RI 8675

Bureau of Mines Report of Investigations/1982

Degasification Study From an Air Shaft in the Beckley Coalbed

By Tobias W. Goodman, Joseph Cervik,
and George N. Aul

UNITED STATES DEPARTMENT OF THE INTERIOR

Report of Investigations 8675

Degasification Study From an Air Shaft in the Beckley Coalbed

By Tobias W. Goodman, Joseph Cervik, and George N. Aul

UNITED STATES DEPARTMENT OF THE INTERIOR
James G. Watt, Secretary

BUREAU OF MINES
Robert C. Horton, Director

This publication has been cataloged as follows:

Goodman, T. W. (Tobias W.)
Degasification study from an air shaft in the Beckley Coalbed.

(Report of investigations ; 8675)

Bibliography: p. 17.

Supt. of Docs. no.: I 28.23:8675.

1. Coal mines and mining–Safety measures. 2. Methane. 3. Mine ventilation. I. Cervik, Joseph. II. Aul, G. N. (George N.). III. Title. IV. Series: Report of investigations (United States. Bureau of Mines) ; 8675.

TN23.U43 [TN295] 622s [622'.8] 82-600098 AACR2

CONTENTS

ILLUSTRATIONS

TABLES

DEGASIFICATION STUDY FROM AN AIR SHAFT IN THE BECKLEY COALBED

By Tobias W. Goodman,[1] Joseph Cervik,[2] and George N. Aul[3]

ABSTRACT

The Bureau of Mines conducted research to degasify a virgin block of coal in the Beckley Coalbed using long horizontal holes drilled in an array from the bottom of a ventilation air shaft. Eight horizontal holes and an in situ pressure hole were drilled in a radial pattern to depths ranging from 418 to 910 ft (127 to 277 m) and 205 ft (62 m), respectively.

The investigation showed the shaft was in a basin saturated with water, which resulted in low gas flows from holes. The in situ pressure at 200 ft (61 m) into the coalbed was 79 psig (544.6 KN/m^2). The average gas and water flows for the eight holes were 94,100 ft^3/day (2,665 m^3/day) and 13 gal/min (49.3 l/min). After 514 days of degasification, 18.7 million ft^3 (0.53 million m^3) of gas had been drained. Methane face emissions, which were measured as a section advanced toward the shaft, were reduced about 77 pct, emphasizing the value of drainage by this technique. All holes were grouted before the area around the shaft was mined.

---

[1]Mining engineer, Pittsburgh Research Center, Bureau of Mines, Pittsburgh, Pa.
[2]Supervisory geophysicist, Pittsburgh Research Center, Bureau of Mines, Pittsburgh, Pa.
[3]Geologist, Occidental Research Corp., Keen Mountain, Va.

INTRODUCTION

Commercial quantities of methane have been produced by using horizontal holes drilled into virgin coal from the bottom of shafts in the Pittsburgh Coalbed; average flow rates were between 120 and 150 ft^3/day (11.1 and 13.8 m^3/day) per foot (meter) of hole for 2-1/2 to 3 years (3-4).[4] The drilling techniques and equipment used at these sites were described earlier (2).

The Pittsburgh and Beckley Coalbeds are similar. Both are blocky-type coals having well-developed cleats and high fracture permeability. A geological study of the Beckley Coalbed (7) showed that coalbed water that collected in the regional syncline at the Maple Meadow Mine might fill the cleat spaces and prevent natural degasification.

The study described herein was carried out by the Bureau of Mines to degasify a portion of the Beckley Coalbed and to determine the effects of degasification on methane flows during mining.

ACKNOWLEDGMENTS

The cooperation of Doug Tolley (Manager of Mines, Cannelton Industries, Inc., Montgomery, W. Va.) and of Dick Busick (superintendent) and Arnold Keaton (chief engineer) of the Maple Meadow Mining Co., Fairdale, W. Va., is greatly appreciated.

EXPERIMENTAL PROGRAM

Description of Study Area

The degasification site was the No. 2 shaft located in a projected set of five entries at the Maple Meadow Mine in the Beckley Coalbed (fig. 1). The concrete-lined shaft, 24 ft (7.3 m) in diameter, is divided for intake and return air. At the shaft, the coalbed is 7 ft (2.1 m) thick and overburden is 800 ft (244 m).

The stratigraphic column is sandstones (sometimes crystallized) and shales (fig. 2). Geological features reported during mining include sand channels, washovers, and splits (fig. 3). Grades of 20 to 30 ft (6.1 to 9.1 m) per 100 ft (30.5 m) are common. The genesis of these structures is attributed to a depositional environment.

The dominant regional geological structure, the Pineville Syncline, is oriented in a NE-SW direction. The No. 2 shaft is located in the bottom of the syncline (7). Local bedding folds are common.

Drilling Procedure

A 30-hp (223.8 × 10^2 W) electrohydraulic drill (fig. 4) was used to drill the holes. The drilling hardware included 3-1/2-in (8.9-cm) drag and rollercone bits, a one-way check valve, an 18-ft (5.5-m) NQ drill collar, spiral centralizers, and BQ drill rods (figs. 5 and 6).

[4]Underlined numbers in parentheses refer to items in the list of references preceding the appendixes.

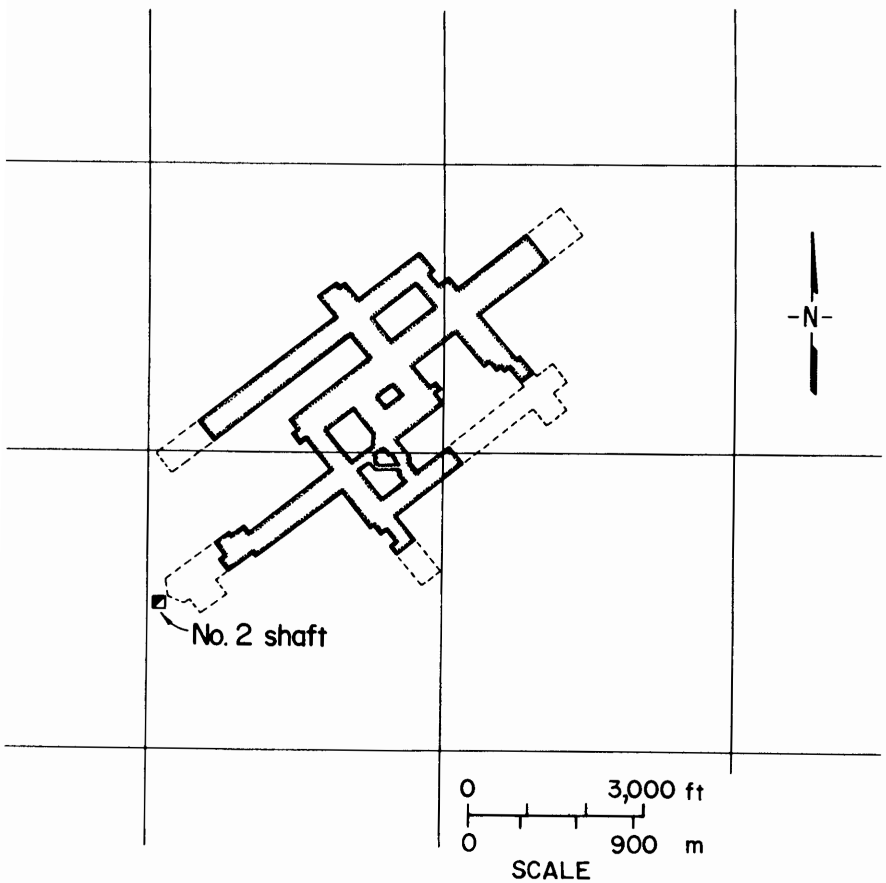

FIGURE 1. - Degasification site.

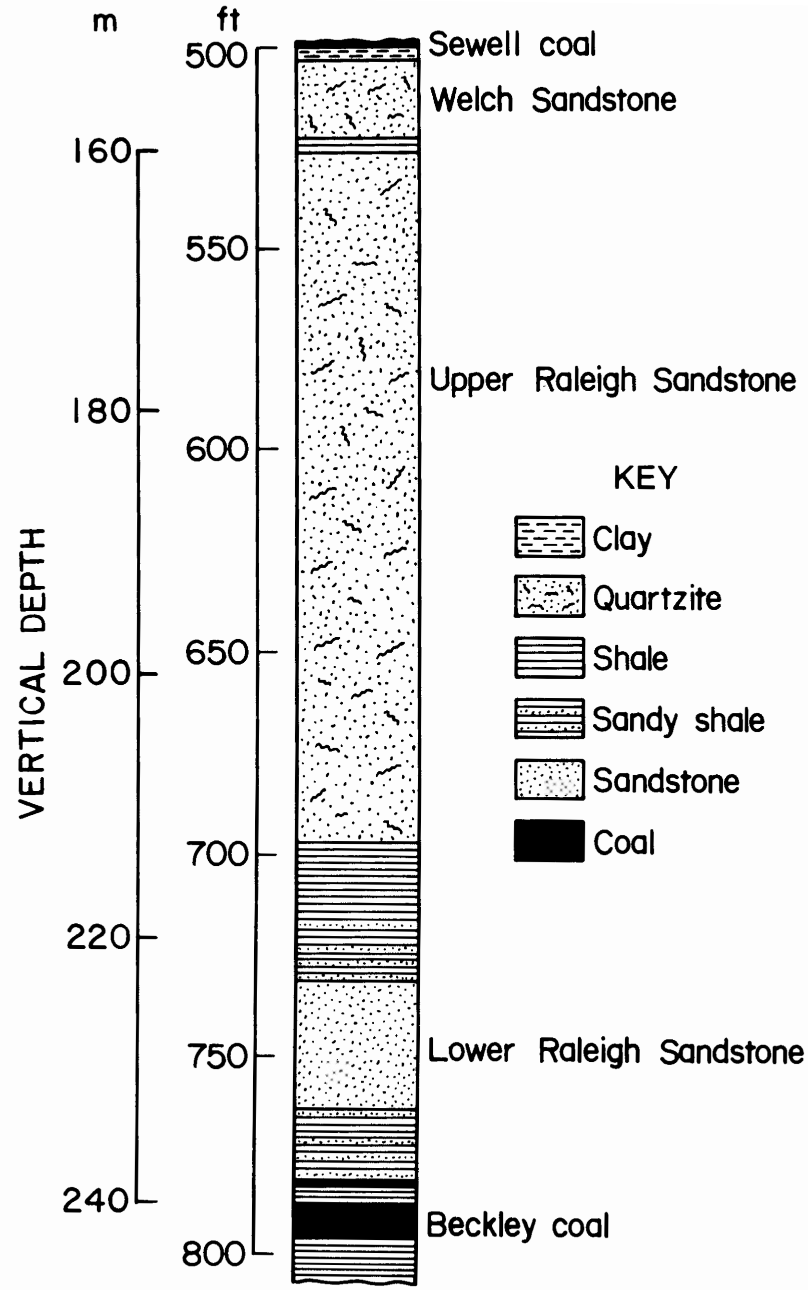

FIGURE 2. - Stratigraphic column above Beckley Coalbed.

