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**Methane Emission Rate Study in a Deep
Pocahontas No. 3 Coalbed Mine
in Conjunction With Drilling
Degasification Holes in the Coalbed**



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**By Stephen Krickovic and J. D. Kalasky
Pittsburgh Mining and Safety Research Center, Pittsburgh, Pa.**



**UNITED STATES DEPARTMENT OF THE INTERIOR
Rogers C. B. Morton, Secretary**

**BUREAU OF MINES
Elburt F. Osborn, Director**

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METHANE EMISSION RATE STUDY IN A DEEP POCAHONTAS NO. 3
COALBED MINE IN CONJUNCTION WITH DRILLING
DEGASIFICATION HOLES IN THE COALBED

by

Stephen Krickovic¹ and J. D. Kalasky²

ABSTRACT

A degasification experiment was conducted in a Pocahontas No. 3 coalbed mine in Virginia. It involved (1) drilling holes in the coalbed in the outside headings of a set of five being developed in virgin area, and (2) conducting a methane emission rate study as mining progressed and additional holes were drilled.

Degasification from all drill holes except the longest in each of the outside headings and the first three drilled (excluding the in-situ pressure hole), was erratic and inconsequential in methane emission rates. The two longest holes liberated 66 and 79 cfm of methane, which is significant for the coalbed, but such quantity lasted a relatively short time; the first three were uniform but low in methane emission.

INTRODUCTION

Methane is contained under pressure within the micropores, joints, and fracture systems in gassy coalbeds. Breaking coal from solid faces produces considerable coal surface areas that when added to the newly exposed solid coal surfaces³ increases methane emission rates appreciably.

The 1969 Federal Coal Mine Health and Safety Act requires that a minimum of 9,000 cfm of air be conducted to the last open breakthrough in any pair or set of developing headings. An additional requirement is that the minimum quantity of air in any coal mine reaching each working face shall be 3,000 cfm unless a greater quantity is needed to dilute the methane concentration, as required by the 1969 act. The dimensions and configurations of most continuous-mining equipment presently used at the face make it difficult to comply with the act generally and, in very gassy mines, practically impossible.

¹Supervisory mining engineer.

²Mining engineer (now employed by the Island Creek Coal Co.).

³Cervik, Joseph. An Investigation of the Behavior and Control of Methane Gas. Min. Cong. J., v. 53, No. 7, July 1967, pp. 52-57.

The objective of this study was to determine the effect on methane emission rates from the immediate face areas of holes drilled in the coalbed as mining progressed.

ACKNOWLEDGMENTS

The cooperation of the mine management of the Island Creek Coal Co. of Cleveland, Ohio, and Keen Mountain, Va., and of J. D. Hadden, mining engineer, Pittsburgh Mining Research Center, and his drilling crews is greatly appreciated.

DESCRIPTION OF STUDY AREA

The study area consisted of a set of five headings and breakthroughs being developed in virgin coal. Figure 1 shows the area and its relationship to the nearest mine workings and to projected mine plans on either side.

