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Methane Emissions From an Advancing Coal Mine Section in the Pittsburgh Coalbed

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CONTENTS

ILLUSTRATIONS

METHANE EMISSIONS FROM AN ADVANCING COAL MINE SECTION IN THE PITTSBURGH COALBED

by

P. W. Jeran,[1] D. H. Lawhead,[2] and M. C. Irani[3]

ABSTRACT

The methane emissions from an advancing coal mine section were continuously monitored for 120 days. During this time, the section advanced 2,000 feet into virgin Pittsburgh coalbed producing 54,565 tons of coal with a total methane emission of 91 million ft^3. Analysis of the data gathered showed that daily methane emissions did not correlate with overburden thickness and daily coal production. A good correlation was found between the daily methane emission and the average length of rib exposed to virgin coal.

INTRODUCTION

Methane gas is a hazard in underground coal mining. It enters the mine ventilation system from the breakup of coal, from the face and virgin ribs, and from the gob. Each of these sources contributes to the total emission from the mine, which can be monitored by a continuous-recording methanometer (4),[4] installed at the exhaust fans of the mine. However, to identify and study the factors that determine methane emission, each individual underground source must be monitored separately. A system of underground methanometers has been developed for this purpose (3).

Based on a survey of the average daily methane emissions from mines in individual major coalbeds (5), a correlation was developed between total mine emission measured at exhaust fans and depth and production. To determine if methane emissions from a local working place would show the same correlation, the methane emitted from an advancing section was monitored continuously while the section was mined under a range of overburden thicknesses. The working place chosen was remote from prior mining and relatively free from stratigraphic or geologic structural changes, in the Pittsburgh coalbed, at the Consolidation Coal Co.'s Loveridge mine near Fairview, W. Va.

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[1]Geologist.
[2]Mining engineering technician.
[3]Mining engineer.
[4]Underlined numbers in parentheses refer to the items in the list of references at the end of this report.

