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Effect of a Surface Borehole on Longwall Gob Degasification (Pocahontas No. 3 Coalbed)

UNITED STATES DEPARTMENT OF THE INTERIOR

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UNITED STATES DEPARTMENT OF THE INTERIOR
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T. D. Moore, Jr.[1] and M. G. Zabetakis[2]

ABSTRACT

The use of a partially slotted 6.5-inch-inside-diameter vertical pipe to remove methane from a longwall gob area at a depth of 2,260 feet in the Pocahontas No. 3 coalbed was investigated. The value of gas removed by such a pipe under free-flow conditions was found to equal the cost of the installation in this case. Approximately 25 percent of the available methane passed through the pipe without the use of an exhauster; an additional 10 percent was removed when an exhauster was employed.

The diversion of methane through a vertical slotted pipe to the surface permitted the use of increased mining rates and decreased the ventilation air requirements.

INTRODUCTION

Extensive studies have been conducted here and abroad on the control of methane in active coal mines. To date, the primary emphasis has been on the dilution of methane in the ventilating air. However, several years ago, Rice and others proposed the use of vertical boreholes to reduce the quantity of methane in a coalbed and in abandoned areas.[3] Spindler and Poundstone[4] used 2-, 5-1/2-, and 6-5/8-inch-diameter pipes to remove methane from the Pittsburgh coalbed about 470 feet below the surface, and 6-1/4-inch-outside-diameter pipe to remove gas from a sealed area; Ridenour[5] used 36- and

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[1]Mining engineer.
[2]Research supervisor.

[3]Rice, George S. Safety in Coal Mining. BuMines Bull. 277, 1928, p. 42.
Selden, R. F. The Occurrence of Gases in Coals. BuMines Rept. of Inv. 3233, 1934, p. 2.

[4]Spindler, G. R., and W. N. Poundstone. Experimental Work in the Degasification of the Pittsburgh Coal Seam by Horizontal and Vertical Drilling. Trans. AIME, v. 220, 1961, pp. 37-46.

[5]Ridenour, D. C. Core Drilling of Air Shafts and Manway Portals. Min. Cong. J., v. 43, October 1957, pp. 99-101.
Ridenour, D. C. Ventilation by Large-Diameter Bore Holes. Mechanization, March 1959, pp. 69-70.

48-inch-diameter boreholes to ventilate remote gobs 580, 733, and 976 feet below the surface. More recently, Elder[6] and Ferguson[7] described an experiment in which a partially slotted 8-inch-diameter pipe was used to remove methane from longwall gob areas in the Lower Kittanning coal about 600 feet below the surface. The present work is an extension of this experiment to the Pocahontas No. 3 coalbed at a depth of 2,260 feet. It is a part of a long-range program designed to investigate the feasibility of using degasification holes drilled from the surface into operating mines prior to mining.

TEST SITE

The site chosen for the present study was approximately 2,260 feet below the surface in the Pocahontas No. 3 coalbed in Buchanan County, Va. The coalbed in this region is approximately 51 inches thick (fig. 1), and has a 1-5/8-inch shale parting approximately 15 inches below the top of the bed; its temperature is 70° to 72° F; the horizon above the coal is sandy shale with sandstone streaks and partings. Below the coal is a 10-1/8-inch zone of quartzite, and below this is a massive micaceous sandstone.

An 8-3/4-inch-diameter degasification hole was drilled to a level 4 feet below the coal in the No. 3 panel (fig. 2). A 7-inch-outside-diameter casing (6.5 inches inside diameter) was placed in this hole and pressure-grouted from the surface to within 139 feet of the coal (fig. 1). This left an annular space between the lower slotted section of casing and the hole. The grout prevented the entry of water and gas from the upper horizons but permitted the passage of gas through the slots in the lower 120 feet of casing and through the end of the pipe.

The degasification hole was completed in the spring of 1970; mining of the No. 3 panel was initiated approximately 3-1/2 months later, on August 13. No significant flow of methane was detected at the top of the casing until after the borehole was intersected on November 9 (fig. 3).