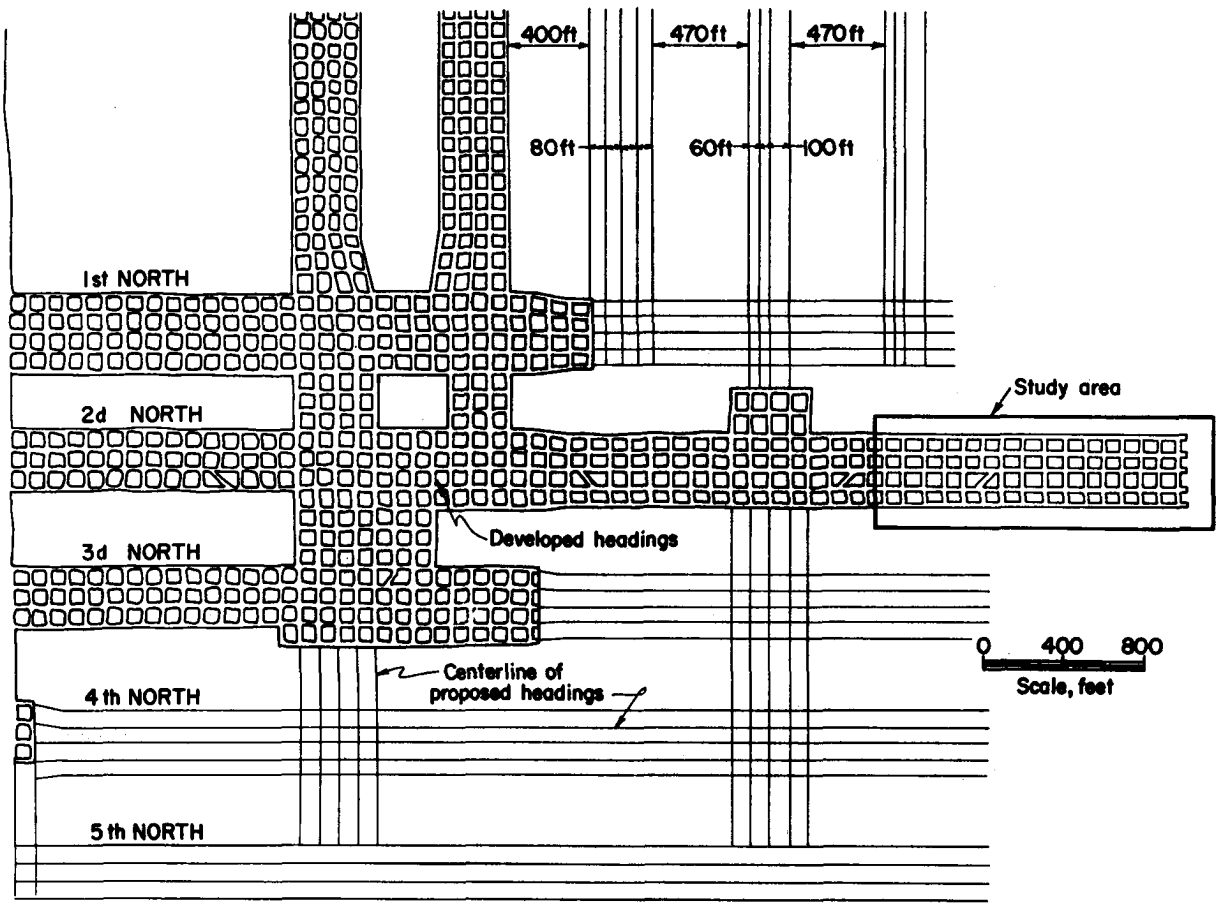


FIGURE 1. - Location of Study Area.

MINING METHOD AND EQUIPMENT

A two-step, ripper-type continuous miner was used in development of the set of five headings on 80- and 95-ft centers, with breakthroughs on 94-ft centers. Width of places averaged 17 ft, and thickness of coalbed mined, 53 in. The miner was equipped with a methane detector located 10 ft ahead of the operator. When the detector indicated a methane concentration of 2 pct, the power was automatically disconnected.

Owing to the very gassy condition of the coalbed, the miner was advanced usually only 4 ft in each lift (one-half the width of the working face) after which it had to be maneuvered to the other half of the place. This procedure would involve 10 maneuvers for the full 20-ft-deep cut, at the end of which the operator was under the last line of roof support. The miner then was trammed to the next face in the cycle where the aforementioned mining procedure was repeated, and bolting of roof was undertaken in the preceding place.

Coal was discharged by the miner directly into 5-ton-capacity cable reel shuttle cars that traveled to the feeder at the tailpiece of the 36-in belt conveyor for unloading. Two shuttle cars serviced the miner.

VENTILATION

Figure 2 shows the arrangements of ventilation, haulage, and locations of recording instruments with respect to working faces at the start of study.

Headings 2-4 served as intakes. Next to the last complete line of breakthroughs, the air was divided by plastic stoppings and line brattice into two splits, one ventilating only heading 5, and the other ventilating the remaining headings. When headings 3 and 4 were mined, the areas ventilated were more evenly divided. In all cases, air was conducted to the working face by line brattice erected to facilitate movement of intake air over the men and equipment and to prevent obstruction of travel to mine equipment.

MONITORING

Recording anemometers and methanometers were installed at stations A and B in headings 1 and 5, respectively, and recording methanometers, only at stations C and D in headings 1 and 5, respectively (fig. 2).

Locations for instrumentation were selected to obtain reasonably uniform air velocities in the cross-sectional areas. At stations A and B, a grid system of horizontal and vertical strings that formed 1-ft squares was set up in the cross-sectional areas. Air velocities were measured in each square with the sensing head of a recording anemometer, and the square in which the air velocity most closely approached the average for the cross-sectional area was selected. The sensing heads of the continuously recording methanometers and anemometers⁴ were installed in the velocity square with value closest to

⁴La Scola, 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.

