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Methane Drainage Study in the Sunnyside Coalbed, Utah

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By J. H. Perry, G. N. Aul, and Joseph Cervik

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METHANE DRAINAGE STUDY IN THE SUNNYSIDE COALBED, UTAH

by

J. H. Perry,[1] G. N. Aul,[2] and Joseph Cervik[3]

ABSTRACT

The Bureau of Mines is conducting research to determine the effectiveness of long holes in degasifying an area of the Upper Split of the Lower Sunnyside coalbed at Kaiser Steel Co.'s Sunnyside No. 1 mine. These holes were drilled from the two outside entries of a section that was closed to mining because of excessive methane emissions.

Two holes drilled to 430 and 450 feet produced initial gas flows of 160,000 and 127,000 cfd, respectively. Sixteen days after the completion of the second hole, the total gas production declined to just over 144,000 cfd. In 9 months of degasification, over 35 MMcf of commercial-quality gas has been removed from the coalbed. The combined gas flows declined to 106,000 cfd in the 9-month period. The two holes have reduced face emissions by about 40 pct.

INTRODUCTION

The Bureau of Mines has demonstrated that removing methane from virgin coal by use of long holes in advance of mining reduces the amount of gas entering the mine during advancement (2).[4] To date, most of this research has been concentrated in the Eastern United States (6).

The rate at which gas flows through coal into either the mine entry or a horizontal hole depends on the gas pressure in the coalbed, fracture permeability and porosity, and diffusivity coefficient. The Pittsburgh coalbed, which has a relatively high permeability, has a measured in situ pressure of 275 psi (1). This means that large amounts of gas can be removed from the coal through long holes drilled in the seam. Two demonstration projects conducted in the Pittsburgh coalbed have removed more than 1.8 billion cubic feet of methane. Methane flows through faces of a section have been reduced by 70 pct, and about 700 MMcf of the gas has been sold commercially (2-4).

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[1] Physicist.
[2] Geologist.
[3] Supervisory geophysicist.
All authors are with the Pittsburgh Mining and Safety Research Center, Bureau of Mines, Pittsburgh, Pa.
[4] Underlined numbers in parentheses refer to items in the list of references at the end of this report.

The objectives of this test are to drill two long holes to determine the methane flow potential of the Upper Split of the Lower Sunnyside coalbed, to establish a decline curve for the two holes, and to observe the effects of degasification on methane flows through the faces of the section.

ACKNOWLEDGMENTS

The cooperation of the management of Kaiser Steel Co.'s Sunnyside No. 1 and No. 3 mines and of the Utah Geological and Mineral Survey is greatly appreciated.

DRILL SITE

This project was designed to degasify the 18 Dips section of Kaiser Steel's Sunnyside No. 1 mine, Sunnyside, Utah (fig. 1). The coalbed in the area of 18 Dips is gassy and has been closed to mining for more than a year.

