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Degasification of the Mary Lee Coalbed Near Oak Grove, Jefferson County, Ala., by Vertical Borehole in Advance of Mining

UNITED STATES DEPARTMENT OF THE INTERIOR

Report of Investigations 7968

Degasification of the Mary Lee Coalbed Near Oak Grove, Jefferson County, Ala., by Vertical Borehole in Advance of Mining

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DEGASIFICATION OF THE MARY LEE COALBED NEAR OAK GROVE, JEFFERSON COUNTY, ALA., BY VERTICAL BOREHOLE IN ADVANCE OF MINING

by

C. H. Elder[1] and Maurice Deul[2]

ABSTRACT

A 5-hole pattern was drilled from the surface at a site near Oak Grove, Jefferson County, Ala., to degasify the gassy Mary Lee coalbed in advance of mining. Gas and water production was monitored for 1 year, 4 months to allow gas flow to stabilize fully. A thickened water stimulation treatment was designed and applied in one hole of the pattern to evaluate this degasification technique for the Mary Lee coalbed. A gas production rate of 70,000 ft^3/day after stimulation treatment indicates that the use of vertical boreholes coupled with hydraulic fracturing in advance of mining the Mary Lee coalbed would provide for more rapid degasification and could provide a possible source of natural gas.

INTRODUCTION

Degasification of coalbeds through vertical boreholes from the surface is part of the comprehensive methane control research program conducted by the Bureau of Mines. The technique has been applied experimentally at selected sites in most of the major bituminous coal producing areas in the United States. One such site is Jefferson County, Ala., where a mine is being developed in the Mary Lee coalbed. A degasification pattern of 5 holes was drilled at this site May 22 through July 11, 1971. Monitoring of gas and water production began September 16, 1971. Production from borehole No. 3SW was nearly continuous until June 28, 1973, when it was stimulated by hydraulic fracture to increase the rate of degasification of the coalbed. This study showed that the combined procedure should decrease the hazard of methane ignitions and explosions during mining. It also demonstrated the feasibility of providing supplemental sources of fuel through the recovery of methane that would otherwise be wasted to the atmosphere.

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[2] Supervisory geologist.

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BACKGROUND

During 1971, underground coal mines in the United States vented nearly 300 million ft^3 of methane to the atmosphere each day. To dilute this gas to safe levels in the mines, more than 100 times this quantity of air had to be circulated through the mine workings. If some of this gas could have been removed from the coalbeds before mining started, mine ventilation costs could have been reduced, and a marketable energy product could have been conserved.

Commercial quantities of gas have been produced from the Pittsburgh coalbed in Wetzel County, W. Va. (1-2)[3] where production decline curve for a group of 20 wells on 1,500-foot spacing was typical and indicated no particular flow characteristics as a coal-gas reservoir. Research on degasification of the Pittsburgh coalbed by surface boreholes to reduce gas emissions into mine workings was pioneered by Spindler and Poundstone (13-14). Their results, coupled with known commercial production, indicated that degasification by vertical boreholes in advance of mining was encouraging but required further study in other coalbeds and using stimulation techniques.

In 1971, a project was initiated to explore this degasification technique at test sites located in the major coal producing basins throughout the United States that are known to have highly gassy coalbeds. The objectives were to drill 5-hole patterns into selected gassy coalbeds, develop reservoir parameters, and evaluate well stimulation techniques for accelerating this degasification procedure. Several criteria were used to establish test sites: A history of gas emission into the mine workings, a site location in virgin coal 3 to 5 years in advance of mine development, a site remote from old mine workings, and at least one hole in each pattern to be stimulated.

DRILLING AND COMPLETION

The test site selected in the Mary Lee coalbed was in 23, T 18 S, R 6 W, near Oak Grove, Jefferson County, Ala., in the Warrior coalfield (figs. 1-3). The site is on a structural nose on the flank of the Sequatchie anticline (fig. 4). The test holes were drilled in virgin coal in an area not be mined for 3 to 5 years and remote from any old mine. A well spacing of 1,500 feet between holes was selected between the corner holes of a square pattern; a fifth hole was located at the center of the square.

Drilling of the 5-hole test pattern began May 22, 1971, and was completed July 11, 1971. Nine-inch-diameter holes were drilled with standard rotary

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

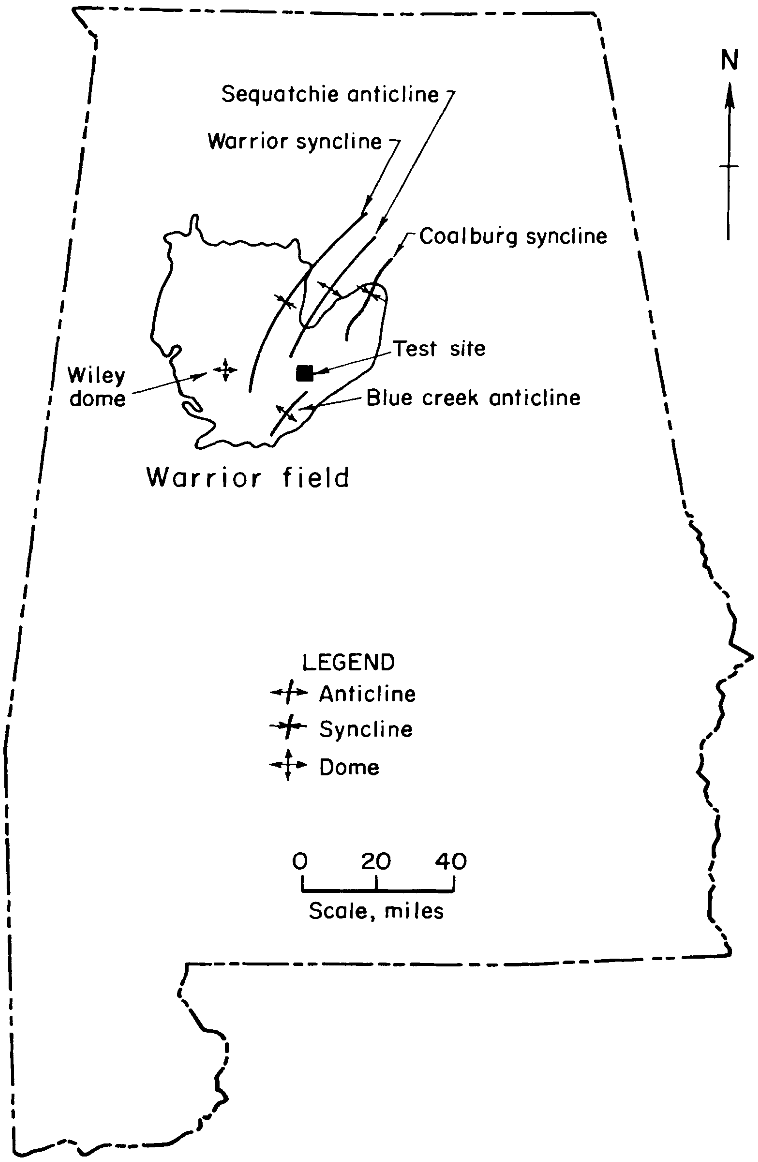

FIGURE 1. - Map showing major structure axes in the Warrior coalfield of Alabama.

drilling equipment. Drill cuttings were removed by circulating air or water during drilling. The holes were drilled to the top of the coalbed and cased to provide for open hole completion in the coal interval. Open hole completion provides the maximum exposure of the coalbed to production of gas with minimal chance of formation plugging by invasion of well cement.

