a yellowish brown to brown color. The till generally occurs in this county as a comparatively thin deposit on the upper slopes of the ridges and uplands, becoming inconspicuous near the margin of the glaciated area. It apparently occurs in thickest development in the southwestern part of Newcastle Township to the south and west of Newcastle and in the northwest corner of Perry Township. Beyond this area bedrock exposures are numerous not only in the valleys but also along roads traversing the more elevated portions of the land surface. Concerning the Illinoian drift in Coshocton County White[2] writes as follows:

"The glaciated part of Coshocton County is more generally till covered than is the territory nearest the glacial boundary farther to the southwest. Indeed the till is so thick in parts of these townships, that the topography has been somewhat subdued by the drift control. The surface is rolling in long smooth sweeps of 100 feet or less per mile except along the valleys of the eastward-flowing streams where the relief is more pronounced."

DRAINAGE CHANGES DUE TO GLACIATION

Coshocton County contains within its borders parts of the drainage basins of several large streams including the Mohican River, the Kokosing River, Killbuck Creek, Wills Creek, the Tuscarawas River, and the Muskingum River. Each of these streams has had a unique development. Any attempt to unravel the history of any one of these streams on the basis of evidence in an area so small as Coshocton County is fraught with much uncertainty. Abundant evidence of drainage changes is found in Coshocton County, however. Some of the minor modifications have been brought about through the natural processes of stream erosion, but many have been induced through the influence of continental glaciation. All major drainage modifications must be interpreted in the light of regional evidence, most of which is found beyond the confines of this area. The chief drainage changes affecting Coshocton County interpreted in the light of present day concepts are outlined in the following paragraphs.

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[1] White, G. W., The Illinoian drift region of northeast central Ohio, Ohio Jour. Sci. Vol. XXXVII, p. 2, 1937.

[2] White, G. W., Op. cit. p. 11.

EARLY PLEISTOCENE (PRE-ILLINOIAN) DRAINAGE

General Considerations

At the beginning of the Pleistocene Period and long before the advent of the Illinoian stage, glacial ice apparently invaded Ohio from the north. Drift sheets of pre-Illinoian age are widespread in the northern Mississippi Valley and drift believed to be older than Illinoian has been reported at a few localities in northern Kentucky[1] but deposits of similar age are not known to have been positively identified in Ohio. The presence of an early ice sheet is postulated to account for profound changes in drainage which occurred in early Pleistocene prior to Illinoian time.

During this early glaciation the ice advanced far enough in western Ohio to choke the old Teays Valley which drained southern, southeastern, and east central Ohio, and it evidently blocked the north-flowing streams which drained much of northern and northeastern Ohio. Water resulting from drainage from the south and from the melting of the ice on the north accumulated in the old valleys to form a series of temporary lakes. The water level rose in these lakes to the height of the lowest divides where new channels were formed from one drainage basin to an adjacent one of lower water level. The ultimate effect of the blocking action of the ice was to form a new drainage system with outlet to the southwest. In this new system the major streams generally followed the old valleys but in places with direction of flow reversed. Deep gorge-like channels here and there mark the location of former divides between drainage basins. Elsewhere during shift in the direction, old channels were abandoned. By the time the ice had melted back to the north a new system of drainage to the southwest had become firmly established. The axial stream in the new drainage system which received the waters of central and southern Ohio is believed to have followed a course closely approximating the line of the present Ohio River.[2]

During the ponded stage of the preglacial valleys sediment in the form of fine silt was deposited widely in the temporary lakes. The source of such material was from both adjacent shores and from the headwater of the Teays River to the southeast beyond the borders of Ohio. Such deposits are not unknown in east central Ohio near the glacial border but they are probably thicker and better preserved in some abandoned valleys in the southern part of the State. In the channel of the old Teays River at Minford, Scioto County, such deposits have a thickness of approximately 25 feet.[3]

During the long interglacial period following the retreat of the pre-Illinoian ice the major streams in the newly formed drainage system intrenched their valleys much below the preglacial or Teays level. The amount of this intrenchment varied from 50 feet to as much as 200 feet. The principal valleys thus formed were deep and gorge-like with narrow valley bottoms and steep precipitous sides. So rapid was the downcutting and so short was the period of time involved that many of the lateral valleys were only moderately affected and the uplands were only slightly reduced. The importance of this stage of deep intrenchment and its correlation with an interglacial period was first pointed out by Coffee in 1930.[4] In numerous papers on drainage changes in Ohio since that date, it has come to be known as Deep Stage drainage. As a stage in erosional history it is conceived to have begun with the advance of the pre-Illinoian ice and to have closed with the advance of the Illinoian glacier.

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[1] Leverett, Frank, The Pleistocene of Northern Kentucky, Ky. Geol. Survey, Series VI, Vol. 31, 1929.

[2] Stout, W., Ver Steeg, Karl, and Lamb, G. F., Geology of Water in Ohio, Geol. Survey Ohio, Bull. 44, Map. opp. p. 78, 1943.

[3] Stout, Wilber, and Schaaf, Downs, Minford Silts of Southern Ohio, Geol. Soc. America, Bull., Vol. 42, pp. 663-672, 1931.

[4] Coffee, G. N., Preglacial, Interglacial, and Postglacial Changes of Drainage in Northeastern Ohio with Special Reference to the Upper Muskingum Drainage Basin, Ohio Jour. Sci., Vol. XXX, pp. 373-384, 1930.

In Coshocton County the preglacial drainage pattern persisted with only minor modifications during the Deep Stage. The drainage basins of some streams were greatly enlarged, however, under the influence of the pre-Illinoian ice and the channels of all the major streams were deeply intrenched below the preglacial or Teays level.

The Newark River

At the beginning of the glacial period, that part of the present Tuscarawas Valley above Gnadenhutten drained to the n orth. The pre-Illinoian ice blocked the outlet of this valley. The waters ponded in front of the ice broke over the high divide previously described, extending past the sites of the present towns of Port Washington and Gnadenhutten, and discharged to the southwest by way of Newcomerstown Creek and the Cambridge River. A southwestern direction for discharge of much of the drainage from western Harrison, Carroll, and Tuscarawas counties and probably from areas still farther north thus first came into existence. To the axial stream of this drainage system in east central Ohio the term Newark River has been applied.[1] In Pickaway County the Newark River turned to the south and following the course of the present Scioto joined at the site of Portsmouth the newly formed stream which occupied the present Ohio Valley.

Deep Stage Holmes River

With the advance of the pre-Illinoian ice, water was ponded north of the high divide extending in a general east-west direction through Holmes County. It broke over this divide about midway between Millersburg and Killbuck into the headwaters of pre-glacial Roscoe Creek, establishing a course to the south along the site of the present Killbuck and Walhonding valleys to the Newark River near the present town of Coshocton. White has named this stream the Deep Stage Holmes River. According to his concept it received the drainage from Richland, Ashland, Holmes, and southwestern Wayne counties.[2] Its chief tributary from the east in Coshocton County was a stream which rose in eastern Mechanic Township, Holmes County, and flowed to the southwest along the site of Doughty Creek. Tributaries from the west occupied the present valleys of Wolf Creek and Big Run. A large tributary from the west apparently headed in northwestern Newcastle Township and flowed southeast along the site of the present Walhonding Valley in Jefferson and western Bethlehem townships.

Much of the northeast quarter of Coshocton County was drained by streams which were tributary to the Newark River and which occupied the valleys of Evans Creek, White Eyes Creek, and Mill Creek.

Plainfield Creek

During the Deep Stage the southeastern corner of Coshocton County was drained by a stream which occupied much the same course as the headwaters of the preglacial Cambridge River. This stream had its source in northern Noble County, flowed northwest through Guernsey County along the site of Wills Creek to Plainfield. From Plainfield its course was northwest through a wide open valley to the Newark Valley near West Lafayette. To the Deep Stage stream occupying this valley Stout and others have applied the name Plainfield Creek.[3] At Plainfield it was joined from the south by a stream that headed in northeastern Muskingum County and flowed north through the valley of present White Eyes Creek. In southern Linton Township Deep Stage White Eyes Creek was joined by a tributary from the southwest which had its headwaters in southwestern Linton Township and flowed northwest along the present site of Wills Creek.

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[1]Stout, Wilber, et al., Geology of Water in Ohio, Geol. Survey Ohio, Bull. 44, p. 81-82, 1943.

[2]White, G. W. Drainage History of North Central Ohio, Ohio Jour. Sci. Vol. XXXIV, pp. 373-374, 1934.

[3]Op. cit., p. 82.

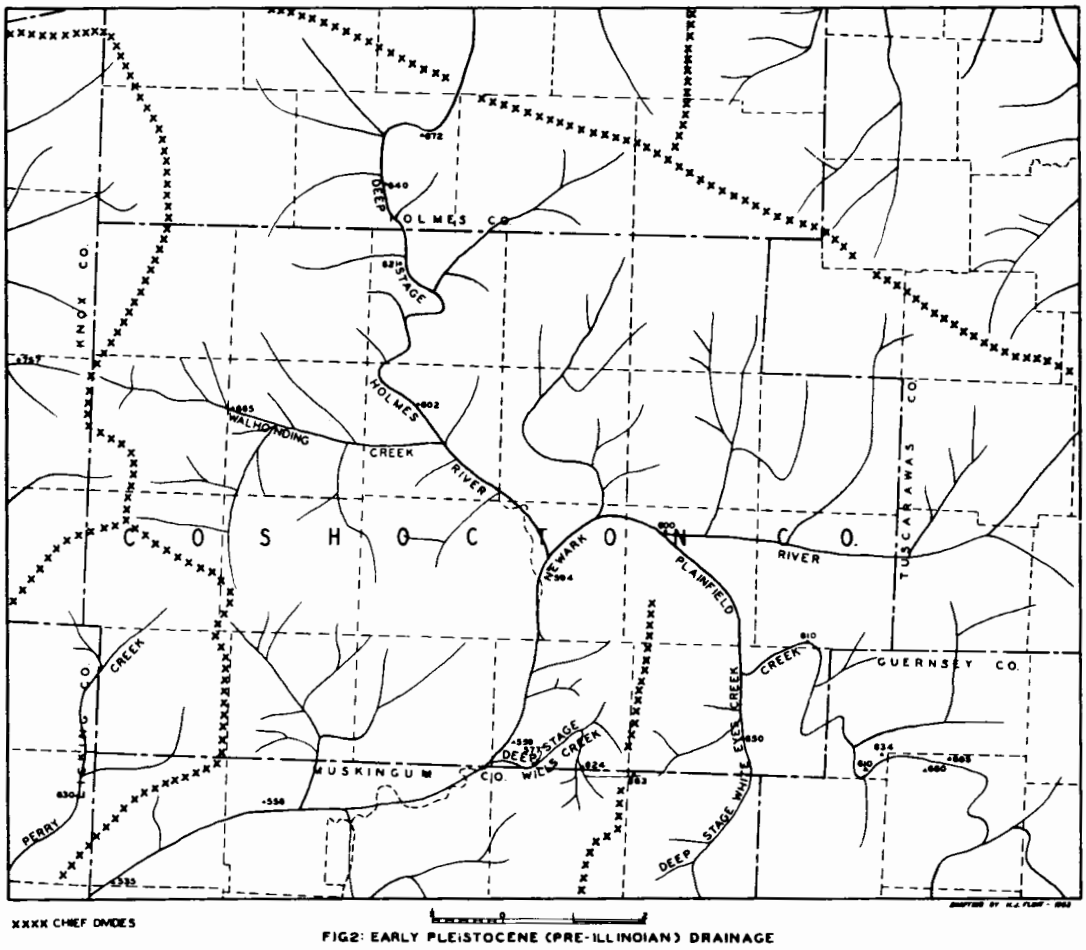

FIG2: EARLY PLEISTOCENE (PRE-ILLINOIAN) DRAINAGE

Deep Stage Wills Creek

According to the writer's interpretation the present pattern of drainage in the lower part of the Wills Creek Valley came into existence during the Deep Stage. The diversion of drainage to the southwest at Plainfield did not take place until much later, probably Recent times. During the Deep Stage a small tributary of the Newark River in southeastern Virginia Township is conceived by head erosion to have diverted the headwaters of preglacial Franklin Creek more directly to the southwest. Continued erosion reduced the divide to the east of the headwaters of Franklin Creek. By the end of the Deep Stage, Wills Creek is believed to have had an extent as shown in Figure 2. The divide between Deep Stage Wills Creek and Deep Stage White Eyes Creek along the site of the present Wills Creek Valley was probably very low, in fact below the level of the present alluvial deposits in this valley. It is not improbable that waters from Plainfield Creek may have discharged to the southwest by way of the Wills Creek Valley during the early part of the Deep Stage cycle.

Western and Southwestern Coshocton County

The general drainage pattern in western and southwestern Coshocton County underwent few changes during the early Pleistocene. In southwestern Holmes County and in western Tiverton and southwestern Newcastle townships, Coshocton County, the drainage was to the southwest through Deep Stage streams tributary to the East Branch of the North Fork of the Newark River.[1] The Newark River received the drainage directly from the southwestern corner of the county through streams occupying valleys similar in configuration to the present Little Wakatomika Valley and to the preglacial Perry Valley.

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[1] Lamborn, R. E., The Newark Drainage System in Knox, Licking, and Northern Fairfield Counties, Ohio Jour. Sci., Vol. XXXII, pp. 449-466, 1932.

VALLEY INTRENCHMENT

General Considerations

The Deep Stage cycle is characterized by the deepening of many large valleys to levels much below that of the Teays Stage. The overdeepening of the major valleys is believed to have resulted chiefly from regional uplift of the land surface with respect to sea level. Other factors such as a shortening of the master streams or changes in the amount and distribution of rainfall may have played a part. Following the period of intrenchment during the Deep Stage the master valleys were aggraded during the Illinoian ice advance, again degraded but to shallower depths during the Sangamon interglacial stage, and again aggraded during the Wisconsin ice advance. Since the retreat of the Wisconsin ice the master streams in Coshocton County have degraded their channels as much as 70 to 80 feet below the level of prominent gravel terraces of Wisconsin age. During the Deep Stage the Newark Valley in Coshocton County was deepened as much as 200 feet below the Teays level and as much as 160 feet below the present valley bottoms. Evidence of such deep intrenchment and subsequent filling rests chiefly on the records of scattered deep wells drilled for oil or gas and from core borings. Such scattered data indicate deep intrenchment for the valleys of the Newark River, Plainfield River, Deep Stage Wills Creek, Deep Stage Holmes River, Walhonding Creek, and Perry Creek.

The Newark Valley

In Coshocton County the old Newark River cut a deep channel through sandstone and shale to a depth much below the level of the present flood plain of the Tuscarawas-Muskingum Valley. Occasional wells drilled along the flood plain indicate alluvial filling to a depth ranging from 150 to 175 feet. In the A. A. Wohlwend No. 1 well, drilled along the Tuscarawas River about $1\frac{1}{2}$ miles southwest of Gnadenhutten, Clay Township, Tuscarawas County, alluvial materials were penetrated to a depth of 190 feet before bedrock was reached. As the well head elevation is approximately 815 feet above tide, the rock channel of the Newark River at this locality must have been as low as 625 feet above tide. The depth of intrenchment here is all the more striking in view of the fact that the high preglacial divide crossed the site of the Newark Valley near this locality. No records of deep borings are available for that part of the Tuscarawas Valley between Port Washington and West Lafayette. Some 2 miles west of West Lafayette and three-eighths of a mile northeast of Morgans Run, a well located on the Ross Property about the middle of the valley penetrated 160 feet of unconsolidated materials before reaching bedrock at an altitude of 600 feet or some 25 feet below the top of bedrock in the Wohlwend well near Gnadenhutten.

Early in the search for oil and gas a deep well was drilled in the Muskingum Valley at Coshocton.[1] The location of this test is near the middle of the flood plain, about five-eighths of a mile southeast of the mouth of the Walhonding River. Here "drift clays and quicksand" were penetrated to a depth of 171 feet, the bedrock floor of the valley being reached at that depth or at an altitude of about 594 feet. No further data are at hand relative to the depth of bedrock along the old Newark Valley south of Coshocton until the vicinity of Conesville is reached. Here several wells have been drilled to the east and southeast of the village. The depths of alluvial fill below the present flood plain vary in these wells from 157 to 169 feet. Bedrock was reached at the lowest level in the Kenneth E. MacLeod No. 1 well located near the east side of the valley about five-eighths of a mile east of south of Conesville and about $1\frac{1}{4}$ miles north of the southern boundary of the county. The drive pipe descended through unconsolidated materials to a depth of 168 feet, reaching bedrock at an altitude of 559 feet above tide. Assuming that in the wells heretofore mentioned the drill has reached bedrock in the lowest part of the valley, it becomes apparent that the rock gorge of the Newark River slopes to the southwest. The total amount of this fall from the Wohlwend well near Gnadenhutten to the MacLeod well near Conesville is 66 feet, yielding an average slope to the southwest across Coshocton County of approximately 2 feet per mile.

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[1] Orton, Edward, Economic Geology, Geol. Survey Ohio, Vol. VI, p. 324, 1888.

Down valley from Conesville the gradient of the rock channel of the Newark River decreases slightly across northwestern Muskingum County. A number of wells have been drilled in this valley at Black Run in southwestern Jackson Township, bedrock being encountered at the lowest level in the Margaret Fleming No. 1 well. At this place bedrock was first reached at a depth of 235 feet or at an altitude of 535 above tide, or 24 feet lower than in the MacLeod well near Conesville. A gradient or slope of 1.45 feet per mile to the southwest is thereby attained for the floor of the Newark Valley across northwestern Muskingum County. The slope of 2 feet per mile in Coshocton County and 1.45 feet per mile in Muskingum County is in rough harmony with the slope of .9 feet per mile (10.8 inches) for this valley southwest of Newark in south central Licking and northeastern Fairfield counties.[1]

Plainfield Valley

Evidence of deep intrenchment in southeastern Coshocton County by Plainfield Creek is rather meager. A few wells drilled along this valley widely spaced and occurring in both Coshocton and northwestern Guernsey counties indicate unconsolidated materials to a depth below the present valley bottoms ranging from approximately 100 to 150 feet. In the Isaac Oldham No. 1 well drilled near the center of the valley in the west central part of Section 3, Cambridge Township, Guernsey County, bedrock was first encountered at a depth of 133 feet below the surface or at an altitude of 650 feet above tide. Drilling in this valley has also occurred near the relocation of the Pennsylvania Railroad northwest of Kimbolton, Liberty Township. Here a number of wells have been sunk to depths of 50 feet or more below the present valley bottom without reaching bedrock.[2] Near the south side of the valley in the southwest quarter of Section 24, Liberty Township, the Ohio Fuel Gas Company drilled a well on the Hay and Webb property which penetrated 134 feet of unconsolidated materials before reaching consolidated rock at an altitude of 660 feet. In the southeast quarter of Section 22, Wheeling Township, a well located near the center of the valley on the A. B. Wilson property reached bedrock at a depth of 153 feet below the surface or at an altitude of 610 feet above tide. Near the north side of the old valley at the south edge of Oxford Township three-fourths of a mile southwest of McCune School, a well was sunk in 1936 to the Berea sandstone on the Hugh Jones property. Bedrock, probably representing the valley floor, was encountered at a depth of 150 feet below the present valley bottoms or at an altitude of about 610 feet above tide. No well data are available for that part of the old valley of Plainfield Creek, now abandoned, extending between Plainfield and West Lafayette. That Plainfield Creek flowed to the northwest from Plainfield and emptied into the Newark River near the present town of West Lafayette, seems assured since the altitude of the bedrock floor in the Jones well is fully 50 feet lower than the rock floor of the valley of Wills Creek near Maysville in southwestern Linton Township. Based on these records the gradient or slope of the old valley floor of Plainfield Creek is approximately 1.8 feet per mile to the northwest between the Oldham and Jones wells and about 1.55 feet per mile between the Oldham well and the Ross well located in the Newark Valley north of Morgan Run and at the mouth of Plainfield Creek as previously described.

Deep Stage Wills Creek Valley

Deep Stage Wills Creek was a short stream which at maximum development probably had its headwaters in southwestern Linton Township and followed closely the present course of Wills Creek to the Newark River. That it cut a deep gorge in the underlying rocks before the end of the Deep Stage is indicated by numerous test borings along its valley. Preparatory to the location of the Wills Creek dam, test borings were made by U. S. Army Engineers at three proposed sites along this valley. At the Conesville site, located 1.9 miles above the mouth of Wills Creek and close to the Muskingum-Coshocton county boundary, a number of test holes were drilled to determine the depth and character of valley filling. The hole reaching the lowest

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[1] Lamborn, R. E., The Newark Drainage System in Knox, Licking, and Northern Fairfield Counties, Ohio Jour. Sci., Vol. XXXII, p. 452-453, 1932.

[2] Records of core borings by U. S. Army Engineers.

level (C-3) penetrated about 150 feet of sand and silt to an altitude of 577 feet above tide without reaching the rock bottom of the valley. At the Wills Creek dam site, located at the south boundary of Coshocton County 1½ miles south of the village of Wills Creek, the lowest point at which rock was reached in a series of holes drilled across the valley has an altitude of 624 feet or 110 feet below the present valley flats. Still farther up valley at the Maysville site, located three-eighths of a mile west of Maysville, the lowest point at which the upper surface of bedrock was encountered in test drilling has an altitude of 663.5 feet above tide and a depth of 81.7 feet below the surface. From these figures a slope of about 15 feet per mile is indicated for that part of the valley of Deep Stage Wills Creek below the Maysville dam site. The exact position of the divide between the headwaters of Wills Creek and the drainage to White Eyes Creek at the end of the Deep Stage is in doubt but it must have crossed the valley east of Maysville. That White Eyes Creek did not drain to the southwest by way of Wills Creek to the Newark River during the latter part of this stage seems assured since the bedrock channel near the present mouth of White Eyes Creek is lower than the rock floor of Wills Creek at the Maysville dam site. In the John McAllister et al No. 1 well drilled near the mouth of White Eyes Creek in the southwest quarter of Section 20, Linton Township, bedrock was first encountered at a depth of 150 feet or at an altitude of 650 feet above tide. This is 13 feet lower than the deepest known point for the bedrock valley floor at the Maysville site. It seems, therefore, that the col separating the headwaters of Wills Creek from the drainage basin of White Eyes Creek at the end of the Deep Stage was located along the line of the present valley of Wills Creek between Maysville and the present mouth of White Eyes Creek.

Deep Stage Holmes River Valley and its Tributaries

Evidence of deep intrenchment of the valley of the Holmes River below the valley flats of present Killbuck Creek is indicated by wells drilled for oil and gas east of Killbuck, Killbuck Township, Holmes County; south of Killbuck in Section 16, Killbuck Township; near Layland, Clark Township; and near the mouth of Killbuck Creek in west central part of Bethlehem Township. In these wells unconsolidated deposits extend to depths below present valley flats ranging from about 135 feet to 180 feet. In the R. J. Moser No. 1 well located toward the south side of the valley in the central part of Section 7, Killbuck Township, 1½ miles east of Killbuck, the drill penetrated 138 feet of sand before reaching bedrock which at this locality has an altitude of 672 feet. This well is located only a mile or two south of the high divide separating northern- and southern-flowing streams in late preglacial time. A second well along the Holmes Valley in Killbuck Township is located some two miles south of Killbuck on the east side of the valley on the Leslie Carpenter property in central Section 16. Here gravel was penetrated to a depth of 160 feet before reaching bedrock having an altitude of 640 feet.

Near Layland in northwestern Clark Township several wells drilled along the valley flats have penetrated unconsolidated materials ranging in thickness from about 150 to 170 feet. In this group of wells bedrock was reached at the lowest altitude in the Cheney-Meyer No. 1 located west of Killbuck Creek and three-eighths of a mile south of Layland. The drill passed through unconsolidated materials having a total thickness of 169 feet and reached bedrock at an altitude of 621 feet. Another group of wells drilled along the valley in the west central part of Bethlehem Township penetrated soil, sand, and gravel having a similar thickness. In the William Sowers No. 4 well located in this group near the middle of the valley, three-eighths of a mile southwest of School No. 3, 178 feet of alluvial material was penetrated before reaching bedrock having an altitude of 602 feet. Well data indicating the depth of fill below present valley bottoms are generally lacking along the Holmes River Valley south of central Bethlehem Township. Assuming that the lowest point at which bedrock was encountered at any locality represents the valley floor at that place the gradient of this old channel in Coshocton County can be approximated using data given above and the deep well drilled at Coshocton near the mouth of the Holmes River. In the latter well, as previously stated, the rock floor occurs at an altitude of 594 feet. This is 8 feet below the rock floor of the valley at the Sowers No. 4 well, yielding a gradient for the lower part of the Holmes Valley of .98 feet per mile to the southeast. Up valley the gradient or slope increases. Between Cheney-Meyer No. 1 and Sowers No. 4 the slope is 1.76 feet per mile; between Leslie Carpenter No. 1 and Cheney-Meyer No. 1 well it is 5.43 feet per mile; and between the Moser and Carpenter wells it is 8.00 feet per mile. The average slope of the rock channel from the vicinity of Killbuck to Coshocton is about 2.9 feet per mile in a southern direction.

In Clark Township the Holmes River was joined by a tributary from the west occupying the site of the valley of Big Run, and by a tributary from the northeast which drained in part the valley of Doughty Creek. The amount of intrenchment along the valley of Big Run is unknown due to the lack of well data. Meager information along the valley of Doughty Creek indicates Deep Stage intrenchment below present valley bottoms in excess of 100 feet for that part of the valley occurring in Clark Township.

The Deep Stage stream that occupied the Walhonding Valley in part and joined the Holmes River in central Bethlehem Township, here known as Walhonding Creek, likewise cut a deep gorge below the present valley bottoms. Test borings in this valley made by the U. S. Army Engineers at the site of the Mohawk dam preparatory to its construction show silt, sand, and gravel having a maximum depth of 133 feet below the level of the present channel of the Walhonding River. The bottom of the rock channel at this locality has an altitude of 665 feet or 71 feet above the level of the bottom of the Newark Valley at Coshocton. Up valley from the Mohawk dam a few wells have been drilled for oil and gas on the bottom lands near the mouth of the Mohican River and along the Kokosing in northern Butler Township, Knox County. In those wells located along the axis of the old channel, the drill passed through unconsolidated materials approximately 100 feet in thickness before entering bedrock. In the Edwin O. Rodehover No. 1 well, located about one-half mile below the mouth of the Mohican River and near the south side of the Walhonding Valley, unconsolidated materials were penetrated to a depth of 112 feet before reaching bedrock. In the H. G. Hammond No. 1 well located near the center of the valley and near the mouth of Brush Run in the central part of Section 3, Butler Township, Knox County, the drill penetrated 100 feet of unconsolidated materials and reached bedrock at an altitude of 757 feet. This is 92 feet above the valley floor at the Mohawk dam, yielding a gradient or slope for the Deep Stage valley between these wells of about 10 feet per mile in an eastern direction.

Well records indicate deep intrenchment in the lower part of the valley of Brush Run, Butler Township, Knox County, during the Deep Stage. The unconsolidated materials along the valley of the Kokosing River west of the mouth of Brush Run seem to thin rapidly to the west. Bedrock outcrops along the gorge of the Kokosing River and wells drilled near the middle of the open valley north of the river in the north central part of Section 4, Butler Township, and west of the river in the southeastern part of Section 25, Union Township, penetrated only 20 feet or so of unconsolidated materials. The preglacial divide is believed to have crossed the Kokosing Valley near the Coshocton-Knox County line and to have extended southward east of Brush Run. During the Deep Stage this divide was pushed westward by differential erosion and the waters of Brush Run were diverted to the east. By the end of the Deep Stage the divide is believed to have crossed the site of the present Kokosing Valley about $1\frac{1}{2}$ miles southeast of Millwood.

No well data are available relative to intrenchment below present levels of Deep Stage streams which occupied the valleys of Mohawk Creek, Simmons Run, and Beaver Run in Jefferson Township.

Valley of Perry Creek and its Tributaries

Numerous wells drilled in the old valley of Perry Creek near the Village of Perryton, Section 10, Perry Township, Licking County, show alluvial materials ranging in thickness from 60 to 158 feet. In the J. E. Seward No. 3 well located near the middle of the old valley one-fourth of a mile east of the village, unconsolidated material was penetrated to a depth of 158 feet, bedrock being reached at an altitude of about 630 feet. North of Perryton well data indicating the depth of fill are lacking along the old valley in Fallsbury Township, Licking County. Wells drilled along Winding Fork in northwestern Pike Township and southern Perry Township, Coshocton County, indicate a depth of fill for this part of the valley ranging from about 35 to 40 feet. A similar thickness for valley filling is recorded in logs of wells drilled along the valley of Fivemile Run in south central Pike Township.

Well data indicating the depth of intrenchment below present levels along the valley of Little Wakatomika Creek in southern Coshocton County are lacking.

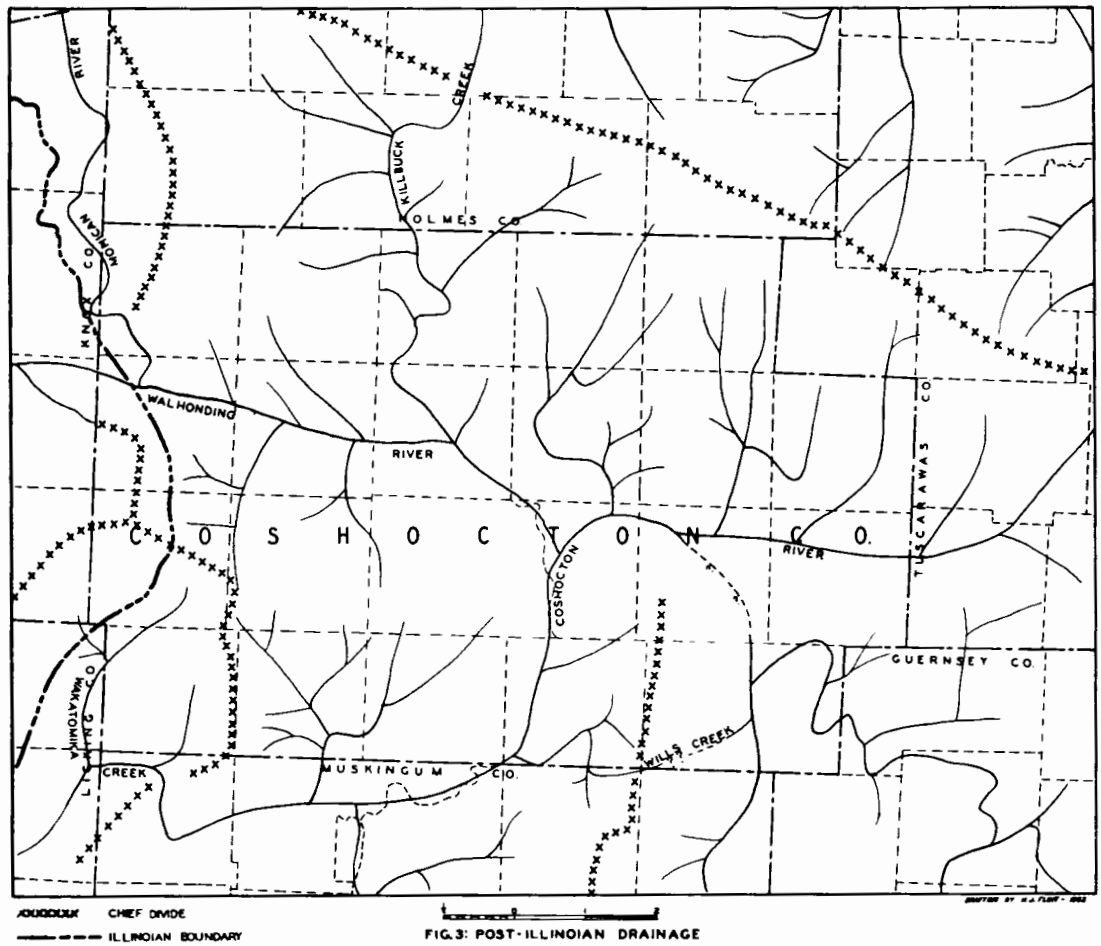

FIG. 3: POST-ILLINOIAN DRAINAGE

ILLINOIAN DRAINAGE CHANGES

General Considerations

The drainage systems established during the Deep Stage were modified to some extent by the Illinoian ice. During this stage the ice covered much of the western half of Ohio. Advancing from the north, it filled the Newark Valley west of Hanover, Licking County, and crossed the present Ohio Valley into northern Kentucky in the Cincinnati region. At the time of its maximum extent it blocked the southwestern avenue of discharge for drainage of eastern Ohio established during the Deep Stage. From Hanover, which marks its eastern extent along the Newark Valley, the eastern boundary of the ice advance extended to the north through eastern Licking County and central western Coshocton County as shown on the map in Figure 3. A short distance northwest of Coshocton County, the Illinoian drift margin passes beneath drift of Wisconsin age and loses its identity. The erosive action of the Illinoian ice increased the load of streams flowing from its margin and led to aggradation along many of the deep valleys formed during the Deep Stage. Ponded conditions in some areas led to the formation of a few new channels in Coshocton County which persisted after the ice disappeared.

Mohican River

The most outstanding change in drainage in Coshocton County induced by the Illinoian glacier was the formation of the Mohican River. Concerning the beginning of this drainage G. W. White[1] writes as follows:

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[1] White, G. W., Drainage history of north central Ohio, Ohio Jour. Sci., Vol. XXXIV, p. 376, 1934.

"The Illinoian ice front lay from one to five miles west of the present Mohican River in northeastern Knox County and continued just east of south across Newcastle and Perry townships of Coshocton County, from one to eight miles west of a preglacial north-south divide. The ice dammed the headwaters of the westward- and southwestward-flowing tributaries to the Deep Stage East Branch of the North Fork of the Newark River and caused the water to flow south across westward extending spurs of the north-south divide, from one headwater basin to the next as far as southwestern Tiverton Township, Coshocton County. Here a low place in the north-south divide allowed the water to break over to the southeast and enter the valley of the Walhonding River, which then as now, flowed east-southeast to Coshocton where it united with the Tuscarawas River."

As thus described the Mohican River in Coshocton County came into existence as a stream marginal to the Illinoian ice sheet.

Wakatomika Creek and its Tributaries

No radical changes in the drainage of Wakatomika Creek or its tributaries are believed to have taken place in southwestern Coshocton County during or as a result of the Illinoian glacial stage. However, the shift of the course of Wakatomika Creek from the valley of Deep Stage Perry Creek in Perry Township, Licking County, to its present course through Jackson Township, Muskingum County, to the Newark Valley dates to this period. When the Illinoian ice was at its maximum extent in eastern Licking County, a thick deposit of glacial material was laid down in the Newark Valley just east of Hanover.[1] Glacial materials of a similar nature were deposited in the valley of Deep Stage Perry Creek north of Hanover. The waters, which were ponded in Perry Creek Valley, finally broke over the old preglacial divide in the west central part of Section 8, Jackson Township, Muskingum County, into the headwaters of a southern-flowing tributary to the Newark River. The position of the old divide is represented by the gorge along the present course of Wakatomika Creek above and below which the valley widens with well developed valley flats.

Coshocton River

No marked changes in the configuration of the Newark Valley occurred in Coshocton County during the Illinoian ice advance or in post-Illinoian time. The direction of flow of the river, however, may have been reversed during a part of this period. If the Illinoian glacier did not extend into northeastern Ohio the waters ponded in the Newark Valley by the ice and drift dam at Hanover, Licking County, may have broken over the divide at the headwaters of the Newark drainage and flowed to the north through channels now filled in part by Wisconsin drift.[2] Under this conception, the drainage of the Newark Valley in Coshocton County during the Illinoian stage was to the northeast. If the Illinoian ice covered northeastern Ohio[3] and its period of advance in that area was simultaneous with the farthest extension of the ice in the Cincinnati region, there is no apparent outlet for the drainage from the non-glaciated area of southeastern Ohio for that time. A short recession in the southwest, however, would have freed the Ohio Valley and permitted drainage to the southwest from east central Ohio providing the waters from the Newark Valley discharged to the south along the course of the present Muskingum River south of Trinway and across the preglacial divide at the Muskingum-Morgan County line.

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[1] Carney, F., Valley dependencies of the Scioto-Illinoian lobe in Licking County, Ohio, Jour. Geol., Vol. 15, p. 494, 1907. White, G. W., The Illinoian drift of eastern Ohio, Am. Jour. Sci., Vol. 237, p. 167, 1939.

[2] Stout, Wilber, Ver Steeg, Karl, and Lamb, G. F., Geology of Water in Ohio, Geol. Survey Ohio, Bull. 44, pp. 89-90, 1943.

[3] See Schaefer, E. J., White, G. W., and Van Tuyl, D. W., Groundwater resources of the glacial drift deposits in the vicinity of Canton, Ohio, Ohio Water Resources Board Bull. 3, p. 11, 1946.

To this stream which flowed through Coshocton County but of probable inconstant point of exit the writer has applied the term Coshocton River. It is probable that the direction of discharge of the Coshocton River was to the southwest for a large fraction of Illinoian stage time.

Wills Creek Drainage Basin

No great changes are known to have taken place in the upper part of the Wills Creek drainage basin during or as a result of the Illinoian ice advance. With the damming of the Newark Valley at Hanover, waters were ponded in the valleys of Deep Stage Wills Creek and Plainfield Creek. These valleys were apparently filled with comparatively fine-grained sediments washed in, in part, from the hills to the south and in part from the Coshocton River from the west. That the main river current did not pass through the old valley extending south from West Lafayette is indicated by the absence in it of coarse outwash deposits. Sands with fine gravel of glacial origin do occur a few feet above Wills Creek south of Plainfield. In test drilling by the U. S. Army Engineers at the dam sites along Wills Creek, clay, silt, and medium to fine sand were the materials penetrated. The texture of this material is in striking contrast to the coarse sands, gravels, boulders, and hardpan which make up the valley filling in the Muskingum and Tuscarawas valleys in Coshocton County. Whether or not Plainfield Creek discharged to the southwest through the Wills Creek Valley at the end of the Sangamon interglacial stage is not clear.

WISCONSIN DRAINAGE CHANGES

General Considerations

Little change took place in the drainage configuration in Coshocton County during or as a result of the Wisconsin ice advance. During this stage the glacier covered all of northern Ohio and adjacent parts of Pennsylvania on the east and Indiana on the west. Along the Killbuck Valley the ice advanced as far south as south central Holmes County, in places nearly reaching and at other localities slightly overriding the high preglacial divide which crosses that area.[1] Along the Scioto and Miami valleys the ice pushed much farther south but it failed to reach the Ohio River. Along the east side of the Scioto lobe it extended as far as central Licking and central Knox counties, ten miles or so west of the west boundary of Coshocton County. The melt waters flowing from the ice front in Holmes County on the north and from Knox County on the west carried large quantities of glacial debris and deposited it as valley trains. Remnants of these valley trains are found at many localities along the through-flowing streams as gravel terraces. The post-Wisconsin drainage is shown in Figure 4 .

Muskingum River

The Muskingum River is conceived to have become firmly established with the advance of the Wisconsin ice. The presence of glacial ice in northeastern Ohio blocked all possibilities of a northern outlet for the old Newark Valley. An outlet was established along the line of the present Muskingum River south of Trinway and across the divide at the southern edge of Muskingum County into a tributary to the Ohio River and thence to the southwest.[2] There is a possibility that a southwestern outlet by way of the Muskingum River through Muskingum County may have been developed before the beginning of the Wisconsin stage.

Wills Creek

It is believed that by Wisconsin time the old channel below Plainfield had been abandoned and that the present course of Wills Creek to the southwest had been established. That the main

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[1] White, G. W., Geology of Holmes County, Geol. Survey Ohio, Bull. 47, Map opp. p. 18, 1949.

[2] Stout, Wilber, et. al., op. cit., map opp. p. 94.

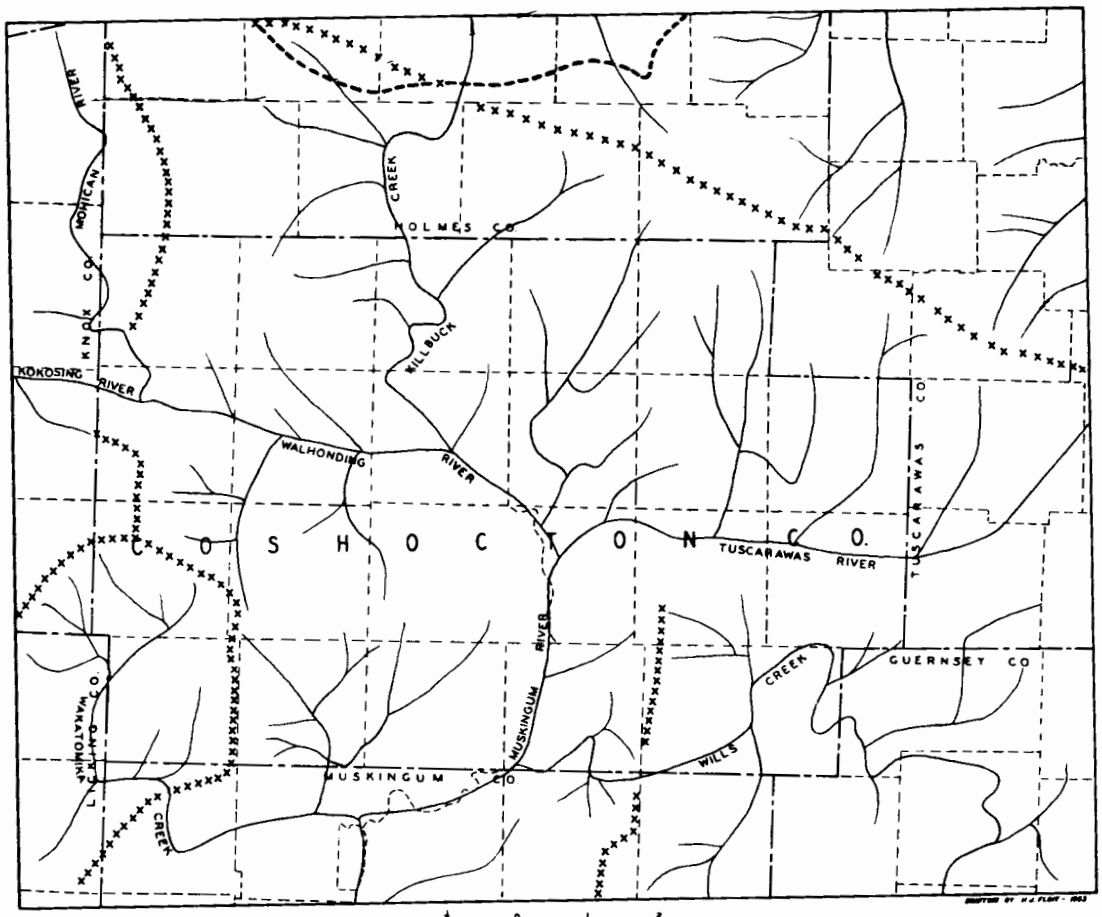

FIG.4: POST-WISCONSIN DRAINAGE

current of melt waters from the Wisconsin ice with its load of glacial debris did not flow southward from West Lafayette and discharge into the Muskingum River by way of Wills Creek seems assured since deposits of sand and coarse gravels of any magnitude are wanting at the surface along the old valley south of West Lafayette.

OUTWASH DEPOSITS

GENERAL CONSIDERATIONS

The waters released by the melting of the glacier were instrumental in transporting and ultimately depositing much rock debris produced by ice erosion. Where the ice margin was bordered by a region of slight relief, stratified deposits of glacial outwash were laid down as broad outward-sloping apron-like deposits margining the ice front. In more maturely dissected regions such as the territory embracing Coshocton County, the melt waters were concentrated in preexisting valleys which served as avenues of escape. So great was the load of rock debris, including cobbles, gravel, sand, and silt, that large quantities were deposited aggrading the valleys to various levels.

Thus during the Illinoian ice advances the Deep Stage valleys were partially filled with Illinoian outwash most of which was removed during the long interglacial stage (Sangamon) which elapsed before the approach of the next ice sheet. The Wisconsin glacier yielded another flood of rock debris to major streams flowing southward from the ice front. Their channels were again the locus of deposition for large quantities of glacial outwash. A part of this Wisconsin outwash has been removed by erosion but large quantities remain as valley terraces.

In Coshocton County during the Pleistocene, large quantities of glacial outwash were swept into the Killbuck Valley from the north; into the Mohican, Kokosing, and Walhonding valleys from the northwest and west; and into the Tuscarawas Valley from the northeast. Glacial material was also carried into the Muskingum Valley. Remnants of these deposits remaining as gravel terraces are conspicuous topographic features along the Killbuck, Walhonding, Tuscarawas, and Muskingum valleys.

HIGH LEVEL (ILLINOIAN ?) TERRACES

In Coshocton County outwash deposits from the Illinoian ice were almost completely removed before the Wisconsin ice advance. Remnants of high level gravel terraces attributed by G. W. White to Illinoian time have been noted by him along the Mohican Valley three-fourths of a mile southwest of Cavallo and along the Walhonding Valley one-fourth of a mile north of the Village of Walhonding.[1] The upper surface of these gravels is from 50 to 100 feet above the prominent Wisconsin outwash deposits in the same vicinity.

In the Tuscarawas Valley remnants of outwash deposits have been noted along the road about one mile north of Canal Lewisville. The altitude of these deposits is about 880 feet or approximately 60 feet above the level of prominent gravel terraces at Coshocton, considered here as of Wisconsin age.

Along the Muskingum Valley, high level gravels have been noted at several localities in the vicinity of Conesville. In the road cut one-half mile west of the village, the exposures consist of Pennsylvanian shale overlain by a few feet of fine-grained plastic silts above which is glacial outwash. The upper surface of the gravel deposits at this place has an altitude of 850 to 860 feet or 50 to 60 feet higher than the prominent Wisconsin terraces just northwest of the village. About two and one-half miles northeast of Conesville prominent remnants of valley flats occur in the west central and south central parts of Section 8, Franklin Township. The upper surface of these flats, which has an altitude of 860 to 870 feet, is rather smooth and featureless. Its outer margin is indented by past depositional stream erosion. Exposures along the roadside indicate sand and gravels which are highly weathered and oxidized.

WISCONSIN TERRACES

Mohican-Walhonding Valley

Terrace-like remnants of outwash deposits of gravel and sand are intermittently present along the entire course of the Mohican-Walhonding River from the western edge of the county in Tiverton Township to the union of this stream with the Tuscarawas River at Coshocton. The upper surface of these deposits ranges in altitude from about 900 at Walhonding to about 820 feet at Coshocton. In Newcastle Township the deposits are broad terrace-like features, rising 20 to 40 feet above the flood plains and extending from the valley walls outward into the concave side of meander bends of the rivers. In Jefferson and Bethlehem townships terrace deposits of outwash materials are generally lacking bordering the flood plains except at the mouths of tributary valleys where small remnants of once more extensive deposits have been preserved. Such remnants occur as conspicuous valley restrictions at the mouths of Mohawk Creek, Simmons Run, Beaver Run, Crooked Run, and other smaller tributaries entering the Walhonding from both the north and the south.

The outwash deposits in the Mohican-Walhonding Valley in Coshocton County range in texture from cobbles measuring six inches or more across to sand. In general the texture of

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[1] White, G. W., Illinoian drift region of northeast central Ohio, Ohio Jour. Sci., Vol. XXXVII, p. 18, 1937.

the material becomes coarser and the percent of coarse tends to increase to the westward or headwards in the valley. When traced laterally up short tributary valleys the gravels of the Walhonding Valley rapidly become finer and with a great diminution in thickness pass into silts of more local source. The cobbles and gravels in outwash deposits along the Mohican-Walhonding Valley consist in large part of fragments of hard weather-resistant types of igneous and metamorphic rocks, with only minor amounts of sandstone, limestone, and chert. Field inspection of the gravels at several localities has failed to reveal any appreciable amount of soft shale, clay, or coal.

The outwash deposits along the Mohican-Walhonding Valley in Coshocton County have long been the source of much gravel for concrete aggregate and for road construction. Pits have operated in these gravels at Walhonding, Warsaw, near Randle in Bethlehem Township, and above Roscoe in northeastern Jackson Township. At the present time (1952) pits are being operated by W. P. McCarren Co. in terrace gravels just north of Walhonding; by Fletcher Pugh in deposits just north of Warsaw, and by Bert W. Boyd and Son in outwash gravels one mile northwest of Roscoe. The part of the deposits utilized varies from pit to pit from 15 feet to an estimated 50 feet and requires little stripping. In predominating practice the material is screened and washed, the larger cobbles being crushed in the process to necessary size. Workmen estimate that prepared gravel of marketable size varies from about 55 percent to 65 percent of material handled.

Killbuck Valley

Remnants of outwash deposits of sand and gravel have been noted at scattered localities along the Killbuck Valley in Clark and Bethlehem townships. The most conspicuous of these deposits occur just west of Layland, across the valley above Helmick, on the east side of the valley just south of Blissfield, and at Metham, and on the west side of the Killbuck Valley one-half mile or more north of Bantum School. The altitudes of the somewhat flattened upper surface of these deposits range from approximately 860 feet near Layland to about 830 feet near Bantum School, becoming in general progressively lower to the south. The material comprising the deposits is comparable in general aspect to sand and gravel beds in the upper part of the Walhonding Valley, but the size and percent of gravel appears on field inspection to be somewhat smaller. This material has been utilized from time to time from pits located in deposits near Helmick, Blissfield, and Metham. These operations were not active when visited in 1952.

Various mixtures of silts and fine-grained sand are widely distributed along the flood plains of the Killbuck Valley in Coshocton County. These materials have resulted from deposition from silt-laden waters at flood stage during the general process of valley degradation and are post-Pleistocene or Recent in age. The material has a reddish brown color, is fine grained, and contains some clay material to serve as a bond. Pebbles and coarse sand are wanting. Alluvial material of this nature has been worked from time to time from shallow pits located on the flood plain near Layland and Metham and marketed for molding sand.

Tuscarawas Valley

Outwash deposits of sand and gravel in the form of terrace-like features are broad and extensive in the Tuscarawas Valley south of the Tuscarawas River in Oxford and Lafayette townships. The most prominent deposit extends with only one conspicuous break from the central part of Section 13, Oxford Township, to a point one mile west of West Lafayette. In Oxford Township where the deposit is continuous from the northwest quarter of Section 11, its upper surface is broad and irregular due in part to post depositional erosion. It seems highest along its southern margin where surface altitudes range from about 820 to 830 feet. Numerous gravel pits have operated from time to time in this deposit. At the pit of the Miller Gravel Company located about three-fourths of a mile south of Isleta an estimated vertical thickness of 25 feet is being worked and the washed and screened products sold for economic use. The gravel which is regularly stratified in this deposit is composed in large part of fragments of igneous and metamorphic rock.

West Lafayette is located on a broad terrace of outwash material fully one and one-half miles in length extending at its west end from the rock hills in the Tuscarawas Valley on the north to the valley walls on the south. The southeastern margin of this deposit is vague and ill defined where it adjoins the abandoned valley of the old Cambridge River. The upper surface of this terrace is flat and featureless, having an altitude a little in excess of 800 feet.

On the north side of the Tuscarawas River outwash deposits have been in large part removed by post-Wisconsin erosion. Remnants have been preserved, however, at a few localities protected by the contours of the valley walls. Such small deposits have been noted in the mouths of small tributaries just above Blue Ridge Run in northeastern Oxford Township, north of the Blue Hole in northwestern Oxford Township, and just west of the narrows in the Tuscarawas Valley in northwestern Lafayette Township and northeastern Tuscarawas Township. At the last locality, narrow gravel terraces having a summit elevation of about 815 feet border the valley walls. The gravel is medium to coarse on the terrace front but gives way to sand where traced north in the central southern part of Section 25, White Eyes Township.

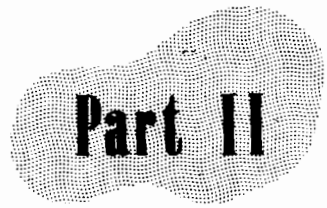
Muskingum Valley

Remnants of glacial outwash in the form of sand and gravel terraces are conspicuous along the Muskingum Valley in Coshocton County. The largest and most prominent of these deposits underlies the city of Coshocton and extends along the eastern side of the valley for a distance of about two and one-fourth miles. It is broadest on the north opposite the junction of the Walhonding and Tuscarawas rivers, where it measures a mile or more in width. Its upper surface, which shows some small relief, has a maximum altitude of 810 to 820 feet.

On the east side of the Muskingum River gravel has been utilized from a small terrace deposit located just north of the mouth of Robinson Run. The surface of the terrace has an altitude a little less than 800 feet. A few feet above the surface of the deposit rises a rock hill having a summit altitude a little in excess of 800 feet. East from the axis of the Muskingum Valley the material appears to become finer in texture. A similar gradation is apparent in gravel deposits located on the east side of the valley one mile northwest of Wills Creek.

Terrace deposits of outwash gravels are conspicuous on the west side of the Muskingum River between Franklin Station and Conesville. Just south of Franklin Station gravels are found flanking a rock hill the summit of which rises to an altitude a little above 800 feet. South of this deposit and south of a small tributary which enters the Muskingum from the west, a prominent terrace-like feature with gravels in evidence at the surface extends to Conesville, a distance of one mile. The surface of this feature varies in altitude from about 770 to 800 feet, being in general highest near its eastern border. Sand and gravel have been utilized from a pit located at the northern end of this deposit. Whether or not this feature is a rock terrace with a surface veneer of outwash materials or is a gravel terrace composed entirely of glacial outwash has not been determined.

Small but conspicuous deposits of sand and gravel in the form of terrace remnants occur on the county line just back of Adams Mills. The highest of these deposits has an altitude of 780 to 800 feet.



STRATIGRAPHIC AND ECONOMIC GEOLOGY

MISSISSIPPIAN SYSTEM

GENERAL CONSIDERATIONS

The Mississippian system in Ohio includes in vertical section that rock succession which overlies the thick series of Ohio shales and which extends upward to the base of the Pennsylvanian or coal bearing series. This succession in Ohio consists in large part of various beds or formations of sandstone and shale. The shales, which range in character from soft plastic types to hard arenaceous or siliceous varieties, have been widely utilized for building brick and other ceramic products, and they constitute an inexhaustible source of raw materials for future production. The sandstones ranging in texture from fine to coarse and in color from gray to various hues of pleasing shade are widely quarried on the outcrop for rough masonry construction, for cut stone for building purposes, and for various fashioned products. Below drainage the sandstone formations are excellent reservoir rocks and have yielded large quantities of oil, gas, and water. A limestone, the Maxville, is the top formation of the system over small areas. This limestone has been quarried extensively at a few localities and utilized for furnace flux, Portland cement, building stone, agricultural limestone and many other uses. Under shallow cover the Maxville limestone constitutes a potential economic resource of no mean importance.

In Ohio the Mississippian system is formed at the surface over an area of 8,580 square miles or approximately one-fourth of the area of the State. Its chief outcrops occur over a broad belt extending from Adams and Scioto counties on the south to Erie, Huron, and Medina counties on the north and then east to the Pennsylvania State Line in Ashtabula and Trumbull counties. This belt includes part or all of 37 counties of which Coshocton County is one. Of minor importance is the outcrop belt in northwestern Ohio where strata of Mississippian age occur below glacial drift in Fulton, Williams, and Defiance counties. The thickness of Mississippian strata on the outcrop in Ohio varies from approximately 300 feet to as much as 1,000 feet. It is apparently thinnest in parts of Cuyahoga County[1] and has its greatest known thickness in Wayne[2] and Vinton[3] counties. Such great variations in development along the outcrop may be due in part to variations in the thickness of sediments originally laid down, but the chief cause is post-Mississippian erosion which has removed varying thicknesses of Mississippian sediments before the deposition of the overlying coal measures. Based upon differences in lithology, strata of Mississippian age have been divided into six formations which in descending order are as follows:

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[1] Prosser, C. S., The Devonian and Mississippian formations of northeastern Ohio, Geol. Survey Ohio Bull. 15, pp. 33, 143, 194, 1912.

[2] Conrey, G. W., Geology of Wayne County, Geol. Survey Ohio Bull. 24, p. 50, 1921.

[3] Stout, Wilber, Geology of Vinton County, Geol. Survey Ohio Bull. 31, p. 43, 1927.

6. Maxville limestone
5. Logan formation
4. Cuyahoga formation
3. Sunbury shale
2. Berea sandstone
1. Bedford shale

In Coshocton County only the upper part of the Mississippian system is represented in surface outcrops. Exposures of this series are confined in their distribution for the most part to the lower slopes of deep valleys in the northwest and southwest quarters of the county. Owing to the drainage pattern and the general eastern inclination of beds the greatest thickness of Mississippian strata reaches the surface along the walls of the deep valleys at the western edge of the county. The exposed series consists for the most part of beds of greenish gray to brown fine-grained sandstones and siltstones interbedded with shales, all here referred to the Logan formation. The Maxville limestone is wanting on the outcrop in this part of Ohio.

LOGAN FORMATION

General Considerations

The term Logan was first applied by E. B. Andrews about 1870 to a group of fine-grained sandstones 133½ feet in thickness, occurring in Hocking County between the base of the coal measures and the Waverly conglomerate.[1] After a detailed study of the clastic beds of the Mississippian in southern Ohio J. E. Hyde[2] in 1915 subdivided the Logan formation of Andrews in ascending order into Byer, Allensville, and Vinton members. A few years later he extended the Logan formation downward to include the thin Berne conglomerate.[3]

The Berne member, so-called for its occurrence in Berne Township, Fairfield County,[4] is a thin basal member of the Logan formation measuring a few inches or only a few feet in thickness and consisting of conglomerate and sandstone. It is widely distributed on the outcrop south of Licking County and has been recognized in Wayne[5] and Holmes[6] counties.

Overlying the Berne member and extending upward for 20 feet or more is a series of brown to yellowish brown fine-grained sandstone often interstratified with shale which Hyde[7] named the Byer member for occurrences near Byer, Jackson County. This member is widely distributed in southern Ohio and has been identified at Newark, Licking County, where it has been quarried for building stone. It has likewise been recognized in Wayne[8] and Holmes[9] counties. The Byer member is terminated upward by the appearance of a coarse sandstone, which in places may be a conglomeratic and at other localities is interstratified with fine-grained sandstone or shale. To this sandstone and conglomerate member the name Allensville was applied by Hyde for its occurrence near Allensville in western Vinton County.[10] The Allensville member

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[1] Andrews, E. B., Report of Progress in 1869, Geol. Survey Ohio Vol. II, p. 79, 1871.

[2] Hyde, J. E., Stratigraphy of the Waverly formations in central and southern Ohio, Jour. Geol. Vol. 23, p. 659, 1915.

[3] Hyde, J. E., Geology of Camp Sherman quadrangle, Geol. Survey Ohio Bull. 23, p. 154, 1921.

[4] Hyde, J. E., Stratigraphy of the Waverly formations in central and southern Ohio, Jour. Geol. Vol. 23, p. 674, 1915.

[5] Conrey, G. W., Geology of Wayne County, Geol. Survey Ohio Bull. 24, pp. 68-78, 1921.

[6] White, G. W., Geology of Holmes County, Geol. Survey Ohio Bull. 47, p. 47, 1949.

[7] Hyde, J. E., op. cit., p. 773, 1915.

[8] Conrey, G. W., op. cit., pp. 78-81, 1921.

[9] White, G. W., op. cit., pp. 47-48, 1949.

[10] Hyde, J. E., op. cit. p. 775, 1915.

is rather persistent on the outcrop from eastern Scioto County to central Licking County in which area its usual thickness ranges from 15 to 25 feet. In north central Ohio the Allensville member has been recognized by G. W. Conrey in Wayne County[1] and by G. W. White[2] in western Holmes County. In these latter areas it is usually represented by a thin conglomerate or conglomeratic sandstone a few inches in thickness.

That part of the Logan formation above the Allensville member is generally made up of fine-grained gray to light greenish gray sandstone and shales which tend to weather to a yellowish brown. As this part of the Logan formation is well developed in Vinton County it has been named the Vinton member.[3] It is quite persistent, however, in north central, east central and in southern Ohio, where its thickness may range from 50 feet to as much as 200 feet or more. The similarities in lithologic characteristics of the Vinton and Byer members in many areas are such that their separation is difficult in the absence of the intervening Allensville.

The Logan formation as a unit is traceable on the outcrop from Scioto County to northern Wayne and southern Medina counties. In this field its total thickness ranges from approximately 150 to 275 feet. East and northeast from Medina the Logan formation is wanting on the outcrops in Ohio.

Character and Distribution in Coshocton County

In Coshocton County outcrops of beds here referred to the Logan formation are confined for the most part to the lower slopes of Killbuck Valley and its tributaries in Clark, Monroe, Jefferson, and Bethlehem townships, to the Mohican Valley and its deep tributaries in Tiverton and Newcastle townships, to the Walhonding and Kokosing valleys and their tributaries in Newcastle, Tiverton, Monroe, Jefferson, Bedford, Perry, and Bethlehem townships; to Winding Fork Valley and its tributaries in Pike and Perry townships, and to the valley of Little Wakatomika Creek in Washington Township. The maximum thickness of beds exposed is a little in excess of 200 feet. The series consists of siltstones and sandstones interstratified with shale. The sandstone generally has a gray to greenish gray color and weathers to a brown or yellowish brown on long exposure. The beds are generally thin and platy in the upper part of the series, but often become more heavy bedded at lower levels where individual strata may measure $1\frac{1}{2}$ to 2 feet in thickness. The shales which occur interstratified with the sandstones are generally gray to bluish gray in color and are rather highly siliceous in composition. Fossils are generally thinly scattered throughout the series. Along some thin highly ferruginous zones they occur in great abundance. Coarse-grained clastics corresponding in lithology to the Allensville member of the Logan formation of southern Ohio have not been recognized in outcrops in Coshocton County. Neither has the Berne member which marks the base of the Logan formation been positively identified in field exposures in this county.

In view of the lithologic similarity of the top part of the exposed series to beds of Vinton age and of the apparent absence of strata at lower levels bearing typical Allensville characteristics, the monotonous series of sandstones, sandy shales, and shales exposed in Coshocton County is here referred to the Vinton member.

The upper part of the Vinton member occurs above drainage along Killbuck Creek in Clark and Bethlehem townships, where it consists for the most part of greenish gray sandstone and shale. Near Layland over 100 feet of this series rises above the flood plain. Sandstone and shale of similar character are present along Doughty Creek in northeastern Clark Township and along Big Run in northern Monroe Township. The character of the upper part of the Vinton member is indicated in the following description of exposures along the north-south road on the west side of the Killbuck Valley in sections 16 and 25, Clark Township.

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[1] Op. cit., pp. 81-86, 1921.

[2] Op. cit., p. 48, 1949.

[3] Hyde, J. E., op. cit., p. 778, 1915.

	Ft.	In.
Pennsylvanian system		
Pottsville formation		
Sandstone, white, fine-grained, argillaceous	1	6
Conglomerate zone consisting of chert nodules, iron ore nodules, and silt, Harrison member	-	6
Mississippian system		
Logan formation		
Vinton member		
Clay shale, ocher yellow, reddish at top, weathered	7	2
Shale, argillaceous, light olive green, weathers brown	6	8
Shale, light olive green, sandy platy layers interstratified with more argillaceous zones	116	8
Sandstone, greenish gray, fine-grained, heavy-bedded, fossiliferous	7	5
Altitude, 795 feet		

Sandstone and shale at least 200 feet in thickness, here referred to the Vinton member, occur above drainage along the Mohican Valley in western Tiverton and northwestern Newcastle townships. The various features of this succession are shown in the following description of exposures along the road which ascends the high hill one fourth of a mile southeast of Brinkhaven, in northeastern Union Township, Knox County.

Mississippian system		
Logan formation, top		
Vinton member, top, altitude 1,132 feet		
Clay, reddish, soft, very plastic	11	0
Shale, greenish gray, sandy fossiliferous, weathers a yellow brown	30	0
Shale, very sandy, to argillaceous sandstone, very fossiliferous, weathers a reddish brown	1	0
Shale, greenish gray, lower part quite sandy	35	6
Sandy, ferruginous layer, very fossiliferous weathers yellow brown	-	6
Shale, light greenish gray, silty	33	6
Sandstone, light greenish gray, shaly, and thin sandstone, separated by shale partings	10	6
Shale, greenish gray, finely laminated	36	6
Sandstone, greenish gray, shaly, fossiliferous	10	0
Shale, greenish gray, silty	54	0
Shale, gray to greenish gray	5	0
Shale, soft, argillaceous, friable	4	0
Shale, with sandy layers separated by more argillaceous beds	7	0
Sandstone, fine-grained, bluish gray, massive, weathers buff	4	0
Track level, Railroad Station, Brinkhaven		

The lithologic characteristics of the upper 238 feet of strata described in this section suggest its correlation with the Vinton member of southern Ohio exposures. If this correlation is correct the underlying massive sandstone may represent in part the Allensville member although it does not present features characteristic of that member in central Licking and in Wayne counties. Should the massive sandstone prove to be Byer in age, the Allensville must be considered either wanting or represented by shale and as such indistinguishable from beds of Vinton age above.

Mississippian strata here referred to the Vinton member of the Logan formation was well exposed in 1947 along the road leading to the southeast down the hill in the eastern part of Section 15, Tiverton Township. The base of the Pennsylvanian system outcrops at an altitude of about 1,122 feet.

	Ft.	In.
Pennsylvanian system		
Pottsville series		
Sandstone and covered	16	0
Clay, dark, coal indication	-	1
Clay, gray, short	2	4
Ferruginous zone, a few iron ore nodules, Harrison member	-	6
Mississippian system		
Logan formation		
Vinton member		
Shale, greenish gray, sandy, and shaly sandstone	33	8
Ferruginous zone, sandy, very fossiliferous	1	0
Shale, olive green, and shaly sandstone	28	10
Shale, brown, sandy, very ferruginous, very fossiliferous	1	6
Shale, light olive green, sandy	51	2
Shale, brown, ferruginous, soft, with many fossils	3	0
Shale, greenish gray, sandy, and shaly sandstone, exposed intermittently along road	84	10
Forks of road, altitude 920± feet		

The thickness of Mississippian beds described at this locality is about 204 feet. The lithologic characteristics of this series suggest that it is all Vinton in age.

Strata of Logan age occur above drainage along the Kokosing-Mohican valley and its chief tributaries as far east as the southeastern part of Bethlehem Township. One of the best outcrops in the Walhonding Valley is found at the Mohawk Dam, in the southwest quarter of Section 6, Jefferson Township, where 160 feet of Logan strata is exposed to view. A description of exposures at this locality is given below.

	Ft.	In.
Mississippian system		
Logan formation		
Vinton member		
Sandstone with thin shale partings	15	6
Shale, bluish gray	14	1
Sandstone, bluish gray, several layers, shattered	4	3
Shale, bluish gray, with a few thin sandstone lenses	7	8

Shale, bluish gray, sandy, and shaly sandstone	6	6
Shale, gray black	-	6
Sandstone, bluish gray, soft	4	0
Shale, bluish gray, with a few thin sandstone lenses	2	9
Sandstone layer, one bed	2	0
Shale, bluish gray	4	6
Sandstone layer	1	0
Shale	-	3
Sandstone, heavy-bedded	13	2
Shale and thin sandstone	5	0
Sandstone, greenish gray, somewhat shattered	2	0
Ferruginous sandy zone with many fossils	-	4
Sandstone, greenish, weathering reddish	4	4
Sandstone, shaly, and sandy shale	3	4
Sandstone, shaly	1	9
Shale parting	-	3
Sandstone, olive green, one layer	3	6
Shale, greenish gray to bluish gray	3	9
Sandstone, greenish gray, fine-grained, laminated	1	5
Shale, bluish gray to greenish gray	1	11
Sandstone, olive green, fine-grained	2	3
Sandstone, ferruginous, very fossiliferous	1	6
Sandstone, light olive green, sparingly fossiliferous	2	8
Shale, bluish gray, argillaceous	2	8
Sandstone, greenish gray, fine-grained, laminated	6	6
Shale, bluish gray to light olive green, with sandy zones, laminated	12	10
Sandstone, greenish gray, fine-grained	1	2
Brecciated zone, fossiliferous	-	4
Sandstone, ferruginous, fossiliferous	1	4
Sandstone, light buff, fine-grained	-	3
Shale, bluish gray, soft	4	2
Sandstone, buff, fine-grained	1	10
Shale, bluish gray, soft and friable	12	2
Sandstone, bluish gray, thin-bedded	1	0
Shale, bluish gray, sandy	4	2
Sandstone, brown, thin-bedded	1	8
Sandy zone, with many iron carbonate concretions	-	6
Sandstone, brown to buff, fine-grained	1	8
Sandstone, fine-grained, bluish gray, massive	5	6
Water level		

The contact between the Vinton and overlying Pottsville strata was not exposed at the time of measuring the above section. It cannot be many feet above the highest exposure described.

In the southwestern part of Coshocton County the top of the Logan formation occurs close above drainage along the valley of Little Wakatomika Creek across Washington Township. It also outcrops along the valley of Winding Fork and its tributaries in western Pike and southwestern Perry townships. The Mississippian beds exposed along these valleys consist of fine-grained sandstones and shales similar in lithologic characteristics to beds described in sections already given.

The Logan sandstone as exposed in Coshocton County does not add greatly to the economic resources. The monotonous brown color developed on weathering, the thinness of the beds, the fineness of grain, and the amount of impurities present preclude possibilities for dimension stone on the one hand or as sources of roofing granules, mason's sand, or plasterer's sand on the other. Its most apparent possibilities include rip-rap, fill material, or stone for rude construction such as foundation stone. Other sandstones in the area are of equal or better quality for such purposes. The shales associated with the siltstones and fine-grained sandstones are generally of the sandy or siliceous type. They may serve as sources of material for red burning face brick or common brick.

MAXVILLE LIMESTONE

The Maxville limestone, the top formation of the Mississippian system in parts of Ohio, is not present in Coshocton County. This limestone, which at one time capped the Logan formation in Coshocton County, was entirely removed by erosion before the deposition of the younger and overlying Pennsylvanian sediments. The basal member of the Pottsville series (Harrison member) frequently contains nodular masses of gray chert and silicified limestone. The chert and silicified material is a residuum from the erosion of the Maxville. It was left as float on the Mississippian surface and was incorporated in the basal Pennsylvanian sediments.

PENNSYLVANIAN SYSTEM

GENERAL CONSIDERATIONS

The Pennsylvanian system of rocks includes the chief productive coal bearing series in the eastern part of the United States. In the Appalachian Basin its outcrops extend from Pennsylvania where it was early studied, classified, and described by H. D. Rogers[1]; southwest to northern Alabama, occurring in parts of Pennsylvania, West Virginia, eastern Ohio, western Maryland, eastern Kentucky, Tennessee, and northern Alabama. In this area the Pennsylvanian is unrivaled in the complexity of its stratigraphic succession and in the potential value of its economic resources. It consists of many recurring beds of coal, clay, limestone, iron ore, shale, and sandstone. Coal from this series provides the fuel for industry and heat for millions of human habitations. The shale and clay beds guarantee an inexhaustible supply of raw materials for an ever-increasing variety of ceramic products. Sandstone from this system yields material for rough construction and for fashioned products, and when deeply buried below the surface, provides reservoirs for oil and gas. The iron ores though thin and widely scattered have contributed much toward the establishment of early industry. The limestones are now widely used for the local needs of man.

The bedrocks of the Pennsylvanian age outcrop over an area of about 10,464 square miles in the eastern half of Ohio embracing all or parts of forty counties. The average thickness of the system on outcrops is close to 1,100 feet. Forty-four separate and distinct coal beds occur with underlays in varying degree of development, separated by beds of shale and sandstone with minor deposits of limestone and iron ore. Twenty-seven limestone members have been recognized widely distributed through the series. Based on the grouping of important coal beds in vertical section, the Pennsylvanian was early divided into four groups which in modern terminology in ascending order are the Pottsville, Allegheny, Conemaugh, and Monongahela series.

In Coshocton County the Pennsylvanian system is represented in outcrops by the Pottsville and Allegheny series and the lower 170 feet of the Conemaugh series. In general the oldest group

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[1]Rogers, H. D., Geology of Pennsylvania, Vol. II, p. 109, 1858.

is exposed in the western part of the county and along the lower slopes of the deeper valleys in the central and eastern parts, whereas the youngest or Conemaugh series outcrops in the high hills and ridges in the central and eastern parts. The area of outcrop of the Pennsylvanian system in this county is about 481.8 square miles or about 85 per cent of the area of the county. The beds of sandstone, shale, limestone, coal, clay, and iron ore comprising this succession have a total average combined thickness of about 535 feet.

POTTSVILLE SERIES

The lowest division of the coal-bearing series in Pennsylvania was first named the Seral Conglomerate by H. D. Rogers[1] in 1858. Later, in 1877, J. P. Lesley in describing the succession of coal-bearing strata in western Pennsylvania named this basal division the Pottsville conglomerate and defined it as extending from the Mauch Chunk red shales, (Mississippian) below to the base of the Lower Productive Coal measures.[2] Following the major features of Lesley's classification the Pottsville series in Ohio includes the strata overlying the Mississippian and extending upward to the Brookville coal, the lowest coal bed of the Lower Productive Coal measures (Allegheny series).

As thus defined the entire Pottsville series is represented in outcrops in Coshocton County, although some members described elsewhere in Ohio are wanting in this area. Rocks of Pottsville age outcrop in every township. The areas of exposure are large in Pike, Perry, Newcastle, Tiverton, Monroe, Jefferson, Bedford, Washington, Clark, Bethlehem, Keene, and Mill Creek townships in the western half, but in the eastern half of the county they are confined to the lower slopes of the larger valleys. The coals of this series are relatively unimportant as they are generally too thin for extensive mining. The clays have not been utilized to any extent, but nevertheless constitute a potential resource for future need. The limestones are thin and often cherty in character, but they are remarkably persistent, providing stratigraphic horizons of great value in correlation. The iron ores are negligible in economic importance, but the sandstones provide much material for structural purposes. The total average thickness of the Pottsville series in Coshocton County is about 188 feet. Some variation in thickness occurs from place to place owing to changes in sandstone and shale intervals between well-defined members and due in part to the uneven erosion surface developed on the Mississippian rocks upon which the series rests. An average section of the Pottsville series exposed in Coshocton County is here presented showing the name, character, and thickness of the members recognized, and the thickness of the intervening sandstone and shale. A consideration of each member will be given in ascending order in the pages that follow.

Harrison Member

STRATIGRAPHY AND EXTENT

Concerning the general character and stratigraphic relations of the Harrison member, Stout writes as follows: [3]

"The Harrison ore is noteworthy, not for its economic value, but for its relation to both the Pennsylvanian and Mississippian rocks, as it is deposited along the irregular zone of contact between these systems and as it contains in many places material from both. It lies in the Pottsville, but it is bedded on the eroded surface of the Maxville limestone or on that of the

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[1] Rogers, H. D., Geology of Pennsylvania, Vol. 1, p. 109, 1858.

[2] Lesley, J. P., Cambria and Somerset District, Second Geol. Survey Pa., Rept. HHH, p. 23, 1877.

[3] Stout, Wilber, Geology of Muskingum County, Geol. Survey Ohio, Bull. 21, p. 48, 1918.

Average Section of the Pottsville Series in Coshocton County

Member	Character and General Description	Thickness Ft.	In.
Brookville	Clay, gray, plastic	5	2
Homewood	Sandstone, generally replaced by shale	16	1
Tionesta or No. 3b	Coal, shaly, local	--	6
	Clay, gray, plastic	3	10
	Shale, gray, generally arenaceous	13	11
Upper Mercer	Ore, generally wanting	--	2
	Shale, dark	2	0
Upper Mercer	Limestone, black, with black flint, fossiliferous, generally present	3	0
	Shale, dark, carbonaceous	--	2
Bedford	Coal, generally shaly, persistent	1	5
	Clay, gray, plastic	4	10
	Shale	2	10
Upper Mercer or No. 3a	Coal, thin, locally developed	--	11
	Clay, gray, plastic	2	8
	Shale, bluish gray	12	10
Lower Mercer	Ore, generally wanting	--	--
Lower Mercer	Limestone, gray to gray black, fossiliferous, persistent	2	6
	Shale, dark argillaceous	--	6
Middle Mercer	Coal, shaly, and carbonaceous shale	1	4
	Clay, gray, lower part arenaceous	5	6
	Shale, gray to dark, generally arenaceous	3	5
Flint Ridge	Coal, shaly, and carbonaceous shale, locally present	1	5
	Clay, gray, plastic	4	6
	Shale, arenaceous	12	7
Boggs	Arenaceous bed, ferruginous, calcareous, fossiliferous	--	6
	Shale, dark, arenaceous	2	0
Lower Mercer or No. 3	Coal, generally shaly, not persistent	--	3
	Clay, gray, plastic	1	7
	Shale, often replaced by sandstone	23	0
Lowellville	Limestone, dark, ferruginous	--	3
	Shale, light to dark	--	10
Vandusen	Coal and carbonaceous shale, local	--	4
	Clay, locally developed	2	11

Average Section of the Pottsville Series in Coshocton County
(Continued)

Member	Character and General Description	Thickness Ft.	In.
	Shale, arenaceous, often replaced by sandstone	5	8
Bear Run	Coal and carbonaceous shale locally present	--	5
	Clay, gray, locally developed	2	2
Massillon	Sandstone, generally persistent, locally replaced by shale	19	0
Quakertown or No. 2	Coal, generally thin, locally wanting	1	0
	Clay, dark	1	9
	Shale, bluish, with occasional ore nodules	9	5
Anthony	Coal, shaly, and black shale, of local occurrence	--	2
Sciotoville	Clay, gray	3	0
	Sandstone, light gray, very local	--	--
	Shale, dark, with ore nodules	11	6
Sharon	Coal, very local	--	--
Harrison	Brecciated conglomeratic layer containing quartz pebbles, and fragments of chert and silicified limestone, fossiliferous, ferruginous	--	9

Logan strata. In places it is composed of a brecciated mass of siliceous fragments cemented by iron compounds. This siliceous material appears to be what was once pieces of Maxville limestone as it contains imperfect impressions of marine animal life, and it is usually present not far distant from Maxville areas. In general the pieces are quite angular, which suggests their origin from shore deposits by marine action, or from land areas by weathering agencies. These limestone fragments through solution lost their calcium and magnesium carbonates and by replacement gained additional silica. In other words such deposits are apparently the remains of deposits of Maxville limestone that were broken up by terrestrial and littoral forces, strewn over the eroded Mississippian plain by waves and currents, then covered by Pottsville sediments, and later cemented by iron compounds deposited from ground waters that circulated along this contact zone . . . At other places the Harrison ore is a mixture of angular siliceous fragments and of well-rounded quartz pebbles, the whole cemented by iron compounds. The pebbles are similar in every respect to those that compose the Sharon conglomerate which often lies directly above the ore . . . In a few localities this ore is a rather pure ferrous carbonate or, where weathered, a hydrous ferric oxide. This is the condition usually when the bed lies directly on the Maxville limestone of which it appears to be a part."

The iron ore bed resting on the Maxville limestone was early noted by Andrews,[1] and later more fully described by Orton[2] who apparently considered it of Maxville age. While studying the Maxville limestone in northern Perry County, W. C. Morse found this ore in contact

[1]Andrews, E. B., Report of progress in the second district, Geol. Survey Ohio, Report of Progress in 1869, pp. 84-85, 1871.

[2]Orton, Edward, Economic Geology of Ohio, Geol. Survey Ohio, Vol. V, pp. 373, 379, 1884.

with both limestone and shale phases of the Maxville and, concluding that it was of later age than Maxville, placed it in the Pennsylvanian series.[1] In 1916, Wilber Stout described similar deposits in contact with the Logan formation in southern Ohio and named it the Harrison for occurrences in Harrison Township, Scioto County.[2]

In Coshocton County the Maxville limestone in an undisturbed condition is wanting on the outcrop, the basal Pennsylvanian resting on the eroded upper surface of sandstones and shales of Logan age. The Harrison member occurs here in all the varying lithologic forms so ably described by Stout, but the sandy, conglomeratic, and brecciated types, all somewhat enriched by hydrated ferric oxide, are the most common. The fragmentary material of the Harrison member here may consist of sand, well-rounded quartzite pebbles, pieces of sandstone or shale from the underlying Logan, and irregularly-shaped pieces of cherty or silicified fossiliferous limestone, the latter representing float remnants of the Maxville on the post-Mississippian erosion surface. This brecciated bed is generally highly ferruginous in character. In only a few localities however is the contact marked by the presence of thin deposits of iron ore. Where the Mississippian-Pennsylvanian contact is covered along the road sides its position can be approximated closely by the occurrence of nodules of cherty or silicified limestone which have been freed by the erosion of this member. The thickness of the Harrison member where observed in Coshocton County varies from 2 inches to 2 feet, but the usual measurements range from 6 inches to 1 foot. Exposures have been noted in Tiverton, Monroe, Newcastle, Jefferson, Washington, Bethlehem, and Clark townships.

The Harrison member as exposed along the abandoned road in the north central part of Section 8, Monroe Township, is represented by a thin iron ore as shown in the following section.

	Ft.	In.
Coaly shale, Lower Mercer	-	1
Sandstone, white, clay-bonded	1	4
Clay, bluish gray, plastic	2	4
Clay, gray, with many iron carbonate nodules	1	2
Clay, with purple hue, arenaceous	-	10
Covered interval	33	10
Shale, arenaceous	12	0
Ore, Harrison member	-	6
Shale, light olive green, Vinton	10	0

Altitude, 945 ft.

The Harrison member here is bedded on the Vinton shale, the top member of the Logan, and occurs about 75 feet below the Middle Mercer coal. The basal contact of the Pennsylvanian series is well exposed along the north-south road ascending the hill near the mouth of Killbuck Creek seven-eighths of a mile northeast of Bantum School, Bethlehem Township. Here the contact is represented by a brecciated bed 3 feet 6 inches in thickness containing angular pieces of flinty or silicified limestone, and well-rounded pebbles. It is overlain by a few inches of iron ore and underlain by a bed of shale of reddish brown and greenish gray colors. The altitude of the contact at this place is about 875 feet. The contact is also exposed along the road near the crest of the ridge west of Killbuck Creek in the north central part of Section 25, Clark Township, about 1 mile southwest of Blissfield. A description follows.

Brecciated bed with cherty nodules and nodules of iron ore embedded in argillaceous material, Harrison member	2	0

[1] Morse, W. C., The Maxville limestone, Geol. Survey Ohio, Bull. 13, p. 47, 1910.

[2] Stout, Wilber, Geology of southern Ohio, Geol. Survey Ohio, Bull. 20, p. 481, 1916.

	Ft.	In.
Clay shale, reddish at top, grading to ocher yellow downward, Vinton	7	2
Shale, olive-colored, argillaceous, Vinton.	6	8

Altitude, 919 ft.

A number of exposures of the Harrison member occur along the valleys of the Walhonding River and its tributaries in Newcastle and Jefferson townships. Near the head of Laurel Run about one-half mile north of Newcastle the Harrison is represented by 1 to 2 feet of ferruginous shale containing pebbles of quartzite and nodular masses of flinty limestone bedded on shales of Logan age. As exposed at a number of localities in the northern half of Jefferson Township, the Harrison is represented by a ferruginous bed a few inches in thickness generally with pebbles or fragments of cherty or silicified limestone. No importance can be attached to the Harrison member in Coshocton County except for its stratigraphic interest.

Sharon Coal

The Sharon coal, so named by the early geologists in Pennsylvania for its occurrence in the Sharon coal group near Sharon, Mercer County,[1] is the lowest coal bed recognized in the Pottsville series in Ohio. It lacks continuity in this State owing to the fact that the organic material from which it was derived was laid down in basins or depressions on the old eroded Mississippian land surface. Where well developed the Sharon coal generally occurs close above the equally discontinuous Sharon conglomerate. Sharon coal of mineable thickness in Ohio is confined chiefly to Jackson County in southern Ohio and to an area under thin cover extending from eastern Wayne and eastern Medina counties to eastern Mahoning and southeastern Trumbull counties in the northeastern part of the State. In Coshocton County the Sharon is generally wanting in outcrops. At only one locality, namely, along the south bank of the Walhonding River $1\frac{1}{2}$ miles west of Warsaw Junction, Jefferson Township, has this coal been recognized. Here Mr. Meyers describes the Sharon as represented by a few inches of black carbonaceous shale with an inch of bony coal at base lying immediately above the Harrison member. Elsewhere on the outcrop in this county the Mississippian-Pennsylvanian contact apparently occurs above the stratigraphic horizons of the Sharon coal.

