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Foam Stimulation To Enhance Production From Degasification Wells in the Pittsburgh Coalbed

UNITED STATES DEPARTMENT OF THE INTERIOR

Report of Investigations 8286

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Cecil D. Andrus, Secretary

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FOAM STIMULATION TO ENHANCE PRODUCTION FROM DEGASIFICATION WELLS IN THE PITTSBURGH COALBED

by

Peter F. Steidl[1]

ABSTRACT

Seven degasification wells have been completed in the Pittsburgh coalbed at the new Emerald mine near Waynesburg, Pa. Funding was provided by the Bureau of Mines to perform stimulation treatments on five of the wells, to show that this is a feasible and economical means of degasifying part of a coalbed. The seven wells ranged in depth from 590 to 910 feet. Stimulation treatments used 25,260 to 42,660 gallons of foam and 7,400 to 12,800 pounds of 20/40-mesh prop sand. Pumping rates were 10.8 to 11.6 bbl/min and treating pressures were from 1,050 to 1,600 psig. On the day following stimulation, gas production ranged from a few hundred cubic feet per day to more than 100,000 cu ft/day.

INTRODUCTION

This project was designed to decrease the hazard of methane, allow increased production by reducing downtime, and lower ventilating costs. The proposal from Lykes Resources, Inc., suggested the use of foam stimulation, which was an innovation to the method being used by the Bureau.

The Bureau has conducted research on hydraulic stimulation of coalbeds to increase gas production and speed degasification. The stimulation treatment propagates a fracture which connects many small fractures, thus increasing gas production from the coalbed. Degasification prior to mining in gassy coalbeds is important to mining safety and efficiency. Degasification wells have been completed and hydraulically stimulated with gelled water in the Hartshorne, Illinois No. 6, Mary Lee, Pittsburgh, and Pocahontas No. 3 coalbeds (4-5).[2] The highest sustained production from any of these has been about 45,000 cu ft/day from a well in the Pittsburgh coalbed in Greene County, Pa.

In 1974, the management of Lykes Resources, Inc., appropriated funds for a program for coal degasification prior to mining when it was determined that

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[2]Underlined numbers in parentheses refer to items in the list of references preceding the appendices.

the Pittsburgh coalbed at the Emerald Mines Corp. property in Greene County would average more than 200 cu ft of methane per ton of coal in situ. This estimate was based on two coal cores analyzed by the direct method (6-7) that showed the coalbed to contain 188 to 208 cu ft of methane per ton. Moreover, these cores were taken from the part of the property with lowest overburden and probably the lowest gas content. A degasification program using 12 wells, spaced at about 12 acres per well around the slope and shaft, was proposed to reduce emissions of methane into the initial mine development (fig. 1). Lykes Resources, Inc., has had some previous experience with foam stimulation of gas wells completed in the upper portion of the Devonian shale near Youngstown, Ohio. The Bureau contracted with Lykes Resources for foam stimulation treatments on five of the seven wells completed.

