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GEOLOGICAL SURVEY

Results from 1983 Drilling and Core Analyses of the Anderson Coal Deposit Wyoming

By

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

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INTRODUCTION

The Tertiary rocks of the Powder River Basin in northeastern Wyoming contain some of the largest coal deposits in the world. Perhaps best known is the 100-ft-thick Wyodak bed of subbituminous coal which has been and is currently being strip-mined extensively along its north-south trend east of Gillette, Wyo. Recently, however, a natural gamma log of an oil and gas test hole in the central part of the basin revealed the presence of a single bed of coal 180 ft thick. Pierce and others (1982) described the coal occurrence as follows:

> "One or more of the upper beds forming the Wyodak merge westward with several overlying coal beds to form the coal deposit described here. The deposit is defined as a single bed of coal, and the boundary of the subarea containing the deposit is placed at the approximate locations where the single bed splits. For convenience, the single bed is defined collectively as Anderson coal, because that name identifies one of the principal coal beds included."

Geophysical logs of 300 oil and gas test wells were used to outline the "footprint" shape of the Anderson coal deposit (fig. 1), and the deposit was assessed as a unit resource containing 113 billion tons of coal (Pierce and others, 1982). Researchers were quite convinced of the existence of the coal deposit, but it soon became imperative to confirm it by drilling and obtaining core samples for quality analysis. A deposit of such magnitude represents a significant addition to Powder River Basin coal resources in Wyoming, previously estimated to be about 110 billion tons (Glass, 1978, table 6, p. 80).

The cooperative efforts of the U.S. Geological Survey (USGS)/Branch of Coal Resources, the USGS/Water Resources Division, and the Bureau of Land Management were rewarded when, in June 1983, a rotary hole (B23-BG1R) and an offset core hole (B23-BG1C) were drilled in the northwest part of T. 48 N., R. 77 W. (fig. 1). This site was selected because previous work (Pierce and others, 1982) indicated the deposit would occur within 1,100 ft of the surface, access was by way of good gravel roads, and the Powder River, less than a mile away, was a good source of drilling water.

The coal deposit was found to be 202 ft thick in core hole B23-BG1C with one significant parting of less than 4 ft in thickness. The apparent rank of the coal is subbituminous B. This report presents the results of the drilling and chemical analyses of the first core samples recovered in the Anderson coal deposit by U.S. Government agencies.

GEOLOGIC SETTING

The site selected for drilling and coring the Anderson coal deposit is located in the west-central part of the Powder River Basin. The Powder River flows north through the area which is characterized by rolling grasslands and dissected highlands.

Drill holes B23-BG1R and B23-BG1C penetrate the Eocene Wasatch Formation and the underlying Paleocene Tongue River Member of the Fort Union Formation.

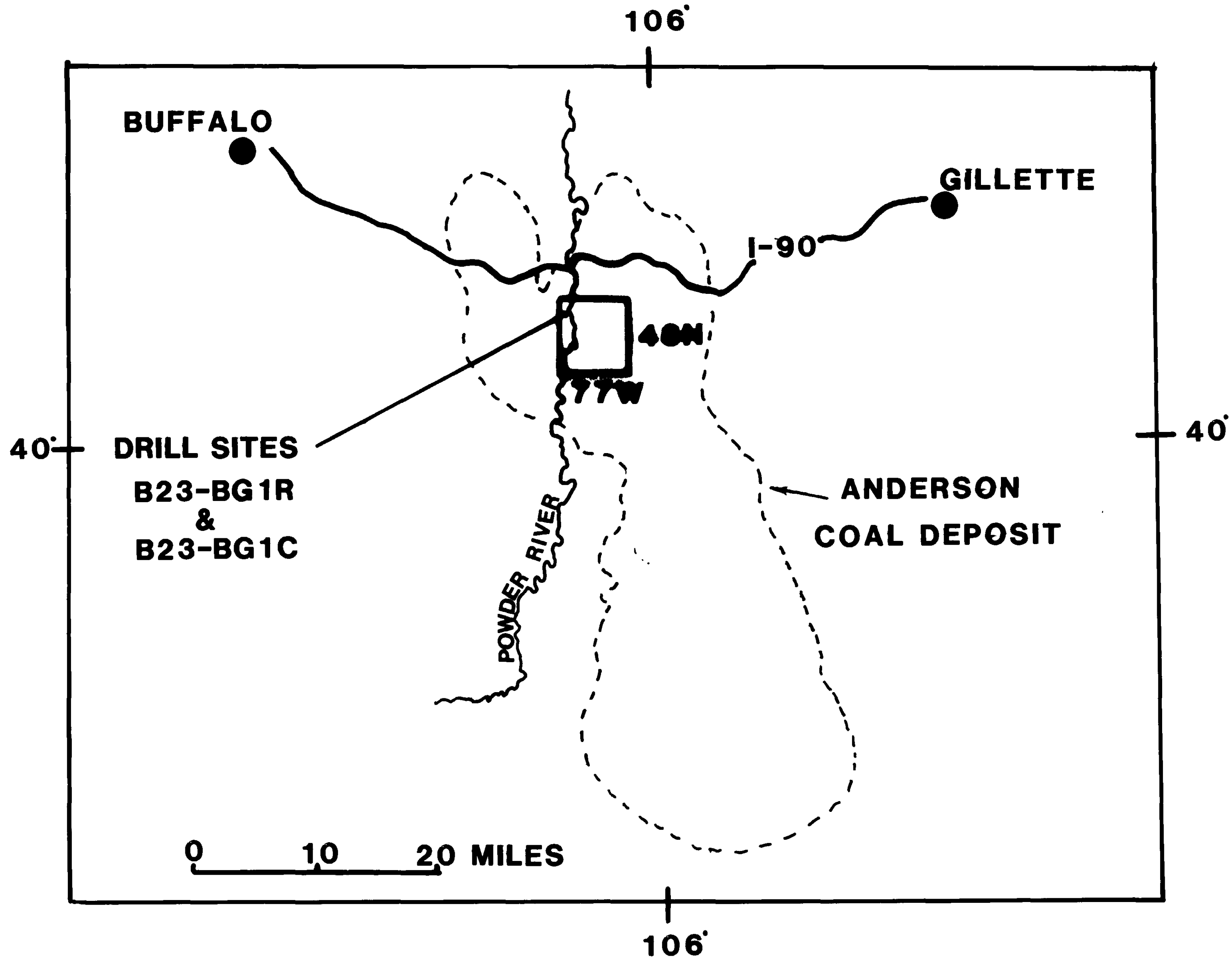

Figure 1.--Generalized index map showing drill-hole locations in the northwest corner of T. 48 N., R. 77 W., in Wyoming.

