

UNITED STATES DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY

Coal exploratory holes drilled in 1978-79 in  
the Birney  $1^{\circ} \times 1/2^{\circ}$  quadrangle, Big Horn and Rosebud Counties,  
Montana, for coal beds in the Tongue River Member of the Paleocene  
Fort Union Formation

By

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This report is preliminary and has not  
been edited or reviewed for conformity  
with U.S. Geological Survey standards.

#### Literature Cited

- Culbertson, W.C., Kent, B. H., and Mapel, W. J., 1979, Preliminary diagrams showing correlation of coal beds in the Fort Union and Wasatch Formation across the northern Powder River Basin, Northeastern Wyoming and Southeastern Montana; U.S. Geological Survey Open File Report 79-1201, 11 p.

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Coal exploratory holes drilled in 1978-79 in  
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by William C. Culbertson, Thresa M. Gaffke, and George Correia

Introduction

In late 1978 and early 1979, the U.S. Geological Survey conducted a drilling program for the purpose of evaluating the quantity and quality of the coal in the upper part of the Tongue River Member of the Fort Union Formation in the Birney 1° x 1/2° quadrangle, Big Horn and Rosebud Counties, Montana (see Index map, fig.1). Twelve holes were rotary drilled to depths ranging from 217 to 906 feet (66 to 276 m), and 1 to 5 coal beds were cored in each of 5 offset holes. Samples of the cuttings were caught during rotary drilling to determine the lithology of the coal-bearing rocks. A suite of geophysical logs were run to determine the thickness and position of the coal beds; these logs included gamma ray, density, resistivity and caliper. In the core holes, only thick coal beds and adjacent floor and roof rocks were cored.

The original plan was to drill rotary holes at 7 sites, and run geophysical logs to identify the coal beds. An offset hole would then be drilled in which one or more coal beds more than 10 feet thick (3 m) would be cored. Drilling began in August 1978, but in the first offset core hole, Birney 3B, the coal recovery was poor, so a new core barrel was ordered by the contractor. While waiting for delivery of the core barrel, rotary holes were drilled at Birney 2A, 1A, 6A and 7A. After arrival of the new core barrel, Birney holes 4A and 5A were drilled, and offset holes 4B and 5B were cored with excellent core recovery. A rotary hole was drilled at a new location, Birney 8A, but when this hole was lost at 247 feet, (75 m) a new hole was drilled at Birney 8B.

At this time, the contractor moved his drilling rig to northeast Wyoming to complete the Wyoming part of the contract. Drilling was resumed in the Birney area January 10, 1979 by a subcontractor, the Navaho Drilling Co. A road was cleared through deep snow to the Birney 1 site, and coal beds in Birney 1B were cored to a depth of 506 (154 m) feet. The hole was then rotary drilled to 800 feet (244 m) and logged. However, the sites at Birney 2A, 6A and 7A were inaccessible, so new sites were picked. Birney 2B was drilled and logged, and the uppermost coal beds were cored in the offset hole at Birney 2C. Birney 9 and 10 were rotary drilled and logged, but no beds were cored. The drilling program was completed on Jan. 25, 1979.

The drilling program was hampered in several ways. A variety of problems caused the abandonment of several holes short of target depth--Birney 7A, 8A, and 8B--because of lost circulation problems; Birney 2A because of surface casing falling into the hole; Birney 4B and 5A because of excessive caving of the hole. In addition, the coal-bearing sequence contained beds of sandy or silty limestone, or limy siltstone and sandstone 1 to 6 feet thick that required the use of rock bits and thus slowed drilling considerably.



## Geologic Setting

The coal beds occur in the upper part of the Tongue River Member of the Fort Union Formation of Paleocene age. The Tongue River Member consists of interbedded sandstone, siltstone, shale, and coal, and many thin lenticular beds of silty or sandy limestone. Most of these rocks are poorly consolidated and weather to slopes, but the beds of limestone, or limy sandstone, locally form resistant ledges and benches. Where the thick coal beds have burned back from the outcrop, the overlying rocks have been baked or fused into a reddish resistant rock called clinker, or locally "scoria" or "red shale". Thick masses of clinker cap many of the peaks and upland surfaces in this area.

The regional dip of the strata in this area is generally low, about 30 to 50 feet to the mile (5.7 to 9.3 m/km) in a southerly direction. The regional dip is modified by a few low amplitude flexures, and is locally disrupted by normal faults as much as several miles long, with displacements as much as 300 feet (91 m).

### Coal beds

A total of 14 named beds were penetrated in the drill holes; from the top down, the Smith, Anderson, Dietz, Cox, Dietz 3, Canyon, White, Cook, Otter, Wall, Poker-Jim, Brewster-Arnold, King and Knobloch (See diagram figure 2). Other thin beds were penetrated whose identity is unknown; they may be either locally occurring beds, or splits from a named bed. (For a discussion of the coal bed nomenclature, see Culbertson and others, 1979).

The Smith bed exceeds 10 feet (3 m) in thickness only near drill hole Birney 5 and westward; it thins eastward to less than five feet thick (1.5 m) at Hanging Woman Creek. The Anderson and Canyon beds are the thickest persistent beds in this area, attaining thickness of 33 and 32 feet (10.1 and 9.8 m), respectively. The Canyon is interpreted to split into two beds at the northernmost site, Birney 3.

The beds in the Anderson-Canyon interval are difficult to correlate. West of Birney 4 in the East Decker Coal Mine, (fig. 1), thick Dietz 2 and Dietz 3 coal beds are found in this interval. At Birney 4, (fig. 2), the 13 foot (4m) bed at 470 feet (143 m) is thought to be Dietz 3, but the other 3 beds in the Anderson-Canyon interval may be splits of the Dietz 2, Dietz 3, or Anderson. From Birney 4 eastward to Hanging Woman Creek, coal beds in the interval are thin and cannot be correlated with confidence with either Dietz 2 or Dietz 3. The Cox bed is one of several beds in this interval near Hanging Woman Creek, but from Birney 10 eastward there is only one thick bed. This bed is called Dietz without differentiating it as Dietz 2 or 3.

The sequence of coal beds below Canyon are also difficult to correlate across the area because the intervals between beds change, new beds appear, and others split or pinch out. The pair of beds called Cook and Otter are correlative with the beds called Carney near Decker. They locally come together to form a bed 22 feet (6.7 m) thick in Birney 9. The Wall bed, which is 30 to 60 feet (9.1 to 18.3 m) thick in a large area northwest of Birney 6 and 7, abruptly thins from the vicinity of these holes eastward and southward. It is uncertain what bed, if any, is correlative with the Wall bed in Birney 9, 2B, and 3.

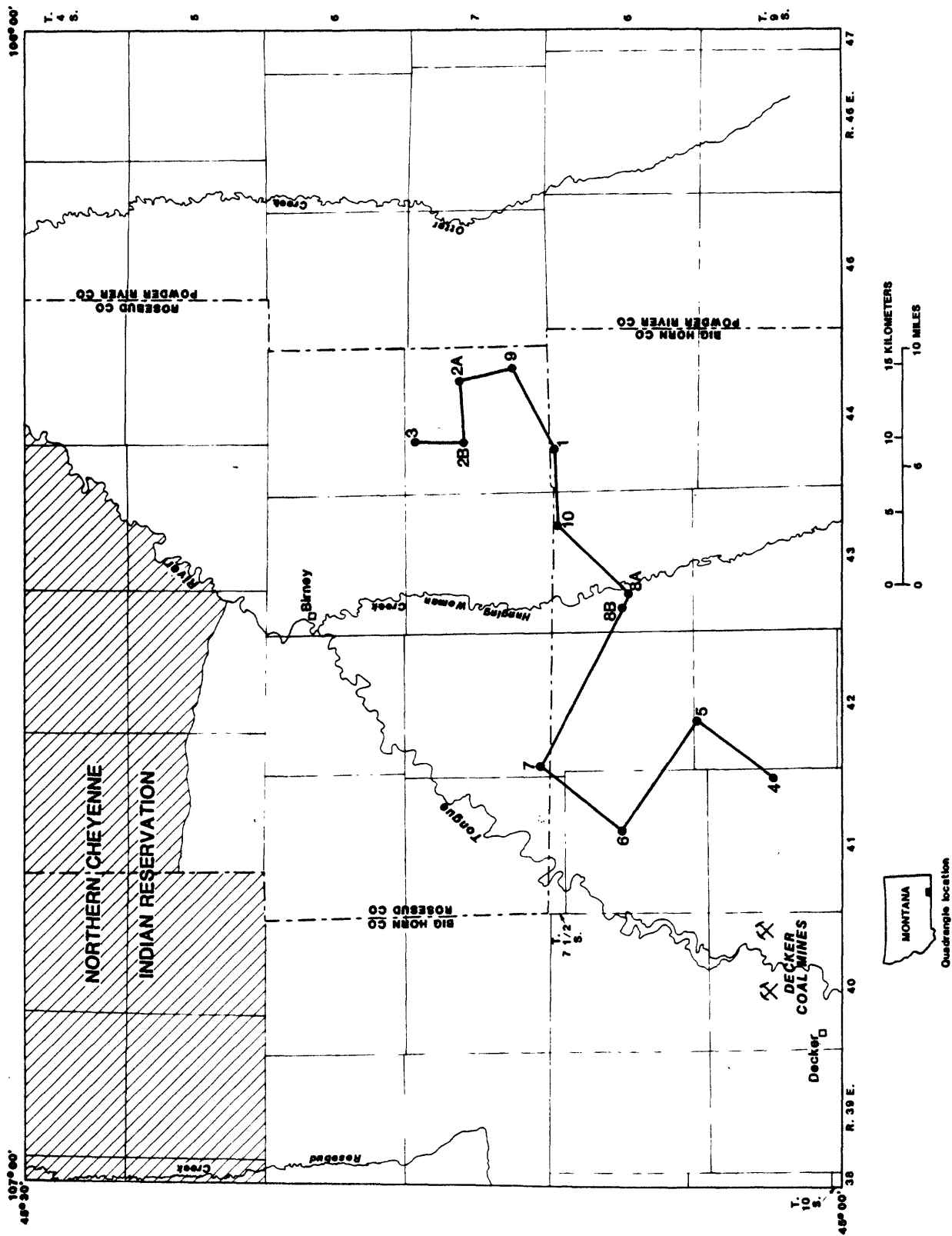


Figure 1.—Index map of Birney 1° x 1 1/2° quadrangle showing location of the Birney coal exploratory holes drilled by

U.S. Geological Survey in Big Horn and Rosebud Counties, Montana

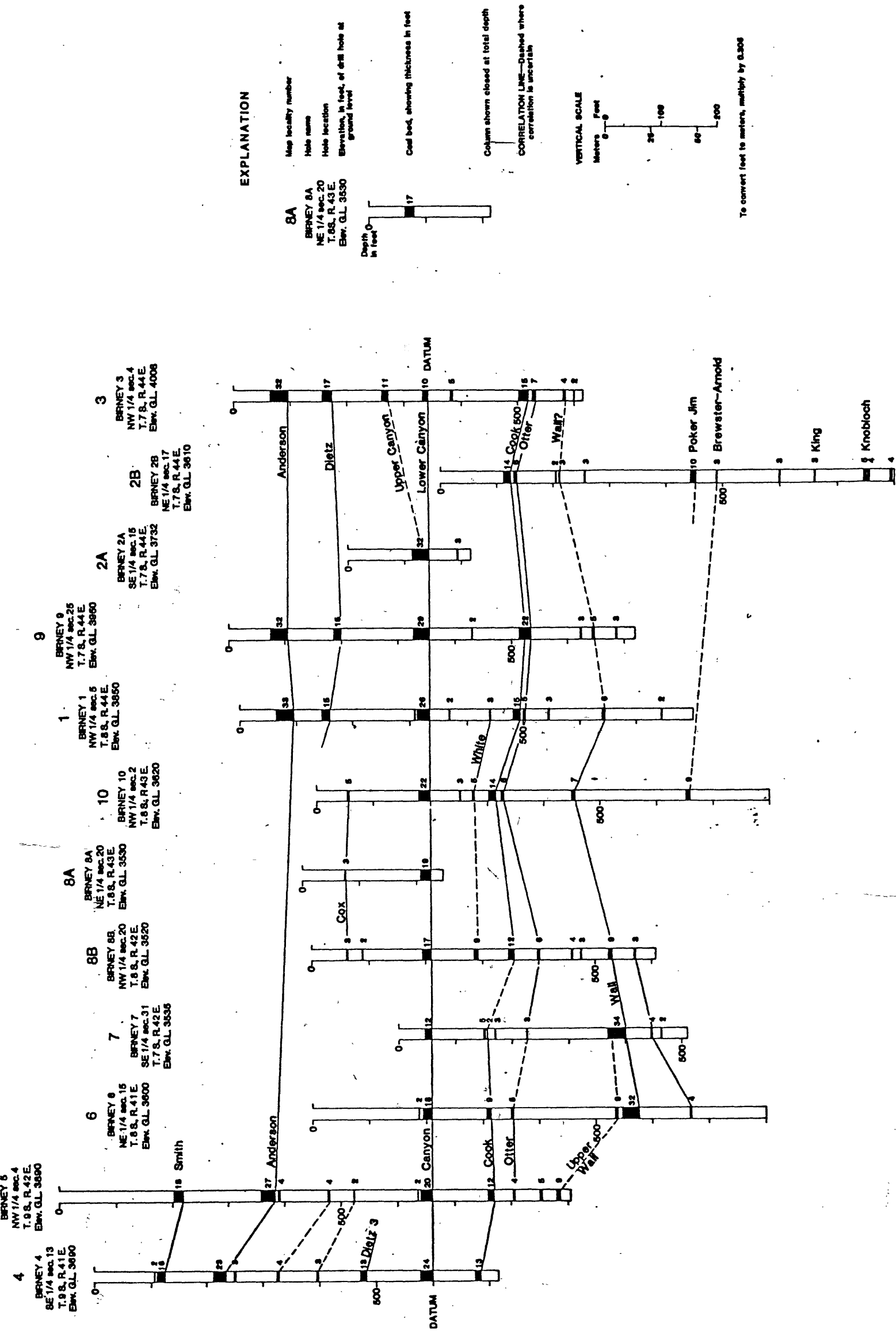


Figure 2.—Diagram showing correlation of coal beds in the Birney coal exploratory holes, Big Horn and Rosebud Counties, Montana

The inferred position of the Poker Jim, Brewster-Arnold, King and Knobloch beds are shown in Birney 2B.

