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**Geology and Methane Content
of the Upper Freeport Coalbed
in Fayette County, Pa.**



UNITED STATES DEPARTMENT OF THE INTERIOR

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By Peter F. Steidl



**UNITED STATES DEPARTMENT OF THE INTERIOR
Cecil D. Andrus, Secretary**

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CONTENTS

	<u>Page</u>
Abstract.....	1
Introduction.....	1
Acknowledgments.....	2
Previous work.....	3
Stratigraphy.....	3
Structure.....	5
Overburden.....	7
Joint and cleat data.....	8
Coal thickness and methane resources.....	10
Methane content.....	12
Summary and conclusions.....	14
References.....	15
Appendix.--Average of coal cleat trends for individual quadrangles in the study area.....	17

ILLUSTRATIONS

1. Location of data points.....	2
2. Generalized stratigraphic column of the Upper Freeport coalbed and adjacent strata.....	4
3. Fence diagram of the 50 feet of strata above the Upper Freeport coalbed.....	5
4. Structure map drawn on the base of the Upper Freeport coalbed with structure northwest of Chestnut Ridge anticline projected down from structure for the Pittsburgh coalbed.....	6
5. Isopach of overburden thickness above the Upper Freeport coalbed...	7
6. Cleat spacing in specimen of Upper Freeport coal.....	8
7. Rose diagrams of coal cleat and rock joint measurements in Fayette County, Pa.....	9
8. Diagram of the face and butt cleat trends in each quadrangle.....	10
9. Isopach of the Upper Freeport coalbed.....	11
10. Graph of depth versus gas content for Pittsburgh coal cores.....	13
11. Graph of fixed carbon versus gas content of coal cores from several coalbeds.....	13

GEOLOGY AND METHANE CONTENT OF THE UPPER FREEPORT COALBED IN FAYETTE COUNTY, PA.

by

Peter F. Steidl¹

ABSTRACT

As part of the Bureau of Mines methane control program, the Upper Freeport coalbed was studied in Fayette County, Pa., where this coalbed lies about 650 feet below the Pittsburgh coalbed and contains the largest remaining reserves of any coalbed in the county. Coal and overburden isopachs, structure and joint pattern maps, and a fence diagram were prepared using data from gas and oil exploration logs and coal outcrops. These maps will aid in determining the need and/or feasibility of degasifying the Upper Freeport coalbed in the study area. Much of the coalbed in this area is under 600 to 1,400 feet of overburden. By correlation with data from the Pittsburgh coalbed, the gas content at depths of this order is estimated to be between 140 to 300 cf/ton of coal, for a total of 190 to 400 billion cubic feet of methane in this coalbed in Fayette County.

INTRODUCTION

The Upper Freeport coalbed has been mined in Fayette County since about 1840, with the most active mining occurring from about 1900 to about 1945. Strip mines continue to operate in this coalbed in the eastern part of the county, but there are no longer any active underground mines although much coal is still minable.

The free swelling index and agglutinating values of the Upper Freeport coal are within the normal range for coking coals. High ash and sulfur content of this coal and the difficulty in cleaning it to levels acceptable for coking will limit its use for metallurgical purposes (16).² Blending may be necessary since analyses indicate a sulfur content greater than 1.5 pct.

The present study was undertaken as part of the Bureau of Mines methane control program and provides data on methane content, cleat orientation, and other characteristics of this coalbed where much coal is still present. Over 370 data points, including gas and oil wells, coal exploration holes, and outcrop exposures were used in preparing the maps (fig. 1).

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²Underlined numbers in parentheses represent items in the list of references preceding the appendix.

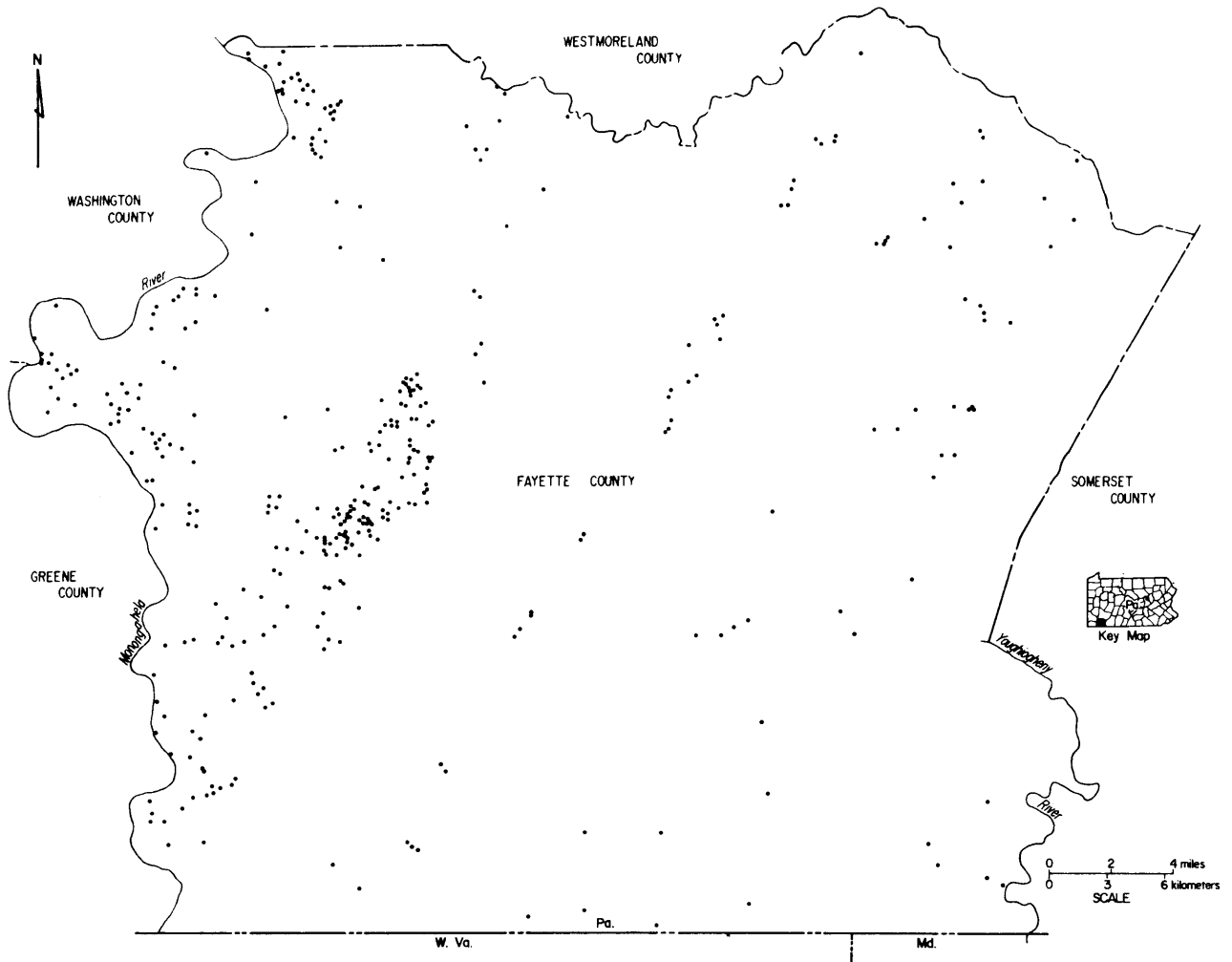


FIGURE 1. - Location of data points.

