STATE OF OHIO
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL SURVEY

REPORT OF INVESTIGATIONS NO. 34

COAL BEDS OF THE CONEMAUGH FORMATION IN OHIO

By

Theodore A. DeBrosse

COLUMBUS
1957

STATE OF OHIO

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Governor

DEPARTMENT OF NATURAL RESOURCES

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ABSTRACT

The Conemaugh formation underlies approximately 8,000 square miles of eastern Ohio. This formation contains at least 18 coal horizons, of which only 6 seams occur with any degree of persistency; even these 6 seams are extremely erratic and vary in thickness and quality within short distances. However, there are several localities where one or more of the Conemaugh coal beds make a considerable contribution to the fuel resources of the State. Available information indicates that the original recoverable coal reserves of the Conemaugh formation in Ohio is approximately 1,329,368,000 tons. Coal beds 14 inches or more in thickness are considered as constituting recoverable reserves.

The Mahoning, Wilgus, Anderson, and Harlem coal beds account for most of the reserves. The Mahoning coal bed in Columbiana and Jefferson Counties contains 284,304,000 tons; the Harlem coal reserve is 34,560,000 tons in Carroll County; the Anderson coal reserve is 837,504,000 tons in Muskingum, Guernsey, Noble, and Morgan Counties; and the Wilgus coal field of Lawrence County has an original reserve of 173,000,000 tons.

PREFACE

This report is the sixth of a series by the Ohio Division of Geological Survey on Ohio's coal reserves. The previous reports of this series include:

"The Meigs Creek No. 9 Coal Bed in Ohio," 1952, O. G. S., Rept. of Inv. No. 17.
"The Lower Kittanning No. 5 Coal Bed in Ohio," 1954, O. G. S., Rept. of Inv. No. 21.
"The Pittsburgh No. 8 and Redstone No. 8A Coal Beds in Ohio," 1955, O. G. S., Rept. of Inv. No. 26.
"Coal Resources of the Upper Part of the Allegheny Formation in Ohio," 1956, O. G. S., Rept. of Inv. No. 29.
"Coal Resources of the Lower Allegheny Formation in Ohio," 1957, O. G. S., Rept. of Inv. No. 31

A report entitled "Coal Beds of the Pottsville Formation" is still in preparation.

The purpose of this investigation is to summarize the known information about the coal beds of the Conemaugh formation in Ohio. It is hoped that this report may serve as a guide to coal operators and owners of coal-bearing land in evaluating holdings, as well as in prospecting for areas of minable coal. The information contained herein is based on county reports, many miscellaneous reports, and numerable unpublished measured sections in the files of the Ohio Division of Geological Survey, and thus represents a summarization of previous work.

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GENERALIZED SECTION OF THE CONEMAUGH FORMATION IN OHIO

System	Formation	Member	Kind of Material	Thickness Ft.	Thickness In.	Interval Ft.	Interval In.
Pennsylvanian	Monongahela	Pittsburgh No. 8. .	Coal, persistent.	3	7	-	-
						247	8
	Conemaugh	Upper Pittsburgh .	Clay shale	-	6	-	-
			Limestone, irregular . . .	5	0	19	0
			Clay shale	13	5	-	-
		Upper Little Pittsburgh	Coal, very local.	-	1	-	-
		Bellaire	Clay shale	4	0	-	-
			Sandstone, local.	10	6	-	-
			Shale, siliceous.	2	5	17	0
		Lower Little Pittsburgh	Coal, seldom present . . .	-	1	-	-
		Summerfield Lower Pittsburgh .	Shale, variable	8	0	-	-
			Limestone	12	0	-	-
			Shales, variable	26	0	69	0
		Connellsville . . .	Sandstone, local.	20	0	-	-
			Clay shale	2	10	-	-
		Clarksburg	Coal, local	-	2	-	-
		Clarksburg	Limestone and marly shale.	4	0	-	-
		Morgantown. . . .	Sandstone, local.	30	0	34	1
		Elk Lick	Coal, usually wanting . . .	-	1	-	-
		Elk Lick	Limestone and marly shale.	5	0	-	-
			Shale, variable	5	0	-	-
		Birmingham. . . .	Shale, siliceous.	10	0	20	5
		Skelley	Limestone, local, marine .	-	4	-	-
		Duquesne	Coal, seldom evident . . .	-	1	-	-
		Gaysport	Shale, variable	9	0	-	-
			Shale, siliceous.	11	0	-	-
			Limestone, siliceous, marine	1	0	-	-
			Shale, siliceous	16	0	54	6
		Ames	Limestone, marine	1	6	-	-
			Shale, siliceous	15	0	-	-
		Harlem	Coal, persistent	1	0	-	-
		Round Knob - Pittsburgh. . . .	Clay, calcareous	2	0	-	-
			Clay shale, red	12	0	-	-
		Saltzburg	Sandstone, local.	8	0	26	0
			Shale, siliceous.	3	0	-	-
		Barton	Coal, local	1	0	-	-
		Ewing	Clay shale	4	0	-	-
			Limestone, ferruginous . .	1	0	-	-
			Shale, siliceous.	3	0	-	-
		Cow Run	Sandstone, local.	15	4	29	0
			Shale, siliceous.	2	0	-	-
		Portersville. . . .	Limestone, marine	2	0	-	-
		Anderson.	Coal, persistent.	1	8	-	-
		Bloomfield	Clay shale	3	7	-	-
			Limestone, local	1	5	-	-
			Shales, variable.	19	0	30	0
		Cambridge	Limestone, marine	4	0	-	-
		Wilgus	Coal, unsteady	2	0	-	-
		Buffalo	Clay shale	3	8	-	-
			Shale or sandstone.	23	0	-	-
		Brush Creek . . .	Limestone, marine	20	0	47	0
		Brush Creek . . .	Coal, local, thin	-	4	-	-
		Mason	Shales, variable.	10	6	11	0
			Coal, local	-	6	-	-
		Upper Mahoning . .	Shale or sandstone.	10	0	11	0
		Mahoning, Groff. .	Coal	1	0	-	-
		Thornton	Clay, irregular	5	0	-	-
		Mahoning	Limestone, local	2	0	32	0
		Lower Mahoning. .	Shale or sandstone.	25	0	-	-
						400	0
	Allegheny	Upper Freeport, No. 7.	Coal, patchy.	3	0	-	-

Figure 1. - The above generalized section shows the named coal beds of the Conemaugh formation and their relation to other members of the formation.

CHAPTER 1

GENERAL DESCRIPTION OF THE CONEMAUGH FORMATION

The Conemaugh is one of the four formations which constitute the Pennsylvanian system of rocks in Ohio. This formation was named by Franklin Platt (1875, p. 8) for a sequence of rocks exposed along the Conemaugh River in western Pennsylvania. Today, Conemaugh is the term used by geologists throughout the Appalachian Basin to designate all the strata lying between the top of the Upper Freeport No. 7 coal and the base of the Pittsburgh No. 8 coal.

The strata within this interval consist of shales of diverse textures and colors; sandstones with many different lithologic characteristics; limestones of marine, brackish, and fresh water origin; clays, usually calcareous and ferruginous; conglomerates; iron ores, either in nodular form disseminated through the shales or in thin beds of local extent; and coal beds which are mostly thin and impure (see fig. 1).

The geologic conditions necessary for the deposition of great coal beds were not nearly so favorable during Conemaugh time as they had been during the preceding period. While it is true that many coal beds were formed, they are generally thin, inferior in quality, and of local extent. However, a few of the coal beds do thicken sufficiently locally to warrant their being worked by systematic mining operations in Ohio. Because of the sparce and generally unproductive nature of the coal beds in the Conemaugh formation, it was formerly called the Lower Barren Coal Measures.

The outcrop area of the Conemaugh formation in Ohio forms a broad band, 5 to 28 miles in width, stretching from Columbiana County southwestward to Lawrence County, at the extreme southern portion of the state (see fig. 2). Conemaugh rocks underlie approximately 8,000 square miles of southeastern Ohio. Their thickness ranges from 100 feet in Hocking County to 450 feet in Harrison County (see fig. 3).

The area in Ohio underlain by the Conemaugh formation lies on the western flank of the northern Appalachian coal basin. The geologic structure here is relatively simple. The regional dip of the beds is in a southeastern direction, with the greatest thickening of the beds occurring to the east. However, the regular slope of the strata is frequently broken by the presence of many small structural features such as anticlines, synclines, domes, basins, terraces, and a few faults of small magnitude. The effects of these structures are only local in extent. The most significant structural features are the Cambridge Arch and the Parkersburg-Lorain syncline whose areal expressions are quite pronounced. None of these geologic structures create extraordinary difficulties in the recovery of the coals.

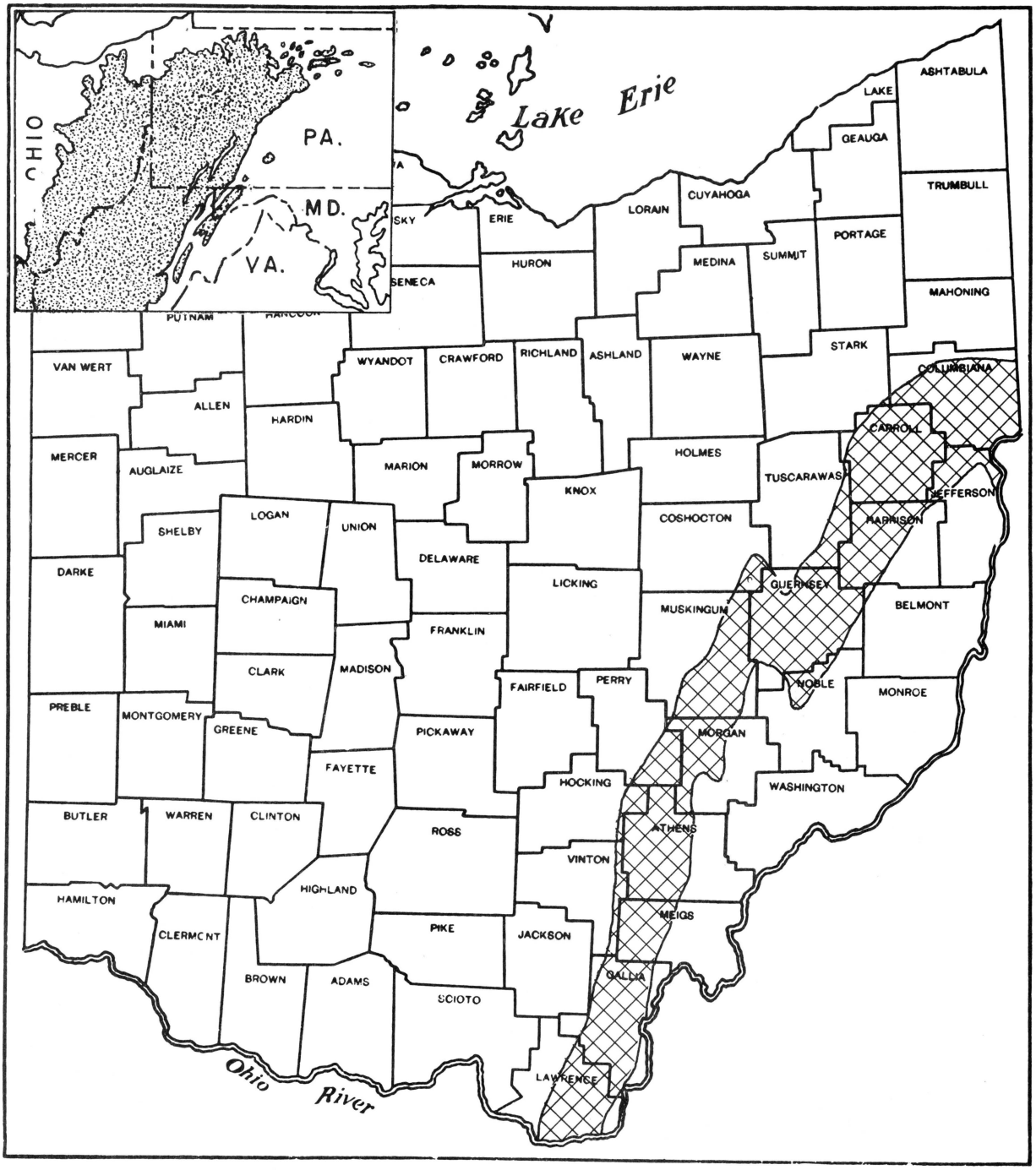


Figure 2. - Generalized map showing the approximate outcrop area of the Conemaugh formation in Ohio. Inset shows the location of the Northern Appalachian coal basin.