#### Rank and quality of the coal

Coal from the 17 coal beds that were cored in the 5 core holes were sent to the Coal Analysis Section of the U.S. Bureau of Mines in Pittsburgh, Penna. A split of the core from 13 coal beds (excluding the 4 coal beds in Birney 3B below the Anderson that had poor core recovery) were sent to the Analytical Laboratories of the U.S. Geological Survey in Denver, Colo.

On the basis of the initial chemical analyses received, (tables 1 and 2), the coal beds range in apparent rank from lignite A in the northeast to subbituminous B in the southwest. Excluding the thin benches of coal above and below the Smith bed in Birney 4B, the heating value, on an "as received basis", ranges from 7515 to 9530 Btu per lb (4254 to 5394 kcal/kg), the sulfur content from 0.3 to 1.5 percent, the ash content from 3.8 to 11.7 and the moisture content from 23.1 to 32.8 percent.

#### Sample, core, and geophysical logs

The following pages contain the sample logs of the rotary drilled holes nos. 1A, 2A, 2B, 3A, 4A, 5A, 6A, 7A, 8A, 8B, 9 and 10; a combination sample and core log of Birney 1B; geophysical logs of all these holes except 2A; and core descriptions of holes 2C, 3B, 4B and 5B.

Sample logs were made of all rotary drilled holes by examination of the cuttings during drilling. These sample logs were later modified by interpretation of the geophysical logs of the hole. For some intervals, no samples or very poor samples were returned, so the sample log of these intervals relies largely on interpretation of the geophysical logs.

Geophysical logs were run on all rotary drilled holes except Birney 2A, and on Birney 1B which is a combination core and rotary drilled hole. None were run on the offset core holes Birney 2C, 3B, 4B and 5B. In general the suite of logs included gamma ray, density, resistivity and caliper; but because of equipment problems, the caliper log was not run in some holes. In Birney 7A, the gamma ray and density log do not appear to show a normal response from 0 to about 175 feet (0 to 53 m), but the sample log corroborates the thicknesses shown for the coal beds. All logs were recorded at a linear scale of 1 inch equals 10 feet (1 cm = 1.2 m), but were reduced to a scale of 1 inch equals 50 feet (1 cm = 6m) for this report.

Core descriptions were made only of the actual rocks cored in the Birney holes 2C, 3B, 4B, and 5B, and to a depth of 506 feet in 1B. Hole 1B, however, was drilled deeper than the adjacent hole 1A, so a sample log of the interval 506 to 800 feet (154 to 244 m) is attached to the core description.

Table 1.--Identification of samples of coal from core in the Tongue River Member of the Fort Union Formation, Big Horn and Rosebud Counties, Montana. See Table 2 for analyses.

[To convert feet to meters, multiply by 0.305]

Hole name	Location	Sample no.	Depth interval (in feet)	Bed name	Remarks
B. Geological Survey Birney 1B	NW 1/4 sec. 5, T. 8 S., R. 44 E.	D211762	64.9- 93.0	Anderson	Upper 28.1 ft of 32.8 ft bed.
		D211763	93.0- 97.7	Anderson	Lower 4.7 ft of 32.8 ft bed.
		D211764	144.0-157.0	Dietz	Lower 13.0 ft of 14.0 ft bed.
		D211765	314.0-332.9	Canyon	Lower 18.9 ft of 25.5 bed.
		D211766	481.4-496.1	Cook	All of 14.7 ft bed.
		D211767	500.3-505.6	Otter	All of 5.3 ft bed.
B. Geological Survey Birney 2C	NE 1/4 sec. 17, T. 7 S., R. 44 E.	D211768	115.0-127.5	Cook	Lower 12.5 of 14.5 ft bed.
		D211769	133.1-138.6	Otter	All of 5.5 ft bed.
B. Geological Survey Birney 3B	NW 1/4 sec. 4, T. 7 S., R. 44 E.	D209945	62.6- 94.6	Anderson	Recovered 22.3 ft of 32 ft bed.
		D3B-2	154.8-171.8	Dietz	Recovered 8.0 ft of 17 ft bed.
		D3B-3	255.4-260.4	Upper Canyon	Recovered 2.0 ft of 5 ft upper bench.
		D3B-4	261.6-267.3	-----do-----	Recovered 3.7 ft of 5.7 ft lower bench.
		D3B-5	332.1-341.6	Lower Canyon	Recovered 6.2 ft of 9.5 ft bed.
		D3B-6	500.3-515.6	Cook	Recovered 3.4 ft of 15.3 ft bed.
B. Geological Survey Birney 4B	SE 1/4 sec. 13, T. 9 S., R. 41 E.	D209946	106.3-107.5	Smith	Upper bench.
		D209947	109.0-122.8	-----do-----	Middle bench.
		D209948	124.2-125.8	-----do-----	Lower bench.
		D209949	211.2-233.2	Anderson	
		D209950	470.3-483.0	Dietz 3	Upper 12.7 ft of 13.7 ft bed.
B. Geological Survey Birney 5B	NW 1/4 sec. 4, T. 9 S., R. 42 E.	D209951	575.4-588.0	Canyon	Upper 12.6 ft of 24 ft bed.
		D209952	201.0-218.9	Smith	Lower 17.9 ft of 18.4 ft bed.

Table 2.--Proximate and ultimate analyses, heat-of-combustion, forms-of-sulfur, and ash-fusion-temperature determinations for 13 coal samples from the Tongue River Member of the Fort Union Formation, Big Horn and Rosebud Counties, Montana. See Table 1 for identification of samples.

[All analyses except heat of combustion, free-swelling index, and ash-fusion temperatures in percent. For each sample number, the analyses are reported three ways: first, as received; second, moisture free; and third, moisture and ash free. All analyses by Coal Analysis Section, U.S. Bureau of Mines, Pittsburgh, Pa.  $Q_p = 9/5C + 32$ ; Kcal/Kg = 0.556 Btu/lb. Leaders (---) mean no data.]

Sample Number	Proximate analysis				Ultimate analysis					Heat of Combustion		Forms of sulfur				Ash-fusion temperature, of	
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb	Air-dried loss	Sulfate	Pyritic	Organic	Initial deformation	Softening Fluid
D211762	29.5	30.6	36.0	3.9	6.7	49.2	0.9	39.0	0.3	4645	8360	22.8	.00	.26	.04	2310	2400
	---	43.4	51.1	5.5	4.8	69.8	1.3	18.1	.4	6593	11866	---	.01	.37	.06	---	---
	---	45.9	54.1	---	5.1	73.9	1.4	19.2	.5	6978	12559	---	.01	.39	.06	---	---
D211763	30.1	29.0	31.9	9.0	6.4	44.0	.9	38.2	1.5	4175	7515	23.5	.12	.17	.20	2130	2310
	---	41.5	45.7	12.8	4.3	63.0	1.2	16.4	2.2	3969	10743	---	.74	1.06	1.22	---	---
	---	47.6	52.4	---	5.0	72.2	1.4	18.8	2.5	6848	12323	---	.68	.97	1.12	---	---
D211764	31.2	28.0	36.6	4.2	6.7	47.7	.9	40.2	.3	4482	8061	24.8	.01	.24	.08	2110	2200
	---	40.7	40.7	6.0	4.7	69.4	1.4	18.0	.5	6512	11721	---	.02	.35	.11	---	---
	---	43.3	56.7	---	5.0	73.8	1.5	19.2	.5	6932	12476	---	.02	.37	.12	---	---
D211765	29.8	30.3	36.2	3.7	6.5	49.8	1.0	38.6	.3	4700	8460	23.0	.00	.07	.26	1940	2030
	---	43.2	51.5	5.3	4.5	70.9	1.5	17.5	.5	6696	12051	---	.01	.10	.37	---	---
	---	45.6	54.4	---	4.8	74.9	1.5	18.2	.5	7073	12730	---	.01	.10	.40	---	---
D211766	29.1	28.5	37.4	5.0	6.4	48.9	.9	38.5	.2	4600	8280	22.9	.01	.15	.08	1960	2070
	---	40.3	52.7	7.0	4.5	69.0	1.3	17.8	.3	6487	11676	---	.01	.22	.12	---	---
	---	43.3	56.7	---	4.8	74.2	1.4	19.2	.4	6974	12553	---	.01	.23	.12	---	---
D211767	26.9	26.1	38.7	8.3	6.2	48.1	1.0	35.8	.6	4569	8224	19.1	.01	.26	.35	2000	2090
	---	37.7	53.0	11.3	4.4	65.8	1.3	16.2	.8	6254	11257	---	.01	.35	.48	---	---
	---	40.2	59.8	---	5.0	74.3	1.5	18.3	.9	7054	12697	---	.01	.40	.54	---	---
D211768	31.5	26.3	37.8	4.4	6.5	47.9	.9	40.0	.2	4448	8006	25.1	.01	.17	.06	2030	2120
	---	38.3	55.4	6.3	4.4	69.9	1.4	17.6	.3	6490	11681	---	.01	.25	.09	---	---
	---	40.9	59.1	---	4.7	74.6	1.5	18.8	.4	6930	12473	---	.01	.27	.10	---	---
D211769	28.9	27.6	36.8	6.7	6.4	48.2	1.0	37.2	.4	4563	8213	22.3	.01	.19	.25	2000	2110
	---	38.8	51.8	9.4	4.5	67.8	1.4	16.2	.6	6417	11549	---	.01	.26	.36	---	---
	---	42.8	57.2	---	5.0	74.8	1.5	17.9	.7	7082	12748	---	.01	.29	.39	---	---

Table 2.--Proximate and ultimate analyses, heat-of-combustion, forms-of-sulfur, and ash-fusion-temperature determinations for 13 coal samples from the Tongue River Member of the Fort Union Formation, Big Horn and Rosebud Counties, Montana. See Table 1 for identification of samples.--Continued