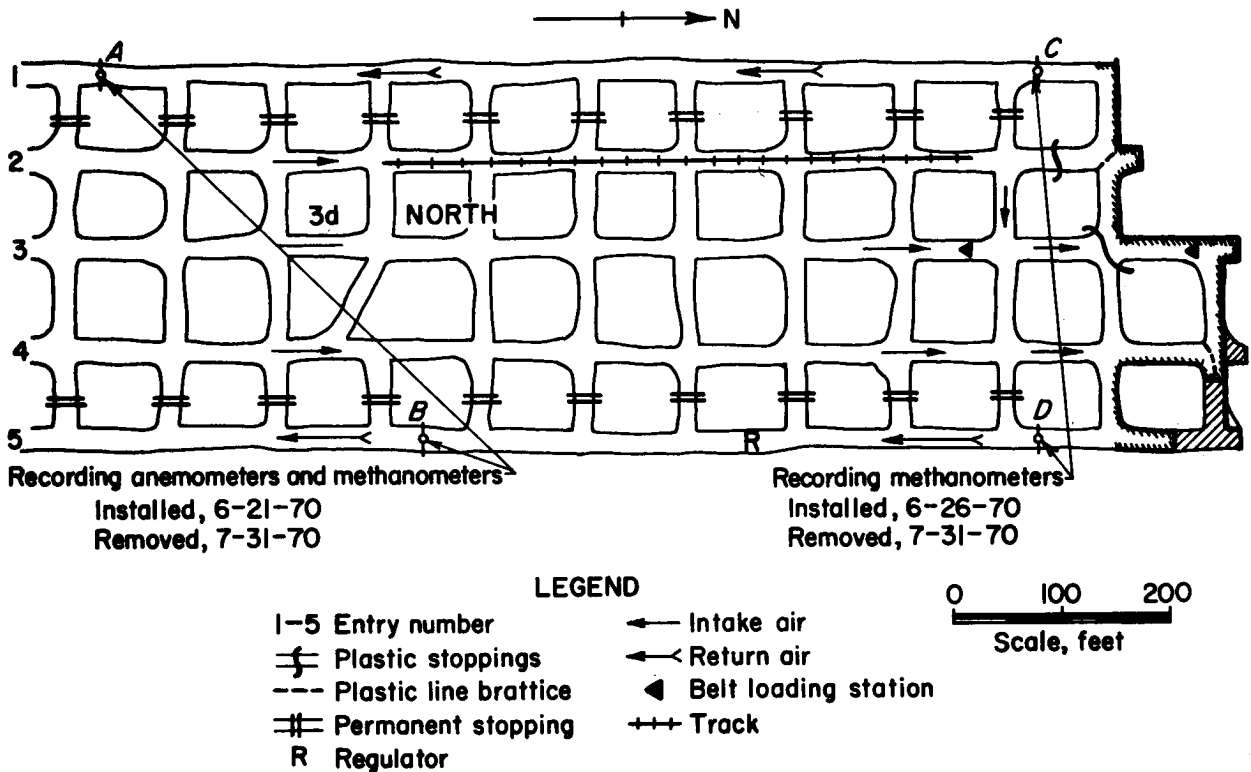


FIGURE 2. - Arrangement of Ventilation, Haulage, and Locations of Recording Instruments.

the average. Area at station A in heading 1 was 73.9 sq ft, and average velocity was 347 fpm. The area with 350-fpm velocity was used. The corresponding values at station B in heading 5 were 72.0 sq ft, 285 fpm, and 290 fpm (fig. 2). At stations C and D, the sensors of the methanometers were located at the point of average methane concentrations in the cross-sectional areas as determined by three hand-held methanometer readings at each location.

The air volumes measured at stations A and B were used also for stations C and D, since air leakage through stoppings between the two sets of stations was negligible.

A monitoring team consisted of the following: A mining engineer, who time-studied the miner, observed unusual conditions at the face affecting methane emissions, measured the methane content in the intake air 5 ft in by the belt conveyor tailpiece, and secured other pertinent data; and two technicians who maintained the instruments in satisfactory operating condition by adjusting them, by replacing weak or dead batteries and malfunctioning instruments with spare units, and by making check readings periodically with hand-held instruments.

Although the mine worked two shifts per day, monitoring was conducted mostly on the first shift (8 a.m. to 4 p.m.). Owing to transportation problems, the monitoring crew could not start the instruments until 10 or 11 a.m., and all instruments could not be started simultaneously. The monitoring time,