The No. 3 panel was 370 feet wide and 3,920 feet long. It was located east of panels 1 and 2, which had been mined earlier. A bidirectional plow was used to mine the 370-foot face with the roof supported by self-advancing, double frame, heavy-duty, hydraulic units; each unit consisted of four double-acting 140-ton jacks. The face equipment required a minimum space of 11 feet between the coal face and the gob. A single split of air was used to ventilate the longwall panel (figs. 2-3). The airflow rate past the head end of the face ranged from 77,000 to 82,000 cfm during the study period; approximately 20 percent of this air reached the tail end of the face, with the remainder flowing past the roof support units into the gob.

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[6]Elder, C. H. Use of Vertical Boreholes for Assisting Ventilation of Longwall Gob Areas. BuMines Tech. Prog. Rept. 13, 1969, 6 pp.

[7]Ferguson, Pete. Methane Control by Boreholes. Coal Age, January 1972, pp. 76-77.

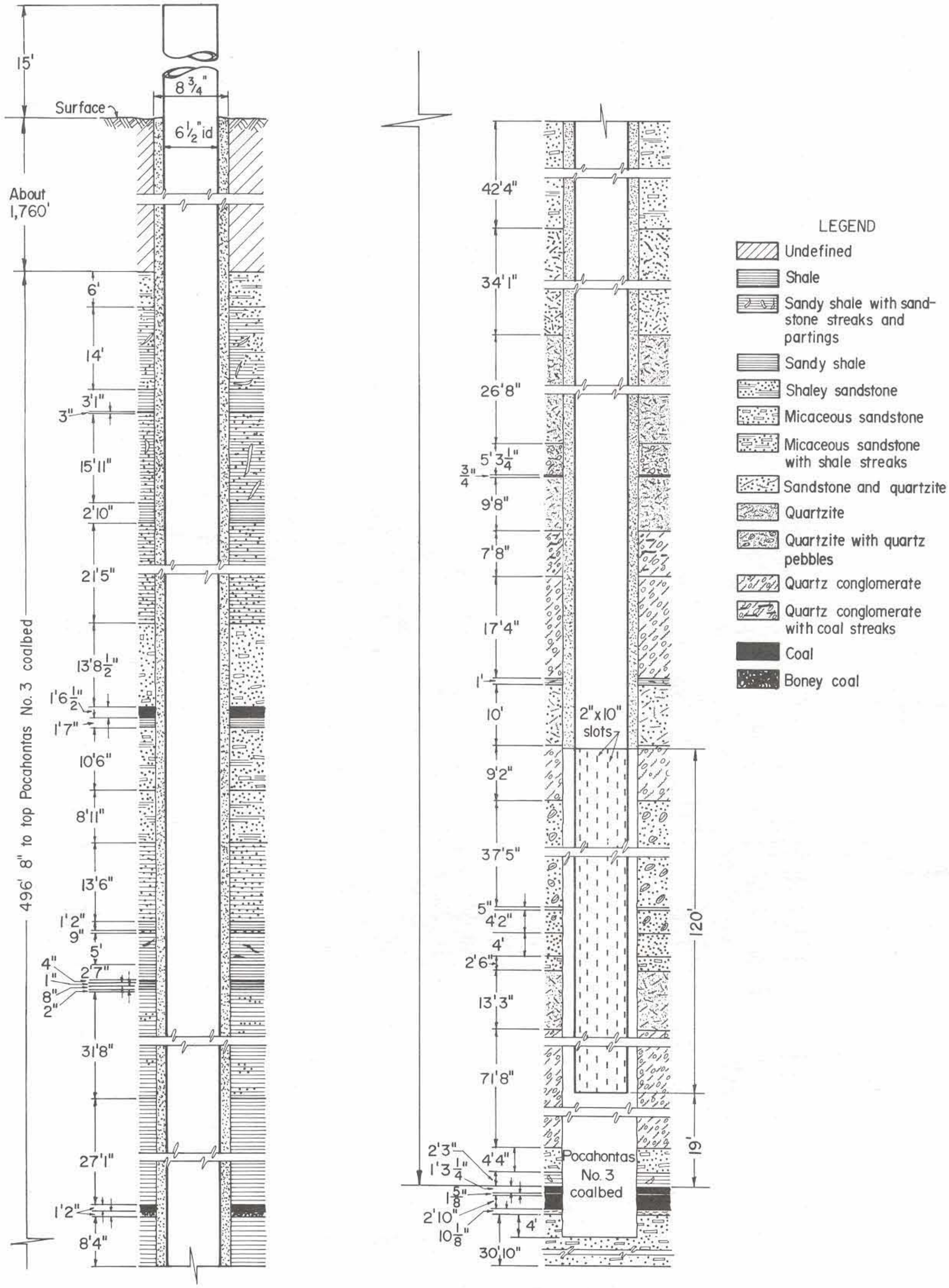

FIGURE 1. - Cross Section of Borehole.