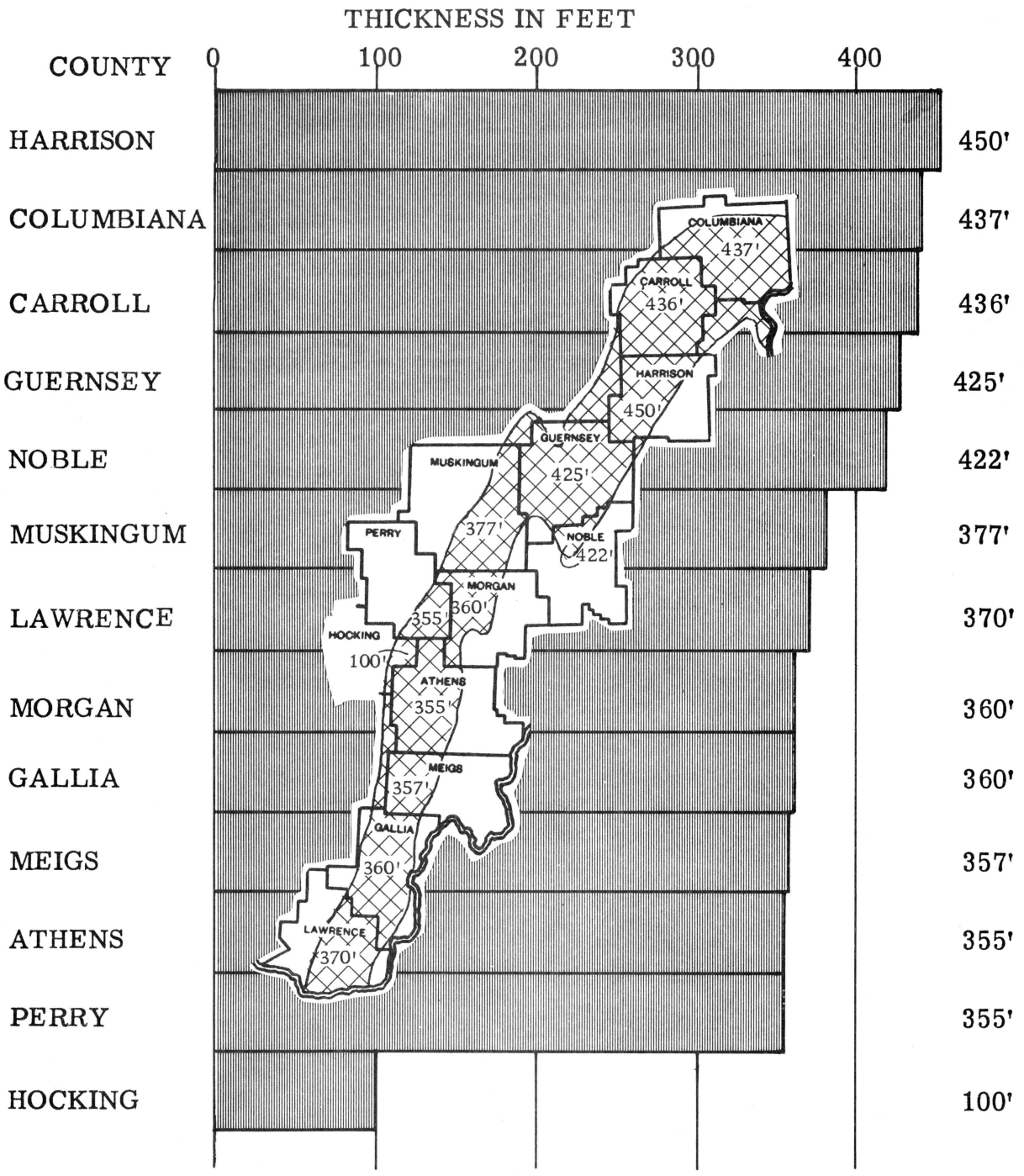


Figure 3. - Thickness of the Conemaugh formation present in several Ohio counties. In many cases this does not include the entire formation but only that portion present.

CHAPTER 2

PRINCIPAL COAL BEDS OF THE CONEMAUGH FORMATION

There are 18 known horizons in the Conemaugh formation where coal beds may occur, but most of these seams do not attain sufficient thickness to be of economic importance. According to Condit (1912), it is not unusual to find exposures of the entire formation with just a few carbonaceous streaks which, when taken together, might not total even a foot of coal. Nevertheless, there are six coal seams which locally attain a minable thickness; the Mahoning, Mason, Wilgus, Anderson, Barton, and Harlem coal beds. The relative positions of these coal beds in the geologic column are noted in figure 1. These coal beds vary locally and their occurrence as minable bodies of coal can be determined only by careful prospecting.

Although the characteristics of the Conemaugh coal beds in individual counties will be discussed in chapter III, it is felt desirable to briefly discuss the six above-named coal beds in the following pages.

THE MAHONING COAL BED

The Mahoning coal bed, which is the oldest Conemaugh formation coal, is economically the most important one of the whole formation. It occurs in minable quantities in Columbiana, Jefferson, and Carroll Counties, where the bed ranges from 2 to 3 feet in thickness. It is best developed in the vicinity of Salineville, Columbiana County, where its thickness is known to reach 38 inches, including a shale parting about 10 inches above the base of the coal. In this area it lies 32 feet above the Upper Freeport coal bed. Along Island Creek in northern Jefferson County this coal bed is from 36 inches to 54 inches thick.

Early geological reports referred to the Mahoning coal bed as the Brush Creek coal. Other terms by which this coal seam has been designated and the areas in which they were used are: the Groff vein in the upper Ohio Valley, the Strip vein at Salineville, and the Finley coal along Island Creek in northern Jefferson County.

THE MASON COAL BED

This coal seam is present in nearly every county along the Conemaugh outcrop belt, but the area of its greatest importance lies in the extreme eastern part of the state, particularly in Columbiana County. It occurs about midway between the Upper Freeport coal bed and the Cambridge limestone. In Columbiana County the interval between it and the Upper Freeport coal is approximately 75 feet.

A measurement taken at the "Round Knob" mine, Madison Township, Columbiana County, showed $3\frac{1}{2}$ feet of coal with a clay parting five inches above the bottom. The coal bed is mined at several localities in this area. This same coal bed is exposed in cuts along the railroad near Salineville, Columbiana County, where its thickness varies from 3 feet to just a carbonaceous streak in a very short distance.

This coal bed was named by I. C. White (1903, p. 285), of the West Virginia Geological Survey, for a coal bed that had long been mined at the village of Mason on Elk River, seven miles northeast of Charleston, Kanawah County, West Virginia.

THE WILGUS COAL BED

The Wilgus coal bed was named by Condit (1912, p. 126) for deposits near the village of Wilgus, Mason Township, Lawrence County, Ohio. Its best-known occurrence is in the southern part of the state, particularly in Lawrence and Gallia Counties. The measurements reveal from 18 to 36 inches of coal nearly everywhere in the Symmes Creek valley of Lawrence County. Because its position is directly below, or at the most a few feet below, the Cambridge limestone, it is frequently referred to as the "limestone" coal. The following section measured in Section 9 Mason Township, Lawrence County, is characteristic of the Wilgus coal in this area:

	Ft.	In.
Limestone, Cambridge	-	11
Coal, Wilgus	2	11
Clay, unmeasured	-	-

THE ANDERSON COAL BED

The type locality for the Anderson coal bed is near Lore City, Guernsey County, Ohio, where it was named by Professor Andrews (1874, p. 539) after the owner of a small mine in that vicinity. In this area the coal bed is found about 12 feet above the Cambridge limestone. E. Lovejoy (1888, p. 634) applied the name "Patriot" to this coal bed in Gallia and Meigs Counties. However, this term is not valid since it was antedated by the name Anderson. I. C. White, of the West Virginia Geological Survey, called the same seam the Bakerstown coal when he described it from a core obtained from a deep drill hole at Glenova near Wheeling, West Virginia (Grimsley, G. P., 1906, pp. 11-16). As the nomenclature stands today, the Anderson coal bed of Ohio is probably the equivalent of the Lower Bakerstown coal bed of West Virginia.

The Anderson coal bed is one of the most valuable seams of the Conemaugh formation. There are minable occurrences of it in much of Muskingum County, where it is by far the most widely exploited coal bed of the Conemaugh formation. Here it is very regular in thickness, the average is about 23 inches. Morgan, Noble, Guernsey, and Harrison Counties likewise contain an abundance of this coal in minable quantities.

In Ohio, the thickness of the Anderson coal seam throughout its outcrop area varies from a smut streak to 3 feet. Its quality is reported to be good everywhere that it has been mined. The pyritiferous shale forming the roof and the hard siliceous clay which makes up the floor of the mines present very favorable conditions for successful mining.

THE BARTON COAL BED

The Barton coal bed, which lies beneath the Round Knob horizon and above the Ewing limestone, is apparently the same as the Barton of Maryland and the Bakerstown of Pennsylvania (Condit, D. Dale, 1912, p. 37). P. T. Tyson (1837) has proposed the term Barton to designate this coal seam in Ohio. A coal seam in West Virginia that occupies the same position in the geologic column as the Barton in Ohio is referred to as the Upper Bakerstown (Reger, 1924, p. 223).

Carroll County and adjacent portions of Columbiana, Jefferson, and Harrison Counties contain the only known areas of minable Barton coal in Ohio. The most important locality is Perryville, Perry Township, Carroll County, where for many years it has been mined in a small way. Here it lies approximately 40 feet below the Ames limestone. The following section, measured east of Perrysville at the W. R. Amos mine, is representative of the Barton in this area:

		Ft.	In.
Shale, black		3	-
Coal		-	8
Pyrite band	Barton	-	$0\frac{1}{4}$
Coal		1	-

Southwest from the above-named counties, the Barton is seldom represented by more than a thin blossom or a carbonaceous streak.

THE HARLEM COAL BED

The type locality of the Harlem coal bed is near Harlem Springs, Carroll County, Ohio, from which locality it was named by Dr. Newberry (1874, pp. 156-157). In Maryland the term Friendsville has been applied to this coal, while in the older reports of West Virginia (White, I. C., 1903, p. 262) it is called the Crinoidal coal. In geologic reports of Ohio, it has been designated the No. 7B coal by J. J. Stevenson (Newberry, 1874, p. 157). This coal bed has its best development in Jefferson, Carroll, and Harrison Counties. It seldom reaches a thickness of three feet, although 30-inch measurements are common over a large area. The following section, measured at the type locality in southeastern Carroll County, is fairly representative:

	Ft.	In.
Limestone, Ames	1	6
Shale, carbonaceous	12	-
Coal, Harlem	2	4
Clay	-	-

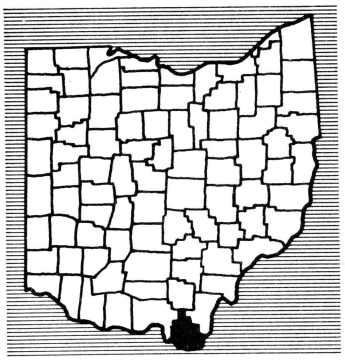
Coal was mined from this bed at Harlem Springs for many years and at one time it was the principal fuel supply for local consumption.

CHAPTER 3

AREAL DESCRIPTION BY COUNTY

LAWRENCE COUNTY

The rocks exposed in Lawrence County range from near the base of the Allegheny formation through the Conemaugh to the middle of the Monongahela. The dip of these beds is 15 to 25 feet to the mile in an eastward direction. For this reason the Conemaugh rocks, which appear at the surface in the central portion of the county, pass below drainage in the eastern part, where they are capped by the Monongahela formation.



Location of Lawrence County

Although the total thickness of the Conemaugh in Lawrence County is about 370 feet, the only coal of this formation which has any economic importance is the Wilgus. Both the coal and the overlying Cambridge limestone are of considerable local value. The coal has an extensive domestic use and the limestone is much in demand for road building. They are best developed near Wilgus in Mason Township, near Arabia in Aid Township, and on the ridge north of Sherritts in Symmes Township (see figure 4). They are found likewise, but with less persistence, in Decatur, Washington, Elizabeth, Lawrence Perry, Fayette, Windsor, and Union Townships.

The better quality and greater volume of the Wilgus coal in Symmes, Aid, and Mason Townships have made it very attractive for mining ventures. Here the coal bed has no regular partings and contains but little shale impurities. The coal is very regular, bright and solid. Its usual thickness is between 2 and $3\frac{1}{2}$ feet. The Cambridge limestone which forms the roof throughout the entire field, except in small areas on Long Creek and in the southern part of the county, and the dense, siliceous, calcareous clay which makes up the floor present ideal mining conditions. The absence of "rolls" in the floor facilitates drainage when the mines are driven against the dip.

Table 1 which follows gives the estimated coal tonnage in reserve in the Wilgus seam of Lawrence County and Table 2 summarizes the analyses.

Table 1

Estimated Coal Tonnage in Reserve in the Wilgus Seam of Lawrence County*

Name of Coal Bed	Average Thickness Ft.	In.	Area (sq. mi.)	Tons Per Square Mile	Tonnage
Wilgus	2	0	75	2,034,000	173,000,000

*Clark, F. R., 1917, p. 93.

