GEOLOGICAL SURVEY OF OHIO

WILBER STOUT, State Geologist

FOURTH SERIES, BULLETIN 35

GEOLOGY OF JEFFERSON COUNTY

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COLUMBUS
1930

Published by authority of the Legislature of Ohio,
under the supervision of the State Geologist.



Printed by the Consolidated Press
Cleveland, Ohio

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INTRODUCTION

LOCATION AND AREA

Jefferson County is located along the eastern edge of the State, about 100 miles south of Lake Erie, between latitudes 40° 9½′ and 40° 36′, and longitudes 80° 5′ and 80° 36′, and comprises parts of the



Map I. Shows the position of Jefferson County in the State, and of other counties for which bulletins have been issued by the Geological Survey of Ohio.

Wellsville, Salineville, Steubenville, Cadiz, Wheeling, and Saint Clairsville quadrangles. The area is, roughly speaking, rectangular in shape with a maximum length of 30 miles in a north-south direc-

tion and a width of 18 miles in an east-west direction. It is bounded on the north by Columbiana and Carroll counties, on the west by Carroll and Harrison, on the south by Belmont County, and on the east by the Ohio River, which flows along the western margin of Brooke and Hancock counties, West Virginia. The county is divided into 14 townships, with a total area of 410 square miles. In a geological sense the county comprises a part of the Allegheny Plateau where rocks of Pennsylvanian and Permian systems outcrop at the surface.

PURPOSE OF INVESTIGATION

The recorded data on the geology of Jefferson County are in large part taken from an early report written by J. S. Newberry and published in 1878 in Volume III of the Geological Survey of Ohio. However, at that time the stratigraphic succession was very imperfectly known except in its major details. The economic importance of the coal beds and the limestones so attracted the notice of the workers in the field that little attention was given to the small, inconspicuous, but no less important, stratigraphic details. Furthermore, in Jefferson County, mistakes were made in the identification of some of the important coal beds, and these errors have greatly impaired the value of the early report. Within the last 20 years the stratigraphy of the Pennsylvanian system has been worked out in great detail in Ohio, in Muskingum and Columbiana counties, as well as in many parts of West Virginia, and it is with the purpose of extending this detailed study that this bulletin on Jefferson County has been prepared. A treatise of this nature must of necessity be largely descriptive in character with a due regard for the interpretative side in so far as the limited area studied in the field will permit.

CHAPTER I

TOPOGRAPHY

GENERAL RELATIONS

The eastern half of Ohio forms a part of that physiographic subdivision of the United States known as the Appalachian Plateau, which consists of a broad dissected upland distinctly higher than the bordering provinces and separated from these by outward facing escarpments. In southern Ohio the upper surface of this plateau stands at an elevation of about 1,200 feet above sea level and 300 feet above the adjacent lowlands, from which it rises in an irregular manner to the east, reaching altitudes along the eastern rim of 2,200 feet in southern New York, 4,000 feet in central West Virginia, and 1,700 feet in southern Tennessee.

North of the Cumberland River, the Appalachian Plateau, ordinarily known as the Allegheny Plateau, is very rugged and many of the plateau-like characters have been erased by prolonged stream erosion. Here the stream flows in deep, gorge-like valleys or steep-sided ravines, and the uplands have been reduced to flat-topped hills and ridges or ridge-like divides. On the basis of the characteristics of the topography, three sections or subdivisions of the Allegheny Plateau have been recognized. First, the northern or Glaciated section extends from the Ontario and Erie basins southward to the glacial drift border. Its southern limit in Pennsylvania is represented by a line passing from Russelsburg in Warren County, southwest to Homewood in Beaver County, and from thence westward through northern Ohio, near Saint Clair and Dungannon in Columbiana County, Canton in Stark County, and Millersburg in Holmes County. The second subdivision, or Conemaugh section, lies south of the glacial boundary and is poorly marked off from the third, or Kanawha section, which comprises the southern part of this plateau. Jefferson County lies a few miles south of the glacial boundary and is therefore a part of the Conemaugh division of the Allegheny Plateau.

DRAINAGE

THE MAJOR STREAM

The surface waters of Jefferson County pass either directly into the Ohio River, which flows along its eastern margin, or are collected by a system of streams tributary to the Ohio River, which have parallel eastward direction of flow. Beginning at the north, the chief tributary streams are Yellow Creek, Croxton Run, Island Creek, Wills Creek, Cross Creek, Rush Run, and Short Creek.

The Ohio River, the major water course affecting the drainage of this area, has, in general, a southern direction of flow where it borders Jefferson County. From the mouth of Yellow Creek at the northeastern corner of the county the river takes a straight southeasterly course to Toronto. From Toronto to Brilliant the general direction of flow is southward, although many broad curves are present in its course, the most conspicuous of which occurs a little below the south end of Browns Island. From Brilliant to the southern edge of the county the channel is more regular, but bears slightly to the west. Throughout the 33 miles of its course bordering this area, the channel of the river lies entirely in sands and gravels, and the waters are sluggish, with an average gradient of about 9 inches per mile. The valley of the Ohio is narrow and rugged with few valley flats or terraces except on the concave side of broad meander-like curves or at the mouths of the larger tributary streams. At some places the valley walls rise directly from the water's edge to reach heights of 400 to 500 feet. Here and there deep, notch-like openings occur where the smaller tributary streams enter the major stream.

TRIBUTARY STREAMS

Yellow Creek, which is the most northern tributary of the Ohio River in Jefferson County, follows a winding course about 30 miles in length in this county and receives the drainage from an area of approximately 132 square miles in Saline, Brush Creek, Springfield, Ross, Salem, and Knox townships. This stream is formed near the western edge of Section 24, Springfield Township, by the union of Elk Fork, which rises in Section 6, Louden Township, Carroll County, and of Elk Lick, which has its source in Section 27, German Township, Harrison County. From its source, Yellow Creek has a northeasterly direction of flow to Bergholz, where it turns abruptly to the east, follows a very winding course through a deep valley through Ross, Knox, and Salem townships, and reaches the Ohio River two

miles below Wellsville. In Springfield Township there are four important tributaries, namely, Goose Creek, Wolf Creek, Elkhorn Creek, and Upper North Fork. Goose Creek, which enters from the south at Amsterdam, and Wolf Creek, which flows into Yellow Creek near the north edge of Section 8, receive most of the surface waters from the southern part of Springfield Township. In the western part of Lee Township, Carroll County, are the headwaters of Elkhorn Creek, a large tributary which enters Yellow Creek three-fourths of a mile south of Bergholz. Upper North Fork, which has its mouth about one-fourth of a mile north of the town of Bergholz, drains the northern part of Springfield Township. East of Bergholz, Ralston Run, Roach Run, and many unnamed tributaries from the north, as well as Long Run and Town Fork from the south, drain Ross, the southwestern part of Brush Creek, the north third of Saline, and the western part of Knox townships. Brush Creek and North Fork are tributary streams near Hammondsville and drain much of Brush Creek and also the northwestern part of Saline townships. About one mile above its mouth, Hollow Rock Run, a tributary from the south, discharges the waters from south-central Saline and north-central Knox townships into Yellow Creek.

Croxton Run, the second drainage line worthy of consideration, heads about one mile east of Knoxville, flows in a southeasterly direction, and empties into the Ohio River about one mile north of Toronto. It is joined, about one mile above its mouth, by two tributaries entering nearly at right angles to its course, one from the north and the other from the south. Croxton Run and its tributaries are short, have comparatively steep gradients, and drain an area of only a few square miles in the southeast part of Knox Township.

Island Creek has its headwaters in a number of small branching streams near Richmond, in the eastern part of Salem Township. Its valley first leads northeast to the village of Island Creek, thence it turns abruptly to the southeast and joins the Ohio Valley at Costonia. The valley is deep, sinuous, and rugged, although narrow valley flats have developed along the stream near its mouth. Only three important tributaries are present: Skelley Run and Hale Run enter from the north near the village of Island Creek and drain the south-central part of Knox Township, whereas near its mouth Little Island Creek enters from the south. The drainage basin of Island Creek has a total area of 35 square miles which lies largely in the northern part of Island Creek Township, but also includes small areas in eastern Salem and south-central Knox townships.

The southern part of Island Creek Township is drained by Wills Creek and its tributaries. The main stream has its source in the

north-central part of Section 26, a little north of Nortons Hill. It parallels Island Creek in its direction of flow and empties into the Ohio River at Alikanna. Its entire drainage basin comprises about 15 square miles. The only tributary of noteworthy size is North Fork, which heads in the southeast corner of Section 33, and flows into Wills Creek at the eastern edge of Section 7.

As a tributary of the Ohio River receiving the drainage of Jefferson County, Cross Creek is second only to Yellow Creek. About 100 square miles of the county is drained by this stream and its tributaries. Heading near Cadiz Junction, in German Township, Harrison County, about four miles west of the western boundary of Jefferson County, the stream takes an easterly direction through the northern part of Wayne Township. Half a mile northwest of Reeds Mill it turns abruptly to the southeast, flows across Cross Creek Township, and joins the Ohio River below Mingo Junction. The valley is deep and gorge-like, and valley flats are either narrow or wanting except near the mouth of the stream. The tributaries which enter from the north are long and branching: Salem Creek, with its branches, namely, Lea Branch, Grassy Run, Clay Lick Creek, and Cedar Lick Creek, drains northern Wayne and southern Salem townships, and Cedar Lick Run and Dry Fork, with some unnamed tributaries, receive the waters from southwestern Island Creek and northwestern Cross Creek townships. The southern tributaries, with the exception of Gunyon Hollow, Opossum Hollow, and McIntyre Creek, are few in number and poorly developed. Gunyon Hollow and Opossum Hollow drain eastern Wayne and western Cross Creek townships, and McIntyre Creek, the largest of the tributaries of Cross Creek, rises near the western edge of the county and receives the waters from southern Wayne, northeastern Smithfield, southern Cross Creek, and northwestern Wells townships.

The next important stream south of Cross Creek is Rush Run. From its headwaters, half a mile northeast of Smithfield, in Smithfield Township, its course lies in a southeasterly direction until it meets the Ohio River in Section 8, Warren Township. The valley is steep and narrow and there are few well developed tributaries. The area drained by Rush Run includes 12 square miles in southern Wells and northeastern Warren townships.

The southern part of Jefferson County is drained by Short Creek and its tributaries. The stream is formed near Adena by the confluence of North Fork, which rises near Rexford, Green Township, Harrison County, Middle Fork, which heads near Cadiz, Harrison County, and Smith Fork, which has its source in eastern Athens Township, Harrison County. From Adena the stream flows south-

eastward through southern Smithfield Township to Dillonvale in Mount Pleasant Township, and thence eastward through Warren Township to the Ohio River at Warrington. Throughout its length Short Creek follows a very winding and devious course, and has many short meanders with steep sides and with projecting rock spurs which characterize the valley and afford good rock exposures. Occasionally valley flats are well developed, although they are by no means continuous. The northern tributaries which are best developed are Coal Run, Goose Run, Perrin Run, Piney Fork, and Dry Fork, which drain Smithfield and western Wayne townships, and Jug Run and Williamson Run, which receive the waters from northern Warren Township. The southern tributaries are Long Run, which drains a large part of Mount Pleasant Township, and Little Short Creek, which drains southern Warren Township. The drainage basin of Short Creek has a total area of 74 square miles in Jefferson County.

EFFECT OF ROCK STRUCTURE ON DRAINAGE

In a region underlain with sedimentary rocks of nearly horizontal position no conspicuous effects of structure upon the development or arrangement of streams is expected. Nevertheless, if the region stands at sufficient altitude to permit deep stream dissection, and if the erosion cycle has progressed far enough, small effects of rock structure become evident. In Jefferson County, where the beds slope gently in a direction 30 degrees east of south, the influence of rock position on the drainage is expressed chiefly in the unequal development of the tributary streams. The three major drainage basins tributary to the Ohio River in this county, namely, Yellow Creek, Cross Creek, and Short Creek, show this feature to an unusual degree. The secondary tributaries, which enter the major streams from the north and, therefore, flow in the general direction of dip, are numerous and well developed, whereas those which enter from the south are short and few in number. This drainage feature, well illustrated in the western half of the county, gives an asymetric shape to the drainage basins with the divides close to the southern edge of the eastward flowing streams.

EFFECT OF GLACIATION ON DRAINAGE

The southern limit of continental glaciation in northeastern Ohio can be represented by a line drawn a few miles north of Jefferson County, passing through Saint Clair and Dungannon in Columbiana County and through Massillon in Stark County. The influence of the great ice sheet on Jefferson County is therefore of an indirect nature

and is effective only because its presence has produced marked drainage changes, such as the reversal of the direction of flow of the preglacial Ohio River and the intrenchment of its tributaries. As shown by Tight, Leverett, and others, the present Ohio River Valley along the eastern and southern boundary of the State is a composite of parts of several preglacial channels through which the river established its course under the influence of the continental glacier. It was first suggested by J. W. Spencer[1] and later shown by Chamberlin and Leverett[2] that the headwaters of the Ohio River drainage basin formerly flowed toward the north and, therefore, have suffered a reversal of direction of drainage. According to Leverett[3], the headwaters of this preglacial stream were located in the highlands between Bellaire, Ohio, and New Martinsville, West Virginia; thence the stream flowed to the north along the line of the present Ohio River to the mouth of the Beaver River and by the way of the Beaver and Grand River channels to some unknown outlet within the glaciated area. The evidence for this northward direction of flow is found, first, in the absence of any large streams tributary to the Ohio from New Martinsville northward along the Pan Handle area, second, in the trend of the tributary streams along the Pan Handle area, and, third, in the heights of the bluffs and uplands along this stream, as these are higher than the ones along the Muskingum River to the west and the Monongahela River to the east. The level of this former northward flowing stream is considered by Leverett to be represented by remnants of a gradation plain which has an elevation of 1,000 feet at Wheeling, 990 feet at the mouth of Buffalo Creek, 975 feet at New Cumberland, and 965 feet at Beaver[4]. Remnants of this early gradation plain are not in evidence along the valleys tributary to the Ohio River in Jefferson County although the position of the tributary streams has remained essentially the same as indicated by the angle at which the lower courses of many of these meet the Ohio. Following the reversal of drainage, the Ohio River channel bordering Jefferson County was deepened as much as 300 feet. The tributary streams likewise degraded their channels, widened their valleys, and lengthened their courses, thus increasing the roughness of the surface and the relief of the region. Where the major tributary streams had developed meandering courses, in preglacial time,

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[1]Spencer, J. W., Second Geol. Survey Pennsylvania Rept. QQQQ, pp. 405-406. 1879.

[2]Chamberlin, T. C., and Leverett, F., Am. Jour. Sci., 3rd Ser., Vol. 47, pp. 247-283. 1894.

[3]Leverett, F., U. S. Geol. Survey Mon. 41, p. 83. 1902.

[4]Idem, p. 92.

these meanders became intrenched, producing winding, sinuous channels such as occur along parts of the valleys of Short Creek and Yellow Creek.

RELIEF

The surface of Jefferson County is very hilly. To a large extent the features which should characterize a plateau region have been destroyed through the action of physiographic processes, chief of which is stream erosion. Deep valleys have been cut in the nearly horizontal sedimentary beds and have reduced the region in large part to a condition of slope. The basal slopes of the hillsides along the lower courses of the major streams are usually steep and precipitous, but these slopes become more gentle upward and end in flattened or rolling divides. Near the headwaters of these streams, the valleys become wider and the slopes more gentle, with here and there small, inconspicuous, terrace-like flats.

The divides have their greatest elevation in the western part of the county but gradually descend in an irregular manner to the east. The watershed between North Fork of Yellow Creek and Brush Creek in Brush Creek Township has many points which rise to the 1,320 foot level. About one-half mile south of Monroeville, a single hill rises to a height of 1,388 feet and represents the highest elevation in the county. In southwestern Ross and northeastern Springfield townships, many knobs on Timothy Ridge and Middle Ridge have summits ranging from 1,340 to 1,360 feet in altitude. Farther south, the highest hills reach 1,300 to 1,340 feet in southwestern Wayne and northeastern Smithfield townships, and 1,320 feet in Mount Pleasant Township. In the eastern part of the county the surface elevations of the ridges bordering the Ohio River range from 1,100 to 1,280 feet.

The lowest levels occur along the Ohio River where, at the north edge of the county, the elevation is about 650 feet; at the mouth of Wills Creek, 638 feet; at the mouth of Cross Creek, 635 feet; at the mouth of Short Creek, 628 feet; and at the southern boundary of the county, about 627 feet.

As a result of the deeper dissection of the land surface by streams, the relief is greatest in the eastern part of the county and decreases to the west. The average difference in elevation between the hilltops and the valleys along the Ohio River is 520 feet; in the central part of the county, 360 feet; and along the western boundary, about 250 feet. The maximum relief is about 760 feet.

UPLANDS

Harrisburg Upland

In his paper on the Geographic Development of Northern Pennsylvania and Southern New York, Campbell describes an old erosion surface well developed in portions of western Pennsylvania and northeastern Ohio, to which he gave the name Harrisburg peneplain[1]. In Jefferson County, Ohio, the level of this old erosion surface is represented by a few hills flattened at their summits, or by the general accordance of summit elevations over the area bordering the Ohio River Valley and the valleys of the chief tributaries, Yellow Creek, Cross Creek, and Short Creek. The Harrisburg peneplain reaches its maximum elevation in the northern part of the county, and slopes gradually to the south. It is best represented in the northeastern part where the majority of the hills rise to elevations ranging from 1,240 to 1,270 feet. When followed to the south, however, this accordance is not so well marked although it can be identified with certainty as far as the southern boundary of the county, where the summit levels range from 1,200 to 1,220 feet. In an east and west direction there is little change in the elevation of the accordant levels within the county.

At many localities in the area there are isolated hills or ridges which rise as monadnocks above the Harrisburg level. These monadnocks are usually arranged in east and west belts and parallel the present drainage tributary to the Ohio River. If the old land surface is restored in the imagination, these residual elevations or monadnocks may be thought of as the remains of old cuesta slopes, or as divides on the Harrisburg peneplain with steep, abrupt northern slopes and more gentle southern slopes. The most prominent and least dissected of these divides extends from Monroeville toward Irondale and lies, in large part, in Brush Creek Township. The summit of this ridge is narrow with a flat to rolling surface. The Morgantown sandstone forms the crest of this old divide and its resistance to weathering has retarded stream dissection, which has reached a considerably less advanced stage than in other parts of the county. Middle Ridge in Ross Township and the high ridge, which extends from Springfield to Richmond and thence northeastward in the direction of Knoxville and Somerset, represent a more advanced stage of stream dissection. These ridges, as well as many others in the central and southern parts, have numerous knobs rising

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[1]Campbell, M. R., The Geographic Development of Northern Pennsylvania and Southern New York: Bull. Geol. Soc. America, Vol. 14, pp. 277-296. 1903.

above the 1,300 foot level, which are entirely without the protective covering of resistant beds, and which pass by more or less gentle slopes to the accordant level representing the Harrisburg flats.

Worthington Upland

In portions of the Appalachian Plateau of western Pennsylvania, there are remnants of a well-defined gradation plain which lies 100 feet below the Harrisburg level and which has been named by Butts the Worthington Upland on account of its excellent development near the town of Worthington in Armstrong County, Pennsylvania.[1] This level can be traced westward into northeastern Ohio, where in eastern Columbiana County, it is well developed at elevations ranging from 1,140 to 1,160 feet. To the south in Jefferson County, the Worthington level cannot be definitely identified, although small terrace-like flats, which stand at various elevations ranging from 1,100 to 1,140 feet, may represent this level. These are present along the Ohio River Valley near Steubenville, in Steubenville Township, in the southeastern part of Wells, and in the eastern part of Warren townships, and at various places along the valley of Cross Creek in northern Wells Township.

Parker Strath

Below the remnants of the old valley flats representing the Worthington Upland, there are remains of several terrace levels, the highest and most important of which is widely known in Ohio and in western Pennsylvania as the Parker Strath. This stage consists of remnants of rock terraces which are covered in places with veneers of glacial drift and which lie at levels ranging from 100 to 300 feet below the Worthington Upland. Historically speaking, the Parker Strath level represents the valley bottoms at the close of the Tertiary Period or just preceding the advance of the continental glacier.

In Jefferson County the evidence for the Parker stage is very meager. As this region lies near the headwaters of the Ohio branch of the former northward-flowing Monongahela River system, the valley flats of the Parker stage consequently occur here in their poorest stage of development. Subsequent reversal of drainage of this portion of the Ohio River and the cutting of the river channels 300 feet below the level of the Parker valley flats have almost completely erased much of the evidence of their existence. According to

[1]Butts, Charles, U. S. Geol. Survey Folio 115, p. 93. 1904.

the detailed work of Chamberlin and Leverett[1] over a large area in the upper Ohio River drainage basin, the level of the Parker stage along the Ohio River should range from 1,000 feet at the southern to about 975 feet at the northern boundary of the county. Rock terraces belonging to the Parker stage have not been positively identified in Jefferson County.

VALLEY FLATS

Valley flats or flood plains are, as a whole, inconspicuous features of the topography of Jefferson County. The major streams have reached a condition of grade and have begun the process of flood plain development, but the erosion cycle has not progressed far enough to permit the growth of continuous well-defined valley flats. Along the Ohio River, flood plains are best developed on the concave side of the broad meander-like curves, as, for example, at Toronto and at Mingo Junction, where they reach a width of about one-half mile. The surface of the flood plain along the Ohio River is usually 25 to 40 feet above the mean water level.

Along Yellow Creek, narrow valley flats are present which reach their best development near Bergholz in Springfield Township where they attain a width of about one-fourth mile. The lower courses of Island Creek, Wills Creek, and Cross Creek have narrow valley flats about one-eighth mile in width. The valley flats along Short Creek are well developed entirely across the county and have an average width of about one-eighth mile, but near Dillonvale they rapidly broaden out to one-fourth mile. The portion of Jefferson County which has been reduced to a condition of grade constitutes a very small part of the total area.

[1]Chamberlin, T. C., and Leverett, F., Am. Jour. Sci., 3rd Ser., Vol. 47, pp. 247-283. 1894.

CHAPTER II

STRATIGRAPHY AND ECONOMIC GEOLOGY

INTRODUCTION

The rocks outcropping at the surface in the eastern part of Ohio belong to the Pennsylvanian and Permian systems. On the basis of lithology or differences in the character of the rocks, these systems have been subdivided into smaller parts known as series. The major classification in descending order is as follows:

Permian system
- Greene series
- Washington series

Pennsylvanian system
- Monongahela series
- Conemaugh series
- Allegheny series
- Pottsville series

In these pages chief interest is centered in Jefferson County where all or part of the Allegheny, Conemaugh, Monongahela, and Washington series are represented in surface outcrops. The entire section, which is of sedimentary origin, is composed of the common varieties, such as sandstone, shale, clay, coal, and limestone, with a total thickness of 1,045 feet. In the study of the surface outcrops, about 320 measured sections have been obtained from which the following have been chosen as representing in a typical way the character and thickness of the beds and their stratigraphic sequence.

SECTIONS ILLUSTRATING THE STRATIGRAPHY

The stratigraphy of the Allegheny series is well shown in the following geologic section measured near the plant of the Banfield Clay Co., at Irondale, Saline Township[1]:

Allegheny series	Ft.	In.
Coal, varies from 1 to 4 feet, *Upper Freeport*	2	6
Shale and covered	52	0
Coal, *Lower Freeport*	2	8
Clay, light, calcareous	1	0
Limestone, nodular, *Lower Freeport*	2	0
Clay, part flint	2	0
Shale and shaly sandstone	60	5
Shale, black, bony, fossiliferous near top, *Washingtonville*	2	3
Shale, with ore nodules	5	4
Coal, good } *Middle Kittanning*	2	2
Coal, very bony }		6
Clay, arenaceous, with concretions	5	0
Shale, with ore nodules	14	0
Coal, *Lower Kittanning*	3	0
Clay, plastic	6	0
Clay, shaly	3	0
Shale and sandstone	65	0
Coal, *Clarion*		3
Clay, plastic, arenaceous	6	0
Clay shale, blue	8	0

The following section was secured near the mine of the Saline Coal Co., in the western part of Section 13, Saline Township:

Conemaugh series	Ft.	In.
Coal, measured on outcrop, *Mahoning*	2	4
Sandstone, shale, and covered	38	0
Shale, black, fissile, bony at bottom	3	4
Allegheny series		
Coal, *Upper Freeport*	3	6
Sandstone, shale, and covered	57	0
Shale, black	1	0
Coal, measured on outcrop, *Lower Freeport*	2	8
Sandstone, shale, and covered	55	0
Shale, black	5	0
Coal, *Middle Kittanning*	2	6
Clay, arenaceous	5	0
Shale	17	0
Coal, *Lower Kittanning*	2	6
Clay, unmeasured.		

The upper part of the Allegheny and lower part of the

[1]Stout, W. and Lamborn, R. E., Geol. Survey Ohio, Fourth Series, Bull. 28, p. 121. 1924.

Conemaugh series are well shown along a small tributary to Yellow Creek in the western part of Section 8, Saline Township, where the following measurements were secured:

Conemaugh series		Ft.	In.
Limestone, black, fossiliferous	*Brush Creek*	1	0
Shale, black, bony, fossiliferous	*Brush Creek*		8
Limestone, black, fossiliferous	*Brush Creek*		5
Coal and black shale	*Brush Creek*		5
Coal	*Brush Creek*		7
Clay, dark blue		3	0
Covered interval		47	0
Clay, gray, plastic		2	0
Covered interval		73	6
Sandstone, heavy bedded, *Lower Mahoning*		30	0
Coal	*Upper Freeport*	2	0
Coal, cannel nature	*Upper Freeport*		10
Clay, bluish-gray, arenaceous		7	8
Limestone, nodular, *Upper Freeport*		1	0
Clay, bluish-gray, arenaceous		3	4
Clay, ferruginous, flinty	*Bolivar*	2	2
Shaly coal and black shale	*Bolivar*		6
Clay, gray, flinty	*Bolivar*	2	0
Coal, shaly			9
Clay, shaly		2	3
Coal and black shale	*Lower Freeport*	2	6
Coal, good	*Lower Freeport*	2	6
Clay, bluish-gray, arenaceous		5	6
Clay shale, gray		3	6
Sandrock, argillaceous		5	8
Covered interval		10	0
Shale and covered		30	0
Shale, black, fissile, fossiliferous, *Washingtonville*		1	3
Shale, dark, with iron ore nodules		8	0
Clay, arenaceous, *Wilgus horizon*		4	0
Clay, unmeasured.			

In the southeastern part of Section 29, Saline Township, the lower members of the Conemaugh series are exposed along a small tributary of Yellow Creek. The Upper Freeport coal is a few feet below water level along Yellow Creek at the place where the geologic section was measured, as the heavy bedded sandstone, which appears as the lowest member of the section, lies close above the coal in this region.

Conemaugh series	Ft.	In.
Shale, arenaceous near top	27	0
Clay, arenaceous, *Wilgus horizon*	4	0
Covered interval	24	0
Shale, reddish-brown	13	0
Sandrock, bluish		8
Shale, gray, arenaceous	1	0

		Ft.	In.
Limestone, blue, fossiliferous	*Brush Creek*		4
Shale, arenaceous, fossiliferous	*Brush Creek*	1	8
Limestone, bluish, fossiliferous	*Brush Creek*		6
Clay shale, blue, fossiliferous	*Brush Creek*	1	10
Clay shale, blue	*Brush Creek*	23	0
Coal, shaly, with black shale, *Mason*			8
Covered interval		33	0
Clay, yellow, *Mahoning horizon*		3	0
Covered interval		36	6
Sandstone, heavy bedded, *Lower Mahoning*		10	0
Water level of Yellow Creek.			

The best exposure in Brush Creek Township was observed in the south central part of Section 12 where the following measurements were obtained:

		Ft.	In.
Conemaugh series			
Sandstones, thin-bedded, *Cow Run*		40	0
Clay, blue, arenaceous		2	2
Clay, yellowish, arenaceous, *Anderson horizon*		3	0
Shale, arenaceous		1	2
Sandstone, shaly		4	7
Shale, drab-colored, arenaceous		16	1
Limestone, bluish	*Cambridge*	1	2
Shale, bluish, fossiliferous	*Cambridge*	2	2
Shale with thin coal bands, *Wilgus*			1
Clay, gray		5	0
Covered		5	4
Shale, bluish-gray, arenaceous		30	0
Shale, black, with iron ore nodules		5	4
Shale, black, fossiliferous	*Upper Brush Creek*	5	0
Limestone, black	*Upper Brush Creek*	1	2
Shale, black, micaceous	*Upper Brush Creek*	4	0
Clay shale, dark, fossiliferous	*Upper Brush Creek*	7	8
Coal, bony, *Brush Creek*			9
Clay, bluish-gray, arenaceous		6	8
Shale, bluish-gray, argillaceous		12	10
Sandy layer, fossiliferous	*Lower Brush Creek*		3
Limestone, black, ferruginous	*Lower Brush Creek*		3
Shale, black	*Lower Brush Creek*		10
Shale, black, ferruginous, fossiliferous	*Lower Brush Creek*		2
Shale, black, sparingly fossiliferous	*Lower Brush Creek*	2	9
Shale, black, very fossiliferous	*Lower Brush Creek*	2	6
Shale, gray, arenaceous		12	2
Shale, black, with plant impressions, *Mason coal horizon*			8
Clay, bluish-gray, arenaceous		4	8
Sandstone, heavy bedded, *Upper Mahoning*		9	5
Clay, bluish-gray, arenaceous		5	0
Covered interval		15	8
Sandstone, cross-bedded, *Lower Mahoning*		44	4
Allegheny series			
Shale, black, with thin coal bands, *Upper Freeport*			7

	Ft.	In.
Clay, bluish-gray, arenaceous	4	0
Sandrock	1	0
Clay, ferruginous, arenaceous	2	6
Clay shale, blue	10	6
Sandstone, heavy bedded } *Upper Freeport*	5	0
Sandstone, platy } *Upper Freeport*	31	0

The exposures recorded in the following geologic section occur along the road in the northern part of Section 3, Ross Township:

Conemaugh series	Ft.	In.
Clay shales, red, *Round Knob*	31	0
Shale and shaly sandstone	67	0
Shale and covered	26	0
Clay, yellow	2	0
Covered interval	5	0
Shale, arenaceous	29	0
Shale, black, with nodular masses of black limestone, *Brush Creek*	21	6
Shale, with thin coal bands, *Brush Creek*		8
Clay, arenaceous at bottom	13	10
Covered interval	6	0
Sandstone, platy, *Upper Mahoning*	7	0
Shale, arenaceous at top	14	9
Shale, bony, *Mahoning*		3
Clay, yellow	4	0
Sandstone, shale, and covered, *Lower Mahoning*	16	5
Allegheny series		
Coal blossom, *Upper Freeport*	4	5
Clay, bluish-gray	5	2
Sandstone and covered	31	0
Clay, yellowish-gray, *Lower Freeport*	3	0

Following is a record of the exposures in the central part of Section 23, Ross Township:

Conemaugh series	Ft.	In.
Shale, dark, micaceous } *Brush Creek*	6	0
Shale, gray, fossiliferous } *Brush Creek*	10	6
Coal, shaly, *Brush Creek*	1	3
Clay, gray, arenaceous	10	6
Covered interval	30	0
Sandstone, heavy bedded, *Upper Mahoning*	15	0
Clay, mottled	3	0
Sandstone, shale, and covered	52	0
Allegheny series		
Coal, bony } *Upper Freeport*		7
Coal, good } *Upper Freeport*	3	0
Covered	47	0
Shale, gray, arenaceous near top	10	0
Coal, good } *Lower Freeport*	1	2½
Bone band } *Lower Freeport*		½
Coal, good } *Lower Freeport*	1	10
Clay, plastic	1	0
Clay, hard, shaly	1	0

The following geologic section, typical of the Bergholz region, was measured in the eastern part of Section 11, Springfield Township:

Conemaugh series	Ft.	In.
Sandstone, *Morgantown*	10	0
Clay, gray, plastic	5	6
Shale and covered	25	6
Clay shale, red, *Round Knob*	12	6
Shales, gray, arenaceous	74	2
Clay, ferruginous, *Wilgus horizon*	5	0
Shale, gray, arenaceous at top	24	10
Clay, red and yellow, mottled	7	6
Shale, gray to dark, fossiliferous near base	58	2
Ferruginous layer, fossiliferous, *Brush Creek*		2
Coal blossom, *Brush Creek*		2
Clay and covered	10	0
Shale and covered	24	0
Clay, with nodular fossiliferous limestone, *Mason*	15	10
Sandstone, massive, *Upper Mahoning*	15	8
Shale and shaly sandstone	15	4
Shale, arenaceous	5	2
Clay, *Upper Freeport*	2	6
Sandrock	2	0
Clay, ferruginous, flinty } *Bolivar*	7	10
Clay, ferruginous, arenaceous } *Bolivar*	15	6

The stratigraphic relation of the Lower Freeport (Bergholz) coal to the overlying members is shown below in geologic section measured in the central part of Section 10, Springfield Township:

Conemaugh series	Ft.	In.
Clay shales, reddish	5	6
Covered interval	30	0
Clay, light, arenaceous, *Mahoning*	1	0
Covered interval	25	10
Allegheny series		
Clay, light, plastic } *Upper Freeport*	1	0
Clays, ferruginous, arenaceous } *Upper Freeport*	9	4
Covered interval	7	8
Clay, arenaceous, flinty, *Bolivar*	1	4
Covered interval	29	4
Shales, arenaceous	20	0
Coal, shaly } *Lower Freeport*		1
Coal, good } *Lower Freeport*	2	11
Clay		6

The section given below was measured along the hill road in the central part of Section 2, Springfield Township:

Conemaugh series	Ft.	In.
Clay, with nodular limestone	10	0
Shale, gray, arenaceous	34	0
Sandstone, coarse-grained, conglomeratic at base, *Connellsville*	38	0

	Ft.	In.
Shale, gray, arenaceous	14	10
Clay, gray, plastic, *Clarksburg horizon*	2	6
Shale, arenaceous	6	10
Sandstone, heavy bedded, *Morgantown*	53	2
Limestone, fossiliferous, *Ames*	1	2
Shale and covered	24	8
Shale, red, *Round Knob*	33	0
Shale, gray	24	0
Sandstone, *Cow Run*	15	4
Clay, *Wilgus horizon*	2	0
Covered interval	13	6
Clay shale, dark	4	0
Shale, gray, arenaceous	65	2
Coal blossom, *Brush Creek*		1
Clay and covered	8	0
Clay, shale, and covered	24	5
Shale, ferruginous, arenaceous	1	4
Clay, gray, plastic, *Mason horizon*	8	0
Covered interval	110	0
Coal, reported thickness in the mine of the Ohio & Pennsylvania Coal Co., *Lower Freeport*	4	0

Exposures along Jeremy Run in sections 33 and 4, Knox Township, have the character and stratigraphic relations as indicated below:

Conemaugh series		Ft.	In.
Sandstone, unmeasured, *Morgantown.*			
Shale, arenaceous		20	0
Limestone, gray, fossiliferous, *Ames*		1	0
Clay, gray, arenaceous		5	4
Sandstone, one layer			8
Shale, arenaceous		46	0
Clay shale with thin coal bands, *Anderson*		1	3
Clay, blue, ferruginous		13	7
Limestone, nodular	*Cambridge*		4
Clay shale, ferruginous	*Cambridge*	5	4
Limestone, blue, nodular	*Cambridge*	1	2
Shale, gray, arenaceous		33	6
Clay, arenaceous		5	4
Shale and covered		74	4
Sandrock		2	0
Coal, bony, *Mahoning*			8
Clay		1	6
Covered interval		29	0
Allegheny series			
Coal, *Upper Freeport*		2	6
Sandstone and covered		100	0
Shale, bony, fossiliferous, *Washingtonville*			6

Following is geologic section which shows the stratigraphic relations of a part of the Conemaugh series as it is developed along Croxton Run in the central part of Section 32, Knox Township:

Conemaugh series		Ft.	In.
Limestone, greenish, fossiliferous, *Ames*		1	9
Shale, gray, arenaceous		8	0
Clay shale, red, *Round Knob*		28	2
Clay, dark, shaly, *Barton*		10	4
Clay, with nodules of limestone	*Ewing*	2	6
Limestone, nodular, fossiliferous	*Ewing*	1	4
Sandstone, shaly, *Cow Run*		28	6
Shale, arenaceous		2	0
Shale, black, with thin coal bands		2	0
Shale and covered		46	0
Limestone, blue, arenaceous, fossiliferous, *Cambridge*			11
Clay shale, blue to yellow in color		14	4
Shale, black, with shaly coal, *Wilgus*		1	10
Clay, dark, arenaceous		3	0
Clay shale		23	10
Limestone, black, fossiliferous, *Brush Creek*		1	3
Shale, dark, fissile		1	10
Shale, bony		1	2
Shale, black, with many plant impressions		4	6
Coal, bony, *Mason*			8
Clay, dark, with iron ore nodules		5	0

A record of the exposures of a part of the Conemaugh series in Section 5, Island Creek Township, is given below:

Conemaugh series		Ft.	In.
Sandstone, unmeasured, *Morgantown.*			
Shale, gray, arenaceous		5	0
Limestone, massive	*Ames*		11
Limestone, shaly	*Ames*		11
Limestone, massive	*Ames*	1	6
Shale and covered		57	0
Shale, calcareous, with fragments of fossils	*Ewing*	1	0
Limestone, dark, fossiliferous	*Ewing*		7
Clay, gray, arenaceous		7	6
Shale and covered		21	6
Sandstone, *Cow Run*		25	0
Clay, gray, plastic, *Wilgus horizon*		5	0
Sandstone, shale, and covered		42	0
Shale, dark, arenaceous in upper part		14	6
Limestone, black, fossiliferous, *Brush Creek*			6
Shale, gray, arenaceous		9	6
Sandstone		6	0
Clay, gray, plastic, *Mason horizon*		3	0

The following section of rocks was measured along the road overlooking Stanton Park where a part of the Conemaugh series is well exposed. The massive sandstone at the bottom of the section is the one which overlies the Mahoning coal.

Conemaugh series	Ft.	In.
Shale, gray to red, mottled	12	4
Sandstone, thin-bedded, *Cow Run*	9	2
Shale, greenish to red in color, arenaceous	62	0

	Ft.	In.
Limestone, gray, fossiliferous, *Cambridge*	1	2
Clay shale, red, with limestone nodules	8	2
Shale, greenish, arenaceous	2	6
Sandstone, coarse-grained, beds 6 to 18 inches in thickness, *Buffalo*	10	4
Shale, gray, arenaceous, in upper part	29	0
Clay shale, fossiliferous, with fossiliferous ore nodules, *Brush Creek*	6	10
Shale, dark	1	4
Coal, shaly, with bone shale } *Brush Creek*		11
Parting } *Brush Creek*		1
Coal } *Brush Creek*		6
Clay, gray, arenaceous, ferruginous	4	0
Shale and covered	26	8
Sandstone, massive, *Upper Mahoning*	21	0

The following geologic section was obtained along a small ravine tributary to Cross Creek in the eastern part of Section 33, Steubenville Township:

	Ft.	In.
Monongahela series		
Coal blossom, *Pittsburgh*	3	6
Conemaugh series		
Covered interval	20	0
Limestone, *Pittsburgh*	3	6
Clay	1	0
Covered	7	6
Shale, calcareous	2	6
Clay, with nodules of limestone, *Summerfield*	2	6
Covered interval	8	0
Sandstone, shale, and covered, *Connellsville horizon*	85	0
Covered interval	3	6
Limestone, dark, *Clarksburg*	1	8
Covered interval	48	0
Shale, gray, arenaceous	8	0
Sandstone, *Morgantown*	26	0
Limestone, gray, fossiliferous, *Ames*	1	8
Shale, gray, arenaceous, ferruginous	2	6
Covered interval	34	11
Sandstone layer	1	0
Shale, gray, arenaceous	2	0
Clay shale, dark		6
Coal, good, *Harlem*		11
Clay, dark	1	0
Shale and covered	86	0
Limestone, gray, ferruginous, with fossil fragment, *Cambridge*		5
Shale, bluish-gray		2
Coal blossom, *Wilgus*		2
Clay, gray, plastic	1	0

About two miles east of Salem, in the southern part of Section

21, Salem Township, a part of the Conemaugh series is exposed along the east-west road. The record is as follows:

Conemaugh series	Ft.	In.
Sandstone, shaly near top, *Connellsville*	24	0
Clay shale and covered	31	0
Clay shale, dark	5	0
Shale, with thin coal bands, *Clarksburg*	1	0
Clay, ferruginous	1	0
Shale, gray, arenaceous	13	6
Coal blossom, *Elk Lick*		3
Clay	7	6
Shale and covered	52	7
Limestone, gray, nodular, *Ames*	5	4
Shale and covered	7	2
Coal blossom, *Harlem*	2	0

A record of the outcrops exposed along the road at the north edge of Section 19, Salem Township, is given below:

Conemaugh series	Ft.	In.
Coal blossom, shaly, *Elk Lick*	1	0
Clay and covered	3	2
Limestone, *Elk Lick*	1	0
Clay, gray, and covered	16	0
Shale and covered	15	0
Shale, gray, fossiliferous, *Skelley horizon*		4
Coal blossom, *Duquesne*		4
Clay, gray to red, mottled	7	10
Shale and covered	16	0
Limestone, nodular, *Ames*	2	2
Shale, dark, arenaceous	6	3
Coal blossom, *Harlem*	2	2

Near the hilltop, one mile east of Amsterdam, in the southwestern part of Section 7, Springfield Township, the members of the Conemaugh and Monongahela series are as follows:

Monongahela series		Ft.	In.
Shale, gray, arenaceous		2	6
Coal blossom, *Redstone*		1	0
Covered interval		9	4
Limestone, dark	*Redstone*	1	0
Covered interval		4	0
Limestone, dark		1	0
Covered interval		9	4
Coal blossom, *Pittsburgh*		4	6
Conemaugh series			
Covered interval		3	2
Limestone, dark, *Pittsburgh*		1	0
Covered interval		16	2
Clay, gray, plastic, *Upper Little Pittsburgh horizon*		3	6
Limestone, nodular			4

	Ft.	In.
Shale and covered	17	0
Clay, gray, plastic, *Lower Little Pittsburgh horizon*	8	6
Shale, gray, arenaceous	46	6
Clay, gray, plastic, *Clarksburg horizon*	2	0

The following excellent geologic section was measured along the road one-half mile north of New Alexandria, Section 7, Cross Creek Township:

Monongahela series		Ft.	In.
Limestone, nodular		2	0
Shale and covered		10	4
Limestone, nodular		2	6
Shale, bluish-gray	*Uniontown*	4	6
Limestone, nodular			8
Shale, Ferriferous		2	2
Limestone, nodular		4	9
Shale, greenish, *Fulton*		3	5
Shale, gray, calcareous		1	4
Limestone, nodular, impure		1	7
Shale, gray, calcareous		3	7
Limestone			9
Shale, calcareous		6	11
Limestone, gray	*Benwood*		8
Shale, gray, calcareous		2	10
Limestone, gray			3
Shale			9
Limestone, gray		2	0
Shale, soft, calcareous		15	4
Shale with nodular limestone		4	6
Shale, gray, arenaceous		2	4
Shale, black, carbonaceous, *Sewickley*			6
Shale, gray, arenaceous		3	2
Sandstone		7	10
Shale, gray, micaceous, arenaceous		4	8
Shale, black, carbonaceous, *Fishpot*[1] *horizon*		3	0
Clay and covered		5	2
Shale, gray, arenaceous		9	6
Shale, dark		5	0
Limestone, nodular, *Fishpot*		1	0
Shale, bluish-gray		7	0
Sandrock			4
Shale, gray, arenaceous		15	0
Coal, shaly, *Redstone*		1	9
Shale, greenish-gray, arenaceous		3	11
Clay, gray		5	8

[1]The term Fishpot was adopted by Wilber Stout for the names of the coal and limestone at this horizon of the Monongahela series. See Proceedings of the West Virginia Academy of Science, Vol. 3, Aug. 1929, pages 118-133.

	Ft.	In.
Clay, with nodules of limestone, *Redstone*	9	0
Clay, dark, and covered	6	0
Coal blossom, *Pittsburgh*	3	0
Conemaugh series		
Clay and covered	6	4
Sandstone, calcareous	2	0
Shale, ferruginous, arenaceous	4	4
Sandstone	7	4
Shale, ferruginous, arenaceous		8
Clay, arenaceous, *Upper Little Pittsburgh horizon*	3	2
Shale, arenaceous	3	3
Sandstone, platy, *Bellaire*	3	11
Shale, gray, arenaceous		9
Sandstone, one layer		11
Shale, gray, arenaceous	3	6
Clay, yellowish-gray, arenaceous, *Lower Little Pittsburgh horizon*	4	0

The greater part of the Monongahela series is well shown in the following geologic section measured along the north and south road in the western part of Section 35, Wells Township:

Monongahela series		Ft.	In.
Coal blossom, *Uniontown*			6
Clay, with nodular limestone, *Uniontown*		8	0
Shale, and covered		85	0
Coal blossom, *Sewickley*			3
Shale, gray, arenaceous		37	0
Limestone, with clay partings, *Fishpot*		6	0
Shale, greenish		13	0
Sandstone, shaly		8	0
Coal, shaly, *Redstone*		2	3
Shale, dark		1	6
Clay, yellow, with limestone nodules	*Redstone*	1	6
Clay, yellow, arenaceous	*Redstone*	5	2
Clay, gray, with limestone nodules	*Redstone*	8	2
Shale, with thin coal bands	*Pittsburgh*		4
Clay	*Pittsburgh*		10
Coal	*Pittsburgh*	2	6
Parting	*Pittsburgh*		1
Coal	*Pittsburgh*		2
Parting	*Pittsburgh*		1
Coal	*Pittsburgh*	2	0

A very complete section of the Monongahela series was secured near the mouth of Little Short Creek, in the northern part of Section 23, Warren Township. The record is as follows:

Monongahela series	Ft.	In.
Coal blossom, *Uniontown*		6
Covered	5	0

		Ft.	In.
Limestone, dark, *Uniontown*		1	0
Shale, gray, arenaceous		40	0
Shale, greenish, *Fulton*		4	0
Shale, calcareous		15	6
Limestone, dark	*Benwood*	1	0
Shale, calcareous		4	2
Limestone, dark		1	0
Shale, calcareous		17	10
Limestone, one layer		2	0
Shale, gray, arenaceous		27	4
Coal blossom, *Sewickley*			3
Shale, gray, arenaceous		19	0
Limestone, *Fishpot*		2	0
Clay shale		5	0
Covered interval		11	5
Coal blossom, *Redstone*			3
Clay and covered		2	0
Limestone, dark	*Redstone*		8
Clay, with nodular limestone		18	4
Coal blossom, *Pittsburgh*		1	8
Conemaugh series			
Clay, gray, arenaceous		6	10
Limestone, dark, compact, *Pittsburgh*			9
Clay, gray		2	3
Shale, yellowish, arenaceous		3	6
Covered interval		1	8
Clay, gray, *Upper Little Pittsburgh horizon*		10	4
Shale, gray, arenaceous		6	9
Sandstone, shaly, *Bellaire*		3	7
Shale, gray, arenaceous		4	6
Limestone, light, *Summerfield*		1	4
Clay, ferruginous, arenaceous		8	0
Shale, gray, arenaceous		27	4
Sandstone, *Connellsville*		4	0
Shale, gray, arenaceous			6
Limestone	*Clarksburg*		6
Shale, gray, arenaceous			8
Limestone			10
Clay, gray and red mottled		9	0
Shale, gray, arenaceous		69	6
Sandstone, heavy bedded, *Morgantown*		13	4
Shale, gray, arenaceous		12	3
Limestone, one layer	*Ames*		11
Limestone, one layer		2	6
Covered interval		10	2
Clay, gray to red mottled, *Harlem horizon*		10	10

A good section of the rocks of the Monongahela series was obtained about one-half mile west of Tiltonsville in Warren Township. The measurements are given below:

Monongahela series	Ft.	In.
Clay, bluish-black, *Waynesburg horizon*	3	0

		Ft.	In.
Shale and covered		18	0
Sandstone, shaly, *Gilboy*		10	0
Shale and covered		14	8
Coal blossom, *Uniontown*			8
Clay, light, plastic		9	0
Shale, gray, and covered		35	0
Limestone, yellowish	*Uniontown*		10
Shale and covered	*Uniontown*	3	2
Limestone, yellowish	*Uniontown*	1	0
Shale, green, *Fulton*		2	8
Shale and covered		2	10
Limestone, yellowish			6
Shale and covered, *Benwood*		17	6
Limestone, yellowish			10
Shale and covered		27	2
Shale, black, with shaly coal	*Sewickley*	2	0
Shale, black, fissile	*Sewickley*	1	10
Sandstone, shaly, with some shale		14	0
Shale, dark		14	0
Shale, bony, *Fishpot*			6
Shale, with limestone nodules, *Fishpot*		11	6
Covered interval		36	0
Level of old coal mine, *Pittsburgh coal.*			

Parts of the Conemaugh and Monongahela series are exposed at a few places along Piney Fork in Smithfield Township. The following record, obtained in the southeastern part of Section 15, is typical for this region:

Monongahela series		Ft.	In.
Limestone, yellow, nodular, *Uniontown*		1	0
Shale, green, *Fulton*		10	0
Shale and covered		22	10
Limestone	*Benwood*	1	0
Shale and covered	*Benwood*	3	5
Limestone	*Benwood*	2	9
Shale and covered		19	10
Shale, black, fissile, *Sewickley*			10
Shale, gray, arenaceous		10	4
Shale, black, fissile, *Fishpot*			10
Shale, arenaceous			10
Clay, gray, arenaceous		1	0
Shale and covered		2	8
Sandstone, platy		11	6
Shale, gray, arenaceous		20	8
Limestone, one layer, *Fishpot*		2	0
Shale and covered		10	10
Coal blossom, *Redstone*		1	6
Clay and covered		6	4
Limestone, yellowish-brown, *Redstone*		4	0
Clay and covered		10	6
Coal blossom, *Pittsburgh*		5	0

		Ft.	In.
Conemaugh series			
Shale and covered		36	0
Sandstone, shaly in part, *Bellaire*		15	8
Limestone, dark	*Summerfield*	1	6
Clay and covered	*Summerfield*	14	0
Limestone, nodular	*Summerfield*	1	0
Shale, gray to dark		58	2
Shale, dark, fissile		2	0
Shale, dark, fossiliferous		3	0
Shale, gray, arenaceous		7	0

The following measurements were taken in Section 11, Mt. Pleasant Township, along a small ravine which heads at Mt. Pleasant:

		Ft.	In.
Permian system			
Washington series			
Shale, gray, arenaceous		3	0
Shale, black, fissile		1	0
Clay shale, yellowish-gray		1	0
Limestone, dark, nodular, *Elm Grove*			8
Shale, gray		4	8
Clay, black			2
Clay shale, gray		1	2
Pennsylvanian system			
Monongahela series			
Coal, *Waynesburg*		2	6
Covered interval		111	8
Limestone, dark	*Benwood*	4	4
Shale	*Benwood*		6
Limestone	*Benwood*	5	10
Covered interval	*Benwood*	6	6
Limestone, dark	*Benwood*	3	0
Clay, gray		4	8
Coal and black shale, *Sewickley*		3	0
Clay shale, black		5	0
Sandstone, *Pomeroy*		19	6
Clay shale with layers of limestone	*Redstone*	15	0
Limestone, dark	*Redstone*	29	0
Covered interval		8	5
Coal	*Pittsburgh*	2	8
Parting	*Pittsburgh*		½
Coal	*Pittsburgh*		8
Parting	*Pittsburgh*		½
Coal	*Pittsburgh*	2	2
Conemaugh series			
Clay, gray, plastic		2	6
Limestone, dark, *Pittsburgh*		4	3

A record of the outcrops near the crest of the hill in Section 14, Warren Township, is as follows:

	Ft.	In.
Permian system		
Washington series		
Sandstone, shaly, *Waynesburg*	10	0
Limestone, dark, arenaceous, *Elm Grove*		8
Shale and covered	6	6
Pennsylvanian system		
Monongahela series		
Shale, black, with thin coal bands, *Waynesburg*	2	0
Shale and covered	39	2
Coal blossom, *Uniontown*		10
Clay and covered	4	10
Limestone, dark, *Uniontown*		8

The youngest rocks occurring in Jefferson County underlie the crest of the ridge in the southern part of Mt. Pleasant Township. One-half mile south of Mt. Pleasant, the measurements are as given below:

	Ft.	In.
Permian system		
Washington series		
Shale, gray arenaceous	6	0
Clay, bluish-black, *Waynesburg A horizon*	3	0
Clay, with nodules of limestone, *Mt. Morris*	2	0
Shale and covered	16	0
Sandstone, shaly, *Waynesburg*	15	0
Pennsylvanian system		
Monongahela series		
Clay, gray, *Waynesburg horizon*	3	0

The geologic section given below is exposed along the road in the eastern part of Section 22, Mt. Pleasant Township:

	Ft.	In.
Permian system		
Washington series		
Clay, black, plastic, *Waynesburg A horizon*	7	0
Limestone, dark, *Mt. Morris*	1	0
Shale and covered	31	0
Limestone, black, nodular, arenaceous, *Elm Grove*		7
Clay shale and covered	3	0
Pennsylvanian system		
Monongahela series		
Coal blossom, *Waynesburg*	2	10
Clay, arenaceous	10	0

The highest stratigraphic horizons exposed in this county occur in the western part of Section 28, Mt. Pleasant Township. A section including these members follows:

Permian system		Ft.	In.
Washington series			
Shale, calcareous		4	0
Limestone	*Lower Washington*	2	0
Limestone and shale		4	0
Limestone		2	6
Shale, calcareous		1	6
Limestone		1	4
Shale, calcareous			5
Limestone		1	4
Covered interval		22	0
Clay, dark		2	0
Coal blossom, *Washington*		3	4
Clay, yellowish		10	0
Covered interval		94	8

Old mine, *Waynesburg.*

STRUCTURE OF BED ROCKS

The sedimentary rocks of Jefferson County have a comparatively simple structure. In addition to the gentle undulations of individual beds, due to irregularities of the surface at the time of deposition, earth movements have produced a slight regional slope in an easterly direction and a more marked dip to the south, together with the development of a small syncline in the northern part of the county. The attitude of the beds is best shown by comparing the elevations of the Pittsburgh coal in different parts of the area. This coal bed has its highest altitude near East Springfield in Springfield Township where it outcrops at an elevation of 1,300 feet. When traced to the east, it slopes gradually downward to an elevation of 1,200 feet in Section 32, Knox Township; then descends abruptly to 1,100 feet in Section 15 of the same township; from which level it rises to 1,240 feet on the hilltops above Empire, Section 3, Knox Township. This rapid change in the amount and direction of dip in the central part of Knox Township is due to the fact that the coal bed crosses the southern end of a syncline, known as the Somerset syncline, the axis of which passes in a northeast-southwest direction about half a mile east of Somerset. Along an east and west line through Bloomingdale, the Pittsburgh coal slopes more uniformly to the east, having an elevation of 1,200 feet in Section 34, and 1,180 feet in Section 4, Wayne Township; 1,100 feet in Section 6, Cross Creek Township; and 1,030 feet in Section 28, Steubenville Township. The average slope of the beds along this line, using the Pittsburgh coal as a basis, is about 13 feet per mile. Across the southern part of the county, the general eastward slope of the Pittsburgh coal is shown by the following figures: 980 feet in Section 30 and 928 feet in Section 12, Mt. Pleas-

ant Township, and 915 feet in Section 18, Warren Township. The average slope to the east is, therefore, about 7 feet per mile.

The slope of the Pittsburgh coal to the south is well shown by the following figures: 1,230 feet in Section 2, Ross Township; 1,200 feet in Section 3, Salem Township; 1,180 feet in Section 4, Wayne Township; 1,040 feet in Section 6, Smithfield Township; and 910 feet in Section 36, Warren Township. The average slope of the coal to the south along this line is, therefore, about 15 feet per mile.

Careful measurements and computations, using the Pittsburgh coal as a base, show the maximum dip of the rocks for Jefferson County to be 17 feet per mile in a direction 33 degrees east of south.

ALLEGHENY SERIES

GENERAL STATEMENT

That part of the Pennsylvanian system now known as the Allegheny series was originally included in No. XIII of the Rogers' system of classification, according to the early writings on the geology of Pennsylvania. This series was first explored and developed along the Allegheny River, and for this reason became known as the Allegheny River series. The number and importance of the coal beds also caused it to be known among geologists as the Lower Productive Measures. As thus defined, this series of rocks extended from the top of the Pottsville conglomerate measures to the top of the Mahoning sandstone, but later the limits of the formation were changed. In 1875, F. Platt, describing the series as it is now known among geologists, placed the lower boundary at the top of the Homewood sandstone, and the upper limit at the top of the Upper Freeport coal.

The Allegheny series consists of a number of beds of clay, coal, limestone, shale, and sandstone. The top of the formation is marked by the Upper Freeport coal which is widely distributed but variable in thickness. Concerning the base of the formation in West Virginia, I. C. White writes as follows[1]:

"The physical change at the base of the formation is very striking, so that the observer, once familiar with the lithologic type of the Allegheny sediments, finds but slight difficulty in differentiating the basal beds of the latter from the underlying Pottsville."

In Ohio the separation of the Allegheny and Pottsville series is much more difficult than is apparently the case in West Virginia.

[1]White, I. C., West Virginia Geol. Survey Vol. II, p. 334. 1903.

The Homewood sandstone, where well developed, is easy of recognition, but, in its absence, the Pottsville sediments pass into those of the Allegheny without any lithologic or structural evidence of the transition. For this reason the base of the Brookville coal is used in Ohio as the plane of separation between the two series.

The thickness of the Allegheny series varies greatly in different parts of the field. In general, this series has its greatest development along the eastern belt of outcrops, and thins westward. In western Pennsylvania and northern West Virginia, the thickness varies from 250 to 300 feet, but expands rapidly southward and reaches 1,000 feet in the region of the Great Kanawha River[1]. Along the western belt of outcrops in Ohio, this series has a thickness of 270 feet in Columbiana County[2], about 180 feet in Muskingum County[3], and 180 feet in Lawrence County[4].

A portion of the Allegheny series is exposed above drainage in the northern part of Jefferson County, as shown on the accompanying map. This part, which includes all the members above the Lower Kittanning coal, has a thickness of about 160 feet, but when the covered portion is included, the total thickness of the series is about 250 to 260 feet. The dominant types of rock are sandstones and shales, but coals, ranging in thickness from a few inches to 7 feet, and clay beds of untold value are also present.

The following geologic sections are introduced here to show the succession and character of the rocks at the type localities along the Allegheny River, where many of the coals were first named:

Section at Freeport, Armstrong County, Pennsylvania[5]

Allegheny series	Ft.	In.
Coal, *Upper Freeport*	3	9½
Fire clay	1	6
Limestone, *Upper Freeport*	3	6
Sandy shales	20	0
Coal, *Middle Freeport*	2	0
Sandy shales and sandstone	39	0
Coal, *Lower Freeport*, and shale	14	0
Fire clay and shale	2	0
Sandstone, massive	45	0
Coaly slate, *Upper Kittanning*	4	0

[1]White, I. C., West Virginia Geol. Survey Vol. II, pp. 334-335. 1903.

[2]Stout, W., and Lamborn, R. E., Geol. Survey Ohio, Fourth Series, Bull. 28, p. 55. 1924.

[3]Stout, W., Geol. Survey Ohio, Fourth Series, Bull. 21, p. 124. 1918.

[4]Stout, W., Geol. Survey Ohio, Fourth Series, Bull. 20, p. 607. 1916.

[5]White, I. C., U. S. Geol. Survey Bull. 65, p. 111. 1891.

	Ft.	In.
Sandstone, gray, massive	15	0
Coal, *Middle Kittanning*	1	6
Fire clay, with limestone nodules in upper half	6	0
Total	155	3½

The Freeport coals were named from their occurrence in the locality of the section given above. The Lower and Upper Freeport coals are persistent members, but the Middle Freeport coal is not usually reported in other sections in Pennsylvania and has not been recognized as a distinct member in Ohio. The Upper Kittanning coal is also irregular in its occurrence, and, in Ohio, is present in Columbiana County only.

In the vicinity of Kittanning, Pennsylvania, the succession of the Allegheny series is as follows:

Section near Kittanning, Armstrong County, Pennsylvania[1]

Allegheny series	Ft.	In.
Coal, *Upper Freeport*	4	0
Shale and concealed	35	0
Coal, *Lower Freeport*	2	0
Concealed and massive sandstone	35	0
Shale and sandstone	40	0
Coal, slate in center, *Middle Kittanning*	1	6
Fire clay	4	0
Sandy shales	6	0
Fire clay	3	0
Flaggy sandstone	17	0
Shales, dark, sandy, with iron ore	40	0
Coal, *Lower Kittanning*	3	3
Fire clay	5	0
Sandstone and sandy shales	40	0
Shales and iron ore	5	0
Iron ore, *Buhrstone*		6
Limestone, *Ferriferous*	11	6
Sandy shales	15	0
Coal		3
Sandy shales and sandstone	21	0
Coal, *Clarion*	1	0
Concealed to top of No. XII sandstone	25	0
Total	315	0

This section shows the Allegheny series at the type locality for the Kittanning coals. The total thickness to the base of the formation is 315 feet.

[1]Idem. p. 109.

A general geologic section of the Allegheny series in Clarion County, as given by Mr. Chance in Report VV of the Second Geological Survey of Pennsylvania, is as follows:

Section of Allegheny formation, Clarion County, Pennsylvania[1]

Allegheny series	Ft.	In.
Coal, *Upper Freeport*	4	0
Fire clay	5	0
Limestone, *Upper Freeport*	3	0
Shale, with ore	8	0
Sandstone	25	0
Shale	4	0
Coal, *Lower Freeport*	6	0
Fire clay	2	0
Limestone, *Lower Freeport*	3	0
Sandstone and shales	75	0
Shale	10	0
Coal, *Upper Kittanning*	2	0
Fire clay and shale	3	0
Limestone, *Johnstown Cement bed*	2	0
Shaly measures	40	0
Coal, *Middle Kittanning*	2	0
Fire clay	2	0
Shale and sandstone	30	0
Coal, *Lower Kittanning*	4	0
Sandstone and shale with ore	25	0
Ore, *Buhrstone*	1	0
Limestone, *Ferriferous*	8	0
Shale	7	0
Coal, *Clarion*, with slaty shale	30	0
Fire clay	2	0
Shale and sandstone	27	0
Coal, *Brookville*	2	0
Fire clay	3	0
Massive sandstone, XII	----	----
Total	335	0

The Johnstown Cement rock of this section is not present in the Allegheny formation of Ohio. However, the sandy horizons appearing above and below the Lower Freeport coal are wide spread in their occurrence and have been named the Upper and Lower Freeport sandstones, as they are well developed along the Allegheny River near Freeport, Pennsylvania. These sandstones are represented in some localities in Ohio.

A general section of the part of the Allegheny series exposed in Jefferson County, Ohio, showing the succession and thickness of the members, is given below. The chief differences between the series as developed here and at the type localities along the Allegheny

[1]Chance, H. M., Second Geol. Survey Pennsylvania Rept. VV, p. 32. 1879.

River consist in a thinning of the series, in the absence of the Ferriferous limestone and overlying iron ore, and in the presence of the Washingtonville shale member, which is not represented in the geologic sections of this series in Pennsylvania.

General Section of the Allegheny Series of Jefferson County

	Ft.	In.
Coal, *Upper Freeport or No. 7*	2	8
Clay, plastic, arenaceous	4	0
Limestone, local, *Upper Freeport*	1	0
Clay, flint and plastic, *Bolivar*	5	0
Shale, arenaceous	30	0
Sandstone, local, *Upper Freeport*	16	0
Shale, arenaceous	6	8
Coal, *Lower Freeport or No. 6a*	2	6
Clay, plastic, arenaceous	2	4
Limestone, local, *Lower Freeport*	1	0
Clay, plastic arenaceous	3	0
Sandstone, massive, local, *Lower Freeport*	30	0
Shale with ore nodules	11	0
Shale, black, fossiliferous, *Washingtonville*	1	4
Shale, dark, with ore nodules	6	2
Coal, *Middle Kittanning or No. 6*	2	2
Clay	4	11
Shale and sandstone	25	8
Coal, bony } *Lower Kittanning or No. 5*		0
Coal, good } *Lower Kittanning or No. 5*	2	10
Clay, plastic	5	4
Clay, arenaceous	4	1
Shale and shaly sandstone	66	6
Coal, *Clarion or No 4a*		3
Clay, plastic, arenaceous	3	6
Clay shale, blue	4	2

The surface exposures of the Allegheny series in Jefferson County include all above the Lower Kittanning coal. The general geologic section has been extended to the base of the Clarion clay by adding the record of the shaft at the plant of the Banfield Clay Co., at Irondale.

DESCRIPTION OF MEMBERS

Clarion Coal and Clay

The first coal above the Pottsville series along the Allegheny River was named the Clarion coal by the First Geological Survey of Pennsylvania[1]. Although it is variable in character and thickness, this coal bed and its associated clay form a distinct stratigraphic horizon, 15 to 25 feet below the Ferriferous limestone, which can be traced

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

with little difficulty across Clarion, Butler, and Lawrence counties, Pennsylvania, into Ohio. In this State the coal or its associated clay is persistent in Columbiana and Mahoning counties, uncertain in Stark, Wayne, Tuscarawas, Holmes, Coshocton, and Muskingum counties, again becomes distinct in Perry County, and is traceable through Athens, Hocking, Vinton, Jackson, Gallia, and Lawrence counties to the Ohio River.

In Jefferson County, the Clarion coal and clay do not outcrop at the surface, but the development of the ceramic industry at Irondale has led to the opening of mines in the Clarion clay; therefore the stratigraphic features of these members are well known. The coal varies in thickness from 1 inch to 1 foot, but the associated clay, which is of the plastic variety, ranges from 9 to 12 feet in thickness. At the plant of the McLain Fire Brick Co. at Irondale, W. Stout obtained the following measurements[1]:

		Ft.	In.
Shale		15	0
Shale, calcareous, fossiliferous		1	0
Coal, *Clarion*			3
Clay, gray, plastic	*Clarion*	4	0
Clay, light, arenaceous	*Clarion*	4	0
Clay, dark, plastic	*Clarion*	3	6

The coal and clay are variable in thickness in this mine, the coal having a maximum thickness of 1 foot and the clay of 12 feet.

A sample of clay from this mine, tested in the laboratories at Ohio State University, shows the following chemical and physical properties[2]:

Tests of the Clarion clay from mine of the McLain Fire Brick Co., Irondale, Jefferson County

Chemical analysis			*Percentage oxide ratio*				
Loss at 105° C	1.43	K_2O	.098				
Ignition loss	7.69	Na_2O	.020				
Silica, SiO_2	59.12	CaO	.005			SiO_2	2.542
Alumina Al_2O_3	23.26	MgO	.025	Al_2O_3	1.00	TiO_2	.090
Ferric oxide Fe_2O_3	2.87	FeO	.111			P_2O_5	.004
Lime, CaO	.11	MnO	.000				
Magnesia, MgO	.58		———				
Titanic oxide, TiO_2	2.10	RO	.259				
Phosphorus pentoxide P_2O_5	.09						
Sodium oxide, Na_2O	.48						
Potassium oxide, K_2O	2.27						
Manganese oxide, MnO	trace						
Sulphur, S	.38						
Total carbon, C	.52						
Inorganic carbon, C	.08						

[1]Stout, W., Geol. Survey Ohio, Fourth Series, Bull. 26, pp. 264-265. 1923.
[2]Idem.

Mineralogical examination

Sand separate carries a large amount of primary quartz ranging in size from tiny grains to .2 mm. in diameter. Aggregates in which primary quartz grains are cemented together with clay substance are also plentiful. Muscovite is fairly abundant in the sand separate as bright fragments and also plentiful in the clay as sericite. Rutile is found abundantly disseminated in the clay as tiny needles and limonite as small grains. Other minerals less abundant are pyrite as large fragments in the sand separate, tourmaline, zircon, siderite, and rutile as inclusions in muscovite.

Physical tests

Working properties: Siliceous, practically non-plastic. Dextrine added to facilitate molding and give bonding strength.

Tempering water	12.45 per cent
Drying linear shrinkage	2.93 per cent
Drying volume shrinkage	9.05 per cent

Burning behavior

Burning temperature	Per cent linear shrinkage	Per cent volume shrinkage	Per cent volume absorption	Color
Cone 010	0.56	1.66	19.92	Light buff
Cone 03	1.32	3.90	20.19	Medium buff
Cone 3	1.35	4.01	17.77	Medium buff
Cone 4½	0.61	1.83	15.75	Medium buff
Cone 6	.00	.00	15.40	Dark buff speckled
Cone 9	.050	1.50	9.75	Dark buff speckled
Cone 10	.....	.....	9.45	Brown buff speckled
Cone 12	.....	.....	5.91	Brown buff speckled
Cone 14	.....	.....	1.52	Brown speckled

Overburning temperature: Cone 6 (1,250° C. or 2,282° F.).