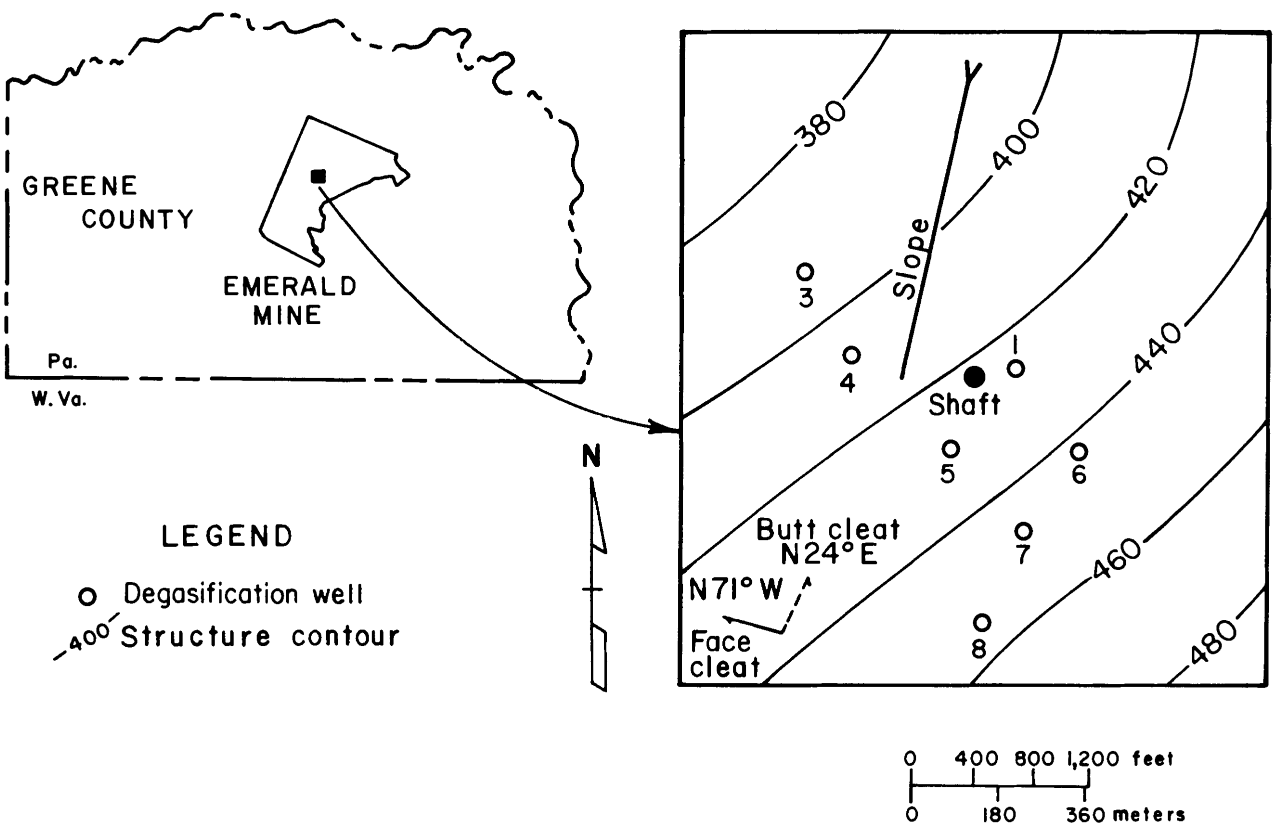

FIGURE 1. - Location of degasification wells.

ACKNOWLEDGMENTS

The author wishes to thank G. H. Denton, former director of geology, Lykes Resources, Inc., and now with the Pittston Co., for setting up this project and negotiating the contract with the Bureau. Thanks are also extended to R. G. Rahsman, district geologist with Lykes, for providing information and data.

DRILLING, LOGGING, AND COMPLETION

Seven wells were rotary drilled to about 40 feet below the Pittsburgh coalbed to provide a sump for water accumulation. The 6-1/4-inch-diam wells were cased with 4-1/2-inch-OD casing that was set in the shale above the coalbed and cemented to the surface. A drillable, formation-packer shoe was set in the shale above the main bench of the Pittsburgh coalbed and below the rider coals to keep cement out of the coalbed and sump. This procedure was satisfactory except in the case of the deepest well (well 3), in which the packer failed and the hole was filled with cement. Another problem was that 1 to 3 days were required for the service rig to drill out the packers.

To accurately set the casing, gamma ray and neutron logs were run. These logs also provided information on thicknesses and depths of the Pittsburgh coalbed, roof shale (draw slate), rider coals, and overlying formations.

In an attempt to demonstrate that the stimulation treatments did not damage the overlying rock, 3-D velocity logs were to be run on four of the wells, before and after stimulation. However, owing to gas bubbling through the water in two of the wells, the logs were not run after stimulation. In another hole, flowback after stimulation carried coal and rock into the bottom of the well, which prevented logging of the interval immediately above the coal. In the fourth well, the casing-to-cement bond was broken when the formation packer shoe was drilled out, and the rock properties of the roof interval were obscured on the log.