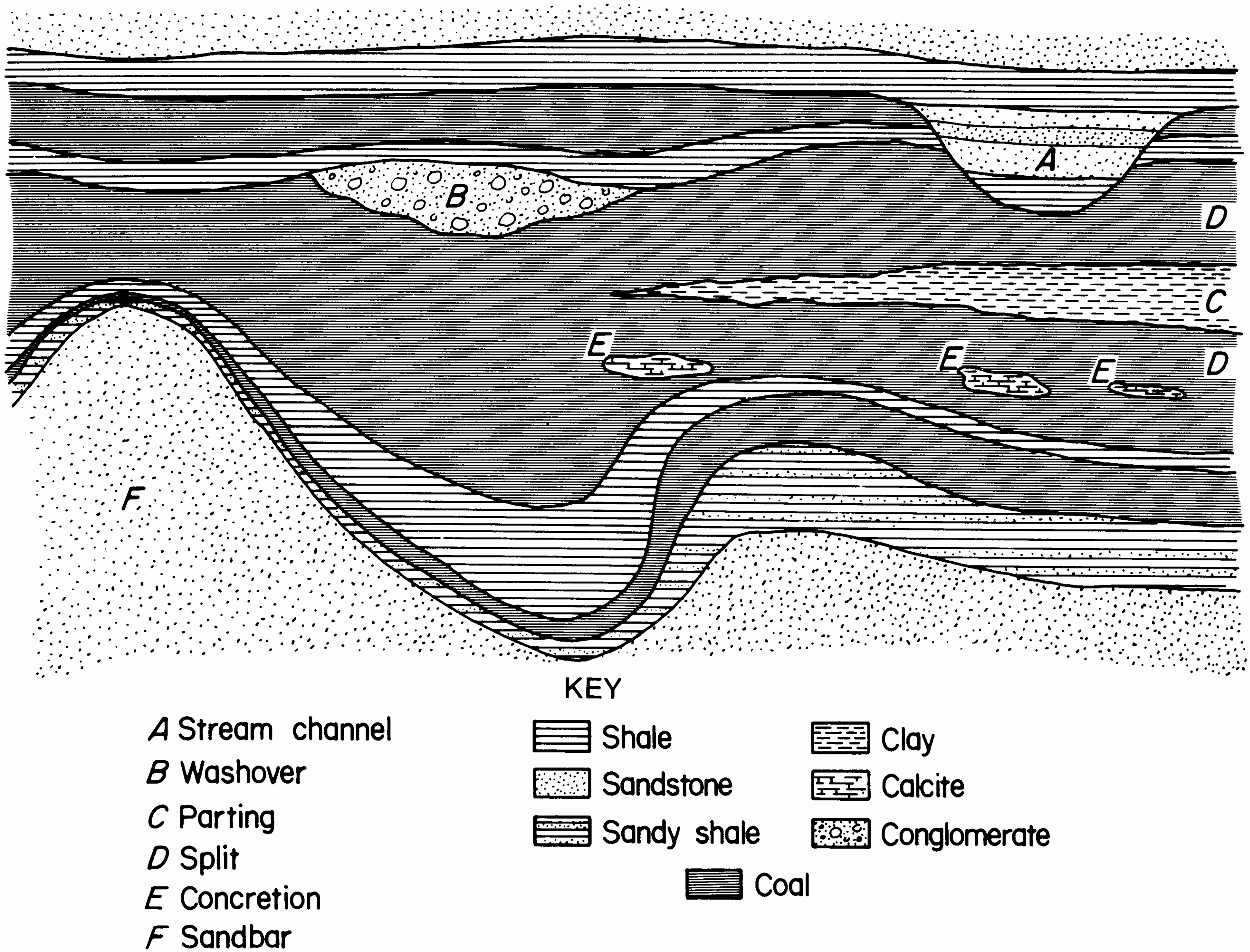

FIGURE 3. - Geological features in Beckley Coalbed.

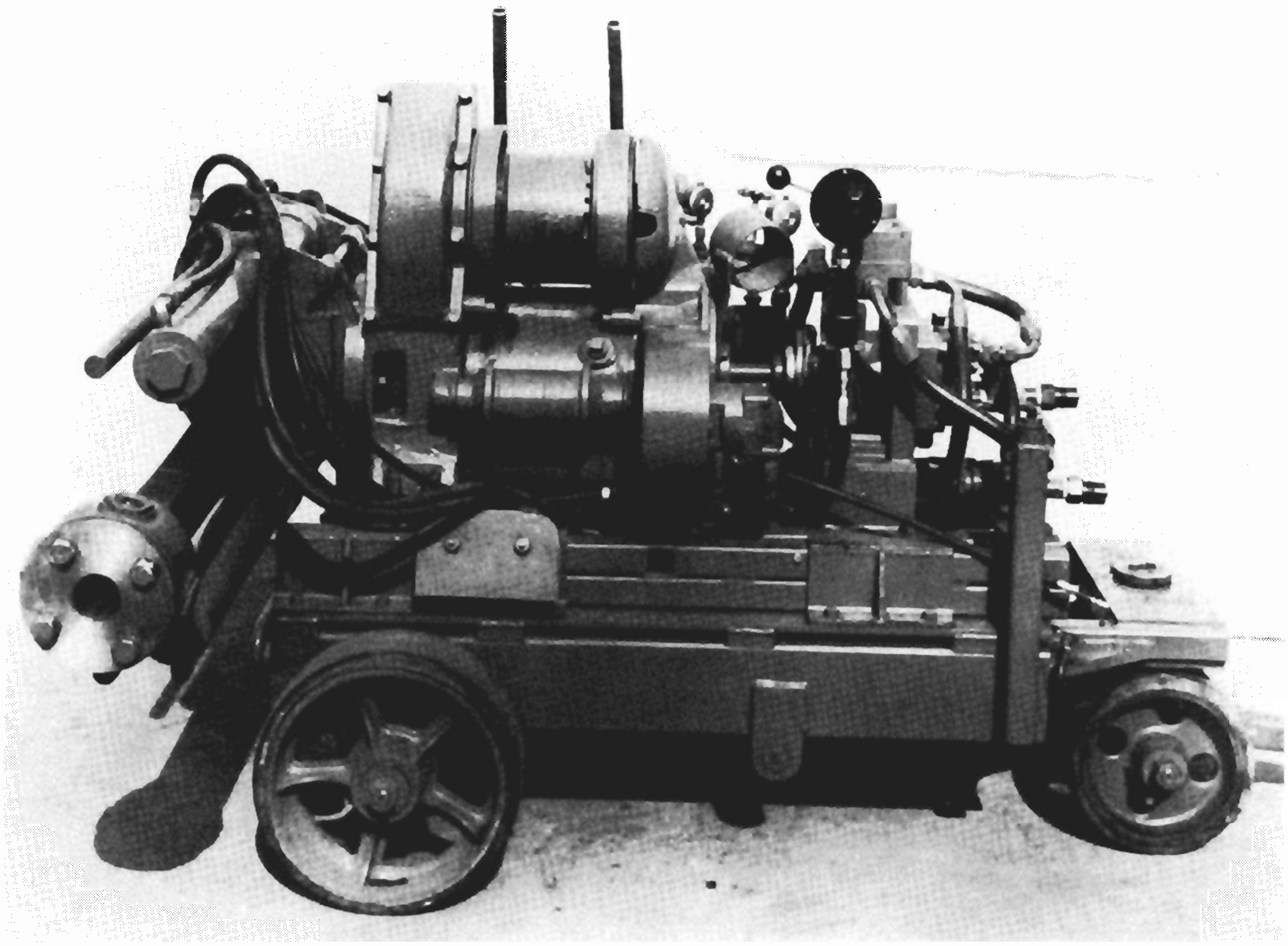

FIGURE 4. - Electrohydraulic drill.

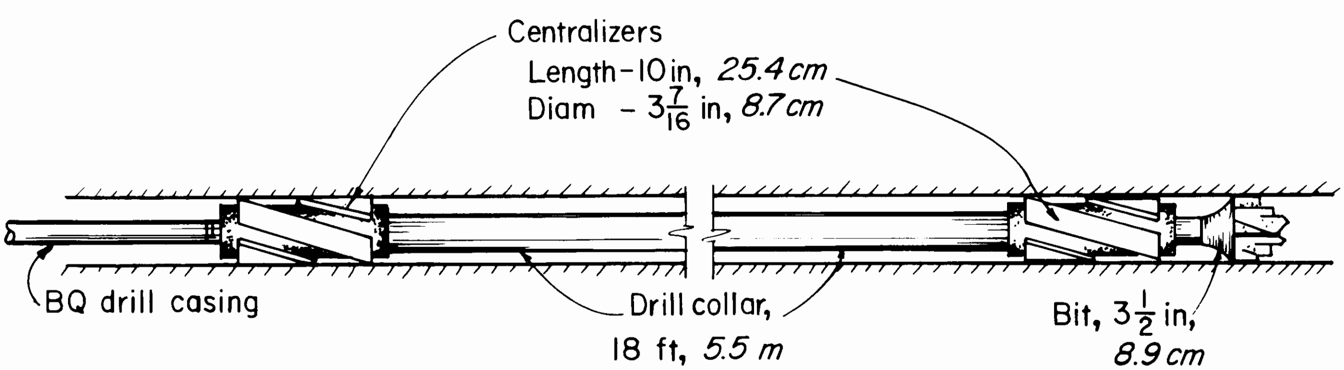

FIGURE 5. - Drilling assembly, standard.

