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BUREAU OF MINES TECHNICAL PROGRESS REPORT

DEMONSTRATION OF SAFETY PLUGGING OF OIL WELLS PENETRATING APPALACHIAN COAL MINES

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DEMONSTRATION OF SAFETY PLUGGING OF OIL WELLS PENETRATING APPALACHIAN COAL MINES

by

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ABSTRACT

An oil well penetrating the Pittsburgh bituminous coalbed in northern West Virginia was plugged and safely mined through 3 months later. A sensitive chemical tracer, introduced into the oil reservoir before the test, was not detected in the mine air following the plugging and during mining of the pillar and penetration of the well. Effectiveness of the plugging in preventing reservoir gas from entering the mine through the well hole was verified by continuous monitoring of the mine air for indications of sulfur hexafluoride, an inert gas detectable in amounts as minute as 1/2 part per billion. Expandable cement and fly ash-gel-water slurry were utilized to seal the well above and below the coal seam. Three other wells were also plugged using various techniques.

INTRODUCTION

Plugging of abandoned oil wells is being investigated as a means of solving various problems these wells pose to coal-mining operations. Coalbeds at relatively shallow depths are often penetrated by boreholes drilled into oil and gas formations below the coal. In the Appalachian area, thousands of oil and gas wells that penetrate minable coalbeds have been abandoned or produce only marginal amounts of oil and/or gas. Only about 40 percent of the wells are still producing oil or gas; the rest quite likely could be abandoned in favor of mining operations.

The Federal coal-mining regulation[5] requires barriers to be established and maintained around oil and gas wells in accordance with State laws and regulations. These barriers must be at least 300 feet in diameter, although greater or lesser barriers may be permitted by the Secretary of the Interior or his authorized representative. The purpose of the barriers is to prevent

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[1] Petroleum engineer.
[2] Research supervisor.
[3] Project leader.
[4] Electronic development technician.
[5] Interim Mandatory Safety Standard for Underground Mines, section 317(a), Federal Coal Mine Health and Safety Act (30 U.S.C. 877(a), 30 CFR 75.1700).

combustible gases from entering the mine and to prevent accidental shearing of wells in mining operations. Many of the wells that intersect coalbeds in the Appalachian area enter essentially pressure-depleted reservoirs, and of them, many have been plugged and abandoned. A 300-foot pillar around a well represents a quantity of unminable coal and complicates the design of entryways, haulageways, and ventilating systems. Areas in which wells are drilled on close, irregular spacing (2.5 acres or less) can be completely unminable. Also, 300-foot pillars around wells in which the pressures exceed several hundred pounds per square inch would not contain the gas in the event of serious leaks. In the case of marginally productive reservoirs, it would be more satisfactory to permanently and safely plug the well below the coalbed, thereby permitting mining of the pillar.

Elimination of random well pillars would allow the use of longwall and shortwall mining systems (which are inherently safer than conventional mining techniques), improve the ventilation system to reduce hazards associated with methane, and simplify the haulage system. Additional advantages that increase safety include modification of the mining cycle to eliminate abrupt changes and improved roof conditions relative to those that exist when there are random pillars.

ACKNOWLEDGMENTS

The authors thank John L. Rozance, president, Michael O'Brien, vice president of operations, William A. Light, manager, real estate, and Wilbur T. Simon, safety director, all with the Christopher Coal Co.; Fred E. Smith, Ralph Hicks, and Riley L. Thomas, safety committeemen, Osage Mine No. 3, Christopher Coal Co.; and Donald F. Poland, safety coordinator, District 31, United Mine Workers of America, for their assistance and cooperation in planning and conducting the mining through of the S. Barrackman well 5, Osage No. 3 mine, Consolidation Coal Co.

Mining through of this well was witnessed by Frank Rutledge, district mine inspector, State of West Virginia; Joseph Marshalek and Paul J. Componation, Federal coal mine inspectors, Bureau of Mines Coal Mine Health and Safety District D; Messrs. Poland, Simon, Smith, Hicks, and Thomas and Stanley Hopwood, section foreman, Osage No. 3, Christopher Coal Co.; and J. Pasini III, research supervisor, and G. E. Rennick, petroleum engineer, Morgantown Energy Research Center, Bureau of Mines.

WELL-PLUGGING MATERIALS

Various cement types and water mixtures were tested in the laboratory to determine the properties that could be expected of the cement plugs. Properties of the three cements that were selected for plugging the four test wells are as follows:

	Chem Comp[1] (expanding cement)	Pozmix[1] (fly ash and cement)	Portland
Water..............gal/sack..	6.30	5.80	6.30
Shrinkage[2]..............pct..	.80	7.60	5.70
Sand grain density..g/cu cm..	2.07	2.12	2.23
Bulk density........g/cu cm..	1.71	1.48	1.53
Porosity................pct..	17.40	30.10	31.30
Effective air permeability md..	.14	3.90	.40

[1] Reference to specific brands is made for identification only and does not imply endorsement by the Bureau of Mines.
[2] Shrinkage is very difficult to determine; therefore, these values show the relative shrinkage effect.

Weight of the fly ash-gel-water slurry used as filler plug was 14.4 pounds per gallon when 98 pounds of fly ash and 2 pounds of Aquagel were mixed with 6.3 gallons of water.

WELL SELECTION

Several coal companies in the Morgantown, W. Va., area were particularly interested in well plugging because they planned to conduct longwall mining in certain sections that would necessitate mining through wells rather than pillaring around them. Timing of the work, however, necessitated selection of wells in an area that could be mined through within a 1-year period. Also, permission of the well owner was required to plug and mine through the wells to coincide with mining operations within the 1-year period. Ultimately, four wells in Clay district, Monongalia County, W. Va., were selected because at least one could be mined through within the necessary time. Figure 1 shows the locations of the four wells and the status of mining operations when the well owner agreed to let the Bureau of Mines plug the wells.

WELL TESTING AND PLUGGING

Three of the four wells selected for plugging had been drilled in the early 1890's, and the fourth--Fetty Heirs well 10, a water injection well--was drilled in 1965. Two wells still had derricks over them; the engine house, belt hall, and band wheel were intact and operative (fig. 2). Fieldwork was commenced in the same way operators normally do in this area: The pipe derricks were first cut down; then the engine house, belt halls, and other equipment was dismantled for salvage. A portable drilling rig was then set up over the well.

The rods and tubing were first pulled, and then tools were run to bottom to make sure that the well was open to the original productive sand (Big Injun). A pressure-recording instrument was run in, and the well was then shut in to build up the pressure at the bottom of the hole.