Sharon Ore

A thin ore is found in or close above the Sharon coal in Jackson, Lawrence, and Scioto counties, which is known as the Sharon ore. At the one exposure of Sharon coal in Coshocton County the bed is overlain by several feet of dark shales containing ore nodules, which may represent this member.

Sciotoville Clay

The position of the Sciotoville clay in the Pottsville series of Ohio is on an average about 30 feet above the Sharon or No. 1 coal, and about 28 feet below the Quakertown or No. 2 coal. This clay seems rather widely distributed in Ohio, but the bed lacks continuity. Like the Sharon coal, it developed in somewhat localized basins or depressions flanked by uplands composed of strata of Mississippian age. The field of chief economic importance is found in eastern Scioto, eastern Pike, and southern Jackson counties, but clay deposits on the Sciotoville horizon have been reported in widely scattered areas in Vinton, Perry, Hocking, Muskingum, Wayne, Stark, Summit, and Portage counties.

In southern Ohio where the Sciotoville has been a very important source of material for refractory ceramic products several varieties of clay may be represented. The usual sequence

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[1] Rogers, H. D., Geology of Pennsylvania, Vol. II, p. 489-490, 1858.

of these varieties in descending order is plastic, flint, semi-flint, and "pink eye." The flint clay is a hard, dense, homogeneous material which breaks with a conchoidal fracture, and is not reduced to a plastic mass by weathering. The semi-flint is much like the flint clay but tends to have a little plasticity and is generally marked by slickensides. The plastic variety, as the name indicates, is characterized by plasticity; slickensides are abundant. The "pink eye" variety is a plastic clay rich in iron oxides. Deposits of Sciotoville clay may consist of any one or combination of these varieties. The flint clay is the type sought for ceramic refractories.

The horizon of the Sciotoville clay is above drainage over a large area in Coshocton County including parts of every township in the western half of the territory. Few exposures have been found, however, owing in part to the fact that in many localities the Mississippian-Pennsylvanian contact occurs above the horizon of this clay member. Exposures of the Sciotoville clay have been found in Newcastle, Bedford, and Jefferson townships. Here it is chiefly of the gray plastic type ranging in thickness from a few inches to 6 feet. The interval to the Quakertown or No. 2 coal varies from 6 to 28 feet. Where exposed along a ravine about one-half mile north of Newcastle, Newcastle Township, the Sciotoville is a gray to bluish gray, siliceous, plastic clay, 2 feet 4 inches in thickness, occurring 13 feet below the Quakertown coal and 10 feet above the Harrison ore. The following section showing unusual thickness of the Sciotoville clay was secured by T. R. Meyers in the southwestern part of Section 4, Bedford Township.

	Ft.	In.
Sandstone, medium-grained, somewhat ferruginous, and covered, Massillon	26	1
Clay, carbonaceous } Quakertown	-	3
Clay, dark } Quakertown	-	6
Sandstone, very ferruginous, medium-grained, soft near bottom	5	2
Clay, siliceous, mottled white to brick red	-	10
Coal, weathered, Anthony	-	2
Clay, light, siliceous, and covered, Sciotoville	5	6
Shale	10	0

Altitude, 853 ft.

Mr. Meyers measured the following section along the east-west road about one-half mile east of Warsaw Junction, Jefferson Township.

Sandstone and covered, Massillon	20	10
Coal stain, Quakertown or No. 2	-	1
Clay	1	0
Covered interval	1	7
Sandstone, gnarled appearance	-	8
Clay shale, light	-	4
Shale, blue	1	10
Shale, carbonaceous	1	0
Shale, blue, siliceous, with small ore nodules	1	8
Clay, coaly, Anthony coal horizon	-	2
Clay, carbonaceous, sandy, Sciotoville	0	10
Sandstone, white, rather massive	1	10
Sandstone, thin-bedded	2	0
Ore, dark red in color, Harrison	-	2

Altitude, 856 ft.

Owing to its poor development and impure character, the Sciotoville clay occurring in Coshocton County has no conceivable economic importance.

Anthony Coal

Closely associated with the widely scattered deposits of Sciotoville clay is a coal horizon which is usually represented on the outcrop by thin streaks of coaly clay or by a few inches of coal. Over small areas in Scioto County and in southern Jackson County this bed is thick enough for mining. To a local development of this coal mined on the Samuel Anthony property in Section 7, Coal Township, Jackson County, E. B. Andrews in 1870 applied the name Anthony coal.[1] Only a few scattered exposures of the Anthony member have been found in Coshocton County. These occur in Jefferson, Bedford, and Newcastle townships and consist of a few inches of black shale and shaly coal immediately overlying the Sciotoville clay. The sole importance of the Anthony member in this county rests on its stratigraphic interest.

Quakertown Coal and Clay

STRATIGRAPHY, EXTENT, AND VALUE

The Quakertown coal was first named by I. C. White for exposures at the Falls on Quakertown Run, near the Ohio-Pennsylvania line in Mahoning Township, Lawrence County, Pennsylvania.[2] Here the coal is found immediately below the Upper Connoquenessing sandstone and is separated from the top of the Lower Connoquenessing sandstone by only a few feet of clay and shale. This coal horizon is quite persistent in Lawrence County but it is generally thin and in places is represented by dark carbonaceous shale. Westward in Ohio the Quakertown coal and clay have been recognized at scattered localities along the outcrop from Mahoning County to Scioto County. In general the horizon lacks continuity and persistence for in some areas it is wanting, and at other places it is represented by thin coal, black shale, or by a few feet of dark siliceous clay. The Quakertown coal has been mined in a small way in a few scattered areas in Wayne, Holmes, Coshocton, Muskingum, Perry, and Vinton counties but the field of best development is found in Jackson County. Here where the coal is known as the Wellston or Jackson Hill bed it has a thickness of about 30 inches, is of excellent quality, and has been mined for many years. The position of the Quakertown or No. 2 coal in the series in Ohio is on an average about 60 feet above the Sharon or No. 1 coal, about 28 feet above the Sciotoville clay, and about 98 feet below the Lower Mercer limestone.

In Coshocton County the horizon of the Quakertown coal outcrops in parts of Tiverton, Newcastle, Perry, Pike, Monroe, Jefferson, Bedford, Washington, Clark, and Bethlehem townships, all located in the western half of the county. Small pockets or areas of mineable coal may occur in this area but usually the horizon is represented by a few inches of black shale or thin coal overlying a thin bed of dark tough siliceous clay. In parts of the field the coal horizon is closely overlain by thick deposits of Massillon sandstone. In places this sandstone seems to extend to the base of the Pottsville series, replacing the Quakertown coal. From scattered exposures of the series the position of the Quakertown is on an average 26 feet above the Sharon or No. 1 coal, 11 feet above the Sciotoville clay, and 88 feet below the Lower Mercer limestone.

In Pike Township, a thin blossom of Quakertown coal was observed along the road in the west central part of Section 23. It has an altitude of about 920 feet and occurs about 80 feet below the level of the Lower Mercer limestone exposed on the hill to the east. The coal is here underlain by 3 feet of dark siliceous clay. Along Fivemile Run Mississippian beds occur along the valley bottom as far north as Section 9. Along an eastern tributary to this valley in the southeast

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[1] Andrews, E. B., Report of labors in second geologic district, Geol. Survey Ohio, Rept. of Progress in 1870, pp. 140-142, 1871.

[2] White, I. C., Geology of Lawrence County, Second Geol. Survey Pa., Rept. QQ, pp. 65-66, 1879.

quarter of Section 19 an ancient prospect in the Quakertown coal is still visible at an altitude of 863 feet. No clean exposures could be found in this vicinity and no information concerning the thickness of the coal could be secured. An exposure of gray siliceous Quakertown clay was observed, however, near road level in the central part of Section 12 where the interval to Middle Mercer clay is about 100 feet. In Washington Township the Quakertown horizon is due to outcrop close above the flood plain along Wakatomika Creek. A good exposure of the lower Pottsville beds was observed along the road and on the point of the hill in the north central part of Section 22, as described in the following section.

	Ft.	In.
Limestone, grayish black, fossiliferous, Lower Mercer	1	3
Covered interval	48	7
Shale, becoming more sandy upward	10	0
Clay shale, soft, gray	1	6
Shale, bony, highly weathered, Vandusen horizon	1	0
Clay, gray, plastic	1	5
Clay, gray, ferruginous, shaly	1	9
Coal, shaly, and bone shale, Bear Run	-	8
Clay, gray, siliceous	2	2
Clay, yellowish brown, ferruginous	2	1
Clay, gray, siliceous	2	0
Covered interval	8	1
Shale, bony, Quakertown, or No. 2	2	6
Clay, gray, siliceous	-	6
Shale, gray, sandy, micaceous	1	0
Clay, gray, siliceous, micaceous	1	4
Clay, siliceous, ferruginous	1	10
Clay, gray, more plastic	-	8

Altitude, 800 ft.

In the above section the intervals from the Quakertown to the Bear Run and Vandusen coals are below average for this county. The base of the section is not far from the top of the Mississippian system, but the contact is not exposed. In the west central part of Section 2, Perry Township, a blossom of Quakertown coal was observed at an altitude of 1,000 feet or about 80 feet below the Lower Mercer limestone. Here it is underlain by 5 feet of dark tough clay. Just east of the north-south road in the southwest quarter of Section 12, a pile of mine waste at the base of the heavy-bedded Massillon sandstone indicates a former mining operation in what is probably Quakertown coal. No exposure of underlying strata is present. The mine waste is probably from Crawford's coal bank concerning which J. T. Hodge wrote as follows:[1] "The bed is from two and a half to three feet thick, with a black shale roof. The coal is of excellent quality, mostly in sound blocks, very free from sulphur, and of 'open burning' character." No good exposures of this coal have been found in the vicinity.

In Bedford Township the horizon of the Quakertown coal occurs close above drainage along the lower courses of the larger valleys. Where exposed along the road up the hill in the west central part of Section 24, it is represented by 1 foot 9 inches of sandy clay 30 feet above the Anthony coal and 20 feet below the Bear Run horizon. The horizon is similarly shown where it outcrops in the southeast corner of Section 5. The stratigraphic relations of the Quakertown horizon are well shown in the following section secured along Laurel Run one-half mile north of Newcastle, Newcastle Township.

Pennsylvanian system		
Pottsville series		
Sandstone, massive, medium to coarse-grained, micaceous, Massillon	44	1

[1] Hodge, J. T., Geology of Coshocton County, Geol. Survey Ohio, Vol. III, p. 580, 1878.

		Ft.	In.
Coal, impure	Quakertown or No. 2	1	0
Shale, bony, with thin coal bands		2	0
Shale, black, argillaceous		8	9
Clay, gray, siliceous		1	0
Covered interval		2	8
Shale, bluish gray		1	6
Shale, dark		2	10
Clay, gray, siliceous	Sciotoville	1	8
Clay, bluish gray		-	8
Sandstone, clay-bonded, hard		1	0
Covered interval		3	0
Shale, bluish gray, arenaceous		6	0
Shale, reddish brown, ferruginous, micaceous, with quartzite pebbles and nodules of cherty limestone, Harrison		1	0
Mississippian system			
Logan formation			
Shale, bluish gray, argillaceous	Vinton Member	1	0
Shale, bluish gray to yellowish brown, arenaceous		38	8
Sandstone, gray to yellowish brown, fine-grained		-	8
Shale, bluish gray		1	0
Sandstone, gray to yellowish brown, fine-grained, somewhat shaly, layers ripple marked		7	10
Altitude, 948 ft.			

In this section the Quakertown horizon is represented by several feet of carbonaceous shale and thin coal with a thin impure clay underlying it. This horizon is similarly represented in outcrops along the Walhonding River Valley in the vicinity of Warsaw, Jefferson Township. In the northern part of Jefferson Township and in adjacent areas to the northwest, north, and northeast in Coshocton County the Massillon sandstone is well developed with little evidence in outcrops of the Quakertown coal and clay at its base.

Outcrops of the Quakertown member in Coshocton County do not indicate a coal bed of any economic importance for fuel. If mineable coal occurs on this horizon, its location and extent must be determined by test drilling. The underlying clays on the outcrop are of an inferior grade, being charged with siliceous impurities, and add little in suitable raw materials to the ceramic industry.

Massillon or Connoquenessing Sandstone

STRATIGRAPHY, EXTENT, AND VALUE

The Massillon sandstone was first named by J. S. Newberry in 1874 for exposures near Massillon, Stark County.[1] Here the base of the sandstone closely overlies the Massillon coal; and, having a thickness varying from 20 to 80 feet, the formation locally replaces the Quakertown coal. From Massillon eastward this sandstone is generally present and is well developed on the outcrop in northeastern Ohio and western Pennsylvania. In Beaver County, Pennsylvania, it was described as the Connoquenessing sandstone by I. C. White in 1878[2], for exposures

[1] Newberry, J. S., Geology of Ohio, Geol. Survey Ohio, Vol. II, Pt. 1, p. 131, 1874. Also, Newberry, J. S., Geology of Stark County, Geol. Survey Ohio, Vol. III, p. 166, 1878.

[2] White, I. C., Progress in the Beaver River district, Second Geol. Survey Pa., Rept. Q, pp. 69-76, 1878.

along the Connoquenessing River. The following year White divided it in Lawrence County, Pennsylvania, into the Upper and Lower Connoquenessing sandstones with the Quakertown coal between them.[1] Southwest from Massillon the Massillon sandstone is quite irregularly present, but exposures occur in every county in Ohio where outcrops are due. In this field the usual deposits are found close above the Quakertown coal and thus correspond in position to the Upper Connoquenessing sandstone of Pennsylvania; but such occurrences are by no means continuous. Locally this sandstone bed thickens, replacing underlying and overlying members. At such localities it extends from near the base of the Pennsylvanian to the horizon of the Lower Mercer limestone. The usual thickness of the Massillon sandstone in Ohio is about 25 feet.

In Coshocton County the horizon of the Massillon sandstone is above drainage in all or parts of Tiverton, Monroe, Clark, Newcastle, Jefferson, Bethlehem, Perry, Bedford, Pike, and Washington townships. South of the Walhonding River the Massillon sandstone is generally thin and patchy in distribution, its horizon in many places being occupied by shale. North of this river it seems less local in occurrence and thicker in development. In places it reaches a depth of 75 to 80 feet, replacing underlying and overlying members and extending from near the base of the Pottsville upward close to the horizon of the Lower Mercer limestone. The Massillon is a medium to coarse-grained sandstone which may or may not be conglomeratic at its base. The color of the stone on fresh exposure is usually a light gray but on weathering it assumes a buff, yellowish brown, or pink hue due to the oxidation and hydration of the iron compounds present as cements. The stone is generally heavy bedded to massive in its lower portion where cross-bedding is also a conspicuous feature. The Massillon sandstone has been quarried at a few localities in the northwestern part of Coshocton County for building purposes.

South of the Walhonding River the Massillon sandstone is exposed at a few localities but at other places its horizon is occupied by shale. As exposed along Laurel Run near Newcastle, it is a massive ledge 44 feet in thickness immediately overlying the Quakertown coal. It is well exposed along the road in Section 4, Perry Township, where its thickness is 21 feet and its character is shaly. In Section 23, Pike Township, the Massillon is a heavy-bedded ledge 45 feet in thickness which has replaced the Bear Run and Vandusen coal horizons. This sandstone is not well exposed along Fivemile Run or Wakatomika Creek, but it has been recorded at a few localities in Bedford Township. The following section secured by T. R. Meyers in 1928 along the road in the northwest part of Section 24, Bedford Township, shows the Massillon sandstone in normal development and its relation to overlying and underlying beds.

	Ft.	In.
Limestone, gray, dense, fossiliferous, Lower Mercer	1	5
Clay and covered	5	0
Shale, arenaceous, and covered	14	0
Covered interval	25	6
Coal, Vandusen	-	4
Clay	1	0
Covered interval	10	0
Shale, arenaceous	7	2
Clay, shale, and covered	13	10
Clay shale	-	8
Coal, weathered, Bear Run	-	2
Clay, dark	-	6
Sandstone, shaly, somewhat ferruginous, Massillon	17	5
Covered interval	3	0
Coal smut, Quakertown or No. 2	-	1
Clay, light, siliceous	-	10
Shale, sandy	4	6
Altitude, 860 ft.		

[1] White, I. C., Geology of Lawrence County, Second Geol. Survey Pa., Rept. QQ, pp. 63-64, 1879.

Sandstone, apparently Massillon in age, was formerly worked by Dr. Moore for rough construction materials in a small quarry located in the south bank of the Walhonding River, east of Simmons Run, about one-half mile southeast of Warsaw. The bed formerly quarried here is a massively developed, coarse-grained micaceous sandstone having a thickness of 20 to 25 feet. In 1910 Arthur Smith collected a sample from this quarry, consisting of chips from the quarry face, and submitted it for analysis. The composition as determined in the laboratory by D. J. Demorest of Ohio State University is as follows.[1]

	Per cent
Silica, SiO_2	92.66
Alumina, Al_2O_3	3.92
Ferric oxide, Fe_2O_3	0.50
Calcium oxide, CaO	0.00
Magnesium oxide, MgO	0.01
Titanium oxide, TiO_2	0.15
Loss on ignition	0.70
Total	97.94

The Massillon sandstone was formerly quarried on a small scale along the southeast slope of the spur ridge just northwest of Warsaw. This quarry was in a bad state of decay when visited by the writer in 1947. Only about 15 feet of heavy-bedded sandstone, somewhat shattered by weathering, was exposed.

North of the Walhonding River the Massillon sandstone occurs in strong development in northeastern Jefferson Township along Killbuck Creek in northern Bethlehem Township and in Clark Township, along the valley of Big Run in Monroe Township, around the headwaters of Wolf Creek in Tiverton Township and northwestern Monroe Township, and in southern Tiverton Township. In northeastern Jefferson Township this sandstone reaches a thickness of 100 feet and extends from the top of the Mississippian up to and even replaces the Lower Mercer limestone over small areas. The sandstone is coarse-grained and cross-bedded but quite massively developed, yielding large blocks on weathering which strew the hillsides below its zone of outcrop. Sandstone float from the Massillon originating in this way is conspicuous on the hillsides in northeastern Jefferson Township and along the Killbuck Valley in Bethlehem and Clark townships. In the southwestern part of Tiverton Township, the Massillon sandstone has been quarried intermittently for building stone for a number of years by the Briar Hill Stone Company of Glenmont, Ohio. The quarry is located along a small valley tributary to the Mohican from the west and situated three-eighths of a mile from the south boundary and three-fourths of a mile from the west boundary of the township. The sandstone is heavy bedded to massive in structure, with cross-bedding conspicuously developed along some zones. The color of the stone varies from pink, gray, and light buff to brown. Blocks from the quarry are transported to Glenmont for sawing into desired size for building construction.

Brown sandstone, probably Massillon in age, was formerly quarried in a small way along the Mohican Valley near Cavallo.[2] The Briar Hill Stone Company have recently opened a quarry in Massillon sandstone in northwest quarter of Section 12, Tiverton Township, for the production of Ashlar blocks for stone veneer. The sandstone member here has a thickness of 42 feet. It is generally heavy bedded to massive with some zones showing cross-bedding. Large blocks of straight-grained stone weighing 8 to 12 tons are quarried and trucked to the mills at Glenmont where the blocks are sawed into slabs at right angles to the natural grain of the stone. The sawed slabs are then split parallel to the grain into rectangular brick-like blocks. In veneer construction such blocks are laid with the sawed surfaces embedded in the mortar and one split surface exposed to view. Pleasing architectural effects are produced by mingling blocks of different shade.

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[1] Bownocker, J. A., Glass Sands of Ohio, Ohio Jour. Sci., Vol. XXVI, p. 36, 1926.

[2] Bownocker, J. A., Building Stone of Ohio, Geol. Survey Ohio, Bull. 18, p. 143, 1915.

The Nichols Stone Company operates a quarry in the Massillon sandstone in the southwest quarter of Section 13, Clark Township. The quarry is located near the crest of a high ridge where the surface elevation is about 980 feet. The stone, which is medium-grained, even-textured, and of a gray to light buff color, occurs in a massive ledge 30 feet or so in thickness. It is quarried into large blocks which are transported by truck to the mill at Killbuck and there sawed to dimensional sizes for sills, cap stones, and Ashlar blocks.

The Massillon sandstone in an unweathered state is rather soft and friable. The grains are chiefly of quartz, medium to coarse in size in the massive to heavy bedded types, but scales of muscovite mica are also quite apparent. The cementing materials appear to be chiefly clay and iron compounds. When exposed to the atmosphere there is an oxidation of the iron compounds near the surface and further cementation, increasing the weather resistant properties of the stone. Much of the mica and clay impurities can be removed by crushing and washing. The quantity of iron compounds can be greatly reduced by treatment with acid. In addition to building stone the Massillon presents possibilities as a source for steel molding sands and possibly for glass sand after cleaning.

Bear Run Coal and Clay

STRATIGRAPHY AND EXTENT

The next coal bed in ascending order above the Quakertown or No. 2 is the Bear Run so named by Wilber Stout for its occurrence along Bear Run in northern Bloom Township, Scioto County,[1] where it reaches a maximum thickness of 4 feet and where it has been mined from a number of openings. This coal horizon is quite persistent on the outcrop in Ohio where its horizon has not been encroached upon by undue thickening of the underlying Massillon sandstone. Although usually represented by a few inches of black shale or shaly coal, its horizon has been recognized over scattered areas in Scioto, Jackson, Vinton, southwestern Perry, and Muskingum counties. In these fields the position of the Bear Run coal is on an average 29 feet above the Quakertown coal, 20 feet below the Vandusen coal, 48 feet below the Lower Mercer coal, and 70 feet below the Lower Mercer limestone.

In Coshocton County the horizon of the Bear Run coal and clay is above drainage level along the larger valleys in the western half of the territory including parts of Tiverton, Monroe, Clark, Newcastle, Jefferson, Bethlehem, Perry, Bedford, Pike, and Washington townships. Over much of this area both the coal and clay are wanting owing to the encroachment of the underlying Massillon sandstone. Neither the coal nor clay has been observed in outcrops in Tiverton, Monroe, and Clark townships and both are wanting in many localities in Coshocton County south of these townships. Where present the coal horizon is generally marked by a few inches of black carbonaceous shale, coaly clay, or shaly coal overlying dark impure siliceous clay having a maximum observed thickness of about 6 feet. The position of the Bear Run coal horizon in Coshocton County is on an average 22 feet above the Quakertown coal, 9 feet below the Vandusen coal, 35 feet below the Lower Mercer coal, and 66 feet below the Lower Mercer limestone. Neither the coal nor clay has any importance in Coshocton County beyond their stratigraphic interest.

As exposed along the road just south of West Carlisle, Section 12, Pike Township, the Bear Run coal horizon is represented by one foot of carbonaceous shale as shown in the following section.

	Ft.	In.
Limestone, dark gray black, dense, Lower Mercer	2	0
Sandy shale and covered	29	0
Shale, black, carbonaceous, weathered, Lower Mercer coal horizon	5	2

[1]Stout, Wilber, Geology of Southern Ohio, Geol. Survey Ohio, Bull. 20, pp. 552, 556, 1916.

	Ft.	In.
Covered interval	16	6
Clay, gray, Vandusen	7	4
Covered interval	7	2
Shale, carbonaceous, highly weathered, Bear Run coal horizon	1	0
Clay, yellowish brown	1	0
Altitude, 963 ft.		

As exposed in the central part of Section 22, Washington Township, the Bear Run is represented by 8 inches of bone shale and shaly coal above 6 feet of siliceous, ferruginous clay, lying 15 feet above the Quakertown horizon, and 64 feet below the Lower Mercer limestone. The following measurements of outcrops secured by Mr. Meyers along the road in the west central part of Section 23, Bedford Township, shows the character of the Bear Run horizon and intervals to overlying and underlying members.

Sandstone, fine-grained, thin-bedded, micaceous	8	3
Coal, weathered, Vandusen	-	1½
Clay, light, plastic	1	4
Sandstone, white, shaly	2	3
Sandstone somewhat massive, and covered	15	2
Shale, sandy	12	4
Clay shale, carbonaceous, Bear Run coal horizon	-	2
Clay and covered	3	10
Clay, plastic, siliceous	3	1
Sandstone, clay-bonded, with plant fossils	-	5
Ore, nodular, impure	-	4
Shale, arenaceous	12	5
Clay, sandy, Quakertown	1	9
Altitude, 842 ft.		

The Bear Run member is generally present in outcrops along the Mohawk Valley in northwestern Bedford Township and in southwestern Jefferson Township. It has also been observed at one or two localities along the Walhonding Valley in Jefferson Township. At these localities the horizon is usually represented by a thin bed of black shale or shaly coal overlying impure clay. The following measurement of outcrops was secured along the road ascending the hill near the mouth of Killbuck Creek in Bethlehem Township one mile northeast of Bantum School.

Pennsylvanian system		
Pottsville series		
Shale, ferruginous, arenaceous	5	0
Ore, siliceous, Boggs	-	6
Clay, gray to bluish gray, sandy, Lower Mercer	2	0
Shale, gray to bluish gray, somewhat ferruginous	13	6
Shale, carbonaceous	-	11
Coal, bony (Vandusen)	-	4
Shale, carbonaceous (Vandusen)	-	6
Clay, bluish gray, siliceous	3	0
Clay, shale, and covered	25	0

	Ft.	In.
Ore, nodular	-	3
Shale, bluish gray	-	6
Covered	1	8
Coal blossom, Bear Run	-	4
Clay, shaly	1	6
Ore	-	6
Brecciated layer containing pieces of cherty limestone (Harrison Member)	3	6
Mississippian system		
Logan formation		
Shale, reddish brown and greenish gray, Vinton member	10	4

The Bear Run member is generally wanting on the outcrop in Tiverton, Monroe, Clark, and northern Bethlehem townships due to the widespread replacement of its horizon by sandy shale and Massillon sandstone.

The poor development of the Bear Run coal in Coshocton County and the impure character of the underlying clay render these beds of little economic value.

Vandusen Coal and Clay

STRATIGRAPHY, EXTENT, AND VALUE

The type locality for the Vandusen coal is near the headwaters of the Little Scioto River in southern Jackson County where this bed is thin but of good quality. On the Marion Vandusen property in Section 1, Hamilton Township, this coal has a thickness of about 11 inches and has been stripped for fuel.[1] Thin deposits of Vandusen coal are also present in Scioto and Franklin townships, Jackson County, and in Green, Vernon, Porter, and Bloom townships, Scioto County. North of Jackson County the Vandusen has been recognized at a few localities in Vinton County and in Muskingum County where it may consist of a few inches of impure coal or carbonaceous shale overlying a thin bed of siliceous clay. The stratigraphic position of the Vandusen is between the Bear Run and Lower Mercer coals. On an average in Ohio it is found about 20 feet above the Bear Run coal, 28 feet below the Lower Mercer coal, and 48 feet below the Lower Mercer limestone. Where the Massillon sandstone is greatly expanded in vertical section it often replaces both the Bear Run and Vandusen coals.

In Coshocton County the Vandusen member is generally present where due in Pike, Perry, Washington, Bedford, southern Jefferson, and southern Newcastle townships as indicated by widely scattered outcrops. In Tiverton, Monroe, Clark, northern Newcastle, northern Jefferson, and Bethlehem townships the horizon of this member is in large part occupied by sandstone or sandy shale. Where present in this county the Vandusen coal is on an average about 57 feet below the Lower Mercer limestone, 26 feet below the Lower Mercer coal, and about 9 feet above the Bear Run coal. The Vandusen is generally represented by thin carbonaceous clay or by 1 to 4 inches of impure coal overlying 1 to 6 feet of gray siliceous clay. At no place has the coal been found with a quality or thickness worthy of stripping on the outcrop. The clay is gray to dark and is generally charged with siliceous and ferruginous impurities. No economic importance is conceived for these members. The general stratigraphic relations are indicated in the few sections and comments that follow.

Near the head of Laurel Run, just north of Newcastle, Newcastle Township, the Vandusen horizon is represented by a 2-foot bed of gray ferruginous clay which outcrops close above a 44-foot exposure of Massillon sandstone and 66 feet below the Lower Mercer limestone. As exposed along the north-south road in Section 21, the coal is represented by a mere smut streak

[1]Stout, Wilber, Geology of Southern Ohio, Geol. Survey Ohio, Bull. 20, pp. 129-131, 1916.

6 feet 6 inches above the Bear Run horizon and 52 feet below the Lower Mercer limestone. The succession as exposed along the road three-eighths of a mile northeast of Wilson Chapel, Section 2, Perry Township, is as follows:

	Ft.	In.
Limestone, gray black, fossiliferous, Lower Mercer	1	4
Shale and covered	34	8
Coal and carbonaceous shale, Lower Mercer or No. 3.	-	3
Clay, gray, plastic, and covered	3	0
Shale, gray, arenaceous	22	7
Coal blossom, Vandusen	-	2
Clay, gray, slightly ferruginous, plastic	4	6

Altitude, 993 ft.

In Pike Township, the horizon of the Vandusen coal is above drainage level along all the larger valleys but few exposures have been noted. In sections 24 and 25 massive sandstone occupies its horizon. As exposed near West Carlisle, the Vandusen horizon is represented by gray plastic clay some 17 feet below the Lower Mercer coal horizon and 50 feet below the Lower Mercer limestone. In Bedford Township the Vandusen horizon is generally represented by a few inches of coal overlying a bed of dark, ferruginous clay. The following measurements of exposures was secured by T. R. Meyers in 1928 along the public road, now abandoned, leading from the valley of Mohawk Creek in Section 15 to West Bedford.

		Ft.	In.
Limestone, gray, dense, fossiliferous, Lower Mercer		1	8
Shale and covered		7	4
Coal, weathered	Flint Ridge	-	11
Clay parting, gray, soft	Flint Ridge	-	$3\frac{1}{2}$
Coal, weathered	Flint Ridge	-	$9\frac{1}{2}$
Clay		-	1
Covered		2	0
Shale, arenaceous		8	11
Coal, poor, Lower Mercer or No. 3		-	$6\frac{1}{4}$
Clay, light, plastic		1	0
Covered		25	4
Coal smut, Vandusen		-	1
Covered interval		5	0
Coal blossom, Bear Run		-	1
Clay, light		2	0

Altitude, 926 ft.

The succession below the Lower Mercer limestone occurring along the road one half mile northwest of Mohawk Village, Jefferson Township, is recorded by T. R. Meyers as follows:

	Ft.	In.
Limestone, gray, dense, fossiliferous, Lower Mercer	1	5
Shale and covered	1	0
Clay, coaly, Middle Mercer	-	2
Clay	3	0
Covered interval	17	11
Clay, coaly, Lower Mercer or No. 3	-	1
Clay	-	6
Sandstone, medium-grained, and covered	16	6

	Ft.	In.
Covered	7	0
Sandstone and covered	6	0
Covered	8	6
Clay, coaly, Vandusen	-	½
Clay	-	6
Covered interval	10	5
Clay, carbonaceous, Bear Run horizon	-	1
Clay	-	6

Altitude, 977 ft.

As exposed near Warsaw Junction, Jefferson Township, the Vandusen is represented by a few inches of shaly coal outcropping 25 feet below the Lower Mercer coal and 11 feet above the Bear Run horizon. Little evidence of the Vandusen member has been found north of the Walhonding River owing to the thickening of the Massillon sandstone and shale which extend upward and transgress this horizon.

Lowellville (Poverty Run) Limestone

STRATIGRAPHY, EXTENT, AND VALUE

The Lowellville is the oldest marine limestone horizon in the Pottsville series in Ohio. It was first named by G. F. Lamb in 1910 for exposures near Lowellville, Poland Township, Mahoning County,[1] where it is a thin impure limestone overlain by dark fossiliferous shale outcropping about 83 feet below the Lower Mercer limestone. In 1918, Wilber Stout described the Poverty Run limestone as occurring close above the Vandusen coal and 55 feet below the Lower Mercer limestone in outcrops along Poverty Run, Hopewell Township, Muskingum County.[2] On the basis of faunal similarities Helen Morningstar in 1922 correlated the Poverty Run limestone with the Lowellville as defined by Lamb.[3]

The Lowellville member is very limited in its known distribution on the outcrop in Ohio having been recognized only in Mahoning, Muskingum, and Coshocton counties. The nature of the Lowellville member in Muskingum County is described by Stout as follows:[4] "When completely represented, the member is made up of a thin limestone, a calcareous shale, and a stratified iron ore. Usually, however, the three strata are not present in the same section. The limestone which forms the lowest stratum is light gray, very hard, somewhat ferruginous, and quite fossiliferous. It seldom exceeds 5 inches in thickness and is broken into rather uniform blocks by joints. Above the limestone lies a shale, which averages approximately 1 foot thick. It is dark gray, rather soft, notably calcareous, and exceedingly fossiliferous. In places this shale contains ferrous carbonate nodules, which often exceed 6 inches in diameter, and which, not infrequently, are traversed by calcite bands. These nodules also contain impressions of moluscan life. The upper stratum, only a few inches in thickness, is a regularly bedded iron ore. It is also sparingly fossiliferous, and is a ferrous carbonate except where weathered along the outcrop to hydrated forms of ferric oxide."

The Lowellville member in Coshocton County is more often wanting than present on the outcrop. Scattered occurrences, however, have been noted in a few localities, in Washington, Jefferson, and Newcastle townships. Here the member is represented by a few inches of dark carbonaceous limestone or a thin bed of iron carbonate ore. No economic value can be conceived for this member in Coshocton County. Its importance rests on its stratigraphic relation to the

[1] Lamb, G. F., Pennsylvanian Limestones in Northeastern Ohio below the Lower Kittanning coal, Ohio Naturalist, Vol. 10, pp. 128, 129, 1910.

[2] Stout, Wilber, Geology of Muskingum County, Geol. Survey Ohio, Bull. 21, p. 65, 1918.

[3] Morningstar, Helen, Pottsville fauna of Ohio, Geol. Survey Ohio, Bull. 25, p. 28, 1922.

[4] Stout, Wilber, op. cit., p. 65.

Vandusen coal and on its fossil content. The Lowellville is the lowest limestone of marine origin occurring in the Pottsville series of Ohio.

In Washington Township, the Lowellville member was formerly well exposed along Opposum Run about 2½ miles southwest of Wakatomika and about one-half mile east of south of Graham Corners. A section at this locality as described by Wilber Stout in 1916 is as follows:

		Ft.	In.
Limestone, in three beds, Lower Mercer		4	0
Coal blossom, Middle Mercer		-	4
Clay and covered		5	8
Sandstone, shaly		6	0
Coal blossom, Flint Ridge		-	1
Clay, siliceous		6	0
Shale		5	0
Shale and covered		5	8
Sandstone, shaly		-	6
Shale		9	6
Sandstone, shaly		-	6
Shale, in part dark and fissile		7	2
Clay, siliceous		1	2
Sandstone, argillaceous		2	6
Coal, with bony bands, thins in short distance to 6 inches, Lower Mercer or No. 3		2	0
Shale		5	8
Ore, blue, siliceous, sparingly fossiliferous, thickens to 8 inches in places	Lowellville	-	3
Shale, gray	Lowellville	1	0
Shale, dark, calcareous, fossiliferous	Lowellville	-	10
Limestone, gray, fossiliferous	Lowellville	-	3
Coal, bony, Vandusen		-	8
Clay, light, very siliceous		2	0

Altitude, 870 ft.

In the above section the Lowellville is represented by thin fossiliferous limestone, fossiliferous shale, and iron ore. The 58-foot interval to the Lower Mercer limestone is about normal for Coshocton County. In the following section secured by T. R. Meyers in the northeast quarter of Section 21, Newcastle Township, the limestone is wanting but an iron ore representing the Lowellville in part is found close above the Vandusen coal.

	Ft.	In.
Coaly clay, Lower Mercer coal horizon	-	2
Clay	2	0
Shale and covered	22	6
Shale, gray	6	4
Shale, carbonaceous	-	4
Covered	-	6
Iron ore, weathered, Lowellville horizon	-	3
Shale	-	6
Coal blossom, Vandusen	-	1
Clay, light, and covered	4	6

Altitude, 1,000 ft.

In 1928 the lower Pottsville strata were well exposed along the south side of the Walhonding Valley about 1½ miles west of Warsaw Junction. The exposures were described by Mr. Meyers in part as follows:

	Ft.	In.
Flint, weathered, Upper Mercer limestone horizon	2	0
Covered interval	54	0
Sandstone, shaly	10	0
Ore, steel gray, rather massive, weathers reddish brown } Lowellville	-	6
Limestone, black, carbonaceous. } Lowellville	-	5
Shale, sandy, and covered	21	1
Shale, carbonaceous	2	0
Shale, siliceous	5	6
Sandstone, hard, massive, medium-grained	2	0
Shale, carbonaceous, coaly at bottom, Quakertown coal horizon	2	11
Clay, gray	-	6

Altitude, 897 ft.

At this locality the Lowellville member is probably represented by the thin black carbonaceous limestone overlain by thin iron carbonate ore.

North of the Walhonding River in Coshocton County the lower Pottsville series seems to be composed of sandstone and sandy shale with little evidence of the Lowellville member on the outcrop.

Lower Mercer Coal and Clay

STRATIGRAPHY, EXTENT, AND VALUE

In Lawrence County, Pennsylvania, a thin bed of impure coal occurring from 0 to 18 feet below the Lower Mercer limestone was named the Lower Mercer coal by I. C. White in 1879.[1] In Ohio three coal horizons having some persistence on the outcrop occur close below the Lower Mercer limestone. Concerning the succession in Muskingum County, Wilber Stout writes as follows.[2]

"In an interval averaging about 25 feet in thickness and lying below the Lower Mercer limestone, three coal horizons are quite distinctly defined in Muskingum County, and these beds or their associated clays are moderately steady except where replaced by sandstone. Each of these beds has been developed sufficiently for drift mining in parts of the State, and each has been called Lower Mercer coal. The lower coal bed lies about 24 feet below the Lower Mercer limestone and, at most, only a few feet below the Boggs limestone and ore, which are exceptionally well developed in central and northern Muskingum County. This lower bed is the most constant in volume of the three and is the one that has been mined in small areas in Vinton, Jackson, and Lawrence counties. As it has been called Lower Mercer coal in southern Ohio, it will be so named in Muskingum County. The second horizon lies, on an average, about 12 feet below the Lower Mercer limestone, and is the one marked in many places by beds of flint and plastic clay. The coal stratum in this horizon is seldom conspicuous, although it has been mined at places in eastern Ohio and on Flint Ridge in Licking County where it is represented by thick beds of cannel coal. The upper coal lies either directly below the Lower Mercer limestone or is separated from it by a few inches of shale, usually carbonaceous. This bed also swells in many places so that it is mined for local consumption, but as a usual thing, the stratum is only a few inches in thickness."

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[1] White, I. C., The Geology of Lawrence County, Second Geol. Survey Pa., Rept. QQ, p. 62, 1879.

[2] Stout, Wilber, Geology of Muskingum County, Geol. Survey Ohio, Bull. 21, pp. 65-66, 1918.

The Lower Mercer coal as thus defined by Stout is rather widely distributed on outcrops in Coshocton County, but as indicated by such outcrops, it lacks both persistence and quality and at no place does it occur in sufficient thickness for mining. Where present in this area the bed generally consists of thin coal, carbonaceous shale, or a mixture of the two. The clay underlying the coal is of the gray plastic type, which is generally siliceous and in places ferruginous in character. Where present the thickness of the coal ranges from 1 inch to about 1 foot but averages about 3 inches, whereas the thickness of the clay varies from 1 to about 4 feet. The stratigraphic position of the Lower Mercer coal in Coshocton County is on an average about 31 feet below the widely distributed Lower Mercer limestone, 20 feet below the Flint Ridge coal, and 26 feet above the Vandusen coal previously described. The horizon is above drainage in parts of every township in this county situated west of the Muskingum River and north of the Tuscarawas River but it is best represented in Pike, Perry, Bedford, and Washington townships.

In Pike Township the Lower Mercer coal is generally represented in outcrops as indicated by a few scattered exposures. Here the altitude ranges from about 1,070 feet in Section 7 to 900 feet in Section 21. The following section descriptive of exposures along the road in the southeast quarter of Section 23 shows the relation of the Lower Mercer coal horizon to the Boggs and Lower Mercer limestone horizons and is typical for this township.

	Ft.	In.
Limestone, dark, somewhat shattered, Lower Mercer	1	0
Clay and covered, mostly covered	14	8
Covered interval	20	8
Ore, nodular } Boggs	-	4
Gray, flinty rock } Boggs	-	4
Shale, gray	2	0
Shale, carbonaceous, weathered, Lower Mercer or No. 3 coal horizon	-	3
Clay, gray, plastic	2	0
Altitude, 960 ft.		

In Washington Township the horizon of the Lower Mercer coal and clay is above drainage along the valleys of Little Wakatomika Creek and its tributaries, outcropping at elevations ranging from about 900 feet in Section 15, to 840 feet in the southeast corner of the area. The best exposures found in this township occur along Oppossum Run where the Lower Mercer horizon is represented by 6 inches of coal overlying 2 feet 6 inches of gray siliceous clay. Where exposed in Bedford Township, the Lower Mercer coal horizon is usually represented by a few inches of shaly coal overlying a thin bed of gray plastic clay. The following measurements secured along the road in the north central part of Section 16 shows the stratigraphic relations of the Lower Mercer coal and clay to closely overlying beds.

	Ft.	In.
Horizon of Lower Mercer limestone	-	-
Shale and covered	7	8
Coal, shaly, weathered, Flint Ridge	-	5
Clay, bluish gray	2	0
Clay, ferruginous	7	11
Clay shale, gray, siliceous	3	8
Shale, light gray, micaceous	5	0
Shale, dark	8	4
Ore layer, Boggs	-	3
Clay shale, slightly ferruginous	-	7
Shale, coaly, sandy } Lower Mercer	-	3
Shale, gray } Lower Mercer	-	3
Coal, shaly, and shales } Lower Mercer	-	6
Clay, yellowish brown, plastic	2	3
Altitude, 935 ft.		

In Perry Township the distribution of outcrops of Lower Mercer coal is confined chiefly to the upper slopes of the high ridges in the northern part. Here the coal where present is generally represented by a mere smut streak overlying a thin bed of plastic clay. Much the same conditions are found in southern Jefferson Township. North of the Walhonding Valley sandstone or sandy shale seems to prevail on the Lower Mercer coal horizon over much of northern Jefferson, Monroe, Tiverton, and northern Newcastle townships. A notable departure from this condition is shown in the following section describing the outcrops along the road in the northeast quarter of Section 8, Monroe Township. Here the limestones are wanting but the coals are identified with some assurance.

	Ft.	In.
Coal blossom, Brookville or No. 4	-	6
Clay, gray, plastic	1	6
Covered interval	3	0
Shale, very sandy	11	0
Covered interval	31	0
Shale, carbonaceous	1	0
Shale, sandy	-	½
Shale, carbonaceous	-	5
Shale, micaceous, arenaceous	-	6
Shale, argillaceous	1	6
Covered interval	21	2
Shale, carbonaceous, Bedford coal horizon	-	3
Clay, gray, and covered	2	3
Clay, ferruginous, siliceous	-	4
Clay, gray, plastic	1	0
Covered interval	19	4
Shale, carbonaceous	-	9
Coal blossom, Middle Mercer	-	3
Clay and covered	7	8
Shale, carbonaceous, Flint Ridge coal horizon	3	0
Clay, shaly, siliceous	2	6
Covered interval	4	4
Shale, arenaceous	3	11
Shale, argillaceous	1	0
Coal, shaly, Lower Mercer or No. 3	-	1
Sandstone, clay bond	1	4
Clay, gray, with a few ore nodules	4	4

Altitude, 1,000 feet.

The Lower Mercer horizon is above drainage along the Killbuck and Walhonding valleys in Clark and Bethlehem townships, but over this field of outcrops both the coal and the clay have been replaced by sandstone and sandy shale. Much the same conditions prevail along the valley of Crooked Run in northeastern Jackson Township. Along Simmons Run in Section 24, however, this coal is represented by a thin blossom overlying 2 feet of dark siliceous clay and outcropping 25 feet below the Lower Mercer limestone.

In Keene and Mill Creek townships the Lower Mercer coal horizon is due close above drainage level in the valleys of Mill Creek and Little Mill Creek and their chief tributaries. Here little evidence of either coal or clay is present on outcrops, the position of these members being occupied by sandstone and sandy shale. Similar conditions exist along the valleys of White Eyes Creek and its tributaries in Crawford and White Eyes townships and in the valley of Evans Creek in Adams Township.

Boggs Member

STRATIGRAPHY AND EXTENT

Edward Orton in 1884 applied the name Boggs to a stratified ore which was well developed and extensively mined on the Boggs property near South Webster, Bloom Township, Scioto County.[1] The stratigraphic position of the Boggs ore was later determined by Wilber Stout as occurring close above the Lower Mercer coal horizon.[2] As thus defined this ore is thin and discontinuous but is widely distributed. Scattered deposits occur in eastern Scioto, western Lawrence, Jackson, Vinton, Hocking, and Perry counties. In some of these counties the ore was formerly mined for smelting in the old charcoal furnaces. Farther north, in Muskingum County, the Boggs member may consist of thin ore, but it is also represented by thin fossiliferous limestone, by flint, by fossiliferous shale, or by gradational varieties between these various types.[3] Where present in Ohio the usual thickness of the Boggs member is about 6 inches and its position is on an average about 1 foot above the Lower Mercer coal and 19 feet below the Lower Mercer limestone.

The Boggs member is not well expressed in outcrops in Coshocton County for it is wanting over large areas and it measures only a few inches in thickness where present. The position of the member is, on an average, about 2 feet above the Lower Mercer coal. Where the Boggs is wanting in the section, its position is generally occupied by shale or sandstone. Where present it may be represented by a few inches of impure ore but more often the member consists of a thin bed of ferruginous siliceous limestone or ferruginous calcareous flint. Fossils of marine forms of life are generally present in both the limestone and the ore. Dark shales generally separate the Boggs from the underlying coal and these too may be fossiliferous. In Coshocton County the horizon of the Boggs outcrops in parts of every township occurring north of the Tuscarawas River and west of the Muskingum River, but this member has been identified in only a few widely scattered areas in Pike, Washington, Bedford, and Bethlehem townships.

In Pike Township a few inches of gray calcareous flint representing the Boggs member occurs along the road at the crest of the hill in the south-central part of Section 16 at an altitude of 1,020 feet. The interval to the Lower Mercer limestone could not be determined at this locality. As exposed along the road in the southeast quarter of Section 23, Pike Township, the Boggs member is represented by 4 inches of nodular ore overlying 4 inches of gray flint which in turn is separated from the Lower Mercer coal by 2 feet of dark gray shale. In Washington Township, flint on the Boggs horizon was observed close above the Lower Mercer coal along the abandoned road near the southeast corner of Section 12. Here it consists of 4 inches of calcareous ferruginous flint at an altitude of 850 feet or 27 feet below the Lower Mercer limestone.

The Boggs member is generally wanting on the outcrop in Bedford Township although a few scattered occurrences have been noted. As exposed along the road crossing the valley of Mohawk Creek near its head in Section 16, the Boggs member is represented by a 3-inch ferruginous layer closely overlying the Lower Mercer coal and outcropping 33 feet below the Lower Mercer limestone horizon. As recorded by Mr. Meyers this member as exposed near Donley School, three miles northeast of Tunnel Hill, consists of 6 inches of dark fossiliferous flint, occurring 2 feet above the Lower Mercer coal. In Bethlehem Township the Boggs member is generally wanting through lack of deposition or by replacement by sandy shales or sandstones. The only exposure noted occurs near the mouth of Killbuck Creek about 1 mile northeast of Bantum School. At this locality the Boggs is represented by 6 inches of siliceous fossiliferous ore. The horizon of the Boggs member is above drainage in parts of Adams, White Eyes, Crawford, Mill Creek, Keene, Monroe, Jefferson, Tiverton, and Newcastle townships, in the northern part of Coshocton County but in this area the member has not been observed on the outcrop.

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[1] Orton, Edward, Economic Geology, Geol. Survey Ohio, Vol. V, p. 421, 1884.

[2] Stout, Wilber, Geology of Southern Ohio, Geol. Survey Ohio, Bull. 20, p. 567, 1916.

[3] Stout, Wilber, Geology of Muskingum County, Geol. Survey Ohio, Bull. 21, p. 70, 1918.

The Boggs member in Coshocton County is of interest chiefly for its fossil content and for its stratigraphic relationships.

Flint Ridge Coal and Clay

STRATIGRAPHY, EXTENT, AND VALUE

The type locality for the Flint Ridge coal is along Flint Ridge in the west central part of Hopewell Township, Licking County, about 2½ miles north of Brownsville. Stout describes the bed at this place as being a cannel coal of excellent thickness occurring about 12 feet below the Lower Mercer limestone.[1] The Flint Ridge coal and clay are always closely associated with the Middle Mercer coal and clay which closely overlie them and which are generally more persistent. Where a complete sequence of strata exists the succession in descending order is as follows: Lower Mercer limestone, a few inches of dark shale, Middle Mercer coal and clay, a few feet of arenaceous shale, and Flint Ridge coal and clay. Not infrequently the Flint Ridge coal and overlying shale disappear from the section and the Flint Ridge clay coalesces with clays of the Middle Mercer horizon. The Flint Ridge coal and clay are widely distributed on the outcrop across Ohio from Mahoning County to Scioto County but in general they lack continuity for their place in the stratigraphic column at many places is occupied by arenaceous shale and locally even by sandstone. The coal has no economic value beyond its type locality but the underlying clay has yielded some raw material to the ceramic industry.

The horizon of the Flint Ridge coal and underlying clay outcrops near the summits of the high hills and ridges in the western part of Coshocton County. Owing to the regional dip of the strata in an eastern direction these members are found at or close above flood plain level along the Tuscarawas Valley and the lower part of its chief tributary valleys east of Coshocton and at or a little below flood plain level along the Muskingum Valley south of Coshocton. The coal and clay are by no means persistent on outcrops as their stratigraphic horizon at many localities is occupied by sandy shales. Outcrops of the coal and clay have been observed, however, at scattered localities in Monroe, Tiverton, Bedford, Jefferson, Pike, and Washington townships. Where present the coal horizon may be represented by black shale, bone shale, or by carbonaceous shale and shaly coal interstratified. Its thickness ranges from a mere soot streak to 3 feet with an average of about 1 foot 5 inches. The underlying clay is of the gray plastic variety which is somewhat arenaceous. Locally it is contaminated with small amounts of iron carbonate which on weathering stain the mass a yellowish tint. At the few localities where outcrops have been found the thickness of the clay ranges from 2 to 10 feet with an average of about 4 feet 6 inches. Although the Flint Ridge clay has been employed in some localities for production of ceramic products it has not been utilized in an economic way in Coshocton County.

In Monroe Township, the Flint Ridge members are present in outcrops along the road in the northeast quarter of Section 8. They are represented by 3 feet of carbonaceous shale overlying 2 feet 6 inches of very sandy clay. The position of the carbonaceous shale is immediately below the Middle Mercer clay. In Tiverton Township the Flint Ridge is generally wanting owing to replacement by shale. Thin plastic clay referred to this horizon, however, occurs in the east central part of Section 18, about 38 feet below the Upper Mercer limestone horizon. Both the coal and the underlying clay have been identified in several localities in southern Bedford Township. As exposed at West Bedford the coal horizon is represented by 1 foot 10 inches of coal and carbonaceous shale outcropping 14 feet below the Lower Mercer limestone. The following section showing the stratigraphic relations of the Flint Ridge to the overlying Lower Mercer limestone was secured by Mr. Meyers in 1928 in the northern part of Section 21.

	Ft.	In.
Limestone, dark blue, fossiliferous, Lower Mercer	3	0
Covered interval	4	10

[1] Stout, Wilber, Geology of Muskingum County, Geol. Survey Ohio, Bull. 21, p. 75, 1918.

	Ft.	In.
Sandstone, thin-bedded, buff	4	0
Sandstone, fine-grained, micaceous, massive	2	2
Shale, chocolate brown, somewhat fissile	-	2½
Shale, dark blue, somewhat fissile	-	7
Shale, bluish, with ore nodules	2	8
Coal and shale, interbedded. . . } Flint Ridge { . .	-	5
Shale, blue gray, hard . . . . . } Flint Ridge { . .	-	2½
Coal, cannelly and shaly . . . . } Flint Ridge { . .	-	5
Clay shale, blue gray, micaceous, slightly carbonaceous	2	0

Near Graham Corners in western Washington Township, the Flint Ridge horizon is represented by 6 feet of gray siliceous clay occurring about 12 feet below the Lower Mercer limestone. In Pike Township the Flint Ridge horizon outcrops high on the ridges bordering the valleys of Fivemile Run and Nickel Valley Run. Few exposures have been recorded. The following section measured along the road in the southeast corner of Section 15 is typical for this township.

Limestone, bluish gray, fossiliferous, Lower Mercer	1	0
Covered interval	5	4
Shale, micaceous, arenaceous	4	0
Coal blossom, Flint Ridge	1	0
Clay, gray to bluish gray, plastic, somewhat siliceous	4	2

Middle Mercer Coal and Clay

STRATIGRAPHY, EXTENT, AND VALUE

The Middle Mercer coal in Ohio as defined by Stout[1] "lies either directly below the Lower Mercer limestone or is separated from the limestone by shale, seldom exceeding 1 foot in thickness." As thus defined this coal "extends with fair continuity from the Ohio-Pennsylvania line in Mahoning County to the Ohio River in Scioto County. Throughout this field the member expands in few places sufficiently to be mined even in a small way. The average thickness of the stratum is not more than 6 inches and the maximum about 3 feet. In character it varies from a bright, bituminous coal to bone coal, to cannel coal, or to carbonaceous shale. . . . Where the limestone is absent and the horizon marked by Lower Mercer ore, several feet of shale may separate the ore and coal. The member is of interest chiefly for its stratigraphic features."[2]

The horizon of the Middle Mercer coal and underlying clay occurs above drainage in parts of every township in Coshocton County. The coal horizon is generally represented by carbonaceous shale, shaly coal, or coal and shale interstratified, but at a few localities all traces of such carbonaceous deposits are wanting and the Lower Mercer limestone rests on the Middle Mercer clay. Where present the coal ranges in thickness from a fraction of an inch to 2 feet 4 inches with an average for this county of 1 foot 4 inches. It is usually separated from the overlying limestone by soft dark shale, 1 to 9 inches in thickness. At no place in this county has the Middle Mercer coal sufficient thickness or quality to be of economic value.

The Middle Mercer clay, which is generally more persistent than the overlying coal, has been observed to vary in thickness on the outcrop from 1 to 13 feet. The usual measurements,

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[1]Stout, Wilber, Geology of Muskingum County, Geol. Survey Ohio, Bull. 21, p. 81, 1918.

[2]Stout, Wilber, Geology of Vinton County, Geol. Survey Ohio, Bull. 31, p. 119, 1927.

however, are 4 to 5 feet. The clay is of the gray plastic variety, which is moderately to highly siliceous and micaceous in composition. Small nodules of iron carbonate are generally present but are not a conspicuous element in the clay. The stratigraphic relations of the Middle Mercer coal and clay to the Lower Mercer limestone are well shown in the following section secured along a western tributary of Bucklew Run one-half mile north of School No. 5, Bethlehem Township.

		Ft.	In.
Limestone, bluish gray, shaly. .	Lower Mercer	2	8
Limestone, flinty		-	4
Limestone, bluish gray.		1	3
Limestone, hard, black, flinty .		-	4
Limestone, bluish gray.		-	5
Shale, dark		-	4
Coal, shaly, Middle Mercer		-	6
Clay, gray, arenaceous, shaly		4	0
Shale, gray to dark.		3	0
Water level, altitude, 902 ft.			

Clay, probably Middle Mercer in age, was at one time dug just north of Newcastle, Newcastle Township, and used in the vicinity for pottery.[1] This use has been discontinued. Clays from the Middle Mercer horizon are not now being utilized for ceramic products in Coshocton County.

Lower Mercer Limestone

STRATIGRAPHY, EXTENT, AND VALUE

The Lower Mercer limestone, known in early reports of this State as the Zoar limestone for its occurrence near Zoar, Tuscarawas County,[2] is invariably thin but is remarkably persistent on the outcrop in southwestern Pennsylvania and eastern Ohio. It was first named the Mercer limestone by Rogers[3] in 1858 for occurrences near Mercer, Mercer County, Pennsylvania. Later it was called the Lower Mercer limestone by White[4] to distinguish it from a closely overlying limestone which he (White) designated the Upper Mercer. From Mercer County the line of outcrops enters Ohio in Mahoning County and extends to the west and south through Portage, Stark, Summit, Wayne, Tuscarawas, Holmes, Coshocton, Muskingum, Licking, Perry, Hocking, Vinton, Jackson, Scioto, and Lawrence counties. North of the central part of Jackson County this limestone is remarkably persistent and is an invaluable guide in the field in determining the detailed stratigraphic succession in the Pottsville series. From central Jackson County to the Ohio River the Lower Mercer is generally wanting but its horizon is closely marked by the Lower Mercer ore. The thickness of the Lower Mercer limestone where present varies from a very few inches to a maximum of about 10 feet. It is everywhere a dark bluish gray to grayish black stone containing a profusion of fossils. Its field of thickest development in Ohio includes western Muskingum County and Coshocton County.

In Coshocton County the horizon of the Lower Mercer limestone is present above drainage in parts of every township. The limestone is generally present where due although in a few areas its horizon is occupied by sandstone or arenaceous shale. Thick deposits of glacial outwash in the Tuscarawas Valley have so masked the rock outcrops along its lower slopes that the continuous presence of the Lower Mercer limestone is uncertain. The thickness of this member

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[1] Hodge, J. T., Geology of Coshocton County, Geol. Survey Ohio, Vol. III, p. 575, 1878.

[2] Newberry, J. S., Geology of Tuscarawas County, Geol. Survey Ohio, Vol. III, pp. 59-60, 1878.

[3] Rogers, H. D., Geology of Pennsylvania, Vol. II, Pt. 1, pp. 474-477, 1858.

[4] White, I. C., Geology of Lawrence County, Second Geol. Survey Pa., Rept. QQ, p. 57, 1879.

in Coshocton County varies from a few inches to 6 feet but the average of about 70 measurements is 2 feet 6 inches. The member consists for the most part of well defined beds or ledges varying in thickness from a few inches to as much as 3 feet separated by bedding planes or by a few inches of calcareous shale. Locally the compact limestone forming the base of the member is overlain by dark calcareous shale although this mode of occurrence is not as prevalent here as in western Muskingum County. The stone on fresh exposure has a black or grayish black color. The texture is dense or not visibly crystalline. On long exposure to weathering the stone becomes bluish gray or bluish black and gives rise to its common designation as the "blue" limestone. Fossils are generally abundant. They are conspicuous elements in the rock for they occur as white or gray masses embedded in a dense dark-colored matrix. The Lower Mercer limestone in Coshocton County is found on an average 27 feet 3 inches below the Upper Mercer limestone, 73 feet 7 inches below the Putnam Hill or "gray" limestone, and 151 feet 5 inches below the Middle Kittanning or No. 6 coal.

The total volume of Lower Mercer limestone in Coshocton County is quite large as the member occurs above drainage in every township. The thickness of the limestone, which has a maximum of about 6 feet and an average of $2\frac{1}{2}$ feet, excludes the possibility of sizable quarry operations except at such places where large areas can be stripped at low cost. The weather resistant character of the stone in contrast to the soft friable nature of the overlying and underlying beds causes the limestone to shelve out along the outcrop. Large rectangular blocks become detached and tend to strew the hillsides below the line of outcrop. In some localities where the member is well developed sizable quantities of limestone are thus prepared for quick utilization.

The better grades of Lower Mercer limestone occurring in Coshocton County are potential sources for stone for local use for rough construction work such as foundation stone, bridge abutments, etc., for crushed stone for road ballast, and for pulverized stone for agricultural lime. The importance of the Lower Mercer as a local source for agricultural lime is overshadowed in the western part of the county by the overlying Putnam Hill limestone which generally occurs there in thicker development and which yields a lighter-colored lime of equal or greater neutralizing value. Analyses of samples of Lower Mercer limestone are given in their appropriate place in the following pages dealing with the character and distribution of that member in the various townships.

Tiverton Township. - The distribution of the Lower Mercer limestone in this township is confined for the most part to the high ridge extending from sections 2, 3, and 4 on the north to sections 22 and 23 on the south. The altitude of the limestone varies from 1,135 feet in the southern part of Section 22, to 1,208 feet in the southern part of Section 3. The limestone is generally thin in the southern part, but just south of Tiverton Center where it is exposed at an altitude of 1,170 feet it becomes shaly in character and attains a thickness of about 5 feet. It has similar characteristics about seven-eighths of a mile southeast of Hunter School where it is exposed along the road in Section 7 at an altitude of 1,205 feet. East of Tiverton Center the Lower Mercer limestone is due to occur near the crests of the high ridges in sections 10, 11, and 20, but here its horizon is occupied by sandstones and sandy shales.

Newcastle Township. - The Lower Mercer limestone is generally present where due in Newcastle Township but it is quite variable in thickness. It measures only a few inches where exposed near the crests of the ridges to the west and east of Honey Run at altitudes ranging from 1,040 to 1,020. South of the Walhonding River the Lower Mercer underlies the ridges extending from Newcastle east toward Mohawk Village and from Newcastle south toward New Guilford. It is well exposed along the old abandoned road in the southeast quarter of Section 13, at an altitude of about 1,137 feet. Here it has a thickness of 4 feet and occurs 61 feet below the Putnam Hill limestone. It is likewise well exposed along the improved road near the head of Opossum Hollow in the southwestern part of Section 11 where the following measurements were secured.

		Ft.	In.
Flint, black, Upper Mercer		2	0
Shale and covered		29	0
Limestone, grayish black, shaly	Lower Mercer	1	6
Limestone, grayish black, hard	Lower Mercer	1	0
Limestone, grayish black, shaly	Lower Mercer	-	6
Limestone, grayish black, a 2-inch zone of flint occurs 6 inches from top of bed	Lower Mercer	3	4
Altitude, 1,120 ft.			

The Lower Mercer limestone is generally present in good development underlying the high spur ridges in sections 19, 20, and 21. It outcrops at an altitude of 1,060 feet along the old abandoned road in the southern part of Section 20 and at an altitude of 1,125 feet in the west central part of Section 19. The limestone occurs in good thickness for this county along a small tributary to the ravine in the northwest quarter of Section 22. Here it consists of three beds ranging in thickness from 4 inches to 2 feet 4 inches and having a total combined depth of 4 feet 4 inches. It outcrops at an altitude 1,076 feet and is found 32 feet 4 inches below a thick development of Upper Mercer flint.

Perry Township. - The total area of Perry Township underlain by Lower Mercer limestone is not large as outcrops of this member are confined to the high ridges in the northern half. The altitude of this horizon varies from 1,045 feet in the northern part of Section 1, and 1,000 feet in the eastern part of Section 20, to about 1,150 feet in the southeastern part of Section 5. The limestone is generally present on the outcrop where it is typical in character in that it is a hard dark bluish gray to gray black fossiliferous rock, but its thickness is generally below average for this county. The thickest development of the member observed in Perry Township is found in the northeast quarter of Section 3, where 2 feet 2 inches of this limestone outcrops at an altitude of 1,083 feet or 22 feet 4 inches below the Upper Mercer black flint.

Pike Township. - The Lower Mercer limestone is generally present where due along Ashcraft Ridge and the spur ridges leading from it southwest of West Carlisle, but it is rather poorly developed in this area. One foot of limestone representing this member caps the ridge at Ashcraft School in the northeastern corner of Section 16 where it has an altitude of 1,083 feet. It has also been recognized near the crest of the ridge at the west central edge of Section 18 at an altitude of 1,042 feet, in the northeast quarter of Section 14 at an altitude of 1,057 feet, and in the west central part of Section 7 at an altitude of 1,100 feet. Lower Mercer limestone, 2 feet in thickness, is exposed along the road at the south edge of West Carlisle at an altitude of 1,030 feet.

In the eastern part of Pike Township the Lower Mercer limestone is generally present in good development along the western flank of Graham Ridge. The altitude here ranges from 955 feet in the southeast quarter of Section 20 to 1,000 feet in the southwest quarter of Section 1. This limestone has a thickness of about 3 feet where it outcrops in the northwest corner of Section 9 at an altitude of 990 feet and a thickness of 4 feet 3 inches where exposed in the southeast quarter of Section 20 at an altitude of 955 feet. An unusual development of the Lower Mercer limestone is exposed along a small ravine at the southern edge of the southeast quarter of Section 10 where the following measurements were secured.

	Ft.	In.
Covered	-	-
Limestone, gray black, heavy-bedded, somewhat shattered by weathering, Lower Mercer	6	0
Shale, dark, carbonaceous	-	6

		Ft.	In.
Coal, bright, blocky	Middle Mercer	-	6
Shale, dark, soft.	Middle Mercer	-	5
Shale, carbonaceous, and shaly coal	Middle Mercer	-	6
Clay, dark, plastic		1	0

Altitude, 967 ft.

Washington Township. - The Lower Mercer limestone is quite persistent in Washington Township where it is found underlying the uplands at altitudes ranging from 940 feet along the western margin to approximately 850 feet at the eastern edge. In this area the member generally consists of two or more beds or layers of limestone which are separated by bedding planes only, and which generally have a total thickness greater than the average for the county. Along Opossum Run one mile southeast of Graham Corners the Lower Mercer limestone, consisting of three beds having a total thickness of 4 feet 4 inches, outcrops at an elevation of 920 feet, and lies about 95 feet below the Putnam Hill limestone. This limestone has similar character and thickness in the southwest quarter of Section 15 where it is exposed at an altitude of 934 feet. It is generally thin in the southeastern part of the township but attains good thickness and quality for this member in sections 1, 2, 8, and 9 in the northeast quarter. The following is a description of exposures along the road and roadside ravine one-half of a mile north of Wakatomika in the southeast quarter of Section 8.

		Ft.	In.
Clay, gray, plastic, Lower Kittanning		1	0
Shale and covered		40	0
Limestone, gray, weathered, Putnam Hill		1	0
Shale and covered		70	8
Limestone, bluish gray, one layer	Lower Mercer	-	10
Limestone, bluish gray, one layer	Lower Mercer	2	0
Limestone, one layer, somewhat shattered	Lower Mercer	1	2
Limestone, bluish gray, one layer	Lower Mercer	1	6
Shale, soft, dark		-	2
Coal, shaly, Middle Mercer		-	2
Clay, soft, gray, plastic		2	0

Altitude, 902 ft.

Lower Mercer limestone, 3 feet in thickness, outcrops at an altitude of 900 feet along a small ravine in the northwest quarter of Section 1.

Bedford Township. - In Bedford Township the Lower Mercer limestone horizon is above drainage along the Mohawk Valley and its eastern tributaries as far as sections 7, 8, 14, 16; along the valleys tributary to Simmons Run as far as sections 3, 8, 11, and 12; and along the valley of Little Wakatomika Creek and its tributaries to sections 16, 25, 17, 14, 12, 18, 19, and 21. The best exposures of the Lower Mercer limestone which have been noted in this area are found in sections 8, 12, 16, 21, and 25. Here the member is a gray black dense fossiliferous limestone ranging in thickness from 1 foot 7 inches to 4 feet 7 inches. As exposed at the old railroad tunnel in Section 12, the outcrops have a thickness of 4 feet and an altitude of 941 feet. The limestone is overlain by arenaceous shale and underlain by 6 inches of Middle Mercer coal. In exposures along the road in the east central part of Section 8, the limestone has a thickness of 1 foot 7 inches at an altitude of 963 feet. The interval to the Upper Mercer limestone at this locality is 25 feet. Lower Mercer limestone in good development has been observed on the outcrop at a number of localities in the vicinity of West Bedford. As exposed along the road just west of the village its characteristics are typical for this member and its thickness is about 4 feet. It occurs in less thickness in outcrops along the diagonal road in the south central part of

Section 25 where the following section showing its relation to overlying and underlying members was secured by T. R. Meyers.

	Ft.	In.
Shale and covered	29	0
Flint, broken, and some gray siliceous limestone, Upper Mercer	2	0
Coal blossom, Bedford.	2	0
Covered interval	12	6
Limestone, bluish gray, dense, fossiliferous, Lower Mercer.	1	6
Covered interval	6	5
Shale	3	0
Coal, bright, Flint Ridge.	-	1½
Clay shale, light.	1	0
Shale, sandy	10	0

No exposures of the Lower Mercer limestone have been observed in the immediate vicinity of Tunnel Hill where its horizon is due at an altitude of a little more than 1,000 feet. The limestone is present in good development, however, in the southeast corner of the township, in the central part of Section 21, where it has a thickness of 3 feet 6 inches and occurs at an altitude of about 900 feet.

Jefferson Township. - The Lower Mercer limestone is generally present where due in Jefferson Township but as indicated by scattered exposures, its thickness is generally below average for the county. North of the Walhonding River the horizon of this limestone occurs 100 feet or less below the summits of the high divides. Where exposed at an altitude of 1,174 feet in the south central part of Section 5 the limestone is typical in general character and has a thickness of 1 foot. It is a bluish gray dense fossiliferous limestone 2 feet 6 inches in thickness at exposures along the road in the east central part of Section 3. Still farther east in Section 1 the Lower Mercer limestone is replaced by sandstone and sandy shale.

In Jefferson Township south of the Walhonding River, the horizon of the Lower Mercer limestone ranges in altitude from about 1,080 feet in the hills above Nellie to about 940 feet in the southeast corner. As exposed along the road one mile northwest of Mohawk Village this member is a dense gray fossiliferous limestone 1 foot 5 inches in thickness occurring 29 feet below the Upper Mercer limestone and 71 feet below the Putnam Hill limestone. The thickest known development of the Lower Mercer limestone in this township is found along Flint Run. At exposures near the diagonal road which crosses this stream two miles southwest of Mohawk Village, the stone is of good quality with a thickness of 3 feet 4 inches. Its character and stratigraphic relations are shown in the following section secured at the locality by T. R. Meyers.

			Ft.	In.
Shale, siliceous			17	6
Clay shale, ferruginous			5	9
Limestone, gray, thin-bedded.	Putnam Hill		-	10
Limestone and covered.	Putnam Hill		3	4
Coal, weathered	Brookville or No. 4		-	6
Clay shale, dark.	Brookville or No. 4		-	2
Coal, weathered.	Brookville or No. 4		-	11
Clay, light gray, sandy.			2	6
Covered			9	6
Flint, bluish black, weathering to chocolate brown	Upper Mercer		3	9
Limestone, dark blue, siliceous, fossiliferous, weathers to a chocolate brown residue.	Upper Mercer		9	3

	Ft.	In.
Flint, black, hard, fossiliferous, Upper Mercer	1	11
Coal, Bedford	2	6
Covered interval	11	7
Limestone, bluish to gray black, dense, hard, fossiliferous, Lower Mercer	3	4
Covered interval	4	6
Clay shale with ore nodules	-	6
Clay shale, bluish gray	1	2

Altitude, 972 feet.

The Lower Mercer limestone is above drainage along Simmons Run in Jefferson Township but no outcrops have been noted in this area. In exposures along the east-west road one-fourth of a mile southeast of Warsaw Junction, the Lower Mercer horizon is occupied by sandy shale and micaceous sandstone.

Monroe Township. - The Lower Mercer limestone is generally present where due in Monroe Township as indicated by scattered exposures but the member is invariably thin, rarely exceeding 2 feet in thickness. Outcrops occur along the upper slopes of the high ridges which extend to the northwest and north, south, southeast, and northeast from Spring Mountain. Observed outcrops of the limestone range in altitude from 1,150 feet in the extreme northwest corner of the township to about 1,000 feet in the southern part of Section 21. The Lower Mercer limestone consists of a single layer 1 foot in thickness where it outcrops at an altitude of 1,086 feet along the road five-eighths of a mile west of south of Spring Mountain. It is likewise well exposed with a thickness of 1 foot at the south central edge of Section 23 at an altitude of 1,045 feet. The limestone is wanting where the series is exposed in the northern part of Section 8, but it is well developed at the west central edge of Section 3 where outcrops occur at an altitude of 1,088 feet. The thickest development of limestone on the Lower Mercer horizon observed in Monroe Township is found on the N. J. Markley property in the southwest quarter of Section 19. Here the member has a thickness of about 4 feet. The succession of strata is described in the following section.

		Ft.	In.
Limestone, black, flinty, Upper Mercer		1	0
Coal, shaly, and carbonaceous shale	Bedford	-	4
Coal, bony	Bedford	1	0
Clay, gray, arenaceous		1	8
Sandstone, shaly		2	0
Shale, dark, argillaceous		-	6
Shale, bony, Upper Mercer coal horizon		-	1
Clay, gray		2	0
Shale and covered		2	9
Covered interval		10	0
Limestone, dark grayish black, heavy-bedded, fossiliferous, Lower Mercer		4	0

Altitude, 1,027 feet.

The Lower Mercer limestone has not been utilized for economic purposes in Monroe Township.

Virginia Township. - Outcrops of Lower Mercer limestone horizon in Virginia Township are confined chiefly to the Tuscarawas Valley and valleys of its small tributaries in sections 18, 23, and 24 in the southern part and to the valley of Mill Fork and its chief tributary, Moscow Brook, in the western part. The altitude of this horizon ranges from about 865 feet in

the western part of Section 15 to about 750 feet along the Muskingum Valley in the southeast corner near Conesville. Owing to the presence of glacial outwash along the valley of the Muskingum River, good exposures are rare in the southern part of Virginia Township. Along Mill Fork the Lower Mercer limestone horizon is above drainage as far northeast as the central part of Section 8 and along Moscow Fork nearly to the northern boundary of the township. In places in these valleys the horizon is apparently occupied by sandstone and sandy shale. Lower Mercer limestone in typical development, 2 feet 10 inches in thickness, is well exposed near the road forks one-half mile south of New Moscow. Here it has an altitude of about 834 feet and lies about 26 feet below the Upper Mercer black flint. It is likewise well exposed near the road forks in the west central part of Section 25, where its altitude is 844 feet. An unusual development of Lower Mercer limestone outcrops along a small ravine on the Ralph Foster property in the west central part of Section 15. Here the following measurements were secured.

		Ft.	In.
Covered		-	-
Limestone, light bluish gray, dense, tough, fossiliferous, one bed	Lower Mercer	1	3
Limestone, dark bluish gray, one bed; appears shaly on weathering	Lower Mercer	1	0
Limestone, bluish gray, dense, fossiliferous, slightly shaly, one bed	Lower Mercer	1	4
Shale, bluish gray		3	0

Altitude, 850 feet

The 3 feet 7 inches of Lower Mercer limestone exposed at this locality was sampled by R. E. Lamborn on July 28, 1943, for chemical analysis. The sample was analyzed by E. Chadbourn at the Rock Analysis Laboratory, University of Minnesota, with results as follows:

	Per cent
Silica, SiO_2	3.28
Alumina, Al_2O_3	1.09
Ferric oxide, Fe_2O_3	0.21
Ferrous oxide, FeO	0.85
Pyrite, FeS_2	0.32
Magnesium oxide, MgO	0.85
Calcium oxide, CaO	50.95
Sodium oxide, Na_2O	0.08
Potassium oxide, K_2O	0.22
Water, hydroscopic, H_2O-	0.13
Water, combined, H_2O+	0.57
Carbon dioxide, CO_2	40.80
Titanium dioxide, TiO_2	0.05
Phosphorus pentoxide, P_2O_5	0.19
Sulphur trioxide, SO_3	0.12
Manganous oxide, MnO	0.12
Total	99.83

The percent of each of the mineral components in the sample, determined by calculation (Lamborn) from the chemical analysis, is essentially as follows:

Silica and hydrated aluminum silicates of sodium (Na) and potassium (K)	5.20
Hydrated ferric oxide, $2Fe_2O_3 \cdot 3H_2O$	0.25
Ferrous carbonate, $FeO \cdot CO_2$	1.37

Iron disulphide, FeS_2	0.32
Titanium dioxide, TiO_2	0.05
Calcium phosphate, $3CaO \cdot P_2O_5$	0.41
Calcium sulphate, $CaO \cdot SO_3$	0.20
Calcium carbonate, $CaO \cdot CO_2$	90.39
Magnesium carbonate, $MgO \cdot CO_2$	1.78
Manganese carbonate, $MnO \cdot CO_2$	0.19
Water, hydroscopic, H_2O-	0.13
Unbalanced components (excess CO_2)	-0.46
Total	99.83

Jackson Township. - In Jackson Township the Lower Mercer limestone horizon is above drainage along Simmons Run and its tributaries in sections 5, 6, and 15; along the valley of Crooked Run and its tributaries from sections 7, 13, and 12 to its mouth; and along the Walhonding-Muskingum Valley to the southeast corner of the township. The altitude of the horizon ranges from 900 feet in Section 15 to about 780 feet along the Muskingum River. The limestone is not a conspicuous element in the rock succession in this township. Exposures are meager along the valley south of Roscoe where the horizon occurs near the base of the hills. The limestone is generally present in good development along the Walhonding Valley northwest of Roscoe but it tends to be thin in the valley of Crooked Creek. Locally in Section 8 it is replaced by sandstone and sandy shales. The following section is a record of exposures along a small ravine opposite the power plant one-fourth mile northwest of Roscoe.

	Ft.	In.
Sandstone, yellow, thick-bedded	10	0
Shale and covered	23	10
Clay, gray, plastic, arenaceous	1	6
Covered interval	1	1
Shale, with short covered intervals	8	2
Limestone, black, dense, irregular, with zone of nodular flint near middle, Upper Mercer	2	5
Covered interval	9	11
Shale, bluish gray	5	0
Flint, nodular and irregular	-	2
Limestone, gray black, dense, fossiliferous } Lower Mercer	2	1
Limestone, gray black, dense, fossiliferous } Lower Mercer	-	9
Shale, gray to bluish gray	7	11
Coal, rather bony, Flint Ridge	-	3
Clay, dark, a little shaly	1	3
Clay, gray, plastic	1	10

Altitude, 834 feet.

The Lower Mercer limestone is well developed along Simmons Run in sections 15 and 6 where its altitude ranges from 885 to 905 feet and where the observed thickness varies from 2 feet to 3 feet 9 inches. The following is a description of exposures along the east-west road in the northeast quarter of Section 15.

Limestone and flint, black, Upper Mercer	2	2
Coal, shaly, and carbonaceous shale, Bedford	1	3
Clay and covered	4	4
Shale, gray, sandy	13	6
Iron carbonate ore, Lower Mercer	-	3

		Ft.	In.
Limestone, dark bluish black, hard, compact, one bed. . . .	Lower Mercer . . .	-	3
Limestone, dark bluish gray, hard, compact, one bed. . . .		3	0
Limestone, dark bluish gray, fossiliferous, one bed		-	6
Shale, carbonaceous, Middle Mercer coal horizon		-	6
Clay, bluish gray, arenaceous		9	2

Altitude, 893 ft.

The Lower Mercer limestone at this exposure, having a total thickness of 3 feet 9 inches, was sampled on June 10, 1941, by R. E. Lamborn for chemical analysis. The analytical work was performed by Downs Schaaf with the following results.

	Per cent
Silica, SiO_2	2.68
Alumina, Al_2O_3	1.01
Ferric oxide, Fe_2O_3	0.03
Ferrous oxide, FeO	1.05
Iron disulphide, FeS_2.	0.19
Magnesium oxide, MgO.	0.92
Calcium oxide, CaO	51.31
Strontium oxide, SrO.	<0.01
Barium oxide, BaO.	<0.01
Sodium oxide, Na_2O	<0.01
Potassium oxide, K_2O	0.01
Water, hydroscopic, H_2O-	0.18
Water, combined, H_2O+	0.29
Carbon dioxide, CO_2	41.80
Titanium dioxide, TiO_2	0.05
Phosphorus pentoxide, P_2O_5	0.15
Sulphur trioxide, SO_3	0.06
Manganous oxide, MnO	0.16
Carbon, organic, C	0.12
Hydrogen, organic, H	0.01
Total	100.02

The per cent of each of the various compounds probably present in the sample as calculated by R. E. Lamborn is as follows:

Hydrated silicates	$(Na, K)_2O \cdot 3Al_2O_3 \cdot 6SiO_2 \cdot 2H_2O$	0.08
	$Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$	2.47
Silica, SiO_2		1.49
Hydrated ferric oxide, $2Fe_2O_3 \cdot 3H_2O$		0.04
Ferrous carbonate, $FeO \cdot CO_2$		1.69
Iron disulphide, FeS_2		0.19
Titanium dioxide, TiO_2		0.05
Calcium phosphate, $3CaO \cdot P_2O_5$		0.33
Calcium sulphate, $CaO \cdot SO_3$		0.10
Calcium carbonate, $CaO \cdot CO_2$		91.19
Magnesium carbonate, $MgO \cdot CO_2$		1.92
Manganese carbonate, $MnO \cdot CO_2$		0.26
Water, hydroscopic, H_2O-		0.18
Organic matter		0.13
Unbalanced components (excess CO_2, H_2O)		-0.10
Total		100.02

Bethlehem Township. - The horizon of the Lower Mercer limestone crops out along the Walhonding and Killbuck valleys and their major tributaries about midway on the slopes between stream level and the hilltops. The altitude of this horizon varies along the western edge of the township from about 915 feet in the southwest corner to about 960 feet in the northwest corner. As the regional dip is to the east the horizon descends in that direction to altitudes of about 890 feet in the heads of the small ravines near the eastern border. The limestone is generally present where due and possesses lithologic characteristics typical for this member. The thickness observed on the outcrop ranges from 1 foot 11 inches to 5 feet but averages about 3 feet 6 inches or about 1 foot greater than the average for the county. Along the north-south road in the extreme southwest corner of the township, the Lower Mercer consists of four strata ranging from 4 to 11 inches in thickness outcropping at an altitude of 916 feet. A greater-than-average thickness is generally found on outcrops along the valley of Bucklew Run and its tributaries in the northeast quarter of the township. At the forks of the ravine one mile north of School No. 5, this member is in part flinty in character and has a total thickness of about 5 feet. In exposures along the prominent ravine tributary to Bucklew Run in the northeast section of the township the limestone is typical in character with a thickness of about 4 feet. The altitude here is 893 feet, and the interval to the Upper Mercer limestone, about 25 feet. About one mile north of School No. 7 the Lower Mercer limestone crops out at an altitude of 898 feet along a small ravine that opens out to the southwest. The succession shown here is as follows:

		Ft.	In.
Limestone, flinty, calcareous, hard	Upper Mercer	-	7
Shale, black, calcareous, fossiliferous	Upper Mercer	1	8
Covered interval	Upper Mercer	2	3
Limestone, black, hard, tough	Upper Mercer	1	4
Coal, shaly, and carbonaceous shale, Bedford		-	6
Clay, dark, arenaceous		4	0
Shale, carbonaceous		-	1
Coal, blocky, Upper Mercer or No. 3a		-	5
Clay, gray, sandy, micaceous		2	0
Covered interval		12	1
Limestone, gray black, one bed	Lower Mercer	3	5
Limestone, gray black, one bed	Lower Mercer	-	9
Shale, bony, Middle Mercer coal horizon		-	2
Clay, dark, shaly		-	11
Clay, gray		1	0
Shale, gray, sandy		3	0

Altitude, 893 ft.

The Lower Mercer in Bethlehem Township is not known to have been worked to any extent for economic use.

Clark Township. - The horizon of the Lower Mercer limestone is above drainage along all the larger valleys in Clark Township. The outcrops of this limestone range in altitude from about 1,020 feet in the northwest corner to about 900 feet in Section 21 in the southeast corner. West of Killbuck Creek and northwest of its chief eastern tributary, Doughty Creek, the Lower Mercer limestone horizon is generally occupied by sandstone and sandy shale but in the southeastern corner of the township the limestone is present in good development. The most westward exposure observed occurs near the top of the ridge about 1 mile west of south of Layland where thin shattered Lower Mercer limestone crops out at an altitude of 990 feet. Along ravines south and east of Helmick the member is generally present in good development and purity. The following section describes the exposures along the ravine and road in the north central part of Section 22.