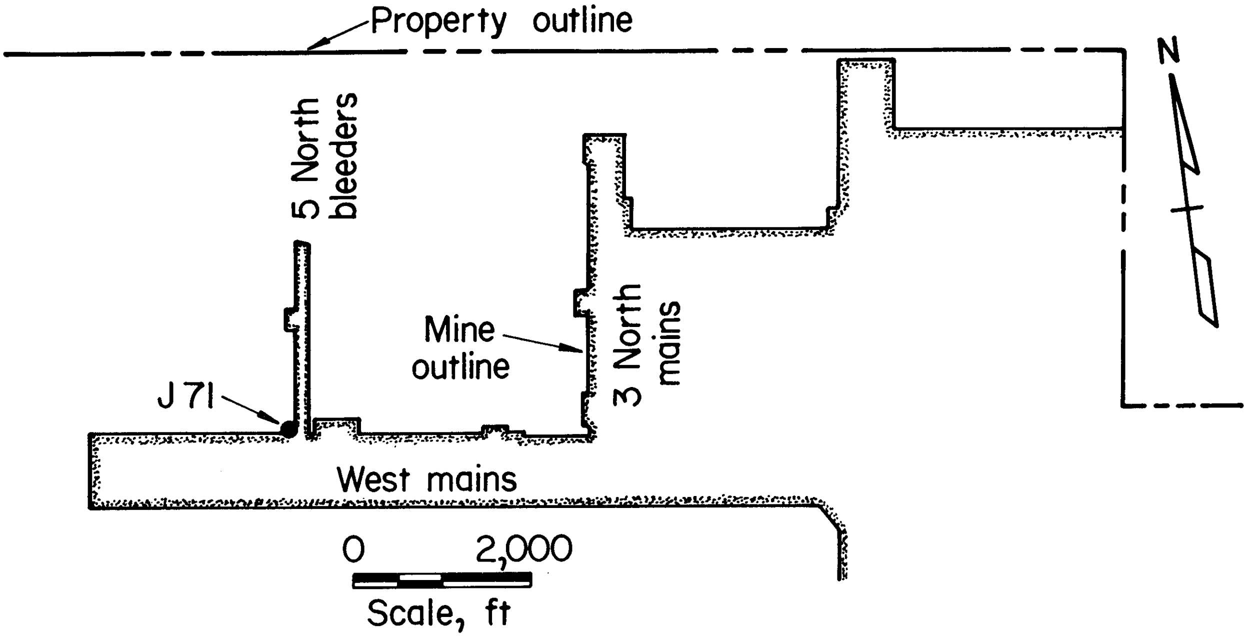

FIGURE 1. - Location sketch map of 5 North bleeders.

During 1973, this mine was known to have produced an average of 10,000 tons d^{-1}, with an average methane emission of 12.1 million $ft^3 d^{-1}$ (2). The mine has two sets of mains driven into the virgin coal. A set of entries driven off either of these mains, remote from parallel workings, would meet the needs of the proposed investigation.

The 5 North bleeders off West mains was chosen for the experiment (fig. 1). The geological reconnaissance and the study of the core logs indicated that the coalbed and adjacent strata should be uniform throughout the projected development.

ACKNOWLEDGMENTS

The authors acknowledge the cooperation of the Mountaineer Division of Consolidation Coal Co. in the successful completion of the project. The authors especially thank K. Kincell, M. Hudak, and H. Gandy for their assistance.

GEOLOGY

The topography over the mine has a well-developed dendritic drainage pattern, which has left narrow ridges between typically V-shaped stream valleys. The relief between ridge and valley elevations averaged 450 feet.

The structure of the Pittsburgh coalbed shown in figure 2 was compiled from company supplied data. The coalbed gently dips northwest toward the axis of the Waynesburg syncline located beyond the western boundary of the mine property.

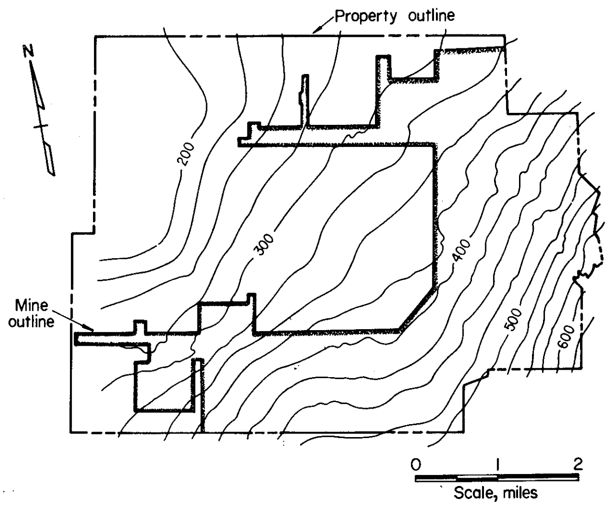

FIGURE 2. - Structure of base of Pittsburgh coalbed.