Gamma ray-neutron and caliper logs were obtained to accurately locate the formation and the five coalbeds penetrated by the wells, obtain a record of the well casings, and select packer seat locations. Several of the wells were

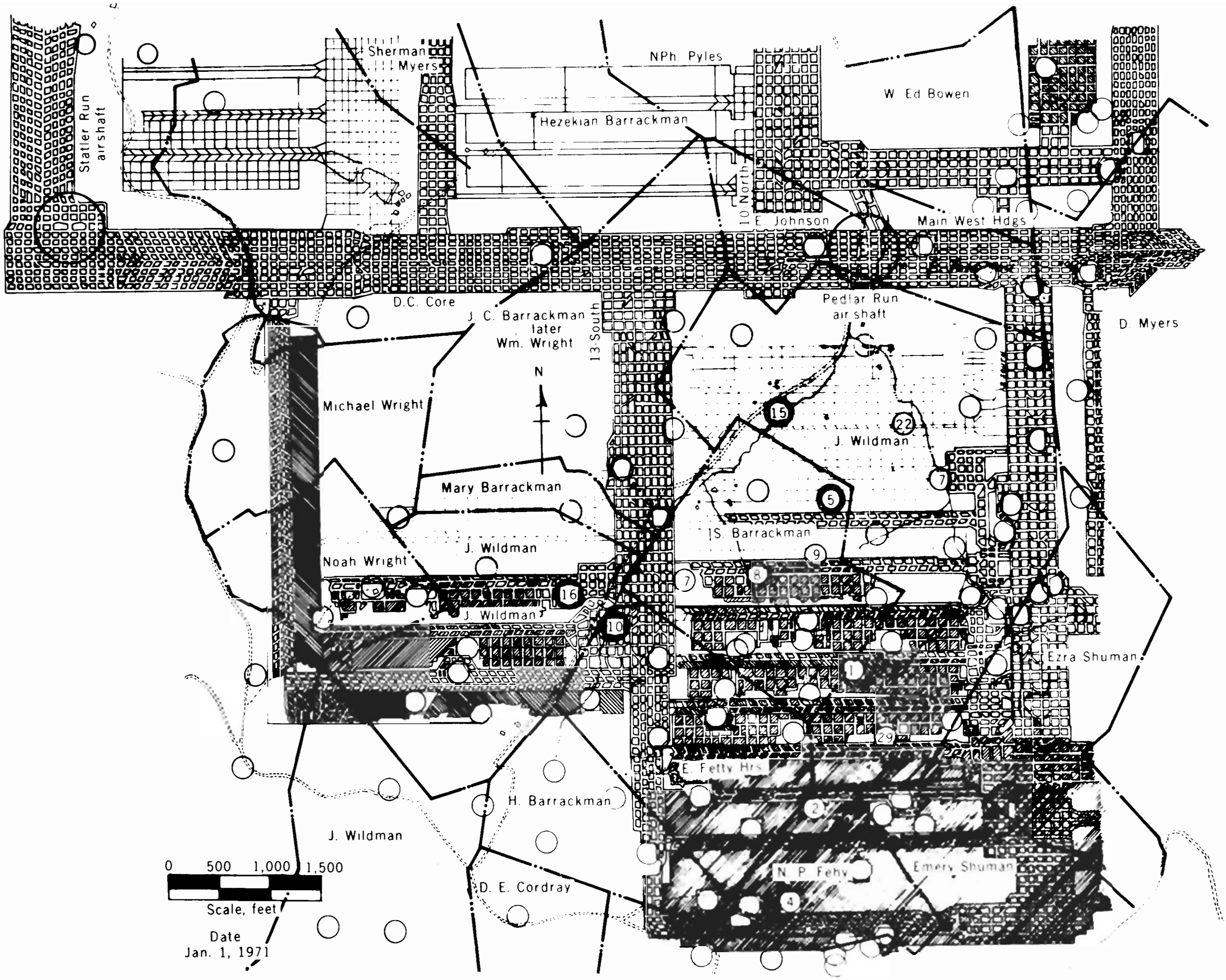

FIGURE 1. - Location of Wells With Respect to Mining Operations in Christopher Coal Co.'s Osage No. 3 Mine, January 1, 1971.

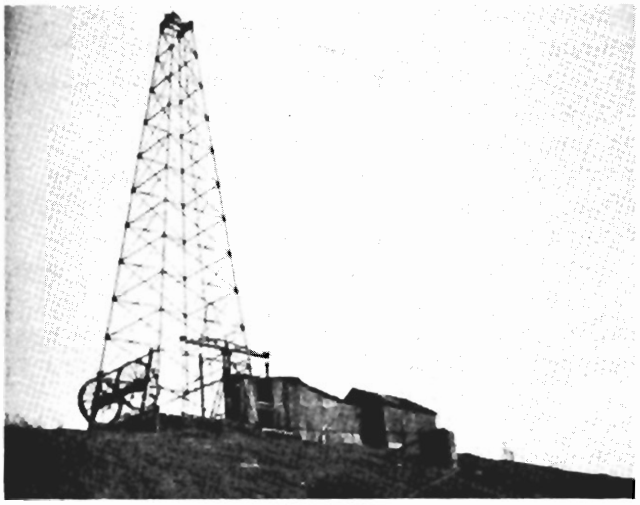

FIGURE 2. - Typical Surface Equipment on Old Wells in Clay District, Monongalia County, W. Va.