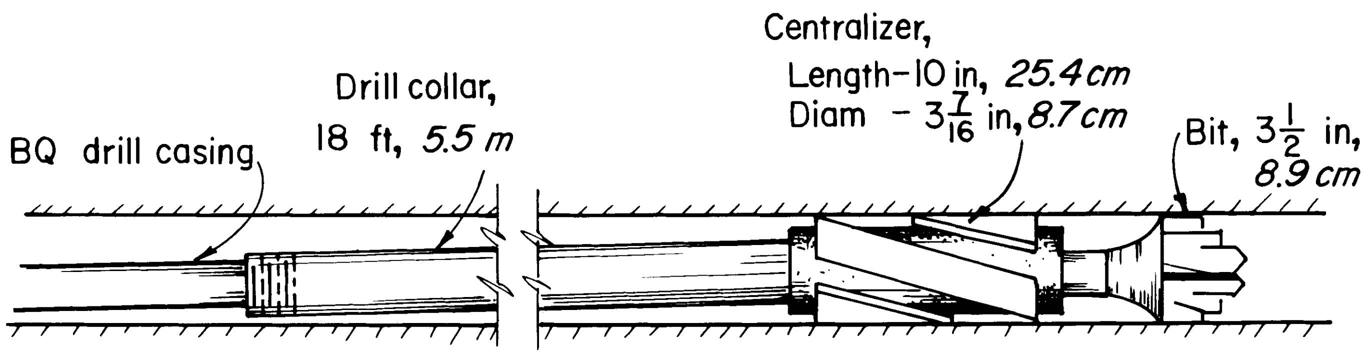

FIGURE 6. - Drilling assembly, modified.

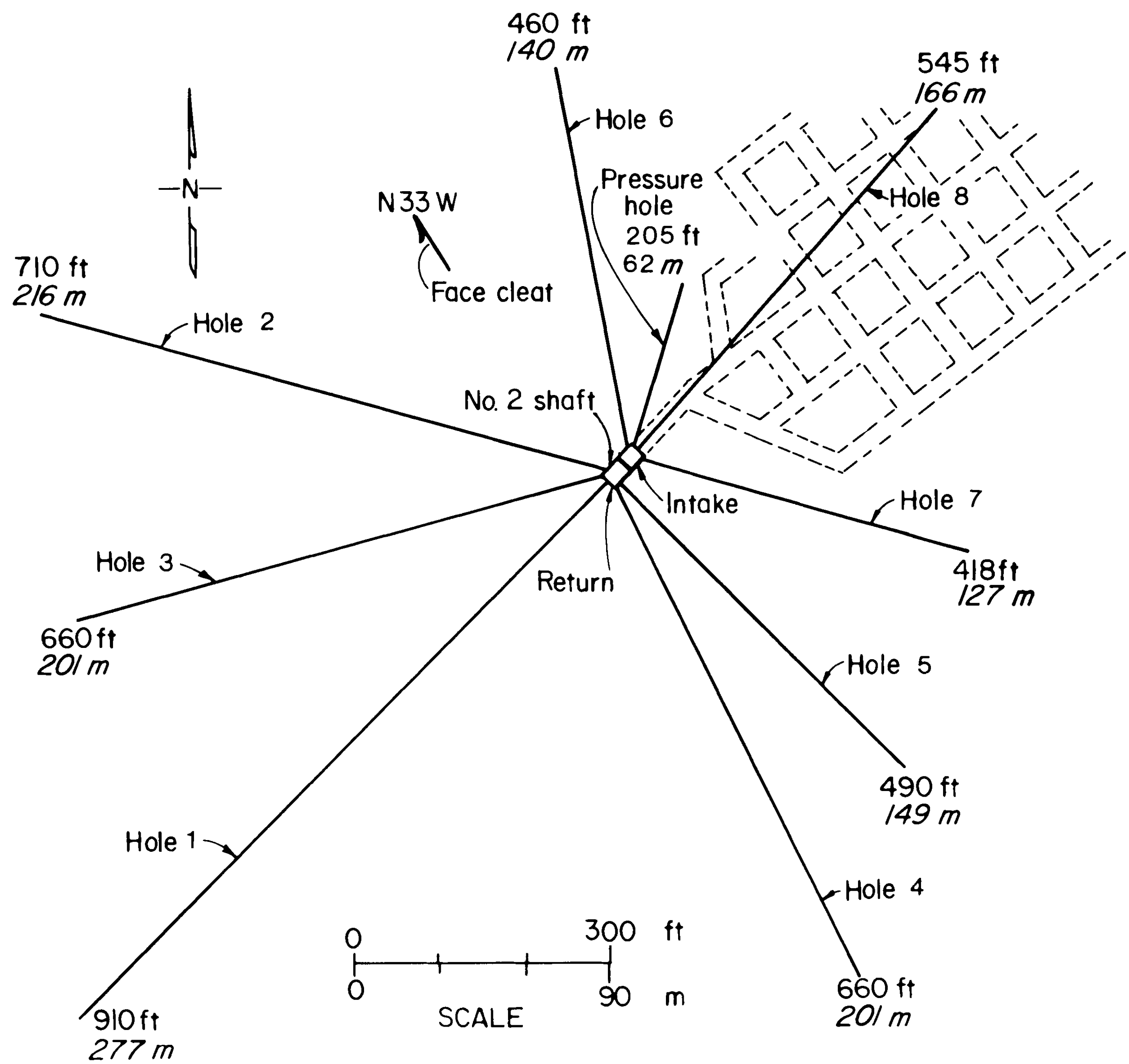

FIGURE 7. - Location and length of holes and projected main entries.

First, a 20-ft (6.1-m), 4-in (10.2-cm) diameter steel pipe was grouted into the coalbed. Then, a Bureau-designed stuffing box and a 4-in (10.2-cm) full-port valve were attached to the steel pipe. The stuffing box separates gas from water and drill cuttings during drilling. Flexible tubing ducts the methane from the separator to a 4-in (10.2-cm) diameter vertical steel pipe in the return side of the shaft. The methane was discharged into the atmosphere at the surface. The 30-ft (9.1-m) venting stack, equipped with a flame arrestor, was grounded.

A Sperry-Sun single-shot survey instrument was used to measure vertical bit inclination every 20 to 40 ft (6.1 to 12.2 m) during drilling. After each hole was completed, its location was determined in the azimuth plane and then plotted on mine maps. Figure 7 shows the location and length of each hole drilled from the shaft.

Several drilling techniques were used during the study to vary the bit response. These include changes in drilling parameters (thrust and rotational speed) and in the drilling assembly. The standard assembly (2), bit plus centralizer plus 18-ft (5.5-m) drill collar plus centralizer (fig. 5), was used to start holes 3, 4, and 6. A four-wing drag bit with a 10-ft (3.0-m) NW drill collar, substituted in the standard assembly to drill hole 7, was found to be uncontrollable. A modified assembly in which the rear centralizer is removed (fig. 6) from the standard assembly was used to start holes 1, 2, and 5 (5).

Underground Pipeline

As each hole was completed it was connected by 2-in (5.1-cm) steel pipe to the vertical steel pipeline in the return side of the shaft. The piping arrangement included a valve, a gas-water separator tank, a venturi meter (for making gas flow readings), and a second gas-water separator directly beneath the vertical steel pipeline.

A methane-monitoring system (6) was installed to detect leaks that might occur in the pipeline. Sensors were positioned at the top and bottom in the return side of the shaft. Air-actuated shutoff valves were connected to each hole and pressurized by a 1-ft^3/min (0.028-m^3/min) compressor located at the surface. The valves close automatically when the methane monitors detect more than 1.5 pct methane.

Gas Analysis

Tests conducted in the Pittsburgh Coalbed at the Federal No. 2 Mine (3-4) have shown that coalbed gas can be substituted for natural gas. Table 1 compares the average composition of gas liberated from the eight holes drilled at the No. 2 air shaft with that of the previous studies.

Table 1. - Comparative gas analysis, pct

Coalbed	Ethane	Carbon dioxide	Oxygen	Nitrogen	Methane
Pittsburgh (multipurpose borehole)	0.16	9.06	0.34	1.24	89.10
Pittsburgh [18-ft (5.5-m) diam. shaft]........................	.05	10.7	.12	0	88.6
Beckley (No. 2 air shaft).........	0	.01	.16	3.12	96.71

RELATIONSHIP BETWEEN DATA OBTAINED FROM HORIZONTAL DRILLING AND THE GEOLOGY OF THE COALBED

A contour map of the Beckley Coalbed, based on data obtained from surface exploratory diamond drill holes irregularly spaced at 500- to 2,000-ft (152.4- to 609.6-m) intervals, was available when drilling started. This generalized structure map (fig. 8) shows that the No. 2 shaft is located in a synclinal trough which trends in the NE-SW direction. The maximum dip of the coalbed along the flanks of the syncline is less than 2° (0.035 rad).