Table 2

Analyses of the Wilgus Coal in Lawrence County*

County	Township		Proximate (percent)				Ultimate (percent)					Heating Value		Fusion of Ash (Degrees F.)		Reference	
			Moisture at 105° C	Volatile Matter	Fixed Carbon	Ash	Sulphur	Carbon	Hydrogen	Oxygen	Nitrogen	Calories	B. t. u.	Insipient	Complete	Organization	
Lawrence	Mason	A	6.95	39.08	46.42	7.55	3.60	66.83	5.43	15.26	1.33	6,649	11,968	2,180	2,345	Ohio	
		B		42.00	49.89	8.11	3.87	71.82	5.01	9.76	1.43	7,145	12,862				
Lawrence	Symmes	A	8.15	38.48	45.90	7.47	2.83	66.18	5.40	16.84	1.28	6,575	11,835	2,098	2,345	Ohio	
		B		41.89	49.98	8.13	3.08	72.05	4.89	10.46	1.39	7,158	12,885				
	Average	A	7.55	38.78	46.16	7.51	3.22	66.51	5.41	16.05	1.30	6,612	11,902	2,139	2,345		
		B		41.95	49.93	8.12	3.47	71.94	4.95	10.11	1.41	7,152	12,874				

*Bownocker and Dean, 1929, p. 311.

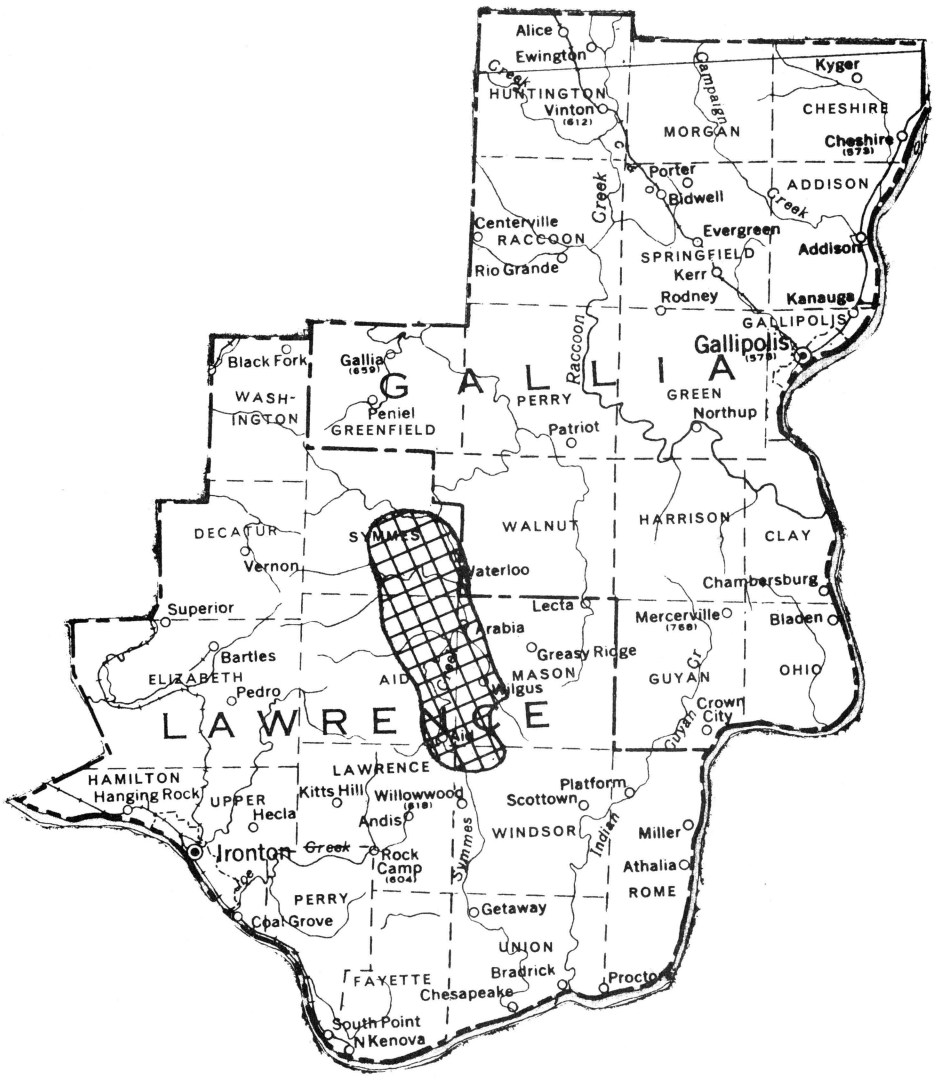
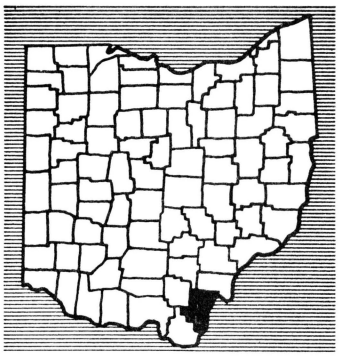


Figure 4. - The Wilgus coal field in Ohio.

The shaded area on figure 4 shows the area in which the Wilgus coal has its best development in Ohio. Note that outcrop lines are not indicated and thus the area shown represents only the known areal extent except for that part lost to erosion.

GALLIA COUNTY

The rocks exposed at the surface in Gallia County belong to the Allegheny, Conemaugh, and Monongahela formations of the Pennsylvanian system. The general dip of the rocks here is a little south of east at a rate of 15 to 40 feet per mile. Rocks belonging to the Conemaugh formation form a broad band extending north and south through the central portion of the county, with a thickness of a little over 360 feet.

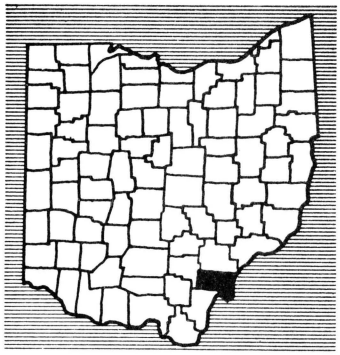


Location of Gallia County

The coal beds of the Conemaugh formation which occur in this county in minable quantities are the Mahoning, Mason, and Wilgus. These coal beds, however, add very little to the economic stability of Gallia County. The Mahoning coal bed is very irregular and seldom thickens to more than 1 foot 6 inches. It is mined along the outcrop by stripping at a few places. Like the Mahoning coal bed, the Mason coal bed is mined by stripping at a few localities along its outcrop, but it is too thin to be followed under cover. The Wilgus coal bed is likewise very irregular and poorly developed here. Except for Morgan Township and a small part of Walnut Township, where the Wilgus coal seam reaches 1 foot 8 inches and is strip mined, its usual thickness is less than 1 foot.

MEIGS COUNTY

Rocks belonging to the Conemaugh formation crop out in a broad band in the western half of this county, where the general dip of the strata is eastward at the rate of 15 to 30 feet per mile. The record of a well drilled at Pomeroy in 1883 and published by Edward Orton (1888, p. 397) shows the Conemaugh to be approximately 357 feet thick here. Along the western border of the county, the base of the Conemaugh has been exposed by stream erosion.



Location of Meigs County

The Mahoning, Mason, Brush Creek, Wilgus, and Anderson coal beds occur in Meigs County with thicknesses ranging from a smut streak to 2 feet of minable coal. Near the south edge of Section 28, Salem Township, the Mahoning coal bed is about 18 inches thick. The Mason coal bed occurs at several localities in Columbia and Salem Townships with a thickness ranging from 5 inches to 14 inches. In Section 16, Columbia Township, the Brush Creek coal reaches a thickness of 16 inches. Here the coal is characterized as follows:

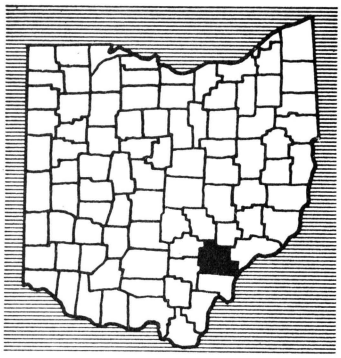
Brush Creek coal	Coal.....	4 inches	
	Clay	14 "	..... 30 inches total
	Coal	12 "	(16" of coal thickness)

The Wilgus coal bed was formerly mined one mile south of the Albany railroad station. It was also mined near Hanesville in the southeastern corner of Salem Township. The Anderson coal

bed has been mined in a small way about one mile east of Dexter. North of Rutland it has a reported thickness of three feet, including a one-foot layer of shale in the middle. Here it has been worked at several localities.

ATHENS COUNTY

The general direction of dip of the strata in Athens County is a little south of east. The Conemaugh strata crop out in the western half of the county where they have a thickness of about 355 feet. The hilltops about one mile east of Bishopville contain small areas of the Pittsburgh coal bed, while Sunday Creek Valley, one mile to the west, exposes the Upper Freeport coal. Thus, within a one-mile radius of Bishopville, the entire Conemaugh formation may be seen.



Location of Athens County

Out of 45 stratigraphic sections in the files of the Ohio Geological Survey which show 12 inches or more of coal in one or more of the Conemaugh beds in Athens County, only one shows the Mahoning coal bed. It is a section measured in the SW$\frac{1}{4}$, NW$\frac{1}{4}$ of Section 18 and E$\frac{1}{2}$, SE$\frac{1}{4}$, NE$\frac{1}{4}$ of Section 24, where a thickness of 21 inches is reported. Here it contains much fusain, is bright, thin-bedded, and somewhat shaly at the top.

The Mason coal bed occurs more frequently than the Mahoning coal. Its average thickness is 19$\frac{1}{2}$ inches, as computed from seven measurements made in Lee, Trimble, and Waterloo Townships.

Two measurements of the Brush Creek coal bed in Waterloo Township show a thickness of 12$\frac{1}{2}$ inches.

The Wilgus coal bed is reported in Dover, Ames, and Lee Townships and formerly supported small scale mining operations in Lee Township.

The Anderson coal bed is considered to be the most prominent of all the Conemaugh coal beds in Athens County. Fifteen measurements from nine townships show an average thickness of 15.6 inches. In Ames Township, at a number of localities along the Federal Creek Valley, the Anderson coal bed has been strip mined for home use.

Outcrops of the Barton coal are sparse and little information is available concerning its thickness in Athens County. The record from an air shaft, drilled for a deep mine in the Middle Kittanning No. 6 coal bed at Canaanville, shows 16 inches of Barton coal.

The Harlem coal bed is very poorly developed throughout the county. It is present as a 6-inch coal bed in Ames Township.

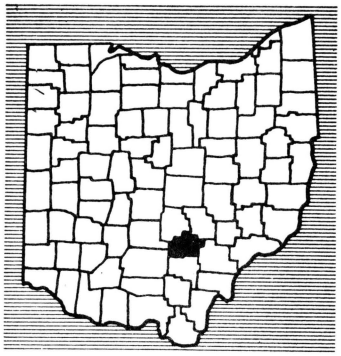
In Section 36, Lodi Township, the Little Clarksburg coal bed attains a thickness of 30 inches; however, no records are known of a similar development elsewhere in the county.

HOCKING COUNTY

Rocks belonging to the Conemaugh formation are absent due to erosion throughout most of Hocking County. In Ward and Starr Townships, in the extreme eastern part of the county,

hilltops are capped by Conemaugh rocks representing the lower third of the formation. The total thickness of the Conemaugh in this area is approximately 100 feet. Elsewhere in the county the Conemaugh is entirely absent.

None of the Conemaugh coal beds in Hocking County are of minable thickness. Three-and four-inch streaks represent their best development.

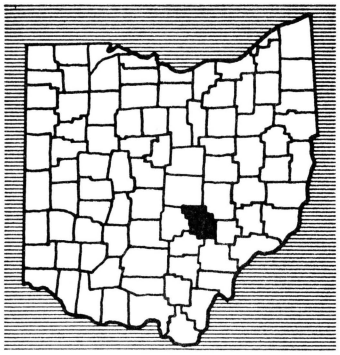


Location of Hocking County

PERRY COUNTY

The rocks exposed at the surface in Perry County range from the middle of the Mississippian system to the Conemaugh formation of the Pennsylvanian system. The regional dip of the strata here is gently to the east-southeast, into the Pittsburgh-Huntington basin, at an average rate of 25 to 30 feet per mile. Rocks belonging to the Conemaugh formation are exposed in the eastern and southeastern part of the county. In this region they have a thickness of about 355 feet, which represents about one-half of the strata in the Conemaugh formation. The Conemaugh formation includes cyclothems from the Mahoning through the Harlem.

The Mahoning coal bed occurs as the following facies in Perry County: 1) black fissile shale, 2) bright, blocky coal, 3) bony coal, 4) shaly coal, and 5) as a ferruginous layer above the Thornton clay. Bony coal and shaly coal occur most frequently. Bright coal is the least abundant of the various facies. The thickness of the coal averages 10 inches and ranges from a thin film to 3 feet. Unfortunately, where thickest, the coal is bony and shaly.



