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Methane Control Program

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METHANE EMISSION RATE STUDIES IN A NORTHERN WEST VIRGINIA MINE

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by

Stephen Krickovic,[1] Charles Findlay,[2] and W. M. Merritts[3]

ABSTRACT

Methane emission rates were studied in a Pittsburgh coalbed mine in northern West Virginia. A fullface boring-type continuous miner, equipped with a methane monitor, was used in the development of a set of eight main headings, one side of which was near old workings; the other side abutted virgin coal. Two air splits ventilated the section. Air volumes and methane percentages were recorded, and time studies of the miner were made during five consecutive operating days, during which a complete cycle of mining the headings and one line of related breakthroughs was accomplished.

Methane emission rates increased significantly as mining progressed from the side near old mine workings toward the virgin area, and generally increased with coal extraction.

Mining in the heading immediately adjacent to virgin coal was interrupted quite frequently, owing to excessive methane concentrations at the face, despite adequate air volumes and acceptable methane concentrations in the immediate return airway.

INTRODUCTION

Methane is contained under pressure within the micropores, joints, and fractures of gassy coalbeds. Breaking down the coal from solid faces tends to steepen the pressure gradient in the coalbed and exposes considerable area in the mined coal and in the newly exposed solid coal surfaces,[4] all of which increases the emission of methane. This condition is particularly severe with the fullface boring-type continuous miner because coal is usually mined in one

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[4]Cervik, Joseph. An Investigation of the Behavior and Control of Methane Gas. Min. Cong. J., v. 53, July 1967, pp. 52-57.