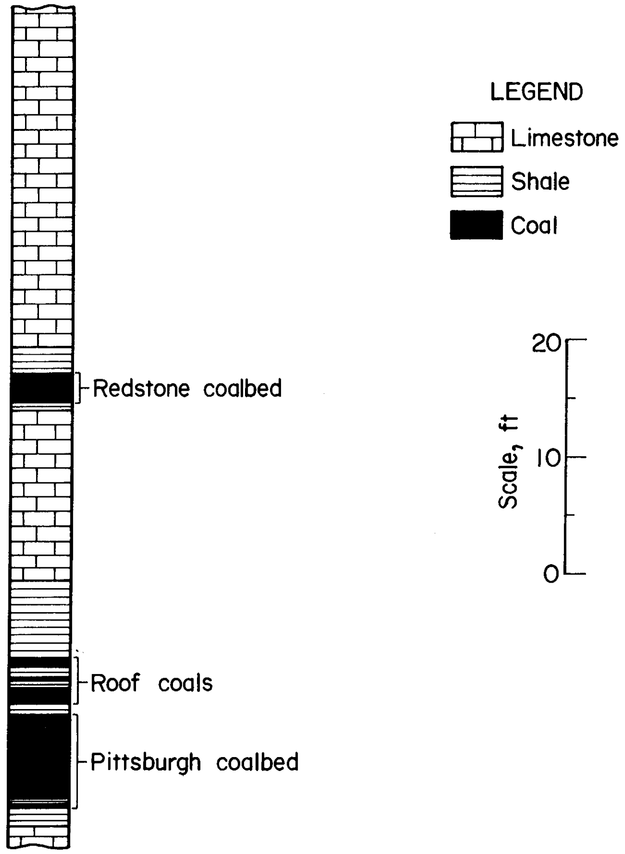

FIGURE 3. - Columnar section Pittsburgh through Redstone coalbeds.

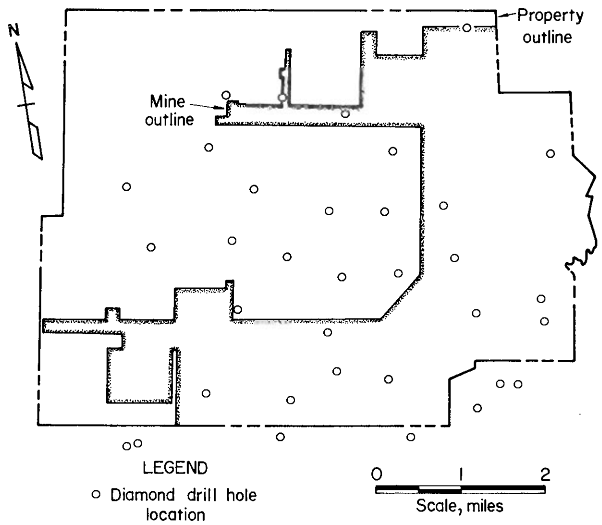

FIGURE 4. - Location map of core test boreholes.

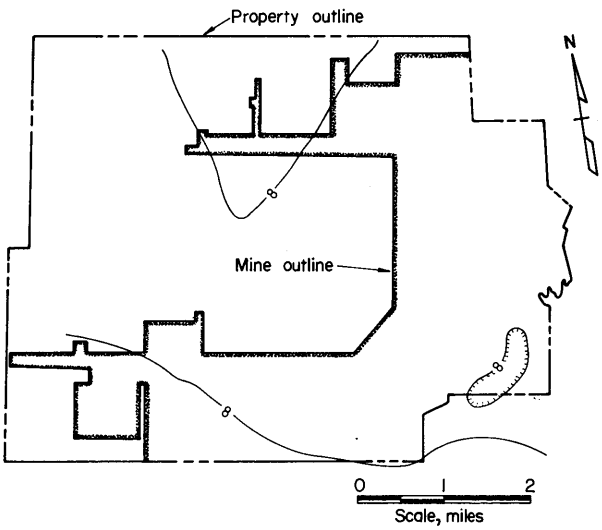

FIGURE 5. - Isopach of Pittsburgh coalbed.

Figure 3 shows the major lithologies immediately above the Pittsburgh coalbed within the mine property. Using the driller's logs from the core test holes located in figure 4, a series of maps were drawn to examine lithology variations over the mine property. These maps showed no abrupt changes in the lithologies over the Pittsburgh coalbed within the mine area. The isopach of Pittsburgh coalbed (fig. 5) shows it to be continuous and fairly uniform in thickness within the mine property.

A geologic reconnaissance and structural survey of the available mine workings showed well-developed coal cleat (8) that rotates clockwise slightly from N 74° W in the south to N 70° W in the north. Two small normal faults of limited lateral extend were judged to be local and attributed to sedimentary slumping. No clay veins were observed in the active workings.