	Ft.	In.
Limestone, bluish gray, Putnam Hill	-	6
Clay and covered	5	0
Shale and covered	38	6
Limestone and black flint, Upper Mercer	2	6
Covered interval	23	2
Limestone bluish gray, hard, fossiliferous (Lower Mercer)	-	7
Limestone, bluish gray, fossiliferous, shaly where weathered (Lower Mercer)	2	6
Limestone, bluish gray, hard, fossiliferous (Lower Mercer)	1	2
Clay, shale, dark bluish gray	-	8

Altitude, 940 ft.

A sample of the 4 feet 3 inches of limestone exposed at this locality was collected by R. E. Lamborn on September 8, 1944, for chemical analysis. The sample was analyzed by E. Chadbourn of the Rock Analysis Laboratory of the University of Minnesota.

	Per cent
Silica, SiO_2	2.38
Alumina, Al_2O_3	0.54
Ferric oxide, Fe_2O_3	0.38
Ferrous oxide, FeO	0.94
Iron disulphide, FeS_2	0.24
Magnesium oxide, MgO	0.87
Calcium oxide, CaO	51.44
Sodium oxide, Na_2O	0.07
Potassium oxide K_2O	0.12
Water, hydroscopic, H_2O-	0.08
Water, combined, H_2O+	0.76
Carbon dioxide, CO_2	41.28
Titanium dioxide, TiO_2	0.02
Phosphorus pentoxide, P_2O_5	0.20
Sulphur trioxide, SO_3	0.12
Manganous oxide, MnO	0.12
Total	99.56

The probable mineral composition of the sample as determined by calculation (Lamborn) from the chemical analysis is as follows:

	Per cent
Silica and hydrated aluminum silicates of sodium (Na) and potassium (K)	3.81
Hydrated ferric oxide, $2Fe_2O_3 \cdot 3H_2O$	0.44
Ferrous carbonate, $FeO \cdot CO_2$	1.52
Iron disulphide, FeS_2	0.24
Titanium dioxide, TiO_2	0.02
Calcium phosphate, $3CaO \cdot P_2O_5$	0.44
Calcium sulphate, $CaO \cdot SO_3$	0.20
Calcium carbonate, $CaO \cdot CO_2$	91.24
Magnesium carbonate, $MgO \cdot CO_2$	1.82
Manganese carbonate, $MnO \cdot CO_2$	0.19
Water, hydroscopic, H_2O-	0.08
Unbalanced components (excess CO_2)	-0.44
Total	99.56

As exposed along the road in the southwest quarter of Section 21 the Lower Mercer member is represented by 3 feet 6 inches of limestone at an altitude of 914 feet. Along Bucklew Run in the central part of Section 21 the thickness is 2 feet 6 inches and the interval to the Upper Mercer limestone is about 23 feet. The Lower Mercer limestone is rarely seen in outcrops in the northeast quarter of Clark Township where sandstone and shale seem to prevail on its horizon.

Mill Creek Township. - The Lower Mercer limestone is generally present where due on the outcrop in Mill Creek Township, but in most places it is below average in development as its thickness ranges from 1 to 3 feet with an average of little more than 1 foot. Its chief value in this area is as a key bed in determining the stratigraphic succession. In the southern part of Section 23, the Lower Mercer limestone, 1 foot in thickness, outcrops near the forks of the road at an elevation of 882 feet and lies 17 feet 6 inches below the Upper Mercer flinty limestone. From this point the limestone rises gently to the west, northwest, and north, reaching an altitude of 910 feet in the southwestern corner of the township, and an altitude of about 895 feet in the southeast part of Section 4 and 930 feet in the west part of Section 6 in the northwest part of the township. The structural rise to the northeast and east to the crest of the Cambridge Arch is more abrupt for outcrops of this member have an altitude of 1,030 feet in the west central part of Section 1, and 985 feet in the east central part of Section 20. A good development of the Lower Mercer limestone and the stratigraphic relations of its outcrops to overlying beds is well shown in the following account of exposures along the road west of Mound in the southeast quarter of Section 18.

	Ft.	In.
Limestone, dark gray, Putnam Hill	1	0
Shale, dark, soft.	-	2
Coal blossom, Brookville or No. 4	1	0
Clay, gray, plastic, and covered	4	0
Shale and covered	42	6
Limestone, black, nodular, flinty, Upper Mercer	-	3
Coal blossom, Bedford	-	3
Clay, gray, plastic.	13	10
Shale, gray, arenaceous	6	2
Coal, and black shale, Upper Mercer	1	0
Clay, gray, plastic	3	2
Shale, gray, arenaceous	13	10
Limestone, bluish gray to gray black, fossiliferous, Lower Mercer	3	0
Coal blossom, Middle Mercer	1	0
Altitude, 884 ft.		

Keene Township. - The Lower Mercer limestone is generally present where due along the valley of Mill Creek and its larger tributaries in Keene Township. The limestone which is typical in characteristics ranges in thickness from 1 foot to 3 feet 6 inches with an average of about 2 feet 6 inches. The altitude of the limestone ranges from 810 feet near School No. 2 to 875 feet near School No. 4, to 900 feet in the ravine five-eighths of a mile east of School No. 1. The Lower Mercer limestone, 2 feet in thickness, is well exposed at an elevation of 817 feet along a small ravine on the east bank of Mill Creek at the southern edge of the township. Here it lies about 26 feet above the Lower Mercer coal. It outcrops at an altitude of 879 along the road one-half mile northwest of Keene where it has a thickness of 2 feet and lies 30 feet below the Upper Mercer flinty limestone and 82 feet below the Putnam Hill limestone. Near School No. 4 and near the junction of Turkey Run and Mill Run the thickness of the Lower Mercer limestone is 3 feet and its altitude 875 feet. The thickest exposures of Lower Mercer limestone observed in Keene Township occur along the road just east of School No. 2 and about 2 miles northeast of Canal Lewisville. Here it is a dark bluish gray to grayish black, tough, heavy-bedded limestone having a thickness of about 3 feet 6 inches. The Lower Mercer limestone has not been utilized to any great extent in Keene Township.

Tuscarawas Township. - Little can be said about the Lower Mercer limestone in Tuscarawas Township as the horizon lies close to the level of the flood plain of the Tuscarawas-Muskingum River and is therefore generally covered with alluvial deposits. The only outcrop observed in this township is found at railroad track level northeast of Coshocton and about 1 mile west of the township line. Here a few inches of limestone representing the Lower Mercer is exposed at an elevation of 775 feet.

Lafayette Township. - The outcrop line of the Lower Mercer limestone extends east from Tuscarawas Township along the Tuscarawas Valley across Lafayette Township and south from West Lafayette close above the old abandoned valley flats now crossed by Bone Run. Owing to the presence of alluvial deposits along the Tuscarawas Valley, outcrops are confined chiefly to the hilly section of the township lying to the southwest of West Lafayette. Near the mouth of Morgan Run the Lower Mercer limestone is well exposed at an altitude of 800 feet. Here it lies about 25 feet below the Bedford coal. About 1 mile north of Burt School the limestone outcrops near the base of the hills at altitudes ranging from 840 to 860 feet. It is generally a single bed of limestone, a foot or so in thickness. The Lower Mercer limestone and overlying strata are well exposed along the road leading up the hill to the southeast of Burt School where the following measurements were secured.

	Ft.	In.
Coal blossom, Middle Kittanning or No. 6	1	6
Clay, bluish, gray, siliceous	6	6
Shale, arenaceous, and covered	31	6
Coal blossom, Lower Kittanning or No. 5	-	8
Clay, shale, and covered	36	8
Limestone, dark gray, Putnam Hill	-	5
Clay and covered	4	10
Shale and covered	32	11
Limestone, dark, blocky, Upper Mercer	-	8
Clay, dark bluish gray	3	6
Shale, yellowish gray, arenaceous	22	8
Limestone, grayish black, one layer, Lower Mercer	2	4
Coal, shaly, and carbonaceous shale, Middle Mercer	1	0

Altitude, 876 ft.

Oxford Township. - Little can be seen of the Lower Mercer limestone in Oxford Township as its horizon lies close to flood plain level of the Tuscarawas Valley in the north central part and near valley bottom along Wills Creek in the southwest part. This limestone consists of a single layer about 1 foot in thickness where exposed close to water level at an altitude of 790 feet about 1 mile west of Newcomerstown. It is poorly exposed near the mouth of Blue Ridge Run at an altitude of 796 feet. In the southwest part of the township Lower Mercer limestone, 1 foot in thickness, occurs at road level along Wills Creek $1\frac{1}{4}$ miles southwest of McCune School. Here the interval is 35 feet to the Upper Mercer limestone and about 90 feet to the Putnam Hill limestone.

Linton Township. - The Lower Mercer limestone horizon is due to outcrop close to the level of the flood plain along Wills Creek from the southern part of Section 7 east to the eastern part of Section 18 but few outcrops of the limestone have been noted in this valley. Where exposed along the east bank of Wills Creek at Plainfield the limestone is typical in character with a thickness of 2 feet 8 inches. One and one-fourth miles south of Plainfield where outcrops of this member occur near the highway bridge at an altitude of 763, the stone has a thickness of 3 feet 6 inches. The member also shows good development along Bacon Run in the central part of Section 2. The exposures at this locality are described as follows:

	Ft.	In.
Shale, gray, argillaceous	4	0
Limestone, gray black, shaly } Lower Mercer	-	6
Limestone, gray black, dense, fossiliferous } Lower Mercer	4	0
Clay, gray, plastic, Middle Mercer	1	4
Shale, gray, sandy	3	6
Clay, dark, plastic, Flint Ridge	1	0
Covered interval	6	4
Clay, dark, sandy	1	4
Shale, carbonaceous	-	6
Flint, black, ferruginous, discontinuous, Boggs	-	6
Clay, dark, plastic	1	0

Altitude, 772 ft.

The Lower Mercer limestone has been quarried along Bacon Run in the east central part of Section 2 for local uses, but the operations have been discontinued.

Franklin Township. - The horizon of the Lower Mercer limestone is below drainage in Franklin Township except along the Muskingum Valley in the southwestern corner. Near the southern end of the spur of highlands which extends to the southwest from Wills Creek, Lower Mercer limestone, 3 feet in thickness, outcrops along the road near flood plain level at an altitude of 765 feet. When projected up stream in accordance with local structure this limestone horizon passes below flood plain level in the vicinity of Conesville.

Adams Township. - The distribution of the outcrops of the Lower Mercer limestone horizon in Adams Township are confined to the valleys of Evans Creek and its tributaries from Section 23 to sections 1 and 2, and to the valley of East Fork from Powell and vicinity to the southern edge of Bucks Township, Tuscarawas County, in Section 24. The altitude of exposures range from about 850 feet one mile southeast of Powell to approximately 920 feet in the northeast corner of the township. The limestone is generally present where due along the valley of Evans Creek but sandstone and sandy shale have apparently replaced the limestone at many localities along East Fork. The limestone is typical in lithologic characteristics but has a thickness which varies from a few inches to 4 feet. The Lower Mercer limestone and overlying beds are well exposed along the diagonal road west of Davis Run and about three-fourths mile north of Orange where the following measurements were secured.

Coal blossom, Middle Kittanning or No. 6	2	0
Clay, bluish gray, siliceous	10	0
Shale and covered	28	6
Coal blossom, Lower Kittanning or No. 5	-	10
Clay, gray, plastic, and covered	4	4
Shale, arenaceous, and covered	33	0
Limestone, dark gray, Putnam Hill	-	10
Smut streak, Brookville or No. 4	-	4
Clay, gray, plastic	3	0
Shale, gray, arenaceous, and shaly sandstone	50	8
Limestone, black, somewhat shaly, Upper Mercer	1	1
Coal blossom, Bedford	-	5
Clay, gray, and covered	2	6
Shale, gray, arenaceous	15	0
Limestone, bluish gray, fossiliferous, Lower Mercer	1	0

	Ft.	In.
Clay and covered	13	10
Shale, bony, Flint Ridge coal horizon	1	0

Altitude, 843 feet.

The Upper Mercer coal, Tionesta coal, and Vanport limestone and flint, which appear elsewhere in this general region, are not present on the outcrops at this locality.

About one-fourth mile north of Powell, 4 feet of Lower Mercer limestone is exposed along the road at an elevation of 870 feet. The limestone is heavy bedded, has a grayish black color, and is fossiliferous. In the vicinity of Bakersville this limestone is generally present but is thin as attested by numerous outcrops. Just northwest of the village it has a thickness of 1 foot 4 inches where it is exposed along the roadside at an altitude of 914 feet. The thickest deposit of Lower Mercer limestone observed in Adams Township occurs at an altitude of 890 feet near the head of a small valley which is tributary to White Eyes Creek about two miles northeast of Fresno. The outcrop is located close to the border between Adams and White Eyes townships. A description of the limestone exposures together with the overlying beds is as follows:

		Ft.	In.
Shale, dark, bony, Bedford coal horizon		-	6
Clay, gray, siliceous		5	0
Shale, sandy, and covered		20	0
Limestone, dark bluish gray, dense, one bed	Lower Mercer	1	0
Limestone, dark bluish gray, dense, one bed		-	9
Limestone, dark bluish gray, dense, one bed		-	9
Limestone, dark bluish gray, dense, one bed		2	0
Limestone, dark bluish gray, dense, hard, one bed		1	0

Altitude, 890 feet.

A sample of the five layers of Lower Mercer limestone described above, having a total thickness of 6 feet 6 inches, was secured by R. E. Lamborn in April 30, 1941, for chemical analysis. The composition as stated below was determined by Mr. Downs Schaaf, chemist.

	Per cent
Silica, SiO_2	4.59
Alumina, Al_2O_3	1.25
Ferric oxide, Fe_2O_3	0.02
Ferrous oxide, FeO	0.86
Iron disulphide, FeS_2	0.16
Magnesium oxide, MgO	1.10
Calcium oxide, CaO	49.92
Strontium oxide, SrO	<0.01
Barium oxide, BaO	<0.01
Sodium oxide, Na_2O	0.02
Potassium oxide, K_2O	0.05
Water, hydroscopic, H_2O-	0.19
Water, combined, H_2O+	0.35
Carbon dioxide, CO_2	40.61
Titanium dioxide, TiO_2	0.05
Phosphorus pentoxide, P_2O_5	0.28
Sulphur trioxide, SO_3	0.18

	Percent
Manganous oxide, MnO	0.14
Carbon, organic, C	0.27
Hydrogen, organic, H	0.02
Total	100.06

The percent of each of mineral components probably present in the sample has been calculated (Lamborn) from the chemical analysis.

Silicates $(Na, K)_2O \cdot 3Al_2O_3 \cdot 6SiO_2 \cdot 2H_2O$	0.67
Silicates $Al_2O_3 \cdot 2SiO_2\ 2H_2O$	2.50
Silica, SiO_2	3.12
Hydrated ferric oxide, $2Fe_2O_3 \cdot 3H_2O$	0.02
Ferrous carbonate, $FeO \cdot CO_2$	1.39
Iron disulphide, FeS_2	0.16
Titanium dioxide, TiO_2	0.05
Calcium phosphate, $3CaO \cdot P_2O_5$	0.61
Calcium sulphate, $CaO \cdot SO_2$	0.30
Calcium carbonate, $CaO \cdot CO_2$	88.28
Magnesium carbonate, $MgO \cdot CO_2$	2.30
Manganese carbonate, $MnO \cdot CO_2$	0.23
Water, hydroscopic, H_2O-	0.19
Organic matter	0.29
Unbalanced components (excess H_2O, CO_2)	-0.05
Total	100.06

White Eyes Township. - The Lower Mercer limestone is generally present where due on the outcrop in White Eyes Township. Exposures of this member are widely distributed as the horizon reaches the surface in practically every square mile of the area with the exception of the northwest and southeast corners. The altitude of the outcrops varies from about 970 feet to about 850 feet, the greatest altitudes occurring along the axis of the Cambridge Arch which extends from sections 23 and 24 in a northerly direction to the northwest corner of the township. From the axis of this structure the strata dip irregularly to the west and to the east. The observed thickness of Lower Mercer limestone in White Eyes Township ranges from 1 foot to 3 feet 6 inches. The limestone is normal in characteristics in that it is a grayish black fossiliferous stone free from chert or flint. Along the east-west road near the mouth of White Eyes Creek Lower Mercer limestone, 10 inches in thickness, outcrops at an altitude of 850 feet. The member rises to the north along White Eyes Creek, reaching an altitude of 940 feet near Chili. Three-fourths of a mile south of Chili, 3 feet 6 inches of Lower Mercer limestone is exposed along the road at an altitude of 899 feet. It is rather shaly in structure at this locality where it occurs about 35 feet below the Upper Mercer flinty limestone. The general stratigraphy of the beds exposed in central White Eyes Township and their relation to the Lower Mercer limestone are shown in the following record secured along the road in the east central part of Section 7.

	Ft.	In.
Coal outcrop, Middle Kittanning or No. 6	1	0
Sandstone, shale, and covered	35	0
Clay, gray, siliceous, Lower Kittanning or No. 5	5	0
Shale, gray, and shaly sandstone	67	4
Coal blossom, Brookville or No. 4	1	3
Clay, gray, lower part siliceous	5	4
Shale and covered	31	0
Flint, black, Upper Mercer	1	0
Shale, arenaceous, and covered	37	6
Limestone, grayish black, Lower Mercer	2	6

Altitude, 918 feet.

The Putnam Hill limestone, which in normal succession lies close above the Brookville coal, is wanting at this locality as is also the Lower Kittanning coal.

The Lower Mercer limestone has been quarried in a small way on the Boyd property in the west central part of Section 6, White Eyes Township. The quarry is located in the bed of the creek just south of the east-west road. The stone was ground to the necessary fineness and was utilized in the carbonate form for agricultural purposes in the community. A description of the exposures at the quarry is given below:

	Ft.	In.
Shale, soft, carbonaceous.	2	6
Limestone, dark bluish gray, dense texture, fossiliferous, one bed, Lower Mercer	3	2
Coal, shaly, and black shale, Middle Mercer.	-	6
Clay, dark, plastic.	1	0

The 3 feet 2 inches of Lower Mercer limestone exposed in this quarry was sampled by R. E. Lamborn on May 23, 1941, for chemical analysis. The composition of the sample was determined by Downs Schaaf.

	Per cent
Silica, SiO_2	3.11
Alumina, Al_2O_3	1.40
Ferric oxide, Fe_2O_3.	0.02
Ferrous oxide, FeO	1.55
Iron disulphide, FeS_2	0.23
Magnesium oxide, MgO.	1.14
Calcium oxide, CaO	49.95
Strontium oxide, SrO.	<0.01
Barium oxide, BaO.	<0.01
Sodium oxide, Na_2O	0.02
Potassium oxide, K_2O	0.10
Water, hydroscopic, H_2O-	0.24
Water, combined, H_2O+.	0.40
Carbon dioxide, CO_2	41.36
Titanium dioxide, TiO_2	0.07
Phosphorus pentoxide, P_2O_5	0.07
Sulphur trioxide, SO_3	0.09
Manganous oxide, MnO	0.19
Carbon, organic, C	0.07
Hydrogen, organic, H	- -
Total	100.01

The per cent of each of the compounds in the sample has been calculated (Lamborn) from the chemical analysis.

Silicates	$(Na, K)_2O \cdot 3Al_2O_3 \cdot 6SiO_2 \cdot 2H_2O$	1.09
	$Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$.	2.47
Silica, SiO_2		1.46
Hydrated ferric oxide, $2Fe_2O_3 \cdot 3H_2O$		0.02
Ferrous carbonate, $FeO \cdot CO_2$		2.50
Iron disulphide, FeS_2.		0.23
Titanium dioxide, TiO_2		0.07
Calcium phosphate, $3CaO \cdot P_2O_5$		0.15

	Per cent
Calcium sulphate, $CaO \cdot SO_3$	0.16
Calcium carbonate, $CaO \cdot CO_2$	88.89
Magnesium carbonate, $MgO \cdot CO_2$	2.38
Manganese carbonate, $MnO \cdot CO_2$	0.31
Water, hydroscopic, H_2O-	0.24
Organic matter	0.07
Unbalanced components (excess CO_2, H_2O)	-0.03
Total	100.01

Crawford Township. - In Crawford Township the Lower Mercer limestone is quite persistent on the outcrop, but its thickness is generally below average for Coshocton County. Recorded measurements show a variation ranging from 10 inches to 2 feet 7 inches with an average of 1 foot 7 inches. Outcrops occur along the valley of White Eyes Creek and its tributaries as far north as Section 11; along the West Fork of White Eyes Creek and its chief tributaries as far as sections 4 and 8; at the head of Mill Creek and its tributaries in sections 5 and 6; and along the valley of Little Mill Creek in sections 15, 16, and 25. Lower Mercer limestone, 2 feet 7 inches in thickness, outcrops at an altitude of 924 feet along the road in the east central part of Section 22. Here it lies 24 feet below the Upper Mercer limestone and about 64 feet below the horizon of the Brookville coal. The following record is a measurement of outcrops along the road about one-half mile east of Halifax School. The section begins near the point where the Lower Mercer passes below drainage on White Eyes Creek in Section 11.

	Ft.	In.
Limestone, bluish gray, Putnam Hill	-	5
Shale	-	2
Coal, Brookville	-	9
Clay and covered	5	0
Shale and covered	42	9
Limestone, black, flinty } Upper Mercer {	1	6
Limestone, black, dense } Upper Mercer {	2	0
Clay and covered	5	0
Shale and covered	30	0
Limestone, gray black, fossiliferous, Lower Mercer	1	6
Coal, Middle Mercer	-	3
Creek level, altitude, 935 ft.		

The altitude of outcrops of the Lower Mercer limestone along the valley of the West Fork of White Eyes Creek and its tributaries ranges from about 915 feet near Chili in Section 23, to near1,000 feet in the northern tier of sections. Where this limestone crops out in the northeast quarter of Section 17 at an altitude of 933 feet it has a thickness of 1 foot 4 inches and occurs 32 feet below the Upper Mercer limestone. The Lower Mercer limestone is generally present in outcrops along tributaries to Mill Creek in Sections 16 and 25 where it attains a thickness of 2 feet or less.

The Lower Mercer limestone is, in general, too thin in Crawford Township to merit much consideration as a source of limestone for economic use.

Lower Mercer Ore

The Lower Mercer ore, known among early ore miners as the "little red block" ore and so designated in the early reports of the Geological Survey[1], has been found at widely scattered

[1] Andrews, E. B., Geol. Survey Ohio, Rept. Prog. 1870, Pt. II, p. 168, 1871; Stout, Wilber, Geology of Southern Ohio, Geol. Survey Ohio, Bull. 20, p. 570, 1916.

localities on the outcrop in Ohio from Scioto County to Mahoning County. It is not a continuous deposit. Where present, the member consists of a thin bed of ferrous carbonate which is generally oxidized and hydrated on the outcrop. The stratigraphic position of this ferruginous member is either directly above the Lower Mercer limestone or is separated from it by a few feet of intervening shale. The ore is quite constant in Scioto and Lawrence counties where it was formerly stripped along the outcrop and utilized in charcoal furnaces. It has been identified at only a few scattered localities in Muskingum County where it is only a few inches in thickness.

The Lower Mercer ore merits little consideration in a description of the stratigraphic succession in Coshocton County for it is generally wanting in outcrops. Only one occurrence was noted, namely along Simmons Run in the northeast quarter of Section 15, Jackson Township, where 3 inches of an impure ore, representing the Lower Mercer, is found lying directly on 3 feet 9 inches of Lower Mercer limestone.

Upper Mercer Coal and Clay

The interval between the Upper Mercer and Lower Mercer limestones in Ohio, measuring on an average about 32 feet on the outcrop, consists chiefly of dark shales with two well-defined coal and clay horizons. The upper coal lies close below the Upper Mercer limestone whereas the lower coal occurs about midway between the limestones where the interval is normal in thickness. According to recent usage in Ohio the lower coal is designated the Upper Mercer or No. 3a and the upper coal, the Bedford. This usage is at variance with the terminology applied in western Pennsylvania where immediately below the Upper Mercer limestone there is a persistent coal which White has named the Upper Mercer coal.[1] In Ohio the Upper Mercer coal and clay are widely distributed on the outcrop from Mahoning to Scioto counties. These beds lack prominence on the outcrop in the northeastern and east central parts of the State for they are discontinuous and the coal is invariably far too thin for mining. The chief field of economic importance in Upper Mercer coal extends from southern Jackson County to the Ohio River in Scioto County. Here the bed has been worked for many years and yields a limited supply of fuel of good quality. The underlying clay deposits are likewise best developed in southern Ohio where this material is of the gray, plastic, siliceous, micaceous type of slight potential economic importance.

In Coshocton County the Upper Mercer coal and clay are by no means constant and persistent elements in the rock succession. The horizon of these members outcrops in parts of every township but exposures of the coal and clay observed in the field are limited to small areas in Jefferson, Bethlehem, Mill Creek, and Crawford townships. In the absence of the Upper Mercer coal and clay, dark, sandy shales comprise much of the succession between the Lower Mercer limestone and the Bedford clay. Over poorly defined areas in Bedford, Jefferson, Clark, and Monroe townships sandstone is irregularly developed in this interval and in some localities has displaced the Lower Mercer limestone. Where present on the outcrop the Upper Mercer coal horizon is generally represented by thin, shaly coal interstratified in places with carbonaceous shale. The thickness ranges from a few inches to as much as 1 foot 3 inches. The underlying clay is of the gray to bluish gray arenaceous type varying in depth from 1 foot 6 inches to 6 feet but averaging about 2 feet 8 inches. The position of the coal is on an average about 18 feet above the base of the Lower Mercer limestone and about 9 feet below the base of the Upper Mercer limestone. The coal is too thin in this county for utilization and the clay is too siliceous and impure to rank well as a potential ceramic resource.

In Jefferson Township the horizon of the Upper Mercer coal and clay is generally occupied by sandy shale or sandstone. At one exposure along the road northwest of Mohawk Village this horizon is represented by a thin bed of impure clay some 6 feet above the Lower Mercer limestone and 23 feet below the Upper Mercer limestone. Similar conditions prevail in Bethlehem Township where this coal and clay are generally wanting except along a tributary to Bucklew Run in the east central part. Here 5 inches of Upper Mercer coal is found close below the Bedford clay.

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[1] White, I. C., Geology of Lawrence County, Second Geol. Survey Pa., Rept. QQ, p. 58, 1879.

The Upper Mercer coal and clay are generally present in outcrops along the valley of Mill Creek in the east half of Mill Creek Township and the southwest part of Crawford Township. Just west of Mound in the southwest quarter of Section 18, Mill Creek Township, the horizon is represented by 1 foot of coal and black shale, underlain by 3 feet 2 inches of gray plastic clay. Here the interval from the coal to the Lower Mercer limestone is 20 feet, and to the Upper Mercer limestone, 21 feet. The following section of outcrops showing these members was secured in the central part of Section 8, Bethlehem Township.

	Ft.	In.
Smut streak, Bedford coal horizon	-	3
Clay, gray, arenaceous	5	0
Shale, gray	21	0
Coal blossom, Upper Mercer	-	9
Clay, gray, arenaceous	1	6
Shale, gray, arenaceous	18	6
Limestone, bluish gray, Lower Mercer	1	8

Altitude, 925 ft.

In the central part of Section 25, Crawford Township, the Upper Mercer horizon is represented by 9 inches of shaly coal which outcrops at an elevation of 995 feet or about 16 feet above the Lower Mercer limestone and about 7 feet below the Upper Mercer limestone horizon. The following section was secured along the road in the central part of Section 16:

		Ft.	In.
Carbonate ore, Upper Mercer		-	3
Limestone and black flint	Upper Mercer	1	6
Limestone, black	Upper Mercer	-	9
Shale, dark		-	5
Coal, shaly, Bedford		-	4½
Clay, sandy		1	0
Sandstone		-	4
Clay shale, soft		3	6
Coal	Upper Mercer	1	0
Clay shale	Upper Mercer	-	2
Coal	Upper Mercer	-	1
Clay, blue gray, short		6	2
Shale, sandy, and covered		5	0
Limestone, Lower Mercer		1	4
Clay, gray, arenaceous		1	0

Altitude, 968 ft.

Owing to its limited occurrence, thin development, and generally shaly character the Upper Mercer coal has little conceivable economic importance in Coshocton County. In possible utilization, the accompanying clays are overshadowed by other clay members of superior quality and greater lateral extent.

Bedford Coal and Clay

STRATIGRAPHY, EXTENT, AND VALUE

The Bedford coal was so named by Orton because of its thick development in Bedford Township, Coshocton County.[1] In this area the coal bed occurs in contact with or close below the Upper Mercer limestone. Here it consists of coal of both the bituminous and cannel varieties with one or more partings and reaches a total thickness ranging from a few inches to 8 or 9 feet.

[1] Orton, Edward, Economic Geology, Geol. Survey Ohio, Vol. V, p. 845, 1884.

Although identified by Orton and Hodge[1] as Upper Mercer (No. 3a) in age, Wilber Stout[2] has shown that it occurs a few feet above Upper Mercer coal and therefore represents another period of coal formation. Concerning the distribution of the Bedford coal in Ohio, Stout writes as follows:[3]

"The Bedford coal has fair continuity and is of some importance in central Ohio, where in Muskingum, Coshocton, Holmes, and Tuscarawas counties, it is mined for a part of the local fuel supply. In Perry and Hocking counties, the member is more erratic in character and more uncertain in distribution. The most southern deposit that has been mined by drifting is in central Green Township of Hocking County. In southern Ohio or in Vinton, Jackson, Scioto, and Lawrence counties, the horizon is very poorly marked, as the member is in few places represented by more than a few inches of shaly coal and usually by only a soot streak of coal underlain by a thin stratum of impure clay. Further, in many localities both materials are wanting."

The horizon of the Bedford coal and clay is above drainage level in parts of every township in Coshocton County, but the area of outcrops in the southeastern part, including Franklin, Linton, and Oxford townships, is small as outcrops occur only near bottom levels of the chief valleys. The clay and coal are quite persistent except in a few local areas when their horizon is occupied by sandstone. The Bedford members are more persistent in this county as a rule than the Upper Mercer coal and clay which lie a few feet below them or the Upper Mercer limestone and flint which in normal succession closely overlies the coal. The coal member in this area is quite variable in character. It may consist of carbonaceous shale and shaly coal interstratified, of bituminous coal, of cannel coal, or of bituminous and cannel split by one or more shale partings. In places the coal horizon is represented entirely by a black fissile carbonaceous shale. Where the coal is present, it is usually directly overlain by the Upper Mercer black limestone and flint, but here and there a few inches of shale intervenes. The thickness of the Bedford member over a large part of Coshocton County ranges from a few inches to a maximum of about 2 feet. It expands greatly, however, over an area of several square miles south of the Walhonding River, embracing southern Jefferson and northern Bedford townships. In these townships it consists of both cannel and bituminous coal and over small areas reaches a maximum thickness of 8 or 9 feet. The position of the Bedford coal in Coshocton County is on an average about 26 feet above the base of the Lower Mercer limestone and about 48 feet below the well developed Putnam Hill limestone. The coal has little future economic possibilities in Coshocton County. In its field of best development in Bedford and Jefferson townships, it has been largely exhausted by mining. Coal in this field was formerly mined extensively and utilized on the ground for the production of illuminating oil.

The clay underlying the Bedford coal is not an important bed economically in Ohio, and it has not been used to any great extent for ceramic products. In Coshocton County it is quite persistent and in places has good volume. The clay is of the gray plastic type rather high in siliceous and micaceous impurities. Its rating as a possible ceramic resource is not high.

Tiverton, Newcastle, Perry, and Pike Townships. - In the western tier of townships in Coshocton County outcrops of the Bedford coal and clay are found high on the hills ranging in altitude from approximately 1,200 feet in the central part of Tiverton Township to approximately 1,080 feet in the north-west quarter of Pike Township. The altitude declines moderately to the east bringing the outcrops to somewhat lower levels along the eastern margin of these townships. In Tiverton Township the Bedford coal and clay are generally present near the summits of the high ridges extending to the east and south from Tiverton Center. In Section 12 the coal is represented by a heavy blossom immediately below Upper Mercer flint at an altitude of 1,200 feet. As exposed along the road in the central part of Section 18, the Bedford horizon is represented

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[1] Orton, Edward, op. cit., p. 852, 1884; Hodge, J. T., Geology of Coshocton County, Geol. Survey Ohio, Vol. III, pp. 576, 582, 1878.

[2] Stout, Wilber, Geology of Muskingum County, Geol. Survey Ohio, Bull. 21, pp. 91, 93, 1918.

[3] Stout, Wilber, Geology of Vinton County, Geol. Survey Ohio, Bull. 31, p. 141, 1927.

by 6 inches of black shale and shaly coal outcropping at an altitude of 1,185 feet, and overlying 6 feet 8 inches of gray plastic clay. Along the road following the extension of this ridge into northern Newcastle Township, the Bedford horizon, represented by 1 foot 5 inches of shaly coal overlying 2 feet of gray clay, outcrops at an altitude of 1,165 feet or 24 feet above the Lower Mercer limestone.

South of the Walhonding River the Bedford coal and clay horizon underlies the upland in the southwestern part of Newcastle Township and the high divide extending from Newcastle east to the head of Opossum Hollow. Although the Upper Mercer flint is quite evident on the outcrop at many localities in this area few clean exposures of the Bedford coal and clay have been noted. In Perry Township the field of outcrops of these members is confined to the ridge paralleling the north boundary and to the highlands extending from New Guilford to the southeast in the direction of New Bedford. As exposed along the road in the northeast quarter of Section 3, the Bedford is represented by 1 foot 2 inches of thin coal and black shale interbedded outcropping at an altitude of 1,104 feet or 21 feet above the Lower Mercer limestone. Here black flint 1 foot in thickness lies immediately above the coal. In the east central part of Section 12 the Bedford is represented on the outcrop by a mere soot streak underlain by 5 feet 6 inches of gray clay. The altitude at this place is about 1,080 feet which is 19 feet above the Lower Mercer limestone. In Pike Township a few exposures of the Bedford member occur near the summit of Ashcraft Ridge in the vicinity of Gardner School in Section 8. Here the horizon is generally represented by a mere soot streak or a few inches of weathered shaly coal. The horizon of the Bedford coal and clay is due to crop out along Graham Ridge in the eastern part of Pike Township at altitudes ranging from 1,025 feet in Section 1 to about 1,000 feet in Section 21. Scattered exposures indicate that neither the coal nor clay is strongly marked along this ridge.

Monroe Township. - Outcrops of the Bedford coal horizon in Monroe Township are confined to the high ridges in the northwestern and southwestern corners of the township and to the uplands between Big Run and Beaver Run extending to the southeast past Spring Mountain in the central part. Its altitude ranges from approximately 1,160 feet along the western border to about 1,040 feet in Section 20. Scattered exposures do not indicate coal of mineable thickness on the Bedford horizon in Monroe Township. As exposed along the road in the north central part of Section 8 it is represented by 3 inches of carbonaceous shale overlying a thin bed of plastic clay and outcropping at an altitude of 1,055 feet. The Upper Mercer limestone does not occur at this exposure but it is well developed overlying carbonaceous shale of the Bedford along the high ridge west of New Princeton in the southwestern corner of the township where exposures occur at altitudes ranging from 1,150 to 1,160 feet.

The Bedford coal and clay are of questionable continuity along the high ridge extending to the southeast by Spring Mountain as no exposures have been found at many places where the horizon is due on the outcrop. The members are well developed for this area just south of Spring Mountain as indicated by the following description of outcrops along the road.

	Ft.	In.
Coal blossom, Bedford	-	6
Clay, gray, plastic, and covered	4	8
Shale, with short covered intervals	31	0
Limestone, gray black, fossiliferous, Lower Mercer	1	0
Shale, dark	-	4
Coal and carbonaceous shale, weathered, Middle Mercer	1	8

Altitude, 1,084 ft.

As exposed at an altitude of about 1,050 feet on the N. J. Markley property in the south central part of Section 19, the Bedford is represented by 1 foot of bony cannel coal overlain by 4 inches of carbonaceous shale and shaly coal interstratified, and underlain by 1 foot 8 inches of gray siliceous plastic clay. The black flinty Upper Mercer limestone is found immediately

above the coal bed. The interval to the underlying Lower Mercer limestone is 25 feet, and to the overlying Putnam Hill limestone, about 30 feet.

Jefferson and Bedford Townships. - North of the Walhonding River in Jefferson Township outcrops of Bedford coal are confined chiefly to the high ridge extending to the northwest from the southwest corner of Section 7. Along this ridge the Bedford is generally represented by a thin blossom cropping out close below the well developed Upper Mercer flint. South of the Walhonding River this coal horizon underlies all the uplands bordering Mohawk Creek and Simmons Run in southern Jefferson and Bedford townships and crops out at altitudes ranging from about 1,020 feet on the hills northwest of Mohawk Village to about 920 feet in the northern part of Section 21 in the southeast corner of Bedford Township. The coal is generally present where due over this field, but it varies greatly in character and development. As usually found in these townships it is an impure bituminous bed ranging from 1 inch to 2 feet in thickness. Over small disconnected areas in southern Jefferson Township and extending into northern Bedford Township, however, the Bedford is made up of a lower bench of slaty or curly cannel coal which may reach a thickness of 5 feet or so overlain by impure bituminous coal measuring as much as 3 feet. The maximum thickness reported for the Bedford in these areas is about 9 feet.[1] Before the Civil War the cannel coal in the thicker portions of bed was mined from a number of openings and was utilized for the production of illuminating oils.

In Jefferson Township the Bedford coal was formerly mined near the crest of the hill three-fourths of a mile northwest of Mohawk Village. The coal bed is here closely overlain with 3 feet of gray flinty limestone representing the Upper Mercer member. Cannel coal on the Bedford horizon is well developed along the high ridge some three-fourths of a mile east of Mohawk Village. Here on the Moore property, Orton reports a regular bed of cannel coal 6 feet in thickness, overlain by 1 foot of soft bituminous coal.[2] A section of the exposures in this vicinity as recorded by T. R. Meyers in 1928, is as follows:

		Ft.	In.
Sandstone and covered		40	0
Limestone, massive, Putnam Hill		5	0
Covered interval		27	9
Flint, buff, weathers rapidly	Upper Mercer	2	0
Flint, dark blue, massive	Upper Mercer	1	1
Limestone, gray, dense, fossiliferous, very siliceous	Upper Mercer	7	3
Coal, bony		-	2½
Coal, bituminous	Bedford	-	4
Shale, carbonaceous	Bedford	-	2
Coal, cannel, probably not entire thickness	Bedford	4	3
Bottom of exposure			

In passing east from the locality last described, the Bedford coal apparently thins for at exposures along the west bank of Flint Run near its head this bed, consisting of both cannel and bituminous coals, measures 1 foot 4 inches. It apparently thickens again east of Flint Run in the area extending to Simmons Run.

Another area of thick Bedford coal underlies the ridge between the east fork and the west fork of Mohawk Creek and includes the northwest part of Section 4 and the northeast part of Section 5, Bedford Township, and adjacent areas in southwestern Jefferson Township. A section of the exposures at the Hagan mine, located in the northwest quarter of Section 4, but now abandoned, which was secured by T. R. Meyers in 1928, follows:

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[1] Orton, Edward, Economic Geology, Geol. Survey Ohio, Vol. V, p. 851, 1884.

[2] Orton, Edward, op. cit., p. 847, 1884.

	Ft.	In.
Flint, blocky	-	7½
Limestone, gray to dark blue, dense, very fossiliferous, Upper Mercer	-	10
Shale, carbonaceous	-	¼
Coal, bituminous	-	3
Clay, gray, siliceous	-	3½
Coal, bituminous	1	5
Coal, cannel	2	¼
Shale, black (Bedford)	-	⅛
Coal, cannel	-	7½
Coal, bituminous	1	4½
Clay	-	2
Shale, very ferruginous, sandy	1	6

Altitude, 998 ft.

South from Hagan's mine the Bedford coal thins rapidly for at the southern edge of Section 4 it is represented by only a few inches of coal underlying gray sandy shale which has replaced the Upper Mercer limestone. The Bedford member is likewise represented by only a few inches of coal to the north and south of West Bedford. One-half mile west of Tunnel Hill the Bedford is represented by 2 feet of weathered coal outcropping close below 6 inches of dark Upper Mercer limestone. Beyond Tunnel Hill Bedford coal approaching 2 feet in thickness outcrops along the road in the north central part of Section 21, and at the railroad tunnel a short distance north of Section 12. The exposures occurring at the north end of the tunnel mentioned above are described by T. R. Meyers as follows:

	Ft.	In.
Flint, black, fossiliferous, with many solution cavities (Upper Mercer)	-	6
Limestone, gray, fossiliferous (Upper Mercer)	1	6
Limestone, carbonaceous, fossiliferous (Upper Mercer)	-	1½
Clay, carbonaceous	-	1
Coal, bony (Bedford)	-	3¾
Shale, black (Bedford)	-	4
Coal, good (Bedford)	-	2¼
Coal, cannel type (Bedford)	-	8¾
Coal (Bedford)	-	8
Clay, siliceous	-	2
Clay, light gray, very sandy	1	6
Shale, sandy, micaceous	3	0
Shale, siliceous	8	6
Limestone, dark gray, dense, fossiliferous (Lower Mercer)	4	0
Limestone, with coaly streaks, very fossiliferous (Lower Mercer)	-	1
Coal, poor, Middle Mercer	-	6
Clay	-	1

Altitude, 940 ft.

North from the railroad tunnel the Bedford coal expands to a seam of workable thickness and it occurs as such over an elongated area extending in a general north-south direction south of Flint Run and west of Simmons Run in the northeast quarter of Bedford Township and the southeast quarter of Jefferson Township. This coal was formerly mined from a number of openings in Jefferson Township south of Flint Run. According to Orton[1] the bed in this area consists of

[1] Orton, Edward, Economic Geology, Geological Survey Ohio, Vol. V, pp. 848-849, 1884.

an upper 3 feet of soft somewhat pyritiferous bituminous coal overlying 5 feet of close-grained curly cannel coal. The coal continues in good development to the south in Bedford Township nearly to the abandoned railroad tunnel. The coal near the eastern boundary of the field is described in the following section reported by T. R. Meyers in 1928 at the old Shaw mine, now abandoned, located near the north boundary of Bedford Township about three-fourths of a mile west of Simmons Run.

		Ft.	In.
Coal, bituminous	Bedford	1	8
Coal, shaly	Bedford	1	0
Cannel coal, straight-grained	Bedford	-	7
Cannel coal, curly	Bedford	3	0

In 1926 T. R. Meyers and G. W. White of the Geological Survey cut a sample of Bedford coal for analysis from the now abandoned mine on the Woodbury Estate located about one-half of a mile north of the railroad tunnel. A description of the coal at the place of sampling is as follows.[1]

		Ft.	In.
Shale roof		-	-
Coal, not used	Bedford	-	-4
Shale, dark, full of pyrite	Bedford	-	2½
Coal, bituminous, canneloid	Bedford	2	0
Clay, carbon	Bedford	-	½
Coal, cannel, laminated, not sampled	Bedford	1	0
Coal, cannel, sampled	Bedford	2	6
Clay floor.			

Only the 2-foot-6-inch bed of cannel coal was sampled. The analysis by D. J. Demorest is as follows.[2]

Proximate Analysis	As received	Moisture free
Moisture	1.54	0.00
Volatile matter	46.57	47.29
Fixed carbon	35.42	35.97
Ash	16.47	16.74
	100.00	100.00

Ultimate Analysis	As received	Moisture free
Carbon	64.63	65.61
Hydrogen	4.95	4.86
Nitrogen	1.67	1.70
Oxygen	8.54	7.29
Sulphur	3.74	3.80
Ash	16.47	16.74
	100.00	100.00

Air drying loss 0.23 per cent

		As received	Moisture free
Heating value	Calories	6,591	6,694
	B. t. u.	11,864	12,049
Fusion of ash	Incipient	2,240°F	
	Complete	2,354°F	

[1] Bownocker, J. A., and Dean, E. S., Analyses of the coals of Ohio, Geol. Survey Ohio, Bull. 34, p. 26, 1930.

[2] Op. cit.

At the central eastern edge of Section 8, Bedford Township, less than one mile westerly from the Woodbury mine, the Bedford coal as exposed along the road measures less than 1 foot in thickness. At the railroad tunnel mentioned above, about one-half mile south of the Woodbury mine, the Bedford has likewise thinned to less than 2 feet of clean coal. East of Simmons Run in southeastern Jefferson and northeastern Bedford townships the Bedford coal is generally too thin for mining.

Before the age of petroleum, illuminating oil was produced in Ohio chiefly by distillation of carbonaceous shale and cannel coal. Among the beds utilized for that purpose, the Bedford cannel coal in Jefferson and Bedford townships, Coshocton County, occupied an important place. The following is a brief account of the rise and decline of mining of cannel coal in these townships.[1]

"From 1858 to 1860, and to some extent for a few years later, a large amount of capital was invested in coal oil manufacturies in this (Bedford) and in Jefferson township. Beds of cannel coal, of the richest description, from which the oil was extracted, lie in the hills in the northeastern part of this and the southern part of Jefferson township. The vein is largest on Simmons Run, where it attains a thickness of 6 feet 3 inches, cannel coal, and 3 feet bituminous. The average thickness of the cannel is between 3 and 4 feet, with the bituminous in proportion. It is sporadic, however, liable to swell into a deep rich vein, or dwindle away into a worthless seam, in a very short distance. The bituminous lies over the cannel coal, and was little mined, having no market.

"Previous to 1858, coal oil had been manufactured to a considerable extent in the east, and about that time extensive works were springing up in Newark, the manufacturers designing to ship the coal from the various mines to that place, and there extract the oil. Colonel Metham, of Jefferson Township, was probably the first person in this vicinity to enter the promising field of future wealth. He purchased a piece of land containing coal, in this township, with William Stanton, of Coshocton, as partner, and went to Newark to acquaint himself with the minutiae of the distilling process. He there met J. E. Holmes and found high excitement prevailing. The coal he was able to supply could be easily disposed of to the various speculators at a fair figure. He was the first to suggest transferring the works to the coal fields, and thus save the freightage on the coal, which was a considerable item of expense. The suggestion was acted upon, and a number of firms came with their works to the coal beds in this township. The coal beds were, as a rule, leased by the operators from the land owners. Three companies were located on the Metham and Stanton tract-Captain Stewart, of Steubenville, with two sets of works, one consisting of fourteen, the other of ten retorts; Forsythe & Brothers, of Pittsburgh, Pennsylvania, having thirty-two retorts, and a Mr. Edwards, of Muskingum County, with six retorts. Wilcox and Osborn made heavy investiments in the coal regions here, still owning about 650 acres of land. Judge Wilcox, the senior member of the firm, is a banker in Painesville, Mr. Osborn, a banker of Chicago. On their property Dr. Semple, of Steubenville, has a set of works, Mr. Carnahew, of Pennsylvania, another, and Alza Cornell, of New York, a third. Mr. Cornell superintended his works here in person. Some of the companies not only distilled the crude oil here, but also, at least, partially refined it. Others sent the oil to Newark, or elsewhere, to be refined. . . . . .

"The extent of the business in Jefferson was considerably greater than in Bedford township, and as nearly as can be ascertained, was as follows: on Lyman's place, in the southern part of the Simmon's section, six companies were at work, viz: Lunburg & Co., of New York, whose works consisted of about twenty retorts; Porter Fields & Co., an eastern firm, also about twenty retorts; John Dickey, of Pennsylvania; J. E. Holmes & Co., of Newark, Ohio; Holmes was a contractor, and also had an interest in a number of other works. Mr. Baker, an eastern man, and the American Company, of Newark, running about thirty retorts. On John Wood's farm was a company composed of Coshocton County men, called the Home Company, running about ten retorts. On James Moore's farm were two companies: Ranbo, Stilwell & Co., of Dresden, and one from Knox County. On Given's place, was one set of works owned by J. E. Palmer & Co., consisting of about twenty retorts. Palmer was a well known Methodist preacher, and had as a partner a young New York capitalist.

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[1] Hill, Norman N., History of Coshocton County, A. A. Graham & Co., pp. 466-467; 518-519, 1881

"The retorts by which the oil was distilled were of various kinds, the most common pattern being an upright, cast iron retort, about nine feet high and four feet thick. It was filled with coal, made air tight, and heat was then applied on the outside. The vapors thus set free were conveyed through a worm and condensed. At first, two charges were run a day, but this was found to be too many, and the number was reduced to one. A ton of coal usually produced about forty gallons of crude oil, worth at first fifty cents per gallon, but toward the end sold at a narrow margin at ten cents a gallon. Mixed with the crude lamp oil were lubricating oil, asphaltum and paraffin. . . . For a year or two after the war some of the works were operated solely for these latter compounds, the crude oil being relied upon, however, to pay expenses.

"The works had scarcely become thoroughly established when the petroleum oil wells in western Pennsylvania, which developed rapidly and produced oil in immense quantities, furnished the burning fluid at a figure which made it utterly impossible for the manufacturers here to compete with them, and the business received its death blow. All the costly preparations for a permanent business, by way of machinery, etc., became at once so much dead capital, completely valueless. It is estimated that $300,000 were lost through these enterprises in the two townships. This was not felt to any great extent by the county, however, for the most of it was foreign capital. A few of the retorts were removed only a short time ago, but most of them were taken away during the war, and, it is said, cast into shells and used on various battlefields in the late conflict."

Washington and Virginia Townships. - Scattered outcrops indicate the general presence of the Bedford coal and clay where due across Washington and Virginia townships, but over much of the area the coal is too thin and impure for mining and the clay lacks merit as a potential ceramic resource. As the altitude of the horizon ranges from approximately 96 feet along the western edge of Washington Township to approximately 680 feet in southeastern Virginia Township, the horizon of this member underlies all the uplands bordering the valley of Little Wakatomika Creek and its tributaries in Washington Township and outcrops near the base of the valley slopes along Mill Fork, Moscow Fork, and the Muskingum River in Franklin Township. Exposures of the Bedford coal and clay are rare west of Little Wakatomika Creek in Washington Township and in places its horizon is occupied by shale. Much the same condition exists in the northern part of Washington Township west of Sand Fork. As exposed along the road in the east central part of Section 10, the Bedford is represented by 1 foot 11 inches of coal, bony coal, and bony shale interstratified, overlying a thin bed of bluish plastic clay. The coal member which at this locality has an altitude of 866 feet is immediately overlain by 2 feet 4 inches of black flinty limestone representing the Upper Mercer. The interval from the coal to the Lower Mercer limestone is about 12 feet, and to the Putnam Hill limestone, about 67 feet. Near the head of Sand Fork in the northwest corner of Virginia Township, the Bedford coal has been mined in small way for local use. The opening is located on the east side of the road about one-fourth mile east of the west boundary of the township, where the following measurements were secured.

		Ft.	In.
Limestone, and black flint, Upper Mercer		1	0
Shale, dark		-	6
Coal, bony, to shaly, and carbonaceous shale	Bedford	1	10
Shale, gray, soft.	Bedford	1	6
Coal, bright, blocky, not cannel	Bedford	2	6
Clay		-	6
Altitude, 869 ft.			

Only the part of the coal bed occurring below the shale parting has been mined at this locality, the upper part of the vein being left for a roof.

In the central part of Virginia Township the Bedford coal and clay horizon is above drainage along Mill Fork as far as the northern part of Section 8 and along Moscow Brook to the north boundary of the township. As exposed along the road 1 mile north of Moscow, the Bedford horizon

is represented by 1 foot 2 inches of black carbonaceous shale overlying 4 feet 8 inches of gray siliceous clay and outcropping at an altitude 864 feet or 43 feet below the Putnam Hill limestone. Similar conditions of thickness of coal and clay are found at exposures occurring along the road one-half mile south of Moscow, where the Bedford is overlain by 2 feet of black flinty Upper Mercer limestone. No outcrops of the Bedford coal and clay have been observed along the Muskingum Valley in Virginia Township.

Jackson Township. - In Jackson Township outcrops of the Bedford coal and clay are confined to the Muskingum-Walhonding Valley along the eastern and northeastern margin to the valley of Crooked Creek in the north central part, and to the valley of Simmons Run in the west central part. The coal horizon is generally represented by 1 to 2 feet of shaly coal and carbonaceous shale except over a small area near the head of Crooked Creek where sandstone is found on the level of the coal. As exposed along the east slope of Simmons Run in the northeast quarter of Section 15, the Bedford is represented by 1 foot 3 inches of shaly coal and carbonaceous shale outcropping at an altitude of 925 feet. Two feet two inches of Upper Mercer flinty limestone overlies the coal. Where exposed along the road in the west central part of Section 13, 1 foot 6 inches of Upper Mercer limestone overlies a thin coal blossom representing the Bedford which in turn overlies gray siliceous plastic clay. An excellent exposure showing the development of the Bedford and its relations to overlying and underlying members occurs along a small ravine tributary to Crooked Run near its mouth in the eastern part of Section 1. The following measurements were secured along this ravine.

	Ft.	In.
Limestone, dark, dense, fossiliferous, with many flint nodules, Upper Mercer	3	2
Shale, bony	-	10
Coal	-	2
Clay shale, soft	-	2
Coal, poor. (Bedford)	-	7
Clay, dark	-	6
Covered interval	2	0
Shale, gray, sandy	10	1
Covered interval	8	10
Limestone, gray black, hard, fossiliferous	3	8
Limestone, gray black, a little shaly (Lower Mercer)	-	10
Limestone, gray black, fossiliferous (Lower Mercer)	1	0
Shale, soft, carbonaceous	-	3
Shale, bony	-	1
Coal, bony (Middle Mercer)	-	4
Clay, bluish gray	1	6

Altitude, 846 Ft.

Bethlehem and Clark Townships. - The Bedford coal and clay are generally present where due along the valleys of the Walhonding River and Killbuck Creek in Bethlehem and Clark townships as indicated by numerous scattered outcrops. The coal horizon generally consists of thin coal, bony coal, and carbonaceous shale interstratified, the series rarely exceeding 2 feet in thickness. The underclay is generally siliceous and impure and is often shaly in character. The altitude of the horizon ranges from about 1,050 feet in the northwest part of Clark Township to approximately 930 feet across the southern margin of Bethlehem Township. South of the Walhonding River the horizon of the Bedford coal is widely indicated by numerous exposures of the overlying Upper Mercer flinty limestone. Few exposures of the coal occur. Prospect diggings have been noted on its horizon near Soggy Hill School. As exposed along a ravine one-half mile west of the township boundary and three-fourths mile north of the Walhonding River, the Bedford is represented by carbonaceous shale interstratified with thin coal having a thickness of 2 feet 11 inches. It is underlain by 3 feet 6 inches of gray siliceous plastic clay. The Bedford member is similar in composition and structure but thinner in development where exposed along

Bucklew Run and its tributaries in the northeastern part of Bethlehem Township. In outcrops along a ravine three-fourths of a mile east of School No. 5 the Bedford member is represented by 10 inches of shale and shaly coal at an altitude of 917 feet. In Bethlehem Township, west of Killbuck Creek and north of the Walhonding, the Bedford member outcrops along the ridge at an altitude of about 980 feet but it is poorly represented in this area.

The Bedford horizon is not strongly expressed on the outcrop in Clark Township. Exposures which have been noted in this area are confined chiefly to the valley of Bucklew Run and to tributaries to the Killbuck Valley in the southeastern part. The Upper Mercer limestone is constant in its occurrence here as indicated by numerous exposures but the underlying Bedford coal and clay are poorly expressed on the outcrop, as they consist of a few inches of black shale and shaly coal overlying a thin bed of impure clay.

Mill Creek Township. - The Bedford coal and clay as a stratigraphic horizon occur with some persistence on the outcrop in this township, but the coal is generally represented by only a few inches of shaly coal or carbonaceous shale, and the clay by 3 to 5 feet of plastic material which is generally siliceous and micaceous in character. The field of outcrops of the Bedford horizon embraces small valleys tributary to Doughty Creek in the northwest corner, where its altitude ranges from 950 feet to 980 feet; the valley of Mill Creek and its tributaries in the central part, where altitudes vary from about 900 feet in Section 23 to 1,050 feet in Section 1; and the valley of Little Mill Creek in the southeast corner, where the altitude of the horizon ranges from 935 feet in Section 22 to approximately 1,025 feet in the eastern part of Section 20. As exposed along the road northwest of Mound in Section 18, the Bedford is represented by 3 inches of badly weathered coal outcropping at an altitude of 926 feet. It is immediately overlain by 3 inches of black nodular flinty limestone representing the Upper Mercer. The interval to the Lower Mercer limestone at this locality is 41 feet and to the Putnam Hill limestone 48 feet. The description of the coal and underlying clay appearing in the following section secured along the road in the south central part of Section 23 is characteristic for the Bedford in this township but the interval to the Lower Mercer limestone is much below average for this county.

	Ft.	In.
Shale, gray, sandy	8	0
Limestone, black, nodular, flinty, Upper Mercer	-	6
Coal blossom, weathered, Bedford	-	6
Clay, bluish gray, siliceous	3	0
Shale and covered	13	0
Limestone, typical, Lower Mercer	1	0

Altitude, 882 ft.

The Bedford coal and clay are generally present along Little Mill Creek in Sections 22, 21, and 20, but like in other areas in this township the coal is thin and shaly, and the clay is siliceous and impure.

Keene Township. - In Keene Township the horizon of Bedford coal and clay outcrops above drainage along the valley of Mill Creek and along the lower courses of its major tributaries. With few exceptions the horizon is represented by a very few inches of bone shale or shaly coal overlying a few feet of impure clay. Locally near School No. 2 in the southeastern part and in Section 10 in the eastern part, both the Bedford coal and clay are wanting, their place being occupied by dark clay shale. The Bedford coal and clay are generally present along Mill Creek where the altitude of outcrops ranges from about 900 feet in Section 3 on the north to about 840 feet near Canal Lewisville on the south. The coal horizon is generally closely overlain by Upper Mercer black flinty limestone. One-half mile northwest of Keene, the horizon of this member outcrops at an altitude of about 909 feet. Along the road 1 mile west of Keene the Bedford is represented by 6 inches of weathered coal overlying 4 feet of gray plastic siliceous clay and outcropping at an altitude of 880 feet. The Upper Mercer limestone is wanting at this locality.

Here the interval from the coal to the Putnam Hill limestone is 56 feet and to the underlying Lower Mercer limestone 26 feet. On the east bank of Mill Creek at the southern edge of the township, this interval is about 24 feet. The Bedford coal horizon is most strongly expressed in Keene Township at exposures along a ravine three-fourths of a mile northwest of Canal Lewisville where it is represented by two beds of bone shale having a combined thickness of 17 inches separated by 5 inches of clay shale, the whole overlying 5 feet of gray siliceous clay. Neither the Bedford coal nor underclay warrants more than stratigraphic interest in Keene Township.

Tuscarawas, Franklin, Lafayette, Linton, and Oxford Townships. - In the southeastern part of Coshocton County the horizon of the Bedford coal and clay occurs close above the bottoms of the larger valleys. Its altitude tends to be highest along the axis of the western rim of the Cambridge Arch which crosses western Lafayette Township in a general north-south direction. West of this axis along the Tuscarawas-Muskingum valley the altitude ranges from 825 feet in northeastern Tuscarawas Township to about 745 feet in central Franklin Township. Few good exposures occur along this valley owing to the general presence of alluvial materials. The following section secured along the east bank of the Muskingum River, $1\frac{3}{4}$ miles northeast of Conesville, seems typical of the Bedford coal on the outcrop in these townships.

		Ft.	In.
Flint, black, one bed. . .	Upper Mercer	2	4
Flint, black, one bed. . .	Upper Mercer	-	6
Limestone, dark.	Upper Mercer	-	6
Shale, soft, dark.		1	0
Shale, carbonaceous	Bedford	1	6
Shale, soft, carbonaceous. . .	Bedford	-	5
Coal, bony	Bedford	-	6
Altitude, 745 ft.			

East of the high crest of the Cambridge Arch in western Lafayette Township the crop line of the Bedford coal extends east along the Tuscarawas Valley through Lafayette and Oxford townships close above flood plain level. Few exposures have been observed along this valley. One and one-fourth miles south of West Lafayette the Bedford horizon is exposed along the road at an altitude of 869 feet. It is represented by 1 foot 10 inches of weathered coal overlying 1 foot of gray clay. Nodular masses of black flint representing the Upper Mercer limestone are found close above the coal. Near Burt School, one and one-half miles farther to the southwest, the Upper Mercer limestone, exposed along the road at an altitude of 905 feet, is immediately underlain by 3 feet 6 inches of bluish gray siliceous Bedford clay, the coal being wanting. The interval here to the underlying Lower Mercer limestone is 29 feet and to the Putnam Hill limestone above 39 feet. Near the mouth of Blue Ridge Run in northeastern Oxford Township the Bedford horizon outcrops close above road level at an altitude of about 835 feet, or about 95 feet below the Lower Kittanning coal.

South of West Lafayette the Bedford horizon is due above the bottoms along the old abandoned valley extending south to Plainfield through eastern Lafayette Township, up the Wills Creek Valley in southwestern Oxford and eastern Linton townships as far as southern Section 7, and down the valley of Wills Creek through central Linton Township as far as Section 18. Although scattered evidence of the overlying Upper Mercer occurs along these valleys, there is little direct evidence of the Bedford coal and associated clay. The following section was secured at the mouth of a ravine near road level at the west central edge of Section 19, Linton Township.

	Ft.	In.
Sandstone, weathered.	-	-
Coal, badly weathered, Bedford ?	2	2
Clay, dark, siliceous.	1	0
Shale, gray, sandy, micaceous	5	2
Sandstone	2	0

	Ft.	In.
Shale, gray, sandy	10	4
Limestone, gray black, fossiliferous not entire thickness, Lower Mercer	-	6
Altitude, 750 ft.		

Crawford Township. - In Crawford Township the Bedford horizon is generally represented on the outcrop by a few inches of black shale or shaly coal overlying a thin bed of gray plastic siliceous clay. At no place in this township is the coal of a thickness or quality necessary for mining. At a few localities it is wanting, the underlying clays occurring in contact with the Upper Mercer limestone. Where exposed along the roads in central Section 16 and in central Section 25, it consists of 4 to 6 inches of black shale and shaly coal overlying thin impure clay and occurring from 20 to 25 feet above the Lower Mercer limestone. Much the same conditions of thickness occur at the south central edge of Section 5, where the Bedford is exposed at an altitude of about 1,050 feet. Along the valley of the West Fork of White Eyes Creek the Bedford crop line ranges in altitude from about 950 feet in Section 22 to 1,040 feet in Section 4. Few exposures have been noted in this valley. Where outcrops occur along the road in the southeast quarter of Section 13 the Upper Mercer limestone is immediately underlain by Bedford clay 3 feet in thickness, the coal being wanting. This coal is likewise absent in exposures along the road in the northwest quarter of Section 11. Here 3 feet 6 inches of Upper Mercer limestone outcropping at an altitude of 972 feet is immediately underlain by 5 feet of gray siliceous plastic clay. Along the valley of White Eyes Creek, south of this locality the Upper Mercer limestone is in evidence at several places but no good exposures of Bedford coal and clay have been found.

White Eyes Township. - The Bedford coal and clay horizon underlies all the uplands and high ridges in White Eyes Township and outcrops high on side slopes of all the larger valleys. East of White Eyes Creek the Bedford horizon ranges from about 910 feet near Bowman School to about 950 feet near Chili. The coal is wanting at exposures along the road a mile north of Fresno. Here 3 feet of gray siliceous Bedford clay occurs in contact with the Upper Mercer limestone member, 3 feet or more in thickness. The altitude of the exposure is 920 feet or 25 feet above outcrops of the Lower Mercer limestone west of White Eyes Creek. The Bedford horizon underlies the high ridge extending from sections 4 and 5 on the north to sections 24 and 25 on the south. The following record of outcrops along the road in the west central part of Section 18 shows the relation of the Bedford coal to the Putnam Hill limestone. The Mercer limestones which are generally present in the area are not shown in this section.

		Ft.	In.
Limestone, black, shaly	Putnam Hill	1	0
Shale, gray, arenaceous	Putnam Hill	7	7
Limestone, dark gray	Putnam Hill	1	2
Clay shale		-	3
Coal, Brookville or No. 4		-	6
Clay, bluish gray, ferruginous, sandy		5	6
Shale, gray, arenaceous		20	10
Coal blossom, Bedford		-	2
Clay, gray, and covered		4	0
Shale, gray, arenaceous		37	3
Coal blossom, Middle Mercer		1	0
Clay, dark, siliceous, short		5	0
Altitude, 938 ft.			

Adams Township. - The field of outcrops of the Bedford coal and clay in Adams Township is confined to the valleys of East Fork and Evans Creek and their chief tributaries. Along the valley of East Fork the Bedford coal and clay horizon outcrops at altitudes ranging from 900 feet near Powell to 950 feet at the north boundary of the township. As exposed along the road just north of Powell the Bedford coal has a thickness of 10 inches. It is directly overlain by 1

foot of Upper Mercer limestone and underlain by 4 feet 4 inches of gray plastic clay. The intervals to the bases of the underlying Lower Mercer limestone and the overlying Putnam Hill limestone are 29 feet and 70 feet respectively. Where exposed along the road, 1 mile east of Woods School, at an altitude of 890 feet, the Bedford is represented by 6 inches of coal separated from the Lower Mercer limestone above by a few inches of soft shale. Along the valley of Evans Creek which traverses east central Adams Township, the altitude of the Bedford horizon varies from about 875 feet near the mouth of Davis Run to about 910 feet at the township line north of Bakersville. At the former locality it is represented by a weathered blossom 5 inches in thickness underlying 1 foot 1 inch of Upper Mercer limestone and occurring 18 feet 6 inches above the base of the Lower Mercer limestone and 55 feet 6 inches below the Putnam Hill limestone. The stratigraphic relations of the Bedford coal to the Upper Mercer limestone are shown by the following section secured just south of the road at the central eastern edge of Section 13.

		Ft.	In.
Limestone, black, flinty	Upper Mercer	1	0
Shale, calcareous	Upper Mercer	5	0
Limestone, dark	Upper Mercer	2	8
Shale, soft		-	6
Coal blossom, Bedford		-	6
Clay, grayish white, plastic		8	0

Altitude, 901 ft.

The Upper Mercer limestone is well exposed along the road in the north central part of Section 9, at an altitude of about 915 feet but the Bedford coal was not visible here or at any other locality in the immediate vicinity of Bakersville.

Upper Mercer Limestone

STRATIGRAPHY, EXTENT, AND VALUE

From 15 to 40 feet above the Lower Mercer limestone previously described there is another prominent limestone which is widely distributed on outcrops in western Pennsylvania and eastern Ohio. This member was called the Mahoning limestone in western Pennsylvania by Rogers in 1858,[1] and the Gore limestone in southern Ohio by Orton in 1878,[2] but it was named the Upper Mercer limestone by White in 1879[3] for exposures near Mercer, Mercer County, Pennsylvania. From western Pennsylvania the belt of Upper Mercer outcrops enters Ohio in Mahoning County. The limestone is generally present although not continuous on the outcrop in Mahoning, Columbiana, Portage, Summit, Stark, Wayne, Holmes, Tuscarawas, Coshocton, Muskingum, Licking, Hocking, Perry, and Vinton counties. South of Vinton County, in Jackson, Lawrence, and Scioto counties, the limestone is seldom present although its stratigraphic position is closely marked by the Upper Mercer ore which normally lies close above the limestone. Where present the thickness of the Upper Mercer limestone member varies from a few inches to a known maximum of about 15 feet with an average thickness of little less than 2 feet. Its stratigraphic position on an average in Ohio is about 34 feet above the Lower Mercer limestone and about 48 feet below the Putnam Hill limestone. Of the limestones of the Pottsville series the Upper Mercer is second only to the Lower Mercer in continuity, and it is, therefore, a valuable guide to the stratigrapher in determining and tracing the stratigraphic succession.

In Coshocton County the horizon of the Upper Mercer limestone is above drainage in parts of every township. It occurs near the tops of the hills in Pike, Perry, Newcastle, and

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[1] Rogers, H. D., Geology of Pennsylvania, Vol. II, p. 417, 1858.

[2] Orton, Edward, Supplementary report on the geology of the Hanging Rock district, Geol. Survey Ohio, Vol. III, p. 898, 1878.

[3] White, I. C., Geology of Lawrence County, Second Geol. Survey Pa., Rept. QQ, pp. 57-58, 1879.

Tiverton townships, along the west edge of the county but the regional dip to the southeast carries it to such low levels in the southeastern part that in Linton, Oxford, Franklin, and Tuscarawas townships the outcrops are in many places obscured by alluvial deposits. The Upper Mercer limestone lacks persistence on the outcrop in Coshocton County. Where present it varies in thickness from a few inches to a maximum of about 15 feet, but the usual measurements are between 2 and 3 feet. As generally developed the member is made up of hard compact dense textured fossiliferous limestone of a dark bluish gray to gray black color with or without varying amounts of black flint. The flint may be present as nodular masses interspersed throughout the limestone but the common mode of occurrence where the member is of average thickness is a basal siliceous limestone bed capped by a nodular flint layer of irregular thickness. Where an abnormal thickness of the flinty phase is found, the flint may be present as thin nodular layers often separated by thin beds of flinty limestone. The flint is generally black or grayish black in color and is often fossiliferous and somewhat porous. On fracture characteristic smooth conchoidal surfaces are developed, which on fresh exposure tend to have a semivitreous luster.

In some localities the Upper Mercer limestone occurs in excessive thickness without a conspicuous development of flint. At such places the member may be composed of several layers of limestone often irregular in thickness and nodular in character, separated by bedding planes or by zones of calcareous shale. The total thickness of the interstratified shale at some such outcrops is equal to the combined thickness of the limestone layers. The mode of occurrence, however, is only occasional and sporadic. An excessive thickness of the Upper Mercer member, either of the flinty or limestone phase, has been noted at a few localities in Adams, White Eyes, Crawford, Keene, Bethlehem, Jefferson, and Bedford townships.

The position of the Upper Mercer member in Coshocton County is on an average about 28 feet above the Lower Mercer limestone and 46 feet below the Putnam Hill limestone.

Owing to the generally high content of silica in the form of flint or chert, the Upper Mercer member is not well adapted to economic uses where a high content of calcium and magnesium carbonates is desired. Furthermore the usual thickness of the member is too low to warrant large operations of any kind. The most obvious use to which the limestone and flint can be employed is for local use as foundation stone in road construction. The material is not well adapted to the surface coating of roads, however, owing to the hardness of the material and owing to the sharp edges developed by crushing. If finely ground, it is conceivable that the flint would yield a sand well adapted for sand blast and for other abrasive purposes. The stratigraphy and extent of the Upper Mercer member is discussed in the following paragraphs.

Tiverton Township. - The area underlain by the Upper Mercer limestone horizon in Tiverton Township is relatively small as the outcrops occur near the summit of the highest part of the ridge extending from sections 3 and 4 on the north to sections 22 and 23 on the south, and from Tiverton Center east toward Harmony School. The limestone or flint is only occasionally present in this area. In the southwest part of Section 23, the Bedford coal outcrops at an altitude of 1,180 feet along the highway but no flint or limestone is found above it. One and three-eighths of a mile east of Tiverton Center a few inches of black flint representing the Upper Mercer member is exposed along the road at an altitude of 1,200 feet. Here it is closely underlain by a thin blossom of Bedford coal. The following is a measurement of exposures along the road in the east central part of Section 18.

	Ft.	In.
Shale, arenaceous	15	0
Flint, black, nodular, Upper Mercer	-	3
Coal and carbonaceous shale, Bedford	-	6
Clay, gray, plastic, and covered	6	8
Shale, gray, arenaceous, ferruginous	5	0
Covered interval	6	0
Shale and covered	20	0

		Ft.	In.
Clay and covered.	Flint Ridge	1	0
Clay, gray, plastic		2	6
Sandstone, yellowish in color		1	4
Shale, arenaceous, and shaly sandstone.		28	0

Altitude, 1,113 ft.

Newcastle Township. - The distribution of the outcrops of Upper Mercer limestone and flint in Newcastle Township are confined to the high hills and ridges where the altitude varies from 1,200 feet at the west central edge to approximately 1,125 feet in the southeast corner. The following section was secured along the ridge road west of Honey Run in north central part of the township.

	Ft.	In.
Limestone float, flinty, Upper Mercer.	-	-
Coal and carbonaceous shale, weathered, Bedford	1	5
Clay, gray, and covered.	2	0
Covered interval	21	11
Limestone, grayish black, Lower Mercer	-	6

Altitude, 1,140 ft.

The Upper Mercer limestone is generally present where due near the summit of the east-west ridge past Newcastle. In the southeast corner of Section 11, Butler Township, Knox County, the member is exposed along State Route No. 715 at an altitude of 1,200 feet. Here it is thin and is composed in large part of dark flint.

It is likewise flinty just north of Newcastle where it outcrops along the road at an elevation of 1,165. Its characteristics are similar about 1 mile southeast of Newcastle where it is exposed along the road at an altitude of 1,145 feet. The flinty phase of the Upper Mercer is exceptionally well developed at the head of a small ravine just east of the road in the northwest quarter of Section 22. A description of exposures follows:

		Ft.	In.
Flint, gray, red, reddish brown to black, one bed, Upper Mercer		3	6
Covered interval		28	0
Limestone, grayish black, fossiliferous, shaly.	Lower Mercer	-	4
Limestone, grayish black, fossiliferous, with a thin zone of black flint in middle portion . .		1	6
Limestone, grayish black, fossiliferous		2	4

Altitude, 1,076 ft.

Perry Township. - In Perry Township the Upper Mercer limestone is sporadic in its occurrence and where present is invariably thin and flinty in character. It is generally present in outcrops along the high ridge in the northern part of the township where it ranges in altitude from 1,100 to 1,190 feet. Where exposed at an altitude of 1,181 along the road northeast of Wilson Chapel in Section 2, it consists of 5 inches of black flint overlain by 6 inches of black limestone with flint nodules. Here the interval to the Lower Mercer limestone is about 22 feet, and to the Putnam Hill limestone, about 41 feet. The following record was secured in the head of a small ravine near a farm house in the northeast quarter of Section 3.

	Ft.	In.
Limestone, black, flinty, Upper Mercer	1	0
Coal and carbonaceous shale, weathered, Bedford	1	2
Covered interval.	19	0
Limestone, bluish gray, fossiliferous, one layer, Lower Mercer.	2	2
Altitude, 1,083 ft.		

The Upper Mercer limestone is due near the summit of the high ridge extending from Section 5 to the southeast towards New Bedford. In the north central part of Section 6, blocks of black flint representing the Upper Mercer occur along the roadside at an altitude of about 1,180 feet. This is about 20 feet above the level of the Lower Mercer limestone which crops out along the road one-fourth of a mile to the south. The Upper Mercer limestone is likewise due near the summit of the ridge at New Guilford in Section 7, but no outcrops were found in this locality. Much the same situation exists along the high ridge in the southeast quarter of Section 8. In the east central part of Section 12, the Upper Mercer is a black flint at an altitude of about 1,080 feet or about 20 feet above the Lower Mercer limestone. It is due high on the hillsides in sections 19, 20, 21, and 22, but no exposures have been noted in this area. The Upper Mercer is likewise due near the summit of the high ridge in Section 16, but the limestone or flint is apparently wanting.

Pike Township. - Little can be said concerning the Upper Mercer limestone in Pike Township as the member is apparently wanting in many areas. The horizon is due near the summits of the highest hills along Ashcraft Ridge from Ashcraft School northeast to West Carlisle. The Bedford coal outcrops along the road in the north central part of Section 8, at an altitude of 1,077 feet, but here it is immediately overlain by sandy shales, the Upper Mercer member being wanting. Along Graham Ridge the Upper Mercer member is due at altitudes ranging from about 1,000 to 1,050 feet. As few exposures were noted in this area the continuous presence of the member is in doubt. A few inches of black flint representing the Upper Mercer was observed at an altitude of 1,015 feet along the road in the west central part of Section 11.

Monroe Township. - The Upper Mercer limestone is not an important bed in the stratigraphic succession exposed in Monroe Township for it is seldom seen on the outcrop. It is generally represented by a few inches of black flint along the high ridge southwest of Beaver Run where exposures range in altitude from 1,140 to 1,160 feet. Northeast of Beaver Run the Upper Mercer limestone and flint are due to crop out along the upper slopes of the high ridges which extend to the southwest, south, southeast, and northeast from Spring Mountain, but the member is either thin or wanting. Just southwest of Spring Mountain the Bedford coal outcrops along the road at an altitude of 1,160 feet but no limestone or flint is exposed above it. The Upper Mercer member is likewise wanting above the Bedford horizon where exposed along the road in the southwest quarter of Section 23 at an altitude of 1,070 feet. It is represented by 1 foot of flinty limestone at exposures along a small ravine on the N. J. Mackley property south of the road in the southwest quarter of Section 19. At this locality the Upper Mercer has an altitude of 1,051 feet and occurs 25 feet above the Lower Mercer limestone and about 29 feet below the Putnam Hill limestone. The member has a similar character at exposures in the southcentral part of Section 20. North of Big Run in Monroe Township there is little indication on the outcrop of the presence of Upper Mercer limestone and flint as the horizon is generally occupied by shale.

Jefferson Township. - Exposures of the Upper Mercer limestone and flint member are widespread in Jefferson Township for its horizon is well above drainage along the larger valleys and the limestone or flint is nearly everywhere present where due. In the northern part of the township this member consists for the most part of 1 to 2 feet of black to bluish black flint which often appears porous and nodular on the outcrops. The altitude of the horizon ranges from 1,115

feet in Section 5 to about 1,000 feet in the east central part of Section 10. At the central west edge of Section 5, flint rubble, some fossiliferous, representing the Upper Mercer, occurs along the highway 20 feet or more above outcrops of the Lower Mercer limestone. A similar indication of outcrop occurs at an altitude of about 980 feet along the road in the southeast quarter of Section 8. Sandstone is found intermittently for many feet below this exposure. In the south central part of Section 1, T. R. Meyers reports the Upper Mercer member as represented in a roadside exposure by 2 feet of dark blue to black badly weathered flint outcropping at an altitude of about 1,035 feet or about 35 feet below the Putnam Hill limestone exposed on the same hillside. The record of outcrops along the road in the east central part of Section 3, as described by T. R. Meyers, is typical of exposures of the Upper Mercer and underlying members in the northern part of Jefferson Township.

	Ft.	In.
Flint fragments, black, fossiliferous, Upper Mercer	1	0
Coal, weathered	-	4½
Sandstone, gray, ferruginous } Bedford	-	1½
Coal, weathered	-	9
Sandstone, medium-grained, micaceous, and covered	17	2
Limestone, blue gray, dense, fossiliferous, Lower Mercer	2	6
Shale	1	6
Clay, carbonaceous, Middle Mercer coal horizon	-	4
Clay, light, plastic	1	0
Clay shale, white, sandy	4	0
Sandstone, fine-grained, somewhat ferruginous	10	0

South of the Walhonding River in Jefferson Township the Upper Mercer member expands greatly reaching its thickest known development in Coshocton County and possibly in Ohio. The member here is generally made up of a basal limestone portion overlain by beds of black flint, the two parts having a combined thickness which may exceed 15 feet over small areas. The limestone and flint are generally overlain by shale and in a part of the area at least are underlain by an exceptional development of the Bedford coal. The thick development of the limestone and flint in this area is generally accompanied by intervals to the overlying Putnam Hill limestone and to the underlying Lower Mercer reduced much below the average for the county as a whole.

West of Mohawk Creek in the southwestern part of Jefferson Township the Upper Mercer member occurs near the summits of the high ridges bordering Opossum Hollow. According to Mr. Meyers, it is made up of 3 feet of siliceous limestone with irregular masses of dark flint embedded in the lower part, where it is exposed along the road 1 mile northwest of Mohawk Village at an altitude of 1,077 feet. The interval here is 29 feet to the bottom of the Lower Mercer limestone and 42 feet to the base of the Putnam Hill limestone. East of Mohawk Creek the Upper Mercer limestone member underlies a large area of uplands bordering Flint Run. Where exposed along a ravine near the road, three-fourths of a mile east of Mohawk Village, it is represented, according to Mr. Meyers, by 7 feet 3 inches of dense siliceous fossiliferous limestone overlain by 3 feet of flint. The interval from the base of the limestone to the overlying Putnam Hill member is here about 38 feet. Along the north-south road 1 mile northeast of this locality the Upper Mercer is represented by 5 feet of dark fossiliferous flint outcropping 38 feet below the Putnam Hill limestone. The thickest known development of the Upper Mercer member occurs near the head of Flint Run. A description of the outcrops exposed on the west side of the valley along the northwest-southeast road which crosses near the head of the stream is recorded by Meyers as follows.

		Ft.	In.
Clay shale		12	0
Clay shale, slightly ferruginous		31	4
Limestone, gray, dense, fossiliferous, Putnam Hill		6	6
Covered interval		17	11
Flint, light	Upper Mercer	2	1
Flint, gray black, hard, fossiliferous	Upper Mercer	11	8
Limestone, dark blue, fossiliferous, with nodules of flint	Upper Mercer	5	6
Clay shale		-	8
Coal, weathered	Bedford	-	4
Clay shale, light	Bedford	-	1
Coal, cannel nature, shaly	Bedford	-	11
Clay, light, plastic, slightly siliceous		2	6

Altitude, 1,008 ft.

The total thickness of the Upper Mercer member is 19 feet 3 inches. The interval from its base to the Putnam Hill horizon above is nearly 10 feet less than the average interval for the county.

East of Simmons Run the Upper Mercer outcrops along the valley in good development at altitudes ranging from about 975 to 960 feet. It is 6 feet in thickness where exposed along the road three-eighths of a mile southeast of Warsaw Junction. A contraction of intervals is indicated for this locality by a vertical distance of 32 feet to the Putnam Hill limestone above and 11 feet to the Lower Mercer limestone below.

Bedford Township. - In Bedford Township the horizon of the Upper Mercer limestone and flint member is widely distributed for outcrops occur in parts of every section. This limestone member is generally thin along the valley of Mohawk Creek and its tributaries in the western part of the township and in a few localities it is wanting, its place being taken by shale. Where exposed in the northwest quarter of Section 4 it is represented by 10 inches of gray dense limestone overlain by a thin bed of flint. In the southwest quarter of Section 4 both the flint and the limestone have been replaced by sandy shale. Nine inches of flint again marks the horizon in the northeast quarter of Section 16 where it outcrops at an altitude of 1,028 feet or 30 feet below exposures of well developed Putnam Hill limestone. In the west central part of Section 25 the Upper Mercer is represented by 2 feet of flint and dark gray siliceous limestone outcropping along the road at an altitude of 989 feet.

Scattered exposures along the valley of Simmons Run and its tributaries and along tributaries to Sand Fork indicate that the Upper Mercer member is generally present in the eastern part of Bedford Township, but quite variable from place to place in both general lithological character and thickness. Near the old Shaw mine three-fourths of a mile west of Simmons Run and close to the northern boundary of the township, the Upper Mercer is represented by 2 feet of dark gray siliceous limestone overlain by 5 feet of black flint rubble. The Bedford coal lying immediately below the Upper Mercer was formerly mined at this locality. As exposed along the road in the east central part of Section 8, the Upper Mercer is represented by about 2 feet of dark siliceous limestone as indicated in the following record of exposures secured by Mr. Meyers along this road.

		Ft.	In.
Limestone, dark gray, dense, fossiliferous	Putnam Hill	1	2
Limestone, heavy-bedded	Putnam Hill	1	8
Limestone, gray, fossiliferous, thin-bedded	Putnam Hill	3	2

	Ft.	In.
Clay shale	-	8
Coal, weathered, Brookville or No. 4	2	2
Clay, light, plastic, and covered	2	0
Covered	14	0
Shale, bluish, siliceous	2	0
Ore, iron gray, with many well preserved fossils	-	4
Shale, bluish, ferruginous, and covered	6	2
Limestone, dark, hard, siliceous, Upper Mercer	2	2
Covered interval	1	0
Coal, cannel nature, Bedford	-	10
Covered	1	0
Clay, light, sandy	2	6
Covered interval	18	6
Limestone, dark gray, hard, fossiliferous, Lower Mercer	1	7
Coal smut and clay	-	6

Altitude, 963 ft.

At this locality the interval from the Upper Mercer to the Lower Mercer limestone is about 25 feet and to the Putnam Hill limestone about 30 feet. As exposed at the north end of the old railroad tunnel, the Upper Mercer is represented by 1 foot 7 inches of limestone overlain by 6 inches of flint. It outcrops at an altitude of about 960 feet or 20 feet above the Lower Mercer limestone exposed on the slopes below it. Near the forks of the road north of Section 11, it is represented by 1 foot of black limestone and flint. The Upper Mercer again appears in good development in Section 21 south of the divide, where it is represented by 4 feet 10 inches of black flint in a roadside exposure at an altitude of 931 feet.