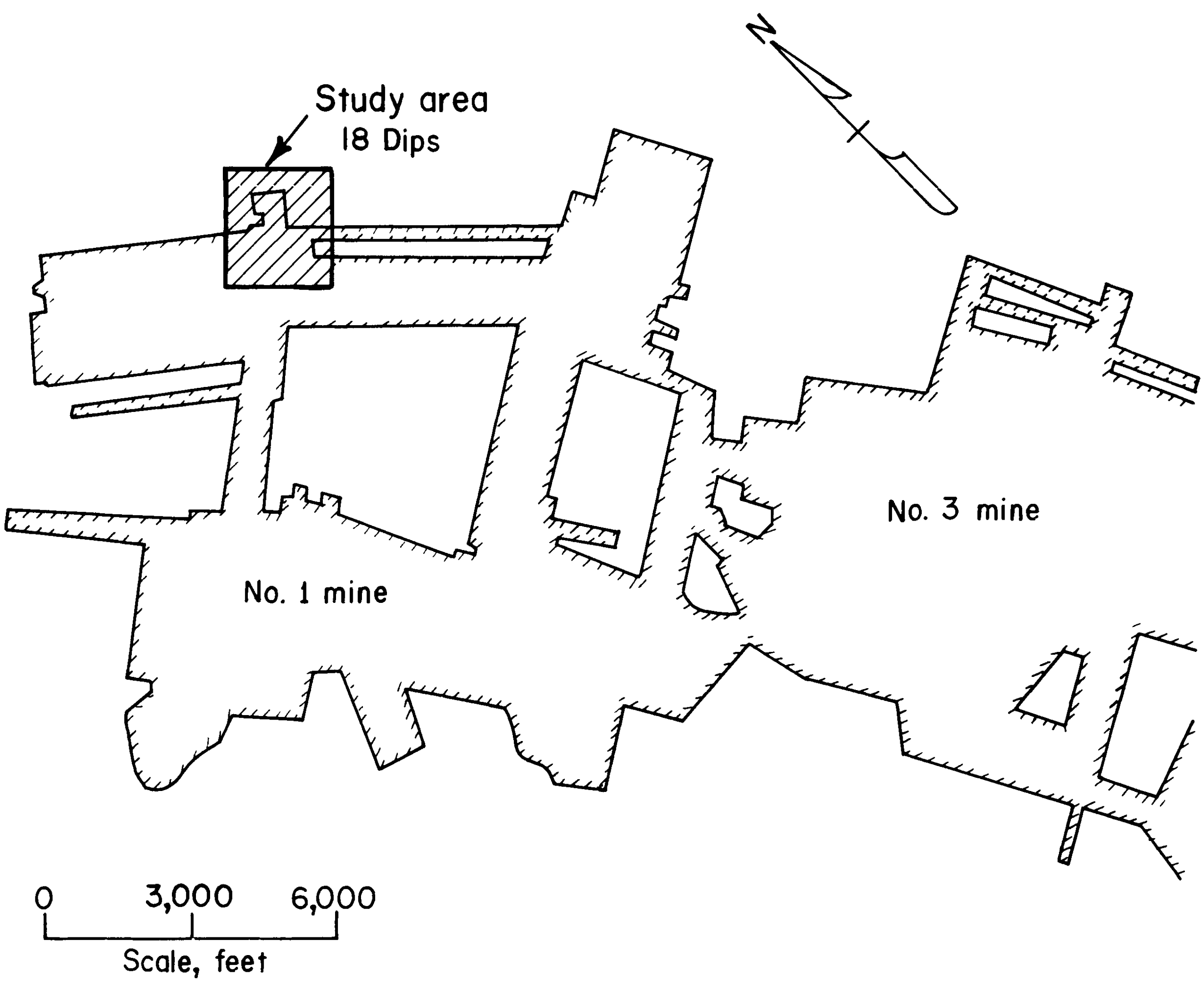

FIGURE 1. - Location of study area at the Sunnyside No. 1 mine.

Mine personnel tried to degasify the area with two short holes. These holes, 85 and 95 feet deep, were drilled perpendicular to the face cleat (fig. 2). The combined gas flow from these two holes over a period of 1 year averaged 55,000 cfd.

Figure 2 shows the location of the two long horizontal holes. Hole 1 was started 30 feet outby the face of the rightmost entry and was drilled at an angle of about 20° off the entry's heading. Hole 2 was located in an offset in the left outside return, about 110 feet outby the face, and was drilled directly in line with the entry heading. This section of the mine dips about 5° below horizontal in the direction of section advance. The face cleat direction is at 90° to the direction of section advance.