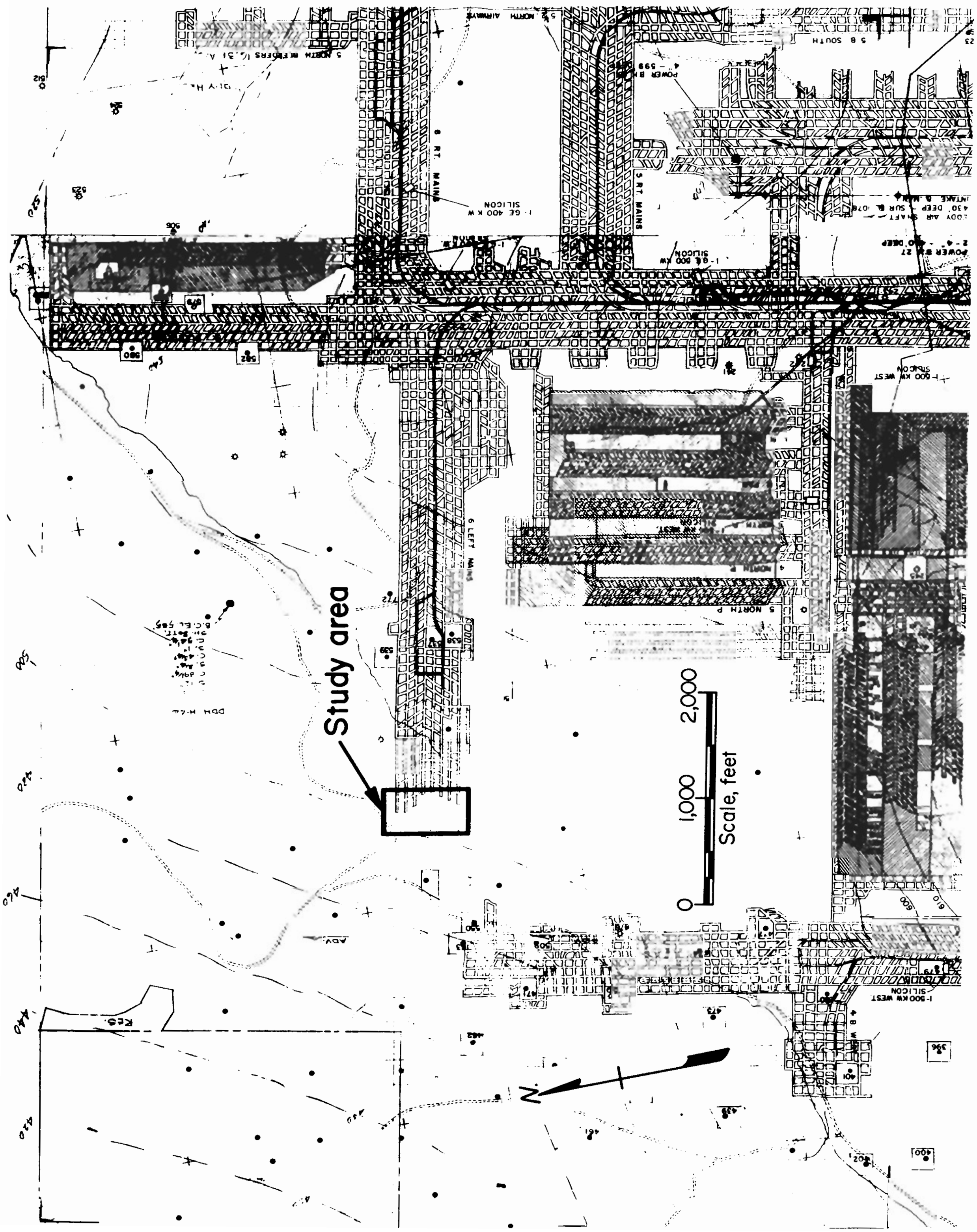

FIGURE 1. - Location of Study Area.

workplace during an entire shift, and because restricted space around such miners makes it practically impossible to ventilate the face in the development of very gassy mines with conventional line brattice. In some cases, it is difficult to obtain safe dilution of methane even with an auxiliary fan or fans and reinforced tubing.

The objective of the present Bureau of Mines study was to determine the methane emission rates during operating and idle periods of a boring continuous miner during the development of a set of eight headings. Studies of this type are an essential part of the Bureau's comprehensive methane control research program.[5]

ACKNOWLEDGMENTS

The cooperation of the mine management is greatly appreciated.

DESCRIPTION OF STUDY AREA

The study area consisted of a set of eight headings with active and mined-out workings on one side, and with virgin coal on the opposite side. Figure 1 shows the location of the study area in relation to a portion of the mine.

MINING METHOD AND EQUIPMENT

The set of eight headings and related breakthroughs were developed on 100-foot centers. Figure 2 shows the location of the faces and monitoring

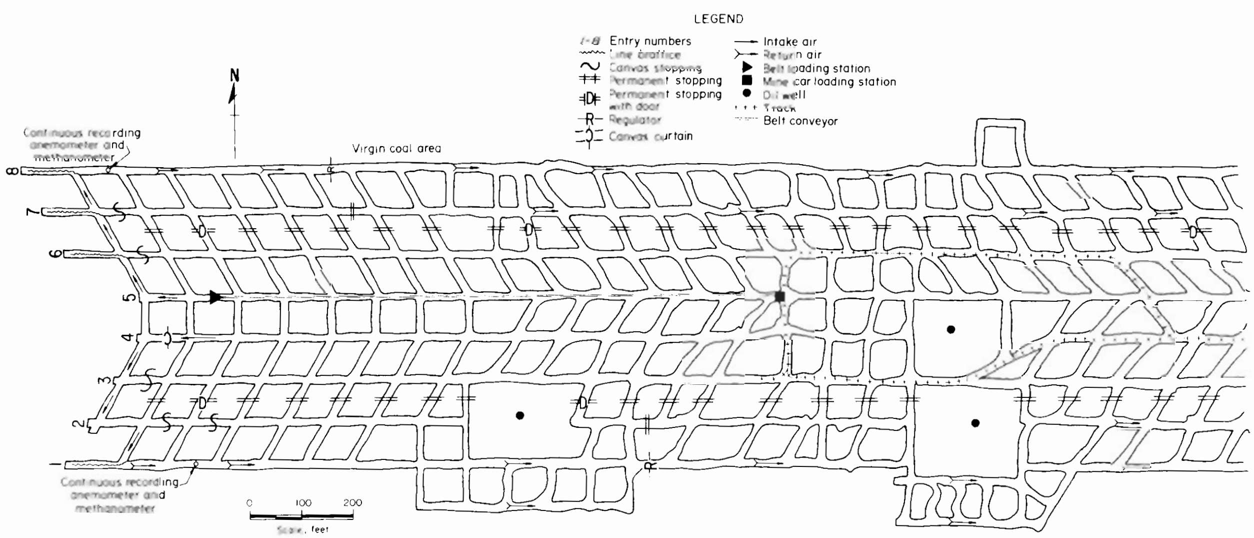

FIGURE 2. - Location of Faces and Monitoring Instruments and Arrangement of Ventilation and Face Haulage at Start of Study.

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[5] Cervik, Joseph. Behavior of Coal-Gas Reservoirs. BuMines Tech. Prog. Rept. 10, April 1969, 10 pp.

Deul, Maurice. Methane Drainage From Coalbeds: A Program of Applied Research. Proc. 60th Ann. Meeting of the Rocky Mountain Coal Min. Inst., Estes Park, Colo., June 28-July 1, 1964, pp. 54-60.