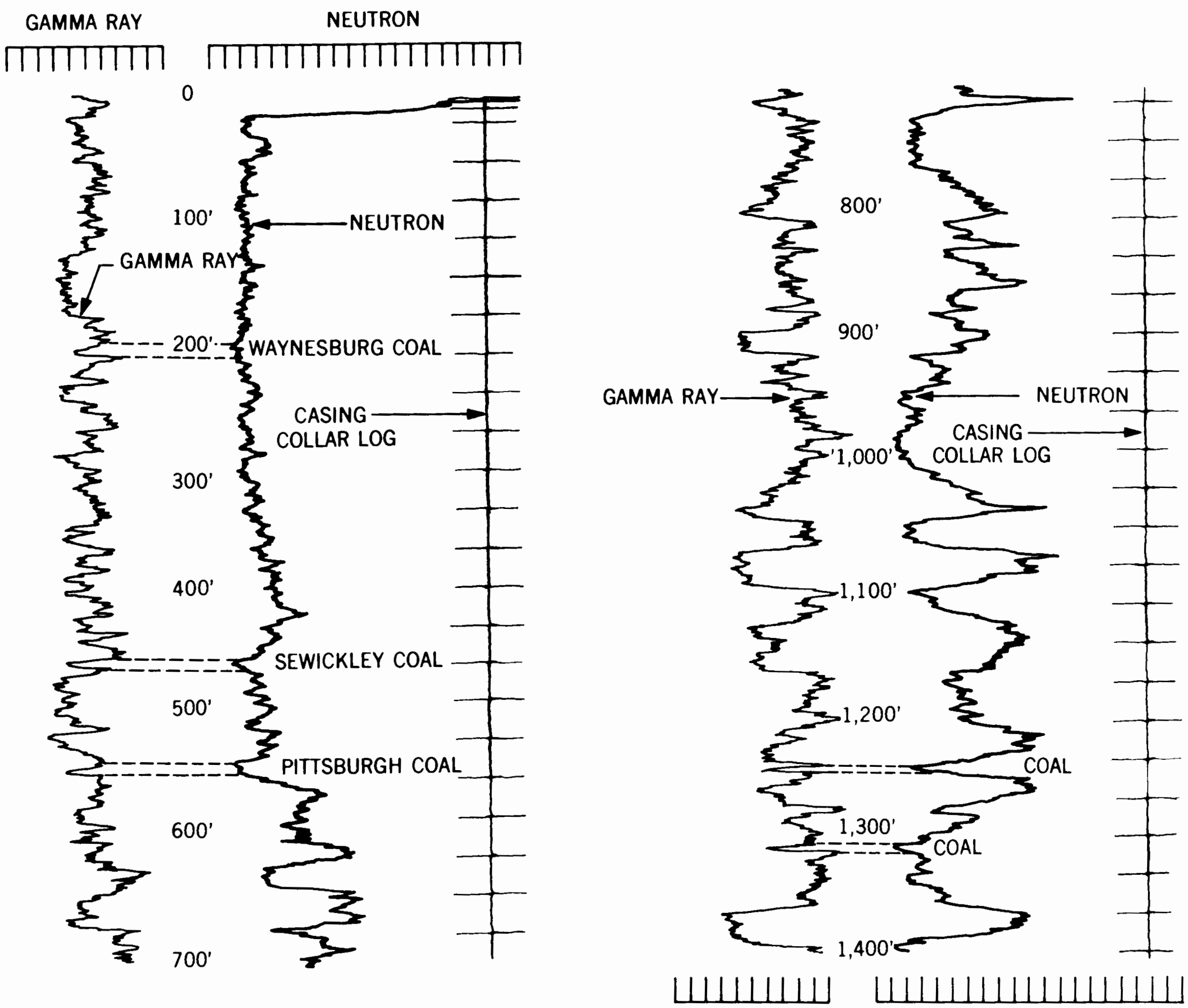

FIGURE 3. - Gamma Ray-Neutron Well Log Showing Location of Coalbeds.

logged two or three times because they had three to four strings of casing. In several cases, the presence of gas behind the casing made it difficult to interpret the neutron log and accurately locate the coalbeds. Figure 3 illustrates the combination of gamma ray-neutron logs used to detect coalbeds through the well casing. Figure 4 shows the caliper log that was used to select a packer seat and determine hole and casing size. The casing-collar log shows casing collars, bottom of casing, and holes or breaks in the casing. The gamma ray-neutron log was used to determine the depth of the petroleum-producing formation, to ascertain lithology (such as sandstone or shale), and for correlating with other wells. The caliper log was used to determine the condition of the pipe and locate a suitable place in open hole, below the casing and above the producing formation, to set a packer. (Details are given in the appendix.)

A mechanical packer was set in all four wells--the main deviation from normal plugging procedure. A Lynes production-injection packer was used because of its expanding feature: the element can pass through the smallest well casing but can expand enough to seal against the wall of the open hole, thereby preventing leakage. To determine if each well was properly plugged--that is, to establish that there was no communication in the wellbore between the oil- and gas-producing formations and the coalbeds--a gas tracer was injected into the producing formation before it was plugged.

Sulfur hexafluoride (SF_6) was used as the tracer gas. SF_6 is inert, not present in the environment, and can be detected with a gas chromatograph in quantities as low as 1/2 part per billion. The SF_6 was injected at pressures below 300 psi so it would remain in a gaseous state. Injection of the tracer (100 lb--about 250 scf) was followed by injection of enough nitrogen to force SF_6 from the tubing into the oil and gas formation. A 2-inch bridge plug was then set in a tubing nipple at the top of the packer. When the bridge plug was run in the tubing, a high-pressure lubricator with grease seals was used to prevent the tracer and nitrogen from leaking back into the casing. A J-tool in the tubing string above the nipple on the packer released the tubing from the packer. An expanding cement plug was then placed on top of the packer by pumping the slurry through the tubing. After the cement plug was in place, the tubing and the inner (production) string of casing was pulled from the well. Field experience in the areas where plugging is being conducted is important because the formation can cave in if too much casing is pulled, thus preventing reentry to place cement plugs.

Three wells were plugged back up to the base of the Pittsburgh coalbed and the casing was either pulled to expose the coal or ripped opposite the coalbed (figs. 5-7). The casing in Fetty Heirs well 10 was only 6 years old and had been cemented in. To prevent any possible safety hazard in the mine from perforation of the casing opposite the coal, a sand formation below the coal was perforated and the well was plugged back up to the base of this perforated zone (fig. 8). This provided test conditions similar to the other wells; that is, the annulus could be checked for tracer leaks. After each well was ready for testing, a vacuum pump was connected at the top of the well and samples were withdrawn daily (fig. 9). Samples were also obtained from all wells that are numbered in figure 1, and from two return air shafts