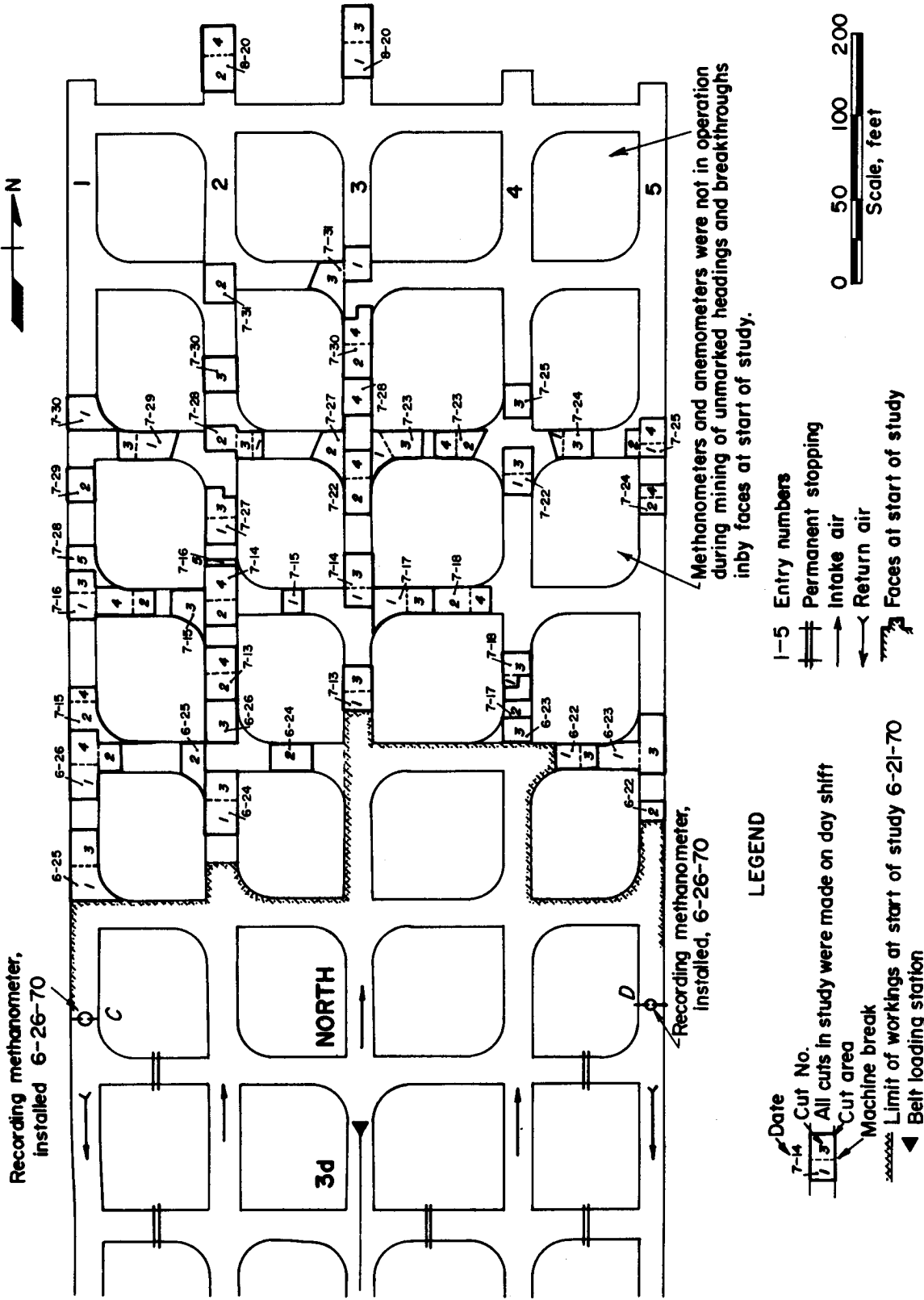


FIGURE 3. - Sequence of Mining by Shifts and Dates During Study Period.

therefore, was based on the recording methanometer having the shortest operating period, and the data recorded on the other three units for the corresponding periods were used.

The areas mined and the sequence of mining are shown in figure 3.

DRILLING HORIZONTAL METHANE CONTROL HOLES INTO COALBED

A 56-lb Thor⁵ hand-held air drill equipped with EW, 1-13/16-in-diam smooth-walled drill casing 2-31/32-in-OD centralizers, and a 3-in Blue Demon three-pronged insert bit were used. A 1-ton hand-operated hoist provided the thrust for the drill, and water was used as the flushing agent.

Eight holes were drilled in the coalbed (fig. 4 and table 1); hole 1 (in-situ gas pressure) was packed with nine packers spaced with 5-ft lengths of 3/4-in pipe. Fifteen ft of the hole was left open at the front end, and 10 ft, at the back end.

TABLE 1. - Summary of drilling data

Hole	Hole drilled 1970	Depth of hole, ft	Hole started	Angle of hole in coalbed	Hole terminated in
1	06-27	108	Inby rib of breakthrough between headings 2 and 3.	Parallel to headings.	Coal.
2	06-28	255	12 in below binder left rib of heading 1.	4° angle with respect to rib in heading 1.	Do.
3	06-29	259	24 in below binder left rib of heading 5.	5° angle with respect to rib in heading 5.	Do.
4	07-01	95	12 in right of hole 3 in heading 5.	10° angle with respect to rib in heading 5.	Roof rock.
5	07-19	503	12 ft back from face of heading 1.	10° angle with respect to rib in heading 1.	Coal.
6	07-23	140	Near hole 3 in heading 5.	Unrecorded angle with respect to outside rib in heading 5.	Roof rock.
7	07-25	90	Near hole 3 in heading 5.	Unrecorded angle with respect to outside rib in heading 5.	Bottom rock
8	07-26	300	190 ft from hole 3 and 30 ft outby face in heading 5.	10° angle with respect to rib in heading 5.	Coal.

⁵Reference to specific brands is made for identification only and does not imply endorsement by the Bureau of Mines.