Figures 9 and 10 show the hole trajectories in the vertical plane for the eight holes drilled. A contour map was drawn based on these sections by evaluating the differences in elevation between the collars of the holes and contacts with the roof and floor rock along the lengths of the holes (fig. 11). This map, which adds refinements to figure 8, shows several rolls in the area east of the shaft. The trough of the syncline is rotated and trends in a N-S direction, in contrast to figure 8. Dips northeast of the shaft are greater than 2° (0.035 rad).

After the areas around the shaft had been mined, a contour map based on the elevation surveys in these entries was constructed (fig. 12). Close agreements exist between figures 11 and 12. Figure 13 shows final refinement of geological structure around the shaft.

PATTERNS OF GAS AND WATER FLOWS

Gas and water flows from the individual holes are shown in figures 14 and 15. Average gas flows ranged from 3,400 ft^3/day (96.3 m^3/day) from hole 2 to 26,100 ft^3/day (739.4 m^3/day) from hole 6. Average water flows ranged from 0.2 gal/min (0.8 l/min) from hole 7 to 4.5 gal/min (17.1 l/min) from hole 1 (table 2).

Table 2. - Average gas and water flows

Hole	Hole length		Average gas production		Average water production	
	ft	m	ft^3/day	m^3/day	gal/min	l/min
1	910	277.4	4,800	136.0	4.5	17.1
2	710	216.4	3,400	96.3	2.0	7.6
3	660	201.2	19,500	552.4	1.4	5.3
4	660	201.2	8,400	238.0	1.8	6.8
5	490	149.4	8,200	232.2	1.4	5.3
6	460	140.2	26,100	739.4	1.0	3.8
7	418	127.4	5,500	155.8	.2	.8
8	545	166.0	18,200	515.6	.7	2.7

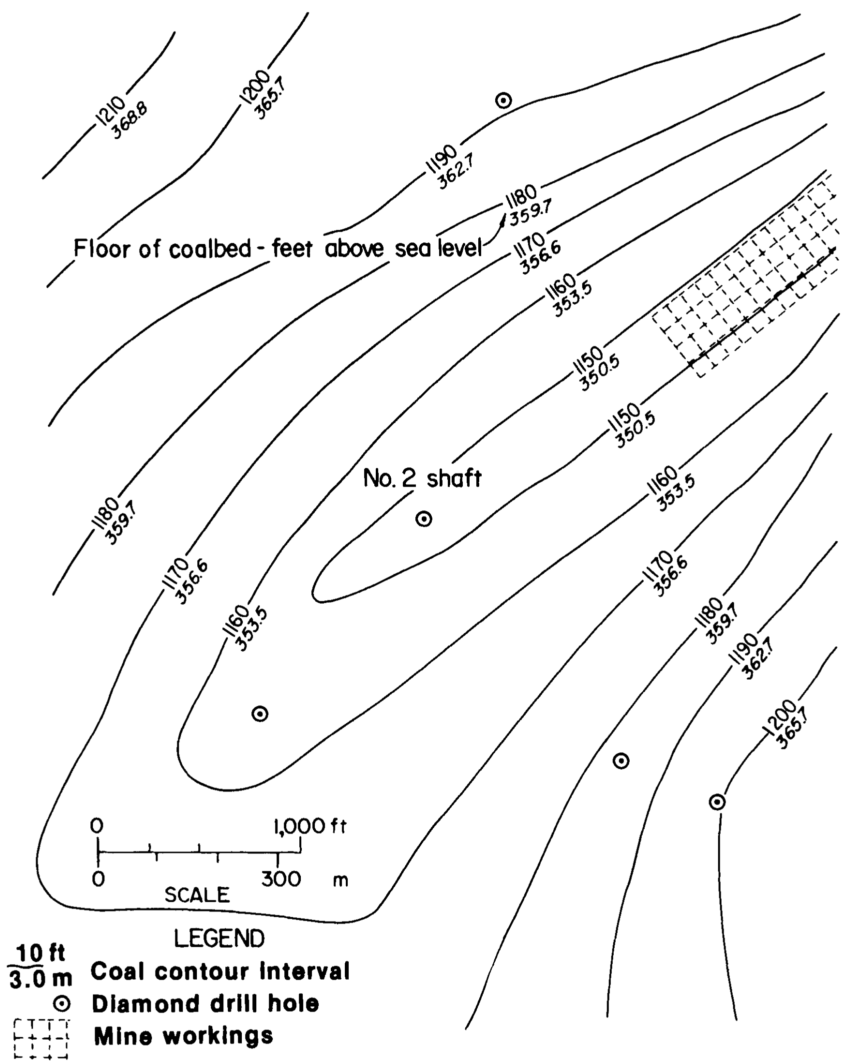

FIGURE 8. - Contour map of coalbed from vertical boreholes.

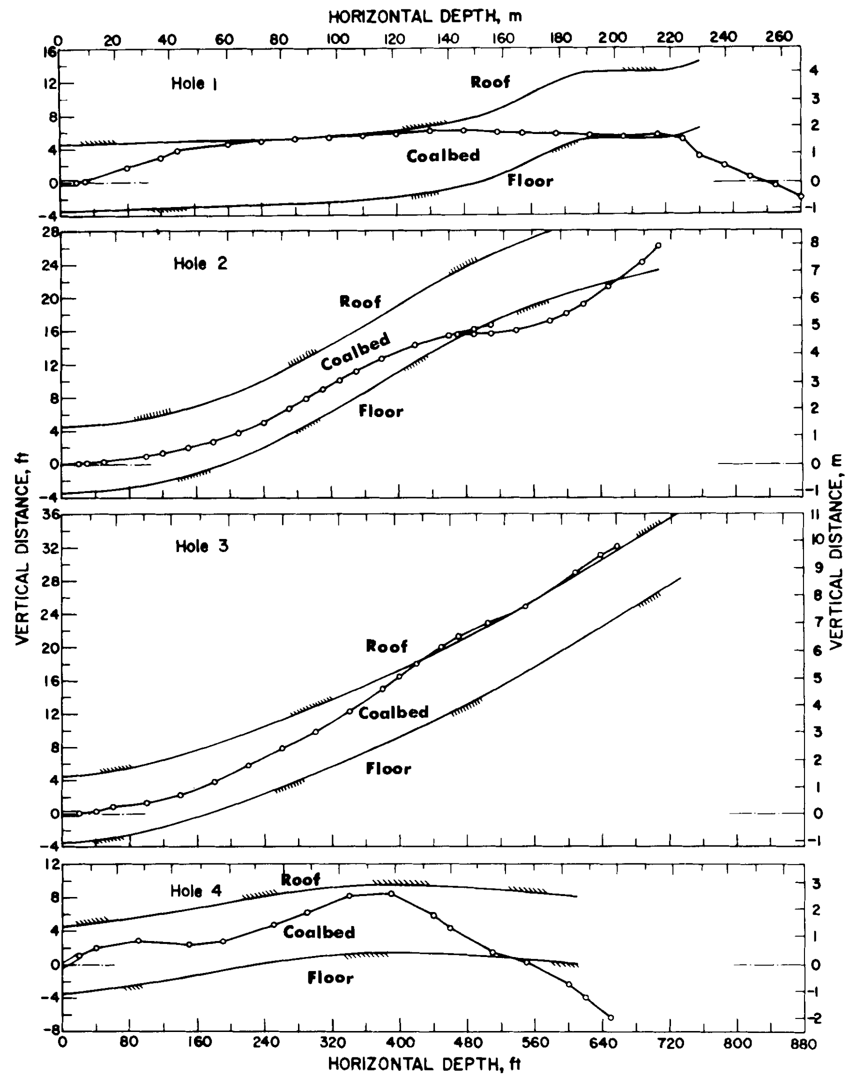

FIGURE 9. - Vertical sections of horizontal boreholes 1, 2, 3, and 4.