Best apparent burning range: Cones 03 to 5 (1,090° C. to 1,230° C. or 1,994° F. to 2,246° F.).

Total linear shrinkage at cone 4½: 3.54%.

Deformation temperature: Cone 23 (1,590° C. to 2,894° F.).

Possibilities: Low heat duty refractories.

The addition of a suitable plastic clay would evidently make this clay valuable for sewer pipe, fire proofing, and face brick. Exceptionally clear uniform color, developing occasional fine iron specks at cone 6.

The Clarion clay is mined at the plant of the Banfield Clay Co., at Irondale. The stratigraphic succession and thickness of the beds are as given below:

		Ft.	In.
Shale and shaly sandstone		68	0
Coal, good	*Middle Kittanning*	2	2
Coal, bony	*Middle Kittanning*		6

		Ft.	In.
Clay, arenaceous, with concretions		5	0
Shale		14	0
Coal, *Lower Kittanning*		3	0
Clay, *Lower Kittanning*		9	0
Shale, shaly sandstone, and covered		65	0
Coal, *Clarion*			3
Clay, plastic	*Clarion*	2	0
Clay, arenaceous	*Clarion*	4	0
Clay shale, blue		8	0

The Clarion clay is also mined at the plants of the East Ohio Sewer Pipe Co. at Irondale, where the clay is used for the manufacture of sewer pipe. This clay was formerly worked at Calumet for the manufacture of sewer pipe and refractory products, but operations in this clay bed there have been abandoned.

Lower Kittanning Clay

The Lower Kittanning clay is the most important clay horizon of the Allegheny series in Ohio, if not of the entire Pennsylvanian system. This rank is due in part to the thickness of the clay, which reaches a maximum of 20 feet; in part to its wide-spread distribution in the eastern part of the State; and finally to its quality, which is unexcelled for the manufacture of many ceramic products. The stratigraphic position of this clay is easily determined as it lies immediately below the Lower Kittanning coal. Although the Lower Kittanning clay in Ohio includes both the flint and plastic varieties, in Jefferson County the material is entirely of the plastic kind. The color varies from a light to a dark gray, and little change in color takes place on weathering, due to the small quantity of impurities in the form of disseminated iron compounds. Weathering, however, does tend to produce a light yellow tint, which is characteristic for this clay bed. The thickness of the Lower Kittanning clay in Jefferson County varies from 5 to 14 feet, with an average of about 9 feet 6 inches, the maximum thickness of 14 feet occurring at Port Homer and Toronto. Exposures of Lower Kittanning clay in the county are limited to the Yellow Creek Valley in Saline Township, and to the Ohio River Valley north of Toronto in Knox Township.

In the northern part of Section 24, Saline Township, J. F. Dando has sunk a shaft to the Lower Kittanning clay and is utilizing this material for the manufacture of fire brick. The clay bed, which consists of both the plastic and arenaceous varieties, has a thickness of 8 feet. At Irondale the Lower Kittanning clay is also mined for

ceramic purposes by the Banfield Clay Co. A representative section of the exposures in the mine is as follows[1]:

		Ft.	In.
Coal, *Lower Kittanning*		3	0
Clay, dark	*Lower Kittanning*	1	2
Clay, light, plastic	*Lower Kittanning*	4	10
Clay shale		3	0

A representative sample of the clay in this mine was taken for testing. The results of the tests are given below:

Test of Lower Kittanning clay from mine of the Banfield Clay Co., Irondale, Jefferson County[2]

Chemical analysis			*Percentage oxide ratio*				
Loss at 105° C	1.35	K_2O	.139				
Ignition loss	8.46	Na_2O	.020				
Silica, SiO_2	55.53	CaO	.006			SiO_2	2.251
Alumina, Al_2O_3	24.67	MgO	.025	Al_2O_3	1.00	TiO_2	.065
Ferric oxide, Fe_2O_3	4.01	FeO	.146			P_2O_5	.008
Lime CaO	.16	MnO	.002				
Magnesia, MgO	.63						
Titanic oxide, TiO_2	1.60	RO	.338				
Phosphorus pentoxide P_2O_5	.20						
Sodium oxide, Na_2O	.49						
Potassium oxide, K_2O	3.42						
Manganese oxide, MnO	.04						
Sulphur, S	.98						
Total carbon, C	.68						
Inorganic carbon, C	.18						

Mineralogical examination

The sand separate consists largely of a rather impure clay aggregate whose quartz grains are small, about .05 mm. in diameter, and not plentiful. Muscovite in cleavage fragments is present in the sand separate but is not abundant. The associated minerals such as tourmaline and zircon are silt-like and are found embedded in a clay matrix.

The clay aggregate contains quartz, sericite, pyrite, and rutile. The pyrite is found as small bright crystals (octahedrons), .01 mm. in diameter, but not all of the clay aggregate contains this mineral. Pyrite is also found in fragments of large crystals broken in sampling the clay. The carbonate present has an index of refraction of the ordinary ray greater than 1.69, indicating ankerite. The clay separate contains abundant sericite and rutile which are finely dispersed as tiny needles.

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[1]Stout, W., and Lamborn, R. E., Geol. Survey Ohio, Fourth Series, Bull. 28, p. 86. 1924.

[2]Stout, W., Geol. Survey Ohio, Fourth Series, Bull. 26, pp. 346-347. 1923.

Physical tests

Working properties: Coarse grained, though fairly plastic. Molds without serious difficulty, contains soluble salts, causing scumming during drying.

Tempering water	15.51 per cent
Drying linear shrinkage	4.20 per cent
Drying volume shrinkage	13.12 per cent

Burning behavior.

Burning temperature	Per cent linear shrinkage	Per cent volume shrinkage	Per cent volume absorption	Color
Cone 010	2.01	5.91	16.96	Cream
Cone 03	3.24	9.41	15.96	Light buff
Cone 2	2.13	6.25	11.11	Dark buff
Cone 4½	.....	.....	9.21	Dark buff
Cone 6	.....	.....	5.44	Gray buff speckled
Cone 9	.....	.....	1.79	Gray buff speckled
Cone 10	.....	.....	1.84	Brown buff speckled

Overburning temperature: Cone 4½ (1,220° C. or 2,228° F.).

Best apparent burning range: Cones 03 to 4 (1,090° C. to 1,210° C. or 1,994° F. to 2,210° F.).

Total linear shrinkage at cone 2: 6.33%.

Deformation temperature: Cone 23 (1,590° C. or 2,894° F.).

Possibilities: Low heat duty refractories doubtful, face brick, fire proofing.

Its low burning temperature makes a doubtful clay for the manufacture of refractories. Scumming not serious enough to be injurious to color.

Along the Ohio River Valley, the Lower Kittanning clay lies so near drainage level that few exposures are available for study except where mines have been opened in this bed. At the plant of the Peerless Clay Manufacturing Co., at Port Homer, the Lower Kittanning clay is used for the manufacture of sewer pipe, flue lining, wall coping, stove pipe, chimney tops, etc. The clay bed lies about 30 feet below track level and is reached by sloping. A geologic section of the beds exposed in the mine is as follows[1]:

		Ft.	In.
Shale, good roof.			
Coal, bony	*Lower Kittanning*	1	0
Coal, good	*Lower Kittanning*	2	8
Clay, dark, hard, somewhat flinty	*Lower Kittanning*	1	6
Clay, light, plastic	*Lower Kittanning*	10	0
Clay, dark	*Lower Kittanning*		10
Clay, light, plastic	*Lower Kittanning*	2	0

[1]Stout, W., Geol. Survey Ohio, Fourth Series, Bull. 26, p. 347. 1923.

The thickness of the clay in this mine is variable but averages about 14 feet.

The Lower Kittanning clay is mined by the Union Clay Manufacturing Co., at Empire, where the plastic clay varies from 4 to 10 feet in thickness and the arenaceous material from 3 to 5 feet. At the plant of the Minor Fire Brick Co., located about midway between Empire and Freemans, the clay has the character and thickness shown in the following section[1]:

		Ft.	In.
Shale		5	0
Coal, *Lower Kittanning*		3	0
Clay, plastic, light gray	*Lower Kittanning*	4	0
Clay, light, arenaceous	*Lower Kittanning*	5	6
Shale, arenaceous.			

A sample of clay from this mine was analyzed and tested with the following results[2]:

Tests of the Lower Kittanning clay from the mine of the Minor Fire Brick Co., Empire, Jefferson County

Chemical analysis		*Percentage oxide ratio*					
Loss at 105° C	1.00	K_2O	.114				
Ignition loss	7.44	Na_2O	.016				
Silica, SiO_2	61.01	CaO	.003			SiO_2	2.893
Alumina, Al_2O_3	21.09	MgO	.014	Al_2O_3	1.00	TiO_2	.076
Ferric oxide, Fe_2O_3	4.27	FeO	.182			P_2O_5	.003
Lime, CaO	.06	MnO	.001				
Magnesia, MgO	.30						
Titanic oxide, TiO_2	1.60	RO	.330				
Phosphorus pentoxide, P_2O_5	.06						
Sodium oxide, Na_2O	.33						
Potassium oxide, K_2O	2.40						
Manganese oxide, MnO	.03						
Sulphur, S	.78						
Total carbon, C	.43						
Inorganic carbon, C	.13						

Mineralogical examination

In the sand separate, primary quartz and muscovite as bright cleavage fragments are abundant and many quartz-clay-sericite aggregates also are present. Pyrite crystals are found embedded in clay substance. Accessory minerals are present in fair amount and arranged in the order of importance are tourmaline, siderite, zircon, rutile, and microcline (rarely).

[1]Stout, W., Geol. Survey Ohio, Fourth Series, Bull. 26, pp. 348-349. 1923.
[2]Idem.

The clay separate carries easily deflocculated clay particles, considerable sericite, (hydromica), and primary quartz fragments. Rutile and pyrite are found embedded in the clay, the former in tiny needles. Siderite is also present in clay separate as very small rounded grains.

Physical tests

Working properties: Not very plastic, coarse, but molds fairly well.

Tempering water .....13.84 per cent
Drying linear shrinkage ..... 3.28 per cent
Drying volume shrinkage .....10.17 per cent

Burning behavior

Burning temperature	Per cent linear shrinkage	Per cent volume shrinkage	Per cent volume absorption	Color
Cone 010	0.57	1.70	19.74	Light buff
Cone 03	1.95	5.75	18.96	Light gray buff
Cone 2	1.53	5.23	18.73	Dark gray buff
Cone 4	1.14	3.38	14.38	Dark gray buff
Cone 5½	1.06	3.14	7.13	Medium gray speckled
Cone 8	.....	.....	2.63	Brown gray speckled
Cone 11	.....	.....	3.00	Brown gray speckled

Overburning temperature: Cone 5½ (1,240° C. or 2,264° F.).

Best apparent burning range: Cones 03 to 4 (1,090° C. to 1,210° C. or 1,994° F. to 2,210° F.).

Total linear shrinkage at cone 4: 4.42 per cent.

Deformation temperature: Cone 23 (1,590° C. or 2,894° F.).

Possibilities: Low heat duty refractories, face brick, sewer pipe, fire proofing.

Above cone 5 the clay burns to a very pleasing background with black iron spots, somewhat resembling granite.

The Lower Kittanning clay is well developed at Toronto where it yields much raw material for the ceramic industry. The plastic part of the bed is worked extensively in the mines of the Kaul Clay Manufacturing Co., and has an average thickness of about 6 feet.

This clay bed is likewise mined at plants Nos. 13 and 14 of the American Sewer Pipe Co., where W. Stout reports the following thickness and structure[1]:

		Ft.	In.
Shale, dark		10	0
Shale, dark, fossiliferous			8
Coal, *Lower Kittanning*		3	2
Clay, light gray, plastic		4	0
Clay, light, very arenaceous		2	6
Clay, dark gray, shaly	*Lower Kittanning*	2	6
Clay, dark gray, ferruginous			3
Clay, shaly, dark, arenaceous		2	0

[1]Stout, W., Geol. Survey Ohio, Fourth Series, Bull. 26, pp. 350-351. 1923.

A sample of clay collected from this mine for physical and chemical tests shows the following characteristics[1]:

Tests of the Lower Kittanning clay from mine of the American Sewer Pipe Co., Toronto, Jefferson County

Chemical analysis

Loss at 105° C.	1.43
Ignition loss	8.11
Silica, SiO_2	58.09
Alumina, Al_2O_3	21.77
Ferric oxide Fe_2O_3	5.45
Lime, CaO	.41
Magnesia, MgO	.65
Titanic oxide, TiO_2	1.10
Phosphorus pentoxide P_2O_5	.02
Sodium oxide, Na_2O	.32
Potassium oxide, K_2O	2.27
Manganese oxide, MnO	.07
Sulphur, S	.54
Total carbon, C	.55
Inorganic carbon, C	.54

Percentage oxide ratio

K_2O	.104				SiO_2	2.668
Na_2O	.015					
CaO	.019					
MgO	.030	Al_2O_3	1.00		TiO_2	.051
FeO	.225					
MnO	.003				P_2O_5	.001
RO	.396					

Mineralogical examination

The sand separate contains abundant quartz and quartz-clay aggregates. Muscovite is plentiful in this sand as clear cleavage fragments and is also found in both separate and undispersed clay aggregates as fibrous sericite. Siderite is plentiful as broken fragments of large crystals. Pyrite is common as bright splendent crystals, generally as octahedrons or octahedrons modified as cubes. These crystals range in size from .002 to .02 mm. and are found embedded in the clay. Zircon, biotite, and chlorite occur as accessory minerals in the sand separate.

The clay separate carries as accessory minerals: siderite, rutile (as needles, some twinned), and sericite.

Outstanding characteristics of this clay are the presence of considerable quartz, muscovite, siderite, and pyrite, and the rather rare occurrence of the other accessory minerals.

Physical tests

Working properties: Coarse-grained, not very plastic, works fairly weil. contains soluble salts, responsible for scumming in drying.

Tempering water	12.59 per cent
Drying linear shrinkage	2.71 per cent
Drying volume shrinkage	8.34 per cent

[1]Stout W., Geol. Survey Ohio, Fourth Series, Bull. 26, pp. 350-351. 1923.

Burning behavior

Burning temperature	Per cent linear shrinkage	Per cent volume shrinkage	Per cent volume absorption	Color
Cone 010	0.45	1.33	20.70	Light buff
Cone 03	1.69	4.99	20.25	Medium buff
Cone 3	1.58	4.67	17.13	Medium buff
Cone 5	2.52	7.37	13.87	Gray buff
Cone 6	.....	.....	5.26	Dark gray speckled

Overburning temperature: Cone 6 (1,250° C. or 2,282° F.).

Best apparent burning range: Cones 03 to 5 (1,090° C. to 1,230° C. or 1,994° F. to 2,246° F.).

Total linear shrinkage at cone 5: 5.23 per cent.

Deformation temperature: Cone 17 (1,470° C. or 2,678° F.).

Possibilities: Face brick, sewer pipe, fire proofing.

The Lower Kittanning clay at Toronto is also used in plants Nos. 1 and 2 of the Toronto Fire Clay Co. for the manufacture of building brick and low grade refractory ware. The entire bed is used for the manufacture of brick, but only the upper part is utilized in the making of refractory ware. The clay bed, which is highly arenaceous, has a thickness of about 14 feet.

Lower Kittanning Coal

The Kittanning coal was named by H. D. Rogers of the First Geological Survey of Pennsylvania for the town of that name along the Allegheny River, in Armstrong County[1]. Later the names Upper and Middle Kittanning were introduced for coal beds above the Kittanning coal, and the term Lower Kittanning was used for the coal which had previously been named Kittanning. The Lower Kittanning coal with the accompanying clay is of wide extent in Pennsylvania, where it becomes a valuable economic asset. In West Virginia this coal bed is more irregular in its occurrence, but has been identified from Monongalia and Preston counties as far south as Nicholas and Fayette counties. In Ohio it extends with a few interruptions entirely across the State from Columbiana County on the east to Lawrence County on the south.

The Lower Kittanning coal outcrops in the northern part of Jefferson County where it is locally known as the "Creek Vein," but the position of the bed is so near water level that the regional dip soon carries it below drainage. Exposures of this coal bed occur along Yellow Creek from its mouth to Section 32, Saline Township, and along the Ohio River as far south as Toronto, Knox Township.

[1]Rogers, H. D., Geology of Pennsylvania, Vol. II, Pt. 1, p. 491. 1858.

The Lower Kittanning coal is regular in its occurrence in Jefferson County, consisting of a single block without noticeable partings. It is bright in appearance but contains a high percentage of sulphur in the form of finely disseminated pyrite. The thickness varies from 2 feet 6 inches to 5 feet 5 inches, but averages about 3 feet. In Jefferson County the Lower Kittanning coal lies on an average about 30 feet below the Middle Kittanning coal and 155 feet below the top of the Allegheny series.

The Lower Kittanning coal was formerly mined by the Yellow Creek Coal Co., in Section 13, Saline Township. A measurement of the outcrops near the mouth of the mine is as follows:

	Ft.	In.
Shale	20	0
Coal, *Middle Kittanning*	2	6
Shale and covered	30	0
Shale, bony		8
Coal, *Lower Kittanning*	3	6
Clay, unmeasured.		

A little farther west in Section 13, Lower Kittanning coal, 2 feet 6 inches in thickness, was formerly worked by the Saline Coal Co., but operations have been abandoned. At Hammondsville this coal was likewise the source of fuel for local consumption for many years although here too the mines have been abandoned. The Banfield Clay Co., at Irondale, formerly mined the Lower Kittanning coal and used the fuel for the burning of ceramic products, but due to bad engineering practice, "squeezes" developed in the mine and mining was discontinued. In the northwestern part of Section 26, Saline Township, Lower Kittanning coal is mined and used for fuel by the East Ohio Sewer Pipe Co. The coal bed at this place was sampled for chemical analysis by J. H. Hance in 1916. A section of the coal bed at the place of sampling is given below[1]:

	Ft.	In.
Coal		4½
Clay		½
Coal		9½
Clay and pyrite, rejected		⅜
Coal		10½
Clay and pyrite, rejected		1
Coal	1	1½
Pyrite, coal, and clay, rejected		2¾

[1]U. S. Bureau of Mines Bull. 193, p. 209. 1922.

The sample was analyzed with the following results[1]:

Proximate analysis

	As received	Moisture free
Moisture	2.21	.....
Volatile matter	39.63	40.53
Fixed carbon	47.50	48.57
Ash	10.66	10.90
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	71.04	72.65
Hydrogen	5.28	5.14
Nitrogen	1.34	1.37
Oxygen	6.72	4.87
Sulphur	4.96	5.07
Ash	10.66	10.90
	100.00	100.00

Air drying loss ..... 0.7 per cent

		As received	Moisture free
Heating value	Calories	7,236	7,400
	B. t. u.	13,025	13,320

The Lower Kittanning coal is exposed in a number of clay mines along the Ohio River Valley as far south as Toronto. At the mine of the Peerless Clay Manufacturing Co., at Port Homer, the Lower Kittanning coal occurs as a single block 2 feet 8 inches in thickness, capped by one inch of bone coal; in the mine of the Union Fire Clay Co., the thickness is 2 feet 3 inches overlain by 3 inches of bone coal; whereas at the opening belonging to the American Sewer Pipe Co., at Toronto, the coal measures 3 feet 2 inches.

The Lower-Middle Kittanning Coal Interval

The interval between the Lower and Middle Kittanning coals in Ohio is composed generally of dark bluish-gray shale through which kidney-shaped concretions of ferrous carbonate are arranged in zones or distributed irregularly throughout the shale mass. In Ohio this normal shale interval varies from 17 to 40 feet. In some localities, however, this shale gives way in part or entirely to sandstone which is restricted in areal extent and is lens-like in form. With the introduction of sandstone between these coal beds the interval may remain normal in thickness for that region, may be greatly expanded, or one of the coal beds may be displaced. Sandstone between the Lower and Middle Kittanning coals is of common occurrence in the eastern part of West Virginia, especially in Webster and Nicholas counties, where it is known as the East Lynn sandstone.

In Jefferson County shale is the usual type of rock found between the Kittanning coals. At one locality, however, namely in

[1]U. S. Bureau of Mines, Bull. 193, p. 209. 1922.

the southwestern part of Section 35, Saline Township, a bed of sandstone occurs between these coals and this sandstone has been quarried on a commercial scale and is therefore worthy of consideration. The following measurements obtained in the quarry pit and along the ravine near by show the stratigraphic relations of this sandstone:

		Ft.	In.
Shale, dark, fissile		4	0
Coal, shaly at top	*Lower Freeport*	1	4
Parting			½
Coal, fair		1	0
Clay, bluish, arenaceous		4	2
Sandrock, micaceous			6
Shale, gray, arenaceous		2	0
Covered interval		9	4
Clay shale		10	0
Shale, fossiliferous, *Washingtonville*		1	1
Clay shale, dark		5	3
Coal, good	*Middle Kittanning*		7
Parting			1½
Coal, good			6
Clay, dark, arenaceous		2	5
Sandstone		1	9
Sandstone, massive		25	0
Covered interval		15	0
Coal, *Lower Kittanning*		2	6
Clay		8	0

The sandstone between the Kittanning coals has been quarried by the Empire Pulp Stone Co. of Empire, for the manufacture of pulp stones for the grinding of wood pulp. The stone is heavy bedded, uniformly coarse grained, and contains a little mica. The cementing material is in part iron oxide. When first visited by the writer in 1923, the quarry was operating on a commercial basis, but the increase in the overburden so increased the cost of quarrying that operations were later suspended.

Middle Kittanning Clay

The Middle Kittanning clay derives its name from its close association with the Middle Kittanning coal which is invariably present immediately below. In Ohio this clay bed is even more persistent than the associated coal for, in many localities where the latter is absent, the clay occurs in normal or in only slightly diminished thickness. Outcrops of the member are found along a belt of varying width extending from Columbiana County to Lawrence.

In Jefferson County outcrops of Middle Kittanning clay are limited to Saline and Knox townships where the member lies near drainage level. The bed has a thickness varying from 1 to 8 feet, with an average of about 7 feet. On fresh exposure the material has a characteristic bluish color, but oxidation incidental to weathering may cause a bleaching of the clay due to the removal of dark organic material, and where iron compounds are present, a yellowish brown tint is produced. The clay is arenaceous and low in plasticity. Due to the superior qualities of the Lower Kittanning clay, which is well developed in this county, the Middle Kittanning clay is not utilized for the manufacture of ceramic products.

In Saline Township the Middle Kittanning clay outcrops at a number of localities along Yellow Creek. At the mouth of the stream in Section 8, it lies at the level of the railroad tracks; in Section 13, the clay is well developed with a thickness of about 5 feet. No exposures of this member are found in the vicinity of Hammondsville, but at Cream City and Irondale the clay has a thickness of 8 feet 10 inches and 7 feet respectively. In both of these localities the material is arenaceous and ferruginous. The clay is also characteristically developed in the southwestern part of Section 35 where it has a thickness of 2 feet 6 inches.

In Knox Township the horizon of the Middle Kittanning clay lies near drainage level and as a result is generally covered with surface debris. In Section 31, however, a few inches of clay exposed below the Middle Kittanning coal indicates the general position of this member.

Middle Kittanning Coal

The next important member above the Lower Kittanning coal is the Middle Kittanning coal, so named by Lesley of the Second Geological Survey of Pennsylvania. This coal bed with its accompanying clay, although more variable in thickness, is no less important stratigraphically than the Lower Kittanning member. It enters Ohio from Pennsylvania, where it is a persistent element of the Allegheny series, and can be traced almost continuously across Ohio to the Ohio River; and locally, in the Hocking River Valley, it becomes the thickest coal bed in Ohio.

In Jefferson County the Middle Kittanning coal lies, on an average, about 31 feet above the Lower Kittanning. The part of the county over which it outcrops is therefore essentially the same as for the Lower Kittanning coal. The thickness of the bed varies from a few inches to 2 feet 6 inches, but averages about 2 feet 3 inches. North of Yellow Creek, in Saline Township, where the coal is present

in greatest thickness and purity, it consists of a single bench without partings. South of Yellow Creek, however, the lower part of the coal bed becomes shaly and impure, whereas over a few small areas the coal is wanting.

In that part of Saline Township which lies north of Yellow Creek, the Middle Kittanning coal is persistent, ranging in thickness from 1 foot 8 inches to 2 feet 6 inches. At Yellow Creek Station, Middle Kittanning coal 1 foot 8 inches in thickness outcrops in the bank a few feet above the railroad track. Along Rocky Run in Section 14, where it was formerly mined in a small way, this coal bed thickens to 2 to 4 inches. The Middle Kittanning coal has been worked extensively in the northern half of Section 13 by the Yellow Creek Coal Co. and the Saline Coal Co. The bed in these mines has a thickness of 2 feet 6 inches, is without partings, and is of good quality. The following section, measured near the mine of the Saline Coal Co., illustrates the stratigraphic relations of the Middle Kittanning coal:

	Ft.	In.
Coal, *Upper Freeport*	3	6
Sandstone, shale, and covered	57	0
Shale, black	1	0
Coal, *Lower Freeport*	2	8
Sandstone, shale, and covered	55	0
Shale, black	5	0
Sulphur band		1
Coal, *Middle Kittanning*	2	6
Clay, arenaceous	5	0
Shale	17	0
Coal, *Lower Kittanning*	2	6
Clay, unmeasured.		

Middle Kittanning coal, 2 feet 6 inches in thickness, outcrops at water level along Yellow Creek in the northern part of Section 24 near the brick plant of F. J. Dando. The interval to the Lower Freeport coal is about 60 feet. The Middle Kittanning coal was also formerly mined at Hammondsville for the manufacture of coke. The coke industry has long since passed away, but the coal is still worked in a small way for local consumption. Along a steep bank on the south side of Yellow Creek, in Section 26, Middle Kittanning coal outcrops 2 feet 4 inches in thickness, and lies about 24 feet above the Lower Kittanning coal. At the Cream City mine at Cream City, the Middle Kittanning coal occurs as a single block without partings, 2 feet 4¼ inches in thickness. The coal in this mine was

sampled for chemical analysis by J. H. Hance[1] in 1916. The results of the analysis are as given below:[2]

Proximate analysis

	As received	Moisture free
Moisture	2.64	.....
Volatile matter	36.75	37.75
Fixed carbon	49.46	50.80
Ash	11.15	11.45
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	71.04	72.97
Hydrogen	5.26	5.10
Oxygen	8.99	6.82
Nitrogen	1.49	1.53
Sulphur	2.07	2.13
Ash	11.15	11.45
	100.00	100.00

Air drying loss ..... 0.7 per cent

		As received	Moisture free
Heating value	Calories	7,158	7,352
	B. t. u.	12,884	13,234

Other analyses of the Middle Kittanning coal from various localities in Saline Township are given below:

	No. 1	No. 2	No. 3
Moisture	1.89	1.20	.90
Volatile matter	37.17	31.60	30.70
Fixed carbon	53.67	55.00	55.40
Ash	7.27	12.20	13.00
Sulphur	.72	2.36	2.03

No. 1, W. H. Wallace and Sons mine, Hammondsville. Geol. Survey Ohio, Vol. V, p. 209. 1884.

No. 2, Strip Vein, Irondale, Geol. Survey Ohio, Vol. III, p. 779. 1878.

No. 3, Strip Vein, Hammondsville. Idem.

Few exposures of Middle Kittanning coal are found in Saline Township south of Yellow Creek and little prospecting for this bed has been carried on. An outcrop near the mouth of Yellow Creek in Section 7, however, shows 1 foot 9 inches of clean coal.

In many localities along the Ohio River Valley the Middle Kittanning coal is replaced by sandstone and arenaceous shale. A good exposure of this member, however, occurs in the pit of the Empire Pulp Stone Co., in the west part of Section 35, Saline Township. The bed has a thickness of 1 foot 2 inches and is separated near the middle into two blocks by a clay band 1 inch in thickness. The elevation of the coal bed at this locality is about 740 feet. In Knox Township the Middle Kittanning coal is exposed near drainage level

[1]United States Bureau of Mines, Bull. 193, p. 207. 1922.

[2]Idem. p. 51.

along Croxton Run in the southeastern part of Section 32. It is shaly and impure in character with a thickness of about 12 inches.

Washingtonville Shale

A few feet above the Middle Kittanning coal is a thin bed of fossiliferous shale, named by Stout and Lamborn the Washingtonville shale from exposures near Washingtonville, Columbiana County, Ohio. The original description is as follows[1]:

"The Washingtonville is a bony, carbonaceous shale, varying in color from a dark slaty gray to black. It is hard and tough and resistant to the weathering agencies. It decays by breaking up into thin plates, which through oxidation are changed to a brownish color. On the outcrop it is regularly divided into regular prismatic blocks by joint planes which are spaced about as far apart as the bed is thick. The fauna is everywhere marine. In places the material is very fossiliferous whereas in other localities it is only sparingly so. The fossils may be confined to certain zones in the shale or be present throughout the entire mass. In the fresh material they are well preserved, but in weathered shale they are usually indistinct or totally obliterated."

The Washingtonville shale member is generally present in Saline Township, Jefferson County, where it lies on an average about 6 feet above the Middle Kittanning coal. Its thickness varies from a few inches to 2 feet, but averages about 1 foot 6 inches. Shale representing this member is exposed in the bank a few feet above the level of the railroad tracks at Yellow Creek station. The bed is also exposed along the road in Section 7, where it has a thickness of 1 foot 3 inches and lies 8 feet above the Middle Kittanning coal. When traced westward along Yellow Creek, the Washingtonville shale retains its character and thickness. At Cream City it measures 2 feet and lies about 6 feet above the Middle Kittanning coal. Fossils were collected from this horizon at a good exposure along the road at the southern edge of Irondale, in Section 26, Saline Township. A measurement of the exposure is given below:

		Ft.	In.
Shale with ore nodules		41	6
Shale, black, fossiliferous, *Washingtonville*		2	3
Shale with ore nodules		5	4
Coal, *Middle Kittanning*		2	4
Clay, arenaceous, ferruginous		7	2
Shale, gray, arenaceous, with ore nodules		16	6
Coal, bony	*Lower Kittanning*		2
Coal		2	10
Clay, plastic		4	2

[1]Stout, W., and Lamborn, R. E., Geol. Survey Ohio, Fourth Series, Bull. 28, p. 176. 1924.

The different fossil forms identified from the Washingtonville at this locality are listed below:

Serpulopsis insita (White)

Lingula carbonaria Shumard
Chonetes mesolobus var. decipiens Girty
Marginifera muricata (Norwood and Pratten)

Solenomya radiata Meek and Worthen
Nucula beyrichi von Shauroth
Nuculopsis ventricosa (Hall)
Deltopecten eaglensis Price?

Euphemus carbonarius (Cox)
Sphaerodoma intercalaris Meek and Worthen?

Pseudorthoceras knoxense (McChesney)
Metacoceras sp.

Few exposures of the Washingtonville member occur along the Ohio River Valley, but the following record, showing the stratigraphic features of this bed, was secured in the southeastern part of Section 5, Saline Township:

	Ft.	In.
Coal, *Lower Freeport*	2	4
Clay, arenaceous	4	2
Sandrock, micaceous		6
Shale, arenaceous	2	0
Covered interval	9	4
Clay shale	10	0
Shale, dark, fossiliferous, *Washingtonville*	1	1
Shale, dark	5	3
Coal, *Lower Freeport*	1	2

In Knox Township a few inches of Washingtonville shale is exposed along Jeremy Run in the northern part of Section 33.

Lower Freeport Sandstone

The Lower Freeport sandstone has a wide distribution in the Appalachian field and, according to I. C. White[1], is never less than 30 feet in thickness in Pennsylvania, but is present in much greater thickness in West Virginia. In Ohio this sandstone is irregular in its occurrence. The stratigraphic limits placed on this member are the Upper Freeport clay above and the Middle Kittanning coal below, but in some localities it replaces the latter member and extends down to the Lower Kittanning coal.

[1]White, I. C., U. S. Geol. Survey, Bull. 65, p. 163. 1891.

In Jefferson County the Lower Freeport sandstone does not exceed 45 feet in thickness and is usually much less. Where best developed it is a heavy-bedded, coarse-grained sandstone, but as it thins it becomes fine grained with admixtures of clay material until it finally grades into sandy shale. The color is bluish-gray, but weathering oxidizes the iron compounds present in the stone and changes the color to a yellowish-brown.

The Lower Freeport sandstone is generally present in Saline Township north of Yellow Creek, but south of this stream it passes into arenaceous shale interbedded with a few thin layers or lenses of sandstone. At the mouth of Yellow Creek, in Section 8, Saline Township, this member is a heavy-bedded, coarse-grained stone measuring 42 feet in thickness. In the northern part of Section 14 it is thin-bedded, with shale partings, and measures 20 feet in thickness. At Irondale it is soft and friable and has a thickness of 8 feet. The stratigraphic relations of this sandstone to the other members of the Allegheny series are shown in an indefinite manner in geologic sections from the Banfield Clay Co. property and from the Saline Coal Co. property on page 20 of this bulletin.

Lower Freeport Limestone

The Lower Freeport limestone is everywhere patchy and irregular in its occurrence. This member has been recognized at many places in southwestern Pennsylvania and has been identified at widely separated localities in West Virginia and Ohio, but wherever found, it is thin. In Butler County, Pennsylvania, this horizon is known as the Butler limestone.

In Jefferson County of this State the Lower Freeport limestone is found at only a few localities. Its position in the stratigraphic column is a few feet below the Lower Freeport coal. At some localities it is found at the base of the clay bed associated with this coal, but usually it is embedded in the clay in the form of distinct layers or nodular masses. This limestone has a gray to dark bluish-gray color, which, on weathering, changes to buff. It is hard, compact, and usually nodular in appearance. In Section 6, Brush Creek Township, the Lower Freeport limestone outcrops as a single layer 1 foot 6 inches in thickness, as shown in the following record:

	Ft.	In.
Shale, dark	8	0
Coal, *Lower Freeport*	2	11
Clay, bluish-gray, arenaceous	2	0
Limestone, nodular, *Lower Freeport*	1	6
Clay, arenaceous	4	0
Sandrock	2	0

Along Brimstone Run in Section 7, Saline Township, the Lower Freeport limestone has a thickness of 1 foot 8 inches, and lies about 4 feet below the Lower Freeport coal. A common mode of occurrence of this limestone is well illustrated in the following interesting record measured in the southeastern part of Section 25, Saline Township:

		Ft.	In.
Shale, dark			7
Coal, shaly	*Lower Freeport*		9
Coal, poor	*Lower Freeport*	1	9
Clay, arenaceous		1	5
Clay with nodular limestone	*Lower Freeport*		10
Clay, bluish-gray, arenaceous	*Lower Freeport*	3	4
Clay with nodular limestone	*Lower Freeport*	1	6
Clay, bluish-gray, arenaceous, shaly		5	2
Sandstone, argillaceous		1	0
Shale		1	0

Only one exposure of Lower Freeport limestone was found in Knox Township. This was in the northeastern part of Section 21, where it consists of a nodular layer, 10 inches in thickness, and lies 1 foot below the Lower Freeport coal.

The association and irregular occurrence of the Lower Freeport limestone suggests a fresh or brackish water origin. It has been carefully examined at various localities in the county for fossils, but *Spirorbis anthracosia* Whitfield only has been found. This form, however, is fairly abundant.

Lower Freeport Clay

The Lower Freeport clay, which lies immediately below the Lower Freeport coal, is well represented in Jefferson County, although at a few localities shale is found immediately below the coal. The clay is gray to bluish gray in color, but on weathering becomes yellowish brown or buff. Impurities in the form of iron compounds and calcium carbonate are present in the clay either in disseminated form or as nodular, concretionary masses. The clay is of both the plastic and flint varieties, but the plastic type is the more common form. Where the Lower Freeport limestone is present in the section, it is usually found embedded in this clay. The maximum thickness of the Lower Freeport clay is about 13 feet, but the average does not exceed 5 or 6 feet. In Jefferson County this clay is exposed above drainage in Saline, Brush Creek, Springfield, Ross, Knox, and Island Creek townships.

In Saline Township, the Lower Freeport clay is present with a thickness ranging from a few inches to 10 feet. It is chiefly of the plastic type, although at a few localities flint clay is found on this

horizon. The stratigraphic features of this member are shown in the following section measured near the plant of the East Ohio Sewer Pipe Co. at Irondale:

		Ft.	In.
Coal, *Upper Freeport*		3	6
Sandstone and covered		65	0
Coal, *Lower Freeport*		1	0
Clay, arenaceous	*Lower Freeport*	5	10
Shale, arenaceous		3	0
Shale, carbonaceous			2
Clay, arenaceous		4	5
Sandstone, thin-bedded		8	4
Shale, gray		2	0
Shale, carbonaceous			2
Shale, with iron ore nodules		41	6
Shale, fossiliferous, *Washingtonville*		2	3
Shale with iron ore nodules		5	4
Coal, *Middle Kittanning*		2	4

The Lower Freeport clay shown in the above section is abnormally developed for this county as it is broken into two parts by a few feet of sandy shale. A sample of Lower Freeport clay, taken for analysis at an exposure near the plant of F. J. Dando at Hammondsville, shows the following composition[1]:

Lime, CaO	2.70
Magnesia MgO	.61
Titanic oxide, TiO_2	.64
Potassium oxide, K_2O + Sodium oxide, Na_2O	4.24
Fusion point	2,318°F.
Loss at 105° C	.....
Ignition loss	6.66
Silica, SiO_2	53.53
Alumina, Al_2O_3	23.58
Ferric oxide, Fe_2O_3	4.12

In Brush Creek Township, the Lower Freeport clay is above drainage in Sections 6 and 12, where it is very arenaceous and impure. The same features prevail at the few exposures of this clay along Yellow Creek in Ross Township. In Knox Township the Lower Freeport clay is thin and poorly developed. The best exposure is found in Section 31, where the bed is very sandy with a thickness of about 5 feet. The clay is also exposed along Island Creek, in sections 4 and 34, Island Creek Township, where it is quite variable in thickness, and is arenaceous and impure.

At no place in Jefferson County is the Lower Freeport clay utilized in a commercial way. The arenaceous character of the clay and

[1]Stout, W., Geol. Survey Ohio, Fourth Series, Bull. 26, p. 424. 1923.

the abundance of harmful ingredients, such as limestone nodules and various iron compounds, render it unfit for the manufacture of ceramic products; and, therefore, it adds nothing to the economic wealth of the county.

Lower Freeport Coal

The Lower Freeport coal derives its name from its occurrence near Freeport, Armstrong County, Pennsylvania, where it was originally described by H. D. Rogers of the First Geological Survey ot Pennsylvania[1]. This coal bed is one of the most distinct and well-marked horizons of the upper part of the Allegheny series. It is wide spread in its occurrence in southwestern Pennsylvania, and has been identified over large areas in West Virginia as far south as Cabell County. In Ohio it is known in every county, although not continuous, from Columbiana and Jefferson on the north to Lawrence on the south.

In Jefferson County, the Lower Freeport coal, or Roger coal, as it is known in this region, is quite variable in character and thickness. Where typically developed, it is broken a little below the middle by a clay shale parting or by a thin band of bone coal which varies from a fraction of an inch to 4 inches in thickness. Both the upper and lower benches of the coal are of about equal quality where the coal bed is at its best, but where a thinning of the bed occurs, the upper bench becomes shaly in character, or gives way to black shale interstratified with thin coal bands. The bed varies in thickness from a few inches to 5 feet, but an average of 27 measurements is 2 feet 6 inches. The position of the Lower Freeport coal in Jefferson County is, on an average, about 65 feet below the Upper Freeport coal, 55 feet above the Middle Kittanning coal, and 87 feet above the Lower Kittanning coal. The horizon of this coal lies above drainage in Saline, Brush Creek, Ross, Knox, and Island Creek townships. It was formerly mined at many places in this county, but the chief centers of activity at the present time are in the Yellow Creek Valley near Amsterdam, Springfield Township, and in the Ohio River Valley near Steubenville.

Saline Township

The Lower Freeport coal is above drainage along Yellow Creek in Saline Township as far as the northern part of Section 29. The elevation of the coal ranges from 740 feet in Section 7 to 770 feet in

[1]Rogers, H. D., Geology of Pennsylvania, Vol. II, Pt. I, p. 595. 1858.

Section 35 along the eastern margin, and from 810 feet in Section 32 to 703 feet in Section 29 in the western part of the township. The coal is generally present along the line of its horizon in this township, but it varies in thickness from a few inches to nearly 3 feet. In the western part of Section 13, the Lower Freeport coal was formerly worked for railroad shipment by the Saline Coal Co. At this place it has a thickness of 2 feet 8 inches and lies about 58 feet below the Upper Freeport coal and 60 feet above the Middle Kittanning coal. A good exposure of Lower Freeport coal occurs in the central part of Section 24, where the following record was secured:

	Ft.	In.
Shale and sandstone, not measured.		
Coal blossom, *Lower Freeport*		6
Clay, arenaceous, ferruginous	5	0
Sandstone with shale partings	21	6
Shale, gray, with iron ore nodules	15	0
Coal, *Middle Kittanning*	2	4
Covered		10
Shale, carbonaceous		10
Clay, arenaceous, with iron ore nodules	5	0

At Cream City, the Lower Freeport coal is mined by the McLain Fire Brick Co. and used for the burning of the brick. The rock succession at this place is as follows:

	Ft.	In.
Coal, *Upper Freeport*	1	4
Sandstone, shale, and covered	40	0
Shale, gray, arenaceous	20	0
Coal, *Lower Freeport*	2	8
Covered	30	0
Shale, gray	15	0
Shale, fossiliferous, *Washingtonville*	2	0
Shale, dark, with ore nodules	6	4
Coal, *Middle Kittanning*	2	0

Lower Freeport coal was formerly mined by the Banfield Clay Co. at Irondale, but the coal was variable in thickness, and, for this reason, the mine was abandoned. The coal in this mine was sampled for chemical analysis in 1916 by J. H. Hance, who reported the following structure[1]:

	Ft.	In.
Clay shale, rejected		1½
Bone and pyritiferous coal, rejected		3
Pyrite, sandy band, rejected		2⅛

[1]U. S. Bureau of Mines, Bull. 193, p. 208. 1922.

	Ft.	In.
Coal	1	1¾
Clay and pyrite, rejected		1
Coal	1	2

This section was measured 250 feet south 10° west from main entry mouth, where there was 120 feet of cover.

The coal sample was analyzed and shows the following composition[1]:

Proximate analysis

	As received	Moisture free
Moisture	4.26	
Volatile matter	35.55	37.13
Fixed carbon	48.10	50.24
Ash	12.09	12.63
	100.00	100.00
Sulphur	2.36	2.46

Air drying loss.....2.5 per cent

		As received	Moisture free
Heating value	Calories	6,941	7,250
	B. t. u.	12,494	13,050

The Lower Freeport coal is normally developed along Salt Run in the western part of Section 32, where it has a thickness of 2 feet 3 inches. This coal has been opened at a number of places along Brush Creek, but it is usually thin and of poor quality. In Section 25 the bed has a thickness of 2 feet 6 inches, but the upper bench is very shaly. A measurement in an old opening in the northern part of Section 30 shows 2 feet 6 inches of good coal. In the south central part of Section 30, Lower Freeport coal lies near water level on Yellow Creek and together shows the following measurements:

		Ft.	In.
Coal blossom, *Upper Freeport*			6
Clay, gray		3	0
Covered interval		52	0
Shale, dark		1	0
Shale with shaly coal			2
Coal	*Lower Freeport*	1	4
Shale and shaly coal			2
Coal		1	2
Clay, arenaceous			2

The Lower Freeport coal is generally present in that part of Saline Township which lies south of Yellow Creek, but it is of an inferior quality. An exposure in Section 7 shows 2 feet 6 inches of

[1]U. S. Bureau of Mines, Bull. 193, p. 51. 1922.

coal overlain by black shale with thin coal bands. Along Brimstone Run the coal measures 10 inches in thickness and is closely overlain by the Upper Freeport sandstone. A test opening in this bed was made at Port Homer, but due to the poor showing, operations were soon abandoned. In the southwestern part of Section 35, Lower Freeport coal, 2 feet 4 inches in thickness, outcrops along a small ravine at an elevation of 763 feet. The bed has the structure characteristic of this coal, but the upper bench is very shaly. The Lower Freeport coal at this place lies 24 feet above the middle Kittanning and 73 feet below the Upper Freeport.

Brush Creek Township

In Brush Creek Township, the Lower Freeport coal is above drainage along Brush Creek as far west as the eastern edge of Section 18. In the south central part of Section 6 this coal bed has a thickness of 2 feet 11 inches, but is of poor quality. A number of openings have been made in Section 12, but all have been abandoned. The following measurements were obtained at one of these openings located on the north side of the stream:

		Ft.	In.
Shale, dark		5	0
Shale, carbonaceous			5
Coal with thin bands of black shale	*Lower Freeport*	1	3
Coal, poor	*Lower Freeport*	1	3
Clay			2

At this place Lower Freeport coal has an elevation of 825 feet above tide. On the south side of Brush Creek, in the eastern part of Section 12, the coal measures 1 foot 9 inches in thickness and is overlain by 11 inches of black shale and shaly coal. At this locality the interval to the Upper Freeport is about 44 feet.

Ross Township

The Lower Freeport coal lies very close to drainage level along Yellow Creek in Ross Township. In Section 4 this coal has an elevation of 775 feet and lies about 20 feet above water level along Yellow Creek. It passes beneath drainage, however, in the west central part of Section 4, but due to a variation in the dip of the rocks, it rises in the western part of Section 10 and is exposed at a few places along the stream as far as the northeastern corner of Section 28. At this place it again passes below drainage level to emerge again in the southern part of Section 34. In Section 4, the Lower Freeport coal is represented by a thin blossom which outcrops about 40 feet below

the Upper Freeport coal. In the southern part of Section 23, the full thickness of this coal bed is exposed along Yellow Creek as indicated in the following geologic section:

		Ft.	In.
Shale, gray, arenaceous		10	0
Coal	*Lower Freeport*	1	2
Coal, bony	*Lower Freeport*		½
Coal	*Lower Freeport*	1	10
Clay shale		1	0

In Section 34, the Lower Freeport coal lies at water level near the bridge across Yellow Creek. A quarter of a mile west of this exposure, a small country bank has been opened in this coal which has the characteristics given below:

		Ft.	In.
Shale, dark		15	0
Coal	*Lower Freeport*	1	1
Coal, bony	*Lower Freeport*		1
Coal	*Lower Freeport*	1	6
Clay, dark			6

Springfield Township

In Springfield Township, the Lower Freeport coal lies a few feet below the creek level in Section 4, but rises a few feet above water level at the western edge of Bergholz, in Section 10. Due to the strong southerly dip of the rocks in this locality, the coal again passes below drainage near the railroad bridge a quarter of a mile south of town. At Bergholz, the Lower Freeport coal was worked for a number of years for railroad shipment at the XL mine of Blackburn Coal Co. The following record shows the thickness of the coal and its stratigraphic relation to the rocks exposed in the hill above the mine opening:

		Ft.	In.
Shale, black, fossiliferous, *Brush Creek*		10	0
Sandstone and covered		30	8
Clay shale, reddish		5	6
Covered interval		30	0
Clay, light, arenaceous		1	0
Covered interval		25	10
Clay, ferruginous, arenaceous, *Upper Freeport*		10	4
Covered interval		7	8
Clay, flinty, *Bolivar*		1	4
Covered interval		29	4
Shale and shaly sandstone		20	0
Coal, shaly	*Lower Freeport*		1
Coal, good	*Lower Freeport*	2	11
Clay			6

The elevation of the Lower Freeport coal at this place is about 876 feet, or 11 feet above water level in Yellow Creek. A measurement of this coal at the railroad bridge over Yellow Creek in the southeastern part of Section 10 is as follows:

		Ft.	In.
Sandstone and covered		16	0
Coal, good	*Lower Freeport*	1	2
Coal, bony			½
Coal, good		2	0
Clay, unmeasured.			

The Lower Freeport coal is above drainage along Elkhorn Creek in the northwestern part of Section 9 and in the southwest part of Section 10. Where this bed outcrops along the road in Section 10, it has a thickness of 3 feet 11 inches of good coal. In the eastern part of Section 15, the Goat Hill Coal Co., formerly known as the Blackburn Coal Co., has sunk a shaft to the Lower Freeport coal, which they are mining for railroad shipment. The coal is reported by miners to vary from 2 feet 6 inches to 5 feet in thickness. A thin band of impure bone coal, 1 inch to 2 inches in thickness, is generally present about 1 foot from the bottom of the bed. At the Eastern Ohio mine of the Ohio and Pennsylvania Coal Co., located near the mouth of Wolf Run in the northern part of Section 8, the Lower Freeport has been worked for railroad shipment since October, 1901. The coal, which lies about 60 feet below the surface at the mouth of the mine, is reported by miners to vary in thickness from 3 to 5 feet, with an average of about 4 feet. In 1912, D. D. Condit measured the Lower Freeport coal at three places in this mine and cut samples for chemical analysis. His measurements are as follows[1]:

	A.		B.		C.	
	Ft.	In.	Ft.	In.	Ft.	In.
Roof, shale.						
Coal, impure, rejected		4		4		3
Coal	2	5	2	9	3	1
Bone, rejected		2		3		2½
Coal	2	3	2	0	1	10
Coal, impure, rejected		2				
Floor, clay and shale.						

Section A was measured 3,000 feet west of the mouth of the slope.
Section B was measured at the west entry, 13, off of south face entry.
Section C was measured 2,700 feet northeast of the mouth of the slope.

[1]U. S. Bureau of Mines, Bull. 85, p. 247. 1914.

The sample of coal cut from Section A has the following composition[1]:

Proximate analysis

	As received	Moisture free
Moisture	3.58	——
Volatile matter	37.58	38.97
Fixed carbon	49.17	51.00
Ash	9.67	10.03
	100.00	100.00
Sulphur	3.08	3.19

Air drying loss.....1.5 per cent

		As received	Moisture free
Heating value	Calories	7,156	7,421
	B. t. u.	12,881	13,358

Sample from Section B

Proximate analysis

	As received	Moisture free
Moisture	3.47	——
Volatile matter	38.61	40.00
Fixed carbon	49.66	51.44
Ash	8.26	8.56
	100.00	100.00
Sulphur	2.40	2.49

Air drying loss.....1.5 per cent

		As received	Moisture free
Heating value	Calories	7,346	7,610
	B. t. u.	13,223	13,698

Sample from Section C

Proximate analysis

	As received	Moisture free
Moisture	4.04	——
Volatile matter	38.61	40.24
Fixed carbon	48.93	50.99
Ash	8.42	8.77
	100.00	100.00
Sulphur	2.95	3.07

Air drying loss.....2.00 per cent

[1]U. S. Bureau of Mines, Bull. 85, p. 61. 1914.

		As received	Moisture free
Heating value	Calories	7,234	7,539
	B. t. u.	13,021	13,570

A composite of the samples cut from A, B, and C has the following composition:

Proximate analysis

	As received	Moisture free
Moisture	3.69	.....
Volatile matter	37.97	39.42
Fixed carbon	49.50	51.49
Ash	8.75	9.09
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	71.76	74.51
Hydrogen	5.32	5.10
Oxygen	9.96	6.93
Nitrogen	1.39	1.44
Sulphur	2.82	2.93
Ash	8.75	9.09
	100.00	100.00

Air drying loss.....1.7 per cent

		As received	Moisture free
Heating value	Calories	7,283	7,562
	B. t. u.	13,109	13,612

In the southeastern part of Section 7 is the Wolf Run mine (formerly the Elizabeth mine) of the Warner Collieries Co., where Lower Freeport coal has been mined since 1906. The depth of the shaft is 293 feet and the thickness of the coal is reported to average about 4 feet 9 inches. The mine is electrically equipped. When running to capacity, about 270 men are employed, with a daily output of about 1,300 tons of coal. The future life of the mine is estimated at about 20 years. D. D. Condit, in 1912, measured and sampled the coal at three places in the Wolf Run mine. The measurements are as follows[1]:

	A		B		C	
	Ft.	In.	Ft.	In.	Ft.	In.
Roof shale		—		—		—
Coal, bony, rejected		—		7		4½
Coal, impure		5		7		6
Bone, rejected		2		2½		1
Coal	1	9	1	9	1	7
Bone, rejected		3½		3		3½
Coal	1	7	1	9	1	9½
Coal, impure, rejected		3		4		—
Floor clay						

Section A was measured 2,600 feet northwest of the shaft.
Section B was measured 2,400 feet west of the shaft.
Section C was measured 2,600 feet northeast of the shaft.

[1]U. S. Bureau of Mines, Bull. 85, p. 247. 1914.

The sample of coal cut at the place where Section A was measured has the following composition[1]:

Proximate analysis

	As received	Moisture free
Moisture	3.40	———
Volatile matter	38.01	39.35
Fixed carbon	52.37	54.21
Ash	6.22	6.44
	100.00	100.00
Sulphur	2.20	2.28

Air drying loss.....1.7 per cent

		As received	Moisture free
Heating value	Calories	7,518	7,783
	B. t. u.	13,532	14,009

Sample of coal taken at the location of Section B

Proximate analysis

	As received	Moisture free
Moisture	3.50	———
Volatile matter	37.93	39.31
Fixed carbon	50.63	52.46
Ash	7.94	8.23
	100.00	100.00
Sulphur	3.14	3.25

Air drying loss.....1.4 per cent

		As received	Moisture free
Heating value	Calories	7,364	7,631
	B. t. u.	13,255	13,736

A composite sample, formed by taking equal parts of samples from A and B, was analyzed with the following results:

[1]U. S. Bureau of Mines, Bull. 85, p. 61. 1914.

Proximate analysis	As received	Moisture free
Moisture	3.38	——
Volatile matter	38.01	39.34
Fixed carbon	51.64	53.45
Ash	6.97	7.21
	100.00	100.00

Ultimate analysis	As received	Moisture free
Carbon	73.31	75.88
Hydrogen	5.40	5.20
Oxygen	10.15	7.40
Nitrogen	1.46	1.51
Sulphur	2.71	2.80
Ash	6.97	7.21
	100.00	100.00

Air drying loss.....1.6 per cent

		As received	Moisture free
Heating value	Calories	7,438	7,698
	B. t. u.	13,388	13,856

Sample cut from Section C

Proximate analysis	As received	Moisture free
Moisture	3.59	——
Volatile matter	37.03	38.41
Fixed carbon	50.46	52.52
Ash	8.74	9.07
	100.00	100.00

Ultimate analysis	As received	Moisture free
Carbon	71.30	73.95
Hydrogen	5.19	4.97
Oxygen	9.68	6.73
Nitrogen	1.39	1.44
Sulphur	3.70	3.84
Ash	8.74	9.07
	100.00	100.00

Air drying loss.....1.8 per cent

		As received	Moisture free
Heating value	Calories	7,224	7,493
	B. t. u.	13,003	13,487

The Lower Freeport coal is worked for railroad shipment at the mine of the Amsterdam Coal Co., formerly owned by the Ohio and Pennsylvania Coal Co., located at the northern edge of Amsterdam in the western part of Section 13. The depth of the shaft is 185 feet. The thickest part of the coal in this mine has been worked out, but in 1926 reports indicated that 1,145 acres of three-foot coal were still available for mining. The bed was measured and sampled at a point one mile northwest of the shaft on June 30, 1926, by White

and Meyers of the Geological Survey of Ohio. The measurements at the place of sampling are given below[1]:

	Ft.	In.
Coal, bony, rejected		3
Shale, dark, with coal bands, rejected	1	5
Coal, good	3	2
Coal, bony, with sulphur, rejected		2

The sample, analyzed by D. J. Demorest, has the following composition:

Proximate analysis

	As received	Moisture free
Moisture	3.83	——
Volatile matter	41.00	42.64
Fixed carbon	47.68	49.57
Ash	7.49	7.79
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	71.76	74.62
Hydrogen	5.50	5.28
Oxygen	11.22	8.11
Nitrogen	1.17	1.22
Sulphur	2.86	2.98
Ash	7.49	7.79
	100.00	100.00

Air drying loss.....1.9 per cent

		As received	Moisture free
Heating value	Calories	7,269	7,558
	B. t. u.	13,084	13,604

Fusion of ash: Incipient.....2,358° F.
Complete.....2,415° F.

Along Goose Run in the southwestern part of Section 18, the Lower Freeport coal has been worked for a number of years at the Amsterdam mine of the Youghiogheny and Ohio Coal Co. The depth of the shaft at the bottom of the coal is 276 feet. The coal, which is of good quality, varies from 4 to 4½ feet in thickness. D. D. Condit measured and sampled the coal in this mine in December, 1912. His measurements are as follows[2]:

[1]Geol. Survey Ohio, Fourth Series, Bull. 34, p. 136. 1929.
[2]U. S. Bureau of Mines, Bull. 85, p. 246. 1914.

	A.		B.		C.	
	Ft.	In.	Ft.	In.	Ft.	In.
Roof shale and bony coal.						
Coal, bony, rejected	1	3	1	2	1	2
Coal	1	11	1	7½	1	6½
Bone, rejected		2½		3½		3
Coal	1	10	1	8½	1	11
Coal, impure, rejected		5		5		5
Floor shale.						

Section A was measured 1,000 feet northeast of the shaft.
Section B was measured 4,000 feet northwest of the shaft.
Section C was measured 4,500 feet southwest of the shaft.

The analysis of the sample cut from Section A is as follows[1]:

Proximate analysis

	As received	Moisture free
Moisture	3.66	——
Volatile matter	37.43	38.85
Fixed carbon	51.23	53.18
Ash	7.68	7.97
	100.00	100.00
Sulphur	3.07	3.19

Air drying loss.....1.6 per cent

		As received	Moisture free
Heating value	Calories	7,342	7,621
	B. t. u.	13,216	13,718

Sample cut from Section B

Proximate analysis

	As received	Moisture free
Moisture	3.52	——
Volatile matter	38.31	39.71
Fixed carbon	50.78	52.63
Ash	7.39	7.66
	100.00	100.00
Sulphur	2.99	3.10

Air drying loss.....1.4 per cent

[1]U. S. Bureau of Mines, Bull. 85, p. 61. 1914.

		As received	Moisture free
Heating value	Calories	7,363	7,632
	B. t. u.	13,253	13,738

Sample cut from Section C

Proximate analysis

	As received	Moisture free
Moisture	3.27	——
Volatile matter	38.87	40.18
Fixed carbon	50.37	52.08
Ash	7.49	7.74
	100.00	100.00
Sulphur	3.23	3.34

Air drying loss.....1.2 per cent

		As received	Moisture free
Heating value	Calories	7,359	7,608
	B. t. u.	13,246	13,694

A composite of the three samples cut in this mine was analyzed with the following results:

Proximate analysis

	As received	Moisture free
Moisture	3.50	——
Volatile matter	37.98	39.36
Fixed carbon	51.08	52.93
Ash	7.44	7.71
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	73.39	76.05
Hydrogen	5.43	5.22
Oxygen	9.19	6.31
Nitrogen	1.46	1.51
Sulphur	3.09	3.20
Ash	7.44	7.71
	100.00	100.00

Air drying loss.....1.4 per cent

		As received	Moisture free
Heating value	Calories	7,381	7,649
	B.t.u.	13,286	13,768

As implied in the preceding pages, the Lower Freeport has been the basis of an active mining industry in the Amsterdam region for many years. The coal is of good quality, and in the center of the field is of sufficient thickness to work with a fair degree of profit. Along the margins of the area available to the present mines, the coal

bed has been found to decrease in thickness and to become faulty, increasing the mining hazards and rendering the future development of the mining industry in this region somewhat problematical.

Knox Township

In Knox Township, the Lower Freeport coal was formerly mined along the Ohio River front at Freemans and Calumet, but these mines have long since been abandoned. In the eastern part of Section 32, Clarence Slocum owns and operates a small country bank in the Lower Freeport or Roger coal. The bed has a thickness of 3 feet, but has a shale parting 1 inch in thickness near the middle. The altitude of the coal at this place is 775 feet above tide. Lower Freeport coal is also mined in a small way along Croxton Run in the southern part of Section 32. In Section 25, this coal bed was formerly worked and was used for the burning of clay products at Toronto, but the supply has been exhausted. The Kaul Clay Manufacturing Co., of Toronto, owns and operates a mine in the Lower Freeport coal in Section 31. A measurement of the rock exposures near the mouth of the mine is as follows:

		Ft.	In.
Shale, gray		2	0
Coal, shaly	*Lower Freeport*	1	1
Coal, good			11
Parting			1
Coal, good		1	0
Clay, arenaceous		1	0
Limestone, nodular, *Lower Freeport*		1	0
Clay, bluish-gray, arenaceous		4	0
Sandrock		2	0
Clay, bluish-gray		4	0

The elevation of the coal bed at this place is about 745 feet. The mine is electrically equipped throughout, with a capacity of about 105 tons per day. The coal is used for the burning of clay products.

Island Creek Township

In Island Creek Township, the Lower Freeport coal is worked on a small scale at the Hilsinger mine of the Locust Grove Coal Co. in the northern part of Section 30. The coal in this mine was measured and sampled for chemical analysis by White and Meyers on July 1, 1926. The measurement of the coal at the place of sampling is as follows[1]:

[1]Geol. Survey Ohio, Fourth Series, Bull. 34, pp. 127-8. 1929.

	Ft.	In.
Coal, good	1	10
Clay shale, gray, soft, rejected		3
Coal, bony, rejected		1
Clay shale, rejected		2
Coal, bony, rejected		3
Coal, good		9
Clay, unmeasured.		

The sample from this mine was analyzed by D. J. Demorest with the following results:

Proximate analysis

	As received	Moisture free
Moisture	3.10	——
Volatile matter	38.06	39.28
Fixed carbon	48.91	50.47
Ash	9.93	10.25
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	70.53	72.79
Hydrogen	5.14	4.96
Oxygen	9.70	7.15
Nitrogen	1.10	1.14
Sulphur	3.60	3.71
Ash	9.93	10.25
	100.00	100.00

Air drying loss.....1.78 per cent

		As received	Moisture free
Heating value	Calories	7,222	7,453
	B. t. u.	12,999	13,415

Fusion of ash: Incipient 2,390° F.; Complete 2,840° F.

The coal in the Hilsinger mine is reached by a slope which extends to a vertical depth of about 75 feet. About 20 tons of coal are mined per day, all of which is sold to local trade.

The Lower Freeport coal has been mined for a number of years at the Follansbee Forge mine, located in the northern part of Section 29. On July 8, 1926, White and Meyers measured the coal in this mine and sampled it for chemical analysis at a point 1½ miles west of the mine entrance. The measurements are as follows[1]:

	Ft.	In.
Coal	1	10
Shale, gray, rejected		1½
Coal, bony, rejected		1¾
Shale, dark, hard, rejected		¼
Coal	1	2
Clay shale, unmeasured.		

[1]Geol. Survey Ohio, Fourth Series, Bull. 34, p. 128. 1929.

The analysis by D. J. Demorest gave the following results:

Proximate analysis

	As received	Moisture free
Moisture	0.00	——
Volatile matter	40.89	40.89
Fixed carbon	48.41	48.41
Ash	10.70	10.70
	100.00	100.00
Sulphur	3.47	3.47

Air drying loss.....0.00 per cent

		As received	Moisture free
Heating value	Calories	7,184	7,184
	B. t. u.	12,931	12,931

Fusion of ash { Incipient 2,372° F. / Complete 2,480° F.

The Lower Freeport coal dips rapidly to the south along the Ohio River Valley below Jeddo and is soon carried below river level. It was formerly mined along a small tributary of the Ohio in the northern part of Section 29, as indicated by the number of slack dumps along this stream. Lower Freeport coal is exposed at a number of places along Island Creek from its mouth to the northern part of Section 4. An outcrop near water level and about 1 mile from the mouth of this stream has the following measurements:

		Ft.	In.
Shale, black, arenaceous		10	0
Shale, with thin coal bands	*Lower Freeport*		6
Coal, shaly	*Lower Freeport*		5
Coal, good	*Lower Freeport*	1	11
Clay		4	0
Sandstone		3	0

The elevation of the coal at this place is about 682 feet. The Upper Freeport coal is wanting near this locality, but the interval to the top of the Upper Freeport clay is about 60 feet.

No outcropping exposures of Lower Freeport coal occur south of the mouth of Island Creek. Along the Ohio River Valley from the mouth of Wills Creek in the southern part of Island Creek Township to Rush Run in the northern part of Warren Township, a coal has been mined at a number of places by shafting, which is widely known as the Steubenville shaft coal. Various opinions have arisen concerning the stratigraphic identity of this coal bed. Dr. Orton and his

assistants made a detailed study of this coal a number of years ago and concluded that the Steubenville shaft coal is the Lower Freeport[1]. Although an element of doubt may still exist as to the exact correlation of the bed in question, due in part to the lack of outcrops at critical points, the writer's opinion, based on the data now available, is in full accord with Orton's conclusions, namely, that the Steubenville shaft coal and the Lower Freeport belong to the same stratigraphic horizon.

The Lower Freeport coal is being worked at the shaft mine of the Castner Coal Co., located at the northern edge of Section 31. The shaft has a depth of 60 feet to the top of the coal. The coal bed is reported by miners to have a thickness of 4 feet, but it is broken by a thin parting, 1 to 1½ inches in thickness, which lies about 6 inches from the bottom of the bed. The coal is bright and blocky, but is rather tender and does not stand handling well. The mine is electrically equipped and has a daily capacity of about 200 tons. The Lower Freeport coal has also been worked for a number of years at the High Shaft mine at Steubenville. In July, 1926, White and Meyers measured the coal in this mine and cut a sample for chemical analysis. The measurements, which were made 1¾ miles west of the shaft, are as follows[2]:

	Ft.	In.
Coal	3	6
Mother coal, with sulphur, rejected		1
Coal, rejected		1
Coal, dark, hard, rejected		1
Coal		9
Clay shale, unmeasured.		

The sample of coal taken from this mine was analyzed by D. J. Demorest, who reported the following composition:

Proximate analysis	As received	Moisture free
Moisture	0.00	——
Volatile matter	40.91	40.91
Fixed carbon	53.66	53.66
Ash	5.43	5.43
	100.00	100.00

Ultimate analysis	As received	Moisture free
Carbon	76.95	76.95
Hydrogen	5.17	5.17
Oxygen	9.47	9.47
Nitrogen	1.40	1.40
Sulphur	1.58	1.58
Ash	5.43	5.43
	100.00	100.00

Air drying loss.....0.00 per cent

[1]Orton, Edward, Geol. Survey Ohio, Vol. V, pp. 49-62. 1884.
[2]Geol. Survey Ohio, Fourth Series, Bull. 34. p. 129. 1929.

		As received	Moisture free
Heating value	Calories	7,633	7,633
	B. t. u.	13,740	13,740
Fusion of ash	Incipient	2,480° F.	
	Complete	2,566° F.	

The depth of the shaft at the Steubenville mine is 219 feet. When working to capacity, about 600 tons of coal is mined per day, most of which is used at the steel mills in Steubenville. At the LaBelle mine, located at the LaBelle Iron Works at Steubenville, Lower Freeport coal has been mined for a number of years and used for fuel in the plant. Mr. John P. Wilson, former superintendent of the mine, reports the coal to vary from 3 feet 2 inches to 4 feet in thickness. A thin clay band, 2 to 3 inches thick, is present about 3 feet from the top of the coal. The depth of the shaft is about 200 feet. The bed was measured and sampled at two places in this mine by D. D. Condit in January, 1913, as described below[1]:

	A		B	
	Ft.	In.	Ft.	In.
Roof, shale.				
Coal	1	9	1	9
Bone	....	¼	....	.1
Coal	....	9	....	8½
Shale, rejected	....	1¼	....	3
Coal	....	6½	....	7

Section A was measured 5,200 feet southeast of the shaft.
Section B was measured 4,400 feet southeast of the shaft.

The results of the analysis of the sample cut from Section A are given below[2]:

Proximate analysis

	As received	Moisture free
Moisture	3.82	—
Volatile matter	35.90	37.33
Fixed carbon	53.43	55.55
Ash	6.85	7.12
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	74.20	77.15
Hydrogen	5.24	5.01
Oxygen	10.36	7.23
Nitrogen	1.45	1.51
Sulphur	1.90	1.98
Ash	6.85	7.12
	100.00	100.00

Air drying loss.....1.6 per cent

[1]U. S. Bureau of Mines, Bull. 85, p. 250. 1914.
[2]Idem p. 63.

		As received	Moisture free
Heating value	Calories	7,418	7,712
	B. t. u.	13,352	13,882

The composition of the sample cut from Section B is as follows:

Proximate analysis

	As received	Moisture free
Moisture	3.80	.....
Volatile matter	35.39	36.79
Fixed carbon	53.39	55.50
Ash	7.42	7.71
	100.00	100.00
Sulphur	1.91	1.99

Air drying loss.....1.5 per cent

		As received	Moisture free
Heating value	Calories	7,344	7,634
	B. t. u.	13,219	13,741

Thirteen shafts have been sunk to the Lower Freeport coal in the Steubenville field, but, with the exception of the three shaft mines described above, all have been abandoned.

Upper Freeport Sandstone

The Upper Freeport sandstone has a wide areal distribution in Pennsylvania, West Virginia, and Ohio, but at many localities in Ohio, as in Jefferson County, it is thin and patchy. Where this member is well developed, it consists of a coarse-grained, micaceous sandstone, 10 to 15 feet in thickness. About the margins of these sandstone areas, the material changes to thin-bedded sandstone interstratified with shale. At a great number of exposures the member is cross bedded and poorly cemented. The color is light gray, weathering yellowish or reddish brown. Iron compounds, silica, and clay are the chief cementing substances.