DATA SOURCES

The methane analyzer system (3) developed at the Bureau of Mines was used for continuous recording of the volume-percent of methane in the ventilation air at selected locations. Basically, the system is composed of sensor assemblies installed at desired locations in the mine, power supplies for the sensor assemblies located in fresh air underground, and a central receiving station, generally located at the surface, that records the output from each sensor. The resulting data are accurate to ±0.04 vol-pct methane in air on a scale from 0 to 2 pct.

The mine operators provided copies of mine maps and daily coal production figures. The air readings used in all calculations were provided by mine personnel.

MINING HISTORY

The 5 North bleeders are a set of five entries driven on 60-foot centers north off West mains (fig. 6). The section was advanced 2,700 feet into virgin coal. This section mined under overburden that declined from an average 1,350 feet over room 7 (the point where monitoring began) to an average 950 feet over room 27. The nearest parallel workings were almost 4,000 feet away.

Throughout the mining of the section, the coal and adjacent strata remained as shown in figure 3. The only discontinuity was a clay vein first encountered inby room 11 in the right return airway and subsequently mined through by all the entries (fig. 7). This clay vein did not exceed 12 inches in thickness and extended from roof to floor. Its extent to the left and right of the section is undetermined.

Mining up to the clay vein was rapid with production of coal averaging over 1,000 tons d^{-1} and gas emissions of less than 400,000 ft^3d^{-1}. When mining encountered the clay vein, gas emission increased and coal production declined. Mining around the well block between rooms 15 and 17 was slowed by gas emission and ventilation problems due to the irregular entries. Methane emissions continued to retard mining after the face had advanced past the well block.

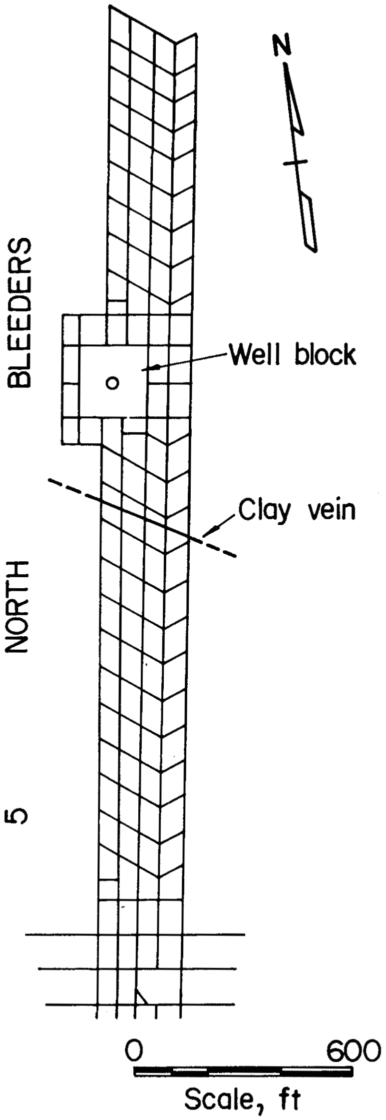

FIGURE 6. - Sketch map of 5 North bleeders.