When drilling to the top of the coalbed was completed, the holes were logged with geophysical logging equipment (fig. 5). Gamma ray, neutron, density, and caliper logs are used to determine hole condition before casing the hole and to evaluate porous zones in the strata overlying the coalbed that may contain water or gas.

The holes were cased with 7-inch-OD steel casing cemented from bottom to surface with expanding type cement. Seven-inch-OD casing was selected so that the degasification boreholes could be used for other purposes after mine development has bypassed them, such as power and communication system entry into the mine, bulk supply point for rock dust, and for gob degasification of longwall panels or after pillar recovery.

After casing was set, the coalbed was cored cutting a 6-inch hole and retrieving a 4-inch core. Coring was done with air to limit possible physical damage to the coalbed that would inhibit the flow of gas during the degasification period.

Immediately following coring, the coalbed was tested for formation pressure and flow rates of water and gas. For this purpose a test tool and packers on the bottom of a string of drill pipe were inserted into the hole,

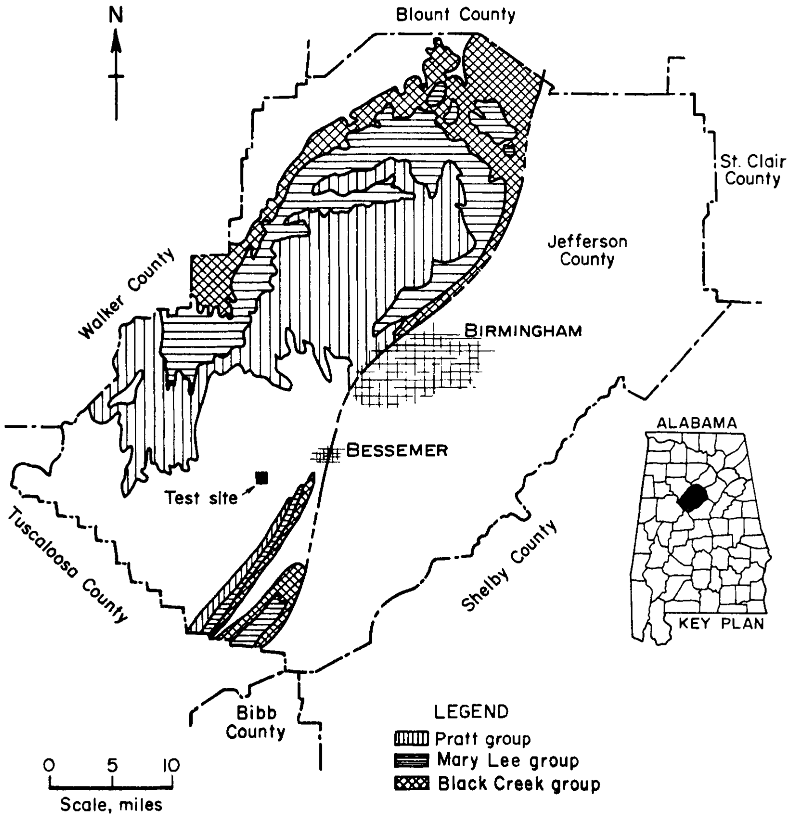

FIGURE 2. - Outcrop map of coal producing stratigraphic groups in Jefferson County, Ala.

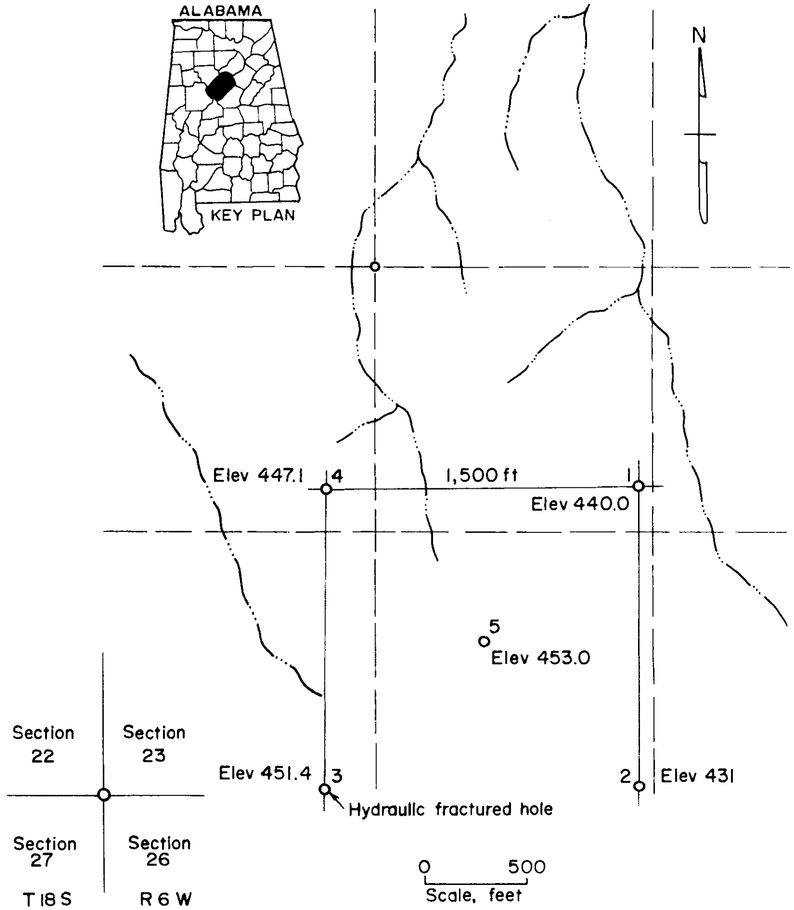

FIGURE 3. - Plot showing location of drill pattern in sec 23, T 18 S, R 6 W, Jefferson County, Ala.