The Upper Freeport sandstone has its greatest distribution in Saline Township. It is generally present north of Yellow Creek, although it is shaly in character. In Section 30, where it lies immediately below the Upper Freeport coal, it is soft and friable with a thickness of 13 feet. Along Brimstone Run in Section 6, the Upper Freeport sandstone has a thickness of 15 feet and lies close above the Lower Freeport coal. The following measurements taken along a

small ravine in Section 35 illustrate the stratigraphic relations of the Upper Freeport sandstone:

	Ft.	In.
Abandoned mine, *Upper Freeport*	—	—
Covered interval	19	0
Shale, gray, arenaceous	3	0
Covered interval	8	4
Sandstone, massive, *Upper Freeport*	15	6
Shale, gray, arenaceous	2	0
Sandstone, shaly	21	10
Shale, dark	4	0
Coal, shaly	1	4
Parting		½
Coal	1	0

In Section 34, Knox Township, the Upper Freeport sandstone is quarried by the Smallwood Pulp Stone Co. and turned into wheels for the grinding of wood pulp. The ledge of stone worked at this place lies about 28 feet below the Upper Freeport coal and has a thickness of 15 to 70 feet. The stone, which is massive and coarse grained, is well adapted for the purpose for which it is quarried. In Section 31, Knox Township, the Upper Freeport sandstone is present in normal thickness and character, but where followed south along the Ohio River, it grades into arenaceous shale, which is the predominating type of rock south of Jeddo. In Brush Creek and Ross townships, the Upper Freeport sandstone is generally wanting, as is also the case in a large part of Springfield Township. However, at one locality in the eastern part of Section 10, Springfield Township, a few feet of massive Upper Freeport sandstone is exposed above the Lower Freeport coal.

Bolivar Clay

The Bolivar clay, which was first named for exposures near Bolivar, in Westmoreland County, Pennsylvania, is rather widely known, although its areal distribution is limited. It is generally confined to small, isolated patches from a few acres to a few square miles in extent. In West Virginia, this member is reported along Deckers Creek in Monongalia and Preston counties and at New Cumberland in Hancock County, whereas in Ohio small isolated areas of this clay have been recognized in almost every county where its horizon outcrops. The Bolivar clay is present at a few localities in Jefferson County, but its stratigraphic features are very imperfectly shown. The position of this clay member and its relation to the Upper Free-

port clay, with which it is often confused, is well expressed by W. Stout as follows[1]:

"The Bolivar clay does not belong to the Upper Freeport coal as ordinarily attributed but to a thin coal lying below the Upper Freeport limestone. Where the rocks in this interval are normally developed, the succession in ascending order is Bolivar clay, a thin bed of coal, Upper Freeport limestone, a few feet of shale, Upper Freeport clay, and Upper Freeport coal. This order, however, is broken in many places as the Bolivar and Upper Freeport clays may coalesce; as the Upper Freeport limestone may be represented only by nodular material distributed through the clays; and as all the strata above the Bolivar clay may be absent. In fact, the typical stratigraphic relation is seldom found. The usual position of the Bolivar clay is directly below the Upper Freeport limestone and 5 to 12 feet below the Upper Freeport coal."

The Bolivar clay is composed of both the flint and plastic varieties, but the plastic is the more common type. The color of the material is light to dark gray; but iron compounds and calcium carbonate are sometimes present, the former imparting a pinkish, yellowish, or greenish tint to the clay. Silica is also a common constituent.

A few small areas of Bolivar clay are found along Yellow Creek in the northern part of Jefferson County. Near the mouth of the stream, in Section 8, Saline Township, this clay has a thickness of 8 feet and lies immediately below the Upper Freeport limestone. It is highly arenaceous and in part flinty. The member appears to be wanting in Ross Township or to be represented by a thin bed of plastic clay coalescing with the Upper Freeport clay. In Springfield Township, this clay outcrops at the railroad tunnel in the east central part of Section 11, where the deposit is composed of both the flint and plastic varieties, each of which is arenaceous and ferruginous in composition. The thickness of the bed is about 23 feet. A few poor exposures of this clay are also found in Section 10. In the east central part of Section 16, clay belonging to the Bolivar horizon outcrops along the public road, where the geologic section given below was measured:

		Ft.	In.
Shale, gray, arenaceous		8	0
Sandstone		2	6
Shale, blue		2	0
Limestone, nodular	*Upper Freeport*		11
Clay, blue, arenaceous	*Upper Freeport*	1	8
Limestone, nodular	*Upper Freeport*	1	8
Clay, blue, arenaceous	*Bolivar*	3	4
Clay, shaly	*Bolivar*	5	0
Clay, flinty, ferruginous	*Bolivar*	8	0

[1]Stout, W., Geol. Survey Ohio, Fourth Series, Bull. 26, p. 425. 1923.

The Bolivar clay is not exposed along the Ohio River Valley in Knox Township, but outcrops with good development at Costonia in Island Creek Township, where the following record was secured:

		Ft.	In.
Limestone	*Lower Freeport*	2	2
Clay, dark	*Lower Freeport*	2	6
Limestone, shaly	*Lower Freeport*	1	0
Clay, bluish gray, arenaceous	*Bolivar*	1	2
Clay, greenish, flinty	*Bolivar*	7	0
Clay, dark gray, plastic	*Bolivar*	1	6
Limestone	*Bolivar*	1	8
Clay with nodular limestone	*Bolivar*	1	6
Clay, dark, arenaceous	*Bolivar*	1	6
Sandrock		2	6
Shale		4	0

The Bolivar clay was formerly worked at this locality for the manufacture of fire brick, but operations ceased many years ago. An analysis of the flint clay once utilized at this place is given by Dr. Orton as follows[1]:

Loss at 105 C	1.69
Ignition loss	8.90
Silica (combined), SiO_2	29.22
Silica (sand), SiO_2	31.34
Alumina, Al_2O_3	24.97
Ferric oxide, Fe_2O_3	1.66
Lime, CaO	.63
Magnesia, MgO	.40
Titanic oxide, TiO_2	1.30
Sodium oxide, Na_2O	trace
Potassium oxide, K_2O	.28

The Bolivar clay in Jefferson County has not been utilized in recent years for the manufacture of clay products. Objectionable impurities in the form of calcium carbonate and various iron compounds occur in sufficient quantities to make the clay of low grade; and, in a region such as this, where clays of much better quality, such as the Lower Kittanning, occur in abundance, the Bolivar has little potential economic possibilities within the near future.

Upper Freeport Limestone

Early geologists in southwestern Pennsylvania found a thin limestone a few feet below the Upper Freeport coal which was named by Rogers the Upper Freeport limestone, in reports of the

[1]Orton, Edward, Geol. Survey Ohio, Vol. 5, p. 1,111. 1884.

First Geological Survey of that State[1]. Later, as field studies continued, this limestone was recognized at widely separated localities in West Virginia and Ohio, but not as a continuous member of the intervening areas.

In Jefferson County, Ohio, the Upper Freeport limestone is present at only a few localities. In lithology and mode of occurrence it is similar to the Lower Freeport limestone which lies 40 to 60 feet below it. It is light to dark bluish-gray in color, weathering buff, although due to the segregation of coloring material, the surface often shows a mottled appearance. It consists either of one or more distinct layers, which lie at the base of the clay associated with the Upper Freeport coal, or which are separated from the clay by a few feet of intervening shale, or, as is generally the case, this limestone occurs as nodular masses embedded in the clay. A brecciated structure is present at some places. In Jefferson County, the position of this limestone varies from 1 to 8 feet below the Upper Freeport coal.

In the northwestern part of Section 21, Saline Township, a single layer of Upper Freeport limestone, 1 foot 6 inches in thickness, is present 3 feet below the Upper Freeport coal. The following record of outcrops in Section 7 illustrates the stratigraphic relations of the Upper Freeport limestone:

	Ft.	In.
Sandstone, coarse-grained, *Lower Mahoning*	30	0
Coal, good } *Upper Freeport*	2	0
Coal, bony } *Upper Freeport*		10
Clay, arenaceous	7	8
Limestone, nodular, *Upper Freeport*	1	0
Clay, arenaceous	3	4

No deposits of Upper Freeport limestone are found in Brush Creek Township, and it is present at only one locality in Ross Township, namely in the central part of Section 28, where the limestone has a thickness of 1 foot. It is equally rare in Springfield Township where the only exposure, in Section 16, has a thickness of 1 foot 8 inches. This limestone is wanting in Knox Township, but is well developed along Island Creek, near Costonia, in Island Creek Township. Near the forks of the road at Costonia, it outcrops along the bank several feet above road level; at this place it consists of two layers separated by 2 feet 6 inches of shale, the upper bed having a thickness of 2 feet 2 inches and the lower a thickness of 1 foot.

[1]Rogers, H. D., Geology of Pennsylvania, Vol. II, Pt. 1, p. 585. 1858.

Upper Freeport Clay

Closely associated with the Upper Freeport coal is a bed of plastic clay which is widely known as the Upper Freeport clay. The stratigraphic position of this member, where the normal sequence is developed, is below the Upper Freeport coal and immediately overlying or a few feet above the Lower Freeport limestone. Where this limestone is wanting and the Bolivar clay is normally developed, the two clay beds either coalesce or are separated from each other by a few feet of shale.

In Jefferson County, the Upper Freeport clay is above drainage along Yellow Creek and its tributaries in Saline, Brush Creek, Ross, and Springfield townships and along the Ohio River Valley in the eastern part of Saline, Knox, and Island Creek townships. The thickness of the Upper Freeport clay in this county varies from 1 to 10 feet. It is light to dark bluish-gray in color, weathering to a light buff. The clay is arenaceous at all places and contains impurities in the form of iron compounds and calcium carbonate. Upper Freeport clay in Jefferson County is too impure to be of value in the manufacture of ceramic products, and therefore it has little more than stratigraphic interest.

In Saline Township, the Upper Freeport clay is generally present with a thickness ranging from 1 to 8 feet. It is usually charged with lime and iron impurities. The following measurements secured in the northwestern part of Section 21 illustrate the stratigraphic relations in this township:

	Ft.	In.
Sandstone and covered	33	0
Shale, with thin coal bands, *Upper Freeport*		6
Clay, arenaceous, with iron ore nodules, *Upper Freeport*	3	0
Clay	4	0

The Upper Freeport clay is exposed at a few places along Brush Creek in Brush Creek Township as far west as Section 19. A record obtained in the north-central part of Section 6 is representative for this township.

		Ft.	In.
Sandstone, massive, unmeasured.			
Shale, gray, arenaceous		8	0
Coal, good, *Upper Freeport*		2	6
Clay, bluish-gray, arenaceous	*Upper Freeport*	4	7
Clay, ferruginous, with limestone nodules		1	8
Clay, arenaceous			6
Clay, bluish-gray, arenaceous		1	2

In Ross Township, the Upper Freeport clay is of a somewhat better quality than is found in other parts of the county, but it is very unsteady in occurrence. It is blue to bluish-gray in color and arenaceous in composition, but the percentage of ferruginous and calcareous impurities is somewhat low. The thickness varies from 1 to 10 feet. Near Bergholz, in Springfield Township, the Upper Freeport and Bolivar clays are separated by a thin limestone layer or by concretionary masses of limestone embedded in clay. The Upper Freeport clays are always plastic, whereas the Bolivar clay may be plastic, but in this region is chiefly of the flint variety. Along the Ohio River Valley, no marked changes occur in Upper Freeport clay, which is uniformly of a poor quality. The stratigraphic sequence above and below this member is illustrated in the following record of outcrops along Brimstone Run in Section 6, Saline Township:

	Ft.	In.
Coal, shaly, *Mason*		6
Shale, gray	6	0
Shale	72	0
Sandstone, friable, *Lower Mahoning*	15	0
Clay, arenaceous, with limestone nodules and iron carbonate concretions, *Upper Freeport*	6	0
Sandrock, bluish-gray	1	0
Shale and covered	34	0
Sandstone, massive, *Upper Freeport*	15	0
Covered interval	1	0
Coal, *Lower Freeport*		10
Clay, blue	4	9
Limestone, dark, *Lower Freeport*	1	8
Clay, blue		8

The elevation of the Upper Freeport clay at this locality is 817 feet. This clay, 10 feet in thickness, is exposed along the road in the northwestern corner of Section 33, Saline Township. Clay on this horizon is also exposed at a few places along Island Creek in Island Creek Township, but the bed is rather impure and ill defined.

Upper Freeport Coal

The youngest member of the Allegheny series is a prominent bed of coal, which was named the Upper Freeport coal by the First Geological Survey of Pennsylvania for exposures near the town of Freeport on the Allegheny River. The chief reason for choosing this coal horizon as the boundary line between the Allegheny and Conemaugh series becomes evident in part from the following description by I. C. White[1]:

[1]White, I. C., West Virginia Geol. Survey, Vol. II, pp. 403-404. 1903.

"Next to the Pittsburgh bed, at the other limit of the Conemaugh series, the Upper Freeport coal is probably of more importance than any other single bed of coal in the entire Appalachian basin. Unlike the Pittsburgh, it does not thin down and vanish to the southwest, but appears to extend entirely across the State, at least along the belt of its eastern crop, and is quite as important in southern Mingo County at the Kentucky line as in eastern Monongalia and Preston at the Pennsylvania border.

"Like the Pittsburgh bed, however, it thins away when followed westward from the belt of its thick development, and disappears and becomes unimportant under a large area of the State where its horizon underlies the surface . . . When this coal horizon comes up to daylight again on the western side of the Appalachian trough near Kenova on the southwest and New Cumberland on the northwest, it is either missing entirely as at New Cumberland (unless indeed, the 'Roger' vein of the Ohio Valley may prove to be this bed), or is thin, slaty and worthless as at the Big Sandy River near Kenova."

West of the Ohio River the Upper Freeport coal is very sporadic in its occurrence. This coal, however, or its associated clay, forms a distinct stratigraphic horizon which can be followed, with difficulty in some localities, entirely across the State.

The areal distribution of the Upper Freeport coal horizon in Jefferson County is represented on the map accompanying this report (See Map III) by the line separating the Allegheny and Conemaugh formations. The character and thickness of the coal show marked variations between places not widely separated and coal of good quality and thickness often grades within a few hundred feet into a mere smut streak or into a thin layer of shaly coal. This bed in its typical development consists of two benches separated by a thin shale parting, but in Saline, Brush Creek, and Ross townships a thin layer of bone coal or cannel coal, 1 to 3 inches in thickness, is usually present at the base of the lower bench. Along the Yellow Creek Valley, in Ross and Springfield townships, the Upper Freeport coal is overlain with a few inches of clay shale, above which is a thin layer of carbonaceous or bone shale. These alternating layers of roof shale are of value in the identification of exposures of this coal in the field. The thickness of the Upper Freeport coal in Jefferson County varies from a few inches to 7 feet, with an average of about 2 feet 8 inches. It is, on an average, about 119 feet below the base of the Brush Creek fossiliferous shale and about 154 feet above the Lower Kittanning coal.

The most productive area of the Upper Freeport coal in Saline Township lies north of Yellow Creek, although this bed is present south of Yellow Creek and east of Section 18. It reaches its greatest

thickness in the county in the region of the old Diamond mine, concerning which Dr. Orton writes as follows[1]:

"This well known body of coal, the thickest in the region, situated at Linton, just above Yellow Creek Station, on the Cleveland and Pittsburgh Railroad, stands by itself among the coal mines of the country. There are several anomalies in its structure and association. . . . Comparing sections at the Diamond mine and others at Hammondsville and at Collinwood, we find that the interval from the Strip Vein or Middle Kittanning and the Big Vein or Upper Freeport in the first is 90 feet and in the second 133 feet. The Diamond coal was thus brought nearer to the place of the Roger Vein or Lower Freeport than to the Upper Freeport and in addition it was noted that the Lower Freeport was not present on the Diamond property. It was hard to understand how so great a descent of the Upper Freeport coal swamp could be made so abruptly. . . . The coal has been found in the north entry to climb a hill as steep as is to be seen in any other mine of the State, and to gain all the elevation required to make it normal, within 150 yards of the lowest portion of the mine. The interval from the Middle Kittanning coal to this portion of the mine is not less than 140 feet.

"In structure the Diamond coal agrees in its uppermost 6 feet with the structure of the Upper Freeport coal at Salineville and elsewhere, as is shown in the following section:

	Ft.	In.
Sandstone.		
Shale, black	4	0
Coal, varies from 3 feet 6 inches to	4	7
Clay		2
Coal	2	0
Shale		½
Coal, varies from 1 foot to	1	3
Coal, cannel		5

"The progress of the mine has shown that the upper portion is in reality the normal seam, and that the increase in thickness of this mine over the other Upper Freeport mines in the neighborhood is to be found in the bottom bench. This sometimes rises to 1 foot 8 inches, and to this extent the Diamond coal is reinforced beyond the Upper Freeport measures. The coal in the deepest swamp of the mine has been known to measure 9 feet, but it does not often rise above 8 feet. . . . When it grows thin, as it does in every direction from the 'swamp,' the bottom bench shrinks and finally disappears altogether.

"In the center of the 'swamp' of the mine, a bottom bed of cannel, 4 to 6 inches, is found, which is of wonderful paleontological interest. More than fifty species of fish and reptiles have been collected here by Newberry, almost all of which are not only new to science, but almost all of which are confined to the acre or two of cannel that lies in the center of the mine. They have never been found elsewhere. Newberry justly says of this locality, 'there are few places in the world more interesting to the paleontologist than the Diamond mine at Linton, since we get here such a view of the life of the carboniferous age as is afforded almost nowhere else.'"

[1]Orton, Edward, Geol. Survey Ohio, Vol. V, pp. 210-214. 1884.

The Diamond mine was worked for a number of years to supply local trade, but the thickest part of the coal has now been exhausted and the mine has been abandoned. Dr. Orton reports the following analysis of a sample of coal from the Diamond mine[1]:

Proximate analysis

Moisture	1.67
Volatile matter	39.28
Fixed carbon	52.16
Ash	6.89
	100.00
Sulphur	3.43

In 1916, J. H. Hance measured and sampled the Upper Freeport coal at the Yellow Creek mine in Section 14. The measurements, which were made 30 feet west of the mouth of the entry, are as follows[2]:

	Ft.	In.
Roof, shale and sandstone, not measured.		
Shale, bituminous, rejected		4½
Coal	4	2½
Clay, rejected		1½
Coal	1	7
Clay, rejected		¾
Coal	1	2
Bone, rejected		3

The analysis of the sample is given below[3]:

Proximate analysis

	As received	Moisture free
Moisture	4.75	.....
Volatile matter	38.28	40.19
Fixed carbon	51.91	54.50
Ash	5.06	5.31
	100.00	100.00
Sulphur	1.76	1.85

Air drying loss.....2.7 per cent

[1]Orton, Edward, Geol. Survey Ohio, Vol. V, p. 214. 1884.
[2]U. S. Bureau of Mines, Bull. 193, p. 210. 1922.
[3]U. S. Bureau of Mines, Bull. 193, p. 51. 1922.

		As received	Moisture free
Heating value	Calories	7,480	7,853
	B. t. u.	13,464	14,135

A second sample was cut by J. H. Hance in the Yellow Creek mine at a point 50 feet southwest of the opening, where the coal has the following structure and thickness[1]:

	Ft.	In.
Roof, shale and sandstone.		
Coal, bony, rejected		2½
Coal	1	6
Bone and clay, rejected		1
Coal	1	0
Bone and clay, rejected		1¾
Coal	1	1½
Floor, clay.		

The analysis of the sample is as follows[2]:

Proximate analysis

	As received	Moisture free
Moisture	3.43	.....
Volatile matter	36.26	37.55
Fixed carbon	49.57	51.33
Ash	10.74	11.12
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	69.66	72.13
Hydrogen	5.15	4.94
Oxygen	8.03	5.16
Nitrogen	1.37	1.42
Sulphur	5.05	5.23
Ash	10.74	11.12
	100.00	100.00

Air drying loss.....1.5 per cent

		As received	Moisture free
Heating value	Calories	7,068	7,319
	B. t. u.	12,722	13,174

In the western part of Section 13, the Upper Freeport coal is worked by the Saline Coal Co. The bed has a thickness of 3 feet 6 inches and lies at an elevation of 813 feet. At Irondale, the Upper Freeport coal is mined by the East Ohio Sewer Pipe Co. and is used in the plant as a steam coal and for the burning of ware. The bed has an average thickness of 3 feet 6 inches, but varies from 2 feet 6 inches to 5 feet. The coal lies at an elevation of 862 feet, which is 65

[1]U. S. Bureau of Mines, Bull. 193, pp. 210-211. 1922.
[2]U. S. Bureau of Mines, Bull. 193, p. 51. 1922.

feet below the Mahoning coal and 55 feet above the Lower Freeport coal. In 1916, Upper Freeport coal was also sampled by J. H. Hance at the Nicholson mine near Irondale, in Section 26, Saline Township. The following record shows the structure and thickness of the coal at the place of sampling[1]:

	Ft.	In.
Roof, shale and sandstone.		
Clay, bituminous, rejected		¾
Coal		10⅞
Clay, black		1/16
Coal		5⅛
Pyrite band, irregular		1/16
Coal	1	11½
Clay bench, rejected		1¼
Coal		10
Bone, rejected		2½
Floor, clay.		

The results of the analysis are given below[2]:

Proximate analysis

	As received	Moisture free
Moisture	3.73	.....
Volatile matter	36.54	37.95
Fixed carbon	51.24	53.23
Ash	8.49	8.82
	100.00	100.00
Sulphur	2.87	2.98

Air drying loss.....1.8 per cent

		As received	Moisture free
Heating value	Calories	7,290	7,572
	B. t. u.	13,122	13,630

A thin blossom of Upper Freeport coal outcrops in the west central part of Section 32 at an elevation of 870 feet. The interval to the Lower Freeport or Roger Vein at this place is about 58 feet, which is normal for this region. The Upper Freeport member was formerly worked a fourth of a mile south of Irondale, in the northwestern corner of Section 25, where the interval to the Brush Creek marine beds is 110 feet. A thin blossom of this member is present

[1]U. S. Bureau of Mines, Bull. 193, p. 209. 1922.

[2]U. S. Bureau of Mines, Bull. 193, p. 51. 1922.

in the northern part of Section 30 at an elevation of 790 feet, and also in the central part of Section 30 at an elevation of 773 feet.

South of Yellow Creek, the Upper Freeport coal is wanting west of Section 18. In the northwestern corner of this section, the Upper Freeport shows 5 feet 6 inches of good coal and the elevation of the outcrop is 788 feet. Near the mouth of Hollow Rock Run, the coal has been mined in a small way for steam purposes and for domestic use in Wellsville and adjoining territory. The following geologic section shows the nature of this coal bed at a small mine on the G. D. Brown farm in Section 13:

	Ft.	In.
Roof, sandstone, unmeasured.		
Coal, good	4	2
Parting		3
Coal, good	2	0
Clay		6

The elevation of the bed at this place is 750 feet and the thickness of the coal under the hill is reported by miners to vary from 6 feet 10 inches to 7 feet. In the southern part of Section 13, O. V. McMorrow and W. W. Rallings operate a mine in the Upper Freeport coal, where the structure and thickness of the bed are as given below:

	Ft.	In.
Shale	1	0
Coal, good	3	6
Sulphur band, irregular		1
Coal, good	2	4
Coal, cannel		1
Clay	1	0

The thickness of this coal at the mouth of the mine is about 6 feet, but variations of 5 to 7 feet are reported by miners to occur under cover. The coal, which is of good quality, finds a ready market for domestic use in the neighborhood and for the burning of clay products at Irondale. In the central part of Section 7, the Upper Freeport coal outcrops along a small ravine at an elevation of 753 feet. The bed consists of 2 feet of good coal underlain by 10 inches of cannel coal and overlain by coarse, massive sandstone. The interval to the Lower Freeport coal is 23 feet and to the Middle Kittanning coal 88 feet.

From the mouth of Yellow Creek south to Ekeyville, the Upper Freeport coal is either wanting or is too poorly developed for profitable mining. In the southeastern part of Section 5 this coal bed was prospected to some extent but without encouraging results.

Brush Creek Township lies just south of Washington Township, Columbiana County, where the Upper Freeport, or "Big Vein" of Salineville, occurs in unusual thickness. In Brush Creek Township, much of the land surface lies above the horizon of the Upper Freeport coal, and therefore no exposures of this member are found except near the bottom of the deepest valleys. Along Salt Run, Upper Freeport coal occurs above drainage in Sections 2 and 3. A small country bank has been opened in this coal in the northeastern corner of Section 2 where the coal has a thickness of 2 feet 3 inches. The elevation of the member at this place is 860 feet.

Upper Freeport coal is above drainage along Brush Creek as far west as Section 19. The elevation of the bed varies from 850 feet in Section 6 to 900 feet in Section 19. A measurement of the coal in an old mine north of Brush Creek in the east-central part of Section 6 shows the structure and thickness as follows:

		Ft.	In.
Shale, gray, arenaceous		4	0
Shale, bony			2
Clay shale, black			2
Coal, good	*Upper Freeport*	2	6
Parting			½
Coal, good		1	0
Parting			2
Coal, bony, cannel nature			4
Clay, bluish-gray, arenaceous		1	0

The thickness of the minable portion of the bed is about 3 feet 6 inches and the elevation of the coal at this locality is 850 feet above tide. In the north-central part of Section 6, Upper Freeport coal, 2 feet 6 inches in thickness, outcrops at an elevation of 885 feet. The interval to the Lower Freeport coal is 60 feet. South of Brush Creek, in Sections 6 and 12, the Lower Mahoning sandstone entirely displaces this coal bed. Upper Freeport coal of good quality and of fair thickness is exposed near drainage level in Section 13 and in the eastern part of Section 19. Near the mouth of Roach Run, the member has a thickness of 3 feet 2 inches and the interval to the Brush Creek fossiliferous beds is 131 feet. At the eastern edge of Section 19, the coal is 3 feet 3 inches thick and lies 127 feet below the Brush Creek shale. This coal bed passes below drainage at the 900-foot level.

In Ross Township, the deep intrenchment of Yellow Creek provides many exposures of the Upper Freeport coal along its valley from the northeastern corner of Section 4 to the western edge of Section 34. The elevation of the horizon ranges from 776 feet at the eastern edge of Section 4 to 900 feet at the western edge of Section 34. In this township, the Upper Freeport coal shows much variation

in character, structure, and thickness, and for this reason its occurrence will be treated in detail. At the northeastern corner of Section 4, the Upper Freeport coal horizon lies at about water level, but the coal is wanting, having been replaced by the Lower Mahoning sandstone. A fourth of a mile south of Holt, in the northern part of Section 3, Upper Freeport coal has been mined in a small way for local use. It has the thickness and structure indicated in the following geologic section:

		Ft.	In.
Coal, bony	*Upper Freeport*	1	4
Coal, fair quality		1	0
Parting			2
Coal, fair quality		2	6
Clay		1	0

At this place the thickness of the minable coal is about 3 feet 6 inches and the elevation of the bed 784 feet above tide. The coal bed rises to the west and is exposed along the road a quarter of a mile west of Holt at an elevation of 811 feet. Several exposures of this member are also found along Longs Run as far as the west-central part of Section 9, where it passes beneath drainage at an elevation of 820 feet.

Upper Freeport coal has been mined for a number of years on the J. B. Saltzman farm in the central part of Section 4. The coal does not outcrop near the opening, but Mr. Saltzman reports 4 feet of good coal at the head of the mine. The member has an elevation of 810 feet and lies 59 feet below the Mahoning coal horizon and 110 feet below the Brush Creek marine beds. In the northwestern part of Section 10, a prospect on the Upper Freeport coal horizon shows the following measurements:

		Ft.	In.
Sandstone, massive		20	0
Shale, dark, arenaceous		3	0
Shale, bony	*Upper Freeport*	2	2
Shale, parting			3
Coal, good		2	2
Clay, arenaceous		1	0

The thickness of the minable coal is 2 feet 2 inches. The upper bench of the bed is represented by 2 feet 2 inches of hard bone shale, this local variation being due to the infiltration of silts during the period of coal deposition. The member at this place has an elevation of 840 feet and lies about 155 feet below the Brush Creek marine limestones and shales. On the south side of Yellow Creek, in the

central part of Section 16, the following excellent record was obtained:

		Ft.	In.
Sandstone		20	0
Clay, dark, with iron ore nodules		7	2
Shale, dark, arenaceous, fossiliferous	*Brush Creek*	10	6
Limestone, black, nodular	*Brush Creek*		2
Shale, dark, fossiliferous	*Brush Creek*	3	9
Covered interval		15	6
Clay, yellow to red		5	0
Shale and covered		29	6
Covered interval		17	2
Clay, yellowish-gray with limestone nodules, *Mahoning*		3	0
Shale and covered		12	10
Sandstone, massive, *Lower Mahoning*		26	0
Shale, bony		1	6
Coal	*Upper Freeport*	1	4
Coal, bony	*Upper Freeport*		1½
Coal	*Upper Freeport*		10
Coal, bony	*Upper Freeport*		3
Clay, gray, arenaceous		10	6
Clay, dark			6
Clay, blue, arenaceous			6
Clay, blue			2

The elevation of the Upper Freeport coal at this place is about 845 feet. The bed lies 44 feet below the Mahoning coal horizon and 113 feet below the Brush Creek limestone and shale. The Lower Freeport coal, which does not appear in this record, lies about 45 feet below this member.

In the east-central part of Section 23, Upper Freeport coal, 3 feet in thickness, outcrops along a stream bed at an elevation of 870 feet. The distance to the Lower Freeport coal is 60 feet; to the Mahoning coal horizon 58 feet; and to the Brush Creek marine shales 113 feet. This coal has been mined for a number of years in the west-central part of Section 23. A short distance below the mouth of the mine the Lower Freeport coal outcrops along the road and with the intervening beds shows the following record:

		Ft.	In.
Shale, gray, arenaceous		4	0
Shale, bony			8
Clay with iron ore nodules			2
Coal	*Upper Freeport*	1	8
Bone band	*Upper Freeport*		½
Coal	*Upper Freeport*	1	8
Clay, bluish-gray, arenaceous		5	0
Sandstone, shale, and covered		46	0
Coal, *Lower Freeport*		3	2
Clay, gray		1	0

The Upper Freeport coal has an elevation of 870 feet and lies 55 feet above the Lower Freeport coal.

Upper Freeport coal is well exposed in the northeastern corner of Section 28, where it has a thickness of 2 feet 10 inches and lies 108 feet below the Brush Creek shales. At the southern end of the bridge across Yellow Creek, Upper Freeport coal is 3 feet 4 inches in thickness; has an elevation of 842 feet; and the interval to the Brush Creek shale measures 103 feet. On the north bank of Yellow Creek, in Section 23, Upper Freeport coal is well exposed, as shown in the following record of outcrops:

	Ft.	In.
Shale, gray, arenaceous	10	0
Shale, black, fissile		6
Shale, gray, arenaceous	3	4
Shale, black, fissile		8
Coal, good, *Upper Freeport*	3	4
Clay	1	0

At the northern end of the bridge across Yellow Creek in Section 34, the Upper Freeport coal horizon is represented by a bed of black shale and shaly coal, 6 inches in thickness, which lies 38 feet below the Mahoning coal. A fourth of a mile south of this exposure, the coal is exposed along the road in normal character and thickness, as indicated by the following measurements:

		Ft.	In.
Shale, gray, arenaceous		6	0
Shale, bony			3
Shale, dark, carbonaceous		4	0
Coal, good		1	6
Parting	*Upper Freeport*		½
Coal, good		1	8
Clay			6

The coal at this place has an elevation of 871 feet, but at the west edge of Section 34, it has an elevation of 900 feet. When traced westward along Yellow Creek, the Upper Freeport coal disappears from the section, and in the vicinity of Bergholz is wanting; although the associated clays are well developed.

The Upper Freeport coal is wanting in that part of Springfield Township which lies north of an east-west line along the southern boundary of Section 10. South of this line the Upper Freeport coal is exposed above drainage in Sections 3, 9, and 15, and it is to this area that the productive field in this township is limited. In the northwestern corner of Section 9, the coal outcrops a few feet above water

level along Elkhorn Creek, whereas the Lower Freeport coal is exposed at road level in the southwestern corner of Section 10. A measurement of the outcrop is given below:

		Ft.	In.
Shale, arenaceous, with some shaly sandstone		10	0
Clay shale, black			3
Shale, gray		3	2
Coal, shaly	*Upper Freeport*		5
Shale			9
Coal, shaly			9
Clay, gray, arenaceous		1	0
Covered interval		25	9
Sandstone, massive		10	0
Shale, gray		2	8
Coal, good, *Lower Freeport*		3	11
Clay		1	0

The elevation of the Upper Freeport coal at this place is 938 feet.

The member is mined on a small scale by James Stribler in the central part of Section 9, where the coal, which contains much pyrite, has a thickness of 3 feet 4 inches near the mouth of the mine. The elevation at this place is 900 feet above tide. Mr. Stribler has made a second opening in this coal bed on the east side of Yellow Creek in the east-central part of Section 9, where the member has about the same thickness and structure. Along a small stream tributary to Yellow Creek in the east-central part of Section 15, is the Goat Hill mine of the Goat Hill Coal Co., formerly owned by the Blackburn Coal Co. The Upper Freeport coal was worked at this mine for a number of years. The thickness of the coal is reported to vary from 3 feet 3 inches to 4 feet 2 inches. Due to the faulty condition of this coal, the shaft was sunk, within recent years, to the Lower Freeport coal, which is reported to lie 40 feet below the Upper Freeport. The Upper Freeport coal passes below drainage near the southern edge of Section 9, and no data on its extent or thickness under cover in Springfield Township are available.

Upper Freeport coal has been worked at a few places in the northeastern corner of Knox Township, where it ranges from 2 feet 6 inches to 3 feet 6 inches in thickness. In the northern part of Section 34, this member is 3 feet 4 inches in thickness with the structure indicated in the following geologic section:

		Ft.	In.
Sandstone, unmeasured.			
Coal, good	*Upper Freeport*	2	8
Parting			4
Coal			8
Clay		1	0

The elevation of the bed at this place is 871 feet above tide, and the interval to the Lower Freeport coal is 83 feet. This member is also well exposed in the quarry of the Smallwood Pulp Stone Co., where the thickness is 2 feet 8 inches and the elevation 875 feet above tide. Upper Freeport coal was formerly worked along Jeremy Run west of Empire, but operations have long since ceased. The horizon is above drainage along the Ohio River Valley from Empire south to Section 26, Island Creek Township, but the coal is generally wanting.

CONEMAUGH SERIES

GENERAL STATEMENT

The rocks now included in the Conemaugh series have been described under various names by workers in different parts of the Appalachian Basin. The most striking feature of this series, as described by the early geologists of the First Geological Survey of Pennsylvania, was the absence of thick or widely extended coal beds such as characterize the underlying and overlying series; hence the name "Lower Barren Coal Measures" was adopted. As thus described, this series is bounded above by the floor of the Pittsburgh coal, and below by the top of the Mahoning sandstone. The difficulty of using a plane of separation as vague and indefinite as the upper limit of the Mahoning sandstone soon became apparent, and therefore, to remedy this practical difficulty, the lower limit of the "Lower Barren Measures" was placed at the top of the ever-present Upper Freeport coal, about 100 feet lower in the series. About 1875, Franklin Platt applied the name Conemaugh to the rocks of this series, because of their good development along the Conemaugh River in western Pennsylvania. Later, in 1891, I. C. White[1] proposed to name this series the "Elk River Series" for exposures along the Elk River above Charleston, West Virginia. The name proposed by Platt in 1875 has come into general use, and this series is now widely known as the Conemaugh.

The Conemaugh occurs in its greatest development along the eastern margin of the field, where it has a thickness of 550 feet in Pennsylvania[2], and, increasing to the south, reaches 800 feet at Charleston, West Virginia. The series in passing westward decreases in thickness, as in Muskingum County, Ohio, it measures only 377 feet.[3]

[1]White, I. C., U. S. Geol. Survey, Bull. 65, p. 70. 1891.
[2]Idem. p. 71.
[3]Stout, W., Geol. Survey Ohio, Fourth Series, Bull. 21, p. 229. 1918.

The distribution of the Conemaugh series in Jefferson County, Ohio, is shown on Map III. The average thickness is about 518 feet, The series as a whole is composed of frequently recurring beds of all the common varieties of sedimentary rocks. The lower 100 feet, formerly grouped with the Allegheny series, is dominantly sandstone or arenaceous shale, above which are various beds of clay, thin irregular coals, thin limestones with calcareous clay shale of varying color, and a few ledges of massive sandstone. The clay and calcareous clay shale are of gray, pink, red, or greenish color; the red and pink varieties, which are the most conspicuous parts of the series, are irregularly distributed in vertical section and grade into other forms when traced laterally. The limestone members, nine in number, are of both marine and fresh water origin. The marine types are thin, variable in composition, but relatively persistent, whereas the brackish water types are fairly constant in composition, but nodular in form, and irregular in areal distribution. The coals are thin, inconstant, and poor in quality. The associated clays are full of impurities and therefore have no economic value. Heavy-bedded sandstones are occasionally present, but their proportion in the rock column is small.

The following geologic sections are introduced here to show the stratigraphy of the Conemaugh series in various parts of the field of outcrop.

General Section, Conemaugh Series, Allegheny County, Pennsylvania[1]

	Ft.		
Conemaugh series			
Concealed	20		
Limestone, *Upper Pittsburgh (Pittsburgh)*	2		
Shale, variegated	65		
Coal, wanting, *Little Pittsburgh*	....		
Limestone, *Lower Pittsburgh (Summerfield)*	5		
Shale, red	20		
Concealed	70		
Sandstone, *Morgantown*	45		
Shale, variegated	50		
Coal, *Elk Lick*	0	to	3
Limestone, *Elk Lick*	0	to	5
Shale, variegated	35		
Limestone, *Ames*	2	to	3
Coal, *Harlem*	0	to	1½
Shale, red, *Pittsburgh (Round Knob)*	30		
Shale, sandy, with shaly sandstone	50		
Coal, *Bakerstown (Anderson)*	0	to	4
Shale and sandstone	40		
Limestone, *Cambridge*	2		
Sandstone, *Buffalo*	60		

[1]White, I. C., Geol. Survey Pennsylvania, Rept. Q, p. 24. 1875.

	Ft.		In.
Limestone, *Brush Creek*	1	to	2
Shale, dark	10	to	15
Coal, *Brush Creek (Mason?)*	0	to	3
Shale	20		
Sandstone, *Mahoning*	40	to	80
	570	to	630

Where the names of the members recognized in Ohio do not correspond to those used in Pennsylvania, the former is placed in parentheses in the section quoted above.

A typical section of the Conemaugh series in West Virginia as measured by I. C. White at Morgantown, Monongalia County, is as follows[1]:

Section at Morgantown, Monongalia County, West Virginia

Conemaugh series	Ft.	In.
Clay	2	0
Shale, sandy, and sandstone	32	0
Coal, *Little Pittsburgh*	1	6
Shale, sandy	17	0
Limestone	1	0
Shale, yellowish, with iron ore	10	0
Shale, sandy, and concealed	17	0
Sandstone, rather massive	25	0
Shale, sandy, and concealed	15	0
Sandstone, massive, *Connellsville*	20	0
Beds, bluish-green, sandy	20	0
Slate, black, fossiliferous	1	0
Limestone, *Clarksburg*	1	0
Shale and sandy beds	45	0
Sandstone, *Morgantown*	20	0
Coal, *Elk Lick*	3	0
Shale and concealed	55	0
Limestone, crinoidal, *Ames*	1	6
Shale, variegated	85	6
Limestone, *Upper Cambridge (Cambridge)*	1	0
Shale,	14	0
Sandstone, *Buffalo*	3	6
Shale and shaly sandstone	30	0
Sandstone, massive, *Upper and Lower Mahoning*	100	0
Shale	40	0
	561	0

[1]White, I. C., West Virginia Geol. Survey, Vol. II, p. 230. 1903.

The thickness and succession of members of the Conemaugh series of Muskingum County, Ohio, are as follows[1]:

Conemaugh series	Ft.	In.
Clay, calcareous	3	0
Clay shale with limestone nodules	4	0
Limestone, *Upper Pittsburgh*	9	6
Clay shale, calcareous, mottled	3	0
Sandstone, *Bellaire*	5	0
Clay shale with some marly limestone	12	0
Coal, *Lower Little Pittsburgh*		6
Clay shale, light to red, calcareous	11	0
Limestone with shale parting, *Summerfield*	6	0
Clay shale, red	8	0
Sandstone, *Connellsville*	5	0
Clay shale, red	12	0
Coal, poorly marked, *Clarksburg*	----	--
Limestone, *Clarksburg*	3	8
Clay shale, red and mottled	31	0
Sandstone, *Morgantown*	6	0
Shale, drab, arenaceous, *Birmingham*	10	0
Clay shale, red	3	4
Limestone, fossiliferous, *Skelley*		4
Clay shale, red	9	0
Shale, and shaly sandstone, gray	11	4
Limestone, arenaceous, or fossiliferous sandstone, *Gaysport*	1	2
Shale, and shaly sandstone	16	3
Limestone, fossiliferous, *Ames*	1	7
Shale and shaly sandstone, gray	17	9
Coal, steady, *Harlem*	1	5
Clay, arenaceous	1	4
Clay shale with limestone, *Round Knob*	16	6
Sandstone, *Saltzburg*	7	6
Coal, thin, *Barton*		6
Clay and shale	5	9
Limestone, fossiliferous, *Ewing*		8
Shale and shaly sandstone	12	0
Sandstone, locally present	20	0
Shale, gray	1	4
Shale, with nodular limestone, very fossiliferous, *Portersville*	4	9
Coal, steady, *Anderson*	1	11
Clay and shale	3	9
Limestone, nodular, *Bloomfield*	1	5
Shale, usually gray	8	8
Limestone, nodular, fossiliferous, *Cambridge*	1	11
Coal, *Wilgus*		4
Clay and shale	10	0
Sandstone, *Buffalo*	26	0
Limestone and shale, dark, fossiliferous, *Brush Creek*	3	11

[1]Stout, W., Geol. Survey of Ohio, Fourth Series, Bull. 21, Pl. III, opp. p. 230.

	Ft.	In.
Shale, gray	5	4
Coal, thin, shaly, *Mason*		3
Sandstone, unsteady, *Upper Mahoning*	14	0
Coal, thin, *Mahoning*		5
Clay, light, *Thornton*	3	9
Limestone, nodular, *Mahoning*		3
Sandstone, *Lower Mahoning*	33	0
	377	1

The following general geologic section of the Conemaugh series of Jefferson County has been made by combining a number of short sections, measured at various places over the county, and represents a typical section of the rocks in this area:

General Section of Conemaugh Series in Jefferson County, Ohio

Conemaugh series	Ft.	In.
Clay, gray	3	10
Limestone, local, *Pittsburgh*	2	7
Clay, gray	3	6
Shale, gray	9	3
Coal, local, *Upper Little Pittsburgh*		1
Clay, gray	5	6
Shale, gray	3	6
Sandstone, local, *Bellaire*	5	0
Shale, gray, arenaceous	12	2
Clay, with limestone, local, *Summerfield*	7	10
Shale, arenaceous	32	0
Sandstone, local, *Connellsville*	25	0
Coal, local, *Clarksburg*	1	0
Clay, with nodules or layers of limestone, *Clarksburg*	6	4
Shale, arenaceous	7	0
Sandstone, *Morgantown*	37	0
Coal, local, *Elk Lick*		7
Clay, with nodules of limestone, *Elk Lick*	6	2
Shale, gray, arenaceous	18	5
Limestone and shale, fossiliferous, *Skelley*		8
Coal, local, *Duquesne*		6
Clay, gray, plastic	6	2
Shale, gray	11	9
Limestone, fossiliferous, *Ames*	2	9
Shale, gray, arenaceous	17	0
Coal, *Harlem*	1	4
Clay, bluish	4	7
Shale, red and pink mottled, *Round Knob*	29	4
Coal, shaly, with black shale, *Barton*		2
Clay, with limestone, *Ewing*	4	9
Shale, gray, arenaceous	22	0
Sandstone, local, *Cow Run*	18	0
Shale, arenaceous	18	0
Coal blossom, local, *Anderson*		1

	Ft.	In.
Clays, mottled	7	3
Shale, arenaceous	15	5
Limestone, ferruginous, fossiliferous, *Cambridge*		9
Coal blossom, local, *Wilgus*		1
Clay, arenaceous, ferruginous	6	1
Shale, arenaceous	18	3
Sandstone, local, *Buffalo*	15	0
Shale, gray, arenaceous	20	0
Shale, dark, with nodules of black limestone, fossiliferous, *Brush Creek*	8	2
Coal, shaly, *Brush Creek*		6
Clay, with limestone nodules	6	0
Shale, arenaceous	25	10
Shale, black, with shaly coal, *Mason*		4
Clay, gray to pink mottled	4	0
Shale, arenaceous	15	7
Sandstone, local, *Upper Mahoning*	14	8
Coal, local, *Mahoning*	2	11
Clay, light, plastic, *Thornton*	5	4
Shale, arenaceous	12	3
Sandstone, local, *Lower Mahoning*	28	10

DESCRIPTION OF MEMBERS

Lower Mahoning Sandstone

Approximately the lower 100 feet of the Conemaugh series, formerly grouped with the Allegheny, consists for the most part of sandstone and arenaceous shale. Dr. I. C. White writes of this group as follows[1]:

"Separated from the Mason coal by 5 to 30 feet of fireclay and shales, there comes in below, almost universally, a very massive sandstone group, sometimes in one massive solid ledge, 80 to 100 feet thick, but more frequently separated into two sandstones by an intervening coal, and an underlying limestone, fireclay, or both; so that when all of the members are present the Mahoning stage is made up of the following succession:

Upper Mahoning sandstone
Mahoning coal
Thornton fireclay
Mahoning limestone
Lower Mahoning sandstone."

With the thinning of the Conemaugh series as it is traced westward to Ohio, some of these members become inconspicuous or entirely disappear. Of the two sandstone members, the Lower Mahoning is the best developed, and, in Jefferson County, it is locally

[1]White, I. C., West Virginia Geol. Survey, Vol. II, p. 305. 1903.

a medium to coarse-grained, micaceous, heavy-bedded sandstone, ranging in thickness from 10 to 40 feet. Like all the sandstone members of the Conemaugh series, the Lower Mahoning is lacking in persistency and, when traced laterally, grades into arenaceous shale. This sandstone reaches its best stage of development along the Ohio River Valley in Knox and Saline townships, and along Yellow Creek and its tributaries in Saline, Ross, and Brush Creek townships. Near the mouth of Yellow Creek, the Lower Mahoning sandstone is present in thicknesses ranging from 30 to 50 feet. The stone is coarse-grained and heavy-bedded in the lower part, but is soft and friable in the upper part of the member. Near Irondale it has a thickness of 50 feet with the base close to the Upper Freeport coal.

It is likewise well developed along Brush Creek in Brush Creek and the western part of Saline townships. The stratigraphy of the member is well represented in the following geologic section obtained near the mouth of Brush Creek in Section 25, Saline Township:

	Ft.	In.
Shale, yellowish-gray, arenaceous	8	0
Clay, yellow, arenaceous	13	0
Limestone, dark, *Mahoning*	1	0
Clay, bluish-gray, with iron ore nodules	10	0
Sandstone, *Lower Mahoning*	51	0
Shale, bony, with streaks of clay	1	0
Clay, bluish-gray, *Upper Freeport*	4	6
Sandstone	13	0
Shale, platy, blue	7	6
Sandstone, *Upper Freeport*	21	6
Covered interval	20	9
Coal, *Lower Freeport*	2	6

At Tunnel Mill in Section 34, Knox Township, the Mahoning sandstone has a thickness of 15 feet. It is generally present along Yellow Creek in Ross Township east of Section 28 with thicknesses ranging from 15 to 50 feet, but westward, in Ross and Springfield townships, it passes into arenaceous shale. Along the Ohio River, the Lower Mahoning sandstone is generally present as far south as Costonia at the mouth of Island Creek, in Island Creek Township, but it is quite changeable in its physical characteristics. In Section 33, Knox Township, the sandstone has a thickness of 40 feet; in Sections 31 and 32 of 15 feet. Along Island Creek arenaceous shale is the type of rock found on this sandstone horizon.

Mahoning Limestone

The Mahoning limestone is closely associated with the Mahon-

ing coal and clay, but it is by no means as persistent in its occurrence as these associated members. It usually consists of well-defined layers of limestone lying at the bottom of the Mahoning or Thornton clay, or of nodular layers or masses of limestone scattered throughout the clay. The limestone is dense and homogeneous in appearance with a dark gray color. In physical properties it is very similar to the Freeport limestones and like them is evidently of fresh or brackish water origin. *Spirorbis anthracosia* Whitfield is the only fossil found, but it is very abundant.

In Jefferson County, the Mahoning limestone is very poorly developed. The clay associated with the Mahoning coal is usually calcareous and locally contains small nodules of limestone embedded in it. At only one locality, however, namely in Section 13, Brush Creek Township, is the Mahoning limestone a well-defined member; and here it is composed of a single layer 8 inches in thickness embedded in clay.

Mahoning Clay

The Mahoning clay, known in West Virginia as the Thornton clay,[1] lies immediately below the Mahoning coal. In general, this clay is much more persistent than the coal which normally overlies it, and it is therefore a much better stratigraphic guide. In Jefferson County the Mahoning clay varies from 2 feet to 14 feet 6 inches in thickness, but an average of 21 measurements is about 5 feet. The material is of the plastic variety, although in a few localities it tends to become flinty in character. Its color is light gray or buff with here and there a mottling of red or pink. Calcium carbonate and iron compounds are found disseminated through the clay or segregated in nodular masses in sufficient quantity to render the clay of low grade for ceramic purposes. The Mahoning clay in Jefferson County lies, on an average, about 5 feet above the Upper Freeport coal and 55 feet below the Brush Creek marine limestones and shales.

The Mahoning clay is generally present in Saline Township where it occurs from 45 to 50 feet below the Brush Creek marine beds and from 45 to 70 feet above the Upper Freeport coal. It is of fair quality for this bed. The Mahoning clay is well shown at various localities along the Brush Creek Valley in the western part of Brush Creek Township, where the thickness ranges from 3 to 8 feet. The material is generally of the plastic type, but at one locality, namely along the road in Section 19, it is hard and flinty in charac-

[1]White, I. C., West Virginia Geol. Survey, Vol. II, pp. 322-323. 1903.

ter. The following section, measured in the southwestern part of Section 13, shows the thickness and stratigraphic relations of this clay:

		Ft.	In.
Shale, arenaceous		25	0
Clay, *Wilgus*		7	0
Shale, gray, arenaceous		73	8
Shale, black, fossiliferous, *Brush Creek*		8	8
Covered interval		9	0
Shale, gray, arenaceous		71	6
Clay, with nodules of limestone, *Mahoning*		6	0
Covered interval		29	5
Sandrock		10	0
Clay shale, dark		1	1
Coal, bony	*Upper Freeport*		3
Coal, good	*Upper Freeport*	3	3

In Ross Township, the Mahoning clay is usually present along Yellow Creek, where it ranges in elevation from 832 feet in Section 3 to 900 feet in Sections 33 and 34. The clay, which varies in thickness from 3 to 14 feet, is generally impregnated with iron compounds and is therefore of a yellowish pink, or reddish color. In Section 14, this clay, which is plastic and highly arenaceous, outcrops at an elevation of 870 feet and has a thickness of 14 feet. In Section 28, it has a thickness of 10 feet and is entirely arenaceous in character. The following geologic section, measured along the road in the western part of Section 28, illustrates the stratigraphy of this member:

	Ft.	In.
Shale, gray, arenaceous, fossiliferous, *Brush Creek*	15	0
Clay, yellow	2	0
Shale, sandy	9	2
Clay and covered, *Mason horizon*	5	0
Shale, sandy	34	6
Clay, gray, arenaceous	10	8
Shale, arenaceous	15	8
Clay, light, plastic, *Mahoning*	5	6
Shale, gray, arenaceous	33	6
Shale, bony		5
Shale, dark	4	0
Coal blossom, *Upper Freeport*	1	2

In Springfield Township, the Mahoning clay is poorly developed and of low quality. In Knox Township, Mahoning clay 5 to 6 feet in thickness is present along the Yellow Creek Valley in Sections 28 and 34, where it is normal in its characteristics for this region. West of Empire, in the northwestern part of Section 33, 6 feet of Mahoning clay outcrops at an elevation of 880 feet. It is yellow

in color due to the inclusions of iron compounds. A record showing the Mahoning clay was secured about one mile west of Toronto in Section 3, as shown below:

	Ft.	In.
Limestone, fossiliferous, *Cambridge*		11
Shale, arenaceous	39	0
Shale, dark, fossiliferous } *Brush Creek*		6
Limestone, black, fossiliferous } *Brush Creek*		6
Shale, black, fissile		9
Shale, bony, with thin coal bands, *Brush Creek*		8
Shale, dark, arenaceous	5	8
Clay, bluish-gray, arenaceous, with iron ore nodules	7	2
Shale, bluish-gray, arenaceous	5	2
Covered interval	27	0
Sandstone, *Upper Mahoning*	15	0
Clay, bluish-gray, arenaceous, with iron ore nodules, *Mahoning*	4	6

In Island Creek Township, the Mahoning clay is persistent along the Ohio River Valley as far south as Section 26, and along Island Creek as far as Section 11. In Section 6, this clay has a thickness of 10 feet, is gray, plastic, and of fair quality. At other localities in the township, it is thin and highly charged with impurities.

Mahoning Coal

In some localities in West Virginia, the Mahoning sandstone is separated into two parts by a coal bed which has been named the Mahoning coal. Along the western belt of outcrops of the Conemaugh series, this sandstone is rather poorly developed, but the Mahoning coal and associated clay are wide-spread in their occurrence and in Ohio have been recognized by Condit in almost every county where due. In Jefferson County the Mahoning coal, locally known as the Groff or Finley coal, has a thickness which varies from 0 to 5 feet, but averages a little less than 3 feet. The character of the member is quite variable; it changes from black carbonaceous shale, or a mixture of black shale and shaly coal, to solid coal of good quality. At a few localities the Mahoning coal has been replaced by the Upper Mahoning sandstone, but in the majority of cases where this coal is wanting its absence is due to lack of deposition. The position of the Mahoning coal in Jefferson County is, on an average, about 60 feet below the Brush Creek marine limestones and shales and about 39 feet above the Upper Freeport coal. Outcrops are found in Saline, Brush Creek, Ross, Springfield, Knox, and Island Creek townships where, on account of the economic importance of this coal, its occurrence will be treated in detail.

Saline Township

The Mahoning coal is due in every section in Saline Township, but it is very unsteady in its occurrence. In that part of the township which lies south of Yellow Creek, no exposures of importance are present, but in some localities north of this stream the coal occurs in minable thickness. Near the mouth of Yellow Creek in Section 8, Mahoning coal 2 feet in thickness outcrops at an elevation of 861 feet. A local thickening of the bed occurs in Section 14, where two openings have been made by Thomas Hudson. The coal has a thickness of about 4 feet and is of good quality, and the fuel finds a ready market for domestic use in the vicinity. The stratigraphic relations of the Mahoning coal and the underlying beds are well shown in the following record obtained in the western part of Section 13:

	Ft.	In.
Coal on outcrop, *Mahoning*	2	4
Sandstone, shale, and covered	38	0
Shale, black, fissile	3	4
Coal, *Upper Freeport*	3	6
Sandstone, shale, and covered	57	0
Shale, black	1	0
Coal, *Lower Freeport*	2	8

The elevation of the Mahoning coal at this locality is 855 feet.

A quarter of a mile northeast of Hammondsville in Section 19, a mine in the Mahoning coal has been opened by the Saline Coal Co. of Steubenville. The minable part of the bed has a thickness of about 4 feet 5 inches. Its structure and thickness are well shown in the following measurements secured near the mouth of the mine:

		Ft.	In.
Shale		2	0
Coal, bony	*Mahoning*		6
Coal, good		1	4½
Shale, parting			½
Coal, good		3	0
Sulphur band, not persistent.			
Clay, dark, arenaceous		2	0

The coal at this place has an elevation of 855 feet above tide.

The Mahoning coal has been prospected at a few places west and southwest of Port Homer in Sections 5 and 6 but has yielded little except black shale and shaly coal.

Brush Creek Township

In Brush Creek Township, the Mahoning coal horizon is above drainage along Brush Creek as far as the northern edge of Section 31,

and along Salt Run to the eastern edge of Section 9. The coal, however, is generally wanting through lack of deposition, but in a few places it has been replaced by the Upper Mahoning sandstone. A small area of this coal occurs in the northeastern corner of Section 31, where a small country bank has been opened by Ed. Peterson of Salineville. The minable part of the bed has a thickness of 3 feet 4 inches and is of good quality. It is overlain by a 5-inch bed of bone coal and underlain by clay. The elevation of the coal at this locality is 980 feet above tide. A thin blossom of Mahoning coal occurs also in the south-central part of Section 25, where the elevation is 975 feet above tide, and the interval to the base of the Brush Creek marine shales measures 53 feet.

Ross Township

The Mahoning coal horizon is present in Ross Township along Yellow Creek at elevations ranging from 822 feet in Section 3 to 930 feet in Section 34. No coal, however, is present on this horizon except in Section 34. About 1¼ miles east of Bergholz, a small country bank in Mahoning coal has been opened on the Dr. Malone farm. The characteristics of the coal are well shown in the following section secured at the mouth of this opening:

		Ft.	In.
Shale, dark		1	6
Coal	*Mahoning*	3	5
Shale, with thin coal bands			4
Coal, good			2
Coal, bony			2
Clay, gray, plastic			4

The coal at this locality has an elevation of 930 feet. The fuel which is of good quality is sold for local consumption.

The general stratigraphic relations of the Mahoning coal of this region and the underlying and overlying members are well shown in a record obtained in the south-central part of Section 34:

	Ft.	In.
Sandstone and arenaceous shale	26	0
Shale, dark, fossiliferous, *Brush Creek*	17	2
Shale, dark, with many plant fossils	3	0
Clay and covered, *Mason horizon*	14	10
Limestone, impure, ferruginous	1	2
Clay, with limestone nodules	15	8
Shale, gray to pink	28	4
Coal blossom, *Mahoning*	2	6

	Ft.	In.
Clay, gray, plastic	2	0
Covered interval	9	4
Shale, gray, arenaceous	25	10
Black shale and shaly coal, *Upper Freeport*		6
Shale and covered	29	6
Coal, not entire thickness, *Lower Freeport*	2	0

The elevation of the Mahoning coal at this locality is about 898 feet.

Springfield Township

The horizon of the Mahoning coal is above drainage in that part of Springfield Township which lies north of the mouth of Wolf Run. The coal, however, is very irregular in its occurrence and is subject to many wants, and a few feet of clay in some localities is the only indication of this coal horizon. Mahoning coal was formerly worked at the eastern edge of Bergholz in the west-central part of Section 4, but the mine has long been abandoned. It also occurs in minable thickness in Section 12; and at the old Jumbo mine, located in the southwestern corner, the coal was mined for railroad shipment for a number of years, but the mine is now abandoned. Near the mouth of Burgett Run in Section 12, a small country bank is operating in Mahoning coal on the Peterson farm. The minable part of the bed has a thickness of about 3 feet 10 inches above which are several inches of black shale and shaly coal. The coal is of good quality and finds a ready market among the farmers of the neighborhood. The interval from the Mahoning coal to the Brush Creek marine beds at this locality is about 53 feet.

Knox Township

The Mahoning coal is of little value in Knox Township, as it is variable in thickness and is wanting over large areas. Coal of minable thickness is present along the river front, where it has been worked at a number of places as far south as Calumet. These mines have now been abandoned due to the exhaustion of available coal or to a thinning of the bed to an extent that it cannot be mined with profit. In the old mine at Calumet, Mahoning coal is reported to have a thickness of 4 feet 6 inches. The bed has an elevation of 860 feet above tide and lies about 100 feet above the Roger or Lower Freeport coal. The stratigraphic relations of the Mahoning coal horizon and the overlying beds are well shown in the following section measured along a small ravine in the central part of Section 1:

		Ft.	In.
Limestone, blue, fossiliferous, *Cambridge*			11
Shale, arenaceous		39	0
Shale, dark, fossiliferous	*Brush Creek*		6
Limestone, black, fossiliferous	*Brush Creek*		6
Shale, dark, fissile			9
Shale, dark, with coal bands, *Brush Creek*			8
Shale, dark, arenaceous		5	8
Shale, gray, arenaceous, with iron ore nodules		7	2
Covered interval		27	0
Sandstone, *Upper Mahoning*		15	0
Coal horizon, *Mahoning.*			
Clay, bluish-gray, arenaceous, with iron ore nodules		4	6

Island Creek Township

In Island Creek Township, the Mahoning coal horizon is above drainage along the Ohio River Valley as far south as the northern part of Section 29, and along Island Creek from its mouth as far as Section 11. The coal is generally wanting except in Sections 35, 36, and 5, where it occurs in minable thickness and is known as the Finley coal. One mile west of Jeddo this coal was formerly worked in a small way for local use. The member has a thickness of 2 feet on the outcrop but is reported to be 3 feet 6 inches in thickness under cover. The Mahoning coal along Island Creek was formerly worked on the Wm. S. Findley farm in the northern part of Section 4, but this mine has long been abandoned. A number of openings in the Mahoning coal have been made along the north side of Island Creek Valley in Sections 35 and 5, but with one exception none are now in operation. The coal is well exposed in a small bank on the Johnson farm in the southern edge of Section 35, where it has the characteristics given in the following geologic section:

		Ft.	In.
Shale		2	0
Coal, bony, with sulphur bands	*Mahoning*		4
Coal	*Mahoning*		4
Coal, bony	*Mahoning*		8
Coal, good	*Mahoning*		4
Clay			6

The coal at this locality has an elevation of 751 feet and lies 71 feet above the Lower Freeport coal. In 1904, W. T. Griswold sampled the Mahoning coal in a small mine about one mile from the mouth of Island Creek. This sample, analyzed in the laboratories of the U. S. Bureau of Mines, shows the following composition[1]:

[1]U. S. Bureau Mines, Tech. Paper No. 344, p. 22. 1923.

Proximate analysis

	As received	Moisture free
Moisture	3.9	.....
Volatile matter	36.5	37.9
Fixed carbon	52.2	54.4
Ash	7.4	7.7
	100.0	100.0
Sulphur	3.6	3.8

Air drying loss.....1.9 per cent

Upper Mahoning Sandstone

The Upper Mahoning sandstone normally lies in the interval between the Mahoning coal and the Mason coal and clay. At many places in West Virginia, southwestern Pennsylvania, and eastern Ohio, however, this member exceeds its stratigraphic limits by replacing the Mahoning coal. Locally it is continuous with the Lower Mahoning sandstone, and in such places these two members can not be distinguished.

In Jefferson County, Ohio, the Upper Mahoning sandstone is poorly represented, being local in its development and variable in character and thickness. It is best represented in Saline, Brush Creek, and Ross townships, where in places it is massively developed with thicknesses ranging from 5 to 20 feet. At other localities in the county, this member gives way to soft, friable, shaly sandstone or arenaceous shale. The stone is composed of quartz grains, medium to coarse in texture, with admixtures of mica and ferruginous material. The color is bluish-gray weathering to a buff or brown.

The Upper Mahoning sandstone is generally present in Saline Township north of Yellow Creek, but is somewhat variable in thickness. The following measurements secured near the mouth of this stream show the stratigraphic sequence:

	Ft.	In.
Coal blossom, *Mason*	1	0
Clay, gray, arenaceous	3	0
Covered interval	12	6
Sandstone, *Upper Mahoning*	12	0
Shale, gray, arenaceous	24	2
Coal blossom, *Mahoning*	2	0
Clay and covered	12	0
Sandstone and covered, *Lower Mahoning*	48	0
Coal, *Upper Freeport*	3	0

In the extension of the Upper Freeport sandstone member to the south in Saline Township, the massive character of the stone disappears and arenaceous shale with a thin layer of soft friable

sandstone takes its place. In Brush Creek Township, Upper Mahoning sandstone outcrops at a few places along the Brush Creek Valley. The maximum thickness of 15 feet was observed in the northern part of Section 25.

In Ross Township, shaly sandstone and sandy shale are the prevailing types of rock above the Mahoning coal. At some localities lenses of sandstone are present as shown in the following record obtained in the east-central part of Section 23:

	Ft.	In.
Shale, dark, fossiliferous, *Brush Creek*	6	0
Shale, gray	10	6
Coal, shaly, *Brush Creek*	1	3
Clay, gray, arenaceous	10	6
Covered interval	30	0
Sandstone, massive, *Upper Mahoning*	15	0
Clay, mottled	3	0
Sandstone, shale, and covered	52	0
Shale, bony		7
Coal, good, *Upper Freeport*	3	0
Covered interval	47	0
Shale, gray, arenaceous	10	0
Coal, *Lower Freeport*	3	1
Clay, plastic	1	0

The Upper Mahoning sandstone horizon is above drainage along the Ohio River from Yellow Creek south to Stanton Park in Section 31, Island Creek Township. Little sandstone is found on this horizon, however, except near Stanton Park, where it occurs massively developed with a thickness of 20 feet.

Mason Coal and Clay

The next members above the Upper Mahoning sandstone are a coal bed and the clay underlying it. This coal, irregular in its occurrence, was named the Mason coal by I. C. White for the village of Mason, Kanawha County, West Virginia[1]. In Ohio, this coal and its associated clay, which lie about midway between the Mahoning coal and the Brush Creek marine beds, are unimportant members of the Conemaugh series on account of their lack of economic value and on account of their stratigraphic discontinuity. The coal is always shaly and unsteady in its occurrence; whereas the clays are likewise uncertain in character and thickness and at many places are wanting.

[1]White, I. C., West Virginia Geol. Survey, Vol. II, p. 285. 1903.

The Mason coal and clay are poorly represented in Jefferson County. The coal bed has a maximum thickness of 10 inches and usually consists of interstratified black shale and shaly coal. At a few localities the bed is overlain by a few feet of black shale in which are many plant fossils. The associated clay varies from 1 to 15 feet, but averages about 4 feet. The clay is usually gray in color, but at some localities is mottled pink or red. It is usually arenaceous, highly calcareous with abundant limestone nodules, and at some localities is impregnated with iron compounds. The Mason coal and clay in Jefferson County lie, on an average, about 32 feet below the Brush Creek marine shale and 37 feet above the Mahoning coal. Exposures of these members are present in Saline, Brush Creek, Ross, Springfield, Knox, and Island Creek townships.

In Saline Township, the Mason coal is well exposed along Brimstone Run in Section 6, where the bed has a thickness of 6 inches, is overlain by bluish-gray shale containing many plant impressions, and underlain by 6 feet of yellowish clay. At other exposures in this township the coal is wanting, but the associated clay varies in thickness from 2 to 12 feet. In Brush Creek Township, exposures of the Mason horizon are present in Sections 2, 12 and 13. The clay, which varies in thickness from 5 to 12 feet, is overlain by a few inches of black shale representing the Mason coal. The stratigraphic relations are well shown in a record obtained in the central part of Section 13, as given below:

	Ft.	In.
Shale, black, fossiliferous, *Brush Creek*	10	6
Covered interval	34	10
Clay, arenaceous, *Mason horizon*	5	4
Shale, shaly sandstone, and covered	36	0
Clay, gray, plastic	1	6
Limestone, nodular, *Mahoning*		8
Clay and covered	6	6
Covered interval	30	6
Shale, gray, arenaceous	4	0
Shale, dark	8	6
Coal, *Upper Freeport*	3	2
Clay	5	0

In this record the interval from the Mason clay to the Brush Creek shale above and the Mahoning horizon below are about normal for this county. Thin beds of clay are found on the Mason horizon in Sections 3, 16, and 34, Ross Township, but the coal is wanting. Along the road in Section 3, a measurement of the outcrops is as follows:

	Ft.	In.
Shale, dark, fossiliferous, *Brush Creek*	5	0
Clay and covered	3	0
Shale and covered	31	2
Shale, black, carbonaceous		10
Clay, arenaceous, *Mason horizon*	2	0
Covered	9	0
Shale, arenaceous	5	0
Clay, light, *Mahoning*	5	6
Shale, gray, arenaceous	9	10
Sandstone, massive, *Lower Mahoning*	31	2
Clay, *Upper Freeport*	3	0

At other localities in this township the Mason clay has a thickness of about 5 feet. The overlying coal is either wanting or is represented by a few inches of black carbonaceous shale. The same condition holds true in Springfield Township, where this clay has been observed in Sections 11 and 15. In Knox Township, the Mason horizon is well developed in Sections 31 and 32, where the clay ranges from 3 to 5 feet and the coal, at one locality in Section 32, measures 10 inches.