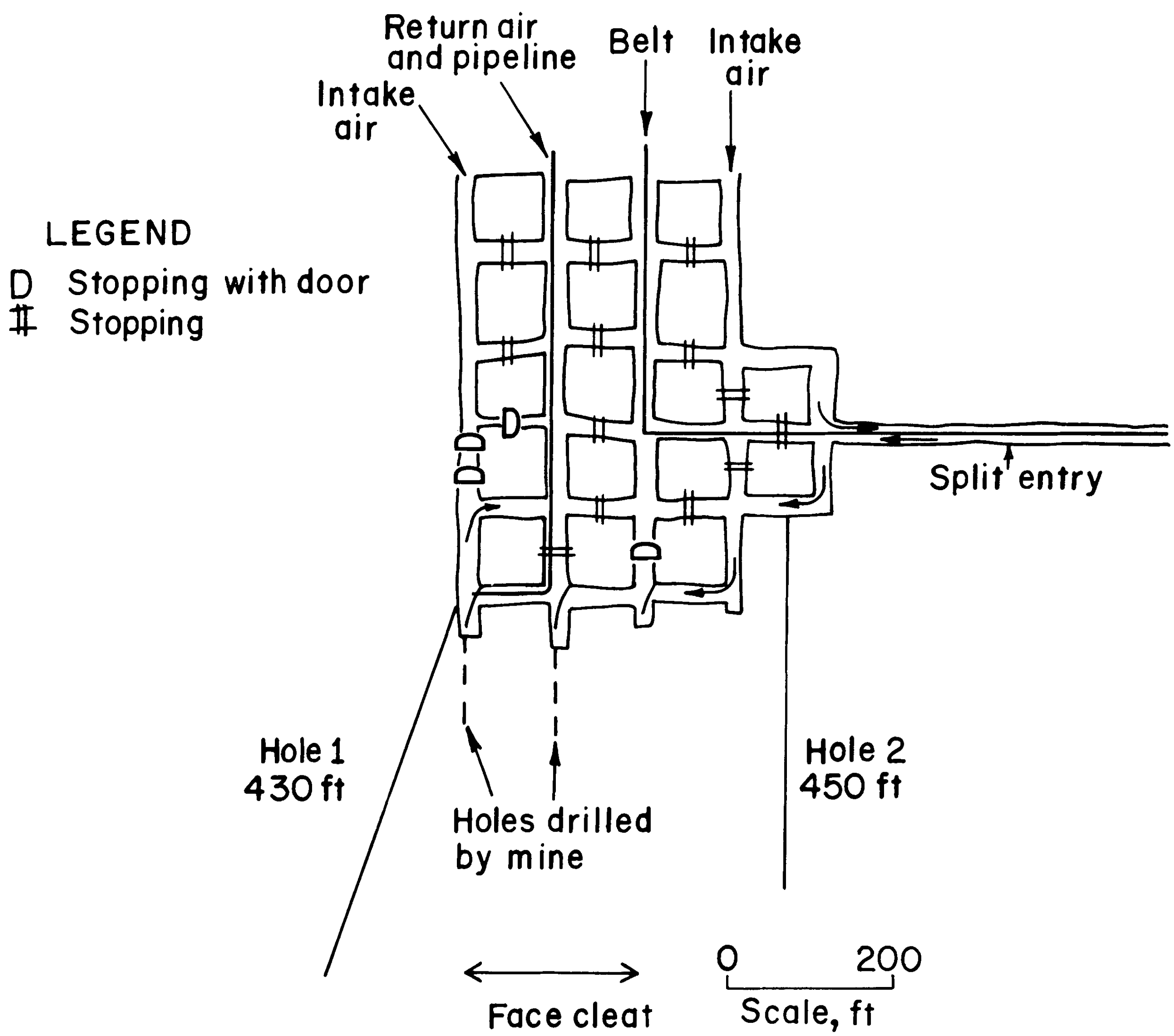

FIGURE 2. - Location of holes drilled in 18 Dips section.

DRILLING PROCEDURE

A 30-hp electrohydraulic horizontal drill was used to drill the holes (fig. 3). For each hole, a 6-inch-diam hole was drilled to a depth of 22 feet, and a 20-foot length of 4-inch schedule 40 pipe was grouted in place. When grouting was completed, a Bureau-designed stuffing box and a 4-inch full-ported valve were attached to the pipe (fig. 4). The stuffing box is designed to separate the gas from water and drill cuttings during drilling. Either a three-bladed, 3-5/8-inch-diam drag bit or a 3-5/8-inch roller bit was used, followed by a check valve, a 3-7/16-inch centralizer, a 20-foot-long NQ drill collar, another 3-7/16-inch centralizer, and BQ drill rods (1).

A Sperry-Sun single-shot survey instrument was used to determine the inclination of the hole (1). Initially, surveys were taken every 20 feet to determine the proper drilling parameters. Thereafter, survey intervals were increased to 30 feet, and then to 50 feet.

During drilling, the inclination of the hole could be changed by changing the amount of thrust applied to the drill string. A thrust of 1,800 pounds would drop the bit 1° every 40 feet. A thrust of 2,400 pounds would raise the bit 1° every 50 feet.

A drastic difference in the penetration rates was observed between the two holes. For hole 1, bit penetration rate averaged 36 ipm; for hole 2, it averaged only 6 ipm. Hole 1 was drilled with one drag bit. A roller bit had to be used in hole 2 after only 200 feet of drilling with a drag bit. No noticeable difference in the penetration rates was observed between the two types of bits in hole 2. Apparently, the hardness of the coalbed changed drastically over the distance of 350 feet that separated the holes. Samples of coal were taken from each drilling site to test for hardness. The Hardgrove Grindability Index for samples taken from both sites was the same. To date, we have been unable to explain the difference in penetration rates.

When drilling of each hole was completed, about 400 feet of 1-1/2-inch plastic pipe was inserted, which will be used to grout the hole in the future. Then the stuffing box was removed, and each hole was connected directly to a 4-inch pipeline (fig. 5).