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PREVIOUS WORK

There have been few previous investigations of the Upper Freeport coalbed in Fayette County. Past reports contain analyses and give carbonizing properties of the coal, as well as isopach and structure maps for parts of the county. Some coal thicknesses and outcrop descriptions from early reports provided useful data (1, 3-4, 13, 15). Hickok and Moyer (7) published a geologic map with coalbed outcrop lines for Fayette County in 1938. The structure map was drawn on the base of the Pittsburgh coalbed for the part of the county northwest of Chestnut Ridge and on the base of the Upper Freeport coalbed for the remainder of the county.

It has been estimated that the recoverable coal from this coalbed was 1,029 million tons in Fayette County in 1928 (12). This estimate was based on the assumption that the coalbed has a uniform thickness of 42 inches in townships along the Monongahela River. However, since its thickness is variable, a conservative 50 pct was used for the estimate of recoverable coal which does not include any part of the coalbed less than 18 inches thick. Subsequently this estimate was revised to 1,150 million tons (7). According to Dowd (5), the Upper Freeport coalbed contained the largest reserves of any coalbed in the county, but Dowd's estimate, which does not include inferred coal, was much lower than Hickok's (7). Dowd's figure of 127 million tons was based on reserves in beds 28 inches or more thick and a 52.9 pct recovery.

Hickok and Moyer reported that the Upper Freeport coalbed is fairly persistent in Fayette County and is cut out in some places and replaced by sandstone. Their study found the coalbed to range from 2 to 9 feet thick, with persistent clay partings. Unusual thicknesses of up to 16 feet, including sizable partings, were also observed.

A study by Koppe (9) of the Upper Freeport in adjacent parts of Allegheny, Butler, Armstrong, and Westmoreland Counties found basal partings in structurally low areas. He reports that "ancient topographic highs (areas of no partings) occupy positions relative to present anticlines suggesting that the paleotopography was controlled by the same structures observable today."

STRATIGRAPHY

The Upper Freeport coalbed occurs at the top of the Allegheny Group, about 650 feet below the Pittsburgh coalbed. Seven relatively thin and often discontinuous coalbeds (fig. 2) which may occur in 200 feet of stratigraphic section in the Allegheny and Conemaugh Groups make correlation difficult. One of the most useful aids in correlating these coalbeds is their depth below the Pittsburgh coalbed. Another aid in correlation is the Freeport limestone which sometimes occurs beneath the Upper Freeport coalbed underclay. The Mahoning (Dunkard) sandstone is usually present above as shown in the fence diagram (fig. 3). Two coalbeds occur within 55 feet of the Upper Freeport coalbed, the Mahoning coalbed above and the Lower Freeport below, neither of which is usually as thick or persistent as the Upper Freeport.

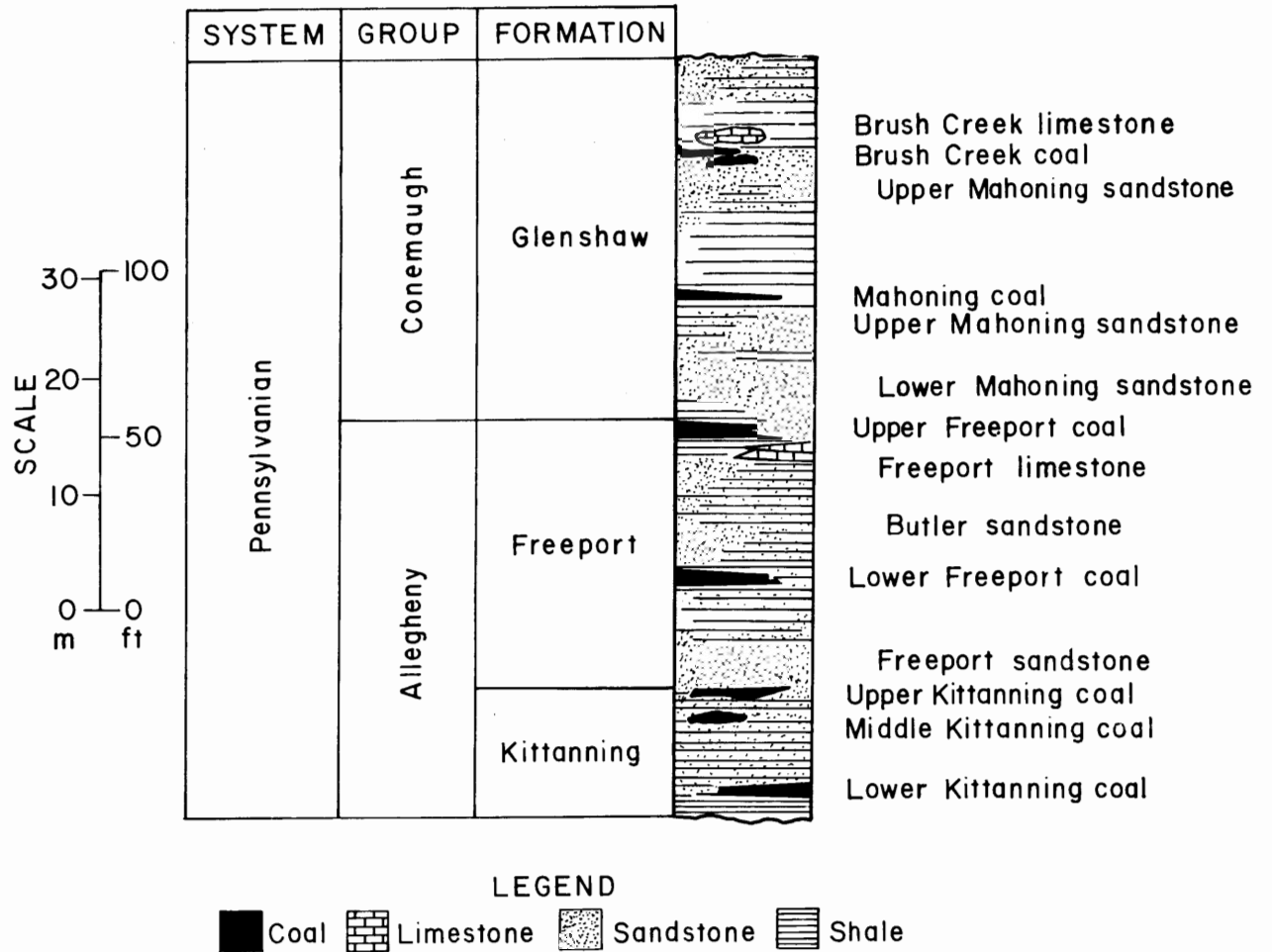


FIGURE 2. - Generalized stratigraphic column of the Upper Freeport coalbed and adjacent strata.