In Island Creek Township, the Mason clay is exposed at various localities along Island Creek, Wills Creek, and the Ohio River. The following record, secured along a small ravine on the western bank of the Ohio River in the northern part of Section 27, illustrates the stratigraphic sequence in this township:

	Ft.	In.
Sandstone, *Cow Run*, estimated thickness	40	0
Shale, gray, arenaceous	43	10
Shale, dark, fossiliferous, *Brush Creek*	3	0
Covered interval	10	0
Shale, arenaceous, in part red	5	4
Shale, gray, arenaceous	14	5
Clay, dark, arenaceous, *Mason*	6	2
Shale, gray, arenaceous	23	10
Clay, gray, plastic, *Mahoning*	5	8
Shale, gray, arenaceous	10	4

At other localities in this township the Mason clay varies from 1 to 8 feet in thickness, and the associated coal is either represented by a thin smut streak or is entirely wanting. The interval from this coal to the Brush Creek marine beds, which varies from 9 to 29 feet with an average of about 23 feet, is below the normal for the county.

Brush Creek Coal and Clay

Over a large area in northeastern Ohio, a thin bed of coal is

found at the base of the Brush Creek fossiliferous limestones and shales, which in the recent reports dealing with the Conemaugh series in Ohio is called the Brush Creek coal. In Jefferson County, this coal and its associated clay have a wide distribution in Saline, Brush Creek, Ross, Springfield, Knox, and Island Creek townships, although at some localities in this area they are wanting. The coal varies in thickness from a smut streak to 1 foot 6 inches, but averages about 6 inches. At a few places where it is found in its best development, it is separated into two benches by a thin shale parting. The underlying clay is well defined, but shows no unique characteristics by which it can be distinguished from other clay beds of the Conemaugh series. It is everywhere dark gray in color, and arenaceous, calcareous, and ferruginous in composition. Its thickness varies from 1 to 13 feet with an average of about 6 feet.

The only exposure of the Brush Creek coal in Saline Township occurs in Section 7, where the bed has a thickness of 1 foot and is immediately overlain by the Brush Creek fossiliferous beds of limestone and underlain by 3 feet of clay. In Brush Creek Township, the Brush Creek coal horizon is represented in Section 31 by a thin blossom which outcrops at an elevation of 1,040 feet, whereas in Section 12 this member is represented by 9 inches of coal at an elevation of 990 feet. In Ross Township, the horizon of the Brush Creek coal and clay is well exposed at many places, but at only two localities, namely in sections 3 and 33, is the coal found to be present. In Section 3, the member is composed of 7 inches of shaly coal overlain by dark shale and underlain by dark clay outcropping at an elevation of 900 feet above tide. In Springfield, Knox, and Island Creek townships, the Brush Creek coal and clay are much more regular in occurrence than in Saline, Brush Creek, and Ross townships. In Springfield Township, the coal, although never more than 2 or 3 inches in thickness, has been recognized in sections 2, 4, 8, 10, 11, and 12. This bed has an elevation of 1,060 feet in Section 11; 933 feet in Section 12; and 1,036 feet in Section 8. It is underlain by yellowish-gray clay which varies from 2 to 11 feet in thickness. The following record was secured in the northern part of Section 12:

	Ft.	In.
Shale, gray, arenaceous	30	0
Limestone, ferruginous, *Cambridge*		2
Clay, ferruginous, arenaceous, *Wilgus*	5	6
Shale, arenaceous	24	8
Shale, red	6	0
Shale, gray, arenaceous	34	8
Shale, dark, fossiliferous, *Brush Creek*	6	6

		Ft.	In.
Coal blossom, *Brush Creek*			2
Clay shale, and covered		48	6
Shaly coal and blue shale	*Mahoning*		9
Coal		3	7
Parting			1
Coal			3

In Knox Township, the horizon of the Brush Creek coal and clay is above drainage along the Ohio River Valley and the valleys of Yellow Creek and Town Fork. These members are best represented, however, along Croxton Run in Sections 31 and 32, where the coal has a thickness of 8 inches and the clay varies from 6 to 8 feet. In Island Creek Township, the coal and clay reach their best development along Wills Creek in Sections 1, 7, 31, and 32. The following measurements, secured in the southeastern part of Section 1, are representative:

		Ft.	In.
Sandstone, massive, *Buffalo*		10	0
Shale, gray, arenaceous		6	0
Shale, dark, fissile, fossiliferous	*Brush Creek*	15	10
Iron ore, nodular			4
Shale, dark, fossiliferous			6
Coal, shaly	*Brush Creek*		9
Parting			1
Coal, good			4
Clay, ferruginous		2	0
Shale, arenaceous		26	0
Clay, dark, arenaceous, *Mason*		7	6

The elevation of the coal at this locality is 713 feet above tide.

The Brush Creek coal is also well exposed near the entrance to Stanton Park where the bed consists of two benches separated by a shale parting. The upper bench has a thickness of 11 inches and is composed of bone shale with interstratified shaly coal; the underlying clay is arenaceous and ferruginous in composition with a thickness of 4 feet.

Brush Creek Limestone and Shale

The Brush Creek beds were first named by I. C. White in Report Q. of the Second Geological Survey of Pennsylvania for exposures in Crawford Township, Butler County, Pennsylvania. This member, consisting as it does of dark fossiliferous shale with nodular masses of dark limestone, constitutes one of the most widely distributed and easily recognized horizons of the Conemaugh series. In fact, its characteristics are so unique and constant that it is of much value

as a guide horizon for stratigraphic studies, especially in the tracing and identification of various coal beds. The Brush Creek horizon in Ohio has been described by Stout and Lamborn as follows:[1]

"The Brush Creek limestone and shale is the lowest marine member of wide distribution in the Conemaugh formation of Ohio, extending at it does from Lawrence County on the south to Columbiana County on the east. The bed, however, is variable in thickness and character across this area. In the more typical exposures in southern Ohio the member consists of two limestones, regularly bedded and very fossiliferous, separated by twenty to thirty feet of gray siliceous shale, also bearing a few marine fossils. In other localities the entire interval is filled with thin-bedded cherty limestone alternating with calcareous shale. The most common representative of the member in central Ohio is dark fossiliferous shale overlain by impure limestone which varies from a few inches to ten feet in thickness and changes from carbonaceous limestone through gray flinty limestone to gray calcareous flint. In eastern Ohio and especially in Columbiana County, the Brush Creek member consists of carbonaceous shale, part of which is very fossiliferous and through which nodules of black fossiliferous limestone are irregularly distributed or are locally concentrated into one or two layers in the basal part of the shale. The black shales make up by far the greater part of the deposits."

The mode of occurrence of the Brush Creek beds in Jefferson County is very similar to that in Columbiana County. The member usually consists of a single bed of dark fossiliferous shale with nodular masses of black limestone embedded in it, at the base of which lie the Brush Creek coal and clay. At one locality, however, namely in the southern part of Section 12, Brush Creek Township, it is found in two beds separated by about 20 feet of non-fossiliferous shale and clay. This arrangement is similar to the mode of occurrence of the member in southern Ohio, where it normally consists of two beds. Furthermore, the Brush Creek coal, which is wide spread in its occurrence in Jefferson County, lies at the base of the upper bed at this locality. It is apparent, therefore, that the Brush Creek limestone and shale as they are usually developed in this county represent only the upper part of the member, and that at most exposures the lower part is wanting.

The Brush Creek fossiliferous limestone and shale in Jefferson County vary in thickness from a few inches to 27 feet but average about 8 feet. They lie about 59 feet below the Cambridge limestone; 67 feet above the Mahoning coal; and 116 feet above the Upper Freeport coal. These members are above drainage in Salem, Brush Creek, Ross, Springfield, Knox, and Island Creek townships. As the member is very persistent and well marked, it is especially valuable

[1]Stout, W., and Lamborn, R. E., Geol. Survey Ohio, Fourth Series, Bull. 28, p. 323. 1924.

as a guide horizon, and therefore its occurrence will be traced in detail in the following pages.

Saline Township

In Saline Township, the Brush Creek limestone and shale are regularly present along the Ohio River and Yellow Creek valleys at elevations ranging from 910 feet in Section 7, 830 feet in Section 29, to 990 feet in Section 25; and measure from 2 to 17 feet in thickness. The stratigraphic relations of the member are well shown in a geologic section measured along Brimstone Run in Section 6:

		Ft.	In.
Limestone, massive, bluish-gray, *Cambridge*		1	9
Clay, yellow, arenaceous		7	4
Clay, bluish-black			6
Clay, yellow, arenaceous		1	9
Covered interval		15	0
Shale, bluish-gray, fossiliferous	*Brush Creek*	15	0
Shale, gray, fossiliferous		2	0
Shale, arenaceous, fossiliferous			6
Shale, bluish-gray, with plant fossils		11	7
Coal, shaly, *Mason*			6
Clay, gray		6	0

The base of the Brush Creek beds at this locality lies at an elevation of 922 feet.

The Brush Creek beds are represented by 7 feet of dark fossiliferous shale which outcrops at an elevation of 990 feet and which lies 110 feet above the Upper Freeport coal in the northwestern part of Section 25. In the southeastern part of Section 29, the member consists of one or more layers of hard blue limestone interstratified with fossiliferous shale, as is shown in the following record:

		Ft.	In.
Shale, reddish brown		13	0
Sandrock, hard, blue			8
Shale, gray, arenaceous		1	0
Limestone, blue, fossiliferous	*Brush Creek*		4
Shale, gray, arenaceous, fossiliferous		1	8
Limestone, hard, blue, fossiliferous			6
Shale, bluish-gray, fossiliferous		1	10
Shale, blue		23	0
Coal and shale, *Mason*			8

The Brush Creek beds at this locality lie at an elevation of 834 feet and occur about 100 feet above the level of Yellow Creek.

Brush Creek Township

The Brush Creek limestone and shale are regularly present in Brush Creek Township along Brush Creek and have been recognized at a few places along Salt Run. Dark, micaceous, fossiliferous shale is the predominating type of rock although thin layers or nodular masses of black fossiliferous limestone are usually present. The elevation of the member varies from 960 feet in sections 2 and 12, to 1,040 feet in Section 32. The limestone and shale with the overlying and underlying beds are well exposed near the forks of the road in Section 25, where the following measurements were made:

		Ft.	In.
Shale, gray, arenaceous		50	0
Shale, black, fossiliferous, with nodular limestone	*Brush Creek*	7	0
Shale, gray, arenaceous, fossiliferous	*Brush Creek*	10	2
Shale, black, fossiliferous	*Brush Creek*	3	6
Shale, gray, arenaceous		20	10
Sandstone, ferruginous, *Upper Mahoning*		25	0
Clay, dark blue, *Mahoning horizon*		3	0

The elevation of the Brush Creek beds at this locality is 1,025 feet.

In the central part of Section 13, Brush Creek Township, the member is represented by 10 feet of black fossiliferous shale which outcrops at an elevation of 1,036 feet. An excellent exposure of the Brush Creek beds occurs in the southern part of Section 12, where the measurements given below were obtained:

		Ft.	In.
Limestone	*Cambridge*	1	2
Shale, blue, fossiliferous	*Cambridge*	2	2
Shale, with coal bands, *Wilgus*			1
Clay, bluish		5	0
Covered		5	4
Shale, bluish-gray, arenaceous		30	0
Shale, black, carbonaceous, with ore nodules	*Upper Brush Creek*	5	4
Shale, black, arenaceous, fossiliferous	*Upper Brush Creek*	5	4
Limestone, black	*Upper Brush Creek*	1	2
Shale, black, micaceous	*Upper Brush Creek*	4	0
Shale, dark, fossiliferous	*Upper Brush Creek*	7	8
Coal, bony, *Brush Creek*			9
Clay, bluish-gray, arenaceous		6	8
Shale, bluish-gray		12	10
Sandrock, dark, fossiliferous	*Lower Brush Creek*		3
Limestone, black, ferruginous	*Lower Brush Creek*		3
Shale, black	*Lower Brush Creek*		10
Shale, black, fossiliferous	*Lower Brush Creek*	5	5
Shale, gray, arenaceous		12	2
Shale, black, with plant impressions			8
Clay, bluish-gray, *Mason*		4	8

The Brush Creek limestone and shale member at this locality occurs in two beds separated by 12 feet of gray arenaceous shale. This mode of occurrence is typical for the Brush Creek member in southern Ohio where it usually consists of two benches of limestone separated by an interval of 12 to 18 feet of shale. The thin Brush Creek coal, which at this locality lies below the upper fossiliferous beds, is generally present in this county, and as the lower Brush Creek beds are as a rule wanting, it is underlain by a thin layer of clay or arenaceous shale, below which lies the Mason coal.

Fossils were collected from the Brush Creek horizon in the central part of Section 19, where the measurements of the outcrops are as follows:

		Ft.	In.
Shale, black, fossiliferous	*Brush Creek*	15	6
Limestone, black, fossiliferous		2	4
Shale, black, arenaceous, micaceous, fossiliferous		2	7
Shale, gray, to bluish-gray		70	8

The following fossils were identified from collections made at this locality:

Ambocoelia planoconvexa (Shumard)
Solenomya radiata Meek and Worthen
Cardiomorpha missouriensis Shumard
Nucula parva McChesney
Lima retifera Shumard
Allorisma subcostatus Meek and Worthen
Pleurophorus subcostatus Meek and Worthen

Ross Township

Many exposures of the Brush Creek shale member in Ross Township are found along the valley of Yellow Creek from Holt to Bergholz. The elevation of this shale is 873 feet in Section 3; 983 feet in Section 23; and 970 feet in Section 33. The thickness of the beds ranges from 1 to 27 feet, but averages about 12 feet. The thickness and stratigraphic relations of the member are shown in the following record obtained in Section 3:

	Ft.	In.
Shale, red, *Round Knob*	31	0
Shale and shaly sandstone	67	0
Shale and covered	26	0
Clay, yellow, *Wilgus horizon*	2	0
Covered interval	5	0
Shale, gray, arenaceous	29	2
Shale, black, fossiliferous, with nodules of black limestone, *Brush Creek*	21	6

	Ft.	In.
Coal with much shale, *Brush Creek*		8
Clay, yellow, arenaceous	13	10
Covered interval	6	0
Sandstone, shaly	7	0
Shale, gray to black, arenaceous	14	7
Shale, bony, *Mahoning*		3
Clay, yellow	4	0
Sandstone, shale, and covered	16	5
Coal blossom, *Upper Freeport*	4	5
Clay, gray	5	2

The elevation of the Brush Creek member at this locality is 876 feet.

In the central part of Section 16, the member outcrops at an altitude of 958 feet, where it is represented by 14 feet of dark, sandy, fossiliferous shale, with a 2-inch layer of dark limestone occurring about 3 feet 9 inches above the base. The relation of the Brush Creek beds to the other members of the Conemaugh series in the western part of the township is well illustrated in the following record measured in the southwestern part of Section 22:

		Ft.	In.
Shale, red, *Round Knob*		36	0
Shale, gray, arenaceous		53	1
Iron ore with fossil fragments, *Cambridge*			3½
Clay, ferruginous, arenaceous		3	6
Shale, gray, arenaceous		21	0
Clay shale, red		5	0
Shale, gray, arenaceous		25	0
Shale, black, arenaceous, fossiliferous	*Brush Creek*	6	0
Shale, gray		4	0
Shale, fossiliferous		17	2
Clay, ferruginous, arenaceous		1	8
Shale, arenaceous		3	4
Clay, ferruginous, arenaceous		2	0
Clay, red to gray, with nodules of limestone		23	8
Clay, gray, arenaceous		10	4
Sandstone, shale, and covered		51	8
Shale, gray, arenaceous		1	8
Shale, bony			8
Shale, gray, arenaceous		4	6
Shale, black, fissile			8
Coal, *Upper Freeport*		3	4
Clay and covered		1	2

At this locality the base of the Brush Creek beds has an elevation of 945 feet. The interval to the Upper Freeport coal is about normal for this county.

Springfield Township

In Springfield Township, the Brush Creek limestone and shale are above drainage along North Fork, Yellow Creek, and Wolf Run as far south as the southern boundary of sections 8 and 14. Due to the marked dip of the rocks, this member has an elevation of 1,063 feet in the western part of Section 11; 993 feet in the northern part of Section 12; and 948 feet at the southern edge of Section 8. The stratigraphic relations of the Brush Creek beds are well illustrated in the following record measured along the road leading southeast from Bergholz, where the elevation of the member is 1,040 feet:

	Ft.	In.
Shale, red, *Round Knob*	12	0
Shale, gray, arenaceous	53	2
Limestone, nodular, ferruginous, *Cambridge*		2
Clay, mottled	8	2
Limestone, nodular		6
Shale, gray, red, and black	36	6
Shale, arenaceous, fossiliferous, *Brush Creek*	4	0
Clay		6
Coal blossom, *Brush Creek*		2
Clay, ferruginous	2	0
Shale, gray, arenaceous	60	0
Clay, dark, *Mahoning horizon*	4	6

Along Wolf Run at the northern edge of Section 7, the Brush Creek member outcrops at an elevation of 960 feet. It consists of a single layer of blue fossiliferous limestone, 1 foot 6 inches in thickness, which lies 77 feet below the Cambridge member. In the northern part of Section 12, it is represented by 6 feet 6 inches of dark fossiliferous shale, and is underlain by the Brush Creek coal and overlain by gray arenaceous shale.

Knox Township

Outcrops of Brush Creek limestone and shale occur in the southeastern corner of Knox Township in sections 31 and 32 and at a few localities along Town Fork and Yellow Creek in the northwestern part of this township. The member, which consists of black fossiliferous shale with a few nodules or thin layers of black shale, has a maximum thickness of 8 feet. The elevation of the bed in sections 31 and 32, in the southeastern part of the township, varies from 850 to 920 feet, and along Town Fork a few exposures are present which range in altitude from 860 to 870 feet.

Island Creek Township

The Brush Creek member is well exposed at a number of localities in Island Creek Township. Good outcrops are present along the road in the southern part of Section 36, three-quarters of a mile west of Jeddo, where the member lies at an elevation of 860 feet and is composed of 4 feet of black fossiliferous shale. It is poorly developed along Island Creek, although good exposures may be seen at a number of places from the Ohio River to Section 17. The altitude varies from 840 feet in Section 35 to 800 feet in Section 17. The measurements recorded below were made in the southern part of Section 5:

	Ft.	In.
Limestone, massive		11
Limestone, shaly, *Ames*		11
Limestone, massive	1	6
Shale and covered	57	0
Shale, black, calcareous	1	0
Limestone, dark, impure. *Ewing*		7
Clay, gray, arenaceous	7	6
Shale and covered	21	6
Sandstone, *Cow Run*	25	0
Clay, gray, *Wilgus*	5	0
Sandstone, shale, and covered	42	0
Shale, gray to dark	14	6
Limestone, black, fossiliferous, *Brush Creek*		6
Shale, gray, arenaceous	9	6
Sandstone, massive	6	0
Clay, gray, *Mason horizon*	3	0

The Brush Creek member along Island Creek is usually thin and is composed of only a few inches of black limestone or a few feet of black shale. The development of this member, as shown in the above geologic section, is therefore typical of the exposures along this valley.

Excellent exposures of the Brush Creek limestone and shale occur at Stanton Park, in the northern part of Section 21, where the member has an elevation of 730 feet and where the measurements below were obtained:

	Ft.	In.
Shale, arenaceous, green to red	62	0
Limestone, fossiliferous, *Cambridge*	1	2
Shale with limestone nodules	8	2
Shale, green, arenaceous	2	6
Sandstone, coarse-grained, *Buffalo*	10	4
Shale, gray to dark, arenaceous	29	0
Shale, fossiliferous, with ore nodules, *Brush Creek*	6	10

		Ft.	In.
Shale, dark		1	4
Shale, bony, with shaly coal	*Brush Creek*		11
Parting	*Brush Creek*		1
Coal	*Brush Creek*		6
Clay, gray, arenaceous, ferruginous		4	0

The Brush Creek limestone and shale are also well exposed along Wills Creek and North Fork as far as the southeastern corner of Section 8. The maximum thickness of the member in Island Creek Township is found in the eastern part of Section 1, where it is composed of 16 feet of dark shale. A collection of fossils was made at a good exposure of this shale along the road near the forks of Wills Creek in Section 1. The following forms were identified:

Lophophyllum profundum (Milne-Edwards and Haime)

Lingula tighti Herrick

Solenomorpha solenoides (Geinitz)

Prothyris elegans Meek
Nucula anodontoides Meek
Nucula parva McChesney
Nuculopsis ventricosa (Hall)
Leda bellistriata Stevens
Leda meekana Mark
Yoldia stevensoni Meek
Aviculopecten coxanus Meek and Worthen
Aviculopecten hertzeri Meek
Euchondria neglecta (Geinitz)
Astartella vera Hall
Plagioglypta annulistriata (Meek and Worthen)
Pharkidonotus percarinatus (Conrad)
Euphemus carbonarius (Cox)
Worthenia tabulata (Conrad)
Patellostium montfortianum (Norwood and Pratten)
Phanerotrema grayvillensis (Norwood and Pratten)

Buffalo Sandstone

The Buffalo sandstone, which derives its name from Buffalo Creek, Butler County, Pennsylvania, where it was first described by I. C. White, lies in the interval between the Brush Creek fossiliferous limestone and shale and the Cambridge limestone. This sandstone is widely extended in its distribution, as it is a prominent member in southwestern Pennsylvania and is reported to be present in almost every county along the line of the Conemaugh outcrop in West Virginia. In Ohio it reaches its best development from Carroll County south to Muskingum County.

In Jefferson County the Buffalo sandstone is present along the Ohio River in southern Island Creek and Steubenville townships, where it varies from 10 to 35 feet in thickness. Elsewhere in the county arenaceous shale occupies the stratigraphic position of the sandstone. Where the member is typically developed, it is a medium to coarse-grained, micaceous sandstone composed of quartz sand and material resembling altered feldspar. The color of the stone is a light greenish-gray which on weathering becomes spotted or speckled brown. Although some clay material is present, silica is the chief binding material. Above Stanton Park, in Section 31, Island Creek Township, the Buffalo sandstone, 10 feet in thickness, is exposed along the road. The stone is coarse-grained with beds ranging in thickness from 6 inches to 1 foot 6 inches. Above the river road, in Section 25, Buffalo sandstone was being worked in 1924 by the General Stone Co. of Amherst, Ohio, and marketed as pulp stone for the grinding of wood pulp. When this quarry was again visited in 1926, work had been discontinued and much of the machinery had been removed. The following measurements are a record of the outcrops at this quarry:

	Ft.	In.
Shale, arenaceous, (estimated)	40	0
Clay, bluish-gray, with limestone nodules	4	0
Clay shale, red	20	0
Coal blossom, *Wilgus*		1
Clay, gray, arenaceous	6	2
Clay shale, red, with ore nodules	18	0
Sandstone, massive, *Buffalo*	35	0
Covered interval	32	2
Shale, gray, calcareous	8	0
Clay, dark, shaly	1	4
Clay, grayish-brown, arenaceous	5	4
Shale, calcareous	18	8
Shale, dark, with plant impressions	1	2
Coal, shaly, *Mason*		3
Clay, gray, plastic	8	0

The Buffalo sandstone was formerly worked for commercial purposes near the mouth of the ravine which heads near the Steubenville water reservoir in Section 30, Steubenville Township, where the thickness of the sandstone, as shown in the quarry face, is about 25 feet.

Wilgus Coal and Clay

The Wilgus horizon consists of a thin coal and clay which lies immediately below the Cambridge limestone and which was first

named by D. D. Condit for exposures near the village of Wilgus in Mason Township, Gallia County, Ohio. Condit describes the occurrence of the coal as follows:[1]

"It is generally present with a thickness of 1 to 3 feet in Lawrence and Gallia counties, and is occasionally seen as far north as the southern edge of Athens County, but in more northern localities there is rarely more than a carbonaceous streak at this horizon."

In Jefferson County, the Wilgus coal and clay form a persistent horizon immediately below the Cambridge limestone in Saline, Brush Creek, Ross, Springfield, Knox, Island Creek, Cross Creek, and Steubenville townships. The coal is rarely more than 1 inch in thickness and is usually wanting entirely. The clay varies from 1 to 13 feet in thickness, is bluish-gray in color, and arenaceous and ferruginous in composition.

The Wilgus coal is almost entirely wanting in Saline Township but the associated clays are wide spread, ranging in thickness from 4 to 13 feet. Along Brimstone Run in Section 6, the clay is ferruginous, arenaceous, and impure, 9 feet 7 inches in thickness, with an altitude of 964 feet. In Section 31, the Wilgus horizon is represented by 6 feet of ferruginous clay, which outcrops about 40 feet above the Brush Creek marine shale. The clay member is likewise well developed in Section 29, and the rock succession above and below the Wilgus member is shown in the following geologic section. The elevation of the member at this locality is 833 feet.

	Ft.	In.
Limestone, bluish-gray, fossiliferous, *Ames*	2	6
Shale, gray, arenaceous	10	2
Coal blossom, *Harlem*		1
Clay, gray to pink, arenaceous	8	0
Covered interval	5	0
Shale, gray, arenaceous	79	10
Shale, red, arenaceous	14	0
Smut streak, *Wilgus*		1
Clay, gray, arenaceous	4	8
Shale, gray, arenaceous	14	8
Shale, arenaceous, red to reddish-brown	10	6
Limestone, blue, compact, fossiliferous, *Brush Creek*	1	0

In Brush Creek Township, the Wilgus horizon is represented by impure clay beds, 5 to 10 feet in thickness, which outcrop at elevations ranging from 1,056 feet in Section 12 to 1,133 feet in Section 32. At only one locality, namely in Section 12, is the clay overlain by a thin layer of carbonaceous shale representing the Wilgus coal. In Ross

[1]Condit, D. D., Geol. Survey Ohio, Fourth Series, Bull. 17, p. 47. 1912.

Township, this member is very poorly represented, but in Springfield Township, it is wide spread, everywhere consisting of impure clay which ranges in thickness from 2 to 14 feet. The altitude of the bed varies from 1,070 feet in Section 12 to 980 feet in Section 7. In Section 12, the Wilgus member consists of 5 feet 6 inches of ferruginous, arenaceous clay, which outcrops about 42 feet above the Brush Creek marine shale. In the western part of Section 11, where the clay lies at an elevation of 1,088 feet, a measurement of the outcrops is as follows:

	Ft.	In.
Clay, gray, *Harlem horizon*	2	0
Covered interval	15	0
Clay shale, red, *Round Knob*	10	10
Covered interval	36	2
Shale, gray, arenaceous	46	6
Clay, arenaceous, ferruginous, *Wilgus*	5	2
Clay shale, red	5	6
Shale, gray, arenaceous	40	8
Shale, black, fossiliferous, *Brush Creek*	5	6
Coal blossom, *Brush Creek*		3
Clay, arenaceous, ferruginous	11	6

In the southwestern part of Section 4, Wilgus clay, with an elevation of 880 feet and a thickness of 8 feet, is exposed along the road and lies about 50 feet above the Brush Creek coal. This clay bed is persistent along Wolf Run although it is everywhere highly arenaceous and impure. In Section 1, the clay has a thickness of 13 feet 4 inches and is overlain by 1 inch of carbonaceous shale, which represents the Wilgus coal horizon. In Knox Township, 1 foot of impure Wilgus clay outcrops in Section 32 at an elevation of 900 feet. It lies 40 feet above the Brush Creek marine shales and is overlain by a 2-inch nodular layer of Cambridge limestone and underlain by shale.

In Island Creek Township, the Wilgus horizon is persistent along the Ohio River Valley, Island Creek, and Wills Creek, where it ranges in elevation from 925 feet in Section 5 to 780 feet in Section 1. The clay varies from 2 to 8 feet in thickness, and the coal is usually represented by a 1-inch layer of carbonaceous shale. The following geologic section, measured along a small ravine in the eastern part of Section 1, illustrates the stratigraphic sequence at this locality. The elevation of the Wilgus coal here is 782 feet.

	Ft.	In.
Shale, gray to red, arenaceous	72	4
Sandstone, calcareous	2	8
Limestone, ferruginous, *Cambridge*	1	0

	Ft.	In.
Coal blossom, *Wilgus*		1
Clay, gray, arenaceous	2	4
Sandstone, *Buffalo*	11	10
Covered interval	40	0
Limestone, black, fossiliferous, *Brush Creek*		5
Clay shale, gray	1	0
Covered interval	4	0
Bone shale		9
Clay shale, dark		6
Coal, poor, *Brush Creek*		6
Clay	1	0

In Steubenville Township, the Wilgus horizon is represented in Section 34 by 10 feet of impure clay overlain by 1 inch of black shale, which outcrops at an elevation of 724 feet. In Section 33, the clay has a thickness of 1 foot and an altitude of 670 feet. The only exposure of this member in Cross Creek Township occurs in Section 34, where 11 feet 4 inches of impure clay underlies the Cambridge limestone.

Cambridge Limestone

Near Cambridge, Guernsey County, Ohio, there is a fossiliferous limestone lying about 90 feet below the Ames limestone and 138 feet above the Upper Freeport coal, which E. B. Andrews named the Cambridge limestone. A common characteristic of all marine limestones of this formation is their wide-spread distribution, a feature well illustrated by the Cambridge whose outcrops are found across Ohio, southwestern Pennsylvania, and northern West Virginia as far south as Lewis and Gilmer counties. Locally in Pennsylvania this member is known as the Pine Creek limestone. In Jefferson County, which lies along the line of outcrop, the Cambridge limestone occurs in thicknesses ranging from 1 inch to 2 feet 4 inches, but an average of 21 measurements is about 9 inches. It usually consists of a single bed of limestone, impure in places, having a bluish-gray color and a dense texture. At some localities the limestone is coarsely crystalline and much resembles the Ames limestone in physical appearance as it has its characteristic color. At some places in the county, especially in Springfield Township, the member is represented by 1 or 2 inches of ferruginous material approaching an iron ore in composition. The Cambridge limestone is abundantly fossiliferous; in fact, it constitutes one of the most fossiliferous of the marine limestones of the Conemaugh series. However, the character of the material composing the rock influences to a marked extent the number, size, and kind of species present. For example, where the member is normally developed, the fossils are fairly large and robust, and there is an abundance of

such forms as *Productus* and other brachiopods; but with increasing amounts of ferruginous material, the fauna becomes more and more dwarfed, changing to one composed almost entirely of pelecypods and gastropods. As indicated in the general geologic section of the Conemaugh series for Jefferson County, the Cambridge limestone lies about 59 feet above the Brush Creek fossiliferous shale and 158 feet below the Ames limestone. The outcrops of this member are limited to Saline, Brush Creek, Ross, Springfield, Knox, Salem, Island Creek, Cross Creek, Wayne, and Steubenville townships.

Saline Township

The only exposures of Cambridge limestone observed in Saline Township occur along Brimstone Run in Section 6, and along Goose Run in Section 5. In the former locality the member has a thickness of 1 foot 6 inches and in the latter of 6 inches. In both places it consists of a dense, compact, blue limestone which weathers to a yellow color and which has an elevation of about 970 feet.

Brush Creek Township

The Cambridge limestone outcrops in Brush Creek Township in the northwestern part of Section 32, where it consists of a crystalline limestone with abundant fossil fragments, and has an altitude of 1,133 feet. The stratigraphic succession at this place is given below:

	Ft.	In.
Shale, arenaceous.		
Limestone, ferruginous, fossiliferous, *Cambridge*	2	4
Clay, yellow	4	8
Shaly sandstone and sandy shale	67	0
Shale, dark, fossiliferous, *Brush Creek*	21	4
Coal blossom, *Brush Creek*		2
Clay, gray, arenaceous	5	6

This member is also present along a ravine in the southern part of Section 12, where the limestone is compact, blue in color, with a thickness of 1 foot 2 inches. It is overlain by arenaceous shale and underlain by 2 feet 2 inches of bluish-gray calcareous shale in which fossils are abundant. The elevation of the limestone at this locality is 1,057 feet. Elsewhere in the township sandstone or arenaceous shale replaces the Cambridge member.

Ross Township

The Cambridge limestone occurs at only one locality in Ross

Township, namely along the road in the south-central part of Section 28, where the member consists of a single layer of ferruginous, fossiliferous material, 3½ inches in thickness. The elevation here is 1,037 feet.

Springfield Township

In Springfield Township, the Cambridge member is generally present although usually thin and very impure. It outcrops along the road south of Burgett Run in Section 12, where it is very fossiliferous and ferruginous with a thickness of 2 inches. It lies about 76 feet above the Brush Creek coal and has an elevation of 1,069 feet. It is also well exposed along the road in the southwestern part of Section 4, where its thickness is 2 inches. This limestone lies about 50 feet above the Brush Creek coal. The Ames limestone above is not present at this locality, but the clay underlying the Harlem coal is well exposed about 85 feet above the Cambridge limestone. The following interesting record, measured along the road which leads westward from Timothy Ridge at the northern border of Section 1, shows the stratigraphic relation of the Cambridge limestone and the other important limestones of the Conemaugh series:

	Ft.	In.
Sandstone and covered, *Morgantown*	40	0
Limestone, fossiliferous, *Ames*	46	0
Shale, gray to reddish brown	103	4
Limestone, nodular, *Cambridge*		1
Coal blossom, *Wilgus*		1
Clay, light, plastic	2	4
Clay, arenaceous, ferruginous	11	0
Sandstone, gray	5	2
Shale, gray, arenaceous	22	6
Clay, ferruginous	5	0
Shale and covered	29	6
Limestone, bluish-black, fossiliferous, *Brush Creek*	1	6
Shale, gray, arenaceous	8	0

The Cambridge member here is an irregular nodular layer of ferruginous limestone with a large number of minute fossil gastropods. Fossils were collected from the Cambridge limestone outcropping along a small ravine in the central part of Section 7, Springfield Township. The geologic section at this locality follows:

	Ft.	In.
Shale, dark	3	0
Limestone, bluish, ferruginous, *Cambridge*		3
Clay, bluish, ferruginous, *Wilgus horizon*	2	6
Covered interval	14	4
Shale, dark, fossiliferous, *Brush Creek*	4	0

The following forms were identified from the Cambridge limestone collected at this locality:

Derbya crassa (Meek and Hayden)
Pustula pertenius (Meek)
Ambocoelia planoconvexa (Shumard)

Naticopis ventricosus (Norwood and Pratten)
Parallelodon obsoletus (Meek)
Parallelodon tenuistriatus (Meek and Worthen)
Euchondria neglecta (Geinitz)

Euphemus carbonarius (Cox)
Pleurotomaria valvatioformis Meek and Worthen

The Cambridge limestone is also well exposed in the village of Amsterdam, where it consists of a massive, hard, blue, sparingly fossiliferous limestone. Nodular limestone underlain by a thin bed of coal likewise outcrops on this horizon along the brick road a quarter of a mile northwest of Amsterdam.

Knox Township

Exposures of Cambridge limestone are present in Knox Township in Sections 4, 30, and 31. Along Jeremy Run, in Section 4, exposures with an elevation of 978 feet consist of two nodular layers of limestone separated by 5 feet 4 inches of blue ferruginous shale, in which fossils are sparingly present. Cambridge limestone, 2 inches thick, outcrops in the southwestern part of Section 32 at an elevation of about 900 feet, and lies 43 feet above the Brush Creek coal and 110 feet below the Ames limestone; whereas in the central part of Section 31, this limestone with a thickness of 11 inches lies about 41 feet above the Brush Creek coal.

Island Creek Township

The Cambridge limestone is well developed along the valley of Wills Creek in the southeastern part of Island Creek Township. It usually consists of a single bed of compact, blue limestone which varies from 6 inches to 1 foot 6 inches in thickness. Although fossils are present they are by no means abundant. The following geologic section was measured along a small ravine in the southwestern part of Section 31, where the member has an elevation of 801 feet:

	Ft.	In.
Limestone, *Cambridge*	1	0
Coal blossom, *Wilgus*		1

	Ft.	In.
Shale, gray, arenaceous, with iron ore nodules	4	0
Sandstone, shale, and covered, *Buffalo*	52	10
Shale, dark	3	6
Limestone, black, fossiliferous } *Brush Creek*		5
Shale, black, sparingly fossiliferous } *Brush Creek*	7	8
Shale, bony		6
Coal, *Brush Creek*		9
Covered interval	30	9
Shale, gray, arenaceous	15	0
Clay, bluish-gray, with iron ore nodules	5	8

The rock succession above the Cambridge limestone is well shown along a small ravine in the southern part of Section 1 where the measurements given below were obtained:

	Ft.	In.
Sandstone, massive	40	10
Shale, arenaceous	9	6
Coal, good } *Harlem*	1	4
Parting } *Harlem*		1
Coal } *Harlem*		10
Clay, dark	1	0
Clay, light, arenaceous	2	6
Shale and covered	114	0
Limestone, *Cambridge*		6
Shale, dark, ferruginous	2	0

The elevation of the Cambridge limestone at the above locality is 800 feet. It consists of a dark gray crystalline limestone in which abundant fossils are present. The rock succession shown between the Cambridge limestone and the Harlem coal is normal for this township. Likewise, Cambridge limestone outcrops along the road above Stanton Park, where it has a thickness of 1 foot 2 inches and lies at an elevation of 787 feet. Another exposure is found along a small ravine tributary to Little Island Creek in the northeastern corner of Section 33, where the member consists of a dense blue, sparingly fossiliferous limestone with a thickness of 1 foot 6 inches. The Cambridge limestone outcrops at an elevation of 788 feet and lies 135 feet below the Ames limestone.

Steubenville Township

In Steubenville Township, the Cambridge limestone is exposed along Wells Run in the southeastern corner of Section 35, and consists of ferruginous, nodular, fossiliferous material embedded in shale. It lies 102 feet below the Ames limestone and outcrops at an elevation of 724 feet. Another exposure of Cambridge limestone, which

has a thickness of 5 inches and is bluish-gray in color with many fossil fragments, occurs near the mouth of a tributary to Cross Creek in the southwestern corner of Section 27. It is underlain with 3 inches of dark shale, below which lies 2 inches of coal. The limestone at this locality has an elevation of 670 feet and is found 127 feet below the Ames limestone.

Cross Creek Township

Cambridge limestone, 1 foot 11 inches in thickness, is present in Cross Creek Township in the northwestern corner of Section 28. at an elevation of 821 feet.

Wayne Township

An unusual development of the Cambridge limestone is found near Skelley Station in Section 12, Wayne Township. The following geologic section was obtained at this locality:

		Ft.	In.
Limestone, *Skelley*		1	2
Clay, gray, arenaceous		5	6
Covered		12	6
Limestone, *Ames*		1	6
Sandstone and covered		62	11
Sandstone, cross-bedded		4	0
Shale, fossiliferous	*Cambridge*	5	0
Limestone, flinty			2
Shale, gray, arenaceous		5	11
Limestone, gray, very fossiliferous		1	1
Shale, fossiliferous			9
Shale, dark, bituminous			1
Shale, gray, arenaceous		2	5
Shale, red		4	0
Limestone, bluish-gray, fossiliferous		1	6

The Cambridge member at this locality, unlike other modes of occurrence in Jefferson County, is composed of fossiliferous limestone layers interstratified with fossiliferous shale having a total thickness of more than 20 feet. The limestone is bluish gray in color, nodular in appearance, and fine grained in texture. The interval to the Ames limestone is about 66 feet which is much less than the normal interval for this county. The fossils listed below were collected from this locality:

Lophophyllum profundum (Milne-Edwards and Haime)

Crinoid segments

Chonetes verneuilanus Norwood and Pratten
Marginifera wabashensis (Norwood and Pratten)
Spirifer cameratus Morton

Nucula parva McChesney

The Cambridge limestone in Jefferson County is too thin, too irregular in occurrence, and too variable in composition to be of any economic value.

Anderson Coal and Clay

The Anderson coal was first named by E. B. Andrews for the operator of a small bank in this coal near Lore City, Guernsey County, Ohio, and was otherwise known as the Norwich coal in Muskingum County, and the Patriot coal in Meigs and Gallia counties. It is widely distributed in Ohio, but rarely exceeds 2 feet in thickness and is usually much less. The average position of the bed is about 18 feet above the Cambridge limestone. It is overlain in some localities with dark shale containing nodules of limestone, both of which contain marine fossils.

In Jefferson County, the Anderson coal is practically wanting, a thin blossom occurring at only one locality, namely in Section 32, Knox Township, where the interval to the Cambridge limestone is about 20 feet. The following geologic section, measured along the diagonal road in the southwestern part of Section 32, Knox Township, shows the stratigraphic relations of the Anderson coal to other members of the Conemaugh series:

		Ft.	In.
Limestone, *Ames*		1	6
Shale and covered		20	8
Clay, light, arenaceous		4	6
Shale, red		7	10
Limestone, nodular	*Ewing*		3
Clay, with limestone nodules	*Ewing*	6	0
Shale and covered		6	9
Sandstone, *Cow Run*		21	2
Shale, red		22	10
Coal blossom, *Anderson*			1
Clay, mottled		4	6
Shale, gray to red		15	2
Limestone, nodular, *Cambridge*			2

Thin beds of clay, belonging to the Anderson coal horizon and ranging in thickness from 1 to 9 feet, are present in Section 29, Saline Township; in Section 12, Brush Creek Township; in sections 4 and 32, Knox Township; in Section 31, Island Creek Township; and

in Section 34, Cross Creek Township. The average interval between the Cambridge limestone and the top of the Anderson clay is 23 feet.

Portersville Member

The Portersville member was first named by D. D. Condit[1] for exposure near Portersville, Perry County, Ohio, and was reported by him as occurring at many widely separated localities in Ohio. It consists of dark, nodular, fossiliferous limestone embedded in or interstratified with dark fossiliferous shale which closely overlies the Anderson coal. In Jefferson County, the Anderson coal is overlain by non-fossiliferous, arenaceous shale, and therefore the Portersville member is wanting.

Cow Run Sandstone

The interval between the Barton coal horizon and the Cambridge limestone is usually made up of shale, but at some localities a massive sandstone occurs in this interval. This sandstone has been named the Cow Run from a small stream in the eastern part of Washington County, Ohio, where this sand was first discovered to be a source of oil and gas. The Cow Run sandstone is well developed along the line of outcrop in northern Morgan County, in northern Muskingum County, near Trimble in Athens County, and near Tippecanoe in Harrison County; and is well known as a source of oil and gas in Washington, Noble, Athens, Morgan, and Muskingum counties.

In Jefferson County, local deposits of Cow Run sandstone are found in Brush Creek, Springfield, Island Creek, Knox, and Steubenville townships. The area of well-developed sandstone, however, is small, as the member passes laterally into arenaceous shale. In thickness it varies from 0 to 70 feet, with an average of about 20 feet. The sandstone is normally gray, changing to yellow on weathering; is medium to coarse-grained in texture; and at a few places is conglomeratic at the base. In Brush Creek Township, the Cow Run sandstone is locally developed, with a thickness of 40 feet in Section 12, but of only 15 feet in Section 8, Springfield Township. In Island Creek Township, the stone is well developed in sections 5, 27, 31, and 34 and ranges in thickness from 10 to 45 feet. The following geologic record from Section 8, Springfield Township, illustrates the stratigraphic relations of the Cow Run sandstone:

[1]Condit, D. D., Geol. Survey Ohio, Fourth Series, Bull. 17, pp. 41-42. 1912.

	Ft.	In.
Limestone, fossiliferous, *Ames*	1	2
Shale and covered	24	8
Shale, red, *Round Knob*	33	0
Shale, gray	24	0
Sandstone, *Cow Run*	15	4
Clay, gray, *Wilgus horizon*	2	0

The Cow Run sandstone is of no economic importance in Jefferson County.

Ewing Limestone

The name Ewing was first applied by Dr. Orton to a thin limestone just below the Barton coal and outcropping near Ewing Site, Sunday Creek Valley, Athens County. Although this member is not an important one, nevertheless it is rather persistent, and has been reported to occur in Perry, Morgan, Muskingum, Noble, Guernsey, Tuscarawas, Belmont, Harrison, Carroll, and Jefferson counties. The general characteristics of this member are well described by D. D. Condit as follows[1]:

"Ordinarily, there is only a nodular layer a foot or so thick, or a single course of limestone less than 2 feet, but here and there in the eastern part of the State are areas where the limestone attains a thickness of 5 to 10 feet and consists of a number of layers interlain with clay."

In parts of Jefferson County, sandy shale and sandstone are found on the Ewing horizon, but at a few localities in Knox and Island Creek townships these shales and sandstones give place to thin nodular limestones embedded in the clays associated with the Barton coal. The limestone is dark in color and dense and homogeneous in appearance. *Spirorbis anthracosia* Whitfield is present in the limestone, although it is by no means abundant. In the west central part of Section 32, Knox Township, the Ewing limestone outcrops along the diagonal road at an elevation of 1,047 feet. The member here consists of 1 foot 4 inches of light-colored limestone overlain by 2 feet 6 inches of clay with nodules of limestone embedded in it. The interval to the Ames limestone is about 46 feet. Likewise, limestone of a similar nature occurs in the southwestern part of Section 30, Knox Township. In the south-central part of Section 5, Island Creek Township, the Ewing limestone, with an elevation of 974 feet, is present along a northern tributary of Island Creek and lies 112 feet above the base of the Brush Creek shale. The following geologic section is a record of the rock outcrops at this place:

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[1]Condit, D. D., Geol. Survey Ohio, Fourth Series, Bull. 17, pp. 37-38. 1912.

		Ft.	In.
Sandstone.			
Shale, gray, arenaceous		5	0
Limestone, massive	*Ames*		11
Limestone, shaly	*Ames*		11
Limestone, massive	*Ames*	1	6
Shale and covered		57	0
Shale, black, calcareous, with fossil fragments	*Ewing*	1	0
Limestone, dark, impure, fossiliferous	*Ewing*		7
Clay, gray, arenaceous		7	6
Shale and covered		21	6
Sandstone, *Cow Run*		25	0

Barton Coal and Clay

The Barton coal, first named by P. T. Tyson in 1837 for exposures in Allegany County, Maryland, is a persistent member of the Conemaugh series in Maryland and West Virginia. In Ohio, the Barton coal is of little importance although it has been recognized in Jefferson, Harrison, Carroll, Belmont, Guernsey, and Muskingum counties. It is of no economic value, except in Lee Township, Carroll County, but even here D. D. Condit reports that the coal rarely exceeds 2 feet in thickness[1].

In Jefferson County, the Barton coal is represented by a thin smut streak or by a few inches of black carbonaceous clay at only a few localities in Knox, Island Creek, and Steubenville townships. At a few places the clays underlying the coal horizon are well exposed where no coal is present. This coal horizon in Jefferson County lies on an average about 52 feet below the Ames limestone and about 85 feet above the Cambridge limestone.

Approximately 2 feet 6 inches of dark clay belonging to the Barton coal horizon is present in the west-central part of Section 32, Knox Township, where it is overlain by red clay shale and underlain by arenaceous shale. It is represented by 1 inch of coal along the road in the northwestern part of Section 31, Island Creek Township, and its position is 25 feet below the Harlem coal and 85 feet above the Wilgus coal horizon. This coal is also found in sections 1 and 5, Island Creek Township. In the central part of Section 1, 5 feet of impure clay belonging to this horizon outcrops at an elevation of 863 feet and lies 80 feet above the Wilgus coal. In Section 5, the clay has a thickness of 7 feet 6 inches and lies 106 feet above the Brush Creek marine beds and 60 feet below the Ames limestone.

The Barton coal horizon is exposed near the west end of Tunnel

[1]Condit, D. D., Geol. Survey Ohio, Fourth Series, Bull. 17, p. 240. 1912.

No. 11 on the Pittsburgh, Toledo, and Western Railroad, in Section 32, Steubenville Township, where it lies about 50 feet above the Harlem coal. A measurement of the outcrops is as follows:

	Ft.	In.
Sandstone, massive, *Morgantown*	30	0
Shale, (estimated)	8	0
Coal, *Harlem*	2	11
Clay, bluish-gray	9	7
Shale, gray, arenaceous	18	11
Clay shale, mottled red and gray, with limestone nodules	29	8
Iron ore, nodular		3
Clay shale, mottled red and blue	1	3
Clay, black } *Barton*		2
Clay, bluish-gray, arenaceous } *Barton*	3	2
Sandrock	2	0

Round Knob Shale

At many localities the Ames limestone and the Harlem coal are underlain by red clay shale, which is known in Ohio as the Round Knob shale and in West Virginia as the Pittsburgh Red shale. Although the high coloring and the soft, yielding properties of this shale make it a conspicuous member of the Conemaugh series, its stratigraphic limits are not very sharply defined. It may lie immediately below the Harlem coal or it may replace that member and entirely fill the interval to the Ames limestone. Its lower limit is the top of the Barton coal, but this coal is often wanting so that the red shale extends far below its stratigraphic horizon.

In Jefferson County, the Round Knob beds consist of light to dark red clay shale, occasionally with brownish layers. This shaly character, which is well developed on fresh exposures, becomes entirely eliminated with slight weathering. Concerning the coloring matter of these shales D. D. Condit writes as follows:[1]

"There has been much dispute as to the cause of the red clay in the 'Coal Measures' beds. That it is in the case of the Round Knob horizon, original rather than a secondary phenomenon due to the reactions of weathering, is evident, since the redness is persistent where the beds are hundreds of feet below the surface, as is shown by oil drillings. Such colors are entirely wanting in the lower beds of the Pennsylvanian series, and appear near the middle of the Conemaugh for the first time. It is true that reddish tints are seen at a few horizons in the lower third of the formation but these are largely secondary, or in other words, the result of weathering, and only appear at or near the outcrop. It is probable that the changes in climate, together with varied sources of supply of the sediments, are largely responsible for the red beds."

In Jefferson County, the Round Knob shale is best developed in

[1]Condit, D. D., Geol. Survey Ohio, Fourth Series, Bull. 17, p. 36. 1912.

Springfield Township where measurements show thicknesses ranging from 10 to 30 feet. The member is also well shown along Croxton Run in the eastern part of Knox Township; along North Fork of Wills Creek in Island Creek Township; and at Tunnel No. 11 on the Pittsburgh, Toledo, and Western Railroad in Steubenville Township. The following geologic section measured along the road in the central part of Section 32, Knox Township, shows the stratigraphic sequence above and below the Round Knob shale:

		Ft.	In.
Limestone, *Ames*		1	9
Shale, gray, arenaceous		8	0
Shale, red, *Round Knob*		28	2
Clay, dark, shaly		10	4
Clay with limestone nodules	*Ewing*	2	6
Limestone, nodular	*Ewing*	1	4
Sandstone, shale, and covered		28	6
Shale, arenaceous		2	0
Black shale and shaly coal		2	0
Shale and covered		46	0
Limestone, blue, arenaceous, fossiliferous, *Cambridge*			11
Shale, blue to yellow		14	4
Black shale and shaly coal		1	10
Clay, dark, arenaceous		3	0
Shale, dark		23	10
Limestone, dark, fossiliferous, *Brush Creek*		1	3
Shale, black, fissile		1	10
Bone shale		1	2
Shale, black, fissile, with plant impressions		4	6
Coal, bony, *Brush Creek*			8
Clay, dark, arenaceous		5	0

On the same stratigraphic horizon as the Round Knob shale, a well developed sandstone occurs over local areas in Pennsylvania and West Virginia, which was named by J. J. Stevenson the Saltzburg sandstone from exposures near the town of that name in Pennsylvania. The Saltzburg sandstone is not well developed in Jefferson County; where the typical Round Knob shale is wanting, its place is taken by gray arenaceous shale with an occasional thin platy sandstone layer separated by shale partings. This phase of the member is represented in eastern Island Creek and Steubenville townships.

Harlem Coal and Clay

A few feet below the Ames limestone, there occurs a thin coal bed which was named the Harlem coal by J. S. Newberry for exposures near Harlem Springs, Carroll County, Ohio. Although rarely reaching a thickness sufficient for mining, this coal is a persistent member of the Conemaugh series and has been recognized over a large area in Ohio,

Pennsylvania, and West Virginia. According to J. J. Stevenson, it is present along the northern outcrop of the Conemaugh series in Pennsylvania; and in Garrett County, Maryland, where the term Friendsville has been applied, the bed is of sufficient thickness for mining. In West Virginia, the member is usually represented by a thin coal or by black shale and is present along the eastern outcrop from Monongalia and Preston counties on the north to Kanawha County on the south. However, in only a few places is it of sufficient thickness to be of economic importance.

In Ohio, the Harlem is a well-defined coal with few exceptions from Jefferson to Morgan counties, but south of Morgan although the member is present, it becomes thin and shaly in character. The average thickness of the coal in this State does not exceed 1 foot, but locally in Muskingum, Carroll, and Jefferson counties twice this thickness is occasionally found.

In Jefferson County, the Harlem coal horizon is found above drainage in all or parts of Saline, Springfield, Knox, Salem, Island Creek, Cross Creek, Steubenville, Warren, and Wells townships; but in some localities it is replaced by massive sandstone. Where typically developed, the bed consists of two benches of coal separated by a thin shale parting; the lower part is blocky and of fair quality whereas the upper part may consist of shaly coal, bone coal, or may give way entirely to carbonaceous shale. However, it may consist entirely of black shale although this mode of occurrence is rare in the area under discussion. The Harlem coal in Jefferson County varies in thickness from a mere smut streak to 2 feet 11 inches but averages about 1 foot 4 inches. It is underlain by a thin clay and overlain by arenaceous shale or shaly sandstone. The average distance of the Harlem coal below the Ames limestone in this county is 17 feet, but variations range from 6 to 30 feet.

In Saline Township, the Harlem coal is generally wanting. The accompanying clay bed, overlain by sandstone, outcrops at elevations ranging from 1,050 feet in Section 5 to 1,145 feet in Section 31. In Knox Township, the horizon is above drainage along tributaries of the Ohio River and Town Fork, but the coal is wanting. This coal horizon is also well above drainage in the central and northern part of Springfield Township, although the coal itself is not present. Its occasional occurrence in the southern part of the township is indicated by exposures of coal along the road in the southern part of Section 18, where it has a thickness of 1 foot 4 inches. The Ames limestone, to which it is best referred, lies 20 feet above the top of this coal.

In Salem Township, the horizon of the Harlem coal is above drainage along Town Fork as far as Section 30 and along the tributaries

to Cross Creek south of the northern boundaries of sections 3 and 33. The best development of the Harlem coal in this township, however, is found to the east and southeast of Annapolis as far as sections 19 and 20. The following record of outcrops along the public road in the northwestern part of Section 26 shows the thickness and stratigraphic position of the coal as represented in this area:

	Ft.	In.
Shale, gray, arenaceous	10	0
Coal blossom, *Clarksburg*		3
Clay	5	8
Shale, arenaceous, and covered	35	8
Shale, gray, arenaceous	15	6
Coal blossom, *Duquesne*		3
Covered interval	18	6
Limestone, massive, *Ames*	5	2
Shale and covered	5	4
Coal, *Harlem*	2	11
Clay and covered	5	6

The thickness of the coal here exceeds twice the average thickness for the county and the interval between the top of the coal, which averages about 17 feet for the county, is greatly reduced. In the southeastern part of the township and in the eastern part of the valley of Town Fork, the coal is replaced by sandy shale or by massive sandstone.

In Island Creek Township, the Harlem coal appears well above drainage along Island Creek from its mouth to Section 22 and along Wills Creek to Section 13. In this region the elevation of the member ranges from 900 to 1,000 feet. Along Island Creek it consists of a few inches of bone shale underlain by a thin coal bed. The stratigraphic relation of this member with respect to overlying and underlying beds is well illustrated in the following geologic section measured along a southern tributary to Little Island Creek in the northern part of Section 33, where the elevation of the Harlem coal is 900 feet:

		Ft.	In.
Limestone, *Ames*			6
Shale, gray to pink		22	0
Coal, *Harlem*			10
Clay, gray, arenaceous		3	0
Shale, and covered		48	8
Sandstone, massive	*Cow Run*	46	6
Shale, gray, arenaceous		4	0
Sandstone, massive		4	10
Shale, gray, arenaceous		3	6
Limestone, blue, ferruginous, fossiliferous, *Cambridge*		1	6
Clay, arenaceous		5	6
Covered		22	0
Limestone, dark, shaly, *Brush Creek*			9
Shale, dark		1	6

Along Wills Creek, exposures of Harlem coal varying from 1 to 2 feet in thickness occur in sections 1 and 13. The member is overlain by arenaceous shale and shaly sandstone, which in sections 7, 14, and 20 have completely replaced the coal.

In Cross Creek Township, exposures of Harlem coal are limited to the valleys of Cross Creek and McIntyre Creek, good exposures occurring in sections 2, 8, and 9. The member, which has a maximum thickness of 2 feet, consists of two benches separated by a thin shale parting, the upper part being shaly and the lower part blocky in character. In sections 13, 16, 22, 28, and 35, the Harlem coal is wanting.

Harlem coal is regularly present in the central and southern part of Steubenville Township, where it occurs at elevations ranging from 850 feet along Wells Run in Section 35 to 760 feet in Section 31. The coal is well exposed in the eastern part of Section 34 along a small tributary to Wells Run, which heads near Altamont Park. Here the coal, 1 foot 6 inches in thickness, is underlain by 4 feet of clay and overlain by 2 inches of black shale, above which occurs the arenaceous shale associated with the Ames limestone, a vertical distance of 24 feet. In sections 26 and 32, the Pittsburgh, Toledo, and Western Railroad passes through tunnels which lie a few feet below the Harlem coal and therefore afford excellent exposures of this member. The coal varies from 2 feet to 2 feet 11 inches in thickness, is blocky in character, and appears to be of fair quality.

In Wells Township, the horizon of the Harlem coal is below drainage except in the extreme eastern part. In Warren Township, the coal is due above drainage as far south as the mouth of Short Creek. Good exposures, which are rare in this locality, indicate that the member is thin and of little value.

Ames Limestone

Few limestone members of the Pennsylvanian system are quite so unique or distinctive in their characteristics as the Ames. On account of the persistent color of this member and its large content of fossil fragments, it is known as the Green Fossiliferous limestone or the Crinoidal limestone in the reports of the First and Second Geological Survey of Pennsylvania. These terms have gradually fallen into disuse, as the horizon is now known in Ohio, Pennsylvania, and West Virginia as the Ames limestone, a term applied by Andrews in 1873 for exposures in Ames Township, Athens County, Ohio.

This member is widely distributed and shows similar features over large areas, although locally it undergoes marked changes in lithological character. In general the limestone is dark-bluish to greenish-gray in

color and usually occurs as a single stratum 1 to 3 feet in thickness, but at some localities it is divided into two or more layers separated by bedding planes or by thin partings of calcareous shale. The stone is hard, tough, and, being more resistant to weathering than the associated shale, breaks up into large rectangular blocks which are strewn over the surface below the place of outcrop. On fracture it shows a more or less crystalline granular texture due to the cleavage surfaces of the calcite. It is usually very fossiliferous: in the Ames limestone of Ohio no less than 87 species have been identified including brachiopods, pelecypods, gastropods, and other forms, the most important being the crinoids which occur as stem fragments that stand out in relief on the weathered surface of the stone and give it the peculiar crinoidal appearance for which it is widey known. The position of the Ames limestone with reference to the Pittsburgh coal and Cambridge limestone is shown in the following table given by D. D. Condit[1]:

	Ames-Cambridge interval	Ames-Pittsburgh coal interval
Jefferson County	130	220
Harrison County	117	200
Guernsey County	108	187
Muskingum County	90	163
Morgan County	70	165
Athens County	68	160
Meigs County	75	155
Gallia County	73	158
Lawrence County	77	175

In Jefferson County the position of the Ames limestone is on an average about 138 feet above the Cambridge limestone, 211 feet above the base of the Brush Creek marine shale, and 212 feet below the bottom of the Pittsburgh coal. The thickness of the Ames varies from 6 inches to 12 feet 2 inches, but an average of 45 measurements shows a thickness of 2 feet 9 inches. At most localities the characteristics are typical for this member, but in a few places it shows a high percentage of impurities in the form of silica, clay material, or iron carbonate. Outcrops of Ames limestone occur in Saline, Ross, Springfield, Knox, Salem, Island Creek, Wayne, Cross Creek, Steubenville, Wells, and Warren townships; but the member is not continuous over this area, being replaced at some localities by the Morgantown sandstone.

Saline Township

In Saline Township, the Ames limestone is not continuous as in some places it is replaced by the Morgantown sandstone. A few exposures are found, however, which show the limestone of normal char-

[1]Condit, D. D., Geol. Survey Ohio, Fourth Series, Bull. 17, p. 34. 1912.

acter and thickness. Northeast of Irondale, in Section 26, the limestone has a thickness of 5 feet 8 inches and outcrops at an elevation of about 1,200 feet. Just west of Hammondsville, in the south-central part of Section 25, it occurs near the top of the hill at an elevation of 1,155 feet in sufficient thickness and purity to be quarried. In Section 17, the member outcrops along a small ravine just west of the camp grounds at an elevation of 969 feet. The character and thickness of the Ames are shown in the following geologic section measured along a small tributary which joins Hollow Rock Creek in the eastern part of Section 17:

	Ft.	In.
Sandstone, *Morgantown*	30	0
Limestone, gray, crystalline		8
Limestone, gray, crystalline, *Ames*		9
Limestone, gray, crystalline	1	1
Clay shale, gray	8	0
Shale, red, *Round Knob*	13	0

A half a mile south of the above locality, in the southwestern part of Section 11, the horizon of the Ames limestone is occupied by Morgantown sandstone.

Brush Creek Township

The main ridges to the north and south of Brush Creek in Brush Creek Township stand well above the position of the Ames limestone, which is apparently wanting, the horizon being occupied by Morgantown sandstone.

Knox Township

In Knox Township, several exposures of Ames limestone are present along valleys tributary to the Ohio River and Yellow Creek. Near the head of Jeremy Run, in Section 4, this limestone, 1 foot in thickness, outcrops at an elevation of 1,051 feet and lies 73 feet above the Cambridge limestone. Along Croxton Run and its tributaries, exposures of the limestone are present at a number of places, ranging in elevation from 955 feet in the west-central part of Section 2 to 1,010 feet in the northwestern part of Section 1. The member has a thickness of 1 foot and is gray, crystalline, and very fossiliferous. Fossils were collected in the western part of Section 32, where the following measurement of the exposure was made:

	Ft.	In.
Shale and covered	10	0
Limestone, *Ames*	1	9

	Ft.	In.
Clay shale, red, *Round Knob*	28	2
Clay, dark, *Barton horizon*	10	4

The Ames limestone at this locality is greenish-gray, dense in appearance, and argillaceous in composition. The fossils listed below were collected here:

Crinoids segments

Productus cora d'Orbigny
Marginifera wabashensis (Norwood and Pratten)
Composita subtilita (Hall)

Along the valley of Yellow Creek, Ames limestone occurs at elevations ranging from 1,000 to 1,040 feet. In the eastern part of Section 27, limestone 6 feet in thickness occurs in the bed of Dry Run, where it is typical in color, somewhat shaly in structure particularly in the middle part, and very fossiliferous. Along the east-west road in the north-central part of Section 32, the member outcrops at an elevation of 1,000 feet and lies 160 feet above the Brush Creek marine shale.

Ross Township

The Ames limestone is best developed in the southern half of Ross Township. Although many hills and ridges rise above this level, the horizon is for the most part occupied by sandstone or arenaceous shale. Along the northern slopes of Timothy Ridge, no limestone is present except in the south-central part of Section 10, where it outcrops by the road side at an elevation of 1,130 feet or 315 feet above the Upper Freeport coal. Along the road leading south to Longs Run, in the southeastern part of Section 27, the Ames limestone outcrops at an elevation of 1,123 feet and has a thickness of 2 feet 10 inches, with the lower part typically developed and the upper part consisting of hard flinty material with few fossils. Another exposure of limestone is found along the road in the central part of Section 31 at an elevation of 1,100 feet. The following geologic section shows its character and position with reference to the Pittsburgh coal:

	Ft.	In.
Coal blossom, *Pittsburgh*	4	6
Shale and covered	18	6
Clay, gray, plastic	2	6
Covered interval	24	8
Clay, gray, plastic	6	4
Sandstone, sandy shale, and covered	160	0
Limestone, bluish-gray, fossiliferous, *Ames*		9

In the southeastern part of Ross Township, this limestone outcrops at various places ranging in altitude from 990 to 1,090 feet. Ames limestone is also exposed in the north-central part of Section 14 at an altitude of 1,060 feet or 180 feet above the Brush Creek shale. However, the greatest development of the member in Ross Township occurs in the eastern part of Section 8, where it is found at an elevation of 1,090 feet and has a thickness of 12 feet 2 inches, and where both the lower and upper parts are typical, being massive, bluish gray in color, and crystalline in texture, with the middle portion shaly.

Island Creek Township

In Island Creek Township, the Ames limestone occurs with very few omissions at elevations ranging from 920 to 1,040 feet. It is 3 feet 4 inches in thickness in Section 5, and is separated into three divisions: The upper and lower parts, which are typical in their characteristics, are separated by a middle zone of shaly limestone. The Ames has an elevation of 1,032 feet at this locality and lies about 132 feet above the Brush Creek shale. To the north and south of Island Creek, in the southern part of Section 18, it outcrops at an elevation of about 970 feet. The Ames limestone is also present along the northeast-southwest road in the southeastern part of Section 23 at an altitude of 960 feet or 220 feet below the Pittsburgh coal. Near the headwaters of Wills Creek, several exposures of Ames limestone occur at elevations ranging from 940 to 970 feet. The member is thin although normal in lithologic characteristics. The following geologic section, measured in the central part of Section 13, where the Ames limestone outcrops at an elevation of 950 feet, shows its relation to the overlying and underlying members:

	Ft.	In.
Shale, gray, arenaceous	10	0
Coal, *Elk Lick*		8
Clay, dark bluish-gray, arenaceous	2	2
Clay, with nodules of limestone, *Elk Lick*	1	6
Clay, arenaceous	8	4
Shale and covered	35	0
Clay, bluish-gray, arenaceous	6	0
Shale, gray to red mottled	4	6
Covered interval	5	0
Limestone, bluish-gray, crystalline, fossiliferous, *Ames*	1	0
Shaly sandstone and sandy shale	9	0
Shale, gray, arenaceous	9	8
Coal, *Harlem*	1	6
Shale and shaly sandstone	40	0

In the southeastern part of the township, including Sections 1, 2,

7, 8, 31, and 32, the horizon of the Ames limestone is occupied by sandstone or sandy shale.

Salem Township

The Ames limestone in Salem Township is the most persistent member of the Conemaugh series and is present at every locality where its horizon outcrops. It has an average thickness in this township of 3 feet 6 inches but varies from 1 foot to 7 feet 6 inches. In the valley of Town Fork and its tributaries in the northern part, it occurs at elevations ranging from 974 to 1,060 feet. In the northeast part of Section 6, a good exposure of Ames limestone is found along a small ravine on the north side of Town Fork, where the character and thickness of this member and its position with relation to the overlying beds are as shown below:

		Ft.	In.
Sandstone, coarse-grained, *Morgantown*		55	0
Shale, gray, arenaceous		23	0
Shale, bony, *Duquesne*			8
Rock, dark, argillaceous, with fossil fragment			6
Clay, bluish-gray		1	0
Covered interval		17	2
Shale, bluish-gray, arenaceous		4	6
Limestone, bluish-gray, fossiliferous	*Ames*		8
Shale, calcareous, sparingly fossiliferous		1	6
Limestone, bluish-gray, fossiliferous		1	2
Shale, red to gray mottled, *Round Knob*		18	2

Near the mouth of Culp Run, in the southern part of Section 18, the Ames limestone is well exposed at an elevation of 1,040 feet. Another good exposure occurs on the north side of this creek in the northeastern part of Section 24, at an altitude of 1,020 feet. In the bed of Town Fork, in the central part of Section 30, Ames limestone 7 feet 6 inches in thickness outcrops at an elevation of 1,060 feet. It is typically bluish-gray in color, crystalline, and fossiliferous, and lies 102 feet below the Clarksburg coal and 218 feet below the Pittsburgh coal.

In the southern part of Salem Township, many exposures of this member are found along the valley tributary to Cross Creek, with elevations ranging from 1,165 feet in Section 33, near the western boundary of the township, to 990 feet in the central part of Section 1. In this area the limestone is typical in its characteristics although variable in thickness. The bed is well developed on the Cain farm, a half of a mile north of Annapolis, in the west-central part of Section 33, where it is being quarried and used for road construction. The measurements given below show its thickness in this locality.

		Ft.	In.
Covered.			
Limestone, bluish-gray, massive, fossiliferous	*Ames*	2	5
Limestone, bluish-gray, fossiliferous			9
Limestone, bluish-gray, massive, fossiliferous		2	10
Shale, blue			6

The following fossils were collected from the Ames limestone at this locality:

Crinoid segments

Productus cora d'Orbigny
Productus semireticulatus (Martin)
Pustula nebraskensis (Owen)
Marginifera wabashensis (Norwood and Pratten)
Spiriferina kentuckyensis (Shumard)
Squamularia perplexa (McChesney)
Hustedia mormoni (Marcou)
Composita subtilita (Hall)

Along the road in the southwestern part of Section 21, Ames limestone 5 feet 4 inches in thickness outcrops at an elevation of 1,180 feet and lies 80 feet below the Clarksburg coal horizon, whereas along the east-west road in the central part of Section 14, it is found at an elevation of 990 feet with a thickness of 2 feet 6 inches. A thin blossom of Clarksburg coal is exposed along the road at the latter place, 102 feet above the limestone. A ledge of Ames limestone outcrops along the east slope of Cedar Lick in the southeastern part of Section 9, having an elevation of 1,040 feet and lying 80 feet below the Clarksburg coal and 220 feet below the Pittsburgh coal.