Location of Perry County

Exposures of the comparatively persistent Mahoning coal bed are distributed throughout the Conemaugh outcrop belt (see fig. 2), but they are most abundant in Bearfield, Pleasant, and Monroe Townships in eastern Perry County. More specific localities where outcrops of the Mahoning coal bed may be observed are: in the vicinity of Santoy, Monroe Township, where the coal is near stream level; along Happy Hollow Road south of Congo, Monroe Township; and in northeastern Salt Lick Township on the road bank seven-tenths of a mile southeast of the Ironpoint School. In the last-mentioned locality, the Mahoning coal bed is 3 feet thick and is a bony and shaly coal.

The Mason coal bed weathers rapidly on the outcrop because of its shaly character. However, variations are noted; at some localities the coal is bright and at others it is bony. It is very "patchy" in its occurrence, its thickness does not exceed 12 inches, and because its average thickness is only six inches, the Mason coal bed has no economic value in Perry County

The Brush Creek and Wilgus coal beds are not present in Perry County (Flint, 1951, pp. 62, 65). However, the marine Brush Creek limestone, which usually directly overlies the Brush Creek coal bed, is a persistent unit and a valuable stratigraphic guide.

The Anderson coal bed is dominantly bright and blocky, but locally it is very shaly. Its thickness ranges from slightly less than a foot to 2 feet and averages 1 foot. It is a persistent unit throughout most of the southeastern part of the county and is an especially good stratigraphic guide in eastern Bearfield Township and Pleasant and Monroe Townships. Outcrops of the

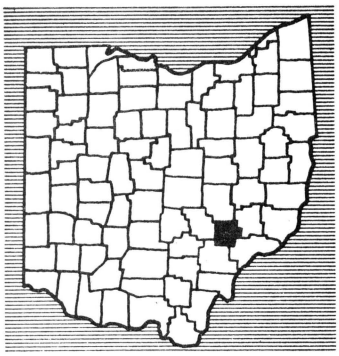
Anderson coal bed are found on the ridges in the vicinity of Corning, Congo, and Rendville, Monroe Township, but it is near valley bottom in Wildcat Hollow, two and a half miles east of Corning. In the southeast corner of Monroe Township and in adjoining Morgan County, the Anderson coal bed is replaced by the massive Cow Run sandstone.

The Barton coal bed is not recognized in Perry County (Flint, 1951, p. 70). In adjoining Muskingum County, this unit is found overlying the Ewing limestone.

The Harlem coal bed is recognized only locally in Perry County; no minable bodies of this coal seam are known in the area.

MORGAN COUNTY

The surface of Morgan County is underlain by rocks belonging to the Allegheny, Conemaugh, and Monongahela formations of the Pennsylvanian system. The general dip of the strata is southeastward. The surface of the eastern half of Morgan County consists almost entirely of Monongahela beds with exposures of the top layers of the underlying Conemaugh formation occurring only in the deeper valleys. The Monongahela rocks rise westward until they are found only as isolated outliers at the tops of the high hills, while the Conemaugh beds are present throughout most of the county. One valley at the extreme northwestern corner of the county is cut below the base of the Conemaugh and exposes Allegheny strata. Here, along branches of Moxahala Creek in York Township, the Upper Freeport coal bed, the topmost member of the Allegheny formation, is exposed. The total thickness of the Conemaugh formation in Morgan County is about 360 feet.



Location of Morgan County

Coal beds of the Conemaugh formation in Morgan County, except for the Anderson, are very sparsely developed. The Mahoning coal bed in this county is seldom more than six or seven inches thick, and the Mason coal is seldom more than a carbonaceous streak. A minable thickness of the Anderson coal bed is present throughout most of the Conemaugh outcrop area in Morgan County. In Sections 4, 5, 16, 25, and 28, Bloom Township, the Anderson measures 24 inches thick. This coal bed maintains a rather steady thickness along the Muskingum Valley of Morgan County. South of this valley it is interrupted and, in some localities, entirely replaced by the overlying Cow Run sandstone. York and Deerfield Townships likewise contain thick occurrences of the Anderson coal bed. Union and Homer Townships contain many 18-inch exposures of this coal. In southwestern Homer Township the Anderson coal bed has been strip mined along the valley of Hyde Fork of Federal Creek. In this area the coal maintains a moderately persistent thickness of 18 inches.

It has been calculated from available information that the Anderson coal bed underlies some 202 square miles of Morgan County and averages 21 inches thick over much of this area. Using a figure of 2,016,000 tons of coal per square mile for this thickness, a total of 407,232,000 tons of coal in reserve has been calculated for the Anderson seam of Morgan County. As reserves in the major coal seams decrease, the Anderson coal bed should assume a more and more important role.

The Barton coal bed attains minable thickness in several small areas. In Section 16, Bloom Township, 18 inches of Barton coal are frequently observed. In Section 5 of Deerfield Township, and in Section 32 of Malta Township, the Barton coal bed has a thickness of 12 inches.

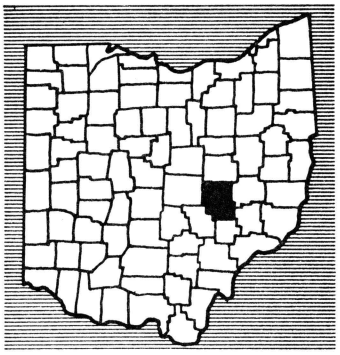
The Harlem coal bed reaches a foot or more in thickness in parts of Bloom and Homer Townships, but its occurrence is very erratic.

The Upper Little Pittsburgh coal bed is present in Section 21, Union Township, where its

measured thickness is 24 inches. This is the only place in the county where a development of this nature has been observed.

MUSKINGUM COUNTY

The rocks at the surface in Muskingum County belong to the Pennsylvanian system and include the Pottsville, Allegheny, and Conemaugh formations and a part of the Monongahela. The dip is generally southeastward, so the highest or youngest strata in the geologic column occur in the southeastern part of the county and to the northwest, lower and lower formations appear at the surface. The Conemaugh formation is present in its full thickness of about 377 feet in southeastern Muskingum County and its basal beds are found as far west as the Muskingum River and Moxahala Creek. Near Nashport, at the northwestern edge of the county, the base of the Pennsylvanian rocks is exposed.



Location of Muskingum County

Rocks belonging to the Conemaugh formation are present above drainage in Meigs, Blue Rock, Harrison, Brush Creek, Clay, Newton, Rich Hill, Salt Creek, Wayne, Union, Perry, Washington, Highland, Salem, Madison, Adams, and Monroe Townships. The Conemaugh coal beds that are fairly well developed in these townships include the Mahoning, Anderson, and Harlem. These coal beds, while remarkably persistent in this area, are rather thin.

The Mahoning coal is a rather persistent bed in the southern part but is seldom present in the northern part of Muskingum County. The average thickness of the bed is about 5 inches and the maximum measurement is not more than 8 inches. The coal is inferior in quality and often tends towards a dense cannel type. The position of the bed is about 37 feet above the Upper Freeport coal and nearly 20 feet below the Brush Creek limestone. This coal bed, although thin, is rather steady in Clay and Brush Creek Townships, and extends eastward into Harrison and Blue Rock Townships. Along the Muskingum Valley, in the western part of Blue Rock Township, it is regularly present and lies near the base of the hills.

The Mahoning coal in Muskingum County is of interest only as a stratigraphic unit, since the bed has almost no economic value. In a few localities where this coal is only 5 to 8 inches thick, it is overlain by a foot or more of dark carbonaceous shale with thin coal bands. In such outcrops the bed is somewhat deceptive, since it may be mistaken for that of a coal of minable thickness. The fact that this coal is hard, dense, and tends toward the cannel type also contributes to its lack of importance. A small amount of fuel has been obtained from this seam along stream beds.

The Mason coal, a moderately uniform bed averaging about 1 foot in thickness in southern Ohio, is poorly defined in Muskingum County. Its position in the geologic column is about 14 feet above the Mahoning coal and nearly 5 feet below the Brush Creek limestone. In the northern part of this area it is replaced by massive sandstone or siliceous shale and, in the southern part of the county, a dark carbonaceous shale occupies its position. Aside from stratigraphic interest, the Mason coal has no value in Muskingum County.

The Wilgus coal, whose position is either directly or only a few feet below the Cambridge limestone, is a very poorly marked horizon in this county. In only a very few places can a thin bed of impure coal, or even a soot streak, be observed. This coal bed, thin and shaly in character, has no value.

The Anderson coal bed, formerly referred to locally as the Norwich seam, is undoubtedly the most prominent coal bed in the Conemaugh formation of Muskingum County. It is very steady

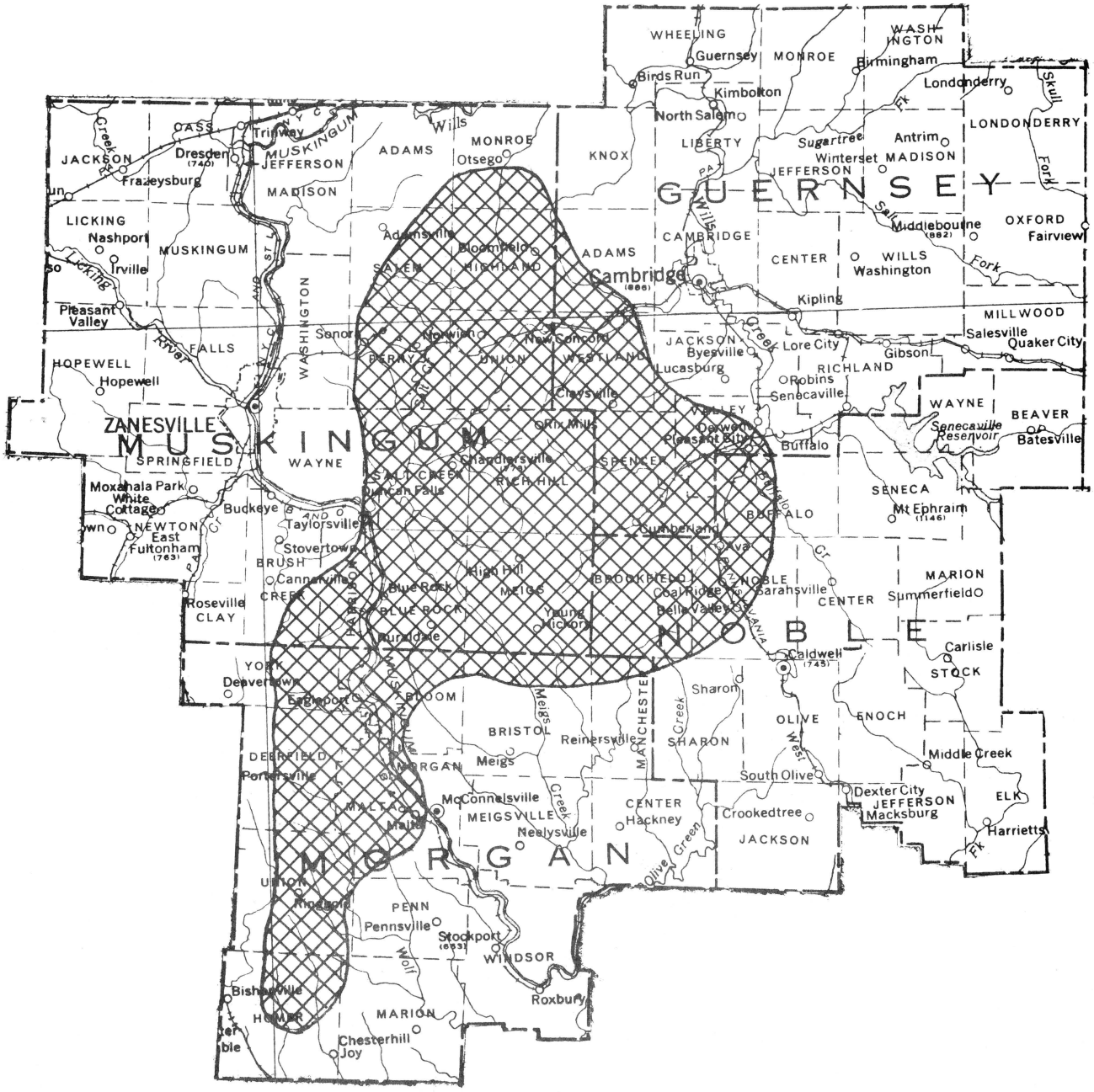


Figure 5. - The Anderson coal field in Ohio. The ruled area shows the area in which the Anderson coal has its best development in Ohio. Note that outcrop lines are not indicated and thus the area shown represents only the known areal extent, except for that part lost to erosion.

in both thickness and areal extent, being absent in only a few places and there only for short distances. Its thickness is seldom less than 1 foot 4 inches or more than 2 feet 6 inches. The average thickness taken from all available records is 1 foot 11 inches. In many localities there is a thin parting near the middle of the seam. This parting is usually a thin layer of bony coal or carbonaceous shale and varies in thickness from $\frac{1}{4}$ inch to 2 inches. With few exceptions this coal bed is overlain by dark carbonaceous and fossiliferous shale and limestone of the Portersville member. The bed is usually underlain by a few feet of light-colored, siliceous and calcareous clay. Its position in the geologic column is, on the average, about five feet above the Bloomfield limestone. This coal bed is present above drainage in Clay, Brush Creek, Harrison, Blue Rock, Wayne, Salt Creek, Rich Hill, Perry, Union, Salem, Highland, Adams, and Monroe Townships. Due to the work of erosion, the area of coal in some of these townships is small.