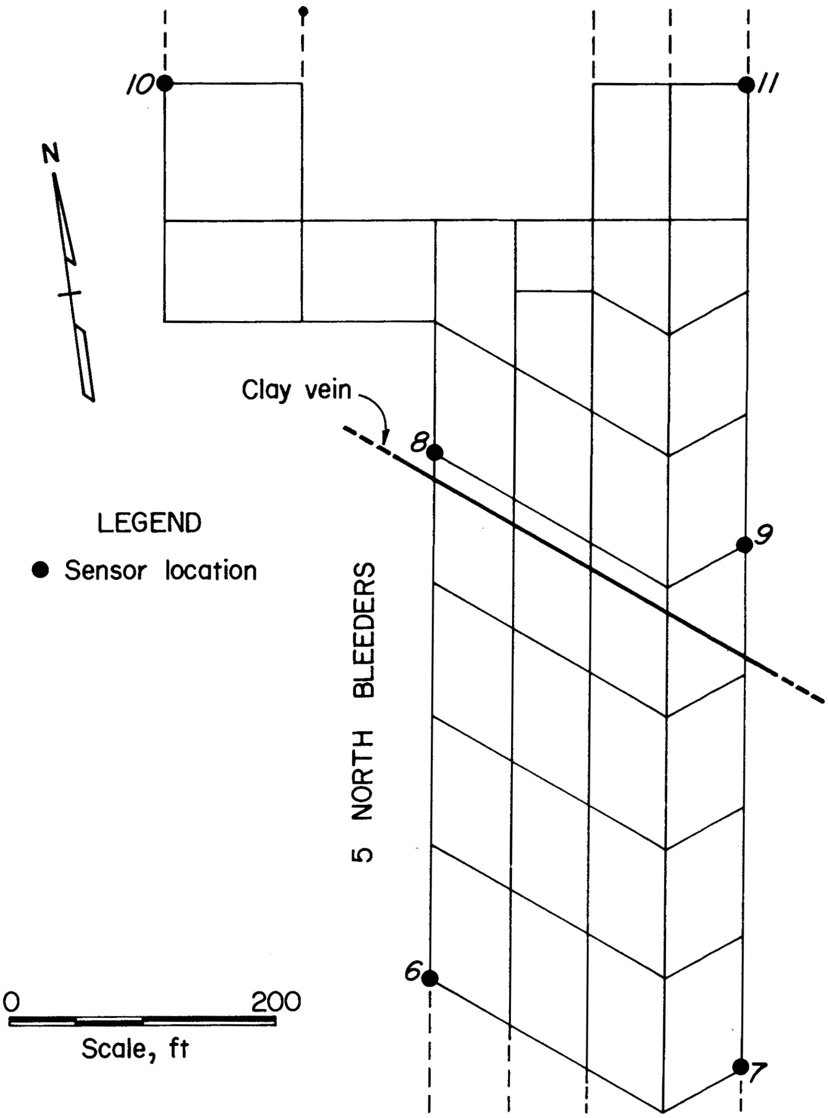

FIGURE 7. - Sketch map of clay vein location.

At room 23, the decision was made to shorten crosscut center lines to 80 feet to improve ventilation. A zone of heavy roof encountered between rooms 19 and 21 required additional roof bolts. Some of the bolt holes were reported to have audible gas emissions. Mining ceased on January 4, 1974, at room 27.

MONITORING HISTORY

Monitoring began on September 7, 1973. Additional sensors were installed as mining progressed (fig. 8). At the time of installation, each sensor was generally 100 feet back from the active face. All sensors were located in the return airways except sensor 1, which was used to monitor the intake air. This sensor was first installed at location 1A. Later it was moved to