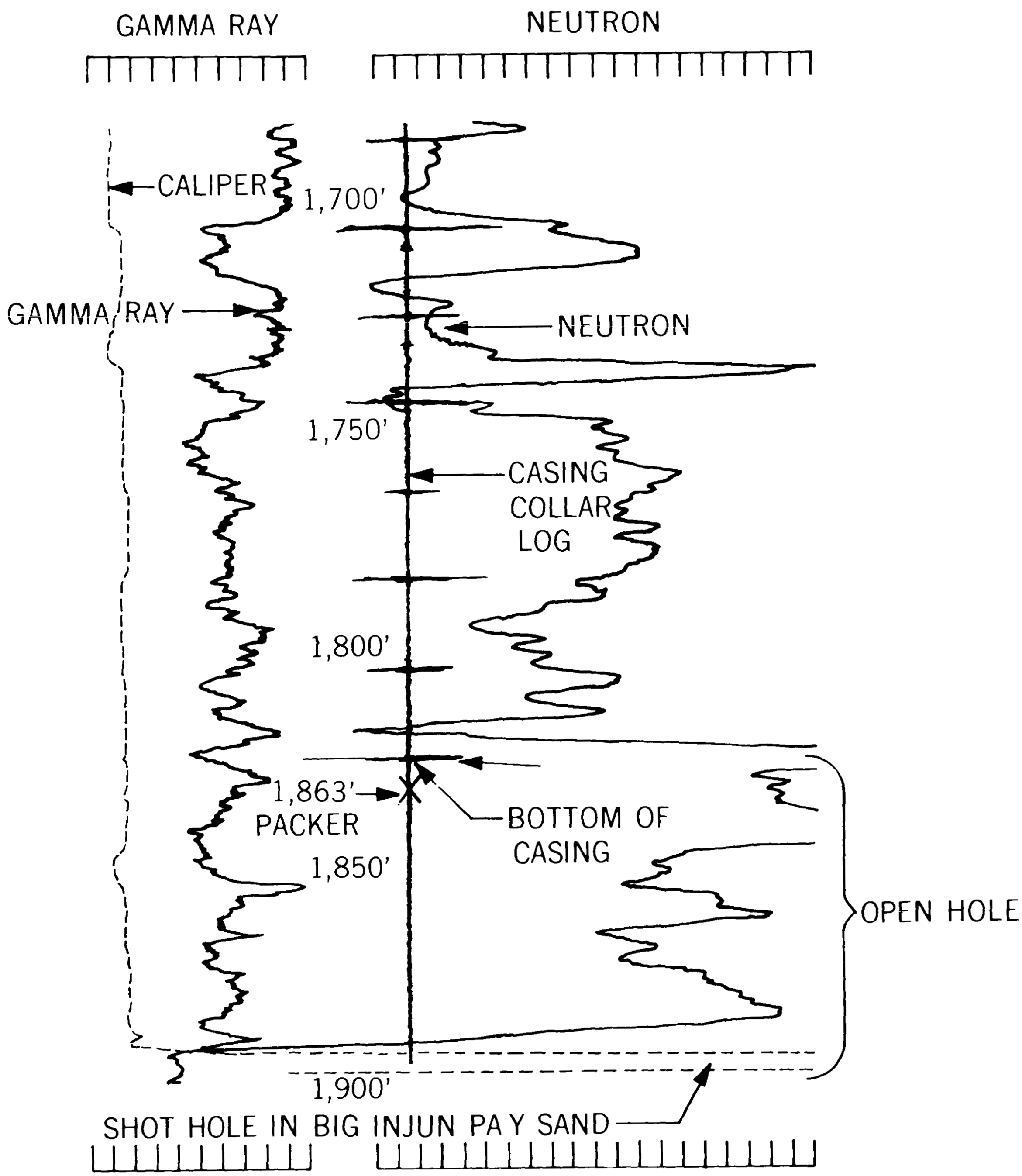

FIGURE 4. - Gamma Ray, Neutron, Caliper, and Casing-Collar Logs Showing Bottom Section of Plugged Well.

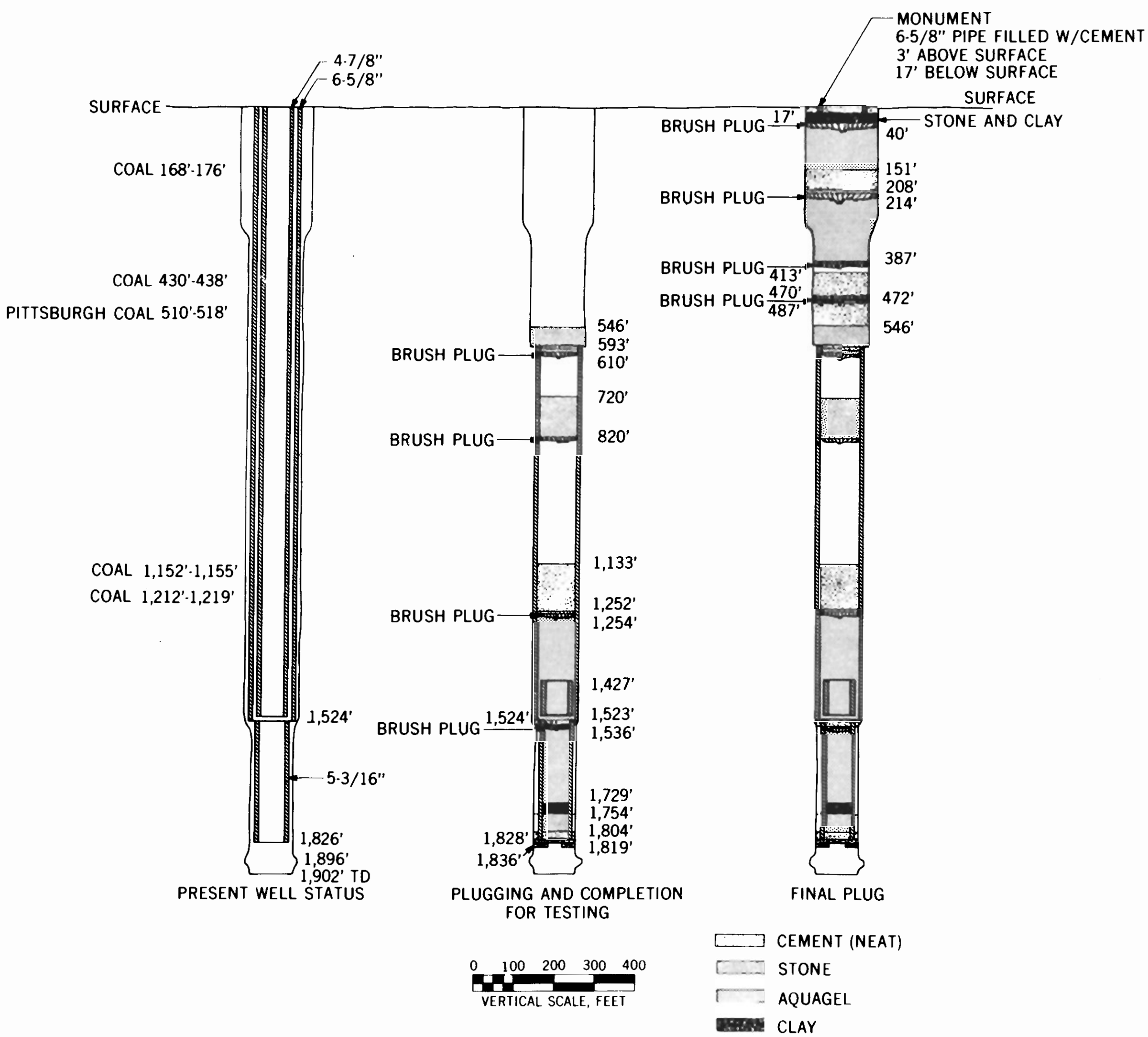

FIGURE 5. - J. Wildman Well 15, l to r, Before and After Partial Plugging and Completion for Testing, and After Plugging to Surface.

