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Methane Emission Rate Studies in a Central Pennsylvania Mine

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METHANE EMISSION RATE STUDIES IN A CENTRAL PENNSYLVANIA MINE

by

Stephen Krickovic[1] and Charles Findlay[2]

ABSTRACT

A methane emission rate study was conducted in 1969 on a longwall section of a Lower Kittanning coalbed mine in central Pennsylvania. The longwall face was mined with a drum shearer between developed headings on the head end and headings on the tail end that were driven with a ripper-type continuous miner as needed. The study was conducted over 22 consecutive shifts (7-1/3 days).

The average methane emission rate from the Lower Kittanning coalbed during mining at the face and developing the headings at the tail end of the face was 34 cfm. Caving of the gassy overlying strata as the result of mining at the face increased the methane emission to rates ranging from 702 to 1,049 cfm.

INTRODUCTION

Methane is contained under pressure within the micropores, joints, and fractures of gassy coalbeds and may be present in adjacent strata at various distances above and below the coalbed.[3] Thus, methane may enter the mine from the coalbed, from the strata overlying the coalbed as a result of caving, and from the strata underlying the coalbed as a result of floor heaving.

In mining systems where roof caving is part of the mining cycle, a properly designed and maintained bleeder system usually is satisfactory to remove excess methane to reduce the concentration to a safe working level. The gob area created by the cave usually is small, and a proper air differential pressure can be applied across the area to bleed off the excess gas to a suitable extent. However, in longwall mining, the overlying strata are caved across the entire face. Overlying gassy strata, when caved, emit a flow of methane which the usual type of bleeder system cannot remove entirely.

The purpose of this Bureau of Mines study was to determine the characteristics of methane emissions during coal extraction by a longwall mining system.

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[1] Supervisory mining engineer.
[2] Mining engineer.
[3] Cervik, Joseph. An Investigation of the Behavior and Control of Methane Gas. Min. Cong. J., v. 53, July 1967, pp. 52-57.

Studies of this type are an essential part of the Bureau's comprehensive methane control program.[4]

ACKNOWLEDGMENTS

The cooperation of the mine management is greatly appreciated.

DESCRIPTION OF THE STUDY AREA

Figure 1 shows the location of the longwall study area in the Lower Kittanning coalbed. The longwall block being mined was 585 feet wide and 3,000 feet long, and averaged 54 inches thick. At the start of the study, 1,200 feet of the block had been mined out.

An area on the easterly side of the longwall block was mined out with a ripper-type continuous miner. A 50-foot barrier was left between this area and the three entries at the head end of the longwall face.

MINING METHOD AND EQUIPMENT

As shown in figure 2, three headings (3 Right) and related breakthroughs were developed on 100-foot centers the entire length of the longwall panel on the head end, and four headings (4 Left) and related breakthroughs were being developed with a ripper-type continuous miner keeping ahead of the face as needed on the tail end. Three of the 4 Left headings were driven on 60-foot centers; the one farthest from the longwall panel was driven on a 90-foot center.

The coal was mined with a 15-foot-long, bidirectional shearer equipped with a single 48-inch-diam, double-spiral vane drum which made a 27-inch-wide shear. Approximately 200 tons of coal was produced during one pass of the shearer across the face. The vertical position of the drum could be adjusted to compensate for undulations in the coalbed.

Roof was supported with self-advancing hydraulic units, each equipped with four, 42-ton-capacity, hydraulically operated steel props mounted on a rigid base and topped with shielded-type steel beams. Two units were connected to be operated jointly as an eight-prop chock. These chocks were spaced on 42-inch centers across the entire length of the face.

An armored flexible face conveyor discharged the extracted coal into a short chain conveyor hopper which, in turn, discharged onto a 36-inch belt conveyor.

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[4] 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 Mt. 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.