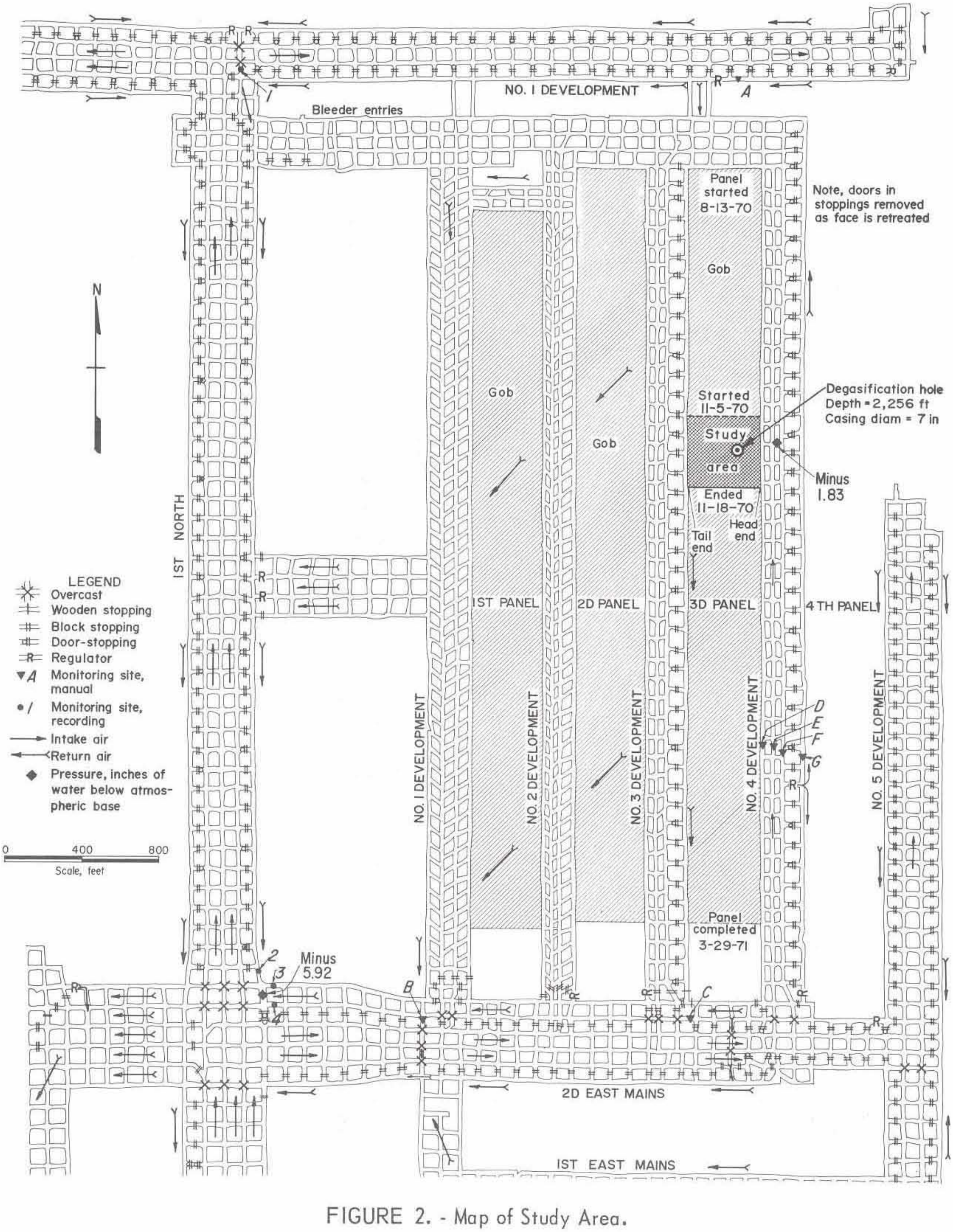

FIGURE 2. - Map of Study Area.