The rocks in the Wasatch Formation consist of interbedded tan to light-brown sandstone and siltstone, mudstone, carbonaceous shale, and coal. In drill hole B23-BG1R (appendix, geophysical logs), the Felix coal bed occurs at a depth of 83 ft and is 6 ft thick with a parting. The 11.5-ft-thick coal bed occurring at a depth of 640 ft is tentatively identified as the Arvada coal (B. Kent, oral commun., 1983). If this is correct, the contact between the Wasatch and Fort Union Formations can arbitrarily be placed just below the Arvada coal.

The Tongue River Member of the Fort Union Formation is characterized by interbedded gray sandstone, mudstone, sandy shale, carbonaceous shale, and coal; it ranges in thickness from 900 to 1,100 ft in the area of the drill holes. The Anderson coal deposit occurs about in the middle of the Tongue River Member.

Figure 2 shows the locations of three drill sites. Site A includes both the rotary drill hole (B23-BG1R) and the offset core hole (B23-BG1C). Sites B and C are oil and gas test wells drilled by the Davis Oil Company. The columnar sections show the interval of occurrence of the Anderson coal deposit at each of the three sites.

DRILLING METHODS AND EQUIPMENT

The twin-hole method, outlined in Hobbs (1979), was used in the drilling and coring of the Anderson coal deposit. A pilot rotary hole (B23-BG1R) was drilled through the coal to a depth of 1,255 ft. Geophysical logs were recorded (appendix) and the core interval was chosen. The drill rig was then offset about 30 ft and the core hole (B23-BG1C) was started. The upper 1,028 ft of the core hole was rotary drilled; 5.5-in.-diameter steel casing was set to this depth. The hole was then cored to a total depth of 1,265 ft.

All drilling was completed by a truck-mounted drill rig. Water was the primary circulation medium, though four to five 50-lb sacks of bentonite were added at the start of each hole. As drilling progressed, natural shales and clays from the rocks downhole maintained a satisfactory viscosity of the drilling fluid to prevent caving or bridging in the borehole, and no additional bentonite was added.

Overall, the Wasatch and Fort Union Formations in this area are quite soft with respect to drilling, and rapid penetration rates are commonly accomplished by using carbide-tipped drag bits. For the most part, such was the case at sites B23-BG1R and B23-BG1C. However, a problem occurred when thin, very resistant limestone stringers were encountered downhole. These beds show up quite well as high resistance and high density responses on the geophysical logs. Carbide drag bits did not work well in these stringers, and rollercone bits were used in those cases. B23-BG1R was drilled at a diameter of 5 5/8 in.; the rotary drilled portion of B23-BG1C (0-1,028 ft) was drilled at a diameter of 9 3/4 in.

The coring was accomplished using a 20-ft-long, conventional core barrel with split inner tube sampler. The outer diameter of the barrel is 4 5/8 in., and it recovers a 3-in. diameter core. Carbide bits were used in all coring.

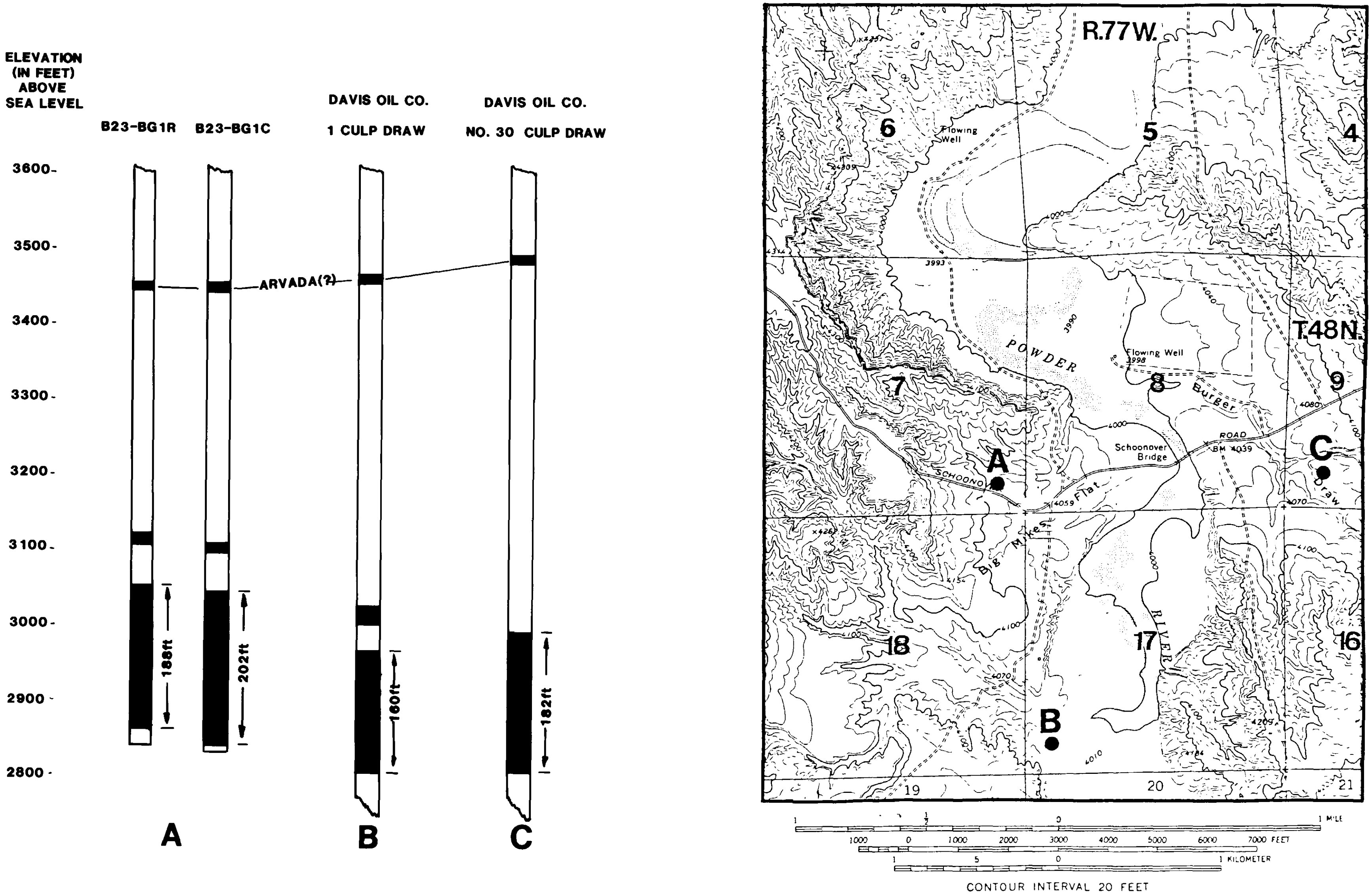

Figure 2.--Location map and columnar sections of test holes penetrating the Anderson coal deposit. A, coal exploratory holes B23-BG1R and B23-BG1C described in this report. B and C, oil and gas test holes. Location map is part of the Juniper Draw 7.5-minute topographic quadrangle map.