Washington Township. - The Upper Mercer limestone has no spectacular development in Washington Township for it is apparently discontinuous on the outcrop and thin where present. It is generally represented by thin limestone and flint through the eastern part of the county where the altitude of the horizon ranges from about 860 feet in Section 21, to 890 feet in Section 11, to 870 feet in Section 1. The following measurements of outcrops were secured along the ravine south of the road in the east central part of Section 10.

	Ft.	In.
Limestone, gray, crystalline, Putnam Hill	1	6
Covered interval	63	2
Limestone, grayish black, compact, one bed. Upper 8 inches contains much black flint, Upper Mercer	2	4
Shale, black, bony	-	5
Coal, impure, bony	-	5
Shale, black, bony	-	3
Coal, impure	-	10
Clay, bluish	-	8
Covered interval	10	1
Limestone, gray black, shaly, Lower Mercer	1	8

(Shale, black, bony; Coal, impure, bony; Shale, black, bony; Coal, impure — Bedford)

Altitude, 854 ft.

Throughout the central and western parts of Washington Township where the altitude of the Upper Mercer limestone and flint horizon varies from about 900 to 975 feet, the member is apparently wanting over large areas, its horizon being occupied by sandy shales.

Virginia Township. - In Virginia Township the Upper Mercer limestone and flint horizon is above drainage along Mill Fork Valley southwest of Willowbrook, along the valley of its chief tributary, Moscow Fork, and along the Tuscarawas Valley southwest of Conesville. Exposures, however, are confined chiefly to Mill Fork Valley and its tributaries, where the member is a black flinty limestone, 2 feet or more in thickness. One-half mile southwest of Willowbrook, Upper Mercer limestone, typical in character, outcrops near the forks of the road at an altitude of 823 feet. It likewise outcrops along the highway in the southeast quarter of Section 8 where its thickness is 2 feet 10 inches and its altitude above sea level is 820 feet. Along Moscow Fork the Upper Mercer is everywhere a hard, black, weather-resistant bed which is siliceous and flinty in character. The following measurements were secured along the diagonal road west of Moscow Brook, one-half mile south of the village of Moscow.

	Ft.	In.
Shale, very sandy	15	0
Shale and covered	33	2
Limestone, black, tough, flinty, Upper Mercer	2	3
Coal and carbonaceous shale, Bedford	1	6
Clay, gray, siliceous	4	0
Shale, very sandy	11	8
Covered interval	5	0
Limestone, bluish gray, Lower Mercer	2	10
Clay, gray, and covered	11	0

Altitude, 834 ft.

Upper Mercer limestone lies close above drainage near the head of Sand Run in the extreme northwestern corner of the township. The following measurements secured along the road leading up the southeast side of the valley in the direction of Brush Creek School show the thickness of the Upper Mercer and its relation to the Putnam Hill.

Limestone, gray, shaly, Putnam Hill	1	0
Clay and covered	10	0
Shale, gray; short covered intervals	54	0
Limestone, black, flinty, Upper Mercer	2	0
Clay shale, gray	-	8
Coal, shaly, and carbonaceous shale	2	8

Altitude, 866 ft.

Jackson Township. - The Upper Mercer is generally present where due along the valley of Simmons Run in the western part of Jackson Township where its altitude ranges from about 950 feet in Section 5 to about 900 feet in the southern part of Section 15. Where exposed along the road in the northeastern part of Section 15, it is made up of black flinty limestone, 2 feet 2 inches in thickness, lying 23 feet above the Lower Mercer limestone. The Upper Mercer limestone is apparently wanting where due in Section 3, and also along the valley of Crooked Creek in sections 2, 8, and 9 where sandstones and sandy shales occupy its horizon. The member appears again on the outcrop with somewhat diminished thickness in Section 13. The following is a record of measurements occurring along the road in the west central part of Section 13.

Shale, arenaceous	5	0
Coal blossom, Middle Kittanning	2	0
Shale and covered	27	0
Coal blossom, Lower Kittanning	-	6
Clay, gray, siliceous	4	10
Shale and covered	36	2
Sandstone, soft, friable	31	0

	Ft.	In.
Shale, arenaceous	13	2
Limestone, black, shaly, Upper Mercer	1	6
Coal blossom, Bedford	1	6
Clay, gray, and covered	10	0
Shale and covered	30	2
Limestone, grayish black, Lower Mercer	1	6
Shale, carbonaceous, and shaly coal } Middle Mercer	1	0
Clay, black } Middle Mercer	-	4
Coal, weathered } Middle Mercer	7	0
Clay, bluish gray } Middle Mercer	3	0

Altitude, 877 ft.

The Upper Mercer limestone is generally present along the Walhonding-Muskingum Valley in the eastern part of Jackson Township. Outcrops along this valley range in altitude from about 875 feet near the mouth of Crooked Run, to about 790 feet near the southeast corner a mile or so above Franklin. The character and thickness of the Upper Mercer and its relation to underlying beds are shown in the following record of outcrops secured in a ravine in east-central Section 1.

Limestone, dark, fossiliferous, with many flint nodules, Upper Mercer	3	2
Shale, bony	-	10
Coal } Bedford	-	2
Clay shale } Bedford	-	2
Coal, shaly } Bedford	-	7
Clay, dark } Bedford	-	6
Covered	2	0
Shale, gray, sandy	10	1
Covered interval	8	10
Limestone, gray black, dense } Lower Mercer	3	8
Limestone, gray black, shaly } Lower Mercer	-	10
Limestone, gray black, dense } Lower Mercer	1	0
Shale, black, soft	-	3
Shale, bony } Middle Mercer	-	1
Coal, bony } Middle Mercer	-	4
Clay, bluish gray } Middle Mercer	1	6

Altitude, 846 ft.

Where exposed near the power plant above Roscoe, the Upper Mercer is represented by 2 feet 5 inches of black flinty limestone outcropping at an altitude of 863 feet. The interval here to the base of the Lower Mercer limestone is about 18 feet. It again appears in good development east of Section 20 and about three-fourths of a mile north of Bowman School. Here it is represented by 3 feet 11 inches of black limestone and flint outcropping at an altitude of 828 feet. Only 1 foot of black flinty limestone is found on the Upper Mercer horizon in a ravine just west of the river road and close to the south boundary of the township.

Bethlehem Township. - The Upper Mercer member is usually present where due on the outcrop in Bethlehem Township but it is generally quite flinty in character. Over small areas it is exceptionally thick for this county, being composed of several beds with some shale interstratified. The altitude of the horizon varies from about 980 feet in the west-central part of the area to about 900 feet along its western edge. The Upper Mercer is a thin flinty bed where it outcrops at an altitude of 980 feet along the crest of the ridge west of the Killbuck Valley and north of the Walhonding Valley. South of the Walhonding River, the limestone suffers many

variations in character and thickness but it is exceptionally well developed where exposed along a small ravine which parallels the road in the extreme southwest corner of the township. At this locality the member consists of several layers or beds of black siliceous limestone interstratified with beds of bluish gray shale having a total thickness of about 10 feet. The interval to the base of the underlying Lower Mercer limestone is 25 feet and to the base of the overlying Putnam Hill limestone about 39 feet. The altitude of the Upper Mercer limestone here is 941 feet.

Good exposures of the Upper Mercer are rare along the slopes facing the Walhonding River and Killbuck Creek in Bethlehem Township. The following measurements, however, were secured along a small ravine which intersects the north-south road about five-eighths of a mile south of School No. 7.

		Ft.	In.
Sandstone, massive		23	0
Shale, dark, and covered		19	4
Limestone, black, tough	Upper Mercer	2	4
Shale, dark, and shaly limestone	Upper Mercer	1	0
Shale, dark	Upper Mercer	4	6
Limestone, black, very flinty	Upper Mercer	-	10
Limestone, black, impure	Upper Mercer	1	8
Coal and carbonaceous shale	Bedford	-	11
Shale, dark, bony	Bedford	-	4
Coal, bony	Bedford	-	7
Coal and bone shale	Bedford	1	1
Clay, gray, siliceous		3	6
Shale, dark, and covered		11	-3
Limestone, grayish black, fossiliferous, Lower Mercer		3	0
Coal, shaly, and carbonaceous shale, Middle Mercer		-	6

Altitude, 895 ft.

The Upper Mercer member, including both limestone and shale, has a thickness of 10 feet 4 inches at this locality and an altitude of 915 feet. It is likewise well developed $1\frac{1}{4}$ miles due north of School No. 7 where 5 feet 10 inches of this member is exposed along a small ravine at an altitude of 921 feet. The following measurements were obtained in a ravine five-eighths of a mile due east of School No. 5.

		Ft.	In.
Mine level, Middle Kittanning or No. 6		-	-
Covered interval		125	0
Limestone, black, flinty, Upper Mercer		2	0
Shale, dark		-	2
Coal, Bedford		-	4
Shale, dark, carbonaceous		-	4
Covered		4	4
Shale and thin sandstone		15	6
Limestone, grayish black, one bed.	Lower Mercer	1	0
Limestone, grayish black, one bed.	Lower Mercer	1	0
Limestone, grayish black, one bed.	Lower Mercer	1	0
Limestone, grayish black, one bed.	Lower Mercer	-	11
Shale, dark		-	3
Coal, Middle Mercer		-	2
Clay, gray		2	0

Altitude, 891 ft.

The Upper Mercer is average in thickness at this locality but the Lower Mercer limestone is exceptionally well developed. The Upper Mercer limestone and flint have not been utilized for economic purposes in Bethlehem Township.

Clark Township. - The Upper Mercer limestone is generally present in the southeast quarter of Clark Township where the altitude of its outcrops ranges from about 965 feet in the southwest quarter of Section 12 to about 925 in the central part of Section 21. Where exposed at an altitude of 950 feet along a ravine in the south part of the southwest quarter of Section 23, this member is black, hard, and flinty with a thickness of about 3 feet. Its thickness ranges from 6 inches to 2 feet 6 inches as measured at exposures along the northwest-southeast road in sections 21 and 22. The interval to the overlying Putnam Hill limestone is about 43 feet and to the underlying Lower Mercer limestone in Section 21, 36 feet. The following section secured along a ravine in the east central part of Section 21 is typical of the rock succession above and below the Upper Mercer limestone in the southeast quarter of Clark Township.

	Ft.	In.
Shale, gray, siliceous	12	0
Coal and carbonaceous shale, weathered, Tionesta ?	-	6
Clay, bluish gray, siliceous	2	6
Shale, gray, arenaceous	3	0
Shale, gray	5	0
Shale, dark bluish gray	8	0
Covered interval	14	0
Limestone, black, dense, flinty at top, Upper Mercer	2	2
Covered interval	5	4
Shale, dark, siliceous	5	0
Covered interval	10	4
Limestone, dark, a little shaly, fossiliferous, Lower Mercer	2	6

Altitude, 900 ft.

In the northeastern quarter of Clark Township the Upper Mercer limestone is due at altitudes ranging from about 985 feet in the northwest part to about 960 feet on the eastern margin, but in this field the member is wanting from the section, its place being taken by shale and sandstone. West of the Killbuck Valley the Upper Mercer is due high on the ridges to the southeast and southwest of Layland and 100 feet or so below the crest of the high ridge in Section 15, but its horizon is here likewise filled with shale and sandstone.

Mill Creek Township. - The Upper Mercer limestone horizon is widely distributed above drainage in Mill Creek Township but in the northern half its position in the rock succession is generally filled with shale. The member is generally thin in the southern half of the township, lacking the conspicuous development that it attains in some other townships of this county. It has its lowest altitude in the southwest corner where outcrops occur at about 920 feet above sea level. In general the horizon rises to the north and east reaching levels of about 1,000 feet in the northwest corner, 1,050 feet in the northeast corner, and about 1,000 feet in the southeast corner. The interval to the Lower Mercer limestone previously described varies from 18 feet to about 48 feet. Where present the Upper Mercer consists of black flinty limestone varying in thickness from 3 inches to 1 foot 6 inches. This member is generally present along the valley of Mill Creek as far north as Section 9. Where well exposed along the road just west of Mound it is represented by 3 inches of black flinty limestone occurring 41 feet above the Lower Mercer limestone. The stratigraphic relations of the Upper Mercer to overlying and underlying beds are well displayed by the following section secured along the road leading to the northwest from Little Mill Creek in the south central part of Section 22.

	Ft.	In.
Limestone, gray, somewhat shattered, Putnam Hill	-	6
Shale, dark	-	4
Coal, on outcrop, Brookville or No. 4	-	9
Clay, gray, arenaceous	6	2
Shale, gray, arenaceous	26	0
Coal, shaly	-	5
Clay, gray, and covered	3	9
Limestone, blocky, flinty, Upper Mercer	-	3
Shale, ferruginous	-	10
Shale, bony, Bedford coal horizon	-	9
Clay, gray, shaly	4	5
Coal, shaly, Upper Mercer	-	6
Clay, gray, arenaceous	2	6
Shale and covered	19	0
Limestone, grayish black, fossiliferous, Lower Mercer	1	8

Altitude, 905 ft.

Keene Township. - The Upper Mercer limestone and flint horizon is above drainage along all the major valleys in Keene Township. The altitude of the bed is somewhat variable owing to the structural irregularity produced by a broad shallow synclinal trough the axis of which crosses the central part of the township in a north-south direction. Along this axis the altitude of the Upper Mercer ranges from 814 feet near Canal Lewisville at the south central edge to about 900 feet at the north central edge of the township south of Mound. From the bottom of this trough the beds rise irregularly to the west and to the east reaching altitudes of approximately 870 feet in the southwest corner, 930 feet in the northwest corner, 980 feet in the northeast corner, and about 900 feet in the southeast corner. The limestone is generally present where due, with a usual thickness ranging from 1 to 3 feet but it is everywhere siliceous and impure. It is well exposed along the road one-half mile northwest of Keene at an altitude of 910 feet. At this place it has a thickness of 3 feet and is found 30 feet above the Lower Mercer limestone and 52 feet below the Putnam Hill limestone. The general stratigraphic relations of the Upper Mercer to beds above and below it is well shown in the following section secured along the north-south road three-fourths of a mile west of Canal Lewisville,

		Ft.	In.
Coal blossom Lower Kittanning		-	8
Clay, gray, plastic		5	0
Nodular, ferruginous, concretionary layer		-	4
Clay, dark, plastic, siliceous		5	0
Shale, arenaceous, and covered		77	6
Limestone, dark, compact	Upper Mercer	-	9
Limestone and black flint	Upper Mercer	-	9
Limestone and black flint	Upper Mercer	1	0
Clay shale, dark		-	5
Shale, bony	Bedford	-	9
Clay shale	Bedford	-	5
Shale, bony	Bedford	-	8
Clay, gray, arenaceous		2	0
Clay, dark gray, siliceous		3	0

Altitude, 807 ft.

An exceptional development of Upper Mercer limestone is displayed by the outcrops along the east-west road in the northeast quarter of Section 10. It consists here of a lower 3-foot 6-inch bed of black flinty limestone and an upper 2-foot bed of black ferruginous limestone separated by 6 feet 8 inches of bluish gray shale.

Crawford Township. - Outcrops of the Upper Mercer limestone horizon in Crawford Township are confined in their distribution to the valley of White Eyes Creek in the eastern part, to the valley of West Fork of White Eyes and its tributaries in the central part, and to the heads of the valleys of Little Mill Creek and Mill Creek in the western part. The altitude of the horizon varies from about 1,050 feet in the northwestern part to about 900 feet in the southeastern corner of the township. The Upper Mercer limestone is a rather persistent bed in Crawford Township but it is generally below the average for the county in thickness. It is typical in character in that it is a tough, black, impure, limestone with varying amounts of black flint. It is generally thin along White Eyes Creek where it varies in altitude from about 900 feet in Section 21 to about 950 in the northern part of Section 11. Much the same conditions of development prevail in the valley of the West Fork of White Eyes Creek where the altitude ranges from about 920 feet in Section 23 to about 1,000 feet in Section 4. Beds overlying the Upper Mercer are well exposed along the road in the south central part of Section 13 where the following measurements were secured.

	Ft.	In.
Limestone, bluish gray, shaly, Putnam Hill	-	6
Shale, soft, dark	-	4
Coal blossom, Brookville or No. 4	-	6
Clay, bluish gray, short	7	8
Shale, light gray, arenaceous	17	0
Clay, light gray, plastic, Tionesta	5	0
Shale, gray, arenaceous	26	0
Limestone, black, Upper Mercer	-	6
Clay, gray, plastic	3	0

Altitude, 993 ft.

The Upper Mercer limestone is replaced by shale along Little Mill Creek in Section 16. It is present, however, in the north central part of Section 25 where it is represented by 9 inches of black limestone overlain by 1 foot 6 inches of limestone and flint.

White Eyes Township. - The Upper Mercer limestone member is generally present where due on the outcrop in White Eyes Township although in a few localities it is wanting. Its lithologic characteristics tend to be normal for that member.

Its thickness varies from a few inches to a maximum of about 3 feet. The member has its greatest altitude along the crest of the Cambridge Arch. Here its altitude varies from 940 feet in the eastern part of Section 24 to about 1,000 feet in Section 5. From the crest of this arch the limestone dips steeply to the southwest and moves gently and irregularly to the east, descending to altitudes of about 870 feet in the southwest corner and from 910 to 950 feet along the eastern border of the township. Where exposed along the road at an altitude of 920 feet, about 1 mile north of Fresno, the Upper Mercer is a black flinty limestone 3 feet in thickness, occurring about 24 feet above the Lower Mercer limestone. At the west central edge of Section 23, Upper Mercer limestone having a thickness of 2 feet is exposed along the road at an altitude of 940 feet or 39 feet above the Lower Mercer limestone. It is apparently wanting where its horizon is exposed in the eastern part of Section 17, but it appears again in east central Section 7, where it is a flinty bed 1 foot in thickness outcropping at an altitude of 958 feet or 38 feet above the Lower Mercer limestone.

The following measurements secured along the road seven-eighths of a mile south of Chili are typical for the Upper Mercer in the northern part of White Eyes Township.

Shale, gray, sandy	15	6
Limestone, grayish black, flinty, Upper Mercer	1	4

	Ft.	In.
Shale and covered	31	8
Limestone, bluish gray to grayish black, a little shaly, Lower Mercer	3	6
Altitude, 899 ft.		

Adams Township. - In Adams Township the Upper Mercer limestone is generally present where due to outcrop along the valley of East Fork of White Eyes Creek in the western part and along the course of Evans Creek which traverses the eastern part of the township. In the southern part, the member generally consists of a single layer of black flinty limestone ranging in thickness from a few inches to 2 feet, whereas in the northern part it is made up of two or more beds of limestone separated by a few feet of shale. The altitude of the limestone ranges from about 875 feet at the south central edge to about 930 feet where exposed along the northern boundary. A description of the limestone and the stratigraphic succession exposed along the road extending east from Powell are recorded below.

Coal blossom, Middle Kittanning	2	6
Clay, yellowish gray, siliceous	3	0
Covered interval	49	10
Flint, gray to amber-colored, Vanport	1	6
Shale and covered	15	6
Limestone, dark gray, fossiliferous, Putnam Hill	-	8
Coal smut Brookville or No. 4	-	2
Clay, gray, plastic	7	4
Shale, arenaceous, and covered	50	8
Limestone, black, Upper Mercer	1	0
Coal and covered, Bedford	-	10
Clay, gray, plastic	4	4
Shale, very arenaceous	20	8
Limestone, grayish black, fossiliferous, heavy-bedded, Lower Mercer	4	0
Altitude, 870 ft.		

A thick development of the Upper Mercer limestone member is exposed near the head of a small ravine near the western edge of the township about 1 mile northwest of Woods School. Here it is composed of a lower limestone, 4 feet in thickness, overlain by 5 feet of shale above which are two zones of limestone, the upper one being quite flinty, each measuring 1 foot 8 inches in thickness. The altitude of the Upper Mercer here is 920 feet which is 21 feet above the underlying Lower Mercer limestone and 36 feet below the overlying Putnam Hill limestone. A similar development of the member outcrops along the road leading up the east side of the valley of East Fork about seven-eighths of a mile east of Woods School. At this locality the Upper Mercer consists of two beds of limestone separated by 5 feet 2 inches of shale. The lower bed is black, tough, and impure, whereas the upper one is composed of black limestone and black flint. The altitude of the outcrops here is about 890 feet.

The Upper Mercer limestone is generally present in outcrops along Evans Creek where it is above drainage entirely across the township. As exposed along Davis Run near the south boundary it is a shaly bed 1 foot 1 inch in thickness outcropping at an altitude of 877 feet. This is 19 feet above the Lower Mercer limestone and 55 feet below the Putnam Hill limestone exposed on the same hillside. Where outcrops occur along the road in the central part of Section 19, the Upper Mercer is represented by 1 foot 9 inches of black flinty limestone at an altitude of 904 or 19 feet above underlying Lower Mercer limestone. The following section showing the Upper Mercer limestone and underlying Bedford coal is descriptive of outcrops along the road in the northeast quarter of Section 13.

		Ft.	In.
Limestone, black, tough, flinty	Upper Mercer	1	0
Shale, dark	Upper Mercer	5	0
Limestone, black, a few flint nodules in top part	Upper Mercer	2	8
Shale, dark, soft		-	6
Coal smut, Bedford		-	6
Clay, gray, plastic		8	0

Altitude, 901 ft.

The Upper Mercer limestone is well developed in the vicinity of Bakersville where it occurs some 50 feet above the level of the valley of Evans Creek. The member is black and flinty with a thickness of 4 feet 8 inches where exposed at an altitude of 917 feet along the road just southeast of Bakersville. Upper Mercer limestone has not been utilized for economic purposes in Adams Township.

Tuscarawas Township. - Few statements can be made concerning the occurrence of the Upper Mercer limestone in Tuscarawas Township as the horizon is confined to the Tuscarawas Valley where it lies close above drainage and where it is generally covered with surface deposits.

Lafayette Township. - The Upper Mercer is exposed at a few places along the lower courses of small valleys tributary to the Tuscarawas from the south in Lafayette Township. From an altitude of about 825 feet near Morgans Run the bed rises to an elevation of about 900 near Burt School and then descends to the southeast to a height of about 850 feet above sea level near Block School. The limestone is dark and ferruginous with a thickness of about 8 inches where it is exposed along the road near the Burt School at an altitude of about 905 feet. The interval to the Lower Mercer limestone is here about 28 feet, and to the Putnam Hill limestone, about 39 feet. The Upper Mercer is represented chiefly by dark flint at a few exposures near the base of the slopes south of West Lafayette. About one mile south of this village, it is exposed at an altitude of 862 feet or about 40 feet below the Putnam Hill limestone.

Franklin Township. - The Upper Mercer limestone horizon outcrops close to the level of the flood plain of the Muskingum River across Franklin Township. Its altitude ranges from approximately 780 to 800 feet. Few outcrops have been observed due to the general presence of alluvial material. About 1 mile north of Franklin, outcrops have been observed along State Route 16, at an altitude of 790 feet. The best exposures, however, occur at a railroad culbert $1\frac{3}{4}$ miles northeast of Conesville where the member is represented by 6 inches of limestone overlain with 2 feet 10 inches of black flint. The altitude of the exposure is 745 feet.

Oxford and Linton Townships. - The continuous presence of the Upper Mercer limestone member on the outcrop along the valley of the Tuscarawas River in north central Oxford Township and along the valley of Wills Creek in southwestern Oxford Township and in Linton Township is in doubt as its horizon occurs close to drainage level in these areas where alluvial deposits permit few exposures. In Oxford Township a thin bed of black flinty limestone representing this member was observed along the canal road $1\frac{3}{4}$ miles east of Orange at an altitude of 836 feet. A 6-inch bed of Upper Mercer limestone was also noted on the north bank of Wills Creek in the southwestern part of Oxford Township, $1\frac{3}{4}$ miles northeast of Plainfield. The altitude of the exposure here is 810 feet, and the intervals to the underlying Lower Mercer limestone and overlying Putnam Hill limestone are 34 feet and 54 feet respectively.

In Linton Township the horizon of the Upper Mercer occurs above drainage from Section 14 in the vicinity of Stringtown to Section 18 west of the mouth of White Eyes Creek. The only occurrences of Upper Mercer observed in this valley are found in the southwest quarter of Section 7 and in the west central part of Section 8 where the altitudes are 778 feet and 796

feet respectively. At an exposure of the Upper Mercer horizon in Section 18, sandstone has replaced the limestone.

Upper Mercer Ore

Along its line of outcrop in east central Ohio the Upper Mercer limestone is closely overlain in local areas by a thin bed of iron carbonate ore which has long been known as the Upper Mercer ore. Where traced along the outcrop in a southerly direction the limestone and flint of the Upper Mercer horizon become less prominent and are only occasionally present south of Vinton County. The iron ore, however, which is only locally present in Muskingum, Perry, and Hocking counties tends to gain in magnitude and continuity in its extension southward. It is quite persistent in Vinton, Jackson, Scioto, and Lawrence counties where it was early known as the "big red block ore"[1] and where it was an important source of ore for the iron furnaces that formerly flourished in that area. In its field of best development the usual thickness of the ore ranges from 16 to 24 inches.[2]

In Coshocton County the Upper Mercer ore is generally wanting where due on the outcrop. In a few scattered localities in Adams, Crawford, Jefferson, and Bedford townships, however, a thin ore is found close above the Upper Mercer limestone which is here assigned to the Upper Mercer member. The thickness of the ore ranges from 2 to 6 inches. It may occur immediately above the Upper Mercer limestone, but more often it is separated from that member by a few feet of dark shale. Where exposed in Section 19, Adams Township, it occurs as a 4-inch bed separated from the Upper Mercer limestone by 8 feet of dark bluish gray shale. In the central part of Section 16 it is represented by 3 inches of iron carbonate immediately above Upper Mercer black flinty limestone. The following section by T. R. Meyers of exposures along the road in the central part of Section 8, Bedford Township, shows the Upper Mercer ore in development typical of several exposures in Jefferson and Bedford townships.

	Ft.	In.
Coal, weathered, Brookville	2	2
Clay, light, plastic, and covered	2	0
Covered	14	0
Shale, blue, siliceous	2	0
Iron carbonate, iron gray, with many fossils, Upper Mercer	-	4
Shale, bluish gray, ferruginous, and covered	6	2
Limestone, dark, hard, siliceous, Upper Mercer	2	2
Covered interval	1	0
Coal, cannel, Bedford	-	10
Covered	1	0
Clay, light, sandy	2	6
Covered	18	6
Limestone, dark gray, hard, fossiliferous, Lower Mercer	1	7
Clay and coal smut	-	6
Altitude 963 ft.		

The thin discontinuous iron carbonate members of the Pennsylvanian series in Coshocton County, such as the Upper Mercer described above, have practically no importance as sources for ores of iron.

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[1] Andrews, E. B., The second geologic district, Geol. Survey Ohio, Rept. Prog. 1870, p. 111, 1871.

[2] Orton Edward, Economic geology, Geol. Survey Ohio, Vol. V, p. 425, 1884.

Tionesta Coal and Clay

STRATIGRAPHY, EXTENT, AND VALUE

In the interval between the Upper Mercer limestone below and the Brookville coal and clay above a thin coal with underclay is occasionally found on outcrops in Ohio which is correlative with the Tionesta coal of western Pennsylvania. This coal was first named by Rogers in 1858[1] and more clearly defined by White in 1879.[2] In Ohio the Tionesta is neither a widely continuous bed on the outcrop nor an important source of fuel even in local areas. At many places where it is due the Tionesta horizon may be represented by a few inches of coal overlying a bed of plastic clay or by clay only. The coal thickens locally in Muskingum, Tuscarawas, Stark, Wayne, and Holmes counties so that it has been mined at times for local use. More extensive than the coal is the bed of plastic clay which in normal succession is found immediately below it. Outcrops occur over a broad belt in Ohio extending from Lawrence and Scioto counties on the south to Columbiana and Mahoning counties on the east.[3] In the value of ceramic products made from it, this clay ranks first among the clay beds of the Pottsville in Ohio. Its chief field of utilization includes Hocking, Perry, Muskingum, and Stark counties.

In Coshocton County the horizon of the Tionesta coal and clay reaches the surface in parts of every township, but these members are generally wanting on the outcrop in the western half of the county, their horizons being occupied by shale and sandstone. Outcrops have been noted chiefly in Adams, Crawford, Keene, and Virginia townships. Here the coal horizon is represented by black shale and shaly coal varying in thickness from 2 inches to about 1 foot. In some localities in the eastern part of the county the coal is wanting from the section apparently through lack of deposition. The more persistent underclays are of the gray moderately siliceous plastic variety ranging in thickness from 1 foot to 7 feet but averaging nearly 4 feet. The coal and clay horizon is underlain and overlain by siliceous to sandy shale which with few exceptions in this area extends to the Upper Mercer limestone below and to the Brookville clay above. The position of the Tionesta coal in eastern Coshocton County is on an average about 23 feet above the base of the Upper Mercer limestone to which it is best referred. Variations from this mean occur, however, ranging from 12 to 36 feet.

The Tionesta coal in Coshocton County is too thin and impure for mining. The associated clays are apparently suitable for the common types of ceramic products, but they are not known to have ever been utilized for such purposes in Coshocton County.

The Tionesta coal and clay are generally present in the northern part of Adams Township as indicated by a few scattered exposures in the vicinity of Bakersville and along the valley of East Fork. About three-eighths of a mile southeast of Bakersville the coal is represented by a thin blossom occurring about 15 feet above the base of the Upper Mercer limestone which is well developed at this locality. Just west of Bakersville 2 inches of Tionesta coal is underlain by 4 feet 6 inches of gray plastic clay which in turn is found some 26 feet below the Brookville coal. The following section secured along the road about one mile southeast of Myser School describes the Tionesta coal and clay and shows its stratigraphic relation to members occurring higher in the column.

	Ft.	In.
Coal blossom, Middle Kittanning	1	0
Clay, gray, short	4	0
Shale and covered	58	4
Limestone, bluish, Ferriferous	1	0
Shale and covered	26	0

[1] Rogers, H. D., Geology of Pennsylvania, Vol. II, p. 489, 1858.

[2] White, I. C., The Geology of Lawrence County, Second Geol. Survey Pa., Rept. QQ, pp. 55-57, 1879.

[3] Stout, Wilber, et. al., Coal Formation Clays of Ohio, Geol. Survey Ohio, Bull. 26, pp. 195-196, 1923.

	Ft.	In.
Limestone, gray, Putnam Hill	1	0
Shale	-	6
Coal, on outcrop, Brookville or No. 4	2	0
Clay, gray, siliceous	4	0
Shale, gray	27	4
Coal blossom, Tionesta	-	6
Clay and covered	3	0

Altitude, 915 ft.

The Tionesta horizon is generally present on the outcrop in Crawford Township, where it is represented by a few inches of black shale and shaly coal underlain by a bed of gray plastic clay which varies in thickness from 2 to 5 feet. The following section showing the succession above the Tionesta was secured along the road leading west from White Eyes Creek, $1\frac{1}{4}$ miles southwest of Baltic.

Coal blossom, Lower Kittanning or No. 5	-	2
Clay, gray, plastic	5	0
Shale, gray, arenaceous	51	6
Limestone, gray, Putnam Hill	1	0
Coal blossom, Brookville or No. 4	-	10
Clay, gray, lower part arenaceous	4	6
Shale, sandy, and shaly sandstone	25	7
Smut streak, Tionesta or 3b	-	1
Clay, gray, plastic	3	0
Shale, gray, arenaceous	20	0

Altitude, 1,002 ft.

In the east central part of Section 22, Crawford Township, the Tionesta coal horizon is represented by 2 inches of black shaly coal which occurs about 12 feet above the Upper Mercer limestone and about 31 feet below the horizon of the Brookville coal. The coal is underlain by one foot of gray siliceous clay. In the southeast quarter of Section 13 an outcrop of 5 feet of clay midway between the Upper Mercer and Putnam Hill limestones is the only indication of Tionesta. A similar situation exists in the central part of Section 25, with the additions of a few inches of black shale and shaly coal overlying the clay.

In Keene Township the Tionesta coal and clay have been observed at a few localities, chiefly in the eastern part. Here the coal is thin, measuring only an inch or so in thickness. The clay, however, is generally well developed as it usually measures about 5 feet. The following measurements of outcrops secured along the east-west road in the northeast quarter of Section 10 show the relation of the Tionesta to overlying and underlying members.

Coal blossom, Middle Kittanning or No. 6	1	0
Shale and covered	17	10
Clay and covered, Lower Kittanning or No. 5	3	0
Shale, gray, arenaceous	46	6
Limestone, gray, Putnam Hill	-	6
Coal and black shale, Brookville or No. 4	1	0
Clay and covered	3	0
Shale and covered	13	0
Coal, Tionesta or 3b	-	3
Clay, bluish gray, plastic	5	6
Shale, bluish gray	12	11
Limestone, black, ferruginous Shale, bluish gray Limestone, black, flinty } Upper Mercer	2 6 3	0 8 6

Altitude, 941 ft.

Where exposed along the northwest-southeast road 1 mile west of Keene the Tionesta is represented by a mere smut streak overlying gray plastic, siliceous clay. The interval to the underlying Bedford coal here is 27 feet and to the overlying Putnam Hill limestone 29 feet.

An occasional outcrop of the Tionesta coal and clay has been noted in the southern and southwestern parts of Coshocton County, but these members are generally wanting in this area. An exposure of 3 feet of gray siliceous clay at an altitude of 892 feet marks the Tionesta horizon in exposures along the east-west road 1 mile north of Moscow in Virginia Township. The clay is underlain and overlain by gray siliceous shale. The interval here from the top of the clay to the base of the Upper Mercer limestone is 28 feet and to the bottom of the Putnam Hill limestone, 15 feet. Wilber Stout found Tionesta coal, 1 foot 6 inches in thickness, outcropping along Opossum Run near Graham Corners in western Washington Township. Here the coal is underlain by 4 feet of plastic clay.

Homewood Sandstone

The stratigraphic position of the Homewood sandstone member is in the interval between the Brookville coal above and the Tionesta coal below. Sandstone occupying this horizon is widespread in western Pennsylvania where it was first designated the Tionesta sandstone by Rogers[1] in 1858 and later named the Homewood by White[2] for exposures at Homewood in Beaver County. In Ohio the Homewood horizon outcrops over a belt extending from Mahoning and Columbiana counties on the east to the Ohio River in Lawrence and Scioto counties but it is occupied in large part by arenaceous shale. Bodies of sandstone of apparently limited areal extent have been recognized on the Homewood horizon in parts of Perry, western Muskingum, Coshocton, and Holmes counties. The sandstone bodies are generally thin, but they may expand locally to such an extent that they replace the Brookville and Putnam Hill members above and the Tionesta members below.

In Coshocton County sandstone is of common occurrence on the Homewood horizon in Jackson, Bethlehem, western Clark, northern Jefferson, and in Monroe townships. In the eastern part of the county and in that part to the south and southwest of Jackson Township the Tionesta-Brookville interval consists for the most part of sandy shale with an occasional thin bed or zone of fine-grained shaly sandstone. Where occurring in good development in this county the Homewood is a yellowish brown medium-grained sandstone which is both micaceous and argillaceous in character. In structure it ranges from medium-bedded to massive. Cross-bedding is a conspicuous feature in some localities. The thickness of the sandstone varies greatly. In normal development it is confined to the Tionesta-Brookville interval but here and there it seems to unite with an overlying sandstone member producing a sandstone succession that blots out the normal stratigraphic succession. The Homewood sandstone is not known to have been utilized to any extent in Coshocton County in recent times although the better grades of stone are suitable for rough construction purposes.

Sandstone on the Homewood horizon occurs with some regularity along the river front in eastern Jackson Township. Where the succession is exposed $1\frac{1}{2}$ miles north of Franklin, sandstone appears a short distance above the Upper Mercer limestone and extends upward, replacing the Brookville and Putnam Hill members. A similar condition exists along the small valley 1 mile southwest of Roscoe. Along the river front northwest of Roscoe, the base of a massive sandstone appears about 30 feet above the Upper Mercer limestone and extends upward for an undetermined distance. Sandstone on the Homewood horizon is generally present along the valley of Crooked Creek. The following description of outcrops along the road in west central Section 13 and east central Section 14 shows the relation of this sandstone to associated members.

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[1] Rogers, H. D., Geology of Pennsylvania, Vol. II, p. 489, 1858.

[2] White, I. C., Report of progress in the Beaver River district, Second Geol. Survey Pa., Rept. Q, p. 67, 1878.

	Ft.	In.
Shale, sandy	5	0
Coal blossom, Middle Kittanning or No. 6	2	0
Shale and covered	27	0
Coal blossom, Lower Kittanning or No. 5.	-	6
Clay, gray, siliceous	4	10
Shale and covered	36	2
Sandstone, soft, friable, Homewood	31	0
Shale, arenaceous	12	2
Limestone, dark, shaly, Upper Mercer	1	6
Coal blossom, Bedford	1	6
Clay and slump	10	0
Shale and covered	30	2
Limestone, dark, hard, Lower Mercer	1	6
Coal, shaly, and black shale } Middle Mercer	1	0
Clay, dark } Middle Mercer	-	4
Coal, weathered } Middle Mercer	1	0
Clay, bluish gray	3	0

Altitude, 877 ft.

In Bedford Township somewhat sandy shales predominate on the Homewood horizon. In the southwest quarter of Section 4, however, the Brookville clay is underlain by several feet of fine-grained, ferruginous sandstone representing this member. Thin sandstone on the Homewood horizon has also been reported by T. R. Meyers at a few localities in southern Jefferson Township. In northern Jefferson Township this sandstone is prominently developed, filling much of the interval between the Upper Mercer limestone and the Putnam Hill limestone. It is likewise strongly developed along the high ridges north of Big Run in northern Monroe Township and along the ridges in eastern Monroe Township projecting into western Clark Township.

The Putnam Hill limestone is generally wanting where due near the crest of the ridges in eastern Monroe and western Clark townships due to the transgressive nature of this sandstone.

In Bethlehem Township the Homewood horizon is generally represented by some sandstone east of the valleys of Killbuck Creek and the Walhonding River. Where exposed three-fourths of a mile south of School No. 7 it is represented by 23 feet of massive sandstone occurring 19 feet above the Upper Mercer limestone. One and one-fourth miles north of School No. 7 it is well developed at exposures along a small valley tributary to Bucklew Run. Three-fourths of a mile east of School No. 5 thick sandstone occurs above the Upper Mercer limestone which has replaced the Putnam Hill limestone. In southeastern and eastern Clark Township sandy shale is the prevailing type occurring on the Homewood horizon.

Brookville Clay

STRATIGRAPHY, EXTENT, AND VALUE

The Brookville clay, so called because of its close association with the Brookville coal which belongs just above it, is the top member of the Pottsville series. In Ohio outcrops of this member occur over a broad curving belt extending from the state line along eastern Columbiana County to the Ohio River bordering southern Lawrence County. The clay is persistent when compared with many Pottsville members but nevertheless it has many wants, where the base of the Clarion sandstone falls and transgresses the clay horizon. In addition to its stratigraphic interest the Brookville clay is of much value as it is mined for ceramic use in Vinton, Perry, Muskingum, Holmes, Tuscarawas, and Stark counties. Concerning the character of the Brookville clay in Ohio Wilber Stout writes as follows:[1]

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[1]Stout, Wilber, Coal formation clays of **Ohio, Geol. Survey Ohio, Bull.** 26, p. 216, 1923.

"The Brookville horizon yields only plastic clay with occasional thin layers or small lenses of flint or flinty material. The plastic clay is siliceous in character and fine in texture. The color range is from light gray to dull black. The flint clay is generally light gray, medium hard, and somewhat siliceous and is most frequently bedded in the upper part of the plastic stratum."

In Coshocton County the areal distribution of the Brookville clay includes parts of every township with the exception of Tiverton in the northwest corner. As indicated on the geologic map of the county, where the Brookville clay represents the top of the Pottsville series, the position of this clay bed is near the summits of the high hills and ridges in Pike, Perry, Newcastle, and Monroe townships in the western part of the area, but due to the regional dip to the southeast this horizon is found approximately 75 feet above the level of the Tuscarawas River in northeast Oxford Township and a like distance above Wills Creek in eastern Linton Township. In vertical section Bedford clay occurs on an average about 71 feet above the Lower Mercer limestone and about 80 feet below the Middle Kittanning coal. In normal succession it is immediately overlain by Brookville coal, close above which is the Putnam Hill limestone. Below the clay sandy shale predominates to the Tionesta coal and clay or, in their absence, to the Upper Mercer limestone. Where the Homewood sandstone is clearly defined, Brookville clay occurs close above it. The thickness of the Brookville clay on the outcrop in Coshocton County varies from a few inches to a maximum of about 10 feet but the average of some 40 measurements is 5 feet 2 inches. The clay is of the gray plastic moderately siliceous type which is often visibly micaceous in the lower part of the bed. It has not been utilized for ceramic purposes in Coshocton County although it seems worthy of consideration for moderate temperature refractories.

Newcastle, Perry, Pike, and Washington Townships. - In Newcastle Township the Brookville clay is due near the crest of the high ridge which extends to the east and south from Newcastle. It is likewise due closely underlying the Putnam Hill limestone at an altitude of about 1,120 feet near Wilson Chapel in sections 1 and 2, Perry Township. This clay horizon appears again near the crest of the uplands in sections 9, 10, 11, and 12, Perry Township, where its altitude ranges from 1,085 to 1,100 feet. As exposed at the road intersection at the central west edge of Section 11, it is represented by 10 feet of gray plastic siliceous clay overlain by 6 inches of carbonaceous shale and shaly coal. South of Winding Fork Valley outcrops of the Brookville clay occur high on the slopes of Graham Ridge in eastern Pike Township and western Washington Township at altitudes ranging from 1,000 feet to 1,050 feet. Good exposures of the clay are rare along this ridge but fragmentary outcrops indicate that it is present in good thickness and quality. Brookville clay is likewise due in the northeast half of Washington Township to the northwest and southeast of Sand Fork Valley at altitudes ranging from 980 feet in Section 8 to about 940 feet in the eastern part of Section 20. Few clear exposures have been found in this area.

Bedford Township. - The Brookville clay is everywhere present where due on the outcrop in Bedford Township. The position of the bed is high on the ridges in the western part where the altitude of its outcrops is near 1,060. The irregular structural descent to the east and southeast depresses the member to altitudes approximating 940 in Section 21. Measured exposures of the clay range in thickness from 2 feet to nearly 8 feet. The following section measured by T. R. Meyers in 1928 along the road in the southwest quarter of Section 4 shows the character and thickness of the Brookville clay and its relation to overlying beds in that vicinity.

	Ft.	In.
Sandstone, fine-grained, shaly, and covered	16	6
Shale, siliceous, and covered	24	5
Limestone, gray, dense, fossiliferous, heavy-bedded at top; lower 18 inches thin-bedded, Putnam Hill	6	0
Clay shale	-	5

	Ft.	In.
Coal, weathered . . . . } Brookville or No. 4 { . .	-	6
Shale parting, black . . } Brookville or No. 4 { . .	-	3
Coal, weathered . . . . } Brookville or No. 4 { . .	1	1½
Clay, light, siliceous . . . } Brookville {	2	6
Clay, light, sandy . . . . } Brookville {	3	0
Sandstone, fine-grained ferruginous, micaceous, irregular-bedded	16	0

Altitude, 995 ft.

Similar correlations of Brookville clay development prevail at West Bedford where outcrops occur at an altitude of 1,025 feet and near Union Church in Section 23, where this member is exposed at an altitude of 1,000 feet. Brookville clay occurs in unusual thickness for this township in Section 21. The following section by T. R. Meyers describes the series from the Lower Mercer limestone to the Putnam Hill limestone as exposed along the east-west road in the north central part.

Shale, ferruginous	12	0
Limestone, Putnam Hill	4	2
Coal and covered, Brookville or No. 4	1	0
Clay, light, plastic, siliceous, Brookville	7	10
Shale, siliceous with occasional ore nodules	23	4
Flint, dark blue black, fossiliferous, Upper Mercer	4	10
Shale, carbonaceous	-	3
Clay shale, bluish gray	-	7
Coal, weathered, Bedford	1	8
Clay, blue gray, sandy	-	2
Clay, impure, ferruginous, sandy	1	4
Shale, sandy.	13	2
Limestone, dark blue, slightly fossiliferous, Lower Mercer	3	0

Altitude, 900 ft.

Jefferson Township. - In Jefferson Township the Brookville clay occurs near the summits of the high hills and ridges in the southeast half at altitudes ranging from 1,000 to 1,080 feet. The area underlain by this member is not large north of the Walhonding River as the distribution of the clay is confined to a few hills in sections 10 and 1. The following section secured by T. R. Meyers in 1928 along the north-south road in the southeast quarter of Section 1 shows the character, thickness, and stratigraphic relations of this clay member.

Shale with many iron ore nodules	4	0
Limestone, gray, fossiliferous massive, Putnam Hill	2	4
Clay, carbonaceous . . . . . } Brookville {	-	5
Clay, white, plastic . . . . . } Brookville {	-	10
Clay and covered . . . . . } Brookville {	16	5
Sandstone, medium-grained, micaceous, ferruginous.	3	0
Covered	10	10
Flint, dark blue to black, badly weathered, Upper Mercer.	2	0
Coal smut, Bedford coal horizon	-	2
Clay, light	1	0

Altitude, 1,033 ft.

South of the Walhonding River Brookville clay is confined in its distribution chiefly to the ridges east of Simmons Run and east and west of Flint Run. Outcrops in these areas indicate about 5 feet of gray plastic clay for the Brookville member. Where exposed along a ravine paralleling the north-south road, $1\frac{1}{2}$ miles southeast of Nellie, the Brookville is represented by 5 feet of plastic siliceous clay overlain by 1 inch of weathered coal. Massive Putnam Hill limestone 5 feet 2 inches in thickness outcrops a few inches above this coal or 38 feet above the base of the Upper Mercer flint exposed lower on the hillside. Clay of a similar character is poorly exposed along the diagonal road which crosses the valley of Flint Run near the southern boundary of the township. About one-half mile southeast of Warsaw Junction, Brookville clay was formerly dug from an open pit near the road and utilized at Warsaw for the production of building tile and brick. The clay is of the gray plastic siliceous type having a thickness of about 5 feet.

Monroe Township. - Just south of Spring Mountain, Monroe Township, the Brookville horizon is represented by a few inches of black shale outcropping along the road at an altitude of 1,160 feet. Neither the Putnam Hill limestone above nor the Brookville clay below is clearly shown at this locality. East of Spring Mountain the Brookville clay is due near the summits of the high ridges occurring to the north and south of Hoagland Run, and extending into southeastern Jefferson Township, but here its horizon is generally occupied by thick sandstone. It is likewise due near the summits of the high hills across the northern part of the township in sections 2, 3, 4, 5, and 6. Few exposures have been noted in these localities. In the southern part of Section 3, 1 foot 6 inches of gray plastic clay representing the Brookville is exposed along an abandoned road at the crest of the ridge. The Putnam Hill limestone is wanting at this locality.

Clark Township. - The horizon of the Brookville clay reaches the surface in Clark Township at altitudes ranging from about 975 feet in the southeast part of Section 21 to 1,100 feet along the ridge north of Layland in the northwest corner. South of Layland and west of the Killbuck Valley, Brookville clay is due near the crests of the high ridges north of Green Valley School and ridges bordering the valley of Hoagland Run. At the last locality the clay horizon seems to be replaced by sandstone. East of the Killbuck Creek the Brookville clay seems to be generally present in the southeastern quarter of Clark Township. At the central eastern edge of Section 11, the Brookville horizon is represented by thin gray plastic clay exposed at an altitude of 990 feet or 70 feet above outcrops of Lower Mercer limestone. It is likewise well exposed along the northwest-southeast road in Section 22. It is here typical in lithogical characteristics for this county with a thickness of about 5 feet. It is closely overlain by thin Putnam Hill limestone and underlain by shale. In the east central part of Section 21, the Brookville horizon is replaced by massive sandstone.

Few good exposures of the Brookville clay have been identified in the northern part of Clark Township east of Killbuck Creek. The horizon is closely indicated along the road about $1\frac{1}{8}$ miles west of Shepler School where float from the overlying Putnam Hill limestone occurs at an altitude of 1,022 feet.

Bethlehem Township. - The Brookville clay is poorly represented in outcrops in Bethlehem Township as its horizon is occupied over large areas by sandstone. North of the Walhonding River and west of Killbuck Creek this horizon outcrops at an altitude of 1,028 feet on the point of hill crossed by the diagonal road 1 mile south of Metham. East of Killbuck Creek heavy-bedded sandstone comes into the section close above the Upper Mercer limestone and extends upward for many feet, apparently replacing the Brookville horizon. South of the Walhonding River clay is of uncertain occurrence where due along the high ridge south of Soggy Hill School. It is normal in characteristic and development where exposed along the road at an altitude of 977 feet in the extreme southwestern corner of the township. It is here found close below 5 feet of gray Putnam Hill limestone. The interval from the top of the clay to the Lower Mercer limestone is 61 feet, and to the Upper Mercer limestone, 36 feet.

Jackson Township. - The horizon of the Brookville clay is above drainage along all the larger valleys in Jackson Township. In the eastern part including the Walhonding-Muskingum Valley and its chief tributary valleys from the west, south of the mouth of Crooked Creek, the Brookville clay is generally wanting, its place being taken by heavy-bedded sandstone. The member is likewise generally wanting in the lower part of the valley of Crooked Creek due to sandstone encroachment. In the west central part of Section 13, the Upper Mercer limestone is exposed at an altitude of 924 feet. Here it is overlain by 12 feet of shale above which is 31 feet of sandstone with the Brookville clay and overlying coal wanting. At the south central edge of Section 13, the Putnam Hill limestone outcrops along the highway with the normal succession of Brookville members below it.

Brookville clay is due close above drainage along Moscow Brook south of central Section 14, and along the valley of Simmons Run north of Section 16, but few exposures have been found in these valleys.

Virginia Township. - The Brookville clay horizon is above drainage along all the major stream courses in Virginia Township, where it is generally represented by a bed of gray plastic siliceous clay having a maximum thickness of about 10 feet. It is generally overlain by a few inches of black shale or shaly coal above which is thin Putnam Hill limestone. The elevation of the top of the clay varies from 950 feet near Brush School at the west central edge of the township to about 820 feet along the Muskingum Valley in the southeastern corner. At the forks of the road along Mill Fork in the central part of Section 2, the Brookville is represented by 3 feet of gray siliceous micaceous clay outcropping at an altitude of 871 feet. It is underlain by gray sandy shale and overlain by a few inches of carbonaceous shale above which is Putnam Hill limestone in good development.

Brookville clay occurs in good development along the valley of Moscow Brook in the vicinity of Moscow. Along the east-west road about one mile north of that village, Brookville clay having a thickness of about 6 feet crops out at an altitude of about 906 feet. The clay is of the typical bluish gray siliceous type which is overlain at this locality by 10 inches of black shale and shaly coal. The clay here occurs about 60 feet below the Middle Kittanning coal and about 42 feet above the Upper Mercer limestone. Just east of New Moscow, this clay has a similar thickness where exposed at an altitude of 855. Three-fourths of a mile west of New Moscow, Brookville clay is thin where exposed at an altitude of 920 feet.

In the southern part of the township above Adams Mills the position of the Brookville clay is closely indicated by several exposures of Putnam Hill limestone at altitudes ranging 860 to 870 feet, but good exposures of the clay are wanting.

Mill Creek Township. - In Mill Creek Township the Brookville clay is regular in character and occurrence with a thickness which varies from 4 to 7 feet. It is generally overlain by a few inches of Brookville coal which in turn is overlain by a foot or so of Putnam Hill limestone. The altitude of Brookville clay in this township ranges from a low of 955 feet in southern Section 23 to 1,040 feet in Section 5, to 1,060 feet in Section 11. Where exposed along the road in the west central part of Section 22 at an altitude of 970 feet, the clay is gray plastic and sandy with a thickness of 5 to 6 feet. It appears again along the road a short distance west of Mound with a thickness of 4 feet at an altitude of 973 feet. It is closely overlain by one foot of Putnam Hill limestone and underlain by sandy shale which extends downward to the Upper Mercer limestone about 43 feet below. The following measurements of outcrops secured along the road in the central part of Section 8 is typical of the succession involving the Brookville members in Mill Creek Township.

	Ft.	In.
Clay, gray, plastic, Lower Kittanning	5	0
Shale, gray, arenaceous	38	6
Limestone, gray, fossiliferous, Putnam Hill	-	9

	Ft.	In.
Clay shale	-	3
Coal, Brookville or No. 4	1	6
Clay, gray, plastic, siliceous	6	8
Shale, gray, arenaceous	24	4
Coal blossom, Bedford	-	3
Clay, gray, siliceous	5	0

Altitude, 968 ft.

In the southwest quarter of Section 5 about 5 feet of bluish gray sandy micaceous Brookville clay outcrops along the highway at an altitude of 1,040 feet. It is here overlain by 6 inches of shaly Brookville coal close above which is 8 inches of Putnam Hill limestone.

Keene Township. - In Keene Township the Brookville clay is generally present above drainage along all the chief valleys and underlies the high ridges and divides. Scattered exposures of this member indicate that the clay is normal in character for this county with a thickness ranging from 3 to 7 feet. Along the prominent divide east of Little Mill Creek the altitude of this clay horizon ranges from about 920 feet in Section 13 to about 1,040 in Section 1. Where exposed along the road in the east central part of Section 1, the clay is gray plastic and siliceous with a thickness of 5 feet. It is overlain by thin Brookville clay and underlain by arenaceous shale which extends to the Tionesta clay, a distance of 16 feet. Arenaceous shale is also the predominating type extending upward for 56 feet to the Lower Kittanning clay. Similar conditions of thickness and succession prevail at exposures along the road in the northeastern quarter of Section 10. Along the road in the northwest quarter of Section 9, bluish gray siliceous clay, 7 feet in thickness, is exposed at an altitude of 940 feet and probably represents the Brookville horizon.

The Brookville clay as developed along the Mill Creek Valley in the northwestern part of Keene Township is well shown in the following record of exposures along the diagonal road west of Keene and about $1\frac{1}{4}$ miles southwest of School No. 4.

Clay, Lower Kittanning	3	0
Shale and covered	42	0
Limestone, gray, shaly, Putnam Hill	-	8
Coal, weathered, Brookville or No. 4	1	0
Clay and covered	5	0
Shale and covered	23	4
Coal smut, Tionesta or 3b	-	2
Clay, gray, and covered	7	0
Shale, gray, arenaceous	19	8
Coal blossom, Bedford	-	6
Clay, gray, plastic, and covered	4	0
Shale and covered	10	4
Limestone, dark bluish gray, shaly, fossiliferous, Lower Mercer	1	6
Clay and covered, Middle Mercer	6	6
Shale, arenaceous	7	0

Altitude, 850 ft.

Few exposures of the Brookville clay horizon have been noted in the southern part of Keene Township owing in part to the veneer of alluvial deposits which are so prevalent in the southern facing slopes of the Walhonding-Tuscarawas valleys. About three-fourths of a mile west of Canal Lewisville a road ascends the steep northern bank of the Tuscarawas River. Along the road bed the different strata are well exposed from the Upper Mercer limestone to the Lower Kittanning coal. The Brookville horizon is here apparently replaced by sandy shale.

Tuscarawas Township. - Outcrops of the Brookville clay horizon are due along the valleys of the Tuscarawas and Muskingum rivers at altitudes ranging from about 775 feet in the southwest corner to about 875 feet in the northeast corner. Owing to the widespread presence of surface deposits along these valleys no exposures of the Brookville clay were observed.

Franklin Township. - There is little evidence of Brookville clay on the outcrop in Franklin Township. The crop line of this member lies close to the level of the valley flats along the Muskingum River and the valley of Wills Creek nearly to the village of Wills Creek where unconsolidated deposits mantle the bedrock surface.

Lafayette Township. - Brookville clay occurs in Lafayette Township in normal thickness and development. As exposed along the east side of the valley of Morgan Run a mile from its mouth, it is gray, plastic, and siliceous with a thickness of 5 feet. It is overlain by 1 foot 11 inches of impure Brookville coal close above which is the Putnam Hill limestone. The top of the clay at this locality occurs 23 feet 7 inches below the base of the Vanport limestone and 94 feet below track level at an abandoned mine in Middle Kittanning coal.

Brookville clay is well exposed along the road just above the Burt School located in the southwest quarter of the township. The succession involving this clay as exposed along the road is as follows:

	Ft.	In.
Coal blossom, Lower Kittanning	-	8
Clay, shale, and covered	36	8
Limestone, gray, fossiliferous, Putnam Hill	-	5
Clay, gray, Brookville	4	10
Shale and covered	32	11
Limestone, dark, blocky, Upper Mercer	-	8
Clay, dark bluish gray, Bedford	3	6
Altitude, 901 ft.		

White Eyes Township. - In White Eyes Township the Brookville clay outcrops at altitudes ranging from 930 feet to 1,040 feet along the high ridge extending in general from Section 24 northwest to Section 5. Outcrops are likewise due near the crests of the highlands east of White Eyes Creek where the altitude of the crop line varies from 940 feet in the southeast corner to 1,000 feet in the northeast corner. Scattered exposures in these areas indicate that the Brookville clay is a persistent member varying in thickness from 4 feet to 5 feet 6 inches. The overlying coal is generally less than 1 foot 6 inches in thickness. The following description of exposures along the east-west road in the east-central part of Section 17 shows the Brookville clay in typical development for this township.

Shale, gray, sandy	19	0
Limestone, black, shaly	1	0
Shale, gray, siliceous	7	7
Limestone, dark gray, fossiliferous, Putnam Hill	1	2
Clay shale	-	3
Coal, Brookville or No. 4	-	6
Clay, bluish gray, ferruginous, sandy, Brookville	5	6
Shale, gray, siliceous	20	10
Smut streak, Bedford	-	2
Clay and covered	4	0
Altitude, 980 ft.		

In the southeastern part of the township about three-fourths of a mile west of Bowman School, the Brookville clay is exposed along the road at an altitude of about 960 feet. The clay is micaceous and siliceous in composition with a thickness of 5 feet. It is overlain by thin Brookville coal above which is 6 inches of Putnam Hill limestone. At this locality the interval from the top of Brookville clay to the Upper Mercer limestone is 48 feet; to the Vanport member, 26 feet; and to the top of the Lower Kittanning clay, about 40 feet. In the east central part of Section 7, 5 feet 4 inches of Brookville clay is exposed along the road at an altitude of 895 feet. At this locality the lower part of the bed is quite sandy. The thickness of the Brookville clay is 4 feet at exposures in the southeast quarter of Section 5. Here the clay is overlain by 1 foot 4 inches of Brookville coal and above the coal is thin nodular Putnam Hill limestone.

Crawford Township. - The Brookville clay is generally present where due on outcrop in Crawford Township. It underlies all the high ridges and uplands and meets the surface in a long crop line which ranges in altitude from 1,000 feet in the southeast corner of the township to approximately 1,080 feet along the northern border. Measured exposures of the clay range from 4 feet 6 inches to 7 feet 8 inches. The clay is often overlain by a few inches of coal. The Putnam Hill limestone which overlies the coal is generally less than 1 foot in thickness in this township.

Brookville clay occurs in good development along the ridge west of White Eyes Creek in eastern Crawford Township. As exposed along the east-west road $1\frac{1}{2}$ miles southwest of Baltic it is 4 feet 6 inches thick but the lower part is quite sandy. At exposures one-half mile east of Halifax School the Brookville horizon is represented by 5 feet of gray plastic clay overlain by 9 inches of coal cropping out at an altitude of 923 feet. It has similar thickness and lithology at exposures along the road in central Section 22. The following description of outcrops along the diagonal road in the southeast quarter of Section 13 shows the Brookville clay and its stratigraphic relation to closely overlying and underlying beds.

	Ft.	In.
Limestone, bluish gray, shaly, Putnam Hill	-	6
Shale, soft	-	4
Coal blossom, Brookville or No. 4	-	6
Clay, bluish gray, siliceous	7	8
Shale, light gray, sandy	17	0
Clay, light gray, Tionesta	5	0
Shale, gray, arenaceous	26	0
Limestone, dense, black, Upper Mercer	-	6
Clay, gray, plastic, Bedford horizon	3	0

Altitude, 996 ft.

In the central part of Section 25 the Brookville horizon is represented by 7 feet of gray very sandy clay overlain by 1 foot 4 inches of Brookville coal. The Putnam Hill limestone is absent at this locality, the coal being immediately overlain by gray shales. The position of the clay and coal, however, is normal for this county as the interval from the top of the clay of the Bedford coal is 48 feet and to the Middle Kittanning coal, 81 feet. At the northeastern edge of Section 6, the horizon of the Brookville clay is apparently occupied by shale and shaly sandstone.

Adams Township. - The horizon of the Brookville clay is above drainage along the entire extent of the valleys of Evans Creek and the East Fork of White Eyes Creek in Adams Township. The altitude of the horizon varies in general from about 1,000 feet in the north central part to about 880 feet in the southeast corner, but the direction and amount of inclination is by no means regular and uniform throughout the county. The Brookville clay is generally present where due with a thickness ranging from 3 to 8 feet and with lithologic characteristics normal for this county. It is generally overlain by Brookville coal which in turn is found close below Putnam Hill limestone, one foot or less in thickness.

Along Evans Creek at Powell the Brookville is represented by 7 feet 4 inches of gray plastic clay exposed along the road at an altitude of about 970 feet. The clay measures 4 feet in thickness at exposures along the highway one mile east of Woods School where it is of the plastic siliceous type. It is overlain by thin Brookville coal and this in turn by one foot of Putnam Hill limestone. The top of the clay outcrops 44 feet above the Upper Mercer limestone which is heavily developed at this locality. The exposures along the road three-fourths of a mile southeast of Myser School, as described in the following section, are typical of the succession occurring in the upper part of the valley of East Fork.

	Ft.	In.
Coal blossom, Middle Kittanning or No. 6	1	0
Clay, gray, plastic, siliceous	4	0
Shale and covered	58	4
Limestone, bluish, compact, Vanport	1	0
Shale and covered	26	0
Limestone, gray, dense, fossiliferous, Putnam Hill	1	0
Shale	-	6
Coal, Brookville or No. 4.	2	0
Clay, gray, plastic, siliceous	4	0
Shale, gray, sandy	27	4
Coal blossom, Tionesta or No. 3b	-	6
Clay and covered	3	0

Altitude, 915 ft.

Along the valley of Evans Creek in the eastern part of Adams Township the altitude of the Brookville clay ranges from 900 feet in the west central part of Section 22 to 980 feet in the southwest quarter of Section 2. This clay has a thickness of 3 feet as exposed along the road just below the Hoffman School. It is dark, plastic, and siliceous in character and is directly overlain by 1 foot of impure coal. The top of the clay has an altitude of 965 feet and is found 40 feet below the Vanport flint and 60 feet below the Lower Kittanning coal which outcrop on the hillside above it. Three-fourths of a mile southeast of Bakersville the Brookville is a gray, plastic, siliceous clay having a thickness of 5 feet and outcropping at an altitude of 940 feet. Brookville clay of similar character and thickness occurs in the hills just northwest of Bakersville at an altitude of about 980 feet.

Oxford Township. - The horizon of the Brookville clay is easily identified in Oxford Township as the closely overlying Putnam Hill limestone is persistent, varying from a few inches to 2 feet in thickness. The clay horizon is due above drainage along the Tuscarawas Valley but few exposures have been found on the valley-facing slopes. In the southwestern and southern parts Brookville clay is generally present outcropping along numerous tributaries to Wills Creek at altitudes ranging from about 900 feet on the west to 860 feet near the southeast corner. Along a small northern tributary to Center Creek about one-half mile from the west boundary of the township, Brookville clay, about 6 feet in thickness, outcrops at an altitude of 900 feet. The clay is siliceous and micaceous in composition and is immediately overlain by 10 inches of Brookville coal. Here the top of the clay occurs 43 feet 6 inches below the Lower Kittanning coal and 74 feet below the Middle Kittanning coal. At exposures along the valley of Center Creek, one mile west of Morrison corners, 3 feet of Brookville clay is immediately overlain by a foot of Putnam Hill limestone, the Brookville coal being wanting. The altitude of the clay at this locality is 886 feet which is 41 feet below Middle Kittanning coal. Brookville clay is well exposed along the road in the northeast corner of Section 21, where the following measurements were secured.

Limestone, gray, fossiliferous, Putnam Hill	1	5
Shale, carbonaceous	-	5
Coal, shaly, Brookville or No. 4	-	4

	Ft.	In.
Clay, gray, plastic, sandy, micaceous, Brookville	5	10

Altitude, 850 ft.

The top of the Putnam Hill shown in this section occurs 84 feet below track level at an abandoned mine in Middle Kittanning coal located one-fourth mile northwest of the limestone exposures.

Linton Township. - In Linton Township the Brookville clay is due not far above drainage along Wills Creek from the eastern edge of Section 13 to the western part of Section 24 where its horizon passes below the level of the flood plain. Owing to its nonresistant character and to the general presence of alluvial deposits in this valley, the Brookville clay is seldom clearly exposed for examination and measurement. A short distance south of Plainfield, Brookville clay and underlying beds outcrop along the road and in a ravine in the central part of Section 11. A description of the exposures is as follows:

		Ft.	In.
Clay, gray, plastic, siliceous, Brookville		2	0
Shale, ferruginous		2	0
Shale, gray, siliceous		13	10
Covered interval		54	10
Limestone, dark, shattered by weathering. .	Lower Mercer	2	10
Limestone, gray black, dense. .		-	8

Altitude, 763 ft.

No evidence of the Brookville coal or of the Putnam Hill limestone which normally lies close above it was found at this place. The interval at this locality from the base of the Lower Mercer limestone to the Brookville clay is 74 feet which is about average for this county. In the north central part Section 21, Linton Township, the Brookville exposed consists of one foot of gray plastic clay underlain by 2 feet of buff impure sandy clay. The coal has a thickness of 11 inches and is overlain by thin nodular limestone representing the Putnam Hill member. The altitude of the limestone at this locality is 836 feet.

ALLEGHENY SERIES

In his report of the geology of Pennsylvania, published in 1858, Rogers called the series closely overlying the Seral conglomerate (now Pottsville) and containing some valuable coal beds the Older Coal Measures[1] or Lower Coal Measures. As the coal beds of this group were early explored and developed along the Allegheny River they were widely known as the Allegheny Group or the Allegheny River Series. In 1873, J. J. Stevenson defined this series as extending from the great conglomerate to the base of the Mahoning sandstone.[2] Following the general classification of Rogers this series in Ohio was long termed the Lower Coal Measures or the Lower Productive Measures. According to present terminology the Allegheny series in this State includes all the strata from the base of the Brookville coal to the top of the Upper Freeport coal.

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[1]Rogers, H. D., Geology of Pennsylvania, Vol. II, pp. 16, 497, 1858.

[2]Stevenson, J. J., Notes on the geology of West Virginia, Am. Philos. Soc. Trans., Vol. 15, p. 16, 1873.

In Ohio the Allegheny series outcrops over an elongated belt of territory exceeding 2,000 square miles in area, extending entirely across the eastern part of the State from the Pennsylvania line in Mahoning and Columbiana counties to the Ohio River in Scioto and Lawrence counties. The thickness of the series varies from 160 to 280 feet but averages about 212 feet. In Ohio this series is especially rich in coal beds of mineable thickness, in beds of shale and plastic clay suitable for a wide variety of ceramic products, and to a less extent in limestone for agricultural and other uses.

The entire thickness of the Allegheny series is represented in outcrop in Coshocton County. From the geologic map accompanying this report it is evident that the distribution of these outcrops includes parts of every township with the possible exception of Tiverton in the northwest corner. The lower members are much more extensive than the upper units of this series as the latter are confined in their distribution to the higher ridges in the eastern two-thirds of the county. The total thickness of the Allegheny series in Coshocton County is about 170 feet. In character it consists chiefly of sandstone and shale. The various coal, clay, and limestone members have a relatively small aggregate thickness but nevertheless are of chief economic importance. The most prominent members of the Allegheny series in Coshocton County are the Brookville, Lower Kittanning, and Middle Kittanning coals, and the Putnam Hill limestone. The succession of members together with a lithologic description and mean thickness of each are given in the average section on opposite page.

Brookville Coal

STRATIGRAPHY, EXTENT, AND VALUE

The Brookville coal was first named by Rogers in 1858 for its occurrence in Jefferson County, Pennsylvania, where it is found close above the well developed Tionesta (Homewood) sandstone.[1] Later work by I. C. White extended the occurrence of this member through Beaver, Lawrence, and Mercer counties in western Pennsylvania to the state boundary.[2] In Ohio, the Brookville horizon can be traced with fair continuity on the outcrop from Mahoning County to Scioto County, but local wants are numerous due to the overlying Clarion sandstone transgressing the horizon. The Brookville coal is generally thin and economically unimportant in Ohio except in Vinton County and in southwestern Stark County and areas adjacent to it on the south and west where the coal is thick enough for mining. Throughout the central part of its field of outcrop in Ohio the position of the Brookville coal is made evident by the presence of the Putnam Hill limestone close above it.

In Coshocton County the Brookville coal horizon reaches the surface in parts of every township except Tiverton in the northwest corner. As it is the lowest member of the Allegheny series the position and distribution of its outcrops are indicated on the geologic map accompanying this report by the line of contact between the Pottsville and Allegheny series. In the field, outcrops of this coal are often rendered conspicuous by the presence of the gray Putnam Hill limestone which closely overlies the coal and which is prominently developed in part of the county. The Brookville coal is generally present where due on the outcrop in Coshocton County but it is wanting in a few small areas through lack of deposition and in others through replacement by sandstone. Where present the coal ranges in thickness from a mere soot streak to 5 feet 4 inches, but the usual measurements are between 1 and 2 feet. More than 40 measurements on the outcrop yield an average for this bed of 1 foot 4 inches. Where the coal is thin it is often soft and shaly. Thicknesses sufficient for mining are usually broken by one or more shale partings and generally cover small areas. In Coshocton County the stratigraphic position of the Brookville coal is on an average 73 feet above the base of the Lower Mercer limestone, 45 feet above the Upper Mercer limestone, 45 feet below the Lower Kittanning coal, and 80 feet below the Middle Kittanning coal. Brookville coal has been mined in a small way from a few

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[1] Rogers, H. D., Geology of Pennsylvania, Vol. II, p. 490, 1858.

[2] Second Geol. Survey, Pa., Repts. Q, QQ, QQQ, 1878-1880.

Average Section of the Allegheny Series in Coshocton County

Member	Character and General Description	Thickness Ft.	In.
Upper Freeport or No. 7	Coal, shaly, and carbonaceous shale, locally present	--	6
	Clay, gray, plastic, calcareous	3	0
Upper Freeport	Sandstone, local, generally replaced by sandy shale	22	3
Lower Freeport or No. 6a	Coal, shaly, and carbonaceous shale, local in occurrence	--	9
	Clay, gray, calcareous, locally present	3	0
Lower Freeport	Sandstone, very local, horizon generally occupied by sandy shale	57	0
Middle Kittanning or No. 6	Coal, bony to shaly, and carbonaceous shale	--	3
	Coal, good	2	8
	Shale parting, persistent	--	1
	Coal, good	--	9
	Clay, gray to bluish gray, arenaceous	3	4
	Shale, gray to bluish gray, with iron carbonate nodules	25	10
Hamden	Shale, dark, carbonaceous, fossiliferous	4	0
Lower Kittanning or No. 5	Coal, generally thin	1	10
	Clay, gray, plastic	5	8
	Shale, gray to bluish gray	5	0
Ferriferous	Iron carbonate ore, local in occurrence	--	2
Vanport	Limestone, shaly, with much light-colored flint, not persistent	3	6
	Shale, dark	1	0
Clarion	Coal, thin, locally present	--	3
	Clay, gray, plastic	4	8
Clarion	Sandstone, local in occurrence, horizon generally represented by arenaceous shale	20	6
Putnam Hill	Limestone, dark gray, generally dense, fossiliferous	2	1
	Shale, dark	--	4
Brookville or No. 4	Coal, generally thin	1	4

scattered openings in Newcastle, Bedford, Jefferson, Clark, and Adams townships. As this coal bed adds little to the economic resources of the county, its character and occurrence are traced here in only a very general manner.

Newcastle Township. - In Newcastle Township the horizon of the Brookville coal comes to the surface near the summit of the high ridge extending to the east and southeast from Newcastle. Here the altitude of the coal ranges from 1,180 to 1,210 feet. No good exposures of the coal were found in this vicinity. The coal was formerly mined, however, from several openings along this ridge. At one opening half a mile northeast of Newcastle, the coal is described as "two and one-half feet thick, and much mixed with small seams of shale and pyrites."[1] It has a similar thickness 1½ miles southeast of Newcastle but the coal is of better quality with not so much sulphur.[2]

In Newcastle Township the coal is everywhere closely overlain by Putnam Hill limestone several feet in thickness.

Perry, Pike, and Washington Townships. - In Perry Township Brookville coal is due close below the Putnam Hill limestone at an altitude of about 1,120 feet near Wilson Chapel in sections 1 and 2, but no exposures were observed at this locality. It is likewise due near the crest of the high ridge extending from southwestern Section 10, through northeastern Section 12, and south central Section 11. Where exposed at the crossroads at the central west edge of Section 11 the Brookville is represented by 6 inches of black shale and shaly coal occurring 4 inches below 6 feet 10 inches of Putnam Hill limestone.

Southeast of Winding Fork Valley the horizon of the Brookville coal outcrops high on the slopes of Graham Ridge in eastern Pike and western Washington townships at altitudes ranging from about 1,000 to 1,050 feet. Scattered exposures indicate that the coal is only a few inches in thickness. Similar conditions of development are indicated for the Brookville along the high ridges northwest and southeast of Sand Fork in the northeastern half of Washington Township where its altitude ranges from 980 feet in Section 8 to 940 feet in Section 20.

Bedford Township. - In Bedford Township the Brookville coal is generally present where due on the outcrop ranging in thickness from a minimum of 2 or 3 inches to more than 4 feet. The position of the outcrops is high on the sides of the high ridges and divides where they range in altitude from about 1,060 feet in sections 5, 15, 16, and 25 along the western border to about 940 feet in Section 21 in the southeast corner. The coal seems to occur in best development in the north central part of the township and to decrease rapidly in thickness to the south. The following measurements of Brookville coal secured by T. R. Meyers in an abandoned mine in the northeast quarter of Section 4 shows the structure and thickness of the coal in its best development in this township.

	Ft.	In.
Limestone, gray, Putnam Hill	3	6
Clay shale, gray	-	2
Coal, fair quality	-	11
Shale, parting, dark	-	1½
Coal, fair quality	3	3

(Coal, fair quality; Shale, parting, dark; Coal, fair quality — Brookville or No. 4)

Brookville coal was formerly mined on the Hogan property in the northwest quarter of Section 4. A description of the bed at this locality as reported by Mr. Meyers is as follows:

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[1] Hodge, J. T., Geology of Coshocton County, Geol. Survey Ohio, Vol. III, p. 575, 1878.

[2] Op.Cit.

		Ft.	In.
Coal, good quality		1	0
Shale, hard, black		-	2
Coal, good quality	Brookville or No. 4	2	0
Shale, hard, black		-	2
Coal, good quality		1	0

Due to the presence of a fault which was encountered in this mine the operation was abandoned.

Brookville coal thins rapidly when traced south from the northern part of Section 4. Where exposed along the east-west road in the southwest quarter of Section 4 the coal is reported to have a thickness of about 1 foot 10 inches, broken near the top by a 3-inch shale parting. In the east central part of Section 8 the Brookville is represented by 2 feet 2 inches of coal closely underlying 6 feet of Putnam Hill limestone and exposed at an altitude of 1,015 feet. The following section secured by T. R. Meyers along the abandoned northwest-southeast road in the northeast quarter of Section 16 shows the Brookville coal as developed in the vicinity of West Bedford.

Sandstone, micaceous, ferruginous, shaly		5	0
Coal, clayey		-	2½
Shale, carbonaceous		-	6
Clay shale		1	0
Covered interval		14	1
Shale, carbonaceous		-	3
Shale, sandy, and covered		11	11
Limestone, gray, dense, fossiliferous, Putnam Hill		4	1
Clay shale		-	4
Coal smut, Brookville or No. 4		-	3
Clay and covered		5	5
Clay shale, bluish		5	0
Covered interval		13	1
Flint, dark bluish, ferruginous, fossiliferous, Upper Mercer		-	9
Shale		-	2
Coal, shaly		-	3
Clay shale with carbonaceous streaks	Bedford	-	10
Clay, gray		1	0
Altitude, 1,026 ft.			

The Brookville coal has a thickness of 1 foot as exposed at an altitude of 1,000 feet just west of the Union Church in Section 23. Here it is split near the middle into two benches by a parting one inch in thickness. Near the McCurty School in the southeast quarter of Section 19 Brookville coal, 2 feet in thickness, crops out along the road at an altitude of 958 feet. Five feet seven inches of Putnam Hill limestone closely overlies the coal.

Jefferson Township. - In Jefferson Township south of the Walhonding River the Brookville coal is generally only a few inches in thickness where it outcrops along the high ridge east of Simmons Run. West of Simmons Run it occurs in better development along the high ridges bordering Flint Run. Where exposed along the diagonal road crossing this stream near its head the coal has a thickness of 1 foot 7 inches and is immediately overlain by 4 feet 2 inches of Putnam Hill limestone. The altitude of the coal at this locality is 1,022 feet, along a small ravine west of Flint Run and about one mile south of east from Mohawk Village. Mr. Meyers reports

3 feet 6 inches of Brookville coal underlying 3 feet of Putnam Hill limestone exposed at an altitude of about 1,080. This locality is less than one mile north of the old Hogan mine in Section 4, Bedford Township.

North of the Walhonding River outcrops of the Brookville horizon are confined to the high knobs and ridges in sections 1 and 10. The following section by T. R. Meyers is descriptive of the exposures along the northeast-southwest road ending at the east edge of Section 10.

	Ft.	In.
Limestone, weathered, Putnam Hill	1	0
Clay shale	-	2
Coal blossom, Brookville or No. 4	-	3
Shale, sandy	13	4
Shale	2	6
Iron carbonate ore, steel gray, weathers brown	-	5
Clay shale with ore nodules	5	2
Flint, black, badly weathered, Upper Mercer	-	8
Coal smut, with clay, Bedford	-	3
Clay, light, plastic	1	0

Altitude, 1,003 ft.

In Section 1 the Bedford coal with overlying Putnam Hill limestone have been replaced by heavy-bedded sandstone.

Monroe Township. - The Brookville coal is represented by a few inches of black shale where it outcrops along the road just south of Spring Mountain at an altitude of 1,160 feet. On the high ridge northwest of Spring Mountain a thin coal blossom representing the Brookville horizon outcrops at several places near Harmony Church in Section 6 at altitudes ranging from 1,250 to 1,260 feet. The Putnam Hill limestone was not observed at these localities.

East of Spring Mountain the Brookville is due along the high ridges north and south of Hoagland Run, but sandstone has replaced the coal over much of this area. Where exposed on the N. J. Markley property in the southwest quarter of Section 19, the Brookville coal has a thickness of 1 foot 6 inches and is directly overlain by 6 feet of Putnam Hill limestone.

North of the valley of Big Run, Brookville coal is due near the summits of the highest hills and ridges in sections, 1, 2, 3, 4, and 5. Sandstone seems to occupy the position of the coal over much of this area. At the central northern edge of Section 8 the Brookville horizon is represented by a few inches of coal exposed along the road at an altitude of 1,125. The Putnam Hill limestone is wanting at this locality.

Clark Township. - The Brookville coal is irregularly developed in Clark Township for in a few places it is present in sufficient thickness for mining in a small way and at other localities it is only a few inches in thickness or its horizon may be occupied by sandstone. In the northeast corner of Section 22, Brookville coal was formerly mined in a small way on the Lowe property. Here the thickness of the coal is about 3 feet and the interval from the base of the coal to the Upper Mercer limestone is about 43 feet. In the east central part of Section 21 the Brookville coal and clay as well as the overlying Putnam Hill limestone have been replaced by massive sandstone. The coal appears in the succession again in the east central part of Section 20, where the altitude of prospect diggings is about 990 feet. Old working in the west central part of Section 20 indicates that the coal was formerly mined there in a very small way, but a measurement of the coal could not be secured. The altitude of the old diggings is 998 feet or about 70 feet above the Lower Mercer limestone exposed lower on the same hillside. No outcrop of the Putnam Hill limestone was found at this locality. The stratigraphic relations of the

Brookville coal are well shown in the following section secured along the road and ravine in the northeast quarter of Section 22.

	Ft.	In.
Shale, carbonaceous, Lower Kittanning or No. 5 coal horizon	-	4
Clay, gray, plastic	5	0
Covered interval	35	0
Limestone, dark bluish gray, shaly, Putnam Hill	-	6
Coal blossom, Brookville or No. 4	1	8
Clay, gray, short	1	8
Shale, gray, sandy	5	0
Covered interval	33	4
Limestone and black flint, Upper Mercer	2	0

Altitude, 989 ft.

Few exposures of the Brookville coal have been observed in the northern part of Clark Township. Along the road about $1\frac{1}{8}$ miles west of Shepler School this horizon is closely indicated by float from the overlying Putnam Hill at an altitude of approximately 1,022 feet. No exposure of the coal was found on the hill east of Layland, but the Putnam Hill limestone has been encountered in a water well at an altitude of about 1,080 feet. West of Killbuck Creek this coal horizon is due near the crest of the high ridges in Section 15 and north of Green Valley School in Section 14 but here its place is taken by sandstone.

Bethlehem Township. - In Bethlehem Township the Brookville coal is generally wanting east of Killbuck Creek and north of the Walhonding River due to replacement by sandstone. West of Killbuck Creek the Brookville is represented by a few inches of coal outcropping near the crest of the ridge a mile west of south from Metham. South of the Walhonding River it is of uncertain occurrence along the ridges extending southwest from Randle and the Soggy Hill School due to sandstone replacement. The Brookville coal appears in good development, however, in the extreme southwestern corner of the township. Here it is represented by 2 feet 8 inches of coal closely underlying 5 feet of Putnam Hill limestone and outcropping 36 feet above the base of the Upper Mercer limestone and 61 feet above the base of the Lower Mercer limestone. The coal bed is normal in structure in that it is composed of two benches separated by a 2-inch shale parting.

Jackson Township. - In Jackson Township the horizon of the Brookville coal reaches the surface at altitudes ranging from about 1,000 feet in the northwest corner to about 840 feet north of Franklin in the southeast corner. Over much of the northeastern half of this township, including the Walhonding and Muskingum valleys and smaller valleys tributary thereto, the crop line of the Brookville coal is occupied by sandstone. In the southwestern half of the township the normal descending succession of Putnam Hill limestone, Brookville coal, and Brookville clay seems to prevail although the crop line is confined chiefly to the valleys of Simmons Run and Moscow Brook and exposures are not plentiful. Here the Brookville is generally represented by a few inches of carbonaceous shale or shaly coal. The following skeleton record of outcrops along the road near the central south edge of Section 13 shows the relation of the Brookville coal to the Upper Mercer and Putnam Hill limestones and to the Middle Kittanning coal.

Smut streak, Middle Kittanning or No. 6	-	-
Covered interval	87	6
Limestone, bluish gray, a little shaly, Putnam Hill	2	6
Coal blossom, Brookville or No. 4	1	0

	Ft.	In.
Covered interval	39	0
Limestone and black flint, Upper Mercer	1	6
Altitude, 881 ft.		

Along Moscow Brook where the horizon of the Brookville occurs above drainage south of central Section 14, this member is generally represented by a few inches of black shale and shaly coal. A similar condition seems to prevail in the valley of Simmons Run. A local thickening of the coal apparently occurs in Section 5 where it is reported to have been formerly mined in a small way for local use.[1] No good exposures of the coal were found by the writer in this section.

Virginia Township. - The horizon of the Brookville coal occurs above drainage level along all the chief water courses in Virginia Township. The member is generally present where due on the outcrop, but at all localities observed in the field, it is thin consisting of only a few inches of carbonaceous shale and shaly coal overlying a bed of gray plastic clay. It is easily recognized for thin Putnam Hill limestone is generally present in this township close above the coal. Along a tributary to Barnes Hollow in the southeast quarter of Section 21, the Brookville is represented by a 6-inch coal blossom outcropping at an altitude of 838 feet. It is immediately overlain at this locality by 1 foot of gray fossiliferous limestone representing the Putnam Hill member. The following section was secured along the diagonal road ascending the west bank of the Mill Fork Valley in the south central part of Section 2.