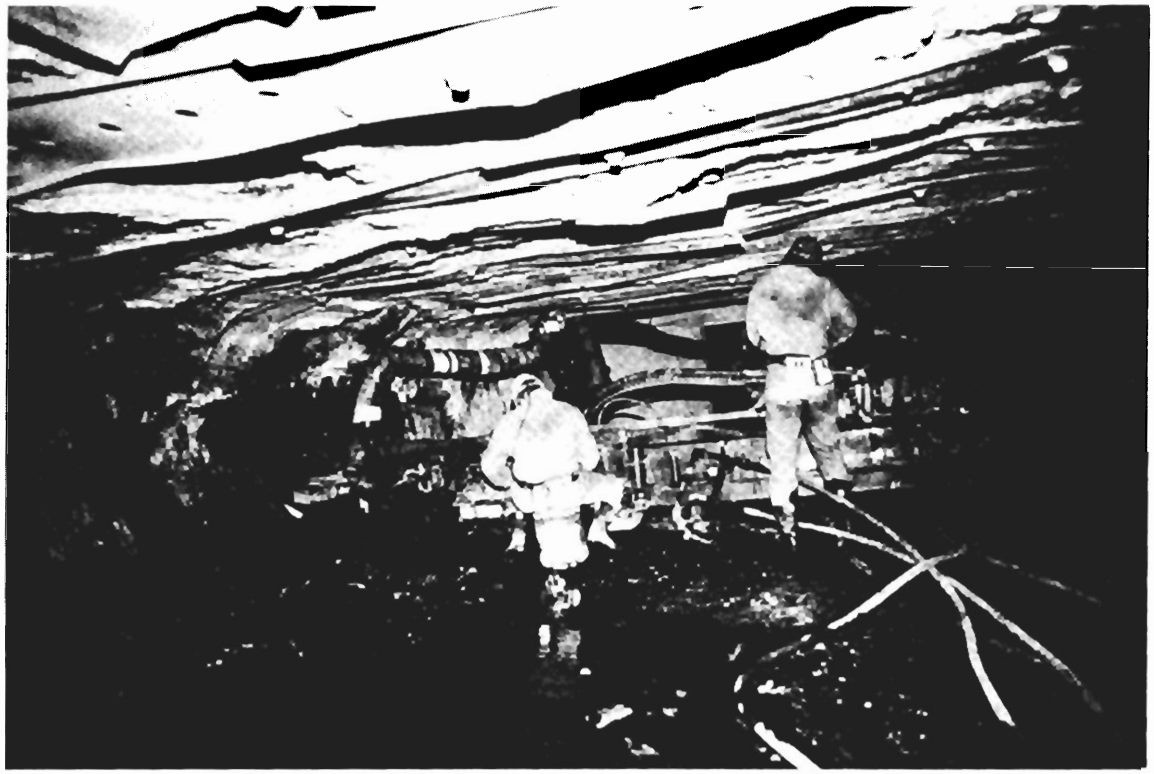

FIGURE 3. - Horizontal drilling at Sunnyside No. 1 mine.