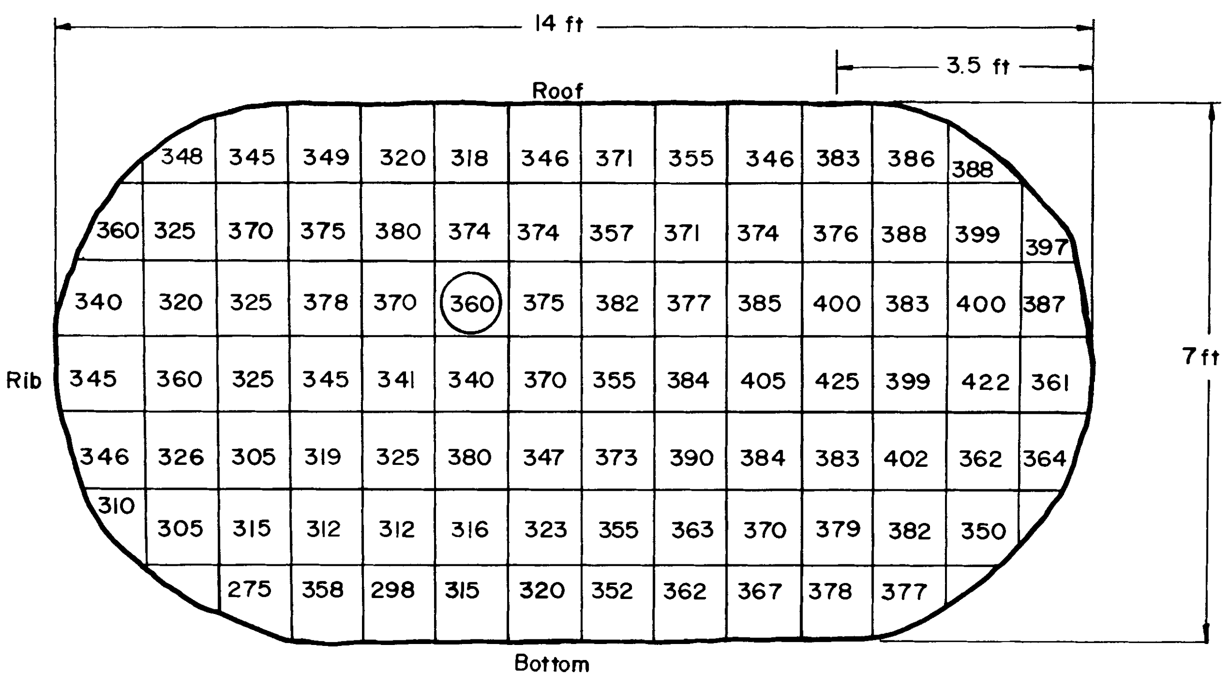
Perkins, J. H., and Joseph Cervik. Sorption Investigations of Methane on Coal. BuMines Tech. Prog. Rept. 14, May 1969, 6 pp.

instruments at the beginning of the study. A continuous boring-type fullface miner, equipped with a methane monitor located 5 feet back of the rotors, was used to drive the headings 14 feet wide (between semicircle ribs at center) and 7 feet high, with 6 to 10 inches of roof coal left in place for protection. Coal was discharged onto the floor for subsequent loading with a conventional loader into shuttle cars, which trammed the coal to a conveyor-belt loading station.

VENTILATION

As shown in figure 2, the four middle headings served as air intakes to the last complete line of breakthroughs where, by canvas stoppings and a check, air was confined into heading 5 for splitting into left and right air splits, both of which were regulated.

During mining, the faces of the headings and breakthroughs were ventilated by a portable 10,000-cubic-foot-per-minute, free-flow capacity, auxiliary fan equipped with 16-inch-diameter reinforced tubing. The fan was relocated progressively for each working place, to prevent recirculation of air and interference with haulage; the end of tubing always was maintained as far ahead of the operator as practicable and safe. Upon completion of mining, the miner was trammed out of the place, line brattice was installed immediately to maintain ventilation, and the auxiliary fan was moved to the proper location for mining at the next working face.