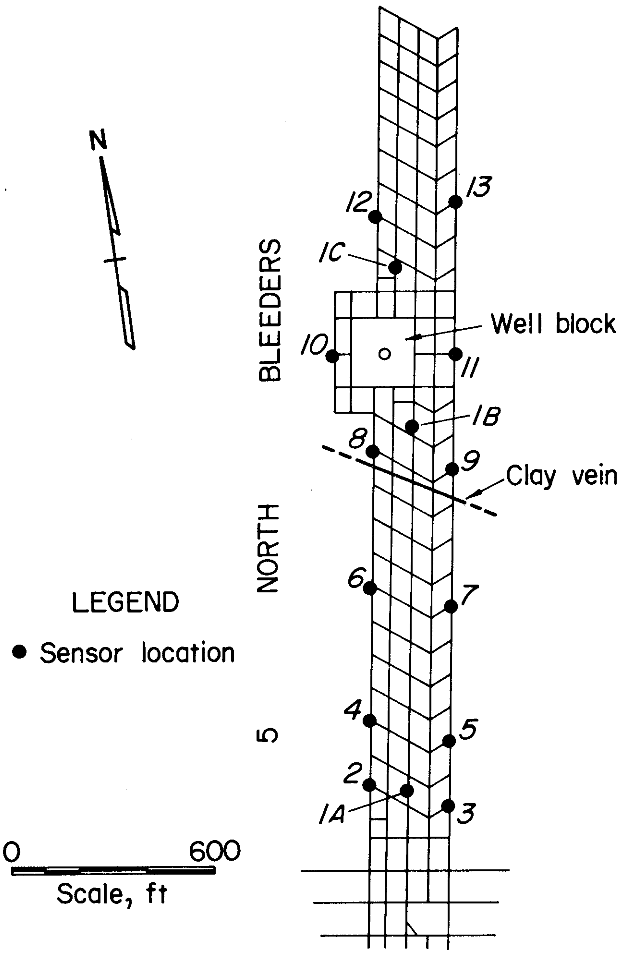

FIGURE 8. - Sketch map of sensor assembly locations.

location 1B when mining had reached the well block to determine if any gas was entering the intake air from the clay vein, and then to location 1C to determine if any gas was entering the intake air from the well block (fig. 9). Neither the clay vein nor the well block contributed methane to the intake air after the face had been advanced past them.

During the experiment, the sensor nearest the face only once recorded a higher methane volume-percent than those located outby. This was when the clay vein was mined through. At all other times the peak volume-percent occurred from 1,000 to 1,500 feet outby the face indicating a large gas emission from the ribs.

DISCUSSION

In the 120 days of monitoring, this section emitted a total of 91 million ft^3 of methane, of which 49 million ft^3 came from the left side and 42 million ft^3 came from the right. The slightly lower emissions from the right are attributed to some depletion of gas in the virgin coal to this side due to the development 3 years earlier of the 3 North mains some 4,000 feet distant.

Figure 10 shows the continual rise of emissions throughout the experiment from almost 300,000 ft^3d^{-1} initially to over 1.2 million ft^3d^{-1} at the end, whereas both overburden thickness and daily coal production declined. Emissions generally declined during idle periods.

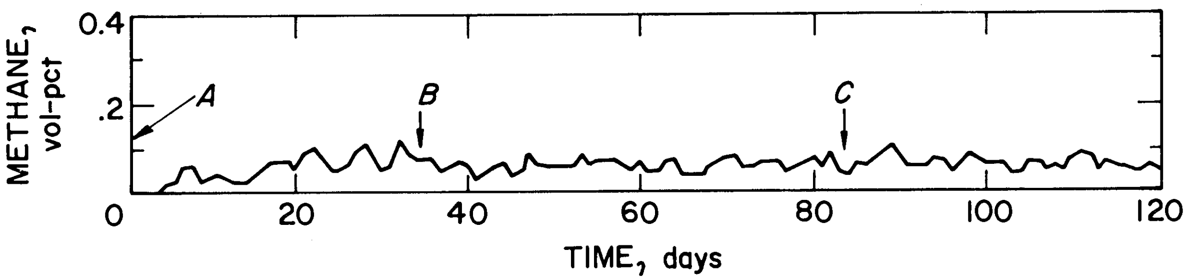

FIGURE 9. - Graph of average daily methane volume-percent recorded from sensor 1.