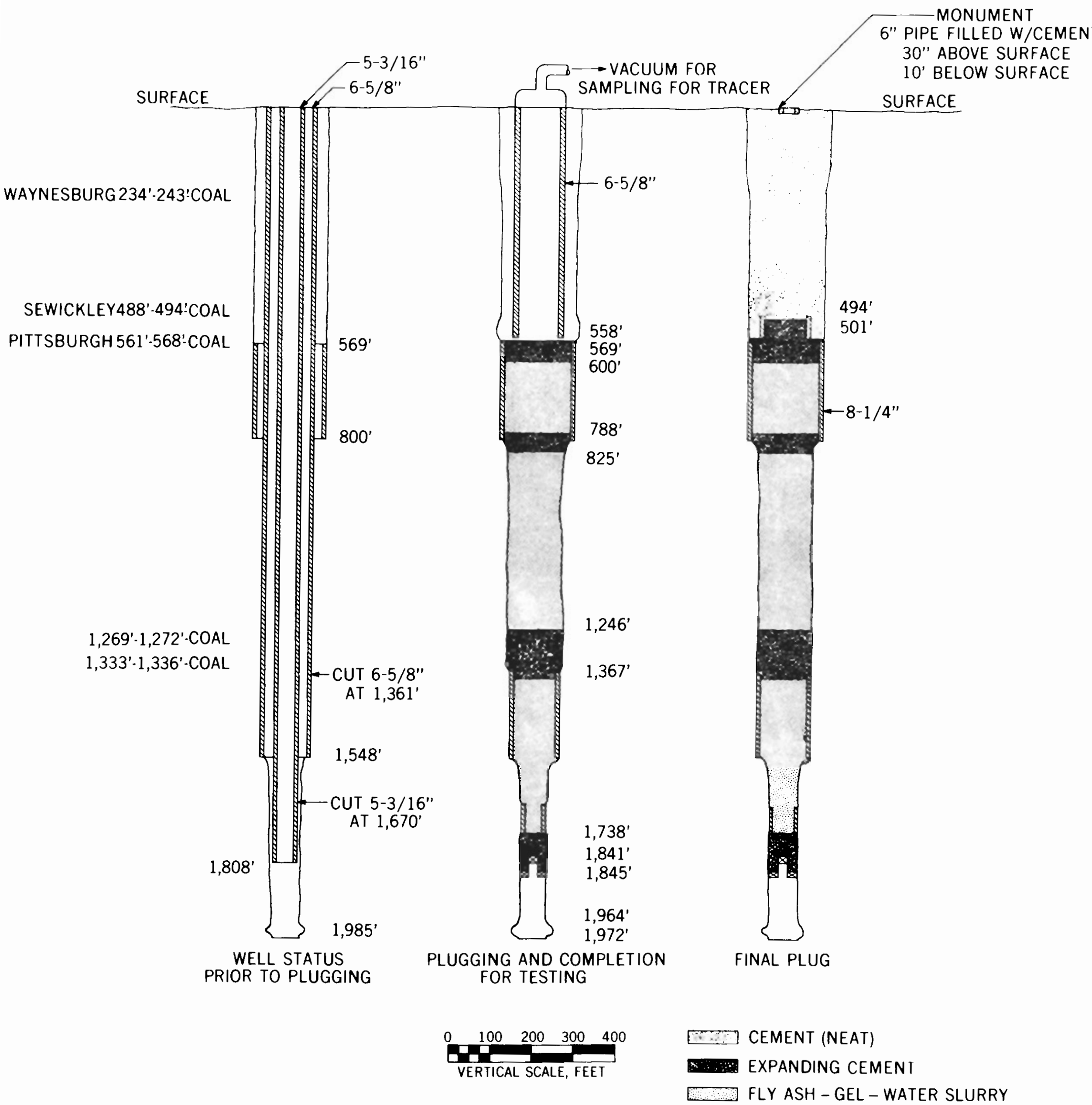

FIGURE 6. - J. Wildman Well 16, l to r, Before and After Partial Plugging and Completion for Testing, and After Plugging to Surface.

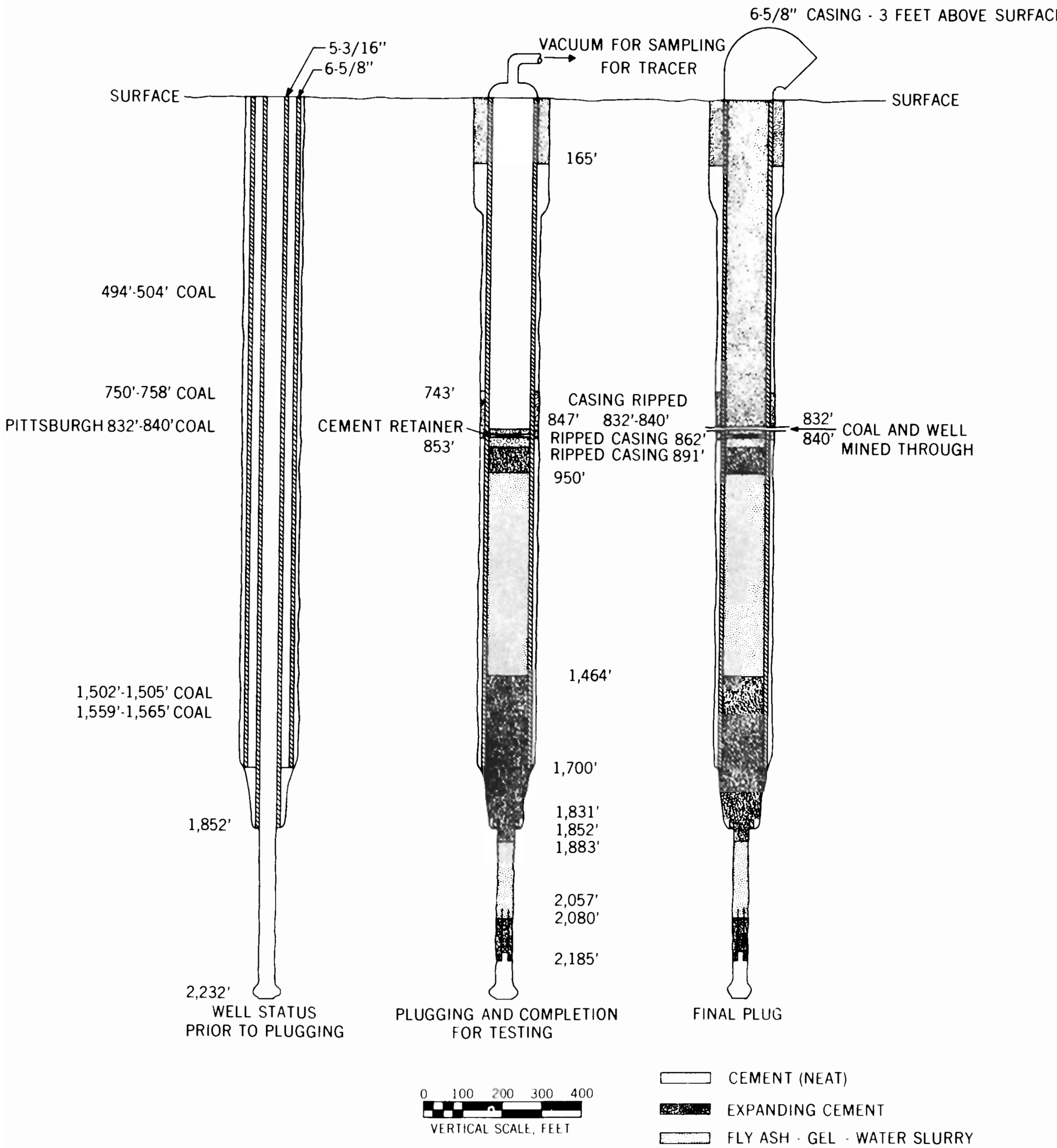

FIGURE 7. - S. Barrackman Well 5, l to r, Before and After Partial Plugging and Completion for Testing, and After Plugging to Surface.