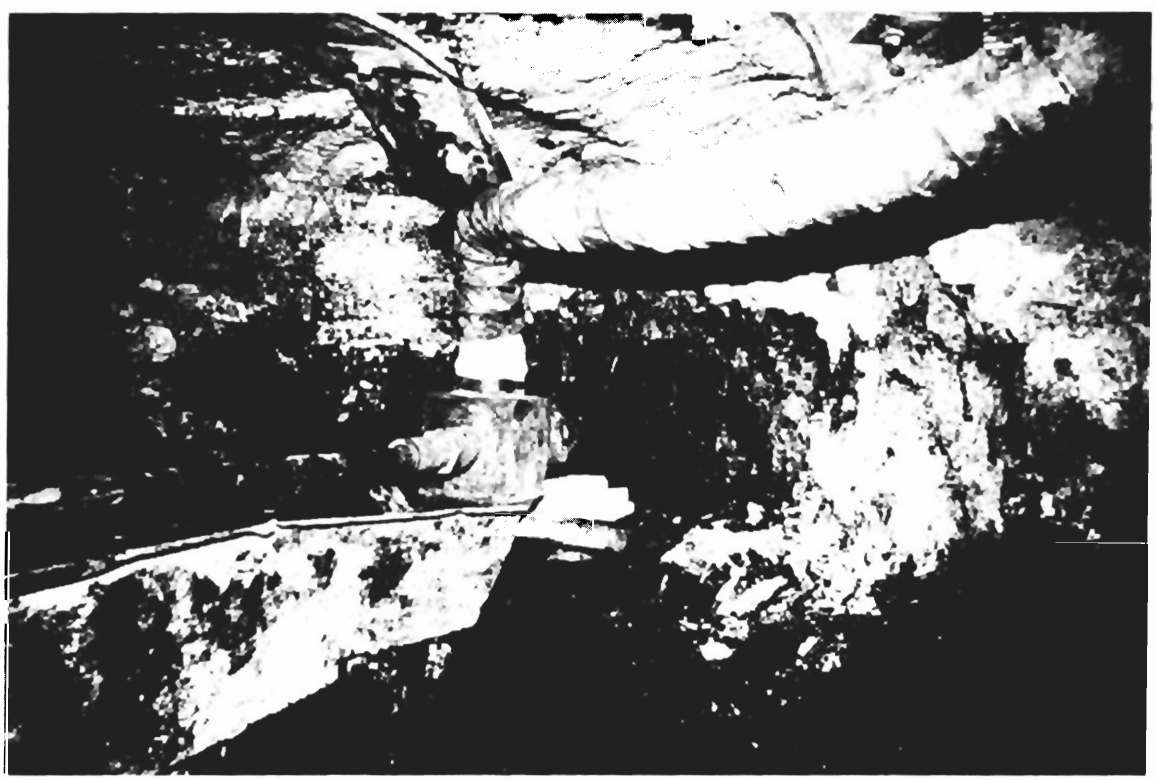

FIGURE 4. - Stuffing box and 4-inch valve on grouted pipe.