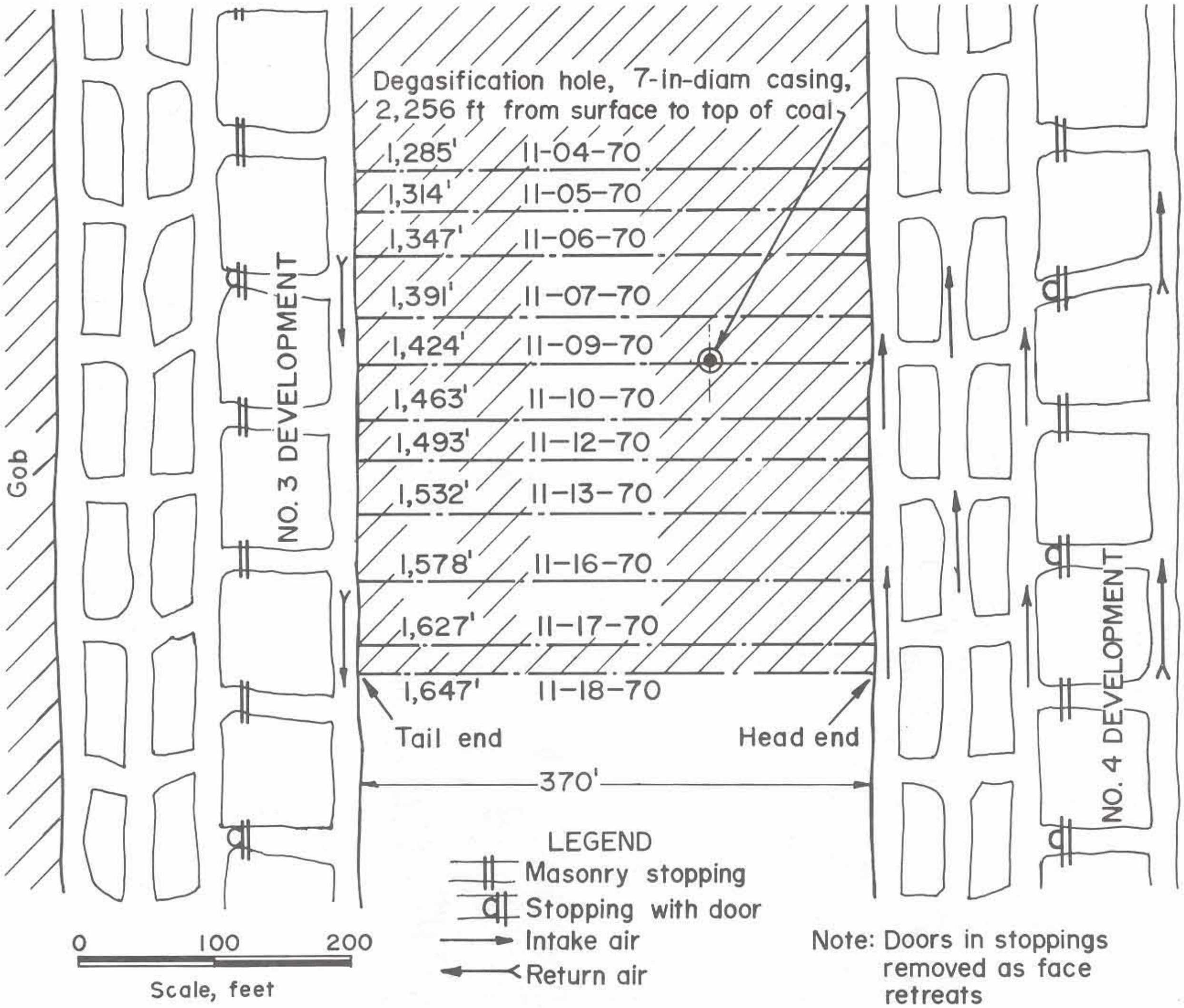

FIGURE 3. - Face Advance During Study.

INSTRUMENTATION

Both hand-held and recording units were used to measure air volumes and methane concentrations in the study area. Hand-held anemometers were used initially to determine the location of the average airspeeds at each of the monitoring sites 1-4 (fig. 2). Subsequent measurements were made by mounting Bureau of Mines sensors[8] at each of these locations. These instruments were used to record methane levels and airspeeds during the study period. Similar measurements were made with commercial hand-held units at sites A-G; remote sensors could not be used at these locations because they interfered with the haulage equipment. Microbarographs were used to record the pressure changes on the surface and at sites 2-4.

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[8]LaScola, J. C., and Joseph Cervik. Development of Recording Methanometers and Recording Anemometers for Use in Underground Coal Mines. BuMines Tech. Prog. Rept. 15, 1969, pp. 9-13.

EXPERIMENTAL PROCEDURE

A preliminary survey of the study area was made by the senior author with representatives of Island Creek Coal Co. This survey was used to inspect the immediate and surrounding areas and to determine airflow patterns and methane levels. These data were then used to determine suitable monitoring sites for the study.

The methane emission study was initiated on November 5, 1970, when the face was about 110 feet inby the borehole (fig. 3). Data were taken for 14 consecutive days from 3:00-11:15 p.m. Airspeed and methane concentrations were determined at 15-minute intervals at sites A through G and recorded continuously at sites 1 through 4. In addition, periodic checks were made with hand-held instruments at each of the latter sites; gas samples were also taken periodically for gas chromatographic analysis to check the accuracy of the gas monitors.