In preparation for gas production, powerlines were run to all the wells. After stimulation and flowback, each well was equipped with 2-3/8-inch-OD production tubing, a rocker arm pump jack, sucker rods, and a downhole pump to dewater the coalbed (fig. 2). The pump was set about 10 feet off the bottom of the sump to allow for sand and debris accumulation. (See costs in appendix A.)

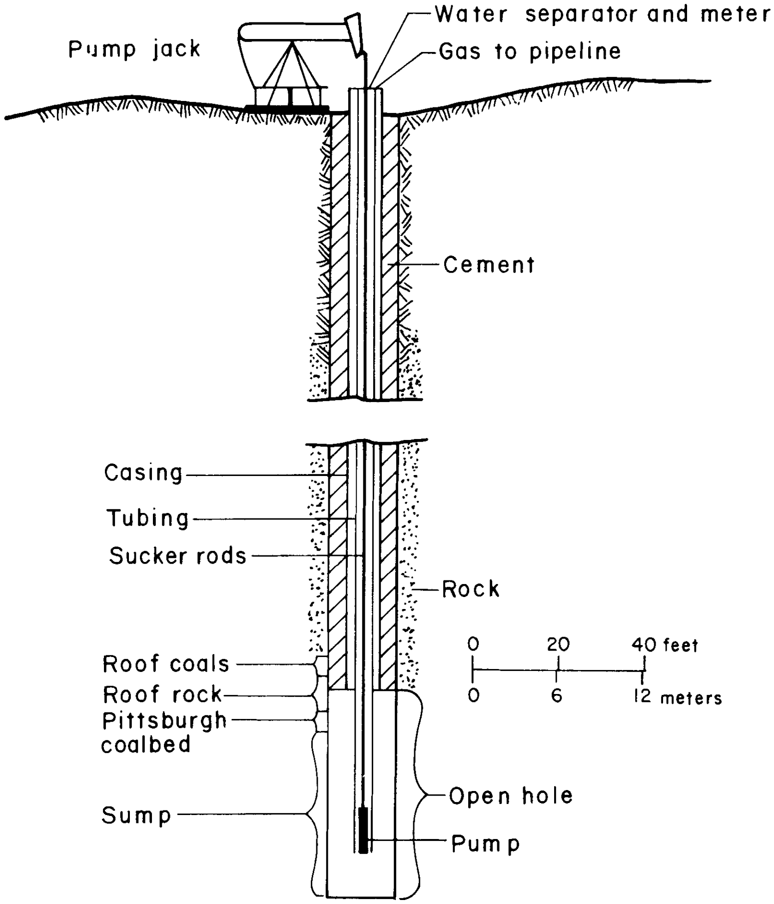

FIGURE 2. - Casing and surface equipment for degasification well.

DESIGN AND PROCEDURE FOR FOAM STIMULATION

A stimulation treatment propagates a fracture to increase the drainage radius of the well. To initiate fracture propagation, fluid is pumped into the coalbed under pressure. The foam used in these treatments was formed by pumping nitrogen into the water, which contained a foaming agent, to produce a 75-percent nitrogen foam. Prop sand is added to the foam to keep the fracture open after the pressure is released, and the stimulation fluid is allowed to flow back. Compared with other stimulation fluids, foam has the advantages of high sand-carrying capability, low fluid loss, little formation damage, and quick fluid recovery (1).

Halliburton Services and Aircowell[3] performed the stimulation treatments on these wells. Design of foam stimulation treatments must take into account such factors as coalbed thickness, permeability and porosity of the coal, hydrostatic pressure, viscosity of foam, quality of water, downhole temperature, prop sand size and concentration, well-casing diameter, and others. Each of the seven foam treatments used an average of 8,200 gallons of water, 5 gallons of foaming agent per 1,000 gallons of water, 10,900 pounds of 10/20- or 20/40-mesh sized prop sand, and 300,000 std cu ft of nitrogen. (Details of each treatment are given in appendix B.)