Springfield Township

The horizon of the Ames limestone is above drainage in the central and northern parts of Springfield Township, passes below creek level near the southern boundary of Sections 12, 18, and 24, and is not exposed north of the central part of Section 15. The clay belonging to the Harlem coal, which normally lies about 17 feet below the Ames limestone, is exposed near the hilltops to the north and southeast of Bergholz, but the Ames member is wanting, its place being occupied by the Morgantown sandstone. Through the central part of the township the limestone appears as a continuous member which ranges from 6 inches to 4 feet 6 inches in thickness, six measurements giving an average of 1 foot 9 inches. The most western exposure in the township is found at an elevation of 1,047 feet along a small ravine tributary to Yellow Creek in the western part of Section 24. In the northwestern part of Section 1, Ames limestone outcrops along a small valley tributary to Wolf Creek,

where it has a thickness of 4 feet 6 inches with an elevation of 1,136 feet, and is overlain by Morgantown sandstone and underlain by the mottled shales of the Round Knob horizon. A collection of fossils made at this locality yields the following forms:

Crinoid segments

Productus cora d'Orbigny
Productus semireticulatus (Martin)
Pustula nebraskensis (Owen)
Pustula pertenuis (Meek)
Marginifera wabashensis (Norwood and Pratten)
Spirifer cameratus Morton
Composita subtilita (Hall)

About 1½ miles south of Amsterdam, the Ames limestone appears a few feet above track level along the Lake Erie, Alliance, and Wheeling Railroad, where the following geologic section was measured:

		Ft.	In.
Sandstone, shattered, *Morgantown*		7	0
Clay with iron ore nodules		4	0
Sandrock, hard, ferruginous		3	2
Shale, olive green to gray		1	6
Limestone, bluish-gray, fossiliferous	*Ames*		4
Shale, gray	*Ames*		2
Limestone, bluish-gray, fossiliferous	*Ames*	2	9
Shale, gray, arenaceous		11	4
Sandstone, shaly in lower part		2	4
Shale, gray, arenaceous		3	4
Coal, *Harlem*		1	4
Clay, dark, arenaceous			6

Steubenville Township

The Ames limestone is well exposed along the river road in Steubenville Township between Steubenville and Mingo Junction. The following section was secured at an exposure a short distance north of Mingo Junction:

		Ft.	In.
Limestone, shaly at base			8
Limestone, massive	*Ames*	4	6
Limestone layer, massive	*Ames*	2	8
Shale, calcareous, fossiliferous, with nodules of fossiliferous limestone		3	8
Shale, gray, arenaceous		13	3
Coal, blocky, *Harlem*		2	0

A quarter of a mile farther to the north, the Ames limestone

thins to 1 foot 2 inches and is embedded in sandy shale. In the eastern part of Section 34, it outcrops along the road which descends to Wells Run. The limestone has a thickness of 1 foot 10 inches, is typically bluish-gray in color, and fossiliferous. It has an altitude of 826 feet and lies 102 feet above the Cambridge limestone and 204 feet below the Pittsburgh coal.

South of Cross Creek, the member outcrops at an elevation of 767 feet above the western end of the tunnel on the Pittsburgh, Toledo, and Western Railroad in the northwestern part of Section 26. Another good exposure is found in the southern part of Section 25, where the member outcrops at an elevation of 760 feet and lies 204 feet below the Pittsburgh coal. The following record shows the character and thickness of the limestone at this locality:

	Ft.	In.
Limestone, shaly, fossiliferous	2	9
Limestone, bluish-gray, fossiliferous	2	4
Shale, calcareous, *Ames*		2
Limestone, massive, fossiliferous	1	2
Shale, blue, calcareous, fossiliferous		6
Limestone, massive, fossiliferous	2	5

Cross Creek Township

In Cross Creek Township, the horizon of the Ames limestone outcrops along Cross Creek Valley at elevations which vary from 800 to 935 feet. Although the lithologic characteristics are typical in most respects, the member is below the normal thickness, averaging 1 foot 10 inches. In the southeastern part of Section 16, blue, compact, fossiliferous limestone, 1 foot in thickness, is exposed along a valley tributary to Cross Creek at an elevation of 836 feet and lies 239 feet below the Pittsburgh coal. Ames limestone, massive in structure and highly ferruginous, with a thickness of 2 feet 4 inches, outcrops above the railroad tunnel in the northeastern part of Section 34 at an elevation of 964 feet, and 143 feet above the Cambridge limestone. This member is also characteristically developed in the vicinity of Reeds Mills, as shown by good exposures along the road a few hundred feet south of the bridge. In the southern part of Section 8, the Ames outcrops along the Pittsburgh, Toledo, and Western Railroad a short distance east of Tunnel No. 12, where the following measurements were secured:

		Ft.	In.
Limestone, bluish-gray, massive, fossiliferous, *Ames*		3	0
Sandy shale and shaly sandstone		9	2
Shale, light to dark		15	6
Coal, bony	*Harlem*		6
Coal	*Harlem*	1	4
Clay, gray		1	0

At the western end of Tunnel No. 12, the Ames limestone is entirely replaced by massive sandstone as is also the case at many localities to the southwest along McIntyre Creek.

Wayne Township

In Wayne Township, stream erosion has exposed the Ames limestone in the northern and northeastern portions only. Along Cedar Lick in Section 6, the limestone, which is well developed, lies above a massive sandstone. An outcrop of typical Ames is present along the road a quarter of a mile southwest of Skelley Station. It also occurs along the northeast-southwest road in the eastern part of Section 18, where it has a thickness of 2 feet and an elevation of 1,008 feet, and where it lies 92 feet below the Clarksburg coal and 31 feet above the horizon of the Harlem coal. Thin nodular limestone on the Ames horizon is exposed along the east-west road in the northeastern part of Section 35, where the altitude is 1,000 feet.

Wells Township

A thin bed of Ames limestone outcrops in Wells Township along Tarrs Run in the southwestern part of Section 30, at an elevation of 761 feet, and lies 179 feet below the Pittsburgh coal. In the southwestern part of Section 5, it is present at an altitude of 770 feet.

Warren Township

In Warren Township, Ames limestone outcrops along the valleys tributary to the Ohio River from Little Rush Run to Short Creek. Along Little Rush Run it is exposed in the stream bed at an elevation of 945 feet. Likewise, typical bluish-gray, crystalline, fossiliferous limestone, 2 feet 2 inches in thickness, occurs along Williamson Run in the northern part of Section 18, where the interval between the Pittsburgh coal and the Ames limestone measures 183 feet. There is an unusual development of the member along Little Short Creek in the central part of Section 33, the total thickness measuring 6 feet; the lower bench consists of 3 feet 6 inches of gray compact limestone but the upper bench is more shaly in character. It is overlain by massive sandstone and underlain by red shale. The following geologic section, measured in the south-central part of Section 30 in a cut along the Wheeling and Lake Erie Railroad, shows the character and thickness of the Ames limestone at this locality:

	Ft.	In.
Sandstone, *Morgantown*	5	0
Shale, chocolate-colored	15	0
Shale, compact, arenaceous	3	0

	Ft.	In.
Shale, bluish-gray	19	0
Shale, red	16	0
Limestone, shaly, fossiliferous, *Ames*	2	6
Shale, bluish-gray	10	0

When traced laterally 100 feet from the place where the above section was measured, the limestone thins and finally disappears, its place being taken by red shale. West of this exposure, the Ames limestone may be seen at a few places near water level to the western edge of Section 31, where it apparently passes below drainage at an elevation of about 735 feet.

Duquesne Coal and Clay

The Duquesne coal was first named by Percy E. Raymond for exposures near the town of Duquesne located on the Monongahela River in Allegheny County, Pennsylvania. This coal, which lies about 30 feet above the Ames limestone at the type locality, has been recognized in Jefferson, Belmont, Harrison, Carroll, and Tuscarawas counties, Ohio. In Jefferson County, however, it is very poorly developed, varying in thickness from 1 inch to 1 foot 3 inches, with an average of about 6 inches. It is everywhere shaly in character, usually consisting of thin coal bands interstratified with black carbonaceous shale. The bed lies on an average of 18 feet above the Ames limestone, although this interval varies in places from 9 to 26 feet. The accompanying clays are well developed, bluish-gray to mottled in color, usually arenaceous in composition, and have an average thickness of 6 feet. In Jefferson County, the Duquesne coal has been identified in Salem, Island Creek, Cross Creek, Steubenville, and Springfield townships. Although there are large areas in Saline, Brush Creek, Ross, Wayne, Wells, and Warren townships where this horizon is present above drainage, the coal is replaced to a large extent by arenaceous shale or massive sandstone.

In Salem Township the Duquesne coal is present in sections 1, 6, 14, 19, 20, and 26. Its thickness varies from 1 inch to 1 foot 3 inches and its position is 10 to 25 feet above the Ames limestone. In the northwestern part of Section 1, it outcrops at an elevation of 992 feet and lies 12 feet above the Ames limestone. A good exposure of this coal, 1 foot in thickness, is found along the road in the north-central part of Section 14 at an elevation of 1,005 feet. It lies 11 feet above the Ames limestone and 91 feet below the Clarksburg coal. The member is likewise well developed in the central part of Section 14 where it is overlain by 1 foot 3 inches of Skelley limestone. In Section 26, the elevation of the Duquesne coal is about 1,030 feet and

its position is 18 feet above the Ames limestone and 57 feet below the Clarksburg coal. The stratigraphic relations of the member are illustrated in the following geologic section measured along the road in the northwestern part of Section 19:

	Ft.	In.
Coal, shaly, *Elk Lick*	1	0
Clay and covered	3	2
Limestone, light, compact, *Elk Lick*	1	0
Clay and covered	16	0
Shale and covered	15	0
Shale, gray, fossiliferous, *Skelley*		4
Coal blossom, *Duquesne*		4
Clay, gray to mottled	7	10
Shale and covered	16	0
Limestone, nodular, *Ames*	2	2
Shale, dark, arenaceous	6	3
Coal, *Harlem*	2	2

The position of the Duquesne coal in Island Creek Township is generally occupied by sandstones and sandy shale, but a few exposures of the coal have been found. In Section 36, along the public road, a good outcrop occurs, the measurements of which are shown in the following section:

	Ft.	In.
Sandstone, cross-bedded, *Morgantown*	100	0
Shale, bluish-gray	17	2
Shale, black } *Duquesne*		6
Shale, bony } *Duquesne*		4
Clay, gray, arenaceous	5	0
Shale, blue, sandy	18	8
Limestone, bluish-gray, *Ames*	1	6

The Duquesne coal has a shaly structure and a thickness of 3 inches where it is well exposed, along Permars Run in the northern part of Section 5 in Cross Creek Township. It occurs at an elevation of 900 feet and lies 9 feet 4 inches above the Ames limestone, which outcrops in the bed of the stream, and 176 feet below the Pittsburgh coal. In the southeastern part of Section 16, along a small valley tributary to Cross Creek, a good exposure shows the strata from the Ames limestone to the Pittsburgh coal. However, the Duquesne coal is not present here although the clay associated with it, which is blue to pink in color and arenaceous, is well shown.

In Steubenville Township, the coal with its associated clay is exposed along Wells Run in the southwestern part of Section 35,

where the horizon is represented by 3 inches of shaly coal overlying 7 feet 9 inches of bluish-gray arenaceous clay. The Ames limestone is also well developed about 12 feet below the coal.

In Springfield Township, the horizon of the Duquesne coal is usually occupied by sandstone. About 1½ miles south of Amsterdam, a few feet of arenaceous clay is exposed on this horizon in a railroad cut above the Ames limestone, but the coal is wanting.

Skelley Limestone

The Skelley limestone, named by D. D. Condit from exposures near Skelley Station, Jefferson County, Ohio, lies immediately above the Duquesne coal. Although at no place a conspicuous horizon, it has been recognized in Ohio in Morgan, Muskingum, Noble, Monroe, Guernsey, Belmont, Harrison, and Jefferson counties, and has been noted in West Virginia, where it is known as the Upper Ames limestone. At the type locality the member consists of a single layer of limestone which is similar to the Ames although it differs from it in being thinner and more ferruginous in composition. On fresh exposure it is a granular, crystalline limestone in which fossil crinoids are conspicuous, but on weathering the oxidation of the iron produces a dark brown color. In Athens, Morgan, Muskingum, Noble, Monroe, and Guernsey counties, the underlying Duquesne coal is wanting and the Skelley limestone becomes nodular in character, consisting of two or more layers of impure fossiliferous limestone interstratified with shale. In Ohio, it has an average thickness of about 10 inches and lies 20 feet above the Ames limestone.

In Jefferson County, the Skelley limestone presents many phases: at some localities it is composed of a single layer of granular, crystalline, fossiliferous limestone which is highly ferruginous; at other places, however, the horizon is marked by a few inches of gray to black calcareous, fossiliferous shale; or again it may consist of black, fossiliferous, shaly limestone or limestone nodules embedded in dark shale. The thickness varies from 3 inches to 1 foot 6 inches with an average of 8 inches. On the average, this member lies 18 feet above the Ames limestone, but the interval varies from 11 to 26 feet. The horizon of the Skelley limestone is found above drainage in every township in the county except Smithfield and Mount Pleasant, but sandstone occupies the position of the Skelley limestone everywhere with the exception of Steubenville, Cross Creek, and Salem townships, where the development of the member is normal.

In Salem Township, the Skelley limestone is exposed along the road five-eighths of a mile south of Annapolis, where it is a compact,

ferruginous, fossiliferous limestone, 1 foot 6 inches in thickness, which outcrops at an elevation of 1,184 feet and lies 10 feet above the Ames limestone. In the west-central part of Section 13, the Ames limestone and overlying beds are exposed along the road which follows a small tributary to Salem Creek. At this locality the Skelley limestone is a ferruginous, crystalline, fossiliferous rock, 3 inches in thickness, which lies 9 feet above the Ames limestone. Along the east-west road in the north-central part of Section 14, a good exposure of Skelley limestone occurs, the measurement of which is given below:

	Ft.	In.
Coal blossom, *Clarksburg*		6
Clay	2	0
Shale and covered	50	0
Limestone, dark blue		8
Shale, gray	6	4
Coal blossom, *Elk Lick*		3
Clay	5	0
Shale and covered	20	10
Limestone, gray, crystalline, fossiliferous, *Skelley*		10
Shale	1	2
Coal, *Duquesne*	1	0
Shale and covered	10	8
Limestone, massive, *Ames*	2	6

In Cross Creek Township, an exposure of Skelley limestone occurs along a ravine in the southwestern part of Section 16, where it consists of 4 inches of calcareous, fossiliferous shale. It has an elevation of 852 feet and lies 16 feet above the Ames limestone and 222 feet below the Pittsburgh coal. Another exposure is found along Permars Run near the northern edge of Section 5, where the measurements given below were obtained:

	Ft.	In.
Coal, *Pittsburgh*	4	8
Covered interval	172	0
Shale, dark	4	0
Limestone, black, fossiliferous, *Skelley*		3
Coal, shaly, *Duquesne*		3
Clay, dark, bluish-gray, arenaceous	5	8
Shale, bluish-gray	3	8
Limestone, bluish-gray, fossiliferous, *Ames*	2	0

In Steubenville Township, 5 inches of black, shaly, fossiliferous Skelley limestone outcrops along Wells Run in the southeastern part of Section 35, at an elevation of 880 feet and 17 feet above the Ames limestone and 180 feet below the Pittsburgh coal.

Elk Lick Limestone

Messrs. Platt of the Second Geological Survey of Pennsylvania described a thin limestone lying a few feet below the Elk Lick coal in Somerset County, which they called the Elk Lick limestone. At the type locality this limestone, overlain by 4 feet of coal, is reported to be 6 feet in thickness and to lie 210 to 220 feet below the Pittsburgh coal. From Somerset County, Pennsylvania, this limestone extends to the south to Monongalia, Marion, Taylor, Barbour, and Lewis counties, West Virginia, where I. C. White describes it as follows[1]:

"The stratum is frequently 10 to 15 feet thick in several layers, separated by shales. The limestone is of fresh or brackish water origin like all of those in the series above it, but some of the layers are fairly pure, and burn into a good quality of lime for building or fertilizing purposes."

The Elk Lick limestone has never been reported in the Conemaugh series of Ohio; but in Jefferson County a few outcrops of limestone, overlain by a thin coal blossom and lying about 25 feet above the Skelley limestone and 48 feet below the Clarksburg coal in Salem and Island Creek townships, are here referred to the Elk Lick limestone horizon. The limestone occurs embedded in clay, never exceeds 2 feet in thickness, and is usually much less than this. It is light to dark gray in color and at most exposures is nodular in character. A careful examination for fossils shows *Spirorbis anthracosia* Whitfield to be the only form present, although it is fairly abundant.

In Salem Township, the Elk Lick limestone, 1 foot in thickness and light gray in color, is found along the east-west road between sections 19 and 20. It outcrops at an elevation of 1,148 feet and lies 58 feet above the Ames limestone and 32 feet above the Duquesne coal.

A good exposure of Elk Lick limestone occurs in Island Creek Township along a southern tributary to Wills Creek in the southern part of Section 1, where the member is dark gray and compact, is 2 feet in thickness, and outcrops at an elevation of 1,000 feet. The character of the limestone and its stratigraphic position are shown in the following section, which was measured in the southern part of Section 15, along the south branch of the North Fork of Wills Creek:

	Ft.	In.
Limestone, gray, compact, *Elk Lick*	1	6
Clay, gray	4	6
Covered interval	6	6
Shale, gray, arenaceous	40	8

[1]White, I. C., West Virginia Geol. Survey, Vol. II, p. 254. 1903.

	Ft.	In.
Limestone, bluish-gray, fossiliferous, *Ames*		4
Shale, arenaceous	18	10
Coal, *Harlem*.		

Elk Lick Coal and Clay

The Elk Lick coal is much more important as a stratigraphic horizon than the limestone of the same name. Its first recognition dates back to 1840 when it was named by Lesley for exposures along Elk Lick Creek, in Somerset County, Pennsylvania, where it has a thickness of 4 feet and lies 200 feet below the Pittsburgh coal. Since that time it has been found to be present with few omissions in southwestern Pennsylvania and northern West Virginia as far south as Kanawha County, and also in Brooke and Hancock counties of the Pan Handle region of West Virginia.

In Ohio, the horizon of the Elk Lick coal is usually occupied by sandstones or sandy shale and therefore the member has not been previously recognized. In Jefferson County, however, this coal and clay are locally present in Springfield, Salem, Island Creek, and Mount Pleasant townships, although neither the coal nor the clay has any economic value. The coal varies in thickness from 3 inches to 1 foot, and the associated clay from 3 to 10 feet. The coal bed is composed, in the main, of bone coal or thin coal bands interstratified with carbonaceous shale. The underlying clay is arenaceous and calcareous, gray to bluish-gray in color, and of an inferior quality. The coal lies, on an average, 50 feet above the Ames limestone, 51 feet below the Clarksburg coal, and 162 feet below the Pittsburgh coal.

In Springfield Township, the Elk Lick coal is not present. The associated clay, however, is exposed along the road leading from Circle Green to Wolf Run in the west-central part of Section 2, where outcrops occur at an elevation of 1,258 feet and lie 60 feet above the Ames limestone. Likewise this associated clay is present along the road in the south-central part of Section 13 where the following section was secured:

	Ft.	In.
Coal horizon, Clarksburg.		
Clay, bluish-gray, plastic	3	0
Covered interval	10	0
Shale, pink, argillaceous	39	0
Shale and covered	13	0
Coal horizon, *Elk Lick*.		
Clay, gray	2	0
Sandstone, shale, and covered	57	0
Limestone, bluish-gray, fossiliferous, *Ames*		6

In Salem Township, the Elk Lick coal and the associated clay are well developed in Sections 1, 13, 14, 19, and 20, where the coal usually outcrops as a thin blossom 3 inches to 1 foot in thickness and the underlying clay is bluish gray, arenaceous in character, and varies from 3 to 7 feet in thickness. The following geologic section of an exposure along the northeast and southwest road in the south-central part of Section 1 shows the character and stratigraphic position of this member:

	Ft.	In.
Sandstone	10	0
Clay shale, pink	16	0
Shale, gray, arenaceous	25	6
Coal blossom, *Elk Lick*		3
Clay and covered	4	6
Shale, gray, arenaceous	54	2
Covered interval	6	0
Limestone, *Ames*	2	6
Clay shale with limestone nodules	17	6
Shaly sandstone and sandy shale	36	0

In Island Creek Township, the Elk Lick coal is generally replaced by sandstone or sandy shale. In the southern part of Section 15, the associated clay and limestone outcrop along the south bank of the North Fork of Wills Creek at an elevation of 1,022 feet, but the coal is wanting. The coal, however, is exposed along a small tributary to Wills Creek in the central part of Section 13, where it is 8 inches thick, is underlain by 12 feet of gray, arenaceous clay, has an altitude of 1,014 feet, and lies 63 feet above the Ames limestone.

Morgantown Sandstone

The next member above the Elk Lick coal is the Morgantown sandstone, so named by J. J. Stevenson for exposures near Morgantown, Monongalia County, West Virginia. The member constitutes one of the most important and persistent sandstones of the Conemaugh series, extending as it does along the eastern margin of the series in Pennsylvania and entirely across the State of West Virginia to the Kentucky line. The thickness of the sandstone is usually about 25 to 30 feet but locally it reaches 100 feet. Concerning the characteristics of the stone at the type locality, I. C. White writes as follows[1]:

"It (Morgantown) is usually of a yellowish gray cast, and splits readily into building blocks of any desired size. The rock contains much feldspathic material, and occasionally some lime, and in weathering the rock changes from

[1]White, I. C., West Virginia Geol. Survey, Vol. II, p. 250. 1903.

a bluish gray cast to a dirty brown, and frequently decomposes readily, so that as a building stone for exposed surfaces, it is not a success, some of the stone works at the State University in Morgantown having disintegrated badly within a period of only 25 years."

In Ohio, the Morgantown sandstone appears more or less well developed in every county where it is due from Lawrence on the south to Jefferson on the east. Like all sandstone members of the Pennsylvanian system of Ohio, the Morgantown is subject to much variation in character and thickness. In Lawrence, Gallia, Meigs, Athens, Carroll, and Harrison counties, where it is best developed, it is medium to coarse grained, massive, and of a bluish to a yellowish gray color. In much of Morgan, Muskingum, Noble, and Tuscarawas counties, it becomes shaly in character or is replaced by sandy shale. The Morgantown sandstone in Ohio has an average thickness of 25 feet. The base of the member lies on an average about 37 feet above the Ames limestone, but locally it approaches much nearer or even replaces that member.

In Jefferson County, the Morgantown sandstone is rather patchy in distribution and variable in thickness. It is present in some degree of development in Saline, Brush Creek, Ross, Knox, Springfield, Salem, Island Creek, Steubenville, and Warren townships. The thickness of the sandstone varies from 30 to 100 feet. Where the normal thickness occurs, the base of the member lies immediately above the Elk Lick coal or is separated from it by a few feet of shale. Excessive thickness of the stone usually involves a lowering of the base and a replacement of the underlying members. It is of medium texture but may become coarse and conglomeratic in the lower part where great thicknesses occur. The color on fresh exposure is a bluish gray which changes to a yellowish brown on weathering. Cross-bedding is common in some localities but does not constitute a characteristic feature.

In Saline Township, Morgantown sandstone lies high in the hills south of North Fork of Yellow Creek. Along Hollow Rock Creek, in the western part of Section 11, the base of the sandstone occurs immediately above the Ames limestone. The ridges to the north and south of Brush Creek in Brush Creek Township, and also Timothy Ridge, which lies between Long Run and Yellow Creek in Ross Township, are capped by this sandstone. Along the tributaries to Town Fork, in the southern part of Ross Township, it outcrops in good development at elevations ranging from 1,025 feet in Section 1 to 1,100 feet in Section 31.

In Springfield Township, the Morgantown sandstone is invariably present wherever its horizon outcrops. To the north, west, and

southeast of Bergholz, it lies near the hilltops at elevations varying from 1,178 to 1,204 feet and has replaced the Ames limestone, lying immediately above or very close to the Harlem coal horizon. It also occurs in good development in the northeastern part of Knox Township. In Section 4, the base of the sandstone lies a few feet above the Ames horizon at an altitude of 1,070 to 1,100 feet. It is also well marked along the valley of Town Fork, having an elevation of 1,045 feet. In Island Creek Township, the Morgantown sandstone underlies the uplands to the north and south of Island Creek. It varies in thickness from 10 to 100 feet and occurs at altitudes ranging from 1,065 feet in Section 36 to 945 feet near Stanton Park in Section 32. In the northern part of Salem Township, the member is present in good development along the valley of Town Fork, but in the southern part of the township it is replaced by sandy shale.

In Steubenville and Cross Creek townships, the Morgantown sandstone is present wherever it is due, but it is usually thin and in places shaly in character. It varies in thickness from 30 to 100 feet and is present at elevations ranging from 966 feet in Section 28, Cross Creek Township, to 794 feet in Section 35, Steubenville Township. It is well exposed along the valleys tributary to Cross Creek from the north, where its outcropping edges produce very steep slopes. Good exposures are found along the Pittsburgh, Toledo, and Western Railroad from Mingo Junction westward. Thirty feet of massive, bluish-gray sandstone appears above Tunnel No. 11, in the northern edge of Section 32, Steubenville Township, and, as the base lies 8 feet above the Harlem coal, it replaces the Ames limestone. For several miles west of Tunnel No. 12, in the northwestern part of Section 7, Cross Creek Township, massive sandstone belonging to this member is exposed in the various railroad cuts.

The Morgantown sandstone is typical in character and development in Wells Township where it outcrops along the small valleys tributary to the Ohio River. In the eastern half of Warren Township, it is normal and well developed; but it gives way to shale in the western part of Warren and in the eastern part of Mount Pleasant townships. Near the mouth of Little Short Creek in Section 23, Warren Township, sandstone occurs immediately above the Ames. About a half of a mile from the mouth of Williamson Run, good exposure of this member occurs, the character and thickness of which are shown in the following section:

	Ft.	In.
Sandstone, massive, conglomeratic near base, *Morgantown*	30	0
Limestone, bluish-gray, fossiliferous, *Ames*	2	2
Shale with thin sandy layers	8	5

Five feet of Morgantown sandstone appears at the top of the railroad cut in Section 30, Warren Township, where the base of the stone lies 53 feet above the Ames limestone.

Clarksburg Limestone

The Clarksburg limestone, although locally of sufficient thickness and purity to be of some economic value, is of importance chiefly for its stratigraphic interest. It is variable in thickness but wide-spread in its distribution, being present in southwestern Pennsylvania and in large areas in northwestern West Virginia. Near the type locality at Clarksburg, Harrison County, West Virginia, the limestone has a thickness of 10 to 30 feet and lies a few feet above the Morgantown sandstone and 100 to 140 feet below the Pittsburgh coal. In regard to the characteristics of this member near Clarksburg, I. C. White, who first described this limestone, writes as follows[1]:

> "The whole stratum is often 20 to 30 feet thick and some of the layers are quite ferruginous, so much so that they were once mined as ore and used in the manufacture of iron at an old charcoal furnace on Elk, near Clarksburg."

Along the western belt of outcrops of the Conemaugh series in Ohio, the Clarksburg is thinner and less persistent than in West Virginia. In Jefferson County, it is poorly represented. Like the Elk Lick limestone which lies about 50 feet below, it is a light to dark gray, dense, fresh or brackish water limestone. *Spirorbis anthracosia* Whitfield is the only fossil found, but it is fairly abundant. This limestone usually occurs as a single layer embedded in or lying at the base of the clays associated with the Clarksburg coal, but at a few localities two or more layers of limestone are found interstratified with the clay. The thickness in Jefferson County varies from a few inches to 8 feet with an average of 1 foot 6 inches. Its position is on an average 87 feet above the Ames limestone and 114 feet below the Pittsburgh coal. Although the member is wide-spread, outcrops are scattered and are limited to Island Creek, Cross Creek, Steubenville, Smithfield, and Warren townships.

The only exposure of Clarksburg limestone observed in Island Creek Township is found along the northern slope of Island Creek in the eastern part of Section 28, where the member consists of a nodular layer of limestone 5 inches in thickness embedded in red ferruginous clay. At this locality, the limestone outcrops at an elevation of 1,050 feet and lies 80 feet above the Ames limestone. In Steubenville Township, 1 foot 8 inches of dark gray, somewhat brecciated limestone out-

[1]White, I. C., West Virginia Geol. Survey, Vol. II, p. 249. 1903.

crops at an elevation of 892 feet along a small ravine in the eastern part of Section 35, where it lies 83 feet above the Ames limestone and 133 feet below the Pittsburgh coal. The Clarksburg limestone is also well exposed along Wells Run in the southwestern part of Section 35, where its character, thickness, and stratigraphic relations are as shown in the following geologic section:

	Ft.	In.
Coal, *Pittsburgh*	5	0
Covered interval	118	10
Clay, gray, arenaceous	2	0
Limestone, dark gray, *Clarksburg*	2	6
Shale and covered	70	0
Limestone, dark, shaly, *Skelley*		5
Coal, shaly, *Duquesne*		3
Clay, bluish-gray, arenaceous	7	9
Clay shale, red to pink	4	10
Limestone, *Ames*	4	4
Shale, bluish-gray, arenaceous	10	2
Shale, black, carbonaceous, *Harlem horizon*		½
Clay, gray, arenaceous	4	0

In Warren Township, a single layer of dark, compact Clarksburg limestone outcrops along a small ravine west of Yorkville in Section 22; it has a thickness of 1 foot 2 inches, an elevation of 793 feet, and lies 101 feet below the level of the Pittsburgh coal at the opening of the Walnut Hill Mine of the Ohio and Pennsylvania Coal Co. This limestone is also well exposed along the road leading to the west from the mouth of Little Short Creek in the northeastern part of Section 23. At this locality, the member consists of two layers separated by a few inches of shale. The elevation of the limestone is 798 feet, the interval to the Ames limestone 103 feet, and to the Pittsburgh coal 84 feet.

The Clarksburg limestone is thin and very irregular in its distribution in Jefferson County and therefore adds little to the economic resources.

Clarksburg Coal and Clay

The Clarksburg coal, first named by I. C. White from exposures near Clarksburg, Harrison County, West Virginia[1], lies immediately above or within a few feet of the Clarksburg limestone. Like the associated limestone, it is a persistent member of the Conemaugh

[1]White, I. C., U. S. Geol. Survey, Bull. 65, p. 88. 1891.

series of West Virginia, although it is thin and of poor quality. In Harrison and Barbour counties, it occurs in two benches separated by a few feet of shale or limestone. This structure is also present in Garrett and Allegheny counties, Maryland, where the coal is frequently called the "dirty nine-foot coal." In Ohio, the member is usually represented by a thin band of shaly coal or by a few inches of black shale. It has been recognized by Condit in Lawrence, Meigs, and Athens counties, although it is not a persistent or conspicuous horizon.

In Jefferson County, exposures of the Clarksburg member are found in Saline, Springfield, Salem, Island Creek, Steubenville, Smithfield, Mount Pleasant, and Warren townships. The coal has an average thickness of 1 foot but varies from 2 inches to 4 feet. The structure is shaly, but locally where good thicknesses occur it becomes blocky and is of fair quality. The associated clay is bluish-gray to yellow in color and is usually highly ferruginous and calcareous in composition, with thicknesses ranging from 3 to 8 feet. The position of the Clarksburg coal in Jefferson County is on an average 101 feet above the Ames limestone, 56 feet above the Elk Lick coal, and 110 feet below the Pittsburgh coal.

Saline Township

The Clarksburg coal outcrops along a small ravine in Saline Township in the southeastern part of Section 24, where it is shaly in structure and is underlain by about 1 foot of hard, blue, arenaceous clay. In the southeastern part of Section 11, clay belonging to the Clarksburg horizon appears at an elevation of 993 feet along the road which descends from the east into Hollow Rock Creek, but the coal is wanting.

Island Creek Township

Although the horizon of the Clarksburg coal is above drainage in some parts of every section in Island Creek Township, it is either replaced by shale and sandstone or is covered, so that few exposures occur. In the eastern part of Section 28, the coal with an elevation of 1,052 feet is exposed along the road which crosses Island Creek. The record of the outcrops at this place is given below:

	Ft.	In.
Coal blossom, *Clarksburg*		6
Clay, red, ferruginous	1	6
Limestone, nodular, fossiliferous, *Clarksburg*		4

	Ft.	In.
Covered interval	28	6
Shale, gray, arenaceous	52	0
Limestone, bluish-gray, *Ames*	1	0

In the eastern part of Section 28, there is a local thickening to 4 feet. An opening has been made a few rods south of the road on farm of W. J. Schwartz, where the coal is mined in a small way. The following section measured along the road shows the character of the overlying and underlying members:

		Ft.	In.
Limestone, dark		2	0
Shale and covered		76	0
Shale, dark		1	0
Shale, black, carbonaceous			7
Coal, bony	*Clarksburg*		4
Coal, blocky	*Clarksburg*	4	0
Sandstone and covered		82	0
Shale and covered		52	0
Limestone, *Ames*		1	7

Attempts to obtain coal of workable thickness on this horizon to the eastward have proved unsuccessful, and residents in the community report that the coal passes rapidly into black shale interstratified with thin coal bands. About five-eighths of a mile north of the Schwartz opening, an unsuccessful test for oil has been made and the records indicate that a coal lies 96 feet below the Pittsburgh bed, that it is thin and of no economic value.

Springfield Township

In Springfield Township, 3 feet of bluish-gray clay representing the Clarksburg horizon outcrops at an elevation of 1,216 feet along the road a half of a mile southeast of Amsterdam, where it lies 62 feet above the Elk Lick clay and 121 feet above the Ames limestone.

Salem Township

In the central part of Section 30, Salem Township, 4 inches of shaly coal outcrops along the road at an elevation of 1,162 feet. The following geological section was measured at this place:

	Ft.	In.
Coal blossom, shaly, *Clarksburg*		4
Clay, yellowish, ferruginous	3	0
Shale, gray, arenaceous	67	0
Covered interval	25	0
Limestone, bluish-gray, fossiliferous, *Ames*	7	6

In the south-central part of Salem Township, the Clarksburg coal is of common occurrence and is usually represented by a thin coal blossom or by a few inches of black shale. Near the forks of the road, in the southeastern corner of Section 15, a thin blossom of this coal outcrops at an elevation of 1,120 feet. The overlying and underlying beds, however, are not exposed so that no geologic section could be obtained. In the southwestern part of Section 21, a good record of the Clarksburg coal with the overlying and underlying beds was secured and is given below:

	Ft.	In.
Sandstone, shaly	24	0
Shale and covered	31	0
Shale, dark	5	0
Shale and shaly coal, *Clarksburg*	1	0
Clay, ferruginous	1	0
Shale, gray, arenaceous	13	6
Coal blossom, *Elk Lick*		3
Clay	7	6
Shale and covered	52	7
Limestone, gray, nodular, *Ames*	5	4
Shale and covered	7	2
Coal blossom, *Harlem*	2	0

A half of a mile east of Annapolis, the Clarksburg member, which is represented by 4 inches of shaly coal overlying 5 feet 8 inches of gray, arenaceous clay, outcrops at an elevation of 1,085 feet and lies 75 feet above the Ames limestone. In the southeastern part of Section 20, a thin coal blossom is exposed along the road at an altitude of 1,105 feet.

Steubenville Township

No exposures of Clarksburg coal are found in Steubenville Township, but the associated clay outcrops along Wells Run in the southwestern part of Section 35 at an elevation of 953 feet. The limestone, which usually lies a few feet below the coal, appears along a small ravine in the central part of Section 33, but the coal and clay are wanting.

Smithfield Township

In Smithfield Township, the horizon of the Clarksburg coal is above drainage along the valleys of Short Creek and the lower part of its tributaries, Piney Fork and Dry Fork. The member, however, is somewhat variable in character and is either wanting or is entirely replaced by dark, fossiliferous shale. At the town of Hayesville, in the northeastern part of Section 14, dark, fossiliferous shale represent-

ing the Clarksburg horizon outcrops a few feet above the level of the tracks on the Lake Erie, Alliance and Wheeling Railroad. The following section, measured along this road leading to the northeast, shows the character and thickness of the rocks below the Pittsburgh coal:

	Ft.	In.
Coal blossom, *Pittsburgh*	5	0
Shale and covered	36	0
Sandstone, shaly near base, *Bellaire*	15	8
Limestone, dark	1	6
Clay and covered, *Summerfield*	14	0
Limestone, nodular	1	0
Shale, gray to dark	58	0
Shale, dark	3	0
Shale, dark, fossiliferous, *Clarksburg horizon*	3	0
Shale, gray, arenaceous	7	0

Warren and Mount Pleasant Townships

The horizon of the Clarksburg coal outcrops at many localities along Short Creek Valley in Warren and Mount Pleasant townships. This member, however, is wanting except in the northern part of Section 14, Warren Township, where 2 feet of shaly coal is exposed along Rush Run at an elevation of 830 feet, and where the interval to the Pittsburgh coal is 140 feet.

Connellsville Sandstone

The stratigraphic position of the Connellsville sandstone is above the Clarksburg coal and below the Summerfield or Little Pittsburgh limestone. Like all sandstone members of the Pennsylvanian system, however, it is somewhat patchy in distribution and variable in thickness. It is well developed along the Youghiogheny River in Fayette County, Pennsylvania, where it was first named by J. J. Stevenson from exposures near Connellsville. From the type locality the member extends to the south in West Virginia, where it has been recognized in every county where it is due from Monongalia on the north to Wayne on the southwest. It usually varies from 20 to 40 feet in thickness but occasionally is as much as 70 feet thick. It is gray to light brown in color and, where massive in structure, it yields a building stone of good quality.

In Ohio, the Connellsville sandstone is not a persistent member. It occurs in massive development in the southern part of the State in Lawrence, Gallia, Meigs, and Athens counties, where it varies from 30 to 50 feet in thickness. In Harrison, Guernsey, Muskingum, Noble,

and Morgan counties, it either becomes shaly in character or is replaced by sandy shales or clays. The average thickness of the Connellsville sandstone in Ohio is 35 feet. It lies on an average 94 feet above the Ames limestone and 44 feet below the Pittsburgh coal.

In Jefferson County, the Connellsville sandstone is poorly represented. Along the higher ridges in Saline, Knox, Island Creek, and Springfield townships, it is replaced by sandy shale. In Sections 1, 7, and 21, Salem Township, a few feet of thin-bedded sandstone is present underlying the high ridges. The following geologic section is a record of the rock succession outcropping along the northeast-southwest road in the central part of Section 1, Salem Township:

	Ft.	In.
Limestone	1	0
Shale and covered	33	4
Clay and covered		8
Limestone, nodular, *Summerfield*		8
Shaly sandstone with some sandy shale, *Connellsville*	26	0
Shale, red	88	0
Coal blossom, *Duquesne*		3
Clay	4	6
Shale, gray, arenaceous	7	10
Limestone, shaly at top, *Ames*	1	6

Massive sandstone outcrops on the north side of Cross Creek in Sections 16, 22, 28, and 35, Cross Creek Township. The following geologic section, measured along a small ravine in the southern part of Section 16, shows the thickness and stratigraphic position of this sandstone:

	Ft.	In.
Coal horizon, *Pittsburgh.*		
Covered	80	0
Clay, bluish-gray, with nodules of limestone	2	0
Covered interval	11	0
Sandstone, massive at base, shaly in upper part, *Connellsville*	104	0
Shale, bluish-gray, arenaceous	24	0
Shale, calcareous, fossiliferous, *Skelley*		4
Clay, blue to mottled	7	4
Sandrock, nodular, calcareous		6
Clay, blue		4
Shale, gray, arenaceous, reddish in places	2	10
Covered interval	5	0
Limestone, *Ames*	1	0

In the above section the Clarksburg coal and clay, which mark the base of the Connellsville sandstone, are wanting, and the excessive development of the sandstone above the Skelley horizon probably

represents a period of continuous deposition throughout Morgantown and Connellsville time.

In Wells, Wayne, Warren, Smithfield, and Mount Pleasant townships, the Connellsville horizon is marked by arenaceous shale.

Summerfield Limestone

The stratigraphic position of the Summerfield limestone is immediately above the Connellsville sandstone although in places a thin shale bed intervenes. It was named in Ohio by D. D. Condit from exposures near Summerfield, Noble County, and is thought to be the equivalent of the Little Pittsburgh limestone described by I. C. White. Although frequently thin, of little value, and irregular in its occurrence, this limestone has been recognized at many localities in Pennsylvania, West Virginia, and Ohio. It is present in Allegheny County, Pennsylvania, where its thickness is about 5 feet and its position 87 feet below the Pittsburgh coal. In West Virginia, I. C. White describes the bed as a rather earthy, impure limestone, 8 to 10 feet in thickness, and lying 50 to 60 feet below the Pittsburgh coal.

In Ohio, the Summerfield limestone has been recognized in Jefferson, Harrison, Belmont, Guernsey, Noble, and Muskingum counties. At the type locality, D. D. Condit describes the limestone as follows[1]:

"The limestone is 3 to 5 feet thick where exposed along the hollows. There are usually several beds of gray, buff or brownish, amorphous limestone, interbedded with clay. *Spirorbis* and other minute fossils are plentiful. The principal bed is usually conglomeratic, consisting of more or less rounded white limestone fragments, firmly cemented in a matrix of dense, buff limestone. This buff layer, with imbedded lumps of white limestone, is so characteristic that the Summerfield limestone is of some value as a stratigraphic key."

The average thickness of the Summerfield limestone in Ohio is about 4½ feet and its position is on an average 73 feet below the Pittsburgh coal.

The Summerfield limestone in Jefferson County is not as well developed or as distinct a stratigraphic horizon as found at the type locality in Noble County. It usually consists of nodules or of one or more thin layers of gray, compact, amorphous limestone embedded in clay. Where distinct beds occur, their aggregate thickness does not exceed 3 feet, or about one-half the average thickness of the associated clay. On the average the limestone lies 45 feet below the Pittsburgh coal although this interval may vary from 24 to 77 feet. It is

[1]Condit, D. D., Geol. Survey Ohio, Fourth Series, Bull. 17, p. 23. 1912.

not a persistent member and is subject to many wants. Outcrops, however, have been identified in Salem, Cross Creek, Steubenville, Smithfield, Mount Pleasant, and Warren townships.

In Salem Township, a thin ledge of Summerfield limestone outcrops along the east and west road in the southwestern part of Section 1, where it is overlain by 9 feet of clay and underlain by the sandy shale and shaly sandstone of the Connellsville member. On the eastern edge of Section 10, the Pittsburgh coal outcrops at an elevation of 1,225 feet, 59 feet below which the clay associated with the Summerfield limestone is exposed, but the limestone is wanting.

In Cross Creek Township, the Summerfield limestone outcrops along the road in the southeastern part of Section 4. The following section is a record of the exposures below the Pittsburgh coal:

	Ft.	In.
Coal, *Pittsburgh*	5	0
Clay and covered	5	2
Limestone, blue, nodular, *Pittsburgh*	2	8
Clay	3	0
Covered interval	9	10
Shale and shaly sandstone	10	4
Clay, gray to pink mottled	10	4
Shale, gray, arenaceous	20	8
Limestone, nodular, *Summerfield*		6
Shale, gray, arenaceous	4	10
Covered interval	20	0
Limestone, nodular	3	6
Clay and covered, *Clarksburg*	5	6
Limestone	3	0

The Summerfield member, consisting of nodules of limestone embedded in yellowish gray clay, outcrops at an elevation of 1,035 feet, or 43 feet below the Pittsburgh coal, in the west-central part of Section 2 of Cross Creek Township. In the southwestern corner of Section 14, the Pittsburgh coal, together with the underlying Summerfield limestone, are exposed along the road. The character and thickness of these members are recorded in the geologic section, which follows:

	Ft.	In.
Coal blossom, *Pittsburgh*	2	0
Clay and covered	5	0
Limestone, nodular		6
Covered interval, *Pittsburgh*	8	2
Limestone, bluish	1	0
Shale and covered	25	0

	Ft.	In.
Clay	5	6
Limestone, dark, nodular, *Summerfield*		8
Clay, light	3	0

In Steubenville Township, nodules of Summerfield limestone embedded in clay are exposed along a small ravine in the southeastern part of Section 33. At this place it occurs at an elevation of 1,020 feet and lies 34 feet below the Pittsburgh coal and 88 feet above the Clarksburg limestone.

In Smithfield Township, a good exposure of Summerfield limestone is found along the east bank of Piney Fork in the southeastern part of Section 15. The member here consists of one layer of dark, compact limestone, 1 foot 6 inches in thickness, which lies 52 feet below the Pittsburgh coal. Another outcrop of this member also appears at an elevation of 982 feet along the road a quarter of a mile north of Adena, where it is composed of a single layer of rusty, nodular limestone, 8 inches in thickness.

In Mount Pleasant Township, the Summerfield outcrops along Short Creek and its tributaries at an elevation of about 900 feet. The following geologic section, measured along the road leading from Long Run south to Emerson, is representative for this township:

	Ft.	In.
Coal, *Pittsburgh.*		
Clay, light, plastic	2	6
Limestone, nodular, *Pittsburgh*	5	0
Clay, gray, arenaceous	10	6
Shale, gray, arenaceous	20	0
Clay with nodules of limestone	5	0
Sandstone, *Bellaire*	3	0
Shale, dark	9	10
Shale with thin layers of limestone, *Summerfield*	5	0
Clay, dark	6	0

In Warren Township, outcrops of Summerfield limestone occur along the road leading west from the mouth of Little Short Creek. It consists of one layer of light, compact limestone overlain by sandy shale and underlain by clay. At this place it lies 41 feet below the Pittsburgh coal and 147 feet above the Ames limestone. Exposures are also found in the northern part of Section 24, and the following record shows the character and thickness of the member at this place:

	Ft.	In.
Coal blossom, *Pittsburgh*	5	0
Clay and covered	10	0
Shale, gray, arenaceous	3	0

	Ft.	In.
Covered interval	8	0
Clay, yellow, arenaceous	5	0
Sandstone and sandy shale, *Bellaire*	16	0
Clay, dark		6
Limestone, dark, *Summerfield*		6
Clay and covered	4	0

Lower Little Pittsburgh Coal and Clay

Overlying the Summerfield or Lower Pittsburgh limestone, in Somerset County, Pennsylvania, and in Garrett County, Maryland, is a well-defined coal bed, which is usually designated the Lower Little Pittsburgh coal. Aside from the localities mentioned, this coal is thin or wanting and is of no importance except for its stratigraphic interest. In West Virginia, it is usually represented by black shale or shaly coal. The horizon has been recognized in Muskingum County, Ohio, where the bed consists of a few inches of coal, irregular in thickness and occurrence.

In Jefferson County, the clays associated with the Summerfield limestone are usually directly overlain by arenaceous shale, and therefore the coal is wanting. At only one locality, however, north of Gabbletown in Section 8, Warren Township, a thin coal blossom occurs at this horizon. The following geologic section shows the rock succession below the Pittsburgh coal, including this representative of the Lower Little Pittsburgh coal:

	Ft.	In.
Coal horizon, *Pittsburgh.*		
Clay, gray, plastic	6	8
Shale, gray, arenaceous	48	6
Coal blossom, *Lower Little Pittsburgh*		3
Clay shale and covered	12	6

The clay underlying the Lower Little Pittsburgh coal, in which the Summerfield limestone is usually embedded, has a wide distribution from Saline Township on the north to Warren and Mount Pleasant townships on the south. It is always impure in composition, as it is highly charged with calcium carbonate and iron compounds. Its position varies from 35 to 70 feet below the Pittsburgh coal. In Saline Township, this clay has a thickness of 5 feet 6 inches in Section 23, where it lies 38 feet 4 inches below the Pittsburgh coal. It is also well exposed in Section 31, Ross Township, with a thickness of 6 feet 4 inches; in Section 7, Springfield Township, with a thickness of 8 feet 6 inches; and in Sections 1 and 10, Salem Township, with a thickness of about 9 feet. In Cross Creek Township, the clay occurs in Sections 2, 4, 7, 14, and 16, where it ranges from 2 to 10 feet in thick-

ness and lies 35 to 60 feet below the Pittsburgh coal. In Smithfield, Mount Pleasant, and Warren townships, it is interstratified with the Summerfield limestone and its position below the Pittsburgh coal varies from 35 to 75 feet. The Lower Little Pittsburgh clay is too impure to be of any potential economic value in Jefferson County.

Bellaire Sandstone

Near the town of Bellaire, Belmont County, Ohio, there is a massive sandstone immediately below the Pittsburgh limestone and about 10 to 12 feet below the Pittsburgh coal, named by D. D. Condit[1] the Bellaire sandstone. Although it is of little importance in Ohio, this sandstone is well developed in southwestern Pennsylvania, where it is known as the Lower Pittsburgh sandstone. In Jefferson County, which bounds Belmont County on the north and which is therefore near the type locality, the Bellaire sandstone is very poorly represented. It is never thick, rarely massive, and over large areas is replaced by arenaceous shale. The sandstone is present only in Mount Pleasant, Warren, and Smithfield townships and very few outcrops have been observed in any of these areas.

In Section 23, Mount Pleasant Township, the Bellaire sandstone has a thickness of 3 feet, and lies about 43 feet below the Pittsburgh coal. In Smithfield Township, 15 feet of sandstone occurs in Section 15, but in Section 32 it is broken into two ledges by 6 feet of arenaceous shale. Exposures are also found in Sections 19, 23, and 28, Warren Township, in all of which the sandstone is shaly, with a thickness of 3 to 10 feet. The following geologic section, measured near the mouth of Little Short Creek, in Section 23, Warren Township, illustrates the stratigraphic relations and position of the Bellaire sandstone:

	Ft.	In.
Coal blossom, *Pittsburgh*	1	8
Clay, gray, arenaceous	6	10
Limestone, dark, *Pittsburgh*		9
Clay, gray, arenaceous	2	3
Shale, arenaceous	3	6
Covered interval	1	8
Clay, gray, arenaceous, *Upper Little Pittsburgh coal horizon*	10	4
Shale, gray, arenaceous	6	9
Sandstone, shaly, *Bellaire*	3	7
Shale, gray, arenaceous	4	6
Limestone, gray, *Summerfield*	1	4
Clay, ferruginous, arenaceous	8	0

[1]Condit, D. D., Geol. Survey Ohio, Fourth Series, Bull. 17, p. 22. 1912.

Upper Little Pittsburgh Coal and Clay

The Upper Little Pittsburgh coal and its associated clay lie above the Bellaire sandstone and below the Pittsburgh limestone. Although the coal is of minable thickness in parts of Tucker and Lewis counties, West Virginia, and Somerset County, Pennsylvania, it is usually wanting in Ohio, or is represented by a thin smut streak. In the Pan Handle area of West Virginia, a thin blossom of this coal has been observed about 16 feet below the Pittsburgh coal.

In the geologic section of the Conemaugh series of Jefferson County, the Lower Little Pittsburgh coal is wanting, but the clay underlying the coal is more or less irregularly developed from Saline Township on the north to Warren and Mount Pleasant townships on the south. This clay bed, which has a minimum thickness of 3 feet and a maximum thickness of 10 feet, is separated from the Pittsburgh clay by a shale interval of 4 to 20 feet. The material is usually light gray in color, but at a few localities it is mottled red and pink. It is everywhere arenaceous, calcareous, and ferruginous in composition. Exposures of this clay in the northern half of the county are limited to Section 23, Saline Township; Section 31, Ross Township; and Section 7, Springfield Township; and to the eastern part of Cross Creek and the central part of Steubenville townships. Other outcrops of this horizon are found in Sections 27 and 32, Smithfield Township; Sections 19, 23, and 28, Warren Township; and Sections 12 and 23. Mount Pleasant Township.

In Saline Township, a good exposure of the Upper Little Pittsburgh clay occurs in the southern part of Section 23, where it is bluish-gray in color with many limestone nodules, has a thickness of 5 feet 6 inches, and lies 16 feet 10 inches below the Pittsburgh coal. Twenty feet below the base of the Pittsburgh coal, 3 feet 6 inches of this clay outcrops at an elevation of 1,235 feet along the southern side of Section 7, Springfield Township. In Cross Creek Township, exposures of Upper Little Pittsburgh clay are present in Sections 2, 4, and 7. The following geologic section, measured along the road leading from New Alexandria Station south to New Alexandria, shows the rock succession at this locality:

	Ft.	In.
Coal blossom, *Pittsburgh*	3	0
Clay and covered	6	4
Sandrock, hard, calcareous	2	0
Shale, arenaceous, ferruginous	4	4
Sandstone	7	4
Shale, arenaceous, ferruginous		8
Clay, light to dark, arenaceous, *Upper Little Pittsburgh horizon*	3	2

Along the north-south road in the west-central part of Section 30, Smithfield Township, the Pittsburgh coal, together with the underlying Upper Little Pittsburgh member are well exposed. The record given below shows the character of the strata at this place:

	Ft.	In.
Coal blossom, *Pittsburgh*	5	0
Clay and covered	5	6
Limestone, nodular, *Pittsburgh*	3	6
Shale and covered	7	6
Smut streak, *Upper Little Pittsburgh*		2
Clay and covered	11	0

The Upper Little Pittsburgh horizon outcrops along the road which descends the hill to the mouth of Little Short Creek in Section 23, Warren Township. At this place the horizon is represented by 10 feet 4 inches of gray arenaceous clay which is overlain and underlain by arenaceous shale. The top of the clay at this locality lies 15 feet below the base of the Pittsburgh coal. Along the east-west road in southern part of Section 28, Warren Township, good exposures of the clay are found at a vertical distance of 40 to 45 feet below the Pittsburgh coal, as shown in the record given below:

	Ft.	In.
Coal horizon, *Pittsburgh.*		
Limestone	1	6
Clay, gray, plastic	5	0
Shale, gray, arenaceous	6	0
Coal horizon, *Upper Little Pittsburgh.*		
Clay, gray, plastic	1	0
Limestone; dark, compact, nodular	1	2
Clay, gray, arenaceous	5	10
Shale, ferruginous	2	0
Sandstone, *Bellaire*	6	0
Shale, arenaceous, ferruginous	5	4
Coal horizon, *Lower Little Pittsburgh.*		
Clay, gray to mottled	9	8

In the central part of Section 15, clay belonging to the Upper Little Pittsburgh horizon outcrops along the road leading up the west bank of Blues Run. The clay is yellowish gray in color with nodules of limestone and lies between beds of gray arenaceous shale. As indicated in the foregoing paragraph, the clay underlying the Upper Little Pittsburgh coal is thin and high in fluxing components and therefore is of no economic value.

Pittsburgh Limestone

The stratigraphic position of the Pittsburgh limestone, as origi-

nally defined by H. D. Rogers in 1839, is "immediately underlying the Pittsburgh coal seam[1]." It is therefore the highest member of the Conemaugh series, although at many localities in Ohio it is separated from the Pittsburgh coal by a thin bed of clay. In West Virginia, this clay bed gives way to sandy shale which may reach a thickness of 25 to 35 feet.

The Pittsburgh limestone in Ohio usually consists of several limestone layers separated by thin beds of clay shale or clay. Concerning the characteristics of this member, D. D. Condit writes as follows[2]:

"The limestone varies widely in lithologic and chemical character. It is usually somewhat dolomitic and has some silica and clayey material. A buff to brownish color is common in the more ferruginous beds, while others show a bluish, or almost black color, due to finely disseminated carbonaceous material. The rock has rarely any trace of crystalline texture and is more often entirely amorphous, and only shows its crystalline character when viewed in thin sections."

Outcrops of Pittsburgh limestone have been noted in every county where it is due from Jefferson on the east to Meigs on the south. In Meigs, Gallia, and Lawrence counties, it is somewhat patchy in distribution, and sandy shale and sandstone are frequently found at this horizon.

In Jefferson County, the Pittsburgh limestone, which is of fresh water origin, is similar in mode of occurrence and in lithologic character to the Summerfield, Clarksburg, and Elk Lick limestones. It consists of one or more layers of limestone embedded in clay, or clay shale containing nodules of limestone. These layers are discontinuous and may disappear and again reappear within a mile. The stone is hard and dense in appearance and of a light gray to bluish-black color, the latter shade being due to finely disseminated organic material. Fossils are present, but they are all extremely minute forms, consisting chiefly of the fresh water annelid *Spirorbis anthracosia* Whitfield. The Pittsburgh limestone in Jefferson County varies from a few inches to 8 feet in thickness with an average of 2 feet 7 inches, and is distributed throughout parts of Springfield, Knox, Salem, Cross Creek, Smithfield, Mount Pleasant, and Warren townships.

The only exposure of Pittsburgh limestone observed in Springfield Township outcrops by the road along the southern side of Section 7 at an elevation of 1,252 feet. It consists of a single layer

[1]Rogers, H. D., Geol. Survey Pennsylvania, Ann. Rept., p. 95. 1839.
[2]Condit, D. D., Geol. Survey Ohio, Fourth Series, Bull. 17, p. 21. 1912.

of dark, compact stone 1 foot in thickness, the top of the limestone lying about 2 inches below the Pittsburgh coal. In Knox Township, a good exposure of Pittsburgh limestone appears near the head of Carter Run in the southeastern part of Section 7, where the member has a thickness of 4 feet 4 inches and is separated from the Pittsburgh coal by 3 feet 3 inches of brown, arenaceous clay. Along the diagonal road, also in the southeastern part of Section 7, where the following measurements were made, the Pittsburgh limestone has been quarried in a small way for local use:

		Ft.	In.
Coal, *Pittsburgh*		4	8
Shale		1	1
Limestone			9
Shale			7
Limestone	*Pittsburgh*	2	0
Shale			7
Limestone		1	0

The Pittsburgh limestone is very poorly developed south of Richmond in the eastern part of Section 10, Salem Township, where the Pittsburgh coal and underlying beds are exposed along the road. It consists here of small lenses or nodular masses of limestone embedded in clay. Limestone, 3 feet 2 inches in thickness and composed of two layers of dark, compact rock which is overlain and underlain by clay, outcrops along the road in the southwestern part of Section 30 at an elevation of 1,275 feet.

In Cross Creek Township, the Pittsburgh limestone is generally wanting. However, in the southwestern part of Section 14, compact, light bluish-gray limestone belonging to this member outcrops a few feet below the Pittsburgh coal. It is separated into two benches by 8 feet of clay, the upper bench lying about 5 feet below the base of the Pittsburgh coal. Near the head of Longs Run in the east-central part of Section 33, the limestone is well exposed near the mouth of a coal bank on the James Lewis farm, where the measurements given below were taken:

		Ft.	In.
Coal		1	2
Clay	*Pittsburgh*		10
Coal		5	0
Clay and covered		2	9
Limestone			8
Clay	*Pittsburgh*		2
Limestone, massive		1	2

In Smithfield Township, 3 feet 6 inches of gray, nodular Pittsburgh limestone is exposed in the west-central part of Section 30 at an elevation of 1,145 feet, and it is overlain by clay and underlain by shale. A second exposure occurs along the eastern slope of the valley of Cabbage Fork in the southern part of Section 17, where the limestone is represented by 3 feet 4 inches of massive limestone overlain by 5 feet 4 inches of clay, the elevation of the limestone here being about 1,041 feet.

In Mount Pleasant Township, the Pittsburgh limestone is more persistent and regular in its occurrence than in the central and northern part of the county. It is well exposed in a small ravine a half of a mile north of Mount Pleasant, where it is composed of compact, bluish-gray to bluish-black limestone with a thickness of 4 feet 3 inches. At this place it has an elevation of 941 feet and is separated from the Pittsburgh coal by a clay bed 2 feet 6 inches in thickness. In the northern part of Section 23, the Pittsburgh coal outcrops along the public road at an altitude of 960 feet. Two and a half feet below the base of the coal, a nodular ledge of limestone, about 5 feet thick, representing the Pittsburgh member, is exposed about 1 mile northwest of this locality near the mouth of mine No. 4 of the New Pittsburgh Coal Co., where the following geologic section was secured:

		Ft.	In.
Coal			6
Clay	*Pittsburgh*	1	0
Coal		5	2
Clay, gray, arenaceous		2	6
Limestone, massive, *Pittsburgh*		8	5

In Warren Township, the Pittsburgh limestone is well exposed near the Walnut Hill Mine No. 3 of the Ohio and Pennsylvania Coal Co. in the southwestern part of Section 22, where it consists of a single layer of limestone, 1 foot 2 inches in thickness, which is overlain and underlain by clay. Only one ledge of this limestone, 9 inches in thickness, outcrops along the road in the northwestern part of Section 23 at an elevation of 875 feet.

MONONGAHELA SERIES

GENERAL STATEMENT

Above the Conemaugh series, or "Lower Barren Measures," a group of rocks occurs which is marked by the frequent recurrence of valuable coal beds. In the early geological explorations of southwestern Pennsylvania, H. D. Rogers described this series as the "Upper or Newer" coal shales, and defined it as extending from the bottom of the Pittsburgh coal to the top of the Waynesburg coal[1]. Later, however, Rogers named this series the Monongahela because of the great development of its coal beds along the Monongahela River in Pennsylvania. The limitations of the series as thus defined by Rogers were logical in so far as it was bounded above and below by two persistent and easily recognizable coal beds. Years later, however, I. C. White found that the shales overlying the Waynesburg coal were the lowest members of the series to contain a typical Permian flora[2]; and for this reason the top of the Waynesburg coal has since been retained as the natural boundary plane between the Conemaugh series below and the Permian rocks above. The lower limit of the series is purely arbitrary as it records neither a change in life, a general lithologic transition, nor a diastrophic break in the rock succession.

The Monongahela series attains its greatest thickness along the eastern border of its outcrops, as it measures 413 feet in Harrison County, West Virginia[3], and 367 feet in Fayette[4] and Westmoreland counties, Pennsylvania, and in Ohio attains a thickness of 263 feet at Bellaire in Belmont County[5], and 248 feet in Muskingum County[6]. A complete section of this formation is exposed in Jefferson County, Ohio, where it has a thickness of 232 feet. The distribution of the series is shown on Map III (in pocket).

This series in Jefferson County is, as a whole, composed of materials which are easily weathered, such as friable sandstone, shale, limestone, clay, and coal, and, as a result, the surface slopes are usually smooth and gentle. The sandstones of the series are in the minority. With the exception of the Gilboy sandstone, which has only a local development, a large fraction of the outcropping material is argillaceous and ferruginous shale of a green, buff, or brown color. Thin, lens-like masses of dense, compact limestone are of frequent occur-

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[1]Rogers, H. D., Geology of Pennsylvania, Vol. II, Pt. I, p. 19. 1858.
[2]White, I. C., West Virginia Geol. Survey, Vol. II, p. 100. 1903.
[3]White, I. C., U. S. Geol. Survey, Bull. 65, p. 43. 1891.
[4]Stevenson, J. J., Second Geol. Survey Pennsylvania, Rept. KK, p. 31. 1877.
[5]White, I. C., U. S. Geol. Survey, Bull. 65, p. 50. 1891.
[6]Stout, W., Geol. Survey Ohio, Fourth Series, Bull. 21, p. 266. 1918.

rence and have been grouped on the basis of their stratigraphic position into five different members. The coals, with the exception of the Pittsburgh, are thin and relatively unimportant in this area; and the clays also are poorly developed and too impure to be of more than stratigraphic interest.

At a few places in Pennsylvania, West Virginia, and Ohio, the stratigraphic features of the Monongahela series have been worked out in detail. The following geologic sections are introduced here as typical of this series.

Section in Fayette and Westmoreland counties, Pennsylvania[1]

Monongahela series	Ft.	In.
Coal, *Waynesburg*	6	0
Sandstone or sandy shales	20	0
Coal, *Little Waynesburg*	2	0
Limestone, *Waynesburg*	20	0
Shale and shaly sandstone	50	0
Coal, *Uniontown*	3	0
Limestone, *Uniontown*	12	0
Sandstone	30	0
Limestone, *Great Limestone*	80	0
Coal, *Sewickley*	3	0
Sandstone	30	0
Limestone, *Sewickley*	25	0
Shale and shaly sandstone	20	0
Coal, *Redstone*	4	0
Limestone, *Redstone*	10	0
Sandstone and shale	40	0
Coal, *Pittsburgh*	12	0
	367	0

A very complete section of the Monongahela series at Wheeling is given in the report of the West Virginia Geological Survey for Ohio, Brooke, and Hancock counties[2].

Chapline Hill Section, Wheeling, West Virginia

Monongahela series	Ft.	In.
Coal, *Waynesburg*	2	0
Shale	6	0
Black slate.		
Shale, buff	4	4
Sandstone, shaly	3	0
Shale, buff	3	0
Limestone, gray, *Waynesburg*	2	0
Shale and thin sandstone	30	4
Clay blossom, *Uniontown coal horizon*		8

[1]Stevenson, J. J., Second Geol. Survey Pennsylvania, Rept. KK, p. 31. 1877.

[2]Grimsley, G. P., West Virginia Geol. Survey, Rept. Ohio-Brooke-Hancock Counties, p. 39. 1906.

		Ft.	In.
Sandstone			6
Shale, buff		6	0
Limestone, *Uniontown*		4	0
Shale, buff, with sandstone		41	4
Shale, green, *Fulton*		4	0
Limestone and shale, *Benwood*		86	8
Coal, *Sewickley*		33	0
Coal, *Redstone*			8
Limestone, *Redstone*		18	0
Shale (in part of area)		10	6
Coal, roof	*Pittsburgh*	1	2
Shale	*Pittsburgh*	1	0
Coal	*Pittsburgh*	5	0

The following is a generalized section of the Monongahela series in Muskingum County, Ohio, as reported by Wilber Stout[1].

Generalized Section of Monongahela Series, Muskingum County, Ohio

Monongahela series		Ft.	In.
Coal, *Waynesburg*		1	0
Clay shale, red		18	0
Coal, *Little Waynesburg.*			
Clay shale, red		6	0
Limestone, *Waynesburg.*			
Clay shale, red		3	0
Sandstone, massive, *Gilboy*		35	0
Shale, dark		1	0
Coal, thin, *Uniontown*		2	0
Clay, calcareous		2	0
Limestone, *Uniontown*		10	0
Clay shale, mottled, marly		34	0
Shale, green, *Fulton.*			
Limestone with shale partings, *Benwood*		47	0
Sandstone, *Sewickley*		10	0
Coal, poorly represented, *Upper Sewickley.*			
Shale and sandstone		16	0
Shale, dark, carbonaceous		3	10
Coal	*Meigs Creek, (Lower) Sewickley*	1	6
Shale	*Meigs Creek, (Lower) Sewickley*		1
Coal	*Meigs Creek, (Lower) Sewickley*	1	4
Shale	*Meigs Creek, (Lower) Sewickley*		1
Coal	*Meigs Creek, (Lower) Sewickley*	1	2
Shale, red, calcareous		9	0
Limestone with clay shale partings, *Sewickley*		10	0
Shale, red, calcareous		5	0
Sandstone, *Pomeroy*		3	6

[1]Stout, W., Geol. Survey Ohio, Fourth Series, Bull. 21, Table IV. opp. p. 268. 1918.

	Ft.	In.
Sandstone, *Pomeroy or Redstone*		6
Clay and shale, calcareous	2	0
Limestone, locally present, *Redstone*	4	0
Sandstone, local, *Upper Pittsburgh*	16	0
Shale, dark, siliceous	3	0
Coal, *Pittsburgh*	2	0

Where the names of the members in the sections given above do not correspond with those used in this report, the latter are placed in parentheses.

A generalized section of the Monongahela series compiled from a number of sections taken at random over the field of outcrop in Jefferson County is as follows:

Generalized Section of the Monongahela Series, Jefferson County, Ohio

Monongahela series	Ft.	In.
Coal, *Waynesburg*	2	8
Clay, gray, arenaceous	5	4
Shale, arenaceous	13	4
Sandstone, locally developed, *Gilboy*	10	0
Shale, gray, arenaceous	14	9
Coal, shaly, unsteady, *Uniontown*		5
Clay and clay shale	4	4
Limestone, locally developed, *Uniontown*	1	4
Shale, gray, *Arnoldsburg sandstone horizon*	32	9
Limestone, marly, *Arnoldsburg*	12	10
Shale, olive green, persistent, *Fulton*	5	8
Limestone, dark, persistent, *Benwood*	18	10
Shale, gray	19	4
Shale, black, with shaly coal, *Sewickley*	1	1
Shale and sandstone, *Fishpot*	18	2
Shale, black, with shaly coal, *Fishpot coal*	1	1
Shale, gray, arenaceous	11	0
Limestone, *Fishpot*	3	2
Shale, arenaceous	15	0
Sandstone, local, *Pomeroy*		8
Coal, persistent, *Redstone or Pomeroy*	1	7
Clay, calcareous	3	6
Limestone, *Redstone*	9	1
Sandstone, locally developed, *Upper Pittsburgh*	11	1
Pittsburgh coal		
Roof coal	1	2
Clay and clay-shale	1	0
Breast coal	2	4
Parting		½
Bearing-in coal		3

	Ft.	In.
Parting		½
Brick coal	1	3
Parting		½
Bottom coal	1	1

DESCRIPTION OF MEMBERS

Pittsburgh Coal

The Pittsburgh coal, which was first named by J. P. Lesley in 1856 for exposures near Pittsburgh, Pennsylvania, is one of the most wide-spread and easily recognized members of the Pennsylvanian system. Extending in workable thickness over an area of 6,000 square miles[1] in Pennsylvania, Ohio, West Virginia, and Maryland, and possessing a characteristic structure which makes it easily distinguished, this coal bed is a valuable datum plane of use to the field geologist in the mapping of formations. The wisdom of using the bottom of this coal bed as the plane of separation between the Monongahela and Conemaugh series therefore becomes apparent; but the stratigraphic importance of this bed should not be overemphasized to the neglect of a due appreciation of its economic worth. As a producer of enormous quantities of coal, the Pittsburgh bed has been one of the most potent factors contributing to the industrial growth of the Ohio River Valley.