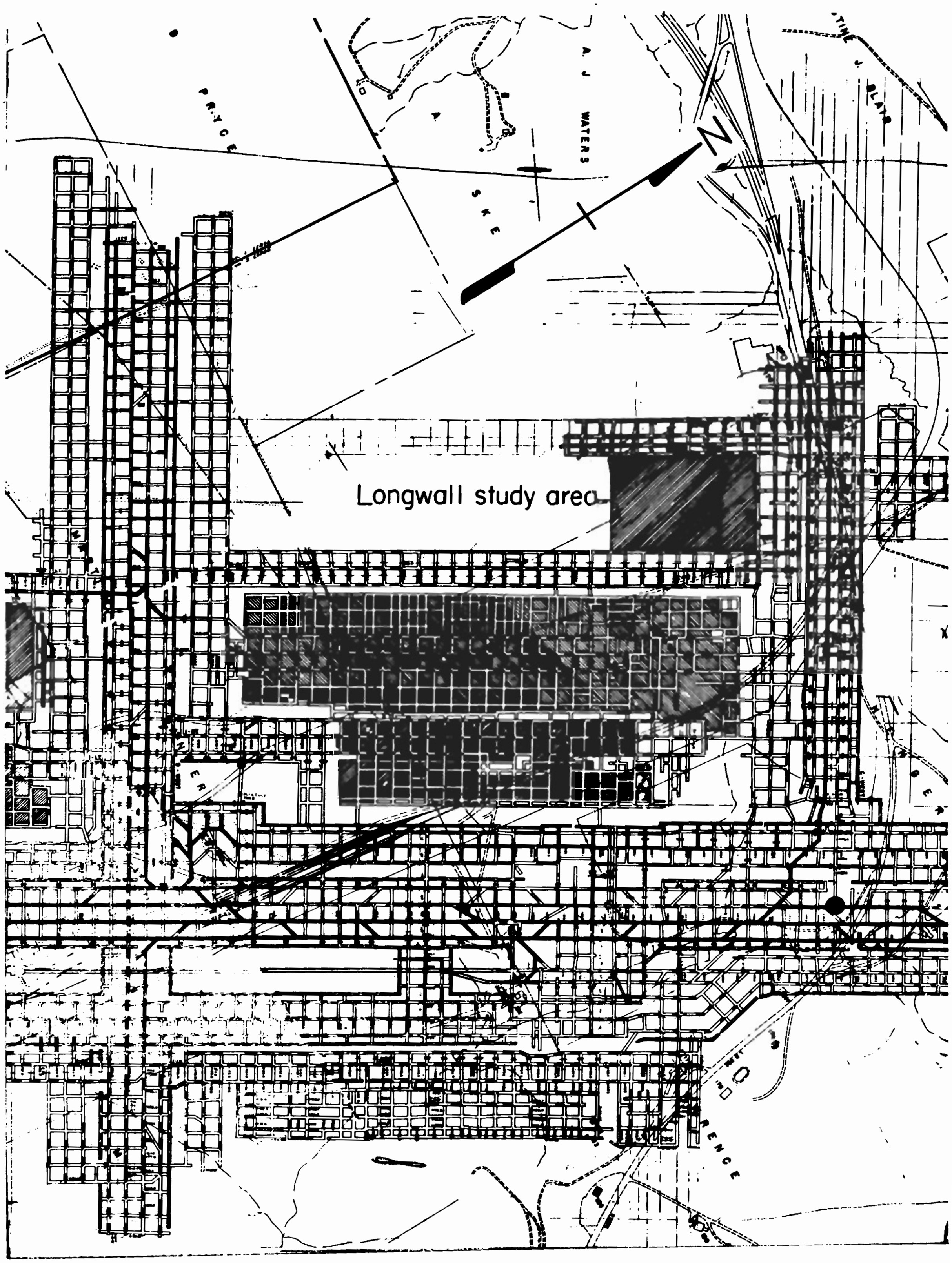


FIGURE 1. - Location of the Study Area.