Limestone, gray, fossiliferous, Putnam Hill	2	6
Shale, dark, argillaceous	-	4
Shale, carbonaceous, Brookville or No. 4 coal horizon	-	6
Clay, gray, siliceous, micaceous	3	0
Shale, arenaceous	10	0
Altitude, 958 ft.		

At this locality the Brookville coal horizon occurs 89 feet below the Middle Kittanning coal exposed higher on the hillside.

The relation of the Brookville coal to overlying members appears in the following measurement of outcrops along the diagonal road one-half mile northwest of Wright School.

Sandstone, soft, friable. Not measured	-	-
Coal blossom, Middle Kittanning or No. 6	2	0
Shale and covered	16	0
Clay, gray, plastic	5	0
Shale and covered	60	0
Limestone, gray, shaly, Putnam Hill	-	8
Smut streak, Brookville or No. 4 coal horizon	-	2
Clay, gray	6	0
Altitude, 912 ft.		

Good exposures of the Brookville member have been observed at a few localities along Moscow Brook in the vicinity of Moscow, but the coal is so thin it lacks economic importance.

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[1] Hodge, J. T., Geology of Coshocton County, Geol. Survey Ohio, Vol. III, p. 583, 1878.

As it appears along the east-west road one mile north of the village, it is represented by a 10-inch blossom exposed at an altitude of 906 feet. Three-fourths of a mile southwest of New Moscow it is represented by a 2-inch blossom outcropping at an altitude of 922 feet, which is 62 feet above the Upper Mercer flinty limestone and 74 feet below the Middle Kittanning coal.

Mill Creek Township. - In Mill Creek Township the Brookville coal is confined in its distribution to the high ridges and divides which tend to trend in a northeast-southwest direction. The crop line of this coal horizon is represented on the geologic map accompanying this report by the line of contact between the Allegheny and Pottsville series. Brookville coal is generally present where due in Mill Creek Township, but it is lacking in economic appeal as it is everywhere thin and impure. Field measurements show variations in thickness ranging from a few inches to 1 foot 6 inches with an average of about 9 inches. The coal is underlain by a bed of gray plastic clay and generally closely overlain by Putnam Hill limestone which in this township is one foot or less in thickness.

Brookville coal is generally represented by a few inches of coal where exposed along the divide between Mill Creek and Little Mill Creek. As exposed along the road south of Mound School in the west central part of Section 22 it is represented by 4 inches of coal outcropping at an altitude of 970 feet. The interval here to the Lower Kittanning coal is 49 feet and to the Middle Kittanning coal 88 feet. At outcrops one-half mile farther south, the coal measures 9 inches in thickness immediately below 6 inches of Putnam Hill limestone. Here the Brookville occurs 36 feet 7 inches above the Upper Mercer limestone and 66 feet 9 inches above the Lower Mercer limestone.

In the northwest quarter of Mill Creek Township, Brookville coal is found underlying the uplands and cropping out at altitudes ranging from 980 to 1,040 feet. It has a thickness of 1 foot 6 inches where exposed along the highway in the central part of Section 8 at an altitude of 1,005 feet. Here it is closely overlain by a 9-inch bed of Putnam Hill limestone above which gray sandy shale extends to the Lower Kittanning clay, a vertical distance of $38\frac{1}{2}$ feet. Siliceous shale likewise underlies the Brookville clay at this locality and extends downward to the Upper Mercer limestone horizon. The following section shows the details of the Brookville horizon as exposed along the road in the southwest quarter of Section 5.

	Ft.	In.
Limestone, bluish gray, fossiliferous, Putnam Hill	-	8
Shale	-	10
Coal, shaly, weathered, Brookville or No. 4	-	6
Clay, bluish gray, siliceous, micaceous	5	0

Altitude, 1,034 ft.

About one-half mile northwest of Mound the Brookville coal crops out along the diagonal road at an altitude of 973 feet. The coal has a thickness of 1 foot and is here exposed 47 feet above the Upper Mercer limestone and 88 feet above the Lower Mercer limestone. West of Turkey Run in southwestern Mill Creek Township sandstone occurs on the Putnam Hill horizon.

Keene Township. - In Keene Township stream erosion has so deepened the valleys that the field of Brookville coal has been cut into a number of patches or elongated areas underlying the higher hills and ridges. The altitude of this coal horizon varies from 860 feet at the central southern edge of the township to 980 feet at the northwest corner, to 1,040 feet in the northeast corner. Scattered exposures in Keene Township indicate that the Brookville coal is generally present where due on the outcrop but that it invariably measures less than 1 foot in thickness and therefore has slight economic importance. It is immediately underlain by gray plastic clay, and is generally closely overlain by Putnam Hill limestone which is 1 foot or less in thickness in this township. The following section secured along the north-south road in the northeast quarter of Section 1 is typical for the succession involving the Brookville coal in the eastern half of this township.

	Ft.	In.
Shale, not measured	-	-
Clay, yellowish gray, sandy, Middle Kittanning	5	0
Shale, gray, siliceous, upper part ferruginous	55	0
Limestone, dark, dense, fossiliferous, Putnam Hill	-	3
Shale, dark, soft.	-	4
Coal blossom, Brookville or No. 4	1	0
Clay, gray, siliceous	5	0
Shale, siliceous	16	0
Clay, dark, plastic	5	0

Altitude, 1,005 ft.

The succession involving the Brookville member seems to be normal in exposures west of Mill Creek in northwestern Keene Township. Along the road west of School No. 4 this horizon outcrops at an altitude of 960 feet. One mile west of Keene, Brookville coal 1 foot in thickness outcrops along the diagonal road at an altitude of 936 or 72 feet above the Lower Mercer limestone and 46 feet below the Lower Kittanning coal horizon exposed on the same hillside. The Brookville coal is here directly overlain by 8 inches of Putnam Hill limestone and underlain by thin plastic clay.

About three-fourths of a mile west of Canal Lewisville a road ascends the steep northern bank of the Tuscarawas Valley. Exposures along this road indicate that the Brookville horizon is replaced by sandy shale.

Tuscarawas Township. - In Tuscarawas Township outcrops of the Brookville coal are due along the Muskingum-Tuscarawas Valley at altitudes ranging from 800 feet in the southwest corner to 870 feet along the eastern boundary near the mouth of Morgan Run. No exposures of the Brookville coal were found in this township.

Franklin Township. - In Franklin Township outcrops of the Brookville coal are due close above the valley flats along Muskingum River and close to drainage level along the lower courses of its chief tributaries. Owing to the general presence of mantle deposits, few exposures of this member were found in Franklin Township. One exposure along the south fork of Barnes Hollow near the west line of the township showed 6 inches of Brookville coal immediately below 1 foot of gray fossiliferous limestone representing the Putnam Hill member. The altitude of the exposure at this locality is about 937 feet or about 70 feet below exposures of Middle Kittanning coal on the hills south of Barnes Hollow. A second exposure located along the east slope of the Muskingum Valley two miles northeast of Conesville yielded the following section.

		Ft.	In.
Shale, carbonaceous, weathered, Brookville or No. 4 coal horizon		1	0
Sandstone, gray, micaceous, shaly.		1	6
Shale, dark gray, sandy		3	0
Shale, dark, siliceous		1	0
Shale, carbonaceous, weathered, Tionesta coal horizon		1	4
Clay, gray, rather short.		3	0
Shale, gray, argillaceous.		2	6
Covered interval.		26	2
Flint, dark.	Upper Mercer	2	10
Limestone, dark.	Upper Mercer	-	6

Altitude, 745 ft.

The carbonaceous shale here interpreted as representing the Brookville coal horizon occurs 70 feet below the level of an old mine opening in Middle Kittanning coal located higher on the hillside.

Lafayette Township. - Brookville coal is generally present where due on the outcrop in Lafayette Township, but it lacks economic importance for its maximum thickness is less than 2 feet and its usual measurements range from a few inches to 1 foot. The altitude of this member is greatest along the axis of the Cambridge Arch in the west central part from the crest of which the beds dip gently to the southeast and more abruptly to the west. The best development of the coal found in Lafayette Township is described in the following section secured along a ravine tributary to Morgan Run about one mile from its mouth.

	Ft.	In.
Shale, gray, siliceous	16	8
Limestone, dark gray, dense (Putnam Hill)	-	6
Shale, bluish gray, calcareous (Putnam Hill)	-	5
Limestone, dark gray, dense (Putnam Hill)	-	4
Shale, bluish gray, calcareous, soft (Putnam Hill)	-	5
Limestone, dark, dense, fossiliferous (Putnam Hill)	-	5
Shale, bluish gray, soft	1	7
Coal, bony (Brookville or No. 4)	-	5
Coal, blocky (Brookville or No. 4)	1	6
Clay, gray, plastic, siliceous	5	0

Altitude, 847 ft.

The Brookville coal at this locality occurs 94 feet below the Middle Kittanning coal which was formerly mined up dip on the hillside to the east.

The Brookville coal is wanting at exposures of its horizon along the road near the Burt School. Here the Putnam Hill limestone lies in contact with the Brookville clay. One foot of coal is present below the limestone, however, at exposures a mile farther south along the prominent eastern-flowing tributary to Wills Creek. The altitude of the coal at this place is 917 feet and the interval to the Middle Kittanning coal, about 75 feet. The coal has a similar thickness at exposures along the north-south road one-half mile south of McLean School. The coal is overlain by 9 inches of Putnam Hill limestone, above which is 40 feet of shale extending upward to the Lower Kittanning coal.

White Eyes Township. - Little economic importance can be attached to the Brookville coal in White Eyes Township for scattered exposures indicate a thickness ranging from a few inches to a maximum of 1 foot 3 inches. The coal is usually overlain by thin Putnam Hill limestone and underlain by a well developed bed of plastic clay. East of White Eyes Creek the horizon of the Brookville member underlies the high ridges north and south of East Fork and crops out at altitudes ranging from 1,000 feet near Chili to 940 feet near the Bowman School in the southeast corner of the township. As exposed along the highway $\frac{1}{2}$ mile west of this school, the Brookville is represented by 1 foot of coal blossom underlying 6 inches of Putnam Hill limestone and outcropping 74 feet below the Middle Kittanning coal. The altitude of the Brookville coal is 963 feet at this place.

West of White Eyes Creek the Brookville horizon underlies the high ridge and lateral spurs extending in general from Section 5 to Section 24. Along the main ridge the altitude of the horizon ranges from 1,060 feet on the north to 980 feet on the south. As exposed along the road in the southeast quarter of Section 5, the Brookville horizon is represented by 1 foot 4 inches of coal overlying 4 feet of gray plastic clay. Its altitude is 1,033 feet or 67 feet below the Middle Kittanning coal. In the east central part of Section 7, Brookville coal, 1 foot 3 inches in thickness on the outcrop, is exposed at an altitude of 895. This coal has a thickness of 6 inches where exposed in the east central part of Section 17 at an altitude of 1,011 feet.

Crawford Township. - In Crawford Township the Brookville coal is generally present where due on the outcrop but it rarely exceeds 1 foot in thickness. Along the valley of White Eyes Creek in the eastern part of the township the altitude of the outcrops ranges from about 980 feet in the central part of Section 21 to about 1,050 feet in the valley a mile below Baltic. As exposed along the east-west road $1\frac{1}{2}$ miles southwest of Baltic the Brookville is represented by 10 inches of coal outcropping at an altitude of 1,054 feet. It is overlain by 1 foot of Putnam Hill limestone and underlain by 4 feet 6 inches of siliceous, plastic clay. The stratigraphic relation of the Brookville coal to underlying members is shown in the following description of outcrops along the road ascending the west slope of the valley in the north central part of Section 11.

	Ft.	In.
Limestone, bluish gray, dense, Putnam Hill	-	5
Shale	-	2
Coal, Brookville or No. 4	-	9
Clay and covered	5	0
Shale and covered	42	9
Limestone and flint, dark } Upper Mercer {	1	6
Limestone, dark, dense }	2	0
Clay, Bedford	5	0
Shale and covered	30	0
Limestone, dark, dense, Lower Mercer	1	6
Coal, Middle Mercer	-	3
Creek level, altitude, 935 ft.		

The horizon of the Brookville coal underlies the high ridge west of the West Fork of White Eyes Creek and crops out at altitudes ranging from 980 feet near Crawford in Section 4 to 1,000 feet in the northwest quarter of Section 23, and 1,060 feet in the southwestern quarter of Section 25. The thickest development of Brookville coal found on the outcrop along this ridge occurs in the north central part of Section 25, where 1 foot 4 inches of coal is exposed along the road at an altitude of 1,047 feet. At this locality the Brookville occurs 48 feet above the Bedford coal and 81 feet below the Middle Kittanning coal.

Adams Township. - The field of outcrops of the Brookville coal horizon in Adams Township includes the high ridge west of East Fork in the northwest part, the ridge between East Fork and Evans Creek in the central part, and the uplands east of Evans Fork in the eastern part of the township. The altitude of the horizon ranges from about 980 feet along the northern border to about 880 in the southeast corner. The coal is generally present where due occurring close below the Putnam Hill limestone which rarely exceeds 1 foot in thickness in this township. The thickness of the coal ranges from a few inches to a maximum of more than 4 feet. Where thickest it has been utilized to a small extent for fuel. Concerning the distribution and character of this coal in Adams Township, Hodge writes as follows:[1] "Throughout the north part of Adams, the coal bed most worked is No. 4, under the gray limestone. It is a bed of inferior character, both as regards the amount and quality of the coal it affords. It is commonly known as the 'double bed' from a seam of fire-clay, about a foot thick, in the middle of the bed. It has been worked half a mile west from Bakersville, where the whole bed was four feet thick, the upper part mixed with cannel coal."

Mining activity in the Brookville coal has nearly ceased in the northern part of Adams Township, and good exposures yielding detailed characteristics of the bed are rare. An opening near the head of a small ravine 1 mile northwest of Woods School together with exposures along the ravine yielded the following section showing the structure and thickness of the Brookville coal and its relation to the Putnam Hill and Upper Mercer limestone.

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[1] Hodge, J. T., Geology of Coshocton County, Geol. Survey Ohio, Vol. III, p. 579, 1878.

		Ft.	In.
Limestone, gray, Putnam Hill		1	6
Shale, dark, soft		-	6
Shale, carbonaceous, and shaly coal	Brookville or No. 4	-	6
Coal	Brookville or No. 4	1	4
Clay shale	Brookville or No. 4	1	0
Coal	Brookville or No. 4	2	6
Covered interval		37	0
Limestone, dark, dense, flinty, shattered, 2 or 3 layers	Upper Mercer	1	8
Limestone, dark, dense, shattered, one bed	Upper Mercer	1	8
Shale and covered	Upper Mercer	5	0
Limestone, black, nodular, somewhat flinty	Upper Mercer	4	0

Altitude, 921 ft.

Brookville coal ranging in thickness on the outcrop from a few inches to 2 feet has been noted at a number of localities along the valley of East Fork. As exposed along the road three-fourths of a mile southeast of the Myser School, it is represented by 2 feet of coal closely underlying 1 foot Putnam Hill limestone. Its altitude at this locality is 950 feet. Seven-eighths of a mile east of Woods School the Brookville coal outcrops along the road at an altitude of 944 feet. Here its position is immediately below the Putnam Hill limestone and 54 feet above the base of the Lower Mercer limestone. Farther south along the valley of East Fork good exposures of the Brookville horizon are found near Powell, but the coal is thin. As exposed one-fourth of a mile east of the school house, it is represented by a 2-inch blossom underlying 8 inches of Putnam Hill limestone and cropping out at an altitude of 970 feet. The following is a record of exposures along the roadside near Hoffman School at the central western edge of Section 18.

		Ft.	In.
Level of abandoned coal opening, Lower Kittanning or No. 5		-	-
Covered interval		20	0
Flinty bed, Vanport horizon		2	6
Shale and covered		37	8
Limestone, gray, Putnam Hill		1	0
Shale, soft, carbonaceous		-	6
Shale, bony, and shaly coal	Brookville or No. 4	-	6
Coal	Brookville or No. 4	-	6
Clay, dark, plastic		3	0

Altitude, 962 ft.

Along the valley of Evans Creek the altitude of the Brookville coal ranges from approximately 900 feet in Section 22 at the south to 980 feet in Section 2 near Bakersville on the north. The general presence of the coal is indicated along this valley by a thin blossom on its horizon at scattered localities. Although the bed is reported to have been formerly worked near Bakersville,[1] no good exposures of the member were found in that locality.

Oxford Township. - The Brookville coal is too thin in Oxford Township to warrant more than stratigraphic interest for it is generally less than 1 foot in thickness and the usual measurements range from 4 to 10 inches. The altitude of its exposures vary from approximately 940 feet in the northwestern corner to 860 feet in the southern part. Outcrops are rare along the Tuscarawas Valley due to the presence of alluvial material but occasional exposures occur along

[1] Hodge, J. T., op. cit., p. 579, 1878.

the valley of Wills Creek and its tributaries in the southern part. Along a small northern tributary to Center Creek, three-fourths of a mile from the west boundary of the township, the Brookville is represented by 10 inches of coal separated from overlying Putnam Hill limestone by 8 inches of ferruginous shale. The altitude of the exposures is here about 900 feet. In the northeast corner of Section 23, the measurement of the coal on the outcrop is 8 inches and its altitude, 875 feet. At this locality the interval to the Middle Kittanning coal is 76 feet which is about average for the county. A similar section is exposed in the northwest quarter of Section 21, where the Brookville horizon is represented by 4 inches of shaly coal. The Putnam Hill limestone, 1 foot 5 inches in thickness, is separated from the coal by 5 inches of carbonaceous shale and the Middle Kittanning coal outcrops 84 feet higher on the hillside.

Linton Township. - The crop line of the Brookville coal horizon is indicated on the geologic map by the contact between the Pottsville and Allegheny series. The distribution of outcrops of this horizon includes the valley of Wills Creek from the eastern margin of the township to Section 24, the valley of White Eyes Creek from the southern boundary of the township and the lower parts of many small valleys tributary to Wills Creek in the west central part of the township. Outcrops of the coal are not numerous owing to the general presence of alluvial deposits in the valleys. As exposed along the road in the central part of Section 11, about 1 mile south of Plainfield, the Brookville horizon is indicated by 2 feet of gray plastic clay outcropping 76 feet above the base of the Lower Mercer limestone. No coal is indicated above the clay at this locality. The coal is present, however, in exposures along the road in the north central part of Section 21. The following is a description of these exposures.

	Ft.	In.
Limestone, gray, nodular, Putnam Hill	-	-
Coal, weathered, Brookville or No. 4	-	11
Clay, gray, plastic.	1	0
Clay, buff, plastic, siliceous	2	0
Altitude, 832 ft.		

Along Bacon Run and other valleys tributary to Wills Creek south of it in Linton Township, the position of the Brookville coal horizon is closely indicated by occasional outcrops of the Putnam Hill limestone, but little evidence of the coal has been found along these valleys.

Putnam Hill Limestone

STRATIGRAPHY, EXTENT, AND VALUE

The stratigraphic position of the Putnam Hill limestone is close above the Brookville coal, the lowest member of the Allegheny series. This limestone, which is confined in its distribution to the central part of the belt of outcrops in Ohio, was first noted by Foster in 1838 who described it as a blue limestone occurring about 60 feet below the summit of Putnam Hill at Zanesville and extending as far west as Mt. Sterling.[1] It was later named the Putnam Hill limestone by E. B. Andrews in 1869[2] for its occurrence at Putnam Hill, Muskingum County, where it was noted by Foster and where it is so well exposed. In many county reports published during the seventies dealing with the Allegheny series the Putnam Hill limestone was generally referred to as the "gray limestone" to distinguish it from a lower lying "blue limestone," the Lower Mercer. From its type locality the Putnam Hill limestone extends in good development on the outcrop to the south in southwestern Muskingum County and in Perry County and to the north and northeast through Muskingum, Coshocton, Holmes, Tuscarawas, Wayne, and Stark counties. It is thin or wanting on the outcrop in Hocking County and in northern Vinton County,

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[1] Foster, J. G., Geol. Survey Ohio Second Ann. Rept., p. 93, 1838.

[2] Andrews, E. B., Report of progress in the second district, Geol. Survey Ohio, Rept. Prog. 1869, p. 88, 1869.

is thin and shaly in southern Vinton County and in Jackson County, and is generally wanting in Lawrence and Scioto counties. The Putnam Hill limestone is of doubtful occurrence northeast of Stark County in southern Portage County and in Mahoning and Columbiana counties and its presence has never been reported in adjoining areas in western Pennsylvania. In its chief field of exposures in east central Ohio the Putnam Hill limestone is generally a dense-textured, gray compact fossiliferous limestone which varies in thickness from a few inches to a maximum of about 13 feet. The average thickness, however, is not far from 3 feet. Its field of thickest development includes outcrops in northwestern Muskingum, Coshocton, Holmes, and Stark counties.

In Coshocton County the Putnam Hill limestone is widely distributed for outcrops occur in every township with the exception of Tiverton located in the northwest corner. In topographic position such outcrops occur high on the prominent hills and ridges in the western part of the county, but owing to the regional dip of the beds exposures are found nearer the valley bottoms in townships along the eastern and southeastern borders. The Putnam Hill limestone is quite persistent on the outcrop in Coshocton County, being generally present where due except over local areas where it is replaced by Clarion sandstone. Its stratigraphic position is directly on or close above the Brookville coal or, in the absence of the coal, the Brookville clay. It is found on an average 74 feet above the persistent Lower Mercer limestone and 78 feet below the important Middle Kittanning coal. The thickness of the Putnam Hill limestone in Coshocton County varies from a few inches to a maximum of about 13 feet, but the average of more than 50 measurements is 2 feet 1 inch. Greater than average development characterizes this member over local areas in southeastern Monroe and northeastern Jefferson townships and in southern Jefferson, Bedford, Newcastle, Perry, eastern Pike, and Washington townships. In character the limestone is a dark gray to bluish gray dense-textured rock which is very fossiliferous. Flint nodules are occasionally present but they are not a conspicuous element of the member in this county. Where the limestone is average or below average in thickness it generally consists of a single ledge or layer or possibly two layers separated by a bedding plane only. So weather-resistant is this stone in contrast to the enduring properties of the underlying coal and clay that large blocks of limestone become detached and due to gravity tend to creep down slope, strewing the hillsides below the crop line. Thick deposits of Putnam Hill limestone often present a thin-bedded or shelly appearance after long exposure to the elements.

Of the limestone members outcropping in Coshocton County the Putnam Hill ranks first in importance as a potential source for stone for local needs, such as road ballast, agricultural limestone, concrete aggregate or stone for rough construction work. In its field of best development in the southwestern part of the county, Putnam Hill limestone, 4 to 6 feet in thickness, is of common occurrence on the outcrop. Furthermore in this area the limestone horizon lies near the summits of the high hills and ridges where sizable areas can be uncovered with a minimum of stripping. The stone in general meets the requirements for a standard surface macadam stone as it has good hardness, medium resistance to abrasion, and good cementing qualities.[1] On pulverizing the better grades of Putnam Hill yield a gray limestone well suited for agricultural purposes. Chemical analyses show the member to contain from 92 to 95 per cent calcium carbonate, less than 2 per cent magnesium carbonate, and less than 2 per cent each of silica and argillaceous or clay material. The low magnesium carbonate content and low percentage of silica and argillaceous impurities render the stone adaptable to the production respectively of Portland cement and furnace flux but the thinness of the member precludes large and extensive quarry operations. Small quarries in the Putnam Hill limestone have operated from time to time in Pike, Perry, Newcastle, and Monroe townships for the production of road stone and agricultural limestone. Analyses of samples of Putnam Hill limestone are given in the following discussion of this member by townships.

Newcastle Township. - Outcrops of the Putnam Hill limestone in this township are confined to the upper levels along the high ridges extending east and south from Newcastle, one in the direction of Opossum Hollow and the other toward New Guilford. The altitude of the member ranges from 1,210 feet to 1,160 feet, being lowest at the southeastern outcrops. The usual

[1] Morse, W. C., Road Materials of Ohio, Vol. I, p. 247, (unpublished report).

thickness of the limestone where fully exposed ranges from 4 to 6 feet. In the east part of the village of Newcastle, the Putnam Hill is well exposed along the improved road at an altitude of 1,210. It is also exposed along the abandoned road north of the highway in the west central part of Section 13 where its altitude is 1,200 feet or 63 feet above the Lower Mercer limestone. On the Beal property north of the highway in the east central part of Section 13, Putnam Hill limestone was formerly quarried and pulverized for agricultural lime. Operations have been discontinued here and the limestone in the workings is no longer well exposed to view. A good exposure occurs, however, on the north side of the highway just below the Beal home where the following measurements were secured.

		Ft.	In.
Covered		-	-
Limestone, bluish to light brownish gray, fossiliferous, heavy-bedded	Putnam Hill	6	2
Limestone, bluish to light brownish gray, hard, compact, generally dense texture	Putnam Hill	2	2
Bottom of exposure. Altitude, 1,192 ft.			

The limestone at this exposure, having a total thickness of 8 feet 4 inches, was sampled by R. E. Lamborn, on July 26, 1943, for analysis. The sample was analyzed by E. Chadbourn of the Rock Analysis Laboratory of the University of Minnesota, with the following results.

	Per cent
Silica, SiO_2	2.71
Alumina, Al_2O_3	1.00
Ferric oxide, Fe_2O_3	0.29
Ferrous oxide, FeO	0.68
Iron disulphide, FeS_2	0.24
Magnesium oxide, MgO	0.76
Calcium oxide, CaO	51.68
Sodium oxide, Na_2O	0.04
Potassium oxide, K_2O	0.16
Water, hydroscopic, H_2O-	0.05
Water, combined, H_2O+	0.45
Carbon dioxide, CO_2	41.66
Titanium dioxide, TiO_2	0.03
Phosphorus pentoxide, P_2O_5	0.06
Sulphur trioxide, SO_3	0.12
Manganous oxide, MnO	0.07
Total	100.00

As calculated (Lamborn) from the chemical analysis the composition of the sample in terms of mineral constituents probably present is as follows:

Silicates	$(Na . K)_2O . 3Al_2O_3 . 6SiO_2 . 2H_2O$	1.85
	$Al_2O_3 . 2SiO_2 . 2H_2O$	0.72
Silica, SiO_2		1.53
Hydrated ferric oxide, $2Fe_2O_3 . 3H_2O$		0.34
Ferrous carbonate, $FeO . CO_2$		1.10
Iron disulphide, FeS_2		0.24
Titanium dioxide, TiO_2		0.03
Calcium phosphate, $3CaO . P_2O_5$		0.13
Calcium sulphate, $CaO . SO_3$		0.20
Calcium carbonate, $CaO . CO_2$		91.96

	Per cent
Magnesium carbonate, $MgO \cdot CO_2$	1.59
Manganese carbonate, $MnO \cdot CO_2$	0.11
Water, hydroscopic, H_2O-	0.05
Unbalanced components (deficiency, CO_2, H_2O)	+0.15
Total	100.00

The Putnam Hill limestone is present in good development near the crest of the ridge in the southwest part of Section 11 and in the northwest part of Section 20. Where exposed along the road in the latter area, it measures 5 feet in thickness. The stratigraphic relations of this limestone to the chief underlying members exposed in this area are expressed in the following record of outcrops along the road at the east edge of Section 12.

	Ft.	In.
Shale, yellowish gray, sandy	35	0
Limestone blocks, gray; not entire thickness, Putnam Hill	1	0
Coal smut, Brookville or No. 4	-	2
Shale, argillaceous, and covered	25	8
Covered interval	10	6
Flint, gray at top; not full thickness, Upper Mercer	-	6
Covered interval	36	0
Limestone, dark bluish gray to gray black; not entire thickness, Lower Mercer	2	0
Covered interval	20	0
Sandstone, with some arenaceous shale	30	0
Altitude, 1,079 ft.		

A thin deposit of Putnam Hill limestone has been observed near the crest of the high ridge in the northeastern quarter of Section 23 at an altitude of 1,160 feet. It apparently is present near the hilltops to the north and west of this locality in the direction of Newcastle, but owing to the lack of outcrops no definite information as to its thickness and character has been secured.

Perry Township. - The distribution of the Putnam Hill limestone in Perry Township is confined to the summit elevations along the high ridge near to and paralleling the north boundary of the township as far west as Section 4 and to the high ridge in southwest Section 10, east Section 12, and south central Section 11. This limestone caps the ridge of Wilson Chapel in the east central part of Section 2. Its thickness and general stratigraphic relations are expressed in the following record of outcrops occurring along the road leading to northwest, one-fourth of a mile east of the Chapel.

Limestone, gray, heavy-bedded, fossiliferous, Putnam Hill		5	0
Shale and covered		40	4
Limestone, black, with flint nodules.	Upper Mercer	-	6
Flint, black	Upper Mercer	-	5
Shale and covered, chiefly covered	Upper Mercer	20	9
Limestone, grayish black, Lower Mercer		1	4
Altitude, 1,059 ft.			

Putnam Hill limestone, 7 feet 8 inches in thickness, caps the flat-topped hill in the northeast quarter of Section 4. It is likewise present on the crest of the small knoll in the west central part of Section 4. Here, on the W. R. Speckman property, the limestone has been quarried for a number of years and marketed for agricultural lime and for road stone. A description of the exposures in the quarry is as follows:

		Ft.	In.
Top of knoll			
Limestone, bluish gray, weathers into nodular layers an inch or so in thickness	Putnam Hill	5	0
Limestone, bluish gray, thin-bedded		2	0
Limestone, light bluish to brownish gray, one bed		1	3
Limestone, thin-bedded, nodular		-	9
Limestone, bluish to brownish gray, one bed		1	2
Limestone, bluish to light brownish gray, one bed		3	0
Bottom of quarry, Altitude, 1,220 ft.			

The Putnam Hill limestone in this quarry, having a total thickness of 13 feet 2 inches, was sampled for chemical analysis by R. E. Lamborn on June 9, 1941. The composition of the sample as determined by Downs Schaaf, analyst is as follows:

	Per cent
Silica, SiO_2	2.61
Alumina, Al_2O_3	0.55
Ferric oxide, Fe_2O_3	0.02
Ferrous oxide, FeO	0.64
Iron disulphide, FeS_2	0.06
Magnesium oxide, MgO	0.75
Calcium oxide, CaO	52.50
Strontium oxide, SrO	<0.01
Barium oxide, BaO	<0.01
Sodium oxide, Na_2O	<0.01
Potassium oxide, K_2O	0.01
Water, hydroscopic, H_2O-	0.14
Water, combined, H_2O+	0.15
Carbon dioxide, CO_2	42.33
Titanium dioxide, TiO_2	0.06
Phosphorus pentoxide, P_2O_5	0.10
Sulphur trioxide, SO_3	0.01
Manganous oxide, MnO	0.07
Carbon, organic, C	0.07
Hydrogen, organic, H	- -
Total	100.07

The per cent of each of the mineral compounds probably present in the sample has been computed (Lamborn) from the chemical analysis with results as follows:

Silicates	$(Na . K)_2O . 3Al_2O_3 . 6SiO_2 . 2H_2O$	0.08
	$Al_2O_3 . 2SiO_2 . 2H_2O$	1.31
Silica, SiO_2		1.96
Hydrated ferric oxide, $2Fe_2O_3 . 3H_2O$		0.02

	Per cent
Ferrous carbonate, $FeO \cdot CO_2$	1.03
Iron disulphide, FeS_2	0.06
Titanium dioxide, TiO_2	0.06
Calcium phosphate, $3CaO, P_2O_5$	0.22
Calcium sulphate, $CaO \cdot SO_3$	0.02
Calcium carbonate, CaO, CO_2	93.48
Magnesium carbonate, $MgO \cdot CO_2$	1.57
Manganese carbonate, $MnO \cdot CO_2$	0.11
Water, hydroscopic, H_2O-	0.14
Organic matter	0.07
Unbalanced components (excess CO_2, H_2O)	-0.06
Total	100.07

Along the high ridge northwest of Goshen School the Putnam Hill limestone varies in altitude from 1,104 feet in the southwest part of Section 4 to about 1,070 in the southeast part of Section 11. The limestone is unusually well exposed at the cross-road at the central west edge of Section 11, as described below.

	Ft.	In.
Shale, yellowish gray, arenaceous	10	0
Limestone, gray to light brownish gray, on weathering breaks into layers 6 inches to 8 inches thick, Putnam Hill	6	10
Shale, argillaceous	-	4
Coal, shaly, and carbonaceous shale, Brookville or No. 4	-	6
Clay, gray, plastic	10	0

Pike Township. - Putnam Hill limestone in Pike Township is confined in its distribution chiefly to Graham Ridge and its spur ridges in the eastern row of sections. The altitude of the member ranges from 1,032 in the north central part of Section 1 to 1,055 near Clark School in Section 10, to 1,023 in the north central part of Section 21. The limestone is well developed along these ridges, especially near Clark School in Section 10, where it has been quarried in a small way on the Clyde Graham property and pulverized for agricultural use. The quarry is located near the crest of the high ridge about one-fourth mile southwest of the school near the center of the southwest quarter of the section. The limestone is hard, dense, and compact and has a thickness of about 5 feet. The interval to the Lower Mercer limestone which outcrops in the ravine to the east is about 85 feet. The 5 feet of Putnam Hill limestone exposed in the quarry was sampled on May 1, 1941, by R. E. Lamborn for chemical analysis. The composition determined by Downs Schaaf is as follows:

	Per Cent
Silica, SiO_2	1.95
Alumina, Al_2O_3	0.44
Ferric oxide, Fe_2O_3	0.02
Ferrous oxide, FeO	0.50
Iron disulphide, FeS_2	0.15
Magnesium oxide, MgO	0.86
Calcium oxide, CaO	52.82
Strontium oxide, SrO	<0.01
Barium oxide, BaO	<0.01
Sodium oxide, Na_2O	0.01
Potassium oxide, K_2O	0.02
Water, hydroscopic, H_2O-	0.11
Water, combined, H_2O+	0.11
Carbon dioxide, CO_2	42.61

	Per cent
Titanium dioxide, TiO_2	0.03
Phosphorus pentoxide, P_2O_5	0.10
Sulphur trioxide, SO_3	0.04
Manganous oxide, MnO	0.10
Carbon, organic, C	0.15
Hydrogen, organic, H	0.01
Total	100.03

The percent of each of the compounds probably present in the sample, as calculated (Lamborn) from the chemical analysis is essentially as follows:

Silicates	$(Na \cdot K)_2O \cdot 3Al_2O_3 \cdot 6SiO_2 \cdot 2H_2O$	0.29
	$Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$	0.82
Silica, SiO_2		1.43
Hydrated ferrous oxide, $2Fe_2O_3 \cdot 3H_2O$		0.02
Ferrous carbonate, $FeO \cdot CO_2$		0.81
Iron disulphide, FeS_2		0.15
Titanium dioxide, TiO_2		0.03
Calcium phosphate, $3CaO \cdot P_2O_5$		0.22
Calcium sulphate, $CaO \cdot SO_3$		0.07
Calcium carbonate, $CaO \cdot CO_2$		94.01
Magnesium carbonate, $MgO \cdot CO_2$		1.80
Manganese carbonate, $MnO \cdot CO_2$		0.16
Water, hydroscopic, H_2O-		0.11
Organic matter		0.16
Unbalanced components (excess CO_2, H_2O)		0.05
Total		100.03

Washington Township. - The Putnam Hill limestone is generally present in good development where due on the outcrop near the crest of Graham Ridge and along the spur ridges extending to the east, west of the valley of Wakatomika Creek. Here the altitude varies from 1,040 to about 1,000 feet, being lowest along the eastern fringe of outcrop. East of Wakatomika Creek exposures of the Putnam Hill horizon, which ranges in altitude from about 920 feet in Section 20 to about 980 feet in sections 8 and 3, indicate that the limestone is generally present but that it does not exceed 1 foot 6 inches in thickness except in sections 1, 2, and 3 where depths of 3 feet 6 inches to 4 feet have been observed. Where exposed along the road in the east central part of Section 10, the limestone has a thickness of 1 foot 6 inches and occurs 65 feet above the Upper Mercer limestone. At outcrops along the highway in the southeast quarter of Section 8 this limestone has an altitude of 980 feet and a thickness of 1 foot and it lies 76 feet above the Lower Mercer limestone. The thickest development of Putnam Hill limestone observed in Washington Township crops out along the road in the north central part of Section 2. At this locality heavy-bedded limestone, 4 feet in thickness, is exposed at an altitude of 970 feet. The Putnam Hill limestone is not known to have been utilized for economic purposes in Washington Township.

Bedford Township. - The Putnam Hill limestone is a persistent and conspicuous member on the outcrop in Bedford Township where its usual thickness ranges from 4 to 6 feet. In distribution it is found underlying all the higher hills and ridges in the western part of the township where its altitude ranges from about 1,050 feet in west central Section 25 to about 1,040 in the northeast corner of Section 5. Owing to the regional dip the limestone is found at lower levels along the western margin of the township. Here its altitude ranges from 980 to 940, being lowest in the southeast corner. The member is in general typical in its development in that it is a hard, gray, heavy-bedded, fossiliferous limestone closely underlain by the Brookville coal and overlain by arenaceous shale. At West Bedford in Section 16 the Putnam Hill limestone outcrops about 60 feet below the summits of the high hills. The following section secured by ·

T. R. Meyers in 1928 along the road north of the West Bedford Church shows the Putnam Hill limestone in relation to underlying members. The interval to the Upper Mercer limestone at this locality is less than the average for the county.

	Ft.	In.
Limestone, Putnam Hill	4	1
Clay shale	-	4
Coal smut, Brookville or No. 4	-	3
Clay and covered interval	5	5
Clay shale, blue	5	0
Covered interval	5	0
Shale, siliceous	13	1
Flint, dark blue, Upper Mercer	-	9
Shale	-	2
Coal, shaly, Bedford	-	3
Clay shale, with carbonaceous streaks	-	10
Clay	1	0
Shale, siliceous	3	5
Sandstone, massive, micaceous, ferruginous	39	6
Limestone, gray, dense, fossiliferous, Lower Mercer	1	8

Putnam Hill limestone is well exposed along the diagonal road in the southwest part of Section 8, where it has a thickness of about 6 feet. It has a like thickness at outcrops near the road forks in the southwest quarter of Section 4. In the northeastern corner of Section 4, the thickness is 3 feet 6 inches of limestone closely overlying an almost equal thickness of Brookville coal. East of the railroad tunnel the Putnam Hill has good continuity and thickness where due in Section 12 and along the high ridges which extend to the south and southeast. It is massively developed with a thickness of more than 7 feet at exposures near the Union Church in Section 23. The following record, secured by T. R. Meyers along a ravine paralleling the road in the south central part of Section 20, is descriptive of the Putnam Hill and overlying and underlying members as they occur in the southeastern part of the township.

		Ft.	In.
Flint, cherty, massive, olive drab	Vanport	2	11
Flint, cherty, olive drab, with calcareous shale layers	Vanport	3	0
Covered interval		3	4
Clay, bluish gray, plastic		4	2
Clay, carbonaceous		-	2
Clay, gray, plastic		1	5
Iron ore, black, massive		-	5
Clay, light-colored, plastic, good quality, Clarion		5	2
Clay shale, bluish, with occasional ore lenses		26	1
Iron ore, gray to tan, dense		-	5
Limestone, gray, dense, sparingly fossiliferous, massive	Putnam Hill	2	0
Limestone, gray, dense, sparingly fossiliferous, massive	Putnam Hill	2	0
Limestone, gray, dense, irregular, 2 to 4 inch beds	Putnam Hill	1	6
Clay shale, gray		1	1½
Coal, fair quality	Brookville or No. 4	-	4
Clay shale, carbonaceous	Brookville or No. 4	-	1½
Coal, fair quality	Brookville or No. 4	-	4
Shale, carbonaceous	Brookville or No. 4	-	3/8

	Ft.	In.
Clay, gray, good quality	-	7
Clay, light, shows a semi-flint character where weathered	6	2
Clay shale, blue gray	3	3

The Putnam Hill limestone is not known to have been quarried in Bedford Township, although at a few localities scattered blocks have been gathered from the fields and pulverized or calcined for agricultural use.

Jefferson Township. - In Jefferson Township north of the Walhonding River outcrops of the Putnam Hill horizon are confined in distribution to the high hills and ridges in sections 1 and 10 where its altitude ranges from 1,040 to 1,070 feet. The limestone is wanting in the northern part of Section 1 owing to replacement by Clarion sandstone but in the northern part of Section 10 it is found with normal lithologic character and with a thickness ranging from 1 to nearly 3 feet.

South of the Walhonding River the Putnam Hill limestone is a persistent member along the high ridges east and west of Simmons Run. Its thickness on outcrops ranges from 1 foot to 6 feet 6 inches but the usual measurements vary from 3 feet to 5 feet. The limestone is more than 5 feet in thickness where exposed along the north-south road one and one-half miles southeast of Nellie. Its relation to underlying members at this locality is shown in the following record of outcrops secured by Mr. Meyers in 1928.

Sandstone and covered	36	10
Limestone, gray, dense, fossiliferous, Putnam Hill	5	2
Shale, ferruginous	-	6
Coal smut, Brookville or No. 4	-	1
Clay, white, plastic, siliceous	5	0
Sandstone, white, medium grained, thin-bedded, clay-bonded	5	7
Covered interval	21	6
Clay shale, ferruginous	1	0
Flint, black, fossiliferous, Upper Mercer	5	0
Coal smut, Bedford	-	1

As exposed along a ravine near the road three-fourths of a mile east of Mohawk Village, the Putnam Hill member has a thickness of 5 feet and is found 38 feet above the Upper Mercer limestone and flint. Six feet six inches of gray dense fossiliferous limestone marks the Putnam Hill horizon on the west slope of the valley of Flint Run near its head. At this locality the limestone outcrops at an altitude of 1,050 feet and occurs 37 feet above the base of the Upper Mercer limestone and flint member.

East of Simmons Run the Putnam Hill limestone crops out along the high ridge in the southeastern part of Jefferson Township at altitudes ranging from 980 to 1,000 feet. The lithologic character, thickness, and shaly stratigraphic relations of the Putnam Hill limestone to the Upper Mercer as described in the following section secured by T. R. Meyers along the east-west road one-half mile east of Warsaw Junction is typical for this member in the southeastern part of Jefferson Township.

Sandstone, medium-grained, thin-to thick-bedded, ferruginous	32	6
Limestone, gray, heavy-bedded fossiliferous, Putnam Hill	3	6

	Ft.	In.
Coal, weathered, Brookville or No. 4	-	10
Clay, white, plastic	-	5
Covered interval	24	9
Flint, Upper Mercer	6	0
Coal smut, Bedford	-	6

Monroe Township. - The Putnam Hill limestone is partly represented on the outcrop in Monroe Township. Where this member is due near the crests of the high hills and ridges north of the valley of Big Run, its place in the stratigraphic column is generally filled with sandstone and sandy shale. Much the same condition prevails along the high ridge extending to the northeast from Spring Mountain north of Hoagland Run, and to the southeast toward Section 21. At one locality, namely on the N. J. Markley property in the southwest quarter of Section 19, the limestone occurs in good development. Here it has been quarried in a small way for the production of agricultural limestone. The quarry is located near the head of a small ravine opening to the southwest situated south of the east-west road. The exposures along the ravine are described as follows:

		Ft.	In.
Soil and slump		5	0
Limestone, dark bluish gray generally dense texture, fossiliferous, one bed,	Putnam Hill	4	0
Limestone, dark bluish to brownish gray, fossiliferous, one bed.	Putnam Hill	-	6
Coal, Brookville or No. 4		1	6
Covered interval		26	0
Limestone, black, flinty, Upper Mercer		1	0
Coal, shaly, and black shale	Bedford	-	4
Coal, bony, cannel nature.	Bedford	1	0
Clay, siliceous, gray.	Bedford	1	8
Sandstone, shaly, and sandy shale		2	0
Shale, dark bluish, argillaceous		-	6
Shale, bony, Upper Mercer coal horizon		-	1
Clay, gray.		2	0
Shale and covered		2	9
Covered interval		10	0
Limestone, dark bluish gray, fossiliferous, heavy-bedded, Lower Mercer		4	0

Altitude, 1,027 ft.

The 4 feet 6 inches of Putnam Hill limestone exposed at this locality was sampled by R. E. Lamborn on June 10, 1941, for chemical analysis. The composition of sample as determined by Downs Schaaf, analyst, is as follows:

	Per cent
Silica, SiO_2	2.21
Alumina, Al_2O_3	0.70
Ferric oxide, Fe_2O_3	0.03
Ferrous oxide, FeO	0.65
Iron disulphide, FeS_2	0.12
Magnesium oxide, MgO	0.90
Calcium oxide, CaO	52.30
Strontium oxide, SrO	<0.01
Barium oxide, BaO	<0.01
Sodium oxide, Na_2O	<0.01
Potassium oxide, K_2O	0.02

	Per cent
Water, hydroscopic, H_2O-	0.14
Water, combined, H_2O+	0.18
Carbon dioxide, CO_2	42.34
Titanium dioxide, TiO_2	0.06
Phosphorus pentoxide, P_2O_5	0.12
Sulphur trioxide, SO_3	0.03
Manganous oxide, MnO	0.14
Carbon, organic, C	0.09
Hydrogen, organic, H	- -
Total	100.03

The per cent of each of the mineral compounds present as determined by calculation (Lamborn) from the above analysis is given below.

Silicates $(Na . K)_2O . 3Al_2O_3 . 6SiO_2 . 2H_2O$	0.17
Silicates $Al_2O_3 . 2SiO_2 . 2H_2O$	1.61
Silica, SiO_2	1.38
Hydrated ferric oxide, $2Fe_2O_3 . 3H_2O$	0.04
Ferrous carbonate, $FeO . CO_2$	1.05
Iron disulphide, FeS_2	0.12
Titanium dioxide, TiO_2	0.06
Calcium phosphate, $3CaO. P_2O_5$	0.26
Calcium sulphate, $CaO. SO_3$	0.05
Calcium carbonate, $CaO. CO_2$	93.05
Magnesium carbonate, $MgO. CO_2$	1.88
Manganese carbonate, $MnO. CO_2$	0.23
Water, hydroscopic, H_2O-	0.14
Organic matter	0.09
Unbalanced components (excess CO_2, H_2O)	-0.10
Total	100.03

Virginia Township. - In Virginia Township the Putnam Hill limestone is generally present where due on the outcrop, but its thickness is usually less than 2 feet. It apparently includes the highland lying between Sand Fork and Moscow Brook, between Moscow Brook and Mill Fork, and between Mill Fork and the Muskingum River, and reaches the surface at altitudes ranging from 950 feet in Section 15 to about 820 feet northeast of Adams Mills in the east central part of the township. It is well exposed at a number of localities along Moscow Brook. At outcrops along the road just east of New Moscow the member is represented by 1 foot 6 inches of gray limestone at an altitude of 913 feet or 56 feet above the Upper Mercer flint. The Putnam Hill is likewise well exposed along the east-west road about 1 mile north of New Moscow where the character, thickness, and relation to underlying beds are as described below.

	Ft.	In.
Level of abandoned coal mine, Middle Kittanning or No. 6	-	-
Covered interval	60	0
Limestone, bluish gray, somewhat shaly, Putnam Hill	1	0
Shaly coal and carbonaceous shale, Brookville or No. 4	-	10
Clay, gray, arenaceous	6	2
Shale, gray, arenaceous	8	2
Clay, dark	-	8
Clay, gray, quite arenaceous. Tionesta	2	4
Shale, gray, arenaceous	23	2

	Ft.	In.
Limestone, black, and black flint, Upper Mercer	2	0
Shale, carbonaceous, and shaly coal, Bedford	1	2
Clay, gray, siliceous	4	8
Altitude, 858 ft.		

Along the valley of Mill Fork the Putnam Hill limestone is above drainage from its mouth in Section 10 to the northeast corner of Section 2. As exposed along the road a short distance northwest of Wright School, the member is represented by 8 inches of limestone at an altitude of 920 feet. Above Willowbrook in south central Section 2 the thickness is 2 feet 6 inches exposed at an altitude of 872 feet. In the southeastern part of the township Putnam Hill limestone is due to crop out in parts of sections 18, 19, 20, 21, 22, and 23. Here a few exposures indicate that the member is normal in lithologic character but thin. The Putnam Hill limestone is not known to have been utilized in Virginia Township.

Jackson Township. - The Putnam Hill limestone is not a prominent member on the outcrop in Jackson Township. The observed exposures of this limestone are confined chiefly to the valleys of Moscow Brook and Simmons Run in the western part where its altitude varies from approximately 910 feet in the southern part of Section 24 to about 980 feet in the northwest corner of Section 5. The limestone is typical in character but it is generally less than 3 feet in thickness. Where exposed at an altitude of 921 feet along the road at the northern edge of Section 18, it has a thickness of 2 feet 6 inches and occurs about 87 feet below the Middle Kittanning coal. The limestone was not observed where due in the western part of Section 13, but is present again with normal character and thickness at an altitude of about 960 feet along the ridge in the western part of Section 7. In the eastern part of Jackson Township the Putnam Hill limestone is due above drainage along the Muskingum and Walhonding valleys and the lower courses of their major tributaries; but where observed in this area its horizon is replaced by sandstones and sandy shales.

Bethlehem Township. - Bethlehem Township contains little Putnam Hill limestone within its boundaries as the limestone horizon is generally replaced by thick deposits of sandstone. The sandstone appears a short distance above the Upper Mercer limestone and in places extends almost to the Lower Kittanning coal. A few exposures of limestone have been noted near the western boundary of the area. About one mile west of south of Metham thin Putnam Hill limestone is exposed along the road at the crest of the ridge at an altitude of 1,028 feet or about 48 feet above the Upper Mercer limestone and flint. An excellent exposure of the Putnam Hill and underlying beds occurs along the road and adjacent ravine in the extreme southwestern corner of the township. Sandstone apparently replaces the limestone along the ridge a mile to the eastward. A section of the exposures along the road is as follows:

		Ft.	In.
Shale and covered		38	2
Limestone, gray, dense, fossiliferous, one bed, Putnam Hill		5	0
Shale, carbonaceous, weathered		-	2
Coal, weathered	Brookville or No. 4	-	8
Clay shale parting	Brookville or No. 4	-	2½
Coal, a little weathered	Brookville or No. 4	1	10
Clay, gray, plastic		3	6
Covered interval		22	3½
Limestone, black to bluish black, fossiliferous, a little shaly	Upper Mercer	3	0
Shale, bluish gray	Upper Mercer	1	0
Covered interval	Upper Mercer	4	3
Limestone, flinty, one ledge	Upper Mercer	2	0

		Ft.	In.
Covered interval		8	4
Shale, yellowish, sandy		7	2
Shale, bluish gray		3	6
Covered		3	2
Limestone, grayish black, fossiliferous	Lower Mercer	-	5
Limestone, grayish black, fossiliferous	Lower Mercer	-	10
Limestone, grayish black, fossiliferous	Lower Mercer	-	11
Limestone, grayish black, fossiliferous	Lower Mercer	-	4
Sandstone, calcareous, micaceous		3	0
Shale, bluish gray, arenaceous		1	0
Clay shale, bluish gray to black		1	6
Coal, bony		-	1
Clay, gray		1	0

Altitude, 910 ft.

Clark Township. - The Putnam Hill limestone lacks both thickness and continuity in Clark Township. Its horizon outcrops over a large area, ranging in altitude from 975 feet in Section 21 to about 1,110 feet in the northwest corner of the township. In some localities the horizon is occupied by sandstone. The limestone where present is generally less than 1 foot in thickness. As exposed along the road in the northeast quarter of Section 22 at an altitude of 1,013 feet, it is a bluish gray stone 6 inches in thickness. The limestone has similar character and thickness at outcrops at the north edge of Section 21 at an altitude of 960 feet and east of Mt. Dispute School in Section 20 at an altitude of 982 feet. At the crest of the ridge northwest of Layland the Putnam Hill is represented by a few inches of gray limestone outcropping at an altitude of 1,110 feet. South of Layland and west of the Killbuck River this member is due at the crest of the high flat-topped ridges in Section 15 and north of Green Valley School in Section 14, but no limestone was observed in these localities.

Mill Creek Township. - The Putnam Hill limestone is generally present where due on the outcrop in Mill Creek Township, but where exposed it is generally less than 1 foot thick. Outcrops of this member have their lowest altitude of about 955 feet at the south central edge of the township, from which point the member rises to the west, north, and east. It reaches altitudes of 980 feet in the southwest corner, 1,040 feet in the northwest corner, and about 1,050 feet in the southeast corner of the township. In the northeast corner of the township the hills are not high enough to yield outcrops of this member. The limestone is a bluish gray dense fossiliferous rock which ranges in thickness from 6 inches to about 1 foot. It is closely underlain by Brookville coal ranging from a few inches to 1 foot 6 inches in thickness and overlain by arenaceous shale which generally extends to the Lower Kittanning clay. Sections showing the stratigraphic relations of the Putnam Hill in Mill Creek Township to important members of the Pottsville series are given in parts of this report dealing with the Lower Mercer and Upper Mercer limestones.

Keene Township. - The Putnam Hill limestone has good continuity on the outcrop in Keene Township but it is not known to exceed 1 foot in thickness and generally measures only a few inches. Outcrops are widespread as the limestone is above drainage over a large area. Along the structural trough whose axis extends in a north-south direction through the central part of the township, the altitude of this limestone varies from about 950 feet in the northern part of Section 3 to about 865 feet near Canal Lewisville. From this axis the limestone rises both to the east and to the west, reaching altitudes ranging from 930 to 980 feet along the western border and from about 910 to 1,040 feet along the eastern margin of the township. Owing to its thinness the Putnam Hill in this township is of importance chiefly for its stratigraphic

interest. The following skeleton record of outcrops along the road just northwest of Keene shows the limestone in better-than-average development for this township and its relation to prominent limestones of the Pottsville series.

	Ft.	In.
Limestone, gray, Putnam Hill	1	0
Shale, clay, and covered	49	0
Limestone, black, hard, flinty, Upper Mercer	3	0
Shale and covered	28	0
Limestone, grayish black, fossiliferous, Lower Mercer	2	0

Altitude, 879 ft.

On the west side of Mill Creek one-half mile west of School No. 4, the Putnam Hill limestone 10 inches in thickness outcrops at an altitude of 963 feet. Here it occurs 85 feet above the Lower Mercer limestone and 44 feet below the Lower Kittanning coal from which it is separated chiefly by sandy shale. In the northeast quarter of Section 1, the Putnam Hill member is represented by 3 inches of dark fossiliferous limestone outcropping at an altitude of 1,032 feet or 55 feet below the Lower Kittanning clay. The limestone is likewise only a few inches in thickness where exposed along the east-west road in the northeast quarter of Section 10. Here its altitude is 990 feet which is 36 feet above the Upper Mercer limestone and 47 feet below the Lower Kittanning clay.

Tuscarawas Township. - Outcrops of the Putnam Hill limestone in Tuscarawas Township are due not far above flood plain level along the valleys of the Muskingum and Tuscarawas rivers, south and east of Coshocton. The altitude of the horizon varies from about 780 feet in the extreme southwestern corner of the township to about 880 feet where the Tuscarawas Valley crosses the eastern boundary of the area. Owing to the presence of unconsolidated materials along the steep valley slopes, bedrock exposures are rare and the presence of the limestone where due is problematical. Thin limestone representing the Putnam Hill member outcrops along Morgan Run about $1\frac{1}{2}$ miles from its mouth. The altitude of the exposure is 845 feet or about 40 feet below the Lower Kittanning coal and 81 feet below the Middle Kittanning coal exposed in the vicinity.

Franklin Township. - In Franklin Township the horizon of the Putnam Hill limestone lies a little above flood plain level along the Muskingum Valley entirely across the county. It is also due along the valley of Wills Creek from its mouth as far northeast as Section 18 where it should pass below drainage. Few exposures of the limestone occur in this area owing to the presence of surface deposits. The limestone was observed, however, along Barnes Hollow near the west edge of the township at an altitude of 838 feet. Here it has a thickness of 1 foot and possesses characteristics typical of the Putnam Hill member.

White Eyes Township. - Although the Putnam Hill tends to be normal in lithologic features in White Eyes Township, it is in general poorly developed, for the thickness on the outcrop ranges from a few inches to a maximum of about 1 foot. Its importance in this township is, therefore, stratigraphic rather than economic in nature. The altitude of the member ranges from 1,050 feet in the northwest corner to about 960 feet in the southeast corner, with the highest altitudes occurring along the crest of the Cambridge Arch in the west central part. Where exposed along the road in the southeast quarter of Section 5 at an altitude of 1,034 feet the Putnam Hill consists of nodular masses of bluish gray limestone overlying 1 foot 4 inches of Brookville coal and occurring about 66 feet below the Middle Kittanning coal. The horizon is likewise exposed along the highway in the southwest quarter of Section 7, but here the limestone is apparently wanting through lack of deposition. In the eastern part of Section 17, Putnam Hill limestone has a thickness of 1 foot 2 inches and is exposed at an altitude of 1,012 feet. The intervals to the Bedford and Middle Mercer coals at this locality are 27 and 69 feet respectively. East of

White Eyes Creek the Putnam Hill outcrops at altitudes ranging from about 1,000 feet near Chili to about 960 feet near Bowman School. The stratigraphic succession is well shown in exposures along the road about three-fourths of a mile west of this school.

	Ft.	In.
Coal blossom, Middle Kittanning or No. 6	-	10
Clay, gray, and covered	4	0
Shale and covered	30	2
Clay, gray, plastic, Lower Kittanning	5	0
Shale and covered	6	2
Flint, light gray, Vanport	2	0
Shale and covered	25	0
Limestone, gray, Putnam Hill	-	6
Coal blossom, Brookville or No. 4	1	0
Clay, gray, siliceous, micaceous	5	2
Shale and covered	42	8
Flint, black, nodular, Upper Mercer	-	10

Altitude, 956 ft.

Crawford Township. - In Crawford Township the Putnam Hill limestone horizon underlies the high ridges bordering the valleys of White Eyes Creek and West Fork of White Eyes Creek and outcrops along their sides at altitudes ranging from 1,080 feet in Section 5 in the northwest corner to about 1,000 feet in Section 21 in the southeast corner. The occurrence of the limestone in this township merits little discussion for its economic value. It generally measures from only 4 to 12 inches in thickness and in some localities it is apparently wanting, its place being taken by arenaceous shale. Where wanting its horizon is indicated by thin Brookville coal which in normal succession is found close below the limestone. The stratigraphic position of this limestone horizon in Crawford Township is about 80 feet below the Middle Kittanning coal and from 40 to 52 feet above the Upper Mercer limestone. Sections showing the detailed stratigraphic relations of the Putnam Hill limestone in this township have been given in preceding pages of this report dealing with various Pottsville members.

Adams Township. - The Putnam Hill limestone horizon is above drainage along the valley of East Fork in western Adams Township where outcrops occur at altitudes ranging from 970 feet near Powell to 980 feet at the northern boundary. It is likewise above drainage along Evans Creek. Here the altitude ranges from 900 in Section 23 to 980 feet just west of Bakersville in Section 2. The limestone, which tends to be normal in lithologic characteristics, is quite persistent on the outcrop. Its thickness, however, is below average for this county, ranging from a few inches to a known maximum of about 1 foot 6 inches. As exposed along the road at Powell, it is represented by 8 inches of gray limestone cropping out 58 feet above the Upper Mercer limestone and 70 feet below the Middle Kittanning coal. The section secured along the road leading into the valley from the east, three-fourths of a mile east of Woods School, is as follows:

		Ft.	In.
Limestone, gray, Putnam Hill		1	0
Coal blossom, Brookville or No. 4		2	0
Clay, gray, and covered		5	0
Covered interval		39	4
Limestone, black, flint at top	Upper Mercer	2	0
Covered interval		5	2
Limestone, black, hard		2	0
Shale		-	2
Coal, Bedford		-	6

Altitude, 889 Ft.

Along the valley of Evans Creek in the northwest quarter of Section 22, the Putnam Hill limestone is exposed at an altitude of 900 feet or 65 feet below the level of the Middle Kittanning coal. It is likewise well exposed in the southeast quarter of Section 13 where it has an altitude of 933 feet or 60 feet above the Lower Mercer limestone cropping out in the valley to the east. Just west of Bakersville 9 inches of Putnam Hill limestone was observed to outcrop at an altitude of 974 feet and to overlie a blossom of Brookville coal, nearly 2 feet in thickness. Owing to its low thickness Putnam Hill limestone has slight economic possibilities in Adams Township.

Oxford Township. - Scattered outcrops of the Putnam Hill horizon in Oxford Township indicate that the limestone is generally present where due, but that its thickness is generally less than 2 feet and probably does not average more than 1 foot. The member has its greatest altitude of about 940 feet in the northwest corner from where it slopes irregularly to the southeast descending to altitudes of about 900 feet in the southwest corner, 880 feet in the northeast corner, and about 850 feet in the southeast part of the township. Few exposures occur along the Tuscarawas Valley owing to the mantle of surficial deposits which cover the valley sides. About 1 mile southwest of Isleta, Putnam Hill limestone of undetermined thickness is exposed along the road at an altitude of 906 feet or about 75 feet below the Middle Kittanning coal. One and one-fourth miles farther southwest, along a small tributary to Center Creek, the Putnam Hill and overlying beds outcrop as described below:

	Ft.	In.
Track level, abandoned coal mine, Middle Kittanning or No. 6	-	-
Covered interval	29	0
Coal blossom, Lower Kittanning or No. 5	1	6
Clay, gray, plastic	13	4
Shale, gray, soft, argillaceous	26	8
Limestone, gray, Putnam Hill	2	0
Shale, ferruginous	-	8
Coal, Brookville or No. 4	-	10
Clay, gray, siliceous, micaceous	6	2
Altitude, 895 ft.		

Exposures of the Putnam Hill limestone member are somewhat more numerous along the valleys of the southern flowing tributaries to Wills Creek in the southern part of Oxford Township. Here the limestone is generally less than 1 foot 6 inches in thickness. Its lithologic characteristics are normal and the interval to the Middle Kittanning coal, to which it is best referred, varies from 75 to 85 feet.

Lafayette Township. - The Putnam Hill limestone is generally present where due on the outcrop in Lafayette Township, but its observed thickness does not exceed 2 feet and its average is much less. As the crop line of the limestone ranges in altitude from about 980 feet at the north central edge of the township to about 870 feet at the southeast corner, the horizon is well above drainage along the Tuscarawas Valley and the deep valley extending south from West Lafayette. The Putnam Hill limestone is well exposed at an altitude of 856 along a ravine tributary to Morgan Run about a mile above its mouth. Here the limestone appears as thin layers ranging from 4 to 6 inches in thickness separated by thin beds of shale. Where exposed along the road near Burt School, this altitude is 944 feet and the thickness of the limestone is 5 inches. One mile farther south the Putnam Hill is represented by 1 foot 6 inches of limestone exposed at an altitude of 918 feet or 72 feet below the level of the Middle Kittanning coal. About one-half mile south of McLean School in the southeast quarter of the township, this limestone and associated beds crop out along the public road. Here the member has an altitude of 902 feet, is 9 inches in thickness, is directly underlain by 1 foot of Brookville coal and is overlain by 40 feet of arenaceous shale, the latter extending to the Lower Kittanning clay.

Linton Township. - The Putnam Hill limestone outcrops along the hillsides in the vicinity of Plainfield, Section 10, Linton Township, at altitudes ranging from 850 to 870 feet. As observed in the northeast quarter of Section 1 this limestone is typical in lithologic character with a thickness of 2 feet. Northwest of Plainfield the horizon of this limestone is above drainage along Bacon Run as far west as Section 5 where it passes below cover at an altitude of about 870 feet. Southwest of Plainfield few exposures of this limestone are present along the valley of Wills Creek owing to the general presence of river silts. A thin deposit was observed to crop out, however, at an altitude of 830 feet a short distance south of Williams School in the southeast quarter of Section 12. Due east of Williams School on the east side of the valley in the central part of Section 11, the Brookville clay and underlying shales are exposed along the highway. The clay bed is normal in position as it lies about 74 feet above the Lower Mercer limestone exposed in the ravine to the north, but no evidence of the Putnam Hill limestone has been found in this vicinity. East of Plainfield the Putnam Hill limestone occurs about 50 to 60 feet above the flood plain of Wills Creek in sections 3, 4, and 5. Its horizon descends rapidly to the south and reaches a position near flood plain level east of Linton Mills. Exposures of this member have been noted near North Bend School, in the central part of Section 3, and near Wills Creek in the southwestern quarter of Section 13. At these localities the limestone is normal in lithologic character, but below average in thickness for this county.

Clarion Sandstone and Shale

The stratigraphic position of the Clarion sandstone as first described by J. J. Stevenson in Fayette and Westmoreland counties, Pennsylvania,[1] is in the interval between the Brookville coal below and the Clarion coal above. In Ohio sandstone deposits in varying degree of development are probably present on the outcrop of the Clarion sandstone in every county where due from the Pennsylvania State Line in Mahoning County to the Ohio River in Lawrence County. The deposits, however, are by no means regular in character and continuous in extent. Similar to other sandstone members of the Pennsylvanian series, the Clarion lacks horizontal continuity. Where thick deposits occur the lower part may replace the Putnam Hill limestone and the Brookville coal and clay and may even extend downward and coalesce with the Homewood sandstone. The upper part may replace the Clarion coal and clay, the Vanport limestone, and the Ferriferous ore and may even extend upward to the Lower Kittanning coal. When traced laterally along the outcrop, local deposits of Clarion sandstone grade to a gray or bluish gray sandy shale which is widely used and highly evaluated as a raw material for ceramic products. The thickest and most continuous deposits of Clarion sandstone known on the outcrop in Ohio are found in western Muskingum County and in Jackson and Lawrence counties. Shale from the Clarion horizon has been utilized for building brick, quarry tile, etc. at numerous plants located along the outcrop in Vinton, Perry, Muskingum, Tuscarawas, Holmes, and Stark counties.

In Coshocton County the Clarion sandstone horizon outcrops in every township with the possible exception of Tiverton in the northwest corner. Sandstone deposits on this horizon are confined chiefly to small local areas in southwestern and central Bedford Township, south central and northeastern Jefferson Township, east central and northern Monroe Township, and a large area embracing eastern and northeastern Jackson Township, the eastern half of Bethlehem Township, and the southeastern and central western Clark Township. Throughout eastern Jackson, eastern Bethlehem, northeastern Jefferson Township, and much of Monroe Township, the Clarion sandstone has largely replaced the Putnam Hill limestone and underlying Brookville coal and locally in eastern Bethlehem Township shaly sandstone may extend to the Lower Kittanning coal horizon. The sandstone is generally a gray to yellowish gray loosely cemented micaceous rock of medium size of grain. The lower part of the Clarion sandstone is in places heavy-bedded to massive and is conspicuous on the outcrop as along the high ridges in eastern Monroe Township. Thin sandstone beds with shale partings are of common occurrence in the upper part of the deposit.

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[1]Stevenson, J. J., Fayette and Westmoreland districts, Second Geol. Survey Pa., Rept. QQQ, p. 43, 1878.

The Clarion sandstone is not known to have been employed to any great extent in Coshocton County for economic use. For all purposes for which sandstone has been utilized preference has been shown in this area for the Massillon sandstone which is less impure in character and which occurs some 150 feet lower in the section.

Throughout much of eastern Coshocton County including Mill Creek, Keene, Tuscarawas, Franklin, Virginia, Linton, Lafayette, Oxford, White Eyes, Crawford, and Adams townships, the Putnam Hill limestone is generally overlain with shale which extends upward to the Clarion clay, a distance of 20 to 30 feet. In the absence of the Clarion coal and clay and the Vanport limestone, shale predominates upward to the Lower Kittanning coal. The lower part of this bed closely overlying the Putnam Hill limestone is generally a bluish to greenish gray argillaceous shale which may be calcareous and ferruginous in composition. The ferruginous character may manifest itself by the presence of numerous small concretions of iron carbonate which on weathering give a yellowish brown color to the shale. A few feet above the Putnam Hill limestone the ferruginous and calcareous character become less pronounced and the shale becomes more siliceous or sandy in composition. The Clarion shale has been used for ceramic products in the bordering counties of Muskingum, Tuscarawas, and Holmes, as well as in Stark, Perry, and Vinton counties but no extended effort at utilization is known to have taken place in Coshocton County.

Clarion Coal and Clay

STRATIGRAPHY, EXTENT, AND VALUE

The Clarion coal, so named for exposures along the Clarion River in western Pennsylvania,[1] is an uncertain element in the stratigraphic sequence in outcrops of the Allegheny series in eastern and southern Ohio. In this State the coal or its associated clay is generally present where due on the outcrop in Columbiana and Mahoning counties; is somewhat uncertain in Stark, Wayne, Tuscarawas, Holmes, Coshocton, and Muskingum counties, becomes more distinct in Perry County; and is generally traceable where due in Athens, Hocking, Vinton, Jackson, Lawrence, Gallia, and eastern Scioto counties. The coal is a mineable bed in Hopewell Township, Muskingum County, and over a large area embracing southern Vinton, northwestern Gallia, southeastern Jackson, northern Lawrence, and eastern Gallia counties. The clays are of much value and importance for ceramic purposes in northeastern Vinton County and along the Ohio River Valley in Columbiana and northern Jefferson counties.

The horizon of the Clarion coal and underlying clay reaches the surface in parts of every township in Coshocton County with the exception of Tiverton and Newcastle in the northwest part. Throughout this county both the coal and clay are generally wanting on the outcrop, apparently through lack of deposition. Where wanting their horizon is usually occupied by shale although locally in Bethlehem and Jackson townships, the Clarion sandstone may be present extending nearly to the Lower Kittanning coal replacing the Clarion members. In a few scattered localities in Pike, Jefferson, and Bedford townships, the Clarion is marked by a thin bed of coal overlying gray plastic siliceous clay, 2 to 5 feet in thickness. The coal in turn is closely overlain by Vanport limestone and flint. The stratigraphic position of the Clarion coal with reference to other prominent members in the succession is on an average 27 feet above the Putnam Hill limestone, 16 feet below the Lower Kittanning coal, and 51 feet below the Middle Kittanning coal.

Owing to its very limited distribution and poor development the Clarion coal has little economic importance in Coshocton County. The underlying clay, which is of the gray plastic siliceous type, is lacking in outstanding qualities. Possibilities of utilization are further hampered by its poor development and limited distribution.

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[1] Rogers, H. D., Geology of Pennsylvania, Vol. II, pp. 475, 490, 1858.

The horizon of the Clarion coal and clay is due near the crest of the high ridge extending from the south central part of Jefferson Township into the north central part of Bedford Township. The following section by T. R. Meyers of exposures along the ridge road just south of the cross-roads in southern Jefferson Township $1\frac{1}{4}$ miles south of east of Mohawk Village shows an unusual development of Clarion coal for this county:

	Ft.	In.
Limestone, bluish gray, argillaceous, thin-bedded, sparingly fossiliferous, Vanport	4	1
Shale, bluish gray, calcareous	1	8
Coal, fair, weathered	1	3
Shale, light (Clarion or No. 4a)	-	$\frac{3}{4}$
Coal, fair, weathered	1	5
Clay, light, plastic, siliceous	3	6
Sandstone, light in color, thin-bedded, clay-bonded, Clarion	11	6
Covered interval	5	6

Altitude, cross-road, 1,087 ft.

Along the extension of this prominent ridge to the southeast into Bedford Township the Clarion horizon is again exposed in the central part of Section 8. At this locality it is represented by a mere soot streak underlying 3 feet 4 inches of Vanport limestone and flint and overlying 2 feet of gray plastic siliceous clay. The altitude of the coal horizon is 1,077 feet, is 60 feet and 89 feet above the bases of the Putnam Hill and Upper Mercer limestones respectively exposed lower on the hillside. Still farther to the southeast along this ridge the Clarion horizon is again well displayed along the road in the south central part of Section 20, Bedford Township. Here over 10 feet of gray plastic clay is found close below 5 feet 11 inches of thin-to thick-bedded calcareous flint of the Vanport member.

Flinty limestone representing the Vanport member outcrops at a few localities near the crest of Graham Ridge in eastern and western Washington Township. Along the western slope of this ridge in the eastern part of Section 20, Pike Township, a few inches of Clarion coal was observed along the road at an altitude of 1,071 feet. At this locality the interval to the Putnam Hill limestone is 35 feet and to the Lower Kittanning coal 31 feet. At exposures of the Clarion horizon along the east slope of Graham Ridge in western Washington Township, the Vanport member is generally underlain by shale, both the Clarion coal and clay being wanting. Similar conditions prevail at scattered exposures of the Vanport noted in Virginia, Lafayette, and Adams townships.

Vanport Limestone

The Vanport limestone was so named by White in 1878 for its occurrence at Vanport, Beaver County, Pennsylvania,[1] where it has been quarried extensively and burned for lime. Previous to 1878 this limestone was known in western Pennsylvania[2] and southern Ohio[3] as the Ferriferous limestone because of its close association with an economically important iron ore. In Ohio the horizon of the Vanport limestone outcrops across the eastern part of the State from Mahoning County on the east to Lawrence County on the south. The limestone has good thickness and continuity in eastern Mahoning County, is generally patchy and discontinuous through Stark, Tuscarawas, Holmes, Coshocton, Muskingum, eastern Licking, Perry, Hocking, and northern Vinton counties, but again becomes prominent through southern Vinton, eastern Jackson,

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[1]White, I. C., Beaver River District, Second Geol. Survey Pa., Rept. Q, pp. 60-63, 1878.

[2]Rogers, H. D., Geology of Pennsylvania, Vol. II, p. 491, 1858.

[3]Andrews, E. B., Report of labors in second Geologic district during the year 1870: Geol. Survey Ohio, Rept. Prog. 1870, p. 61, 1871.

eastern Scioto, and Lawrence counties. In eastern Mahoning County the Vanport limestone has a thickness of about 20 feet and is of good quality. Throughout the central, discontinuous area the member where present is generally thin and quite flinty in character. Flint is likewise often present in small amounts in the upper part of the member from southern Vinton County to southern Lawrence County where its usual thickness is 4 to 8 feet. In this southern field in Ohio the Vanport is closely underlain by the Clarion or No. 4a coal, and generally overlain by the Ferriferous ore.

The Vanport limestone lacks continuity in Coshocton County. Although its horizon outcrops in every township with the exception of Tiverton and Newcastle, exposures of the member are confined for the most part to scattered areas in western Virginia, Washington, eastern Pike, Bedford, and southern Jefferson townships in the western part and to northeastern Tuscarawas, northern Lafayette, southeastern White Eyes, and Adams townships in the eastern part of the county. Where the Vanport is wanting, its horizon is generally occupied by shale except in eastern Jackson, eastern Bethlehem, southeastern Clark, and small scattered areas in Monroe Township where sandstone predominates. Where present the thickness of the Vanport on the outcrop varies from an inch or so to more than 10 feet with an average of about $3\frac{1}{2}$ feet. It is composed for the most part of light to dark shaly limestone interbedded with thin layers or zones of flint or of shaly limestone at the base overlain by massively developed flint. The flint ranges in color from black through various shades of gray and brown to milky white, the light and variegated shades being most common. The stratigraphic position of the Vanport limestone in Coshocton County is on an average about 28 feet above the Putnam Hill limestone, about 14 feet below the Lower Kittanning coal, and about 49 feet below the Middle Kittanning coal.

In the southwestern part of the county, the Vanport limestone has been observed at a few localities along Graham Ridge in western Washington and eastern Pike townships, but it is by no means uniform or persistent. Along the road at the east central edge of Section 20, Pike Township, it is represented by nodular flint outcropping about 33 feet above the Putnam Hill limestone. About three-fourths of a mile north of Graham Corners the Vanport, 2 feet in thickness, crops out along the road at an altitude of 1,046 feet. Here it is a gray to olive gray siliceous shaly limestone with much flint in the top part. The interval to the Putnam Hill limestone is about 36 feet. In southwestern Bedford Township the Vanport is due near the highest summits of the ridge extending to the northeast from Graham Ridge past West Bedford. It is apparently wanting in this area, however, its stratigraphic position being occupied by sandstone and shale. North of Brush College School, the Vanport is generally present along the high ridge which extends from south central Jefferson Township to the southeast across Bedford Township and southwest of Moscow Brook in western Virginia and eastern Washington townships. Near the cross-roads on this ridge in the south central part of Jefferson Township the Vanport consists of thin-bedded argillaceous limestone having a thickness of 4 feet and outcropping at an altitude of 1,110 feet. In the central part of Section 8, Bedford Township, the Vanport and underlying beds are exposed along the road and adjacent ravine. A description of the exposures by T. R. Meyers is as follows:

		Ft.	In.
Covered interval (contains some shaly limestone)	Vanport	5	2
Shale and shaly limestone, fossiliferous	Vanport	-	10
Flint, buff, weathered	Vanport	-	6
Limestone, shaly, ferruginous	Vanport	2	0
Coal smut, Clarion or No. 4a		-	1
Clay, plastic		2	0
Covered		6	5
Sandstone, medium-grained, micaceous		11	0
Sandstone, thin-bedded, and covered		28	0
Sandstone, shaly, and covered		3	0
Clay, light		-	2
Shale, siliceous and covered		3	0

		Ft.	In.
Limestone, dark gray, dense, fossiliferous	Putnam Hill	1	2
Limestone, massive	Putnam Hill	1	8
Limestone, beds 1 to 2 inches thick, irregular, fossiliferous	Putnam Hill	3	2
Clay shale		-	8
Coal, weathered, Brookville or No. 4		2	2
Clay, light, plastic, and covered		2	0

Altitude, 1,013 ft.

At this locality the Vanport member occurs 59 feet above the Putnam Hill limestone, 89 feet above the Upper Mercer limestone, and 115 feet above the Lower Mercer limestone. In the south central part of Section 20, Bedford Township, the Vanport as reported by Mr. Meyers is represented by 3 feet of thin-bedded flint with calcareous shaly layers overlain by 2 feet 11 inches of olive gray calcareous flint. The altitude of the exposure is 1,015 feet or 47 feet above the Putnam Hill limestone exposed at a lower level in the vicinity. In Virginia Township the Vanport member is present at a few localities along the high ridge west of Moscow Brook. As exposed along the road seven-eighths of a mile west of New Moscow, it is represented by 5 feet of bluish fossiliferous limestone, the upper part of which is nodular in character. Its stratigraphic position here is 77 feet above the Upper Mercer limestone, and 59 feet below the Middle Kittanning coal. A mile farther south along the ridge the Vanport is represented by 6 inches of gray flint overlying 2 feet 9 inches of dark fossiliferous limestone. The altitude of the exposure is 952 feet which is 24 feet below the base of the Lower Kittanning clay.

The second area of occurrence of the Vanport member in Coshocton County embraces northeastern Tuscarawas, northern Lafayette, southeastern White Eyes, and Adams townships. The member is not continuous over this field. Where present, its thickness varies from a mere trace to a known maximum of about 10 feet. Flint in various shades of gray, brown, and white is an important component, and flint float derived from the disintegration of this member is conspicuous on many slopes below the cropline of the member. The Vanport flint is well exposed along Route 16, a short distance east of Hardscrabble School in eastern Tuscarawas County. Float from this horizon is also conspicuous on the hillside a mile or so south of Morgan Run in Lafayette Township. An unusual development of Vanport for this county is described in the following section secured along a small ravine tributary to Morgan Run about 1 mile above its mouth in western Lafayette Township.

		Ft.	In.
Track level. Abandoned mine in Middle Kittanning coal		-	-
Covered interval		59	2
Shale, arenaceous		1	0
Flint, black at base, becoming lighter colored upward	Vanport	7	10
Limestone, dark, shaly	Vanport	2	6
Shale, black, calcareous, fossiliferous	Vanport	1	4
Shale, gray, arenaceous	Vanport	16	8
Limestone, bluish gray	Putnam Hill	-	6
Shale, bluish gray, calcareous	Putnam Hill	-	5
Limestone, bluish gray	Putnam Hill	-	4
Shale, soft, bluish gray, calcareous	Putnam Hill	-	5
Limestone, black, dense, fossiliferous	Putnam Hill	-	5
Shale, bluish gray, soft		1	7

		Ft.	In.
Coal, bony.	Brookville or No. 4	-	5
Coal, blocky.		1	6
Clay, gray, siliceous.		5	0

Altitude, 847 ft.

The Vanport member is generally present in the form of flint in the southeast corner of White Eyes Township east of White Eyes Creek and south of Fresno. Where exposed along the east-west road three-fourths of a mile west of Bowman School it is represented by 2 feet of light gray flint occurring about 25 feet above the Putnam Hill limestone, 13 feet below the Lower Kittanning coal horizon, and 47 feet below the Middle Kittanning coal. The Vanport is likewise present along the valley of East Fork in the southwestern part of Adams Township. As exposed along the road at an altitude of 990 feet just west of Powell, it is represented by 1 foot of light-colored flint outcropping 13 feet 6 inches below the Lower Kittanning coal. Just south of Hoffman School the Vanport is represented by a dark flinty rock 2 feet 6 inches in thickness occurring 20 feet below the Lower Kittanning coal. Where it outcrops along the road, three-fourths of a mile southeast of Myser School it is represented by 1 foot of dark compact limestone lying 26 feet above the Putnam Hill limestone and 63 feet below the Middle Kittanning coal. It is generally present along the slopes rising to the west and northwest from Bakersville. Here it is a nodular, somewhat flinty limestone a foot or more in thickness.

The economic value of the Vanport member as a source of limestone in Coshocton County is negligible. It lacks persistence on the outcrop and constancy in composition. Where the bed occurs in sufficient thickness to warrant quarry operations it is invariably highly siliceous and impure in composition.

Ferriferous Ore

The stratigraphic position of the Ferriferous ore is immediately above or closely overlying the Vanport limestone. Along the outcrop from Perry County south to the Ohio River in Lawrence and eastern Scioto counties, this member is present with varying persistence. Formerly it was mined at many localities in Perry, eastern Hocking, Vinton, eastern Jackson, western Gallia, eastern Scioto, and Lawrence counties and utilized in many small furnaces for the production of iron. Locally in this region it was known as the Baird ore, the Ferriferous ore, or the Limestone ore. The Ferriferous ore fails in development and continuity north of Perry County. Thin deposits have been observed at only a few localities where due in western Muskingum County[1] and it is even less conspicuous in Coshocton County. Although its horizon outcrops over a large area in Coshocton County, the Ferriferous member has been noted at only a few places. Where present it is a limonitic ore on the outcrop, 1 to 3 inches in thickness, occurring close above the Vanport limestone. It has no economic importance.

Lower Kittanning Coal and Clay

STRATIGRAPHY, EXTENT, AND VALUE

The Lower Kittanning coal, first named the Kittanning by H. D. Rogers in 1858[2] for its occurrence near Kittanning, Pennsylvania, and later renamed the Lower Kittanning by I. C. White,[3] outcrops across eastern Ohio from Columbiana and Mahoning counties on the east to

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[1]Stout, Wilber, Geology of Muskingum County, Geol. Survey Ohio, Bull. 21, p. 164, 1918.

[2]Rogers, H. D., Geology of Pennsylvania, Vol. II, p. 491, 1858.

[3]White, I. C., Report of Progress in the Beaver River District, Geol. Survey Pa., Rept. K, pp. 43, 57, 59, 1878.

Lawrence County on the south. Regionally both the coal and underlying clay are quite persistent on the outcrop in Ohio, occurrences having been described in every county where due. The coal is quite variable in thickness and in some localities is wanting. It has been mined extensively and is an important source of fuel in Columbiana and southeastern Mahoning counties, in northern Tuscarawas County, and in eastern Jackson and western Lawrence counties. The clay underlying the Lower Kittanning coal horizon is exceeded by none in Ohio in its importance as a source of material for ceramic products. It has been utilized to some extent in every county where it outcrops with the possible exception of Holmes, Wayne, Guernsey, Vinton, and Gallia. Centers of extensive utilization include the Ohio River Valley in Columbiana and northern Jefferson counties, the Big Sandy Valley in northern Carroll County, the valleys of Sugar Creek and the Tuscarawas River in Tuscarawas County, and the Oak Hill region in Jackson County. The stratigraphic position of the Lower Kittanning coal and clay across Ohio is on an average about 27 feet below the persistent Middle Kittanning coal and about 25 feet above the less regular and persistent Vanport limestone.