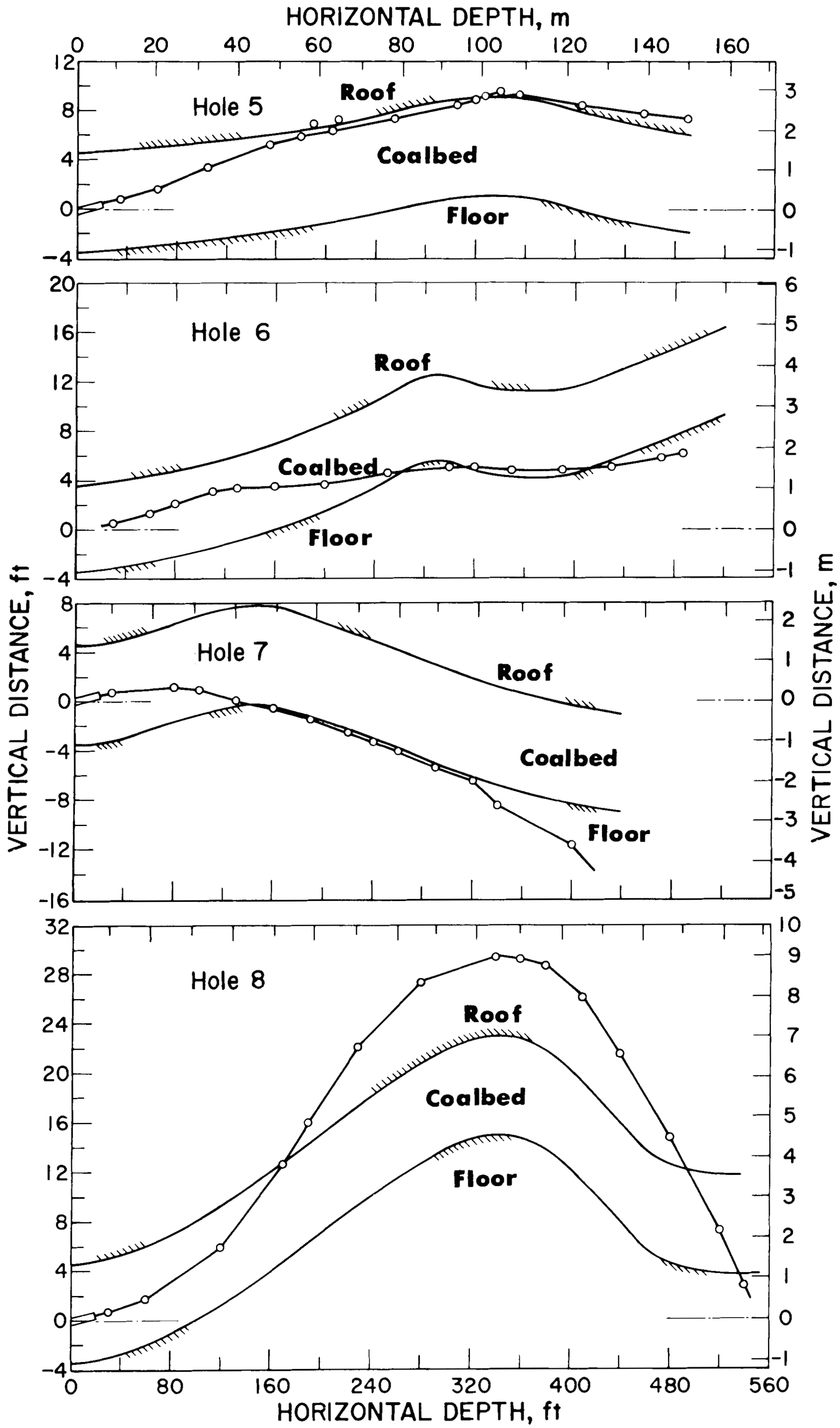

FIGURE 10. - Vertical sections of horizontal boreholes 5, 6, 7, and 8.

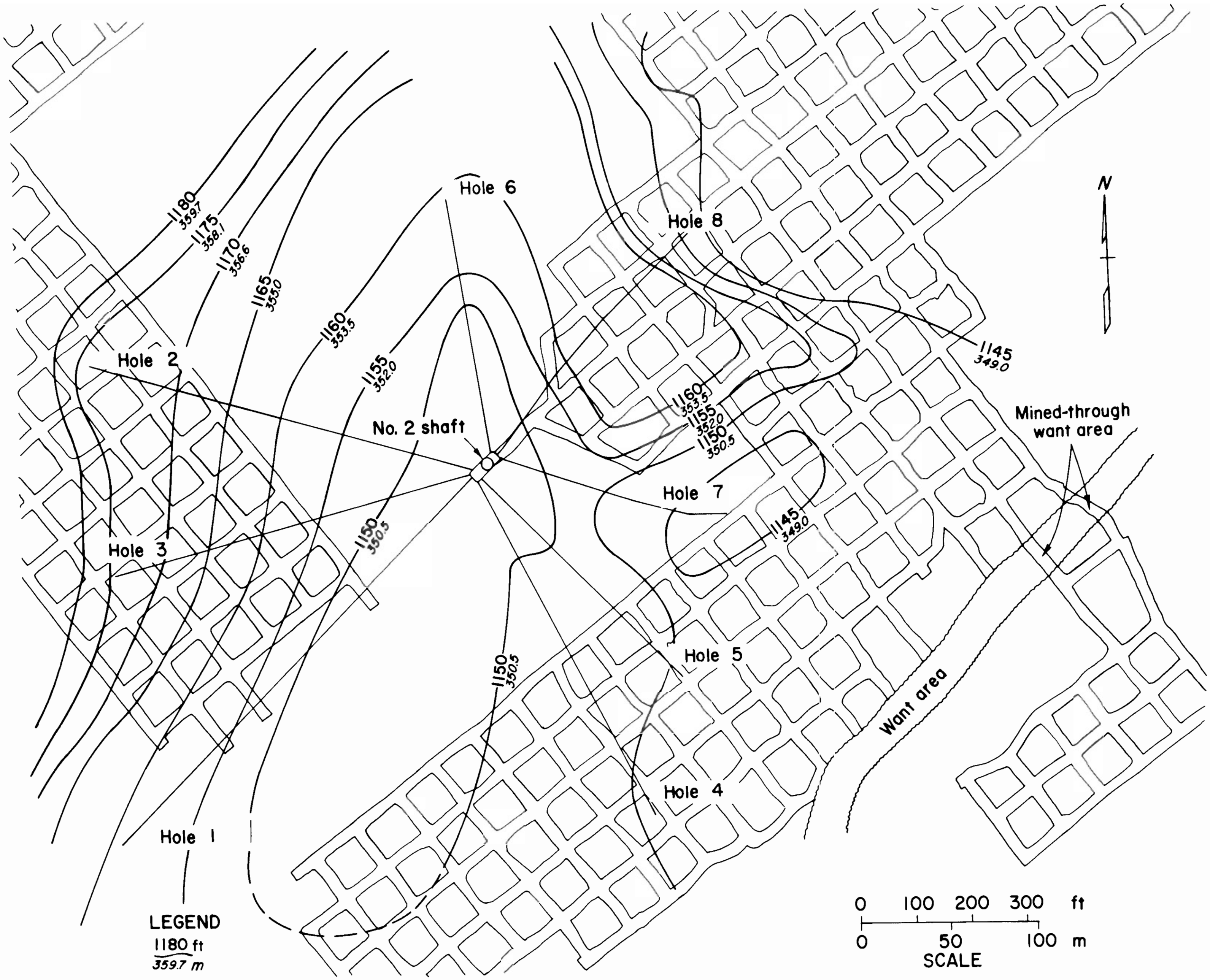

FIGURE 11. - Contour map of coalbed from horizontal boreholes.

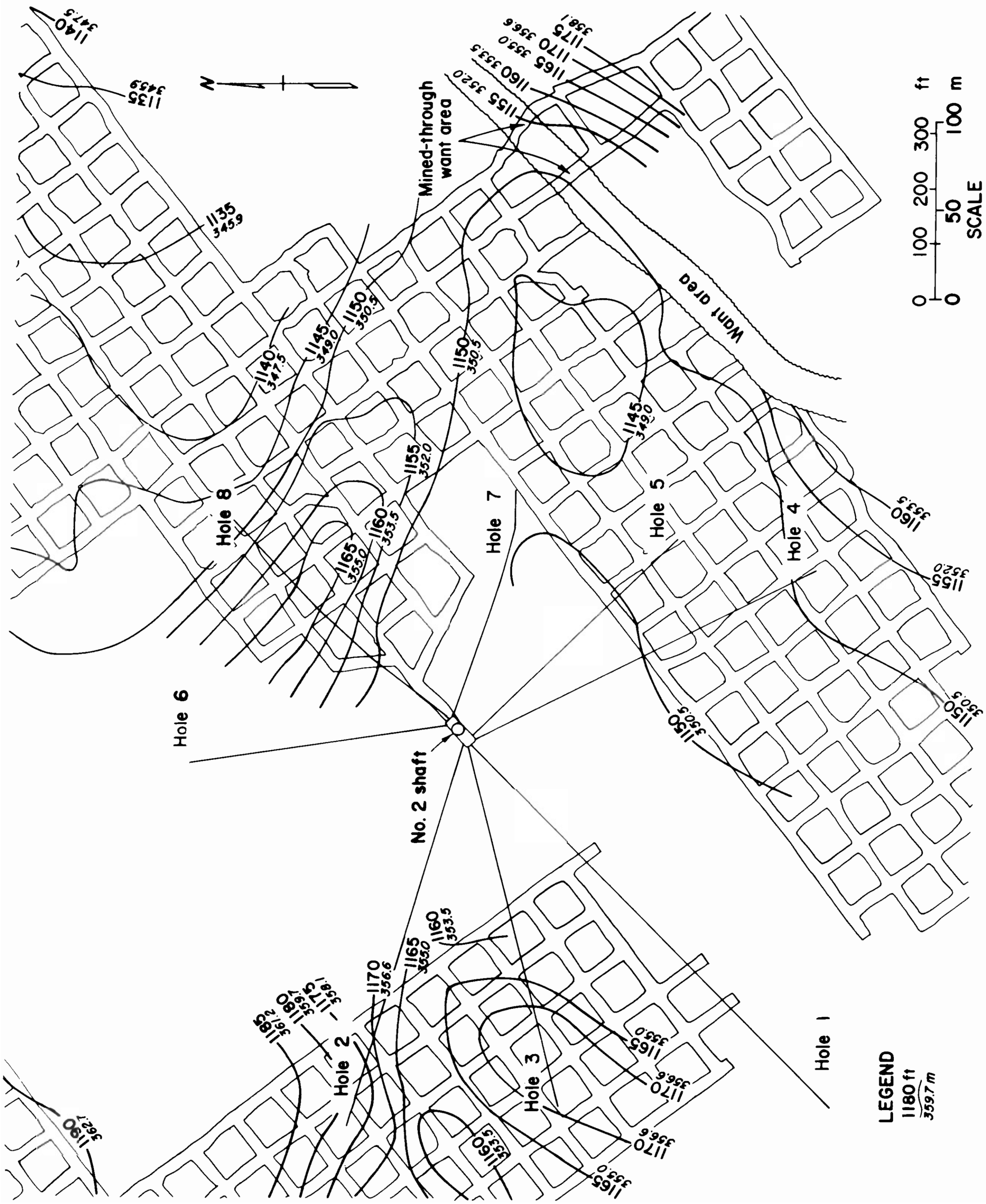

FIGURE 12. - Contour map of coalbed from level surveys.