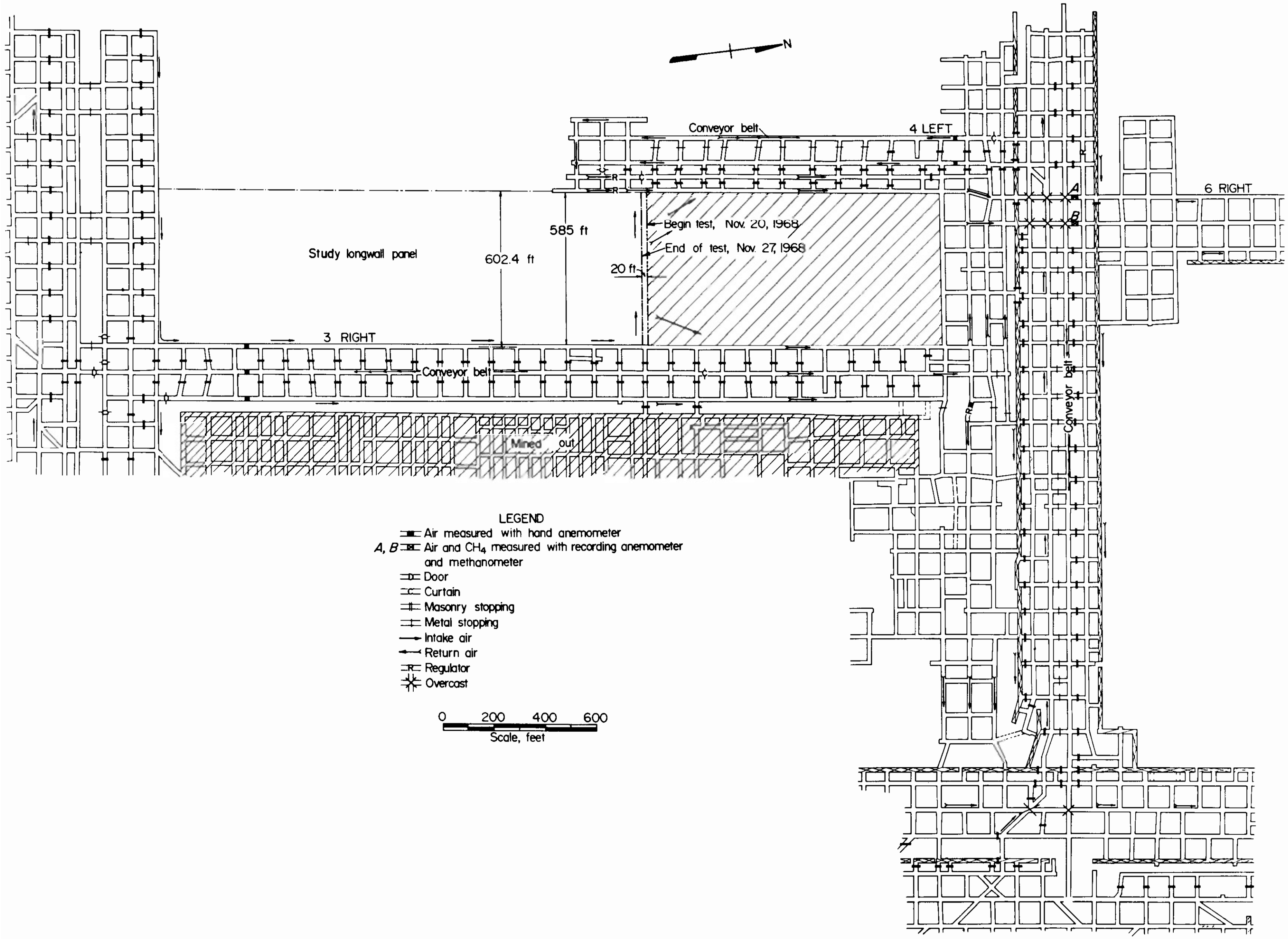


FIGURE 2. - Location of Face and Monitoring Instruments and Ventilation Arrangement During Study.

VENTILATION

As shown in figure 2, the study area was ventilated by two air splits--one for the 4 Left and one for the 3 Right headings. All 3 Right headings on the head end of the longwall served as intake airways, with a belt conveyor for coal transport in the center heading. Approximately 20,000 cfm of air in the easterly heading of 3 Right adjacent to the mined-out area could not be traced exactly. It ultimately entered the main return airways at the back of the longwall area (north end).