Due to the presence of an irregular surface beneath the Upper Freeport coalbed, there are areas where the peat was eroded or was not deposited. Evidence of this can be found along Chestnut Ridge where the lower Mahoning (Big Dunkard) sandstone cuts out some or all of the Upper Freeport coalbed (7). On some higher areas, plant remains were washed away to low areas or decayed before peat formed and therefore no coal is present.

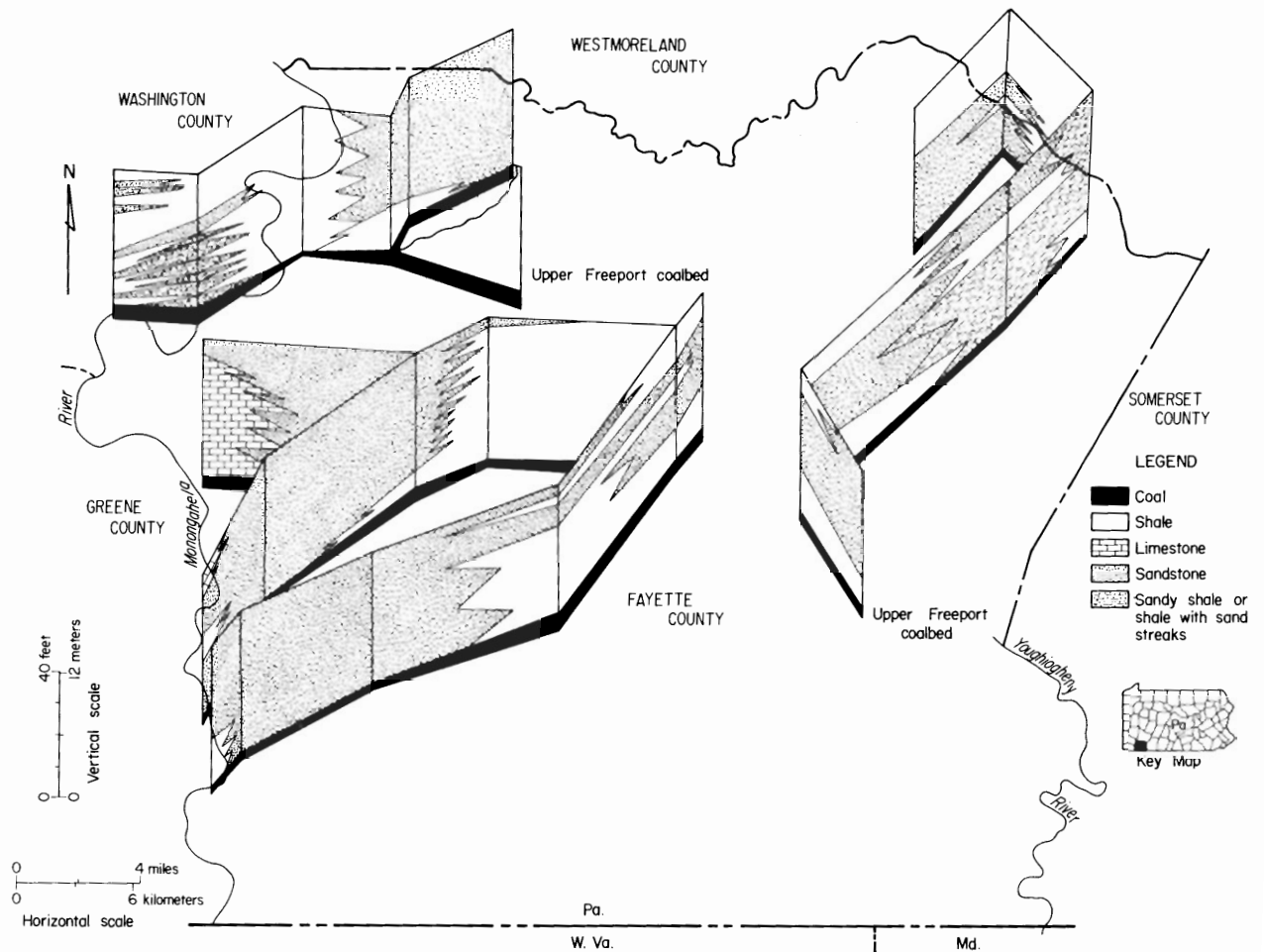


FIGURE 3. - Fence diagram of the 50 feet of strata above the Upper Freeport coalbed.

STRUCTURE

A structure map was drawn using the bottom of the Upper Freeport for the datum base (fig. 4).³ Much of the structure was taken from a previous map (7) drawn on the base of the Pittsburgh coalbed for the part of the county northwest of Chestnut Ridge and on the base of the Upper Freeport coalbed for the remainder of Fayette County. The approximate structure for the Upper Freeport was derived by subtracting 650 feet from the elevation of the Pittsburgh coalbed. Other changes were made wherever additional data showed the need for them.

The major structures present from east to west are Laurel Hill anticline, Ligonier syncline, Chestnut Ridge anticline, Uniontown syncline, Fayette anticline, Lambert syncline, Brownsville anticline, and Port Royal syncline. All these structures trend northeast-southwest and affect the

³The coal isopach, overburden isopach, and structure map are available from the author at scales of 1:24000 (1 inch equals 2,000 feet) and 1:96000.