In the eastern and southern parts of Clay Township, the Anderson coal is confined to the high ridges and knobs. The bed is very steady in this area and appears to maintain an average thickness of 1 foot 8 inches. In Brush Creek Township, this coal is found along the ridges in the southern and eastern parts. The usual thickness here is from 1 foot 4 inches to 2 feet 6 inches.

The Anderson coal is very persistent, with local exceptions, in practically all of Harrison Township. In a few places it is replaced or cut out by the massive Cow Run sandstone. It is mined by drifting for local use near the head of Black Run. Along the ridges north of this locality, it is also strip mined on a small scale.

The Anderson coal is above drainage along all the streams in the western and northern parts of Blue Rock Township, and is utilized extensively for local fuel supply. It is mined both by drifting and stripping. In the vicinity of Coal Hollow, Section 27, this coal is mined at several places; here its usual thickness is about 2 feet and its maximum thickness is 2 feet 6 inches. Small mines have also been operated in Section 16.

The Anderson coal is everywhere above drainage in Salt Creek Township. In the southern part of Section 11 it has been mined for the local trade. The coal is about 2 feet thick along Kent Run and has been mined in a few places. Along White Eyes Creek and its tributaries west of Le Fevers Ford, and along Wiliams Fork northeast of Chandlersville, this coal holds a steady 2 foot thickness.

The areas of Anderson coal are small in Wayne Township, being found in the high ridges and knobs of Sections 19, 29, and 32. In Rich Hill Township this coal is confined to the valley of White Eyes Creek in Section 6, to the valley of Williams Fork in Sections 7 and 8, and to the valley of Buffalo Fork in Sections 18, 19, and 20. Along these streams are several small mines which operate to supply the local trade.

In the eastern half of Perry Township, the Anderson coal occurs along the high ridges and knobs, and it is above drainage along the courses of all the larger streams in the northern part of Union Township as well as along the lower courses of the headwaters of White Eyes Creek to the southwest. Persistency in both thickness and extent is again the general characteristic of this coal here. Conditions for mining are favorable and both the Anderson and the Harlem have been mined in a small way by stripping and drifting near Norwich.

The Anderson coal is present on the high ridges and knobs in the eastern half of Salem Township. An anticline that extends across Highland Township is responsible for the fact that the Anderson coal is above drainage in the entire township. Along the small stream in the central parts of Sections 20 and 21, many small mines have been worked. Most of them are drift mines. The high ridges and knobs in the southeastern part of Adams Township and the ridges in the western and southern parts of Monroe Township are other notable localities where the Anderson coal bed occurs in Muskingum County.

The wide extent, remarkable uniformity in thickness, and fair quality of the Anderson coal bed make it by far the most important coal seam in the Conemaugh formation of Muskingum County. There are approximately 125 square miles of this coal above drainage in Muskingum County. Wilbur Stout (1918, p. 246) made some interesting calculations concerning the Anderson

coal bed in this area. Deducting 25 square miles for the areas of "rotten" coal along the outcrop, under thin covering, and for the parts exhausted by mining, he took the average thickness of 1 foot 11 inches and computed the available coal to be 3,450 tons per acre. Assuming at least a 70% recovery in mining, the figure would be 2,415 tons per acre. This would amount to 1,545,600 tons per square mile, or to 154,560,000 tons for the 100 square miles of workable coal in the Anderson seam. According to a chart entitled "Bituminous Coal Production in Ohio by County, 1800-1955," prepared by Marian S. Klein and published by the Ohio Geological Survey in July 1956, the total coal production from all worked seams in Muskingum County from 1800 to 1955 was only 47,300,379 tons. Muskingum County still has a considerable amount of coal reserves.

The general character of the Anderson coal bed in this area is shown by the following table of analyses:

Table 3

Analyses of the Anderson Coal

			Proximate (percent)				Ultimate (percent)					Heating Value		Fusion of Ash (Degrees F.)		Reference	
County	Township		Moisture at 105° C.	Volatile Matter	Fixed Carbon	Ash	Sulphur	Carbon	Hydrogen	Oxygen	Nitrogen	Calories	B. t. u.	Insipient	Complete	Organization	Bulletin
Guernsey	Valley	A	4.33	40.21	45.07	10.39	3.75	68.30	5.37	10.69	1.50	6,940	12,492			USGS	621
		B		42.03	47.11	10.86	3.92	71.39	5.11	7.15	1.57	7,254	13,057				
Muskingum	Harrison	A	5.66	42.72	39.92	11.70	4.88	63.61	5.30	13.48	1.03	6,579	11,842	2,014	2,199	Ohio	21
		B		45.28	42.32	12.40	5.17	67.43	4.95	8.96	1.09	6,974	12,552				
Muskingum	Salt Creek	A	6.61	39.84	44.96	8.59	2.08	68.90	5.61	13.50	1.32	6,854	12,337			Ohio	21
		B		42.66	48.14	9.20	2.22	73.77	5.23	8.17	1.41	7,339	13,210				
	Average	A	5.53	40.92	43.32	10.23	3.57	66.93	5.43	12.56	1.28	6,791	12,224				
		B		43.32	45.86	10.82	3.77	70.86	5.10	8.09	1.36	7,189	12,940				

*Bownocker and Dean, 1929, p. 312.

The Barton coal in Muskingum County lies 45 feet below the Ames limestone and 62 feet above the Cambridge limestone. The average thickness is not more than 6 inches and its maximum known thickness is 1 foot 4 inches. However, it is very "patchy" in its occurrence. The most prominent outcrops occur in Harrison, Blue Rock, Salt Creek, and Highland Townships. This coal has no economic importance in this county since it is so thin and impure.

The Harlem coal bed is second in order of importance among the Conemaugh coal beds of Muskingum County. Its position in the stratigraphic column is, on the average, 19 feet below the Ames limestone; the extremes of the observed invervals are 11 feet and 33 feet. The average thickness of the bed in this county is 1 foot 5 inches and the maximum thickness does not exceed 2 feet 8 inches. Over most of this area the Harlem coal bed consists of only one bench. However, in local areas, it is split into two benches by a thin clay or shale parting. The upper stratum of coal is generally thin and frequently impure.

The Harlem coal is present in Clay, Brush Creek, Harrison, Blue Rock, Meigs, Wayne,

Salt Creek, Rich Hill, Perry, Union, Salem, and Highland Townships, although the areas of coal in some of these townships are very small. The Harlem coal is confined to high ridges in the eastern part of Clay Township and in the southern and eastern parts of Brush Creek Township. In Harrison Township, the coal may be observed as far north as Butterbean Ridge in the central part of the township. In Blue Rock Township, the Harlem coal is present along all the small streams flowing westward into the Muskingum River and along Manns Fork of Salt Creek as far south as Section 14. The only area where the Harlem coal can be observed above drainage in Meigs Township is along Meigs Creek from the vicinity of Museville to the Muskingum-Morgan County line. In Wayne Township this coal is present in the high knobs along the ridge in Section 32. In Salt Creek Township the coal is present in Sections 1, 8, 25, and 35. The Harlem coal can be frequently observed along the courses of all the larger streams in the western half of Rich Hill Township. In Perry Township, the coal is confined to the high ridges in the area east of Salt Creek and south of the Baltimore and Ohio Railroad. However, this bed is generally thin and in places it is entirely absent.

The best development of the Harlem coal bed in Muskingum County is in the vicinity of Norwich, where the coal is as much as 2 feet 8 inches thick and has been mined by drifting. South of Sundale, Section 14, near the summit of the Baltimore and Ohio Railroad in Section 8, and in the southeastern part of Section 5, Union Township, it has also been mined in a small way. In the vicinity of New Concord small mines have provided a meager amount of fuel for local use.

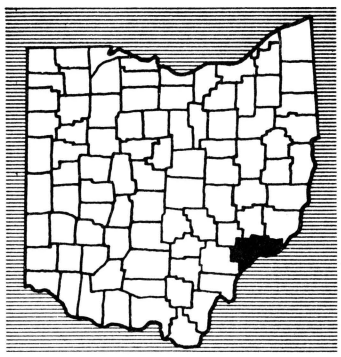
The Harlem coal is confined to the high ridges and knobs in the eastern part of Salem Township. With the exception of some of the extreme northern sections, this coal is regularly present in all of Highland Township and varies from 1 foot to 1 foot 8 inches in thickness.

The contribution of the Harlem coal bed to the fuel resources of Muskingum County is rather small because it is so thin. The thicker deposits are confined mainly to small areas in Union, Salt Creek, and Blue Rock Townships. Only in Union Township has the bed been regularly worked by drifting.

The Lower Little Pittsburgh coal bed, so named from deposits exposed in Somerset County, Pennsylvania, where the bed lies about 50 feet below the thick Pittsburgh coal bed and just above the Lower Pittsburgh limestone, has been observed in Muskingum County (Stout, 1918, p. 263). Here its position is about 37 feet below the Pittsburgh coal bed and 11 feet above the Summerfield or Lower Pittsburgh limestone. This coal, which is locally present in Blue Rock, Meigs, and Rich Hill Townships, has no economic importance, since it is but a few inches thick and shaly in character.

WASHINGTON COUNTY

Only a few square miles of rocks belonging to the Conemaugh formation crop out in Washington County. The exposures are along Duck Creek in the northern part of the county and along the valley of Little Muskingum River in the eastern part. There is also a small area in Newport Township along the Ohio River. The Monongahela and Dunkard formations make up the remaining portion of the surface of this county.

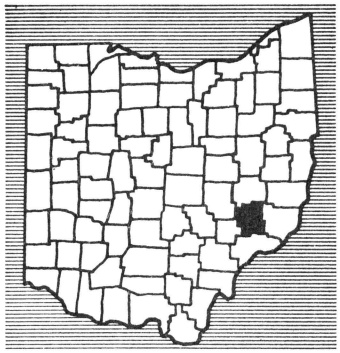


Location of Washington County

The Conemaugh coal beds contribute nothing to the known fuel resources picture of Washington County. However, other members of the Conemaugh formation do make an economic contribution in the county, since it has proven an important source of oil. Production of oil from this formation in the eastern part of the county made it rank at one time among the large producers of the state.

NOBLE COUNTY

The rocks at the surface in Noble County belong to the Conemaugh and Monongahela formations of the Pennsylvanian system. They have a general southeasterly dip, which is locally reversed by gentle anticlinal and synclinal folds. The influence of the broad, gentle Cambridge anticline, extending southward from Guernsey County, is manifested in the northern part of Noble County by a V-shaped outcrop area northward from Caldwell. In this area rocks belonging to the Monongahela formation are absent, although they are present in the tops of the hills to the east, west, and south, and the principal exposures of the Conemaugh rocks are to be seen in the V-shaped area. In the eastern and southeastern part of the county, the Conemaugh rocks are exposed only in the bottom of the deepest valleys. The total thickness of the strata belonging to the Conemaugh formation is about 422 feet in Noble County.



Location of Noble County

The only Conemaugh coal bed that exhibits an appreciable thickness in Noble County is the Anderson coal seam. These exposures are confined mainly to Buffalo and parts of Noble and Seneca Townships. Along the valley of Buffalo Creek, southward from Pleasant City, Buffalo Township, the Anderson coal averages about 2 feet thick and has been mined on nearly every farm. At the shale pit of the Noble Brick Company, located near Glenwood Station, the Anderson coal has a thickness of 2 feet and has been mined in the past. The Anderson coal crops out in a hollow at the east edge of the village of Belle Valley, Section 20, Noble Township. In Section 7 of the same township, this coal was mined at the Congleton Mine.

The following table shows the character of the Anderson coal in Noble County:

Table 4

An Analysis of the Anderson Coal in Noble County

County and Township	O. G. S. File No.[1]	Source[2]	Year	Condition[3]	Proximate (percent)				Ultimate (percent)					Heat Value	
					Moisture	Volatile Matter	Fixed Carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur	Calories	B. t. u.
NOBLE															
Noble	493	OGS	1929	1	3.29	40.84	46.67	9.20	3.84	69.90	.92	13.47	2.67	7,060	12,708
				2		42.23	48.26	9.51	3.59	72.29	.95	10.90	2.76	7,301	13,142
				3		46.67	53.33		3.97	79.88	1.05	12.05	3.05	8,068	14,523
				4		45.76	54.24							8,190	14,742
				5	3.71	44.06	52.23							7,885	14,193

[1] Number carried in Ohio Geological Survey file of coal analyses.