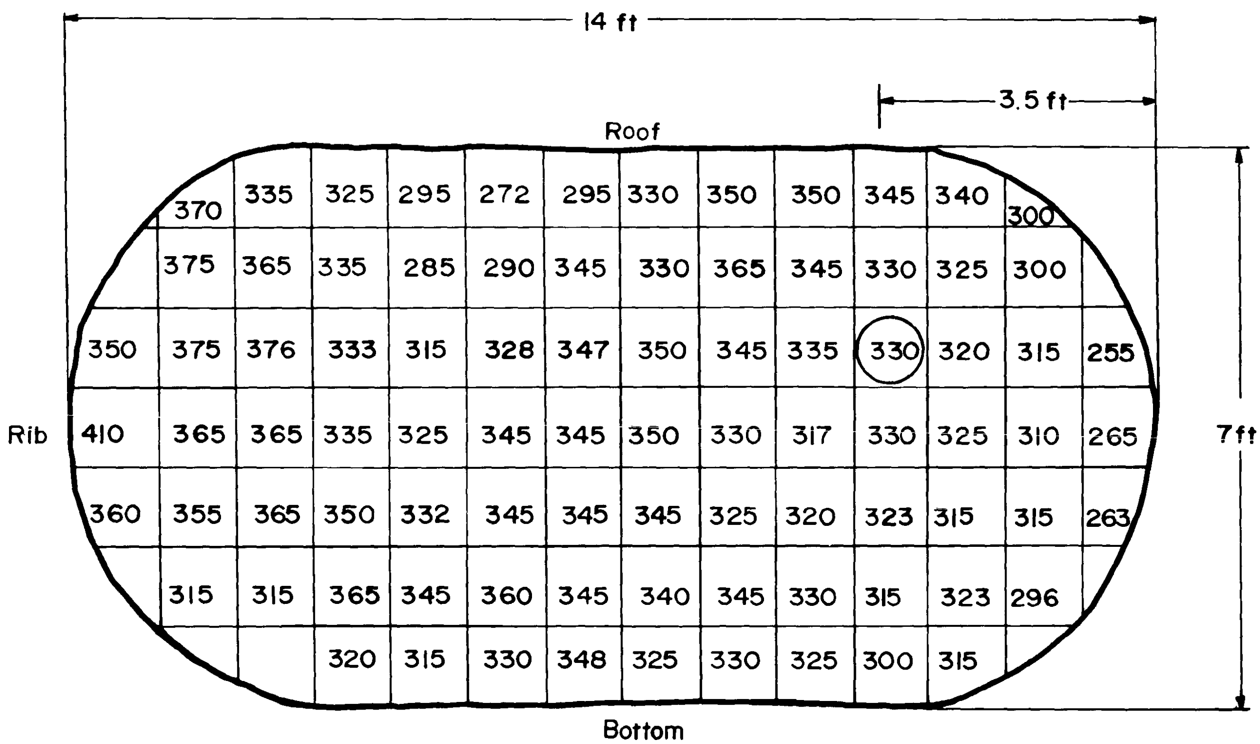


Note:

Cross-sectional area = 88 sq ft

Average air velocity = 359 ft/min

FIGURE 3. - Air Velocities in Heading 1 Showing Location of Average Air Velocity (Circled).



Note:

Cross-sectional area = 88 sq ft
Average air velocity = 331 ft/min

FIGURE 4. - Air Velocities in Heading 8 Showing Location of Average Air Velocity (Circled).

MONITORING

Reconnaissance

After the study area was selected, Bureau mining engineers examined the area with the company's representative to note details of the arrangement of temporary stoppings, line brattice, canvas checks, auxiliary fan, and haulage routes.

Location of Instruments

To simplify monitoring, the return air of each split was confined to one heading instead of the two normally used. Locations for instrumentation in these headings were selected to obtain reasonably uniform air velocities in the cross-sectional areas. A grid system of vertical and horizontal strings to form 1-foot squares was set up in each of the two headings. Air velocities were then measured with a handheld vane-type anemometer in each square, and the square in which the air velocity most closely approached the average for the total cross-sectional area was determined. Figures 3 and 4 show the air velocities in the 1-foot squares and the average air velocity in headings 1 and 8, respectively.

Instrumentation

The sensing heads of the continuously recording methanometer and anemometer developed by the Bureau[6] were installed in the average velocity square in each cross-sectional area in headings 1 and 8. Due to interference from haulage equipment, handheld anemometers and methanometers were used to measure air velocities and methane concentrations in the intake air heading just outby the point where the air was split.

The methane monitoring team consisted of a mining engineer and an engineering aid on each shift. The engineer studied the continuous miner to record the operating and idle times, feet of mining advance, and production per shift, to secure data on all mining, ventilation, and haulage equipment, and to observe any unusual conditions relating to the study.

The engineering aide was responsible for the adjustment and replacement of instruments and the changing of batteries as required. He also took periodic check measurements of the air velocities and the methane concentration near the "average squares" with handheld instruments to ascertain the accuracy of the recording instruments. These check measurements and the times taken were recorded on the respective instrument charts.

RESULTS

Figure 5 shows the sequence of cuts made with the continuous miner by dates and shift numbers. The first shift is 8 a.m. to 4 p.m., the second is 4 p.m. to midnight, and the third is midnight to 8 a.m.