Treatments started with about 900 gallons of water (water pad) followed by 600 gallons of foam pumped into the coalbed. This opens a fracture, creates a fluid-filled channel for the propping sand to pass through, and helps to prevent a blockage of sand (screenout) when foam, carrying prop sand, is pumped into the coalbed. The amount of sand added to the foam was increased gradually as an additional precaution against a screenout; the injection rate was also increased. Slight formation breaks (drops in pressure

[3]Reference to specific manufacturers does not imply endorsement by the Bureau of Mines.

as a fracture is initiated) were observed on some of these treatments. The treatments were completed with a flush of foam to push the sand into the coalbed.

There were some exceptions to this procedure on four treatments where screenouts occurred. Following screenouts on wells 1 and 3, the wellhead valve was opened and treatment fluid was allowed to flow back and flush out the sand blockage; then the treatments were completed. Treatments on wells 6 and 7 were terminated after screenouts occurred, since the treatments were almost completed. To avoid loss of treatment fluid into the coalbed and the resulting pressure loss, the wells were allowed to flow back as soon as possible. Flowback of the wells, immediately after the treatment, produced enough water to account for the treatment fluid plus some formation water. Although immediate flowback is advantageous, pieces of coal and underclay that were carried into the well caused cleanup problems on two wells. This might have been prevented by choking off the wellhead valve during flowback.

PRODUCTION AND PRODUCTION DATA

To dewater the coalbed, the wells have been equipped with 16- and 24-inch-stroke Jensen sucker rod pumps with 84- and 100-bbl/day capacities, respectively. The 16-inch pumps are on the two wells that are more than 800 feet deep.

An attempt was made to use a submersible pump on well 4. It pumped only a few minutes and lowered the hydrostatic pressure in the well. This caused the well to unload (gas blew water out through the annulus) and carry propping sand into the sump. Submersible pumps are effective for pumping large volumes of water, but a sufficient amount of clean water must be available.

Water production was not metered since the gas pipeline and water separators were not installed. Gas production was measured several times (table 1) using an orifice meter.

Pumping on well 6 began 3 weeks after it was stimulated. On a few occasions over the following 8 weeks, the water level in this well was lowered enough that the gas pressure was sufficient to unload the well. Then for 5 weeks it unloaded in surges. Flow rates of more than 50,000 cu ft/day of gas were measured with an orifice meter between water surges.

The day after well 7 was stimulated, it began flowing more than 100,000 cu ft/day with some water. Well 6 stopped unloading as water was forced down-dip to it by the stimulation treatment performed on well 7. Well 7 flowed more than 120,000 cu ft/day for the next 7 weeks until the downhole pump failed and the resulting water fill-up in the well stopped gas flow. After 9 weeks, the well was put back on production and flow returned at the previous rate. Orifice meter tests taken before well 7 stopped producing showed a total flow of 220,000 cu ft/day from the six wells in production.

TABLE 1. - Gas production data in cubic feet per day

Date tested	Well						
	1	3	4	5	6	7	8
09-24-76........	-	7,500	([1])	942	20-30,000	120,000	10,800
10-01-76........	14,000	-	([1])	-	2- 8,000	122,000	10,800
10-29-76........	19,500	16,800	([1])	14,000	10,000	140,000	21,000
11-10-76........	25,200	16,700	([1])	-	100-34,000	([2])	-
12-14-76........	-	23,300	([1])	18,100	([2])	([2])	18,200
01-08-77........	-	24,500	([1])	100,000	([2])	105,000	8,100
01-26-77........	-	42,000	40,000	100,000	([2])	58,100	8,390
02-08-77........	10,400	-	-	-	-	([2])	-
03-28-77........	9,100	([2])	-	117,000	[2]800	([2])	-
03-29-77........	-	([2])	16,000	-	([2])	([2])	19,000
08-31-77........	1,070	41,400	7,090	79,800	([2])	44,400	3,510
09-07-77........	1,080	39,800	7,470	86,400	110,000	44,400	3,510
09-14-77........	2,430	39,800	8,840	81,900	86,400	-	3,140
09-19-77........	2,730	44,400	-	69,700	69,700	29,900	4,740
10-13-77........	2,720	28,200	3,510	61,100	64,100	25,200	3,216
10-20-77........	3,060	15,200	3,510	72,300	61,100	25,900	3,140
10-27-77........	3,060	([2])	([2])	74,800	61,100	25,200	3,140

[1]No pump.
[2]Pump down.