SAMPLING PROCEDURE: ON SITE

During the drilling of B23-BG1R and the interval above the core point (0-1,028 ft) in B23-BG1C, cutting samples were collected at 5-ft intervals. Samples were monitored, and lithologic changes and coal bed occurrences were noted as an aid to interpretation of geophysical logs.

In drill hole B23-BG1C, the coal core was sampled in 2-ft intervals. When the core was recovered intact, each 2-ft section was placed in a 3-in.-diameter plastic (PVC) tube, moistened, and sealed with tape for transport. At times, the coal was too badly broken, either from inherent fractures or those induced by drilling, to place in the tubes. These samples, again taken every 2 ft, were moistened and sealed in plastic bags. Coal core was kept moist at all times during examination prior to packaging.

In total, 71 tubes and 22 bags of coal core were obtained. In the first core run in the coal, 11.5 ft were not recovered. About 24 ft of roof rock, 11.4 ft of floor rock, and a parting of about 4 ft were also sampled.

COAL QUALITY

Results of the chemical analyses of the Anderson coal core are shown in table 1. Non-coal partings are not included in the analyses.

Figure 3 shows the intervals of the analyzed coal samples and their corresponding positions on the geophysical logs. The dry-basis ash percent and the BTU/lb (in thousands) are shown alongside the logs for comparison of coal quality change through the deposit.

Both the ash and sulfur content of the coal is low. The weighted average (as-received basis) for the total sulfur is 0.14 percent; organic sulfur is the dominant form. About 91 percent of the samples have an as-received ash content of 3 percent or less (R. Hobbs, oral commun., 1984). The apparent coal rank is subbituminous B.

ACKNOWLEDGMENTS

The author thanks the following people for their invaluable assistance and cooperation in the drilling project: Mike Brogan, Bureau of Land Management (Casper); Pam Daddow and Marlin Lowry, USGS, Water Resources Division (Cheyenne); Frances Pierce, USGS, Branch of Resource Analysis (Denver); Project Chief Robert Hobbs, Donna Boreck, Jim Cathcart, Richard Babcock, Arthur Clark, Larry Kozak, Matthew Washut, and Mike Dahlin, USGS, Branch of Coal Resources (Denver); Wayne Sutherland, Bureau of Land Management (Buffalo).

Project investigators also express their thanks to the ranchers and citizens of Buffalo, Wyo., who were always very helpful and cooperative throughout the duration of this project. In particular, we thank Mr. Charles Marton for providing access to the Powder River, and Mr. Martin Harriet for his valuable information and cooperation.

Table 1.--Proximate and ultimate analyses, BTU/lb, forms of sulfur, and fusibility of ash of 27 coal samples from the Anderson coal deposit, USGS core hole B23-BG1C, SE1/4SE1/4, sec. 7, T. 48 N., R. 77 W., Johnson County, Wyoming

[All analyses except Btu/lb and ash-fusion temperatures in percent. Forms of analysis: 1, as received; 2, moisture free; 3, moisture and ash free. All analyses by Geochemical Testing, Somerset, Pa. Free-swelling index determinations were made on all samples; all were 0.0]

				Proximate analysis					Ultimate analysis					Forms of sulfur			Ash-fusion temperature (°F)		
Sample No.	Depth (ft)	Thickness (ft)	Form of analysis	Moisture	Ash	Volatile matter	Fixed carbon	Btu/lb	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Sulfate	Sulfide	Organic	Initial deformation	Softening	Fluid
BG-1	1051.00-1054.35	3.35	1	21.15	2.59	34.92	41.34	10041	6.30	58.29	0.85	31.75	0.22	0.02	0.01	0.19	2120	2130	2240
			2		3.29	44.29	52.42	12734	4.99	73.92	1.08	16.44	.28	.02	.01	.25			
			3			45.79	54.21	13167	5.16	76.43	1.12	17.00	.29	.02	.01	.26			
BG-2	1065.35-1068.35	3.00	1	25.41	3.88	31.86	38.85	9399	6.54	54.40	.72	34.30	.16	.01	.01	.14	2100	2220	2310
			2		5.21	42.71	38.85	12601	4.96	72.93	.96	15.72	.22	.01	.01	.20			
			3			45.06	54.94	13293	5.23	76.94	1.01	16.59	.23	.01	.01	.21			
BG-3	1068.35-1085.35	17.00	1	22.48	2.38	32.39	42.75	9889	6.28	57.79	.71	32.70	.14	.01	.00	.13	2130	2240	2230
			2		3.07	41.78	55.15	12757	4.86	74.55	.91	16.43	.18	.01	.00	.17			
			3			43.10	56.90	13161	5.01	76.91	.94	16.95	.19	.01	.00	.18			
BG-3A	1086.55-1087.15	.60	1	21.78	5.98	31.51	40.73	9420	6.18	54.43	.82	31.43	1.16	.04	.35	.77	2260	2340	2370
			2		7.65	40.28	52.07	12043	4.78	69.59	1.05	15.45	1.48	.05	.45	.98			
			3			43.62	56.38	13040	5.18	75.35	1.14	16.73	1.60	.05	.49	1.06			
BG-3B	1087.30-1087.85	.55	1	21.09	6.01	29.93	42.97	9412	6.07	55.13	.67	30.64	1.48	.07	.83	.58	2270	2340	2370
			2		7.62	37.92	54.46	11928	4.71	69.86	.84	15.09	1.88	.08	1.05	.75			
			3			41.05	58.95	12912	5.10	75.62	.91	16.33	2.04	.09	1.14	.81			
BG-4	1087.35-1099.85	12.00	1	23.81	2.36	31.87	41.96	9691	6.31	56.32	.66	34.09	.26	.02	.02	.22	2130	2210	2280
			2		3.09	41.83	55.08	12719	4.79	73.92	.86	17.00	.34	.02	.03	.29			
			3			43.16	56.84	13125	4.94	76.28	.89	17.54	.35	.02	.03	.30			
BG-5	1099.85-1111.65	11.80	1	22.01	2.03	34.27	41.69	10127	6.39	58.47	.70	32.26	.15	.01	.00	.14	2050	2130	2230
			2		2.60	43.94	53.46	12985	5.03	74.97	.89	16.32	.19	.01	.00	.18			
			3			45.11	54.89	13331	5.16	79.97	.91	16.76	.20	.01	.00	.19			
BG-5A	1111.65-1117.65	6.00	1	24.65	1.99	30.37	42.99	9583	6.38	56.42	.59	34.50	.12	.00	.00	.12	2210	2350	2390
			2		2.64	40.31	57.05	12718	4.81	74.87	.78	16.74	.16	.00	.00	.16			
			3			41.40	58.60	13063	4.94	76.90	.80	17.20	.16	.00	.00	.16			
BG-6	1117.65-1119.65	2.00	1	25.32	5.90	28.77	40.01	8637	5.91	51.96	.52	35.59	.12	.00	.01	.11	2240	2290	2330
			2		7.91	38.52	53.57	11565	4.12	69.57	.69	17.55	.16	.01	.01	.14			
			3			41.83	58.17	12558	4.47	75.54	.75	19.07	.17	.01	.01	.15			
BG-7	1119.65-1121.65	2.00	1	26.84	1.86	28.24	43.06	9332	6.38	55.28	.61	35.71	.16	.00	.00	.16	2200	2320	2400
			2		2.54	38.61	58.85	12756	4.62	75.56	.83	16.23	.22	.01	.00	.21			
			3			39.62	60.38	13088	4.74	77.53	.85	16.65	.23	.01	.00	.22			
BG-8	1121.65-1127.65	6.00	1	25.20	2.03	28.36	44.41	9536	6.23	56.66	.64	34.33	.11	.01	.01	.09	2140	2280	2310
			2		2.72	37.92	59.36	12749	4.56	75.75	.85	15.97	.15	.01	.01	.13			
			3			38.98	61.02	13105	4.69	77.86	.87	16.43	.15	.01	.01	.13			
BG-9	1127.65-1141.65	14.00	1	23.75	2.03	28.24	45.98	9777	6.11	57.62	.67	33.48	.09	.02	.01	.06	2130	2250	2290
			2		2.66	37.04	60.30	12822	4.53	75.57	.87	16.26	.11	.03	.01	.07			
			3			38.05	61.95	13172	4.65	77.63	.89	16.72	.11	.03	.01	.07			
BG-10	1141.65-1150.65	9.00	1	25.40	2.83	27.44	44.33	9426	6.19	55.78	.69	34.44	.07	.01	.00	.06	2040	2120	2190
			2		3.79	36.78	59.43	12636	4.48	74.78	.92	15.94	.09	.01	.00	.08			
			3			38.23	61.77	13133	4.66	77.72	.96	16.57	.09	.01	.00	.08			
BG-11	1150.65-1157.65	7.00	1	21.95	4.17	30.42	43.46	9780	6.01	57.70	.83	31.18	.11	.01	.01	.09	2050	2200	2250
			2		5.35	38.97	55.68	12531	4.55	73.93	1.06	14.97	.14	.01	.01	.12			
			3			41.17	58.83	13239	4.81	78.11	1.12	15.81	.15	.01	.01	.13			
BG-12	1157.65-1165.65	8.00	1	22.00	1.80	32.92	43.28	10174	6.43	58.80	.89	31.96	.12	.02	.00	.10	2090	2200	2240
			2		2.30	45.20	55.50	13043	5.09	75.38	1.14	15.93	.16	.03	.00	.13			
			3			43.19	56.81	13350	5.21	77.16	1.17	16.30	.16	.03	.00	.13			
BG-13	1165.65-1173.65	8.00	1	22.86	1.69	32.30	43.15	10071	6.47	58.31	.86	32.55	.12	.01	.00	.11	2110	2240	2270
			2		2.19	41.87	55.94	13056	5.07	75.59	1.12	15.87	.16	.01	.00	.15			
			3			42.81	57.19	13348	5.18	77.28	1.15	16.23	.16	.01	.00	.15			