Table 1 summarizes the results of the study. For example, the first table entry shows that on shift 3 (midnight to 8 a.m.) on April 14, 1969, the continuous miner extracted coal in the breakthrough between headings 2 and 1 and in heading 1, worked 120 minutes and was idle 360 minutes, advanced 74 feet, and produced 258 tons of coal. Sixty-eight cubic feet of methane per minute flowed into the left split of air (35,600 cfm), resulting in a methane concentration of 0.19 percent; 112 cubic feet of methane per minute flowed into the right split of air (28,700 cfm), resulting in a methane concentration of 0.40 percent; the total methane flowing into the section inby the instruments was 180 cubic feet per minute, resulting in 0.28 percent concentration of methane in 64,300 cubic feet of air per minute flowing through the section.

During the 13 operating shifts, the continuous miner was operated 46 percent of the available time, advanced an average of 98 feet per shift, and produced an average of 339 tons of coal per shift.

[6] LaScola, J. C., and Joseph Cervik. Development of Recording Methanometers and Recording Anemometers for Use in Underground Coal Mines. BuMines Tech. Prog. Rept. 15, May 1969, pp. 9-14.

TABLE 1. - Summary of results

Date (1969)	Shift No.	Working face	Minutes		Face advance, ft	Coal production, tons	Left split			Right split			Total		
							Methane		Air, cfm	Methane		Air, cfm	Methane		Air, cfm
			Working	Idle			Percent	Cfm		Percent	Cfm		Percent	Cfm	
Apr. 14.....	3	2-1,1	120	360	74	258	0.19	68	35,600	0.40	112	28,700	0.28	180	64,300
	1	1,2	226	254	142	494	.23	81	35,600	.41	117	28,700	.31	198	64,300
	2	2,3,4	180	300	133	463	.24	81	34,000	.40	113	28,300	.31	194	62,300
Apr. 15.....	3	4	120	360	50	174	.23	75	32,700	.40	114	27,800	.31	189	60,500
	1	4,5	153	327	120	418	.24	77	32,200	.39	107	27,500	.31	184	59,700
	2	5-4,5-6	175	305	83	289	.28	88	32,000	.40	111	28,000	.33	199	60,000
Apr. 16.....	3	-	-	-	-	-	.23	74	32,200	.37	114	31,300	.30	188	63,500
	1	-	-	-	-	-	.23	74	32,200	.37	114	31,300	.30	188	63,500
	2	5-4,5-6,6-7	130	350	118	410	.23	74	32,000	.40	120	30,000	.32	194	62,000
Apr. 17.....	3	6-7,7-8	225	255	42	146	.23	74	32,000	.43	130	30,000	.33	204	62,000
	1	7-8,8	240	240	63	219	.24	71	29,500	.51	151	29,500	.38	223	59,000
	2	8	210	270	70	244	.23	63	27,300	.52	161	31,000	.38	224	58,300
Apr. 18.....	3	7,6	165	315	135	470	.23	63	27,400	.42	137	32,200	.34	200	59,600
	1	6,4-3	245	235	80	278	.20	63	32,000	.40	130	32,000	.30	193	64,000
	2	3-2,2-1,4-3	240	240	158	550	.30	100	33,400	.40	129	32,200	.35	229	65,600
Average......................			187	293	98	339	.24	75	32,000	.41	124	29,900	.32	199	61,900