Two of the 4 Left headings were used for intake air, with a belt conveyor in one, and the next adjacent heading served as the positive return for the development air split and for the longwall face air reaching the tailpiece. The intake air volume was 20,000 cfm in the 4 Left headings, and was reduced to 16,000 cfm near the tailpiece of the longwall conveyor.

Of the 30,000 cfm of air that entered the longwall face area at the head end from 3 Right, approximately 7,000 cfm was measured at the tail end.

Airflow was hardly perceptible in the breakthroughs at the back end (north) of the longwall panel, and bleeding occurred mostly by diffusion to the more permeable caved headings immediately adjacent to the caved longwall area on both sides. Most of the longwall face air found its way to the same two caved headings.

MONITORING

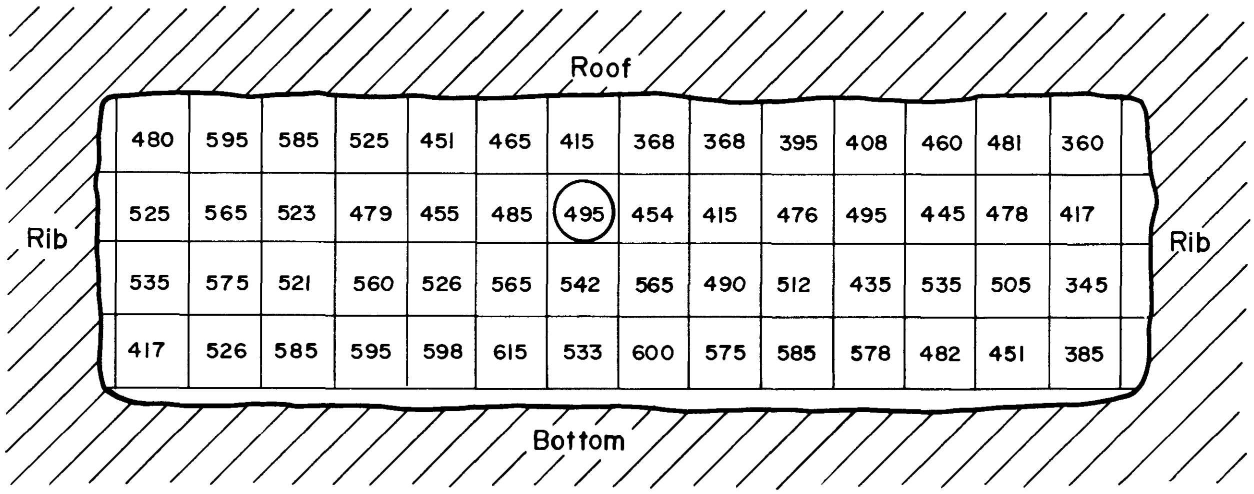
Reconnaissance

After a study area had been selected, Bureau mining engineers and the company's ventilation engineer examined the area to note the details of the ventilation and haulage arrangements and the condition of particular airways to find specific locations for monitoring continuously with recording and handheld instruments.