In Coshocton County the horizon of the Lower Kittanning or No. 5 coal and clay reaches the surface in parts of every township except Tíverton, Perry, and Newcastle in the western part. The areas underlain by these beds, however, are relatively small in eastern Pike and in the eastern parts of Bedford, Jefferson, and Monroe townships where the horizon outcrops near summits of the highest ridges. Owing to the regional dip of the beds to southeast, exposures occur at lower levels throughout the central and eastern parts.

The Lower Kittanning coal is true to regional habit in Coshocton County in that it lacks continuity and uniformity of thickness. In places the only indication of the horizon is a few feet of gray plastic clay and even this may fail in occurrence and no evidence of the coal horizon remain. Where present the coal varies from a mere soot streak to a maximum known thickness of about 4 feet 6 inches, yielding an average for 18 measurements at different localities of 1 foot 10 inches. Bodies of coal of mineable thickness are generally small in area and widely dispersed. This bed has been mined for local use from a few small scattered "banks" in Adams, Oxford, White Eyes, Tuscarawas, Mill Creek, Keene, Clark, Bethlehem, and Virginia townships.

The bed of clay immediately underlying the Lower Kittanning coal is in general more persistent in this county than the coal. In the absence of the latter the clay is generally overlain by shale. The thickness of the clay as observed on the outcrop varies from 1 foot 6 inches to 13 feet 4 inches but an average of a number of measurements is 5 feet 8 inches. The clay is of the gray plastic type with varying amounts of siliceous impurities. Silica tends to be more prominent in the lower part of the bed. No flint clay has been observed associated with the Lower Kittanning bed in this county. This clay is not now being employed for ceramic purposes in Coshocton County. Formerly it was utilized at Coshocton for the production of building brick. Concerning the potential importance of Lower Kittanning clay in Coshocton County Stout writes as follows:[1]

"The Lower Kittanning is the most widely distributed and the most valuable clay member in Coshocton County. The field is favorably traversed by water courses and by transportation lines and has an abundance of coal. This bed in the future will undoubtedly become the source of large revenue to the county."

Monroe, Jefferson, and Bedford Townships.- The Lower Kittanning coal and clay in Monroe Township is confined in its distribution chiefly to the high ridge just east of Spring Mountain in sections 12, 13, 18, and 19. Five feet of clay was observed along the road in the southern part of Section 13 at an altitude of 1,180 feet or 40 feet below the Middle Kittanning coal. It is reported to be overlain in this vicinity by coal 1 foot 10 inches in thickness. Lower Kittanning coal is also due near the crest of the high ridge in the northwest quarter of Section 4,

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[1]Stout, Wilber, Stull, R. T., McCaughey, Wm. J., and Demorest, D. J., Coal formation clays of Ohio, Geol. Survey Ohio, Bull. 26, p. 304, 1923.

extending to the north into Section 24, Richland Township, Holmes County.[1] Here it is reported to have a thickness of about 2 feet 10 inches and to occur about 30 feet above the Putnam Hill limestone.

In Jefferson Township the distribution of the Lower Kittanning coal and clay horizon is confined to the high ridge south of the Walhonding River and east of Simmons Run. Along this ridge outcrops are due at an altitude of about 1,030 but sandstone and shale seem to prevail at this level. This coal and clay member is likewise due along the high ridges in the southeastern quarter of Bedford Township including parts of sections 11, 12, 13, 18, 19, 20, 21, 22, and 23, but little evidence of the coal or clay has been found on the outcrop. It is likewise due below the summits of the high flats north of Brush Ridge School in Section 7 and the southwestern part of Section 8, but no exposures have been observed in these localities. A short distance southwest of West Bedford the Lower Kittanning clay is exposed along the road at an altitude of 1,100 feet. The coal is apparently wanting at this locality.

Pike and Washington Townships. - The Lower Kittanning coal horizon outcrops at a number of localities along the upper slopes of Virginia Ridge in eastern Pike and western Washington townships from Clark School in Section 10, Pike Township, south to the Muskingum County line. Five feet of Lower Kittanning clay outcrops along the road in the north half of Section 21, Pike Township, at an altitude of 1,075 feet or 52 feet above the Putnam Hill limestone. This clay was likewise observed in good thickness just east of Graham Corners where its altitude is 1,060 feet. Outcropping strata are exposed at intervals along the public road leading down the slope to the southwest from Graham Corners where the following record was secured.

		Ft.	In.
Clay, gray, plastic, Lower Kittanning		3	0
Shale and covered		30	6
Flint horizon, loose fragments, Vanport		-	-
Coal blossom, Clarion or No. 4a		-	2
Covered interval		6	2
Clay, yellowish gray		2	0
Covered interval		22	4
Limestone, gray, generally dense, fossiliferous, Putnam Hill		3	0
Covered interval		63	2
Shale, gray, arenaceous		18	0
Limestone, grayish black, fossiliferous	Lower Mercer	1	6
Limestone, grayish black, fossiliferous	Lower Mercer	-	8
Limestone, grayish black, fossiliferous	Lower Mercer	1	9
Altitude, 955 ft.			

In the northeast half of Washington Township the horizon of the Lower Kittanning coal and clay is due to outcrop near the summit of the high knobs along the ridge extending to the northeast from Wakatomika at altitudes ranging from about 1,010 feet to 1,025 feet. These members are also due near the hilltops in sections 1, 10, 11, and 20. No exposures have been noted in these areas.

Clark Township. - Outcrops of the Lower Kittanning coal and clay in Clark Township are confined to the southeastern half, where the altitude ranges from 1,100 feet in Section 17 to about 1,000 feet in the southeastern part of Section 21. The coal has been prospected with

[1] White, G. W., Geology of Holmes County, Geol. Survey Ohio, Bull. 47, p. 234, 1949.

a power shovel by the Oak Hill Coal Company near the crest of the high hill in the southeastern part of Section 17. A measurement of the outcrops near the opening of the pit is as follows:

	Ft.	In.
Shale, dark bluish gray, with a few iron carbonate nodules	15	0
Coal, blocky, Lower Kittanning or No. 5	1	5
Shale, dark bluish gray	1	0
Altitude, 1,107 ft.		

Three feet 4 inches of Lower Kittanning coal is claimed under the highest part of this hill. As the coal dipped rapidly to the southeast under the thick cover drainage became difficult and the overburden increased so rapidly that the project was abandoned.

The Lower Kittanning coal was formerly mined in a small way near the road in the northwest quarter of Section 23. The altitude of the bed at this locality is 1,070 feet. A few small openings have also been made in this bed in the southeast quarter of Section 22 where the altitude is about 1,025 feet, but no measurements of the coal could be secured. The stratigraphic relations of the Lower Kittanning coal and clay to underlying strata in this vicinity are well shown in the following record of exposures along the northwest-southeast road in the north central part of Section 22.

Coal blossom, Lower Kittanning or No. 5	-	6
Clay, gray, and covered	3	0
Shale, gray	44	0
Limestone, bluish gray, generally dense, fossiliferous, Putnam Hill	-	6
Clay and covered	5	0
Shale and covered	38	6
Limestone, black, flinty, and black flint, Upper Mercer	2	6
Covered interval	23	2
Limestone, gray black, generally dense, fossiliferous, in three beds, Lower Mercer	4	3
Altitude, 940 ft.		

In the east central part of Clark Township Lower Kittanning coal and clay are due to crop out at altitudes ranging from about 1,010 feet at the southern edge of Section 20 to about 1,040 feet in the northern part of Section 11. Few exposures of the coal and clay occur in this area and in places sandstone occupies the Lower Kittanning horizon.

Bethlehem Township. - The distribution of the Lower Kittanning coal and clay horizon in Bethlehem Township is confined chiefly to the ridges bordering the valley of Bucklew Run in the northeastern quarter and to the high hills north of the Walhonding River in the southeastern quarter. The altitude of the horizon ranges from about 1,050 feet at the north central edge to about 980 feet at the east central edge. The Lower Kittanning coal was formerly mined on the Elliott property located about 1 mile northwest of School No. 5. The coal is reported to have a thickness of 3 feet 6 inches with a slate roof and a 3-inch clay band located about 8 inches from the floor which at the mouth of the mine has an altitude of 1,040 feet. The coal rises to the west from the Elliott mine outcropping at the south central edge of Section 23, Bethlehem Township, at an altitude of 1,060 feet. A small opening has been made here and the coal is reported to have a thickness of 3 feet. South of the Elliott property the Lower Kittanning coal is due some 80 feet below the crest of the high ridge for a distance of $1\frac{1}{4}$ miles. No coal outcrops were noted along this ridge and in places heavy-bedded sandstone occupies the coal horizon.

East of Bucklew Run the place of the Lower Kittanning coal seems to be generally occupiec by sandstone. Thin coal and clay on this horizon are found, however, at an altitude of 997 feet along the northwest-southeast road in the northeastern corner of the township. Thin Lower Kittanning coal has also been observed just south of School No. 7 at an altitude of 1,025 feet or about 40 feet below the Middle Kittanning coal exposed higher on the hillsides. One and three-fourths miles west of Keene and just east of the north-south road, prospect pits have been dug on the Lower Kittanning coal as attested by a pile of coal waste. The thickness of the bed could not be determined but the altitude of the coal horizon at this locality is 988 feet.

Lower Kittanning coal is due to crop out high on the slopes of the high ridge south of Soggy Hill School but no exposures were found along this ridge in Bethlehem Township.

Jackson Township. - The Lower Kittanning coal horizon outcrops over a large area in Jackson Township embracing parts of every section, but the coal where present is generally too thin for mining and the underlying clays are not known to be of unusual quality. The altitude of the members in this township ranges from about 1,035 feet in the northwest corner to about 880 feet in the southeast part. Locally both the coal and clay are replaced by sandstone. Lower Kittanning coal is generally present near the summit of the high ridge extending from Section 5 to the northwestern part of Section 2 as indicated by a thin blossom from 30 to 40 feet below the Middle Kittanning coal. In the eastern part of Section 10, outcrops of Lower Kittanning coal occur along the road at an altitude of 964 feet or 30 feet below the Middle Kittanning coal. As exposed along the road at an altitude of 927 feet just east of the east central edge of Section 11, the interval to the Middle Kittanning coal is 45 feet and to the Lower Mercer limestone, 107 feet. A good development of Lower Kittanning clay was observed along the road near the head of Moscow Run in the northern part of Section 14 at an altitude of 1,006 feet. The stratigraphic relations of Lower Kittanning coal and clay to overlying and underlying beds are well shown in outcrops along the east-west road in east central Section 14 and the west central Section 13 as described below. The altitude of the Lower Kittanning coal at this place is 1,010 feet.

	Ft.	In.
Shale, sandy.	5	0
Coal blossom, Middle Kittanning or No. 6	2	0
Shale and covered	27	0
Coal blossom, Lower Kittanning or No. 5.	-	6
Clay, gray, plastic, siliceous.	4	10
Shale and covered	36	2
Sandstone, soft and friable	31	0
Shale, arenaceous	12	2
Limestone, dark, Upper Mercer.	1	6
Coal blossom, Bedford.	1	6
Clay and covered.	10	0
Shale and covered	30	2
Limestone, grayish black, hard, Lower Mercer. . .	1	6
Coal, shaly, and black shale . . .	1	0
Clay, dark . . . . . Middle Mercer . .	-	4
Coal, weathered.	1	0
Clay, bluish gray.	3	0
Altitude, 878 ft.		

Lower Kittanning coal 2 feet in thickness was observed to crop out at the east edge of Section 20 at an altitude of 930 feet or 30 feet below the Middle Kittanning coal.

Virginia Township. - The Lower Kittanning coal and clay horizon is above drainage along all the valleys in Virginia Township, where its altitude ranges from about 980 feet west of New Moscow to 860 feet above Conesville along the eastern edge. Few exposures were noted in the eastern half of the township but either the coal or clay is well shown along the valley of

Moscow Brook and its tributaries in the western part. The coal is generally too thin for mining and at some places it is wanting, its horizon being indicated by a few feet of gray plastic clay overlain by shale. Along the road one-half mile southeast of New Moscow the Lower Kittanning horizon is exposed at an altitude of 985 feet. Here it is represented by 5 feet of gray plastic clay which occurs 65 feet above the Putnam Hill limestone and 16 feet below the Middle Kittanning coal. The coal is likewise wanting one-half mile south of Brush School where gray siliceous Lower Kittanning clay 5 feet in thickness is exposed at an altitude of 981 feet. A local pocket of Lower Kittanning coal thick enough for mining occurs just west of Moscow Brook about 1 mile north of New Moscow. The thickness, structure, and stratigraphic relations are shown in the following section secured at this locality.

	Ft.	In.
Coal, Middle Kittanning, reported thickness	2	6
Covered interval	33	4
Coal	2	4
Parting with pyrite	-	½
Coal	-	9
Parting with pyrite	-	½
Coal	-	4
(Lower Kittanning or No. 5)		
Covered interval	82	6
Limestone, black, flinty, Upper Mercer	2	6

Altitude, 846 ft.

Mill Creek Township. - Outcrops of Lower Kittanning coal and clay horizon in Mill Creek Township are confined in their distribution to the high ridge in the western part of the township and to smaller ridge areas in the eastern half in sections 2, 3, 8, and 9 and in sections 10, 11, 19, 20, 21, and 22. Both the coal and clay are generally present where due but the coal is usually too thin for mining and the clay lacks outstanding qualities. A thin blossom of Lower Kittanning coal with its underlying clay occurs along the road near the cemetery in the north central part of Section 22, at an altitude of 1,020 feet. Here the interval to the Middle Kittanning coal is about 42 feet and to the underlying Brookville coal about 49 feet. Along the high ridge in the western part of the township the altitude of Lower Kittanning coal and clay ranges from about 1,010 feet in the southwest corner to about 1,085 feet in the southeast quarter of Section 5. Along the ridge in the west part of Section 8 the horizon is represented by 5 feet of gray plastic clay outcropping at an altitude of 1,050 feet and occurring 44 feet above the Putnam Hill limestone. An outcrop of Lower Kittanning horizon was also observed near the crest of the high ridge $1\frac{1}{8}$ miles northwest of Mound, where the altitude is 1,029 feet. Lower Kittanning coal has been mined in a small way on the Whitcraft property about three-fourths of a mile southwest of the old Grade School. The opening is located along the outcrop just south of the road where the coal bed has an altitude of 990 feet. A description of the coal and nature of the overlying and underlying beds as they are exposed along the road is given in the following section.

	Ft.	In.
Shale, gray	-	-
Shale, black, carbonaceous	-	2
Coal	1	10
Parting	-	1
Coal	-	10
(Middle Kittanning or No. 6)		
Sandstone, shale, and covered	60	0
Coal	1	3
Parting, with pyrite	-	1
Coal	1	0
Parting, variable in thickness	-	1
Coal	-	6
(Lower Kittanning or No. 5)		
Sandstone, shale, and covered	72	0
Limestone, black, and black flint, Upper Mercer	1	6

Altitude, 918 ft.

The lower parting in the Lower Kittanning is reported to be quite variable in this mine, increasing in places to 5 inches in thickness. The coal bed is reported to thicken to 3 feet 6 inches under the hill.

Keene Township. - The field of Lower Kittanning coal and clay has been dissected by stream erosion in Keene Township into a series of irregular, elongated areas underlying the major divides. The altitude of the outcrops varies from about 900 feet at the south central edge to 1,000 feet in the northwest corner to about 1,100 feet in the northeast corner of the township. The coal has been a local source for fuel in a few small areas in the southern half of the township but in the northern half it seems to be thin or wanting. The clay which tends to be more persistent than the coal is of the usual gray plastic type which in some outcrops is quite siliceous. Lower Kittanning clay, 3 feet in thickness, outcrops along the road leading to the northwest from Mill Creek 1 mile west of Keene. The altitude of the outcrop is 982 feet and the interval to the Putnam Hill limestone below is about 47 feet. Where exposed along the road leading to the west from the mouth of Turkey Run the coal measured 10 inches and the underlying plastic clay, 2 feet. Here the altitude of the Lower Kittanning is 1,008 feet and the interval to the Putnam Hill limestone below, 46 feet.

Southeast of Little Mill Creek the Lower Kittanning coal and clay horizon is due to outcrop along the high ridges extending into Section 1 from sections 11, 12, and 13. In the east central part of Section 1, 5 feet of Lower Kittanning clay outcrops along the road at an altitude of 1,092 feet. The coal is apparently wanting at this locality, the clay being overlain with shale. A mile farther south, in the northeast quarter of Section 10, the Lower Kittanning horizon is represented by 3 feet of gray plastic clay separated from the Middle Kittanning coal and the Putnam Hill limestone below by gray sandy shale. Here the intervals to the limestone and overlying coal are 50 feet and 18 feet respectively. A local thickening of Lower Kittanning coal occurs south of Spoon Creek in eastern Keene Township. This coal has been mined in a small way on the Charles Brink property one-fourth mile east of School No. 2. A record of the exposures along the road and in the mine is as follows:

		Ft.	In.
Level of abandoned mine, Middle Kittanning or No. 6		-	-
Covered interval		46	0
Coal	Lower Kittanning or No. 5	-	6
Clay shale parting		-	1
Coal		1	5
Clay shale parting		-	2
Coal		-	3
Coal, bony		-	1
Coal		-	6
Covered interval		78	0
Limestone, black, flinty, Upper Mercer		1	4
Clay shale, dark		6	8
Covered interval		28	0
Limestone, gray black, heavy-bedded, Lower Mercer		3	6

Altitude, 807 ft.

Lower Kittanning coal has been mined for local consumption from an opening located between the ridge road and Spoon Creek about 1 mile east of School No. 2. The following section shows the structure and thickness of the coal.

	Ft.	In.
Coal blossom, Middle Kittanning or No. 6	2	6
Sandstone, shale, and covered	43	0

		Ft.	In.
Coal, shattered		. 1	2
Shale parting		. -	$1\frac{1}{2}$
Coal, good	Lower Kittanning or No. 5	. 1	0
Parting		. -	$\frac{1}{2}$
Coal, good		. 1	5

Altitude, 979 ft.

West of Mill Creek in the southwestern part of the township, the Lower Kittanning coal is generally present near the crest of the ridge north of School No. 5. Here it has been mined from a number of openings nearly all of which have been abandoned. The position of the bed is 85 feet above the Upper Mercer limestone and 35 to 50 feet below the Middle Kittanning coal which crops out near the crest of the highest hills. The Lower Kittanning coal was formerly mined on the E. McClure property near the western boundary of the township about 1 mile north of the Walhonding River. Here in 1902 B. A. Eisenlohr sampled the coal for chemical analysis but incorrectly identified it with the Middle Kittanning bed. His description of the bed at the place of sampling is as follows:[1]

	Ft.	In.
Shale	-	-
Coal, sampled, Lower Kittanning or No. 5	2	1
Clay.	-	-

The composition of the sample as determined by Lord and Somermeier is as follows:[2]

Proximate Analysis

	As received	Moisture free
Moisture	5.40	0.00
Volatile matter	39.92	42.20
Fixed carbon	49.60	52.43
Ash	5.08	5.37
	100.00	100.00

Ultimate Analysis

	As received	Moisture free
Carbon	70.90	74.95
Hydrogen	5.58	5.26
Oxygen	14.02	9.75
Nitrogen	1.24	1.31
Sulphur	3.18	3.36
Ash	5.08	5.37
	100.00	100.00

Heating value	As received	Moisture free
Calories	7,194	7,605
B.t.u.	12,949	13,689

Tuscarawas Township. - The horizon of the Lower Kittanning coal and clay is found above drainage along the Tuscarawas and Mahoning Valleys in Tuscarawas Township, ranging in altitude from 870 feet northeast of Coshocton to about 810 feet in the southwest corner of the area. It also occurs close above drainage along Morgan Run in the eastern part. Few exposures of this coal and clay were noted on the outcrop owing in part to the cover of unconsolidated materials and to the presence in some localities of sandstone which occupies the horizon of these members. The Lower Kittanning clay was formerly used at the plant of the Coshocton Brick Company located about $1\frac{1}{4}$ miles northeast of the Court House at Coshocton. The clay was mined

[1] Bownocker, J. A., and Dean, Ethel, Analyses of Coals of Ohio, Geol. Survey Ohio, Bull. 34, p. 94, 1930.

[2] Op. cit.

by stripping and drifting near the plant and was employed for the production of building brick. Shales overlying the Lower Kittanning and the Middle Kittanning coals were utilized at one time in this plant for paving brick and building brick respectively. A description of exposures near the plant is as follows:

	Ft.	In.
Shale, sandy, estimated thickness	35	0
Coal blossom, Middle Kittanning or No. 6	1	0
Clay, light	5	0
Clay, yellowish gray, sandy	11	9
Shale, soft	5	6
Sandstone, fine-grained	3	0
Shale, gray, sandy	15	0
Shale, gray, a little sandy	3	0
Shale, black, carbonaceous	2	0
Coal, Lower Kittanning or No. 5	2	6
Clay, gray, plastic	10	6
Altitude, about 870 ft.		

Franklin and Linton Townships. - There is little on the outcrop to indicate the continued presence of the Lower Kittanning coal and clay along the Tuscarawas Valley and its tributaries in Franklin Township. In the vicinity of Franklin in the northwestern corner this coal and clay are due at altitudes ranging from 840 to 880 feet, but no outcrops have been found in this area. In the central part of the township the horizon of the Lower Kittanning coal and clay is due along the western-flowing tributaries of the Tuscarawas River at altitudes ranging from about 820 feet in Section 2 to 780 feet at Wills Creek in Section 18. Here unconsolidated surface deposits are conspicuous, permitting few bedrock exposures. In Linton Township the horizon of the Lower Kittanning coal and clay is above drainage along Wills Creek above Marysville and along the courses of its larger eastern-flowing tributaries in the western third of the township. The member has its greatest altitude of about 900 feet in Section 5 from where it dips rapidly to the south and less steeply to the southeast, descending to about 790 feet along Wills Creek in Section 25 and to about 835 east of Carr School in the southeastern corner of the township. The coal is by no means persistent in this area and where present it is too thin for mining. The underlying clay is of the usual gray plastic type.

Crawford Township. - The horizon of Lower Kittanning coal and clay is due to outcrop along the high ridge in western Crawford Township extending from Section 25 northeast to New Bedford. It is likewise due east of the West Fork of White Eyes Creek from Section 18 north to New Bedford, south, west, and north of Halifax School, and west of Baltic in the northeastern parts. The altitude of the horizon varies from about 1,130 feet at New Bedford to about 1,020 feet in Section 22, with altitudes of about 1,100 feet in Section 25 and west of Baltic in the northeastern corner. Few exposures of the coal or clay were noted in the central and western parts. Just east of Halifax School the horizon is represented by 5 feet of clay at an altitude of about 1,070 feet or about 48 feet above the Putnam Hill limestone. North of Halifax School good exposures occur along the east-west road $1\frac{1}{2}$ miles southwest of Baltic. Here the Lower Kittanning is represented by 5 feet of gray plastic clay overlain by a thin coal blossom and outcropping at an altitude of 1,112 feet. The interval here to the Putnam Hill limestone exposed lower on the hillside is 57 feet. Both the coal and clay are well represented in outcrops just west of the railroad near the county line where the thickness and character are as described below:

Coal blossom, Middle Kittanning or No. 6	1	0
Covered interval	31	0
Shale, dark, with iron carbonate nodules	4	0
Shale, black, carbonaceous	-	2
Coal, good, Lower Kittanning or No. 5	2	6
Clay, bluish gray, plastic, siliceous	11	10
Sandstone, thin-bedded, platy	6	0
Track level, altitude, 1,090 ft.		

White Eyes Township. - The Lower Kittanning horizon outcrops along the upper slope of the high ridges extending across the western part of White Eyes Township. Here the altitude varies from about 1,090 feet in the northwest corner of Section 5 to about 1,040 feet in Section 24. The coal has been mined at a few localities in the southwestern part, but outcrops indicate that it is thin or wanting in the northwestern part of the township. Where exposed along the north-south road in the southeast quarter of Section 5, the horizon is replaced by sandstone. At exposures along the road in the southeast quarter of Section 7, the Lower Kittanning is represented by 5 feet of gray plastic arenaceous clay, outcropping at an altitude of 1,078 feet. Here the interval to the Middle Kittanning coal is 35 feet and to the Brookville coal, about 73 feet. The Lower Kittanning coal horizon is well exposed along the road in the northwest quarter of Section 17, where it is found 40 feet below the Middle Kittanning bed. In the northeast quarter of Section 24, Lower Kittanning coal was formerly mined in a small way for local trade. The coal is reported to have a thickness of 6 feet over a very small area from which it thins rapidly in all directions. The level of the old workings occurs about 20 feet below the Middle Kittanning coal which has been mined in this vicinity.

East of White Eyes Creek, the Lower Kittanning coal and clay horizon is due near the crest of the high ridges south of Chili and south of Fresno. The coal was formerly mined on a small scale near the ridge road about 1 mile north of Bowman School. Here the altitude of the bed is 1,013 feet or 25 feet below the Middle Kittanning coal. A fair exposure of Lower Kittanning clay with overlying and underlying members occurs along the road three-fourths of a mile west of Bowman School where the following section was secured.

	Ft.	In.
Coal blossom, Middle Kittanning or No. 6	-	10
Clay, bluish gray, and covered	4	0
Shale and covered	30	2
Clay, gray, plastic, Lower Kittanning	5	0
Shale and covered	6	2
Flint, light gray, Vanport	2	0
Shale and covered	25	0
Limestone, gray, Putnam Hill	-	6
Coal blossom, Brookville or No. 4	1	0
Clay, gray, micaceous, siliceous	5	2

Altitude 957 feet.

Adams Township. - The Lower Kittanning coal and clay are generally present where due on the outcrop in Adams Township but the coal is generally thin and the underlying clay is not especially outstanding in quality. Coal has been mined for local consumption from a few small scattered openings in the southern part of the township. Outcrops of the coal and clay range in altitude from about 1,060 feet in the northwest part to about 940 feet in the southeast corner, with elevations not far from 1,000 feet in the southwest and northeast sections. Where exposed at an altitude of 1,005 feet along the road west of Powell the Lower Kittanning coal has a thickness of about 2 feet 6 inches and occurs about 14 feet above the Vanport limestone. The coal and clay are generally present underlying the south end of the high ridge between East Fork and Evans Creek, but it is generally thin. It was formerly worked on a very small scale near Hoffman School where it has an altitude of 1,027 feet and lies 20 feet above the Vanport flint and 61 feet above the Putnam Hill limestone. Along the road in the southwest quarter of Section 22, Lower Kittanning coal represented by a blossom 1 foot in thickness occurs at an altitude of 945 feet, 32 feet below the Middle Kittanning coal. It is underlain by gray siliceous plastic clay, 5 feet of which is exposed. In the northern part of the township Lower Kittanning coal 3 feet 4 inches in thickness has been mined for local use on the Hotem property in the northeast quarter of Section 3. Here the upper part of the bed is a little shaly and bony but the lower part is of good quality. The altitude at the opening is 1,020 feet.

Lafayette and Oxford Townships. - The Lower Kittanning coal and clay are not conspicuous elements in the outcrops in Lafayette Township. Exposures were noted along a small

ravine tributary to Morgan Run, $1\frac{3}{4}$ miles south of its mouth. At this locality 1 foot 6 inches of weathered Lower Kittanning coal is underlain by 6 feet 6 inches of gray plastic clay. The interval to the Middle Kittanning coal above is about 41 feet. Along the road at Burt School the Lower Kittanning is represented by a thin blossom at an elevation of 944 feet or 37 feet above the Putnam Hill limestone and 39 feet below the Middle Kittanning coal. No outcrops of Lower Kittanning coal were observed in Lafayette Township east of the old valley extending south from West Lafayette. In Oxford Township the coal is generally present about 40 feet below the well known Middle Kittanning bed, having been mined at a few localities south of the Tuscarawas River. Both the coal and clay are well exposed along a small valley tributary to Center Creek $1\frac{1}{4}$ miles southwest of Wagner School. At this locality, 1 foot 6 inches of Lower Kittanning coal overlies 13 feet 4 inches of gray plastic clay. The intervals to the Middle Kittanning coal and Putnam Hill limestone are 30 and 42 feet respectively. The coal was formerly mined along the road three-fourths of a mile southeast of Wagner School where its elevation is 936 feet or 45 feet below the level of old openings in Middle Kittanning coal. Lower Kittanning coal has likewise been worked on a small scale from an opening south of Center Creek and one-half mile west of Morrison Corners. The thickness and structure of the coal could not be determined but the altitude of the old opening is 926 feet and the interval to the underlying Putnam Hill limestone is 41 feet.

Hamden Member

The Hamden is a fossiliferous member of variable character which closely overlies the Lower Kittanning coal. First named for its occurrence near Hamden Furnace, Vinton County,[1] where it is a phosphorus laden iron ore, its known distribution has been extended to include parts of every county along the outcrop from Jackson to Columbiana. Over its field of outcrops this member is both patchy in distribution and variable in lithology. In character it may be composed of bedded limestone, nodular limestone, iron carbonate ore, dark fossiliferous shale, or some combination of these various types. In its usual mode of occurrence in east central Ohio the Hamden member consists of dark fossiliferous shale, with or without embedded nodules or nodular layers of dark ferruginous limestone or iron carbonate ore. The usual position of the member is immediately above the Lower Kittanning coal, but in places it is separated from it by 5 feet or less of shale. Where the overlying Oak Hill clay is well developed nodular limestone of Hamden age may occur embedded in the basal portion. Where present the thickness of the Hamden varies from a few inches to a maximum of 5 or 6 feet but the average is less than 2 feet.

In Coshocton County the Hamden member has been observed at a few localities closely overlying the Lower Kittanning coal. In these localities it generally assumes the form of a thin bed of dark calcareous fossiliferous shale lying close above the Lower Kittanning coal. This type of occurrence is well shown at one locality near the plant of the Coshocton Brick Company in Tuscarawas Township where black fossiliferous pyritiferous shale, 1 foot 3 inches in thickness, representing the Hamden, occurs immediately above the Lower Kittanning coal. Thin nodular limestone associated with the shale has been observed at a few places along Graham Ridge in eastern Pike Township but the deposits are thin. In the absence of the Hamden the Lower Kittanning coal horizon is closely overlain by non fossiliferous siliceous shale or by sandstone. The character and general stratigraphic relations of the limestone phase of the Hamden is illustrated by the following record of exposures along the road and ravine in Section 15, Virginia Township, as recorded by Wilber Stout in 1917.

	Ft.	In.
Shale and covered	15	0
Limestone, nodular, Hamden	1	0
Clay and covered, Lower Kittanning clay top	26	0

[1] Stout, Wilber, Geology of Southern Ohio, Geol. Surv. Ohio, Bull. 20, pp. 252-253, 1916. Also: Andrews, E. B., Report on the second geological district, Geol. Survey Ohio, Rept. of Prog. 1870, Pt. II, pp. 119-121, 1871.

	Ft.	In.
Limestone, ferruginous, upper part flinty, Vanport	5	0
Covered interval	16	0
Limestone, gray, Putnam Hill	4	0
Shale and covered	57	0
Flint, black, Upper Mercer	2	2

The Hamden is an inconspicuous member in the rock succession exposed in Coshocton County. It has no value except for its stratigraphic interest.

Oak Hill Clay and Strasburg Coal

Concerning the Oak Hill clay in Ohio, Stout writes as follows:[1]

"The Oak Hill clay, which was named for deposits occurring at Oak Hill, Jackson County, and which, at that place, is used extensively in the manufacture of refractory ware, is not a persistent bed in the Allegheny coal field of our State but it is found locally from Lawrence County on the south to Columbiana County on the east. The member belongs in the interval between Lower Kittanning and Middle Kittanning coals but it is very unsteady in position, as it may form the roof of the Lower Kittanning coal or may merge with the Middle Kittanning clay. Both flint and plastic clay may occur on the horizon, but the plastic variety is the most common and is usually the thickest. In general, both materials are contaminated with impurities, the most abundant of which are lime and iron oxides."

In Coshocton County the horizon of the Oak Hill clay reaches the surface in parts of every township with the possible exception of Tiverton and Newcastle. Outcrops of this clay, however, have not been recognized in localities where its stratigraphic position could be definitely determined. The existence of this member is suspected near the crest of some of the high knolls on Graham Ridge and the northern continuation of this ridge past West Bedford in western Bedford Township. East of this ridge shales, often sandy in character and in places grading to sandstone, comprise the series between the Kittanning coals with no evidence of the Oak Hill clay. The Strasburg coal which was named for its occurrence near Strasburg, Tuscarawas County, where it overlies clay correlative in position with the Oak Hill, has not been recognized in Coshocton County.

Shales between the Lower and Middle Kittanning Coals

DISTRIBUTION AND VALUE

In Ohio the interval between the Lower Kittanning coal below and the Middle Kittanning clay above is composed in large part of shale. Locally, however, coal, clay, and limestone are present in this interval. Where a complete sequence is developed the succession from the Lower Kittanning coal upward is as follows: Hamden limestone, ore, and shale member, shale, Oak Hill clay, Strasburg coal, shale, Salem limestone, Middle Kittanning clay. These intervening members lack the continuity of the Lower and Middle Kittanning horizons and in their absence shale makes up most of the interval between the Lower Kittanning coal and the Upper Kittanning clay. The thickness of this rock series as exposed on the outcrop in Ohio varies from 13 feet to 60 feet but the average is not far from 25 feet.

In Coshocton County the beds between the Lower and Middle Kittanning coals outcrop over an area embracing parts of every township with the exception of Tiverton and Newcastle in the northwestern part. The areas of exposure are relatively small in the western part of the county

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[1]Stout, Wilber, Geology of Columbiana County, Geol. Survey Ohio, Bull. 28, p. 141, 1924.

where they occur near the hilltops, but they are generally more extensive in the eastern part where they are found at lower levels. The Oak Hill clay and Strasburg coal have not been positively identified in this county and no exposures of the Salem limestone have been found. In Coshocton County shale is the predominating type of bedrock overlying the Lower Kittanning coal and extending upward to the Middle Kittanning clay. This shale is generally dark and siliceous with some ironstone concretions. In places it tends to be more sandy and it may contain thin lenses or beds of sandstone. The thickness of these shales and thin sandstones in Coshocton County ranges from about 15 feet to 45 feet, but the average of a number of measurements scattered over the county is near 26 feet.

The shale occurring in the Lower Kittanning-Middle Kittanning clay interval in Coshocton County is a potential source for raw materials for the ceramic industry. Shale from this horizon was formerly utilized at Coshocton for the production of red face brick by the Coshocton Brick Company, now non-existent. In addition to the shale the Lower Kittanning clay was utilized for buff face brick and the shale above the Middle Kittanning coal for paving block. A measurement of exposures in the pit, secured by the writer in 1929, is as follows.[1]

	Ft.	In.
Shale, sandy, estimated thickness	35	0
Coal blossom, Middle Kittanning	1	0
Clay, light, Clay, yellowish gray, sandy } Middle Kittanning	5	0
	11	9
Shale, soft	5	6
Sandstone, fine-grained	3	0
Shale, gray, sandy	15	0
Bottom of pit		
Shale, gray, a little sandy	3	0
Shale, black, carbonaceous	2	0
Coal, Lower Kittanning	2	6
Clay, gray, plastic	10	6

A sample of shale was cut by R. E. Lamborn from the exposures described above on August 6, 1929. The sample included the 15-foot bed of sandy shale forming the lowest exposure in the pit and the 5-foot 6-inch bed below the Middle Kittanning clay. The 3-foot bed of sandstone between was not included. The results of the tests on the sample are given below.[2]

Sample No. 28

Tests of Strasburg shale from pit of the Coshocton Brick Company
Coshocton, Coshocton County

Chemical analysis
Downs Schaaf, Analyst

	Per cent
Water, hydroscopic, H_2O-	1.24
Water, combined, H_2O+	6.08
Silica, SiO_2	62.10
Alumina, Al_2O_3	18.43
Titanium oxide, TiO_2	1.27
Phosphorus pentoxide, P_2O_5	0.14

[1] Lamborn, R. E., Austin, C. R., and Schaaf, Downs, Shales and Surface Clays of Ohio, Geol. Survey Ohio, Bull. 39, pp. 151-153, 1938.

[2] Op. cit.

	Per cent
Ferric oxide, Fe_2O_3	5.15
Ferrous oxide, FeO	0.81
Lime, CaO	0.60
Magnesium oxide, MgO	0.65
Sodium oxide, Na_2O	0.30
Potassium oxide, K_2O	2.69
Manganese oxide, MnO	0.05
Sulphur, S.	0.04
Carbon dioxide, CO_2	0.00
Carbon, organic, C	0.50
Total	100.05

Oxide, ratio

K_2O	.146		SiO_2	3.369
Na_2O	.016		TiO_2	0.069
CaO	.033	Al_2O_3 · 1.00	P_2O_5	0.008
MgO	.035			
FeO	.295			
MnO	.003			
RO	.528			

Physical properties, determined by Chester R. Austin
Properties in green state

Workability: This material has good plasticity. A good column is extruded from the die.
Time of slaking: 31.25 minutes
Water of plasticity: 20.83 per cent
Dry shrinkage:
Volume: 13.58 per cent
Linear: 4.34 per cent
Drying behavior: This material dries satisfactorily with ordinary care.
Dry nodulus of rupture: 505 pounds per square inch.

Firing Behavior

Cone	Apparent porosity Per cent	Volume shrinkage Per cent	Calculated linear shrinkage Per cent	Absorption Per cent	Bulk specific gravity	Apparent specific gravity
06	24.63	9.91	3.2	12.30	1.99	2.64
04	19.38	13.06	4.2	9.37	2.07	2.55
02	15.51	17.50	5.5	7.40	2.11	2.49
1	13.19	20.16	6.3	6.09	2.17	2.50
3	12.40	21.03	6.6	5.46	2.27	2.59
5	7.61	22.36	6.9	3.30	2.30	2.50
7	6.67	22.54	7.0	2.88	2.32	2.48
8	6.20	22.63	7.0	2.67	2.32	2.47

Fired nodulus of rupture:
Cone 02, 3,141 pounds per square inch
Cone 5, 3,860 pounds per square inch

Fired specific impact strength:
Cone 03, 1.46 centimeter kilograms per square centimeter
Cone 4, 1.28 centimeter kilograms per square centimeter
Fired crushing strength: Cone 5, 11,429 pounds per square inch
Best firing range: Cone 06 to cone 5
Overfiring temperature: Cone 9
Pyrometric cone equivalent: Cone 16
Scumming: Scum occurs on all trials fired to Cone 3 and lower but scum is not apparent on trials fired above cone 3. Two pounds of $BaCO_3$ per ton of material is necessary to prevent scumming.
Salt glazing: The color of the salt glaze produced at 2,100° F. is a brownish green and pinkish gray grading into reddish brown. The glaze produced at 2,050° F. is brown with some green intermingled. When $BaCO_3$ is added the color of the glaze produced at 2,100°F. is a light chocolate brown.
Utilization: This shale was being used for the production of face brick. It is adapted to the production of common brick and because of its good working properties, it can probably be utilized for the production of hollow tile, drain tile, and possibly for sewer pipe. The fired material develops a good red color at cone 1.

Shale similar in general physical aspects to that described above is of common occurrence overlying Lower Kittanning coal in Coshocton County and as such is a potential source of much raw material for the ceramic industry.

Middle Kittanning Coal and Clay

STRATIGRAPHY, EXTENT, AND VALUE

Concerning the continuity and importance of the Middle Kittanning coal in Ohio, Wilber Stout writes as follows:[1]

"The Middle Kittanning is not only the most important but is the most persistent coal bed in the Pennsylvanian system of Ohio. With few wants and not many large areas of impoverishment, this coal outcrops in a narrow belt extending from the Ohio-Pennsylvania State line in Columbiana County southwestward to the Ohio River in Lawrence County. The bed is mined in either a large or small way in Columbiana, Jefferson, Mahoning, Stark, Carroll, Tuscarawas, Holmes, Harrison, Guernsey, Coshocton, Muskingum, Perry, Morgan, Hocking, Athens, Vinton, Gallia, Jackson, and Lawrence counties. In thickness the stratum varies from a few inches to 16 feet but the mean measurement is about 3 feet 6 inches. The Middle Kittanning coal lies, on an average, nearly 33 feet above the Lower Kittanning coal, 61 feet above the Vanport limestone, 47 feet below the Lower Freeport coal, and 95 feet below the Upper Freeport coal. It correlates with the Coalton or No. 7 coal in Kentucky to the south and with the Middle Kittanning or No. 6 coal in Pennsylvania to the east. In Ohio the bed is known locally as the Sheridan, Hocking Valley, Coshocton, Pike Run, and Washingtonville."

The Middle Kittanning coal has good thickness and continuity in Coshocton County. Its field of outcrop includes parts of every township except Perry, Newcastle, Jefferson, and Tiverton in the western part. The altitude of the bed ranges from about 1,200 feet near Spring Mountain in Monroe Township, where it outcrops near the hilltop, to 775 feet along the Wills Creek Valley in southwestern Linton Township. The thickness of bed varies from about 2 feet to 5 feet with an average of 32 widely scattered mine measurements of 3 feet 9 inches. The coal has in general greater-than-average thickness over large areas in Virginia, Franklin, Jackson, and Linton townships, where it has been mined extensively. Less than average thickness prevails in Mill Creek and Monroe townships. The structure of the coal bed is in general typical for the Middle Kittanning of east central and southern Ohio in that it consists of three benches separated by partings. The upper bench is of little value in Coshocton County, where it is known to the

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[1] Stout, Wilber, Geology of Vinton County, Geol. Survey Ohio., Bull. 31, pp. 312, 1927,

miners as "cash" and where it consists of a variable mixture of carbonaceous shale, bone shale, shaly coal, and bone coal. It varies from 1 inch to 1 foot or more in thickness, but the average is about 4 inches. The middle bench of coal has good continuity and excellent quality. A comparison of over 30 mine measurements in different parts of the field show variations ranging from 2 feet 1 inch to 3 feet 4 inches with an average thickness of 2 feet 8 inches for this bench. It is separated from the lower bench by a persistent parting of dark shale with variable amounts of pyrite, ranging in thickness from one-half inch to 2 inches but generally measuring about 1 inch. The lower bench of coal, which is also of good quality, varies much in development. Its observed limits are 3 inches and 1 foot 6 inches with an average of 9 inches. A reduction in thickness of the mineable coal is generally accompanied by a marked thinning of the lower bench.

The clay underlying the Middle Kittanning coal in Coshocton County ranges in thickness on the outcrop from 1 foot to about 5 feet. It is of the bluish gray plastic type which is generally high in silica and in concretionary impurities. This clay bed has not been utilized for ceramic purposes in Coshocton County.

The stratigraphic position of the Middle Kittanning coal and clay in Coshocton County is on an average 35 feet above the Lower Kittanning coal, 78 feet above the Putnam Hill limestone, 64 feet below the Lower Freeport coal, and 90 feet below the Upper Freeport coal.

In Coshocton County the total area underlain by the Middle Kittanning coal is 86.8 square miles. Nearly two-thirds of this area occurs in four townships in the southern part of the county, namely Linton, Franklin, Virginia, and Jackson, where the coal bed has an average thickness of about 3 feet 8 inches. It has long been mined in this county to supply local needs for domestic and industrial purposes and has been transported by truck and train to distant markets. Rough estimates indicate that approximately one sixth of the total tonnage of mineable Middle Kittanning coal in Coshocton County has been mined out and lost in mining.

Monroe Township. - Outcrops of the Middle Kittanning coal and clay horizon in Monroe Township are confined chiefly to the upper slopes of the high ridge east of Spring Mountain in sections 13, 18, 12, and 19. Here the coal has an altitude of about 1,200 feet and lies about 40 feet above the Lower Kittanning coal. The Middle Kittanning is reported to have a thickness of 1 foot 10 inches as encountered in prospect openings.

Clark Township. - In Clark Township the Middle Kittanning coal and clay underlie an area of about 1-1/3 square miles including the highest part of the ridge extending to the northeast from the southeast part of Section 23 and comprising parts of sections 23, 22, 21, 19, 20, 12, and 11 and small areas north of Section 11 and southwest of Shepler School. The altitude of the coal bed in this area ranges from 1,120 feet in Section 23 to 1,060 feet in the eastern part of Section 21. The coal was formerly worked in a small way in the southeast corner of Section 23 as indicated by deposits of mine waste at an altitude of 1,120 feet. Along the high ridge at the southern edge of Section 19 Middle Kittanning coal is being stripped on a small scale by E. D. Lower, and marketed for local consumption. A description of the exposures in the pit follows:

		Ft.	In.
Shale, bluish gray, with a few iron carbonate nodules		10	0
Shale, black, carbonaceous		-	6
Coal, Shale parting, Coal, blocky.	Middle Kittanning or No. 6	2	2
		-	1½
		-	3
Clay, dark		-	3

Altitude, 1,102 ft.

Middle Kittanning coal, formerly identified as Upper Freeport coal, has been mined by William Darr in Section 22. Here in 1902, B. A. Eisenlohr cut a sample and submitted it to Lord and Somermeier for analysis.[1] The description of the bed and the analysis follows.

		Ft.	In.
Shale, tender		-	-
Coal, impure, rejected		-	5
Coal, upper bench, sampled	Middle Kittanning or No. 6	2	4
Shale, rejected		-	2
Coal, lower bench, sampled		-	6
Clay floor.			

Proximate Analysis

	As received	Moisture free
Moisture	6.40	0.00
Volatile matter	37.92	40.51
Fixed carbon	52.49	56.08
Ash	3.19	3.41
	100.00	100.00

Ultimate Analysis

	As received	Moisture free
Carbon	72.72	77.69
Hydrogen	5.67	5.30
Oxygen	15.16	10.12
Nitrogen	1.25	1.33
Sulphur	2.01	2.15
Ash	3.19	3.41
	100.00	100.00

		As received	Moisture free
Heating value	Calories	7,325	7,826
	B. t. u.	13,185	14,086

Along the abandoned road near the southeast corner of Section 20, the Middle Kittanning coal outcrops at an altitude of 1,060 feet. Where exposed a little farther east in western Mill Creek Township, this bed lies 63 feet above the Lower Kittanning coal. Middle Kittanning coal was formerly mined on a small scale on the Leavengood property in the southeast quarter of Section 20, but the mine has been abandoned. No openings in Middle Kittanning coal have been noted along the outcrop near the crests of the high ridges in sections 11 and 12.

Bethlehem Township. - The distribution of Middle Kittanning coal in Bethlehem Township is confined chiefly to the high ridge east of Bucklew Run in the northeastern part, where outcrops range in altitude from 1,040 to 1,060 feet. The best exposures observed in this area occur in the strip mine operated by Michael Barnhart located along the ridge about three-fourths of a mile east of School No. 5. A description of the exposures in the pit is as follows:

		Ft.	In.
Shale, estimated thickness		15	0
Shale, bluish gray, soft		-	3
Coal, bony	Middle Kittanning or No. 6	-	3½
Shale parting, soft		-	1½
Coal		2	1
Clay shale parting		-	1½
Coal		-	6½
Clay, bluish.		-	6
Altitude, 1,044 ft.			

[1] Bownocker, J. A., and Dean, E. S., Analyses of Coals of Ohio, Geol. Survey Ohio, Bull. 34, pp. 150-151, 1930.

The coal from this strip mine is trucked to Blissfield where it is crushed for railroad shipment.

Middle Kittanning coal is due near the crest of the high ridge west of Bucklew Run at altitudes ranging from 1,080 to 1,115 feet, but no exposures have been observed along this ridge.

Mill Creek Township. - The field of Middle Kittanning coal in Mill Creek Township has been reduced by the forces of erosion with a few disconnected patches underlying the highest hills and ridges. Along the divide between Mill Creek and Little Mill Creek such isolated areas occur in sections 11, 19, 20, and 22. Here the altitude ranges from about 1,060 feet in Section 22 to 1,140 feet in the northeastern corner of Section 11. In the north central part of Section 22 the Middle Kittanning is represented by 2 feet 4 inches of weathered coal outcropping at an altitude of 1,062 feet and occurring 42 feet above the Lower Kittanning coal. Middle Kittanning coal is due at an altitude not far from 1,100 feet along the high ridge in sections 2, 8, and 9. No outcrops have been noted in these localities, however, and the presence of the coal is problematical. Middle Kittanning coal is due to outcrop along the high ridge paralleling the western border of Mill Creek Township at altitudes ranging from 1,085 feet in the southern part of Section 5, to 1,060 feet at the southwest corner. Few openings have been found in this area, the coal usually being represented on the outcrop by a thin blossom and the underlying bed by a few feet of bluish gray plastic clay. On the Witcroft property, 1 mile west of Grade School, the Middle Kittanning coal has a thickness of 2 feet 9 inches and outcrops at an altitude of 1,053 feet or 63 feet above the Lower Kittanning member.

Keene Township. - The field of Middle Kittanning coal in Keene Township consists of a number of small widely scattered patches comprising hill and ridge tops and having a total area of about 1.6 square miles. West of Mill Creek the horizon outcrops at an altitude of about 1,040 feet in the northwestern part and at an elevation of 1,000 to 1,040 feet in the southwestern corner. The most continuous field extends to the northeast from Keene along the ridge south of Little Mill Creek. Here exposures are rare and the structure and thickness of the bed are unknown. The coal was formerly worked from a few small openings along the hills north of Canal Lewisville and east of Mill Creek and along the spur ridge south of Spoon Creek where the bed is reported to have a thickness of about 3 feet.

Crawford Township. - In Crawford Township the Middle Kittanning coal is present along the main ridge which extends from the southwest corner to New Bedford. Its altitude here varies from 1,138 feet in Section 24 to 1,168 feet in the north central part of Section 4. Smaller areas underlain by this member are present just east of New Bedford, west of Baltic in the northeast corner, and along the uplands to the north and west of Halifax School in the east central part. The total area of the coal bed in this township is 3.8 square miles, only a very small part of which has been exhausted by mining. The coal has good quality and thickness in a small mine operated by Mr. Leavengood in the east central part of Section 25 where the following measurements were secured:

		Ft.	In.
Roof slate		-	-
Coal, bony	Middle Kittanning or No. 6	-	1½
Coal, good		2	9½
Parting, varies from ½ to 2 inches		-	1
Coal, good		1	2
Clay		-	-

Altitude, 1,130 ft.

At this locality Middle Kittanning coal occurs 81 feet above the Brookville coal, 129 feet above the Bedford coal, and 152 feet above the Lower Mercer limestone.

The Middle Kittanning coal has been mined on a small scale for domestic use by C. B. Wilson in the east central part of Section 16. A description of the bed by Mr. Wilson is given below:

		Ft.	In.
Clay shale (soap stone)		-	-
Draw slate		-	1
Coal, good	Middle Kittanning or No. 6	2	1
Shale parting		-	1
Coal, good, varies from 10 to 15 inches		1	0
Altitude, 1,112 ft.			

Outcrops of the Lower Kittanning coal and Putnam Hill limestone were not found in this vicinity. The interval from the Middle Kittanning coal to the Upper Mercer limestone, however, is 120 feet; and to the Lower Mercer limestone 144 feet. The coal was formerly mined by John S. Baker a short distance west of New Bedford in the northwest quarter of Section 4. The coal in this mine was described and sampled by B. A. Eisenlohr in 1902.[1] A description of the coal follows:

		Ft.	In.
Clay shale, soft		-	-
Shale		-	-
Coal, upper bench, sampled	Middle Kittanning or No. 6	2	6
Clay, rejected		-	2
Coal, lower bench, sampled		-	7
Clay		-	-

The composition of the sample as determined by Lord and Somermeier is given below.[2]

Proximate Analysis

	As received	Moisture free
Moisture	4.70	0.00
Volatile matter	39.20	41.13
Fixed carbon	44.81	47.02
Ash	11.29	11.85
	100.00	100.00

Ultimate Analysis

	As received	Moisture free
Carbon	64.78	67.97
Hydrogen	5.23	4.94
Oxygen	11.98	8.18
Nitrogen	1.12	1.18
Sulphur	5.60	5.88
Ash	11.29	11.85
	100.00	100.00

		As received	Moisture free
Heating value	Calories	6,594	6,919
	B.t.u.	11,869	12,454

No openings were noted in the Middle Kittanning coal on the uplands bordering the valley of White Eyes Creek in the eastern part of White Eyes Township where the altitude of coal outcrops ranges from 1,120 to 1,140 feet.

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[1] Bownocker, J. A., and Dean, E. S., op. cit., p. 90, 1930.

[2] Op. cit.

White Eyes Township. - The Middle Kittanning coal occurs in two major highland areas in White Eyes Township which are separated by the valley of White Eyes Creek. The larger field is made up of a number of small connected tracts in the western part of the township including the higher hills and ridges extending from Section 24 to Section 5. Here the altitude of the bed ranges from 1,060 feet on the south to 1,138 feet at the north. The second area includes the highlands in the southeastern part of the township, east of White Eyes Creek and south of East Fork. The total area underlain by Middle Kittanning coal in White Eyes Township is about 2.2 square miles. In the southeastern part of the township, the coal is generally present to the west and north of Bowman School at altitudes ranging from 1,020 to 1,040 feet. It was formerly mined from a small opening just south of the road forks three-fourths of a mile north of the school. As exposed one-half of a mile west of the school, the bed is represented by a thin blossom at an altitude of 1,035 feet or 34 feet above the Lower Kittanning clay outcropping in the vicinity.

In the western part of White Eyes Township the Middle Kittanning coal has been mined from a number of widely scattered openings some of which have been abandoned. It was formerly worked south of the road in the south central part of Section 17 where its altitude is about 1,094 feet. A description of the bed as exposed in a small opening just south of the road on the Daine Lower property in the northeast quarter of Section 24 is as follows:

		Ft.	In.
Shale, black, and shaly coal.	Middle Kittanning or No. 6	-	6
Coal, with some pyrite, soft.		3	6
Shale parting		-	2
Coal		1	6
Altitude, 1,065 ft.			

Middle Kittanning coal was formerly mined on the Lewis McFarland property in the southwest quarter of Section 24. The coal in this mine was described and sampled by B. A. Eisenlohr in 1902.[1]

Sandstone		-	-
Clay shale, soft		5 to 12	-
Coal, dirty, rejected.	Middle Kittanning or No. 6	-	6
Coal, upper bench, sampled.		2	0
Pyrite, rejected		-	1
Coal, middle bench, sampled.		1	0
Clay rejected		-	2
Coal, lower bench, sampled.		1	2
Clay		-	-

The composition of the sample as determined by Lord and Somermeier follows.[2]

[1] Bownocker, J. A., and Dean, E. S., op. cit., pp. 93-94, 1930.

[2] Op. cit.

Proximate Analysis	As received	Moisture free
Moisture	4.50	0.00
Volatile matter	38.73	40.55
Fixed carbon	50.80	53.20
Ash	5.97	6.25
	100.00	100.00

Ultimate Analysis	As received	Moisture free
Carbon	70.94	74.28
Hydrogen	5.53	5.27
Oxygen	12.63	9.04
Nitrogen	1.30	1.36
Sulphur	3.63	3.80
Ash	5.97	6.25
	100.00	100.00

		As received	Moisture free
Heating value	Calories	7,173	7,511
	B. t. u.	12,911	13,519

Where exposed along the road in the south central part of Section 14 the Middle Kittanning coal has an altitude of 1,087 feet and occurs 42 feet above the Lower Kittanning coal. It was formerly mined just south of the cross roads at the north edge of Section 14 where the altitude is 1,102 feet and the vertical distance to the Lower Kittanning coal is 35 feet. The succession to the Putnam Hill limestone is well shown by the following measurements secured along the public road in the northwest quarter of Section 6.

	Ft.	In.
Coal blossom, Middle Kittanning or No. 6	1	0
Shale and covered	17	10
Clay, gray, plastic, Lower Kittanning or No. 5	3	0
Shale, gray, arenaceous	46	6
Limestone, gray, Putnam Hill	-	6
Coal and carbonaceous shale, Brookville or No. 4	1	0

Altitude, 988 ft.

Within recent years the Middle Kittanning coal has been mined on the John Hothem property in the northwest corner of Section 5 where an imperfect exposure yielded a thickness of 2 feet 7 inches. This coal bed was formerly mined on the Adam Miller property in Section 5, where it was sampled and described by B. A. Eisenlohr as follows.[1]

		Ft.	In.
Sandstone		-	-
Clay, shaly, soft.		-	-
Shale		-	6
Coal, upper bench, sampled.	Middle Kittanning or No. 6	2	9
Clay, rejected.		-	1½
Coal, lower bench, sampled.		-	11
Clay		-	-

The composition of the sample as determined by Lord and Somermeier is as follows:[2]

[1] Op. cit., p. 93, 1930.

[2] Op. cit.

Proximate Analysis	As received	Moisture free
Moisture	5.32	0.00
Volatile matter	37.39	39.49
Fixed carbon	48.69	51.43
Ash	8.60	9.08
	100.00	100.00

Ultimate Analysis	As received	Moisture free
Carbon	67.41	71.20
Hydrogen	5.32	5.00
Oxygen	13.13	8.87
Nitrogen	1.18	1.25
Sulphur	4.36	4.60
Ash	8.60	9.08
	100.00	100.00

Heating value	As received	Moisture free
Calories	6,828	7,212
B. t. u.	12,290	12,982

Adams Township. - The horizon of the Middle Kittanning coal and clay occurs well toward the crest of the long ridge lying to the east and west of Evans Creek and west of East Fork. Its altitude in this township ranges from about 1,060 in the northwest corner to about 960 in the southeast corner. The coal is generally present where due as indicated by the presence of numerous "blossoms" of variable thickness, but clean exposures of unweathered coal are rare. The coal has been worked locally for fuel as attested by occasional piles of mine waste along the coal outcrop. The total area underlain by Middle Kittanning coal in Adams Township is about 6.3 square miles.

The Middle Kittanning coal outcrops along the high ridge west of East Fork from the northwest corner of the township as far south as Woods School. As exposed along the road one-half mile south of Myser School, it is represented by 1 foot of weathered coal outcropping at an altitude of 1,042 feet and underlain by 4 feet of gray siliceous clay. East of East Fork the coal bed extends, with few "cut outs," from the north edge in Section 3 to Powell. It was formerly mined to a small extent in the hills southeast of Powell and in the eastern part of Section 13. From Powell north to Central School in Section 8, the coal lies near the upland surface with generally thin cover. East of Evans Creek the coal has been mined from a few openings in Section 22, where its altitude is approximately 970 feet and the intervals to the Lower Kittanning coal and Putnam Hill limestone are 32 and 65 feet respectively. It has likewise been mined in the northern part of Section 10 but no measurement of the coal could be secured. In the southern part of Section 1 Middle Kittanning coal was formerly mined by Young Brothers. The coal in this mine was sampled by B. A. Eisenlohr who described its character and structure as follows:[1]

	Ft.	In.
Sandstone	-	-
Shale	20	0
Coal, sampled, Middle Kittanning or No. 6	2	4
Clay	-	-

As determined by Lord and Somermeier the composition is as follows:[2]

Proximate Analysis	As received	Moisture free
Moisture	4.58	0.00
Volatile matter	39.18	41.06

Ultimate Analysis	As received	Moisture free
Carbon	67.51	70.75
Hydrogen	5.40	5.12

[1] Op. cit., p. 92, 1930.

[2] Op. cit.

Fixed carbon	47.49	49.77	Oxygen	11.74	8.04
Ash	8.75	9.17	Nitrogen	1.24	1.30
	100.00	100.00	Sulphur	5.36	5.62
			Ash	8.75	9.17
				100.00	100.00

		As received	Moisture free
Heating value	Calories	6,878	7,208
	B. t. u.	12,380	12,974

The elevation of the mouth of the old workings is 1,013 feet. Middle Kittanning coal is persistent but below average in development in this vicinity. Reports indicate variations ranging from 2 feet 6 inches to 2 feet 8 inches for the thickness of the bed. Core drill tests in the vicinity indicate Lower Kittanning coal 1 foot in thickness occurring about 40 feet below Middle Kittanning.

Oxford Township. - In Oxford Township the Middle Kittanning coal bed underlies an area of about 6.6 square miles. Small areas occur underlying the highlands bordering Blue Ridge Run in the northeastern part, but the chief field in Oxford Township is found south of the Tuscarawas River. Here the altitude of the coal bed ranges from 980 feet at the western edge to about 930 feet in the southeast corner. The coal occurs with good thickness and quality in this field where it has long been mined from openings many of which are now abandoned. The position of the coal is on an average about 45 feet above the Lower Kittanning coal and about 80 feet above the persistent Putnam Hill limestone. Along the road southwest of Plains School the position of the bed is marked by old mine waste at an altitude of 940 feet. Along the road three-fourths of a mile farther west the altitude of the Middle Kittanning is 981 feet and the interval to the Lower Kittanning coal 45 feet. The coal has been mined from a number of openings along the valley of Center Run and southwest of Morrison Corners many of which have now been abandoned. Middle Kittanning coal was formerly worked by Peter Henricks in Section 20. The coal in this mine was sectioned and sampled by B. A. Eisenlohr in 1902[1] who describes it as follows:

		Ft.	In.
Sandstone		-	-
Shale		-	-
Coal, upper bench, sampled.	Middle Kittanning or No. 6	1	8
Pyrite, rejected		-	1½
Coal, lower bench, sampled.		-	7
Clay		-	-

The analysis of the sample as determined by Lord and Somermeier is given below.[2]

Proximate Analysis

	As received	Moisture free
Moisture	4.44	0.00
Volatile matter	40.71	42.60
Fixed carbon	50.40	52.74
Ash	4.45	4.66
	100.00	100.00

Ultimate Analysis

	As received	Moisture free
Carbon	72.65	76.03
Hydrogen	5.53	5.27
Oxygen	12.48	8.93
Nitrogen	1.35	1.41
Sulphur	3.54	3.70
Ash	4.45	4.66
	100.00	100.00

[1] Op. cit., pp. 94-95, 1930.

[2] Op. cit.

		As received	Moisture free
Heating value	Calories	7,351	7,693
	B. t. u.	13,231	13,847

Lafayette Township. - The field of Middle Kittanning coal in Lafayette Township is confined to the uplands and ridges south of the Tuscarawas Valley and west of the large valley occupied by Bone Run. The outcrops attain their greatest altitude of 1,000 to 1,020 feet along the western rim of the Cambridge Arch represented in this township by a line extending in a north and south direction just east of Burt School. From this structural crest the bed descends both to the east and west reaching altitudes of 900 to 960 along the western margin of the township and of about 980 on the heights west of Block School in the southeastern quarter. The total area of the coal bed in this township is 4.8 square miles a part of which has been exhausted by mining. Numerous mines have operated along Morgan Run and along other valleys in the southern part of the township. The coal tends in general to be normal in structure and thickness and to be of good quality. Its relation to underlying and overlying strata is shown in the following description of outcrops along a small ravine 1½ miles southwest of Morgan Run.

	Ft.	In.
Shale	20	0
Coal, badly weathered, Middle Kittanning or No. 6	2	0
Clay, gray, siliceous	7	10
Shale, gray, siliceous	32	3
Coal, weathered, Lower Kittanning or No. 5	1	6
Clay, gray, plastic, and covered	6	6

Altitude, 878 ft.

Below average in quality but typical of the structure of the Middle Kittanning coal in Oxford Township, is the bed as exposed in the J. B. Patton mine one mile west of Block School, where it was described and sampled by B. A. Eisenlohr in 1902.[1]

Sandstone		-	-
Shale		-	3
Coal, upper bench, sampled.	Middle Kittanning or No. 6	2	9
Clay, rejected		-	2
Coal, lower bench, sampled.		-	5
Clay		-	-

The sample was analyzed by Lord and Somermeier with the following results.[2]

Proximate Analysis

	As received	Moisture free
Moisture	5.60	0.00
Volatile matter	34.69	36.75
Fixed carbon	46.43	49.18
Ash	13.28	14.07
	100.00	100.00

Ultimate Analysis

	As received	Moisture free
Carbon	61.59	65.24
Hydrogen	4.95	4.59
Oxygen	14.23	9.80
Nitrogen	1.08	1.14
Sulphur	4.87	5.16
Ash	13.28	14.07
	100.00	100.00

[1] Op. cit., pp. 97-98, 1930.

[2] Op. cit.

		As received	Moisture free
Heating value	Calories	6,222	6,591
	B.t.u.	11,200	11,864

Very few mines in the Middle Kittanning coal were in operation or available for measurement of the coal during field work in this township.

Tuscarawas Township. - The Middle Kittanning coal underlies an area of about 5.6 square miles in Tuscarawas Township comprising much of the uplands between the Muskingum Valley on the west and the valley of Morgan Run on the east. The altitude of the coal outcrops varies from a maximum of about 970 feet east of Coshocton in the northern part of the township to about 855 feet along the southern boundary. The coal is persistent varying from 3 feet 3 inches to 3 feet 10 inches in thickness. In the hill just east of Coshocton, where the coal was formerly mined for local consumption and for railroad shipment, it is reported to have a thickness of 3 feet 8 inches. Middle Kittanning coal has been mined for 60 years or more along the valley west of Clark School in the southern part. In the mine owned by Daniel Hudson and located near the head of this valley the coal is reported to have an average thickness of about 3 feet 3 inches and to be overlain by about one inch of black shale and shaly coal. The strip mine of the Sun Coal Company is located near the southeast corner of the township just north of the highway and about one-half mile west of the east boundary of the township. A description of the beds exposed in the pit is as follows:

	Ft.	In.
Shale, bluish gray, with iron carbonate ore nodules	20	0
Coal, shaly	-	1
Coal, good	2	7
Parting	-	1½
Coal	-	10
Clay	-	6

Middle Kittanning or No. 6

Altitude, 855 ft.

The coal is loaded by hand labor into trucks bound for distant markets. Middle Kittanning is likewise mined by stripping at the pit of the Kleen Coal and Mining Company located about three-fourths of a mile east of Pleasant Valley School. A description of the coal and overlying shales as exposed in the pit is given below.

	Ft.	In.
Shale, dark gray, with iron carbonate nodules	20	0
Coal, good	2	10
Parting	-	1½
Coal, good	-	10
Clay, bluish gray, plastic, siliceous	5	0

Middle Kittanning or No. 6

Altitude, 859 ft.

The maximum depth of overburden removed in this pit is estimated at 40 feet. The bluish gray siliceous plastic clay so well exposed here is typical in both character and thickness of the Middle Kittanning clay in Coshocton County.

Linton Township. - The Middle Kittanning coal is generally present with good quality and thickness in Linton Township where it reaches the surface in parts of every section. It is above drainage along the valleys of Wills Creek and White Eyes Creek and along many small

tributaries well toward their headwaters. The altitude of outcrops in this township ranges from about 980 feet in the north part of sections 3 and 4 at the north central edge to 775 feet in Section 25 in the southwest corner to 875 feet near Carr School in the southeast corner. The thickness of the coal varies from 3 feet to 4 feet 2 inches but the usual measurements are from 3 feet 6 inches to 3 feet 9 inches. The parting so characteristic of the Middle Kittanning varies from 1 to 1½ inches in thickness and generally occurs from 6 inches to 10 inches from the bottom of the bed. The upper bench is overlain by black shale and impure coal which in this township is generally less than 6 inches in thickness. The total area underlain by Middle Kittanning coal in Linton Township is 15.6 square miles. Mining has been active and many openings have been made to supply local demand for fuel and for truck distribution to distant markets. The clays underlying the coal are typical of the Middle Kittanning horizon in that they are of the bluish gray plastic kind with many siliceous and other impurities. They have not been utilized in this township.

The Middle Kittanning coal has been mined from several openings along Bacon Run and its tributaries in sections 5 and 6. Its thickness is above the average where formerly mined three-fourths of a mile northwest of Bacon Run School in the northwest quarter of Section 5 as described below.

		Ft.	In.
Shale, bluish gray, argillaceous		1	10
Shale, carbonaceous, and shaly coal	Middle Kittanning or No. 6	-	2
Coal, good		3	4
Parting		-	2
Coal		-	6
Clay. Altitude, 912 ft.			

At the mine of the Gosser Coal Company in the south central part of Section 5, the bed is reported to have a thickness of 3 feet 6 inches to 3 feet 8 inches. In an old opening in the north central part of Section 6 the thickness and structure are as described below.

		Ft.	In.
Shale		-	-
Shale, carbonaceous, and shaly coal	Middle Kittanning or No. 6	-	2
Coal		2	9
Parting		-	1½
Coal		-	10
Clay. Altitude, 895 ft.			

Middle Kittanning coal has been mined at a few places along Bacon Run in sections 3 and 4 as indicated by a few small piles of mine waste. In Section 2 it was formerly worked by Peter Hammersley where in 1902 the coal was sampled and described by B. A. Eisenlohr as follows:[1]

		Ft.	In.
Sandstone		-	-
Shale		-	-
Coal, upper bench, sampled	Middle Kittanning or No. 6	2	10
Clay, rejected		-	2
Coal, lower bench, sampled		-	6
Clay		-	-

[1] Op. cit., p. 96, 1930.

The analysis of the sample by Lord and Somermeier is given below.[1]

	Proximate Analysis	
	As received	Moisture free
Moisture	10.93	0.00
Volatile matter	34.00	38.17
Fixed carbon	48.43	54.37
Ash	6.64	7.46
	100.00	100.00

	Ultimate Analysis	
	As received	Moisture free
Carbon	63.08	70.81
Hydrogen	5.37	4.67
Oxygen	21.73	13.49
Nitrogen	1.15	1.29
Sulphur	2.03	2.28
Ash	6.64	7.46
	100.00	100.00

		As received	Moisture free
Heating value	Calories	6,133	6,885
	B.t.u.	11,039	12,393

A number of small mines have operated in Middle Kittanning coal along the high ridge extending south from Plainfield. An opening of the Minor Coal Company one-fourth of a mile southwest of Stringon in Section 15 exhibits a cross-section of the coal as described below:

		Ft.	In.
Shale, dark		-	-
Shale, carbonaceous, and shaly coal	Middle Kittanning or No. 6	-	5
Coal, good		2	7
Parting, with pyrite		-	1
Coal		-	5
Clay		-	-

Altitude, 911 ft.

Middle Kittanning coal was formerly mined about one-half mile southwest of Linton Mills where the altitude of the bed is 889 feet and where the thickness of mineable coal is 3 feet 6 inches. The operations of the Blake Mining Company are located near Sandbank School in the south central part of Section 20. The coal bed as exposed at this locality is normal in structure with a thickness of 3 feet 5 inches. An unusual development of Middle Kittanning coal is exposed at the mine of the White Eyes Coal Company located in the extreme southwest corner of Section 21. Coal from this mine has been trucked in large part to Berea and neighboring points in northern Ohio. A description of exposures in the mine is here recorded.

		Ft.	In.
Shale		-	-
Shale, carbonaceous, and impure coal	Middle Kittanning or No. 6	-	2
Coal, with occasional lenses of pyrite		2	11
Parting, with pyrite		-	2
Coal, with occasional nodules of pyrite		1	9
Clay, gray		-	6

Altitude, 888 ft.

[1] Op. cit.

Middle Kittanning coal has been mined from a number of openings along valleys tributary to Wills Creek in the west central and southwestern parts of Linton Township. As exposed in the Lapp and Wiggins mines in the northwest quarter of Section 13, the thickness is 3 feet 7 inches and 3 feet 8 inches respectively. The structure and development of the coal is similar in the Dolick mine located in the central part of Section 14 and in a new opening along the valley of Wills Creek in the south central part of Section 17. Middle Kittanning coal has been mined from several small openings south of Wills Creek in Section 24. The character of the bed here is well shown in the account of the W. J. Young mine sectioned and sampled by B. A. Eisenlohr[1] in 1902.

		Ft.	In.
Sandstone		-	-
Shale		-	10
Coal, dirty, rejected	Middle Kittanning or No. 6	-	5
Coal, upper bench, sampled		2	6
Clay, rejected		-	2
Coal, lower bench, sampled		-	10
Clay		-	-

The composition of the sample analyzed by Lord and Somermeier is given below.[2]

	Proximate Analysis			Ultimate Analysis	
	As received	Moisture free		As received	Moisture free
Moisture	4.37	0.00	Carbon	71.34	74.60
Volatile matter	40.97	42.84	Hydrogen	5.56	5.30
Fixed carbon	49.30	51.55	Oxygen	12.85	9.38
Ash	5.36	5.61	Nitrogen	1.28	1.34
	100.00	100.00	Sulphur	3.61	3.77
			Ash	5.36	5.61
				100.00	100.00

		As received	Moisture free
Heating value	Calories	7,247	7,578
	B. t. u.	13,045	13,640

Franklin Township. - The Middle Kittanning coal bed underlies an area of 12.3 square miles in Franklin Township. Its outcrops range in altitude from about 920 to 780 feet, being highest in the northwest corner, along the western edge, and in the northeast corner of the township, and sinking to its lowest level along Wills Creek in the southeast part. The thickness of the coal varies from 2 feet 9 inches to 4 feet 6 inches. It has been mined at a number of places along the Tuscarawas Valley and along the valleys of Wills Creek and Robinson Run for both railroad shipment and for distribution by truck. West of the Muskingum River Middle Kittanning coal underlies an area of eight-tenths of a square mile in Franklin Township. The field consists of several small disconnected areas to the north, northwest, and southwest of Franklin where the altitude ranges from 900 to 920 feet and where the thickness of the coal varies from 3 feet to 3 feet 6 inches. East of the Muskingum River Middle Kittanning coal was formerly worked for railroad shipment at the mine of the Best Coal Company located one mile east of Conesville. The coal in this mine was described and sampled by B. A. Eisenlohr, 1902.[3]

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[1] Op. cit., p. 95-96, 1930.

[2] Op. cit.

[3] Op. cit., pp. 96-97, 1930.

The description is as follows:

		Ft.	In.
Shale		-	-
Coal, upper bench, sampled.	Middle Kittanning or No. 6	2	10
Clay, rejected.	Middle Kittanning or No. 6	-	2
Coal, lower bench, sampled.	Middle Kittanning or No. 6	1	4
Clay		-	-

Lord and Somermeier analyzed the sample with the following results.[1]

Proximate Analysis

	As received	Moisture free
Moisture	4.33	0.00
Volatile matter	41.11	42.97
Fixed carbon	48.97	51.19
Ash	5.59	5.84
	100.00	100.00

Ultimate Analysis

	As received	Moisture free
Carbon	71.42	74.65
Hydrogen	5.41	5.15
Oxygen	12.36	8.90
Nitrogen	1.22	1.28
Sulphur	4.00	4.18
Ash	5.59	5.84
	100.00	100.00

		As received	Moisture free
Heating value	Calories	7,269	7,598
	B. t. u.	13,084	13,676

Middle Kittanning coal has been mined from a number of small openings in the vicinity of the village of Wills Creek. The bed occurs near drainage in the northeast corner of Section 22 where in the D. L. Fliger mine it has the character and thickness described below.

		Ft.	In.
Sandstone		-	-
Shale, carbonaceous, and shaly coal	Middle Kittanning or No. 6	-	2
Coal, good	Middle Kittanning or No. 6	2	9
Parting, varies from 0 to 2 inches.	Middle Kittanning or No. 6	-	1
Coal, good	Middle Kittanning or No. 6	1	3
Clay, gray.		2	0

Altitude, 793 ft.

The Middle Kittanning coal is above the average in thickness at this mine and in the Best mine due in large part to the expansion of the lower bench. As exposed in the Rogers mine one mile northeast of Wills Creek, the depth of the mineable coal is 2 feet 10 inches and the thickness of the lower bench is 3 inches. East and northeast of the village of Wills Creek Middle Kittanning coal has been mined at a few localities in sections 11 and 20, along valleys tributary to Wills Creek. Here its altitude ranges from 800 feet near Grove School to 850 feet in the central part of Section 11.

In the northern part of Franklin Township, Middle Kittanning coal is above drainage along Robinson Run from its mouth to the northwest corner of Section 1. The bed has been mined on the north side of the valley in the northwest quarter of Section 2 where it has a thickness of 3 feet

[1] Op. cit.

6 inches. In the east central part of Section 2 is the old strip mine of the Consumers Collieries Company where exposures were viewed as described below.

	Ft.	In.
Shale, bluish gray, with ore nodules	4	0
Shale, bony, and shaly coal	-	4
Shale, bluish gray, argillaceous	-	2
Coal, Parting, Coal — Middle Kittanning or No. 6	2	9
	-	1½
	1	6
Clay, gray	-	6

Altitude, 830 ft.

Barnes Mine No. 7 of the Columbus Coal Mining Company is located near the head of Robinson Run in the west central part of Section 1. Here Middle Kittanning coal having normal thickness and structure is mined for railroad shipment. This mine was opened about 1934 and has a daily capacity of about 500 tons.

Virginia Township. - The Middle Kittanning coal occurs with mineable thickness in Virginia Township where it underlies all the higher hills and ridges and outcrops at altitudes ranging from 1,020 feet in the northwest part to a low of 885 feet at the central eastern margin. The total area of the field in this township is about 8.8 square miles. The coal is, in general, normal for this county in character, structure, and thickness. It has been mined for many years from a large number of openings widely scattered along the ridges between the Muskingum River and Mill Fork and on both sides of Moscow Brook north of sections 14 and 15. Some of these mines have been abandoned. Middle Kittanning coal has been mined from several openings near the head of Barnes Hollow in the eastern half of Section 1. The following measurements were secured near the mouth of a mine in the northeast corner of the section.

Shale, gray	1	0
Shale, carbonaceous, and shaly coal	-	6
Coal, good	2	4
Clay shale parting	-	1
Coal — Middle Kittanning or No. 6	-	8
Clay, bluish, plastic, siliceous	1	0

Altitude, 914 ft.

The Middle Kittanning coal has been mined for railroad shipment along Davis Hollow in sections 11 and 12. As exposed at the Coleman mine in the north central part of Section 11 the coal has the features described below.

Shale, soft, bluish, discontinuous	-	8
Coal, shaly and carbonaceous shale.	-	5
Coal, good	2	6
Parting	-	1½
Coal — Middle Kittanning or No. 6	1	0

Clay, altitude, 905 ft.

Middle Kittanning coal was formerly worked from a number of small openings located in the vicinity of Chestnut Ridge School south of the central part of Section 12. It was likewise

mined near the crest of the high ridge in northwest quarter of Section 23. At this locality the coal bed was sampled by B. A. Eisenlohr in 1902. He describes it at the place of sampling as follows:[1]

		Ft.	In.
Shale		-	-
Coal, upper bench, sampled.	Middle Kittanning or No. 6	3	0
Clay, rejected.		-	1½
Coal, lower bench, sampled.		-	7
Clay		-	-

The composition of the sample was determined by Lord and Somermeier.[2]

Proximate Analysis

	As received	Moisture free
Moisture	5.12	0.00
Volatile matter	38.99	41.09
Fixed carbon	48.87	51.51
Ash	7.02	7.40
	100.00	100.00

Ultimate Analysis

	As received	Moisture free
Carbon	69.49	73.24
Hydrogen	5.45	5.14
Oxygen	12.97	8.87
Nitrogen	1.20	1.27
Sulphur	3.87	4.08
Ash	7.02	7.40
	100.00	100.00

		As received	Moisture free
Heating value	Calories	7,066	7,447
	B.t.u.	12,719	13,405

Middle Kittanning coal was formerly mined on a small scale in the southwest quarter of Section 18, where the altitude of the outcrop is 971 feet. Within recent years an opening on this horizon has been made along the road in the central part of Section 17. A description of the coal as it appears near the mouth of this mine is as follows:

		Ft.	In.
Shale		-	-
Coal, shaly, and carbonaceous shale.	Middle Kittanning or No. 6	-	4
Coal, good		2	6
Shale parting		-	1
Coal, good		-	4
Clay, gray, plastic.		-	10
Shale and covered		69	0
Limestone, dark gray, sparingly fossiliferous, Putnam Hill		3	6

Altitude, 911 ft.

Middle Kittanning coal has been mined from a number of small openings located high along the sides of the valley of Moscow Brook north of New Moscow. It was formerly worked on a small scale on the east side of the valley about one mile north of the village. At this place the outcrop has an altitude of 967 feet and the interval to the Putnam Hill limestone is 62 feet.

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[1] Op. cit., p. 97, 1930.

[2] Op. cit.

Due west from this opening on the west side of the valley, Middle Kittanning coal was formerly mined in a small way for local use. No measurement of the coal could be secured. The altitude of the crop line, however, is 968 feet and the interval to the Lower Kittanning coal, which has been opened lower on the hillside, is 37 feet. North of Mill Fork in the vicinity of Willowbrook the Middle Kittanning coal outcrops at altitudes ranging from about 950 to 960 feet. The abandoned condition of the small openings in this vicinity did not permit exact determinations of the thickness and structure of the coal.

Jackson Township. - The Middle Kittanning coal is generally present in mineable thickness where due in Jackson Township. It is present closely underlying the summits of the highest hills and ridges in the north row of sections but owing to the southeastern direction of regional dip its position is about midway along the slopes in the southeastern part. The altitude of the outcrops ranges from a high of 1,081 feet in the east central part of Section 5, to 905 feet in the southeast part of Section 1. The coal is quite uniform in thickness in this township. Fifteen measurements of the bed secured in widely scattered mines show a thickness of coal including lower bench, upper bench, and intervening parting, ranging from 3 feet 3 inches to 4 feet 1 inch with the usual measurements falling between 3 feet 6 inches and 4 feet. The coal is of good quality and has been mined from many small openings, widely scattered along the outcrop for both local use and for truck transportation to distant markets. The total area of the Middle Kittanning coal field in Jackson Township is 10.7 square miles.

A few small areas of Middle Kittanning coal occur near the tops of the highest hills in sections 3, 4, and 5 in the northern part of Jackson Township where the altitude of its outcrops ranges from 1,081 in Section 5, to 1,052 feet in Section 3. Where well exposed in the east central part of Section 4, the coal has a thickness of 3 feet 6 inches and is of good quality. West of Moscow Brook this bed also occurs in good development where due. Outcrops range in elevation from 1,050 feet in the northwest corner of Section 14 to about 1,000 feet at the south edge of Section 25. In a small opening on the Hardesty property in the southeast quarter of Section 25, the Middle Kittanning is reported to have a thickness of 4 feet. It was formerly mined for railroad shipment at the works of the Davis Coal Company located in the southwest corner of Section 14. Measurements near the mouth of the mine show 3 feet 11 inches of clean coal with a 1-inch parting about a foot from the bottom of the seam. Where sampled by B. A. Eisenlohr in the mine of A. W. Marshall in the northwest quarter of Section 17, the structure and thickness of the coal are as described below.[1]

		Ft.	In.
Sandstone		-	-
Shale		-	8
Coal, upper bench, sampled	Middle Kittanning or No. 6	2	9
Clay, rejected		-	1
Coal, lower bench, sampled		-	11
Clay		-	-

The composition of the sample as determined by Lord and Somermeier is stated below.[2]

Proximate Analysis

	As received	Moisture free
Moisture	5.32	0.00
Volatile matter	40.93	43.23
Fixed carbon	47.45	50.12
Ash	6.30	6.65
	100.00	100.00

Ultimate Analysis

	As received	Moisture free
Carbon	69.29	73.18
Hydrogen	5.50	5.19
Oxygen	13.45	9.21
Nitrogen	1.24	1.31
Sulphur	4.22	4.46
Ash	6.30	6.65
	100.00	100.00

[1] Op. cit., p. 95, 1930.

[2] Op. cit.

		As received	Moisture free
Heating value	Calories	7,086	7,484
	B. t. u.	12,755	13,471

Middle Kittanning coal has been worked in several small mines located along the valley of Moscow Brook in sections 24 and 25 where the coal varies from 3 feet 10 inches to 4 feet in thickness. In the northwest quarter of Section 23 is the opening of the Burrough-Rich Creek Coal Company where the fuel is being mined for truck distribution. A description of the bed follows:

		Ft.	In.
Coal, shaly, and carbonaceous shale. .	Middle Kittanning or No. 6	-	10
Coal		2	10
Parting		-	1
Coal		1	2
Clay, gray		-	6

Altitude, 990 ft.