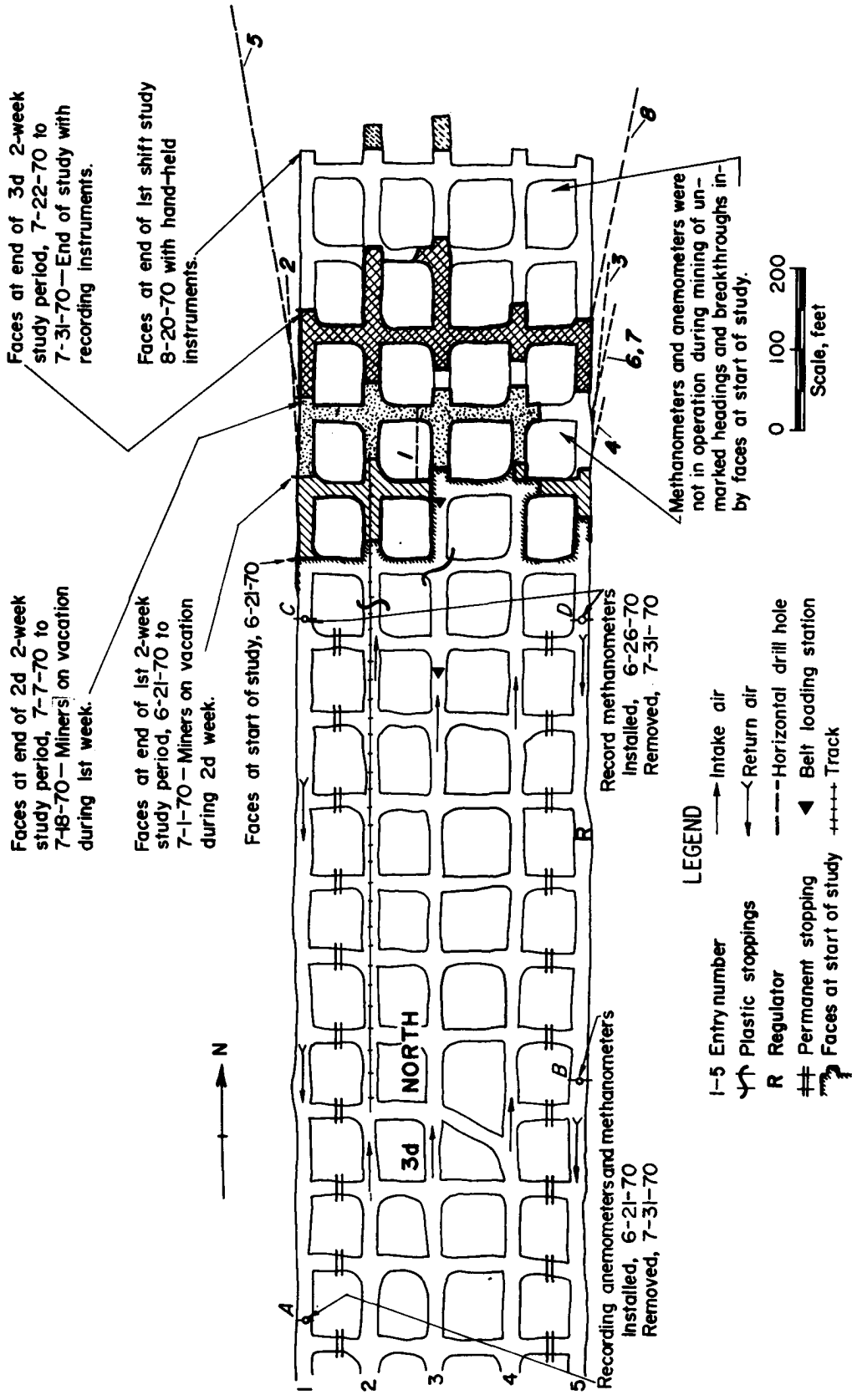


FIGURE 4. - Locations of In-Situ Pressure and Degasification Boreholes Drilled in Coalbed.

A 1-1/2-in-diam plastic pipe was grouted a distance of 8 to 10 ft in holes 2-5. The pipe was extended just outby the recording methanometers at stations C and D in headings 1 and 5, respectively, except that pipe from hole 4 was tapped into pipe from hole 3. A 50-ft-long EW rod was inserted in hole 5 prior to the grouting of the plastic pipe. Drill casing was placed in hole 8, and the plastic pipe was attached to it and extended outby the recording methanometers as were the others. Holes 6 and 7 were left open, because neither liberated any measurable quantity of methane.

RESULTS

The lowest pressure in table 2 is not representative for the total study period, because the usefulness of the hole was negated July 14 (fig. 3-4), after which holes 5-8 were drilled.

TABLE 2. - In-situ gas pressure measured in hole 1

<u>Date, July</u>	<u>Gas pressure, psi</u>
1	649
2	650
8	645
9	642
10	640
13	636

Approximate overburden at hole 1 was 1,450 ft.

Table 3 is a summary of all monitoring data obtained during the study period, and figure 5 shows the effect of the holes drilled in the coalbed on methane emissions from the face areas.

As holes 2-4 were completed, there was some uniformity in methane emissions from them, reaching a maximum of 42 cfm (60,500 cfd) upon completion of hole 4. It is doubtful that hole 1 (in-situ pressure) contributed a measurable quantity of methane.

From July 1 until hole 5 was completed on July 19, and during which period mining in the study area continued for 6 consecutive days, the emission rates from the holes were erratic and, with three exceptions, practically nil. Unknown conditions in the holes, possible errors in instrumentation, relatively short monitoring periods for 8 days, and personal errors could be the explanation for the erratic values.