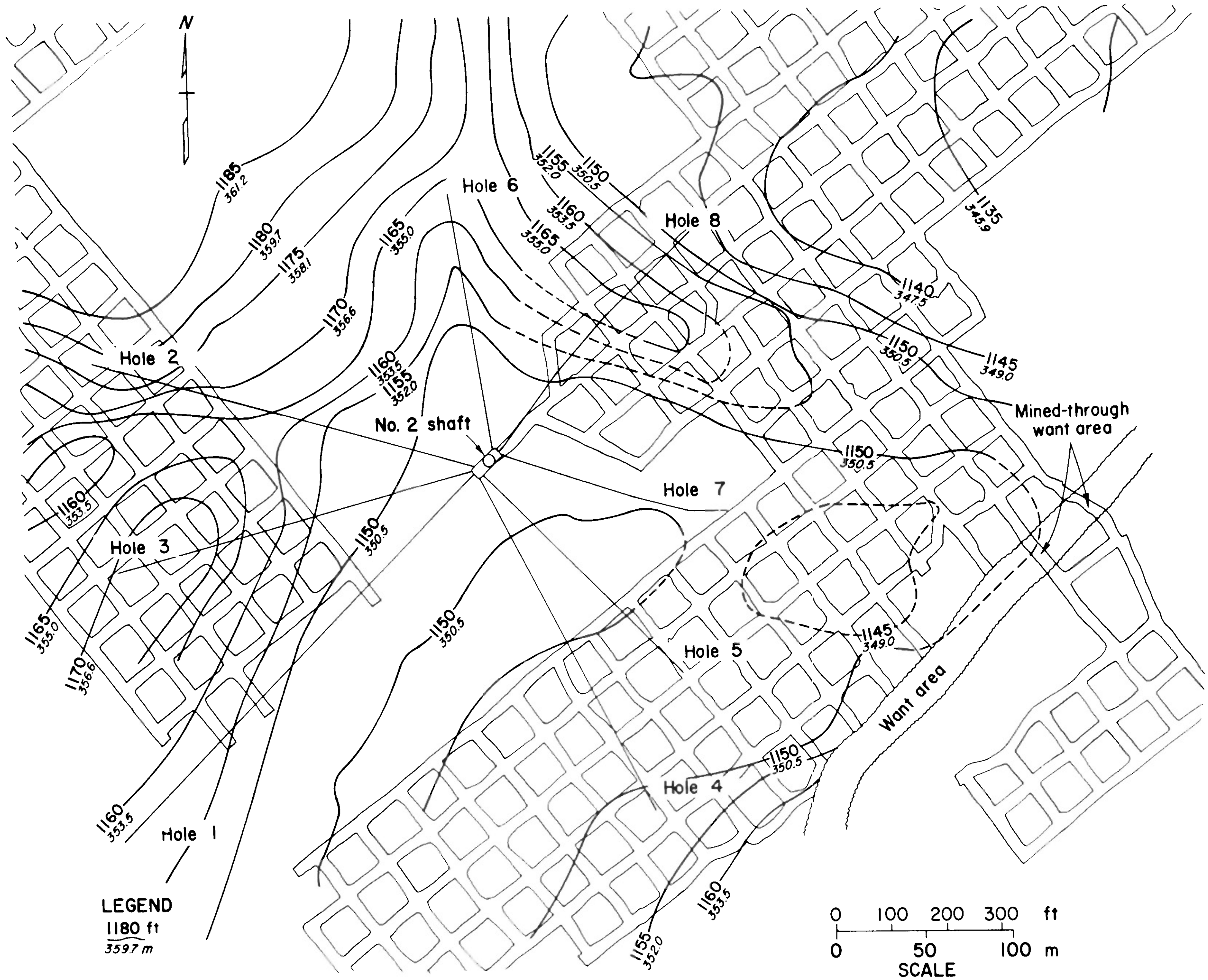

FIGURE 13. - Composite contour map.

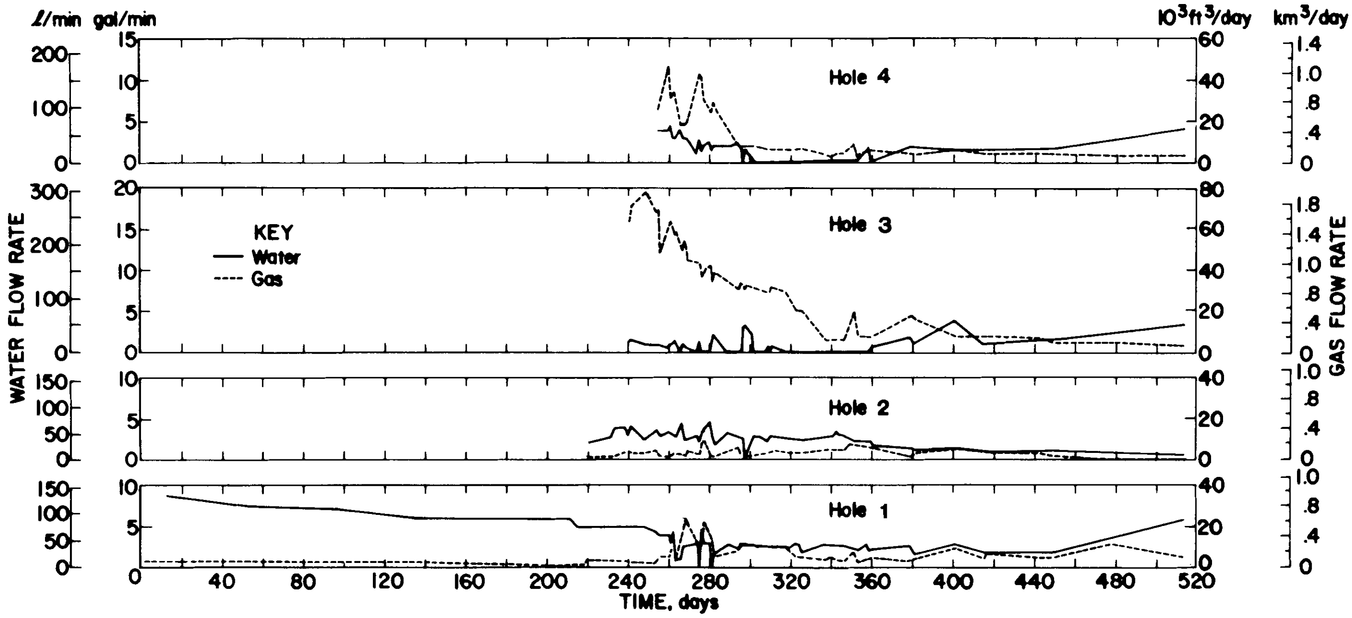

FIGURE 14. - Gas and water flows, holes 1, 2, 3, and 4.

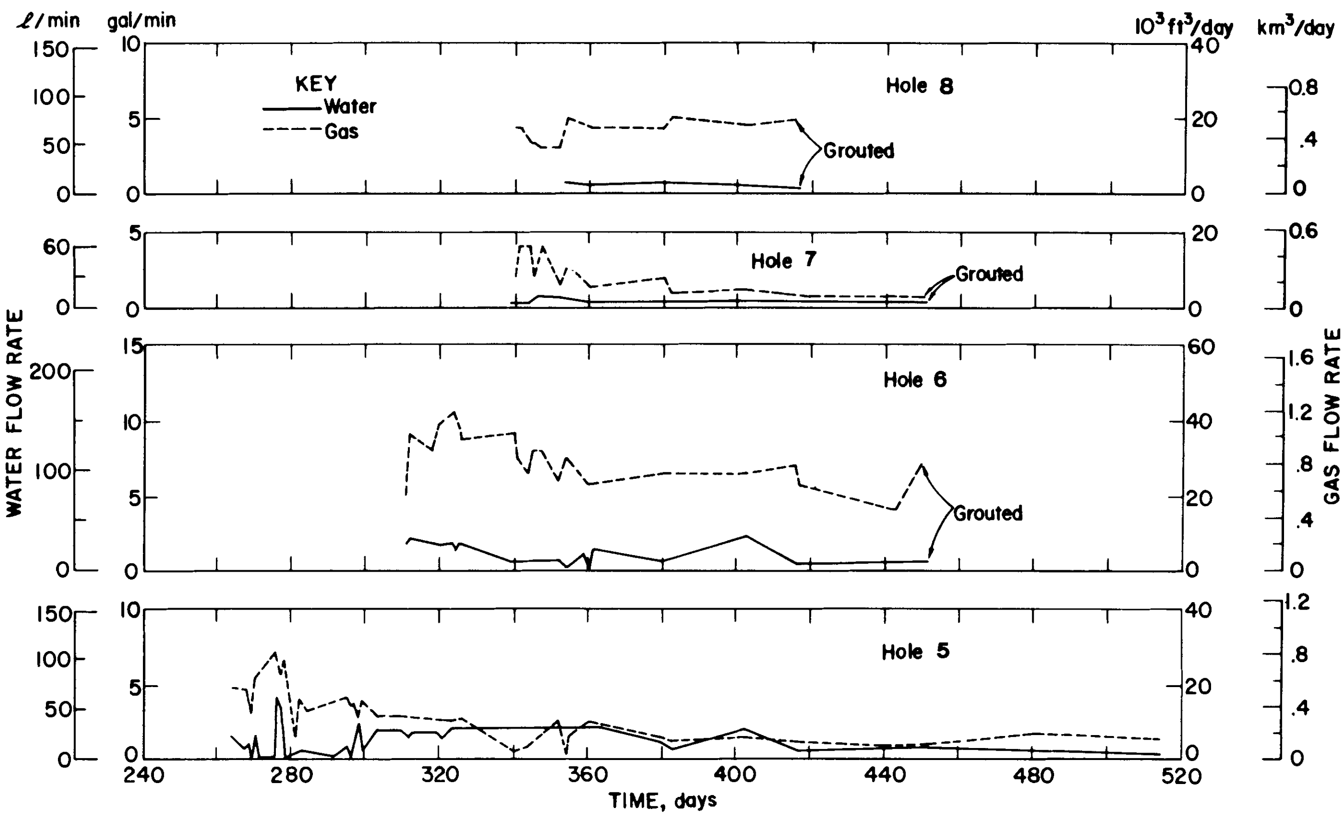

FIGURE 15. - Gas and water flows, holes 5, 6, 7, and 8.