A number of small mines have operated in Middle Kittanning coal along the valley of Mill Fork and its tributaries in sections 20, 21, and 22. East of the road in the northeast quarter of Section 20 is the mine of Raymond McIntyre where the coal measures 3 feet 6 inches in thickness and occurs at an altitude of 966 feet. The roof is a bluish gray shale. Similar conditions occur in mines operating in the west central part of Section 20. East of Section 21 and about three-fourths of a mile south of Bowman School is the Jacobs mine where fuel from the Middle Kittanning bed is extracted for truck delivery. A description of the member as it occurs near the mouth of the opening is as follows:

		Ft.	In.
Clay shale, bluish gray.		1	6
Shale, soft, carbonaceous, fossiliferous		1	2
Shale, carbonaceous, and shaly coal .	Middle Kittanning or No. 6	-	8
Coal		2	10
Parting		-	$1\frac{1}{2}$
Coal		1	1

Altitude, 920 ft.

At this locality the interval from the Middle Kittanning coal to the Upper Mercer limestone exposed in the ravine below is 115 feet. Along the Muskingum Valley north of Bowman School, a number of small mines have operated in Middle Kittanning coal from time to time but most of these have now been abandoned. In this area the interval to the Lower Kittanning coal is about 30 feet. Locally, as in Section 11, thick deposits of sandstone occur in the section close below the Middle Kittanning coal, and extend downward to even below the Putnam Hill limestone horizon. The Middle Kittanning clay in Jackson Township is of the usual bluish gray plastic type with siliceous and other impurities rendering it of no great importance as a potential source for raw materials for the ceramic industry.

Bedford Township. - Outcrops of Middle Kittanning coal horizon in Bedford Township are confined to the uplands in Section 7 and to the high ridges extending to the southeast from Section 8 and including parts of sections 8, 13, 11, 12, 19, 20, 21, 22, and 23. The altitude of the bed ranges from 1,120 feet in Section 7 to about 1,000 feet in the southeast corner of Section 21. The total area of the coal bed in this township is approximately 2.7 square miles. Coal probably Middle Kittanning in age was formerly mined by drifting and by stripping along

the outcrop in Section 7. A section of the coal secured by T. R. Meyers in the slope mine of Frank Sharples, located in the south central part of Section 7, is given below:

		Ft.	In.
Soapstone		2	0
Coal and shale, thinly laminated	Middle Kittanning or No. 6	-	11½
Coal, good		1	2½
Coal, bony, with sulphur		-	½
Coal, good		1	½
Shale parting, gray		-	2
Coal, bony		-	½
Shale parting, good		-	½
Coal, good		-	5

The Middle Kittanning coal was formerly mined on a small scale in the northwest quarter of Section 12. It has likewise been mined northwest of and close to the diagonal road in the southeast quarter of Section 19. A description of the coal and the underlying beds exposed near the road leading to the southwest in Section 19 is recorded by T. R. Meyers as follows:

		Ft.	In.
Shale, blue gray		1	6
Coal, shaly	Middle Kittanning or No. 6	-	7
Shale, dark		-	2½
Coal, good		2	7
Clay shale, gray		-	½
Coal, fair		-	3
Clay, light, plastic		-	4
Shale, siliceous, with plant fossils		1	6
Covered interval		28	8
Shale and covered		6	6
Shales and covered		48	6
Shale, buff, siliceous, with an occasional ore nodule of medium size		10	0
Clay shale with ore nodules, weathers a greenish gray		6	2
Limestone, bluish gray, fossiliferous, weathers to a pinkish brown		5	7
Clay shale		-	3
Coal blossom, Brookville or No. 4		2	0

Altitude, 960 ft.

As exposed along the north-south road in the south central part of Section 20 at an altitude of 1,065 feet the Middle Kittanning coal is closely overlain by yellowish brown sandstone. The coal has been mined in a small way along the road near the crest of the ridge in the southeast corner of Section 22 as indicated by mine waste at an altitude of 1,055 feet. No measurement of the coal could be secured at this locality.

Washington Township. - In Washington Township the Middle Kittanning coal horizon is due in a few disconnected areas near the crests of the highest hills in the north central part of Section 1, through the central part of Section 2, the eastern part of Section 8, and western and northcentral parts of Section 9, the southeast quarter of Section 10, the central part of Section 11, and the north central part of Section 20. No mine openings and few exposures of the coal are known in this area.

Pike Township. - The Middle Kittanning coal is due near the crest of the high ridge in the east central part of Section 21 at an altitude not far from 1,100. No exposures of the coal have been found in this small area.

Lower Freeport Sandstone and Shale

The stratigraphic position of the Lower Freeport sandstone is in the interval between the Middle Kittanning coal below and the Lower Freeport limestone above. It was first named the Freeport sandstone by H. D. Rogers in 1858 for its occurrence near Freeport, Pennsylvania.[1] Later at the suggestion of J. P. Lesley, State Geologist of Pennsylvania, it was renamed the Lower Freeport by I. C. White and the Butler sandstone overlying the Lower Freeport coal was termed the Upper Freeport sandstone.[2] The Lower Freeport sandstone has a wide areal distribution in the Appalachian field. According to I. C. White it is never less than 30 feet in thickness in Pennsylvania and generally appears in thicker development in West Virginia.[3] In Ohio the Lower Freeport sandstone is generally irregular and fitful in its occurrence although in general it is present in some degree of development in every county where due to outcrop from Columbiana on the east to Lawrence on the south. The horizon may be represented at different places by sandy shales, shaly sandstone, or heavy-bedded to massive sandstone. Locally the Lower Freeport sandstone transgresses overlying and underlying horizons, replaces the Middle Kittanning coal and extending upward coalesces with the Upper Freeport sandstone. Shale on the Lower Freeport horizon has been used for brick and tile production in Mahoning, Stark, Carroll, Tuscarawas, Coshocton, and Muskingum counties.

The Lower Freeport sandstone is not a conspicuous and outstanding element in the rock succession in Coshocton County. Thick deposits of heavy-bedded to massive sandstone on the Lower Freeport horizon are generally wanting. The usual type of rock found here is sandy shale, shaly sandstone, or sandstone and shale interbedded. The sandstone generally varies in color from bluish gray to gray to yellowish brown, depending in a measure upon the degree of weathering and the amount of iron-bearing compounds present. Flakes of white mica are generally present. The shales are gray to dark in color and are usually siliceous or sandy in character. The field of outcrops of the Lower Freeport sandstone horizon in Coshocton County includes parts of every township except Pike, Perry, Newcastle, Tiverton, and Jefferson in the western part. Thin sandstone on this horizon is more in evidence in Virginia, Franklin, Tuscarawas, and Linton townships although sandy shales are likewise of common occurrence on the Lower Freeport horizon in these areas. The Lower Freeport sandstone is not known to have been put to economic use in Coshocton County. The sandy shales that occur on this horizon, however, were formerly utilized by the Coshocton Brick Company at Coshocton for the production of paving block.[4] This plant has been abandoned.

Lower Freeport Limestone

The stratigraphic position of this limestone is above the Lower Freeport sandstone and close below the Lower Freeport coal. It is less continuous and well developed than the Upper Freeport limestone and consequently was not recognized by Rogers in early surveys in Pennsylvania. Later, while engaged in field work near Butler in Butler County, I. C. White found a

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[1]Rogers, H. D., Geology of Pennsylvania, Vol. II, p. 476, 1858.

[2]White, I. C., The Beaver River District, Second Geol. Survey Pa., Rept. Q, pp. XIV, 50, 1878.

[3]White, I. C., Stratigraphy of the bituminous coal fields of Pennsylvania, Ohio, and West Virginia, U. S. Geol. Survey, Bull. 65, p. 163-164, 1891.

[4]Lamborn, R. E., Austin, Chester R., and Schaaf, Downs, Shales and Surface Clays of Ohio, Geol. Survey Ohio, Bull. 39, p. 167, 1938.

massive limestone close below the Lower Freeport coal which he named the Butler limestone. At the suggestion of J. P. Lesley the name was later changed by I. C. White to Lower Freeport limestone. [1]

The Lower Freeport is not an important limestone member of the Pennsylvanian in Ohio. Although present in some form of development on the outcrop over a wide area from Mahoning and Columbiana counties to Lawrence and Gallia counties, it is generally both thin in development and patchy in distribution. It occurs in the form of nodular masses or discontinuous layers embedded in calcareous clays or clay shales closely underlying the Lower Freeport coal. Where present on the outcrop the limestone varies in thickness from a few inches to a maximum of 4 or 5 feet. It is generally a gray to light buff dense compact rock with varying amounts of siliceous and ferruginous impurities. The fossils that are present are limited to fresh or brackish water types. The Lower Freeport is similar in character and mode of occurrence to the Upper Freeport and Mahoning limestones occurring higher in the series, but is readily distinguishable from underlying limestones on the basis of lithology, fossil content, and place of occurrence with reference to associated coal beds.

In Coshocton County the horizon of the Lower Freeport limestone occurs about 57 feet above the widespread and persistent Middle Kittanning coal. Outcrops of this horizon occur in every township east of the Walhonding-Muskingum rivers and in Jackson and Virginia townships west of these rivers. The Lower Freeport limestone has not been positively identified on the outcrop in Coshocton County. Its horizon is generally occupied by calcareous clay, clay shale, or arenaceous shale and shaly sandstone.

Lower Freeport Coal and Clay

STRATIGRAPHY, EXTENT, AND VALUE

The Lower Freeport coal, named and described by H. D. Rogers in 1858 for occurrences near Freeport, Armstrong County, Pennsylvania,[2] is widespread on the outcrop in Ohio, but in only a few small scattered areas is it thick enough for mining. The largest and most important of these is located in Columbiana and Jefferson counties where the bed is known as the Rogers coal on the outcrop and the Steubenville Shaft coal under cover. The Lower Freeport coal is represented over large areas along the outcrop by a few inches of shaly impure coal or carbonaceous shale overlying a bed of gray to buff impure clay which, in general, is more persistent than the coal. The position of the Lower Freeport coal in the stratigraphic column is a few feet above the Lower Freeport limestone and about midway in the interval between the Middle Kittanning coal below and the Upper Freeport coal above.

In Coshocton County the Lower Freeport coal with its underlying clay are very poorly represented on the outcrop. In places both the coal and clay seem wanting through lack of deposition, their place being occupied by arenaceous shale. Elsewhere the horizon may be represented by a few inches of dark carbonaceous shale over a thin bed of impure clay, or by massive sandstone which seemingly has replaced the coal and clay. At no place in this county is the coal of sufficient thickness or purity for mining. The clay is of the gray plastic type, with siliceous, ferruginous, and calcareous impurities. On the basis of scanty field data, the position of the Lower Freeport coal in this county is about 64 feet above the base of the Middle Kittanning coal and 26 feet below the Upper Freeport coal. Scattered outcrops are due in all townships east of the Killbuck-Walhonding-Muskingum rivers and at a few localities in Jackson and Virginia townships west of the Walhonding and Muskingum rivers.

The Lower Freeport coal horizon is due near the crests of the highest knobs along the ridge between Killbuck Creek and Mill Creek in western Mill Creek, southeastern Clark,

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[1] White, I. C., The Beaver River District, Second Geol. Survey Pa., Rept. Q, pp. XV, XVI, 49-50, 1878.

[2] Rogers, H. D., Geology of Pennsylvania, Vol. II, pp. 475-476, 492, 1858.

northeastern Bethlehem, and northwestern Keene townships. East of Mill Creek outcrops are due near the summits of the highest hills in sections 5, 7, 14, 17, and 24, White Eyes Township. In Crawford Township outcrops are due in the northeast corner and also near the crests of the highest knobs and ridges in sections 3, 4, 6, 11, 12, 14, 15, 16, 17, and 25 in the western and east central parts. No exposures have been noted in these areas.

South of the Walhonding River and west of the Muskingum River the Lower Freeport horizon is due near the summits of the high hills and ridges in southern Jackson Township and near the crests of the major divides in Virginia Township. Sandy shale is prominently developed on the Lower Freeport horizon over much of this area. The succession as exposed along the road in northwest quarter of Section 19, Jackson Township, is described below.

	Ft.	In.
Shale, carbonaceous, and shaly coal, Lower Freeport or No. 6a	-	9
Clay, yellowish gray, sandy	2	9
Covered interval	10	0
Shale, sandy	56	9
Coal, Parting, Coal — Middle Kittanning or No. 6	2 - -	2 1 3
Clay, gray, plastic	4	8

South of the Tuscarawas River and east of the Muskingum River the Lower Freeport coal and clay are due over a large area of uplands in Tuscarawas, Lafayette, Oxford, Franklin, and Linton townships. Here sandy shales and thin sandstone occur for many feet above the Middle Kittanning coal with only occasional evidence on the outcrop of the Lower Freeport horizon. Along the high ridge just east of Coshocton in Tuscarawas Township the Lower Freeport horizon is represented at a few localities by a thin bed of carbonaceous shale. This condition is described in the following record of outcrops along Route 16, one mile east of Coshocton.

	Ft.	In.
Shales, very sandy	-	-
Clay shale, dark, carbonaceous	1	6
Shale, bony, Lower Freeport or No. 6a horizon	-	6
Shale, gray, and thin platy sandstone	40	6
Coal blossom, Middle Kittanning or No. 6.	1	0
Clay, gray, siliceous	3	0

Altitude 922 feet.

Outcrop data indicate that the Lower Freeport coal and clay are generally wanting where due in Linton and Oxford townships. In these townships the stratigraphic position of the coal and clay is generally filled with sandstone and shale.

Upper Freeport Sandstone

Where a complete sequence of Freeport members is represented the stratigraphic position of the Upper Freeport sandstone is in the interval between the Lower Freeport coal below and the Upper Freeport clay above. This sandstone, however, is generally more variable than adjacent members of the Freeport group. It may be wanting from the section, may fill the entire interval from the underlying coal to overlying clay or may so expand in thickness as to replace overlying and underlying members. It was first named the Butler sandstone by I. C. White for its prominent occurrence near Butler, Butler County, Pennsylvania,[1] but its name was later changed to Upper Freeport at the suggestion of J. P. Lesley to conform in terminology with other

[1] White, I. C., Rept. of progress in the Beaver River District, Second Geol. Survey Pa., Rept. Q, pp. 47-49, 1878.

members of the Freeport group.[1] In Ohio the Upper Freeport sandstone is locally present on the outcrop in almost every county from Lawrence to Columbiana and Jefferson. Where in good development it is a loosely-bonded medium-grained, micaceous sandstone which is generally cross-bedded and which may reach 50 feet or more in thickness.

In a poorer state of development it may consist of thin beds of sandstone interstratified with shale or of shaly sandstone grading laterally into sandy shale. Upper Freeport sandstone has been quarried along the Ohio River Valley north of Steubenville, Jefferson County, for pulp wheels for grinding wood pulp.

In Coshocton County the horizon of the Upper Freeport sandstone is generally filled with sandy shale, shaly sandstone, or somewhat irregularly bedded sandstone. Sandstone somewhat shaly in character is found on the Upper Freeport horizon over small areas in Jackson, Virginia, Franklin, Linton, and Oxford townships. The stone is generally micaceous, soft, and poorly cemented. Hence it is not suitable for building or abrasive purposes. The percentage and nature of impurities present exclude the Upper Freeport as a probable source for glass sand, masons' sand, or molding sand.

Upper Freeport Limestone

The Upper Freeport limestone, first named the Freeport by Rogers[2] and later termed the Upper Freeport by I. C. White[3] to distinguish it from the Lower Freeport limestone, overlies the horizon of the Upper Freeport sandstone and occurs close below the Upper Freeport coal. In Ohio this limestone has been found widely distributed on the outcrop from Lawrence and Gallia counties to Mahoning and Columbiana counties but, in general, it lacks thick development and continuity. It is probably best represented in outcrops in Ohio in Columbiana County where it consists of either nodular masses or one or more layers of bluish gray dense-textured impure limestone embedded in clay or argillaceous shale closely underlying the Upper Freeport coal horizon. The position of the limestone in Ohio is on an average about 7 feet below the coal.

In Coshocton County the horizon of the Upper Freeport limestone reaches the surface near the summits of the high hills and ridges in parts of Jackson, Virginia, Franklin, Linton, Tuscarawas, Lafayette, and Oxford townships. No exposures of this limestone have been found in this county.

Upper Freeport Coal and Clay

STRATIGRAPHY, EXTENT, AND VALUE

The Upper Freeport coal derives its name from its occurrence near Freeport, Armstrong County, Pennsylvania.[4] In Ohio this bed, which is No. 7 in the series of numbered coals of the State, is fitful and inconstant in its occurrence on the outcrop but nevertheless is widespread, for outcrops of the coal, associated clay, or both are found in every county where due from Columbiana to Lawrence and Gallia. In some areas the coal is wanting apparently through lack of deposition. Where present it varies in thickness from a mere soot streak to an occasional occurrence of 7 or 8 feet. It has been mined in many widely scattered areas the most important of which occur in Columbiana, Carroll, Tuscarawas, Harrison, Guernsey, Muskingum, Athens, and Gallia counties. In stratigraphic position the Upper Freeport coal is the youngest and highest member of the Allegheny series being overlain by shale and sandstone of Conemaugh age.

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[1] White, I. C., The geology of Lawrence County, Second Geol. Survey Pa., Rept. QQ, pp. 29-30, 1879.

[2] Rogers, H. D., Geology of Pennsylvania, Vol. II, pp. 476,492-493, 1858.

[3] White, I. C., Op. Cit., p. 47, 1878.

[4] Rogers, H. D., Geology of Pennsylvania, Vol. II, pp. 476, 493, 1858.

The clay directly underlying the Upper Freeport coal is of the gray to buff plastic type which is generally calcareous, siliceous, and ferruginous in character. It is of slight economic importance as it adds little to the resources of the State.

In Coshocton County the Upper Freeport coal horizon is represented in a few areas where due by a thin bed of black shale and shaly coal overlying gray plastic clay and in other areas by a thin bed of clay. At no place in this county is the coal thick enough for mining. Over a part of the field of outcrops both coal and clay are wanting, their place being occupied by sandy shales and sandstones. Where present the coal occurs on an average about 26 feet above the Lower Freeport coal and about 90 feet above the widely distributed Middle Kittanning coal. Outcrops of the Upper Freeport horizon are due over very small areas in Adams, Crawford, White Eyes, Keene, Clark, and Mill Creek townships and over much larger areas in Jackson, Virginia, Franklin, Linton, Tuscarawas, Lafayette, and Oxford townships.

Near the crest of the high ridge near the northeast corner of Bethlehem Township the Upper Freeport coal is represented by thin blossom at an altitude of 1,145 feet or about 100 feet above the Middle Kittanning bed. This coal is due near the crest of the highest knobs in Section 20, Clark Township, and in sections 14 and 15, Mill Creek Township, but no exposures were noted in these areas. The high ridge in the northwest corner of White Eyes Township and extending into Crawford Township is underlain with thin Upper Freeport coal. Here the altitude is about 1,220 feet or 85 feet above the Middle Kittanning coal. In the northeastern part of Crawford Township the Upper Freeport is due near the summit of the ridge north of Halifax School. It is likewise due in the extreme northwest corner of Adams Township and near the crest of the high ridge east of Evans Creek in the southeastern part. Near Hines School in the southwest corner of Section 20 this horizon is represented by a thin bed of clay outcropping at an altitude of 1,085 feet.

South of the Tuscarawas-Walhonding rivers the Upper Freeport coal and clay horizon is due to outcrop over much larger areas but throughout Linton, Franklin, and Virginia townships sandy shale and sandstone seem to occupy the horizon with little evidence on the outcrop of either Upper Freeport coal or clay. Along the high ridge in southern Oxford Township the Upper Freeport coal is generally represented by a thin blossom at altitude ranging from 1,030 to 1,050 feet or 85 to 90 feet above the Middle Kittanning coal. At no place in this area is the coal thick enough for mining. The Upper Freeport horizon is represented at a number of localities in Tuscarawas Township by a thin clay bed or by black shale and shaly coal occurring from 90 to 100 feet above the Middle Kittanning coal. The measurements secured along an old abandoned road leading up the hill east of Coshocton and short distance south of Route 16 are typical for this area.

	Ft.	In.
Shale, gray, sandy.	30	0
Coal and black shale, weathered, Upper Freeport or No. 7	-	4
Shale and covered	11	0
Shale, buff to gray, sandy.	31	4
Covered interval (Lower Freeport coal horizon belongs in this interval)	10	2
Shale, gray, sandy.	41	6
Level of abandoned mine, Middle Kittanning or No. 6 coal	-	-
Altitude, 934 feet.		

Thin clays occurring on the Upper Freeport horizon are exposed at several localities in the south central part of Jackson Township. In the southeast part of Section 12, the altitude of this clay is 1,113 feet or approximately 100 feet above the Middle Kittanning coal. The clay was formerly stripped near the crest of the high ridge in the southwest quarter of Section 11 and was hauled to Coshocton where it is reported to have been utilized for ceramic purposes.

The clay is of the gray to reddish brown mottled plastic type which is rather highly calcareous in composition. No information is at hand of any other attempts at the utilization of the Upper Freeport clay in Coshocton County.

Where due along the ridges and uplands in eastern Franklin and in Linton townships the horizon of the Upper Freeport coal and clay is generally occupied by sandy shale or sandstone.

CONEMAUGH SERIES

The Conemaugh series, so named by Franklin Platt in 1875 for outcrops along the Conemaugh River in western Pennsylvania,[1] includes that group of rocks extending in vertical section from the top of the Upper Freeport coal of Allegheny age upward to the base of the Pittsburgh coal of Monongahela age. From its type locality outcrops of this series extend to the south and southwest through southwestern Pennsylvania, northwestern West Virginia, northeastern Kentucky, and eastern and southeastern Ohio entirely surrounding younger deposits of Monongahela and Permian ages still remaining in the deeper portions of the Appalachian basin. The thickness of the Conemaugh series tends to be greatest along its eastern and northeastern border and to thin in a western and southwestern direction. In southwestern Pennsylvania and northern West Virginia the thickness of this series ranges from about 550 to 650 feet. It thickens to the south in West Virginia, reaching a maximum of about 800 feet in the vicinity of Charleston.[2] Along the western outcrops in Ohio where the series reaches the surface over a belt 15 to 40 miles in width extending from Columbiana and Jefferson counties south of Lawrence County, the thickness varies from 518 feet in the north[3] to about 365 feet along the Ohio River Valley in Lawrence County.[4]

Rocks of Conemaugh age in Ohio consist for the most part of frequently recurring beds of sandstone, shale, limestone, clay, and coal. The lower 100 feet or so is dominantly sandstone and arenaceous shale above which are beds of shale interspersed with thin calcareous clays with discontinuous nodular limestones, thin irregular coals, and a few ledges of heavy-bedded to massive sandstone. The shales and clays are both generally calcareous in composition and may be gray, buff, pink, red, or greenish in color. The pink and red varieties, which are the most conspicuous elements in the series, are somewhat irregularly distributed in vertical section and they often characterize a local development which grades laterally into materials of a more somber hue. The coals, of which there are 12 in number, are generally poor in quality and are usually too thin for mining. Because of the lack of mineable coals in this series it was early known as the Lower Barren Measures.[5] The limestones, nine of which have some stratigraphic importance, are widely dispersed both horizontally and vertically and include types formed under both marine and fresh water conditions. The marine forms are generally thin but persistent whereas the fresh water types tend to be nodular in character and more local in areal distribution. In depositional history, the Conemaugh series represents a transitional stage from the Allegheny series below when marine conditions of deposition predominated to the Monongahela series above where the deposits were laid down in fresh or brackish waters. A series of invasions of the sea occurred during Conemaugh time separated by periods when the surface was more or less covered with fresh or brackish waters. The last known marine invasion is represented in depositional sequence by the Skelley limestone, which is due close above the well known Ames limestone in the lower part of the upper half of the Conemaugh series.

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[1] Platt, Franklin, Rept. of progress in the Clearfield and Jefferson districts, Second Geol. Survey Pa., Rept. H, p. 8, 1875.

[2] White, I. C., Stratigraphy of the bituminous coal-fields of Pennsylvania, Ohio, and West Virginia, U. S. Geol. Survey, Bull. 65, p. 71, 1891.

[3] Lamborn, R. E., Geology of Jefferson County, Geol. Survey Ohio, Bull. 35, p. 98, 1930.

[4] Condit, D. D., Conemaugh formation in Ohio, Geol. Survey Ohio, Bull. 17, p. 63, 1912.

[5] Rogers, H. D. Geology of Pennsylvania, Vol. II, p. 476, 1858.

The Conemaugh series is well represented in eastern Muskingum County where the succession of members with general character and thickness of each are essentially as follows.[1]

Section of Conemaugh Series in Muskingum County, Ohio.

	Ft.	In.
Pennsylvanian system		
Conemaugh series		
Clay, calcareous	3	0
Clay shale, calcareous, with local deposits of marly limestone	4	0
Limestone, Upper Pittsburgh	9	6
Clay shale, mottled, calcareous	3	0
Coal, wanting, Upper Little Pittsburgh	-	-
Sandstone, seldom present, Bellaire	5	0
Clay shale, with some marly limestone	12	0
Coal, locally present, Lower Little Pittsburgh	-	6
Clay shale, light to red, calcareous	11	0
Limestone, thin to medium-bedded, interstratified with clay shale, Summerfield	6	0
Clay shale, red, calcareous	8	0
Sandstone, local, generally shaly, Connellsville	5	0
Clay shale, red, calcareous	12	0
Coal, poorly marked, Clarksburg	-	-
Limestone, locally present, Clarksburg	3	8
Clay shale, red and mottled, calcareous	31	0
Sandstone, locally present, Morgantown	6	0
Coal, wanting, Elk Lick	-	-
Limestone, wanting, Elk Lick	-	-
Shale, drab, siliceous, locally present, Birmingham	10	0
Clay shale, red	3	4
Limestone, rather persistent, fossiliferous, Skelley	-	4
Coal, wanting, Duquesne	-	-
Clay shale, red	9	0
Shale and shaly sandstone, gray	11	4
Limestone, siliceous, or sandstone, calcareous, fossiliferous, Gaysport	1	2
Shale and shaly sandstone, gray	16	3
Limestone, persistent, fossiliferous, Ames	1	7
Shale and shaly sandstone, gray	17	9
Coal, persistent, Harlem	1	5
Clay, siliceous	1	4
Clay shale, red to brown, calcareous, Round Knob	16	6
Sandstone, locally present, Saltzburg	7	6
Coal, thin, generally wanting, Barton	-	6
Clay and shale	5	6
Limestone, fossiliferous, locally present, Ewing	-	8
Shale and shaly sandstone, gray	12	0
Sandstone, locally developed, Cow Run	20	0
Shale, gray	1	4

[1] Stout, Wilber, Geology of Muskingum County, Geol. Survey Ohio, Bull. 21, Table III, opp. p. 230, 1918.

	Ft.	In.
Shale, black with nodular limestone, very fossiliferous, Portersville	4	9
Coal persistent, Anderson	1	11
Clay and shale	3	9
Limestone, nodular, locally present, Bloomfield	1	5
Shale, usually gray	8	8
Limestone, fossiliferous, thickness variable, nodular, Cambridge	1	11
Coal, poorly marked, Wilgus	-	4
Clay and shale	10	0
Sandstone, locally present, Buffalo	26	0
Limestone and shale, dark, fossiliferous, unsteady, Brush Creek	3	11
Shale, gray	5	4
Coal, thin, shaly, very patchy, Mason	-	3
Sandstone, unsteady, Upper Mahoning	14	0
Coal, thin, persistent, Mahoning	-	5
Clay, light, siliceous, Thornton	3	9
Limestone, nodular, seldom present, Mahoning	-	3
Sandstone, locally present, Lower Mahoning	33	0

Conemaugh Beds in Coshocton County

GENERAL STRATIGRAPHY AND EXTENT

Only the lower part of the Conemaugh series outcrops in Coshocton County. At one time in the geologic past the beds comprising this series were much more extensive in this area than at present. The forces of erosion acting through long periods of time have so deepened the valleys and lowered the divides that all beds of Conemaugh age have been entirely removed in the northwestern part of the county and the upper part has been lost by erosion in the southeastern part. Outcrops of the erosional remnants are confined to the upper slopes of the highest hills in Adams, Crawford, White Eyes, Jackson, and western Virginia townships and to the chief divides in Oxford, Linton, Lafayette, Tuscarawas, Franklin, and eastern Virginia townships. The maximum thickness remaining is about 170 feet. A thickness of 100 feet or more is of common occurrence along the major divides in that part of the county south of the Tuscarawas River and east of the Muskingum River. In character the bedrocks of Conemaugh age exposed in Coshocton County consist almost entirely of sandstones and sandy shales. This sandstone and shale series comprises that part of the section occupied by the Lower Mahoning sandstone, Mahoning limestone, Mahoning coal, Upper Mahoning sandstone, Mason coal, Brush Creek, shale, and Buffalo sandstone, as exposed to the south in Muskingum County. These limestones and coal members are believed to be wanting in Coshocton County chiefly through lack of deposition.

In Adams Township beds of Conemaugh age are confined to the crest of the high ridge extending from the central part of Section 22 northeast to eastern portion of Section 10. The maximum thickness here is close to 80 feet as exposed in the eastern part of Section 11. A few hills in Crawford Township extend into the Conemaugh. The most important of these occur about a mile northwest of Halifax School in Section 12 where about 100 feet of Conemaugh beds cap the summit. A few small outliers are also found in Sections 16 and 25, Crawford Township, and in Section 5, White Eyes Township. West of the Muskingum River and south of the Walhonding River a number of small disconnected outliers of Conemaugh beds occur in southern Jackson Township and in Virginia Township. The largest accumulations of these occur along the divide east of Mill Creek and extend from the vicinity of Chestnut Grove School northeast into southeastern Jackson Township. Here erosional remnants of Conemaugh strata, having a usual thickness of 20 to 40 feet and a maximum thickness of 80 feet, cap the highest hills. Small outliers crown the high elevations northwest and northeast of New Moscow, Virginia Township, and in sections 16, 17, 18, 19, 20, 22, 23, 24, and 25, Jackson Township.

Along the high ridge east of Coshocton, Tuscarawas Township, the Upper Freeport coal horizon is overlain by a maximum thickness of about 120 feet of Conemaugh strata to the top of the highest hills. This thickness is comprised almost entirely of sandy shale; at two localities, however, a thin bed of variegated clay has been observed along the ridge about 80 feet above the Upper Freeport coal horizon. Sandy shale and shaly sandstone are prominently developed on the upper slopes of the ridge in its southern extension into southeastern Tuscarawas, southwestern Lafayette, eastern Franklin, and western Linton townships. The maximum thickness of this series is about 170 feet. Where due in Linton and Franklin townships the Upper Freeport coal and clay are generally wanting and consequently there is no clear line of separation between beds of Conemaugh and Allegheny ages. Conemaugh members which in normal sequence occur below the Cambridge limestone are either wanting or vaguely expressed. The character of the sandstone and shale series exposed in Linton and Franklin townships is illustrated by the following description of exposures along the road north of Marysville in the south central part of Section 25, Linton Township. This section describes the only exposure of Cambridge limestone and Wilgus clay found in Coshocton County.

	Ft.	In.
Shale, gray to dark, thinly laminated	12	0
Covered interval	3	0
Limestone, slate gray to dark, ferruginous, fossiliferous, probable position, Cambridge	-	2
Clay, soft, bluish gray	8	2
Clay, yellowish, with iron ore nodules — Wilgus	6	0
Sandstone, lower part coarse-grained, becoming finer-grained and more argillaceous upward, Buffalo	50	6
Shale, gray, parts thinly laminated	50	10
Sandstone, thin to heavy-bedded, cross-bedding conspicuous	31	0
Sandstone and sandy shale, irregularly bedded — Mahoning	41	2
Shale, gray, arenaceous	12	4
Sandstone, heavy-bedded, Upper Freeport	4	8
Shale, gray, arenaceous	40	0
Covered interval	15	3
Shale, bluish gray	1	0
Coal	2	9
Parting — Middle Kittanning or No. 6	-	1
Coal	-	11
Clay, dark	1	0
Altitude, 771 ft.		

In the absence of the Upper Freeport coal the base of the Conemaugh can not be very definitely placed in this section. It belongs in the 41-foot bed of sandstone and sandy shales which with the overlying sandstone has replaced both the Upper Freeport and Mahoning coal horizons.

Along the high ridge extending southeast from Plainfield in eastern Linton Township the Upper Freeport coal horizon is overlain by sandstone and shale of Conemaugh age to a thickness of approximately 100 feet. Sandstone and shale having a similar thickness cap the highest hills in the east central part of Oxford Township.

Beds of Conemaugh age add little to the economic resources of the county.

Part III

OIL AND GAS

INTRODUCTION

Drilling in search for oil and gas in Coshocton County began soon after the finding of oil in the Drake well near Titusville, Pennsylvania, in 1859, and the discovery of natural gas near East Liverpool, Ohio, in 1860. The first well drilled in Coshocton County of which the Survey has knowledge was sunk in the village of Roscoe in 1861-62, presumably to the Berea sand, and is said to have yielded a show of oil and gas. Within the 40 years following this adventure more than 30 tests of the Berea sand had been made in the county. These tests were widely scattered over an area embracing Adams, White Eyes, Lafayette, Linton, Tuscarawas, Franklin, Jackson, Jefferson, and Newcastle townships. Some of these early wells yielded gas; a few produced shows of oil; but most of them were dry holes. The most spectacular results of early drilling were secured in Newcastle Township. Here a well drilled in 1865 along the Kokosing River near the mouth of the Mohican River, yielded a large flow of gas from the Berea sand reached at a depth of about 600 feet. Other wells were drilled in the vicinity which also yielded gas. Eventually after much of the gas had been wasted, the remaining supply was put to use in the production of lamp-black.[1]

Exploration by the drill of strata below the Berea sandstone in Coshocton County apparently began about 1886 when a well was drilled in the west edge of Coshocton to a depth of 1,280 feet or 420 feet below the top of the Berea. When the well was finally abandoned about 1889 the drill had penetrated to a depth of 3,100 or 587 feet below the top of the Big Lime. The first well to reach the Clinton sand in Coshocton County of which the Survey has record was drilled in 1902 on the Kiser property just west of Bloomfield, Clark Township. It yielded a show of gas in the Clinton sand at a depth of 3,404. In 1904 a deep test was drilled on the Wm. Bumpas property in the southwest quarter of Tiverton Township which reached a depth of 2,943 feet and which yielded a show of oil and gas in the Clinton. The following year a show of gas in the Clinton was secured in a deep test drilled on the George Oxley farm in the west part of Perry Township.[2] About 1912 oil and gas were found in the Clinton sand on the G. W. Crawford property in the southwest corner of Pike Township and in the following year oil was secured in the Clinton on the Heft and Anderson properties in the same township. Interest in the Clinton sand increased. Since 1913 hundreds of wells have been drilled to that horizon in the western part of Coshocton County. Exploration of strata below the Clinton sand has been confined to one test, namely the Chaney-Meyer Unit No. 2 well completed in Clark Township by the Ohio Oil Company in 1944. Drilling in this well continued to a depth of 5,660 feet or 2,240 feet below the horizon of the Clinton sand.

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[1] Read, M. C., Geology of Knox County, Geol. Survey Ohio, Vol. III, pp. 340-347, 1878; Orton, Edward, Economic Geology, Geol. Survey Ohio, Vol. VI, pp. 340-343, 1888.

[2] Bownocker, J. A., The Bremen Oil field, Geol. Survey Ohio, Bull. 12, p. 58, 1910.

Estimates of activity with the drill in the search for oil and gas indicate that approximately 1,400 wells have been completed in Coshocton County since 1860. Of this number one-third have gone little deeper than the Berea sand whereas approximately two-thirds have penetrated to the Oriskany or Clinton horizons. Between 25 and 30 percent of all wells drilled have been dry holes. Small pools of oil and/or gas have been found in the Berea sand in Linton, Lafayette, Mill Creek, Clark, Bethlehem, Bedford, and Newcastle townships. Production from the Clinton sand has been secured chiefly from a few pools located in the western part of the county in Pike, Perry, Newcastle, Tiverton, Monroe, and Clark townships. Gas in commercial quantity has been found in the Oriskany sand in a few scattered wells located in the southwestern quarter of Franklin Township and in the southeastern corner of Linton Township. Oil and gas producers are still actively engaged in exploring the Clinton sand in the western part of the county, especially in Newcastle Township.

In the preparation of the map showing the location of wells and the productive areas in the county, field work has been reduced to a minimum. Liberal use has been made of records and location maps filed in the Division of Mines, Ohio Department of Industrial Relations. Additional data have been made available by the Geological Department of the Ohio Fuel Gas Company in Columbus. To all those who by their cooperation have added to the completeness of this report the writer is deeply grateful.

DEVELOPMENT BY TOWNSHIP

ADAMS TOWNSHIP

According to Bownocker,[1] seven wells were drilled in search for oil and gas in Adams Township before 1903. Three of these were on the Corbett farm in sections 18 and 19 and two each on the Ott and Fiat farms near Bakersville. In an early well the drill penetrated to a depth of 1,800. All wells were reported dry in the Berea sand.

Since 1903 exploration for oil and gas in Adams Township has not extended much below the Berea sand and only a few wells have been sunk to that horizon. About 1910 a test well was drilled in the west central part of Section 19, on the John Huffman property, which yielded a show of oil. When visited in 1930 oil was visible in the casing a few feet below the surface. A well drilled about the same time on the Jacob Stilgenbauer tract likewise yielded a show of oil. This hole is located on the valley flats just west of the road in the east central part of Section 18. Three Berea wells were likewise drilled on the Sweigert property in the southeast quarter of Section 18. Two of the wells yielded a show of oil but the third one was a dry hole.

About 1914 a test well was sunk to the Berea sand on the George Davis property near the mouth of Davis Run at the extreme south edge of the township. The Berea was devoid of shows of either oil or gas. No further drilling is known to have occurred in the township until about 1920 when three tests were made on the William Boob property in the northeast quarter of Section 18. The Berea sand which was reached at depths ranging from 840 to 1,050 feet is reported to have yielded shows of oil in each of these tests. In the same year a Berea test was drilled on the William Ott property in the south central part of Section 9, and another on the William Rice property in the northwest corner of Section 11. A show of oil was reported in the Ott well, but the Rice well was dry.

In 1941 the Trinity Petroleum Company drilled a Berea test on the William Young property in the valley of East Fork about one mile east of north of Powell. The Berea was reached at a depth of 844 feet but the sand proved unproductive except for a slight show of oil.

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[1] Bownocker, J. A., The occurrence and exploitation of petroleum and natural gas in Ohio, Geol. Survey Ohio, Bull. 1, p. 292, 1903.

BEDFORD TOWNSHIP

Only a few scattered wells have been drilled for oil and gas in Bedford Township and only small production has been secured. The most concentrated drilling has occurred in Section 11, where about 1913 five wells were sunk to the Berea sand on the Bert Ramsey property by the Two-States Oil and Gas Company. A small quantity of oil is reported to have been secured in the Berea. About 1917, a well was drilled on the same property to a depth of 3,200 feet and a show of oil was reported in the Clinton. Known tests in the northern half of the township include a dry hole to the Berea sand on the McCurdy Hrs. land, Lot 19, northeast quarter, drilled in 1939, and a dry hole to the Clinton sand on the Wm. Bush property southwest quarter of Section 5, drilled about 1918.

Testing for production in the southwest quarter of Bedford Township has led to the completion of several tests in sections 16 and 25. A well completed in 1911 on the H. B. S. Miller property in the northeast quarter of Section 25 is reported to have had an initial production of 1,000,000 cu. ft. of gas. The Clinton was reached at a depth of 3,242 feet and extended to 3,294 feet. A second well drilled on the same tract in 1942 proved dry. In 1946 a Clinton well was drilled on the John W. Lee farm, on the southwest quarter of Section 16. The sand was reached at a depth of 3,350 and yielded a flow of gas. A second test drilled the following year on the adjoining land belonging to F. H. Dixon found the sand broken and yielded only a show of oil. In the southeast quarter of Section 16 a well drilled on the Wheeler property in 1927 proved a dry hole.

BETHLEHEM TOWNSHIP

In the search for oil and gas in Bethlehem Township two wells are known to have been drilled to the Clinton sand. The first of these was sunk in 1936 on the I. G. Crowl farm located south of Killbuck Creek in the northwest quarter of the township. The sand, which was reached at a depth of 3,453 feet and extended with a few breaks to 3,500 feet, yielded a show of oil. The well is reported to have had an initial production of 15 bbls. after shot. The second test, drilled in 1944 on the N. J. Burrell property and located north of the Walhonding River and about three-fourths of a mile below the mouth of Killbuck Creek, proved a dry hole. The Clinton sand, which was hard and unproductive, extended with one thin break from a depth of 3,498 feet to a depth of 3,553 feet.

Drilling in search of oil and gas in the Berea sand began early in Bethlehem Township. About 1911 a number of Berea gas wells were drilled along Killbuck Creek in the southeastern part of the northwest quarter of Bethlehem Township on the Johnson, Waring, Frederick, and Easter properties. During the two or three years that followed 1911, drilling was active in this region. The limits of the gas pool were apparently reached and oil was found in the Berea in contact with the gas on the Frederick, Fox, and Bantam properties on the southwest and on the Infield, Grimes, and Rolff properties on the southeast. The depth to the sand ranges from 750 to 1,050 feet depending in part upon the altitude of the well head. In parts of the field the sand is divided into two parts by a thin shale "break" which according to drillers' records is generally less than 5 feet in thickness. The total thickness of the sand, including the "break," may vary from 10 to 30 feet but the usual depth is from 10 to 20 feet. The wells in this field have been abandoned. West of the producing field in the northwest quarter of the township, one oil well and two dry holes in the Berea sand were drilled on the Henry Ammon property, two Berea gas wells and one dry hole on the McNeal property, and one Berea gas well on the I. G. Crowl property.

Early drilling in Lot 40, northeast quarter, and on adjoining property in the southeast quarter of Section 23, Clark Township, led to the development of a small oil pool in the Berea. In Bethlehem Township, nine wells were secured on the H. J. Adams property in Lot 40.

COSHOCTON COUNTY
OIL AND GAS

COMPILED BY
RAYMOND E. LAMBORN
1954

SCALE IN MILES 0 1 2 3 4

LEGEND

- DRY HOLE, BEREA SAND
- OIL WELL, BEREA SAND
- GAS WELL, BEREA SAND
- OIL FIELD, BEREA SAND
- GAS FIELD, BEREA SAND
- DRY HOLE, ORISKANY SAND
- DRY HOLE, TRENTON FORMATION
- DRY HOLE, CLINTON SAND
- OIL WELL, CLINTON SAND
- GAS WELL, CLINTON SAND
- OIL FIELD, CLINTON SAND
- GAS FIELD, CLINTON SAND
- GAS WELL, ORISKANY SAND

Only a very few scattered wells are known to have been drilled for oil and gas in the southwestern quarter of Bethlehem Township. A dry hole in the Berea is reported to have been drilled on the Ira Kimmerly property in Lot 15. A show of oil, presumably from the Berea sand, was secured in a well drilled on the James L. Stewart farm in Lot 6. Of three wells sunk in 1912 to the Berea sand on the S. W. Hamilton farm in Lot 7, two are reported to have yielded small quantities of oil and the third to have had an initial production of 200,000 cu. ft. of gas. All were soon abandoned.

No tests of the Berea sand are known to have been made in the southeast quarter of Bethlehem Township or in the northeast quarter east of the west tier of lots.

CLARK TOWNSHIP

Exploration with the drill in Clark Township has led to the discovery of both oil and gas in the Clinton sand and of several small oil pools in the Berea sand. Of the 170 wells known to have been drilled in this township, 50 per cent have gone little deeper than the Berea horizon. Oil in commercial quantities in the Berea has been found in and around Bloomfield in the northeast corner of the township, in the southeast quarter of Section 23, and just west of Blissfield in the central and northwestern parts of Section 16. Scattered wells reporting oil in the Berea have been sunk on the C. Conkle farm, Lot 6, northwest quarter, on the Eppley and Bucklew tracts in the southwest part of the northeast quarter, on the Meyer and Layland properties, Lot 27, northwest quarter, and on the Fortune and Bucklew lands in lots 36 and 37, northwest quarter.

Drilling just west of Blissfield is reported to have begun about 1907. Oil was found in the Berea and subsequent drilling led to the development of a small pool consisting of about 14 wells. Here the sand is found at an average depth of about 700 feet below the valley bottoms of the Killbuck. The average production of the wells was about 2 bbls. each. Similar conditions of sand depth prevail at Bloomfield where production from the Berea is reported to have begun about 1910. The average production of the wells, however, was somewhat greater than at Blissfield. A little later, about 1913, drilling in Section 23 led to the finding of oil in the Berea sand on the H. J. Williams property. Subsequent drilling led to the discovery of a small Berea oil pool embracing the southeast quarter of Section 23 and extending south into Lot 40 Bethlehem Township. The Berea sand here has a depth of about 1,000 feet and a thickness of 20 to 25 feet. Like the Berea in many parts of Coshocton County it is broken near the middle by a thin bed of "shale and shells," a few feet in thickness.

Drilling to the Clinton sand has been widespread in Clark Township. From available data it is concluded that at least 85 wells have penetrated that horizon, some 20 percent of which have been dry holes. Oil has been secured over an elongated east-west area in the north part of the northwest quarter of the northeast quarter, extending into lots 5, 6, 7, and 8 of the northwest quarter of the township. West of this occurs a gas-producing area which embraces much of lots 9, 10, 11, 12, 13, 20, 21, 22, 23, 24, and 26 northwest quarter. Scattered dry holes marginal to the gas field have been drilled in lots 6, 11, 20, 28, 27, and 25 northwest quarter. In this field the sand, which is quite broken by one or more shale partings, has a thickness which generally ranges from 50 to 60 feet. Its average depth from the surface is about 3,400 feet.

Several outlying dry holes have been drilled to the Clinton sand in Clark Township. About 1925 and 1926 the East Ohio Gas Company put down two Clinton wells on the John Conkle property in Lot 6, northeast quarter. The first well yielded some gas, the second well proved a dry hole. A test drilled in 1949 on the Gamertsfelder tract in the southeast quarter of Section 13 also proved a dry hole. Here the sand was encountered at a depth of 3,409 feet and extended with only one thin break to a depth of 3,445 feet. Other tests of the Clinton horizon include one dry hole on the Benjamin F. Smails property in the southeast quarter of Section 15, one hole drilled in 1930 yielding a show of gas in the Clinton sand, on the Adkins property, Lot 34,

northwest quarter; and one small gas well drilled to the Clinton sand in 1942 on the Benjamin Smails property in Lot 32, northwest quarter. In 1943 a well was drilled on the Ammon property in Section 23 near the southern boundary of the township. The Clinton sand, which was reached at a depth of 3,692 feet, yielded a show of oil and gas.

Only one well has been drilled in Clark Township far below the Clinton sand, namely the No. 1 well on the Chaney-Meyer Unit No. 2 completed by the Ohio Oil Company in 1944. In this well the drill passed through the Trenton and the hole was bottomed at 5,660 feet. The Clinton sand, occurring from 3,250 to 3,318 feet, yielded only a show of gas. No shows of either oil or gas were reported in the Trenton.

CRAWFORD TOWNSHIP

A few deep wells have been drilled in Crawford Township and a little gas production has been secured from the Clinton sand in Section 7. In the Elizabeth Schlagel No. 1 well drilled in Section 7 the Berea sand having a thickness of 15 feet was encountered at a depth of 960 feet and the Clinton sand was reached at a depth of 4,022 feet. The Berea sand proved dry but a small gas well was developed in the Clinton sand. A second Clinton sand well drilled on the Dickeysheet property in the northeast quarter of the same section was a small gas well. Other tests to the Clinton sand on the Pretzins property in Section 7, the Barkman property in Section 8, and the Balder tract in Lot 30, northeast quarter, yielded nothing more in the Clinton sand than small shows of gas.

FRANKLIN TOWNSHIP

Known drilling for oil and gas in Franklin Township has been confined almost entirely to the southwest quarter. Bownocker reports[1] that "about 1898 a well was drilled in on the Lapp farm in Section 18, but the Berea here as almost everywhere else in the county was dry."

In 1929 a well was drilled on the Cornelia B. A. Corry property east of the Muskingum River and about one mile south of east of Conesville. No production was found in the Berea but gas was secured in the Oriskany sand at a depth of 2,575 feet. Subsequent drilling on neighboring properties to the south, southeast, and southwest of the initial well led to the opening of seven additional producers from this sand, all but one of which are located east of the river. According to drillers' records the Oriskany sand in this area ranges in thickness from 4 to 11 feet and is encountered at depths below the surface ranging from about 2,575 feet to about 2,900 feet.

Two Clinton tests are known to have been drilled in the southwest quarter of Franklin Township. The first of these, the C. B. A. Corry No. 2 secured a show of oil in the Clinton sand, which was encountered from depth 3,747 feet to 3,803 feet. A second test drilled on the Kenneth E. MacLeod property yielded a show of gas from the Clinton sand from depths 3,745 feet to 3,775 feet.

JACKSON TOWNSHIP

A scattering of wells have been drilled in Jackson Township during the past ninety years, first to the Berea sand, and more recently to the Clinton, without securing production in paying

[1] Bownocker, J. A., The occurrence and exploitation of petroleum and natural gas in Ohio, Geol. Survey Ohio, Bull. 1, p. 292, 1903.

quantities. The oldest test of which the Survey has record was drilled about 1861-62 along the railroad within the village of Roscoe. The depth of this well is not known but shows of oil and gas were evident for many years after its completion. Other early tests drilled before 1900 in the vicinity of Roscoe include, one on the W. H. Crawford land, $1\frac{1}{2}$ miles southwest of the village to a reported depth of 3,200 feet, and one on the Haight property, one mile northwest of town through the Berea sand to a depth of about 800 feet. The Crawford well encountered nothing but salt water but the Haight well yielded a show of oil.[1]

From 1900 to 1940 dry holes are reported to have been drilled, presumably to the Berea sand, on the Thomas Lowry property in the northwest quarter of Section 6; on the I. P. Houser land in the southwest quarter of Section 20; and on the Retilley property in Lot 9, northeast quarter. In 1943 a small gas well was secured in the Clinton sand on the lands owned by Stella Landis in the southeast quarter of Section 5. The Clinton sand was reached at a depth of 3,562 feet and continued with only one thin break to 3,609 feet. In another test drilled the following year on the Samuel Felver property in Section 5, the Clinton sand proved dry. Other tests of the Clinton sand in Jackson Township include a dry hole on the David Davis Estate in the southeast quarter of Section 23, and a dry hole on the Zebbra McCoy property in the northeast quarter of Section 18. The Clinton sand at the latter locality extended from depth 3,702 to 3,722 feet.

JEFFERSON TOWNSHIP

Only a thin scattering of holes have been sunk in search of oil or gas in this township and to date no sustained production has been secured. Prior to 1902 test wells to the Berea sand as reported by Bownocker[2] are as follows: One dry hole on lands just north of Warsaw, drilled 1896-1898; one dry hole on Elder farm, one mile south of Warsaw; and one dry hole on the Hawthorn farm located at the west edge of the township and just south of the Walhonding River.

Testing in the northern half of the township since 1902 has led to the drilling of a Clinton dry hole on the D. F. McLaughlin property in the northwest quarter of Section 11. Here the Clinton was reached at a depth of 3,320 feet. A test on the Gamertsfelder tract, northwest quarter of Section 9, drilled in 1939, found the Clinton dry. A third hole drilled in Section 5 on property formerly owned by Edward Purdy likewise found the Clinton unproductive.

Known drilling in the southern half of the township has been confined chiefly to lots 13, 14, and 20, southwest quarter, although two Clinton tests have been put down along the Walhonding River. The first of these drilled in 1927 on the R. C. Foster farm, Lot 1, southwest quarter, proved dry in the Clinton. The second well sunk in 1944 on the James Foster Heirs property, Lot 20, southeast quarter, found the Clinton sand at depth 3,294 feet. The well is reported to have had an initial production of 50,000 cu. ft. of gas. In the southwest corner of the township a well was drilled in 1919 on the Given property, Lot 20, to a depth of 3,187 feet but both the Berea and Clinton were unproductive. The Berea proved productive of gas in the C. P. Foster No. 1, Lot 14, drilled in 1935. A second well on the same property, drilled in 1944, found both the Berea and Clinton sands dry.

KEENE TOWNSHIP

No production of oil or gas has thus far been secured in Keene Township. About 1921 a deep test of the sub-surface strata was made on the M. A. McConnell property in the northeast

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[1] Bownocker, J. A., op. cit., p. 291, 1903.

[2] Bownocker, J. A., The occurrence and exploitation of petroleum and natural gas in Ohio, Geol. Survey Ohio, Bull. 1, p. 292, 1903.

quarter of Section 8. The Berea sand was encountered between depths of 841 and 857 feet but was unproductive. The Clinton sand was reached at 3,640 feet and extended to 3,690 feet but was devoid of oil, gas, or water. A second test, drilled in 1949 to the Berea sand on the John Senter property in Section 8, yielded a show of gas. Other Berea tests known to have been completed in this township include one dry hole drilled in 1949 on the J. P. Norman property in Lot 10, northwest quarter, and one dry hole drilled in 1950 on the W. H. Norman tract in Lot 12, southeast quarter. In the first of these wells the Berea was reached at a depth of 841 feet and in the second at a depth of 815 feet.

LAFAYETTE TOWNSHIP

Five wells reaching the Berea sand were drilled in Lafayette Township prior to 1903.[1] One well on the Noble farm along Morgan Run near the west edge of the township yielded a small amount of oil. Others included a dry hole on the McGuire property, a dry hole yielding a show of gas on the Burt property, and a test yielding a show of oil on the Wiggins farm.

Since 1903 a number of Berea tests have been drilled in the northwest quarter of the township resulting in the discovery of one small gas pool. The productive area occurs just south of the railroad and approximately one mile west of West Lafayette. Here more than a dozen wells yielded gas from the Berea which occurs at an average depth of about 750 feet and has a thickness ranging from 20 to 40 feet. The gas was formerly piped to West Lafayette where it was utilized as a domestic fuel. The wells have now been abandoned. North of the railroad, a dry hole in the Berea sand has been secured on the Ross property in the northwest quarter and on the Shaw property in the northeast quarter of the township. A few scattered dry holes have also been sunk to the Berea sand in the southern half of the township as shown on the map.

Two wells are known to have been drilled to the Clinton sand in Lafayette Township. The first of these, drilled in 1943 on the Charles J. Zimmer property, Lot 8, southeast quarter, reached the Berea sand at a depth of 837 feet, passed the Oriskany at depth 2,859 feet, and encountered the Clinton from depth 4,136 to 4,178 feet. No shows of oil or gas were reported from any of these horizons. The second well was drilled on the Mabel S. Rehard property, Lot 2, northwest quarter, in 1945. The Berea sand extending from depth 795 feet to 817 feet yielded a show of gas but the Clinton sand encountered from 3,947 feet to 3,990 feet proved dry. The well was abandoned at a depth of 4,077 feet.

LINTON TOWNSHIP

Over 50 wells are known to have been drilled in Linton Township in search for oil and gas. The chief objective has been the Berea sand, although recently several wells in the southeast quarter of the township have penetrated to the Oriskany horizon. At least one well has gone deep enough to reach the Clinton. Some gas has been secured in the Oriskany and both oil and gas have been produced in a small way from the Berea.

A number of years ago a few small gas wells were secured in the Berea sand on the G. E. Clemens property in Lot 8 southeast quarter. The sand here has an average depth of about 1,000 feet. Dry holes have been secured on bordering areas to the southeast in Lot 8, on the south in Lot 7, and on the north in Section 13. A small flow of gas has also been secured from two Berea wells on the Magers property and one on the Hawthorn property in the northwest quarter of Section 19. A test on the Williams property in the southeast quarter of Section 13, west, proved dry in the Berea.

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[1] Bownocker, J. A., op. cit., p. 292, 1903.

The Berea sand has produced oil in Linton Township from a few wells located in the southern part of Section 23 representing the northern end of the Otsego oil pool of Monroe Township, Muskingum County. Oil has also been reported in Berea wells located in the southeast quarter of Section 6 and the northeast quarter of Section 7.

Eight wells have been drilled to the Oriskany sand in Linton Township of which six have proved productive of gas in commercial quantity. The producing area includes lots 1, 3, 14, 16, 18, and 32, southeast quarter. Here the top of the Big Lime is reached at an average depth of 3,050. The Oriskany sand which varies from 8 feet to 17 feet in thickness in the producing wells is found from 125 to 130 feet below the top of the Big Lime. No Oriskany sand was found in a dry hole drilled to its horizon on the Walters property in Lot 34. In a well on the George Clemens land, Lot 8, eight feet of Oriskany sand was passed through at a depth of 3,088 feet but only a show of gas and oil was secured.

In 1925 a deep well was drilled by the Ohio Fuel Gas Company on the Charles E. Williams property in the southeast quarter of Section 13. The drill reached the Medina Red at 4,337 feet and bottomed at 4,445 feet. No Clinton sand was encountered in this well. Shows of gas were found in both the Berea and the Big Lime.

MILL CREEK TOWNSHIP

At least 55 wells have been drilled in the search for oil and gas in Mill Creek Township, two of which have penetrated to the Clinton sand. One small pool yielding both oil and gas from the Berea sand has been found embracing the southwestern and south central parts of Section 1, the eastern parts of sections 2 and 9, and the northern two-thirds of Section 10. Gas wells in this pool were drilled on the Crawford property in the eastern part of Section 9 as early as 1917, and extensions of the pool continued spasmodically for the following twenty years. In 1929 a number of wells were drilled on the Fender property in Section 1 and a small production of oil was secured in the Berea. The oil-producing area is confined to the south central part of Section 1 where it lies in contact with the gas pool on the west. In this field the Berea is reached at depths below the surface ranging from about 800 to 950 feet. Its thickness, according to drillers' records, varies from 25 to 35 feet. In parts of the gas-producing areas in sections 1, 9, and 10, a thin shale "break" occurs a few feet below the top of the sand with production confined to the part below the "break." West of the producing area a dry hole has been sunk to the Berea on the Guy Crawford property in the southeast quarter of Section 9, a Berea dry hole on the Clewell property in the central part of Section 2, and a dry hole on the Conkle farm in the northwest quarter of Section 2.

Oil has been secured in the Berea sand in a few wells drilled on the Beal and Evans properties in the west part of Section 5. These wells represent the eastern edge of a Berea oil pool most of which occurs in northeastern Clark Township.

In the southwest quarter of Mill Creek Township, a well drilled on the Nathan Bechtol farm in Lot 2 found the Berea sand 25 feet in thickness at a depth of 1,039 feet. It yielded a show of gas. Oil in small quantity was found in the Berea in two wells drilled on the C. C. Conkle property adjoining the Bechtol land on the south. A well on the Charles A. Karr land in Lot 14 found the Berea dry. The sand was likewise dry in a test on the Herbert Hamilton farm in Lot 15. The Berea, which was reached at a depth of 944 feet, yielded only a show of oil and gas. No shows were reported in this sand in a test on the J. P. Norman property in the eastern part of Lot 15.

Two Clinton wells are known to have been drilled in Mill Creek Township without encouraging results from that formation. The first of these was completed in March, 1944, on the Charles A. Karr property, Lot 14, southwest quarter. The Berea extended from depth 860 to 872 feet and the Clinton from depth 3,640 to 3,680 feet. A show of gas was reported in the Berea but the Clinton was dry. The second well completed in June, 1944, is located on the

Wm. Bechtol land in Section 4. Neither the Berea, occurring at a depth of 848 feet, nor the Clinton, reached at a depth of 3,647 feet, yielded shows of oil or gas in this well.

MONROE TOWNSHIP

Active drilling to the Clinton sand in Monroe Township began in 1926-1927 in sections 1 and 2 in the northeast corner and spread rapidly to the south and southwest. Over 50 holes have been sunk to the Clinton sand in this township and some small gas pools have been discovered. The largest of these contains about 15 wells and embraces the northwestern quarter of Section 1 and the eastern half of Section 2. The average depth to the sand is about 3,400 feet. Marginal dry holes, often yielding shows, have been drilled on the Markley and McKelvey properties in eastern Section 1 and on the Dalrymple and Pyers farms in western Section 2.

A second small pool includes the central eastern part of Section 9 and the southern part of the southwest quarter of Section 10. Dry holes are reported bordering this pool on the south on the H. A. Brush and the D. L. Mohler properties. A third small area yielding both oil and gas includes parts of the southwest quarter of Section 9 and the northwest quarter of Section 12. Dry holes have been drilled to the east on the Mary Shaffer property, Section 12, and on the west on the Donaldson farm, Section 13, and on the Snow property, Section 8.

In the northwest quarter of Monroe Township a Clinton test on the Albert Phillips property, northwest corner of Section 4, proved a gas well with an initial open flow of 400,000 cubic feet. Three other tests to the east and south in the same section proved dry holes. Three holes have been drilled in Section 5, one on the F. W. Still property secured gas, the other two yielded nothing more than shows. In the northwest quarter of Section 6, a well drilled in 1942 on the H. B. Carter farm had an initial open flow reported at 2,459,000 cubic feet of gas. Additional drilling of two wells on the Fred Still property, one in the west central part and the other in the southeast quarter of this section, yielded nothing more than shows. In 1930 a well drilled to the Clinton sand on the C. A. Thompson holdings, northwest quarter of Section 14, was a small gas well.

Known drilling in the southern half of Monroe Township includes one dry hole to the Clinton sand on the D. W. Brillhart property, northwest quarter of Section 22; one small Clinton gas well and one Berea dry hole on the Oliver Borde holdings, Section 18; and one Clinton dry hole on the F. E. Ling property in Lot 18, southwest quarter.

NEWCASTLE TOWNSHIP

Drilling in search of oil and gas in Newcastle Township has been confined chiefly to the western half where reservoirs of oil have been discovered in the Clinton sand and gas has been produced from the Berea sand. About 225 wells have been drilled to date in this township, approximately 70 per cent of which have penetrated the Clinton.

Drilling to the Berea has been confined chiefly to the northwest quarter and more particularly to the south bank of the Kokosing River and to the area between the Kokosing and Walhonding rivers. Production began early in this field. In 1865 a well was drilled for oil on the south side of the Kokosing River some 300 feet west of the mouth of the Mohican River. The Berea, which was reached at a depth of 598 feet, yielded a large flow of gas. Other wells followed and by 1887, eleven wells had been drilled along the lower Mohican Valley, some of which are located in eastern Knox County. Those situated near the mouth of the Mohican River yielded much gas. Some wells yielded show of oil and all encountered salt water in the Berea. The gas from the largest producers was utilized for several years for the production of carbon black.[1]

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[1] Read, M. C., Geology of Knox County, Geol. Survey Ohio, Vol. III, pp. 340-347, 1878; Orton, Edward, Economic Geology, Geol. Survey Ohio, Vol. VI, pp. 340-343, 1888.

Since 1887 numerous tests have been sunk to the Berea horizon in the northwestern part of Newcastle Township, some of which have yielded a little gas. In this area the Berea sand is usually reached at depths around 600 feet below the valley flats and is generally less than 20 feet in thickness. In the southwestern quarter a few small gas wells have been secured in the Berea sand just north of Newcastle and on the Ringwalt and Staats properties a mile or so west of that village.

Drilling to the Clinton sand in Newcastle Township has been most active in the southwestern quarter and in adjacent areas in the west, central, and southwest parts of the southeast quarter, and in the south central part of the northwest quarter. At least 130 Clinton wells have been drilled in this field, 95 per cent of which have produced oil. The Clinton sand is quite regular in this township where its thickness, according to drillers' records, generally ranges from 30 to 60 feet, with a usual depth around 50 feet. It seems broken near the middle by a parting which is generally less than 10 feet in thickness. Both the upper and lower parts of the sand are productive but judging from drillers' records the yield from the lower part is more prolific. The average depth to the sand is about 3,150 feet.

In the northeast quarter of Bethlehem Township a well drilled in 1917 to the Clinton horizon in the John F. Fry property, Lot 7, failed to find the sand. The following year a well put down on the Charles Fry property, Lot 29, found the sand at a depth of 4,246 feet. The well was sunk to a depth of 3,314 and is reported to have yielded gas and a show of oil in the Clinton. A second well drilled the same year on the adjoining property of L. G. Reese proved a dry hole. In 1951 a small oil well was secured in the Clinton sand on the Nettie L. McFarland property in Lot 10. Oil was also reported in the Clinton sand in a well drilled in 1952 on the Charles Horn property, Lot 11.

A number of scattered wells have been drilled to the Clinton sand in the northwest quarter of Newcastle Township and small supplies of oil and gas have been secured. On the Rodehaver properties just northwest of Walhonding, four wells have been drilled to the Clinton sand, two of which have been small gas producers, one a light oil well, and one a dry hole. Small shows of gas have been found in the Clinton sand in lots 17 and 8.

East of producing areas in sections 18 and 23, southeast quarter, dry holes in the Clinton sand have been drilled in sections 19 and 21. On the D. R. Foster property, northwest quarter, Section 21, the sand was reached at a depth of 3,133 feet but it proved thin and broken. On the Bowers property, southwest quarter, Section 21, the sand, normal in thickness, was encountered at a depth of 3,359 feet but proved unproductive. A show of gas in the Clinton sand was secured in the Della G. Bell No. 1 well drilled in 1945 in the northeast quarter of Section 19. Here the sand, 45 feet in thickness, was reached at a depth of 3,247 feet. A second well in this section, drilled on the C. I. Williams property, southwest quarter, found the Clinton sand dry.

OXFORD TOWNSHIP

No commercial production of oil or gas is known to have been secured in Oxford Township. A few exploratory tests have been drilled but no well has penetrated far below the Berea sand. As early as 1912 a test was made along Center Creek about one-half mile west of Morrison Corners. The drill descended to a depth of 886 feet, presumably reaching the Berea sand, but the well failed to yield production of either oil or gas. In the same year, another well was sunk to a depth of 900 feet on the Daniels property, located along Wills Creek, one and one-half miles farther south, but it was unproductive. Two or three other tests drilled along Wills Creek in the same vicinity have likewise been failures.

In 1936 a well was drilled on the Alfred Rehard property, Lot 9, southwest quarter, a short distance south of McCune School. The Berea was reached at a depth of 872 feet and extended to 922 feet. A show of oil was secured at depth 890 to 895 feet but water entered the well with the oil. A show of gas was secured in the Berea sand in a well drilled in the northwest

corner of Section 20. Other dry holes include one to the Berea sand in the southeast quarter of Section 20 and one to the Berea sand in the northeast quarter of Section 21.

PERRY TOWNSHIP

The first test of the Clinton sand in Perry Township of which the Survey has any record was sunk on the George Oxley farm near the western margin of the township (probably Section 25) about 1905.[1] It made a show of gas. About 1914 a hole was drilled on the W. Mikesell property in the southwest quarter of Section 13. The Clinton sand was encountered at a depth of 3,120 feet to 3,170 feet but the well proved unproductive. In 1916 a Clinton test was sunk on the Bonham property in the northwest corner of Section 19, but failed to find sand on the Clinton horizon. About 1925 oil was discovered in paying quantity in the Clinton on the Van Winkle farm in Section 15 and since that time exploration with the drill has been active but with decreasing intensity since 1940. About 150 wells have been sunk in this township including every section with the exception of Nos. 2, 8, 11, and 12. A number of small pools in the Clinton sand have been discovered in the western half of the township as follows: a small gas pool in southern two-thirds of Section 24 and the southwest corner of Section 23; an oil pool in Section 17 and eastern part of Section 16; an oil pool in the west central part of Section 14; an oil pool in central and northern part of Section 15 and southwestern quarter of Section 6; and a pool in the northwest part of Section 5. The sand in these areas generally ranges from 45 to 55 feet in thickness and is often broken by one or more thin shale partings. Its depth ranges from 3,000 to 3,250 feet. At least 15 dry holes have been drilled closely bordering the producing areas.

A scattering of test wells have been drilled in the eastern half of Perry Township. In 1926 a hole was put down on the M. C. Wright farm in the central eastern part of Section 21. The Clinton sand was encountered at 3,222 but proved dry. A well drilled on the Twiloh Carle property, northwest quarter Section 22, in 1939, yielded oil from the Clinton sand. Wells drilled on the Mizer and Gault properties adjoining on the south and north respectively proved dry in the Clinton sand. In 1945 five wells were drilled to the Clinton sand in Section 10. Three found gas in commercial quantities and two yielded only shows. A well drilled the same year on the Cullison property in the southeast quarter of Section 1 yielded only a show of gas in the Clinton sand. Dry holes have been drilled on the Crowthers property in the northwest quarter of Section 2, and in the northwest quarter of Section 9.

PIKE TOWNSHIP

The Clinton sand has been a producer chiefly of oil and to a much less extent of gas in this township for at least 40 years. The earliest drilling of which the Survey has positive record dates to 1912 on the G. W. Crawford farm, Section 25, and to 1913 on the Mary M. Anderson property in Section 9. These early wells proved good producers of oil and drilling spread to neighboring lands. During the years that followed the producing area was so extended that it now includes or has included parts of every section except 1, 2, 10, 11, 20, and 21 along the north and east borders. The chief oil-producing area extends to the southwest from Sections 8 and 9 and includes parts of sections 12, 13, 16, 17, 18, 19, 23, 24, and 25. Smaller outlying oil pools are found in sections 8 and 9 and in sections 13 and 14. Oil and gas in contact are found in a small pool located in sections 4 and 5. In all some 250 wells have been drilled in this township, approximately 80 per cent of which have been productive of oil and gas. The Clinton sand is reached at depths ranging from about 2,950 feet to about 3,300 feet. As recorded in drillers' records, its thickness varies from about 45 feet to 60 feet.

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[1] Bownocker, J. A., op. cit., p. 58, 1903.

Numerous dry holes have been drilled in Pike Township surrounding producing areas. Those marginal to the chief pool include a dry hole yielding a show of oil and gas on the Perry Ashcraft property, Section 22; one dry hole on the Mary Phillips property, Section 11; one dry hole on the W. L. Norris property, north central Section 12; two dry holes on the W. H. Ashcraft property, Section 13, one yielding a show of oil; one dry hole on the Ashcraft property, Section 18, yielding a show of oil and gas; one dry hole on the Jake Ashcraft farm, Section 17; one dry hole on the Bert Ashcraft property, Lot 14, yielding a show of oil; and one dry hole on the Harold Criss property, southeast quarter of Section 15.

Drilling in sections 8 and 9 led to the discovery of a small pool of oil which has been tapped by 18 wells. Five tests, most of which yielded a show of oil, have been drilled marginal to this producing area. Other producing areas include a small oil pool, occurring almost entirely in Section 14 and containing at least 16 wells, and two small puddles yielding both oil and gas in sections 4 and 5. Occasional isolated wells, some gas producers, others yielding oil, have been sunk in sections 3, 7, 6, and 15.

TIVERTON TOWNSHIP

The first test of the Clinton sand in Tiverton Township of which we have record was drilled on the Wm. Bumpas land, Lot 27, southwest quarter, in 1904. The sand was reached at 2,872 feet and extended to 2,907 feet, yielding a show of gas. No further drilling is known to have occurred until about 1917 when wells were sunk on the Koch property in Section 3 and on the Hunter farm in Section 6. The Koch well was dry but the Hunter test yielded shows of oil and gas in the Clinton. About the same time (1917) oil and gas were found in the Clinton sand on the Lewis G. and Rosa Reese property in the south central part of Section 21, and in the two years following a small pool was developed occurring almost entirely within the southern half of this section. The sand has a thickness ranging from 50 to 60 feet and occurs at depths varying from 3,000 to 3,100 feet. It is broken by one or more shale partings or "breaks." Gas generally occurs in the top and oil in the lower part of the sand. Gas alone has been secured from a Clinton well on the Petry farm in the northern part of Section 21 and Clinton sand well on the Kanuckle property in the east central part of Section 21. The Clinton has yielded a show of gas in the Miller well drilled in Section 22.

In 1936 gas wells were secured in the Clinton sand on the Oka Black and Ethel Smith properties in the west central part of Section 9. Since that time a small gas pool has been developed embracing the southwest quarter of Section 9, the southeast corner of Section 8, the northeast corner of Section 13, and the northwest quarter of Section 12. Here the Clinton is found at depths varying from about 3,100 to 3,350 feet. The sand ranging from 50 to 55 feet in thickness is broken by a shale "break" 5 to 20 feet in thickness. The lower bed yields the bulk of the gas. Dry holes surrounding this pool, generally yielding shows of oil and gas, have been drilled in sections 8, 13, 12, and 10.

Scattered tests to the Clinton sand have been drilled in sections 5, 6, and 7 and in the southwest quarter of the township. Shows of oil and gas have been secured in many of these wells. Gas in sufficient quantity for commercial production has been secured from the M. A. Giaugue No. 1 and Bernard Devore No. 1 in Section 5; from M. A. Holt No. 1 in Section 7; from the G. S. Kerch No. 1 in Lot 6, southwest quarter; from Alonzo Spurgeon No. 1, Lot 19, southwest quarter, and from the Walter Styres No. 1, Lot 21, southwest quarter. According to drillers' records the thickness and structure of the Clinton sand in these wells are similar to that in the producing pools in the eastern half of the township.

TUSCARAWAS TOWNSHIP

No oil or gas pool of much consequence has been discovered in Tuscarawas Township where drilling has not penetrated far below the Berea sand. The deepest test known to have been drilled in this township was started in 1886 on the flood plain of the Muskingum River, one-half mile or so southeast of the mouth of the Walhonding River. The Berea was encountered at 860 to 880 feet and yielded a show of oil with salt water.[1] Drilling was discontinued in the Ohio shale at 1,280. A few years later (1899 ?) a new company formed to test the Clinton sand deepened the hole to 3,100 feet without encouraging results and abandoned it. The top of the Big Lime was encountered in this well at 2,513 feet.[2] Early tests in the northeast quarter of Tuscarawas Township included one Berea well on the John Hall property, Lot 10, which made a show of oil; one well on the Grace farm, Lot 15, or Lot 16, yielding a show of oil in the Berea; and one well on the Stockum farm, which produced some oil from the Berea sand.[3] These wells were all drilled about 1899.

Recent drilling on record in the office of the Geological Survey is confined to Lot 9, northeast quarter. Here a Berea well was completed on the John Hall property in October 1929. The sand extending from depth 858 to 895 feet yielded an initial production of 10 bbls. of oil. A second well completed in November 1929 to the Berea sand on the Earl Stockum land, Lot 9, had an initial production of 12 bbls. A second well on the Stockum property found the sand at depth 1,043 to 1,080 feet with an initial yield of 24 bbls. a day. The wells produced for a short period of time but owing to the small production and the low price of oil they were soon abandoned.

VIRGINIA TOWNSHIP

Only a few wells are known to have been drilled for oil or gas in Virginia Township and these have proved non-productive. At least three tests have been drilled to the Clinton sand. The first of these drilled in 1912 on the Gray property in the southern part of Lot 28, southeast quarter, reached the sand at 3,582 feet. A show of oil was reported at 3,532. The second well is located on the Chas. Henry land in the northwest quarter of Section 25. The drill descended to a depth of 3,612 feet or 55 feet below the top of the Clinton sand which proved unproductive. The third well drilled in 1944 on the C. W. Norris farm, southeast quarter of Section 14, found the Berea sand from 830 to 860 feet and encountered the Clinton sand from 3,550 to 3,585 feet. No shows of oil or gas were reported in either sand.

Known wells in Virginia Township sunk to the Berea sand as an objective include one test drilled in 1917 on the David Davis land in Section 9; one hole on the Theodore McCoy farm, Lot 39, northwest quarter, drilled in 1935; and two tests on the C. W. Norris tract, Section 14, drilled in 1948. The Berea sand which was unproductive in these wells has a thickness of about 26 feet and is found at a depth of about 850 feet.

WASHINGTON TOWNSHIP

According to information available at this time only a scattering of test wells have been drilled in Washington Township and these are confined chiefly to the southeastern half. Two tests

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[1] Orton, Edward, Economic Geology, Geol. Survey Ohio, Vol. VI, pp. 368-369, 1888.

[2] Orton, Edward, The Clinton limestone as a source of oil and gas, Geol. Survey Ohio, First Ann. Rept. 1890, pp. 245-246, 1890.

[3] Bownocker, J. A., The occurrence and exploitation of petroleum and natural gas in Ohio, Geol. Survey Ohio, Bull. 1, pp. 291-292, 1903.

drilled to the Clinton sand before 1930 proved unproductive. One on the J. W. Phillips property in Section 1 secured the sand at 3,376 to 3,436 feet and the second on the Lyman Fulks land, Lot 9, southwest quarter, reported the Berea at 654 to 669 feet and the Clinton at 3,250 to 3,310 feet. In 1926 a Clinton test was made on the Compton property, northeast quarter of Section 12. It yielded a little water in the Berea sand at 885 to 902 feet and a small supply of gas in the Clinton at 3,401 to 3,452 feet. A show of gas in the Clinton sand was reported in a well drilled in 1937 on the Nolan property, southwest quarter of Section 19, and a show of oil in the Clinton in a well sunk in 1945 on the Gibson property in the southwest quarter of Section 11. Other Clinton tests include a dry hole on the Nethers property, northeast quarter of Section 14, and a dry hole on the Featheroff land in Section 20. In the last well a show of oil was reported in the Berea sand encountered at depths 952 to 978 feet.

Shallow tests in Washington Township drilled only to the Berea sand are confined to the Meek properties in sections 1 and 10. Early in 1934 a well drilled in the southwest quarter of Section 1 encountered the Berea at 886 to 900 feet with a 1-foot "break" at 888 feet. A show of gas was secured in the top of the sand and a show of oil below the "break." A second well drilled the same year found only water in the Berea.

WHITE EYES TOWNSHIP

Two Clinton sand tests have been drilled in White Eyes Township both of which were failures. The first was sunk in 1937 on the Edward Steiner property in Lot 8, northeast quarter, about one mile northwest of Fresno. The Clinton sand was encountered at a depth of 3,997 feet and was passed through at depth 4,041 feet. The second well was drilled the following year on the lands of Ione Hotem one mile south of west of Chili. The Clinton sand having a thickness of 45 feet was reached at a depth of 4,097 feet.

Drilling to the Berea sand in White Eyes Township has been confined chiefly to sections 24 and 25. About 1925 a well was drilled on the Charles Eddinger property in the southeast quarter of Section 24 and a flow of gas was secured in the Berea sand. Shortly thereafter four tests were made in surrounding territory without success. These failures included one dry hole on the Henderson property in the southeast quarter of Section 24, one dry hole on the Pickerel property in the southwest quarter of Section 24; one dry hole on the Burkshire property in northeast quarter of Section 24; and one dry hole on the Gribble property in the southeast quarter of Section 25.

SUB-SURFACE STRATA PENETRATED IN WELLS

GENERAL FEATURES

In searching for oil and gas in Coshocton County the chief objectives of the driller have been the Berea and Clinton sands. Few attempts have been made to test the possibilities of production in this county from deeper horizons. One well, however, the Chaney-Meyer No. 2, drilled by the Ohio Oil Company in 1944 in Lot 20, Clark Township, was extended downward to a depth of 5,660 feet or more than 2,000 feet lower stratigraphically than other wells drilled in this county. Below the Clinton sand the drill penetrated the Red Medina shales, the shales and thin limestones of the Cincinnati group, the limestones of the Trenton and Black River formations, and stopped in sandy dolomites 150 feet below the probable horizon of the St. Peter sandstone. Thus through activity with the drill some information has been secured relative to at least 5,000 feet of strata lying below the sedimentary series exposed at the surface. The character, thickness, and variations in thickness of different components of this series as well as the most probable geologic correlations, as determined by well logs and to a limited extent by a study of drill cuttings, is shown on the accompanying table (page 208, 209). The succession

Section of Bedrocks Below the Pennsylvanian System Penetrated in Wells Drilled

Coshocton County

System	Formation, Series, or Group	Character of Rocks Penetrated in Wells	Drillers' Terms			Thickness in Wells Feet	
Mississippian	Logan	Sandstone, siltstone, and shale	Sand and shale			-------	
	Cuyahoga	Sandstone, local	Big Injun			25 to 400	
		Shale, bluish gray to gray black	Shale and slate			200 to 500	
	Sunbury	Shale, brownish black, carbonaceous	Black shale or "Coffee shale"			25 to 70 Average, 50	
	Berea	Siltstone to sandstone, gray, calcareous, persistent	Sand	Berea		2 to 72	
		Shale, dark, thin, discontinuous	"Break"				
		Siltstone to sandstone, gray, locally present	Sand				
	Bedford	Shale, bluish gray, sandy, and reddish brown	Shale, slate, redrock			1,150 to 1,950	
Devonian	Ohio	Shale, gray black, bluish gray, and greenish gray	Shale, slate, "Cinnamon"				
	Delaware Columbus Detroit River Sylvania	Limestone and dolomitic limestone, gray to brownish gray; some chert	Lime		Big Lime	100 to 290	850 to 1,250
		Limestone with chert, occasional glauconite and sand	1st Water horizon Oriskany sand				
		Limestone, gray to drab, crystalline, dolomitic	Lime				
Silurian	Bass Island	Dolomite, dark, impure; some anhydrite and shale					
		Dolomite, brown, crystalline	Newburg "sand"				
	Niagara	Dolomite, white, gray, greenish gray to dark brown; crystalline	2nd Water horizon at top. Lime			100 to 380	

Section of Bedrocks Below the Pennsylvanian System Penetrated in Wells Drilled

Coshocton County (continued)

System	Formation, Series, or Group	Character of Rocks Penetrated in Wells	Drillers' Terms	Thickness in Wells Feet	
Silurian (continued)	Osgood	Shale, gray black, argillaceous, calcareous; some nodular limestone	Shale	45 to 160 Average, 100	
	Dayton Brassfield	Limestone, gray to variegated, dolomitic, with chert; glauconite and hematite often present	Little Lime or "Packer Shell"	5 to 40 Average, 22	
		Shale, gray black to reddish brown, often calcareous; with bodies of white, gray, and red sandstone and siltstone	Shale Stray Sand Red Clinton Clinton Sand	155 to 210	
Ordovician	Cincinnatian	Shale, reddish brown	"Red Medina"	350	1,340
		Shale, gray black, with nodules of limestone	Shale and lime		
		Shale, brown black, calcareous	Utica shale	280	
	Trenton	Limestone, gray to brown, dense, crystalline, flaky	Trenton	125	
	Black River	Limestone, gray to brown, dense, with dolomitic streaks		600	
		Dolomite, gray to greenish, impure; with green dolomitic shale and sand	"Lower Green" St. Peter Sand	54	
Cambro-Ordovician		Dolomite, generally gray, crystalline, with some dolomitic shale and sandstone		140 +	

is illustrated by the following description of samples of drill cuttings from the Chaney-Meyer Unit No. 2 well, supplemented above depth 2,171 feet by the driller's log.