Records were made of the plow operating time and idle time, face advance, and coal production per shift. Coal production normally ceased about 2:55 p.m. on the first shift and resumed about 4:20 p.m. on the second shift. The third shift was used primarily for maintenance, but coal was produced as time permitted.

RESULTS AND DISCUSSION

A summary of data obtained during this study is given in table 1. The methane flow rates from the study area and the borehole were obtained by assuming that the gas passing sites 2-4 and B, and that flowing from the borehole, consisted of gas liberated in the study area as well as that brought into the area through the passageways containing sites 1, A, and C-G. Accordingly, the values given here represent the average flow rates measured on the second shift at sites 2-4, and B, minus those measured at the seven inby sites 1, A, and C-G. The scatter per shift ranged from a low of 22.5 cfm (one standard deviation) after the borehole was intersected on November 9 to a high of 119.0 cfm before it was intersected. Typical results obtained during working and idle days before and after borehole intersection are shown in figure 4. The effect of the borehole is quite evident here. Not only is there a decrease in the methane flow rate found underground, but the short-term fluctuations in flow rate are diminished markedly. Presumably, much of the gas liberated by the overlying strata passes through the borehole and is thus prevented from being forced into the mine as immediate roof and adjacent strata collapse, eliminating much of the pumping action associated with the collapse of roof. Further, there was an associated marked decrease in the maximum measured methane concentration at sites 3 and 4. The maximum value recorded before borehole intersection was 1.93 volume-percent and the maximum value after intersection was 1.39 volume-percent in approximately 100,000 cfm of air; this represents a decrease of slightly over 25 percent, approximately the proportion of methane carried away by the borehole under free-flow (natural convection) conditions. However, an even larger portion of the gas was removed by the use of an exhaust fan (table 1, entries opposite November 17 and 18).