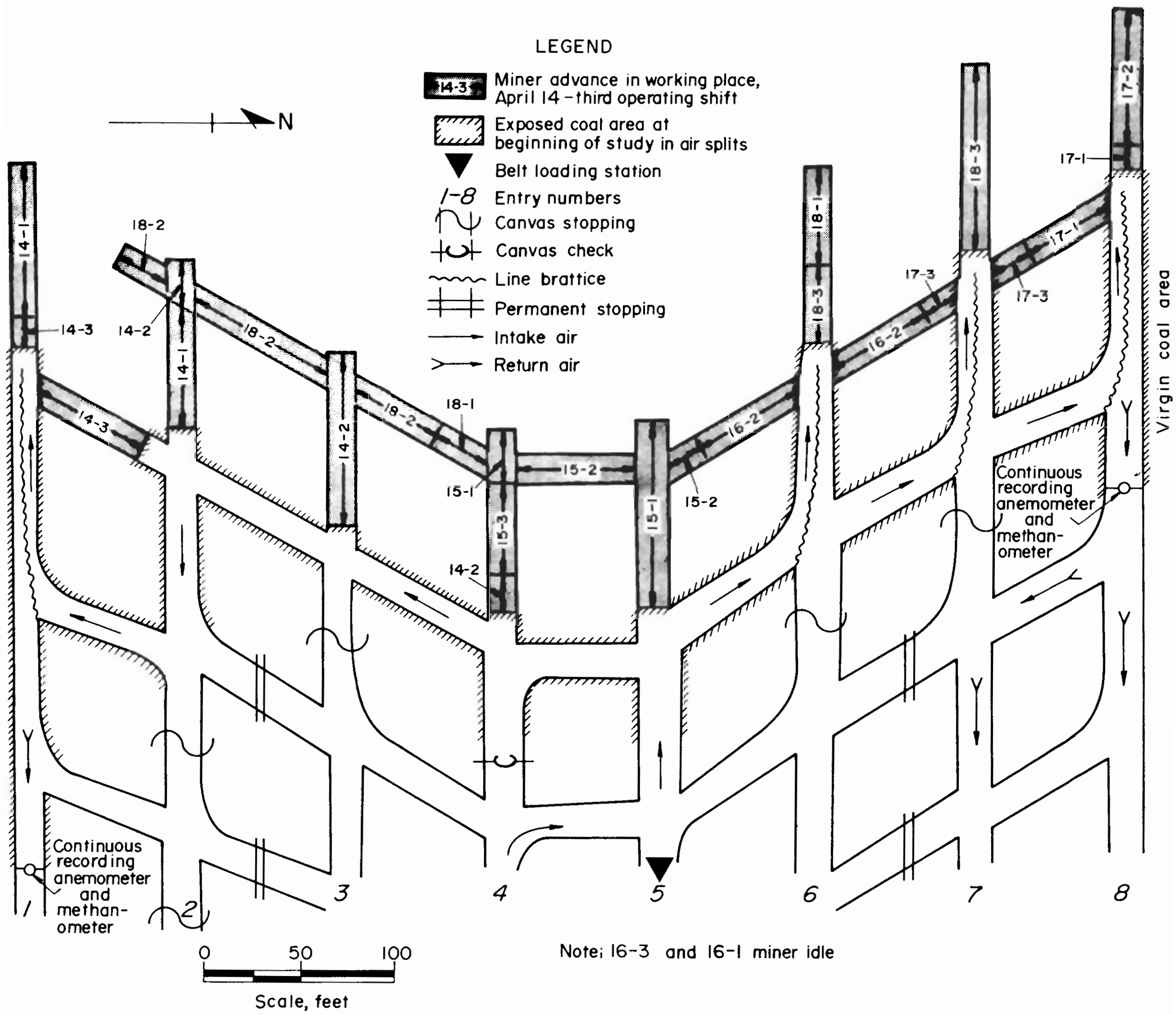


FIGURE 5. - Sequence of Mining.

The effect of the proximity of old workings on methane emission rate is clearly shown by the fact that during the two idle shifts on April 16, 74 cubic feet per minute flowed into the left split of air, while 114 cubic feet per minute flowed into the right split. This is further substantiated by the fact that during the study period, 541,000 cubic feet of methane flowed into the left air split during the production of 2,646 tons of coal, while 893,000 cubic feet of methane flowed into the right split during the production of 1,767 tons of coal. Thus, the methane emission rate was 204 cubic feet per ton of coal mined in the left split compared with 505 cubic feet per ton of coal mined in the right split.

The effect of coal production on methane emission rate could not clearly be shown. While periods of high coal production were generally accompanied by increased gas emissions, the fact that different amounts of coal were not mined under similar circumstances precluded a clear assessment of this factor.

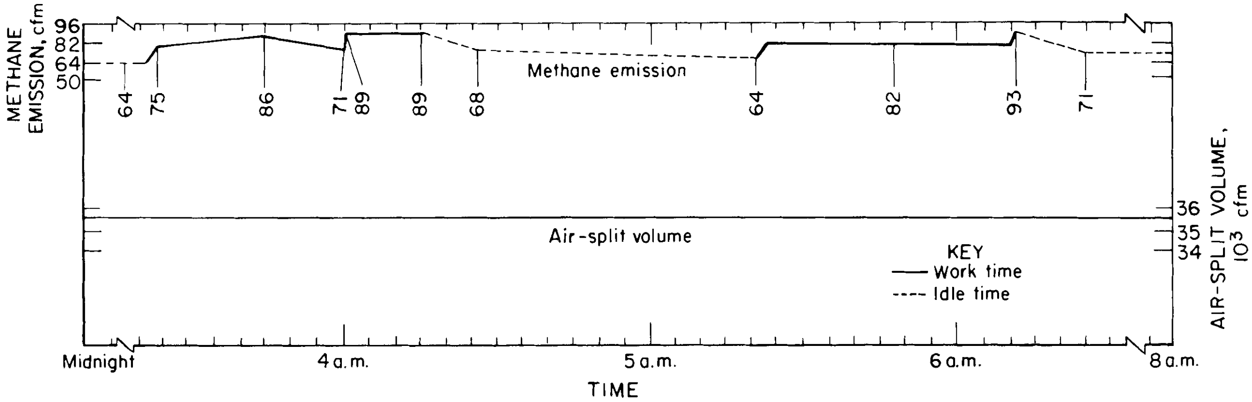


FIGURE 6. - Methane Emission Rates and Air Volumes in the Left Air Split on Shift 3, April 14, 1969.