Table 1.--Proximate and ultimate analyses, BTU/lb, forms of sulfur, and fusibility of ash of 27 coal samples from the Anderson coal deposit, USGS core hole B23-BG1C, SE1/4SE1/4, sec. 7, T. 48 N., R. 77 W., Johnson County, Wyoming--Continued

Sample No.	Depth (ft)	Thick-ness (ft)	Form of analysis	Proximate analysis				Btu/lb	Ultimate analysis					Forms of sulfur			Ash-fusion temperature (°F)		
				Moisture	Ash	Volatile matter	Fixed carbon		Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Sulfate	Sulfide	Organic	Initial deformation	Softening	Fluid
BG-14	1173.85-1175.45	1.60	1	21.44	2.56	30.57	45.43	10089	6.27	58.91	.92	31.26	.08	.02	.00	.06	2060	2170	2220
			2		3.26	38.92	57.82	12843	4.93	74.98	1.17	15.55	.11	.03	.00	.08			
			3			40.23	59.77	13276	5.10	77.51	1.21	16.07	.11	.03	.00	.08			
BG-15	1176.40-1179.65	3.25	1	21.32	3.36	31.78	43.54	10068	6.08	58.74	.95	30.79	.08	.01	.00	.07	2130	2230	2280
			2		4.27	40.39	55.34	12796	4.69	74.65	1.20	15.08	.11	.01	.00	.10			
			3			42.19	57.81	13366	4.90	77.98	1.25	15.76	.11	.01	.00	.10			
BG-16	1179.65-1183.65	4.00	1	23.17	2.62	31.29	42.92	9829	6.31	57.69	.82	32.45	.11	.02	.00	.09	2120	2160	2210
			2		3.41	40.73	55.86	12793	4.84	75.08	1.07	15.46	.14	.02	.00	.12			
			3			42.17	57.83	13245	5.01	77.73	1.11	16.01	.14	.02	.00	.12			
BG-17	1183.65-1188.45	4.80	1	24.47	1.84	28.19	45.50	9693	6.18	57.43	.87	33.58	.10	.02	.00	.08	2090	2150	2170
			2		2.44	37.32	60.24	12833	4.55	76.04	1.15	15.69	.13	.03	.01	.09			
			3			38.25	61.75	13154	4.66	77.94	1.18	16.09	.13	.03	.01	.09			
BG-18	1191.85-1193.45	1.60	1	21.26	1.82	29.64	47.28	10088	6.02	59.29	.90	31.83	.14	.01	.00	.13	2090	2150	2180
			2		2.32	37.64	60.04	12812	4.63	75.30	1.14	16.44	.17	.01	.00	.16			
			3			38.53	61.47	13116	4.74	77.08	1.17	16.84	.17	.01	.00	.16			
BG-19	1194.25-1210.25	16.00	1	23.36	1.90	28.13	46.61	9821	6.08	57.75	.88	33.27	.12	.01	.01	.10	2140	2180	2220
			2		2.47	36.71	60.82	12815	4.52	75.35	1.15	16.35	.16	.01	.01	.14			
			3			37.64	62.36	13140	4.63	77.26	1.18	16.77	.16	.01	.01	.14			
BG-20	1210.25-1216.25	6.00	1	21.18	2.06	31.14	45.62	10232	6.04	59.73	.99	31.07	.11	.02	.00	.09	2090	2140	2170
			2		2.62	39.51	57.87	12982	4.66	75.78	1.26	15.54	.14	.02	.00	.12			
			3			40.57	59.43	13331	4.79	77.82	1.29	15.96	.14	.02	.00	.12			
BG-21	1216.25-1224.25	8.00	1	21.32	2.51	29.56	46.61	10195	6.10	59.12	1.00	31.15	.12	.01	.00	.11	2100	2170	2240
			2		3.19	37.57	59.24	12958	4.72	75.14	1.27	15.53	.15	.02	.01	.12			
			3			38.81	61.19	13385	4.88	77.62	1.31	16.04	.15	.02	.01	.12			
BG-22	1224.25-1230.25	6.00	1	22.85	1.78	31.10	44.27	10118	6.34	58.55	.96	32.26	.11	.01	.00	.10	2150	2210	2240
			2		2.31	40.31	57.38	13115	4.90	75.89	1.24	15.52	.14	.01	.01	.12			
			3			41.26	58.74	13425	5.02	77.68	1.27	15.89	.14	.01	.01	.12			
BG-23	1230.25-1234.25	4.00	1	21.93	2.03	29.46	46.58	10145	6.19	59.13	1.01	31.56	.08	.00	.00	.08	2060	2160	2230
			2		2.60	37.74	59.66	12995	4.78	75.74	1.29	15.48	.11	.00	.00	.11			
			3			38.75	61.25	13342	4.91	77.76	1.32	15.90	.11	.00	.00	.11			
BG-24	1234.25-1240.25	6.00	1	21.79	1.56	31.77	44.88	10215	6.30	59.59	1.03	31.38	.14	.00	.00	.14	2000	2080	2140
			2		2.00	40.62	57.38	13061	4.94	76.20	1.32	15.37	.17	.00	.00	.17			
			3			41.45	58.55	13328	5.04	77.75	1.35	15.69	.17	.00	.00	.17			
BG-25	1240.25-1246.60	6.35	1	20.77	6.98	29.47	42.78	9550	5.70	56.12	.93	30.05	.22	.00	.00	.22	2350	2440	2470
			2		8.81	37.19	54.00	12053	4.26	70.83	1.18	14.65	.27	.00	.00	.27			
			3			40.78	59.22	13217	4.67	77.67	1.29	16.07	.30	.00	.00	.30			
BG-26	1247.45-1252.25	4.80	1	20.21	2.79	31.81	45.19	10300	6.16	59.19	1.09	30.55	.22	.01	.00	.21	1990	2230	2360
			2		3.49	39.86	56.65	12908	4.89	74.18	1.37	15.79	.28	.01	.01	.26			
			3			41.30	58.70	13375	5.07	76.86	1.42	16.36	.29	.01	.01	.27			
BG-27	1252.25-1252.85	.60	1	17.20	22.22	28.64	31.94	7883	5.40	44.82	.83	25.36	1.37	.03	.55	.79	2680	2790	2800
			2		26.84	34.59	38.57	9521	4.20	54.13	1.00	12.17	1.66	.04	.66	.96			
			3			47.28	52.72	13013	5.74	73.99	1.37	16.63	2.27	.05	.90	1.32			