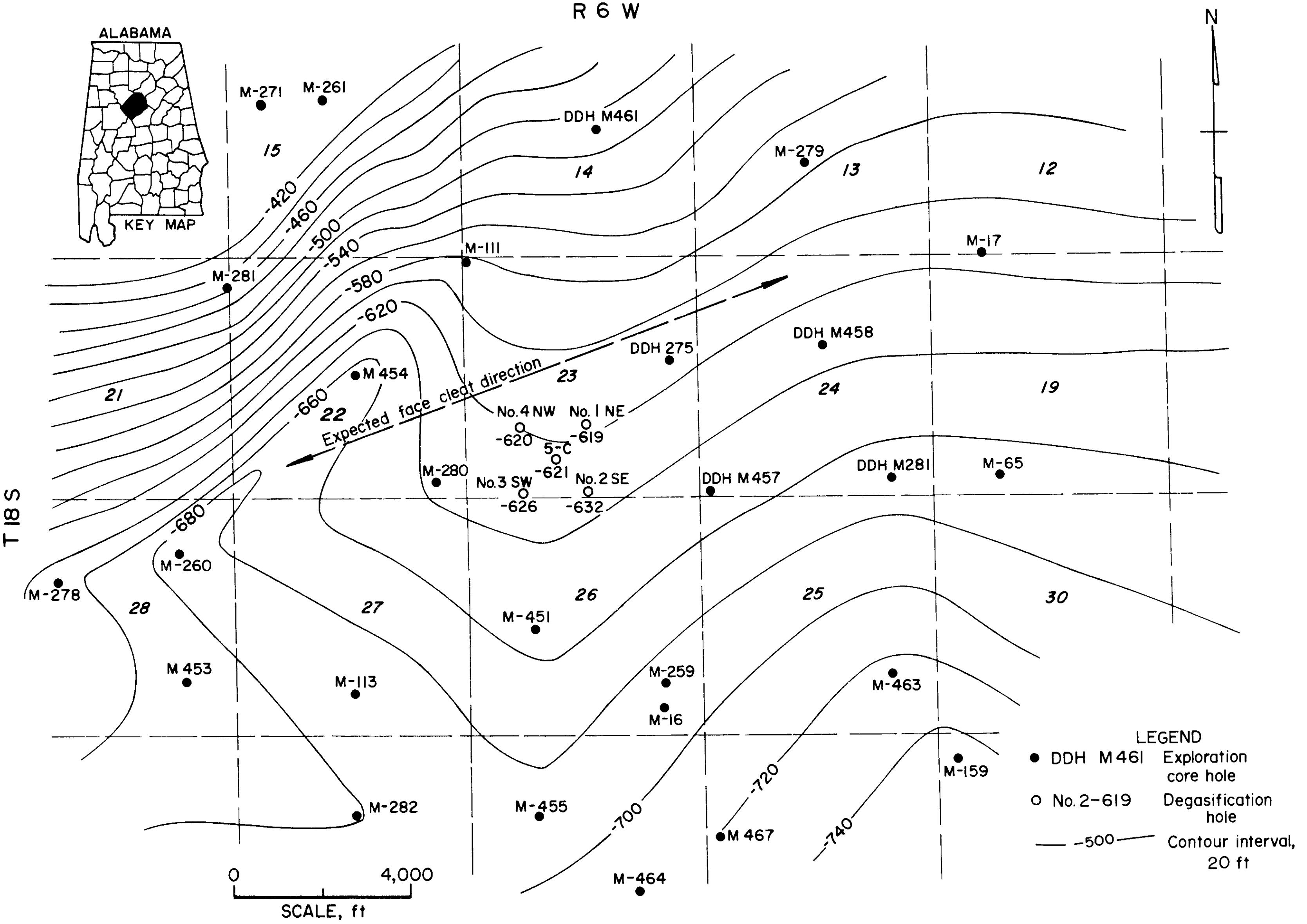

FIGURE 4. - Structure map on Mary Lee coalbed in vicinity of degasification test pattern T 18 S, R 6 W, Jefferson County, Ala.

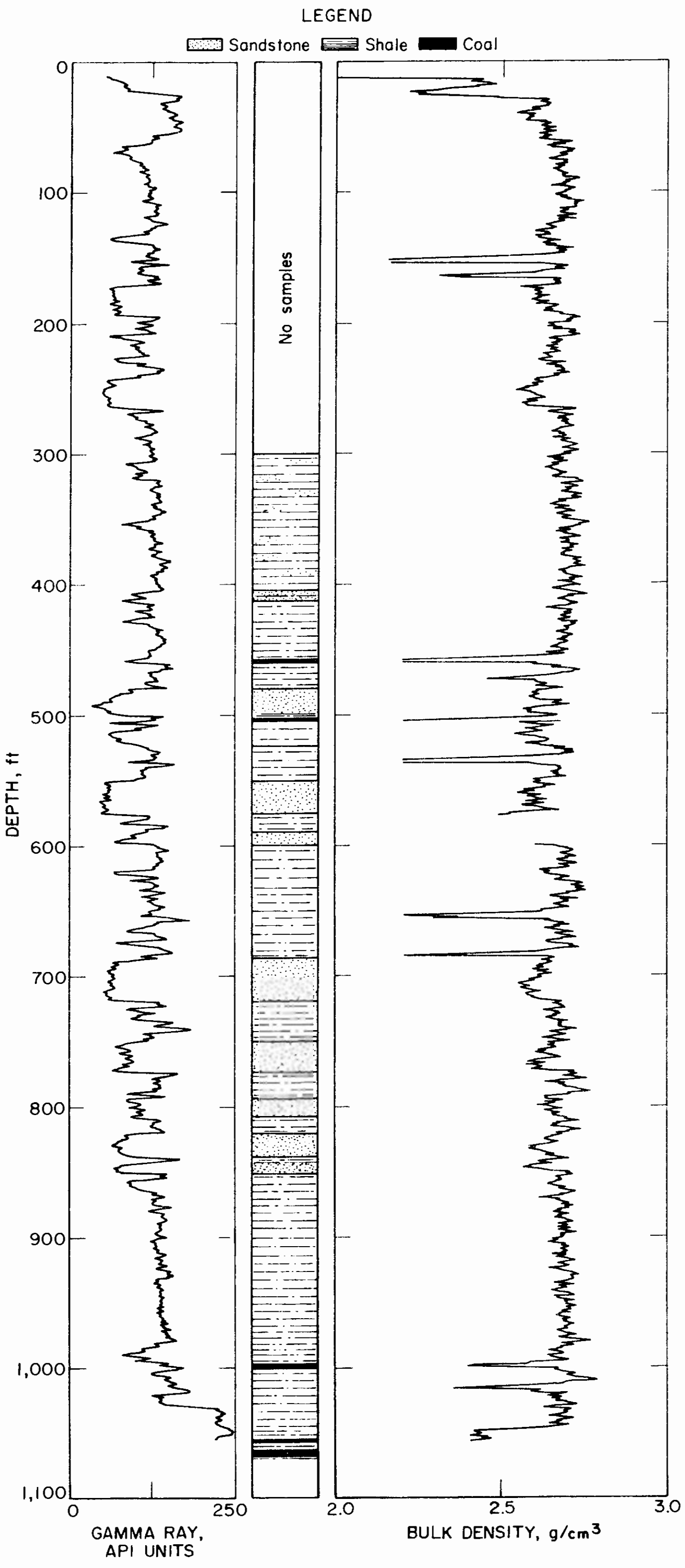

FIGURE 5. - Gamma ray, density, and lithologic logs of the Mary Lee coalbed overburden.

and the coal or producing interval was packed off. Pressure monitoring elements in the test tool continuously recorded the pressure buildup and flow pressures for preselected intervals of time. Finally dewatering pumps and recording gas and water meters were installed. (For further details of drilling, casing, and testing of the holes, gas well histories in appendix B.)

GAS AND WATER PRODUCTION

Gas and water production monitoring began on September September 16, 1971, for hole No. 3SW, and the full pattern was put on production February 24, 1972. The pattern of 5 holes produced 16,215,000 ft^3 og gas and 36,565 barrels of water to April 1, 1974 (figs. 6-7). The daily averages were calculated for 2-week periods of production and plotted (appendix C). The low production from holes Nos. 1NE, 2SE, and 4NW is attributed to low variable permeability and some formation damage from drilling fluids blocking the flow of gas.