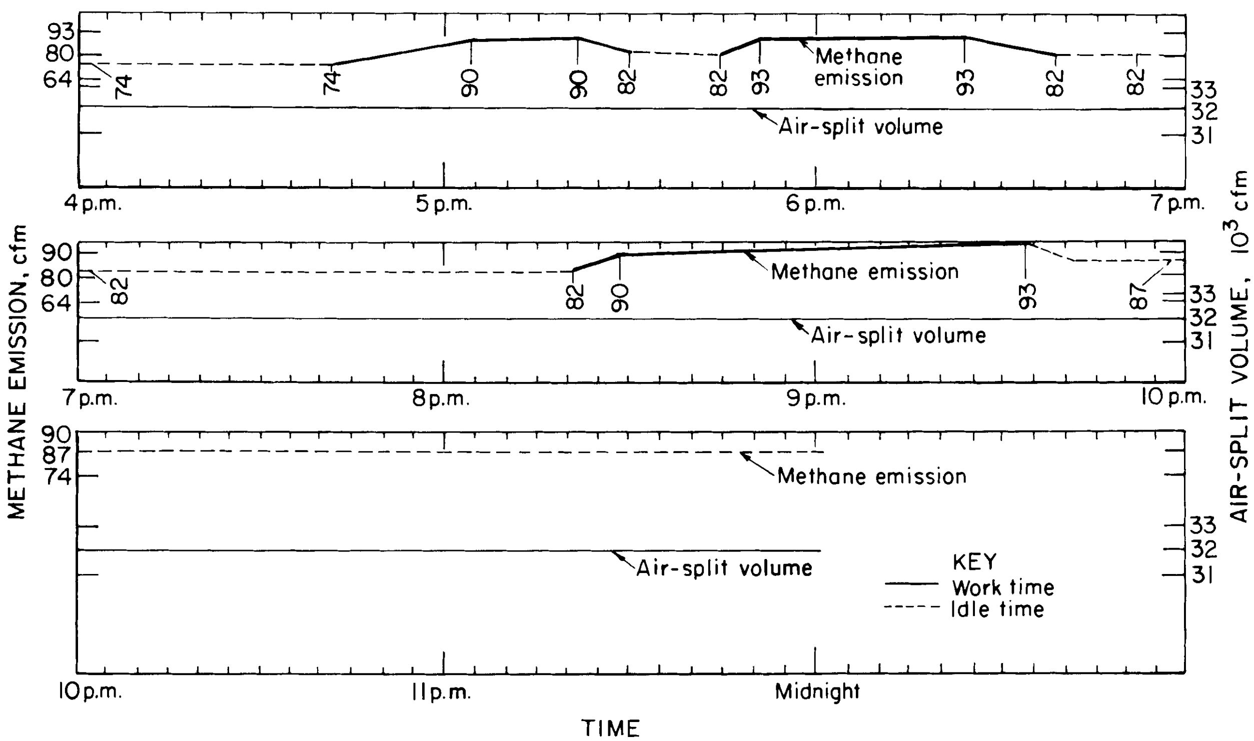


FIGURE 7. - Methane Emission Rates and Air Volumes in the Left Air Split on Shift 2, April 15, 1969.

Table 1 shows weighted average methane emissions over an 8-hour shift. Figures 6, 7, and 8 show fluctuations in methane emission during a shift as a function of production.

Figure 6 shows the methane emitted during the third shift on April 14. Mining was in the breakthrough between headings 1 and 2 and in heading 1. Although the weighted shift average was 68 cubic feet per minute, periods of coal extraction were accompanied by sharp increases in methane emission