Sample Number	Proximate analysis				Ultimate analysis				Heat of Combustion				Forms of sulfur			Ash-fusion temperature, °F		
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	Kcal/kg	Btu/lb	Air-dried loss	Sulfate	Pyritic	Organic	Initial deformation	Softening	Fluid
D209945	32.1	28.4	35.7	3.8	7.2	46.8	0.9	41.0	0.3	4475	7906	23.0	0.01	0.04	0.23	2160	2250	2340
	---	41.8	52.5	5.7	5.3	68.8	1.3	18.5	.4	6586	11636	---	.01	.06	.34	---	---	---
	---	44.4	55.6	---	5.6	73.0	1.4	19.6	.4	6981	12334	---	.01	.01	.36	---	---	---
D3B-2	31.9	26.9	36.4	4.8	---	---	---	---	.4	4491	7934	12.2	---	---	---	---	---	---
	---	39.4	53.5	7.1	---	---	---	---	.6	6596	11653	---	---	---	---	---	---	---
	---	42.5	57.5	---	---	---	---	---	.6	7100	12545	---	---	---	---	---	---	---
D3B-3	32.8	25.8	35.9	5.5	---	---	---	---	.8	4412	7795	17.1	---	---	---	---	---	---
	---	38.4	53.4	8.2	---	---	---	---	1.2	6563	11596	---	---	---	---	---	---	---
	---	41.8	58.2	---	---	---	---	---	1.3	7152	12636	---	---	---	---	---	---	---
D3B-4	30.4	27.7	34.4	7.5	---	---	---	---	1.7	4437	7840	14.8	---	---	---	---	---	---
	---	39.8	49.5	10.7	---	---	---	---	2.4	6373	11259	---	---	---	---	---	---	---
	---	44.5	55.5	---	---	---	---	---	2.7	7138	12611	---	---	---	---	---	---	---
D3B-5	32.7	25.0	37.2	5.1	---	---	---	---	.5	4418	7805	13.9	---	---	---	---	---	---
	---	37.1	55.4	7.5	---	---	---	---	.8	6564	11598	---	---	---	---	---	---	---
	---	40.1	59.9	---	---	---	---	---	.8	7097	12539	---	---	---	---	---	---	---
D3B-6	29.6	27.7	37.9	4.8	---	---	---	---	.3	4764	8417	16.6	---	---	---	---	---	---
	---	39.3	53.9	6.8	---	---	---	---	.5	6766	11955	---	---	---	---	---	---	---
	---	42.1	57.9	---	---	---	---	---	.5	7260	12827	---	---	---	---	---	---	---
D209946	26.0	29.8	35.1	9.1	6.4	47.2	1.2	33.7	2.4	4650	8217	18.5	.02	.91	1.49	1930	2020	2110
	---	40.3	47.5	12.2	4.2	63.9	1.7	14.2	3.3	6287	11107	---	.02	1.23	2.02	---	---	---
	---	45.9	54.1	---	5.4	72.8	1.9	16.2	3.7	7164	12657	---	.03	1.41	2.30	---	---	---
D209947	25.5	28.3	34.5	11.7	6.2	46.2	1.2	33.4	1.2	4495	7942	17.5	.02	.57	.64	2070	2200	2310
	---	37.9	46.3	15.8	4.5	61.9	1.6	14.5	1.6	6031	10656	---	.02	.76	.86	---	---	---
	---	45.0	55.0	---	5.4	73.5	1.9	17.2	2.0	7159	12649	---	.03	.91	1.03	---	---	---
D209948	21.1	20.9	24.8	33.2	5.0	31.6	.8	26.8	2.5	3067	5419	14.9	.17	1.56	.74	2050	2180	2270
	---	26.4	31.5	42.1	3.4	40.0	1.1	10.2	3.1	3887	6868	---	.22	1.97	.94	---	---	---
	---	45.7	54.3	---	5.8	69.2	1.8	17.7	5.4	6717	11868	---	.37	3.41	1.62	---	---	---
D209949	26.7	29.3	39.9	4.1	6.6	52.0	1.2	35.6	.4	5106	9022	18.9	.01	.11	.32	1940	2040	2130
	---	39.9	54.5	5.6	5.0	70.9	1.6	16.2	.6	6962	12300	---	.01	.14	.44	---	---	---
	---	42.3	57.7	---	5.3	75.1	1.7	17.2	.6	7371	13023	---	.01	.15	.47	---	---	---
D209950	23.1	27.7	40.9	8.3	5.8	51.6	1.0	32.5	.8	5045	8913	15.9	.01	.34	.43	2240	2330	2410
	---	36.0	53.2	10.8	4.2	67.1	1.3	15.5	1.0	6562	11593	---	.01	.44	.56	---	---	---
	---	40.4	59.6	---	4.7	75.2	1.5	17.4	1.1	7358	13000	---	.01	.49	.63	---	---	---
D209951	23.5	30.3	42.0	4.2	6.3	55.0	1.1	32.9	.5	5394	9530	15.9	.01	.05	.45	1890	2005	2095
	---	39.7	54.8	5.5	4.8	71.9	1.4	15.7	.7	7053	12461	---	.01	.07	.39	---	---	---
	---	42.0	58.0	---	5.1	76.0	1.5	16.6	.7	7460	13180	---	.01	.07	.63	---	---	---
D209952	27.6	28.0	35.1	9.3	6.3	46.5	1.1	35.4	1.3	4582	8095	20.2	.01	.61	.70	1900	1990	2090
	---	38.8	48.4	12.8	4.5	64.3	1.5	15.0	1.8	6331	11185	---	.01	.85	.97	---	---	---
	---	44.5	55.5	---	5.2	73.8	1.7	17.2	2.1	7263	12833	---	.01	.97	1.11	---	---	---

U.S. GEOLOGICAL SURVEY  
Birney 1° x 1/2° quadrangle

Hole Birney 1A Elev. 3850 feet Total depth 578 feet  
 Location 500 ft FWL, 1400 ft FNL (SW 1/4 NW 1/4) Sec. 5, T. 8 S., R. 44 E.  
 County Big Horn State Mont. Quadrangle Hamilton Draw  
 Drilled by Drane Drilling Service Driller Allen Drane Hole size 5 inches  
 Date Started 8/21/78 Date Completed 8/22/78 Geologist W. Culbertson & T. Gaffke  
 Remarks Sandstone at 413 to 431 may be water-bearing. Sample log modified by interpretation  
of geophysical log

Depth interval (feet)

From	To	Thick- ness	Lithologic Description
0	20	20	Sandstone, and siltstone, clayey
20	41	21	Sandstone, fine-grained
41	51	10	Siltstone, gray; limy siltstone 45-46
51	64	13	Shale carbonaceous, silty from 51-53; silty limestone from 58-59
64	97	33	Coal - ANDERSON BED
97	102	5	Shale, gray; silty from 100-102
102	106	4	Sandstone, fine-grained, gray
106	142	36	Shale, silty, gray and siltstone gray; limy siltstone 140-141
142	145	3	Shale, gray
145	160	15	Coal - DIETZ BED
160	165	5	Siltstone, gray
165	176	11	Sandstone, very fine grained, light gray
176	179	3	Siltstone, limy
179	193	14	Shale, gray, with coal stringer at 182
193	202	9	Shale, carbonaceous
202	210	8	Shale, light gray
210	212	2	Limestone, silty and sandy, light gray
212	217	5	Sandstone, fine-grained, limy, gray
217	222	5	Shale, light gray
222	230	8	Sandstone, fine-grained, gray
230	242	12	Shale, gray to brown, carbonaceous in part; contains coal stringers at 234 and 238
242	245	3	Shale, light gray
245	250	5	Siltstone, clayey, gray
250	253	3	Sandstone, fine-grained, gray
253	261	8	Siltstone, gray
261	270	9	Shale, gray and silty shale
270	308	38	Sandstone, very fine-grained, and light gray siltstone
308	335	27	Coal, with shale 311-312 - CANYON BED
335	344	9	Shale (?)
344	352	8	Sandy limestone
352	360	8	Shale, gray



Depth interval (feet)

From	To	Thick- ness	Lithologic Description
360	365	5	Sandstone, fine grained, gray
365	368	3	Shale, gray
368	370	2	Coal
370	402	32	Shale, silty, and siltstone, gray
402	411	9	Sandstone, very fine grained, gray
411	413	2	Limestone, sandy, gray
413	431	18	Sandstone
431	439	8	Shale, carbonaceous, brown
439	442	3	Coal - WHITE BED
442	464	22	Shale, gray
464	473	9	Sandstone, very fine grained, and siltstone
473	483	10	Shale, carbonaceous
483	498	15	Coal - COOK BED
498	502	4	Shale, carbonaceous
502	507	5	Coal - OTTER BED
507	513	6	Shale, gray
513	526	13	Siltstone, gray, with limy siltstone beds at 513-516 and 524-526
526	544	18	Probably silty shale, carbonaceous from 540-544
544	547	3	Coal
547	578	31	Shale, silty shale, and siltstone

# U.S. Geological Survey

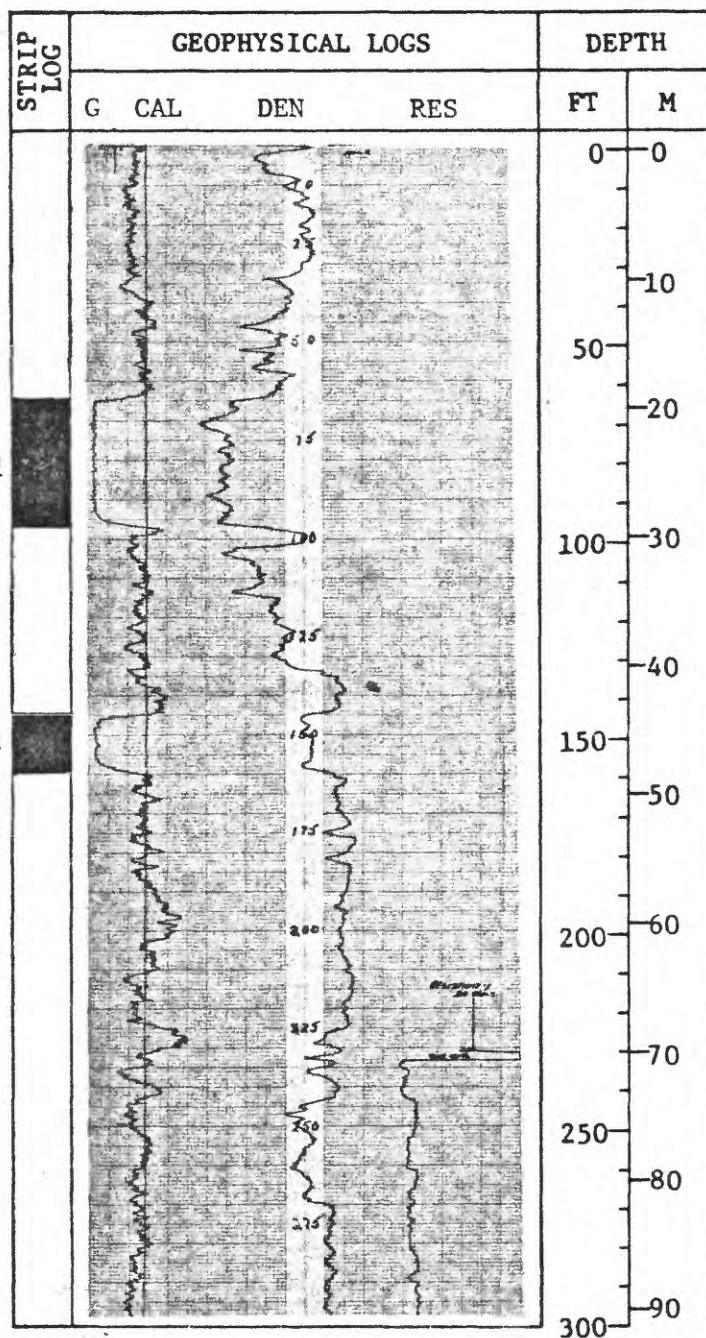
Hole name Birney 1A County Big Horn State Montana  
 Location 500 ft FWL, 1400 ft FNL (SW $\frac{1}{4}$ NW $\frac{1}{4}$ ) Sec. 5 T. 8 S. R. 44 E.  
 Elevation 3850 ft Drilled depth 578 ft Logged depth 577 ft  
 Drilling medium Mud Date logged 8/22/78

## Geophysical logs:

Gamma ray (G): T.C. 3 Scale 10 cps/in. Logging speed 15 fpm  
 Density (DEN): T.C. 3 Scale \_\_\_\_\_ Logging speed 15 fpm  
 Caliper (CAL): Scale \_\_\_\_\_ Logging speed \_\_\_\_\_ fpm  
 Resistance (RES): Scale 20 ohms/in. Logging speed 15 fpm  
 Remarks: \_\_\_\_\_

Anderson coal bed

Dietz coal bed



Hole name Birney 1A continued

U.S. GEOLOGICAL SURVEY  
Birney 1° x 1/2° quadrangle

Hole Birney 1B Elev. 3850 feet Total depth 800 feet  
 Location 500 ft FWL, 1400 ft FNL (SW 1/4 NW 1/4) Sec. 5, T. 8 S., R. 44 E.  
 County Big Horn State Montana Quadrangle Hamilton Draw  
 Drilled by Navajo Drilling Co. Driller Gene Abbott Core size 2.4 inches  
 Date Started 1/10/79 Date Completed 1/17/79 Geologist W. C. Culbertson  
 Remarks Sample log from 506 to 800 feet

## Cored intervals (in feet)

Core No.	From	To	Length of Core Recovered	Core No.	From	To	Length of Core Recovered
1	63.0	73.0	10.0	8	314.0	324.0	10.0
2	73.0	83.0	10.0	9	324.0	334.0	10.0
3	83.0	93.0	10.0	10	480.0	489.0	9.0
4	93.0	100.0	7.0	11	489.0	496.0	7.0
5	144.0	154.0	10.0	12	496.0	506.0	10.0
7	305.0	314.0	2.4				