[2] OGS - Ohio Geological Survey.

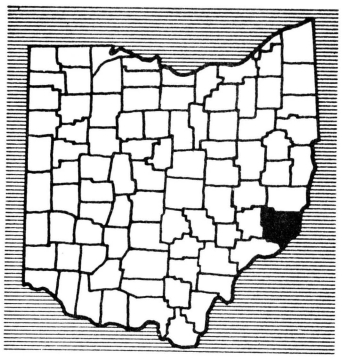
[3] 1, as received; 2, moisture-free; 3, moisture-and ash-free; 4, dry mineral-matter-free (unit coal); 5, moist, mineral-matter-free.

Available information indicated that there are approximately 58 square miles of Noble County underlain by the Anderson coal having an average thickness of 24 inches. This would make a contribution of 133,632,000 tons of coal to the fuel resources of the state.

In Section 21 of Seneca Township, a 16-inch exposure of the Harlem coal bed was observed. Information on the coal elsewhere in the county is lacking.

MONROE COUNTY

Rocks belonging to the Conemaugh formation are present at the surface only in the deeper valleys of Seneca Township, located in the northwestern corner of Monroe County. The dip of the strata carries them far below drainage to the southeast. At the center of the county the top of the Conemaugh is buried by more than 100 feet of cover, even in the deepest valleys. Eastward to the Ohio River, the hills consist entirely of Monongahela and Dunkard strata.

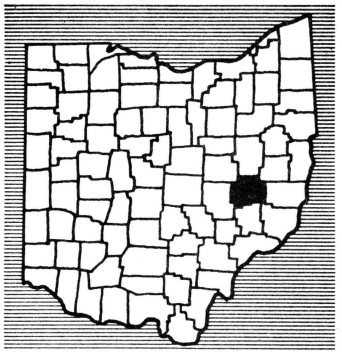


Location of Monroe County

GUERNSEY COUNTY

Rocks belonging to the Conemaugh formation make up the greater part of the surface of Guernsey County. Small areas of overlying Monongahela beds occur in the southeastern and southwestern corners of the county while along the valleys in the western half of the county, rocks belonging to the Allegheny formation are exposed.

Although the general dip of the strata in this area is to the southeast, it is interrupted locally by gentle folds, arches, and troughs. The most prominent structure in this area is the Cambridge Arch. This structure is a broad irregular arch with a crest of varying width, whose axis can be represented roughly by a line extending from Newport, Washington County, northwest in the direction of Cleveland. On the crest of this arch, erosion has removed the Monongahela beds and much of the Conemaugh, but along its western flank near the Muskingum County line, there remain hilltop cappings of Monongahela beds. Eastward in Belmont County, Monongahela beds make up the surface nearly everywhere. The thickness of the entire Conemaugh formation is about 425 feet in Guernsey County.



Location of Guernsey County

The Anderson is the only coal bed of the Conemaugh formation in Guernsey County that exhibits an appreciable thickness over a moderately wide area. Locally minable thicknesses of the Mahoning, Wilgus, Barton, and Harlem coals may be observed. However, they are very "patchy" in their occurrence.

The Anderson coal is best developed in the southwestern part of the county. Thicknesses up to 32 inches may be observed in this area. An average thickness of 20 inches is found from 20 measurements spread over 8 townships.

The type locality for the Anderson coal is located in Guernsey County. It was so named from the owner of a small coal mine near Lore City (Andrews, 1874, p. 539). In Richland Township, this coal bed ranges from a mere streak to a bed about 2 feet thick. It has been mined by

stripping and by drifting into the hillsides at several places. The principal localities where as much as 2 feet of thickness were observed are half a mile west of Blacktop and about 3 miles to the south on Soggy Run.

Jackson, Valley, Spencer, and Westland Townships are among other notable localities where the Anderson coal bed is persistent in both thickness and extent. In fact, throughout the entire Conemaugh outcrop belt of Guernsey County, this coal bed occurs with remarkable persistence.

Available information indicates that there are approximately 74 square miles of Anderson coal with an average thickness of 20 inches within the confines of Guernsey County. Its contribution to the state's coal resources is 142,080,000 tons.

TUSCARAWAS COUNTY

Conemaugh rocks are found only in the southern part of Tuscarawas County where they form a capping for the underlying Allegheny beds. The strata dip to the southeast at an average rate of nearly 20 feet to the mile. The thickest exposures of the Conemaugh strata in the county include only the lower two-thirds of the formation. In order to find the higher beds one must go southeastward into Harrison County.

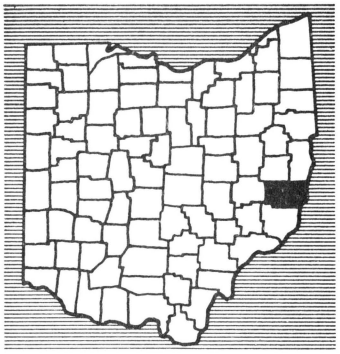
None of the Conemaugh coal beds in this county occur with any appreciable thickness. Where observed, they are very thin and shaly.

Location of Tuscarawas County

BELMONT COUNTY

Rocks belonging to the Conemaugh formation lie at the surface at only a few localities in Belmont County. The most extensive exposures are found in Flushing and Kirkwood Townships, in the northwestern part of the county. Here only the upper two-thirds of the formation are to be seen; the basal beds do not crop out nearer than Freeport in Harrison County, which is about five miles farther west. The exposures in the eastern part of the county are limited to the deeper valleys of the Ohio and its tributaries.

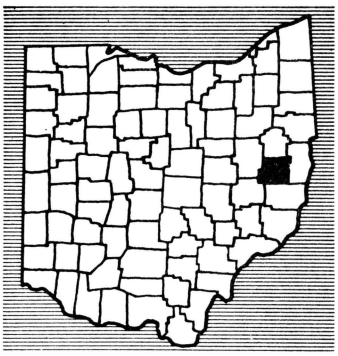
The Conemaugh coal beds in Belmont County contribute very little to the coal reserves of the State. They are usually thin, frequently impure, and under deep cover.



Location of Belmont County

HARRISON COUNTY

The surface of Harrison County is underlain by rocks belonging to the Allegheny, Conemaugh, and Monongahela formations of the Pennsylvanian system. The general southeastward dip of the strata is interrupted here and there by a few gentle anticlinal and synclinal swells. The most pronounced structural feature in the county is the Cadiz anticline, the crest of which passes in a northeast-southwest direction through the town of Cadiz.



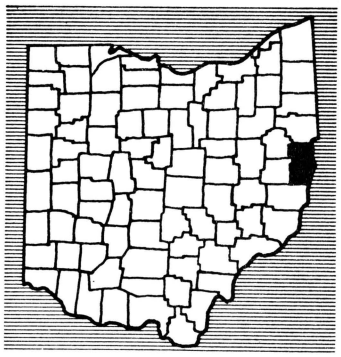
Location of Harrison County

Because of the general southeastward dip of the strata, the youngest beds crop out in the southeastern part of the county. Conemaugh beds occur in the western part and the deeper valleys in the eastern part of the county. The approximate thickness of the Conemaugh beds is 450 feet.

The coal beds of the Conemaugh formation in Harrison County are of little economic importance. While approximately two-thirds of the surface of Harrison County is composed of strata belonging to the Conemaugh formation, the coal beds are usually thin and impure and lack persistence. Exceptions to this are the Harlem and the Anderson coal beds which do occur with a fair thickness and quality and are utilized to some extent. The Harlem coal bed, where present, usually has a thickness of 12 inches or more and is stripped at a few localities. The Anderson coal bed is more persistent and has an average thickness of 18 inches or more. Eastward from Freeport, up Stillwater Creek, it is everywhere present and is mined at a few points.

JEFFERSON COUNTY

The surface of Jefferson County is made up of rocks belonging to the Allegheny, Conemaugh, and Monongahela formations of the Pennsylvanian system. The strata in this area dip to the southeast at rates varying from 15 to 40 feet to the mile. The Conemaugh beds make up the greater part of the surface of this county. The average thickness of the Conemaugh strata in Jefferson County is about 518 feet.



Location of Jefferson County

The thickness of the Conemaugh formation coal beds are quite variable in this county. They range from a mere smut streak to 5 feet of minable coal.

The Mahoning coal bed in Jefferson County, locally known as the Groff or Finley coal, has a thickness which varies from 0 to 5 feet, with an average thickness of nearly 3 feet. Its character changes from a black carbonaceous shale to a coal of economic quality. In this county, the position of the Mahoning coal bed is about 60 feet below the Brush Creek marine limestone and about 39 feet above the Upper Freeport coal. Exposures are found in Saline, Brush Creek, Ross, Springfield, Knox, and Island Creek Townships. There are approximately 60 square miles in Jefferson County underlain by the Mahoning coal bed, with an average thickness of 36 inches. The Mahoning coal bed of Jefferson County thus makes a contribution of 207,360,000 tons to the coal reserves of the State.

The following table shows the character of the Mahoning coal in this area:

Table 5

An Analysis of Mahoning Coal in Jefferson County

County and Township	O. G. S. File No.[1]	Source[2]	Year	Condition[3]	Proximate (percent)			Ultimate (percent)						Heat Value	
					Moisture	Volatile Matter	Fixed Carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur	Calories	B. t. u.
JEFFERSON															
Island Creek	189	USBM	1904	1	3.89	36.46	52.25	7.40					3.63		
				2		37.94	54.36	7.70					3.78		
				3		41.11	58.89						4.10		
				4		39.97	60.03								
				5	4.32	38.24	57.44								

[1] Number carried in Ohio Geological Survey file of coal analyses.

[2] USBM - United States Bureau of Mines.

[3] 1, as received; 2, moisture-free; 3, moisture-and ash-free; 4, dry mineral-matter-free (unit coal); 5, moist, mineral-matter-free.

The Mason coal bed is poorly represented in Jefferson County. It is always shaly, nonpersistent in its occurrence, has a maximum-known thickness of 10 inches, and usually consists of interstratified black shale and shaly coal. Its position in the stratigraphic column is about 32 feet below the Brush Creek marine shale and about 37 feet above the Mahoning coal bed. Exposures of this coal are present in Saline, Brush Creek, Ross, Springfield, Knox, and Island Creek Townships. The Mason coal bed is of no known economic value in this county.

In Jefferson County, the Brush Creek coal bed is widely distributed in Saline, Brush Creek, Ross, Springfield, Knox, and Island Creek Townships. The coal thickness varies from a smut streak to 1 foot 6 inches and averages about 6 inches. At a few places, where it is found in its best development, it is separated by a thin shale parting into two benches.

The Wilgus coal bed forms a persistent horizon immediately below the Cambridge limestone in Saline, Brush Creek, Ross, Springfield, Knox, Island Creek, Cross Creek, and Steubenville Townships. The coal seam is rarely more than 1 inch in thickness and is usually wanting entirely.

The Anderson and the Barton coal beds are not present in Jefferson County, but occasionally a thin carbonaceous shale or a smut streak marks their position in the geologic column.

The Harlem coal bed in Jefferson County varies in thickness from a mere carbonaceous streak to 2 feet 11 inches, but averages about 1 foot 4 inches. This coal bed is usually underlain by a thin clay and overlain by arenaceous shale or shaly sandstone. The average distance of this coal bed below the Ames limestone in Jefferson County is 17 feet, but apparent variations range from 6 to 30 feet. Its horizon is found above drainage in all or parts of Saline, Springfield, Knox, Salem, Island Creek, Cross Creek, Steubenville, Warren, and Wells Townships. In some localities in the above areas, it is replaced by massive sandstone.