Location of Instruments

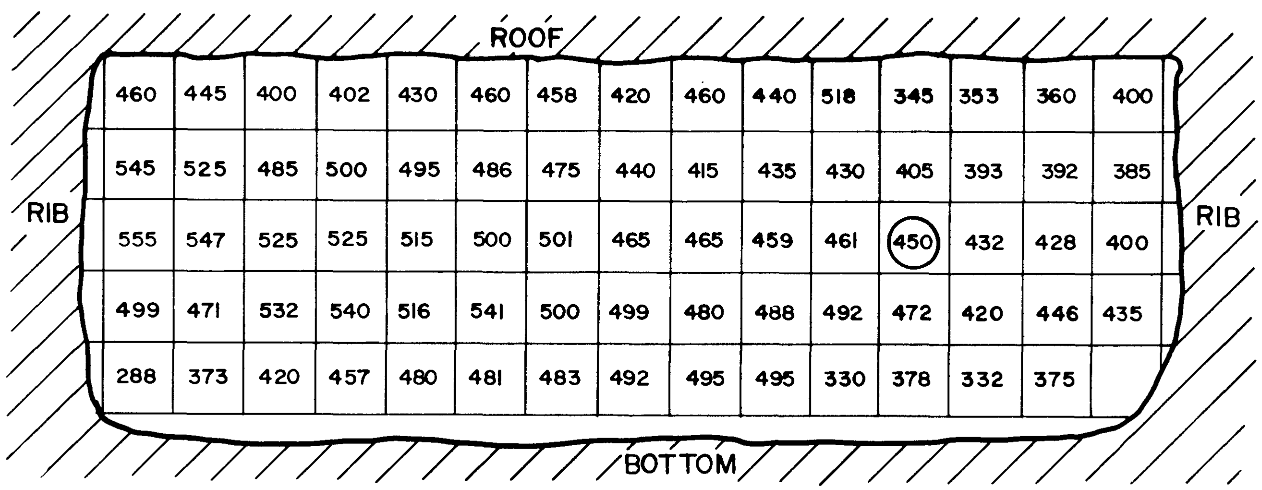
The continuously recording anemometers and methanometers were installed at locations where reasonably uniform air velocities in the cross-sectional areas of two return airways were carrying 85 pct of the total volume of air ventilating the study area. The locations of instrument stations A and B are shown in figure 2.

A grid system of vertical and horizontal strings was set up to form 1-foot squares across each of the two return airways. Air velocities in each square then were measured with handheld, vane-type anemometers to locate the square in which the air velocity most closely approached the average for each total cross-sectional area. Figures 3 and 4 show the air velocities in the 1-foot squares and the average velocity (circled) in the return airways at stations A and B.



Total cross-sectional area = 66 sq ft
Average air velocity = 495 fpm

FIGURE 3. - Air Velocities at Station A in Return Airway Showing Average Velocity (Circled).



Total cross-sectional area = 83 sq ft
Average air velocity = 454 fpm

FIGURE 4. - Air Velocities at Station B in Return Airway Showing Average Velocity (Circled).

Instrumentation

The sensing heads of the recording methanometer and anemometer developed by the Bureau[5] were installed in the average velocity squares. It was

[5] 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.

necessary to supplement the data collected by the recording instruments with handheld anemometers and methanometers in the intake ends of air splits in the return air regulator east, and in the back end of the study area.

A methane-monitoring team consisted of a mining engineer and an engineering aid on each shift. The engineer time-studied the longwall shearer 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 aid was responsible for adjusting and replacing instruments, and changing 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 time at which each was taken during the shift were recorded on the respective instrument charts.

RESULTS

Table 1 is a summary of data collected during the study. The study period comprised 14 operating shifts and eight idle shifts, during which time the longwall face was retreated 20 feet; an estimated 1,842 tons of coal was produced, and the shearer was in operation 1,457 minutes.

More specifically, table 1 shows that on November 20, 1969, during shift 3, the shearer was operated for 140 minutes, was idle for 340 minutes, and produced 180 tons of coal. The 33,400 cfm of air passing station A contained 381 cu ft of methane (1.14 pct); the 34,700 cfm passing station B contained 632 cu ft of methane (1.82 pct); and the 10,200 cfm of air passing through the regulator end of the study area contained 36 cu ft of methane (0.35 pct). The 78,300 cfm of air leaving the section, as a whole, contained 1,049 cu ft of methane for an overall concentration of 1.34 pct.

Handheld instruments were used to measure the airflow and methane content of the ventilating air on the longwall face and at other points. These measurements are not given in table 1 but they showed that--

1. Thirty thousand cubic feet of air per minute entered the head end of the longwall face, but only 7,000 cfm reached the tail end.