## Depth interval (feet)

From	To	Thick- ness	Core Description
63.0	64.7	1.7	Shale, carbonaceous, gray brown
64.7	97.7	33.0	Coal, black, sparse banding, many fusinite layers. Many vertical fractures; framboidal pyrite on bedding planes in upper 2 ft and at 85.0-85.5, sparse disseminated pyrite in rest, sparse flaky gypsum crystals. Contain a 0.01 ft clay parting at 96.6, and a 0.15 ft coaly shale parting at 97.2
97.7	98.0	0.3	Shale, carbonaceous, brownish black
98.0	98.1	0.1	Coal
98.1	99.1	1.0	Shale, clayey, medium gray
99.1	100.0	0.9	Sandstone, medium light gray, unconsolidated, fine grained
143.0	144.0	1.0	Coal - lost because core point was too low
144.0	157.0	13.0	Coal, vertically fractured; some framboidal pyrite on fracture planes, scattered disseminated pyrite
157.0	158.6	1.6	Shale, clayey, olive gray
158.6	159.4	0.8	Shale, silty, light gray
159.4	160.0	0.6	Siltstone, light gray, slightly limy

ANDERSON BED

DIETZ BED

Depth interval (feet)		Thick- ness		Core Description
From	To			
305.0	307.4	2.4		Siltstone, clayey, light olive gray; carbonaceous in lower .03'
307.4	314.0	6.6		Core lost. Density log indicates that lost section was: 307.4-309.4-coal; 309.4-310.4 shale; 310.4-314-coal
314.0	332.9	18.9	CANYON	Coal, vertical fractures, upper 8 ft badly broken, sparse pyrite.
332.9	334.0	1.1	BED	Silty coal from 332.4-332.5
480.0	481.1	1.1		Shale; carbonaceous and banded in upper 0.3'; light gray in rest
481.1	481.4	0.3		
481.4	496.1	14.7	COOK	Sandstone, fine grained, light gray, friable
496.1	500.1	4.0	BED	Shale, carbonaceous, olive gray
500.1	500.3	0.2		Coal with a few buff thin lenses of shale from 491-493. Core
500.3	505.6	5.3		badly broken
505.6	506.0	0.4	OTTER	Shale, olive gray, carbonaceous, several streaks of coal
			BED	Shale, coaly, brownish black
				Coal, badly factured and broken
				Siltstone, clayey, light olive gray, grades down to very fine grained sandstone

Rotary drilled from 506 to 800--Following is a sample log modified by interpretation of geophysical log:

506	511	5	Shale, silty
511	513	2	Limestone, sandy, light olive gray
513	525	12	Siltstone, shaly, limy in part, and shale, gray
525	543	18	Shale, gray
543	546	3	Coal
546	575	29	Shale, gray, and clayey siltstone
575	635	60	Sandstone, fine grained, clayey, light olive gray, friable
635	639	4	Shale, carbonaceous
639	645	6	Coal WALL ? BED
645	670	25	Shale, light gray to brownish gray, silty in part
670	693	23	Siltstone to very fine grained sandstone
693	699	6	Limestone, sandy, light olive gray
699	718	19	Shale, silty to carbonaceous shale
718	735	17	Siltstone, and silty shale
735	743	8	Shale, carbonaceous
743	745	2	1.5' coal
745	800	55	Shale, olive gray, gray, and light brown gray

U.S. Geological Survey

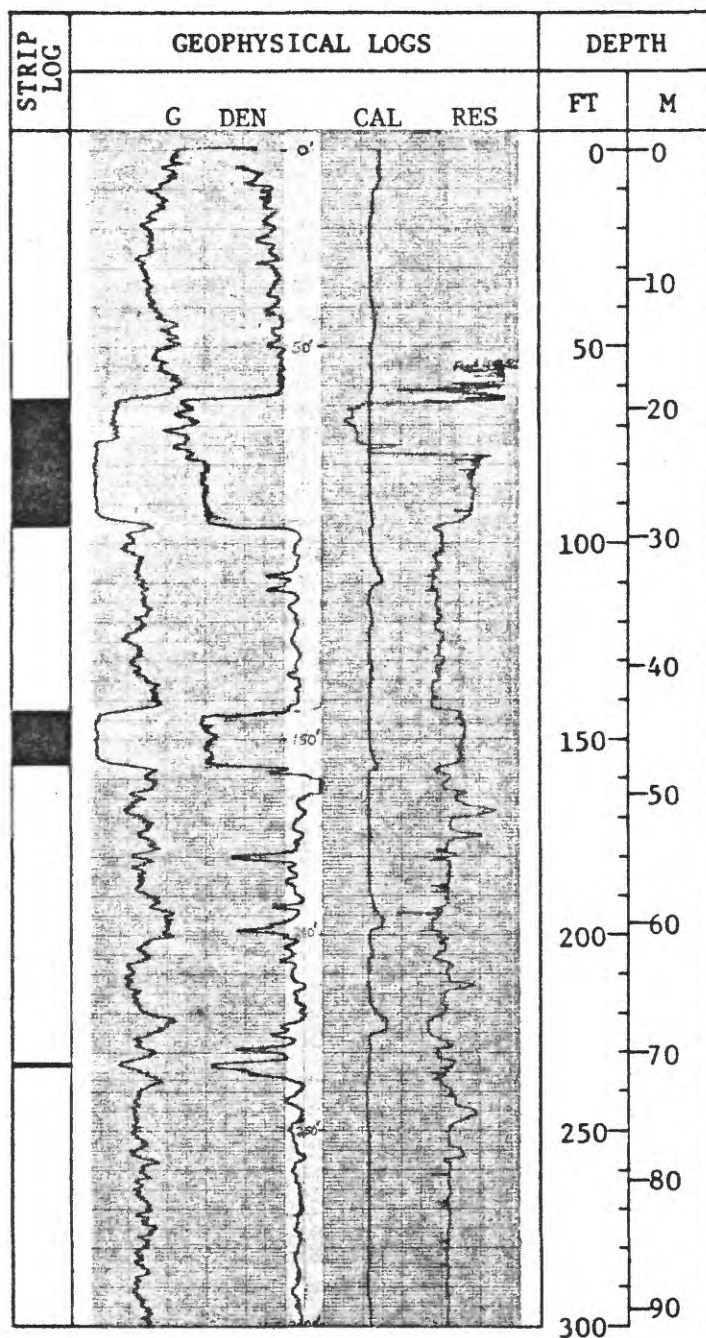
Hole name Birney 1B County Big Horn State Montana  
 Location 500 ft FWL, 1400 ft FNL (SW $\frac{1}{4}$ NW $\frac{1}{4}$ ) Sec. 5 T. 8 S. R. 44 E.  
 Elevation 3850 ft Drilled depth 800 ft Logged depth 800 ft  
 Drilling medium mud Date logged 1/17/79

Geophysical logs:

Gamma ray (G): T.C. 2 Scale 50 cps/in Logging speed 15 fpm  
 Density (DEN): T.C. 2 Scale 100 cps/in Logging speed 15 fpm  
 Caliper (CAL): Scale 5 in/in Logging speed 15 fpm  
 Resistance (RES): Scale 20 ohms/in Logging speed 15 fpm  
 Remarks: \_\_\_\_\_