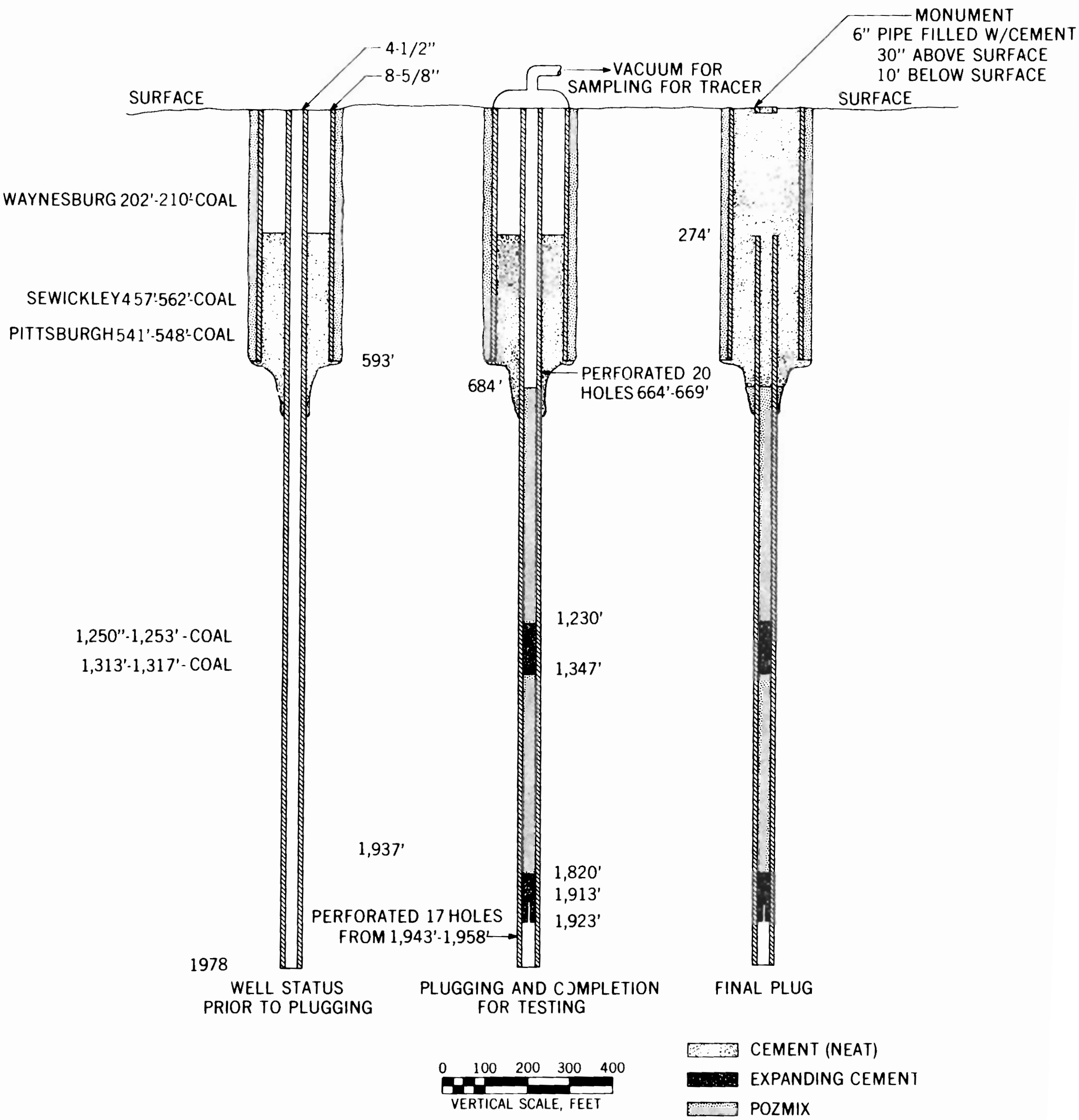

FIGURE 8. - Fetty Heirs Well 10, l to r, Before and After Partial Plugging and Completion for Testing, and After Plugging to Surface.

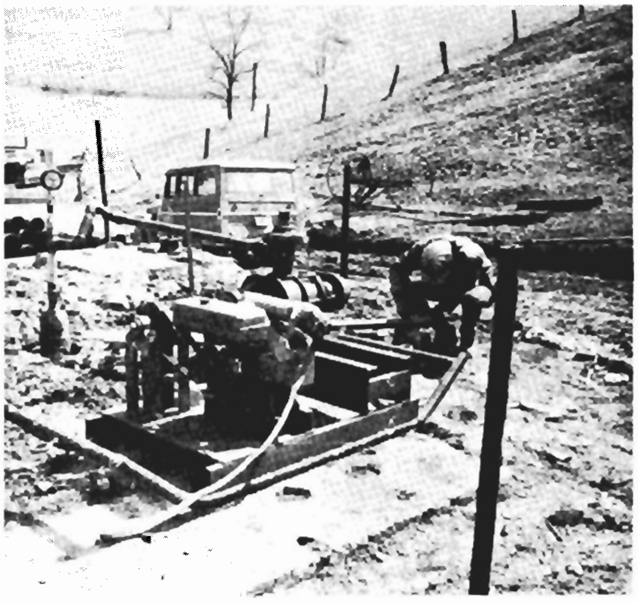

FIGURE 9. - Sampling a Plugged Well for SF_6 Tracer.

FIGURE 10. - Well at Surface After Grading and Reseeding.

serving the area of the mine near the plugged wells. Except for two or three occasions, no SF_6 was detected in samples obtained twice daily, including weekends, from March 16 to August 31. Instances in which SF_6 was detected can be attributed to unavoidable contamination from the mechanics of injection. However, the real effectiveness of the SF_6 as a tracer was revealed when it migrated through the producing formation and showed in the gas samples from S. Barrackman well 9, a producing well, after July 12 in amounts ranging up to about 200,000 parts per billion.

Sampling was continued while all four wells were being plugged back to the base of the Pittsburgh coalbed. Plugging to the surface was then completed and each site was graded to surface specifications and sealed (fig. 10).

Details of the plugging of the four wells are given in the appendix.

MINING THROUGH A PLUGGED WELL

S. Barrackman well 5 was the first well plugged and legally mined through after passage of the Coal Mine Health and Safety Act of 1969. An agreement between the Christopher Coal Co. and the U.S. Department of the Interior, entered into July 31, 1971 (Contract No. 14-09-0070-448), gave the company an exception to the mandatory safety standard in section 317(a) of the Federal Coal Mine Health and Safety Act of 1969 (30 CFR 75.1700) to remove the entire barrier around W. H. Allen well 5 (S. Barrackman) in section 16-A off 12 south, Osage No. 3 mine. Section 501(c) of the Federal Coal Mine Health and Safety Act authorizes the Secretary of the Interior (delegated to the Director, Bureau of Mines, June 25, 1970, 215 DM 9.1L, 9.1P, and 9.1Q) to grant exceptions to the application of mandatory health and safety standards to a coal mine operator who conducts experimental and demonstration projects on behalf of the Director, Bureau of Mines.

Before proceeding with the project, Christopher Coal Co. also obtained a permit from the State of West Virginia for the company to mine to and through the oil well, under the supervision and control of the Bureau of Mines.

The section crew and others who were to observe the mining through of S. Barrackman well 5 entered the mine on the midnight shift, August 7, 1971. Section 16-A had been heavily rock dusted by the previous shift, and a methane check was made and the accessible roof and ribs around the block of coal containing the well were inspected at time of entry. No methane was detected, and the roof and ribs around the well support pillar were in good condition. Mining toward the well was started at 1:00 a.m. No methane was detected until mining had proceeded to within 29 feet of the well, at which time 0.03 percent methane was recorded and crude oil was detected by smell but not by sight. Methane concentration when mining reached 14 feet from the well rose to 0.1 percent and continued at this level until the well was mined into at 4:10 a.m. Vacuum-bottle samples taken from around the casing were subsequently analyzed for SF_6 and methane (table 1); methane content of air in the face area was 0.12 percent (near roof). The crude oil odor was attributed to a 1-1/2-inch hole where the casing had corroded. This hole has probably existed for years and allowed crude oil to enter the coal around the well.