After all the nitrogen from the treatments was flushed out, recent tests showed that the gas averages 91 percent methane (table 2) and has a heating value of 900 Btu/std cu ft. Daily production data is not available because pipeline and metering equipment have not been installed.

TABLE 2. - Gas analyses, percent

Well	Date	O_2	N_2	CO_2	CH_4	C_2H_6	Total
1..................	07-26-76...........	0.5	15.3	3.0	80.8	0.3	99.9
1..................	09-08-76...........	.4	10.2	4.3	85.0	.2	100.1
1..................	03-28-77...........	.6	1.5	5.9	91.7	.4	100.1
3..................	10-28-76...........	.1	.3	3.3	96.3	.1	100.1
3..................	04-01-77...........	1.0	4.9	2.3	91.7	.1	100.0
4..................	03-31-77...........	.7	2.0	9.4	87.7	.3	100.1
5..................	08-25-76...........	.3	2.4	4.6	92.5	.2	100.0
5..................	10-28-76...........	.6	1.2	5.0	92.9	.3	100.0
5..................	03-28-77...........	.6	1.1	7.1	90.9	.4	100.1
6..................	07-19-76...........	.6	2.4	3.9	92.6	.4	99.9
6..................	08-18-76...........	.8	3.5	5.6	89.8	.3	100.0
6..................	03-28-77...........	.1	.7	6.5	92.5	.3	100.1
7..................	10-28-76...........	.0	.3	5.2	94.1	.6	100.2
7..................	03-31-77...........	.4	1.4	4.7	93.4	.1	100.0
8..................	10-28-76...........	.0	.3	4.2	95.3	.2	100.0
8..................	03-29-77...........	.4	2.4	5.9	91.4	.1	100.2

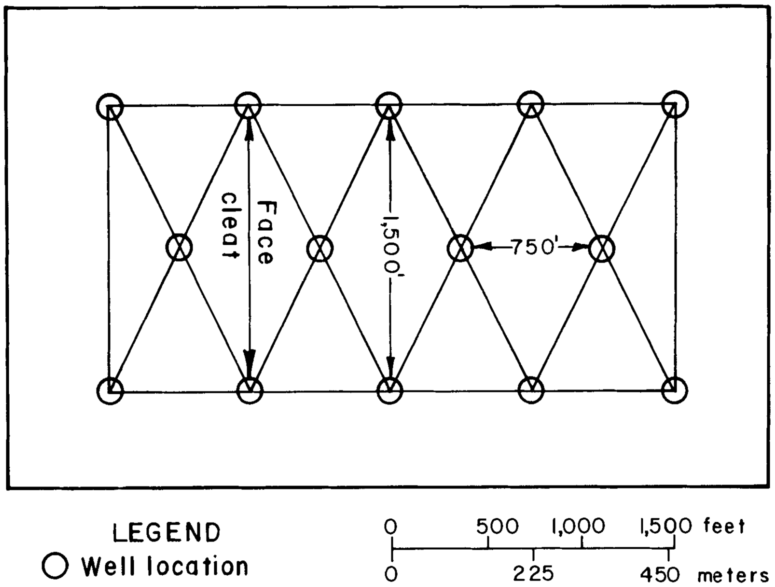

FIGURE 3. - Suggested well pattern to degasify part of a blocky coalbed.

WELL SPACING

Design of an economical degasification scheme depends greatly on proper well spacing (2). The direction of the face cleat in the coal should also be considered when laying out a well pattern (3). If possible, the pattern should be so designed that the largest spacing between wells is parallel to the face cleat direction. The well pattern shown in figure 3 has a spacing of one well per 12.9 acres. This spacing may be too close for a longer term degasification project.