Anderson coal bed

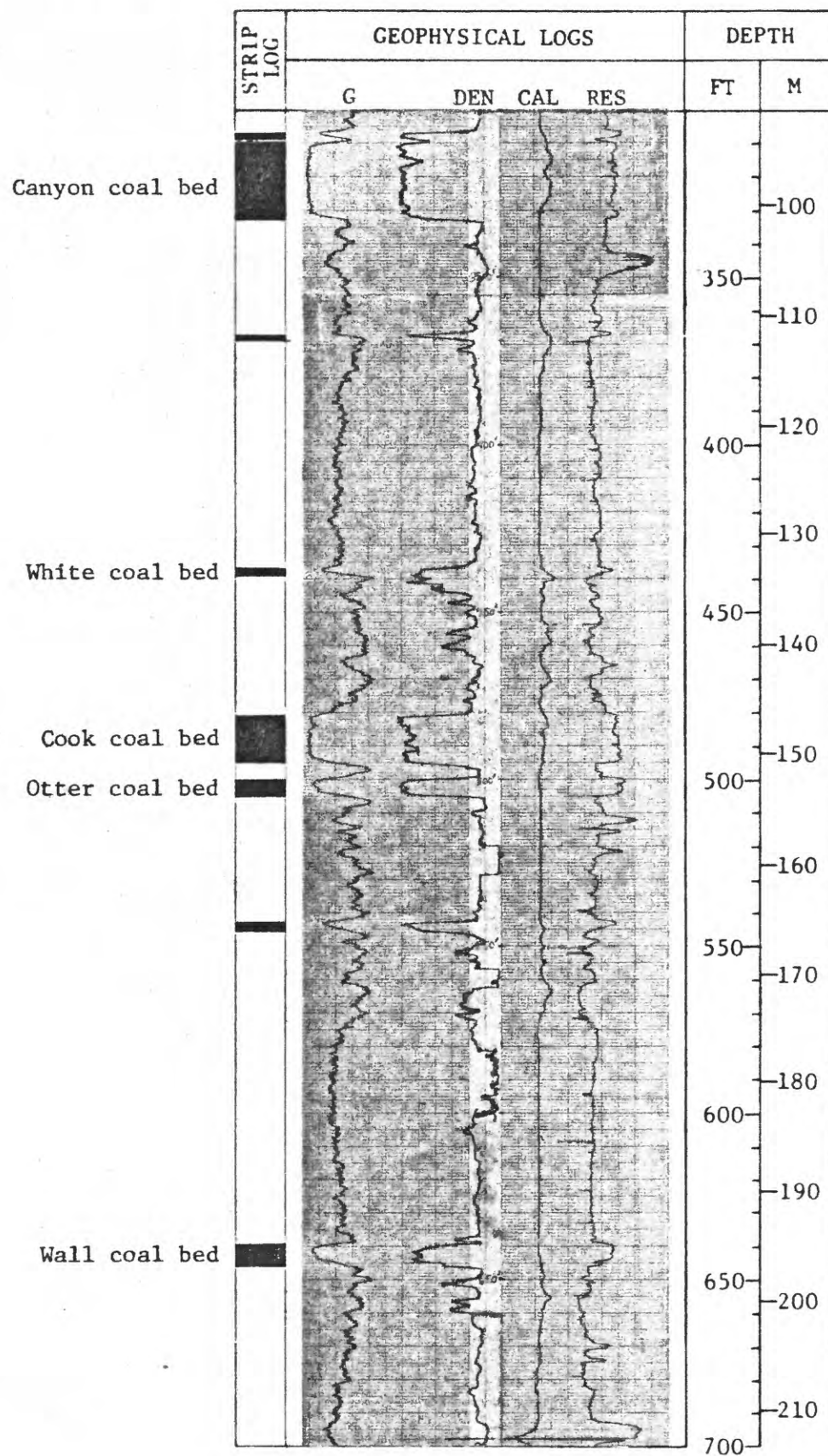
Dietz coal bed





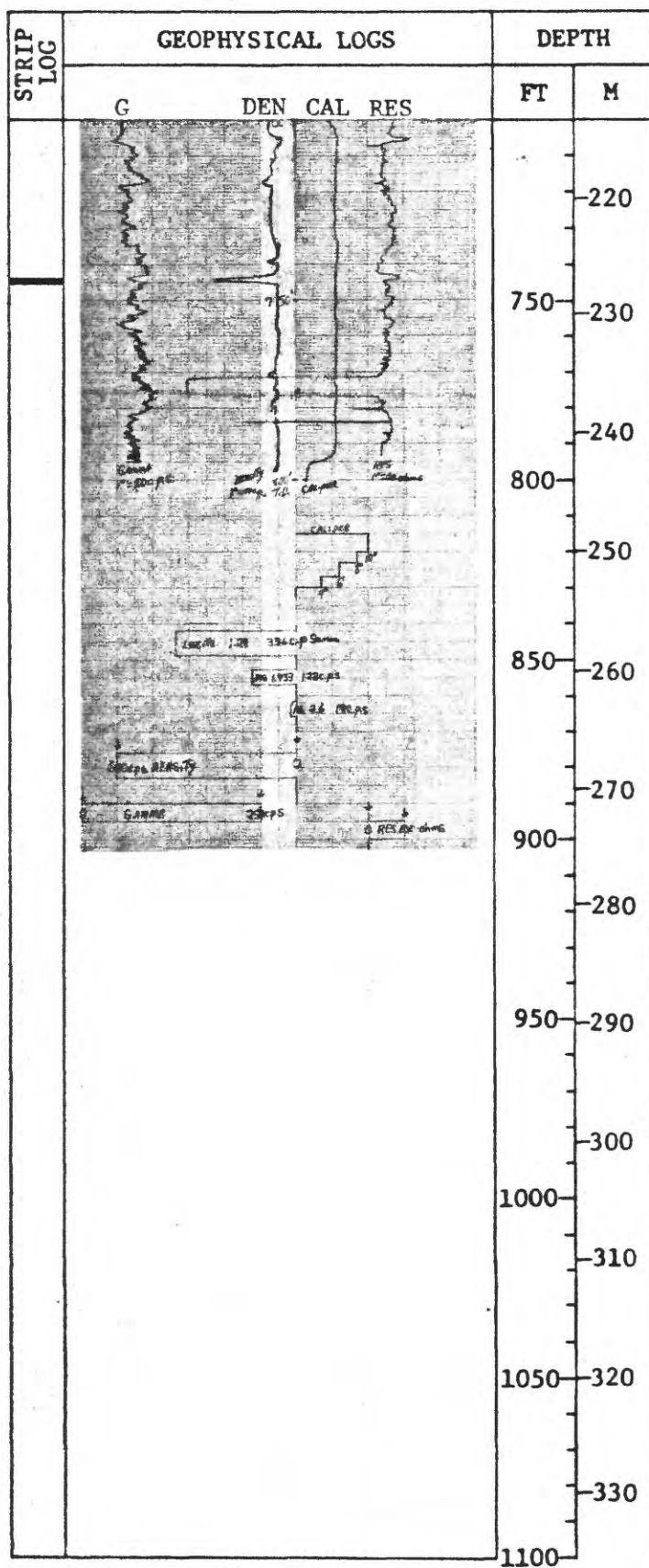
U.S. Geological Survey

Hole name Birney 1B continued



U.S. Geological Survey

Hole name Birney 1B continued





U.S. GEOLOGICAL SURVEY  
Birney 1° x 1/2° quadrangle

Hole Birney 2A Elev. 3732 feet Total depth 217 feet  
 Location 2300 ft FEL, 2050 ft FSL (NW 1/4 SE 1/4) Sec. 15, T. 7 S., R. 44 E.  
 County Rosebud State Montana Quadrangle Hamilton Draw  
 Drilled by Drane Drilling Service Driller Allen Drane Hole size 5 inches  
 Date Started 8/16/78 Date Completed 8/16/78 Geologist T. Gaffke  
 Remarks Hole abandoned at 217 because surface casing was falling into hole. No geophysical logs were run.

Depth interval (feet)

From	To	Thick- ness	Lithologic Description
0	14	14	Alluvium or colluvium-fragments of clinker, limestone, and siltstone in sandy matrix
14	19	5	Limy sandstone, fine grained
19	36	17	Claystone, carbonaceous, dark gray, with coal stringers at 36 ft
36	43	7	Shale, sandy, dark gray, carbonaceous
43	46	3	Shale, carbonaceous, dark gray
46	61	15	Shale, sandy, dark gray
61	65	4	Claystone, gray
65	102	37	Shale, sandy, slightly carbonaceous
102	108	6	Sandstone, fine-grained, gray
108	112	4	Siltstone, gray
112	144	32	Coal - CANYON BED
144	150	6	Shale, carbonaceous, brown
150	156	6	Shale, sandy, gray
156	181	25	Sandstone, fine-grained light gray with thin beds of gray shale
181	182	1	Coal
182	188	6	Shale, light gray
188	190	2	Shale, silty light gray at top, brownish gray at base
190	196	6	Coal and shale - FERRY? BED
196	212	16	Shale, silty, gray
212	217	5	Siltstone, clayey, light gray

U.S. GEOLOGICAL SURVEY  
Birney 1° x 1/2° quadrangle

Hole Birney 2B Elev. 3610 feet Total depth 800 feet  
 Location 700 ft FEL, 2100 ft FNL (SE 1/4 NE 1/4) Sec. 17, T. 7 S., R. 44 E.  
 County Rosebud State Montana Quadrangle Hamilton Draw  
 Drilled by Navajo Drilling Co. Driller Gene Abbott Hole size 5 inches  
 Date Started 1/17/79 Date Completed 1/18/79 Geologist W. C. Culbertson  
 Remarks Hole is about 20 ft below clinker of Canyon coal bed. Lithologic log modified by  
interpretation of geophysical logs.

Depth interval (feet)

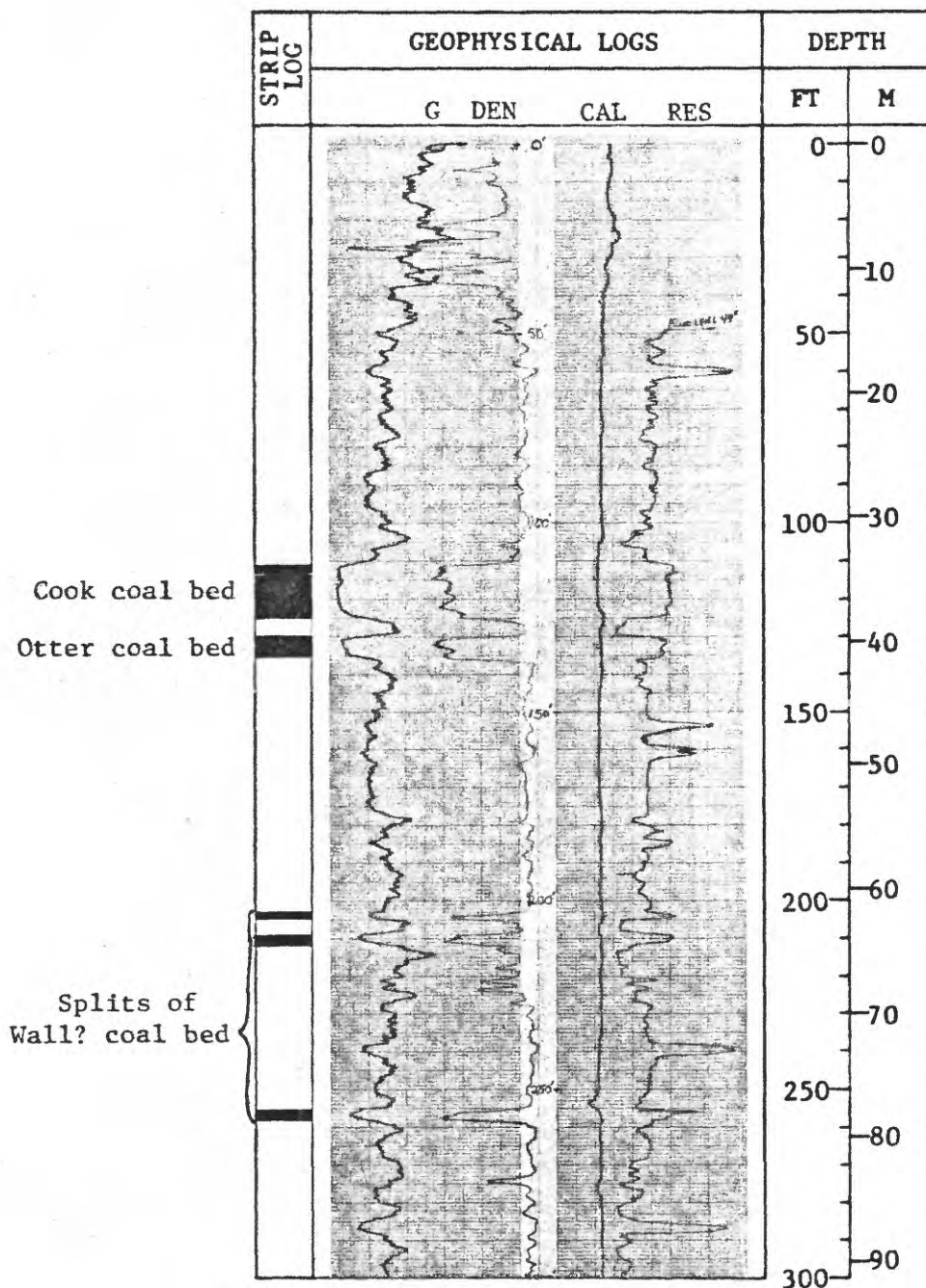
From	To	Thick- ness	Lithologic Description
0	30	30	Sand and gravel, containing pebbles of clinker
30	40	10	Clay, gray, with traces of weathered coal
40	47	7	Shale, clay, olive gray, carbonaceous
47	59	12	Siltstone, clayey and silty shale, gray
59	62	3	Limestone, silty
62	70	8	Siltstone, clayey, light olive gray
70	73	3	Shale, carbonaceous, brownish gray
73	102	29	Siltstone, light olive gray interbedded with fine grained sandstone
102	111	9	Shale, olive gray, carbonaceous in part
111	125	14	Coal - COOK BED
125	130	5	Siltstone and carbonaceous shale
130	136	6	Coal - OTTER BED
136	144	8	Shale, gray and silty shale
144	152	8	Sandstone, fine grained, light gray, grading down to siltstone
152	162	10	Limestone, sandy from 152-155 and 159-162; remainder is sandstone fine grained
162	177	15	Sandstone, fine grained, and siltstone
177	184	7	Shale, gray
184	186	2	Limestone, silty
186	203	17	Shale, gray with gray clayey siltstone
203	205	2	Coal - WALL(?) SPLIT
205	209	4	Shale, brownish gray
209	212	3	Coal - WALL(?) SPLIT
212	238	26	Shale, carbonaceous and gray shale
238	241	3	Limestone, sandy, light olive gray
241	252	11	Siltstone, light gray, and sandstone, very fine grained
252	255	3	Shale, carbonaceous, grayish brown
255	258	3	Coal - WALL(?) SPLIT
258	285	27	Shale, gray and silty shale, gray
285	288	3	Limestone, silty, light olive gray
288	330	42	Interbedded shale and siltstone, gray to brownish gray

Depth interval (feet)

From	To	Thick- ness	Lithologic Description
330	350	20	Shale, carbonaceous, gray shale, and two thin coal layers
350	375	25	Siltstone, clayey, light olive gray
375	394	19	Shale, carbonaceous and coal streaks
394	397	3	Limestone, silty, light olive gray
397	443	46	Siltstone and fine grained sandstone, gray with minor silty shale
443	453	10	9.5 ft coal - POKER JIM BED
453	488	35	Sandstone, fine grained, gray with minor clayey siltstone
488	491	3	Coal - BREWSTER-ARNOLD(?) BED
491	498	7	Siltstone, gray
498	501	3	Limestone, silty, gray
501	522	21	Shale, silty, gray and carbonaceous shale
522	524	2	Limestone, silty, gray
524	565	41	Sandstone, fine grained, light gray and siltstone
565	585	20	Shale, gray to olive gray
585	599	14	Shale, silty and siltstone, gray
599	602	3	Coal
602	640	38	Shale, carbonaceous and gray shale
640	657	17	Sandstone, fine grained, light gray
657	659	2	Shale, carbonaceous
659	662	3	coal - KING BED
662	664	2	Shale, carbonaceous
664	732	68	Siltstone, gray, grading down to sandstone, fine grained, light gray
732	745	13	Shale, gray to carbonaceous shale
745	756	11	Coal bed: 5 ft coal, 2 ft shale, 4 ft coal (Knobloch bed)
756	760	4	Shale, gray to brownish gray
760	770	10	Siltstone, gray
770	792	22	Shale, gray to brownish gray
792	796	4	Coal
796	800	4	Shale(?)