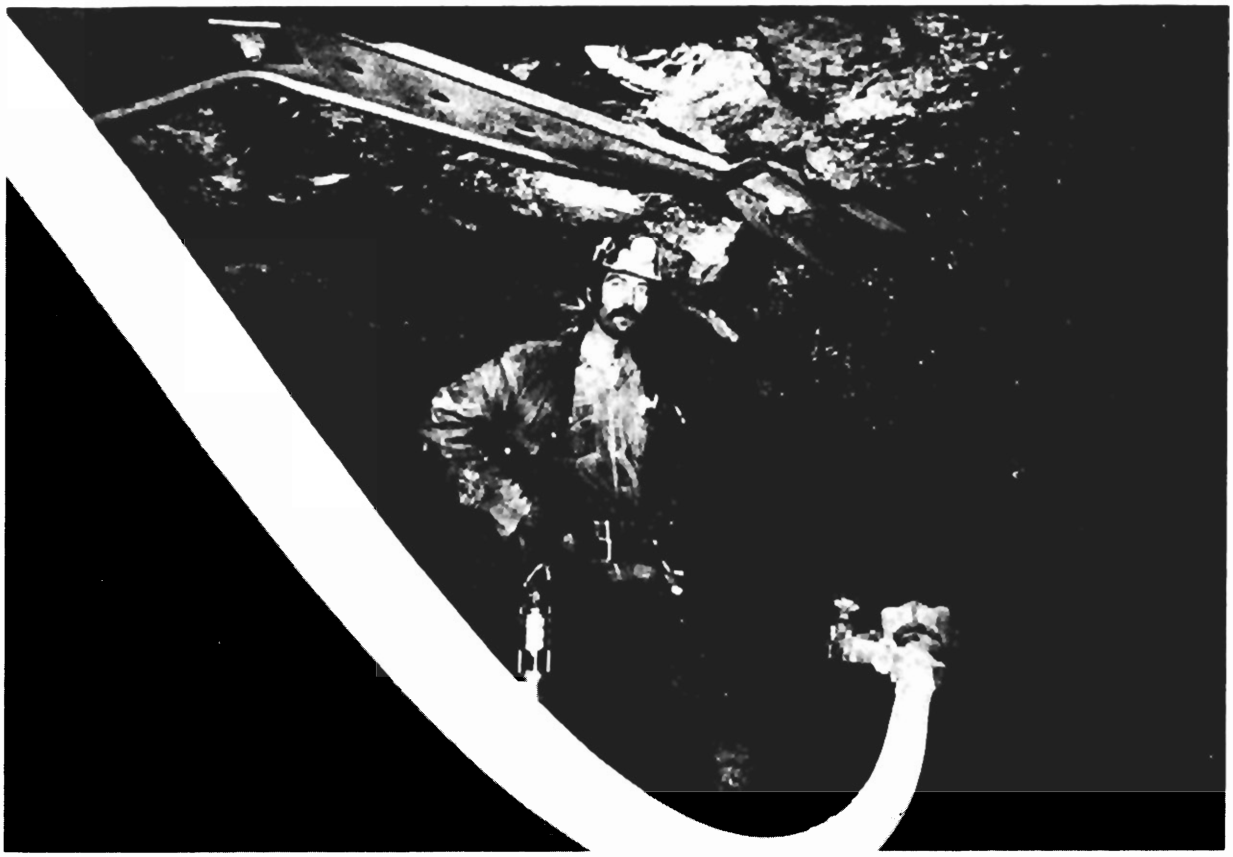

FIGURE 5. - Completed hole.

METHANE FLOW FROM THE HOLES

All methane and air volume flows are reported at conditions existing at the mine. The elevation of the mine is about 6,150 feet above sea level, and the temperature of methane in the coalbed is about 52° F.

Hole 1

The quantity of methane produced from the first 180 feet of hole 1 was determined by measuring the increase in methane concentration in the return air (table 1). During the interval of drilling, methane was being diffused across the return entry. Measurements were made at ventilation station 1 (fig. 6). Prior to drilling, the methane concentration in the return was about 0.9 pct.

TABLE 1. - Ventilation data, station 1

(37,500 cfm air, 62.5-sq-ft area)

Hole depth, feet	CH_4, pct	CH_4 flow rate, cfd
0	0.85-0.90	472,500
150	.92- .90	491,400
180	1.05-1.1	580,500

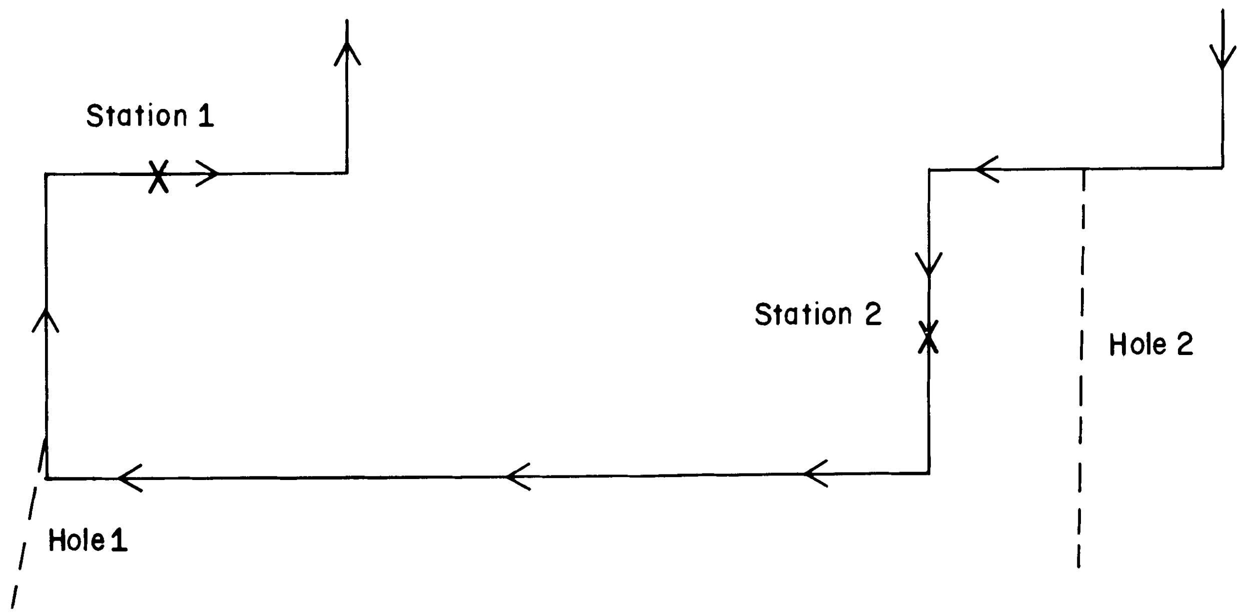

FIGURE 6. - Ventilation diagram of the face of 18 Dips.