Layout of a pattern should be considered before or during exploration drilling because a substantial reduction in cost can be made by using exploration holes as degasification wells. After they have been undermined, degasification wells can be used as rock dust, power drop, or gob degasification holes.

Well spacing at Emerald mine ranges from 645 to 905 feet and averages 720 feet or about 12 acres per well (fig. 1). This spacing proved to be satisfactory, except in the case of well 6 and well 1, which lie on a line parallel to the trend of the face cleat. Well 6 was stimulated; 6 weeks later, well 1 was stimulated and foam came out of well 6. Communication between these two wells suggests the well spacing was too close. In such a blocky coalbed with good fracture permeability, the well spacing could be increased.

SUMMARY AND CONCLUSIONS

Gas production from the treated wells that have low production was expected to rise substantially after the coalbed around them was dewatered, but has not, owing to mining in the vicinity of the wells, which has slowed gas production and will prevent the wells from being economical through gas sales alone. For mining companies, the major benefits to be derived are hazard reduction, increased coal production, and lowered ventilation costs. Continued production rates of 200,000 to 300,000 cu ft/day from the seven wells will show that degasification in advance of mining is feasible and economical in the Pittsburgh coalbed, considering the increased safety and coal production.

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APPENDIX A.--APPROXIMATE COSTS PER WELL

Service Costs

Access and site preparation on company property	$8,500
Drilling costs (735-foot average depth plus 30-foot sump)	8,800
Logging:	
Gamma ray and neutron log	700
Three-D velocity log (used on four wells)	1,600
Total	2,300
Cementing 4-1/2-inch casing:	
Cement (175 sacks 50/50 Pozmix and 5 pct salt)	550
Other costs	495
Total	1,045
Foam stimulation (30,000- to 40,000-gal treatment with sand proppant):	
Aircowell nitrogen service	2,650
Halliburton Services	4,400
Service rig (drill out cement packer and clean well)	6,000
Water tank rental (2 tanks at $150 each)	300
Water hauling (20,000 gal at $100 per 15,000 gal)	140
Total	13,490
Powerline to pump	1,100
Well hookup (running tubing, rods, and setting pump)	600
Total for services	35,835

Material Costs

Casing, 4-1/2 inches OD (10.5 and 10.7 lb/ft yellow band, test to 3,000 psig, with collars and formation-packer shoe, $2.85/ft)	2,570
Tubing, 2-3/8-inches OD (4.6 lb/ft J55, nonupset, 10-round)	500
Sucker rods (reconditioned No. 1 grade, 5/8 inch with 7/8-inch box and pins), and wellhead (Alten threadless casing head, 4-1/2 inches by 2 feet)	400
Pump jack (Jensen 24- and 16-inch-stroke 6.4B 32E24 or 16, 2-hp motor, 1,800-rev/min, three-phase, 220- or 440-volt) and pump (Continental Emsco RWT insert pump, 2 inches by 1-1/2 inches by 7 feet with a Baird positive lift valve)	2,000
Gas pipeline, meters, separators, and installation (not complete)	10,000
Total for materials	15,470
Grand total cost per well	51,305

APPENDIX B.--DATA ON STIMULATION TREATMENTS

Summaries of Fracture Treatments

Well No.	Depth to base of coal, feet	Treatment date, 1976	Treatment pressure, psig	Injection rate, bbl/min	Foam volume, gal	Sand weight, pounds
1.......	641	06-01	1,400	11.2	33,000	12,500
3.......	908	08-18	1,600	11.2	25,260	11,000
4.......	849	08-25	1,300	10.8	39,000	10,000
5.......	770	09-01	1,375	11.6	31,500	10,000
6.......	588	04-15	1,500	17.7	29,200	14,000
7.......	734	09-08	1,400	10.8	29,000	7,400
8.......	652	09-15	1,050	10.8	42,660	12,800

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