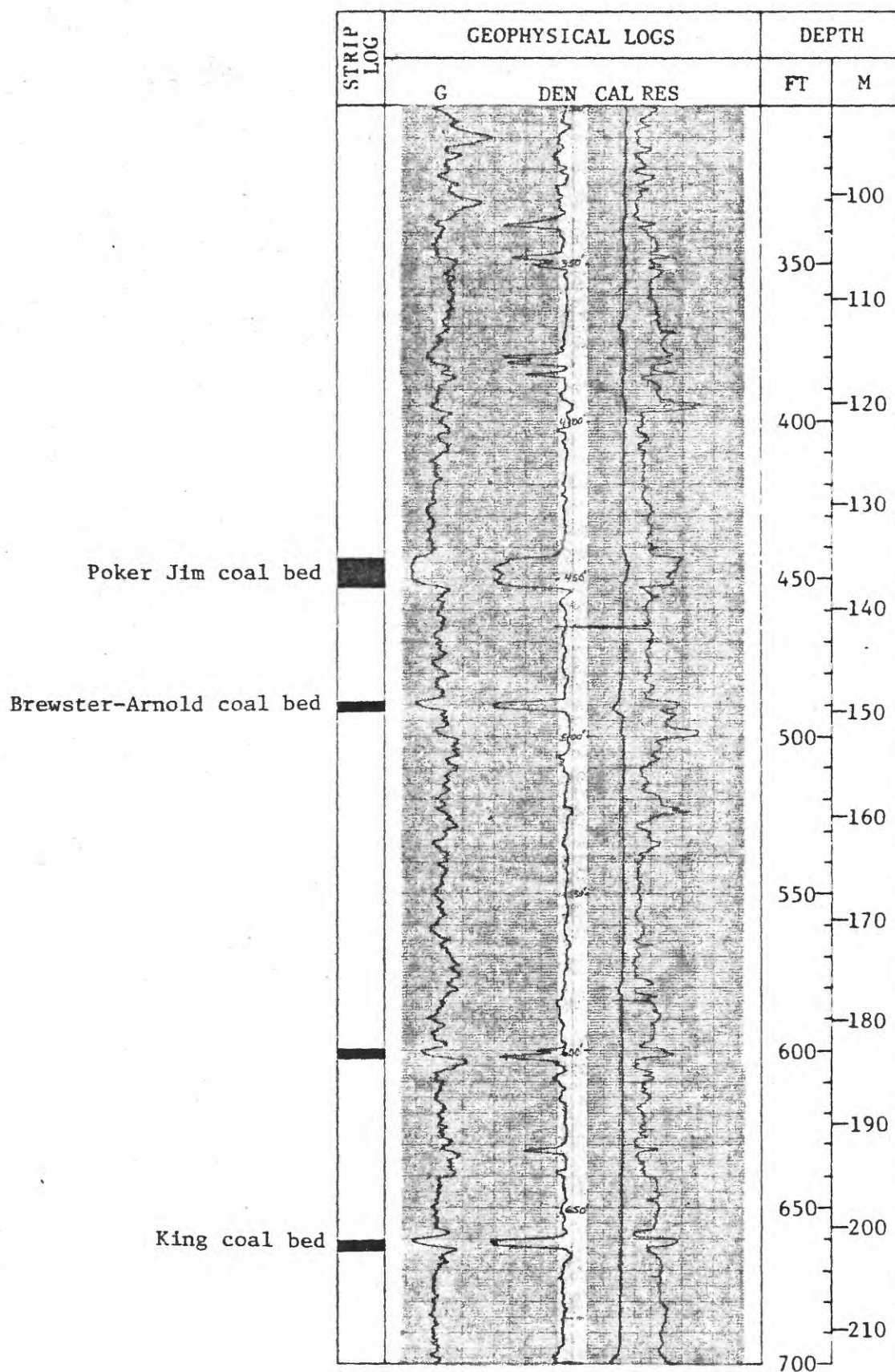
# U.S. Geological Survey

Hole name Birney 2B County Rosebud State Montana  
 Location 700 ft FEL, 2100 ft FNL (SE 1/4 NE 1/4) Sec. 17 T. 7 S. R. 44 E.  
 Elevation 3610 ft Drilled depth 800 ft Logged depth 799 ft  
 Drilling medium mud Date logged 1/18/79  
 Geophysical logs:  
 Gamma ray (G): T.C. 2 Scale 50 cps/in Logging speed 15 fpm  
 Density (DEN): T.C. 2 Scale 100 cps/in Logging speed 15 fpm  
 Caliper (CAL): Scale 5 in/in Logging speed 15 fpm  
 Resistance (RES): Scale 20 ohms/in Logging speed 15 fpm  
 Remarks: \_\_\_\_\_



U.S. Geological Survey

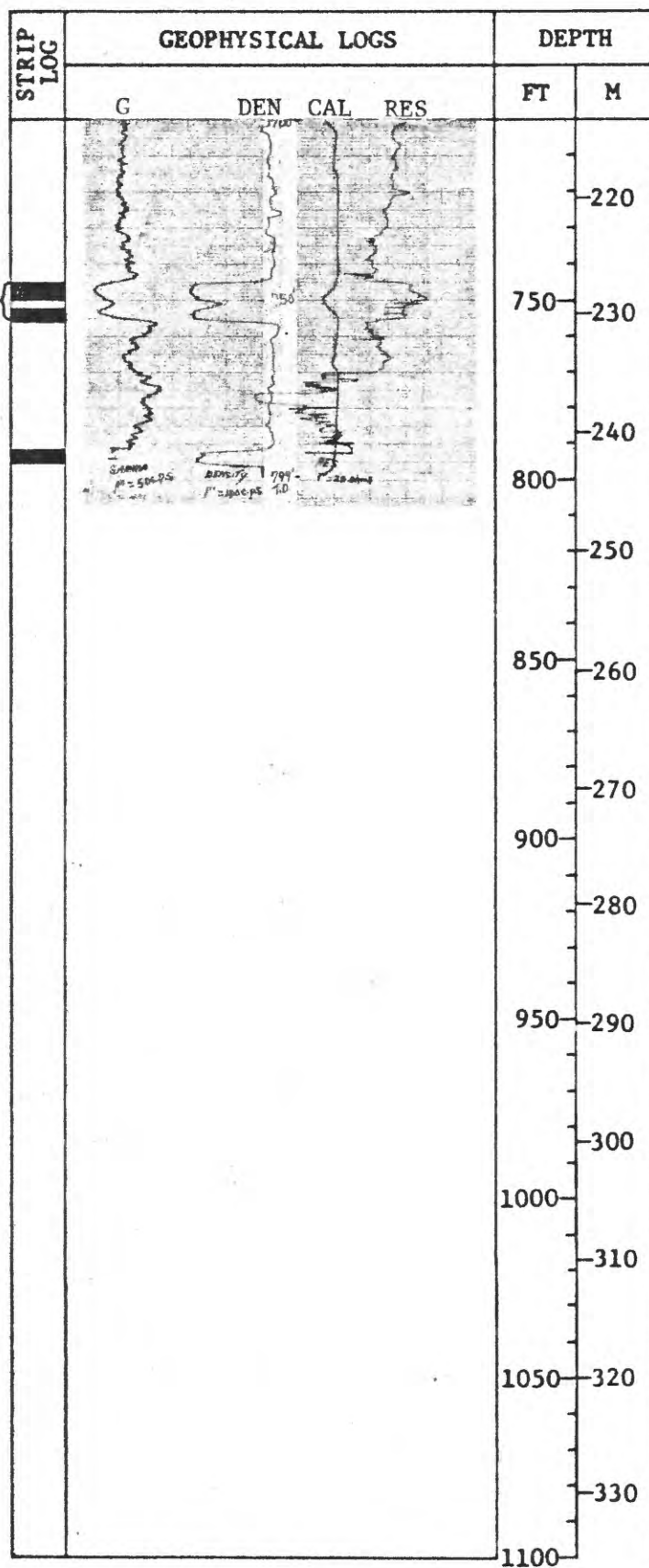
Hole name Birney 2B continued



U.S. Geological Survey

Hole name Birney 2B continued

Knobloch coal bed





U.S. GEOLOGICAL SURVEY  
Birney 1° x 1/2° quadrangle

Hole Birney 2C Elev. 3610 feet Total depth 140 feet  
 Location 700 ft FEL, 2100 ft FNL (SE 1/4 NE 1/4) Sec. 17, T. 7 S., R. 44 E.  
 County Rosebud State Montana Quadrangle Hamilton Draw  
 Drilled by Navajo Drilling Co. Driller Gene Abbott Core size 2.4 inches  
 Date Started 1/18/79 Date Completed 1/19/79 Geologist W. C. Culbertson  
 Remarks Hole is 10 ft west of Birney 2B.

## Cored intervals (in feet)

Core No.	From	To	Length of Core Recovered	Core No.	From	To	Length of Core Recovered
1	115.0	122.0	7.0	3	132.0	140.0	8.0
2	122.0	132.0	10.0				

## Depth interval (feet)

From	To	Thickness	Core Description
113.0	115.0	2.0	Coal. No core because core point was picked too low
115.0	127.5	12.5	Coal, minor incipient vertical fractures, no pyrite, sparse gypsum crystal on fracture planes COOK BED
127.5	132.0	4.5	Siltstone, light gray, clayey to sandy with silty shale from 129.8-130.3
132.0	133.1	1.1	Shale, carbonaceous, light brownish gray
133.1	138.6	5.5	Coal, several vertical fractures, sparse gypsum crystal on fracture planes OTTER BED
138.6	140.0	1.4	Shale, silty grading down to clayey siltstone, light olive gray, carbonaceous from 138.6 to 138.9

U.S. GEOLOGICAL SURVEY  
Birney 1° x 1/2° quadrangle

Hole Birney 3A Elev. 4008 feet Total depth 617 feet  
 Location 450 ft FWL, 2100 ft FNL (SW 1/4 NW 1/4) Sec. 4, T. 7 S., R. 44 E.  
 County Rosebud State Montana Quadrangle Poker Jim Butte  
 Drilled by Drane Drilling Service Driller Allen Drane Hole size 5 inches  
 Date Started 8/5/78 Date Completed 8/6/78 Geologist John Hardie  
 Remarks Sample log of Hardie modified by W. C. Culbertson to conform to geophysical logs and  
to core samples from hole Birney 3B

## Depth interval (feet)

From	To	Thick- ness	Lithologic Description
0	5	5	Soil, "B" horizon, brown clay
5	11	6	Claystone, gray, with iron stains and gypsum
11	13	2	Claystone, silty with iron stains and gypsum
13	19	6	Claystone, silty, light brown
19	20	1	Siltstone, reddish brown with iron stains
20	40	20	Claystone, silty, light brown
40	56	16	Claystone, light gray
56	59	3	Claystone, silty, dark brown
59	63	4	Claystone, gray
63	95	32	Coal - ANDERSON BED
95	97	2	Shale, carbonaceous
97	120	23	Shale, silty gray
120	134	14	Sandstone, very fine grained, clayey, gray
134	135	1	Limestone, gray
135	151	16	Siltstone, clayey, gray
151	155	4	Shale, carbonaceous
155	172	17	Coal - DIETZ BED
172	182	10	Shale, carbonaceous
182	188	6	Siltstone, light gray
188	196	8	Limestone, silty, light gray
196	247	51	Silty shale and siltstone, light gray
247	249	2	Coal
249	257	8	Shale, carbonaceous
257	262	5	Coal
262	263	1	Carbonaceous shale and impure coal
263	268	5	Coal
268	275	7	Carbonaceous shale
275	296	21	Shale, silty and siltstone, gray
296	310	14	Shale, carbonaceous
310	330	20	Siltstone and silty shale, gray
330	332	2	Sandstone, fine-grained, gray

} UPPER CANYON BED



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Depth interval (feet)