There is an increase of permeability with time of dewatering (11). This may account for the continued increase in production rate for holes Nos. 3SW and 5C. Production data from this pattern and other coalbeds indicate that stable flow rates require long periods of time to allow for dewatering of the coalbed and achievement of steady-state flow. Low initial production suggests that all degasification holes should be stimulated

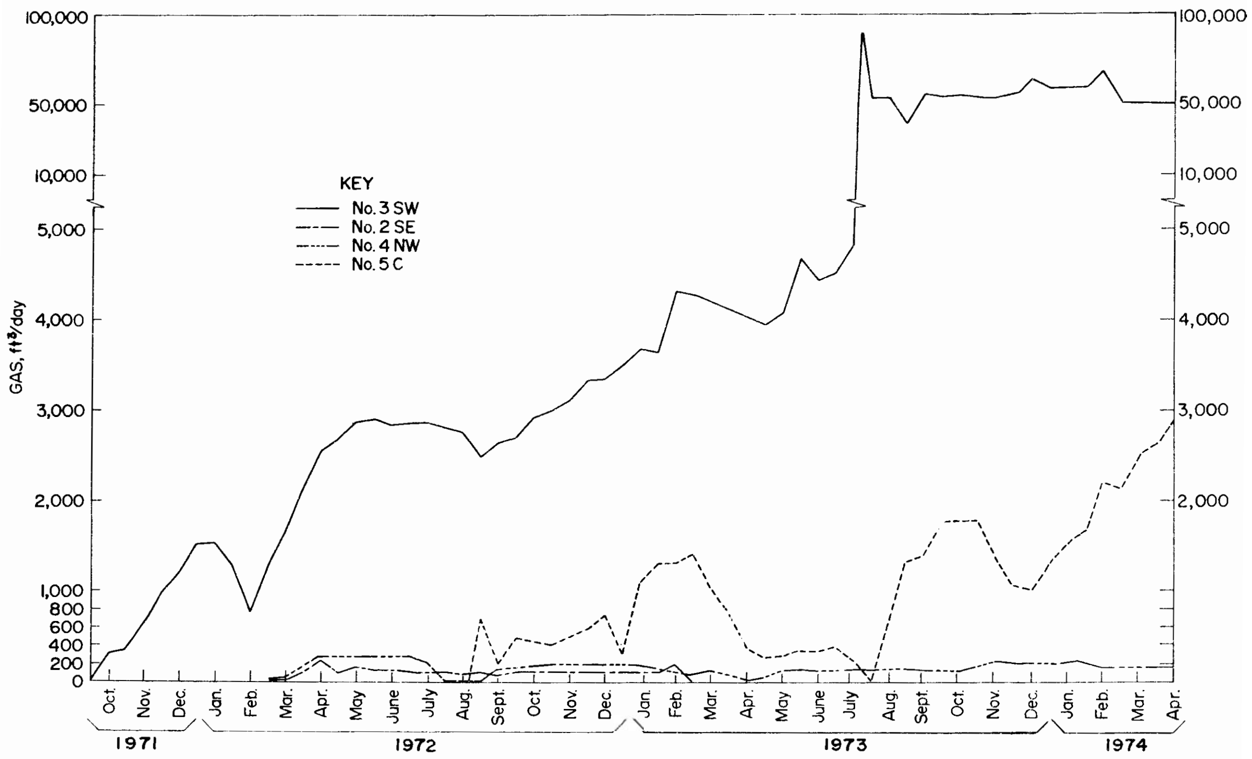

FIGURE 6. - Gas production rates for degasification boreholes. Daily average computed on 2-week production intervals.

to achieve maximum efficiency to degasification. Maximum formation pressure prior to first production was measured at 396 psi. The pressure decline for the No. 3SW hole, up to the time of stimulation, was 56 psi over a period of 16 months. During this period, production rate was still increasing and had not completely stabilized.

Borehole No. 3SW has produced the greatest quantity of gas of the boreholes in the pattern, 1,684,700 ft^3 during the 16 months of production before stimulation. Contrary to many oil and gas reservoirs, production from the Mary Lee coalbed had a very low initial production rate that increased with time and an expanding collection radius resulting from dewatering of the coalbed.

Analyses of water samples from borehole No. 3SW showed 1,530 ppm dissolved solids, of which 9 ppm is calcium, 0.3 ppm iron, and 700 ppm chloride (as NaCl). No magnesium or sulfates were detected. Table 1 gives corresponding gas analyses. The gas from the Mary Lee coalbed has a heat content of 970 to 990 Btu.