The coalbed surrounding the shaft appears to be saturated with water because of the high average water flows for all holes except hole 7. Water is migrating down the flanks of the syncline toward the shaft site (fig. 13). A flooded abandoned mine is located about 5,700 ft (1,737 m) southwest of the shaft site, and this mine may be the source of some of the water migrating toward the shaft. Hole 1, which was drilled toward the abandoned mine, produced water at an average rate of 4.5 gal/min (17.1 l/min) (table 2).

Migration of water toward the shaft from the east is prevented by a roll in the coalbed (fig. 13). Within 400 ft (121.9 m) of the shaft in an easterly direction, the coalbed rises 23 ft (7.0 m) and then rolls over (fig. 16). Northeast of the shaft site, water is migrating down the flanks of the syncline toward the intake side of the shaft. Water production from hole 6 averaged 1.0 gal/min (3.8 l/min).

Figure 17 shows total gas and water flow rates for all holes. The peak gas flow was 136,000 ft^3/day (3,853 m^3/day), compared with 1,000,000 ft^3/day (28,329 m^3/day) from a similar study in the Pittsburgh Coalbed (4). Cumulative gas and water production after 514 days was 18,700,000 ft^3 (529,745 m^3) and 5,705,000 gal (21,621,950 l), respectively.

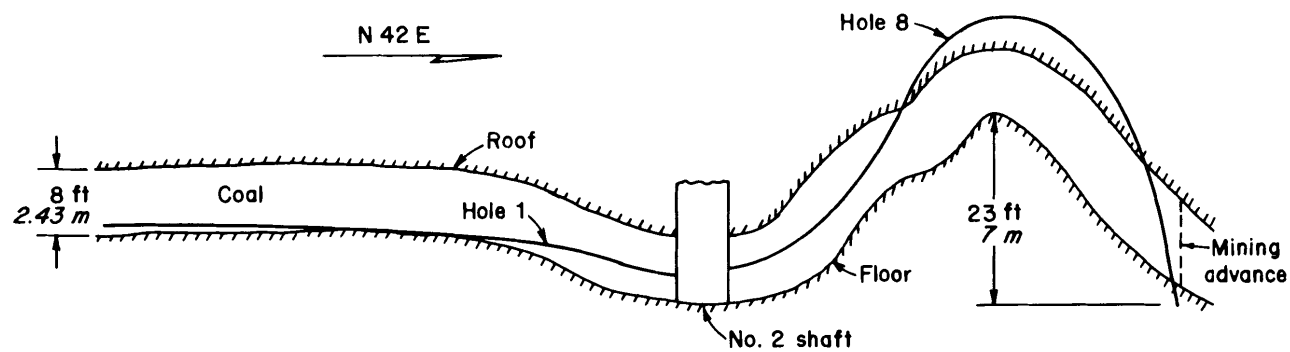

FIGURE 16. - Vertical section through holes 1 and 8.

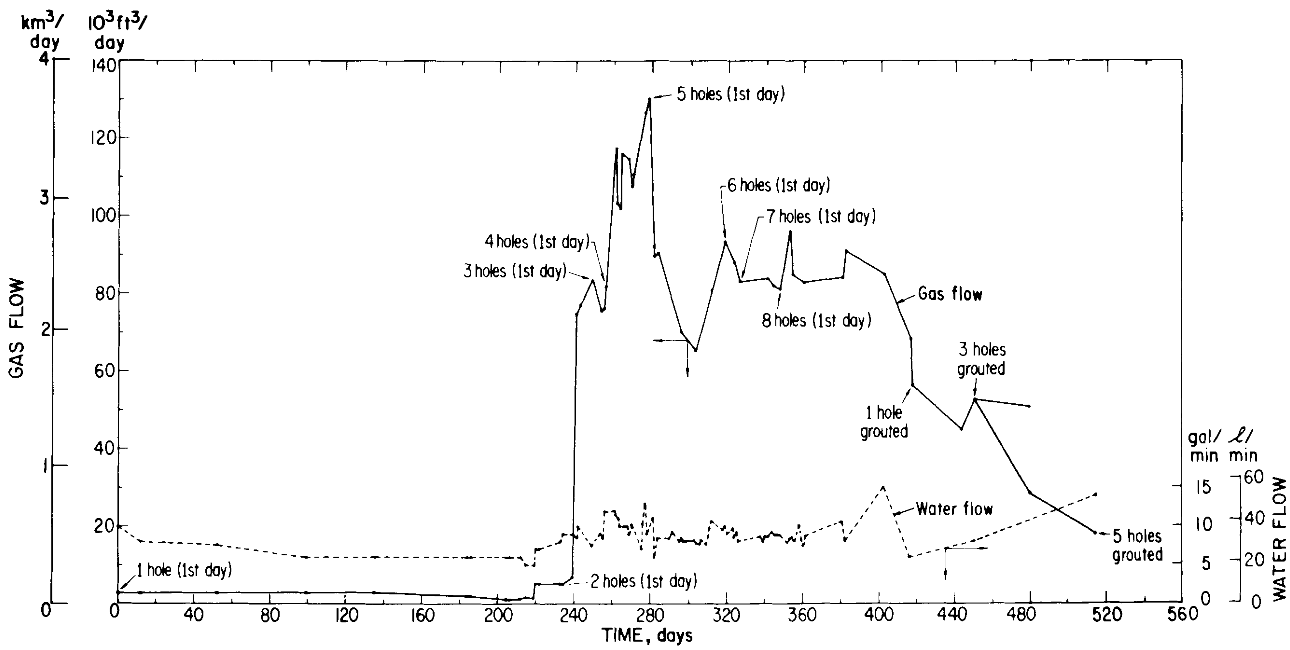

FIGURE 17. - Total gas and water flows.

EFFECTIVENESS OF DEGASIFICATION

Methane emission measurements were made periodically in the section advancing toward the shaft site to determine the effects of degasification on mining. Gas flows from the faces of the section declined from 260 to 60 ft^3/min (7.4 to 1.7 m^3/min), or 77 pct, when the section was about 550 ft (167.6 m) from the shaft (fig. 18). To avoid an explosion hazard when a hole is intercepted by mining, holes in the easterly direction were grouted. Gas flows through the section faces gradually increased to 150 ft^3/min (4.2 m^3/min) after grouting.

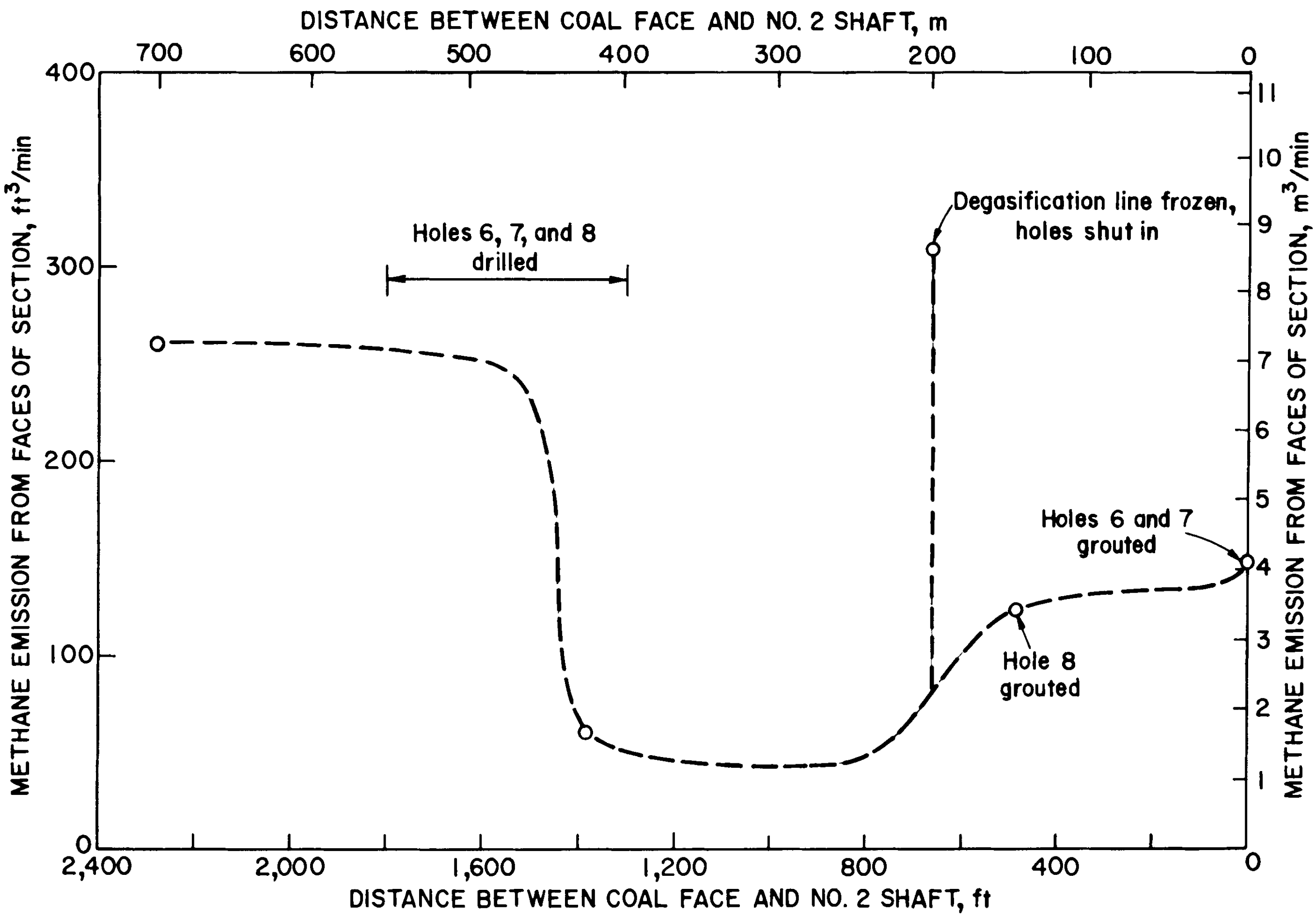

FIGURE 18. - Gas flow from section faces.