A small quantity of methane was produced during the first 150 feet of drilling. The flow rate from the hole was 18,900 cfd (491,000 minus 472,500 cfd). During the next 30 feet of drilling, the methane flow rate increased dramatically from 18,900 to 108,000 cfd. The low flow from the first 150 feet of the hole is probably due to degasification by holes drilled earlier by the company. At 180 feet, drilling was suspended because the concentration of methane in the return had reached 1 pct. By increasing the flow of air to the section from 37,000 to 53,000 cfm and by ducting methane from the stuffing box directly into the 4-inch pipeline, the methane concentration in the return was reduced to about 0.8 pct. Drilling was resumed and continued to a depth of 430 feet. At this time, methane was leaking from the stuffing box, because the frictional resistance to flow in the 4-inch pipeline increased back pressure at the stuffing box. This leakage raised the methane levels in the return to 1 pct, and drilling was therefore terminated.

Hole 1 was closed in for 3 hours to monitor its gas pressure buildup. The maximum pressure was 13.5 psig. Immediately after the hole was permanently connected to the 4-inch pipeline, its initial flow was 160,000 cfd. After 34 days, the flow had declined to 69,000 cfd; after 5 months it was 60,000 cfd (fig. 7). Methane flows from the hole were determined by measuring the discharge velocity at the end of the pipeline in the return air shaft with an anemometer. This measured velocity was corrected to a true average velocity which was determined by a laboratory test with air flowing through a 4-inch-diam pipe. Because the anemometer is calibrated for air measurements, the pipeline flow measurements were also corrected for gas density (0.55 specific gravity) (5).

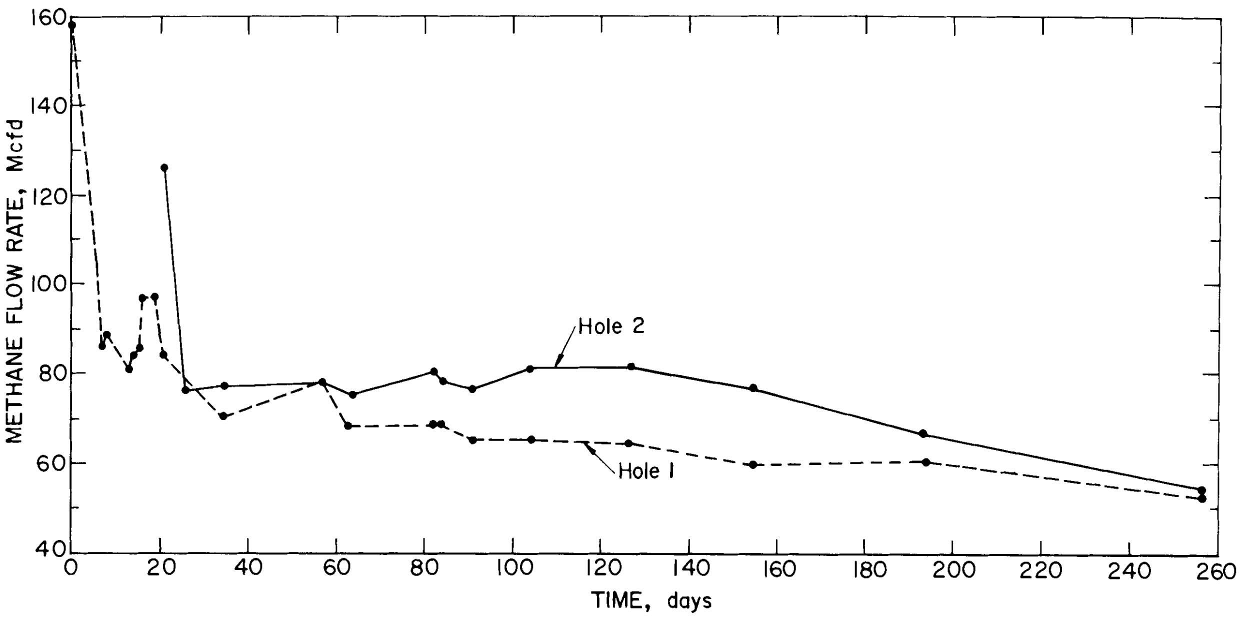

FIGURE 7. - Methane decline curves for holes 1 and 2.

Hole 2

Before hole 2 could be drilled, a second 4-inch-diam pipeline was laid from the drill site to the return air shaft. During the drilling phase, methane flow from the hole was discharged from the stuffing box directly into the pipeline.

Flows from this hole were measured in the same way as for hole 1. The first 100 feet of hole produced little gas because it parallels an adjacent entry (fig. 2). At a depth of 190 feet, gas production increased to 49,000 cfd and at 360 feet it was 58,000 cfd. At the final depth of 450 feet, the gas flow was 127,000 cfd.