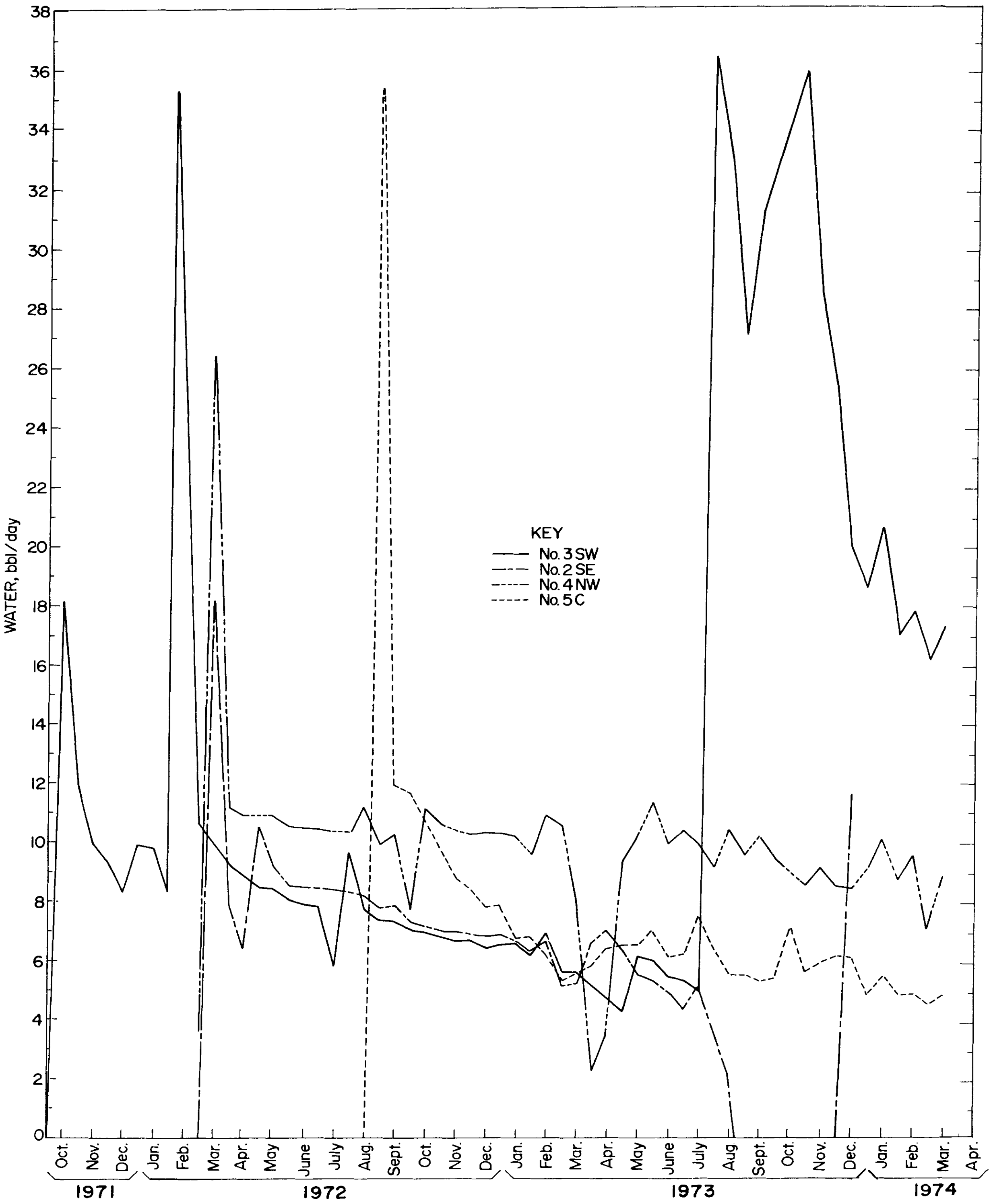

FIGURE 7. - Water production rates for degasification boreholes. Daily average computed on 2-week production intervals.

TABLE 1. - Gas analyses

Date	Sample	Borehole	CO_2	CH_4	C_2H_6	C_3H_8	C_4H_{10}	C_5H_{12}	H_2	He	O_2	Inerts N_2 and A
4/72	1	3SW	0.1	96.2	0.01	-	-	-	0.01	0.26	0.0	3.4
	2	3SW	.1	95.9	.01	-	-	-	.01	.28	.1	3.6
7/3/73	3	3SW	2.9	88.6	.08	0.018	0.002	0.0003	3.9	-	.2	4.3
	4	3SW	2.6	89.1	.08	.019	.002	.0003	3.9	-	.2	4.1
10/17/73	5	3SW	0	96.7	.01	Tr.	-	-	0	.22	0	3.0

Tr--Trace.

INCREASED GAS FLOW BY STIMULATION PROCEDURES

A coalbed generally has low permeability and the rate of desorption of gas from coal around a degasification borehole depends on the surface area exposed. There is need to increase the permeability of coal around the borehole and to extend the drainage radius. This can be done by thickened water stimulation. This process is not explosive and does not create a shatter zone. Experience has shown that it produces vertical fractures or openings and extends existing fractures or joints (4, 7, 9). The fractures are opened 0.2 to 0.4 inches and packed with propping sand, thus increasing permeability along the fracture and extending the drainage radius several hundred feet for gas flow.

The gas emission rate at hole No. 3SW had been monitored long enough to establish a production rate trend against which the effect of a thickened water stimulation procedure could be evaluated.

The following criteria were used in the design of the stimulation procedure:

Injection rate..............................bbl/min..	10.0
Formation thickness...............................ft..	5.0
Elastic modulus of coalbed.......................psi..	3.0×10^5
Formation permeability............................md..	5
Formation porosity ....pct..	4
Bottom hole treatment pressure...................psi..	2,050
Formation pressure...............................psi..	390
Reservoir fluid viscosity.........................cp..	0.02
Type of gel (Halliburton)............................	Wg-6
Gel concentration.......................lb/100 gal..	20
Well bore radius..................................ft..	0.25
Damage ratio..	3.0
Size of prop sand...............................mesh..	10-20
Concentration of prop sand..................lb/gal..	3/4
Stimulation fluid volume.........................gal..	10,000-15,000
Pump truck capacity...................hydraulic hp..	1,000

The stimulation design plan of Halliburton Well Services Co. was used to calculate the following computer simulation output (8):

Fracture fluid volume, gal	Production increase	Propped fracture length, ft	Fracture width, in	Sand lb
10,000	11.7	255	0.24	5,600
15,000	15.6	377	.26	7,400

A fracture treatment using 10,000 gallons fracture fluid and 6,000 pounds of 10 to 20 mesh propping sand was chosen.

For this stimulation experiment, high-pressure (2-7/8-inch) tubing with a tension packer in the string was run in the hole. The packer was set at 988 feet in the 7-inch well casing with the bottom end of the tubing at the midpoint of the coalbed. One thousand six hundred gallons of water was pumped into the coal with increasing pressure to achieve formation break and start fracture propagation. The coalbed broke at 800 psig (fig. 8). Continuous fracture propagation was established at 1,100 to 1,200 psi pumping pressure and a steady 10 bbl/min injection rate. The water was followed with 10,000 gallons of gelled-water fracturing fluid with 1/2 lb of propping sand per gallon at start. After 2 to 3 minutes, the sand injection rate was

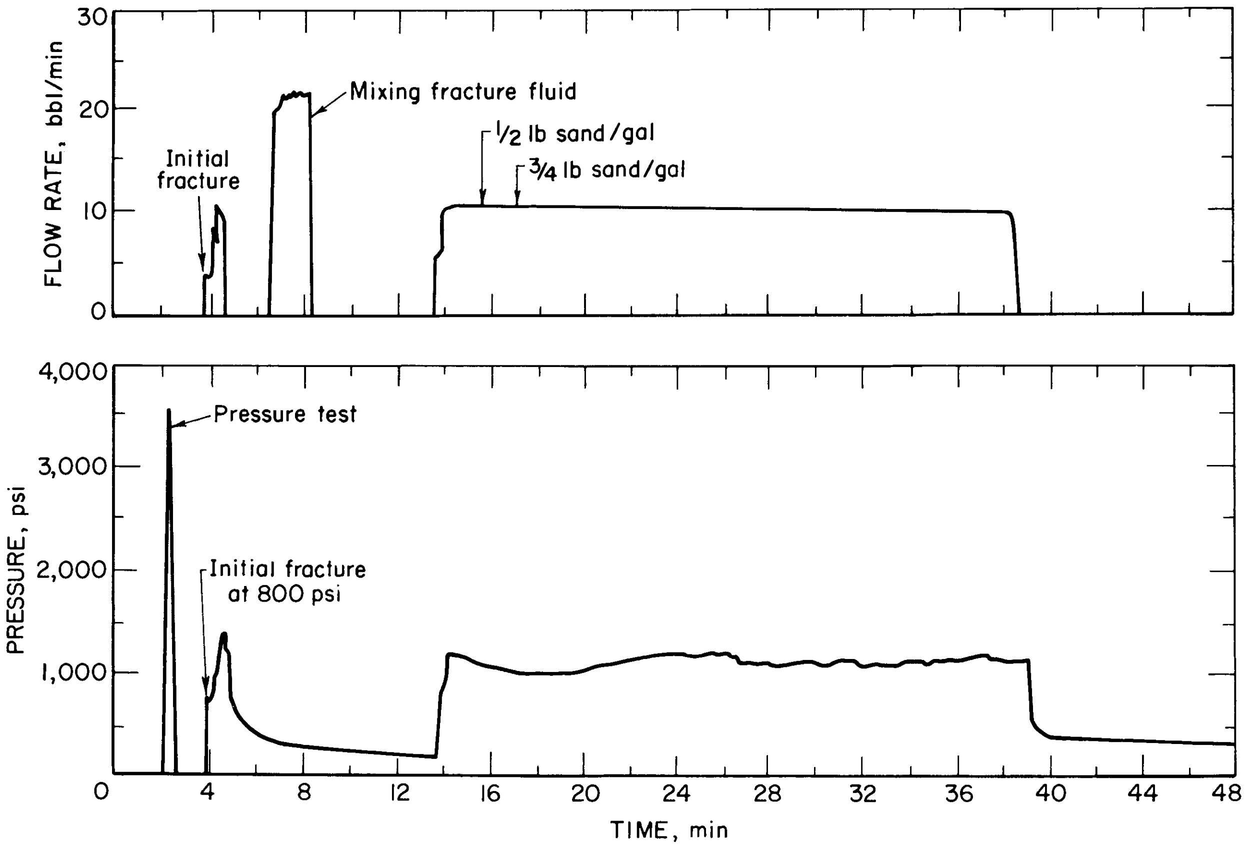

FIGURE 8. - Hydraulic fracture stimulation pressure and fluid injection charts.