TABLE 3. - Summary of monitoring data

Date	Shift	Working face ¹	Monitoring time, min		Face advance, ft	Coal production, tons	Left split		Right split		Total Methane Stations A and B			Methane emission in face of stations C and D minus methane intake in air	Methane emission from ribs between stations C and D	Methane emission from horizontal drill holes, cfm ²	Remarks			
			Miner on split, min	Idle			Miner on split, min	Methane, Pct	Air, cfm	Sta-Station D	Station B	Pct	Station C					Pct	Station D	Pct
06-22-70	3	Idle.....	-	480	480	-	-	25,200	0.55	19,600	0.45	44,800	-	0.50	227	0.23	105	-	All recording instruments installed at stations A and B, 06-21-70.	
06-22-70	1	(4-5), (4-5).....	136	269	405	42	25,000	-	63	18,700	-	48,433,700	-	56	246	24	105	-	-	
06-23-70	1	5, 6, 2, 3, 2.....	91	204	295	31	26,700	-	67	17,300	-	63,424,600	-	65	278	25	105	-	-	
06-24-70	1	2, (3-2), 2.....	105	160	265	38	20,800	-	72	20,400	-	87,412,000	-	80	328	25	105	-	-	
06-25-70	1	1, (2-1), 1.....	79	201	280	37	21,900	-	62	17,400	-	1,031,393,300	-	80	314	27	105	-	-	
06-26-70	1	1, (2-1), 2, 1.....	122	258	380	67	21,000	-	77	18,600	-	92,593,600	0.67	267	84	333	27	105	66	Inby recording methanometers installed at stations C and D.
Average			107	218	325	43	22,700	-	68	18,600	-	79,414,300	-	73	300	25	105	-	-	
06-26-70	2	Idle.....	-	480	480	-	24,800	0.41	63	17,300	0.71	78,421,000	0.53	225	69	291	25	105	120	66
06-27-70	3	do.....	-	480	480	-	26,100	0.37	58	17,200	0.69	77,433,300	0.50	216	65	281	24	105	111	65
06-28-70	2	do.....	-	480	480	-	26,800	0.35	54	17,600	0.64	70,444,000	0.47	207	61	270	24	105	102	63
Average			-	480	480	-	27,000	0.33	52	17,100	0.63	69,444,100	0.45	197	59	259	24	105	92	62
06-28-70	1	do.....	-	480	480	-	26,200	0.36	56	17,300	0.67	74,433,500	0.48	211	63	273	24	105	106	62
06-29-70	1	do.....	-	480	480	-	26,900	0.31	50	17,900	0.50	66,444,800	0.38	170	56	251	23	105	65	61
06-29-70	1	do.....	-	480	480	-	25,800	0.35	52	21,800	0.42	58,474,600	0.38	181	55	262	22	105	76	61
06-30-70	1	do.....	-	480	480	-	30,000	0.33	48	21,200	0.42	59,512,200	0.37	189	53	271	21	105	84	61
07-01-70	1	do.....	-	115	115	-	28,200	0.34	56	18,900	0.47	68,477,000	0.39	184	61	287	22	105	79	61
Average			-	389	389	-	27,700	0.33	52	20,000	0.45	63,477,700	0.38	181	56	267	22	105	76	61
07-07-70	1	do.....	-	140	140	-	26,100	0.30	51	28,100	0.39	40,544,200	0.34	184	45	264	19	104	80	58
07-08-70	1	do.....	-	480	480	-	26,300	0.33	50	28,900	0.33	39,544,600	0.33	180	44	240	19	104	76	58
07-09-70	1	do.....	-	480	480	-	26,300	0.30	51	27,900	0.33	39,544,200	0.32	173	45	243	19	104	69	58
07-10-70	1	do.....	-	480	480	-	26,300	0.31	50	28,100	0.34	40,544,800	0.30	164	45	247	19	104	70	58
Average			69	81	150	18	26,300	0.31	51	28,100	0.34	40,544,800	0.32	174	45	244	19	104	70	58
07-13-70	1	3, 2, 3, 2.....	154	28	182	37	25,200	0.36	53	24,100	0.53	61,493,300	0.44	217	57	281	21	104	113	57
07-14-70	1	(3-2), 1, (2-1), 1.....	106	59	165	33	26,400	0.34	54	21,500	0.60	75,479,900	0.46	221	63	303	22	104	126	57
07-15-70	1	(2-1), 1, (2-1), 2.....	179	40	219	43	23,000	0.40	56	104	21,800	0.76	91,444,800	0.58	259	73	328	23	104	155
07-16-70	1	(3-4), 4, (3-4).....	143	108	251	39	24,000	0.64	75	65	21,500	0.39	54,454,500	0.52	238	65	296	23	104	134
07-17-70	1	4, (3-4), 4, (3-4).....	113	62	175	26	21,500	0.52	71	38	21,500	0.52	62,484,900	0.54	264	67	328	21	104	160
07-18-70	1	do.....	127	63	190	33	25,300	0.47	63	22,100	0.55	68,474,400	0.50	238	65	310	22	104	134	56
Average			96	384	480	65	24,800	0.47	70	42	21,400	0.53	63,466,200	0.50	230	66	305	22	103	127
07-22-70	1	(3-4), (4-3).....	83	397	480	61	24,900	0.42	73	35	21,300	0.53	69,454,800	0.48	219	71	325	22	103	116
07-23-70	1	5, (4-5).....	78	262	340	43	27,400	0.42	73	36	18,500	0.44	59,454,900	0.43	196	67	307	22	103	93
07-24-70	1	4, 5, (4-5).....	35	175	210	22	26,000	0.32	83	20	18,300	0.53	69,454,800	0.48	220	78	326	22	103	135
07-25-70	1	do.....	75	305	378	48	26,000	0.46	75	33	19,900	0.51	65,454,900	0.47	240	62	316	20	103	117
Average			51	269	320	59	25,900	0.59	74	24	25,000	0.35	69,454,900	0.47	240	62	316	20	103	137
07-26-70	1	do.....	51	269	320	59	24,100	0.63	81	24	25,000	0.33	68,484,400	0.48	232	75	363	21	102	130
07-27-70	1	2, (3-2), 2.....	101	379	480	67	25,000	0.59	75	56	22,300	0.57	75,474,300	0.58	273	75	354	22	102	171
07-28-70	1	1, 2, 3, (3-2).....	65	140	205	42	26,100	0.42	72	32	20,100	0.71	85,466,200	0.55	253	77	356	22	102	151
07-29-70	1	1, (2-1).....	41	173	114	29	23,500	0.71	92	11	19,400	0.81	82,424,900	0.76	326	88	378	24	102	224
07-30-70	1	1, 2, 3, (3-2).....	47	153	200	35	21,900	0.75	88	17	19,000	0.76	86,404,900	0.75	307	89	364	23	102	205
Average			61	203	264	42	24,100	0.57	81	28	22,000	0.66	80,454,100	0.61	275	80	361	23	102	173
08-20-70	1	3, 2, 3, 2.....	197	158	355	73	26,600	0.61	74	118	22,000	0.86	89,484,600	0.72	350	81	394	21	102	248