TABLE 1. - Gas concentrations after mining through S. Barrackman well 5, Osage No. 3 mine, Christopher Coal Co., percent

(Dash indicates no analysis)

	Time	Location in mine	SF_6	Methane	Oxygen	Carbon dioxide	Nitrogen
Aug. 7	04:10	At well casing.....	0	-	-	-	-
7	04:42	.......do..........	0	-	-	-	-
7	04:45	.......do..........	-	0.12	21.95	0	77.93
7	10:48	.......do..........	0	-	-	-	-
7	10:49	.......do..........	-	.06	21.94	0	78.00
7	16:32	.......do..........	-	.04	22.08	.05	77.83
7	16:33	.......do...........	0	-	-	-	-
8	08:10	Casing in roof......	-	.04	21.91	0	78.05
8	08:40	Casing in pavement..	0	-	-	-	-
8	08:40	.......do...........	-	.05	21.89	0	78.06
8	08:40	In entry............	-	.03	21.95	.09	77.93
8	16:20	.......do...........	0	-	-	-	-
9	11:30	.......do...........	0	-	-	-	-
10	09:00	At bleeder 16-A[1]....	0	-	-	-	-
11	10:20	.......do...........	0	-	-	-	-
12	09:20	.......do...........	0	-	-	-	-
13	11:30	.......do...........	0	-	-	-	-
14	08:30	.......do...........	0	-	-	-	-
16	08:25	.......do...........	0	-	-	-	-
17	11:00	.......do...........	0	-	-	-	-
18	10:30	.......do...........	0	-	-	-	-
20	13:00	.......do...........	0	-	-	-	-
23	10:45	.......do...........	0	-	-	-	-
24	14:10	.......do...........	0	-	-	-	-
25	12:20	.......do...........	0	-	-	-	-
26	12:30	.......do...........	0	-	-	-	-
27	12:20	.......do...........	0	-	-	-	-
30	12:15	.......do...........	0	-	-	-	-
Nov. 23	-	.......do...........	0	-	-	-	-

[1]Well in "gob."

In mining through, the well casing was broken off (the casing had been ripped from the surface prior to cementing, fig. 11), by moving the continuous miner (ripper) head back and forth. Vacuum-bottle gas samples were taken from the well casing after it was removed. Methanometer readings in face area of the coal showed 0.1 percent methane. Both the dense cement jacket around the casing and the cement within the casing were in excellent condition. Gas samples were extracted from the casing until the section became a "gob" area. No tracer was detected in samples from the "gob" bleeder ventilating section 16-A through November 1971, thus indicating an excellent well seal.

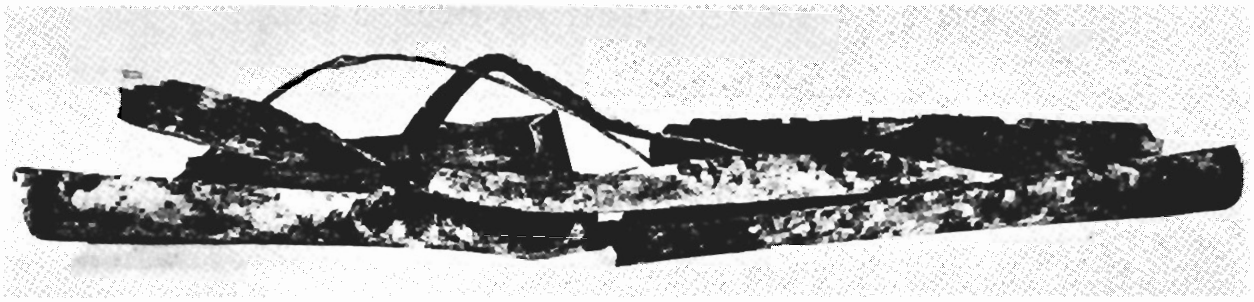

FIGURE 11. - Casing From S. Barrackman Well 5 After Mining Through and Removal From Pittsburgh Coalbed.

CONCLUSIONS

This work demonstrated that active low-pressure oil and natural gas wells intersecting coal seams can be plugged and safely mined through, and will remain sealed even if the petroleum-producing formation is repressured.

The precise location of the well in the coalbed should be known to facilitate safe mining-through operations, and well logs should be run before the wells are plugged to accurately locate the minable coalbeds, petroleum-producing formations, and well casing.

Consideration should be given to possible use of old wells as power and rock-dust-supply holes and for methane drainage before mining through, and later as "gob" drainage holes, thus offsetting part of the costs of plugging.

APPENDIX.--DETAILED SUMMARY FOR PLUGGING WELLS

J. Wildman Well 16 (Fig. 6)

	Operation	Description
1.	Geophysical well logs	Gamma ray-neutron and caliper (total depth)
2.	Bottom-hole pressure buildup	110 psi after 113 hours' shut-in time
3.	Production injection packer set	1,845 feet
4.	Injection test	100,000 scf of nitrogen at 2,200 to 2,400 psi, shut-in pressure 2,400 psi, 5-hour shut-in pressure 600 psi, 19-hour shut-in pressure 350 psi
5.	Injection of SF_6	Bled wellhead pressure down to 50 psi, injected 250 scf SF_6 at 94 psi, injected 17,000 scf N_2 at 300 psi, injected 53,000 scf N_2 at 1,200 psi
6.	2-inch bridge plug set	1,841 feet
7.	Placed plug (through tubing)	Top of packer to 1,738 feet expanding cement (20 sacks)
8.	Cut 5-3/16-inch casing	1,670 feet (pulled all casing)
9.	Cut 6-5/8-inch casing	1,361 feet (pulled 131 feet)
10.	Placed plugs (through tubing)	1,738 to 1,367 feet, fly ash-gel-water slurry (3 tons fly ash and 125 lb Aquagel)
		1,367 to 1,246 feet expanding cement (38 sacks)
11.	Pulled 6-5/8-inch casing to 558 feet	
12.	Geophysical well logs	Gamma ray-neutron and caliper
13.	Placed plugs (through tubing)	1,246 to 825 feet, fly ash-gel-water slurry (5.4 tons fly ash and 65 lb Aquagel)
		825 to 788 feet expanding cement (14 sacks)

Operation	Description
	788 to 600 feet fly ash-gel-water slurry (2.4 tons fly ash and 35 lb Aquagel)
	600 to 569 feet expanding cement (8 sacks)
14. Moved rig from well and connected vacuum pump for sampling	
15. Collect sample to be analyzed for SF_6	80 days
16. Moved rig onto well to complete plugging	
17. Placed cement plug (dump bailer)	569 to 501 feet expanding cement (20 sacks)
18. Cut 6-5/8-inch casing	494 feet
19. Placed cement plug (poured from surface)	501 to 351 feet neat cement (135 sacks)
20. Pulled 6-5/8-inch casing	494 feet
21. Placed plug (through tubing)	351 feet to surface, neat cement (294 sacks)
22. Set well monument	10 feet below to 30 inches above surface (6-5/8-inch casing filled with 15 sacks neat cement)
23. Graded and seeded area	Grass growing

Fetty Heirs Well 10 (Fig. 8)

1. Geophysical well logs	Gamma ray-neutron and caliper (total depth)
2. Bottom-hole pressure buildup	131 psi after 68 hours' shut-in time
3. Production injection packer set	1,923 feet
4. Injection test	50,000 scf of nitrogen, shut-in pressure 1,280 psi, 1-hour shut-in pressure 840 psi