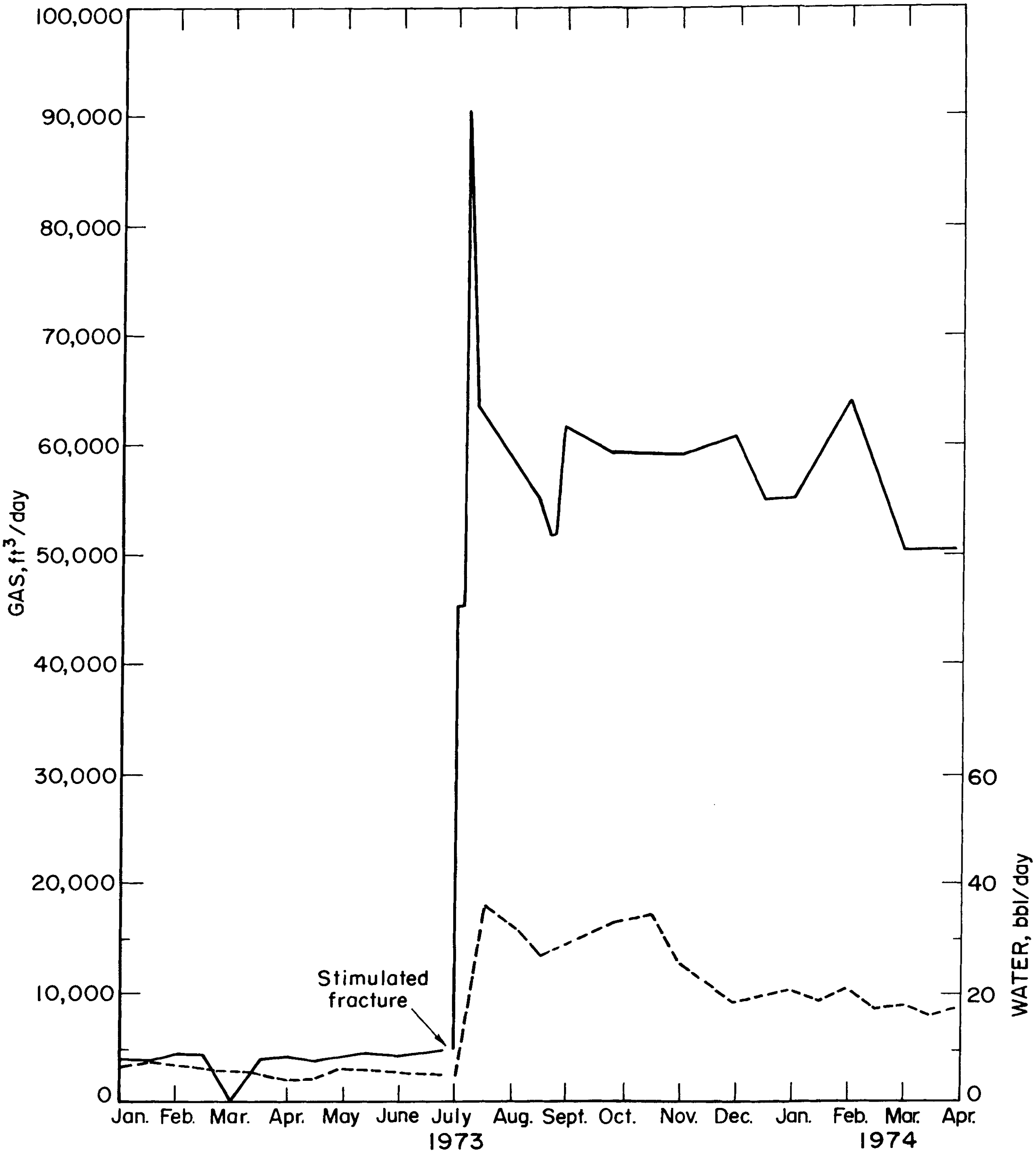

FIGURE 9. - Gas and water production for degasification borehole No. 3SW showing production rate increase after fracture stimulation.

per gallon at start. After 2 to 3 minutes, the sand injection rate was increased to 3/4 lb/gal. The fracture propagated normally during injection.

Following the stimulation the well was shut in for 18 hours, then the packer was unseated and the 2-7/8-inch tubing was removed from the borehole. The hole was swabbed free of fluid, and 30 feet of sand accumulation at the bottom of the hole was removed with a sand pump bailer. After cleanout, the water pump was reinstalled in the hole, and production monitoring was resumed. All of the fracturing fluid was recovered from the formation with pumping.

The gas flow rate increased, after the fracturing process, from 4,520 to 5,000 ft^3/day to a maximum rate of 90,000 ft^3/day in 11 days. During the next 7 months the flow rate declined normally. The gas flow rate levelled off at ±70,000 ft^3/day--a fold increase in flow rate from the borehole (fig. 9). This production increase is very close to the calculated production increase.

SUMMARY AND DISCUSSION

Production history indicated that coal in the Mary Lee coalbed has a variable but low in-place permeability. A stimulation procedure, such as hydraulic fracturing, was needed to extend the collection.radius by increasing the permeability of the coal around the borehole. The propped induced fractures provided a larger, more permeable, collection radius for gas production and increased the gas production rate fourteen fold.

With properly spaced, stimulated degasification boreholes over the entire coal mine property, the coalbed could be materially degasified, with time, prior to mining. This would reduce the cost of mine ventilation, make the mine safer, and increase mine productivity. After mining intercepts the holes, the boreholes can serve as communication, power-drop, and rock-dust supply stations. The holes can also be used to help ventilate gob area following roof collapse with pillar extraction or longwall mining (5). Finally, if sufficient gas is produced, sale or use of the gas could recover the cost of drilling and completion of the degasification boreholes.

REFERENCES

1. Cervik, J. Behavior of Coal-Gas Reservoirs. BuMines TPR 10, April 1969, 10 pp.

2. Cervik, J., and C. H. Elder. Removing Methane From Coalbeds in Advance of Mining by Surface Vertical Borehole. Proc. Conf. on the Underground Mining Environment. Univ. of Mo., Rolla, Mo., Oct. 27-29, 1971, pp. 229-240.