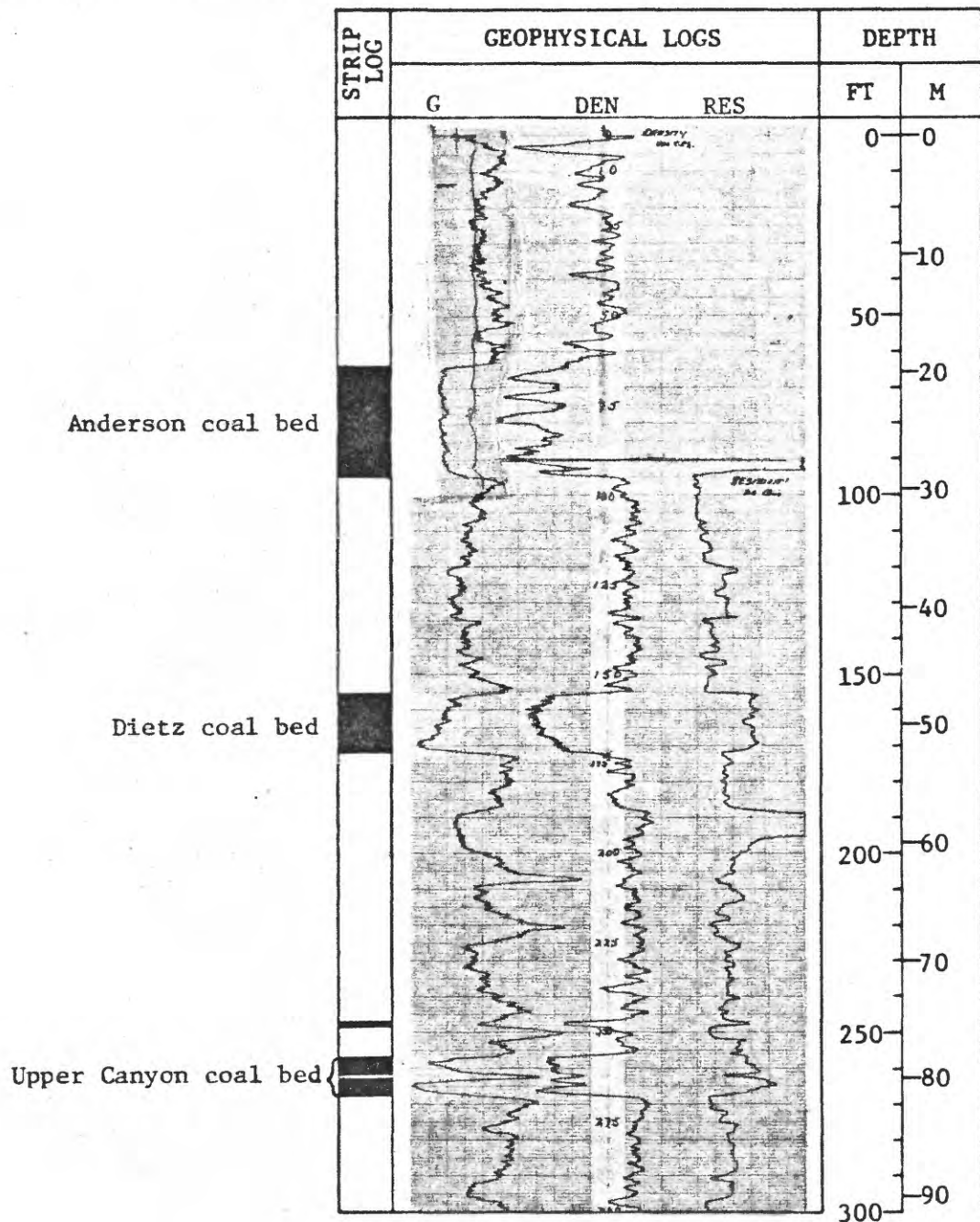
From	To	Thick- ness	Lithologic Description
332	342	10	Coal - LOWER CANYON BED
342	357	15	Shale, gray
357	376	19	Shale, silty, gray
376	380	4	Shale, carbonaceous
380	385	5	Coal - FERRY(?) BED
385	401	16	Shale, silty and siltstone, gray
401	410	9	Shale, carbonaceous
410	454	44	Siltstone, clayey with beds of silty limestone at 425-426, 428-430, 436-437
454	474	20	Sandstone, very fine grained, light gray interbedded with gray shale
474	496	22	Shale, silty and siltstone, gray
496	501	5	Shale, carbonaceous
501	516	15	Coal - COOK BED
516	522	6	Shale, carbonaceous
522	529	7	Coal - OTTER BED
529	577	48	Shale, sandy and clayey sandstone, light gray
577	581	4	Coal - WALL SPLIT
581	601	20	Shale, gray and silty shale
601	603	2	Coal - WALL SPLIT
603	617	14	Shale, gray

# U.S. Geological Survey

Hole name Birney 3A County Rosebud State Montana  
 Location 450 ft FWL, 2100 ft FNL (SW $\frac{1}{4}$ NW $\frac{1}{4}$ ) Sec. 4 T. 7 S. R. 44 E.  
 Elevation 4008 ft Drilled depth 617 ft Logged depth 616 ft  
 Drilling medium air to 158 ft. mud T.D. Date logged 8/6/78

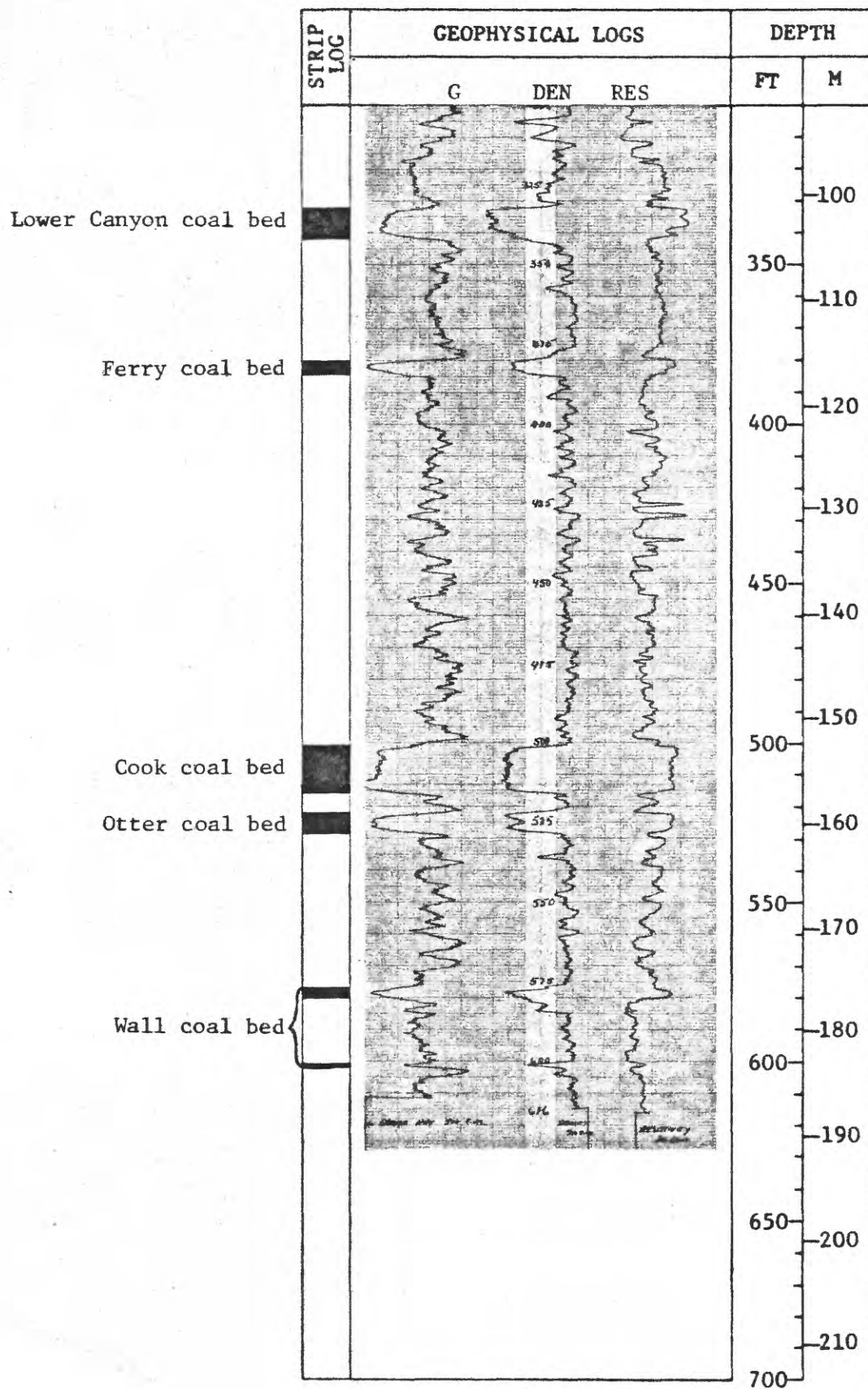
## Geophysical logs:

Gamma ray (G): T.C. 3 Scale 100 cps/in Logging speed 15 fpm  
 Density (DEN): T.C. 3 Scale 100 cps/in Logging speed 15 fpm  
 Caliper (CAL): Scale \_\_\_\_\_ Logging speed \_\_\_\_\_ fpm  
 Resistance (RES): Scale 20 ohms/in Logging speed 15 fpm  
 Remarks: From 0-100 feet, a repeat gamma ray log replaces original log



U.S. Geological Survey

Hole name Birney 3A continued



U.S. GEOLOGICAL SURVEY  
Birney 1° x 1/2° quadrangle

Hole Birney 3B Elev. 4008 feet Total depth 518 feet  
 Location 450 ft FWL, 2100 ft FNL (SW 1/4 NW 1/4) Sec. 4, T. 7 S., R. 44 E.  
 County Rosebud State Montana Quadrangle Poker Jim Butte  
 Drilled by Drane Drilling Service Driller Allen Drane Core size 2 1/8 inches  
 Date Started 8/7/78 Date Completed 8/15/78 Geologist T. Gaffke & W. Culbertson  
 Remarks Hole is 20 ft west of Birney 3A

## Cored intervals (in feet)

Core No.	From	To	Length of Core Recovered	Core No.	From	To	Length of Core Recovered
1	60	67	6.8	9	171	175	3.2
2	67	70	2.0	10	225	265	5.0
3	70	80	3.4	11	265	269	3.4
4	80	86	5.9	12	330	339	7.0
5	86	95.6	7.8	13	339	345	4.7
6	152.5	155.5	3.8	14	498	508	3.6
7	115.5	164.5	2.9	15	508	518	4.5
8	164.5	171.0	3.6				

## Depth interval (feet)

From	To	Thick- ness	Core Description
60.0	62.6	2.6	Carbonaceous shale, dark gray
62.6	94.6	32.0	Coal, broken (24.4 ft recovered) ANDERSON BED
94.6	95.6	1.0	Carbonaceous shale, dark gray
152.5	154.8	2.3	Clay shale, brownish gray, carbonaceous at base
154.8	171.8	17.0	Coal, broken (8.0 ft recovered), 0.02' gypsum at 162.1. DIETZ BED
171.8	172.3	0.5	Clay, carbonaceous, gray
172.3	173.9	1.6	Clay, highly carbonaceous with coal stringers
173.9	174.6	0.7	Coal
174.6	175.0	0.4	Clay, carbonaceous
255.0	255.5	0.4	Shaly siltstone, light brownish gray, carbonaceous in part
255.4	260.4	5.0	Coal, broken (2 feet recovered)
260.4	260.8	0.4	Carbonaceous shale, grayish brown
260.8	261.6	0.8	Shaly impure coal
261.6	267.3	5.7	Coal (3.7 ft recovered)
267.3	269.0	1.7	Shale, clay, olive gray, carbonaceous

UPPER CANYON BED

Depth interval (feet)

From	To	Thick- ness	Core Description
330.0	330.7	0.7	Sandy shale, medium gray
330.7	332.1	1.4	Sandstone, fine-grained, medium light gray, with carbonaceous laminae
332.1	341.6	9.5	Coal, broken (6.2 ft recovered)
341.6	341.8	0.2	Carbonaceous shale, brownish gray LOWER CANYON BED
341.8	342.3	0.5	Coal
342.3	344.3	2.0	Clay shale, light brownish gray, carbonaceous
344.3	345.0	0.7	Clay shale with stringers of coal, some at high angles to bedding
498.0	499.5	1.5	Claystone, medium gray and brownish gray, plastic
499.5	500.3	0.8	Sandstone, clayey, fine grained, light, abundant carbonaceous laminae
500.3	515.5	15.2	Coal, broken (3.4 ft recovered), COOK BED
515.5	517.3	1.8	Shale, light olive gray with thin (<0.01 ft thick) lenses of coal
517.3	518.0	0.7	Sandstone, fine-grained, medium-gray, abundant carbonaceous laminae

U.S. GEOLOGICAL SURVEY  
Birney 1° x 1/2° quadrangle

Hole Birney 4A Elev. 3690 feet Total depth 719 feet  
 Location 500 ft FEL, 1000 ft FSL (SE 1/4 SE 1/4) Sec. 13, T. 9 S., R. 41 E.  
 County Big Horn State Montana Quadrangle Holmes Ranch  
 Drilled by Drane Drilling Service Driller Allen Drane Hole size 5 inches  
 Date Started 8/30/79 Date Completed 9/1/78 Geologist T. Gaffke & W. C. Culbertson  
 Remarks Lithologic log modified by interpretation of geophysical log.