SUMMARY

Although commercial quantities of gas were not produced, methane emissions during mining were lowered in the section advancing toward the shaft. The gas flow into the mine increased after the drainage holes were grouted. Water migrating toward the shaft site from the northerly and westerly directions prevented dewatering of the coalbed, and consequently, gas flows from the drainage holes were low. Total gas and water production was 18,700,000 ft^3 (529,745 m^3) and 5,705,000 gal (21,621,950 l), respectively.

REFERENCES

1. Aul, G. N., and J. Cervik. Grouting Horizontal Drainage Holes in Coalbeds. BuMines RI 8375, 1979, 16 pp.

2. Cervik, J., H. H. Fields, and G. N. Aul. Rotary Drilling Holes in Coalbeds for Degasification. BuMines RI 8097, 1975, 21 pp.

3. Fields, H. H., J. Cervik, and T. W. Goodman. Degasification and Production of Natural Gas From an Air Shaft in the Pittsburgh Coalbed. BuMines RI 8173, 1976, 23 pp.

4. Fields, H. H., J. H. Perry, and M. Deul. Commercial-Quality Gas From a Multipurpose Borehole Located in the Pittsburgh Coalbed. BuMines RI 8025, 1975, 14 pp.

5. Finfinger, G. L., L. J. Prosser, and J. Cervik. Influence of Coalbed Characteristics and Geology on Methane Drainage. Proc. 1980 SPE/DOE Symp. on Unconventional Gas Recovery, Pittsburgh, Pa., May 18-21, 1980, pp. 319-324.

6. Irani, M. C., P. W. Jeran, and D. H. Lawhead. Methane Analyzer System To Record Continuously the Methane Content of Coal Mine Ventilation Air. BuMines RI 8009, 1975, 14 pp.

7. Popp, J. T., and C. M. McCulloch. Geological Factors Affecting Methane in the Beckley Coalbed. BuMines RI 8137, 1976, 35 pp.

APPENDIX A.--GAS PRESSURE TESTS

A 205-ft (62.5-m) long gas-pressure-monitoring hole was drilled on the intake air side of the shaft after holes 1 to 5 were drilled on the return side (fig. 7). The initial pressure, 79 psig (544.6 kN/m^2) (fig. A-1), fell to 37 psig (255.1 kN/m^2) after holes 6 and 8 were drilled nearby.

A gas pressure test was run on hole 3 immediately after its completion. When the hole was shut-in, the pressure increased from 9 to 18.5 psig (62.0 to 127.5 kN/m^2) in 3-1/2 hr. The test was terminated because methane concentration in the immediate area of the shaft had increased to 1.5 pct. This test indicates that the gas pressure in the pipeline to the surface venting stack will build to about 18.5 psig (127.5 kN/m^2) if the pipeline or stack is blocked by debris or frozen water.

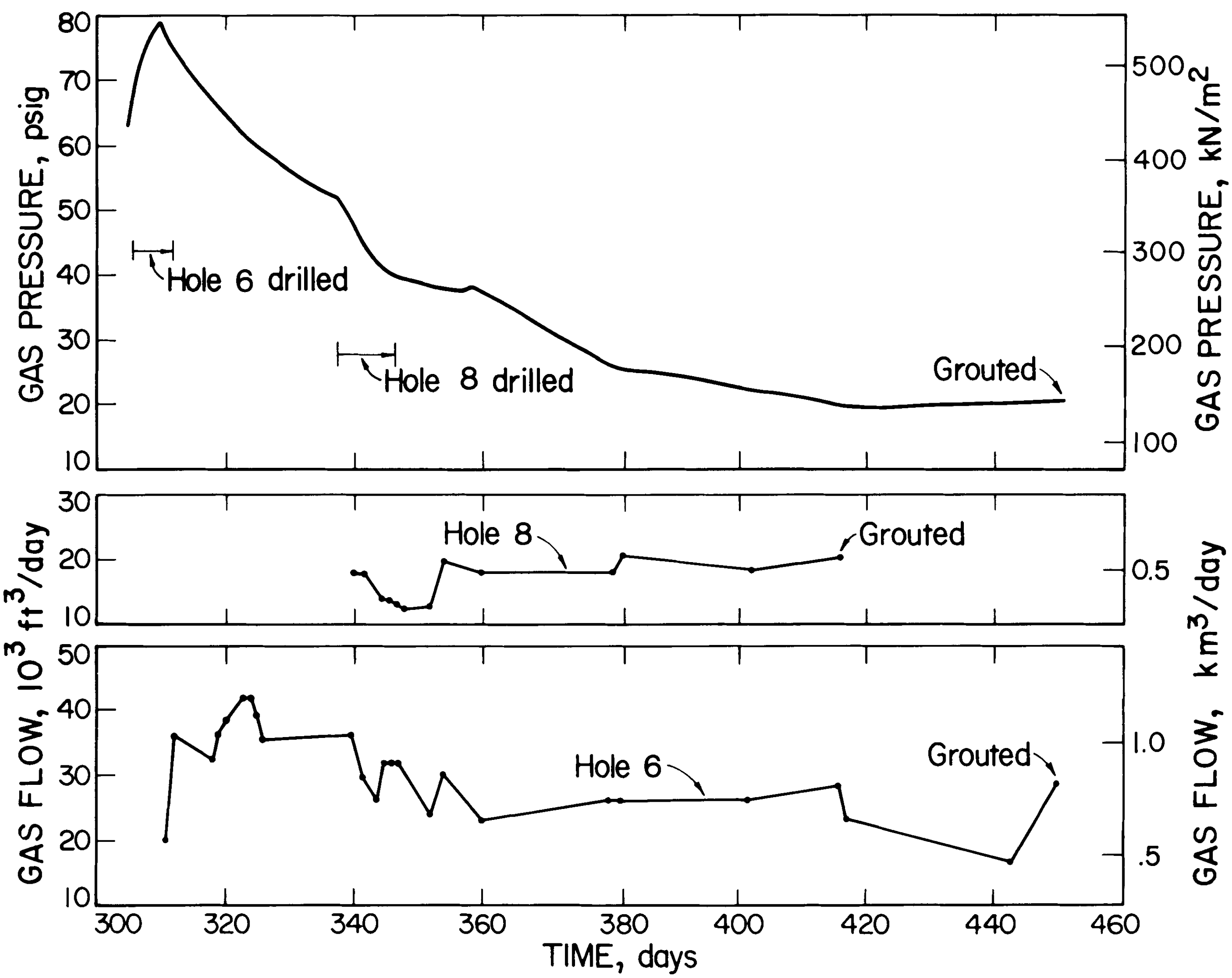

FIGURE A-1. - Gas flows versus in situ pressure, holes 6 and 8.

APPENDIX B.--MINING THROUGH DEGASIFICATION HOLES

Mining into a degasification hole releases large quantities of gas into the cutting head of a miner, and enormous amounts of air would be required to dilute the methane rapidly to below 1 pct. Because such large-volume flows of air are not available at the interception point, drainage holes are sealed with cement before interception by mining.

Procedures for sealing drainage holes at the Maple Meadow shaft site were similar to sealing procedures used in the Pittsburgh Coalbed (1). A 1.5-in (3.8 cm) ID, schedule 40 polyvinyl chloride (PVC) pipe was inserted to the back-end of each hole. The pipe was coupled using a PVC cement and manually pushed into the hole. The cement slurry was pumped through the PVC pipe to the back-end of the hole. When the cement slurry returned through the annulus to the collar of the hole, the hole was shut-in and the slurry was pressurized to 200 to 300 psig (1,378 to 2,068 kN/m^2). The slurry consisted of cement, flyash, and water (table B-1).

Table B-1. - Cement slurry design

Component	Quantity
Class A portland cement......	1 sack (94 lb) (42.6 kg)
Flyash......................	1 sack (75 lb) (34.0 kg)
Water.......................	10 gal (37.9 l)
Friction reducer (CFR-2)[1]....	2.5 lb (1.1 kg)

[1]Reference to specific products does not imply endorsement by the Bureau of Mines.

Hole 8 was grouted (day 415) when the section advancing toward the shaft was about 200 ft (61.0 m) from the end of hole 8 (fig. 7). This hole was subsequently used to guide the mining machine into the shaft. Holes 6 and 7 and the gas-pressure-monitoring hole were grouted on day 450. Holes 4 and 5 were sealed on day 555 and holes 1, 2, and 3 on day 644.

Five of the seven drainage holes were intercepted by mining, and methane problems developed when hole 1 was intercepted. Water flow from hole 1 immediately before grouting was about 5 gal/min (18.9 l/min), which diluted the slurry; subsequently water separation from the slurry created voids. A mechanical packer was placed in the hole to seal a small leakage of methane from the hole at the interception point. Voids were also observed when hole 2 was intercepted by mining, but no gas flow was detected from the hole. Water flow from hole 2 before sealing was about 2 gal/min (7.6 l/min).

Hole 5 was sealed after the hole had been inadvertently intercepted by mining. Methane flow from the hole when intercepted was about 3.5 ft^3/min (0.1 m^3/min), which caused no methane problems. No methane problems developed when holes 3, 4, and 8 were intercepted. Examination of holes 3 and 8 at the interception points indicated the slurry filled the holes; no voids were observed. Holes 6 and 7 were not intercepted by mining.

Generally, where water flow from a drainage hole before grouting is greater than 2 gal/min (7.6 l/min), excessive dilution of the slurry occurs with subsequent formation of voids. When intercepted by mining, the excess water can be forced from the voids by gas pressure, followed by a flow of methane. Where water flows are 0.5 gal/min (1.9 l/min) or less, holes are satisfactorily sealed.

INT.-BU.OF MINES,PGH.,PA 26130