The Duquesne coal bed is very poorly developed in Jefferson County. Its thickness varies from 1 inch to 1 foot 3 inches, with an average of about 6 inches. It is generally shaly in character, usually consisting of thin coal bands interstratified with black carbonaceous shale. The bed lies on the average of 18 feet above the Ames limestone, although this interval varies from 9 to 26 feet. This coal bed is recognized in Salem, Island Creek, Cross Creek, Steubenville,

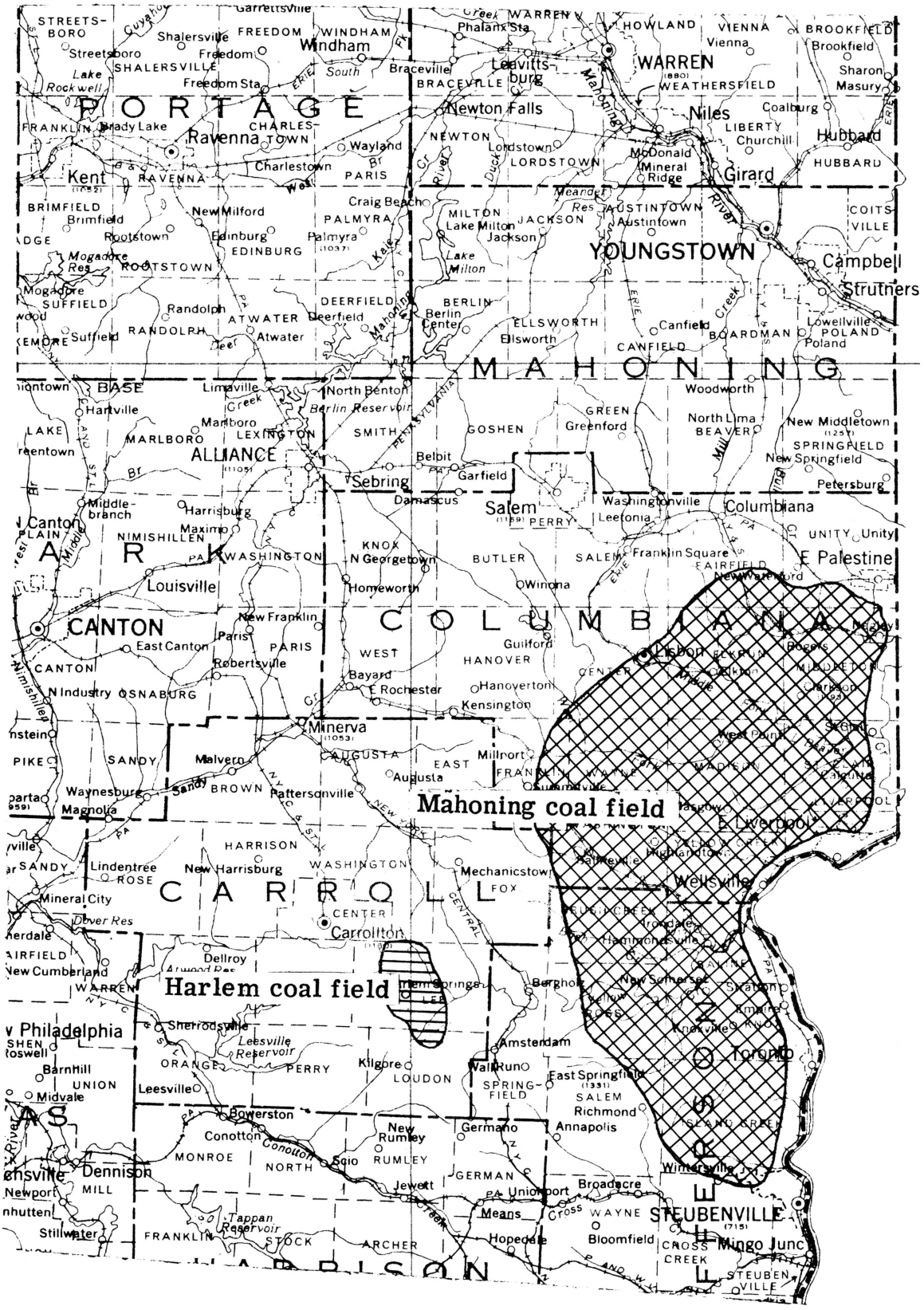


Figure 6. - The above map shows the Mahoning and Harlem coal fields of Ohio. Note that outcrop lines are not indicated and thus the area shown represents only the known areal extent except for that part lost to erosion.

and Springfield Townships. There are large areas of Saline, Brush Creek, Ross, Wayne, Wells, and Warren Townships where this horizon is present above drainage, but the coal is replaced by arenaceous shale or massive sandstone.

The Elk Lick coal bed, which lies about 50 feet above the Ames limestone, 51 feet below the Clarksburg coal bed, and 162 feet below the Pittsburgh coal bed, is locally present in Springfield, Salem, Island Creek, and Mount Pleasant Townships. However, neither the coal nor the underlying clay has an economic value in this county. The coal seam varies in thickness from 3 inches to 1 foot. Where it has been observed, it is usually composed of bone coal or thin coal bands interstratified with carbonaceous shale.

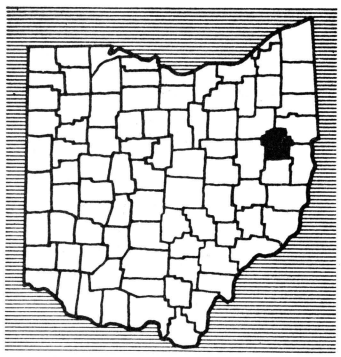
The Clarksburg coal bed in Jefferson County is exposed on the outcrop in Saline, Springfield, Salem, Island Creek, Steubenville, Smithfield, Mount Pleasant, and Warren Townships. The thickness varies from 2 inches to 4 feet and the average thickness is approximately 1 foot. Although it is usually shaly, locally where good thicknesses occur it becomes blocky and is of fair quality. In this county, its position in the geologic column is approximately 101 feet above the Elk Lick coal bed and 110 feet below the Pittsburgh coal bed. Coal has been mined from the Clarksburg bed at a few localities, but its lack of persistence and usual poor quality make it of little economic importance.

The Lower Little Pittsburgh coal is recorded from only one locality in Jefferson County. North of Gabbletown in Section 8, Warren Township, a thin coal blossom occurs at this horizon. Aside from the stratigraphic interest, it is of no importance.

The Upper Little Pittsburgh coal bed is not known to occur in Jefferson County; its position in the stratigraphic sequence is usually represented by a cyclic break or a clay bed.

CARROLL COUNTY

Nearly all of the surface of Carroll County is underlain by rocks belonging to the Conemaugh formation. Along the valleys in the western and northern part of the county, erosion of the Conemaugh formation has exposed Allegheny strata. Near the southeastern margin of the county, a few hilltop outcrops of the Pittsburgh coal, the bottom member of the Monongahela formation, are present.



Location of Carroll County

The strata have a general southeasterly dip. Over most of the area, the eastern component of the dip is slight and the slope to the south is the most marked and the drainage is, for the most part, westward. Following the stream valleys to the west, one finds lower and lower strata exposed at the surface. The thickness of the entire Conemaugh formation in Carroll County is about 435 feet.

The Mahoning coal bed is present in Augusta, Center, Fox, Harrison, Rose, and Union Townships. Its position in the geologic column varies from 16 to 60 feet above the Upper Freeport coal, with an average interval of about $31\frac{1}{2}$ feet. The thickness of the coal bed varies from a few inches to 2 feet 3 inches. Its average thickness from measured sections is about 20 inches. In Augusta Township, the Mahoning coal bed is very poorly developed, and only a few six-inch blossoms are observable. In Center Township, the coal is above drainage in Sections 1, 2, 3, 7, and 8. This seam was formerly mined in the south-central part of Section 2, where it is consistently 24 inches thick. Mining has also been carried on in Section 14, Fox Township, where this seam occurs with a thickness of slightly more than 24 inches. In Harrison Township, it is exposed on the outcrop in Sections 9, 13, 14, 19, 20, 24, 35, and 36, with an average thickness of $22\frac{1}{2}$ inches. A thickness of 12 inches was observed in Sections 20 and 26 of Rose Township. The average thickness of four

measurements taken in Sections 8, 12, 14, and 18 in Union Township is $18\frac{1}{2}$ inches. Mining of this coal for local use is common in many of the above-mentioned localities.

The Brush Creek coal bed is not nearly so well developed or widespread as the Mahoning coal bed. In only one locality has the coal been observed with a minable thickness. This is in Section 7, Orange Township, where its thickness reaches 48 inches and has been mined in the past.

The Wilgus coal bed, very "patchy" and unsteady in its occurrence, has been observed in only two localities with a thickness of as much as 18 inches. One is in Section 20, London Township, and the other is in Section 33, Monroe Township.

Outcrops of the Anderson coal bed, 12 inches thick, occur in Section 10, London Township. It is very poorly developed in Carroll County and, when found, is usually thin and impure.

The Barton coal bed occurs in minable quantities in Perry Township. In Section 25, its maximum-known thickness reaches 30 inches. Minable thicknesses of this coal bed are also present in Sections 19 and 36.

The Harlem coal bed is one of the best developed and most important coal seams of the Conemaugh formation in Carroll County. The type area for this coal is located in Lee Township, Carroll County, near the village of Harlem Springs. This coal has been mined for many years and was once the principal fuel supply for the surrounding countryside. In this area it is relatively uniform and maintains a thickness of 25 inches or more throughout the greater part of Lee Township. Minable thicknesses of this coal bed also underlies portions of Perry and Union Townships.

Approximately 15 square miles in Carroll County is underlain by the Harlem coal bed which averages 24 inches in thickness. Its contribution to the coal resources of the State is 34,560,000 tons.

The following table shows the character of the Harlem coal in this area.

Table 6

An Analysis of the Harlem Coal in Carroll County

County and Township	O. G. S. File No.[1]	Source[2]	Year	Condition[3]	Proximate (percent)				Ultimate (percent)					Heat Value	
					Moisture	Volatile Matter	Fixed Carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur	Calories	B. t. u.
CARROLL															
Lee	316	OGS	1926	1	7.07	36.55	50.34	6.04	5.49	71.04	1.22	15.64	.57	7,025	12,645
				2		39.33	54.17	6.50	5.08	76.44	1.31	10.06	.61	7,559	13,606
				3		42.06	57.94		5.43	81.76	1.40	10.76	.65	8,084	14,552
				4		41.63	58.37							8,141	14,653
				5	7.59	38.47	53.94							7,523	13,542

[1] Number carried in Ohio Geological Survey file of coal analyses.

[2] OGS - Ohio Geological Survey.

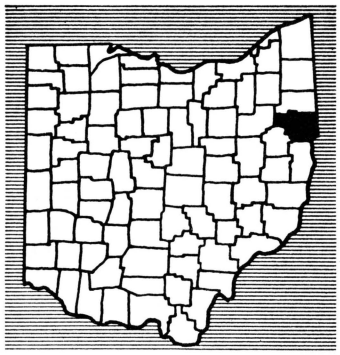
[3] 1, as received; 2, moisture-free; 3, moisture-and ash-free; 4, dry mineral-matter-free (unit coal); 5, moist mineral-matter-free.

Only one thickness record of the Ames coal bed in Carroll County is available and is for Section 6, Lee Township, where this coal measures 18 inches thick.

COLUMBIANA COUNTY

In Columbiana County, the Pennsylvanian system of rocks is represented by the Pottsville, Allegheny, and Conemaugh formations. Due to erosion the upper portion, or approximately 70 feet, of the Conemaugh formation is absent in Columbiana County. Allegheny and Conemaugh rocks are found at the surface in every township of the county. The total thickness of the Conemaugh formation present in Columbiana County is about 437 feet.

The dip of the strata in this area is irregular. In general, the strata dip sharply to the south and slightly to the east. For the county as a whole, the general eastward inclination is approximately 38 feet per mile whereas the southern component of the dip is about 10.7 feet per mile.



Location of Columbiana County

In Columbiana County the Mahoning coal bed ranks third in importance for fuel supply, being surpassed only by the Upper Freeport and Lower Kittanning coal beds. It is present in every township in the county except Knox and Perry. The thickness and character of this seam are quite variable. Its thickness varies from a mere soot streak to more than four feet and its character varies from a carbonaceous shale to coal of excellent quality. In some areas the coal is absent, frequently being replaced or cut out by Upper Mahoning sandstone, or wanting through lack of deposition. The total area of Columbiana County underlain by this coal is about 230 square miles. Stout and Lamborn (1924, p. 311) have classified 40 square miles of this area into the following productive categories: 12 square miles with an average thickness of 3 feet 3 inches, 13 square miles with an average thickness of 2 feet 5 inches, and 15 square miles with an average thickness of 1 foot 8 inches. Assuming at least 70 per cent recovery with present mining practices, the yield per acre foot is 1,260 tons. Thus calculated, the yield for the 12 square miles of 3 feet 3 inches of coal is 31,449,600 tons, that of the 13 square miles of 2 feet 5 inches of coal is 25,334,400 tons, and that of the 15 square miles of 1 foot 8 inches of coal is 20,160,000 tons. This amounts to a total of 76,944,000 tons for the entire county. No reserve figures have been estimated for the remaining 190 square miles.

The Mahoning coal in Columbiana County is locally known as the Groff or the Salineville Strip vein, and was formerly designated as the Brush Creek coal. In the older geologic reports it was frequently referred to as the No. 7 coal. The position of this member in the geologic column is about 43 feet above the Upper Freeport coal and 56 feet below the Brush Creek limestone. The areas where it is best developed and extensively mined are: near East Palestine, Nagley, West Point, and Salineville. Lesser quantities of this coal are obtained from several mines in parts of Yellow Creek, Elk Run, and Salem Townships to supply the local fuel requirements.

The high quality of the Mahoning coal in Columbiana County is illustrated by Table 7 on the following page.

The Mason coal bed is very poorly developed in Columbiana County. Its horizon is usually marked by a few feet of impure clay, with only a soot streak or an inch or two of shaly coal above it. It lies approximately 24 feet below the Brush Creek limestone or marine shale and about 32 feet above the Mahoning coal bed. Both the Mason coal and clay beds are of interest only because of their stratigraphic significance in Columbiana County, for the coal has no value as a source of fuel and the clay is too impure and variable for ceramic work.