2. The concentration of methane measured along the entire face during operation of the shearer was 0.10 pct.

3. The concentration of methane in the return air from 4 Left ranged from 0.0 to 0.2 pct near the tail end of the face.

4. Methane was not detected in any intake air.

5. The 4 Left intake averaged 19,000 cfm, which was reduced by leakage to 16,000 cfm at the face.

TABLE 1. - Summary of results

Date, 1969	Shift No.	Minutes		Coal production, tons	Station A			Station B			Regulator east of study area			Total		
					Methane		Air, cfm	Methane		Air, cfm	Methane		Air, cfm	Methane		Air, cfm
		Working	Idle		Pct	Cfm		Pct	Cfm		Pct	Cfm		Pct	Cfm	
Nov. 20	3	140	340	180	1.14	381	33,400	1.82	632	34,700	0.35	36	10,200	1.34	1,049	78,300
	1	30	450	40	1.14	381	33,400	1.82	631	34,700	.35	36	10,200	1.34	1,048	78,300
	2	10	470	1	1.05	351	33,400	1.64	569	34,700	.35	36	10,200	1.22	956	78,300
Nov. 21	3	120	360	154	1.05	350	33,300	1.60	576	36,000	.35	37	10,700	1.20	963	80,000
	1	45	435	58	1.05	350	33,300	1.44	517	36,000	.35	37	10,700	1.13	904	80,000
	2	0	480	0	1.09	363	33,300	1.46	526	36,000	.35	37	10,700	1.16	926	80,000
Nov. 22	3	110	370	131	1.09	371	34,000	1.38	508	36,700	.35	38	10,800	1.13	917	81,500
	1	180	300	231	1.16	394	34,000	1.34	494	36,700	.35	38	10,800	1.14	926	81,500
	2	100	380	129	1.14	387	34,000	1.25	459	36,700	.35	38	10,800	1.08	884	81,500
Nov. 23	1-3	0	1,440	0	1.02	334	32,700	1.17	413	35,300	.35	44	12,700	.98	791	80,700
Nov. 24	1-3	0	1,440	0	1.02	334	32,700	1.17	413	35,300	.35	44	12,700	.98	791	80,700
Nov. 25	3	120	360	154	.91	287	31,500	1.10	375	34,000	.35	51	14,700	.89	713	80,200
	1	0	480	0	.91	287	31,500	1.07	364	34,000	.35	51	14,700	.88	702	80,200
	2	152	328	185	.95	299	31,500	1.04	354	34,000	.35	51	14,700	.88	704	80,200
Nov. 26	3	155	325	199	.95	299	31,500	1.04	368	35,400	.35	50	14,300	.88	717	81,200
	1	120	360	154	.98	309	31,500	1.09	386	35,400	.35	50	14,300	.92	745	81,200
	2	45	435	59	1.08	340	31,500	1.16	410	35,400	.35	50	14,300	.99	800	81,200
Nov. 27	3	130	350	167	1.11	349	31,400	1.20	427	35,500	.35	49	14,000	1.02	825	80,900
Average.......		91	389	117	1.04	341	32,700	1.29	458	35,400	.35	43	12,300	1.05	842	80,400

The efficiency of a longwall mining system is dependent upon the continuity of the operation. Idleness during operating shifts or on idle weekends disrupts the normal caving cycle, and the coal in the face becomes more difficult to mine.

One advantage during idleness is that methane emission from the freshly exposed faces and gob is reduced. This is shown in table 1 where, during the period November 20 through November 23, the total methane emitted ranged from 1,049 to 884 cfm, which was reduced to 791 cfm during the idle shifts on November 24 and November 25.

The emission rate continued to drop during two shifts after operations were resumed, but on the next shift (shift 2, November 25) it began to increase and continued increasing through the end of the study period.

Methane released by mining coal at the face was 0.10 pct of the average of 18,000 cfm of air, or 18.0 cfm; the 4 Left headings produced an additional 16 cfm of methane for a total of 34.0 cfm. The average daily methane emission rate during the entire study was 842 cfm of methane, of which an average of 808 cfm of methane was released from the strata above the coalbed.

CONCLUSIONS

The total average methane emitted from caving gassy overlying strata during mining was 808 cfm.

The total volume of ventilating air (table 1) would be more than adequate were it not for the large inflows of methane resulting from caving.

Bleeding of gob gases occurred primarily along the long sides of the longwall panel (1,200 feet had been mined out) and to an unmeasurable extent at the back end.