TABLE 1. - Coal production and methane flow rates

Date, November	Face advance, feet	Coal production, tons	Methane flow rate, cfm		
			Study area	Borehole	Total
5	29	1,900	1,600	0	1,600
6	33	2,160	1,970	0	1,970
7	44	2,880	2,040	0	2,040
8	0	0	1,630	0	1,630
9	33	2,160	1,780	0	1,780
10	39	2,560	2,060	0	2,060
11	0	0	1,680	345	2,025
12	30	1,970	1,500	435	1,935
13	39	2,560	1,560	435	1,995
14	0	0	1,330	[1]435	1,765
15	0	0	1,280	[1]395	1,675
16	46	3,010	1,300	435	1,735
17	49	3,210	1,560	[2]460	2,020
18	20	1,310	1,450	[2]520	1,970

[1]Extrapolated values.
[2]With exhaust fan mounted on the borehole.

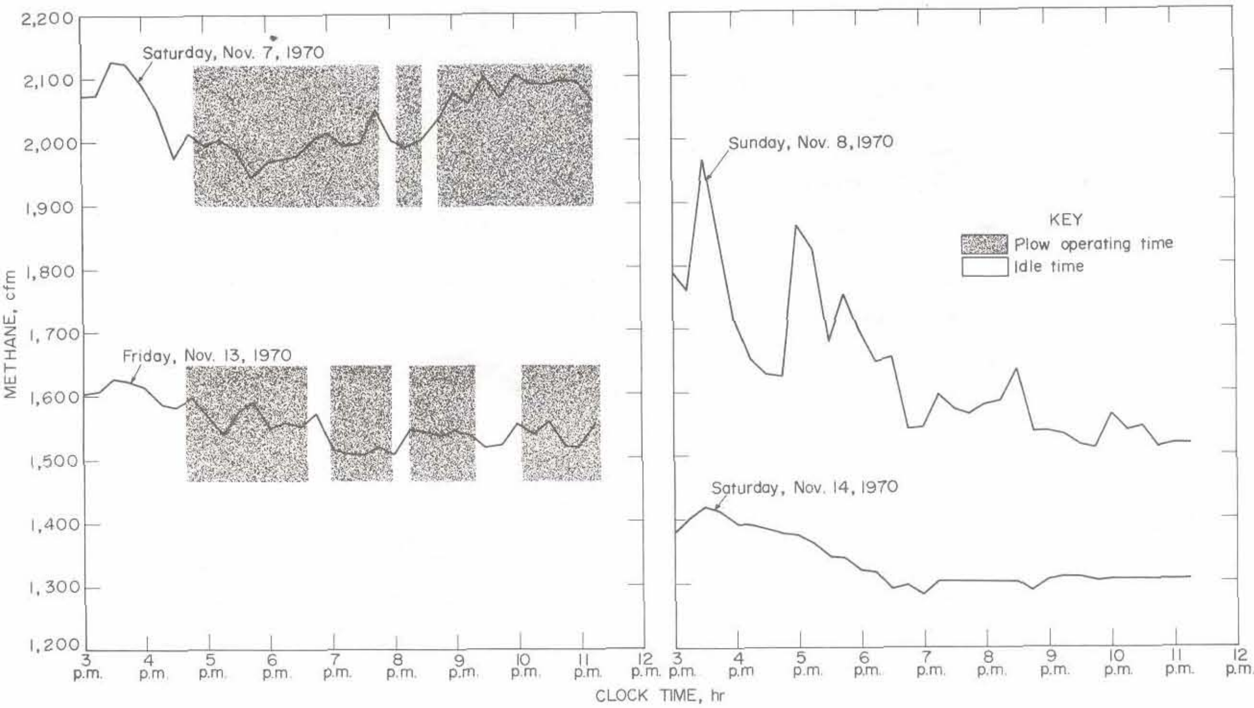

FIGURE 4. - Fluctuations in Methane Flow Before and After Borehole Intersection During Working and Idle Periods.