Operation	Description
5. Injection of SF_6	Bled wellhead pressure down to 160 psi
	Injected 2,000 scf nitrogen and 125 lb SF_6 at 275 psi (N_2 and SF_6 simultaneously)
	Injected 38,000 scf N_2 at 1,040 psi
	Shut-in pressure after 16 hours 480 psi
	1 barrel water used to wash down tubing
6. 2-inch bridge plugs set	1,913 feet
7. Placed plugs (through tubing)	Top of packer to 1,820 feet expanding cement (7 sacks)
	1,820 to 1,347 feet, Pozmix cement (22 sacks)
	1,347 to 1,230 feet, expanding cement (8 sacks)
	1,230 to 684 feet, Pozmix cement (24 sacks)
8. Perforated casing	20 holes, 664 to 669 feet
9. Collect samples to be analyzed for SF_6	58 days
10. Moved rig onto well to complete plugging	
11. Cut 4-1/2-inch casing	274 feet (pulled from hole)
12. Placed plug (through tubing)	684 feet to surface, neat cement (150 sacks)
13. Set well monument	10 feet below surface to 30 inches above (filled 6-inch casing with cement)
14. Graded and seeded area	Grass growing

S. Barrackman Well 5 (Fig. 7)

1. Geophysical well logs	Gamma ray-neutron and caliper (total depth)

	Operation	Description
2.	Bottom-hole pressure buildup	48 psi after 46 hours' shut-in time at 78° F
3.	Production injection packer set	2,185 feet
4.	Injection test	225 scf nitrogen at 110 psi, 12 scf nitrogen at 80 psi (14 hours)
5.	Injection of SF_6	Bled wellhead pressure down to 40 psi, injected 325 scf N_2 and 125 lb SF_6 (N_2 and SF_6 injected simultaneously)
		Injected 800 scf nitrogen, shut-in pressure after 14 hours 80 psi
6.	2-inch bridge plug set	2,180 feet
7.	Placed plugs (through tubing)	Top of packer to 2,080 feet, expanding cement (10 sacks)
		2,080 to 1,883 feet, fly ash-gel-water slurry (1 ton fly ash and 40 lb Aquagel)
		1,883 to 1,843 feet, expanding cement (8 sacks)
8.	Cut 5-3/16-inch casing	1,831 feet (pulled all casing)
9.	Geophysical well log	Gamma ray-neutron and caliper (to 1,843 feet)
10.	Placed plug (dump bailer)	1,843 to 1,778 feet, expanding cement (27 sacks)
11.	Directional survey	1,000 feet, determine exact location of well in mine
12.	Placed plugs (through tubing)	1,778 to 1,464 feet, expanding cement (58 sacks)
		1,464 to 950 feet, fly ash-gel-water slurry (4 tons fly ash and 200 lb Aquagel)
		950 to 887 feet, expanding cement (13 sacks)
13.	Ripped casing	862 feet, 3 cuts 1 foot long
14.	Cement retainer set	853 feet

	Operation	Description
15.	Placed plugs (through tubing)	887 to 853 feet, neat cement (35 sacks)
		864 to 743 feet behind 6-5/8-inch casing (squeezed 16 sacks of neat cement at 400 psi wellhead pressure)
		853 to 847 feet, neat cement (1 sack)
16.	Placed cement behind 6-5/8-inch casing	165 feet to surface, neat cement (300 sacks) (165 feet of 1-inch pipe run in annulus to place cement)
17.	Ripped casing (to weaken casing and to sample for possible tracer leaks behind casing)	832 to 840 feet, 4 cuts (2 cuts, 4 feet fall into other cuts)
18.	Collect samples to be analyzed for SF_6	73 days
19.	Placed plug (through tubing)	847 feet to surface, neat cement (200 sacks)
20.	Set well monument	10 feet below to 3 feet above surface (filled with cement)
21.	Graded and seeded area	See figure 10

J. Wildman Well 15 (Fig. 5)

1.	Geophysical well logs	Gamma ray-neutron and caliper (total depth)
2.	Bottom-hole pressure buildup	99 psi after 64 hours' shut-in time
3.	Production injection packer set	1,836 feet
4.	Injection test	500 scf nitrogen at 60 psi
5.	Injection of SF_6	Injected 250 scf N_2 and 125 lb SF_6 at 90 psi (N_2 and SF_6 injected simultaneously)
		Injected 1,000 scf N_2, shut-in pressure 175 psi, shut-in pressure after 13 hours 110 psi
6.	2-inch bridge plug set	1,828 feet

Operation	Description
7. Placed plugs	Top of packer to 1,819 feet, field stone (bridge)
	1,819 to 1,804 feet, neat cement (2 sacks)
	1,804 to 1,754 feet, limestone chips (bridge)
	1,754 to 1,729 feet, clay
	1,729 to 1,534, gelled water (230 gal water and 1 sack Aquagel)
	1,538 feet set brush plug (branch of tree)
	1,538 to 1,536 feet, limestone chips (bridge)
	1,536 to 1,523 feet, neat cement (3 sacks)
8. Cut 4-7/8-inch casing	1,427 feet (pulled all casing)
9. Placed plugs	1,523 to 1,254 feet, Aquagel and water
	1,254 feet, brush plug
	1,254 to 1,252 feet, limestone chips (bridge)
	1,252 to 1,133 feet, neat cement (30 sacks)
	820 feet, brush plug
	820 to 720 feet, limestone chips (bridge)
	610 feet, brush plug
	610 to 600 feet, limestone chips (bridge)
	600 to 593 feet, neat cement (5 sacks)
10. Pulled casing	532 feet, 6-5/8-inch casing cut at 593 feet (removed 61 feet of casing)

Operation	Description
11. Placed plugs	593 to 546 feet, limestone chips (bridge)
	546 to 534 feet, neat cement (2 sacks)
12. Geophysical well logs	Gamma ray-neutron and caliper (to 534 feet)
13. Pulled casing	511 feet, Pittsburgh coalbed exposed (pulled casing to 468 feet)
14. Geophysical well logs	Gamma ray-neutron and caliper (to 534 feet)
15. Placed plugs	534 to 487 feet, neat cement (21 sacks)
	472 feet, brush plug
	472 to 470 feet, limestone chips (bridge)
	470 to 413 feet, neat cement (pulled casing to 383 feet)
	389 feet, brush plug
	389 to 387, limestone chips (bridge)
	387 to 214 feet, Aquagel and water (4 sacks Aquagel) (pulled casing to 189 feet) 214 feet brush plug
16. Hole caved	192 feet bridged
	Drilled out bridge and lost brush plug (pulled 6-5/8-inch casing from well--189 feet)
17. Placed plugs	214 feet, brush plug
	214 to 208 feet, limestone chips (bridge)
	208 to 151 feet, neat cement (57 sacks)
	151 to 40 feet, Aquagel and water
	40 feet, brush plug
	40 to 17 feet, stone and clay (bridge)

Operation	Description
18. Set well monument	17 feet below to 3 feet above surface, neat cement inside and out (13 sacks)
19. Graded and seeded area	Grass growing