¹Numbers appearing by themselves represent faces of entries; hyphenated numbers appearing in parentheses refer to breakthroughs between entries.

²Methane volume in intake air obtained by hand-held instruments just inby belt calipers during idle shift on July 26 and idle periods on several operating days, including August 20.

³Methane bleed-off from coal ribs between monitoring stations A, B and C, D was obtained by recording methanometers on shift 2, June 26, and by hand-held instruments on August 20; the values in between were prorated.

⁴Methane emissions from holes in coalbed obtained by subtracting from the total rate obtained at stations A and B, the summation of emissions obtained at stations C and D and those from the coal ribs.

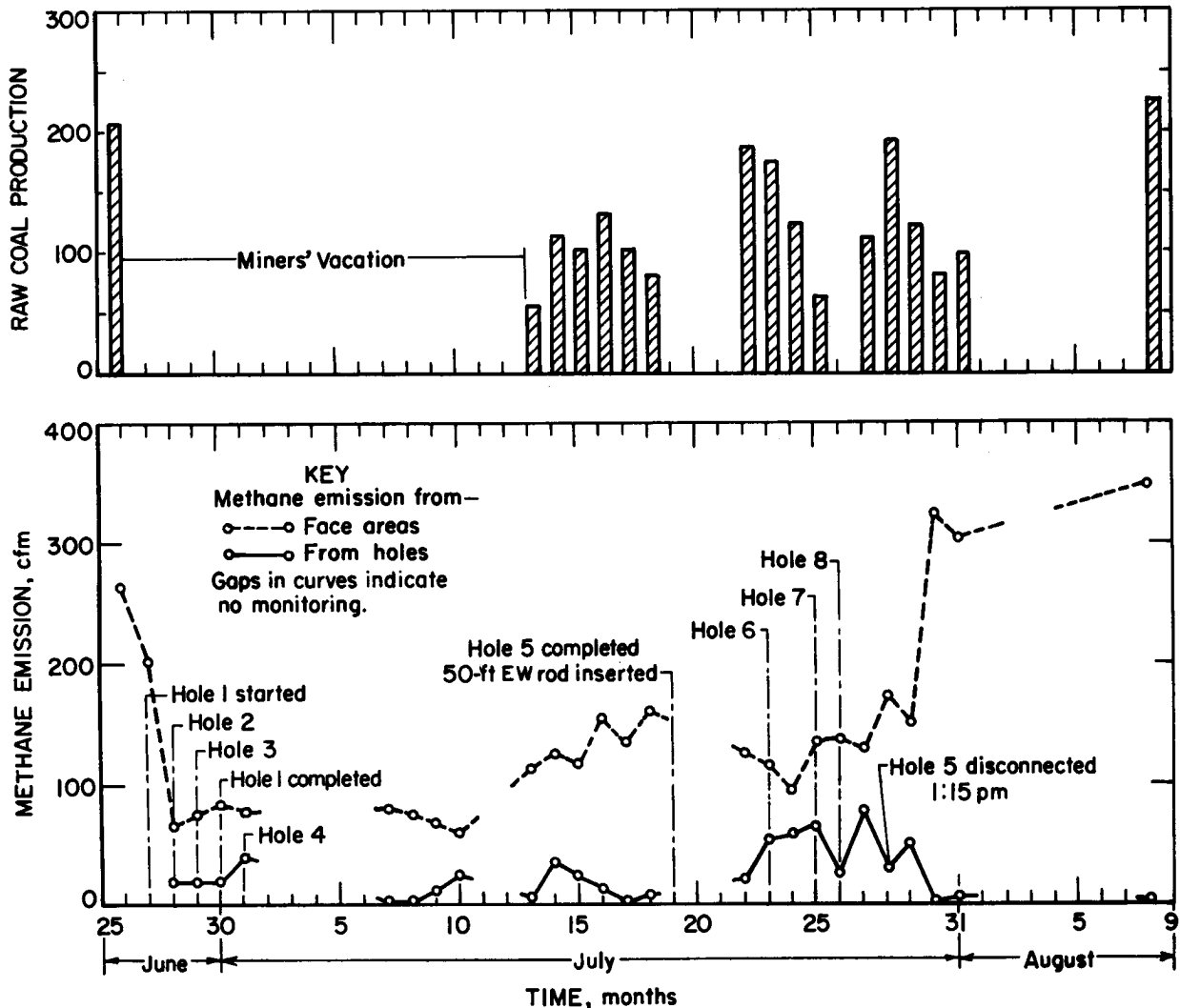


FIGURE 5. - Summary of Pertinent Results Obtained From Degasification Holes in Coalbed.

It is reasoned that on July 18, when face production was 81 tons and methane emission from the face areas was 160 cfm, emission from holes 2-4 was nil. After completion of the 503-ft-deep hole 5 on July 19, methane emission from the coal-producing faces dropped from 160 cfm on July 18 to 93 cfm on July 24, but methane emission from hole 5 increased from 22 to 58 cfm. Hole 6 (140 ft deep) was drilled during this period and showed no measurable methane emission. Although a significant reduction in face emission during July 19 to July 22 can be attributed to the 3 idle days, contribution from hole 5 also was significant due to 3 coal-producing days during the period (189, 177, and 125 tons during monitoring shift). It is not determinable why hole 5 required 2 full days to become more productive. However, there is the desirable correlation between production, lower methane emission from the face areas, and higher methane emission from hole 5. This was expected from the study.

Although the 24-cfm emission rate from hole 8 (300 ft deep) is low, drilling of the hole was completed on July 26 after monitoring was stopped. Thus, most of the 24 cfm can be assumed as being liberated from hole 5.

During the period from July 26 to July 29, holes 5 and 8, particularly the latter, generally had a positive effect on reducing the methane emission from the face areas during mining. Face emission dropped from 137 cfm on idle July 26 to 130 cfm on July 27 when production was 113 tons. Increase in the face emission rate to 171 on July 28 was 32 pct; the production increase was 72 pct. This could explain the apparent discrepancy. At the same time, tubing from hole 5 was disconnected prior to completing monitoring on the same date, which permitted both methanometers in the same heading to record the emissions from hole 5.

Thus, it appears that emission rates from holes 5 and 8, 59 cfm (85,000 cfd) and 79 cfm (113,800 cfd), respectively, were somewhat significant, considering the relatively low permeability of the coalbed.