Description of samples of Drill Cuttings from the Chaney-Meyer Unit No. 2 Well by the Ohio Oil Company, Lot 20, Clark Township, Coshocton County

Completed April 7, 1944
Samples from the Ohio Oil Company, Findlay, Ohio

	Top Ft.	Bottom Ft.
Quaternary system		
Sand and gravel	0	165
Mississippian system		
Shale (driller's log)	165	680
Berea sand (driller's log)	680	700
Devonian system		
Devonian limestone, Big Lime (driller's log)	2,044	
Oriskany horizon		
Limestone, gray, with many quartz sand grains	2,171	2,181
Helderberg group ?		
Limestone, gray to buff, dense to finely crystalline, dolomitic; lower part porous	2,181	2,257
Limestone, gray to light brown, dense to finely crystalline, dolomitic, with some limy dolomite	2,257	2,275
Same, with some gray black impure limy dolomite	2,275	2,310
Silurian system		
Monroe-Salina group		
Dolomite, gray to light brown, with 40 percent anhydrite	2,310	2,343
Dolomite, dark gray, impure, with some anhydrite	2,343	2,390
Dolomite, brown, dense, impure	2,390	2,433
Dolomite, brown to dark, dense, argillaceous, with some anhydrite	2,433	2,475
Same, with a trace of anhydrite	2,475	2,480
Dolomite, brown, dense, argillaceous, with 25 percent anhydrite	2,480	2,501
Same, with 10 percent anhydrite	2,501	2,506
Dolomite, bluish gray, impure, with some anhydrite	2,506	2,537
Dolomite, gray, argillaceous	2,537	2,554
Same, with a trace of anhydrite	2,554	2,570
Same, with much anhydrite	2,570	2,587
Dolomite, dark, dense, impure, with a trace of anhydrite	2,587	2,740
Dolomite, gray black, impure	2,740	2,753
Dolomite, gray to gray black, finely crystalline; fine cuttings	2,753	2,778
Dolomite, brown, crystalline	2,778	2,804

	Top Ft.	Bottom Ft.
Niagara dolomite group		
Dolomite, gray, crystalline	2,804	2,985
Dolomite, gray to dark gray brown, crystalline	2,985	3,010
Dolomite, dark, impure, shaly, and dolomitic shale	3,010	3,032
Dolomite, gray to light brown, crystalline	3,032	3,061
Dolomite, gray rather dense	3,061	3,069
Dolomite, gray to light brown, coarsely crystalline, with 10 percent gray impure dolomite	3,069	3,088
Dolomite, gray to bluish gray, finely crystalline, with 5 percent dark, dense, impure dolomite	3,088	3,108
Osgood shale		
Shale, gray to gray black, calcareous, and shaly limestone and dolomite	3,108	3,139
Shale, dark gray black, calcareous	3,139	3,151
Shale, dark gray black	3,151	3,173
Same, with a few fragments of nodular limestone	3,173	3,191
Dayton-Brassfield limestone		
Limestone fragments with chert, with some red brown shale and traces of glauconite	3,191	3,199
Limestone, white to brown, cherty	3,199	3,207
Limestone, gray to light brown, dolomitic, with pyrite	3,207	3,213
Same, with 50 percent greenish gray shale	3,213	3,219
Clinton sand group		
Shale, bluish gray	3,219	3,227
Same, with 10 percent dark dolomite-bonded sandstone	3,227	3,249
Same, with 50 percent gray, fine-grained sandstone, and 10 percent red sandstone	3,249	3,254
Same, with 90 percent gray to buff sandstone	3,254	3,263
Same, with 60 percent gray to buff sandstone	3,263	3,269
Same, with 95 percent gray to buff sandstone, in part grain free	3,269	3,274
Shale, gray black, with 30 percent sandstone	3,274	3,303
Shale, gray black, with 85 percent sandstone	3,303	3,318
Shale, gray black, with some limestone fragments in part replaced by hematite; a trace of sandstone	3,318	3,332
Shale, gray black with a few fragments of dark fine-grained sandstone	3,332	3,358
Shale, gray black, a few fragments of limestone	3,358	3,385
Shale, gray black, with 5 percent red brown shale	3;385	3,395

	Top Ft.	Bottom Ft.
Ordovician system		
Cincinnati group		
Shale, reddish brown . . . . . (Queenston)	3,395	3,661
Shale, reddish brown and gray black interstratified . . . . (Queenston)	3,661	3,755
Shale, gray black with occasional fragments of nodular limestone	3,755	4,419
Shale, gray black and brown black interstratified . . . . . (Utica)	4,419	4,468
Shale, brown black. . . . . (Utica)	4,468	4,695
Shale, brown black; 5 percent black, dense, impure limestone . . . . . (Utica)	4,695	4,732
Trenton limestone		
Limestone, gray to brown, dense to finely crystalline, flaky, with dark shale decreasing downward	4,732	4,774
Limestone, gray to dark, flaky to shaly, with traces of black shale	4,774	4,856
Black River limestone		
Limestone, gray to brown, dense, chunky	4,856	4,933
Limestone, dark brown to drab, dense, with 25 percent dark shale.	4,933	4,946
Same, with 40 percent dark shale.	4,946	4,950
Limestone, gray, dense texture, 20 percent shale	4,950	4,973
Limestone, gray to brown, dense texture.	4,973	5,096
Same, 50 percent dark shale	5,096	5,105
Limestone, gray to brown, dense texture.	5,105	5,440
Limestone, gray to brown, dense texture, with pyrite	5,440	5,458
Transition beds, probable St. Peter horizon		
Limestone, brown, dense, with 50 percent green gray dolomite, pyrite present	5,458	5,470
Dolomite, gray to light greenish gray, dense, siliceous and impure.	5,470	5,483
Dolomite, gray, siliceous, with greenish gray calcareous shale; 5 percent quartz sand, grains rounded and etched	5,483	5,493
Dolomite, gray and brown, with 15 percent large frosted quartz sand grains.	5,493	5,503
Dolomite, gray to white, crystalline with 5 percent gray black shale; 25 percent quartz sand	5,503	5,512
Deep Sub-Trenton		
Dolomite, gray, finely crystalline, with 5 percent dark shale	5,512	5,519
Dolomite, gray to buff, dense to finely crystalline, with 50 percent gray black dolomitic shale.	5,519	5,524
Dolomite, gray, dense to finely crystalline, with 25 percent gray black dolomitic shale	5,524	5,530

	Top Ft.	Bottom Ft.
Dolomite, gray, crystalline, with 1 percent shale; trace of pyrite	5,530	5,538
Dolomite, gray, crystalline	5,538	5,556
Same, a few sand grains	5,556	5,572
Dolomite, gray to light buff	5,572	5,610
Dolomite, gray, crystalline	5,610	5,660
Total depth		5,660

TRENTON AND SUB-TRENTON SERIES

The Trenton, as that term is used by the oil and gas well driller, consists of a series of limestones with minor amounts of shale measuring several hundred feet in thickness, which is encountered in all wells in Ohio which have been drilled deep enough to reach its horizon. This series is shallowest in southwestern Ohio where along the axis of the Cincinnati Arch its top is brought above water level along the Ohio River near Cincinnati. From this region the Trenton dips moderately and irregularly to the north beneath western and northwestern Ohio and more steeply to the east and northeast throughout central, eastern, northeastern, and southeastern parts of the State. The Trenton is best known in the old Lima-Indiana field of northwestern Ohio where it is reached at depths ranging from 1,000 to 1,300 feet and where it has been a source rock chiefly for oil since 1884. Attempts to extend the Trenton production have led to drilling of many wells to that horizon in central and eastern Ohio. Among such wells the top of the Trenton has been encountered at a depth of 5,360 feet in the George Corbett No. 1, Lenox Township, Ashtabula County; at 5,800 in Sidney Whitmire No. 1 well, Section 26, Salt Creek Township, Muskingum County; and at 6,884 feet in the W. T. Longworth No. 1, Section 23, Olive Township, Meigs County. The Trenton of the driller probably has its least thickness in Ohio of 450 to 500 feet in western Darke and western Preble counties. Its expansion away from these areas is irregular for it may attain a thickness of 800 feet near Toledo, Lucas County; 625 feet near Sandusky, Erie County; 650 feet in Ashtabula County; and about 800 feet in eastern Muskingum County. At all localities it is overlain by a shale series more than 1,000 feet in thickness known as the Cincinnati series, and underlain by a thick rock succession consisting of beds of dolomite, sandy dolomite, and sandstone with minor amounts of shale, all of Lower Ordovician and/or Cambrian ages.

Where samples of drill cuttings are available, the Trenton of the oil and gas well driller of Ohio is generally divisible into two parts, an upper thinner part which probably represents the true Trenton, and a lower thicker portion of Black River age. The upper or true Trenton is generally a gray to brown limestone or dolomitic limestone which is in part dense and stony in appearance and in part finely crystalline. Where highly calcareous it generally fractures into flat flaky or tabular-shaped pieces. Traces of brown chert are generally present, but it is not a conspicuous element. East of the producing fields in the Trenton this upper subdivision is a highly calcareous non-porous rock which is generally less than 40 feet in thickness. It seems to thicken slightly toward the northwest and in the producing fields it becomes more highly magnesian and porous. It has yielded the bulk of the oil which has been produced in northwestern Ohio.

The lower subdivision of the drillers' Trenton in Ohio, the Black River, is made up chiefly of dense limestone of a light gray, dove to brown color. It is very fine grained and homogeneous in appearance and under the action of the drill it tends to break up into chunks or cubical fragments rather than to exhibit the flaky character of the overlying Trenton. In composition it is, as a whole, highly calcareous. Thin dolomitic streaks, however, having a finely crystalline texture, but seemingly lacking widespread continuity, are of common occurrence in the lower part of the Black River. Scattered shows of oil have been reported in these porous dolomitic streaks.

Shale is not entirely lacking in the Black River in Ohio but it is not a conspicuous element. At or within a few feet of the top of this series shales are generally present apparently as thin partings between limestone layers. The shale has a characteristic light greenish gray color and generally a pearly luster. Flakes of dark or bronze-colored mica are a conspicuous element. In general the shale is soft and friable and it goes to pieces rapidly when placed in water. Dark green shales are likewise found in some wells at or near the base of the Black River. In places these shales seem to be interstratified with dark brown dense limestone. In samples they seem to grade downward into a transitional series which is known to the driller in Ohio as the "Lower Green" and which appears to consist of interstratified beds of green to grayish green dolomitic shale, gray dolomite, greenish gray dolomite, and quartz sand. The dolomite is generally dense and argillaceous. In samples the quartz sand may be grain free or in aggregates with dolomite bond. The quartz grains generally range from fine to coarse in texture, the larger grains being well rounded and etched. The thickness of the transitional beds in Ohio is variable. In samples from some 20 wells widely scattered over central and western Ohio their depth ranges from 2 to 70 feet but averages about 30 feet. Some small production of oil has been secured from the "Lower Green" or so called St. Peter horizon at a few scattered localities in Ohio. A strong head of brine, commonly designated as the "blue lick" water, is often encountered at the base of the transitional beds.

Below the transitional series just described, dolomites, sandy dolomites, and sandstones of probable Cambrian age prevail for many hundreds of feet. In Ohio only a few wells have passed through this series and have reached the Basement Complex. These are located chiefly in the northwestern quarter where the sub-Trenton sedimentary series is thinnest. Numerous water horizons are encountered below the transitional beds, but no commercial production of oil or gas is known to have been secured from this series in Ohio.

In Coshocton County the only well to date which has reached and passed through the Trenton is the Chaney-Meyer Unit No. 2 located in Lot 20, Clark Township, a record of which has already been given. The Trenton of the driller was first encountered at a depth of 4,732 feet and extended to a depth of 5,470 feet, yielding a thickness of 738 feet. The upper division of this limestone series, the true Trenton of geologic nomenclature, is normal in lithologic character for central and east central Ohio where it is not noticeably dolomitic. It passes abruptly into the Black River limestone which extends from a depth of 4,856 feet to depth of 5,470 feet. The transitional beds ("Lower Green") consist of greenish gray dolomitic shale, and gray to greenish gray impure siliceous dolomite with some quartz sand at the base. The lowest sample, representing the succession from 5,503 to 5,512 feet, is approximately 25 percent quartz sand. The sand grains range in texture from fine to coarse and are well rounded with surfaces etched to translucence. This is the so-called St. Peter sand of the driller. Its exact stratigraphic age is in doubt.

Below the transitional beds, white, gray, and buff dolomites with some admixture of shale in the upper part extend to the total depth of 5,660. The exact stratigraphic correlation of this series is also in doubt.

ORDOVICIAN SERIES ABOVE THE TRENTON

The Trenton limestone is overlain in Ohio by series of shales of Upper Ordovician age of variable thickness and character. In the Cincinnati region of southwestern Ohio where these beds outcrop and extending below the surface from Preble County northward through the western border counties, these shales vary from about 850 to 650 feet, being thickest in the southwest. From western Ohio these shales thicken toward the axis of the Appalachian basin to the east. Along the western belt of Clinton sand production in east central Ohio, its depth ranges from about 1,150 feet in Lawrence County to approximately 1,200 feet in Lorain County. East of this belt the series has been penetrated in a few scattered wells where its thickness is approximately as follows: 1,360 feet in eastern Meigs County; 1,340 feet in east central Muskingum County; 1,370 feet in south central Wayne County; 1,630 feet in northwestern Geauga County; and 1,700

feet in northeastern Ashtabula County. On the basis of lithologic character at least three subdivisions of the Upper Ordovician beds can be recognized in drill cuttings. The lowest subdivision, the Utica shale of the driller, is a soft brown black carbonaceous shale the basal part of which is calcareous with thin beds of dark limestone present in southern Ohio. It is thin on the outcrop in southwestern Ohio but thickens rapidly to the north and northeast reaching a maximum of 400 feet or so from Logan to Seneca counties. Small yields of gas have been secured from this shale at scattered localities in western Ohio. The top part of the Utica passes by gradation upward to a gray black calcareous shale with thin beds of nodular limestone, constituting the second lithologic unit in this series. The Utica and overlying gray black shales constitute the major part of the Upper Ordovician series in western Ohio. In the belt of Trenton production in west central northern Ohio the gray black shale grades upward into a calcareous shale having a reddish brown or Indian red color constituting the third subdivision. This shale has a thickness generally less than 100 feet in Wyandot and Seneca counties. It thins to the west in Ohio and thickens to the northeast, east, and southeast. Along the first line of Clinton sand production from Lorain County to Lawrence County, it generally measures less than 225 feet, being thinnest in southern Ohio. This red shale seems to expand most rapidly to the northeast. Its greatest recorded thickness in this State is about 800 feet in northeastern Ashtabula County. The red shale of the Upper Ordovician is the Red Medina of the Clinton sand driller and the Queenston shale of surface outcrops in western New York. It is represented on the outcrop in southwestern Ohio by a few feet of red to pink shale known as the Elkhorn shale, the top formation of the Ordovician system.

In the single Trenton test drilled in Coshocton County, namely the Chaney-Meyer Unit No. 2, Lot 20, Clark Township, the top of the Ordovician represented by the reddish brown Queenston (Red Medina) shale was first encountered at depth 3,395 feet and the Trenton was reached at about 4,732 feet yielding a thickness for this series of 1,337 feet. The three phase character of the Upper Ordovician shale is well shown in samples of drill cutting from this well. The Utica is typical, being a soft brown black carbonaceous shale. It grades downward by an increase in calcium carbonate to a dense brown black impure limestone and at its top by the intercalation of gray black argillaceous shales it passes upward into the middle division of this group. The middle division contains fewer beds of nodular interstratified limestone than is indicated in well cuttings from southern and southwestern Ohio. Its upper contact is not sharp and distinct, but through a transition zone consisting of interstratified gray black and reddish brown shales it passes to shale of typical Queenston character.

CLINTON SAND SERIES

The Clinton sand series as that term is used in these pages includes the sandstone and interstratified shales of Lower Silurian age which make up the succession between the top of the Queenston (Red Medina) shale and the base of the Little Lime or Packer Shell. This series underlies the entire eastern half of Ohio and has been productive of gas and to less extent of oil in widely scattered localities. East of the west boundary of Clinton sand production in this State the thickness of this series varies from approximately 125 feet on the west to a little more than 200 feet on the east. West of the belt of Clinton production the sandstone bodies disappear from the series and the shales become thinner and more calcareous and according to Rittenhouse, grade horizontally into the Brassfield limestone.[1]

In Coshocton County the Clinton sand series has been encountered in all wells which have been drilled deep enough to reach its horizon. Its position in the western part of the county is approximately 2,000 feet below sea level. It becomes deeper to the southeastward, however, owing to the regional dip of strata in that direction and to the general eastward thickening of overlying series. Consequently it is expected at a depth of about 3,500 feet below sea level in southeastern Linton Township. The thickness of the series ranges from about 155 feet to about

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[1] Rittenhouse, Gordon, Early Silurian Rocks of the Northern Appalachian Basin, U. S. Geol. Survey, Oil and Gas Investigations, Preliminary Map 100, 1949.

210 feet, being thickest in Crawford Township and thinnest in Pike Township. In test wells drilled through this series one or more sand bodies are generally encountered. The driller usually designates such sands on physical character or position in the series in descending order as Stray sand or Clinton Stray, Redrock, or Clinton Red, Clinton sand or White Clinton, and Medina sand. All of these sands with the possible exception of the Medina sand have been recognized in Coshocton County. The Stray sand and Red Clinton extend from the northeast into the eastern part of the county where they are reported in a few wells, but are generally thin and unproductive. Both of these sands are conceived by Rittenhouse[1] to represent the western continuation under cover of the Thorold and Grimsby sandstones of outcrops in western New York. Their presence is not generally reported in drillers' records from the western part of Coshocton County. The chief production in this area comes from the so-called Clinton or White Clinton sand which seems to be made up of a series of sand bodies of good porosity more or less interlaced with impervious shale and with sand zones of less porosity. Good production is favored by high porosity and thick sand section.

The sandstones and shales which comprise the Clinton sand series have varied lithologic characters. The shales are dominantly bluish gray to gray black in color although greenish gray varieties are common in the top part of the series, and reddish brown shales may be present on the horizon of the Red Clinton sand. The shales are generally calcareous and they often contain nodules of limestone especially in the lower part of the series. In places the limestone has been partially replaced by the red iron oxide hematite. The sandstone and siltstone which are interstratified with the shale are generally composed of fine grains of quartz which are subangular in contour. The color is generally gray or white in the Stray sand and Clinton sand but as the name indicates it is generally pink to reddish brown in the Red Clinton, due to a film of red iron oxide on the grains. In such varieties the red oxide may also serve in part as a bond for the sand grains. Calcium carbonate, however, is generally present and in the white or gray friable varieties it is the chief cementing substance. In the denser more compact varieties the smoothness of the fracture surfaces suggests secondary silica as a part of the bond holding the grains together. Glauconite, a characteristic greenish black mineral occurring as small grains, has been observed in both the sandstones and interstratified shales. From a study of well samples it appears that the contact between the Clinton sand series and the overlying Packer Shell is sharp and distinct as is also its contact with the underlying Queenston (Red Medina) shale. Few wells in Coshocton County have reached the Queenston shale.

The general character of the succession through the Clinton sand series is shown by the following description of samples from the E. P. Balder No. 1 well by the Wittmer Company, Lot 30, Crawford Township, Coshocton County. According to the driller's record the Packer Shell was passed through at a depth of 3,945 feet or 25 feet above the first sample described below.

Description of samples through the Clinton Sand series
from the E. P. Balder No. 1 Well, Lot 30, Crawford Township

		Top Ft.	Bottom Ft.
Clinton sand series (Lower Silurian)			
Sandstone, gray, fine-grained, with 20 percent dark shale . .	Stray Sand	3,970	3,977
Sandstone, gray, with 20 percent red brown shale, and 25 percent gray black shale . . .	Stray Sand	3,977	3,985
Sandstone, gray, pink, and red . .	Stray Sand	3,996	4,000
Sandstone, reddish brown	Red Clinton	4,000	4,008
Sandstone, gray and reddish brown, with 20 percent gray black shale	Red Clinton	4,008	4,013
Shale, gray black, with 40 percent white sandstone . .		4,013	4,018

[1] Rittenhouse, Gordon, op. cit.

		Top Ft.	Bottom Ft.
No sample		4,018	4,020
Shale, gray black, with 10 percent gray sandstone and 5 percent reddish brown shale		4,020	4,022
Shale, gray black, with 10 percent white sandstone		4,022	4,025
Sandstone chips, gray, with one percent gray black shale	Clinton Sand	4,025	4,030
Sandstone chips, gray, with 10 percent gray black shale	Clinton Sand	4,030	4,036
Sandstone chips, gray, with 50 percent gray black shale	Clinton Sand	4,036	4,048
Sandstone chips, gray, with 20 percent gray black shale	Clinton Sand	4,048	4,050
Shale, gray black, 3 percent gray sandstone		4,050	4,058
Shale, gray black, 10 percent gray sandstone		4,058	4,063
Shale, gray black		4,063	4,069

The above section indicates an interstratification of sandstone and shale in the Clinton sand series with sandstone predominating in the Stray, Red Clinton, and Clinton sand zones as those names are used by the driller. A show of gas was reported from 4,026 feet to 4,037 feet. According to the driller's record the Red Medina shale was first encountered at a depth of 4,152 feet and extended to 4,167 feet, the total depth of the well.

On the Gilmore-Randles property, Lot 28, Clark Township, the Ohio Oil Company drilled a dry hole in the Clinton sand in 1943. A description of drill cuttings from the Clinton sand series is as follows:

Description of drill cuttings through the Clinton sand series from the Gilmore-Randles No. 1 well, Lot 28, Clark Township

	Top Ft.	Bottom Ft.
Silurian system		
Packer Shell		3,241
Clinton sand series (Lower Silurian)		
Shale gray to gray black; trace of siltstone; trace of limestone	3,241	3,249
Shale, gray black, with 25 percent calcareous siltstone	3,249	3,256
Sandstone, gray, compact, with 10 percent red sand; trace of shale	3,256	3,265
Sandstone, gray and reddish brown; trace of gray black shale	3,265	3,272
Siltstone chips, fine-grained; trace of dark shale	3,272	3,277
Shale, gray black, with 5 percent sandstone chips	3,277	3,282
Shale, gray black, with 2 percent gray sandstone	3,282	3,289
Shale, gray black; trace of gray sandstone	3,289	3,299
Shale, gray black, with trace to 5 percent of fine-grained gray sandstone	3,299	3,315
Shale, gray, trace of gray sandstone chips	3,315	3,321
Hematite ore by replacement of limestone, with 25 percent gray black shale	3,321	3,328
Shale, gray black, with trace of siltstone	3,328	3,387

		Top Ft.	Bottom Ft.
Ordovician system			
Shale, gray black, with 50 percent reddish brown shale. . .	Queenston Shale	3,387	3,401
Shale, reddish brown, with 5 percent gray black shale. . . .	Queenston Shale	3,401	3,408
Total Depth			3,408

The Stray and Red Clinton sands are probably represented in this well by samples from 3,256 to 3,272 feet. The gray or white Clinton sand underlying these beds is very poorly represented in this well, its horizon being filled chiefly with gray black shale. In the William A. Rahn No. 1 well by the Enterprise Oil Corporation, Section 20, Tiverton Township, both the Stray and Red Clinton sands are apparently wanting but the gray Clinton was productive of oil. A description of drill cuttings from the Clinton sand series, supplemented by data from the drillers, is as follows:

Record in part from drill cuttings from the William A. Rahn No. 1 Well, Section 20, Tiverton Township

		Top Ft.	Bottom Ft.
Silurian system			
Packer Shell (Driller's record)			3,320
Clinton sand series			
Shale (Driller's record).		3,320	3,349
Siltstone chips, gray, with 40 percent gray black shale . . .	Clinton Sand	3,349	3,354
Sandstone, gray, medium-grained, loosely cemented, with 4 percent dark shale . . .	Clinton Sand	3,354	3,359
Sandstone, light gray, fine-grained, with 50 percent gray black shale	Clinton Sand	3,359	3,367
Same, with 5 percent gray black shale	Clinton Sand	3,367	3,381
Same, with 10 percent gray black shale	Clinton Sand	3,381	3,406
Shale, gray black, with traces of gray sandstone . . .		3,406	3,415
Shale, gray black, 1 percent limestone fragments, some replaced by hematite		3,415	3,422
Total Depth			3,422

LITTLE LIME OR "PACKER SHELL"

The Clinton sand series just described is generally overlain by a thin limestone or dolomitic limestone which is widely known among the drillers as the Little Lime or "Packer Shell." In the belts of Clinton sand production which occur east of a line extending from western Lorain County to western Lawrence County the Little Lime may reach a thickness of 75 feet but is generally less than 50 feet. South of Fairfield, Perry, and Morgan counties it rarely exceeds 25 feet and over large areas it is 10 feet or less in thickness. It continues west of the belts of Clinton sand production and has been penetrated by wells drilled in fields of Trenton production of northwestern Ohio and by many test wells in south central Ohio. The Little Lime is represented in part at least by the Brassfield-Dayton limestone of outcrops extending from Miami County southeast to western Adams County and southwest to southern Preble County.

In the belt of Clinton sand production the Little Lime is overlain by a bed of shale which extends upward to the base of the Big Lime (Niagara dolomite). This shale may have a thickness of about 100 feet in east central and northeast central Ohio but it tends to thicken slightly to the east into eastern Ohio and more rapidly to the south into southern Ohio. In Jackson and Lawrence counties it may measure 200 to 250 feet or more in depth. In the western half of Ohio these shales tend to thin out in a northwest direction and in the northwest counties of the State the Big Lime (Niagara dolomite) apparently rests on the Little Lime. In character the shales overlying the Little Lime are generally soft and argillaceous. They usually have a greenish black to gray black color and are generally calcareous in composition. Streaks or zones of pink to red shale may occur on this horizon in the southern half of the Clinton fields in Ohio. The shales between Little Lime or "Packer shell" and Big Lime are correlated with the Osgood shale of surface outcrops in Ohio and with the Rochester shale of the New York section.

In Coshocton County the Little Lime is generally mentioned in records of wells drilled deep enough to encounter its horizon. The thickness of the limestone ranges from 5 to 40 feet with an average of about 22 feet. No directional expansion of this limestone formation can be noted in Coshocton County. The stone is generally a gray to bluish gray dolomitic limestone which may be fine to coarsely crystalline but other shades of color such as white, pink, and brown are of common occurrence. Fragments of gray, pink, and milky chert are generally present in cuttings from this limestone, and at some places chert in the Little Lime is abundant. Grains of dark green to green black glauconite are occasionally found in the limestone and in the shale "breaks" associated with it. Hematitic iron oxide apparently replacing limestone has been noted in a few samples at the base of the Little Lime. Overlying the Little Lime and extending upward to the base of the Niagara dolomite is a shale formation, the Osgood of surface outcrops, which in this county is dominantly gray black in color and argillaceous in character. It is generally calcareous or dolomitic and it contains some nodular limestone. Locally the shale is silty in character. The thickness of these shales in Coshocton County ranges from 45 to 160 feet but averages close to 100 feet. The variation in thickness of the shale bed appears to be local in character and is not the expression of a regional trend. The following description of samples from the Lyle Teeling No. 2 well by the Ohio Oil Company, Lot 22, Clark Township, shows the character of the Little Lime and overlying shales.

Description of samples of drill cuttings through the Little Lime from the Lyle Teeling No. 2 Well, Lot 22, Clark Township

	Top Ft.	Bottom Ft.
Big Lime (Niagara dolomite)		
Dolomite, gray to bluish gray, crystalline	3,124	3,138
Same, with 70 percent gray black dense shaly dolomite	3,138	3,144
Shale, gray black and brown black	3,144	3,150
Dolomite, gray to gray black, siliceous, with 40 percent gray black shale	3,150	3,154
Osgood Shale		
Shale, gray black, argillaceous	3,154	3,164
Shale, gray black, dolomitic	3,164	3,252
Little Lime (Dayton-Brassfield)		
Limestone, gray, dolomitic, with gray to pink chert; 40 percent gray black shale	3,252	3,262
Limestone, gray to pink, dolomitic, with 3 percent gray to gray black shale	3,262	3,274
Limestone, as above, with 70 percent green black shale; pyrite	3,274	3,281

	Top Ft.	Bottom Ft.
Clinton sand series		
Shale, gray black, with fragment of dark limestone and siltstone with carbonate bond. . . .	3,281	3,299

BIG LIME

The Big Lime of the Clinton sand driller in Ohio consists of a series of limestones and dolomites of varying thickness extending in vertical section from the top of the Middle Devonian limestone to the base of the Niagara dolomite of Middle Silurian age. As thus delimited the Big Lime as penetrated in wells is overlain by several hundred feet of Upper Devonian shale and underlain by the Osgood shale previously described. From its field of outcrops which comprises a large area in western Ohio, the Big Lime as a whole dips to the eastward beneath younger overlying beds in eastern Ohio toward the axis of the Appalachian trough. The thickness of this unit along the eastern edge of its belt of outcrops varies from a minimum of 200 feet or so in Adams County, where only the Niagara dolomites are represented, to about 1,000 feet in western Erie County, where the series consists of Niagara and Monroe dolomites and Devonian limestones. East of its outcrops in Ohio the Big Lime series tends to thicken to the northeast by the probable expansion of outcropping formations in that direction and by the presence of other formations under cover which thin and pinch out to the westward before the outcrop is reached. The greatest known thickness of this series in Ohio, according to drillers' records, occurs in west central Columbiana County, where more than 2,000 feet of limestones and dolomites comprising the Big Lime series have been penetrated in wells drilled to the Clinton sand. From west central Columbiana County the Big Lime thins in Ohio toward the northeast and northwest.

In drilling through the Big Lime several horizons are generally recognized by the driller and are often reported in drillers' logs of wells. These include in descending order the First Water or Oriskany sand horizon, the salt beds, the Newburg horizon, and the Second Water. The uppermost of these horizons, the First Water, is a porous zone containing brines which is often present from 100 to 350 feet below the top of the Big Lime. It is a fairly persistent horizon in the Big Lime in the first belt of Clinton sand production north of southern Coshocton County and northern Knox County and it is widely distributed east of this belt but is not recognized in every well. South of northern Muskingum and northern Knox counties, the First Water of the Big Lime is not generally reported in records of wells drilled to the Clinton sand. A few hundred feet below the First Water horizon salt beds appear in the Big Lime in northeastern Ohio constituting the second conspicuous element in this group. These beds seem to have their greatest combined thickness along a belt extending from southeastern Cuyahoga County to southwestern Columbiana County, although they underlie all of eastern Ohio north of eastern Washington County.[1] The salt thins to the southwest and disappears beyond an irregular line extending from Lorain, Lorain County, southeast to eastern Guernsey County, and thence south toward Marietta, Washington County. The salt beds do not extend into Coshocton County.

The Second Water horizon is a zone of porous dolomite filled with brine which occurs in the lower part of the Big Lime below the horizon of the salt beds. It is widely distributed in the eastern half of Ohio, but it is apparently not continuous, for water is not reported on its horizon in all wells. It is generally present in northern Ohio where the First Water may be present and it extends into southern Ohio where the First Water is generally wanting. The position of the Second Water is generally from 100 to 300 feet above the base of the Big Lime. Locally within the belt of Clinton production the Second Water is closely overlain by a discontinuous porous zone in the dolomite which has yielded oil and gas over small areas and is known to the driller as the Newburg "sand". The Newburg may occur immediately above the Second Water but its usual position is from 10 to 40 feet above that horizon.

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[1] Pepper, J. F., Areal extent and thickness of the salt deposits of Ohio, Geol. Survey Ohio, Rept. Inv. No. 3, 1947.

In Coshocton County the Big Lime is encountered in all wells drilled to the Oriskany horizon or deeper at depths below sea level ranging from about 950 feet in northwestern Tiverton Township to about 2,150 feet in southeastern Linton Township. The thickness of the series ranges from about 850 feet in western Pike Township to 1,200 to 1,250 feet along the eastern line of deep drilling in this county from central Crawford Township to central Linton Township. From an examination of drill cuttings through the Big Lime in Coshocton County it is apparent that the series consists of cherty limestone, cherty dolomitic limestone, dolomites, argillaceous dolomites with minor amounts of anhydrite, shale, and sandstone. Dolomite with varying amounts of impurities is the predominating variety.

The First Water of the Big Lime in Coshocton County, as determined by drillers' records, is usually encountered at depths below the top of this series ranging from about 100 to 290 feet. It is not persistent in this county although it has been reported in every township where its horizon has been reached by the drill. The water occurs in a thin zone of porous cherty dolomitic limestone, which is occasionally sandy. Sandstone appears on this horizon in eastern Ohio where it is generally known as the Oriskany sand. The Big Lime series above the Oriskany sand consists chiefly of gray to brownish gray dense to crystalline limestones at the top becoming dolomitic and cherty as the First Water horizon is approached. The widespread occurrence of the First Water, the presence of sand or bodies of sandstone on its horizon, and the irregular interval to the top of the Big Lime suggest that this horizon represents a discomformable surface in the rock series. The bedrocks above the First Water horizon are correlated with the Devonian limestones of surface outcrops in Ohio and the water zone with the disconformable contact surface at the base of these limestones.

In Coshocton County the Second Water is reported in the drillers' records of most of the wells drilled in the producing fields of the Clinton sand. East of these fields its presence may or may not be reported. Where present its position ranges from about 100 feet to 380 feet above the base of the Big Lime. From a study of drill cuttings the water-bearing horizon is identified as a porous dolomite, generally highly crystalline and usually light in color. The Big Lime below the Second Water is dominantly a light-colored crystalline dolomite which becomes dark and impure toward its base. Chert and anhydrite are not conspicuous in this portion of the Big Lime. The widespread occurrence of the Second Water suggests the presence of a zone of porosity associated with a buried erosion surface. That portion of the Big Lime below this porous zone is tentatively correlated with the Niagaran series of surface outcrops and the porous zone with the contact with the overlying Upper Silurian.

That part of the Big Lime between the First Water and Second Water horizons in Coshocton County consists in ascending order of (1) brown highly crystalline dolomites with small anhydrite, (2) dark dense argillaceous dolomites with anhydrite and minor amounts of dolomitic shale, and (3) crystalline dolomitic limestones. The brown highly crystalline dolomites occurring at the base above the Second Water often yield shows of oil and gas. This horizon is the Newburg "sand" of the driller. It has been reported in a number of drillers' records of wells in Clark Township. The middle subdivision consisting chiefly of impure dolomites with anhydrite accounts for most of the strata between the First Water and the Second Water. It tends to thin toward the southwest. The salt deposits occur in eastern Ohio associated with these impure dolomites but the salt thins to the southwest and pinches out before Coshocton County is reached. The upper subdivision consisting of buff finely crystalline dolomitic limestone also thins to the west and is of doubtful occurrence along the western edge of Coshocton County.

In Coshocton County that part of the Big Lime between the First Water and Second Water horizons is in large part Upper Silurian in age. The three lithologic subdivisions outlined above occur with relatively sharp contacts and without evidence in drill cuttings of erosional disconformities between them. The lower and middle subdivisions consisting chiefly of dolomites are here considered to represent the thickened eastern and southeastern extension of the Bass Island formation of surface outcrops in west central and northwestern Ohio. The upper subdivision made up of buff dolomitic limestone pinches out below drainage to the west, but when traced to the east it thickens and seems to be continuous with that part of the Big Lime which has been correlated by Fettke in western Pennsylvania with the Helderberg of Lower Devonian.[1]

[1] Fettke, Chas. R., Subsurface sections across western Pennsylvania, Topog. & Geol. Survey Pa., Prog. Rept., No. 127, 1941.

The succession through the Big Lime is illustrated by the following description of samples of drill cuttings from McCord No. 1 well drilled by the Ohio Oil Company in Section 23, Clark Township.

Description of samples of drill cuttings from McCord No. 1 well, Section 23, Clark Township

	Top Ft.	Bottom Ft.
Devonian system		
Ohio shale		
Shale, chiefly brown black	2,388	2,425
Shale, brown black, highly carbonaceous	2,425	2,435
Shale, as above, with 5 percent gray flaky limestone	2,435	2,444
Devonian limestone		
Limestone, gray, flaky with 25 percent dark shale.	2,444	2,487
Limestone, gray, dense, chalky to microcrystalline, with white chert	2,487	2,497
Limestone, gray, chalky to buff, dense to microcrystalline, with 3 to 5 percent chert	2,497	2,542
Limestone, gray, chalky, dense to microcrystalline, with a trace of chert	2,542	2,587
Limestone, gray to light brown, dense to microcrystalline, with a trace of milky chert	2,587	2,606
Oriskany sand - wanting		
Helderberg (?) group		
Limestone, brown, dense to microcrystalline, dolomitic	2,606	2,680
Silurian system		
Dolomite, dark brown, with 5 to 10 percent white anhydrite	2,680	2,825
Dolomite, dark bluish gray, dense, argillaceous, with traces of anhydrite	2,825	2,886
Dolomite, buff, dense, argillaceous, with traces of anhydrite	2,886	2,921
Dolomite, brown, dense, with 40 percent white anhydrite	2,921	2,956
Dolomite, brown, dense, argillaceous, with 10 percent white anhydrite	2,956	2,977
Dolomite, slate gray, dense, argillaceous	2,977	3,000
Dolomite, black to blue black, dense, impure	3,000	3,062
Dolomite, black to brown black, impure	3,062	3,133
Dolomite, black to buff, dense	3,133	3,142
Dolomite, gray to brown, finely crystalline	3,142	3,161
Dolomite, brown, finely crystalline, splendent	3,161	3,179
Newburg horizon of driller	3,152	3,166
Niagara group		
Dolomite, gray, finely crystalline; stained yellow brown	3,179	3,192
Second Water	3,183	
No samples	3,192	3,265
Dolomite, gray to light buff, crystalline; fine cuttings	3,265	3,430

	Top Ft.	Bottom Ft.
Dolomite, gray with 50 percent light brown dolomite	3,430	3,436
Dolomite, gray, fine cuttings	3,436	3,441
Dolomite, gray to gray black	3,441	3,450
Dolomite, light to slate gray, fine cuttings	3,450	3,472
Dolomite, gray to buff, fine cuttings	3,472	3,518
Same, with 50 percent gray black shale	3,518	3,523
Dolomite, light buff, fine cuttings	3,527	3,534
Osgood shale		
Shale, gray black, dolomitic	3,534	3,571
Shale, gray black	3,571	3,605

BEDFORD-OHIO SHALE SERIES

From its outcrops in western Ohio the Big Lime as a whole dips to the eastward beneath a thick series of shales which extend upward to the Berea sandstone. These shales include the Bedford and Ohio shale formations of outcrops across the central part of Ohio and the so-called Olentangy shale of central and southern Ohio. The thickness of this shale series on the outcrop ranges from about 350 feet in Adams and Pike counties to some 550 feet in southern Erie County. The series thickens under cover east of the outcrop, reaching a probable maximum for Ohio in eastern Belmont County and eastern Monroe County. The greatest thickness of this series thus far penetrated in Ohio is 3,412 feet in Island Creek Township, Jefferson County, and 3,384 feet in Independence Township, Washington County. On the outcrop this series consists chiefly of gray, gray black, and brown black carbonaceous shales with some reddish brown shales in the Bedford formation near the top. Except for the disappearance of the red shale at varying distances east of the outcrop little change in the predominating features of this series occurs over large areas in east central Ohio. Thin sandy zones, generally reported in drillers' records as "shells," are sometines reported in this series. One such shell, of more than usual persistence, occurring from 250 feet to 350 feet below the Berea, has yielded small flows of oil and gas, and has been correlated with the Gordon sand. A second sandstone is locally present from 15 to 75 feet below the Berea from which it is separated in part by reddish brown shale. This sandrock, which is most prominently developed from Muskingum County to Gallia County where it has yielded some production, is known as the Second Berea sand and is correlated with the Euclid sandstone of Bedford age. Other prominent horizons recognized by the driller in the belts of Clinton sand production are the "Big Cinnamon" and Little Cinnamon shales. These zones, made up chiefly of brown black shales with subordinate amounts of gray and gray black varieties, have yielded shows and small production of gas. In eastern and northeastern Ohio the brown black shales become less prominent and the gray and gray black varieties are more micaceous and silty.

In Coshocton County the Bedford-Ohio shales have their direction of maximum thickening along a line which trends slightly south of east. The thickness ranges from about 1,150 feet in northwestern Tiverton Township to about 1,950 feet in southeastern Linton Township. No wells have penetrated these beds in Adams and Oxford townships, but a depth of 1,900 feet or more is expected in the eastern part of these areas. In character the Big Lime-to-Berea series consists chiefly of gray black and brown black shales. Red beds on the Bedford horizon at the top of the series and close below the Berea sand are widely recognized by the driller in the Clinton fields in the western part. The Second Berea sand, however, which where present is found close below these red shales, is not known to be present in this county. Alternating beds of gray black and brown black shale comprise the series extending downward (from the red shales) to the top of the Big Lime. Occasional shows of gas have been secured in these shales but sustained production is wanting.

BEREA SANDSTONE

The Berea sandstone of Mississippian age is so called because of its occurrence near Berea, Cuyahoga County, where it has long been utilized as a quarry stone. The outcrop of the Berea sandstone extends as a narrow belt from southern Ashtabula County west past Berea to eastern Erie County and thence south through eastern Franklin, eastern Ross, and eastern Adams County to the Ohio River. Dipping below cover in an easterly direction from the outcrop, the Berea is widely distributed in the eastern half of Ohio, where it is known to the driller as the Berea sand, and where it reaches a maximum depth of approximately 2,000 feet below the surface in eastern Monroe County and eastern Washington County. The known thickness of the Berea sandstone on the outcrop ranges from a few feet to a maximum of about 200 feet. According to drillers' records it is equally variable in thickness under cover. The Berea sandstone, or "sand" as it is known to the driller, is the reservoir rock of many small oil and gas pools in the eastern part of the State.[1]

The Berea sand is encountered in all wells in Coshocton County which have been drilled deep enough to reach its horizon. Its thickness as recorded in drillers' records ranges from about 2 feet to 72 feet. In general it seems thinnest in the most western townships in the county and thickest in the eastern and southeastern parts. Local thickening to 60 feet or so is found in a few localities in Monroe and Clark townships.[2] In character the Berea in Coshocton County is generally a light gray sandstone composed chiefly of quartz grains with minor amounts of light mica and traces of pyrite and some dark minerals. Calcium carbonate is often present as a bond for the sand grains as indicated by slight effervescence upon application of dilute hydrochloric acid. In texture the stone is generally fine grained, grading into a siltstone. The Berea in this county is everywhere overlain by a brownish black carbonaceous shale known as the Sunbury which meets the underlying sandstone with a sharp contact. From an examination of drill cuttings it appears that thin partings of gray to gray black shale are also of occasional occurrence within the Berea formation. One such parting, ranging in thickness from 2 feet to 20 feet, is recorded in drillers' records of scattered wells in Mill Creek, Clark, Bethlehem. Bedford, and Monroe townships. In these areas production comes chiefly from the sand below the shale break. The Berea sand is generally immediately underlain by gray black or brown black shale. The formation in normal development is indicated in the following description of samples from the George W. Norris No. 2 well drilled by the Bell Drilling Company in Section 14, Virginia Township, Coshocton County.

Description of drill cuttings through the Berea Sandstone from the G. W. Norris No. 2 Well, Section 14, Virginia Township

	Top Ft.	Bottom Ft.
Shale, gray black, with 10 percent gray siltstone	867	872
Sandstone, fine-grained to siltstone, with 30 percent gray black shale	872	876
Sandstone, gray, fine to medium in texture, generally grain free	876	879
Sandstone, gray, medium to fine-grained, grain free and aggregates	879	893
Shale, gray black, with a trace of gray sand	893	898
Shale, gray black, fine-grained	898	903

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[1] Pepper, J. F. et. al., Oil and gas investigations, U. S. Geol. Survey, Preliminary Maps 69, 79, 89, 99, 1946-1949.

[2] Pepper, J. F et. al., Oil and gas investigations, U. S. Geol. Survey, Preliminary Maps 79, 1947; 99, 1949.

The broken character of the Berea sand in some parts of Coshocton County is illustrated by the following description of samples from the Chaney-Meyer Unit No. 2 well by the Ohio Oil Company, Lot 20, Clark Township.

Description of drill cuttings through the Berea formation from the Chaney-Meyer Unit No. 2 Well, Lot 20, Clark Township, Coshocton County

	Top Ft.	Bottom Ft.
Shale, chiefly brown black	649	672
Siltstone, gray, calcareous, with 40 percent gray black shale	672	680
Shale, gray black, with 10 percent gray siltstone	680	688
Shale, gray black, with 20 percent gray siltstone	688	697
Shale, gray black, with 10 to 20 percent gray siltstone	697	721
Shale, gray black	721	756

MISSISSIPPIAN SERIES ABOVE THE BEREA SANDSTONE

The Mississippian series above the Berea sandstone outcrops over a belt of territory extending from Scioto and eastern Adams counties to Medina, Lorain, and southeastern Erie counties and then eastward over a narrower belt to the Pennsylvania line in southern Ashtabula and northern Trumbull counties. From its belt of outcrops this series dips to the southeast beneath the younger beds of Pennsylvanian age. From a comparison of drillers' logs and surface measurements it appears that the thickness of this series is greatest along its western outcrops where it may range from 750 feet in Hocking County to as much as 870 feet in Wayne County.[1] From east central Ohio it thins a little toward the southeast, but the greatest thinning is from the south and west toward east Stark, northern Columbiana, and southern Mahoning counties where the Mississippian series above the Berea is less than 100 feet in thickness. In character the Mississippian series above the Berea consists chiefly of beds of sandstone and shale. The Maxville limestone, the top formation of the series, is present over widely scattered areas in the southeastern quarter of Ohio but is rarely if ever encountered by the drill north of an east-west line extending along the northern edge of Belmont County.

In Coshocton County the sandstone and shale which comprise the Mississippian system above the Berea sandstone have an average thickness which is not far from 750 feet. Some irregularity in thickness is due to post-Mississippian pre-Pennsylvanian erosion which has completely removed the Maxville limestone and has cut to unequal depth in the underlying shales and sandstone. The Mississippian shales and sandstones above the Berea are productive of neither oil nor gas in commercial quantities in Coshocton County. The lower member of this series immediately overlying the Berea sand is a brownish black carbonaceous shale which is quite persistent in this county and is often known to the drillers as the "coffee" shale. According to drillers' records its thickness varies from about 25 feet to 70 feet with an average near 50 feet. This shale seems widespread in its occurrence under cover to the north, east, and south of Coshocton County and it is generally considered to represent the continuation under cover of the Sunbury shale of surface outcrops. The distinctive lithologic character and widespread occurrence of this shale render it an excellent marker for the Berea sandstone which is always found immediately below it.

Overlying the Sunbury shale in Coshocton County and extending upward for many feet is a series of bluish gray to gray black sandy micaceous shales with or without occasional thin beds

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[1] Conrey, G. W., Geology of Wayne County, Geol. Survey Ohio, Bull. 24, pp. 49-50, 1921.

of fine-grained sandstone interstratified, which occupy the stratigraphic position of the Cuyahoga shales of surface outcrops. These shales are overlain by the Big Injun sand of the driller. The thickness of the Cuyahoga shales according to drillers' records ranges from 200 feet to 500 feet or more, but averages about 450 feet. In general they are below average in thickness in the western tier of townships where the so-called Big Injun sand is best developed and average or above average in depth in the central and eastern townships where the overlying sandstone is thin and broken. Thin and persistent sandstones within the body of the Cuyahoga shales are not known to occur in this county. The Hamden, Weir, or Welsh Stray sand which is persistent in parts of southern and southeastern Ohio, 100 feet or so above the Berea, is not recognized by the driller and has not been identified in drill cuttings from Coshocton County.

The Big Injun sand, which where present directly overlies the Cuyahoga shales previously described and is correlated with the Black Hand sandstone of surface outcrops, is generally present in Coshocton County according to drillers' records. Here its thickness ranges from 25 feet to nearly 400 feet, being greatest in the western part of the county where the underlying Cuyahoga shales are much below average in development. It has been productive of neither oil nor gas in commercial quantities in this county. From a limited inspection of drill cuttings lacking great horizontal spread, it appears that the true Big Injun sand may be represented by the lower part of the so called Big Injun sand of the driller along the western edge of the county, that this sandstone grades laterally into the Cuyahoga shale to the eastward, and that the thin Big Injun sand of the driller throughout the central and eastern parts of the county may occur above the Big Injun horizon and be actually Logan in age. Inspection of a more extensive assemblage of drill cuttings may prove or disprove this concept.

In Monroe, Washington, Noble, and adjacent counties in southeastern Ohio a productive sandstone, known to the oil and gas operator as the Keener sand, occurs above the Big Injun horizon and close below the Maxville limestone. From its stratigraphic position it is correlated with the Vinton member of the Logan formation. This sandstone is not known on the outcrop and is not recognized by the driller in Coshocton County. The following description of samples of drill cuttings from the R. J. Dalier No. 3 well drilled by the Pure Oil Company in the southwest quarter of Newcastle Township illustrates the character and succession above the Berea sand.

Description of samples of drill cuttings from the
R. J. Dalier No. 3 Well, 3rd Quarter, Newcastle Township

	Top Ft.	Bottom Ft.
Mississippian system		
Logan formation		
Sandstone, gray, fine-grained, micaceous, calcareous, grading to siltstone, with a trace of gray black shale	220	250
Same, with 50 percent gray black shale, trace of pyrite and iron carbonate	250	262
Sandstone, gray to bluish gray, fine-grained, micaceous with traces of pyrite and brown black micaceous shale	262	292
Sandstone, bluish gray, micaceous, fine-grained, to siltstone, grain free and chips	292	322
Same, with a trace of gray black shale	322	370
Siltstone to fine-grained sandstone, with 15 percent gray black shale, and 15 percent coarse pebbly sandstone, pebbles well rounded, Allensville member ? . . .	370	385
Siltstone, gray, to fine-grained sandstone, with 10 percent gray black shale.	385	398
Siltstone, gray to fine-grained sandstone, micaceous.	398	425

		Top Ft.	Bottom Ft.
Sandstone, white, coarse to pebbly, grains well rounded, grain free .	Berne member ?	425	434
Shale, gray black, with 50 percent fine-grained white sandstone . .		434	439
Sandstone to siltstone, with 50 percent iron carbonate		439	446
Cuyahoga formation			
Siltstone, gray, micaceous to shaly micaceous sandstone, with a trace of shale		446	460
Siltstone, gray black, with 40 percent gray black shale and 20 percent iron carbonate		460	468
Shale, gray black, micaceous		468	502
Shale, gray to gray black, sandy, micaceous		502	538
Siltstone, gray, micaceous, calcareous		538	550
Shale, gray black, micaceous, with 5 percent gray siltstone		550	557
Siltstone, gray, micaceous, with 5 percent gray black shale		557	564
Shale, gray to gray black		564	676
Siltstone, gray, with 40 percent gray black shale . . .		676	699
Shale, gray black, micaceous, with a trace of gray siltstone		699	742
Shale, gray black, argillaceous; somewhat micaceous		742	900
Sunbury shale			
Shale, brown black, carbonaceous		900	965
Berea sandstone			
Sandstone, gray, medium to fine-grained, with 30 percent brown black shale		965	975
Bedford shale			
Shale, gray black		975	985
Shale and siltstone, gray black		985	1,052

SUMMARIES OF LOGS OF SOME TYPICAL DEEP WELLS

Township	Section or Lot, Quarter	Property Name and Well Number	When Drilled	Well-head Elevation	Berea		Big Lime		Oriskany First Water (w)		Newburg		Second Water		Packer Shell		Clinton Sand		Total Depth	Remarks
					Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom		
Adams	Section 9	William Ott, No. 1	1920	825	842	884	---	---	---	---	---	---	---	---	---	---	---	---	940	Show of oil in Berea
Adams	Section 18	William Boob	1920	1,015	1,052	1,098	---	---	---	---	---	---	---	---	---	---	---	---	1,120	Oil shot and pumped a little
Adams		William Young	1941	820	844	889	---	---	---	---	---	---	---	---	---	---	---	---	891	Show of oil
Bedford	L-19, N.E.	McCurdy Hrs., No. 1	1939	---	1,032	1,047	---	---	---	---	---	---	---	---	----	---	---	---	1,104	Dry
Bedford	Section 16	F. H. Dixon, No. 1	1947	---	984	1,020	2,270	3,186	---	---	---	---	---	---	3,315	3,339	3,339	3,442	3,490	Oil show in Clinton
Bedford	Section 16	John W. Lee, No. 1	1946	---	971	1,000	2,135	3,175	---	---	---	---	---	---	3,301	3,324	3,350	3,392	3,392	Gas
Bedford	Section 25	H. B. S. Miller, No. 1	1911	---	810	834	2,121	3,075	---	---	---	---	---	---	3,192	3,222	3,242	3,294	---	Gas
Bedford	Section 16	H. T. Wheeler, No. 1	1927	988	960	972	2,242	3,204	---	---	---	---	---	---	3,317	3,332	3,369	3,414	3,454	Dry
Bethlehem	S.E. Qr.	Jos. N. Burrell, No. 1	1944	---	803	823	2,248	3,346	---	---	---	---	2,995	---	3,444	3,462	3,498	3,553	3,619	Dry
Bethlehem	N.W. Qr.	Ira G. Croul, No. 1	1936	---	883	920	2,227	3,264	---	---	---	---	---	---	3,396	3,419	3,453	3,500	3,545	Oil in Clinton
Bethlehem	N.W. Qr.	Henry Ammon, No. 1	1951	---	1,028	1,050	---	---	---	---	---	---	---	---	---	---	---	---	1,096	Oil show and water in Berea
Bethlehem	L-34, N.E. Qr.	Wm. & Ella Grimes, No. 3	1913	1,035	1,023	1,043	---	---	---	---	---	---	---	---	---	---	---	---	1,065	Oil in Berea
Bethlehem	L-35, N.E. Qr.	Elmer Infield, No. 5	1913	1,088	1,044	1,060	---	---	---	---	---	---	---	---	---	---	---	---	1,088	Oil in Berea
Bethlehem	N.W. Qr.	David Easter, No. 4	--	782	766	768	---	---	---	---	---	---	---	---	---	---	---	---	769	Gas in Berea
Bethlehem	N.W. Qr.	D. L. Waring, No. 2	1911	781	769	781	---	---	---	---	---	---	---	---	---	---	---	---	799	Dry
Bethlehem	N.W. Qr.	David Easter, No. 1	--	817	798	810	---	---	---	---	---	---	---	---	---	---	---	---	---	Oil in Berea
Bethlehem	N.W. Qr.	Wm. Sowers, No. 2	1912	834	806	816	---	---	---	---	---	---	---	---	---	---	---	---	818	Gas in Berea
Bethlehem	N.W. Qr.	John A. Fox, No. 5	1913	873	854	878	---	---	---	---	---	---	---	---	---	---	---	---	897	Oil in Berea
Bethlehem	L-7, S.W. Qr.	S. W. & O. Hamilton, No. 5	1912	---	780	800	---	---	---	---	---	---	---	---	---	---	---	---	810	Oil in Berea
Clark	L-32, N.W. Qr.	Guy B. Smailes, No. 1	1942	807	740	775	2,015	3,165	2,305 (w)	---	---	---	2,833	---	3,264	3,284	3,315	3,379	3,418	Show of oil in Clinton
Clark	N.E. Qr.	John Schneeberger, No. 1	1928	---	721	736	---	---	---	---	---	---	---	---	---	---	---	---	739	Oil
Clark	Section 13	P. W. Gamertsfelder, No. 1	1949	---	740	770	2,145	3,230	---	---	---	---	2,990	---	3,324	3,340	3,387	3,445	3,524	Dry
Clark	L-5, N.W. Qr.	A. G. Eppley Hrs., No. 1	1933	---	805	820	2,172	3,279	---	---	---	---	3,135	3,225	3,367	3,382	3,423	3,432	3,502	Oil and gas in Clinton
Clark	N.E. Qr.	Harry Carpenter, No. 4	1937	---	702	718	2,109	3,200	2,367	---	---	---	3,010	---	3,283	3,315	3,350	3,414	3,420	Gas in Clinton
Clark	L-9, N.W. Qr.	Ruby V. Buren, No. 3	1946	---	785	800	2,021	3,106	---	---	2,784	---	2,784	---	3,151	3,169	3,251	3,265	3,323	Oil show in Newburg, gas in Clinton
Clark	N.E. Qr.	L. D. Fair, No. 15	1929	---	795	827	2,218	3,311	2,395 (w)	---	3,045	---	3,140	---	3,421	3,436	3,482	3,528	3,540	Gas show in Newburg, oil in Clinton
Clark	L-23, N.W. Qr.	C. W. Young, No. 2	1951	---	920	940	2,276	3,300	2,480 (w)	---	2,990	---	3,184	---	3,406	3,428	3,458	3,487	3,487	Gas show in Newburg, gas in Clinton
Clark	L-28, N.W. Qr.	Gilmer-Randles, No. 1	1943	---	690	700	2,050	---	2,275 (w)	---	2,790	---	2,854	---	3,205	3,235	3,272	3,331	3,408	Dry
Clark	L-34, N.W. Qr.	O. B. Adkins, No. 1	1930	---	760	820	2,112	3,184	2,302 (w)	---	---	---	2,853	---	3,254	3,278	3,317	3,369	3,379	Gas show in Clinton
Clark	L-13, N.W. Qr.	Conkle & Burklerr, No. 1	--	---	968	1,000	2,385	3,470	---	---	---	---	---	---	3,528	3,548	3,572	3,630	3,722	Dry hole
Crawford	L-30, N.E. Qr.	F. P. Balder, No. 1	1938	---	850	890	2,600	3,810	---	---	3,560	3,580	3,578	---	3,922	3,945	4,017	4,058	4,167	Show of oil in Berea, Newburg
Crawford	Section 8	A. & E. Barkman, No. 1	1944	---	---	---	2,837	4,065	---	---	---	---	---	---	4,113	4,133	4,217	4,254	4,380	Dry
Crawford	Section 7	Wm. Dirkeysheet, No. 1	1929	1,025	985	1,040	2,700	3,900	---	---	---	---	---	---	3,989	4,019	4,088	4,116	4,152	Show of gas in Clinton
Crawford	Section 7	Lester Pretzius, No. 1	1930	1,057	1,052	1,124	2,770	3,977	---	---	---	---	---	---	4,062	4,097	4,116	4,190	4,389	Gas show in Clinton
Franklin	S.W. Qr.	Kenneth E. McLeod, No. 1	1930	727	870	900	2,458	3,576	---	---	---	---	---	---	3,653	3,670	3,745	3,775	3,978	Show of gas in Clinton sand
Franklin	S.W. Qr.	Cornelia B. A. Corry, No. 2	1929		880	920	2,476	3,597	---	---	---	---	---	---	3,689	3,725	3,747	3,803	3,876	Show of oil in Clinton sand
Franklin	S.W. Qr.	Barnes Coal & Mining Co., No. 1	1929	733	875	910	2,466	---	2,585	2,594	---	---	---	---	---	---	---	---	2,603	Gas in Oriskany
Franklin	S.W. Qr.	S. A. Powelson, No. 1	1930	950	1,130	1,155	2,725	---	2,841	2,850	---	---	---	---	---	---	---	---	2,854	Gas in Oriskany
Franklin	S.W. Qr.	John F. Lapp, No. 1	1937	896	1,046	1,082	2,639	---	2,757	2,762	---	---	---	---	---	---	---	---	2,765	Gas in Oriskany
Jackson	Section 23	David Davis Estate, No. 1	1943	907	965	999	2,438	3,513	3,248 (w)	---	---	---	---	---	3,598	3,618	3,664	3,714	3,812	Dry
Jackson	Section 18	Zebbra McCoy et al, No. 1	1943	978	1,020	1,035	2,502	3,551	2,780	2,783	---	---	3,275	---	3,642	3,660	3,702	3,722	3,913	Show of gas in Oriskany, dry in Clinton
Jackson	Section 5	Samuel Felver, et al, No. 1	1944	1,022	1,055	1,065(w)	2,440	3,450	2,620 (w)	---	---	---	---	---	3,560	3,590	3,655	3,675	3,710	Dry
Jackson	Section 4	A. G. Van Sickle, No. 1	1951	---	1,046	1,064	---	---	---	---	---	---	---	---	---	---	---	---	1,066	Dry
Jefferson	L-20, S.E. Qr.	Jas. Foster Heirs, No. 1	1939	---	775	800	2,150	3,173	2,225 (w)	---	---	---	3,025	---	3,233	3,256	3,294	3,346	3,399	Gas in Clinton sand
Jefferson	Section 9	S. J. Gametsfelder, No. 1	1939	---	780	800	2,100	3.129	2,345 (w)	---	---	---	---	---	3,229	3,252	3,275	3,287	3,422	Dry
Jefferson	Section 5	Ed. Purdy, No. 1	1920	---	775	785	2,040	2,997	2,230 (w)	---	---	---	---	---	3,092	3,125	3,166	3,218	3,225	Show oil in Clinton
Jefferson	L-14, S.W. Qr.	C. P. Foster, No. 1	1944	---	757	763	2,032	2,968	---	---	---	---	---	---	3,094	3,123	3,145	3,198	3,246	Dry
Jefferson	L-20, S.W. Qr.	Kathryn Given, No. 1	1919	---	712	724	2,004	2,938	2,175 (w)	---	---	---	2,865	---	3,066	3,094	3,119	3,169	3,187	Dry
Keene	Section 8	M. A. McConnell, No. 1	1921	816	841	857	2,360	3,500	3,240 (w)	---	---	---	3,285	---	3,590	3,610	3,640	3,690	3,790	Dry
Keene	L-10, N.W. Qr.	J. P. Norman, No. 2	1949	---	841	861	---	---	---	---	---	---	---	---	---	---	---	---	883	Dry
Keene	L-12, S.E. Qr.	W. H. Norman, No. 1	1950	---	815	845	---	---	---	---	---	---	---	---	---	---	---	---	872	Dry
Lafayette	L-8, S.E. Qr.	Charles J. Zimmer, No. 1	1943	823	837	877	2,705	3,958	2,847	2,859	---	---	---	---	4,041	4,071	4,136	4,178	4,265	Dry
Lafayette	L-3, N.W. Qr.	Mabel S. Rehard, No. 1	1945	---	795	817	2,586	3,800	---	---	---	---	---	---	3,912	3,927	3,947	3,990	4,077	Dry in Clinton
Lafayette	N.W. Qr.	J. Edward Martin, No. 1	1950	---	782	820	---	---	---	---	---	---	---	---	---	---	---	---	842	Dry
Lafayette	N.W. Qr.	L. Householder, No. 2	--	---	755	793	---	---	---	---	---	---	---	---	---	---	---	---	---	Dry
Linton	L-1, S.E. Qr.	Powelson-Magness, No. 1	1946	1,035	1,160	1,215	3,184	---	3,319	3,336	---	---	---	---	---	---	---	---	3,351	Gas in Oriskany
Linton	L-18, S.E. Qr.	Derr-Carnes, No. 1	1948	840	940	1,005	2,960	---	3,091	3,102	---	---	---	---	---	---	---	---	3,116	Gas in Oriskany
Linton	L-34, S.E. Qr.	Walters-McAlister, No. 1	1948	1,004	1,090	1,163	3,076	---	---	---	---	---	---	---	---	---	---	---	3,255	Dry
Linton	L-8, S.E. Qr.	Geo. E. Clemens, No. 1	1949	850	908	963	2,954	---	3,088	3,096	---	---	---	---	---	---	---	---	3,119	Show oil and gas in Oriskany
Linton	L-36, S.E. Qr.	Ella Hamilton, No. 1	1930	---	985	1,035	---	---	---	---	---	---	---	---	---	---	---	---	1,035	Dry
Linton	Section 20	John McAllister et al, No. 1	1941	---	874	---	---	---	---	---	---	---	---	---	---	---	---	---	912	Dry
Linton	Section 13	Chas. E. Williams, No. 1	--	895	966	1,011	2,847	4,047	---	---	---	---	---	---	4,132	4,142	---	---	4,445	Show gas in Berea, Niagara
Mill Creek	L-14, S.W. Qr.	Chas. A. Karr, No. 1	1944	---	860	872	2,365	3,485	---	---	---	---	3,230	---	3,559	3,580	3,640	3,680	3,780	Show of gas in Berea, dry in Clinton
Mill Creek	L-2, S.W. Qr.	Nathan Bechtol, No. 1	1944	1,042	1,039	1,064	---	---	---	---	---	---	---	---	---	---	---	---	1,090	Show of gas
Mill Creek	L-15, S.W. Qr.	Herbert Hamilton, No. 1	1044	945	944	956	---	---	---	---	---	---	---	---	---	---	---	---	1,052	Show oil and gas
Mill Creek	Section 4	Wm. Bechtol, No. 1	1944	---	848	858	2,370	3,510	2,670 (w)	---	---	---	3,330	---	3,567	3,583	3,647	3,681	3,768	Dry
Mill Creek	Section 1	H. W. & S. Kaser, No. 1	1949	---	941	953	---	---	---	---	---	---	---	---	---	---	---	---	965	Gas
Mill Creek	Section 10	Gottlirb Ruess, No. 4	1936	---	952	979	---	---	---	---	---	---	---	---	---	---	---	---	981	Gas
Mill Creek	Section 9	A. C. Shumacher, No. 1	1917	879	817	844	---	---	---	---	---	---	---	---	---	---	---	---	844	Gas
Mill Creek	Section 10	Lloyd Holderbaum, No. 4	1938	---	916	938	---	---	---	---	---	---	---	---	---	---	---	---	948	Gas
Monroe	Section 22	David W. Brillhort, No. 1	1927	---	1,059	1,087	2,376	3,391	---	---	---	---	3,230	---	3,481	3,511	3,534	3,581	3,644	Dry
Monroe	Section 18	Oliver Borden, No. 1	1927	---	1,087	1,145	2,407	3,458	2,568 (w)	---	---	---	---	---	3,525	3,555	3,569	3,621	3,658	Gas in Clinton
Monroe	L-28, S.W. Qr.	Floyd E. & Carrie Ling, No. 1	1945	---	760	780	2,040	3,013	2,205	---	2,700	2,755	---	---	3,023	3,029	3,177	3,202	3,246	Dry
Monroe	Section 14	C. A. Thompson, No. 1	1930	---	1,023	1,045	2,297	3,373	---	---	---	---	---	---	3,426	3,456	3,492	3,534	3,657	Gas in Clinton
Monroe	Section 12	Mary Shaffer, No. 1	1949	1,055	953	983	2,275	3,322	2,500 (w)	---	---	---	---	---	3,397	3,423	3,432	3,497	3,525	Dry
Monroe	Section 10	Ellsworth McKelvey, No. 1	1938	---	766	786	---	---	---	---	---	---	---	---	---	---	---	---	809	Show of oil in Berea
Monroe	Section 1	Peter Lepley, No. 1	1927	---	848	878	2,170	3,258	2,350 (w)	---	---	---	---	---	3,320	3,360	3,382	3,411	3,458	Gas well in Clinton
Monroe	Section 2	C. E. Dalrymple, No. 1	1927	1,112	900	940	2,200	3,271	2,375 (w)	---	---	---	2,930	---	3,343	3,378	3,398	3,470	3,521	Dry
Monroe	Section 6	F. W. Still, No. 2	1943	---	995	1,010	2,258	3,269	---	---	---	---	2,954	---	3,384	3,414	3,465	3,482	3,508	Dry
Monroe	Section 5	J. S. Conner, No. 1	1942	---	1,060	1,080	2,315	3,340	2,450 (w)	---	---	---	---	---	3,440	3,460	3,483	3,524	3,620	Dry
Monroe	Section 4	R. D. Weaver, No. 1	1944	---	1,050	1,110	2,328	3,363	2,490 (w)	---	---	---	3,001	---	3,465	3,493	3,520	3,572	3,600	Dry
Newcastle	Section 21	Bowers-Burch, No. 1	1945	---	996	1,010	2,247	3,187	---	---	---	---	---	---	3,317	3,337	3,359	3,408	3,462	Dry
Newcastle	Section 23	Wilma Taylor, No. 1	1951	---	813	822	2,060	2,990	---	---	---	---	2,775	---	3,083	3,106	3,130	3,185	3,215	Dry
Newcastle	Section 23	R. J. Daliere, No. 2	1950	1,109	987	997	2,218	3,147	---	---	---	---	---	---	3,250	3,270	3,300	3,354	3,369	Oil in Clinton
Newcastle	Section 18	Robert Walter, No. 1	1951	---	969	979	2,220	3,125	---	---	---	---	---	---	3,245	3,265	3,288	3,343	3,348	Oil in Clinton
Newcastle	Section 19	Della G. Bell, No. 1	1945	1,056	910	928	2,155	3,085	---	---	---	---	---	---	3,199	3,247	3,247	3,292	3,387	Show of gas in Clinton
Newcastle	S.W. Qr.	Frank O. Garrison	1931	---	966	973	2,170	3,069	2,200 (w)	---	---	---	2,875	---	3,174	3,206	3,238	3,284	3,290	Oil in Clinton
Newcastle	S.W. Qr.	Nina Richard, No. 5	1951	---	960	965	2,180	3,088	---	---	---	---	2,930	---	3,197	3,223	3,261	3,319	3,327	Oil in Clinton
Newcastle	S.W. Qr.	Harry Ringwalt, No. 1	1950	---	973	983	2,190	3,095	---	---	---	---	2,870	---	3,205	3,223	3,245	3,296	3,305	Oil in Clinton
Newcastle	S.W. Qr.	Wm. Frazee, No. 2	1936	1,118	900	908	2,100	2,991	2,225 (w)	---	---	---	---	---	3,096	3,119	3,138	3,188	3,198	Oil in Clinton
Newcastle	S.W. Qr.	Wm. Frazee, No. 2	1933	1,184	963	967	2,155	3,045	2,282 (w)	---	---	---	---	---	3,155	3,180	3,202	3,250	3,264	Oil in Clinton
Newcastle	S.W. Qr.	Wm. Ringwalt, No. 3	1924	---	949	958	---	---	---	---	---	---	---	---	---	---	---	---	963	Gas in Berea
Newcastle	S.W. Qr.	John G. Scott, No. 2	1930	---	718	728	1,920	2,831	---	---	---	---	---	---	2,933	2,958	2,984	3,032	3,037	Gas in Berea and Clinton
Newcastle	N.W. Qr.	H. D. Scott, No. 2	1951	1,137	930	940	2,160	3,065	---	---	---	---	---	---	3,065	3,180	3,205	3,267	3,776	Oil in Clinton
Newcastle	L-16, N.W. Qr.	P. A. Frazee, No. 3	1938	---	650	671	1,845	2,753	1,960 (w)	---	---	---	---	---	2,858	2,883	2,920	2,981	2,981	Dry
Newcastle	N.W. Qr.	Edwin O. Rodehaver, No. 1	1927	---	603	613	---	---	---	---	---	---	---	---	---	---	---	---	613	Gas in Berea
Newcastle	L-29, N.W. Qr.	Chas. Frey, No. 1	1918	---	877	982	2,143	3,084	2,327 (w)	---	---	---	---	---	3,187	3,218	3,246	3,300	3,314	Gas in Clinton
Oxford	Section 20	Clayton Lawrence, No. 1	1950	---	1,003	1,058	---	---	---	---	---	---	---	---	---	---	---	---	1,064	Dry
Oxford	L-9, S.W. Qr.	Alfred Rehard, No. 1	1936	---	872	922	---	---	---	---	---	---	---	---	---	---	---	---	949	Dry
Oxford	L-12, S.W. Qr.	Hugh Jones, No. 2	1936	---	791	831	---	---	---	---	---	---	---	---	---	---	---	---	875	Dry
Perry	Section 1	U. M. Cullison, No. 2	1945	---	904	912	2,185	3,115	---	---	---	---	2,940	---	3,225	3,254	3,280	3,335	3,362	Show of oil and gas in Clinton
Perry	Section 3	C. E. Hawthorn, No. 1	1947	---	---	---	2,155	3,064	---	---	---	---	---	---	3,184	3,189	3,244	3,295	3,416	Dry
Perry	Section 5	Roy Hayes, No. 4	1934	---	908	913	2,095	2,985	---	---	---	---	---	---	3,103	3,119	3,154	3,201	3,211	Oil in Clinton
Perry	Section 10	Hoffstalter Consolidated, No. 1	1945	---	794	802	2,075	2,980	---	---	---	---	2,780	---	3,101	3,131	3,155	3,212	3,213	Gas in Clinton
Perry	Section 7	Albert Mikesell, No. 7	1931	---	970	982	2,165	3,079	2,290 (w)	---	---	---	2,865	---	3,189	3,217	3,240	3,257	3,328	Show of oil in Clinton
Perry	Section 6	J. L. Myers, No. 1	1931	---	871	880	2,069	2,956	---	---	---	---	2,763	---	3,061	3,088	3,108	3,161	3,161	Gas in Clinton
Perry	Section 14	J. J. Wilson, No. 3	1938	---	921	925	2,151	3,010	---	---	---	---	---	---	3,124	3,147	3,172	3,221	3,227	Oil in Clinton
Perry	Section 15	Wheeler Mossholder, No. 7	1941	---	845	860	2,048	2,938	---	---	---	---	2,900	---	3,042	3,068	3,090	3,122	3,150	Oil in Clinton
Perry	Section 16	John R. Rine, No. 2	1932	---	900	907	2,083	2,958	2,195 (w)	---	---	---	2,770	---	3,068	3,098	3,118	3,173	3,179	Oil in Clinton
Perry	Section 17	Everett Van Winkle, No. 1	1936	1,010	848	852	2,062	2,950	---	---	---	---	---	---	3,067	3,092	3,118	3,161	3,169	Gas in Clinton
Perry	Section 25	H. C. Johns, No. 1	1943	---	893	908	2,113	3,014	---	---	---	---	2,783	---	3,110	3,124	3,150	3,191	3,200	Dry
Perry	Section 24	G. O. Haines, No. 1	1941	---	805	812	2,030	3,040	---	---	---	---	2,670	---	3,080	3,095	3,102	3,147	3,157	Gas in Clinton
Perry	Section 23	E. R. Donaker, No. 1	1942	---	905	918	2,107	3,005	---	---	---	---	2,830	---	3,119	3,145	3,176	3,201	3,250	Dry
Perry	Section 22	Twiloh Carle, No. 1	1939	---	745	757	2,000	2,908	---	---	---	---	2,660	---	3,022	3,046	3,066	3,120	3,130	Oil in Clinton
Perry	Section 19	H. C. Bonham, No. 1	1916	---	800	815	2,025	2,935	---	---	---	---	2,800	---	3,033	3,057	---	---	3,342	No Clinton Sand
Pike	Section 10	T. A. Gualt, No. 1	1948	---	967	989	2,256	3,240	---	---	---	---	2,870	---	3,302	3,319	3,361	3,420	3,497	Dry
Pike	Section 11	Grace Phillips, No. 1	1948	---	925	948	2,231	3,154	---	---	---	---	2,894	---	3,291	3,311	3,342	3,381	3,423	Dry
Pike	Section 3	Raymond Mikesell, No. 1	1943	---	844	854	2,075	3,015	---	---	---	---	2,775	---	3,140	3,163	3,187	3,243	3,253	Oil
Pike	Section 9	Kenneth Anderson, No. 1	1947	---	867	887	2,140	3,077	---	---	---	---	2,745	---	2,187	3,214	3,240	3,292	3,401	Dry
Pike	Section 13	Samuel A. Gardner, No. 1	1925	984	870	885	2,112	3,050	---	---	---	---	2,712	---	---	---	3,227	3,267	3,290	Oil and gas in Clinton
Pike	Section 12	Clyde Blair, No. 1	1925	---	965	975	2,200	3,135	---	---	---	---	2,805	---	---	---	3,327	3,381	3,402	Oil in Clinton
Pike	Section 19	Wm. T. Graham Hrs., No. 1	1944	---	803	818	2,105	2,994	---	---	---	---	2,715	---	3,155	3,170	3,205	3,260	3,265	Oil in Clinton
Pike	Section 18	Florence McKee, No. 3	1948	---	908	920	2,178	3,126	---	---	---	---	2,803	---	3,204	3,239	3,262	3,318	3,325	Dry
Pike	Section 23	Lawrence McKee, No. 2	1942	---	845	861	2,112	2,985	---	---	---	---	2,749	---	3,152	3,170	3,201	3,250	3,256	Oil in Clinton
Pike	Section 18	W. H. Ashcraft, No. 16	1944	---	869	882	2,116	3,091	---	---	---	---	2,770	---	---	---	3,212	3,265	3,320	Dry
Pike	Section 23	Clyde McKee, No. 1	1943	---	762	774	2,035	2,935	---	---	---	---	---	---	3,070	3,090	3,110	3,175	3,175	Oil in Clinton
Pike	Section 25	G. W. Crawford, No. 7	1925	---	793	808	1,995	2,896	---	---	---	---	2,615	---	3,009	3,028	3,057	3,105	3,112	Oil in Clinton
Pike	Section 16	W. D. & W. H. Ashcraft, No. 2	1919	---	840	852	2,030	2,927	---	---	---	---	---	---	---	---	3,135	3,185	3,185	Oil in Clinton
Pike	Section 15	H. B. & R. D. Criss, No. 1	1943	---	855	860	2,085	3,000	---	---	---	---	2,685	---	3,130	3,148	3,184	3,224	3,242	Dry
Pike	Section 14	Roger & Myers, No. 1	1940	---	820	834	2,050	2,970	---	---	---	---	2,660	---	3,083	3,107	3,134	3,185	3,185	Oil in Clinton
Pike	Section 6	H. B. Ashcraft, No. 1	1930	---	645	660	1,852	2,725	---	---	---	---	2,435	---	---	---	2,924	2,968	3,028	Dry
Pike	Section 5	C. H. Gardner, No. 1	1943	---	658	671	1,870	2,768	---	---	---	---	2,540	---	2,812	2,822	2,948	2,998	3,000	Gas in Clinton
Pike	Section 4	Howard Mizer	1948	---	680	685	1,925	2,780	---	---	---	---	---	---	2,939	2,970	2,985	3,035	3,040	Oil in Clinton
Tiverton	Section 10	Matilda Fortune, No. 1	1937	---	---	---	1,974	2,960	---	---	---	---	---	---	3,081	3,109	3,129	3,180	3,216	Show of gas in Clinton
Tiverton	Section 2	Wm. R. Koch, No. 2	1920	---	963	978	2,187	3,197	---	---	---	---	---	---	2,187	3,197	3,257	3,273	3,380	Dry
Tiverton	Section 8	Geo. Braustool, No. 1	1940	1,185	1,000	1,045	2,200	3,156	---	---	---	---	---	---	3,253	3,280	3,303	3,357	3,364	Gas in Clinton
Tiverton	Section 8	John J. Hyatt, No. 1	1942	1,122	1,020	1,028	2,218	3,167	2,380 (w)	---	---	---	---	---	3,271	3,291	3,313	3,369	3,392	Dry
Tiverton	Section 5	Bernard DeVore, No. 1	1952	---	885	900	2,042	3,008	---	---	2,685	2,695	2,870	---	3,074	3,094	3,124	3,167	3,179	Oil and Gas in Clinton
Tiverton	Section 6	W. C. & Clara Hunter, No. 1	1917	---	983	995	2,150	3,115	2,285 (w)	---	---	---	3,075	---	3,222	3,247	3,292	3,304	3,335	Show of oil in Clinton
Tiverton	Section 7	Orin W. Holt, No. 1	1942	1,186	990	1,005	2,187	3,124	2,347 (w)	---	---	---	---	---	3,210	3,233	3,255	3,320	3,321	Gas in Clinton
Tiverton	L-28, S.W. Qr.	Alice M. Bumpus, No. 1	1948	---	617	632	1,795	2,723	1 950 (w)	---	---	---	2,585	---	2,817	2,847	2,866	2,915	2,956	Show of oil in Clinton
Tiverton	L-19, S.W. Qr.	Alonzo Spurgeon, No. 1	1936	---	---	---	1,883	2,804	---	---	---	---	---	---	---	---	2,939	2,975	2,996	Gas in Clinton
Tiverton	Section 12	R. L. Hayes, No. 1	1947	---	1,010	1,022	2,227	3,190	---	---	---	---	2,940	---	3,320	3,341	3,385	3,420	3,428	Show of oil and gas in Clinton
Tiverton	Section 21	Hamer-Kanuckle, No. 1	1951	---	760	772	2,021	2,969	2,186	---	---	---	---	---	3,084	3,109	3,132	3,186	3,210	Dry in Clinton
Tiverton	Section 20	C. Conkle, No. 3	1949	1,044	---	---	2,143	3,100	2,338 (w)	---	---	---	2,920	---	3,215	3,235	3,268	3,313	3,400	Dry in Clinton
Tiverton	Section 22	Henry C. Miller, No. 1	1919	---	935	965	2,187	3,120	2,372 (w)	---	---	---	---	---	3,248	3,270	3,284	3,334	3,349	Show of gas in Clinton
Tuscarawas		At Coshocton	1889 ?	765	861	881	2,513	---	---	---	---	---	---	---	---	---	---	---	3,100	Dry
Tuscarawas	L-9, N.E. Qr.	John Hall, No. 1	1929	---	858	895	---	---	---	---	---	---	---	---	---	---	---	---	900	Oil in Berea
Tuscarawas	L-9, N.E. Qr.	E. & F. Stockum, No. 2	--	---	1,043	1,080	---	---	---	---	---	---	---	---	---	---	---	---	---	Oil in Berea
Virginia	Section 23	Mary I. Gray, No. 1	1912	---	835	855	2,345	3,465	---	---	---	---	---	---	---	---	3,582	3,624	---	Show of oil in Clinton
Virginia	Section 25	Chas. Henry, No. 1	1926	865	910	935	2,340	3,435	---	---	---	---	---	---	3,529	3,550	3,557	3,612	3,612	Dry
Virginia	Section 14	C. W. Norris, No. 1	1944	---	830	860	2,315	3,390	---	---	---	---	---	---	3,481	3,500	3,550	3,585	3,671	Dry
Virginia	L-39, N.W. Qr.	Theodore McCoy, No. 1	1935	---	850	875	---	---	---	---	---	---	---	---	---	---	---	---	875	Dry
Washington	Section 20	Wallace Fetheroff, No. 1	1943	---	952	978	2,387	3,439	---	---	---	---	3,177	---	3,520	3,526	3,561	3,624	3,740	Dry
Washington	Section 1	J. W. Phillips, No. 1	--	---	805	831	3,169	3,142	---	---	---	---	---	---	3,268	3,293	3,376	3,436	---	Dry
Washington	Section 11	G. L. Gibson, No. 1	1945	---	973	1,063	2,435	3,415	---	---	---	---	3,160	---	3,505	3,510	3,579	3,615	3,714	Show of oil in Clinton
Washington	L-9, S.W. Qr.	Lyman Fucks, No. 1	--	---	654	669	2,105	3,120	---	---	---	---	2,825	---	3,197	3,220	3,250	3,310	---	Dry
Washington	Section 14	Chas. Hammond, No. 1	1941	---	835	854	2,180	3,115	---	---	---	---	2,876	---	3,248	3,267	3,302	3,356	3,420	Dry
White Eyes	L-25, N.E. Qr.	Irene Hotem, No. 1	1938	---	918	928	2,690	3,885	2,858 (w)	---	---	---	3,670	---	4,015	4,041	4,097	4,142	4,232	Dry
White Eyes	L-8, N.E. Qr.	Ed. E. Steiner, No. 1	1937	795	879	890	2,570	3,800	---	---	---	---	---	---	3,905	3,916	3,997	4,037	4,118	Dry
White Eyes	Section 24	Ed Henderson, No. 1	1925	---	848	---	---	---	---	---	---	---	---	---	---	---	---	---	---	Dry
White Eyes	Section 25	Daniel Gribble, No. 1	1925	---	880	920	---	---	---	---	---	---	---	---	---	---	---	---	---	Dry

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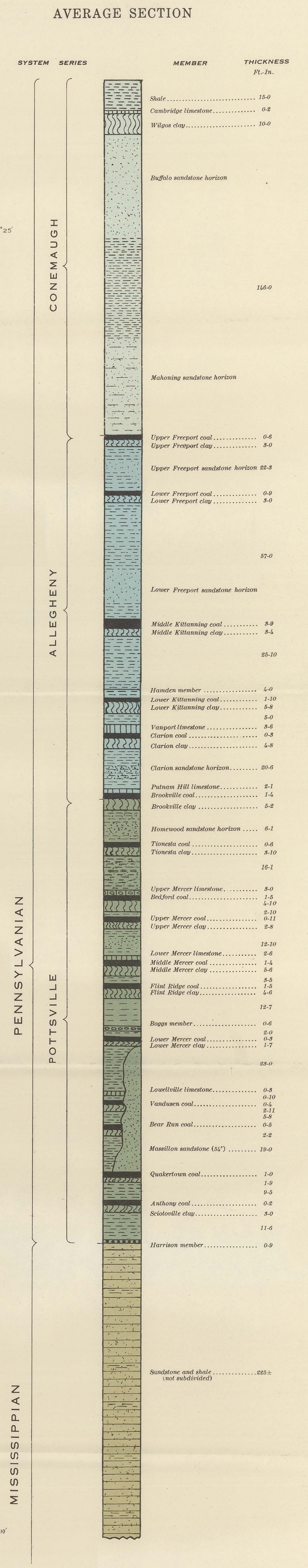

Geology surveyed 1935-1947
Some data by G. F. Lamb (1914) and T. R. Meyers (1928)

STATE OF OHIO
DEPARTMENT OF PUBLIC WORKS

GEOLOGICAL SURVEY OF OHIO
JOHN H. MELVIN, State Geologist

COLUMBUS
1948

GEOLOGIC MAP OF COSHOCTON COUNTY

By Raymond E. Lamborn

Scale $\frac{1}{62500}$

Contour interval 20 feet.
Datum is mean sea level.

EXPLANATION

BEDROCK

PENNSYLVANIAN SYSTEM

- Pc — Conemaugh series
- Pa — Allegheny series
- Pp — Pottsville series

MISSISSIPPIAN SYSTEM

- M — Mississippian (*not subdivided*)

STRUCTURAL AND ECONOMIC DATA

- Outcrop of Middle Kittanning coal
- Structural contours drawn on the base of the Putnam Hill limestone (Contour interval 20 feet)