The Pittsburgh coal is present in Ohio in Jefferson, Harrison, Guernsey, Belmont, Monroe, Noble, Washington, Morgan, Muskingum, Athens, Meigs, Gallia, and Lawrence counties. The thickest and most productive part of the field lies in those counties to the north and east of the Muskingum River. Southwest of this river, the coal bed is somewhat variable in its thickness and structure and therefore of minor importance as a coal producer.

The distribution of the Pittsburgh coal horizon in Jefferson County is represented on the accompanying map by the black line separating the Conemaugh and Monongahela series. An examination of the map shows that this horizon is present in every township in the county with the exception of Brush Creek. The coal is remarkably persistent along its line of outcrop and shows little variation in structure or thickness. The minable part of the bed ranges from 4 feet to 6 feet 4 inches but averages about 4 feet 9 inches. The following structure

[1]White, I. C., West Virginia Geol. Survey, Vol. II, p. 166. 1903.

of the bed, typical over large areas in West Virginia and Pennsylvania, is also well developed in Jefferson County:

Roof coal
    Clay and clay shale parting
Breast coal
    Shale parting
Bearing-in coal
    Shale parting
Brick coal
    Parting
Bottom coal

The roof coal forms the top part of the Pittsburgh bed. It is separated from the main body of the coal by a bed of bluish-gray clay or clay shale, which varies from 4 inches to 1 foot 3 inches in thickness. This roof coal is very persistent in its occurrence, although it is thin and of poor quality. Variations in thickness are found which range from 4 inches to 2 feet 3 inches, with an average of about 1 foot. In only two localities in the county is this portion of the Pittsburgh bed reported by miners to be wanting. The poor quality of the coal is due to the fact that it is shaly in character with clay shale partings.

The breast coal, which varies from 2 feet to 3 feet 6 inches, is the thickest portion of the Pittsburgh bed. The coal is blocky in structure with no continuous partings or bedding planes. The top of the bench usually forms a sharp contact with the roof shale, but in a few localities a transition zone of an inch or two of bone coal or shaly coal is found.

The bearing-in coal is one of the most characteristic features of the Pittsburgh bed. In this county it consists of a thin layer of coal 2 to 5 inches in thickness, overlain and underlain by thin shale partings which do not average more than one-half inch each. The bearing-in coal usually lies about midway between the top of the breast coal and the base of the bottom coal.

The lower half of the minable part of the Pittsburgh bed is made up of two parts, the upper known as the brick coal and the lower as the bottom coal. In Jefferson County, a thin shale parting is sometimes found between these coal benches, but a bedding plane is the usual basis of separation. In a few localities, however, this bedding plane disappears and with it all means of separation between the two coal benches. The brick coal shows variations in thickness ranging from 1 foot to 1 foot 6 inches, and the bottom coal from 1 foot to 1 foot 9 inches.

The structure, which has been described in detail above as common to the Pittsburgh coal in Jefferson County, is well illustrated in the generalized section of the Monongahela series for this county.

Saline Township

In Saline Township, the horizon of the Pittsburgh coal is reached by the hilltops in Sections 17 and 23 only, and, as the coal horizon outcrops at elevations of 1,060 to 1,100 feet, the cover of the coal is not great. The total area of the bed in this township is about three-fifths of a square mile. Along the ridge road in the central part of Section 23, the coal is exposed at an elevation of 1,060 feet. The following geologic section shows the rock succession at this locality:

	Ft.	In.
Clay, gray, plastic	5	0
Clay, dark		6
Coal blossom, *Pittsburgh*	3	0
Clay, gray, plastic, with limestone nodules	7	10
Shale, gray	4	0
Smut streak		1
Clay, brown		3
Shale, gray arenaceous	4	8
Clay, gray, with limestone nodules	5	6
Shale, arenaceous	17	0
Clay, greenish-gray, arenaceous	5	8

Ross Township

The Pittsburgh coal in Ross Township is found underlying the highest knobs of Middle Ridge, where the elevation varies from 1,300 feet in the central part of Section 31 to 1,240 feet in Section 2. As no openings were found in the coal, detailed sections of the bed could not be secured. The total area of the coal in this township is about seven-tenths of a square mile.

Springfield Township

In the southern part of Springfield Township, a few small outliers of Pittsburgh coal cap the ridges to the east and west of Goose Creek. The total area of the coal present in the township is about one square mile. The elevation of the bed varies from 1,300 feet in Section 5 to 1,255 feet in Section 12, and the structure of the coal where exposed is normal for the Pittsburgh bed. A small bank has been opened near the junction of the roads in the eastern part of Section 6, where the following measurements were obtained:

		Ft.	In.
Shale, dark at bottom to gray, arenaceous at top		21	4
Pittsburgh coal			
Coal	*Roof coal*	1	0
Shale			2
Coal			3
Shale		1	1
Coal		1	0
Parting			½
Coal		1	0
Shale		1	0
Breast coal		2	3
Parting			½
Bearing-in coal			2
Parting			½
Brick coal		1	1
Parting			½
Bottom coal			6

The lower part of the bottom coal in this mine is used for floor, and therefore the section does not show the full thickness of the bed.

Knox Township

The Pittsburgh coal in Knox Township underlies the highlands between Town Fork and Yellow Creek on the west, the Ohio River on the east, and Island Creek and Skelley Run on the south. Owing to the Somerset syncline, marked variations occur in the elevation of the coal: near Somerset in Section 22, the coal occurs at an elevation of 1,100 feet, but rises to the east to 1,230 feet in Section 3, and to the southwest to an altitude of 1,210 feet in Section 32. The total area of the coal in this township is about 8.6 square miles.

On the J. W. Edminston farm, near the head of Carter Run in the southwest quarter of Section 16, the Pittsburgh coal has been mined in a small way for local use. A detailed section of the bed at this place, as measured by J. H. Hance in 1916, is as follows[1]:

	Ft.	In.
Roof, bituminous shale and sandstone.		
Shale, coaly.		
Coal		4
Clay, sandy		⅛
Coal		7½
Clay		⅛
Coal		5⅛
Clay		⅛
Coal		3½
Clay, rejected		7/16

[1]U. S. Bureau Mines, Bull. 193, pp. 209-210. 1922.

	Ft.	In.
Coal		2
Clay, black		¼
Coal, parting up to ⅛ inch		5⅞
Clay, bony, rejected		¼
Coal, few irregular partings	1	4¾
Floor, bone and clay.		

An analysis of a sample cut from the coal in this mine is as follows[1]:

Proximate analysis

	As received	Moisture free
Moisture	3.37	.....
Volatile matter	37.86	39.17
Fixed carbon	48.78	50.49
Ash	9.99	10.34
	100.00	100.00
Sulphur	3.94	4.08
Air drying loss	1.4 per cent	
	As received	Moisture free
Heating value—Calories	7,178	7,429
Heating value—B. t. u.	12,920	13,372

In the southwestern part of Section 4, the Pittsburgh coal has been opened on the John Wilcox farm, where it is normal in structure and is reported by miners to vary from 4 feet 2 inches to 4 feet 6 inches in thickness. The fuel is hauled to Empire where it is used as a steam coal and for the burning of clay products. In the southwestern part of Section 9, a small mine has been opened on the farm of George Culp, and the miners report that the coal has an average thickness of about 4 feet. The coal in this mine was measured and sampled in 1916 by J. H. Hance at a point 275 feet southwest of the mine opening. The measurement of the bed is given below[2]:

Roof, sandstone.	Ft.	In.
Coal		9⅛
Clay, sandy		¼
Coal, few irregular partings	1	4⅛
Clay		⅜
Coal		2½
Clay, rejected		⅜

[1]U. S. Bureau Mines, Bull. 193, p. 51. 1922.
[2]U. S. Bureau Mines, Bull. 193, pp. 207-208. 1922.

	Ft.	In.
Coal		8¼
Clay		¼
Coal		3
Clay		½
Coal		5½
Clay, rejected		3/16
Bone, rejected		3
Floor, bone and clay.		

The analysis of the sample is as follows[1]:

Proximate analysis

	As received	Moisture free
Moisture	3.18	.....
Volatile matter	38.11	39.36
Fixed carbon	49.35	50.97
Ash	9.36	9.67
	100.00	100.00
Sulphur	4.02	4.15

Air drying loss.....1.0 per cent

		As received	Moisture free
Heating value	Calories	7,187	7,423
	B. t. u.	12,937	13,361

In the central part of Section 8, a small mine, operated by the Crawford Long Coal Co. of Toronto, yields coal of good quality which is sold for local use. The following measurements were taken at this place:

Covered.	Ft.	In.
Pittsburgh coal		
Clay	3	6
Breast coal	2	4
Parting		¼
Bearing-in coal		3
Parting		¼
Brick coal	2	2
Bottom coal	1	0
Covered interval	11	8
Coal, shaly, *Upper Little Pittsburgh*	1	6
Shale, calcareous	1	8
Limestone	3	6
Shale		10
Limestone	1	6

[1]U. S. Bureau Mines, Bull. 193, p. 51. 1922.

Along Skelley Run, the Pittsburgh coal has been opened on the W. H. McClellan farm in the southwestern part of Section 20. The member is reported to vary from 4 feet to 5 feet 6 inches in thickness with an average of about 4 feet 6 inches and is sold for local use. An excellent exposure occurs along the northeastern side of the diagonal road in the southeastern part of Section 7, where it has a thickness of 4 feet 6 inches on the outcrop and is overlain by clay and underlain by a thin bed of shale.

Salem Township

The field of the Pittsburgh coal in Salem Township consists of a few isolated areas forming the crest of the divide which extends from East Springfield through Richmond to Sections 3 and 4. The total area of the coal in this township is about 3.7 square miles. Only two mines operating in the Pittsburgh coal were found in the township when it was visited by the writer in 1922. In the eastern part of Section 35, John Banks had opened the first of these mines on the John Lyle property where the minable coal, which is of fair quality, has a thickness of about 5 feet and is sold for local use. South of the road in the southwestern part of Section 3, the coal lies at an elevation of 1,260 feet. At the mouth of the second small mine in the township, which is located at this place, the bed is well exposed, showing a thickness of 4 feet 10 inches. It is overlain and underlain by clay, no roof coal being exposed on the outcrop.

A good exposure of Pittsburgh coal and underlying rocks is found along the diagonal road in the southwestern part of Section 30, where the measurement of the outcrop is as given below:

		Ft.	In.
Coal, shaly		1	0
Clay, light, plastic	*Pittsburgh*	1	0
Coal		4	0
Clay and covered		2	4
Limestone, bluish-gray, *Pittsburgh*		3	2
Clay, light, plastic		4	0
Shale, arenaceous, ferruginous		8	6
Covered interval		5	0
Limestone		1	0

In the southeastern part of Section 3, the strata above the Pittsburgh coal are exposed along the road with a thickness and succession as given below:

	Ft.	In.
Shale, gray. arenaceous	10	0
Coal blossom. *Redstone*	1	6
Clay and covered	4	0

		Ft.	In.
Limestone, dark nodular	*Redstone*		10
Covered interval		8	0
Shale, with nodular limestone		5	6
Covered interval		5	0
Coal blossom, *Pittsburgh*		3	6
Clay		2	0

Island Creek Township

The Pittsburgh coal in Island Creek Township occurs near the summits of the finger-like ridges between Island Creek and Town Fork, Island Creek and North Fork, North Fork and Wills Creek, and Wills Creek and Cedar Lick. The elevation of the coal is irregular, due to the variations in the amount and direction of the dip. In Section 3, the coal occurs at the 1,200 foot level, drops to 1,160 feet in Section 21, but rises to an altitude of 1,190 to 1,200 feet along the western margin of the township. The cover of the coal in this township does not exceed 90 feet in thickness, except at one locality, Norton Hill in Section 26, which rises 120 feet above this bed.

Near the bend in the road in the southeastern part of Section 36, Clyde Gray owns and operates a small mine in the Pittsburgh coal, where the following measurements were made:

Pittsburgh coal	Ft.	In.
Breast coal	1	10
Parting		½
Bearing-in coal		3
Parting		¼
Brick coal		6½
Parting		¼
Bottom coal		11
Clay		6

The roof coal in this mine is reported to be missing. About 6 inches of clay overlies the coal, above which is found the Redstone limestone.

Along the north-south road in the western part of Section 2, the Pittsburgh coal outcrops at an elevation of 1,195 feet, and farther to the south the Ames limestone is exposed 235 feet below the coal. Again, along the north-south road in the east-central part of Section 26, there is a good exposure of Pittsburgh coal, 4 feet 6 inches in thickness, overlain and underlain by clay and outcropping at an elevation of 1,203 feet. This coal is also exposed along the road in the northern part of Section 21, where the rock succession is as stated on following page:

	Ft.	In.
Coal blossom, *Redstone*	1	0
Clay and covered	11	0
Limestone, light, nodular, *Redstone*	6	0
Shale and covered	15	0
Coal blossom, *Pittsburgh*	2	0

Wayne Township

The Pittsburgh coal in Wayne Township underlies about 14.8 square miles of the area, all of which lies south of Cross Creek. The outline of this field is somewhat irregular, due to dissection by the many streams tributary to McIntyre Creek and Piney Fork. The elevation of the coal varies from 1,080 feet in Section 1 to 1,200 feet near Bloomfield Station in Section 17. The cover above the coal is thin over a part of the field and therefore favorable conditions exist for working the coal by stripping.

In Sections 32, 33, and 34, the Wayne Coal Co. was conducting extensive stripping operations in 1923. The following record, taken in the northern part of Section 33 on the property of this company, shows the thickness of the coal as well as that of the overlying beds:

	Ft.	In.
Coal blossom, *Meigs Creek*		6
Shale, gray, arenaceous	36	0
Covered interval	18	0
Shale, gray, arenaceous	6	0
Coal, shaly, *Redstone*	2	0
Clay, shaly	2	2
Limestone, massive, *Redstone*	2	0
Clay and covered	19	0
Pittsburgh coal		
Breast coal	2	0
Parting		½
Bearing-in coal		4
Parting		½
Brick and bottom coal	2	4
Covered.		

The Pittsburgh coal in the old McFadden mine of the Wayne Coal Co., located in this area, was sampled for chemical analysis by the Geological Survey of Ohio a number of years ago. The measurement of the bed at the place of sampling is as follows[1]:

	Ft.	In.
Pittsburgh coal		
Roof coal, reported thickness		10
Draw slate		10

[1]Bownocker, J. A., Geol. Survey Ohio, Fourth Series, Bull. 9, p. 54. 1908.

		Ft.	In.
Coal	*Breast coal*	1	2
Shale			½
Coal			1
Shale			⅛
Coal			3
Bearing-in coal and shale			1½
Brick coal			6
Coal with ½ inch of shale			2½
Bottom coal		1	10

Clay, unmeasured.

The sample collected at this mine has the following composition[1]:

Proximate analysis

	As received	Moisture free
Moisture	5.05	0.00
Volatile matter	35.88	37.79
Fixed carbon	51.12	53.84
Ash	7.95	8.37
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	70.68	74.44
Hydrogen	5.32	5.01
Oxygen	12.19	8.11
Nitrogen	1.25	1.32
Sulphur	2.61	2.75
Ash	7.95	8.37
	100.00	100.00

Moisture in air-dried sample about 3 per cent

		As received	Moisture free
Heating value	Calories	7,147	7,527
	B. t. u.	12,865	13,549

In 1912, D. D. Condit measured and sampled the Pittsburgh coal in the Parlett mine in the southeastern part of Section 32, where the coal has an average thickness of about 4 feet 9 inches. The measurements are given below[2]:

	A		B	
	Ft.	In.	Ft.	In.
Roof, clay or coal	....	....	....	....
Coal, impure, rejected	....	....	....	11
Clay, rejected	....	....	....	3
Coal, rejected	....	....	1	1
Clay, rejected	1	2	1	0
Coal	2	5½	2	2
Coal, with several shale bands, rejected	....	3½	....	3
Coal	2	½	2	3

Section A was measured 2,200 feet north of the bottom of the slope.
Section B was measured 400 feet northwest of the bottom of the slope.

[1]Bownocker, J. A., Geol. Survey Ohio, Fourth Series, Bull. 9, p. 54. 1908.
[2]U. S. Bureau Mines, Bull. 85, pp. 248-9. 1914.

The sample of coal cut from Section A has the following composition[1]:

Proximate analysis

	As received	Moisture free
Moisture	5.01	.....
Volatile matter	36.15	38.06
Fixed carbon	52.83	55.61
Ash	6.01	6.33
	100.00	100.00
Sulphur	1.74	1.83

Air drying loss 2.2 per cent

		As received	Moisture free
Heating value	Calories	7,327	7,713
	B. t. u.	13,189	13,883

The sample cut from Section B was analyzed with the following results:

Proximate analysis

	As received	Moisture free
Moisture	4.32	.....
Volatile matter	37.09	38.76
Fixed carbon	49.14	51.36
Ash	9.45	9.88
	100.00	100.00
Sulphur	3.82	3.99

Air drying loss.....2.6 per cent

		As received	Moisture free
Heating value	Calories	7,072	7,391
	B. t. u.	12,730	13,304

A composite of samples A and B has the following composition:

Proximate analysis

	As received	Moisture free
Moisture	4.66	.....
Volatile matter	36.63	38.42
Fixed carbon	50.82	53.30
Ash	7.89	8.28
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	71.72	75.23
Hydrogen	5.28	4.99
Oxygen	10.96	7.14
Nitrogen	1.35	1.42
Sulphur	2.80	2.94
Ash	7.89	8.28
	100.00	100.00

Air drying loss 2.4 per cent

[1]U. S. Bureau Mines, Bull. 85, p. 62. 1914.

		As received	Moisture free
Heating value	Calories	7,193	7,545
	B. t. u.	12,947	13,581

In the northeastern part of Section 34 and in the eastern part of Section 28, the Beacon Coal Co. of Steubenville was carrying on extensive operations in the Pittsburgh coal in 1923. Stripping with steam shovels was the method used where the overburden was not too thick, although underground mining was employed in the deepest portions of the bed. The daily mining capacity was estimated at 800 tons, and 45 men were employed. The coal was shipped for steam purposes to Youngstown, Ohio, and vicinity. The following measurements were secured in the pit in the east-central part of Section 34 and show the character and thickness of the minable coal:

	Ft.	In.
Shale, gray, arenaceous	5	0
Coal, shaly, *Redstone*	1	9
Limestone, nodular, *Redstone*	11	6
Clay and covered	11	0
Pittsburgh coal		
Breast coal	2	2
Parting		½
Bearing-in coal		2
Parting		½
Brick coal	1	0
Parting		½
Bottom coal	1	0

The Superior Coal Co., with offices at Wheeling, West Virginia, owns and operates a large stripping pit along the tributary to McIntyre Creek which heads near Bloomingdale in Section 16. The company began operations in the fall of 1917 and up to 1923 had been working only on the western side of the valley. However, coal suitable for stripping is reported on the eastern side of the valley in sufficient amount to last for a period of ten years. The geologic section which follows gives the character and thickness of the coal and the overlying beds as they appear in the east-central part of Section 15:

	Ft.	In.
Shale, gray, arenaceous	20	0
Coal, blocky, *Redstone*	1	4
Shale, gray	1	0
Limestone, nodular, with clay bands, *Redstone*	18	3
Clay, gray	1	9
Pittsburgh coal		
Roof coal	1	0

	Ft.	In.
Clay		7
Breast coal	2	4
Parting		½
Bearing-in coal		3
Parting		½
Brick and bottom coals	2	3

South of the Pittsburgh, Toledo, and Western Railroad, in Wayne Township, there has been little development of the Pittsburgh bed. The presence of the coal, however, is shown by numerous exposures along the north-south road in the eastern part of Section 7, where the coal outcrops at an elevation of 1,060 feet. It also occurs at this level in the northern part of Section 25. In the southern part of Section 31, a good exposure of coal is found along the roadside at an elevation of 1,135 feet. It is normal in structure, with a thickness of 5 feet 3 inches, and the roof coal is thin.

Cross Creek Township

The field of the Pittsburgh coal comprises about 17 square miles in Cross Creek Township, although deep dissection of the land surface by Cross Creek and its tributaries has rendered it very patchy and irregular in outline. North of Cross Creek, the coal lies near the hilltops and ranges in elevations from about 1,050 feet in Section 3 to 1,205 feet in Section 30. South of Cross Creek, it is more deeply buried, although a few areas of small extent exist with only a thin cover or overburden. The Pittsburgh coal of this township is of good quality, and the minable coal varies in thickness from 4 feet 3 inches to 5 feet 5 inches, with an average of 4 feet 7 inches.

Near the head of Wells Run in Section 5, where the coal has a thickness of 4 feet, a small opening has been made by the Cross Creek Coal Co. of Steubenville. A sulphur band, 3 inches in thickness, separates the bottom coal from the brick coal, which also contains sulphur balls. The roof coal is reported by the miners to be thin and to be separated from the breast coal by clay, which varies from 10 inches to 2 feet 6 inches in thickness. At this locality the coal has an elevation of 1,060 feet. A small country bank has been opened in the central part of Section 4, where the coal is of good quality and has a thickness of 4 feet 8 inches. About a half of a mile east of Wintersville, Julius Henry owns and operates a small mine, which in 1923 had a capacity of about 30 tons per day. The coal is hauled to Steubenville, where a part of it is marketed for domestic use and a part is shipped. The elevation of the bed at this locality is 1,150 feet. The following section shows the thickness and structure of the coal in this mine:

Pittsburgh coal	Ft.	In.
Roof coal.		
Clay	1	2
Breast coal	2	0
Parting		¼
Bearing-in coal		3½
Parting		¼
Brick and bottom coal	2	4
Clay.		

George Lentz of Steubenville operates a small mine in the Pittsburgh coal in the northern part of Section 30. The coal is of fair quality and has a thickness of 4 feet 10 inches, excluding the roof coal, which is left as top for the mine. The coal has also been mined near the head of a small ravine in the eastern part of Section 16, but no measurements could be obtained at this place. The old dump, however, occurs at an elevation of 1,075 feet and lies 239 feet above the Ames limestone.

Extensive operations in the Pittsburgh coal are being carried on by the Wayne Coal Co. above the railroad tunnel in Sections 8 and 9, where both strip mining and underground mining are employed. The following measurements were made in the pit in the southeastern part of Section 9:

		Ft.	In.
Shale and shaly sandstone		25	0
Pittsburgh coal			
Coal	*Roof coal*	1	6
Shale, black			5
Coal, blocky			7
Shale, bony			9
Shale, blue to gray			2
Coal, bony			2
Coal, good			11
Shale, dark			2
Coal			10
Parting			8
Breast, bearing-in, brick and bottom coals		4	8
Clay, gray		2	0

The coal at this place has an elevation of 1,072 feet. The roof coal, which occurs in unusual thickness with four benches separated by shale partings, is either wasted in the process of strip mining or is left as a roof in underground operations. The Redstone coal, which usually lies about 20 to 25 feet above the Pittsburgh bed, is replaced in this section by shale and shaly sandstone.

South of Cross Creek, the Pittsburgh coal has been worked in a

desultory way at a few places to supply local demand among the farmers. At one locality, however, in the southeastern part of Section 31, the Climax Coal Co. of Martins Ferry has opened a stripping mine for railroad shipment. The coal lies at an elevation of 1,060 feet and has a thickness of 4 feet 5 inches. On the Lewis farm in the central part of Section 33, James Long has opened a small mine in the Pittsburgh coal to supply the local demand. This mine was not operating when visited by the writer in 1924, although exposures near the mouth show that the coal has a thickness of 5 feet 5 inches. The elevation of the outcrop is 1,150 feet.

The Pittsburgh coal has been mined at the Scott bank, one mile north of New Alexandria, where W. T. Griswold measured the following section[1]:

	Ft.	In.
Coal		9
Parting, rejected		1
Coal		7
Parting, rejected		½
Coal	2	8½

A sample cut from this mine was analyzed with the following results[2]:

Proximate analysis

	As received	Moisture free
Moisture	5.19	.....
Volatile matter	34.69	36.59
Fixed carbon	50.67	53.44
Ash	9.45	9.97
	100.00	100.00
Sulphur	2.38	2.51

Air drying loss.....2.8 per cent

In the west-central part of Section 2, the Pittsburgh coal outcrops at an elevation of 1,078 feet along a small ravine tributary to Cross Creek. The position of the Pittsburgh coal in relation to the underlying beds is shown in the following geologic section measured along this ravine:

[1]U. S. Bureau Mines, Bull. 22, p. 670. 1913.

[2]U. S. Bureau Mines, Bull. 22, p. 147. 1913. U. S. Geol. Survey, Prof. Paper 48, p. 272.

		Ft.	In.
Sandstone, soft, friable, *Pittsburgh*		5	0
Shale and covered		5	6
Coal blossom, *Pittsburgh*		2	6
Clay and covered		18	6
Limestone, dark		1	6
Shale and shaly sandstone		1	8
Clay, light, with iron ore nodules		1	6
Shale, gray, arenaceous		15	6
Clay, yellow, with limestone and iron ore nodules		10	4
Sandstone, shale, and covered		173	0
Limestone, bluish-gray, nodular, *Ames*		1	3
Shale, with thin layers of sandstone		30	6
Coal	*Harlem*		8
Parting	*Harlem*		4
Coal	*Harlem*	1	2

At this place the interval between the Pittsburgh coal and the Ames limestone, which is the most persistent stratigraphic unit of the Conemaugh series, is 226 feet.

The lower members of the Monongahela series are well exposed along the diagonal road in the southeastern part of Section 2, where the rock succession above the Pittsburgh coal is as given below:

		Ft.	In.
Shale, yellow, with limestone nodules, *Arnoldsburg*		10	0
Limestone, yellow, impure			8
Shale, bluish-green, *Fulton*		3	10
Limestone, shaly	*Benwood*	3	6
Shale and covered	*Benwood*	14	10
Limestone, blue, compact	*Benwood*		8
Covered interval		15	6
Clay, gray, arenaceous		18	6
Shale, gray, arenaceous		53	5
Shale, bony	*Redstone*		1
Clay parting	*Redstone*		2
Coal	*Redstone*	1	2
Clay, yellowish-gray, arenaceous		12	7
Shale, gray, arenaceous		1	9
Limestone, *Redstone*		3	0
Covered interval		12	6
Coal blossom, *Pittsburgh*		2	0

Steubenville Township

The Pittsburgh coal underlies an area of 2.2 square miles in Steubenville Township, where the minable coal varies in thickness from 4 feet 10 inches to 5 feet 3 inches with an average of about 5 feet 1 inch. Near the southwestern corner of Section 35, where the Bernice Coal Co. has been operating a mine for many years, the coal

has a thickness of about 5 feet and is of good quality. The total output of the mine, reported to be 200 tons per day, is sold to brokers in Wheeling. A number of old coal dumps in Sections 28 and 34 show the former mining activity in the Pittsburgh coal, but no good exposures were found. The different members of the Pennsylvanian system from the Wilgus coal horizon to the Pittsburgh sandstone are well shown along the tributary to Wells Run which heads near Altamont Park in Section 28, where the following geologic section was measured:

	Ft.	In.
Sandstone, coarse, friable, *Pittsburgh*	24	0
Shale, gray, arenaceous	2	6
Coal blossom, *Pittsburgh*	3	0
Shale and covered	20	8
Clay, light, plastic	5	0
Shale, gray, arenaceous	51	8
Clay, calcareous	5	0
Limestone, light, *Clarksburg*		8
Clay, greenish-gray	2	0
Shale, calcareous, arenaceous	3	2
Shale, mottled	21	0
Shale and covered	25	10
Sandstone, *Morgantown*	27	0
Limestone, *Ames*	1	0
Shale and covered	23	10
Black shale with plant impressions		2
Coal, *Harlem*	1	6
Clay and covered	5	0
Sandstone, shale and covered	51	6
Shale, gray, arenaceous	20	0
Shale, with nodules of very ferruginous, calcareous, fossiliferous material, *Cambridge*	2	0
Smut streak, *Wilgus*		1
Clay, red to green	10	0

The elevation of the coal in the above section is 1,030 feet, and it lies 204 feet above the Ames limestone and 306 feet above the Wilgus coal.

In the southern part of the township in Section 25 and also along Georges Run in Section 31, the coal has been worked for railroad shipment and for local consumption at the small towns along the Ohio River. The following geologic section of the Pittsburgh coal, at Waugh's coal bank about 1 mile west of the Ohio River and near the mouth of Georges Run in the west-central part of Section 25, was made by W. T. Griswold[1] in 1904:

[1]U. S. Bureau Mines, Bull. 22, pp. 669-670. 1913.

	Ft.	In.
Coal	2	2½
Parting, rejected		½
Coal		2½
Parting, rejected		½
Coal	2	6

A sample cut from the coal in this mine at the place where the above geologic section was measured shows the following analysis[1]:

Proximate analysis

	As received	Moisture free
Moisture	6.55	.....
Volatile matter	34.48	36.90
Fixed carbon	50.36	53.89
Ash	8.61	9.21
	100.00	100.00
Sulphur	2.52	2.70

Air drying loss.....3.8 per cent

On the northern side of Georges Run at the western edge of Section 31, the Hatcher Coal Co. operates a mine in the Pittsburgh coal, where the minable part of the seam has a thickness of 5 feet 4 inches. The coal has a ready market at Mingo Junction. The Marietta mine of the Consolidated Coal Co. of Steubenville is located about a quarter of a mile north of Georges Run, where the following geologic record was secured:

Pittsburgh coal	Ft.	In.
Roof coal		3 to 15
Clay parting		3 to 12
Breast coal	2	3
Parting		½
Bearing-in coal		4
Parting		½
Brick and bottom coals	2	3

This mine was opened in 1920 and is electrically equipped throughout. The coal has an elevation of 1,000 feet.

The Pittsburgh coal was formerly worked near the southern boundary of Section 25, where the bed at the entry of the mine which has now collapsed lies at an elevation of 1,000 feet and at a height of 240 feet above the Ames limestone.

Smithfield Township

The Pittsburgh coal is present in some part of every section in

[1]U. S. Bureau Mines, Bull. 22, p. 147. 1913.

Smithfield Township, its total area being about 26.6 square miles or about 70 per cent of the area of the township. The elevation of the coal varies from 925 feet in Section 1 to 1,150 feet in Section 36, and hence exposures are present along Short Creek and many of its tributaries. The minable portion of the bed throughout the field has an average thickness of 4 feet 11 inches but varies from 4 feet 2 inches to 6 feet.

The Pittsburgh coal is above drainage along Dry Run from its mouth to the southern part of Section 11. Near the place where the coal passes beneath drainage in Section 11, a small country bank has been opened on the J. H. Lowry farm, where the coal which is of good quality has a thickness of 4 feet 7 inches and outcrops at an elevation of 1,030 feet. The Crow Hollow mine of the United States Coal Co. is located in the northeastern part of Section 3, where the following geologic section was measured[1]:

	Ft.	In.
Bone coal, rejected		1
Breast coal	2	1½
Parting, rejected		⅜
Bearing-in coal, rejected		1⅝
Parting, rejected		1
Brick and bottom coal	2	2½
Clay.		

A sample of coal taken from the Crow Hollow mine shows the following analysis[2]:

Proximate analysis

	As received	Moisture free
Moisture	4.96	0.00
Volatile matter	34.51	36.31
Fixed carbon	54.08	56.90
Ash	6.45	6.79
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	72.43	76.21
Hydrogen	5.37	5.07
Oxygen	12.67	8.69
Nitrogen	1.33	1.40
Sulphur	1.75	1.84
Ash	6.45	6.79
	100.00	100.00

Moisture in air-dried sample about 3 per cent

		As received	Moisture free
Heating value	Calories	7,277	7,656
	B. t. u.	13,099	13,781

[1]Bownocker, J. A., Geol. Survey Ohio, Fourth Series, Bull. 9, p. 46. 1908.
[2]Loc. cit.

The coal at the Crow Hollow mine was measured and sampled by J. W. Groves and W. J. von Borries in 1905. Sections showing the thickness and structure of the coal at the place of sampling are given below[1]:

	A		B	
	Ft.	In.	Ft.	In.
Roof: Section A, coal; Section B, soapstone.				
Shale, draw slate, rejected	....	11	....	....
Shale, soapstone, rejected	....	....	1	4
Coal, sampled	1	8	1	8
Mother coal, sampled	....	⅛	....	....
Mother coal and sulphur, sampled	....	....	....	⅛
Coal, sampled	....	9	....	8
Shale, rejected	....	3	....	2
Coal, sampled	1	2	....	8
Pyrite, sampled	....	¼	....	....
Mother coal, sampled	....	....	....	¼
Coal, sampled	....	6	1	5
Pyrite, sampled	....	¼	....	....
Coal	....	6	....	....
Floor, clay.				

Section A was measured 3,000 feet northwest of the tipple.
Section B was measured in room 17, off main entry 2, in district 2.

An analysis of the sample cut from the bed at the locality of Section A is as follows[2]:

Proximate analysis

	As received	Moisture free
Moisture	4.06	....
Volatile matter	38.49	40.12
Fixed carbon	49.70	51.80
Ash	7.75	8.08
	100.00	100.00
Sulphur	3.67	3.82

Air drying loss.....1.7 per cent

		As received	Moisture free
Heating value	Calories	7,304	7,613
	B. t. u.	13,147	13,703

An analysis of the sample cut from the bed at the locality of Section B is as follows:

[1]U. S. Bureau Mines, Bull. 22, p. 669. 1913.
[2]U. S. Bureau Mines, Bull. 22, p. 146. 1913.

Proximate analysis

	As received	Moisture free
Moisture	4.20	.....
Volatile matter	37.16	38.79
Fixed carbon	51.13	53.37
Ash	7.51	7.84
	100.00	100.00
Sulphur	3.22	3.36

Air drying loss.....2.0 per cent

Along Piney Fork, the Pittsburgh coal has been worked at a number of places for both shipping and domestic use. In Section 1 near the mouth of the valley at the Peter Nicholson mine, the coal has a thickness of 5 feet 2 inches, is of good quality, and lies at an elevation of 940 feet. In 1921, H. E. Lakin opened a small mine in the eastern part of Section 1, where the minable coal has a thickness of 6 feet. Here the breast coal, which averages about 2 feet 4 inches in Jefferson County, has an unusual thickness of 3 feet 6 inches. It is of good quality and finds a ready market at Dillonvale. The Pittsburgh coal together with the overlying and underlying strata are well exposed along the north-south road in the northwestern part of Section 1 and the southwestern part of Section 2. The elevation of this member is 934 feet and the interval to the Sewickley coal measures 95 feet. The record of the rock strata exposed along this road is as follows:

	Ft.	In.
Shale, black, with thin coal bands, *Sewickley*	1	0
Shale and covered	49	0
Limestone interstratified with shale	17	0
Clay, yellowish-gray, plastic	5	0
Coal blossom, *Redstone*		10
Clay and covered	21	4
Coal blossom, *Pittsburgh*	2	6
Clay and covered	10	0
Limestone, massive, *Pittsburgh*	2	0
Clay, gray to yellow	5	0

Extensive mining operations are being conducted by the Jefferson Coal Co. in the northeastern part of Section 14. Although openings in the coal have been made on both the east and west side of Piney Fork, only those on the east side of the valley were working in 1923. The thickness of the minable part of the bed measures about 5 feet.

The Pittsburgh coal is being mined for railroad shipment at

Piney Fork mines No. 1 and No. 2 and the Cabbage Hollow mine located near Piney Fork in Section 22. The coal at this locality was measured and sampled for chemical analysis by D. D. Condit in 1913, and sections showing the thickness and structure of the coal are given below[1]:

	A		B		C	
	Ft.	In.	Ft.	In.	Ft.	In.
Roof, coal or clay.						
Bone, rejected	....	2	....	....	....	....
Coal	2	7	2	2½	2	3½
Clay, rejected	....	⅛	....	¼	....	⅛
Coal, rejected	....	3	....	3½	....	3½
Clay, rejected	....	⅛	....	¼	....	¼
Coal	1	1	1	8	1	3
Clay band	....	⅛	....	....	....	⅛
Coal	....	5	....	....	....	6½
Coal, high in sulphur, rejected	....	3	....	3	....	3
Floor, clay and shale.						

Section A was measured in No. 1 mine, 4,000 feet southwest of mine mouth, Section 21.

Section B was measured in No. 2 mine, 5,600 feet northeast of mine mouth, Section 17.

Section C was measured in Cabbage Run mine, 1,050 feet northeast of the mine mouth, Section 16.

The analysis of the sample cut from the coal in Piney Fork No. 1 mine is given below[2]:

Proximate analysis

	As received	Moisture free
Moisture	4.87	.....
Volatile matter	36.63	38.51
Fixed carbon	51.25	53.87
Ash	7.25	7.62
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	71.79	75.59
Hydrogen	5.36	5.07
Oxygen	11.50	7.45
Nitrogen	1.38	1.45
Sulphur	2.60	2.73
Ash	7.25	7.62
	100.00	100.00

Air drying loss.....2.8 per cent

[1]U. S. Bureau Mines, Bull. 85, p. 249. 1914.

[2]U. S. Bureau Mines, Bull. 85, p. 63. 1914.

		As received	Moisture free
Heating value	Calories	7,218	7,588
	B. t. u.	12,992	13,658

The sample from Piney Fork No. 2 mine has the following composition:

Proximate analysis

	As received	Moisture free
Moisture	5.47	.....
Volatile matter	35.77	37.84
Fixed carbon	53.28	56.36
Ash	5.48	5.80
	100.00	100.00
Sulphur	.77	.81

Air drying loss.....3.2 per cent

		As received	Moisture free
Heating value	Calories	7,324	7,748
	B. t. u.	13,183	13,946

The sample of coal from the Cabbage Run mine was analyzed with the following results:

Proximate analysis

	As received	Moisture free
Moisture	5.45	.....
Volatile matter	35.73	37.79
Fixed carbon	54.22	57.35
Ash	4.60	4.86
	100.00	100.00
Sulphur	.84	.89

Air drying loss.....3.2 per cent

		As received	Moisture free
Heating value	Calories	7,401	7,827
	B. t. u.	13,322	14,089

In the southwestern part of Section 17, the Pittsburgh coal is well exposed along the road, where it has an elevation of 1,040 feet and lies about 44 feet below the Fishpot coal. The rock succession from the Pittsburgh coal to the Benwood limestone along this road is as given below:

		Ft.	In.
Limestone, yellowish			6
Shale and covered	*Benwood*	15	6
Limestone, nodular		3	2

	Ft.	In.
Covered interval	19	5
Coal, shaly, *Sewickley*	1	9
Shale and covered	51	7
Coal, shaly, *Redstone*	1	6
Clay, arenaceous, with limestone and iron ore nodules	12	0
Shale, black		10
Pittsburgh coal		
Roof coal, shaly	1	10
Clay, dark	1	8
Coal, including breast, bearing-in, brick, and bottom beds	4	5
Clay and covered	5	4
Limestone massive, *Pittsburgh*	3	4

Pittsburgh coal, with an elevation of 1,130 feet and a thickness of 4 feet, outcrops along the road in the north-central part of Section 22. The bottom of the bed at this place is 65 feet below the Sewickley coal. Near the road in the eastern part of Section 35, an opening occurs in the Pittsburgh coal at an elevation of 1,100 feet; but, as the mine opening was in a bad state of decay when visited by the writer in 1923, the full thickness of the coal could not be determined. The roof coal together with the overlying beds, however, are exposed along the road to the west, where the following record was made:

	Ft.	In.
Shale with nodular limestone, *Benwood*	4	0
Shale, gray, arenaceous	19	6
Sandstone, dark	2	0
Shale and covered	2	6
Black shale with coal bands, *Sewickley*	3	0
Shale and covered	4	4
Coal blossom, *Fishpot*		10
Shale with short covered intervals	46	0
Covered interval	16	0
Clay, gray	5	0
Pittsburgh coal		
Coal } Roof coal		10
Parting } Roof coal		½
Coal } Roof coal	1	1
Clay	1	4
Coal, not entire thickness	2	0

The Pittsburgh coal has been mined extensively by the United States Coal Co., in Section 36, where in 1907, B. A. Eisenlohr cut a sample for chemical analysis. A section of the coal at the place of sampling and an analysis of the sample are as follows[1]:

[1]Bownocker, J. A., Geol. Survey Ohio, Fourth Series, Bull. 9, p. 47. 1908.

	Ft.	In.
Shale, soft, draw slate		9
Coal, breast, sampled	1	11
Shale, rejected		1
Coal, bearing-in, rejected		1
Shale, rejected		¾
Coal, brick and bottom	2	2

Clay, unmeasured.

Proximate analysis

	As received	Moisture free
Moisture	4.30	.....
Volatile matter	35.28	36.87
Fixed carbon	52.54	54.90
Ash	7.88	8.23
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	71.34	74.55
Hydrogen	5.18	4.91
Oxygen	11.39	7.91
Nitrogen	1.20	1.25
Sulphur	3.01	3.15
Ash	7.88	8.23
	100.00	100.00

Moisture in air-dried sample about 3 per cent

		As received	Moisture free
Heating value	Calories	7,144	7,465
	B. t. u.	12,859	13,437

In 1922, the Woodward Coal Co. of Canton opened a shipping mine in the Pittsburgh coal in the western part of Section 30, where the coal measures 5 feet in thickness. About 25 men are employed when the mine is working to capacity. There has been little activity in the mining of the Pittsburgh coal along Perrin Run, although this bed lies well above drainage from the mouth of the stream in Section 13 to the village of York in Section 34. A good exposure of the beds underlying and overlying this coal appears along the road in the eastern part of Section 27, where the record of outcrops is as follows:

		Ft.	In.
Limestone, nodular, *Benwood*			8
Shale and covered		20	4
Coal blossom, *Sewickley*		1	0
Shale, gray, arenaceous		9	11
Sandstone, thin-bedded, platy, *Fishpot*		5	6
Shale, black, bituminous, *Fishpot*			5
Shale, arenaceous, and covered		39	8
Coal, shaly, *Redstone*		1	0
Shale and covered		13	6
Clay, light, plastic		8	0
Coal blossom	*Pittsburgh*		10
Clay			6
Coal blossom		3	2

	Ft.	In.
Clay and covered	11	6
Shale, very arenaceous, platy	3	0
Covered interval	2	0
Clay, ferruginous, arenaceous	3	8
Shale, gray, arenaceous	4	6
Clay, light, plastic	1	0
Clay, yellow, arenaceous	3	10

In the above section the minable portion of the Pittsburgh bed is represented by the coal blossom, which has a thickness of 3 feet 2 inches. Six inches above, lies the roof coal which forms the top of the Pittsburgh bed. The coal at this place has an elevation of 1,038 feet and lies 67 feet below the horizon of the Fishpot coal.

Along the valley of Short Creek westward from the mouth of Perrin Run, mining operations in the Pittsburgh coal have formed an important industry for many years. A large mine in this coal owned by M. A. Hanna of Cleveland has been producing coal for shipping purposes in the north-central part of Section 19. The coal has a thickness of 5 feet and is of good quality for steam purposes. The roof coal is reported to be about 1 foot in thickness and to be underlain by 1 foot of clay. The mine, which is electrically equipped, has an output of about 650 tons per day. The Bellaire Mining Co. also owns and operates a shipping mine in the Pittsburgh coal in the southeastern part of Section 32. The measurements of the coal in this mine are given below:

	Ft.	In.
Pittsburgh coal		
Roof coal, not entire thickness		4
Clay, gray, plastic	1	0
Breast coal	2	7
Bearing-in coal, shaly		2
Parting		½
Brick and bottom coals	2	2
Clay		6

An analysis of the coal from this mine, furnished by the superintendent, is as follows:

Proximate analysis

Moisture	2.5
Volatile matter	43.5
Fixed carbon	49.2
Ash	4.8
	100.00
Sulphur	3.8
Heating value—Calories	7,827
Heating value—B. t. u.	14,088

This mine is likewise electrically equipped throughout. The output, which averages about 50,000 to 60,000 tons per year, finds a ready market in the coal yards of Akron and Cleveland.

Extensive mining operations are also carried on by the Adena Coal Mining Co. half of a mile north of Adena. Strip mining in the Pittsburgh bed began here about 1916 but both open cut and underground methods are now employed. The minable part of the bed has a thickness of 5 feet 6 inches and lies at an elevation of 1,045 feet. The Penova Coal Co. of Pittsburgh began stripping the coal on the hilltop northwest of Adena in 1922. Although operations began in the southwestern part of Section 32, Smithfield Township, the field has been extended westward so that coal is now being mined in Section 2, Short Creek Township, Harrison County. In the summer of 1923, when the mine was visited by the writer, the company was operating two stripping shovels as well as two small loading shovels, with a daily output of about 25 car loads. The entire production of the mine is utilized by the American Steel Co. of Cleveland. An excellent geologic section of the Pittsburgh coal, in which the structural features are well shown, was measured in the pit near the county line, as shown below:

	Ft.	In.
Shale, gray, arenaceous	10	0
Coal, *Redstone*	1	6
Clay, dark	2	6
Limestone, dark } *Redstone*	1	4
Limestone, nodular, with clay } *Redstone*	6	10
Clay, bluish-gray, with pyrite	10	4
Pittsburgh coal		
Roof coal	1	0
Clay, gray, arenaceous	1	0
Breast coal	2	6
Parting		¾
Bearing-in coal		2
Parting		¼
Brick coal	1	6
Parting		¼
Bottom coal	1	0
Clay		6

Mount Pleasant Township

The area of the Pittsburgh coal field in Mount Pleasant Township is about 16.6 square miles or about 92 per cent of the total area. Short Creek and its chief tributary, Long Run, are the only streams of any size that have cut their valleys below the horizon of the Pittsburgh coal and therefore exposures of this bed at the surface

are limited to these valleys. The elevation of the coal on the outcrop varies from 980 feet in the northern part of Section 29 to 910 feet in the eastern part of Section 6. Measurements of minable coal average about 5 feet 2 inches with variations from 5 feet to 5 feet 4 inches.

The Pittsburgh coal has been mined for more than twenty years in the Wheeling and Lake Erie mine No. 2, located in the northeastern corner of Section 6, where coal is still available for several years mining. A detailed section of the bed is given below[1]:

		Ft.	In.
Pittsburgh coal			
Breast coal		2	6½
Parting, rejected			⅛
Coal	Bearing-in coal		1⅝
Parting	Bearing-in coal		⅝
Coal	Bearing-in coal		2¼
Parting			⅛
Brick and bottom coals		2	8

The roof coal, not shown in the above section, has a thickness of about 1 foot 6 inches and is underlain by 1 foot of clay. An analysis of a sample of coal cut from this mine is given below[2]:

Proximate analysis

	As received	Moisture free
Moisture	3.10	.....
Volatile matter	37.92	39.13
Fixed carbon	49.46	51.04
Ash	9.52	9.83
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	69.56	71.78
Hydrogen	5.22	5.04
Oxygen	10.77	8.27
Nitrogen	1.10	1.13
Sulphur	3.83	3.95
Ash	9.52	9.83
	100.00	100.00

Heating value	As received	Moisture free
Calories	7,153	7,382
B. t. u.	12,875	13,287

The Pittsburgh coal was formerly mined in the hills northwest of Dillonvale in Section 6. In the south-central part of Section 12, Harry Walker of Dillonvale owns and operates a mine in Pittsburgh coal which has a daily capacity of about 500 tons. The minable part

[1]Bownocker, J. A., Geol. Survey Ohio, Fourth Series, Bull. 9, p. 45. 1908.
[2]Idem, p. 44.

of the bed has a thickness of 5 feet 4 inches, above which is 1 foot of clay overlain by roof coal. The Pittsburgh coal, with the overlying and underlying beds, are well exposed along a small ravine tributary to Short Creek which heads near Mount Pleasant in the western part of Section 11. Following is a record of the exposures:

		Ft.	In.
Limestone, dark	*Benwood*	4	4
Shale			6
Limestone, dark		5	10
Covered interval		6	6
Limestone, dark		3	0
Clay, gray		4	8
Coal and black shale, *Sewickley*		3	0
Clay shale, black		5	0
Sandstone		19	0
Clay shale with a few limestone layers		15	0
Limestone, dark, regular bedded		15	0
Covered interval		8	5
Pittsburgh coal			
Breast coal		2	8
Parting			½
Bearing-in coal			8
Parting			½
Brick and bottom coals		2	2
Clay, gray, plastic		2	6
Limestone, dark, *Pittsburgh*		4	3

The elevation of the base of the Pittsburgh coal at this place is 948 feet, and it lies 82 feet below the Sewickley coal and 224 feet below the top of the Waynesburg coal, which forms the uppermost member of the Monongahela series.

The Bridgeville and Ohio Coal Co. is operating a shipping mine in the Pittsburgh coal in the northern part of Section 18, where the bed has an elevation of 920 feet. According to the report of the mine superintendent, the bearing-in coal is poorly developed, although the minable portion has a thickness of 5 feet 2 inches. Pittsburgh coal also outcrops at an elevation of 960 feet along a ravine in the northern part of Section 23, the minable part of the member being 5 feet 2 inches thick, and the roof coal 5 inches, and being overlain by 1 foot of gray plastic clay. At Ramseyville, the coal has been worked extensively for lake shipment by the New Pittsburgh Coal Co., and openings have been made on both the north and south sides of Long Run. Although the mine was not operating in 1924, one of the superintendents reported that the coal is about 5 feet in thickness and that the roof coal measures from 2 to 10 inches with an average of about 6 inches. It is underlain by about 1 foot of gray clay.

Wells Township

The field of the Pittsburgh coal in Wells Township embraces an area of 18.5 square miles. The elevation of the coal, which is somewhat variable, ranges from 1,060 feet in Section 30 to 920 feet in Section 3. The thickness of the minable portion of coal is everywhere about 5 feet. Occasionally a thin band of bone coal appears at the top of the bed although it does not constitute a constant feature of the member.

The Pittsburgh coal was formerly worked about one mile from the Ohio River in the northern part of Section 30. As the entry of the mine had collapsed, the thickness of the coal could not be determined. The elevation of the bed, which lies 240 feet above the Ames limestone, is 1,000 feet. The Pittsburgh coal has been worked for a number of years in the Cox mine located in the northeastern corner of Section 35, where J. A. Bownocker reports the structure and thickness of the bed as follows[1]:

		Ft.	In.
Coal	Breast coal	1	7
Parting	Breast coal		¼
Coal	Breast coal	1	2
Parting, rejected			2½
Bearing-in coal, rejected			2½
Parting, rejected			¾
Brick and bottom coals		2	3½

Clay, unmeasured.

A sample of coal from this mine has the following composition[2]:

Proximate analysis

	As received	Moisture free
Moisture*	4.89	0.00
Volatile matter	33.10	34.80
Fixed carbon	51.55	54.20
Ash	10.46	11.00
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	68.01	71.51
Hydrogen	5.03	4.72
Oxygen	11.29	7.30
Nitrogen	1.12	1.17
Sulphur	4.09	4.30
Ash	10.46	11.00
	100.00	100.00

Moisture in air-dried sample about 3 per cent

		As received	Moisture free
Heating value	Calories	6,953	7,310
	B. t. u.	12,515	13,158

*Sample slightly wet. Moisture possibly 1 per cent high.

[1]Bownecker, J. A., Geol. Survey Ohio, Fourth Series, Bull. 9, p. 52. 1908.
[2]Idem, p. 53.

In 1904, W. T. Griswold sampled the Pittsburgh coal in a country bank at Brilliant. A section of the coal bed at the place of sampling is not available, but the composition of the sample is as given below[1]:

Proximate analysis

	As received	Moisture free
Moisture	5.27	.....
Volatile matter	34.87	36.81
Fixed carbon	49.16	51.90
Ash	10.70	11.29
	100.00	100.00
Sulphur	3.07	3.24
Air drying loss	2.9 per cent	

In the southeastern part of Section 6, the Pittsburgh coal was formerly worked for railroad shipment at the Goucher No. 2 mine. The coal was measured and sampled for chemical analysis at two places in this mine by D. D. Condit in 1913. His measurements are as follows[2]:

	A		B	
	Ft.	In.	Ft.	In.
Roof, clay, soapstone.				
Bone, rejected	....	....	....	3
Coal	2	3	2	3
Sulphur band, rejected	....	¼	....	¼
Coal, rejected	....	3½	....	3
Sulphur band, rejected	....	¼	....	¼
Coal	1	3	2	5
Sulphur band	....	⅛	....	....
Coal	....	11	....	....
Floor, clay and shale.				

Section A was measured 500 feet northwest of the mine mouth.

Section B was measured 500 feet northwest of the mine mouth and about 1,200 feet from the point where Section A was measured.

The following shows the composition of the sample cut from Section A[3]:

[1]U. S. Geol. Survey, Professional Paper 48, p. 272, 1906; U. S. Bureau Mines, Bull. 22, pp. 147, 669. 1913.

[2]U. S. Bureau Mines, Bull. 85, p. 248. 1914.

[3]U. S. Bureau Mines, Bull. 85, p. 62. 1914.

Proximate analysis

	As received	Moisture free
Moisture	3.79	.....
Volatile matter	38.78	40.31
Fixed carbon	50.03	52.00
Ash	7.40	7.69
	100.00	100.00
Sulphur	3.84	3.99

Air drying loss.....2.0 per cent

		As received	Moisture free
Heating value	Calories	7,267	7,553
	B. t. u.	13,081	13,595

The analysis of the sample cut from Section B is given below:

Proximate analysis

	As received	Moisture free
Moisture	4.28	.....
Volatile matter	37.41	39.08
Fixed carbon	50.29	52.54
Ash	8.02	8.38
	100.00	100.00
Sulphur	3.72	3.89

Air drying loss.....2.5 per cent

		As received	Moisture free
Heating value	Calories	7,201	7,523
	B. t. u.	12,962	13,541

A composite of the two preceding samples has the following composition:

Proximate analysis

	As received	Moisture free
Moisture	4.11	.....
Volatile matter	37.96	39.59
Fixed carbon	50.23	52.38
Ash	7.70	8.03
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	71.69	74.77
Hydrogen	5.23	4.97
Oxygen	10.15	6.78
Nitrogen	1.39	1.45
Sulphur	3.84	4.00
Ash	7.70	8.03
	100.00	100.00

Air drying loss.....2.3 per cent

		As received	Moisture free
Heating value	Calories	7,230	7,540
	B. t. u.	13,014	13,572

In the central part of Section 11, the Pittsburgh coal outcrops along the east-west road at an elevation of 960 feet. Although the full thickness of the coal is not shown, the overlying beds are well exposed. The stratigraphic relations of the strata at this place are shown in the following record:

		Ft.	In.
Shale, greenish-gray, *Fulton*		14	6
Limestone	*Benwood*	1	0
Shale and covered	*Benwood*	5	2
Limestone	*Benwood*		8
Shale and covered	*Benwood*	9	8
Limestone	*Benwood*		6
Shale and covered		14	6
Coal blossom, *Sewickley*			6
Shale and covered		61	0
Coal blossom, *Redstone*		1	0
Covered interval		15	0
Limestone, dark, nodular, *Redstone*			6
Covered interval		15	6
Coal blossom, *Pittsburgh*		1	0

In the above section the interval to the Sewickley coal, which averages about 61 feet for the county, is expanded to 94 feet.

The Pittsburgh coal along Rush Run is above drainage from its mouth to the central part of Section 29, and along this stream several coal mines have been opened which are productive of large quantities of fuel. In the northern part of Section 9, the United Coal Co. of Danville, Illinois, began stripping coal for railroad shipment in 1913, and in 1923 two electrically operated stripping shovels were in use with a daily production of about twenty car loads. The minable coal has a thickness of about 5 feet with an elevation of 937 feet at the northern edge of the pit. Another shipping mine in the Pittsburgh coal is being operated by the Hudson Coal Co. in the southern part of Section 15, where the coal has an elevation of 937 feet and lies 70 feet below the Sewickley coal. A measurement of the coal taken at the mouth of the mine is as follows:

	Ft.	In.
Pittsburgh coal		
Roof coal	1	0
Clay		11
Breast coal	2	4
Parting		½
Bearing-in coal		2
Parting		½
Brick and bottom coals	2	2
Clay		6

An outcrop of the Pittsburgh coal also occurs along the road on the northern edge of Section 27, where the coal lies 83 feet below the Sewickley coal and 214 feet below the Uniontown coal.

Near the head of Rush Run in Sections 29 and 30, the Pittsburgh coal has long been worked for shipping purposes at the Plum Run mines. The coal bed in this area was measured and sampled for chemical analysis in 1913 by D. D. Condit, who reports the following measurements[1]:

	A		B		C	
Roof, clay.	Ft.	In.	Ft.	In.	Ft.	In.
Coal	2	3	1	10	2	1
Sulphur and clay, rejected	....	¼	....	½	....	¼
Coal, rejected	....	2½	....	2¾	....	2½
Sulphur and clay, rejected	....	¼	....	¼	....	¼
Coal	2	3	2	3	2	2½
Floor, clay and shale.						

Section A was measured in No. 1 mine, 2,500 feet northeast of the mine mouth.
Section B was measured in No. 4 mine, 4,400 feet northeast of the mine mouth.
Section C was measured in No. 5 mine, 1,800 feet southeast of the mine mouth.

An analysis of the sample from mine No. 1 is as follows[2] (Section A):

Proximate analysis

	As received	Moisture free
Moisture	4.78	.....
Volatile matter	35.93	37.73
Fixed carbon	53.98	56.69
Ash	5.31	5.58
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	74.13	77.85
Hydrogen	5.35	5.06
Oxygen	12.77	8.95
Nitrogen	1.46	1.53
Sulphur	.98	1.03
Ash	5.31	5.58
	100.00	100.00

Air drying loss.....2.6 per cent

		As received	Moisture free
Heating value	Calories	7,417	7,789
	B. t. u.	13,351	14,020

Analysis of the sample taken from mine No. 4 (Section B):

Proximate analysis

	As received	Moisture free
Moisture	4.52	.....
Volatile matter	36.40	38.12
Fixed carbon	51.10	53.52
Ash	7.98	8.36
	100.00	100.00
Sulphur	3.33	3.49

Air drying loss.....2.6 per cent

[1]U. S. Bureau Mines, Bull. 85, p. 250. 1914.
[2]U. S. Bureau Mines, Bull. 85, p. 63. 1914.

		As received	Moisture free
Heating value	Calories	7,157	7,496
	B. t. u.	12,883	13,493

Composition of the sample from mine No. 5 (Section C):

Proximate analysis

	As received	Moisture free
Moisture	4.26	.....
Volatile matter	36.61	38.24
Fixed carbon	52.18	54.50
Ash	6.95	7.26
	100.00	100.00
Sulphur	2.57	2.68

Air drying loss.....2.3 per cent

		As received	Moisture free
Heating value	Calories	7,307	7,632
	B. t. u.	13,153	13,738

The Pittsburgh coal has been stripped in a small way from the bed of the stream in the southwestern part of Section 35. The minable part of the coal has a thickness of 4 feet 10 inches and lies at an altitude of 1,050 feet. It occurs 88 feet below the Sewickley coal and 181 feet below the Uniontown coal.

Warren Township

The field of the Pittsburgh coal in Warren Township covers an area of about 13.5 square miles and outcrops can be found in every section of the township. The field, however, is very irregular in outline due to deep dissection by streams. The elevation of the member varies from 970 feet in the northwestern part of Section 14 to 870 feet near Yorkville in the eastern part of Section 22, and the thickness of the minable part of the bed ranges from 4 feet 8 inches to 6 feet 4 inches but averages about 5 feet.

The Pittsburgh coal was formerly worked along Rush Run in Sections 8 and 14 but these mines are now abandoned. In 1905, J. W. Groves sampled the coal in Rush Run Mine No. 1 of the Glens Run Coal Co. at Rush Run in Section 8. Measurements of the bed at the place of sampling are as follows:[1]

[1]U. S. Geol. Survey, Bull. 290, p. 151. 1906; U. S. Bureau Mines, Bull. 22, pp. 147, 670-671. 1913.

	A		B	
Coal, roof, rejected.	Ft.	In.	Ft.	In.
Coal, sampled	1	3	1	4
Pyrite, sampled	....	⅛	....	....
Mother coal	....	....	....	¼
Coal, sampled	....	11	....	9
Shale and coal, rejected	....	3	....	....
Shale, rejected	....	....	....	2
Coal, sampled	1	2	....	2
Shale, sampled	....	⅛	....	....
Pyrite, rejected	....	....	....	1
Coal, sampled	....	11	....	11
Shale, sampled	....	....	....	⅛
Coal, sampled	....	....	1	0
Floor, shale.				

Section A was measured 2,400 feet southwest of the drift mouth.
Section B was measured 2,600 feet south of the drift mouth.

Composition of the sample cut from section A:

Proximate analysis

	As received	Moisture free
Moisture	4.69	.....
Volatile matter	35.57	37.32
Fixed carbon	53.73	56.37
Ash	6.01	6.31
	100.00	100.00
Sulphur	1.54	1.62

Air drying loss.....2.4 per cent

		As received	Moisture free
Heating value	Calories	7,403	7,767
	B. t. u.	13,325	13,981

Composition of the sample cut from Section B:

Proximate analysis

	As received	Moisture free
Moisture	4.99	.....
Volatile matter	35.33	37.18
Fixed carbon	53.98	56.82
Ash	5.70	6.00
	100.00	100.00
Sulphur	.95	1.00

Air drying loss.....2.2 per cent

The Pittsburgh bed was formerly worked along Rush Run in Sections 8 and 14. These mines, however, are now abandoned. In the north-central part of Section 20, the Youghiogheny and Ohio Coal Co. has been operating a mine in this coal for railroad shipment, which was temporarily idle in 1924, so that a section of the coal could not be obtained. The elevation of the bed at the mine entry is 960 feet. In the central part of Section 7, a small country bank in the Pittsburgh coal is operated by Charles Lewis for supplying domestic trade. The coal is of good quality, has a thickness of 4 feet 4 inches, and lies at an altitude of 930 feet, and 185 feet above the Ames limestone. A geologic section, measured along a small ravine in the western part of Section 7, is as given below:

	Ft.	In.
Coal blossom, *Sewickley*	1	6
Shale, gray, arenaceous	39	0
Covered interval	26	2
Smut streak, *Redstone*		4
Limestone, *Redstone*	4	10
Shale and covered	10	11
Shale, black, fissile	3	0
Clay	1	0
Pittsburgh coal		
Roof coal		9
Clay, gray, plastic		10
Breast coal	2	1
Parting		½
Bearing-in coal		2
Parting		½
Brick and breast coal	2	2

The elevation of the Pittsburgh coal at this exposure is 936 feet; and the interval to the Sewickley coal, which is usually about 60 to 70 feet, is expanded here to 91 feet.

Along the western slope of the Ohio River Valley from Rush Run to Yorkville, many mines have been opened in the Pittsburgh coal, but most of them have long ago been abandoned. One of the oldest coal operations on the river front is the mine of the Consolidated Coal Co., located in the northern part of Section 12, a half of a mile north of Warrenton. This mine was opened in 1884 and with the exception of a few short periods of inactivity has been working ever since. In 1923 reports indicated that enough coal is still available to prolong operations for two or three more years. The minable part of the bed has a thickness of about 5 feet. The structure of the coal is, in general, normal for the Pittsburgh bed of this area, the only variation being the presence of a two-inch band of bone coal which overlies the breast coal and

which must be separated from it in mining. The Pittsburgh coal has also been mined extensively at a number of places along the valley of Short Creek from its mouth to the western edge of Section 31, but now the minable part of the coal is to a large extent exhausted. At the northern edge of Section 24, mine No. 3 of the Wheeling and Lake Erie Coal Co. was opened in 1900, but in August, 1924, preparations for abandoning it had begun. The coal is reported to have an average thickness in this mine of about 5 feet and to be of excellent quality. The elevation of the coal bed at this locality is 885 feet. A quarter of a mile west of this mine the Pittsburgh coal and overlying beds are well exposed along the road, where the stratigraphic sequence is as follows:

		Ft.	In.
Limestone, bluish-gray	*Benwood*		6
Shale and covered	*Benwood*	3	9
Limestone	*Benwood*	2	0
Clay shale, gray	*Benwood*	8	8
Limestone	*Benwood*	1	2
Shale and covered	*Benwood*	6	4
Limestone, shaly at top		4	0
Clay shale, dark		5	2
Shale and shaly coal, *Sewickley*		1	8
Sandstone, shaly		5	0
Shale, gray, arenaceous		17	7
Sandstone		1	7
Shale and covered		11	8
Smut streak, *Redstone*			2
Covered interval		1	0
Limestone, shaly		1	6
Shale, gray, arenaceous	*Redstone*	5	2
Limestone	*Redstone*	1	9
Shale and covered	*Redstone*	22	3
Limestone	*Redstone*	1	6
Shale		13	6
Coal blossom, *Pittsburgh*		5	0

The Glens Run Coal Co. formerly operated a mine in the Pittsburgh coal in the eastern part of Section 36, where the structure and thickness are as follows[1]:

Pittsburgh coal	Ft.	In.
Breast coal	2	4
Parting		⅛
Bearing-in coal		1
Parting		⅛
Brick and bottom coals	2	1
Clay, unmeasured.		

[1]Bownocker, J. A., Geol. Survey Ohio, Fourth Series, Bull. 9, p. 51. 1908.

A sample of coal collected from this mine has the following composition[1]:

Proximate analysis	As received	Moisture free
Moisture	4.57	0.00
Volatile matter	32.40	33.95
Fixed carbon	54.03	56.62
Ash	9.00	9.43
	100.00	100.00

Ultimate analysis	As received	Moisture free
Carbon	71.18	74.59
Hydrogen	5.06	4.77
Oxygen	11.89	8.21
Nitrogen	1.32	1.38
Sulphur	1.55	1.62
Ash	9.00	9.43
	100.00	100.00

Moisture in air-dried sample about 3 per cent

		As received	Moisture free
Heating value	Calories	7,105	7,445
	B. t. u.	12,789	13,401

The Pittsburgh coal was formerly mined for railroad shipment along Jug Run in the northeastern part of Section 31. This mine, which is known as the Jug Run mine, was opened in 1898 and was also being abandoned in 1924. The coal is reported to have an average thickness of about 5 feet with a one-inch sulphur band occurring about 8 inches above the bottom of the bed. The base of the member at this mine lies about 77 feet below the Sewickley coal.

The Pittsburgh coal along Little Short Creek is above drainage from the mouth of the stream to the central part of Section 3, Colerain Township, Belmont County. The Youghiogheny and Ohio Coal Co. has opened a shipping mine in the east-central part of Section 29, where the coal is of excellent quality, has a thickness of 4 feet 4 inches, and lies at an elevation of 862 feet and 92 feet below the Sewickley coal. The stratigraphic position of the Pittsburgh coal in the southern part of Warren Township is well shown in the following section measured along the east-west road in the northern part of Section 35:

	Ft.	In.
Coal blossom, *Sewickley*		3
Shale, gray, arenaceous	19	0
Limestone, *Fishpot*	2	0
Clay shale	5	0
Covered interval	11	5
Coal blossom, *Redstone*		3
Clay and covered	2	0
Limestone, dark, massive, *Redstone*		8

[1]Bownocker, J. A., Geol. Survey Ohio, Fourth Series, Bull. 9, p. 51. 1908.

		Ft.	In.
Clay and covered		18	4
Coal blossom, *Pittsburgh*		1	8
Clay, gray, arenaceous		6	10
Limestone, dark, massive, *Pittsburgh*			9
Clay, yellowish-gray		2	3
Shale, yellowish, arenaceous		3	6
Covered interval		1	8
Clay, gray		10	4
Shale, gray, arenaceous		6	9
Sandstone, shaly, *Bellaire*		3	7
Shale, gray, arenaceous		4	6
Limestone, light gray, massive, *Summerfield*		1	4
Clay, ferruginous, arenaceous		8	0
Shale, gray, arenaceous		27	4
Sandstone, massive, *Connellsville*		4	0
Shale, gray, arenaceous			6
Limestone	*Clarksburg*		6
Shale, gray, arenaceous	*Clarksburg*		8
Limestone	*Clarksburg*		10
Clay, gray to red mottled		9	0
Shale, gray, arenaceous		69	6
Sandstone, massive, *Morgantown*		13	4
Limestone, one layer	*Ames*		11
Limestone, one layer	*Ames*	2	6

The elevation of the Pittsburgh coal at this locality is 882 feet, and the interval to the Sewickley coal measures 61 feet and to the Ames limestone 191 feet.