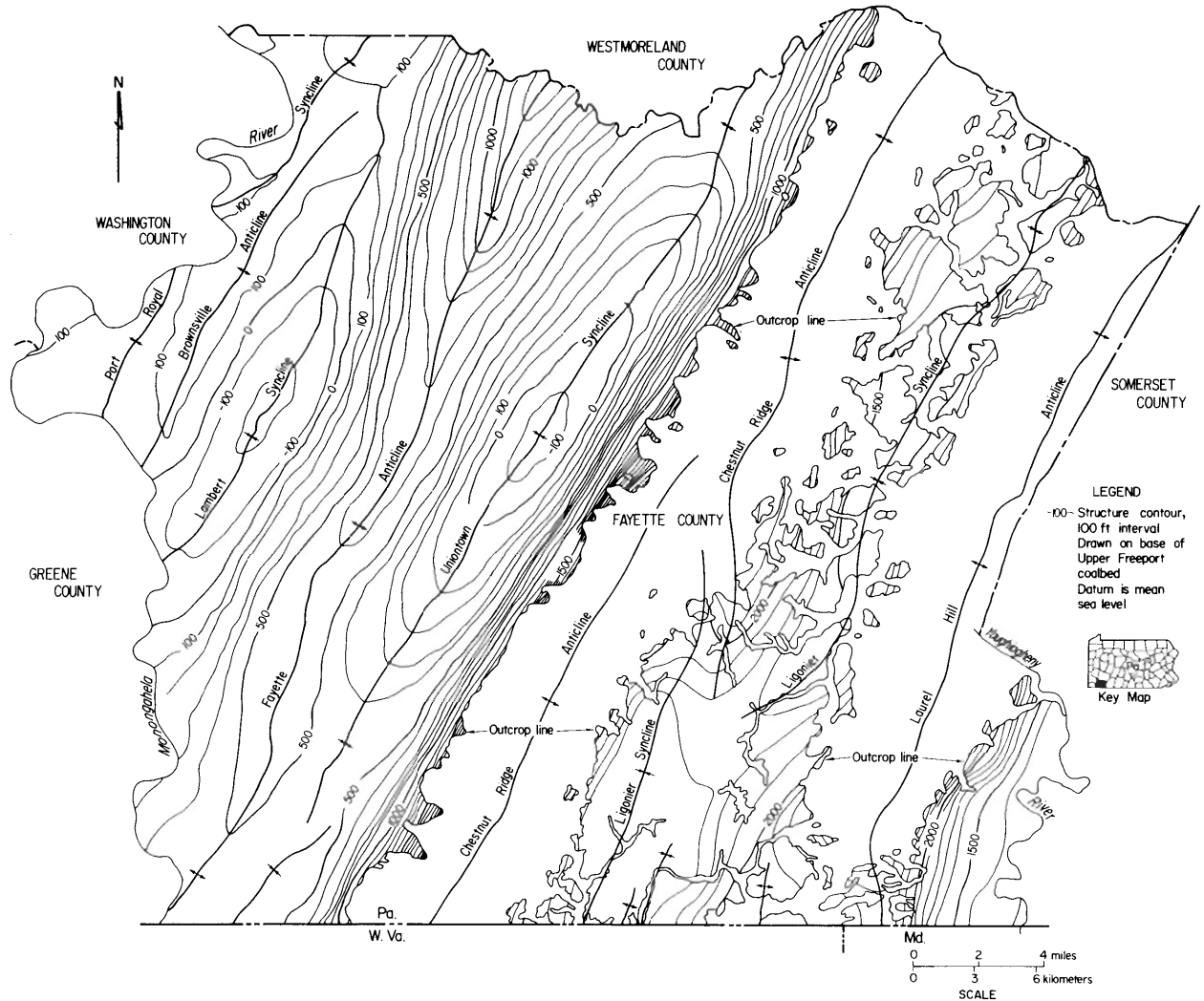


FIGURE 4. - Structure map drawn on the base of the Upper Freeport coalbed with structure northwest of Chestnut Ridge anticline projected down from structure for the Pittsburgh coalbed.

elevation and presence of coalbeds in the area. On Chestnut Ridge and Laurel Hill anticlines there are places where the Upper Freeport coalbed outcrops and large areas where it has been eroded.

Structural relief of the Upper Freeport coalbed in the study area is over 2,800 feet; the highest part (more than 2,600 feet above sea level) is located along the eastern flank of the Chestnut Ridge anticline, and the lowest part (more than 200 feet below sea level) is located in the Lambert syncline. There is moderate dip throughout most of the area with the beds varying from flat lying to dipping 23° (a slope about 2,200 feet per mile) on the western flank of the Chestnut Ridge anticline.

No faults are shown on maps of the study area. However, locations of three have been noted in the literature, two on the western side of Chestnut Ridge. One of the faults lies along the Western Maryland Railroad, south of South Connellsville, another is exposed along U.S. Route 40 near the Lick Hollow Picnic Area. The third fault is near the Monongahela River on the north side of Middle Run, north of Gates, Pa. Seismic study of the Summit gasfield has shown the presence of some subsurface faults (7).

OVERBURDEN

Overburden thickness for the Upper Freeport varies considerably within Fayette County. Overburden is thickest in the west where it is more than 1,400 feet. In the eastern part of the county the coalbed has been eroded from large areas on the Chestnut Ridge and Laurel Hill anticlines (fig. 5). In the Ligonier syncline which lies between these two anticlines, the overburden is usually less than 400 feet thick.