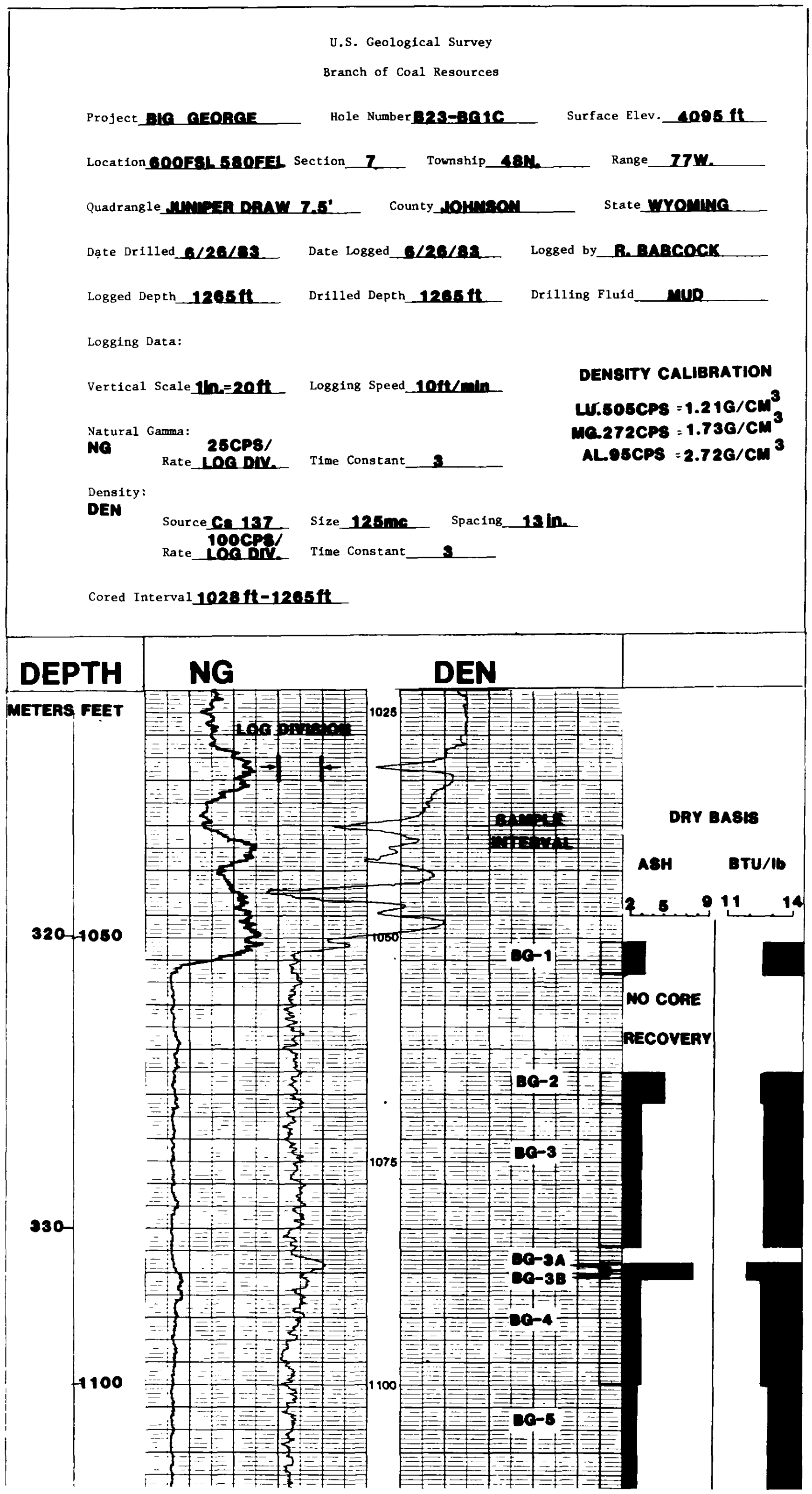

Figure 3.--The geophysical log of the cored interval in the Anderson coal deposit from USGS drill hole B23-BG1C, showing the position of 27 samples analyzed for coal quality. Dry-basis ash in percent. BTU/lb in thousands.