One mile west of Yorkville, the Pittsburgh coal is being worked for domestic trade in Walnut Hill mine No. 3 of the Ohio and Pennsylvania Coal Co. A section of the coal measured near the mine mouth is as follows:

		Ft.	In.
Clay, gray, arenaceous		3	0
Pittsburgh coal			
Shale with thin coal bands	*Roof coal*		5
Clay	*Roof coal*		10
Coal, shaly	*Roof coal*	1	9
Clay, gray, arenaceous			10
Coal, shaly	*Breast coal*		2
Coal, good	*Breast coal*	2	8
Parting			1
Bearing-in coal, good			4
Parting with some pyrite			1
Brick and bottom coals, good		3	0
Limestone, *Pittsburgh*		1	2

As indicated in the above geologic section, the major structural features of this bed are normal for the region, but minor variations

occur such as an increased thickness of the brick and bottom coals and the separation of the roof coal into two blocks by clay partings. A sample of coal taken from the Walnut Hill mine No. 3 has the following composition. The sample, however, includes the breast, brick, and bottom coals only, as the other parts of the bed are discarded at the mine.[1]

Proximate analysis

	As received	Moisture free
Moisture	3.13	.....
Volatile matter	37.88	39.10
Fixed carbon	50.77	52.41
Ash	8.22	8.49
	100.00	100.00

Ultimate analysis

	As received	Moisture free
Carbon	71.03	73.32
Hydrogen	5.38	5.19
Oxygen	10.09	7.55
Nitrogen	1.26	1.30
Sulphur	4.02	4.15
Ash	8.22	8.49
	100.00	100.00

		As received	Moisture free
Heating value	Calories	7,233	7,466
	B. t. u.	13,019	13,439

Moisture in air-dried sample about 3 per cent

Pittsburgh Sandstone

Immediately overlying the Pittsburgh coal or separated from it by a few feet of shale, at many places occurs a prominent ledge of sandstone, which was named by H. D. Rogers, the Pittsburgh sandstone. This member is well developed in Fayette and Westmoreland counties, Pennsylvania, and can be found in almost every county along the eastern outcrop of the Monongahela series in West Virginia from Monongalia County on the north to Wayne and Cabell counties on the southeast. Along the western belt of outcrop of the Monongahela series, local developments of this sandstone are found in the Pan Handle area of West Virginia as well as in Belmont, Noble, Morgan, Athens, Meigs, and Jefferson counties, Ohio.

In Jefferson County, the interval between the Redstone and Pittsburgh coals is usually composed of limestone and shale and therefore the Pittsburgh sandstone is generally wanting. In Section 31, Ross Township, however, the member is represented by sandstone and sandy shale which lie immediately above the Pittsburgh coal. A similar bed of sandstone is exposed in the northern part of the strip mine of the Ohio River Edison Coal Co. in Section 9, Knox Township, where the

[1]Bownocker, J. A., Geol. Survey Ohio, Fourth Series, Bull. 9, p. 50. 1908.

sandstone has a thickness of 5 feet and replaces the roof coal of the Pittsburgh bed. A measurement of the exposure at this mine follows:

		Ft.	In.
Shale, bluish-gray		12	0
Sandstone, shaly		12	0
Coal, with thin shale bands, *Redstone*		1	4
Clay, bluish-gray, arenaceous		6	0
Clay, shale		10	6
Sandstone, medium-grained, *Pittsburgh*		5	0
Coal	*Pittsburgh*	1	9
Parting			1
Coal			3
Parting			1
Coal		1	10
Coal, bony			7

Near Altamont Park at the southern edge of Section 28, Steubenville Township, the Pittsburgh coal is overlain by a few feet of gray, arenaceous shale, above which occurs about 24 feet of coarse, friable, cross-bedded sandstone representing the Pittsburgh sandstone member.

Redstone Limestone

The stratigraphic position of the Redstone limestone is between the Pittsburgh sandstone and the Redstone coal. The top of this member is usually separated from the coal by a few feet of clay shale or clay but the position of the bottom varies greatly. Where the underlying sandstone member is well developed, there is usually a decrease in the thickness of the limestone or a complete disappearance of this member. Poor development of the sandstone, on the other hand, is often accompanied by a thickening of the limestone, which may drop nearly or entirely to the top of the Pittsburgh coal.

The Redstone limestone is well developed in Fayette and Westmoreland counties, Pennsylvania, where it was first named by J. J. Stevenson for its close association with the Redstone coal. In West Virginia, this member has been identified in every county where its horizon outcrops from Monongalia to Braxton counties. Southwest of the latter county, the Pittsburgh sandstone is massively developed and therefore the Redstone limestone is wanting. In the Pan Handle area, limestone and shale are present between the Redstone and Pittsburgh coals. In Ohio, the Redstone member is well represented in Jefferson and parts of Belmont counties, is poorly developed in Noble and Morgan counties, but is again well represented in parts of Athens and Meigs counties.

In Jefferson County, the Redstone limestone consists of one or more layers of dark, bluish-gray stone interstratified with clay or clay shale. The limestone is of the typical fresh or brackish water type, the only fossil present being *Spirorbis anthracosia* Whitfield. The thickness of the member is subject to a variation ranging from 1 to 18 feet, but averaging about 9 feet. Its average position is about 3 feet 6 inches below the base of the Redstone coal and 11 feet above the top of the Pittsburgh coal. Exposures of Redstone limestone are present in Springfield, Salem, Island Creek, Wayne, Cross Creek, Smithfield, Wells, Warren, and Mount Pleasant townships.

In Springfield Township, the Redstone limestone is exposed along the road in the northern part of Section 12, where it is dark in color and compact in texture, weathering to a yellowish brown. Dark, nodular limestone embedded in clay also occurs on this horizon in the southeastern part of Section 3, Salem Township. In Island Creek Township, shale is the predominating rock above the Pittsburgh coal, although in sections 21 and 30, limestone is found on the Redstone horizon. Near the southwestern corner of Section 30, this limestone is nodular, bluish in color, with a thickness of 10 feet 6 inches, and is quarried for use in road construction. In the northwestern part of Section 21, the member is represented by 6 feet of nodular, light bluish stone, which lies 11 feet below the Redstone coal and 15 feet above the Pittsburgh coal.

The Redstone limestone is locally present in good development in Wayne Township, although it is by no means persistent and is frequently wanting entirely. In the stripping mine of the Superior Coal Co. in Section 15, it has a total thickness of about 18 feet and is composed of dark-colored, nodular layers of limestone separated by clay beds. This limestone is also well exposed in the stripping pits of the Beacon Coal Co. and the Wayne Coal Co. in sections 33 and 34. In the latter locality, the limestone consists of a single layer 2 feet in thickness which lies 2 feet below the Redstone coal and 19 feet above the Pittsburgh coal.

In Cross Creek Township, the Redstone limestone is found in good development in sections 7, 14, and 31. In sections 7 and 14, it usually appears as irregular, nodular masses embedded in clay. The following geologic section, measured in the stripping mine of the Climax Coal Co. in Section 31, shows the position, thickness, and stratigraphic relations of the Redstone limestone:

	Ft.	In.
Shale, gray, arenaceous	8	0
Coal, *Redstone*	1	8
Clay, bluish-gray	2	0

		Ft.	In.
Limestone	*Redstone*	2	4
Clay, bluish-gray		2	0
Limestone		3	0
Clay, bluish-gray		2	0
Limestone		3	0
Clay, bluish-gray		5	0
Shale, dark		1	11
Coal	*Pittsburgh*	1	9
Clay, gray		1	2
Coal		2	8
Parting			¼
Coal			2
Parting			¼
Coal		1	7

In Smithfield Township, the Redstone limestone is irregular in its distribution and thickness. It is often entirely wanting although it is present in good development at places only a short distance away. Good exposures of this member have been observed in sections 12, 15, 27, and 32, where it is typical in its development, consisting of layers of dark blue limestone separated by clay shale or nodular masses of limestone embedded in clay. The limestone is usually separated from the overlying coal by a few feet of dark clay.

Very few exposures of Redstone limestone are found in Wells Township. It occurs, however, along the public road in the central part of Section 11, where it has a thickness of 12 feet. The character of the exposure is typical of the Redstone limestone for this county. In Warren Township, the Redstone limestone is more constant in character and regular in distribution than in other parts of Jefferson County, being generally present along Short Creek in sections 18, 19, 23, 25, and 31. Along Jug Run in the northern part of Section 31, the Pittsburgh coal, Redstone limestone, Redstone coal, Fishpot limestone, and the Sewickley coal horizon are well exposed in normal development. The following section, measured at this locality, shows the stratigraphic relations and thickness of these members and forms a good record of this portion of the Monongahela series. The development of the limestone here is typical for this township.

		Ft.	In.
Shale, carbonaceous, *Sewickley horizon*		1	0
Shale, gray, arenaceous		27	0
Limestone, ferruginous	*Fishpot*	1	2
Clay shale, dark		1	6
Clay, ferruginous		5	0
Limestone, gray		4	0
Shale and covered		12	0

		Ft.	In.
Coal blossom, *Redstone*			4
Clay			6
Limestone, dark	*Redstone*	1	2
Clay, gray to yellow		3	0
Limestone		1	0
Clay, yellow		1	2
Limestone		2	0
Clay, yellow		3	4
Clay with limestone nodules		7	8
Shale with thin coal bands	*Pittsburgh*		4
Clay		1	0
Coal blossom		5	4

Redstone Coal and Clay

About 20 to 40 feet above the top of the Pittsburgh coal, is a thin but persistent coal bed which was named the Redstone coal[1] by H. D. Rogers in 1858 for exposures along Redstone Creek, a tributary to the Monongahela River in Fayette County, Pennsylvania. Although this coal is usually thin in Pennsylvania, it is reported to have a thickness of 3 to 4 feet in parts of Fayette and Westmoreland counties. In West Virginia, the Redstone coal also lies about 20 to 40 feet above the Pittsburgh coal and, as in Pennsylvania, is usually thin, but locally in Barbour and Monongalia counties, where it has been mined, it reaches the unusual thickness of 4 to 6 feet. In Ohio and Brooke counties of the Pan Handle area of West Virginia, this coal generally occurs as a thin blossom 30 to 63 feet below the Sewickley coal and 20 to 30 feet above the Pittsburgh coal. In Ohio, the Redstone coal is present in Jefferson County, has been reported in Belmont County, is of doubtful occurrence in Morgan and Noble counties, but is well developed in parts of Meigs County, where it has long been mined and marketed as the Pomeroy coal. Its position varies from 10 to 35 feet above the Pittsburgh coal.

In Jefferson County, the Redstone coal, which lies on an average of 25 feet above the Pittsburgh coal, is very persistent, being present in Ross, Springfield, Knox, Salem, Island Creek, Wayne, Cross Creek, Steubenville, Smithfield, Mount Pleasant, Wells, and Warren townships. In thickness it varies from 6 inches to 2 feet 6 inches with an average of about 1 foot 7 inches, and is usually composed of a single bench of coal, although in places the structure is shaly. It is underlain by a bed of gray, ferruginous, calcareous clay of variable thickness and overlain by arenaceous shale.

In the northern half of the county, the horizon of the Redstone

[1]Rogers, H. D., Geology of Pennsylvania, Vol. II, Pt. I, p. 505. 1858.

coal lies near the summits of the hills where few exposures occur. In Ross Township, the member is represented in the southwestern part of Section 31 by a 5-foot bed of gray plastic clay which lies about 26 feet above the Pittsburgh coal. In Springfield Township, where the horizon of the Redstone coal is confined to the higher elevations, the only exposure of this member occurs in the northwestern part of Section 12 at an elevation of 1,280 feet. It has a thickness of 1 foot 3 inches and lies 25 feet above the Pittsburgh coal.

The Redstone coal is regularly present underlying the hilltops in the central part of Knox Township. It is well exposed along the northeast-southwest road in the south-central part of Section 14, where the coal has a thickness of 11 inches and lies about 23 feet above the Pittsburgh coal. An excellent exposure of this member is also present in the stripping mine of the Ohio River Edison Coal Co., in Section 8, at an elevation of 1,200 feet. The member is 1 foot 4 inches thick and consists of shaly coal interstratified with bands of black shale. The record of the rock succession at this locality is given in the discussion of the Pittsburgh sandstone. (See pages 222, 223.)

In Island Creek Township, good exposures of Redstone coal are found in Sections 21, 29, 30, 31, and 33, where the member is represented by a thin blossom lying at the normal interval above the Pittsburgh bed. The following record, which is typical for the township, was secured along the north-south road in the eastern part of Section 33:

	Ft.	In.
Shale, gray, arenaceous	37	0
Coal blossom, *Redstone*		6
Clay and covered	19	2
Coal blossom, *Pittsburgh*	4	6
Clay		8

The horizon of the Redstone coal in Salem Township lies near the summit of the ridge, extending from East Springfield to Richmond. The presence of this member in the eastern part of the township is indicated by the exposure of a well developed coal on the Redstone horizon in the eastern part of Section 3, where the coal has a thickness of 1 foot 6 inches and lies about 20 feet above the Pittsburgh bed. The Redstone coal is regularly present in the southern part of Steubenville Township, where its thickness and stratigraphic position are normal for this county. North of Cross Creek in Section 28, soft, friable sandstone overlies the Pittsburgh coal and replaces the Redstone coal.

In Cross Creek Township, the Redstone coal is regularly present south of McIntyre Creek. North of McIntyre Creek, this member is in all probability present along the prominent ridge which extends from

Norton Hill to the southeast, although exposures are lacking. The average thickness of the bed in the township is about 1 foot 6 inches. At every exposure it is underlain by calcareous clay with nodular masses of limestone and overlain by arenaceous shale.

The Redstone coal is well exposed in various stripping mines in the southern part of Wayne Township, where it is generally shaly in structure, with a thickness of 1 foot 11 inches. It lies 23 feet above the top of the Pittsburgh coal. In Smithfield Township, this coal is remarkably constant in occurrence, stratigraphic position, and thickness. Mine measurements show variations in thickness ranging from 10 inches to 2 feet with an average of about 1 foot 6 inches. The coal lies on an average about 19 feet above the Pittsburgh bed, although the interval ranges from 13 to 23 feet. The bed is underlain by clay and limestone and overlain by arenaceous shale.

The distribution of the Redstone coal in Wells Township is essentially the same as that of the Pittsburgh bed which lies about 23 feet below this member. A good exposure of the coal occurs along the ridge road in the southern part of Section 11, where it has a thickness of 2 feet 4 inches but is shaly in structure and of no economic value. A thin blossom lying 20 feet above the Pittsburgh coal is also well shown along the northeast-southwest road in the north-central part of Section 27. The bed has an elevation of 1,072 feet and occurs 42 feet below the Sewickley coal and 16 feet above the Pittsburgh coal. The stratigraphic relations of the Redstone coal are well expressed in the following record measured in the southwestern part of Section 33:

		Ft.	In.
Coal blossom, *Uniontown*			6
Clay, with nodular limestone, *Uniontown*		8	0
Shale and covered		85	0
Coal blossom, *Sewickley*			3
Shale, gray, arenaceous		37	0
Limestone, ferruginous, argillaceous, *Fishpot*		6	0
Clay shale		13	0
Sandstone, shaly		8	0
Coal, shaly, *Redstone*		2	3
Shale, dark		1	6
Clay, with limestone nodules	*Redstone*	1	6
Clay, arenaceous	*Redstone*	5	2
Clay, gray, plastic, with limestone nodules	*Redstone*	8	2
Shale, with thin coal bands	*Pittsburgh*		4
Clay parting	*Pittsburgh*		10
Coal	*Pittsburgh*	2	6
Parting	*Pittsburgh*		1
Coal	*Pittsburgh*		2
Parting	*Pittsburgh*		1
Coal	*Pittsburgh*	2	0

In Mount Pleasant Township, the Redstone coal, 2 feet in thickness, is exposed in the central part of Section 24. The interval to the Pittsburgh coal at this place is about 19 feet. In Warren Township, exposures of the coal are found in Sections 8, 13, 19, 23, 28, and 31. The bed, which is thin and of no economic value and which is usually overlain by sandy shale, is separated from the Pittsburgh coal by clay, limestone, and shale, which have an average thickness of about 19 feet.

Pomeroy Sandstone

Above the Pomeroy (Redstone) coal in Meigs County, occurs a massive sandstone which has long been known as the Pomeroy sandstone. This member is of only local importance in Ohio as it is not definitely known to be well developed in any other county in the State. However, in West Virginia, a sandstone member overlying the Redstone coal was described by D. B. Reger in 1916 as the Cedarville sandstone,[1] which represents the same horizon as the Pomeroy sandstone of Ohio, where the member consists of a dark greenish-gray, medium-grained sandstone, about 30 feet in thickness. It has also been reported in Braxton County, West Virginia, but elsewhere in that State it has not been recognized. In Harrison, Belmont, and Jefferson counties, Ohio, the Redstone coal is usually overlain by arenaceous shale whereas farther to the southwest in Noble, Morgan, and Athens counties, this member is of very doubtful occurrence. In Jefferson County, arenaceous shale usually overlies the Redstone coal, but locally a few feet of shaly sandstone is found on this horizon, as for example in the western part of Section 35, Wells Township, where the Pomeroy coal is immediately overlain by 8 feet of shaly sandstone representing the Pomeroy sandstone member.

Fishpot Limestone

In ascending order, the next well-defined member of the Monongahela series is the Fishpot limestone, so named by J. J. Stevenson, and later known as the Sewickley limestone. From Fayette and Westmoreland counties, Pennsylvania, where the member is well developed, it can be traced westward through Greene and Washington counties into the Pan Handle district of West Virginia, where it has a thickness of 10 to 30 feet in Brooke and Ohio counties.[2] From Kanawha County southwest in West Virginia, the limestone disappears and its place is

[1]Reger, D. B., West Virginia Geol. Survey, Rept. Lewis and Gilmer counties, p. 112. 1916.

[2]Grimsley, G. P., West Virginia Geol. Survey, Rept. Ohio-Brooke-Hancock counties, p. 99. 1906.

taken by shale and sandstone. Concerning the character of this member in the Pan Handle area, G. P. Grimsley writes as follows[3]:

"In the Wheeling area the limestone is well developed, but farther north near Wellsburgh the interval contains also shales and sandstones. The rock in its typical development is light gray in color, breaking with smooth and almost shelly fracture. It is hard, but brittle, and is used at a number of places for road material."

In Jefferson County, Ohio, which lies across the Ohio River from Brooke County, West Virginia, the Fishpot limestone is thin and poorly developed. In its typical occurrence it consists of several layers of bluish-gray, compact limestone separated by clay partings, although not infrequently, particularly in the central part of the county, it is represented by a single layer of limestone which is overlain and underlain by shale. The thickness of the interbedded shale layers varies from a few inches to as much as 6 feet, and the average thickness of the Fishpot limestone together with its intercalated shale is about 3 feet, although variations may occur ranging from 6 inches to 13 feet. On the average the base of the member in this county lies about 16 feet below the Sewickley coal and 40 feet above the top of the Pittsburgh coal. The Fishpot limestone, like all limestone members above the Skelley, is of fresh or brackish water origin and contains remains of the fresh water annelid *Spirorbis anthracosia* Whitfield. In Jefferson County, outcrops of this limestone are present in Knox, Cross Creek, Wells, Smithfield, Mount Pleasant, and Warren townships.

Although the Fishpot limestone is due near the summits of the high ridges in Sections 8, 9, 14, and 20, Knox Township, it is nevertheless generally wanting, its place being occupied by shale. The only exposure of this member present in the township is just north of Knoxville in the southern part of Section 15, where it is represented by a single ledge of limestone, 1 foot in thickness, lying 75 feet above the Pittsburgh coal.

In Cross Creek Township, the Fishpot limestone is generally wanting. However, a 6-inch layer of gray limestone occurs on this horizon in the northwestern corner of Section 19, about 21 feet above the Redstone coal. Outcrops also occur along the road in the western part of Section 7, where the member consists of an impure, nodular limestone, 1 foot in thickness, which lies 22 feet above the Redstone coal and which is overlain and underlain by clay shale.

In Smithfield Township, the Fishpot limestone is present in sec-

[3]Grimsley, G. P., West Virginia Geol. Survey, Rept. Ohio-Brooke-Hancock Counties, p. 99. 1906.

tions 1, 2, 12, 15, and 27. At many places the member is wanting and where present it is poorly developed. It often consists of a single layer embedded in shale. In the southwestern part of Section 2, is an unusual development of the Fishpot limestone with a total thickness of about 17 feet. The member at this locality consists of about equal proportions of thin-bedded limestone and shale with the base lying 5 feet above the Redstone coal and the top about 49 feet below the Sewickley coal.

In Wells Township, the Fishpot limestone outcrops in the southwestern part of Section 35 with a total thickness of 6 feet. In Mount Pleasant Township, limestone belonging to the Fishpot member is found at a number of places along Short Creek and Long Run. The character of the limestone and its stratigraphic relations to the overlying and underlying beds are well shown in the following geologic section, measured along a small ravine in the northwestern part of Section 11. The Redstone coal is wanting, its place being taken by the Redstone limestone, and the Fishpot limestone is represented by 15 feet of interstratified limestone and shale directly above the Redstone limestone.

		Ft.	In.
Black shale and shaly coal, *Sewickley*		3	0
Clay shale, black		5	0
Sandstone, shattered		19	6
Clay shale with limestone layers, *Fishpot*		15	0
Limestone, dark, layers varying from 1 to 1½ feet in thickness, *Redstone*		29	0
Covered interval		8	5
Coal	*Pittsburgh*	2	8
Parting			½
Coal			8
Parting			½
Coal		2	2
Clay, gray, plastic		2	2

The Fishpot limestone is regularly present in Warren Township south of Short Creek. In the northern part of Section 23, it is represented by a 2-foot layer of compact limestone 16 feet above the Redstone coal and 19 feet below the Sewickley coal. Outcrops in the south-central part of Section 28 show that the member has a thickness of 2 feet 9 inches. The following geologic section, measured near the mine of the Ohio and Pennsylvania Coal Co. in the southwestern part of Section 22, illustrates the stratigraphic relations of the member, which are also typical for the southeastern part of the township.

		Ft.	In.
Shale, bony, *Sewickley*			10
Shale		14	8
Covered interval		2	0
Limestone, argillaceous, with shale partings, *Fishpot*		13	6
Covered interval		28	0
Clay, gray		3	0
Shale and shaly coal	*Pittsburgh*		5
Clay			10
Coal, shaly		1	9
Clay			10
Coal, shaly			2
Coal, good		2	8
Parting			1
Coal			4
Parting			1
Coal, good		3	0
Clay		3	3

The occasional occurrence of the Fishpot limestone beneath the high ridges in the northern part of the township is shown by the outcrops in the northern part of Section 31 and by the nodules of limestone scattered over the horizon in sections 7 and 8.

Fishpot Coal

In the reports of the First Geological Survey of Pennsylvania, the name Sewickley was given by H. D. Rogers to a thin coal bed outcropping in southwestern Pennsylvania, having a thickness of 1½ to 4½ feet and lying about 100 feet above the Pittsburgh coal[1]. This coal bed is well developed and of local economic importance in parts of Greene, Fayette, and Westmoreland counties, Pennsylvania, and in Monongalia and Marion counties, West Virginia. East of the counties last named, in the Georges Creek Basin of Maryland, two beds of coal are found about 45 feet apart. The lower bed, which lies about 42 feet above the Redstone coal and is thin and of little value, is known as the Lower Sewickley, and the upper bed, the better developed of the two, is called the Upper Sewickley, Tyson, or Gas coal[2]. In the Pan Handle region of West Virginia, two coals likewise occur, as shown in the following section measured by G. P. Grimsley at the Creighton Slope mine at Elm Grove, Ohio County[3].

[1]Rogers, H. D., Geology of Pennsylvania, Vol. II, Pt. I, p. 505. 1858.

[2]Martin, G. C., Maryland Geol. Survey, Rept. Garrett County, pp. 186, 207.

[3]Grimsley, G. P., West Virginia Geol. Survey, Rept. Ohio-Brooke-Hancock counties, p. 81. 1906.

Monongahela series	Ft.	In.
Coal, *Waynesburg*	2	0
Shale, sandy	7	8
Limestone, gray	2	0
Concealed	46	8
Limestone, gray, nodular, *Uniontown*	3	0
Sandstone	4	0
Concealed and sandy shale	60	0
Limestone, blue	10	4
Concealed	25	10
Coal, *Upper Sewickley*	2	0
Shales	22	0
Coal, *Lower Sewickley*	2	0
Limestone and shales	64	0
Coal, *Pittsburgh*	5	0

Concerning the relative persistence of the Sewickley coals in the Pan Handle of West Virginia, G. P. Grimsley writes as follows[1]:

"As the Sewickley coal was traced northward in the Ohio-Brooke County area, one of the two seams disappears and the remaining one is only a few inches thick, being represented in some sections by a black slate. This decrease in thickness of the coal agrees with Dr. Stevenson's observations in Pennsylvania. He also states that while the upper vein is of workable thickness in eastern Belmont County, Ohio, it disappears northward along the river long before Steubenville is reached. The evidence available in the Pan Handle area would indicate that the seam which remains at the north is the Upper Sewickley and that the Lower has been cut out."

In Jefferson County, Ohio, two coals are found on the Sewickley horizon as in the Pan Handle area of West Virginia and the Georges Creek Basin of Maryland. Furthermore, the field data in this county support Grimsley's statement, as the upper coal, correlated with the Upper Sewickley, is not only more persistent in the central and southern part of the county where the lower coal is present, but has been identified as far north as Knoxville, Knox Township, where the lower bed is wanting. The lower coal of this area is correlated with the Lower Sewickley of West Virginia but due to its association with the Fishpot limestone, Wilber Stout, chief of the Geological Survey of Ohio, proposes the name Fishpot for the lower bed. This name will supplant the term Lower Sewickley in future publications on the Monongahela series in Ohio.

In Jefferson County, the Fishpot coal is represented by black, carbonaceous shale with thin coal bands or by a few inches of bone shale. The thickness ranges from 1 inch to 4 feet 8 inches with an average of about 1 foot. This bed lies on an average 39 feet above

[1]Grimsley, G. P., West Virginia Geol. Survey, Rept. Ohio-Brooke-Hancock Counties, p. 81. 1906.

the Redstone coal and about 64 feet above the top of the Pittsburgh coal. The interval between the Fishpot and Sewickley coals in this county varies from 10 to 30 feet with an average of about 18 feet. Outcrops of Fishpot coal are present in Cross Creek, Smithfield, and Warren townships.

In Cross Creek Township, outcrops of Fishpot coal are present in sections 4, 7, and 14. In the southeastern corner of Section 4, this member is represented by 1 inch of bone shale located about 56 feet above the Pittsburgh coal and 18 feet below the Sewickley coal. In the southwestern part of Section 14, the Fishpot is represented by 4 feet 8 inches of black, fissile shale which lies 63 feet above the Pittsburgh coal and about 11 feet below the Sewickley coal. The following geologic section, measured along the road a half of a mile north of New Alexandria, shows the stratigraphic relations of the Fishpot coal to the overlying and underlying members:

	Ft.	In.
Limestone with shale partings, *Benwood*	17	9
Shale, friable, calcareous	15	4
Shale, with nodules of limestone	4	6
Shale, gray, arenaceous	2	4
Shale, black, carbonaceous, *Sewickley*		6
Shale, gray, arenaceous	3	2
Sandstone, *Fishpot*	7	10
Shale, gray, micaceous, arenaceous	4	8
Shale, black, fissile, *Fishpot*	3	0
Clay shale and covered	5	2
Shale, arenaceous	9	6
Clay shale, dark	5	0
Limestone, nodular, *Fishpot*	1	0
Clay shale	7	0
Sandstone		4
Shale, gray, arenaceous	15	0
Coal, shaly, *Redstone*	1	9
Shale, greenish, arenaceous	3	11
Clay, with nodular limestone, *Redstone*	1	9
Clay and covered	6	0
Coal blossom, *Pittsburgh*	3	0

In Smithfield Township, the Fishpot coal is represented by a few inches of black, carbonaceous shale with an occasional thin coal band. The average thickness is about 7 inches, although variations are found which range from 3 inches to 1 foot 6 inches. The position of the Fishpot member is on an average about 21 feet below the Sewickley coal. The intervening rocks are gray, arenaceous shale and shaly sandstone. Exposures are found in Sections 1, 15, 16, and 27. The strati-

graphic position of the Fishpot coal is shown in the following record of outcrops exposed along the northeast-southwest road in the eastern part of Section 16. The interval between the coal horizons as shown in this record is typical for the township.

	Ft.	In.
Shale, unmeasured.		
Shale, black, with coal bands, *Sewickley*	1	0
Shale and covered	4	8
Sandstone	2	0
Shale, gray, arenaceous	23	4
Shale, black, with thin coal bands, *Fishpot*	6	0
Clay	1	0
Shale, gray, arenaceous	45	0
Coal blossom, *Redstone*		3
Covered interval	15	5
Coal blossom, *Pittsburgh*	5	0

Although a few exposures of the Fishpot coal horizon have been noted in Warren Township, this bed is as a rule wanting. In composition it usually consists of black shale or shale with thin coal bands which never exceeds 2 feet in thickness. Exposures have been noted in Sections 8, 13, 14, 19, 28, 29, and 31. One of the best records in this township showing the Fishpot coal was secured along the road west of Tiltonville as given below:

	Ft.	In.
Shale and covered	27	2
Black shale and shaly coal, *Sewickley*	2	0
Shale, black, fissile	1	10
Shale and shaly sandstone	14	0
Shale, dark	14	0
Shale, bony, *Fishpot*		6
Shale and covered	11	6
Covered interval	36	0
Coal, abandoned mine, Pittsburgh.		

Fishpot Sandstone

At some localities along the belt of outcrops of the Monongahela series of eastern Ohio, is a thin sandstone lying between the Fishpot and Sewickley coals, which Wilber Stout, chief of the Geological Survey of Ohio, suggests be named the Fishpot sandstone. The stratigraphic position of this sandstone, a few feet below the Sewickley coal, suggests its correlation with the Lower Sewickley sandstone[1] which has been recognized over large areas in West Virginia.

[1]Hennen, R. V., West Virginia Geol. Survey, Doddridge-Harrison Rept., p. 201. 1912.

In Jefferson County, Ohio, the place of the Fishpot sandstone is marked in a few localities by thin lenses of soft, friable, micaceous sandstone, but the type of rock usually found on this horizon is arenaceous shale. Thus in Section 7, Cross Creek Township, the Fishpot is represented by 7 feet 10 inches of micaceous sandstone overlain by 3 feet and underlain by 4 feet 8 inches of arenaceous shale. In Sections 4, 14, and 19, the sandstone is wanting, having been replaced by shale. In Wayne and Wells townships, the Fishpot sandstone is generally wanting, but in Section 16, Smithfield Township, it is represented by about 2 feet of micaceous sandstone lying 5 feet below the Sewickley coal. In Section 27, Smithfield Township, the Fishpot coal, Fishpot sandstone, and Sewickley coal are well exposed, with the stratigraphic relations indicated in the following section:

	Ft.	In.
Limestone, nodular, *Benwood*		8
Shale and covered	20	4
Coal blossom, *Sewickley*	1	0
Shale, gray, arenaceous	9	11
Sandstone, shaly, *Fishpot*	5	6
Shale, black, carbonaceous, *Fishpot*		5
Shale, arenaceous, and covered	39	8
Coal, shaly, *Redstone*	1	0

In this section the Fishpot coal is represented by 5 inches of black, carbonaceous shale.

In Section 12, Mount Pleasant Township, the Fishpot member is represented by 4 feet 6 inches of micaceous sandrock lying about 16 feet below the Sewickley coal. The only exposure of this member observed in Warren Township occurs in Section 19, where Fishpot sandstone, 5 feet in thickness, forms the floor of the Sewickley coal.

Sewickley Coal

In southwestern Pennsylvania, is a coal bed lying about 100 feet above the Pittsburgh coal, which H. D. Rogers named the Sewickley coal[1]. This coal bed is now correlated with the Sewickley or Upper Sewickley of West Virginia, the Upper Sewickley or Tyson coal of Maryland, and the Meigs Creek coal of Ohio.

In Jefferson County, the Sewickley coal is generally present where due, although it is everywhere thin and always impure and of no economic importance. The thickness of the bed varies from a few

[1]Rogers, H. D., Geology of Pennsylvania, Vol. II, Pt. I, p. 505. 1858.

inches to 3 feet but averages about 1 foot. It consists of shale with thin coal bands, but the proportion of coal is in general greater than in the Fishpot coal bed with which it may be confused in the field. The position of the Sewickley coal in Jefferson County is on an average about 18 feet above the Fishpot coal, about 59 feet above the Redstone coal, and about 85 feet above the top of the Pittsburgh coal. Outcrops of this bed have been recognized in Knox, Cross Creek, Wayne, Wells, Smithfield, Mount Pleasant, and Warren townships.

The Sewickley horizon lies near the summits of the highest hills in Knox Township in Sections 14 and 20. An 8-inch blossom of this coal was observed to occur at the forks of the road three-eighths of a mile south of Knoxville at an elevation of 1,225 feet, 51 feet above the Redstone coal and 75 feet above the Pittsburgh coal.

In Cross Creek Township, the Sewickley coal is present in sections 4, 7, 14, and 19. In the southwestern part of Section 14, the Sewickley coal is represented by 6 inches of black shale below which is about 10 feet of arenaceous shale. A similar condition is found in the southwestern part of Section 7. The following geologic section, measured along the road in the southern part of Section 4, shows the stratigraphic relation of the Sewickley coal to the underlying members:

	Ft.	In.
Shale, gray, arenaceous	10	0
Shale, dark, argillaceous	4	3
Shale, bony, *Sewickley horizon*		3
Clay and clay shale	10	4
Shale, gray, arenaceous	7	2
Clay shale, dark		8
Shale, bony, *Fishpot coal horizon*		1
Clay, gray	8	3
Shale, arenaceous	13	5
Coal blossom, shaly, *Redstone*	2	0

In Wayne Township, a thin blossom of Sewickley coal is exposed at an elevation of 1,276 feet in the northern part of Section 33, where it lies 60 feet above the Redstone coal and 81 feet above the top of the Pittsburgh coal. The Sewickley coal is also represented by a thin blossom in the northern part of Section 15. The altitude of the member is 1,240 feet or its position 90 feet above the Pittsburgh bed.

The horizon of the Sewickley coal lies near the summits of the ridges in the eastern part of Wells Township, but about 100 to 150 feet below the tops of the ridges in the western part of the township. The bed is thin, consisting of only a few inches of black shale, and its

position is about 60 to 65 feet above the Redstone coal. Outcrops are present in Sections 11, 23, 24, 27, 30, and 35. In the central part of Section 11, a 6-inch coal blossom representing the Sewickley member outcrops along the east-west road with an altitude of 1,053 feet. It lies 92 feet above the base of the Pittsburgh coal and 14 feet below the Benwood limestone. Thin blossoms of coal likewise occur in the north-central part of Section 23 and along the western edge of Section 24. At both exposures the interval to the Pittsburgh coal is about 90 feet. Again Sewickley coal, 6 inches thick, is exposed along the road in the northern part of Section 27 at a height of 83 feet above the Pittsburgh.

In Smithfield Township, the Sewickley member is composed either of black shale and shaly coal or entirely of black shale. Its thickness varies from a few inches to 2 feet but averages about 1 foot. The position of the bed is on an average about 50 feet above the Redstone coal and 21 feet above the Fishpot coal. Exposures are found in Sections 2, 15, 16, 17, 27, 28, and 35. In Section 2, the horizon consists of 1 foot of black coaly shale, which outcrops about 92 feet above the Pittsburgh coal. In Sections 15 and 16, the bed has a thickness of about 1 foot and lies 90 feet above the Pittsburgh coal. The following record, secured in the southern part of Section 27, is typical for this township:

	Ft.	In.
Coal blossom, *Sewickley*		2
Shale, gray, arenaceous	10	7
Shale, black, fissile, *Fishpot coal horizon*		6
Shale, gray, arenaceous	16	0
Limestone, one layer, *Fishpot*		6
Shale, gray, arenaceous	6	2
Shale, argillaceous	4	0
Shale, dark, platy	10	6
Coal blossom, *Redstone*		6

In Mount Pleasant Township, the Sewickley coal is regularly present along Long Run and other tributaries of Short Creek. Near Ramseyville, it is represented by 8 inches of black shale with thin coal bands at a height of 83 feet above the Pittsburgh coal. A good exposure of Sewickley coal, 1 foot in thickness, is present along the road in the northeastern part of Section 12, where it is composed of black shale with thin bands of shaly coal. It is underlain by 15 feet of shale, below which is found micaceous sandrock, 4 feet 6 inches in thickness, representing the Fishpot sandstone. In Section 11 along the road leading from Mount Pleasant to Dillonvale, the Sewickley coal has been prospected, and a measurement shows 3 feet of coal and black shale below which is 5 feet of black clay shale underlain with sandstone. The top of the coal lies about 5 feet below the Benwood limestone.

In Warren Township, a black shale and shaly coal representing the Sewickley coal horizon are usually found 50 to 75 feet above the Pittsburgh coal. The Fishpot coal, with which it may be confused in the field, is generally wanting in this township. The thickness of the bed varies from 6 inches to 2 feet but averages about 1 foot 4 inches. The stratigraphic relations of the Sewickley coal in this township are illustrated in the following record secured in the southern part of Section 19:

		Ft.	In.
Limestone layer, bluish-gray	*Benwood*		6
Shale and covered		3	9
Limestone layer		2	0
Shale, gray, argillaceous		8	8
Limestone, bluish, flinty		1	2
Shale and covered		6	4
Limestone, shaly		4	0
Clay shale, dark		5	2
Coal and coaly shale, *Sewickley*		1	8
Sandstone, shaly, *Fishpot*		5	0
Shale, gray, arenaceous		19	2
Shale and covered		11	8
Coal blossom, *Redstone*			2

Sewickley Sandstone

Concerning the Sewickley sandstone, I. C. White writes as follows[1]:

"Along the eastern crop of the Monongahela series, a thick, massive sandstone frequently comes into the section and cuts out a large portion of the Great Limestone. This sandstone overlies the Sewickley coal closely and hence has been termed the Sewickley sandstone."

In Jefferson County, Ohio, the basal part of the Benwood limestone lies only a few feet above the Upper Sewickley coal horizon. Although the intervening shale is usually arenaceous, especially so near the basal part, there is no evidence of a well-defined sandstone at this horizon.

Benwood Limestone

In the reports of the First Geological Survey of Pennsylvania, the Great Limestone of Rogers included the entire rock series between the Uniontown and Sewickley coals. Later this member was divided into two parts[2]: the upper part lying immediately below the Uniontown coal was named by J. J. Stevenson the Uniontown limestone, and the

[1]White, I. C., West Virginia Geol. Survey, Vol. II, p. 152. 1903.
[2]Stevenson, J. J., Second Geol. Survey Pennsylvania, Rept. K, pp. 63-64. 1874.

lower part, which occurs closely above the Sewickley coal, was called the Benwood limestone by I. C. White for exposure near Benwood, Marshall County, West Virginia. In parts of Pennsylvania and West Virginia, sandstone and arenaceous shale are present in sufficient thickness between the upper and lower divisions of the Great Limestone to make these subdivisions easily recognized, but in parts of northwestern West Virginia these sandstones and shales disappear and the two members are therefore difficult to separate. The basis for separation in the Pan Handle area is well expressed by G. P. Grimsley as follows[1]:

"In the Ohio County area, where the Uniontown coal is absent, there is found a very persistent bed of green shale at horizon 80 to 100 feet below the Waynesburg coal and 80 to 90 feet above the Sewickley. There is a marked contrast in the limestone above and below this shale, but the characters of the rock agree closely with those given by Stevenson for the Lower and Upper divisions of the Great Limestone in Pennsylvania. In the present report this green shale is taken as the dividing horizon between the Upper or Uniontown limestone and the Lower or Benwood."

The Benwood limestone is well developed in Greene and Washington counties, Pennsylvania, where it has a thickness of 50 to 90 feet. In West Virginia, this member is present in Monongalia, Marion, Taylor, Harrison, and Doddridge counties, but thins to the southwest, and beyond the Little Kanawha River is replaced by shale. In the Pan Handle area the limestone is present in Ohio and Marshall counties, where G. P. Grimsley describes it as follows[2]:

"The limestone below the Fulton Green Shale forms vertical cliffs along Wheeling, Middle Wheeling, Little Wheeling, and Short creeks. It consists of solid layers alternating with shaly layers. The rock weathers in a very characteristic manner into angular fragments, giving the layers a complex fractured appearance as though broken by some sudden shattering force. It is this property of weathering into small fragments which soon break off that explains the vertical walls.

"The limestone on fresh fracture is blue to black in color, but weathers to a light gray or buff. The lower layers are buff in color, breaking with a smooth almost slaty fracture, and are locally known as the cement beds or cement rock."

The green shale zone, mentioned by G. P. Grimsley and named by him the Fulton Green shale, is regularly present in Jefferson County, where it is used to separate the Benwood and Uniontown members. The lower limestone, the Benwood, is regularly developed and fairly persistent in the southern half of the county, including Cross Creek, Wells, Smithfield, Mount Pleasant, and Warren townships. It usually con-

[1]Grimsley, G. P., West Virginia Geol. Survey, Rept. Ohio-Brooke-Hancock Counties, p. 91. 1906.

[2]Idem. pp. 92-93.

sists of thin but solid lens-like layers of limestone alternating with calcareous shale, the shale predominating in thickness. It is bluish-black in color, weathering to a light gray or buff. In many places the limestone breaks up characteristically into angular pieces resembling fragments of flint. Fossils of minute fresh water forms such as ostracods and the annelid, *Spirorbis anthracosia* Whitfield, are present. This limestone member, which has a thickness ranging from 5 to 45 feet, varies in position from 5 to 35 feet above the Sewickley coal but averages about 19 feet.

The Benwood limestone is regularly present near the summits of the highest knobs in the southern part of Cross Creek Township. It is well exposed in the western part of Section 14, where it has a thickness of 21 feet. The following geologic section, a record of the rock exposures at this place, is representative for this region:

		Ft.	In.
Clay shale, green, *Fulton*		4	8
Limestone, impure, argillaceous			7
Clay shale	*Benwood*	4	0
Limestone, argillaceous		1	6
Clay shale		9	10
Limestone, bluish-black			7
Shale and covered		3	11
Limestone, bluish			8
Shale, gray arenaceous		25	10
Clay, dark		1	2
Shale, black, *Sewickley*			6
Shale, gray, arenaceous		10	6
Shale, dark, fissile, *Fishpot*		4	8

The Benwood limestone is also present in Sections 6 and 7, Cross Creek Township. Where exposed along the road in the western part of Section 7, the member shows a thickness of 19 feet, about 27 per cent of which is limestone.

In Wells Township, the Benwood member, 25 feet in thickness and consisting largely of shale, is well exposed in Section 11. In Smithfield Township, it is usually present but is somewhat variable in thickness and structure, the thickness ranging from 11 to 30 feet. In places the base of the member descends within a few feet of the Sewickley coal, but elsewhere as much as 28 feet of shale intervenes. In the following geologic section, measured along the northeast-southwest road in the east-central part of Section 8, the character and stratigraphic relation of the Benwood limestone to the Fulton Green shale above and to the Sewickley coal below are excellently shown:

		Ft.	In.
Limestone, argillaceous, *Uniontown*		3	0
Shale, olive green, *Fulton*		8	6
Shale, gray, arenaceous		7	0
Limestone, bluish	*Benwood*	1	4
Shale		5	0
Limestone		1	0
Shale and covered		3	0
Limestone		2	3
Shale and covered		2	11
Limestone, light		1	2
Shale, gray, arenaceous		16	6
Shale, dark		3	0
Shale, black, fissile, *Sewickley*		2	2

The Benwood limestone was formerly worked in a small way just south of the road in the northeastern part of Section 23, but the thickness of the stone quarried could not be determined. It has also been quarried for road material just east of the road in the southeastern part of Section 33, where the ledge of stone has a thickness of 1 foot 10 inches and lies at an elevation of 1,130 feet.

Likewise, in Mount Pleasant Township, the Benwood limestone is usually present where due. The member attains its greatest thickness in the township along the ravine which parallels the road in the northeastern part of Section 11, where the record given below was measured:

		Ft.	In.
Coal, not entire thickness, *Waynesburg*		2	6
Covered interval		111	8
Limestone, dark	*Benwood*	4	4
Shale			6
Limestone		5	10
Shale and covered		6	6
Limestone, dark, massive		3	0
Clay shale, gray		4	8
Black shale with shaly coal, *Sewickley*		3	0

The limestone, which at this place has an aggregate thickness of 13 feet, is dark, bluish-gray to black in color and breaks with the conchoidal fracture of flint.

In Warren Township, the Benwood limestone is generally present along the high ridge north of Short Creek although few good exposures can be found. South of Short Creek, however, outcrops are found in Sections 19, 22, and 23, where the thickness varies from 22 to 44 feet. The lithology, structure, and stratigraphic relations of this member are typical for the county and similar to those already described.

Fulton Green Shale

The Fulton Green shale, first named by G. P. Grimsley in 1906 for its occurrence near Fulton, Ohio County, West Virginia, and used by him as a basis for separating the Benwood and Uniontown limestones in that region, has been recognized in Monongalia, Marion, Taylor, Doddridge, Harrison, and Barbour counties of that State, and is also present west of the Ohio River in Jefferson, Belmont, and Monroe counties, where it is thin but very persistent. It is a finely laminated, dark green, clay shale which fades on weathering to a light green or bluish-green color. The thickness of the shale in Jefferson County ranges from 2 to 14 feet, but its usual thickness is from 4 to 6 feet. The average position of the bed, as indicated in the generalized geologic section for Jefferson County, is immediately overlying the Benwood limestone or about 121 feet above the Pittsburgh coal and 95 feet below the Waynesburg coal. Outcrops are limited to Cross Creek, Springfield, Mount Pleasant, and Warren townships.

In Cross Creek Township, the Fulton Green shale is found along the high ridge south of McIntyre Creek and along the eastern end of the spur ridges between McIntyre and Cross Creek. It varies from 3 feet 6 inches to 9 feet in thickness and is overlain by clay shale or impure limestone. In Smithfield Township, the member has been recognized in Sections 1, 14, 15, and 28. The following record made along the east bank of Piney Fork in the southeastern part of Section 15, shows the stratigraphic relation of the Fulton shale to the Uniontown limestone above and to the Benwood limestone below:

		Ft.	In.
Limestone, nodular, *Uniontown*		1	0
Shale, olive green, *Fulton*		10	0
Shale and covered		22	10
Limestone	*Benwood*	1	0
Shale and covered		3	5
Limestone, massive		2	9
Shale and covered		19	10
Shale, black, *Sewickley*			10
Shale, gray, arenaceous		10	4
Shale, black, *Fishpot*			8

Exposures of the Fulton Green shale occur in Mount Pleasant Township in Sections 30 and 35. Although the stratigraphic relations are similar to those shown in the above section, the shale has a thickness of only 2 feet. The rock succession below and including the Fulton Green shale is illustrated in the following geologic section measured near Ramseyville in Section 30:

		Ft.	In.
Shale, green, *Fulton*		2	0
Shale, yellowish		10	4
Limestone, ferruginous, with shale parting	*Benwood*	10	0
Limestone, dark	*Benwood*	1	0
Shale and covered	*Benwood*	5	0
Limestone, dark	*Benwood*	2	0
Shale and covered		26	0
Black shale and coal, *Sewickley*			8
Shale and covered		41	0
Limestone, dark	*Sewickley*	2	0
Covered interval	*Sewickley*	6	10
Limestone, bluish	*Sewickley*	1	2
Covered interval		11	0
Clay, gray, plastic		1	10
Coal blossom, *Redstone*		2	0

In Warren Township, this shale member is present along the ridges on either side of Little Short Creek where its character, thickness, and stratigraphic relations are normal for Jefferson County.

Arnoldsburg Limestone

The upper division of the Great Limestone of the First Geological Survey of Pennsylvania was named the Uniontown limestone by J. J. Stevenson for its close association with the Uniontown coal, and later was more accurately defined by G. P. Grimsley as the limestone lying close above the Fulton Green shale. In Pennsylvania, this member is of common occurrence in Greene, Washington, Fayette, and Westmoreland counties and consists of 6 to 18 feet of limestone which lies immediately below the Uniontown coal. In West Virginia, where the areal extent of this limestone is essentially the same as that of the Benwood, G. P. Grimsley describes it as follows[1]:

"The limestone above the green shale is hard, blue rock, 1 to 2 feet thick, resting directly on the green shale or a short distance above. Then comes a series of sandy lime layers buff to brown in color, and shaly. These calcareous shales finally pass into typical buff shales with thin sandstone layers and in places thin limestone strata. Their thickness varies from 20 to 50 feet."

In many parts of West Virginia and eastern Ohio, including Jefferson County, the limestone between the Uniontown coal and Fulton Green shale is divided into two well-defined limestone horizons separated from each other by arenaceous shale or sandstone. The lower part of the limestone lies in contact with or closely above the Fulton shale, and the

[1]Grimsley, G. P., West Virginia Geol. Survey, Rept. Ohio-Brooke-Hancock Counties, p. 91. 1906.

upper part is usually found a few feet below the Uniontown coal. D. B. Reger of the West Virginia Geological Survey proposes to restrict the Uniontown limestone to that part which lies closely below the Uniontown coal and to use the term Arnoldsburg for the limestone which lies close above the Fulton Green shale. The term Arnoldsburg is hereby accepted by the Geological Survey of Ohio and will be used in this and subsequent reports on the Monongahela series of this State.

In Jefferson County, the Arnoldsburg member is generally thicker than the Uniontown, consisting of several layers of light gray to buff limestone interbedded with buff, calcareous clay shale. Exposures of the Arnoldsburg are present in Wayne, Cross Creek, Smithfield, Mount Pleasant, and Warren townships. The following geologic section, measured along the road in the northeastern part of Section 1, Smithfield Township, shows the stratigraphic relation of the Arnoldsburg limestone to the overlying and underlying beds:

	Ft.	In.
Coal blossom, *Uniontown*		4
Clay and covered	2	6
Limestone, dark, bluish-black, *Uniontown*	2	6
Shale, arenaceous	36	6
Covered interval	5	0
Limestone, yellowish-brown, *Arnoldsburg*	3	0
Shale, green, *Fulton*	3	6
Covered interval	20	8
Limestone, *Benwood*		10
Covered interval	15	0
Shale, arenaceous	11	2
Shale, black, *Fishpot coal horizon*	1	6

In the central part of Section 19, Wayne Township, the Arnoldsburg member is represented by 1 foot of light-colored limestone outcropping 3 feet above the top of the Fulton Green shale. In Cross Creek Township, this member is generally present in Sections 12, 7, 14, and 19, although it is everywhere thin and poorly developed. In the northwestern part of Section 19, it has a thickness of 8 inches and lies about 10 feet above the Fulton Green shale. An 8-inch layer of this limestone is also present a few feet above the Fulton shale in the southwestern part of Section 14. An unusual development of this limestone is shown in the following geologic section measured in the northwestern part of Section 7:

		Ft.	In.
Limestone, buff, nodular		2	6
Shale, blue to bluish-gray		4	6
Limestone, buff	*Arnoldsburg*		8
Clay shale, calcareous		2	3
Limestone, buff, argillaceous		4	9

		Ft.	In.
Shale, green, *Fulton*		3	5
Clay shale, gray, calcareous	*Benwood*	1	4
Limestone, nodular		1	7
Clay shale, gray, calcareous		3	7
Limestone, hard			9
Clay shale, calcareous		6	11
Limestone, hard, gray			8
Shale, gray, calcareous		2	10
Limestone, gray			3
Shale			9
Limestone		2	0
Shale, friable, calcareous		15	4

The Arnoldsburg limestone is generally present near the summits of the divides in the southern half of Smithfield Township, but it is everywhere thin and of no importance except for its stratigraphic interest. In Section 28, it is represented by 1 to 3 feet of impure, argillaceous limestone lying only a few feet above the Fulton Green shale; in Section 15, by 1 foot of limestone lying immediately above the Fulton shale member; and in Section 14, by 8 inches of limestone lying about 5 feet above the Fulton shale.

The Arnoldsburg limestone in Mount Pleasant Township is local in its occurrence and everywhere thin, and similar conditions of thickness and distribution hold true for Warren Township, where only one good exposure of this member was found. Just west of Tiltonville, Warren Township, the Arnoldsburg member outcrops along the road as two thin layers of limestone, each less than one foot in thickness, with the base lying in contact with the Fulton Green shale.

Arnoldsburg Sandstone

The Arnoldsburg sandstone was first named from its exposure near Arnoldsburg, Calhoun County, West Virginia, where it is a heavy-bedded rock 40 to 50 feet in thickness which lies between the Arnoldsburg limestone and Uniontown limestone. Although the Arnoldsburg is a well-developed member along the eastern belt of outcrops of the Monongahela series of West Virginia from Kanawha County to the northward, it is not strongly developed in Ohio. In the southern part of Jefferson County, where the horizon of the Arnoldsburg sandstone outcrops, the sandstone is wanting and its place is occupied by arenaceous shale.

Uniontown Limestone

The Uniontown limestone, first named by J. J. Stevenson for its

close association with the Uniontown coal, and later defined by Grimsley as extending from this coal bed down to the Fulton Green shale, is here used to include the thin limestone which lies above the arenaceous shale or sandstone of the Arnoldsburg horizon and below the Uniontown coal. As thus used the horizon of the Uniontown limestone is more sharply limited as it formerly included the Arnoldsburg sandstone and Arnoldsburg limestone horizons.

The Uniontown limestone is rather thin and patchy in its distribution in the southern part of Jefferson County where its horizon outcrops. It usually consists of a single layer of dark, bluish-black limestone embedded in the argillaceous shales underlying the Uniontown coal, and it ranges in thickness from 6 inches to 2 feet 6 inches, with an average in the county of about 1 foot 4 inches. Its position is about 4 feet 6 inches below the Uniontown coal. Outcrops of Uniontown limestone have been identified in only Smithfield and Warren townships.

In Smithfield Township, the Uniontown limestone is well exposed in the northeastern part of Section 28, where it has a thickness of 1 foot and lies 30 feet above the Fulton Green shale. In the central part of Section 14, the following instructive record was secured showing the rock succession from the Fulton shale to the Uniontown coal:

	Ft.	In.
Coal blossom, *Uniontown*		4
Shale and covered	5	0
Limestone, dark, flinty, *Uniontown*	1	0
Shale, gray, arenaceous	42	10
Sandstone		8
Clay shale, bluish-gray	3	0
Limestone, marly		8
Shale, calcareous, with nodules of limestone, *Arnoldsburg*	4	6
Shale, green, *Fulton*	3	10

In the northwestern part of Section 14, Warren Township, the Uniontown limestone is present with a thickness of 8 inches, and lies about 5 feet below the Uniontown coal. In Section 23, the limestone has a thickness of 1 foot and lies 5 feet below the Uniontown coal. The stratigraphic relations of the Uniontown limestone in Warren Township are well illustrated in Section 28, where the following record was obtained:

	Ft.	In.
Coal blossom, *Uniontown*	1	0
Clay and covered	5	0
Shale, gray, arenaceous	16	0

	Ft.	In.
Clay with layers of light-colored limestone, shows some brecciation, *Uniontown*	6	0
Shale and covered	24	0
Clay and clay shale with limestone, *Arnoldsburg*	10	6

The Uniontown limestone exposed in the above locality is not typical for Warren Township in that it consists chiefly of nodules of stone embedded in calcareous clay. The Uniontown limestone has no economic value in Jefferson County.

Uniontown Coal

The first member above the Uniontown limestone is the Uniontown coal which was named by the First Geological Survey of Pennsylvania for exposures near Uniontown, Fayette County. This coal bed has its greatest development near the type locality, but nevertheless it is wide-spread in its occurrence in both West Virginia and Ohio. In West Virginia, I. C. White describes its importance as follows[1]:

"It is seldom more than three feet thick, often only two, and sometimes represented merely by black slate, so that from an economic standpoint it is of little present value, since in most cases it is rather high in ash and other impurities."

In Jefferson County, the presence of the Uniontown coal is indicated by thin blossoms a few feet above the Uniontown limestone in Wayne, Smithfield, Mount Pleasant, and Warren townships. At no place in the county has the coal been opened for mining nor has it been observed except on weathered outcrops. The blossom, which varies from 3 inches to 2 feet in thickness, is underlain with 2 to 9 feet of clay or clay shale. The position of this coal is on an average about 95 feet above the Upper Sewickley coal and about 43 feet below the Waynesburg coal.

In Wells Township, a thin coal blossom of Uniontown coal is present in Section 27, where the elevation of the bed is 1,210 feet. Outcrops of this coal are found in Smithfield Township at a few places along the ridges northeast and southeast of Piney Fork, but the exposures show the bed to be thin and of no value. In the north-central part of Section 14, a blossom of Uniontown coal appears at an elevation of 1,151 feet, and is underlain by 5 feet of shale below which is the Uniontown limestone. The interval to the Fulton Green shale is about 58 feet. In Mount Pleasant Township, exposures of Uniontown coal are found in Sections 35 and 36. The following geologic section is a

[1]White, I. C., West Virginia Geological Survey, Vol. II, p. 150. 1903.

record of outcrops along the diagonal road in the southern part of Section 36, where the relation of the Uniontown coal to the underlying beds is well shown:

		Ft.	In.
Shale, gray, arenaceous		5	0
Coal blossom, *Uniontown*			4
Shale, gray, arenaceous		37	0
Sandstone, thin-bedded, friable		21	0
Limestone, bluish	*Benwood*	1	0
Shale, gray arenaceous		5	2
Limestone, nodular		5	2
Clay shale, gray		2	4
Limestone, shaly			8
Shale, gray, arenaceous		15	2
Coal blossom, *Sewickley*		2	6

In Warren Township, the Uniontown coal outcrops along the east-west road in the northwestern corner of Section 14, where the elevation of the coal is 1,148 feet and the interval to the Sewickley coal is 98 feet and to the Pittsburgh coal 178 feet. The rock succession from the Uniontown limestone to the Waynesburg coal at this locality is given below:

	Ft.	In.
Sandstone, shaly, *Waynesburg*	10	0
Limestone, dark, arenaceous, *Elm Grove*		8
Shale and covered	6	6
Black shale and shaly coal, *Waynesburg*	2	0
Shale and covered	39	2
Coal blossom, *Uniontown*		10
Clay and covered	4	10
Limestone, dark, *Uniontown*		8

The Uniontown coal is also exposed along the road in the northwestern part of Section 23 at an elevation of 1,062 feet. The bed lies 119 feet above the Sewickley coal and 180 feet above the Pittsburgh coal.

Gilboy Sandstone

The interval between the Uniontown and Waynesburg coals is made up for the most part of sandstone and arenaceous shale. In parts of West Virginia, two distinct sandstones have been recognized in this interval. The lower sandstone member lies close above the Uniontown coal and therefore has been named the Uniontown sandstone. The second sandstone member occurs a few feet below the Waynesburg

coal and is separated from the lower sandstone member by a short shale interval. This lower bed is well developed at Gilboy cut on the Baltimore and Ohio Railroad near Mannington, Marion County, West Virginia, and therefore it has been named the Gilboy sandstone.

In Jefferson County, Ohio, the Waynesburg-Uniontown coal interval is made up for the most part of arenaceous shale. At a few places, however, thin sandstone lenses are found in this interval which are somewhat variable in position but are here considered to represent the Gilboy member. The position of the sandstone is about midway between the Uniontown and Waynesburg coals. The stone is medium grained in texture and of a bluish-white color weathering to a yellowish-brown.

In Wells Township, the Gilboy sandstone forms the crest of the ridge which extends in a northwest-southeast direction through sections 11 and 18. In this locality the top of the member lies a few feet below the Waynesburg coal. Sandstone on the Gilboy horizon is also found along the ridge in the northeastern part of Section 22. In Warren Township, the Gilboy sandstone is present in the hill west of Tiltonville, where it has a thickness of about 10 feet. The stratigraphic relations at this locality are indicated in the following record:

		Ft.	In.
Clay, dark blue to black, *Waynesburg*		3	0
Shale and covered		18	0
Sandstone, shaly, *Gilboy*		10	0
Shale and covered		14	8
Coal blossom, *Uniontown*			8
Clay, light		9	0
Shale and covered		35	0
Limestone, buff	*Arnoldsburg*		10
Shale and covered		3	2
Limestone, buff		1	0
Shale, olive green, *Fulton*		2	8

In the central part of Section 35, Mount Pleasant Township, the Uniontown coal is overlain by about 30 feet of soft, friable sandstone representing the Gilboy member. Elsewhere in the township, however, shale is the predominating rock between the Uniontown and Waynesburg coals and therefore the Gilboy sandstone is wanting.

Waynesburg Limestone

In Greene, Washington, Fayette, and Westmoreland counties, Pennsylvania, and also in Taylor, Monongalia, and Marion counties, West Virginia, is a fresh water limestone lying about 20 to 40 feet below

the Waynesburg coal which was named the Waynesburg limestone by J. J. Stevenson. Although this member has been reported by G. P. Grimsley in the vicinity of Wheeling, West Virginia, it has not been recognized in Jefferson County, Ohio.

Little Waynesburg Coal

From 10 to 20 feet below the Waynesburg coal in Fayette County, Pennsylvania, occurs a thin bed of coal named by J. J. Stevenson the Little Waynesburg coal. This bed, which is usually thin, local in distribution, and of little economic value, is wanting in Jefferson County, Ohio.

Waynesburg Coal and Clay

The upper member of the Monongahela series is the Waynesburg coal, so named by H. D. Rogers of the First Geological Survey of Pennsylvania for exposures near Waynesburg, Greene County. The area of distribution embraces southwestern Pennsylvania, including Washington, Greene, Fayette, and Westmoreland counties, north-central West Virginia from Monongalia to Braxton counties, and a district along the western edge of the State from Tyler to Brooke counties, from which it extends across the Ohio River into Jefferson County, Ohio, where it is present near the summits of the higher ridges in Warren, Mount Pleasant, and Smithfield townships. Dr. I. C. White describes the character and thickness of the coal in West Virginia as follows[1]:

"The seam is always multiple bedded, being generally separated into a 'roof,' 'upper' and 'lower' divisions by shale and fire clay partings, the whole often 9 to 10 feet in thickness. This coal appears to attain its maximum thickness and importance in Marion and Monongalia counties, and the adjoining region of Greene County, Pennsylvania, since it thins down in every direction when traced away from these regions."

In Jefferson County, the coal varies in thickness from 2 feet to 3 feet 4 inches, and, unlike this member in Pennsylvania and West Virginia, it is not broken by conspicuous shale partings although at some localities the entire bed presents a shaly aspect. The average interval to the Uniontown coal below is about 43 feet. The associated clay shows no distinctive features. It is gray in color, ferruginous and calcareous in composition, and from 3 to 10 feet in thickness. The member outcrops near the crests of the higher ridges in the southeastern part of Smithfield and in Warren and Mount Pleasant townships.

[1]White, I. C., West Virginia Geol. Survey, Vol. II, p. 147. 1902.

In Smithfield Township, the Waynesburg coal is present at an elevation of 1,270 feet near the northern end of Smithfield. A thin ledge of Elm Grove limestone lies only a few feet above the coal. In the northern part of Warren Township, a thin coal blossom overlain by shale is exposed at a number of localities near the top of the high ridge in Sections 20 and 26. Waynesburg coal, 2 feet in thickness, is also exposed at an elevation of 1,188 feet in the north-central part of Section 14. The coal is shaly in character and is directly overlain and underlain by shale, with 8 inches of Elm Grove limestone occurring at a height of 6½ feet above the coal. In the southern part of Warren Township, clay belonging to the Waynesburg coal horizon is present in Sections 22 and 34, but the coal is wanting.

In Mount Pleasant Township, the Waynesburg coal occurs along the high ridge south of Long Run and Short Creek at an elevation of about 1,200 feet in the western part of Section 28, and at 1,170 feet in the eastern part of Section 5. An opening was made in this coal on the S. L. Griffith farm in the northern part of Section 28, but the bank was not operating when visited by the writer in 1924, and therefore the thickness of the coal could not be determined. At this locality the bed lies about 96 feet below the Washington coal. The stratigraphic succession below the Waynesburg coal is shown in the following geologic section, which is representative for the southwestern part of Jefferson County and which was measured along the road leading northeast from Pleasant Grove in Section 2, Colerain Township, Harrison County. The Waynesburg coal lies at an elevation of 1,172 feet.

		Ft.	In.
Coal blossom, *Waynesburg*		2	6
Covered interval		38	10
Coal, blossom, *Uniontown*			6
Clay, yellow		2	0
Shale and covered		15	6
Limestone, dark	*Arnoldsburg*	1	0
Covered interval		18	2
Limestone, dark		1	0
Clay shale, green, *Fulton*		2	6
Limestone, *Benwood*		3	0

The rocks overlying the coal are well shown in outcrops along the roads radiating from the village of Mount Pleasant. The following record was secured along one of these roads in the eastern part of Section 22:

	Ft.	In.
Clay and shale, dark, *Waynesburg A*	7	0
Limestone, *Mount Morris*	1	0

	Ft.	In.
Shale and covered	31	0
Limestone, dark, nodular, *Elm Grove*		7
Clay shale and covered	3	0
Coal blossom, *Waynesburg*	2	10
Clay, arenaceous	10	0

DUNKARD GROUP

WASHINGTON SERIES

GENERAL STATEMENT

The youngest deposits of rocks in the Appalachian Basin, with the exception of those belonging to the Glacial and Recent periods, comprise what is now known as the Dunkard group of the Permian system. In the early writings dealing with the Carboniferous rocks, this group was described as the "Upper Barren Group" by H. D. Rogers, the "Upper Barren Measures" by Orton and Stevenson, and the Dunkard Creek Series in the early writings of I. C. White[1]. In 1876, J. J. Stevenson in his report on Greene and Washington counties, Pennsylvania, divided the "Upper Barren Measures" into two subdivisions: The part between the Waynesburg coal and the Washington limestone he named the Washington County group and that part above the Washington limestone the Greene County group. A few years later Fontaine and White made a study of the flora of the "Upper Barren Measures" in Pennsylvania and West Virginia, identified it as Permian in age, and placed the base of the group at the top of the Waynesburg coal[2]. The later folio publications of the United States Geological Survey dealing with areas in Pennsylvania and West Virginia in which these rocks outcrop use the term "Dunkard group," recognize its Permian age, and divide it into the Washington and Greene formations.

The Dunkard group of rocks outcrops over a limited area in the Appalachian Basin including Greene and Washington counties, Pennsylvania, whence it extends south and west in a broad belt across the eastern part of West Virginia as far as the Kanawha River and into the eastern part of Ohio from Meigs to Jefferson counties. The maximum thickness of this group probably occurs in Greene County, Penn-

[1]White, I. C., U. S. Geol. Survey, Bull. 65, p. 20. 1891.

[2]Fontaine, W. M., and White, I. C., Second Geol. Survey Pennsylvania, Rept. PP, pp. 24-25. 1880.

sylvania, where it measures about 1,200 feet. Stauffer and Schroyer describe the Dunkard group in Ohio as follows[1]:

"The Dunkard is a most variable series of rocks. There are sandstones, shales, beds of limestone, and coal; in fact it includes nearly all the different varieties of sediments from coarse sandstone and conglomerate to the finest-grained shale. These change rather rapidly from one to the other so that it is often impossible to trace a horizon for any great distance. And then too there is considerable similarity between a number of beds at different stratigraphic elevations. This is especially true of the shales which are often featureless and devoid of any marks whereby they might be recognized. Shale is the most abundant rock in the series. The higher shales are often red in the northern part of the area, while to the south red is the prevailing color of the shale throughout the whole series. Selenite crystals are occasionally to be found in these red shales. This is especially true in the vicinity of Marietta. Most of the limestones occur in the northern part of the area where the sandstones are but poorly developed. As the limestones are traced southward they pass into calcareous shales which are often full of nuggets of lime. Finally these disappear, as do also nearly all traces of the coal beds, and the series becomes one of chiefly shale and sandstone. These latter increase materially in importance in the southern part of the Dunkard field.

"The base of the Dunkard has been drawn at the top of the Waynesburg coal in order to conform to the usage in other states, but over much of the field there is really no marked stratigraphic break at that horizon. This, however, is the lowest horizon at which Permian plant fossils have been found and therefore probably records a change in flora, at least. In the southern part of the Dunkard Basin this horizon becomes a distinct unconformity and the Waynesburg conglomerate rests directly on the Waynesburg coal or some other portion of the Monongahela formation. In some regions, then, there is recorded a distinct break which may fittingly be used as the division line between the Pennsylvanian and the Permian. The total thickness of the Dunkard in this State exceeds 600 feet. The amount that has been eroded above the highest preserved layers cannot well be estimated, but judging from the length of time during which they have been exposed it must have been enormous. Undoubtedly the beds still remaining are a mere fragment of the series as originally developed."

In Jefferson County, only the lower 130 feet of the Washington series of the Dunkard group is present. The distribution of the outcrops, as indicated on the accompanying map, includes the summits of the high ridges south of Short Creek in Mount Pleasant Township and the ridges on both sides of this stream in Warren Township. Some of the knobs in Smithfield and Wells townships extend to a sufficiently high elevation to be capped by a few feet of rocks of Dunkard age. The Washington formation, as represented in this county, consists of sandstone, limestone, gray and buff shale, and two well-defined coal horizons. A few sections are quoted here to show the stratigraphic succession of members of the Washington formation at well-known localities.