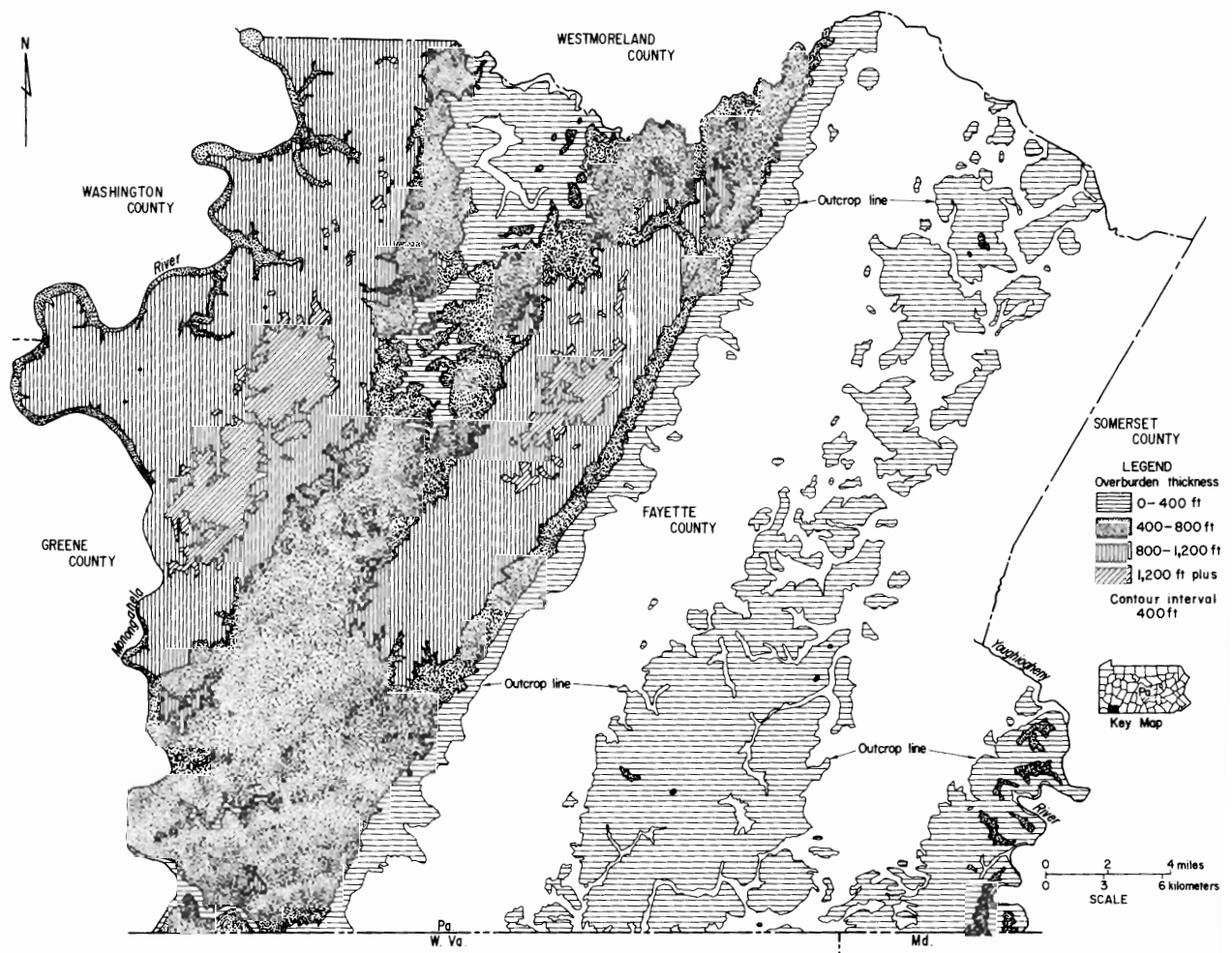


FIGURE 5. - Isopach of overburden thickness above the Upper Freeport coalbed.

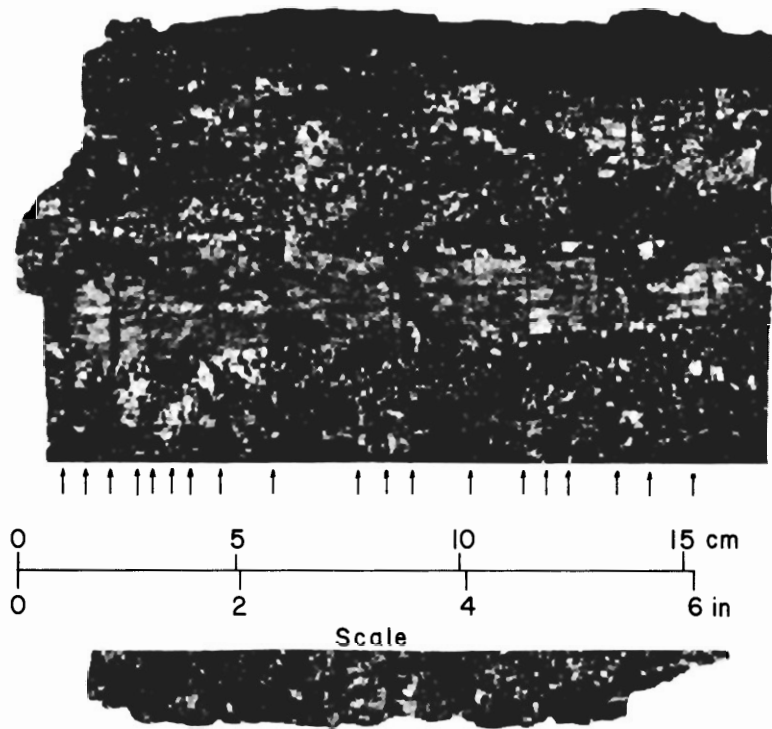


FIGURE 6. - Cleat spacing in specimen of Upper Freeport coal.

holes, and orienting horizontal holes drilled underground. Data were collected from 23 quadrangles and plotted on rose diagrams (fig. 7). For 8 of the quadrangles located totally or partially within the study area, an average of more than 16 locations were used, with an average of more than 8 measurements taken at each location. All but four quadrangles had locations where readings were taken from coalbeds.

In figure 8 distinct trends, corresponding to face and butt cleat directions, are apparent for readings taken in coal. The face cleat and systematic (primary) rock joints in the study area generally trend $N 72^{\circ} W$. Nearly perpendicular to these are the butt cleat and the nonsystematic (secondary) joints which trend $N 21^{\circ} E$. The face cleat direction is parallel to the direction of the principal compressive stress that produced the present structure and perpendicular to the fold axes. The butt cleat is parallel to the structural axes of the Allegheny Front.

Many strip and drift mines have operated in the Upper Freeport on the flanks of the anticlines, where the coalbed outcrops or is close to the surface. In the northwestern part of the county, this coalbed has also been strip mined along its outcrop on the Youghiogheny River and Jacobs Creek.

JOINT AND CLEAT DATA

The Upper Freeport coal is friable and has a close cleat spacing (fig. 6) of around 40 face cleats per foot. Orientation of rock joints and coal cleats was measured from outcrops throughout the county to provide data for mine planning. These data can be important in laying out the mine, spacing vertical bore-