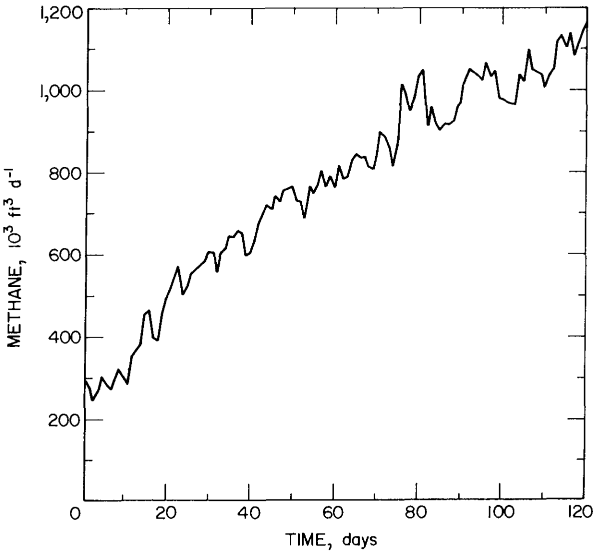

FIGURE 10. - Graph of daily methane emissions from 5 North bleeders.

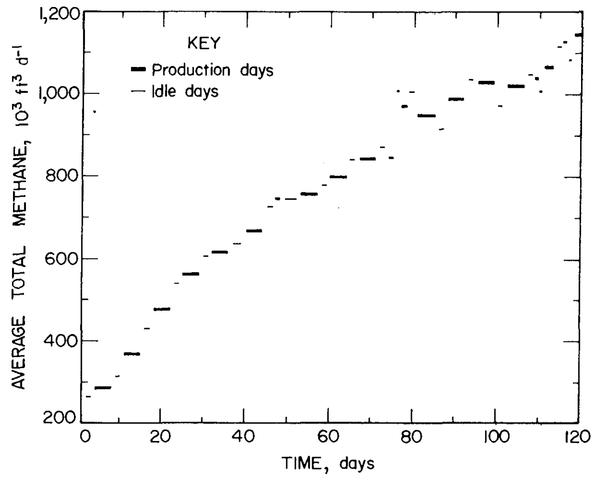

FIGURE 11. - Graph of average daily methane emissions during production and idle periods.

To evaluate the emission due to coal production, the average methane emissions during production periods and idle periods were calculated and plotted (fig. 11). The average emissions were found to increase with time, and average daily emissions on weekends generally exceeded average daily emissions during the preceeding production period.

The data from the methane sensors closest to the face and the average daily air volumes recorded at the face were used to calculate the volumes of methane entering the mine inby these sensors. This amounted to 41 million ft^3, or less than half of the total gas from the section. Thus, most of the methane came from the ribs. The 41 million ft^3 includes the emissions from between 100 and 500 feet of virgin rib between the sensor location and the active face. The (average) length of virgin rib exposed versus time was plotted. The resultant curve (fig. 12) is similar to that of average gas emissions during production and idle periods. Based on this similarity, a plot was made of daily methane emissions versus average length of virgin rib (fig. 13). A linear regression of these data yielded (1)--

$$DME = 499L - 103{,}921,$$

where DME = daily methane emissions ($ft^3 d^{-1}$)

and L = average length of virgin rib (ft)

with a correlation coefficient of 0.98. A correlation coefficient of 1.0 indicates a perfect fit of the line to the data. In this site, the methane emissions correlate directly with the length of the virgin rib with 95 pct of the variation in the emissions explained by the length of virgin rib.

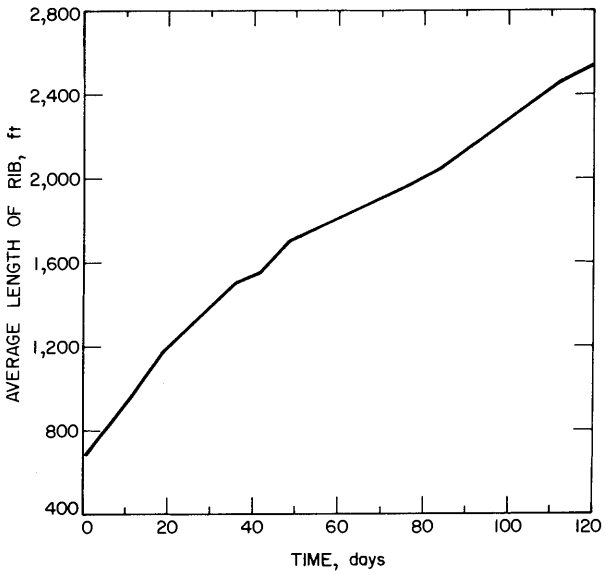

FIGURE 12. - Graph of average length of virgin rib exposed.