The Brush Creek coal bed is widely distributed in Columbiana County. It is present in parts of West, Hanover, Center, Elk Run, Middleton, St. Clair, Liverpool, Yellow Creek, Madison, Wayne, Franklin, and Washington Townships. The average thickness of the bed, taken from more than 30 measurements made at various places in Columbiana County, is only 7 inches and its maximum thickness is 1 foot 4 inches. This coal seam, which lies directly or only a few

Table 7

Analyses of Mahoning Coal in Columbiana County

County and Township	O. G. S. File No. [1]	Source [2]	Year	Condition [3]	Proximate (percent)			Ultimate (percent)						Heat Value	
					Moisture	Volatile Matter	Fixed Carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulphur	Calories	B. t. u.
COLUMBIANA															
Madison	425	OGS	1921	1	3.18	36.47	52.21	8.14	5.31	72.92	1.34	10.76	1.53	7,547	13,224
				2		37.67	53.92	8.41	5.13	75.31	1.39	8.18	1.58	7,587	13,657
				3		41.13	58.87		5.60	82.22	1.52	8.93	1.73	8,284	14,911
				4		40.38	59.62							8,377	15,079
				5	3.52	38.96	57.52							8,083	14,549
COLUMBIANA															
Middleton	424	OGS	1921	1	3.22	36.76	52.38	7.64	5.26	73.10	1.42	10.60	1.98	7,368	13,263
				2		37.98	54.13	7.89	5.07	75.54	1.47	7.98	2.05	7,614	13,705
				3		41.23	58.77		5.50	82.01	1.60	8.66	2.23	8,266	14,879
				4		40.43	59.57							8,364	15,055
				5	3.55	39.00	57.45							8,067	14,520
COLUMBIANA															
Yellow Creek	120	USBM	1916	1	3.15	39.32	51.15	6.38	5.56	75.35	1.35	7.81	3.55	7,548	13,586
				2		40.60	52.81	6.59	5.38	77.80	1.39	5.17	3.67	7,793	14,027
				3		43.46	56.54		5.76	83.29	1.49	5.53	3.93	8,343	15,017
				4		42.49	57.51							8,464	15,235
				5	3.46	41.01	55.53							8,172	14,709

[1] Number carried in Ohio Geological Survey file of coal analyses.

[2] OGS - Ohio Geological Survey.
USBM - United States Bureau of Mines.

[3] 1, as received; 2, moisture-free; 3, moisture-and ash-free; 4, dry mineral-matter-free (unit coal); 5, moist mineral-matter-free.

feet below the Brush Creek fossiliferous shale and limestone, is too thin to be generally attractive even for local needs. However, very small quantities of it are obtained along stream beds and in places where the overburden is so thin that it can be mined with little labor.

The occurrent of the Wilgus coal bed in Columbiana County is not very widespread. It is best developed in the central part of Madison Township, and locally in St. Clair Township. In the remainder of the county, neither coal nor clay is apparent at this horizon. The position of this bed is approximately 5 feet below the Cambridge limestone. Its average thickness, taken from five measurements, is 10 inches. Its maximum thickness is 1 foot 4 inches and its minimum thickness is 6 inches. Except for its stratigraphic interest, the Wilgus coal bed is of little value, since the areal extent is small, the bed thin, and the quality poor.

The Anderson coal bed is described at only one locality in Columbiana County, in Section 22, Madison Township, where a 1-foot blossom of shaly coal occurs. As a source of fuel this seam has no value. The Barton coal bed similarly is of no known economic importance in Columbiana County.

The Harlem coal bed makes but a very small contribution to the fuel resources of

Columbiana County. The areas wherein beds this high in the geologic column occur are small and are confined to high ridges and knobs in parts of Franklin, Wayne, Madison, Yellow Creek, and Washington Townships. There are only a few places in Wayne, Franklin, and Washington Townships where the Harlem coal bed was noticed. In very many of the other localities, the place of this coal is taken by red shales of the Round Knob member. Where found, the average thickness of this coal seam is only 10 inches, the maximum thickness being only 1 foot 1 inch. Its position averages approximately 13 feet below the Ames limestone. A very small quantity of fuel for local consumption is obtained from this bed.

CHAPTER 4

SUMMARY OF RESERVES

The accompanying chart (see table 8) is not intended to give complete coverage for the coal reserves in the Conemaugh formation of Ohio. Estimates have been made only for those seams and areas in which sufficient information was available for an evaluation. The Barton or Mason coal beds are not included because sufficient data were lacking.

Table 8

Estimated Original Reserves in the Coal Beds of the Conemaugh Formation in Ohio

County	Coal Bed	Average Thickness	Area in Square Miles	Original Reserves (in tons)	Estimate By
TOTAL	-	-	624	1,329,368,000	-
Lawrence	Wilgus	24"	75	173,000,000*	F. R. Clark
Morgan	Anderson	21"	202	407,232,000	T. A. DeBrosse
Muskingum	Anderson	23"	100	154,560,000	W. Stout
Noble	Anderson	24"	58	133,632,000	T. A. DeBrosse
Guernsey	Anderson	20"	74	142,080,000	T. A. DeBrosse
Jefferson	Mahoning	36"	60	207,360,000	T. A. DeBrosse
Carroll	Harlem	24"	15	34,560,000	T. A. DeBrosse
Columbiana	Mahoning	29" **	40	76,944,000	W. Stout and R. E. Lamborn

* This figure has been rounded off to the nearest million.

** For a more accurate break-down on the thickness categories and number of square miles in each category, see page 26 of this report.

Stout's tonnage figure for the Anderson seam in Muskingum County and Stout and Lamborn's figure for the Mahoning seam in Columbiana County are recoverable reserve figures. Thirty per cent has been deducted for rotten coal along the outcrop and under thin cover and for the parts exhausted by and lost in mining.

METHODS USED IN MAKING THIS ESTIMATE

In order to calculate the tonnage of coal contained in a given coal bed in a given area, it is necessary to find two values: the volume of the coal and the density of the coal. The volume is determined by measuring the area of occurrence and multiplying this by the average thickness; the density is determined from the specific gravity and is equivalent to 96,000 tons per square mile inch. The volume in square mile inches is multiplied by the density to determine the tons for a given area. Eighteen hundred (1,800) tons per acre foot (one acre in area, one foot thick) is frequently used as a convenient density factor in estimating tonnage for small areas.

LIMITATIONS OF THIS RESERVE STUDY

It has been found that in many areas the thickness of the Conemaugh coal beds is exceedingly variable and may change considerably over short distances. However, the writer has tried to restrict his evaluation to only those areas where information was sufficient to warrant an estimate. It is true that control points in some of the areas are rather widely spread and it is likely that available coal in some of the areas included in the report may vary considerably more than indicated by the reserve estimates. It is believed that, although such unpredictable variations occur and are cause for concern for the coal prospector, the major framework of the characteristics of these coal beds as presented here is essentially correct.

A further limitation of this study arises from the fact that it is based primarily on the original coal reserves. "Original reserves" is here used to define the amount of coal that was in the ground before mining operations began. The writer is aware of the fact that a considerable amount of coal has already been mined from these beds. However, it is almost impossible to tell how much, since the annual production reports did not list the tonnages by seam prior to 1946. In view of this fact, a remaining reserve estimate is impossible.

BIBLIOGRAPHY

Andrews, E. B., 1873, Report on second geological district; Gallia, Meigs, Athens, Morgan and Muskingum Counties: Ohio Geological Survey Vol. I, pt. 1, pp. 225-364.

----------, 1874, Report on second geological district; Washington, Noble, Guernsey (southern half), Belmont (southern half), and Monroe Counties: Ohio Geological Survey Vol. II, pt. 1, pp. 453-587.

----------, 1878, Report of the Geological Survey of Ohio, Vol. III, Geology and Paleontology, pt. 1, Geology, pp. 815-882.

Bownocker, J. A. and Dean, E. S., 1929, Analyses of the coals of Ohio: Ohio Geological Survey Bull. 34.

----------, 1917, The coal fields of Ohio: U. S. Geological Survey, Prof. Paper 100.

Brant, R. A., 1954, The Lower Kittanning No. 5 coal bed in Ohio: Ohio Geological Survey Rept. Inv. No. 21.

Cady, G. H., 1952, A program of activities and research in coal geology: Ohio Geological Survey, I. C. No. 10.

Clark, F. R., 1917, Original coal content of the fields, in The coal fields of Ohio, by J. A. Bownocker. U. S. Geological Survey, Prof. Paper 100.

Condit, D. Dale, 1912, The Conemaugh formation: Geological Survey of Ohio, Bull. 17.

---------- , 1923, Economic geology of the Summerfield and Woodsfield quadrangles, Ohio, with descriptions of coal and other mineral resources except oil and gas: U. S. Geological Survey, Bull. 720.

Dean, E. S., 1948, Additional analyses of coals of Ohio: Ohio Geological Survey, Rept. Inv. No. 4.

Fenneman, N. M., 1938, Physiography of eastern United States: 1st ed., 5th printing, McGraw Hill Book Co., New York, p. 283, pl. 2.

Flint, N. K., 1951, Geology of Perry County: Ohio Geological Survey, Bull. 48.

Geologic map of Ohio, 1920, compiled by J. A. Bownocker, scale 1:500,000, colored, showing major geologic boundaries. Revised glacial boundary, 1949, by G. W. White.

Grimsley, G. P., 1906, Report on Ohio, Brooke and Hancock Counties: West Virginia Geological Survey, Introduction, pp. 11-16.

Lamborn, R. E., 1930, Geology of Jefferson County: Ohio Geological Survey, Bull. 35.

----------, 1942, The coal beds of Carroll County and southeastern Mahoning County: Ohio Geological Survey, Bull. 43.

Lovejoy, E., 1888, The Pomeroy and Federal Creek coal field: Ohio Geological Survey Vol. VI, chpt. XI, p. 634.

Newberry, J. S., 1874, The Carboniferous system: Geological Survey of Ohio Vol. II, pt. 1, pp. 82-180.

----------, 1878, Report on the geology of Tuscarawas County: Ohio Geological Survey Vol. III, chpt. LVI, pp. 52-89.

----------, 1878, Report on the geology of Columbiana County: Ohio Geological Survey Vol. III, pp. 90-132.

----------, 1878, Report on the geology of Jefferson County: Ohio Geological Survey Vol. III, pp. 716-788.

----------, 1878, Supplemental report on Perry County and portions of Hocking and Athens Counties: Ohio Geological Survey Vol. III, pp. 815-882.

----------, 1878, Supplemental report on the geology of the Hanging Rock District: Ohio Geological Survey Vol. III, pp. 883-941.

Ohio Chamber of Commerce, 1949, Information about Ohio and her natural resources; Coal: a brochure by the staff of the Ohio Geological Survey.

Ohio Geological Survey, Stratigraphic sections, core records, oil and gas drilling records, and various maps on file in the offices of the Ohio Geological Survey.

Orton, Edward, 1888, Deep wells of Meigs, Gallia, Athens, and Washington Counties: Ohio Geological Survey, Vol. VI, Economic Geology, pp. 396-401.

Platt, F., 1875, Clearfield and Jefferson District of the bituminous coal fields of western Pennsylvania: Rept. Prog. H., Pennsylvania Geological Survey, p. 8.

Ray, F. A., 1929, The Ohio coal supply and its exhaustion, in Analyses of Ohio coal, by J. A. Bownocker and Ethel S. Dean: Ohio Geological Survey Bull. 34.

Reger, D. B., 1924, Stratigraphy - Conemaugh Series, West Virginia Geological Survey, Report on Mineral and Grant Counties, pp. 202-232.

Stevenson, J. J., 1878, Report on the geology of Carroll County, Harrison County, Guernsey County, Muskingum County, Belmont County: Ohio Geological Survey, Vol. III, pp. 177-287.

----------, 1906, Carboniferous of the Appalachian Basin: Geological Society of America Bull., vol. 17, pp. 154-228.

Stout, W., 1916, Geology of southern Ohio: Ohio Geological Survey Bull. 20.

----------, 1918, Geology of Muskingum County: Ohio Geological Survey Bull. 21.

----------, and Lamborn, R. E., 1924, Geology of Columbiana County: Ohio Geological Survey Bull. 28.

----------, 1931, Pennsylvanian cycles in Ohio: Illinois Geological Survey Bull. 60.

Tyson, P. T., 1837, Frostburg coal formation of Allegheny County, Maryland: Trans. of Maryland Academy of Science and Literature.

Watkins, D. G., 1953, Bibliography of Ohio geology, 1819-1950: Ohio Geological Survey Bull. 52.

White, I. C., 1903, Coal report: West Virginia Geological Survey Vol. II, pt. II, The Appalachian coal field.

----------, 1908, Supplementary coal report: West Virginia Geological Survey Vol. II (A), pp. 622-637.