The methane concentration of the gas discharged by the borehole during the study period ranged from 77 to 100 percent after pure methane started to flow on November 10, about 24 hours after borehole intersection. At this time, the trailing edge of the support units was 27 feet outby the borehole. Because the concentration tended to decrease when the exhaust fan (exhauster) was turned on, it was used only intermittently to keep the methane content above about 30 percent. Because of the excellent flow behavior of the gas passing through the borehole casing, there is some question whether the use of an exhauster was particularly advantageous here unless designed to minimize its effect on the mine ventilation air. Although the exhauster increased the methane flow rate through the borehole from about 25 to 35 percent, it also entrained some air.

Because the borehole diverts methane from the mine returns, the mining rate can be increased with a particular ventilation system without exceeding the legal methane limit. Higher mining rates were actually used here after borehole intersection occurred; the largest production figures encountered during the study period were those obtained on November 16 and 17 (table 1).

Although the cost of a degasification borehole is difficult to assess because of the effect of such a hole on productivity and safety, nevertheless, a few comments are in order. First, the borehole described here initially removed over 800,000 cubic feet of high-purity methane per day under free-flow conditions; over 179 million cubic feet of gas was removed during the period November 1970 through January 1972 (table 2). If we assume a finished cost of approximately \$20 per foot for this borehole, this is sufficient gas to pay for such an installation at current wellhead natural gas prices. Further, the savings in ventilation air (initially 40 million cubic feet per day if we assume it is being discharged at maximum contamination level) and the increases in production rates and safety would be additional bonuses. For example, using the equation[9] air hp $= \frac{Hq}{6,350}$, where H is the pressure drop in inches water gage, and q is the airflow rate in cubic feet per minute, the power required to ventilate the study area and adjacent gobs (fig. 2) is as follows:

$$\text{Air hp} = \frac{(5.92 - 1.83) \times 10^5}{6,350} = 64.4.$$

A decrease of 25 percent in airflow rate causes the pressure drop to decrease by about 44 percent. The corresponding decrease in power is 58 percent, so that 37.2 horsepower is saved; at a modest rate of \$0.01 per kilowatt-hour, this represents a savings in power costs alone of approximately \$200 per month.

[9]Kingery, D. S. Introduction to Mine Ventilation Principles and Practices. BuMines Bull. 589, 1960, p. 27.

TABLE 2. - Monthly and cumulative surface borehole production

Month	Days produced	Methane, percent		Methane, Mcf[1]	
		Average	Range	Monthly	Cumulative
1970					
November.................	20	98	[2]77-100	16,403	16,403
December.................	31	100	100-100	27,967	44,370
1971					
January..................	31	93.8	84-100	24,311	68,681
February.................	28	78.7	72- 83	14,805	83,486
March....................	31	72.0	70- 78	13,684	97,170
April....................	30	69.4	68- 70	12,223	109,393
May......................	31	59.7	56- 65	11,377	120,770
June.....................	30	57.4	53- 60	9,457	130,227
July.....................	31	54.2	53- 56	9,251	139,478
August...................	31	52.1	50- 55	8,462	147,940
September................	30	48.8	47- 53	7,504	155,444
October..................	31	46.4	45- 48	7,111	162,555
November.................	30	44.6	44- 46	7,151	169,706
December.................	31	44.0	43- 45	6,019	175,725
1972					
January..................	25	55.3	37- 97	3,531	179,256

[1]Under free-flow conditions.
[2]Thirty to 100 percent with exhaust fan in use.

CONCLUSIONS

A slotted pipe placed in a vertical surface borehole is usable in longwall gobs at depths in excess of 2,200 feet in the Pocahontas No. 3 coalbed. The gas removed by such an installation may be adequate to offset the cost of the borehole and placement of the pipe. In addition, further savings may be realized in the use of higher mining rates and decreased ventilation requirements.

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