Fourteen days after completion of hole 2, its flow declined from 127,000 to 77,000 cfd. For 5 months the flow has remained near 77,000 cfd (fig. 7). Waterflow from hole 2 is negligible. Table 2 gives the composition of the gas from both holes.

TABLE 2. - Analyses of gas from holes 1 and 2 at 18 Dips

Composition	Hole 1	Hole 2
Methane..........................pct..	99.24	99.24
Ethane...........................pct..	0.28	0.08
Propane..........................pct..	0.03	0.03
Oxygen...........................pct..	0	0.60
Nitrogen.........................pct..	0.65	0.30
Carbon dioxide...................pct..	0	0
Btu..................................	1,005	1,009
Specific gravity.....................	0.56	ND

ND Not determined.

GAS EMISSIONS FROM FACES

The two holes drilled in advance of the section isolate the coal between them and prevent methane from entering this region from the left and right. In the direction of the holes, methane that is flowing toward the faces will be diverted to one of the holes before reaching the mine opening (2). Consequently, gas flow through the faces of the section declines (fig. 8), but not as dramatically as expected.

After completion of hole 1, face flows declined rapidly from a value of about 160 to 100 cfm after 15 days (fig. 8). Hole 2 appears to have had little or no effect on methane face flows. Over a 4-month period, face flows have remained between 90 and 100 cfm. This lack of effect is difficult to explain.

Gas-bearing strata are known to exist above and below the Upper Split of the Lower Sunnyside coalbed. A gassy 2-foot-thick rider seam exists within 2 feet of this coalbed. Methane is encountered during roof bolting. In the floor, the Lower Split of the coalbed (4 to 5 feet thick) is within 2 to 3 feet of the Upper Split of the coalbed. Methane has been observed bubbling through water near the faces of the section. The effect of these methane sources on flows at the faces of the section is unknown. Geological studies are being conducted to obtain a better understanding of the location and effects of the gas-bearing strata.

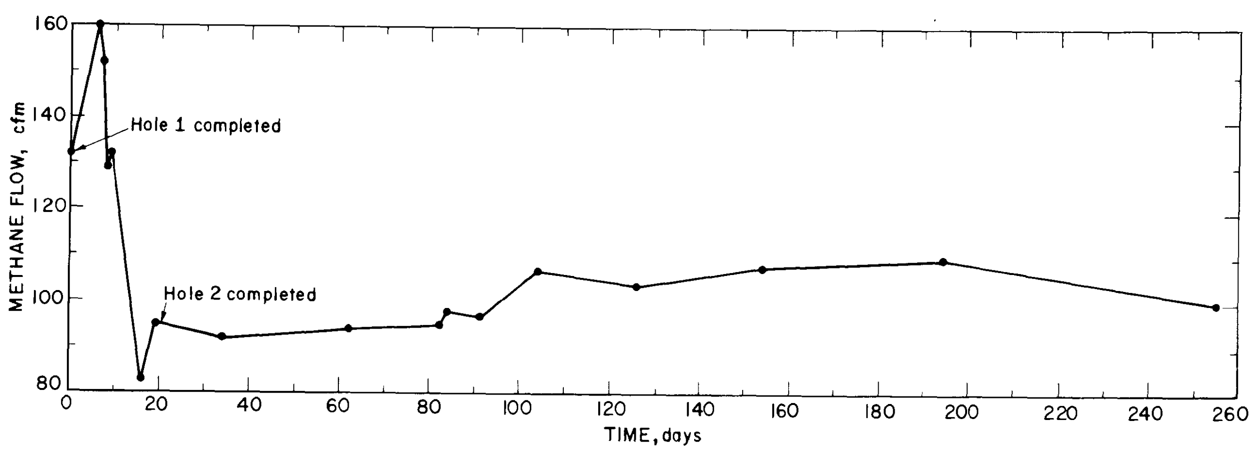

FIGURE 8. - Methane flows through face.

SUMMARY

The two holes drilled in 18 Dips have proved effective in draining commercial-quality methane from the Upper Split of the Lower Sunnyside coalbed. During 9 months of degasification 35 MMcf of methane, with an average heat value of 1,007 Btu, has been removed from the coalbed. Kaiser Steel Co. is now making plans to utilize this gas at its facilities.

The 40-pct reduction in the emission of methane from the face was not as great as expected. Additional methane is entering 18 Dips from coalbeds above and below the Upper Split of the Lower Sunnyside coalbed. The geology of these coalbeds is under investigation, and the results may clarify the effects of these methane-bearing strata on face flows.

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