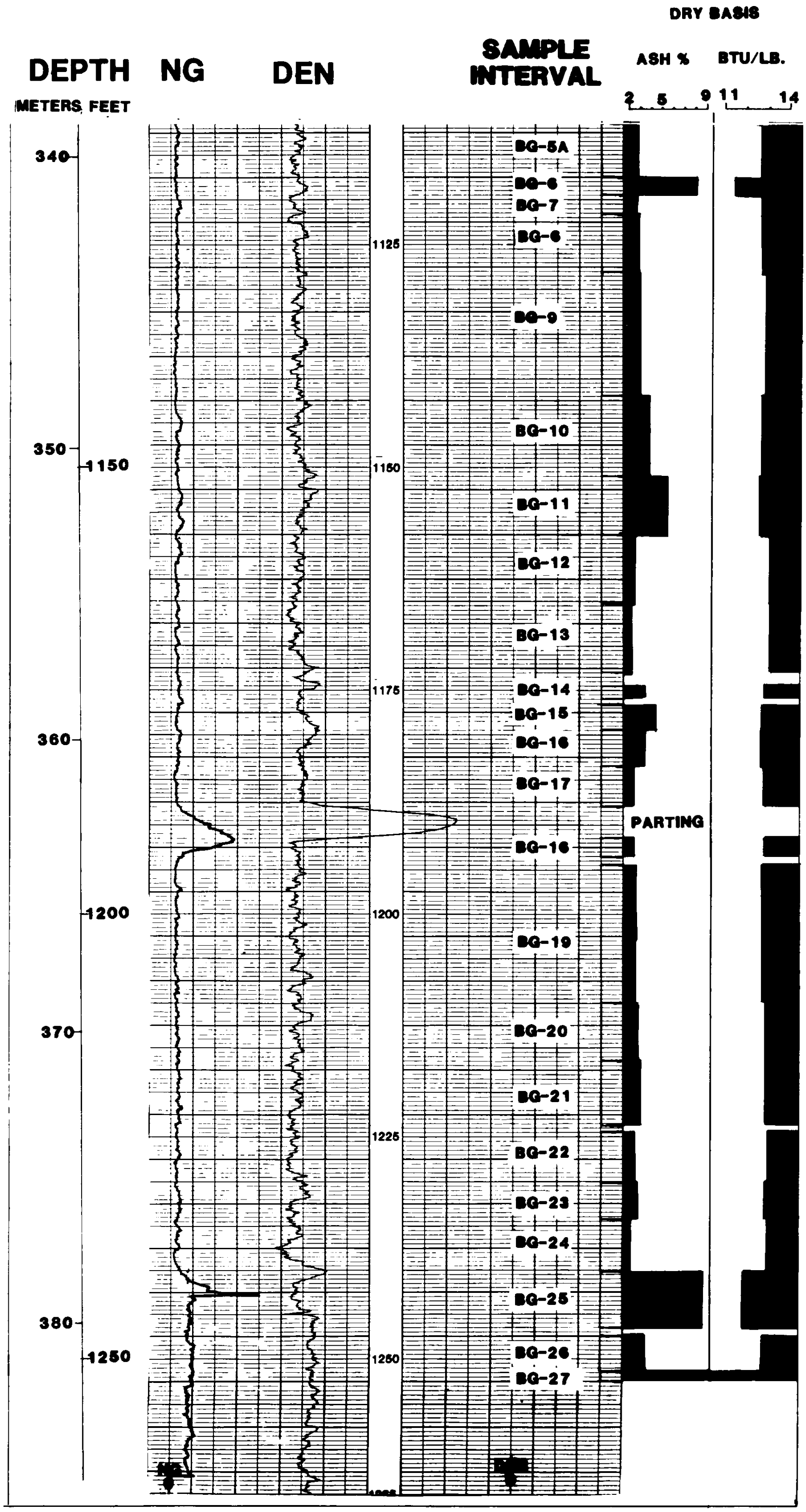

Figure 3.--The geophysical log of the cored interval in the Anderson coal deposit from USGS drill hole B23-BG1C, showing the position of 27 samples analyzed for coal quality. Dry-basis ash in percent. BTU/lb in thousands.--Continued

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Hobbs, R. G., 1979, Coal exploratory drilling: A cost percentage comparison of three methods: U.S. Geological Survey Open-File Report 79-1100, 9 p.

Pierce, F. W., Kent, B. H., and Grundy, W. D., 1982, Geostatistical analysis of a 113-billion-ton coal deposit, central part of the Powder River Basin, northeastern Wyoming, in Gurgel, K. D., ed., Proceedings of the fifth symposium on the geology of Rocky Mountain coal, 1982: Utah Geological and Mineral Survey Bulletin 118, p. 262-272.

APPENDIX

Geophysical Logs

U.S. Geological Survey
Branch of Coal Resources

Project BIG GEORGE Hole No. B23-BG1R Surface Elev. 4095ft.

Location 600FSL 600FEL Sec. 7 Twn. 48N Rg. 77W.

Quad. JUNIPER DRAW 7.5' County JOHNSON State WYOMING

Date Drilled 6/4/83 Date Logged 6/5/83 Logged by R. BABCOCK

Logged Depth 1250' Drilled Depth 1255' Drill Fluid MUD

Logging Data:

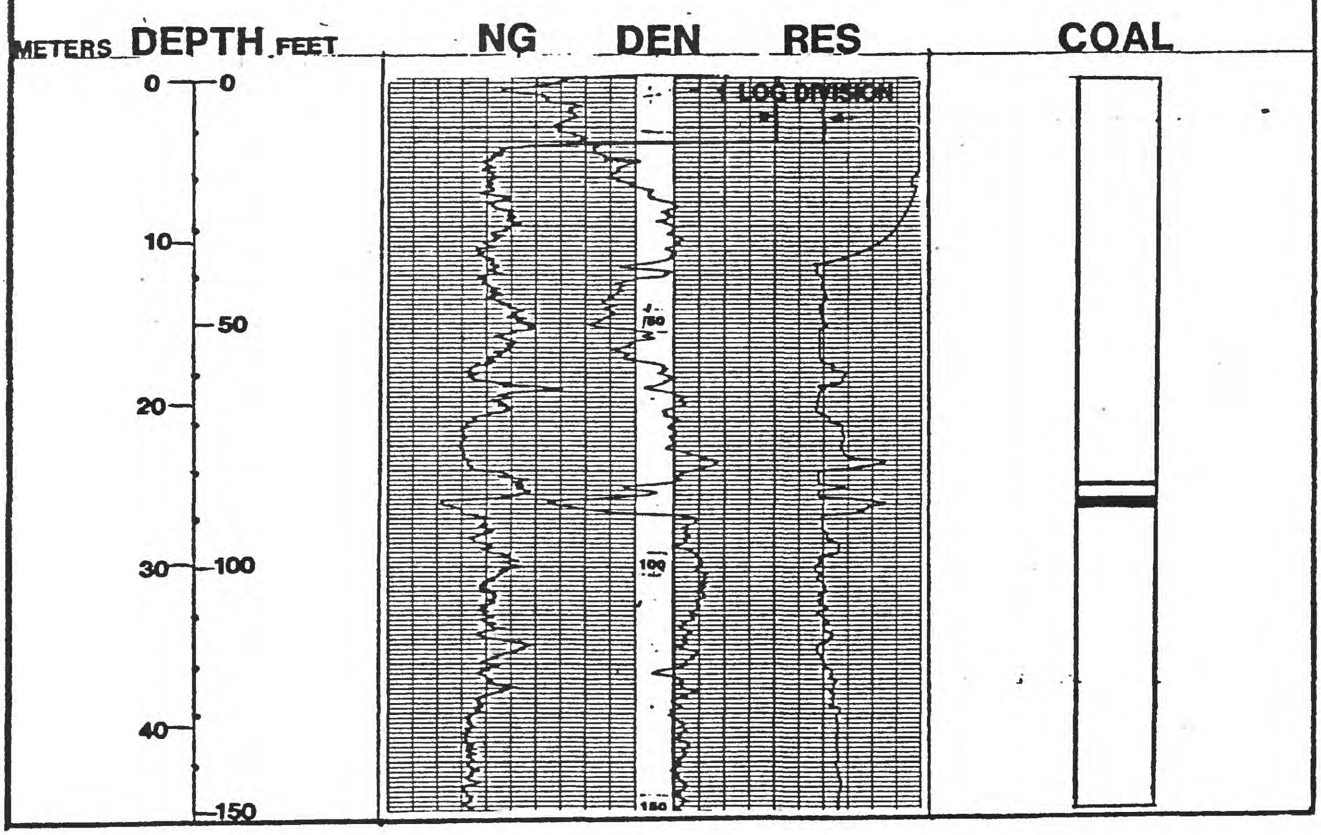
Vertical Scale 1" = 40' Logging Speed 10'/MIN.