3. Culbertson, W. C. Geology and Coal Resources of the Coal-Bearing Rocks of Alabama. U.S. Geol. Survey Bull. 1182-B, 1964, 75 pp.

4. Daneshy, A. A. True and Apparent Direction of Hydraulic Fractures. Soc. Petrol. Eng., AIME, Paper No. SPE 3226, 1971, pp. 1-9.

5. Elder, C. H. Use of Vertical Boreholes for Assisting Ventilation of Longwall Gob Areas. BuMines TPR 13, May 1969, 6 pp.

6. Farmer, I. W. Engineering Properties of Rocks. E. and F. N. Spon Ltd., London, 1968, pp. 1-180.

7. Fraser, C. D., and B. E. Pettit. Result of a Field Test To Determine the Type and Orientation of a Hydraulic Inducedf Formation Fracture. J. Petrol. Technol., May 1962, pp. 463-466.

8. Halliburton Services. The Fracbook Design/Rato Manual for Hydraulic Fracturing. Published by Halliburton Services, Duncan, Okla., 1971, pp. 1-111.

9. Hubbert, M. King, and D. G. Willis. Mechanics of Hydraulic Fracturing. Trans. AIME, v. 210, 1957, pp. 153-166.

10. Irani, M. C., E. D. Thimons, T. G. Bobick, M. Deul, and M. G. Zabetakis. Methane Emission From U.S. Coal Mines, A Survey. BuMines IC 8558, 1972, 58 pp.

11. Kissell, F. N. The Methane Migration and Storage Characteristics of the Pittsburgh, Pocahontas No. 3, and Oklahoma Hartshorne Coalbeds. BuMines RI 7667, 1972, 22 pp.

12. Semmes, D. R. Oil and Gas in Alabama. Ala. Geol. Survey Spec. Rept. 15, 1929, 408 pp.

13. Spindler, G. R. Degasification of Coal Seams. Am. Min. Congr., Coal Mine Modernization, 1953, pp. 206-220.

14. Spindler, G. R., and W. N. Poundstone. Experimental Work in Degasification of the Pittsburgh Coal Seam by Horizontal and Vertical Drilling. Trans. AIME, v. 223, 1962, pp. 37-47.

APPENDIX A.--GEOLOGY

The two coal-producing formations in the Warrior coalfield of Alabama are the Parkwood Formation of Mississippian and Early Pennsylvanian age and the Pottsville Formation of Pennsylvanian age; the Pottsville Formation is the major coal producer (3, 12).

The Pottsville Formation consists of interbedded gray shales, gray sand shales, thin-bedded sandstone, coarse- to medium-grained massive sandstone, and several bituminous coalbeds.

The Mary Lee coal group, a part of the Pottsville Formation, has the largest reserves in the Warrior field and consists of the Ream, Jagger, Blue Creek, Mary Lee, and New Castle coalbeds.

The Mary Lee coalbed includes four seams that may coalesce and/or pinch out. The seams range from 2 to 70 inches in thickness, and the intervening shales range from a few inches to 20 feet.

The Warrior field is situated north and west of the Appalachian Mountains on the Cumberland Plateau. The field is bounded on the southeast by a major thrust fault. The coalfield was structurally folded forming the Coalburg syncline, Sequatchie anticline, Warrior syncline, and Wylie Dome (figs. 1-2).

The test site is located on a small anticlinal nose on the southeast flank on the Sequatchie anticline (figs. 1, 3-4). The Mary Lee coalbed outcrops 5-1/2 miles to the northeast of the test site on the southeastern flank of the Coalburg syncline. Field mapping indicates the expected major cleat direction in the coal to be N 70° E and according to J. L. Huey the major rock joint direction (in the overburden) to be N 75° W.

APPENDIX B.--WELL HISTORIES OF FIVE WELLS IN THE MARY LEE COALBED NEAR OAK GROVE, JEFFERSON COUNTY, ALA.

TABLE B-1. - Bureau of Mines well No. 1NE (CS-1/2, sec 23, T 18 S, R 6 W)

Date started	May 22, 1971	Core recovered...pct..	93
Date completed	June 10, 1971	Do...ft..	12.1
Depth to coal...ft..	1,067.7	Core returned to Pittsburgh, Pa.	July 9, 1971
Coal elevation...ft..	-681.7	Samples:	
Total depth...ft..	1,090	Water	June 10, 1971
Surface elevation...ft..	449	Gas	June 10, 1971
Casing:		Tests:	
Total depth...ft..	1,059	Water	June, 1971
Length of 12-3/4-in-diam		Gas	June, 1971
casing...ft..	11	Logs:	
Length of 7-in-diam casing...ft..	1,059	Density...depth ft..	70-1,056
Gas shows, on drill stem		Neutron...depth ft..	70-1,056
test of coalbed...ft..	1,045-1,076	Gamma ray...depth ft..	70-1,056
Water...ft..	65-70, 805-810,	Caliper...depth ft..	70-1,056
	1,070	Drill stem test No. 1...ft..	1,045-1,076
Rotary to depth...ft..	1,063	Date of drill stem test	June 10, 1971
Bit size...in..	9	Maximum shut-in pressure...psi..	396
Interval cored...ft..	1,063-1,076	Date monitoring equipment	
Core size...in..	5	installation completed	July 2, 1971
		Date pumping equipment installation..	
		completed	July 2, 1971

NOTE.--Formation pressure was measured at 396 psi on test. Monitoring started Feb. 24, 1972, after electric power installation.

TABLE B-2.--Bureau of Mines well No. 2SF (CSL, sec 23, T 18 S, R 6 W)

Date started	June 26, 1971	Rotary to depth ft	1,043
Date completed	July 2, 1971	Bit size in	8-3/4
Depth to coal ft	1,063.3	Interval cored ft	1,043-1,071
Coal elevation ft	-632.3	Core size in	5
Total depth ft	1,081	Core returned to Pittsburgh, Pa.	July 9, 1971
Surface elevation ft	431	Logs:	
Casing:		Density depth ft	10-1,046
Total depth ft	1,043	Neutron depth ft	10-1,046
Length of 10-3/4-in-diam		Gamma ray depth ft	10-1,046
casing ft	13	Caliper depth ft	10-1,046
Length of 7-in-diam casing ft	1,042	Maximum shut-in pressure psi	389
Gas shows, coalbed after		Date monitoring equipment	
completion		installation completed	July 11, 1971
Water ft	50-55,1,065	Date pumping equipment installation	
		completed	July 11, 1971

NOTE.--Formation pressure measured at 389 psi; monitoring started February 24, 1972, after electric power installation.