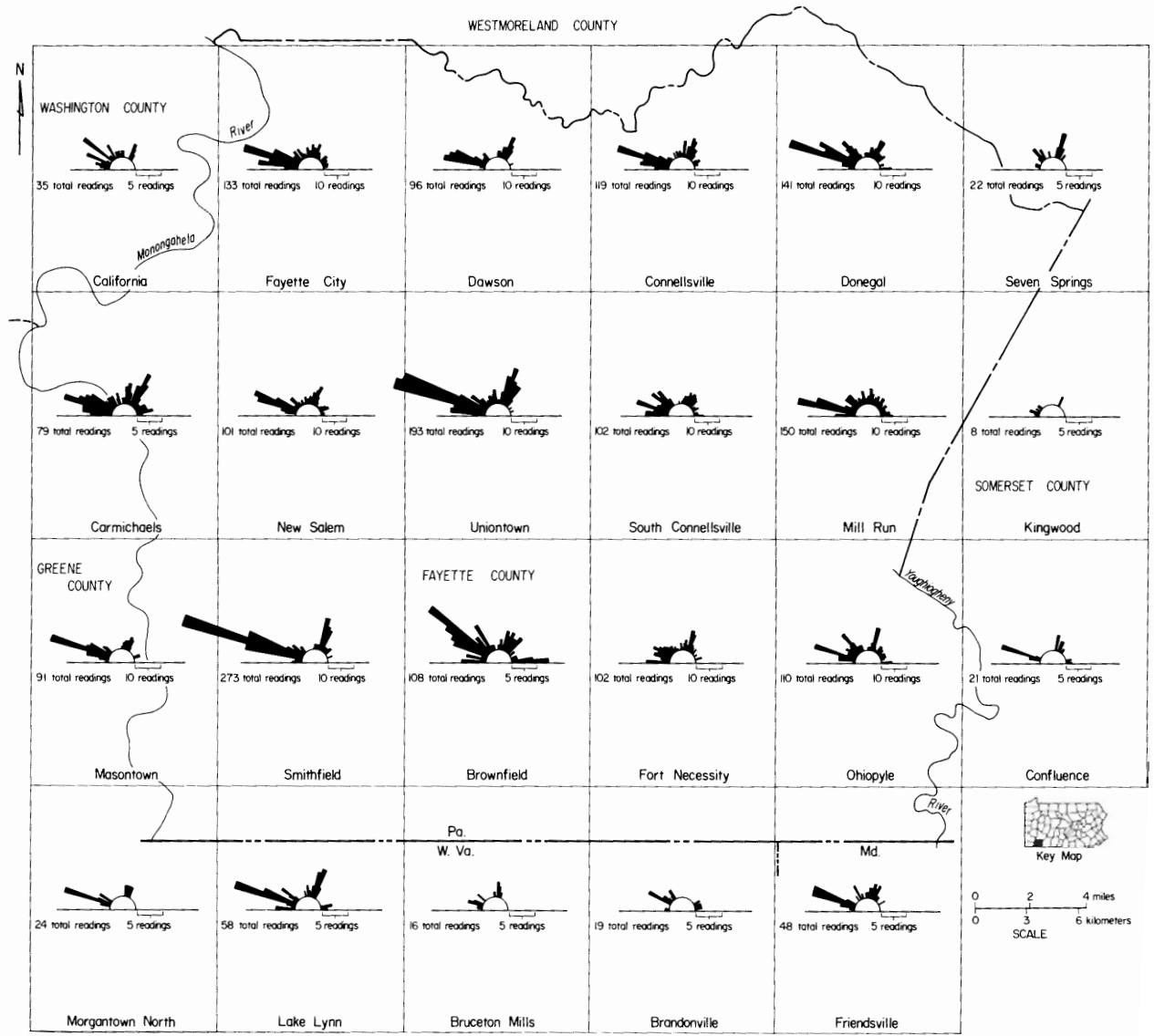


FIGURE 7. - Rose diagrams of coal cleat and rock joint measurements in Fayette County, Pa.

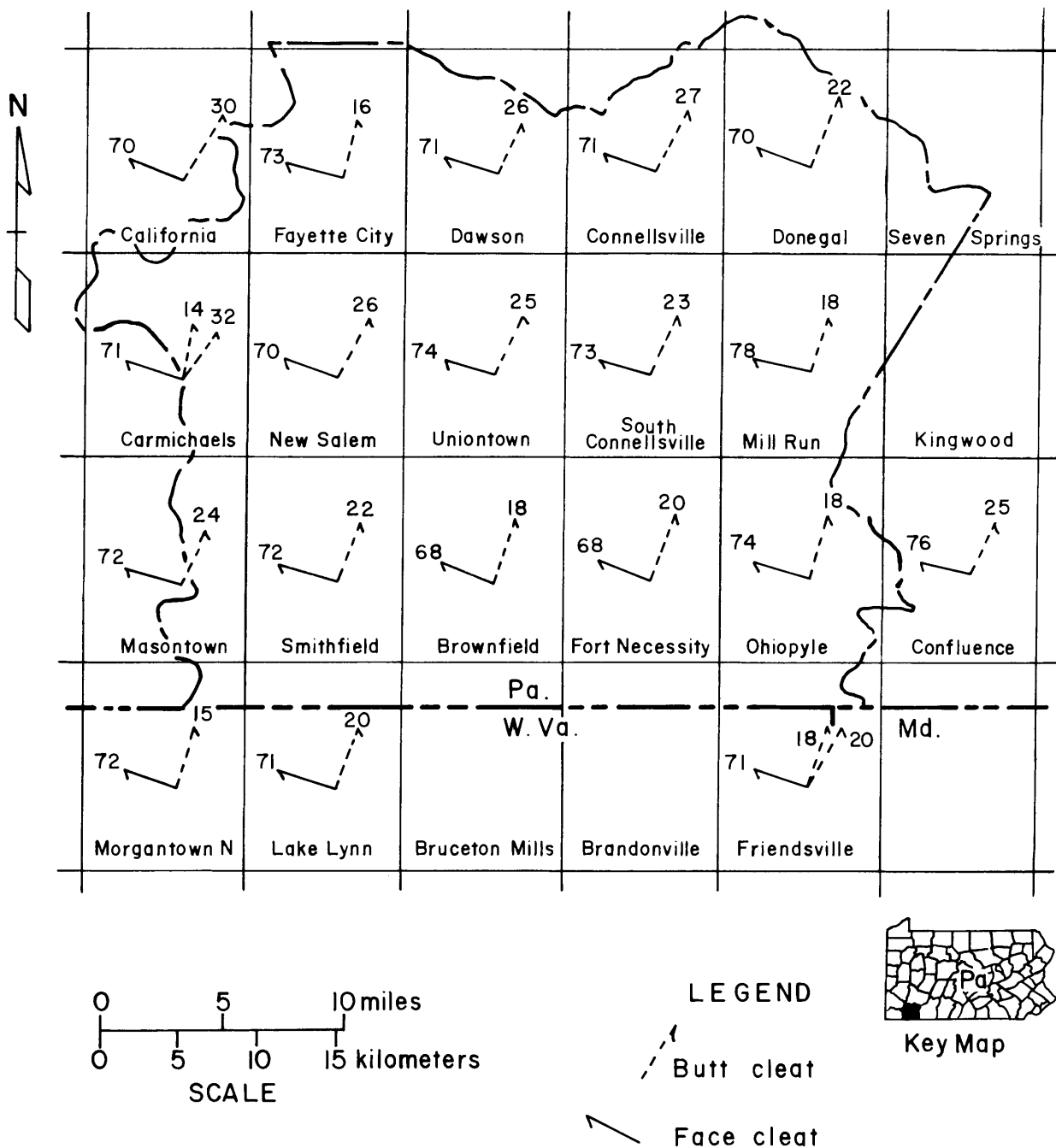


FIGURE 8. - Diagram of the face and butt cleat trends in each quadrangle.