Natural Gamma: (NG) Rate 25CPS/ LOG DIV. Time Constant 3

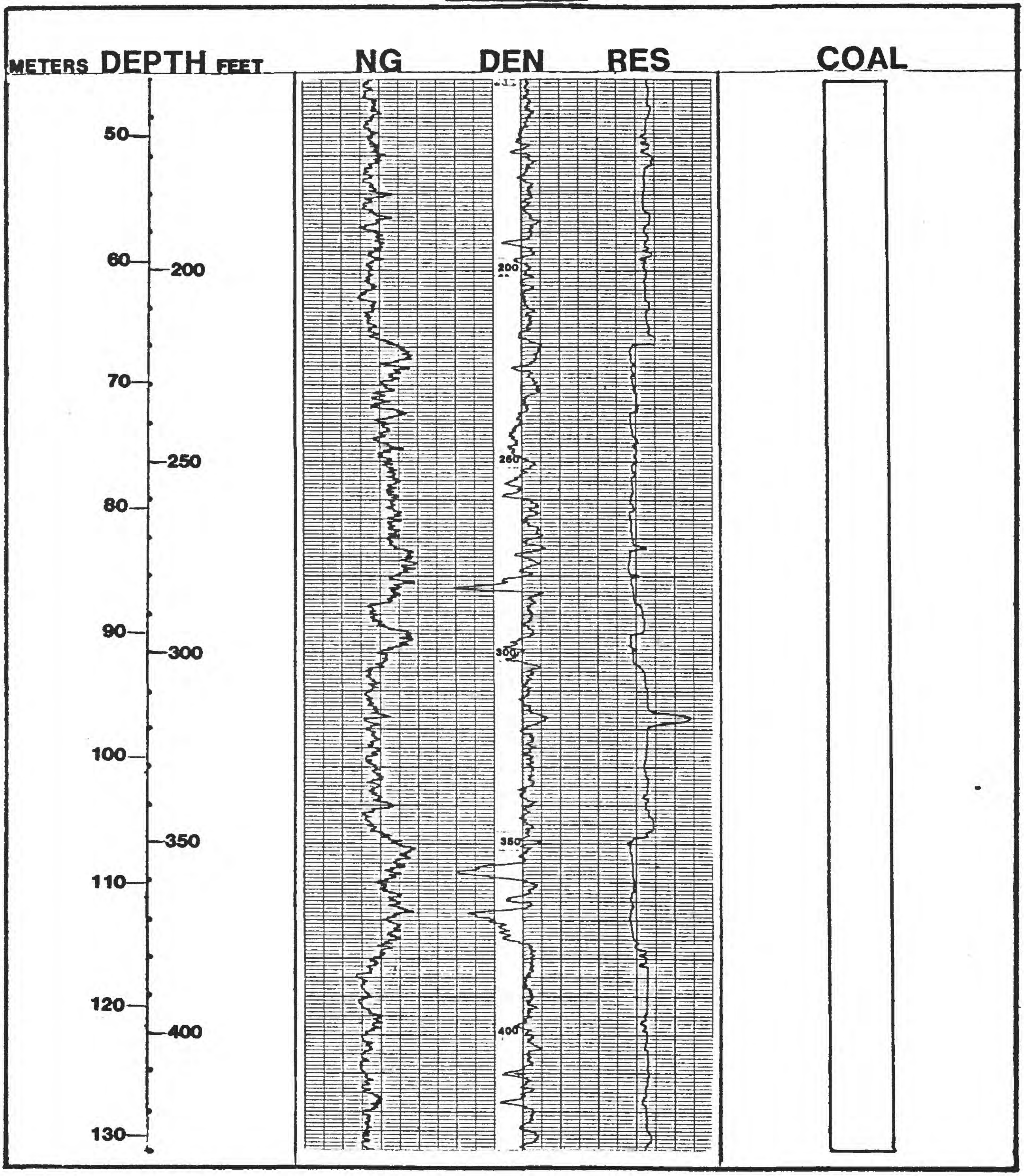
Density: (DEN) Source Cs 137 Size 125 mc Time Constant 3

Rate 100CPS/ LOG DIV. Spacing 13"

Resistance: (RES) Ohms 20/LOG DIV.



Hole No. B23-BG1R cont.