[1]Stauffer, C. R., and Schroyer, C. R., Geol. Survey Ohio, Fourth Series, Bull. 22, p. 15. 1920.

Dr. I. C. White reports the following section from Dunkard Creek, Greene County, Pennsylvania[1]:

Washington series		Ft.	In.
Limestone, *Upper Washington*		4	0
Shales and sandstone		115	0
Limestone, *Middle Washington*		3	0
Shales		40	0
Sandstone		35	0
Shale		5	0
Coal	*Washington A*	1	2
Fire clay		2	6
Coal			6
Shale and sandstone		60	0
Limestone, *Lower Washington*		5	0
Shales		5	0
Coal, slaty, *Washington*		5	0
Shale and sandstone, including a coal bed near the center		110	0
Coal, *Waynesburg A*		2	6
Shale		10	0
Sandstone, *Waynesburg*		50	0
Shale, with fossil plants, *Cassville*		5	0

A good section of the Washington series of the Dunkard group, measured near Elm Grove, Ohio County, West Virginia, by G. P. Grimsley, is as follows[2]:

Washington series	Ft.	In.
Shales and thin sandstone layers	30	0
Sandstone	2	0
Shales, buff	8	0
Limestone, *Middle Washington*	8	10
Shales	30	0
Black slate		4
Limestone, *Lower Washington*	2	0
Shales	9	0
Coal, *Washington*	2	6
Shales, dark	15	0
Limestone, nodular	3	0
Shales	16	0
Limestone	2	0
Shales, sandy	25	0
Coal blossom, *Waynesburg A*	....	....
Shales, buff	16	0
Sandstone		10
Shale, blue	8	0

[1]White, I. C., U. S. Geol. Survey, Bull. 65, p. 22. 1891.

[2]Grimsley, G. P., West Virginia Geol. Survey, Rept. Ohio-Brooke-Hancock Counties, p. 47. 1906.

	Ft.	In.
Limestone,shaly, blue, *Elm Grove*	10	0
Shales	5	0
Monongahela series		
Coal, *Waynesburg.*		

The following is a generalized section of the part of the Washington series exposed in Jefferson County, Ohio, which has been compiled from a number of field sections:

Washington series	Ft.	In.
Limestone with calcareous shale, *Lower Washington*	13	0
Shale	22	0
Coal, shaly, *Washington*	3	0
Clay, dark	1	8
Shale and covered	51	0
Coal, *Waynesburg A.*		
Clay, dark, carbonaceous	4	8
Limestone, dark, massive, *Mount Morris*		10
Clay, dark		10
Shale, gray	8	9
Sandstone, *Waynesburg*	15	0
Limestone, *Elm Grove*		8
Shale, gray to dark	5	2
Monongahela series		
Coal, *Waynesburg.*		

DESCRIPTION OF MEMBERS

Cassville Plant Shale

The lowest stratigraphic member of the Washington series is the Cassville Plant shale, so named by Fontaine and White for exposures near Cassville, Monongalia County, West Virginia[1]. This bed of shale, according to I. C. White, varies from 0 to 20 feet in thickness and lies in immediate contact with the Waynesburg coal. At the type locality it is very rich in plant fossils, many of which are of Permian age.

In Ohio, the fossiliferous Cassville Plant shale has been recognized by Stauffer and Schroyer at various places in Belmont, Monroe, and Noble counties, where it consists of gray to bluish-gray shale, usually argillaceous in character but occasionally highly arenaceous and interbedded with thin sandstone layers. Locally at a few places in Wells, Smithfield, Mount Pleasant, and Warren townships, Jefferson County,

[1]Fontaine, W. M., and White, I. C., Second Geol. Survey Pennsylvania, Rept. PP, p. 25. 1880.

the Waynesburg coal is overlain by a few feet of bluish-gray clay shale in which no fossil plants are found. This forms the only representative of the Cassville Plant shales in this county. Elsewhere the overlying Waynesburg sandstone comes in close contact with the Waynesburg coal and therefore these shales are wanting. The stratigraphic position of the Cassville Plant shale is well illustrated by the yellowish-gray clay shale overlying the Waynesburg coal as shown in the following section secured at Mount Pleasant, Mount Pleasant Township:

	Ft.	In.
Shale, gray, arenaceous	3	0
Shale, black, fissile	1	0
Clay shale, yellowish-gray	1	0
Limestone, dark, nodular, *Elm Grove*		8
Clay shale, yellowish-gray	4	8
Clay, dark		2
Clay shale, gray	1	2
Coal, *Waynesburg*	2	6

Elm Grove Limestone

A few feet above the Waynesburg coal and immediately overlying the Cassville Plant shale, is a bed of limestone which G. P. Grimsley named the Elm Grove limestone from occurrences near that village in Ohio County, West Virginia. Grimsley's description of this limestone is as follows[1]:

'Through Ohio and Brooke counties a very persistent limestone is found a few feet above the Waynesburg coal. It varies in thickness from 30 inches to 10 feet and has a deep blue or black color. It weathers into thin shaly layers almost like a slate, which gives its outcropping edges a peculiar striated appearance. This limestone in some places rests directly on the coal, but more often is separated from the coal by 5 to 8 feet of shales."

Since first named by G. P. Grimsley in 1906, the Elm Grove limestone has been recognized in Monongalia, Marion, Marshall, and Wetzel counties, West Virginia, and has been noted by Stauffer and Schroyer in Belmont County and adjoining areas in Ohio. In Jefferson County, which lies just north of Belmont, the horizon of this member outcrops near the crests of the ridge south of Short Creek at elevations ranging from 1,160 feet in Section 22, Warren Township, to 1,200 feet in Section 34, Mount Pleasant Township, and along the high ridge north of Short Creek at elevations ranging from 1,150 feet in Section 14, Warren Township, to 1,240 feet in Section 34, Wells Township, where a few exposures of the Elm Grove limestone are found. The bed consists of

[1]Grimsley, G. P., West Virginia Geol. Survey, Rept. Ohio-Brooke-Hancock Counties, pp. 68-69. 1906.

a single layer of bluish-gray, arenaceous limestone, 7 to 8 inches in thickness. It is well exposed at Mount Pleasant where it has a thickness of 8 inches. This limestone also outcrops along the road in the east-central part of Section 22, Mount Pleasant Township, where it has a thickness of 7 inches and lies 3 feet above the Waynesburg coal. In Warren Township, this member is found at only one locality, namely along the road in the northwestern part of Section 14, where the limestone has a thickness of 8 inches and shows the following stratigraphic relations:

	Ft.	In.
Sandstone, shaly, *Waynesburg*	10	0
Limestone, dark, arenaceous, *Elm Grove*		8
Shale and covered	6	6
Black shale and shaly coal, *Waynesburg*	2	0
Shale and covered	39	2
Coal blossom, *Uniontown*		10
Clay and covered	4	10

Waynesburg Sandstone

The Waynesburg sandstone, which derives its name from Waynesburg, Greene County, Pennsylvania, lies close above the Elm Grove limestone at some places but at other localities this member extends down to the Waynesburg coal or even rests on the shales of the upper part of the Monongahela series as a result of a disconformity at the base of a sandstone. Concerning its wide-spread distribution in West Virginia, I. C. White writes[1]:

"It has a very wide distribution, extending as a great, coarse deposit entirely across the State. Being seldom less than 50 and often 75 feet in thickness, it makes a line of rugged cliffs along its eastern outcrop from where it enters the State in Monongalia County, across Marion, Harrison, Lewis, Gilmer, Calhoun, Roane, Kanawha, Putnam, and Cabell to where it leaves the Appalachian trough in Wayne County near the Big Sandy."

The characteristics of the westward extension of the sandstone in southwestern West Virginia, Pennsylvania, and Ohio are well summarized by I. C. White as follows[2]:

"Along the western border of the outcrop of this rock it dwindles down and changes its character entirely, being frequently represented in Washington County, Pennsylvania; Marshall and Ohio counties, West Virginia; Belmont and Monroe counties of Ohio, by sandy shales and flaggy sandstones, and occasionally even a stratum of limestone may be found at this horizon."

In Jefferson County, Ohio, the horizon of the Waynesburg coal lies

[1]White, I. C., West Virginia Geol. Survey, Vol. II, p. 118. 1902.
[2]White, I. C., U. S. Geol. Survey, Bull. 65, p. 40. 1891.

near the summits of the highest ridges in Mount Pleasant and Warren townships. It is best developed in the southwestern part of Warren and the southeastern part of Mount Pleasant townships where the maximum thickness is 15 feet. The sandstone varies from medium to fine grained in texture but locally becomes coarse grained in the basal part of the member. It may grade laterally into arenaceous shale, and, in the southern part of Mount Pleasant Township, shale constitutes the chief type of rock above the Elm Grove limestone.

The member is well exposed about three quarters of a mile south of the village of Mount Pleasant, Mount Pleasant Township, where it has the usual thickness of 15 feet. The following section was secured at this locality:

	Ft.	In.
Shale, gray, arenaceous	6	0
Clay, bluish-black	3	0
Clay with nodular limestone	2	0
Shale and covered	16	0
Sandstone, shaly, *Waynesburg*	15	0
Clay, gray, *Waynesburg coal horizon*	3	0

The Waynesburg sandstone is also seen to good advantage in the northern part of Section 14, Warren Township, where it is 10 feet in thickness with the base in contact with the Elm Grove limestone.

Mount Morris Limestone

A few feet below the Waynesburg A coal horizon is a thin bed of limestone, first recognized by J. J. Stevenson and later named by I. C. White the Mount Morris limestone from exposures along Dunkard Creek at Mount Morris, Greene County, Pennsylvania[1]. According to I. C. White, "the stratum is often only one to two feet thick and seldom more than five feet except in Washington County, Pennsylvania, where it is occasionally thicker." In West Virginia, this limestone has been recognized in Marshall and Wetzel counties only, but here it is usually thin and not persistent.

The Mount Morris limestone in Jefferson County, Ohio, occurs at only two localities, namely in the eastern part of Section 22 and in the north-central part of Section 10, Mount Pleasant Township. In the first locality it is dark, bluish-black limestone about 1 foot in thickness overlain by 7 feet of very dark clay. The interval to the top of the Waynesburg coal is about 36 feet, as shown in the following section:

[1]White, I. C., U. S. Geol. Survey, Bull. 65, pp. 39-40. 1891.

	Ft.	In.
Clay, very dark, plastic	7	0
Limestone, dark, *Mount Morris*	1	0
Shale and covered	31	0
Limestone, black, arenaceous, nodular, *Elm Grove*		7
Clay shale and covered	3	0
Coal blossom, *Waynesburg*	2	10
Clay, arenaceous	10	0

In the second locality the member consists of nodules of limestone embedded in clay.

Waynesburg A Coal and Clay

The horizon of the Waynesburg A coal lies a few feet above the Mount Morris limestone. It is generally present in Greene and Washington counties, Pennsylvania, with a thickness of 1 to 3 feet[1], and in West Virginia where it is "quite generally present 10 to 15 feet above the massive Waynesburg sandstone, through Monongalia, Marion, Harrison, Doddridge, and Tyler counties, and occasionally attains a thickness of 3½ feet[2]."

In Jefferson County, Ohio, the Waynesburg A coal is wanting; but the horizon is marked in Sections 10, 17, and 22, Mount Pleasant Township, and in Section 34, Warren Township, by a bed of very dark plastic clay which lies from 31 to 36 feet above the Waynesburg coal. The following geologic section measured along the road leading southwest from Mount Pleasant, in Section 17, Mount Pleasant Township, shows the stratigraphic position of the Waynesburg A coal horizon:

	Ft.	In.
Clay, very dark, plastic, *Waynesburg A*	3	0
Shale and covered	36	0
Coal blossom, *Waynesburg*	2	8
Clay, clay shale, and covered	23	4
Sandstone and arenaceous shale, *Gilboy*	10	0

Washington Coal

The thickest and most important coal bed of the Dunkard group is the Washington coal, so named by J. J. Stevenson for exposures near Washington, Washington County, Pennsylvania[3]. It is wide-spread in its occurrence in southwestern Pennsylvania and has been traced in West

[1]Stevenson, J. J., Second Geol. Survey Pennsylvania, Rept. K, p. 56. 1874.
[2]White, I. C., West Virginia Geol. Survey, Vol. II, p. 116. 1902.
[3]Stevenson, J. J., Second Geol. Survey Pennsylvania, Rept. K, p. 51. 1874.

Virginia as far south as central Cabell County. In Ohio, this coal is present throughout the entire area covered by the Dunkard group, but is best developed in Belmont County where, according to Stauffer and Schroyer, it varies in thickness from 5 to 7 feet[1]. This bed lies on an average 108 feet above the bottom of the Waynesburg coal.

In Jefferson County, outcrops of the Washington coal are present near the top of a few high knobs in Mount Pleasant and Warren townships. In Section 28, Mount Pleasant Township, coal 3 feet 4 inches thick outcrops along the road at an elevation of 1,286 feet and lies 96 feet above the top of the Waynesburg coal. The geologic section measured at this place is given under the discussion of the succeeding member, the Lower Washington limestone. In Warren Township, it is likewise present in Sections 19 and 33. In the western part of Section 19 it is exposed near the crest of a small hill where the coal is shaly in structure and has a thickness of 2 feet 9 inches. It is overlain by black, fissile shale and underlain by black, argillaceous clay. In the south-central part of Section 33, the Washington coal is present near the top of a small knoll at an elevation of 1,280 feet.

Lower Washington Limestone

From 6 to 8 feet above the Washington coal in Greene County, Pennsylvania, is a limestone which J. J. Stevenson named the Lower Washington limestone[2]. In this county the member varies in thickness from a few inches to 5 feet and Stevenson describes it as "dark blue with some flesh-colored layers, weathers bluish-white, and has a slaty fracture[3]." In West Virginia it is generally present in Monongalia, Marion, Harrison, Wetzel, Tyler, Marshall, and Ohio counties.

In Jefferson County, Ohio, the Lower Washington limestone is exposed at only one locality, namely near the top of the high hill in Section 28, Mount Pleasant Township, where it consists of five layers of limestone separated by thin shale partings. It is compact and dark in color and is used locally for road repairing. The base of the limestone has an elevation of 1,313 feet and lies 24 feet above the top of the Washington coal and 123 feet above the top of the Waynesburg coal. The geologic section of the rock strata at this locality, exposed along the road by the school house, is given on following page:

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[1]Stauffer, C. R., and Schroyer, C. R., Geol. Survey Ohio, Fourth Series, Bull. 22, p. 19. 1920.

[2]Stevenson, J. J., Second Geol. Survey Pennsylvania, Rept. K, p. 50. 1874.

[3]Loc. cit.

		Ft.	In.
Shale, calcareous		4	0
Limestone	*Lower Washington*	2	0
Limestone, thin-bedded, with calcareous shale	*Lower Washington*	4	0
Limestone	*Lower Washington*	2	6
Shale, calcareous	*Lower Washington*	1	8
Limestone	*Lower Washington*	1	4
Shale, calcareous	*Lower Washington*		5
Limestone	*Lower Washington*	1	4
Covered interval		22	0
Clay, dark		2	0
Coal blossom, *Washington*		3	4
Clay, yellow		1	0

CHAPTER III

OIL AND GAS

INTRODUCTION

The discovery of oil in the Drake well near Titusville, Pennsylvania, in 1859, and also the securing of gas at a number of wells along the Ohio River Valley in Columbiana County, Ohio, the following year, aroused interest among the inhabitants of Steubenville and vicinity and led to the drilling of the first test in Jefferson County on the Farmer place near Mingo Junction in 1864[1]. The results of this experiment, however, were not encouraging, as the Berea sand, which was reached at a depth of about 1,200 feet, yielded neither oil nor gas. The following year, a well was drilled by the Springfield and Yellow Creek Oil Co. at the mouth of Brimstone Run near Pravo, Ross Township, from which a considerable flow of oil was secured at a depth of 500 feet. The oil, however, was soon exhausted, but the brines from the well were used at Pravo for the manufacture of salt until 1871 when the opening was abandoned. This test has the distinction of being the first oil producer in Jefferson County[2]. Likewise, one or two other tests were drilled in the county without success at about the same time, after which all explorations for oil and gas ceased for a period of twenty years.

In the Pan Handle region of West Virginia, drilling operations were more successful, as a number of good gas-producing wells were secured east of Cumberland and Steubenville, where the fuel was used for the manufacture of lamp black. Early in the eighties, interest was again aroused in the vicinity of Steubenville and in 1883 the Spaulding Iron Works obtained a small gas well in the Berea sand at Mingo Junction. The following year the Jefferson Iron Works drilled two wells at Steubenville with the result that a small flow of gas was obtained from the Berea sand at a depth of about 1,250 feet, although the supply was soon exhausted[3]. Again, in 1885, J. J. Gill made an opening on the Stohley property at Steubenville and secured a good flow of gas which was confined and used for fuel for a number of years. The use of natural gas on an extensive scale in Jefferson County dates back to

[1]Doyle, J. B., History of Steubenville and Jefferson County, p. 267. 1910.
[2]Idem., p. 271.
[3]Idem., p. 268.

1886, when the Royal Gas Co. of Philadelphia, securing a large quantity of gas from a number of wells in the Hickory region in southwestern Pennsylvania, laid pipe lines to Steubenville and supplied that city with fuel for lighting and heating purposes. Later these lines were extended to Mingo Junction and to Brilliant.

A great impetus was given to the search for oil and gas in Jefferson County when in 1889 Josiah C. Ault and B. N. Lindoff struck oil in the Berea sand on the James Blackburn farm in Section 11, Island Creek Township. The well had a depth of about 1,000 feet and an initial production of nearly 30 barrels of oil per day. In 1891-1892, gas was also discovered at Toronto. The Gould pool in the southeastern part of Cross Creek Township first became known in 1896 when George Grime drilled a well on the Featner farm with an initial production of 125 barrels of oil per day. The following year J. J. Crawford drilled the first well in the Knoxville field and, although the production was not large, it led to further exploration with the drill in this vicinity, which has continued to the present time. The years 1899-1900 witnessed the discovery of oil near Port Homer, in the southeastern part of Saline Township, and the opening of the Limestone pool in the southwestern part of Wells Township. The Sugar Grove pool was discovered in Knox Township in 1902, and a well with an initial production of 500 barrels was drilled the same year on the Wigginton farm near the Union Cemetery in the western part of Steubenville Township.

Since 1910 the search for oil and gas has continued in Jefferson County, but with the exception of the discovery of a small oil pool near New Alexander in Cross Creek Township, in 1921, no large reservoirs of oil or gas have been found. The total number of wells drilled in the county is not known, but an estimate of two thousand tests is a conservative figure. In nearly all cases the Berea sand is the reservoir rock sought by the driller, but in a few places oil and gas have been obtained in the Big Injun sand; and at a very few localities the drill has penetrated several hundred feet below the Berea sand, but without success. Many of the wells in this area are long-lived and some have even been producing for more than twenty years. The oil and gas producing wells in this county number between 400 and 450, and the daily yield in oil reaches an average of about a half of a barrel of oil per well.

THE SUB-SURFACE ROCKS OF JEFFERSON COUNTY

The stratigraphy of the sub-surface rocks of Jefferson County is determined by correlating the records of the various strata, passed through in the process of drilling for oil and gas, with the surface outcrops of these beds which are many miles distant from Jefferson County. The results of such a study are vague and indefinite, as the drillers'

records are usually lacking in conciseness and as the changing facies of the rocks are difficult to recognize in detail. The Berea sandstone is usually the objective of the driller in this county, and therefore little is known of the deep-seated rocks below this member. The following table shows the correlation of the oil and gas sands with the rocks of central Ohio[1]:

CORRELATION TABLE

	Generalized section of the rocks exposed in central Ohio	Strata recognized and terms used by the driller in eastern Ohio
Pennsylvanian system	Connoquenessing or Massillon sandstone	Upper Salt sand
	Quakertown coal	
	Shales and sandstones	
	Sharon coal	
	Sharon conglomerate	Lower Salt or Maxton sand
Mississippian system	Maxville limestone	Big Lime
	Logan beds: Vinton sandstone	Keener sand near the top
	Logan beds: Allensville conglomerate	
	Logan beds: Byer sandstone	
	Logan beds: Berne conglomerate	
	Black Hand sandstone or conglomerate	Big Injun sand at top and Squaw sand at base
	Raccoon shale	Shale
	Buena Vista sandstones	Hamden sand of Vinton County, Welsh Stray sand of Monroe County, Stray sand of Columbiana and Jefferson counties, or the Weir sand of West Virginia
	Sunbury shale	Black or brown shale
	Berea sandstone	Berea sand, Butler Gas sand in lower part

[1]Stout, W., and Lamborn, R. E., Geol. Survey, Ohio, Fourth Series, Bull. 28, opp. p. 358 1924.

Berea Sandstone

The Berea sandstone, named by Newberry for exposures near the village of Berea, Cuyahoga County, Ohio, is a widely persistent and very productive source of oil and gas in eastern Ohio, where it is well known to the driller as the Berea sand. This formation, which belongs to the Mississippian system, is composed of thin to heavy-bedded sandstone with thin shale partings. The color is usually light to dark gray and the texture medium to fine grained.

The Berea sand, which is everywhere present in Jefferson County and is one great source of oil and gas, lies at depths ranging from 620 feet in Saline Township in the northern part of the county, to 1,800 feet in Warren Township in the southern part. The thickness of the sand varies from 5 to 65 feet. The upper 6 to 15 feet of the formation is very hard and impervious, forming a cap below which the sand becomes white in color, soft, and easy to drill, being known among the oil men as the "pay" sand. Also in some localities, the Berea sand is separated into two parts by a thin shale bed below which a second "pay" is found. Although most of the oil and gas in Jefferson County comes from the first "pay" or the upper part of the Berea, some production is obtained from the second "pay" or the lower part of the sand.

Stray Sand

At some localities in the eastern half of Ohio, there is also a thin sandstone of Mississippian age lying from 70 to 100 feet above the Berea, which is productive of small quantities of oil and gas. In Vinton County, this sand is an important gas producer and is known as the Hamden sand. It has also been recognized in Columbiana County where it is non-productive but is designated among the drillers as the "Stray" sand. Production has been obtained from beds occupying a similar stratigraphic position in Kanawha County, West Virginia, where it is usually called the Weir sand. In Jefferson County, the Stray sand is present in the western part of Salem Township, where it has a thickness of 15 to 20 feet and lies 35 to 40 feet above the Berea, and also in the southeastern part of Cross Creek Township where on the Williams farm it attains a thickness of 50 feet and lies about 40 feet above the Berea sandstone. The Stray sand is productive of neither oil nor gas in Jefferson County.

Squaw Sand

The Squaw sand lies between the Stray and the Big Injun but is much closer to the latter from which it is separated by only a few feet

of shale. It is very irregular in its occurrence in Ohio and in Jefferson County it is seldom found. It is poorly represented in northeastern Saline Township where it has a thickness of 20 to 25 feet and lies 15 to 25 feet below the Big Injun. The Squaw sand yields neither oil nor gas in the county.

Big Injun Sand

The Big Injun sand of the driller is of Mississippian age and is correlative with the Black Hand conglomerate of central Ohio and the Pocono sandstone of Pennsylvania. It is therefore very wide-spread in its occurrence, but at only a few localities in Ohio is it a source of oil and gas, and therefore its importance as a producing sand is small. It is invariably recognized by the driller, however, because of its coarse or conglomeratic texture and on account of the large flows of salt water which are usually encountered in passing through it. The Big Injun sand is everywhere present in Jefferson County, where it ranges in thickness from 30 to 300 feet. It undergoes rapid variations in thickness, although in general it is thinnest in Saline Township in the northern part and thickest in the southern part of the county. The interval from the base of the Big Injun sand to the top of the Berea in this county ranges from 200 to 390 feet but usually varies from 330 to 370 feet. Showings of oil and gas have been obtained from the Big Injun sand in Jefferson County, but no large production of either fuel has been secured.

Keener Sand

The position of the Keener sand is below the Maxville limestone, or the upper Big Lime of the driller, and above the Big Injun sand, from which it is usually separated by a few feet of shale. It is therefore Mississippian in age and is correlative with some part of the Logan group, probably with the Vinton sandstone, in the table of formations of Ohio. The Keener sand is less persistent in its occurrence than the Big Injun but nevertheless is important in many oil fields in eastern Ohio, where it varies in thickness from 10 to 200 feet. In Jefferson County, the Keener sand either coalesces with the Big Injun and therefore becomes unrecognizable in the drillers' records or is entirely wanting. That the former is probably the case is rendered more probable by the occasional appearance of this sand at a few localities in Saline, Steubenville, and Salem townships, where there is a corresponding thinning of the Big Injun sand. The Keener sand is not productive of oil or gas in Jefferson County.

Big Lime

The Big-Lime of the driller in eastern Ohio is of Mississippian age and corresponds to the Maxville limestone of southern Ohio and to the Greenbriar limestone of West Virginia. It is usually a light-colored, pure rock, variable in thickness, which is separated from the Keener sand, or in its absence from the Big Injun sand, by a short shale interval. The Maxville limestone forms the top formation of the Mississippian system and is separated from the Pennsylvanian or coal-bearing group of rocks by a disconformity, which was the result of an erosion period, and which was of sufficient length to completely remove this limestone in many localities before the deposition of the overlying rocks. The distribution of the Big Lime in eastern Ohio is therefore very irregular. In Jefferson County, it appears in the records of a few wells in Saline, Knox, and Steubenville townships but is not a producer of either oil or gas.

Lower Salt Sand

The Lower Salt sand, so named by the driller from the large quantities of salt water encountered in it, lies immediately on the Maxville limestone and is correlative with the Sharon conglomerate, the basal member of the Pottsville formation of the Pennsylvanian system. This sand is known as the Maxton in southern Ohio where it is an important source of oil and gas. In Jefferson County, the beds at the base of the Pottsville series, or those overlying the Maxville limestone horizon, are generally composed of shale and therefore the Lower Salt sand is wanting.

Upper Salt Sand

The Upper Salt sand of the Pennsylvanian system corresponds in its stratigraphic position to the Upper Connoquenessing or Upper Massillon sandstone. In Jefferson County, this sandstone varies from 25 to 150 feet in thickness and lies in a position ranging from 70 to 160 feet above the Maxville limestone and from 115 to 270 feet above the Big Injun sand. It is productive of neither oil nor gas in Jefferson County.

SEARCH FOR OIL AND GAS BELOW THE BEREA SAND

Little time or effort has been expended in exploring for oil or gas below the Berea sand in Jefferson County. In 1883 a well was drilled to the Berea sandstone by the Jefferson Iron Works at Steubenville, which for a few months yielded a small flow of gas. Later, however, the well was drilled to a depth of 1,290 feet below the Berea without

encountering anything more promising than black shale[1]. Thus the first test below the Berea sand in Jefferson County ended in failure. A second test below the Berea sand in Steubenville Township was made on the Edminson farm where the rocks penetrated by the drill are as follows:

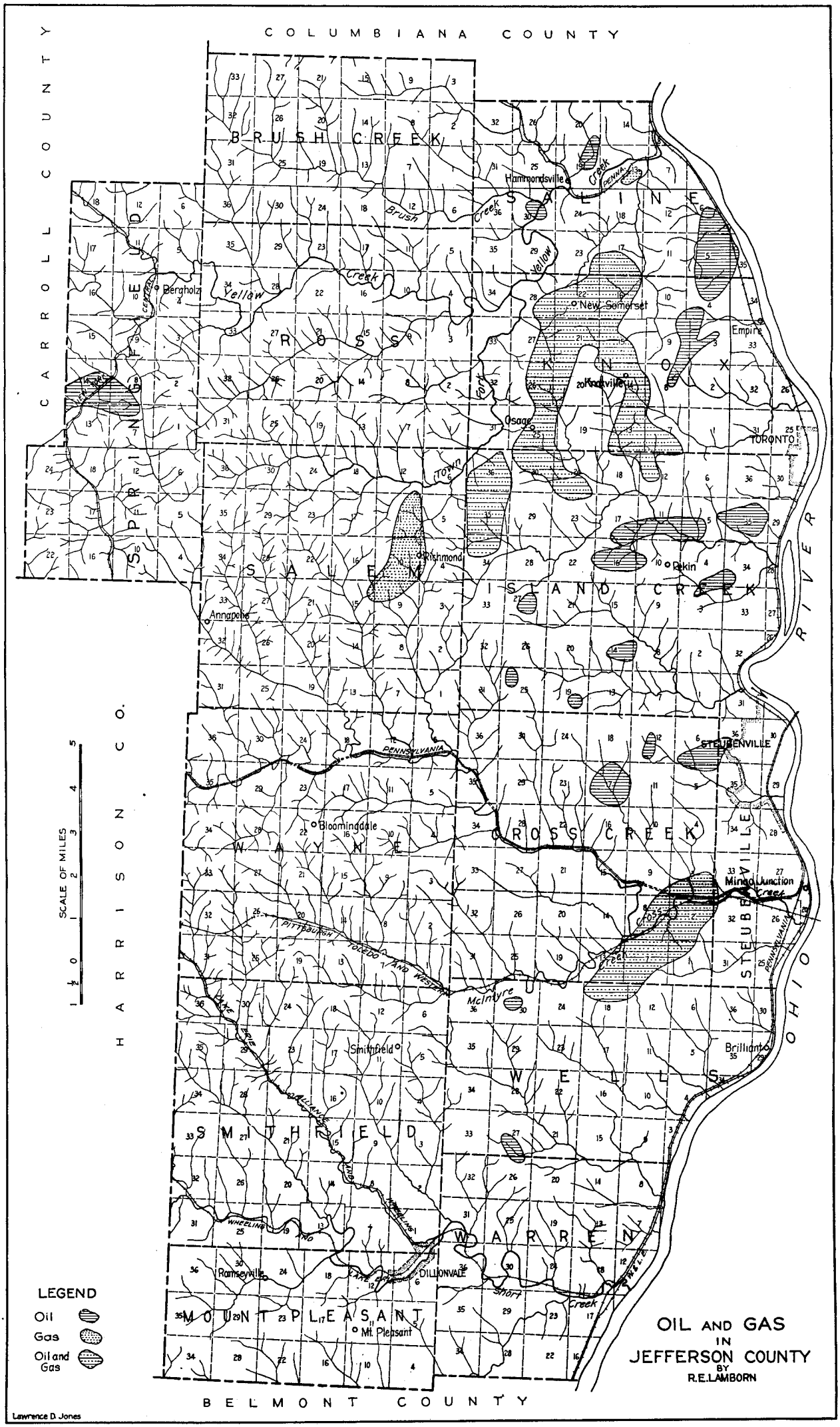
	Depth in feet to Top	Bottom	Thickness in feet
Coal		4	4
Not recorded	4	59	55
Sandstone	59	90	31
Shale	90	140	50
Not recorded	140	520	380
Sandstone, *Salt sand*	520	648	128
Shale	648	970	322
Sand, *Big Injun*	970	1000	30
Shale	1000	1325	325
Black shale, *Sunbury*	1325	1355	30
Sandstone, *Berea*	1355	1402	47
Shale	1402	1800	398
Sandstone, *Gordon sand*	1800	1830	30
Shale	1830	1900	70
Sandstone, *Fourth sand?*	1900	1920	20
Shale	1920	2120	200
Total depth	.....	2120	.....

This test also proved a failure. The two sands below the Berea in the above record correspond closely in their position with the Gordon and Fourth sands of southwestern Pennsylvania and of the Pan Handle area of West Virginia.

In 1910 a well was drilled a short distance west of Irondale in Saline Township to a depth of 708 feet below the Berea sand. At this locality shale is the only type of rock encountered below the Berea. Likewise, the search for the Gordon sand is reported to have led to the drilling of a deep well on the Ezra A. King property in Section 10, Island Creek Township. However, no Gordon sand was found and the well was abandoned. The Elliott Bros. of Steubenville also drilled a deep well for the Unity Coal Company on the W. R. Hales farm in Salem Township but without success. The drillers' record is as follows:

	Depth in feet to Top	Bottom	Thickness in feet
Not recorded	0	430	430
Coal	430	435	5
Not recorded	435	1115	680
Sandstone, *Big Injun sand*	1115	1265	150
Not recorded	1265	1375	110
Sandstone, *Berea sand*	1375	1415	40

[1]Orton, Edward, Geol. Survey Ohio, Vol. VI, pp. 336-337. 1888.


COLUMBIANA COUNTY
CARROLL COUNTY
HARRISON CO.
BELMONT COUNTY
OHIO RIVER
BRUSH CREEK
SALEM
ISLAND CREEK
CROSS CREEK
WAYNE
SPRINGFIELD
ROSS
KNOX
SALINE
WELLS
WARREN
SMITHFIELD
MOUNT PLEASANT
STEUBENVILLE
Hammondsville
Bergholz
New Somerset
Empire
Knoxville
Osage
TORONTO
Richmond
Pekin
Annapolis
Bloomingdale
Mingo Junction
Smithfield
Brilliant
Ramseyville
DILLONVALE
Mt. Pleasant
Brush Creek
Yellow Creek
Town Fork
Short Creek
PENNSYLVANIA
PITTSBURGH, TOLEDO AND WESTERN
McIntyre
SCALE OF MILES
1 0 1 2 3 4 5
LEGEND
Oil
Gas
Oil and Gas
OIL AND GAS IN JEFFERSON COUNTY
BY R.E. LAMBORN
Lawrence D. Jones

	Depth in feet to Top	Bottom	Thickness in feet
Not recorded	1415	1792	377
Sandstone, *Gordon sand*	1792	1810	18
Not recorded	1810	1910	100
Shells, *Fourth sand*	.....	1910	.....
Not recorded	1910	1995	85
Sandstone, *Fifth sand*	1995	2010	15
Not recorded	2010	2040	30
Total depth	.....	2040	.....

Tests which have been made in this county show the presence of sands suitable for the accumulation of oil and gas within easy drilling distance below the Berea, but their patchy distribution and apparently barren nature render their future importance as a source of oil and gas somewhat problematical.

SEARCH FOR OIL AND GAS IN THE BEREA SAND

The Berea is the chief sand sought by the driller in Jefferson County and from it comes nearly all the production in oil and gas in this area. The depth of the Berea is variable in different parts of the county due in part to the southern dip of the rock strata and in part to the rough and hilly topography. This sand usually lies about 650 to 750 feet below the valley bottoms in the northern part of the county and 1,300 to 1,400 feet below the flood plains in the southern part. The sand is variable in thickness, ranging from 5 to 65 feet, although it usually measures from 25 to 45 feet. The upper part of the sand, usually 6 to 12 feet in thickness, is hard and impervious and contains little oil or gas. Below this "cap" rock the sand is white and soft and constitutes the "pay" sand of the driller. In the southeastern part of Cross Creek Township and the northern part of Wells Township, the Berea contains two "pay" sands, one near the top and the other near the bottom of the bed. This two-fold division of the bed, although of frequent occurrence in Columbiana County, Ohio, and in parts of western Pennsylvania, is exceptional in Jefferson County as most of the tests show only one "pay" sand. The stratigraphic sequence above the Berea is typically represented in the following record of a well drilled on the Swickard farm in Section 14, Knox Township:

	Depth in feet to Top	Bottom	Thickness in feet
Not recorded	0	75	75
Coal, *Pittsburgh*	75	81	6
Shale, not recorded	81	187	106
Sand	187	290	103
Shale and sand, not recorded	290	575	265
Sand	575	600	25

	Depth in feet to		Thickness
	Top	Bottom	in feet
Coal	600	.....	.....
Not recorded	600	790	190
Sand, *Salt*	790	830	40
Not recorded	830	900	70
Limestone, *Maxville*	900	920	20
Shale, not recorded	920	940	20
Sand, *Big Injun*	940	1080	140
Shale, not recorded	1080	1445	365
Sand, *Berea*	1445	1491	46
Total depth	.....	1491	.....

The thickness of the Berea sand as recorded in this well is about the average for Jefferson County. The Squaw and Keener sands are wanting but the Big Injun occurs in good development. These features are characteristic of the entire Knoxville field. The interval from the Big Injun to the Salt sand is variable in different parts of the county and in some localities the Salt sand lies almost directly on the Big Injun. The Maxville limestone is usually wanting either through lack of deposition or through erosion prior to the formation of the coal-bearing or Pennsylvanian rocks.

Saline Township

The Berea sand has been well tested for the presence of oil and gas in Saline Township, south of Yellow Creek. North of this stream dry holes were drilled on the J. Iddings and H. Iddings farms in Section 20; three dry holes on the Robert Johnson place in Section 14; and four dry holes on the Ridgeway Burton property in Section 13. Three wells were sunk, however, on the J. Stuart farm in the southeastern part of Section 20 which yielded a small supply of oil, but they are now abandoned. Likewise five wells were drilled on the property of J. Paisley in the eastern part of Section 19, all of which yielded a little oil.

South of Yellow Creek the best production from the Berea sand was obtained from the Port Homer field in Sections 5 and 6, thence extending into the northern part of Section 4, Knox Township. Drilling in this field began in the winter of 1889-1890 and continued for a number of years; but nearly all of the early wells have been abandoned. The Berea sand is reported to occur about 600 to 620 feet below drainage along the river front. At the present time the producing part of the Port Homer field is limited to the C. M. Stratton farm in Section 5, Saline Township, and to the C. M. and H. E. Stratton property in the northeastern part of Section 4, Knox Township. On the former tract, thirteen wells have been drilled to the Berea sand, all of which produced oil in paying quantities and seven of which were pumping in 1926, when

the field was last visited by the writer. On the Stratton property in Section 4, Knox Township, twenty wells were pumping in 1926, although the production was small.

West of the Port Homer field, tests to the Berea sand have been drilled on nearly every farm south of Yellow Creek as far west as Section 29, but a large percentage of the wells were failures. Four holes were sunk on the Smith farm in the southeastern part of Section 13, only one of which produced gas in paying quantities. Likewise two gas wells were secured on the H. C. Iddings farm in the southwestern part of Section 13, but the flow of gas is small. A number of tests were also made on the Taylor farm in Section 17, one of which yielded a small quantity of oil. Again, two oil producers were secured on the Leatherby farm in the north-central part of Section 23, but the supply of oil was soon exhausted.

Along Yellow Creek in Section 30, a small production of oil was secured from the Berea sand. The producing territory includes the J. S. Paisley, E. D. Call, and Ella C. Price farms, where about a dozen wells were drilled, one half of which produce a little oil.

Brush Creek Township

There has been little testing of oil or gas in the Berea sand in Brush Creek Township. Two tests on the J. Lowry farm in the west-central part of Section 6 yielded a little gas, although not in commercial quantities. A few tests were also drilled along Brush Creek near the western edge of the township but without encouraging results.

Ross Township

The first oil discovered in Jefferson County was obtained from a well about 500 feet in depth located near the mouth of Brimstone Run in Ross Township, and the oil apparently came from the Big Injun sand. Within recent years there has been very little prospecting for oil or gas in Ross Township and at the present time there are no producing wells in this area. In 1911 a dry hole, the depth of which is unknown, was drilled on the Ross Crabb farm in Section 28. Another test in Section 28 also proved a failure. In 1928 a hole was sunk on the Henry C. Patterson farm in Section 8, but the project was unsuccessful. As no well records are available, the depth and thickness of the Berea sand in Ross Township are unknown.

Springfield Township

The producing territory in Springfield Township lies in the northern half of Section 14, the southwestern corner of Section 8, and the northwestern corner of Section 7, and constitutes what is known as the

Amsterdam field. Drilling began in this field about 1901, when three wells were sunk on the Rutledge farm in Section 7, two of which were still producing in 1926. At approximately the same time a number of wells were drilled on the Emmet Calhoun property adjoining the Rutledge farm on the east, and of these three are still yielding oil. In 1911 oil was also found on the Allen farm in Section 7 and drilling continued, extending the producing territory to include the Allen, Culp, Shepherd, Lawrence, and Ohio and Pennsylvania Coal Co. properties in Section 14. In 1926 about 40 wells were producing in the Amsterdam field in Springfield Township with an average daily production of about a half of a barrel of oil per well. The Berea sand, which has a thickness in this field ranging from 30 to 40 feet, lies from 875 to 900 feet below the level of the shaft coal at Amsterdam. The "pay" sand, which is soft and white, is 8 to 10 feet thick and is usually struck 20 to 25 feet below the top of the Berea.

Beyond the boundaries of the Amsterdam field, there has been little testing for oil or gas in Springfield Township. Two dry holes were drilled on the Corkhill farm in Section 13 and a third on the Cattrell farm in the same section. Likewise, a dry hole was sunk on the McIntyre farm along Wolf Run in Section 1. Two wells, which are also reported to have been drilled on the L. J. Cox farm in Section 4, produced a small flow of gas, but were soon abandoned.

Salem Township

The search for oil and gas in Salem Township is limited chiefly to the eastern half, where at a few places a small production of gas has been obtained from the Big Injun and Berea sands. Six wells were drilled to the Berea sand in Section 1, all proving failures. In Section 2 a dry hole was sunk on the John Scott farm and also a well with a small gas production on the Blake property. Also tests to the Berea sand were made on the James Irvine land in Section 4 and on the Crawford and Dodds farms in Section 5. Throughout the northern half of Section 9 and the eastern half of Sections 10 and 11, a number of wells have given some gas production, a part of which is derived from the Big Injun sand. Although the supply of gas is small, it is nevertheless used for light and fuel at Richmond and vicinity. A few tests for oil and gas have been drilled in the western half of the township as follows: Two dry holes on the Wilson farm in Section 18, in one of which the Berea sand was reached at a depth of 1,365 feet; one dry hole on the Culp farm in Section 17; one dry hole on the Kirk farm and another on the Dye farm in Section 16; one dry hole on the Kirk farm in Section 22; one dry hole on the Hill farm in Section 23; one dry hole on the Cowden farm in Section 20; one dry hole with a

depth of 1,326 feet on the Lease farm in Section 26; one dry hole on the Kerr farm in Section 35, and one dry hole on the Mills farm in Section 31. A test drilled to the Berea on the Shields farm in Section 32 shows 44 feet of sand at a depth of 1,288 feet. The following record of a well drilled on the Rinehart farm in Section 30 shows the succession and stratigraphic position of the sands in this township:

	Depth in feet to		Thickness
	Top	Bottom	in feet
Drift	0	10	10
Sand, soft	10	155	145
Limestone, blue, *Ames*	155	165	10
Fire clay, white	165	185	20
Shale, red and green	185	350	165
Sand, white, soft	350	390	40
Shale, dark	390	425	35
Coal	425	429	4
Shale, gray, soft	429	445	16
Sand, white, soft	445	465	20
Shale, black	465	475	10
Coal	475		
Fire clay, gray	475	505	30
Shale, black	505	575	70
Sand, gray, hard	575	605	30
Shale, black, soft	605	655	50
Coal showing	655		
Fire clay, white, soft	655	675	20
Shale, black	675	720	45
Sand, hard	720	745	25
Shale and sand	745	785	40
Sand, white, *Salt*	785	885	100
Shale and sand, dark, hard	885	970	85
Sand, yellowish, *Big Injun*	970	1070	100
Shale, gray	1070	1110	40
Shale and blue rock	1110	1380	270
Shale, black, *Sunbury*	1380	1415	35
Sand, bluish, hard, *Berea*	1415	1460	45
Shale, bluish, soft	1460	1497	37
Total depth	.....	1497	.....

This test yielded a showing of oil and gas.

Knox Township

Drilling for oil and gas in Knox Township has been in progress since 1897, when oil was first discovered on the Edminson farm in Section 21. Up to the present time wells have been drilled on almost every farm of any size in the township with the possible exception of those in Sections 31, 32, 33, and 34, located along the western margin and concerning which very little data are available. The producing

territory includes the northeastern part of Section 4, which has already been considered in a discussion of the Port Homer field (see Saline Township); the southwestern part of Section 4; the southeastern part of Section 10; the eastern part of Section 9; the western part of Section 3; and the north-central part of Section 8, which constitutes a small but separate field; as well as the Knoxville pool, which extends entirely across the township from Sections 16 to 28 at the northern boundary to Sections 7 to 25 on the southern edge of the township.

The entire production of this township comes from the Berea sand, which is reached at depths of 1,320 to 1,400 feet below the ever-present Pittsburgh coal. The "pay" sand lies in the upper part of the Berea, usually about 2 to 10 feet below the top. The Big Injun sand is very constant in its occurrence in this township although in some localities it is broken by shale partings or beds of shale. Its usual thickness is about 140 feet and its position approximately 360 feet above the Berea. The Salt sand lies very close to the top of the Big Injun and in some places seems to coalesce with it. The Squaw and Keener sands are not recognized by the driller and are of doubtful occurrence. The following record of well No. 1 drilled on the A. C. McCullough farm in Section 20 shows the succession of sands penetrated by the drill in this township:

	Depth in feet to		Thickness
	Top	Bottom	in feet
Surface material	0	14	14
Sand	14	25	11
Shale	25	100	75
Limestone	100	110	10
Black shale and coal, *Pittsburgh*	110	122	12
Limestone	122	150	28
Fire clay	150	210	60
Sand	210	300	90
Limestone and shale	300	420	120
Red rock	420	435	15
Shale	435	515	80
Limestone	515	530	15
Shale	530	550	20
Red rock	550	562	12
Sand	562	626	64
Shale	626	657	31
Sand, *Salt*	657	726	69
Black shale	726	755	29
Shale	755	940	185
Sand, *Keener*	940	965	25
Shale	965	1025	60
Sand, *Big Injun*	1025	1090	65
Shale	1090	1421	331
Black shale, *Sunbury*	1421	1451	30
Sand, *Berea*	1451	1499½	48½
Total depth	.....	1499½	.....

Island Creek Township

This township has been thoroughly tested for the presence of oil and gas in the Berea sand and the likelihood of finding large pools is slight. The Knoxville oil and gas field extends from Knox Township into the northern part of Island Creek Township, where some oil production is being obtained in the northern part of Section 12, the northeastern corner of Section 18, the western half of Section 24, the northern part of Section 23, and the eastern part of Section 30. The best production in the Knoxville field in Island Creek Township is secured from the Cable farm in Section 30, where five wells were producing in 1926, and from the Hamlin and Clark farms in Section 30, which are considered to be the best wells in the entire Knoxville field. The sand is reached at depths ranging from 1,300 to 1,450 feet, and the "pay" lies about one screw from the top of the sand. A number of gas wells have been secured in the Berea sand in the eastern half of Sections 35 and 36, and several wells yielding oil are located on the Watt and McCausland farms in the western half of Section 36. The following is a record of well No. 1 located on the George H. Patterson farm in the northeastern part of Section 35:

	Depth in feet to		Thickness
	Top	Bottom	in feet
Not recorded	0	300	300
Coal	300	305	5
Not recorded	305	460	155
Coal	460	465	5
Not recorded	465	540	75
Coal	540	546	6
Not recorded	546	675	129
Sand, *Salt*	675	680	5
Shale, not recorded	680	800	120
Sand, *Big Injun*	800	990	190
Shale, not recorded	990	1352	362
Sand, *Berea*	1352	1370	18
"Pay" sand	1352	1368	16
Total depth	.....	1370	.....

Numerous wells in the vicinity of Toronto, reported to have been drilled in 1891-1892, formerly produced gas from the Berea sand which was used for local consumption in Toronto[1]. All, however, are now abandoned. North of Island Creek in Section 35 and in the east-central part of Section 5, many wells have been sunk into the Berea sand, sixteen of which were pumping in 1926. These wells were drilled about 25 years ago and in 1926 had a production of about 38 to 40 barrels of

[1]Bownocker, J. A., Geol. Survey Ohio, Fourth Series, Bull. 1, p. 245. 1903.

oil per week. The Berea sand in this area lies at depths ranging from 1,100 to 1,300 feet.

The Island Creek oil field, which was first discovered in 1889 when a thirty-barrel well was drilled on the James Blackburn farm in Section 11, includes the southwestern part of Section 5, the southern part of Section 11, the southeastern corner of Section 17, and the northern two-thirds of Section 16. More than sixty wells have been drilled in this field, nearly all of which produced some oil. The initial production varied from 2 to 10 barrels of oil per day whereas the present production ranges from a quarter to a half of a barrel daily. The Berea sand in this field lies at depths ranging from 1,350 to 1,450 feet. Formerly this field also included the southern part of Section 22, where a number of wells were drilled on the Joshua Morris farm, all of which have now been abandoned. Likewise a number of wells were sunk in the northeastern quarter of Section 27, and of these, nine were still producing in 1926.

About twenty wells were drilled to the Berea sand on the King, McCullough, Sanders, and Ford farms in the northern part of Section 9 and in the southern part of Section 10, all of which have yielded a little oil but have now been abandoned. A small quantity of oil was also secured from a few scattered wells on the Lee, Sanders, and Ault farms in the northern part of Section 3 and in the southern part of Section 4. A few of these wells are still pumping with a yield of one-half to three-fourths of a barrel of oil per day.

Another small oil pool in the Berea sand was discovered in 1904 when a well was drilled on the Bluck farm in Section 14. The limits of the field were soon determined and were found to include parts of the Elson, Vaughn, and Bluck farms, all of which lie in Section 14. In all, about twenty-five producing wells were drilled in the field, the initial production of the best being about 100 barrels per day. In 1926 all except two had been abandoned: One on the Elson property and the other on the Bluck property, each of which was yielding about one barrel of oil per day. A small amount of oil was likewise secured on the Powell farm in Section 19, where four wells were sunk in 1923-1924, each with an initial production of 9 to 12 barrels per day. Ten dry holes are also reported to have been drilled in the immediate vicinity of these producing wells. A number of tests were made on the Winters farm in the northwestern part of Section 25, six producing oil in small quantities. Other attempts to secure oil and gas in the southwestern part of the township include two dry holes on the Herren farm in the southeastern part of Section 25, a dry hole in the northeastern part of Section 25, and 13 dry holes on the Ekey farm in Section 31, two of which yielded a showing of oil.

Tests in the western part of the township consist of one dry hole

on the Wayne Coal Co. property, one dry hole on the Stark farm, and two dry holes on the Price farm in Section 34; one dry hole on the Abrams farm, two dry holes on the Watts farm, and one dry hole on the Aberegg farm in Section 28. The stratigraphic succession of the rocks penetrated by the drill is well shown in the following record of well No. 10 drilled on the Morrow farm in Section 22:

	Depth in feet to		Thickness
	Top	Bottom	in feet
Not recorded	0	19	19
Limestone, blue	19	25	6
Slate, soft	25	35	10
Coal, *Pittsburgh*	35	38	3
Limestone, blue	38	44	6
Slate, gray, soft	44	95	51
Slate, black	95	175	80
Sand, soft	175	200	25
Slate, white	200	296	96
Red rock, soft	296	310	14
Slate, gray	310	340	30
Sand, white, soft	340	355	15
Slate, gray	355	460	105
Red rock	460	480	20
Limestone, blue, hard	480	485	5
Red rock	485	505	20
Slate, gray	505	540	35
Coal, *Upper Freeport*	540	545	5
Slate, gray	545	580	35
Coal, *Lower Freeport*	580	584	4
Slate	584	620	36
Sand, white, soft	620	640	20
Slate, black	640	650	10
Coal, *Lower Kittanning*	650	653	3
Fire clay	653	665	12
Slate	665	720	55
Sand	720	740	20
Slate, black	740	780	40
Sand, white, *Salt*	780	820	40
Slate, black	820	830	10
Sand, white, hard, *Keener*	830	900	70
Slate, white, soft	900	905	5
Sand, white, *Big Injun*	905	1120	215
Slate, white	1120	1400	280
Sand, white, *Stray*	1400	1450	50
Slate, black, *Sunbury*	1450	1487	37
Sand, *Berea*	1487	1514	27
Total depth	.....	1514	.....

Steubenville Township

In addition to the early tests drilled near Steubenville and mentioned in the preceding pages, a number of wells have been sunk within

recent years in Steubenville Township, chiefly in the northwestern part. Five wells were drilled on the Tait farm in Section 36, all of which produced some oil but have been abandoned. Likewise, five holes which were sunk to the Berea sand on the E. Wiggenton farm in the same section have been abandoned. The only oil production in this section comes from two wells on the Brady farm, both of which were producing small quantities of oil in 1926. A test drilled on the W. F. Walker farm in Section 35 proved a failure. A small production of oil is obtained from wells drilled on the Reisling and Brattle properties in the northern part of Section 27, and some oil was secured on the William Otte farm in the southwestern corner of Section 27; but the prospects of increasing the yield in this vicinity are unfavorable. The following driller's log was obtained from a well sunk to the Berea sand on the Nicholson farm in Section 34:

	Depth in feet to		Thickness
	Top	Bottom	in feet
Not recorded	0	24	24
Shale and lime shells	24	30	6
Lime, very hard, *Ames*	30	40	10
Shale, hard, white	40	100	60
Sand, white	100	140	40
Sand and shells	140	300	160
Shale	300	330	30
Shale and shells	330	593	263
Broken sand, *Salt*	593	653	60
Shale, brown	653	673	20
Lime and sand	673	973	300
Shale, white	973	1313	340
Shale, black, *Sunbury*	1313	1343	30
Sand, *Berea*	1343	1386	43
Shale anl slate	1386	1421	35
Total depth	.....	1421	.....

A test was also drilled to the Berea sand on the Montgomery farm in the southeastern part of Section 31, but without success.

Cross Creek Township

Many small oil and gas producing fields have been discovered in Cross Creek Township, the oldest and probably the most important of which occurs in Sections 1, 2, 3, 7, 8, and 13 in the southeastern part of the township; whence the producing territory extends into northern Wells Township. Drilling began in this field about 1896 when a well with an initial production of approximately 125 barrels of oil a day was drilled in near Gould in the northern part of Section 2. After this, prospecting began in earnest and by 1898 about sixty wells had been drilled in Sections 1, 2, 7, and 8. Nearly all of these wells have

been abandoned, however, with the exception of a few on the J. M. Hook property located in the southeastern part of Section 3, on the E. L. Findley farm in the northeastern part of Section 8, and on the J. S. Raymond land in the northwestern part of Section 2. Again in 1913-1914, a well was drilled on the Carpenter farm near New Alexandria which yielded a small supply of oil and which started further explorations in this vicinity. No large production was secured, however, until several years later when wells with an initial output of 60 barrels per day were obtained on the Linton farm and on the Wayne Coal Co. property. At the present time the producing territory includes the northeastern part of Section 1, the southern part of Section 2, the southeastern part of Section 8, all of Section 7, and the southeastern part of Section 13, Cross Creek Township, as well as the northern part of Sections 12 and 18, Wells Township. More then one hundred wells have been drilled in this field of which sixty-five yielded oil or gas in commercial quantities and fifty-eight of these were producing in 1926 with an average daily yield of about half of a barrel per well. The Berea sand in the New Alexandria field is reached at depths ranging from 1,400 to 1,800 feet. The following record of well No. 5 drilled on the Williams farm in Section 2 is typical for the field:

		Depth in feet to Top	Bottom	Thickness in feet
Not recorded		0	440	440
Coal		440	.....	.....
Not recorded			490	
Coal		490	500	10
Not recorded		500	580	80
Coal		580	584	4
Not recorded		584	880	296
Sand, *Big Injun*		880	1125	245
Shale, not recorded		1125	1390	265
Sand, *Stray*		1390	1440	50
Shale, not recorded		1440	1476	36
Sand, hard	*Berea*	1476	1488	12
Break, shale		1488	1490	2
Sand, hard		1490	1496	6
Break, shale		1496	1498	2
Sand, hard		1498	1505	7
Total depth		.....	1505	.....

In some parts of southeastern Cross Creek and northern Wells townships, the gas and oil production is obtained from the first "pay" sand in the Berea, which has a thickness of 2 to 7 feet and lies very close to the top of the formation. Below the first "pay" is usually 2 to 12 feet of shaly material before the second "pay" sand is encountered. The latter is productive in some wells in the vicinity of New

Alexandria, although most of the fuel is obtained from the upper or first "pay" sand.

In the northwestern part of Section 13 and in the northeastern corner of Section 19, occurs the old McIntyre pool, where about fifteen wells were formerly productive, although all are now abandoned.

The Mount Calvary pool bounds the Catholic and Union cemeteries on the north, west, and south, and includes the northern part of Section 5 and the southern part of Section 6, Cross Creek Township, and the western part of Section 36, Steubenville Township. Operations began in this field more than twenty years ago and more than sixty wells were drilled before the limits of the producing territory were reached. At the present time about twenty-five wells are producing oil at the rate of about one barrel per well a week. A small production has also been secured on the Winters and County Infirmary farms in the central part of Section 12, where fourteen wells have been drilled, eight of which are now producing oil in small quantities. Likewise, a number of small wells were secured in Section 17. The best producers are found on the Stone, Johnson, and Eft farms, where about fifteen wells are yielding small quantities of oil from the Berea sand.

Outside of the producing fields in Cross Creek Township, many tests have been drilled some of which are as follows: Two dry holes in the southern part of Section 35, two dry holes in the northern half of Section 34, one dry hole and one gas producer in the southeastern part of Section 28, two dry holes in the southwestern corner of Section 22. one dry hole in the northwestern part of Section 21, one dry hole in the central part of Section 20, three dry holes in the southern half of Section 19, one dry hole in the north-central part of Section 25, two small oil producers, both abandoned, in the northwestern part of Section 25, one dry hole in the northern part of Section 31, two abandoned oil wells in Section 32, and one dry hole at the southern edge of Section 33. Three tests were also drilled to the Berea sand in Section 15: One on the Benedum farm and one on the George farm are small gas producers, and the third located on the Saulter farm formerly yielded a small quantity of oil, but has now been abandoned.

Wayne Township

Testing for oil and gas in Wayne Township is limited chiefly to the Cross Creek Valley, which comprises the northern third of the township, although a few holes have been drilled in the southeastern corner. The producing territory in the Cross Creek Valley is confined to one small area located in the northern half of Section 23, the southeastern corner of Section 22, the northwestern corner of Section 16, and the southwestern corner of Section 17. The first well in this field

was drilled in 1913 on the Mansfield property in Section 22 and had an initial production which was small but nevertheless sufficient to warrant further testing in the community. Two wells were sunk on the Mallerance farm, one being dry and the other a small producer which is now abandoned; six wells on the Collins farm, five of which are now producing; five tests on the Simerall farm, one of which was dry and the other four small producers; two small wells on the Moore farm, one of which is now abandoned; and two tests on the Mansfield farm, one a dry hole and the other a small producer. The initial production of the wells in this field varied from 2 to 6 barrels of oil a day, but the present daily production averages about half a barrel per well.

A dry hole was drilled to the Berea sand on the Jewell farm in Section 4, and likewise a test yielding a showing of oil was made on the Copeland farm in Section 10. Several holes were sunk in the eastern part of Section 6, all of which were failures, and extensive testing was carried on in Section 12, but without encouraging results. Of the tests drilled in the southern half of Section 18 all have been failures. On the A. M. Brown farm in Section 17, two holes were drilled, one dry and the other yielding a small amount of gas. Five tests were made on the Ratzenberger farm in Section 23 and all have been failures. The driller's record of well No. 3 on the Ratzenberger farm, furnished by O. J. Carr of Jewett, Ohio, is as follows:

	Depth in feet to		Thickness
	Top	Bottom	in feet
Not recorded	0	8	8
Slate	8	38	30
Coal	38	40	2
Slate	40	64	24
Limestone	64	69	5
Slate	69	105	36
Limestone, *Ames*	105	108	3
Slate	108	130	22
Red rock	130	145	15
Slate	145	155	10
Sand	155	200	45
Slate	200	240	40
Sand	240	320	80
Blue slate	320	335	15
Lime shells and slate	335	410	75
Sand	410	510	100
Black slate	510	528	18
Coal	528	530	2
Slate	530	575	45
Sand	575	595	20
Slate	595	610	15
Lime	610	615	5
Slate and shells	615	705	90
Limestone, *Maxville*	705	735	30

	Depth in feet to		Thickness
	Top	Bottom	in feet
Slate	735	745	10
Sand, *Big Injun*	745	1030	285
Slate	1030	1399	369
Sand, *Berea*	1399	1439	40
Total depth	.....	1439	.....

Other tests in the northwestern part of Wayne Township are as follows: One dry hole on the Torra farm, one dry hole on the Rabaczenski property, and one dry hole on the Harwath farm in Section 24; one dry hole on the Starr farm, one dry hole on the Sanders farm, and one dry hole on the Carman farm in Section 29; three dry holes on the Osburn property, one dry hole and one small gas well on the Howarthet farm, and two dry holes on the Tipton property in Section 30. Several tests were also made in Section 1, including five holes on the property of the Piney Fork Coal Co., four of which were failures and the fifth yielded a small amount of oil but is now abandoned; one dry hole on the Purvience farm showing an interval of 1,563 feet from the Pittsburgh coal to the top of the Berea sandstone; and one dry hole on the Andy Lucas farm. Tests were likewise drilled on the Word farm in Section 7 and on the property of the Superior Coal Co. in Section 8, but both were failures.

Wells Township

Production is secured from the Berea sand in three small areas in Wells Township: First, in the northern part of Sections 12 and 18, which forms a part of the New Alexandria pool; second, over a small area in Section 30; and third, from the Limestone pool which lies almost entirely in Section 27. In Sections 12 and 18, the producing territory includes the Rieser, Kirkwood, and Cox farms, where about a dozen wells were yielding a small amount of oil in 1926. The depth and conditions of the sand are described in the discussion of the New Alexandria field in Cross Creek Township.

A small production of oil was secured from the Berea sand on the Graham farm in Section 30. The first well was drilled about 1922 and had an initial production of about 2 barrels of oil a day. A second well on the same farm also had a good showing as an oil producer but was spoiled in shooting. About a dozen wells were drilled in this area, most of which have been failures.

The first well in the Limestone pool, which lies almost entirely in Section 27, was sunk in the spring of 1904, and the entire field was drilled in about eighteen months. The producing territory is located chiefly on the McBride, Cole, Stringer, and Fleming properties, where the initial production varied from 250 to 800 barrels of oil a day. About

twenty-five wells were drilled in the field, fourteen of which produced some oil and gas and eight of which were producing in 1926, with a daily yield of about 11 barrels of oil. The "pay" sand, which forms a part of the Berea, is reported to have a thickness of about 8 to 10 feet and to lie about 1 foot below the top of the formation.

Outside of the producing fields in Wells Township, a number of test wells have been drilled to the Berea sand, located chiefly in Sections 6, 9, 10, 11, 12, 15, 18, 21, 27, 32, 34, and 35. Three holes have been drilled on the W. H. Tarr farm in Section 6, two of which were failures and the third a small producer which is now abandoned. Likewise, two wells were drilled on the C. J. Waddle farm and one on the property of the Beach Flats Coal Co. in Section 9. A small production was obtained from these wells but they have now been abandoned. Again in 1909, two wells were drilled on the Wheeling and Lake Erie Railroad property and two on the W. S. Tarr property, all located in Sections 34 and 35 in the eastern part of the township. Three of these wells were small producers but were abandoned in 1914 and 1915. A number of dry holes were drilled in this township as follows: One dry hole on the Matthews farm in Section 10; one dry hole on the Ekey farm in Section 11; one dry hole on the Hundeman and one on the Linton farm in Section 12; two dry holes on the Large farm in Section 15, one of which had a depth of 1,712 feet; a dry hole on the Cole farm in Section 28; and a dry hole in the southwestern part of Section 35.

Smithfield Township

A number of tests have been drilled to the Berea sand in Smithfield Township but without encouraging results. No important oil or gas fields were discovered in this township, although some wells yielded favorable showings of these fuels. Two dry holes were drilled in Section 6, one on the Sutherland property and the other on the Cope farm; a dry hole has also been sunk on the Hoofer farm in Section 2. A well was being sunk on the Garretson farm in Section 9 when the region was last visited by the writer in 1926. Likewise, there were two dry holes drilled in Section 10, one on the Rosenek and the other on the Garretson farm; also a dry hole on the Vale farm in Section 14; two dry holes on the De Paulis property in Sections 14 and 15; one dry hole on the Kithcart and one on the Iler farm in Section 15; two dry holes on the Galbreath farm in Section 11; and one dry hole on the Runyon property in Section 17. The record of the rock strata penetrated by the drill in the well on the Runyon farm is reported as follows[1]:

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[1]Bownocker, J. A., Geol. Survey Ohio, Fourth Series, Bull. 1, p. 248. 1903.

	Depth in feet to Top	Bottom	Thickness in feet
Not recorded	0	15	15
Coal, *Pittsburgh*	15	21	6
Shale	21	40	19
Rock, buff colored	40	120	80
Shale, white	120	280	160
Sand, black	280	305	25
Shale, white	305	315	10
Sand	315	375	60
Shale	375	385	10
Lime, bastard	385	395	10
Sand	395	445	50
Shale, white	445	505	60
Sand	505	530	25
Shale, white	530	595	65
Shale, black	595	645	50
Coal	645	654	9
Shale, black	654	674	20
Sand, *Salt*	674	754	80
Shale, black	754	864	110
Sand, *Keener*	864	919	55
Sand, *Big Injun*	919	1169	250
Slate	1169	1194	25
Sand, *Squaw*	1194	1214	20
Slate and shale	1214	1572	358
Sand, *Berea*	1572	1607	35
Total depth	.....	1607	.....

The tests drilled to the Berea sand in the western half of the county are as follows: One dry hole on the Isler farm in Section 21, two dry holes near Adena in Section 32, two dry holes in the southwestern part of Section 28, two dry holes in the eastern half of Section 29, and one dry hole in the eastern half of Section 30.

Mount Pleasant Township

Only a few test holes have been drilled to the Berea sand in Mount Pleasant Township, and all have been unsuccessful. These attempts include a dry hole in the southwestern quarter of Section 4, a dry hole on the Meek farm in Section 16 with a depth of 1,749 feet, a test in the northwestern corner of Section 18, and two in the western half of Section 29.

Warren Township

A few tests were drilled to the Berea sand in Warren Township and a small production in gas and oil has been secured, but no producing wells were found in this area in 1926. About twenty-five years ago

a little oil was secured from the Berea sand along Short Creek in the northern part of Section 36 and in the southern part of Section 31, and one well located on the Meekle farm is reported to have had an initial production of 15 barrels a day. The wells in this area, however, were short-lived and have long been abandoned. A little gas has also been secured from wells drilled on the valley flats at Rayland, but these, too, have been abandoned. A number of test wells located chiefly in the northern part of the township are as follows: One dry hole in Section 8; two dry holes on the Haythornswaite farm in Section 20; one dry hole on the T. Burris farm and three dry holes on the J. Burris farm in Section 26, two of the latter yielding a showing of oil; one dry hole on the Sustick farm in Section 32; and one dry hole in the southeastern part of Section 18. It is safe to say that all of these tests reached the Berea sand.

THE SEARCH FOR OIL AND GAS ABOVE THE BEREA SAND

The sands above the Berea, which are potential sources of oil and gas in Jefferson County, include the Stray, Squaw, Big Injun, Keener, and Salt sands. The Big Injun and Salt sands are recognized by the driller over most of the county, while the Stray, Squaw, and Keener sands are thin and local in their occurrence. The usual objective of drilling operations is the Berea sand, but at a few places shallow wells have been drilled to the Salt and Big Injun sands, or where satisfactory production has been obtained in the Big Injun, the drill has stopped before reaching its final goal, the Berea.

Near Pravo in Ross Township, a well is reported to have yielded oil from a sand lying at a depth of about 500 feet, probably the Big Injun sand. Two dry holes were drilled on the Edward George farm, one in Section 22 and the other in Section 23, Ross Township, the former having a depth of 476 feet and the latter a depth of 505 feet. Although the exact depth of the Berea sand in these localities is in doubt, it is very probable that these tests ended in the Big Injun sand. Another well was drilled to the Big Injun sand in the northeastern corner of Section 25, Knox Township, which had an initial production of 50 barrels of oil per day. In Salem Township, a small flow of gas is now secured from wells located on the W. B. Purvience and W. A. White farms in Section 9. The producing sand is reported to be the Big Injun, but as no records are available the depth of the wells and the thickness of the sand are unknown. A good flow of gas was also secured from the Big Injun sand on the J. Stroud farm in Section 2, Cross Creek Township. No oil or gas has been obtained from the Stray, Squaw, Keener, or Salt sands in Jefferson County.

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COLUMBIANA COUNTY

CARROLL COUNTY

HARRISON COUNTY

BELMONT COUNTY

BROOKE COUNTY

HANCOCK COUNTY

OHIO RIVER

PENNSYLVANIA

WEST VIRGINIA

AREAL GEOLOGIC MAP OF JEFFERSON COUNTY, OHIO

SHOWING THE IMPORTANT COAL AND LIMESTONE BEDS

BY

R. E. LAMBORN

B-35

LEGEND

PERMIAN SYSTEM

WASHINGTON SERIES
Thickness exposed 130ft.

PENNSYLVANIAN SYSTEM

MONONGAHELA SERIES
Average Thickness 232ft.

Waynesburg Coal Horizon

Pittsburgh Coal Horizon

CONEMAUGH SERIES
Average Thickness 518ft.

Ames Limestone Horizon

Upper Freeport Coal Horizon

ALLEGHENY SERIES
Thickness exposed 160ft.

SCALE OF MILES

0 ½ 1 2 3

Lawrence D. Jones