COAL THICKNESS AND METHANE RESOURCES

Where present, the Upper Freeport coalbed usually ranges from 2 to 8 feet thick. Commonly the coalbed occurs in two benches with a 6-inch parting. The top and bottom benches average 25 and 21 inches thick, respectively. The shale parting rarely attains a thickness greater than 2 feet, but where it does only

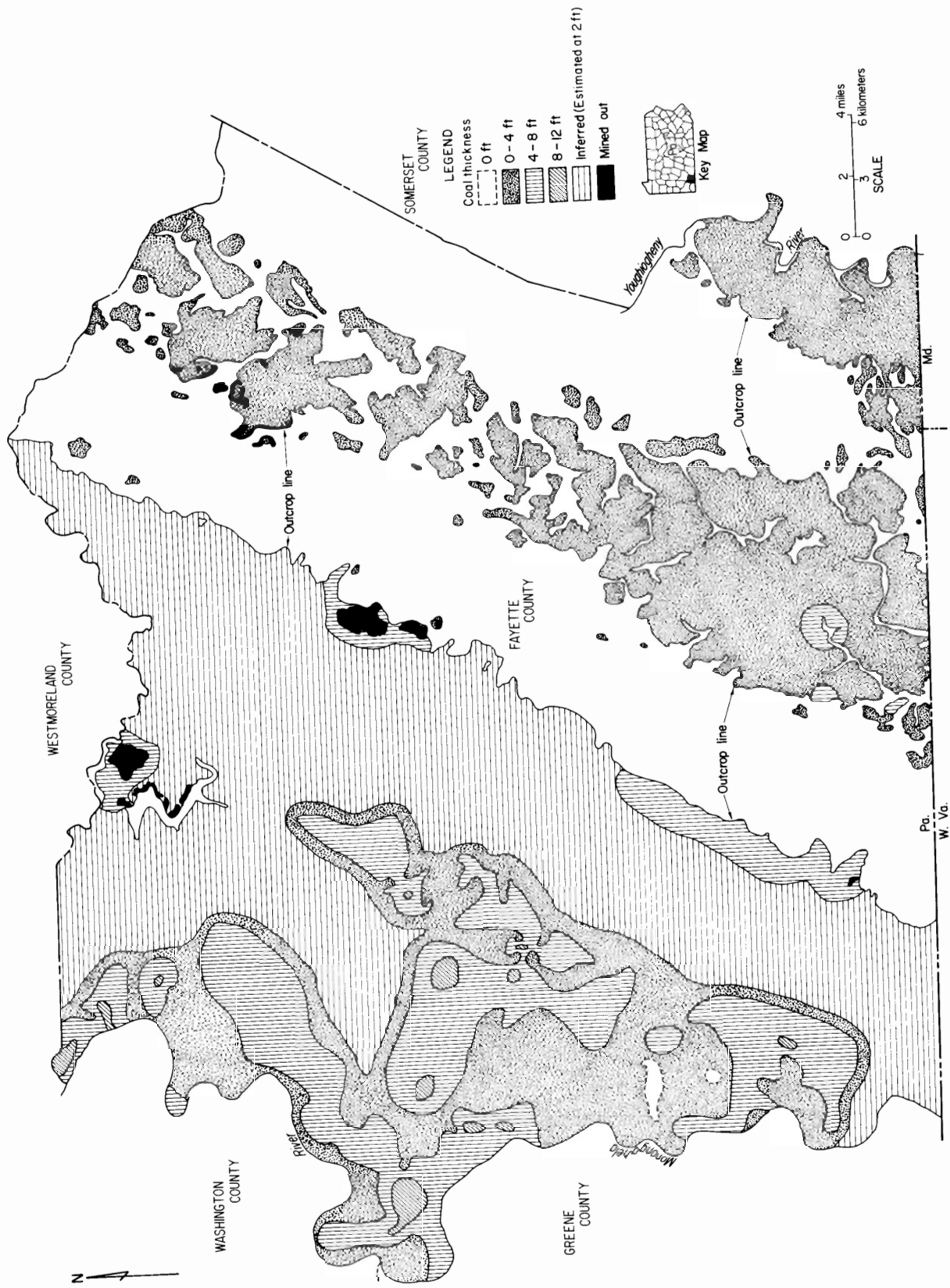


FIGURE 9. - Isopach of the Upper Freeport coalbed.

one bench is usually of minable thickness. Occasionally, there is a middle bench up to 3 feet thick or an upper split of the seam averaging 30 inches.

In order to calculate the total volume of methane in this part of the Upper Freeport coalbed, it was necessary to estimate the total coal in place. The area of each interval was measured from topographic maps. Multiplying this figure times the average coal thickness for the interval (2 feet for the 0- to 4-foot interval and so on) gives the volume of coal. Dividing the volume in cubic feet by 24.6 gives the number of short tons, assuming the specific gravity of this coal to be 1.3 (81.3 lb/cu ft). An equation for this follows:

$$\text{Tons of coal} = \frac{\text{average interval thickness} \times \text{interval area}}{24.6 \text{ cu ft/ton}}$$

An estimate of 1,340 million tons of coal in place was made by using over 370 data points. In some areas there are insufficient data to draw isopach lines (fig. 9). There are, however, sufficient data points surrounding the area to assume an average thickness of 2 feet or more. Due to the highly variable thickness of the Upper Freeport coalbed in the study area, a conservative thickness of 2 feet was used to estimate the coal in place in these areas. Assuming methane content to be 140 to 300 cubic feet per ton of coal, there is 190 to 400 billion cubic feet of methane in the Upper Freeport coalbed in Fayette County.

METHANE CONTENT

The amount of methane adsorbed on the coal microstructure depends on several factors: temperature, pressure, overburden thickness, and rank. Coalbed pressure is the fluid pressure of the bed. At most it is equal to the hydrostatic pressure, which has a gradient of about 0.43 psi per foot of water column. Bureau research has shown that for each additional 100 feet of overburden, an increase of about 0.8 cu cm of methane per gram of coal (25.6 cu ft/ton) can be expected in the Pittsburgh coalbed (fig. 10). This correlates well with tests done on the Upper Freeport coalbed which has a gas content per volume of coal similar to the Pittsburgh coalbed.

In some coalbeds, the increase in gas content with the increase in depth is due partly to the decrease in volatile matter. However, pressure and temperature associated with past tectonic activity have had a much greater effect on the coal rank in the study area than present overburden thickness. The increased yield of methane is associated with the decrease in hydrogen content, which begins in the bituminous coal range (14). Higher rank coals have a structure which can adsorb more of the methane produced during coalification.