TABLE B-3. - Bureau of Mines well No. 3SW (CSL, SW¼, sec 23, T 18 S, R 6 W)

Date started	July 2, 1971	Core recovered...pct..	95
Date completed	July 11, 1971	Samples:	
Depth to coal...ft..	1,075.5	Water	March 28,,1972
Coal elevation...ft..	-625.5	Gas	March 28, 1972
Total depth...ft..	1,093	Tests:	
Surface elevation...ft..	450	Water	April 12, 1972
Casing:		Gas	April 12, 1972
Total depth...ft..	1,056	Logs:	
Length of 10-3/4-diam casing...ft..	11	Density...depth ft..	28-1,054
Length of 7-in-diam casing...ft..	1,056	Neutron...depth ft..	28-1,054
Gas shows...ft..	80,1,075.5	Gamma ray...depth ft..	28-1,054
Water...ft..	500-665,1,077	Caliper...depth ft..	28-1,054
Rotary to depth...ft..	1,065	Drill stem test No. 2...ft..	1,060-1,093
Bit size...in..	8-3/4	Date of drill stem test	July 10, 1971
Interval cored...ft..	1,065-1,093	Maximum shut-in pressure...psi..	151
Core size...in..	5	Date monitoring equipment installation completed	September 16, 1971
		Date pumping equipment installation completed	September 16, 1971

NOTE.--Drill stem test tool had faulty valve; shut-in pressure recorded too low. Monitoring started September 16, 1971.

TABLE B-4. - Bureau of Mines well No. 4 NW (SE, NW, SW, sec 23, T 18 S, R 6 W)

Date started........................	June 19, 1971	Core returned to Pittsburgh, Pa.	July 9, 1971
Date completed......................	June 25, 1971	Samples:	
Depth to coal.................ft..	1,067	Water............................	March 28, 1972
Coal elevation................ft..	-620	Gas..............................	March 28, 1972
Total depth...................ft..	1,092	Tests:	
Surface elevation.............ft..	447	Water............................	April 12, 1972
Casing:		Gas..............................	April 12, 1972
Total depth.................ft..	1,060	Logs:	
Length of 10-3/4-diam		Density.................depth ft..	10-1,061
casing....................ft..	13	Neutron.................depth ft..	10-1,061
Length of 7-in-diam casing...ft..	1,060	Gamma ray...............depth ft..	10-1,061
Gas shows, coalbed after		Caliper.................depth ft..	10-1,061
completion......................		Maximum shut-in pressure.......psi..	396
Water.........................ft..	45-50, 1,068	Date monitoring equipment	
Rotary to depth...............ft..	1,063	installation completed............	July 11, 1971
Bit size......................in..	8-3/4	Date pumping equipment	
Interval cored................ft..	1,063-1,092	installation completed............	July 11, 1971
Core size.....................in..	5		
Core recovered...............pct..	100		

NOTE.--Formation pressure measured at 396; monitoring started Feb. 24, 1972, after electrical power installation.

TABLE B-5. - Bureau of Mines well No. 5C (SE, SW, sec 23, T 18 S, R 6 W)

Date started	June 11, 1971	Core returned to Pittsburgh, Pa.	
Date completed	June 19, 1971	Samples:	
Depth to coal, ft	1,075.8	Water	July 11, 1971
Coal elevation, ft	-620.8	Gas	July 11, 1971
Total depth, ft	1,093	Tests:	
Surface elevation, ft	455	Water	July 8, 1971
Casing:		Gas	Aug. 14, 1971
Total depth, ft	1,065	Logs:	
Length of 10-3/4-diam casing, ft	13	Density, depth ft	30-1,062
Length of 7-in-diam casing, ft	1,065	Neutron, depth ft	30-1,062
Gas shows, coalbed after completion		Gamma ray, depth ft	30-1,062
		Caliper, depth ft	30-1,062
		Maximum shut-in pressure, psi	400
Water, ft	70-77, 860-65, 1,067	Date monitoring equipment installation completed	July 11, 1971
Rotaay to depth, ft	1,065	Date pumping equipment installation completed	July 11, 1971
Bit size, in	8-3/4		
Interval cored, ft	1,065-1,093		
Core size, in	5		
Core recovered, pct	100		

NOTE.--Formation pressure measured at 400 psi; monitoring started February 24, 1972, after electrical power installation.

APPENDIX C.--CUMULATIVE GAS PRODUCTION FOR HOLE NOS. 3SW, 4NW, and 5C

Date		No. 3SW, ft^3	No. 4NW, ft^3	No. 5C, ft^3
1971:				
September	16 - 30	4,250		
October	1 - 15	9,250		
	16 - 31	20,000		
November	1 - 15	34,750		
	16 - 30	53,000		
December	1 - 15	76,000		
	16 - 31	100,775		
1972:				
January	1 - 15	120,000		
	16 - 31	[1]123,000		
February	1 - 15	142,000		
	16 - 29	167,000		
March	1 - 15	199,000	2,001	Well shut in for pressure monitoring.
	16 - 31	239,750	6,318	
April	1 - 15	280,000	10,175	
	16 - 30	323,000	14,210	
May	1 - 15	366,500	18,130	
	16 - 31	412,000	22,470	
June	1 - 15	455,000	26,480	
	16 - 30	498,000	29,435	
July	1 - 15	540,000	Meter stolen	
	16 - 31	584,000		
August	1 - 15	621,000		6,200
	16 - 31	663,500	31,780	9,000
September	1 - 15	704,000	34,050	25,250
	16 - 30	748,000	34,405	32,500
October	1 - 15	793,000	37,140	38,500
	16 - 31	843,000	39,990	46,225
November	1 - 15	893,000	42,440	54,775
	16 - 30	943,225	44,890	65,775
December	1 - 15	996,000	47,440	70,000
	16 - 31	1,055,000	50,040	87,500
1973:				
January	1 - 15	1,109,500	52,220	107,000
	16 - 31	1,174,500	53,750	128,000
February	1 - 15	1,243,500	55,120	149,000
	16 - 28	1,248,000	56,810	166,500
March	1 - 15	-	57,820	179,225
	16 - 30	-	57,760	186,000
April	1 - 15	1,341,430	56,750	190,225
	16 - 30	1,406,490	58,810	195,252
May	1 - 15	1,481,412	60,955	201,000
	16 - 30	1,552,780	62,940	206,500
June	1 - 15	1,626,920	64,720	212,500
	16 - 27	[2]1,684,700	66,830	216,000

See footnotes at end of tabulation.

APPENDIX C.--CUMULATIVE GAS PRODUCTION FOR HOLE NOS. 3SW, 4NW, AND 5C--Continued

Date		No. 3SW, ft^3	No. 4NW, ft^3	No. 5C, ft^3
1973--Con.				
July	1 - 15	2,373,520	69,000	216.000
	16 - 31	2,687,081	71,190	221,650
August	1 - 15	3,683,081	73,285	248,000
	16 - 31	4,102,485	75,290	274,500
September	1 - 15	4,905,985	77,545	301,500
	16 - 31	5,722,485	79,010	330,500
October	1 - 15	6,524,210	81,440	359,225
	16 - 30	7,370,210	84,945	381,000
November	1 - 15	8,081,485	88,000	397,000
	16 - 30	8,951,985	91,160	412,000
December	1 - 15	9,761,985	94,200	432,000
	16 - 31	10,635,985	97,480	456,225
1974:				
January	1 - 15	11,516,985	100,285	483,000
	16 - 31	12,480,485	103,740	516,000
February	1 - 15	13,274,485	106,665	550,500
	16 - 28	13,903,985	109,260	585,500
March	1 - 15	14,700,485	112,215	628,000
	16 - 31	15,437,760	115,050	671,500

[1] Borehole No. 3SW was shut in for 12 days during monitoring period Jan. 16-31, 1972.

[2] Borehole No. 3SW was hydraulically stimulated for greater production June 28-31, 1973.