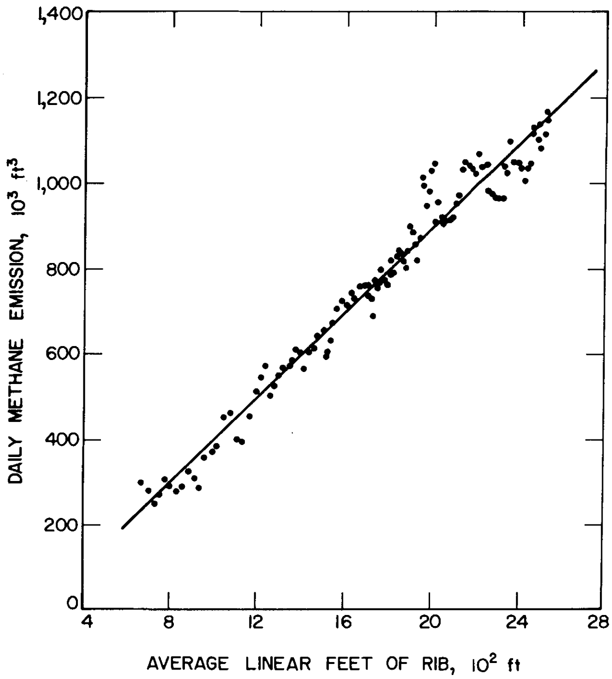

FIGURE 13. - Plot of daily methane emission versus average length of rib exposed.

Kissell, McCulloch, and Elder (7) have reported the methane content of the virgin Pittsburgh coalbed in the Loveridge mine area to be 5.8 $cm^3 g^{-1}$ or about 186 ft^3 ton^{-1}. If all of this gas is assumed to have been present prior to mining and all of it released during mining, the 54,565 tons mined would only have contributed 10 million ft^3. Adding the gas from the outlined pillars only accounts for 29 million ft^3 of methane, leaving 68 pct of the total methane emissions to come from the surrounding virgin coalbed.

Kissell and Deul (6) have reported that the breakage of coal at the face contributes little to methane emissions. We know that the coal at the face does not contain methane under pressure and therefore its methane content is significantly below the 5.8 $cm^3 g^{-1}$ reported by Kissell, McCulloch, and Elder. The methane emissions must therefore come from the virgin ribs, and the data gathered in this experiment verify this.

With the instruments used in this experiment, it is now possible to monitor continuously and simultaneously methane emissions from several sections of a mine for long periods of time. The resultant data would isolate the variations in methane emissions from individual sections of the mine and allow more detailed study of the parameters controlling methane emissions in local areas.

In the advancing section used for this study, the rock strata above and below the coal were not significantly disturbed. In retreat mining, these adjacent rock strata would be disturbed and any gas that they contained would enter mine workings.

SUMMARY

A 5-entry section was monitored for 120 days for methane emissions. During this time, the section advanced about 2,000 feet into virgin Pittsburgh coalbed. Although overburden and daily coal production declined, daily gas emissions increased.

The data accumulated indicate that a large part of the methane entering the section came not from the immediate face but from the ribs adjacent to virgin coal. This is clearly illustrated by a graph of daily methane emissions versus the length of virgin rib exposed (fig. 13). Furthermore, linear regression of the graphed data shows that 95 pct of the variation in methane emission is attributable to the length of virgin rib.

At the study site, the primary source of methane is the surrounding virgin coalbed, and this section acted like a long borehole drilled into a gas reservoir--the daily volume of methane produced increased with borehole length.

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