The relationship of gas content to fixed carbon content is shown on figure 11 (11). In Fayette County the Upper Freeport coal, which varies between 63 and 75 pct fixed carbon in DAF (dry ash free) samples, is expected to have a gas content between 3 and 10 cu cm/g, with some variation due to depth. In the study area this coal averages 68.5 pct fixed carbon from

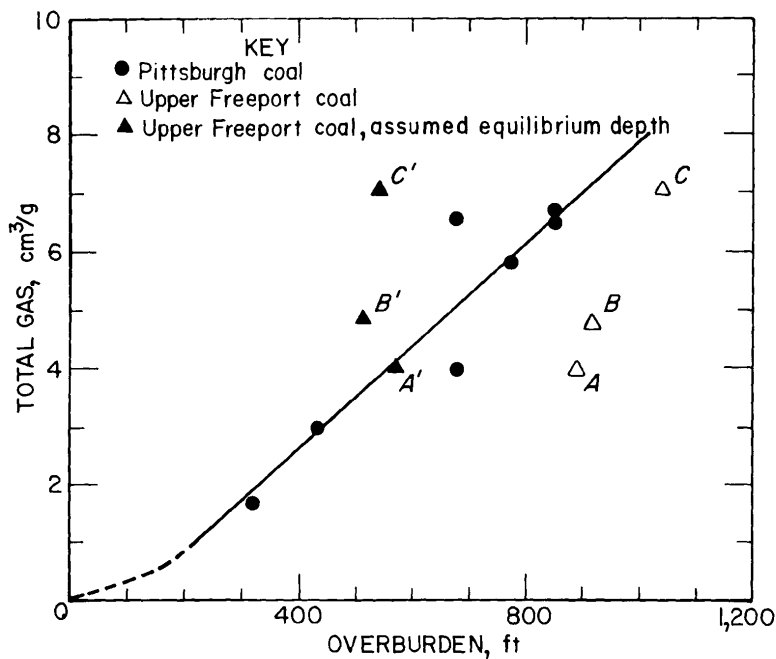


FIGURE 10. - Graph of depth versus gas content for Pittsburgh coal cores.

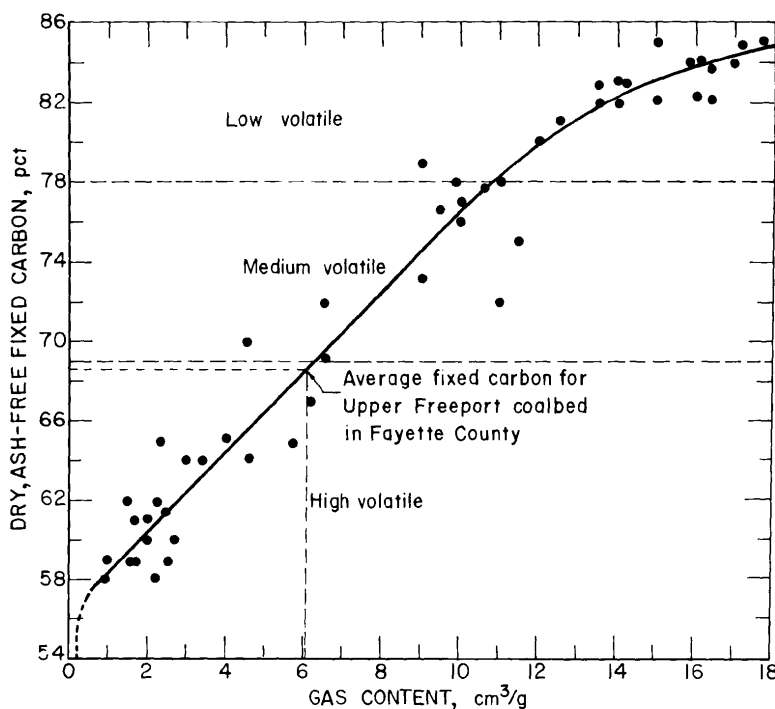


FIGURE 11. - Graph of fixed carbon versus gas content of coal cores from several coalbeds, adapted from previous publication (11).

published analyses (2, 6-7) and should average about 6.1 cu cm of methane/g of coal. This is only 13 pct higher than the value determined by the direct desorption method for three Greene County core samples (8, 10). Results from these tests are plotted on the graph of data from the Pittsburgh coalbed (fig. 10). The average depth of these three samples was 962 feet, and the average gas content was 5.3 cu cm/g. A reason for this anomaly could be a reduction in overburden pressure due to mining of the overlying Pittsburgh coalbed, thus establishing new equilibrium conditions. The lower hydrostatic pressures could cause gas to desorb from the Upper Freeport coalbed. New points have been plotted for the Upper Freeport coalbed by subtracting the overburden above the mined Pittsburgh coalbed to reflect the assumed equilibrium depths (A', B', and C', fig. 10).

An important but unknown factor is the length of time necessary for gas to desorb from a coalbed under such conditions and a new equilibrium to be established. Points A' and B' plot closely to points A and B on the graph for the Pittsburgh coalbed, however, point C' does not. This point could be influenced by the overlying virgin Pittsburgh coalbed to the west and southwest, and point C may indeed be the true depth equilibrium for this core sample.

SUMMARY AND CONCLUSIONS

The Upper Freeport coalbed in Fayette County contains 190 to 400 billion cubic feet of methane based on an estimate of the total coal in place. The methane content is assumed to be 140 to 300 cubic feet per ton of coal. The total coal in place was determined by using 370 data points. The variable thickness of the coalbed in this area will require careful property evaluation and mine planning.

The structural elevation ranges from 200 feet below to 2,600 feet above sea level, and overburden thickness ranges from 0 to over 1,400 feet. The face cleat trends N 72° W, and the butt cleat trends N 21° E.

Degasification in advance of mining may be advisable for parts of the coalbed with more than 200 cu ft of methane per ton of coal in place. Gas contents of this order can be expected where the Upper Freeport is under more than 800 feet of overburden, mostly in the western part of the county. Due to the variable nature of the Upper Freeport coalbed in this area, a core hole spacing of 2,000 feet or less may be necessary to accurately determine reserves and low coal areas.

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APPENDIX.--AVERAGE OF COAL CLEAT TRENDS FOR INDIVIDUAL
QUADRANGLES IN THE STUDY AREA

Quadrangle	Face cleat peak	Butt cleat peak
Brownfield.....	68 W	18 E
California.....	70 W	30 E
Carmichaels.....	71 W ¹	14 E, 32 E ²
Confluence.....	76 W	25 E
Connellsville.....	71 W	27 E
Dawson.....	71 W	26 E
Donegal.....	70 W	22 E
Fayette City.....	73 W	16 E ²
Fort Necessity.....	68 W	20 E
Friendsville.....	71 W	18 E, 28 E ²
Lake Lynn.....	71 W	20 E
Masontown.....	72 W	24 E
Mill Run.....	78 W	18 E
Morgantown North.....	72 W	15 E ¹
New Salem.....	70 W	26 E
Ohiopyle.....	74 W	18 E
Smithfield.....	72 W	22 E
South Connellsville.....	73 W	23 E
Uniontown.....	74 W	25 E ¹

¹Wide peak.

²Double peak.