Other results not related to methane emissions from the holes in the coalbed may be noted in table 3. They are as follows:

1. Methane concentrations in the left air split reached a high of 0.92 pct during the study. In the right air split the high was 1.03 pct; the next highest was 0.92 pct. However, the methane detector on the continuous miner disconnected the power at 2.0 pct concentration too frequently. This occurred despite the fact that the air volume measured at monitoring station A ranged from 20,800 to 30,000 cfm, and at station B, from 17,100 to 28,300 cfm.

2. The methane volume in the intake air measured in by the conveyor belt tailpiece was 105 cfm (151,200 cfd) at the start of the study and 102 cfm at the end of the study. This is a significant volume that accumulated from the bottoms of intake shafts, from the intake airways to the study area, and mostly from the 3,400 ft of three intake airways of the particular section. Coal in cars and on belt conveyors wherever located out by the study section also contributed to the volume of methane. All of these factors could account for the insignificant change in the intake air methane volume.

3. Methane emission from the ribs and parts of breakthroughs (to the stoppings) between monitoring stations A and C in heading 1 and monitoring stations B and D was 66 cfm (95,000 cfd) at the start of study and 44 cfm (63,000 cfd) at the end of study (58 days). The bleed-off is significant in a total distance equivalent to a single heading 2,000 ft long.

CONCLUSIONS

The behavior of methane emissions from the holes drilled in the coalbed, as described under "Results," strongly indicates the need for further research in the development of (1) the most effective spacing and length of holes; (2) proper angle of holes with respect to the outside ribs; (3) the possible use of strong slotted plastic pipe in the holes to prevent closure; and (4) other possible techniques to obtain greater and more lasting methane

emission rates. It is theorized that the somewhat sudden reduction in methane emissions from holes 5 and 8 was caused by closure.

Although not included in the objective of the study, development of techniques for more effective face ventilation and for degasification of gassy coalbeds or major panels before mining within them is needed. With respect to face ventilation, there is an urgent need in very gassy mines to develop air-duct systems for mounting on predominantly used continuous miners. Also needed is telescoping tubing to be used back of the miners in conjunction with reinforced tubing and auxiliary fan. The arrangement would provide greater volume of air as close as practicable to the cutting head while the miner is breaking coal.

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