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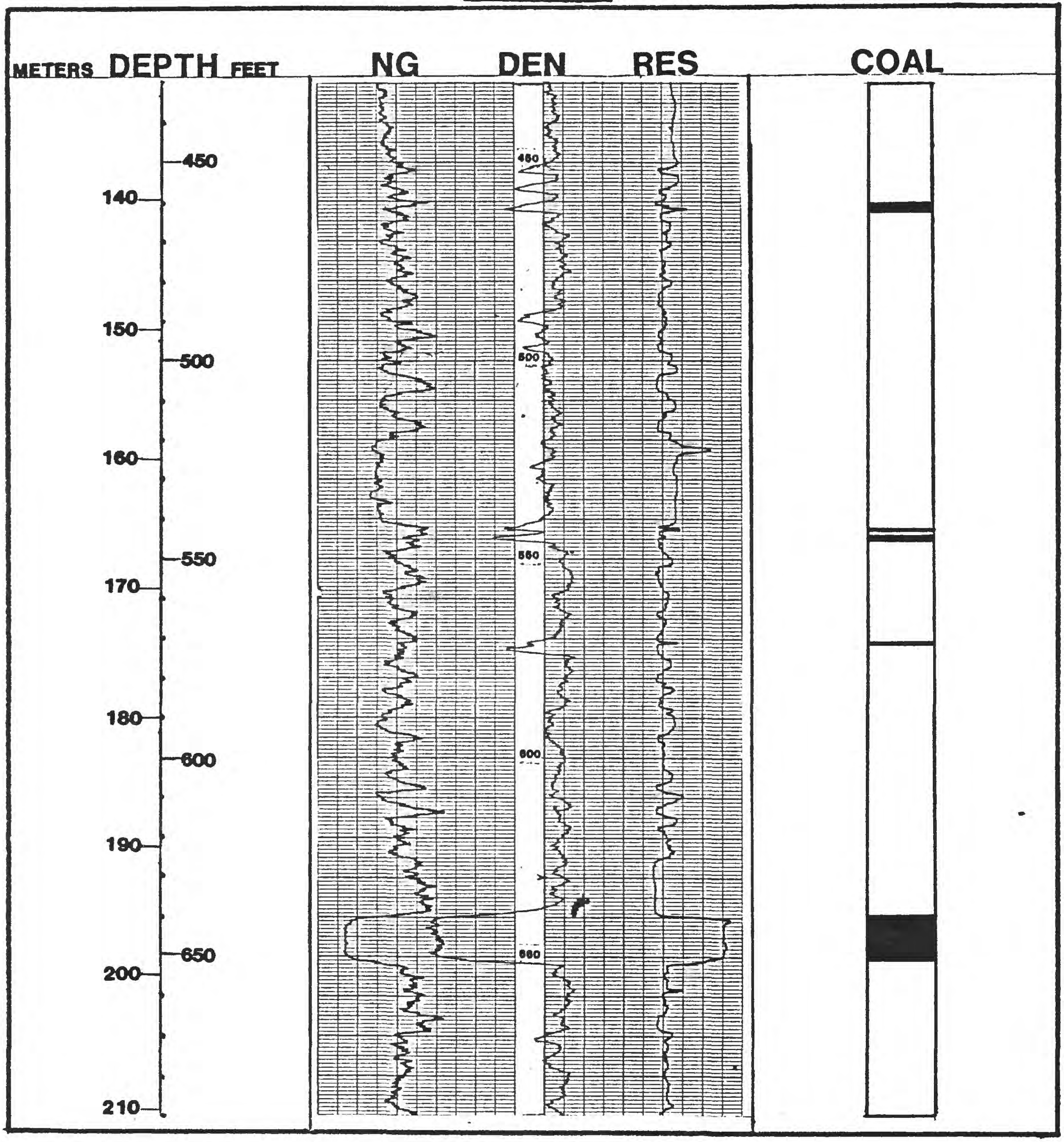
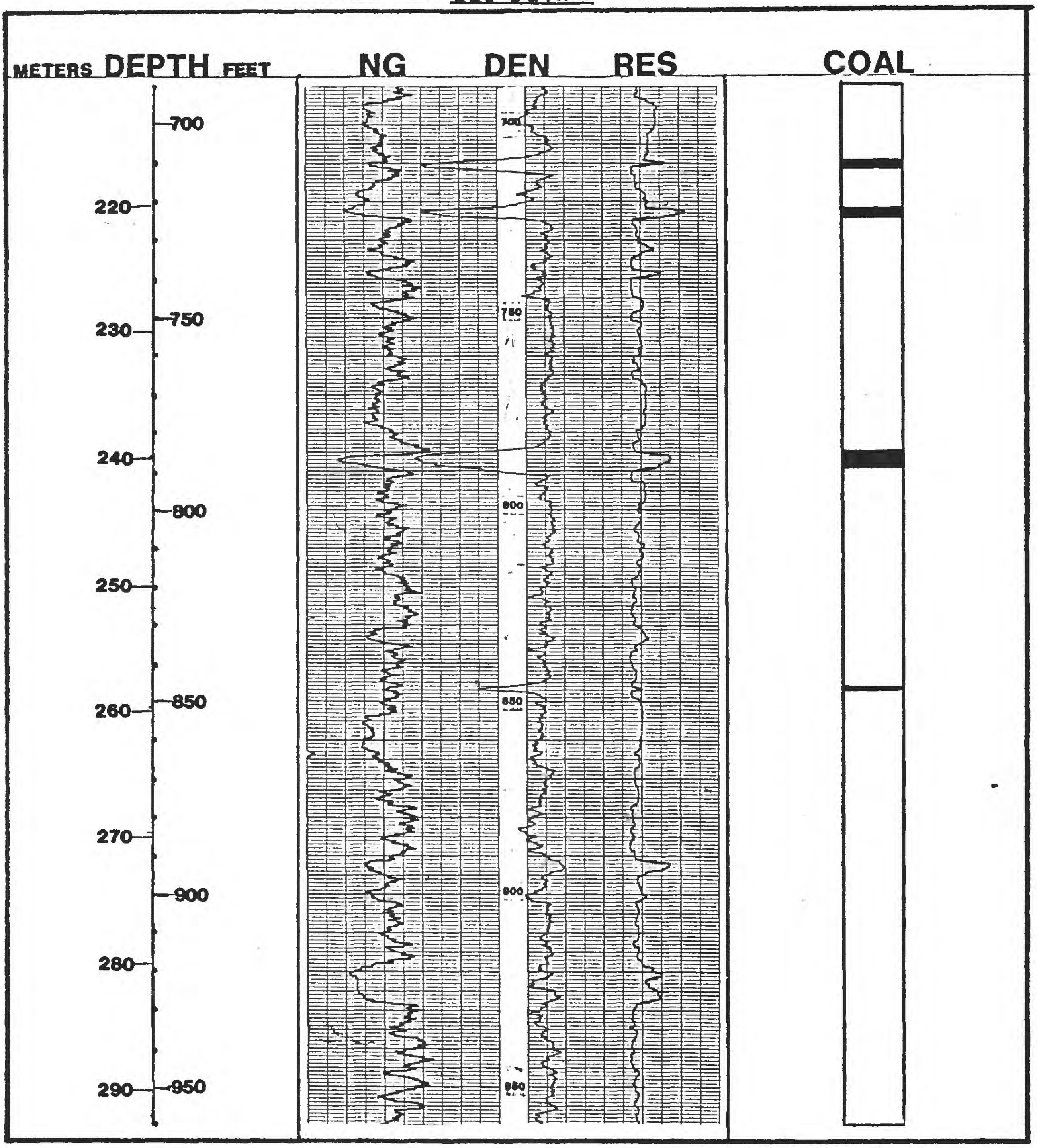


Hole No. **B23-BG1R** cont.



Hole No. B23-BG1R cont.