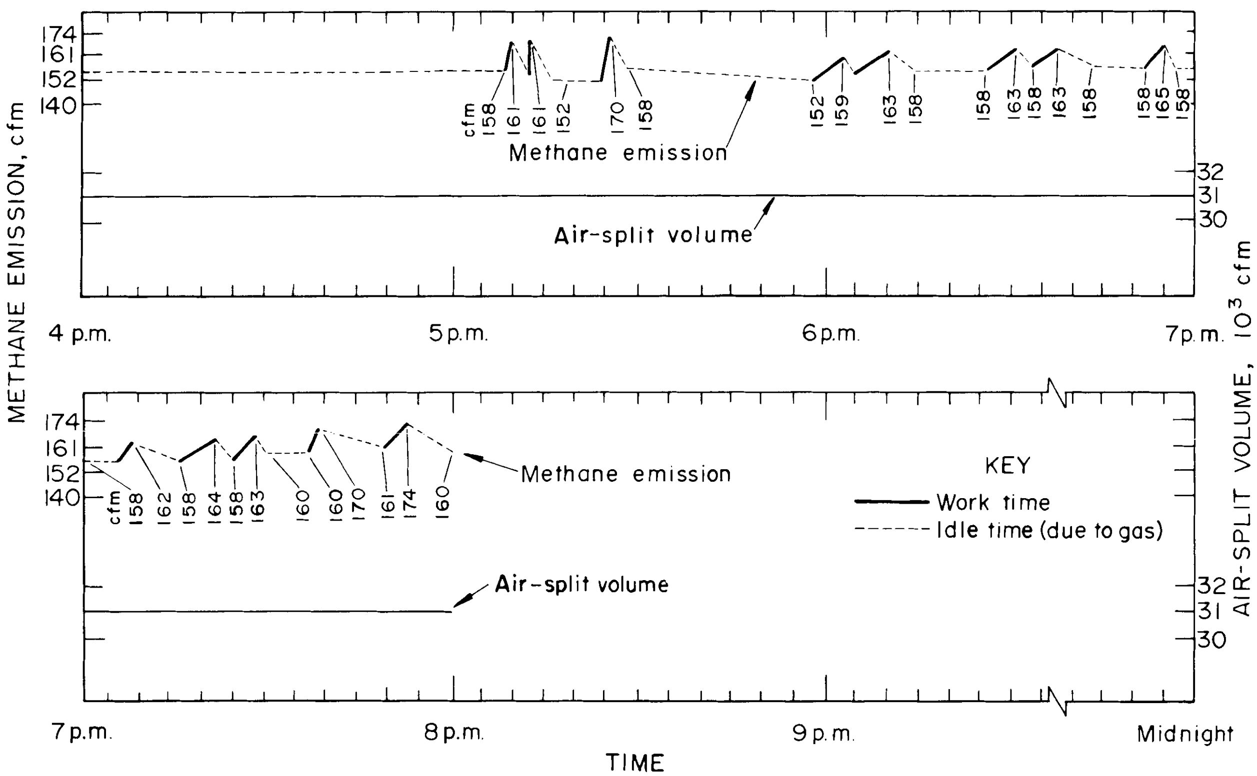


FIGURE 8. - Methane Emission Rates and Air Volumes in the Right Air Split on Shift 2, April 17, 1969.

followed by less sharply declining emission rates following cessation of extraction.

Figure 7 shows the fluctuation in methane emission with production while mining in the breakthroughs between headings 4 and 5 and between headings 5 and 6 on the second shift, April 15. As in figure 6, increased methane emission accompanied coal production.

Figure 8 shows methane fluctuations during mining in heading 8 on the second shift, April 17. This heading abuts virgin coal, and it was anticipated that maximum methane emissions would be encountered in this heading. The methane emitted during the shift ranged from 152 (0.50 percent) to 174 cubic feet per minute (0.56 percent). The methane emission rate was responsive to mining, increasing rapidly during mining and decreasing only slightly less rapidly immediately following the cessation of mining. Usually after mining had progressed for less than 10 minutes, the concentration of methane at the face exceeded safe limits and caused the methane monitor mounted on the continuous miner to cut off the power so that mining ceased. Power was restored and mining resumed after the concentration of methane reached a safe level. Thus, coal was mined for only 20 percent of that shift, and three-fourths of the idle time was caused by excessive methane concentrations at the face.

While figures 6, 7, and 8 are generally similar, the amount of methane produced during idle periods and during production periods increased as mining progressed from the left headings near old workings to the right headings near virgin coal.

CONCLUSIONS

While all the causes of variations in methane emission rates are not known, some general conclusions may be drawn from this study:

1. The rate at which methane flowed into the section ranged from 180 to 229 cubic feet per minute and averaged 199 cubic feet per minute over the study period.

2. Analyses of average emission rates during periods of production and periods of idleness showed that coal production caused a maximum increase in methane emission of 54 cubic feet per minute.

3. The effect of mining adjacent to virgin coal compared with mining adjacent to old workings (heading 8 versus headings 1 and 2) is evident when 244 tons of coal produced in heading 8 during shift 17-2 resulted in the emission of 32 cubic feet per minute of methane more than when 494 tons of coal was produced in headings 1 and 2 during shift 14-1; total mining time during both shifts was approximately the same.

4. The fact that the methane monitor, mounted 5 feet outby the cutters on the continuous miner, frequently sensed excessively high methane concentrations, while the air split of 31,000 cubic feet per minute at the monitoring station contained only 161 cubic feet of methane per minute (0.52 percent), shows the difficulty of ventilating a boring-type continuous miner to control methane.

5. This study shows that it is possible to predict the magnitude of the methane problem that might be encountered during future development and that some qualitative inferences can be made as to the effect of time on the lessening of methane emission rates.