Depth interval (feet)

From	To	Thick- ness	Lithologic Description
0	24	24	Alluvium, silt and sand, minor gravel
24	25	1	Sandstone, fine grained, brown
25	50	25	Shale, brown to gray with layers of very fine grained sandstone
50	53	3	Sandstone, very fine grained, gray, limy from 52-53
53	57	4	Sandstone, fine grained, clayey, gray
57	58	1	Shale, carbonaceous with coal stringer
58	62	4	Shale, sandy, brownish gray
62	79	17	Shale, carbonaceous, brownish gray; brown-black from 72-74
79	83	4	Sandstone, fine grained, light gray
83	87	4	Shale, carbonaceous
87	91	4	Siltstone and very fine grained sandstone, carbonaceous
91	105	14	Shale, carbonaceous, brownish; brownish black from 93-96 and 103-105
105	125	20	Coal, with shale from 106-107, 108-110, 123-124 - SMITH BED
125	134	9	Sandstone, fine-grained, clayey and siltstone, light gray
134	139	5	Limestone, sandy
139	150	11	Sandstone, fine-grained, light gray
150	153	3	Shale, carbonaceous with coal stringers
153	158	5	Shale, silty, gray
158	165	7	Sandstone, fine-grained, gray, sandy limestone from 164-165
165	174	9	Shale, gray
174	203	29	Sandstone, fine-grained, gray; sandy limestone at 174-175 and 194-197
203	211	8	Shale, silty, gray; brown at base
211	234	23	Coal - ANDERSON BED
234	241	7	Shale, gray
241	247	6	Sandstone, very fine grained; limy from 241-245
247	248	1	Shale, carbonaceous
248	251	3	Coal
251	261	10	Shale, carbonaceous with layer of sandstone from 252-254
261	264	3	Shale, silty, gray
264	321	57	Sandstone, very fine grained and siltstone, gray; sandy limestone at 267-268, 285-288 and 311-313
321	325	4	Shale, carbonaceous
325	329	4	Coal



Depth interval (feet)

From	To	Thick- ness	Lithologic Description
329	337	8	Siltstone, sandy and silty shale, gray
337	345	8	Sandstone, very fine grained, gray
345	352	7	Shale, silty, gray
352	367	15	Sandstone, very fine grained, gray
367	375	8	Shale, silty and sandy, gray
375	395	20	Shale, carbonaceous, brownish
395	399	4	Coal
399	408	9	Siltstone, clayey, light gray
408	458	50	Sandstone, fine-grained, very light gray
458	471	13	Siltstone and silty shale, gray
471	484	13	Coal - DEITZ 3 BED
484	498	14	Shale, carbonaceous, and gray silty shale
498	510	12	Siltstone, gray; silty limestone at 502-504 and 548-550
510	537	27	Sandstone, very fine grained; sandy limestone at 529-533
537	550	13	Shale, silty, gray, and gray siltstone; limy siltstone at 548-550
550	555	5	Shale, gray
555	576	21	Siltstone and silty shale, gray
576	600	24	Coal - CANYON BED
600	609	9	Shale, gray
609	629	20	Siltstone and silty shale, gray
629	660	31	Sandstone, very fine grained, gray; sandy limestone at 635-639
660	672	12	Shale, silty, gray
672	685	13	Coal - COOK BED
685	719	34	No cuttings returned. Probably shale and siltstone

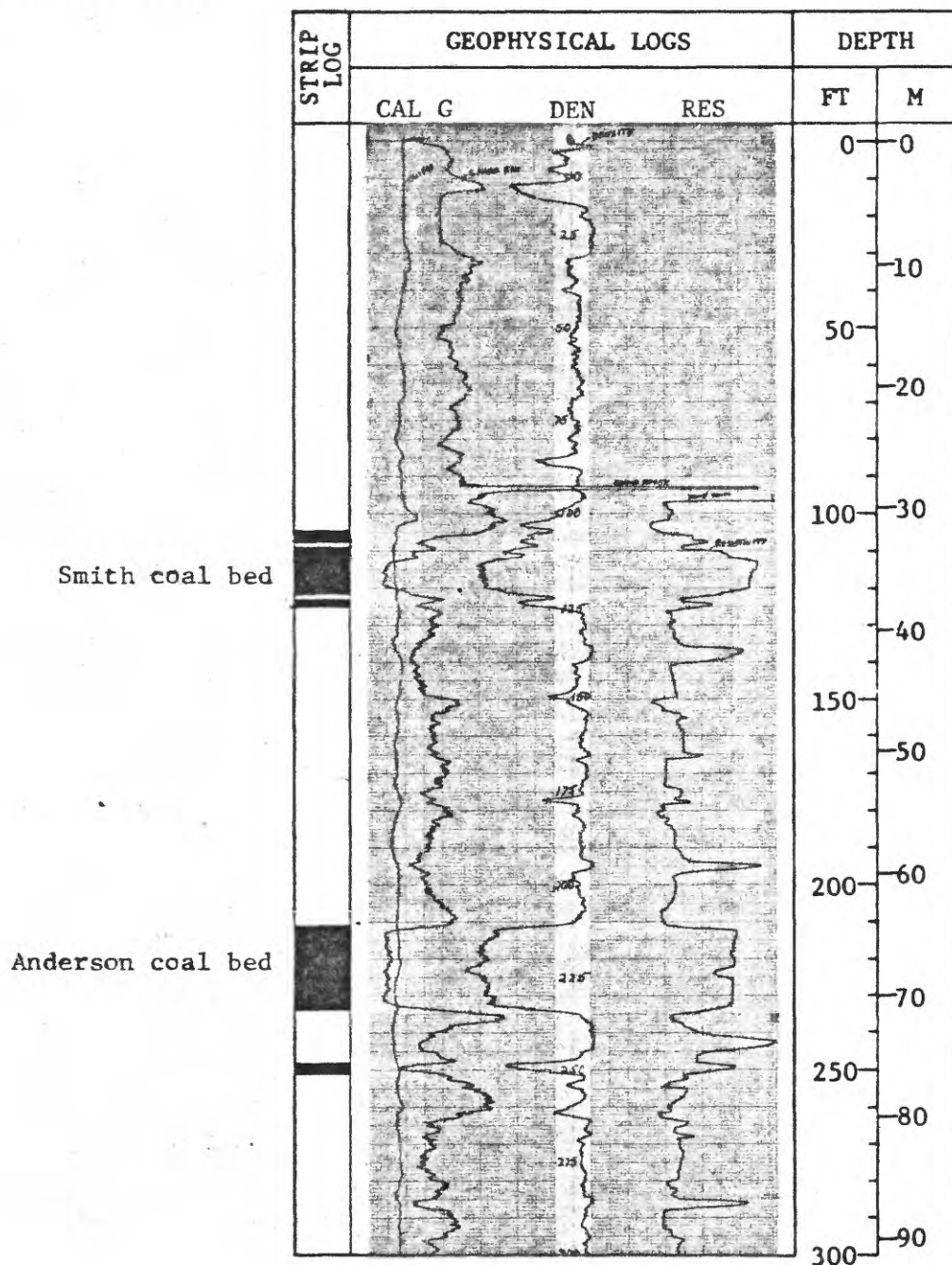
# U.S. Geological Survey

Hole name Birney 4A County Big Horn State Montana  
 Location 500 ft FEL, 1000 ft FSL, (SE<sup>1</sup>/SE<sup>1</sup>) Sec. 13 T. 9 S R. 41 E  
 Elevation 3690 ft Drilled depth 719 ft Logged depth 714 ft  
 Drilling medium mud Date logged 9/1/78

## Geophysical logs:

Gamma ray (G): T.C. 3 Scale 100 cps/in Logging speed 15 fpm  
 Density (DEN): T.C. 3 Scale                      Logging speed 15 fpm  
 Caliper (CAL): Scale 3.3 in/in Logging speed                      fpm  
 Resistance (RES): Scale 20 ohms/in Logging speed 15 fpm

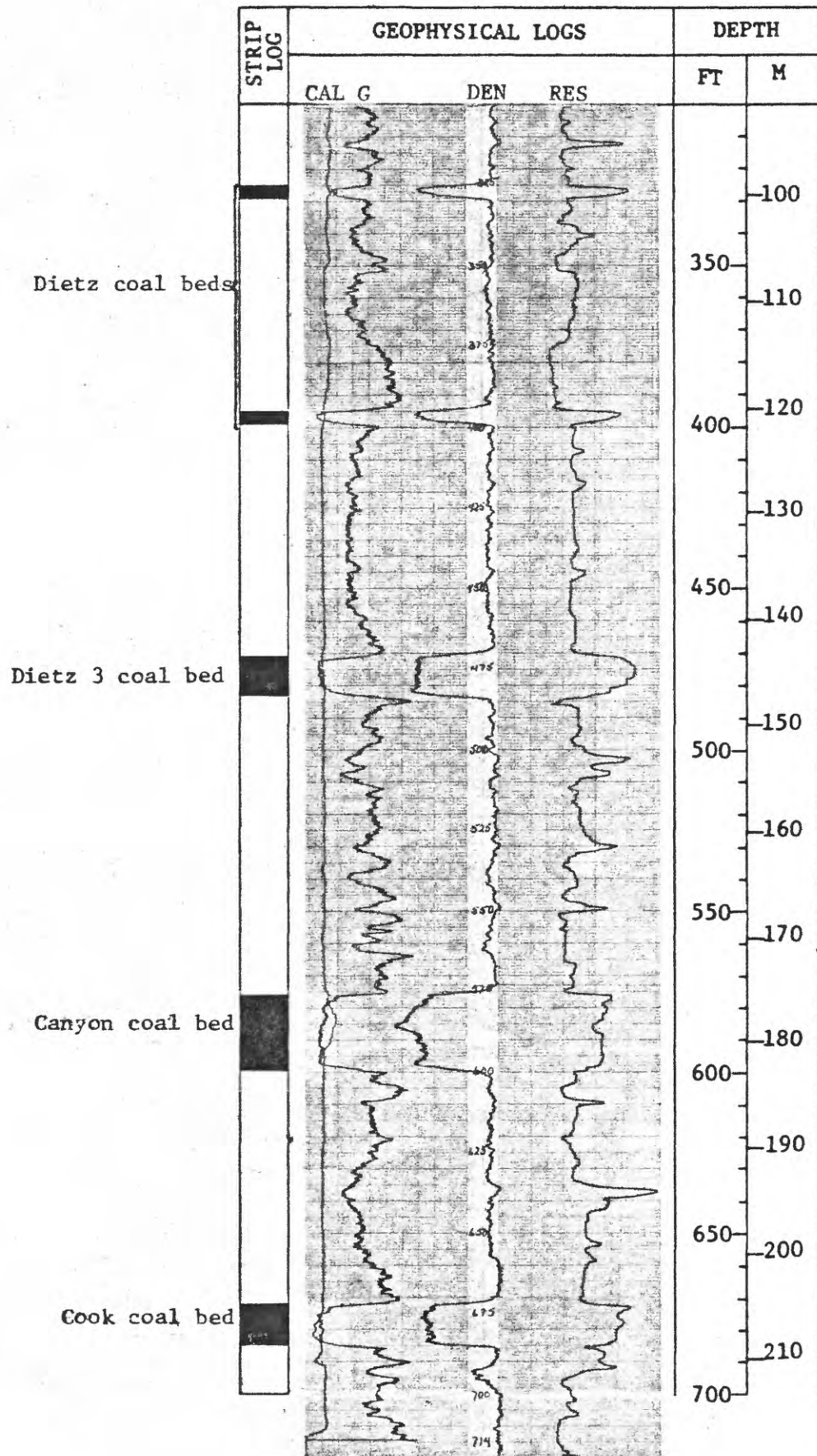
Remarks: Caliper log recorded 2 feet high.





U.S. Geological Survey

Hole name Birney 4A continued



U.S. GEOLOGICAL SURVEY  
Birney 1° x 1½° quadrangle

Hole Birney 4B Elev. 3690 feet Total depth 588 feet  
 Location 500 ft FEL, 1000 ft FWL (SE 1/4 SE 1/4) Sec. 13, T. 9 S., R. 41 E.  
 County Big Horn State Montana Quadrangle Holmes Ranch  
 Drilled by Drane Drilling Driller Allen Drane Core size 2.4 inches  
 Date Started 9/5/78 Date Completed 9/9/78 Geologist W. C. Culbertson  
 Remarks Hole is 6 ft south of Birney 4A

Cored intervals (in feet)

Core No.	From	To	Length of Core Recovered	Core No.	From	To	Length of Core Recovered
1	104.0	109.0	5.0	6	228.0	235.0	7.0
2	109.0	118.0	9.0	7	469.0	479.0	10.0
3	118.0	127.0	9.0	8	479.0	483.0	4.0
4	209.0	219.0	10.0	9	574.0	584.0	10.0
5	219.0	228.0	9.0	10	584.0	588.0	4.0

Depth interval (feet)

From	To	Thick-ness	Core Description
104.0	104.6	0.6	Shale, carbonaceous, brownish black
104.6	105.5	0.9	Coal
105.5	106.3	0.8	Shale, coaly
106.3	107.5	1.2	Coal
107.5	109.0	1.5	Shale, coaly
109.0	122.8	13.8	Coal, vertical fractures; with carbonaceous shale as follows: 0.1' at 111.2, 0.05' at 121.2, and 0.0' at 122.5.
122.5	124.2	1.4	Shale, carbonaceous, gray to dark gray
124.2	125.5	1.3	Coal; 0.03' carbonaceous shale at 124.4
125.5	125.6	0.08	Shale, carbonaceous
125.6	125.8	0.18	Coal
125.8	127.1	1.34	Shale, carbonaceous, with 0.1' lens of silty shale
127.1	127.2	0.1	Coal
127.2	127.3	0.1	Sandstone, very fine grained, gray
209.0	211.2	2.2	Shale, carbonaceous, brownish gray
211.2	233.2	22.0	Coal, vertical fractures with carbonaceous shale as follows: 0.02' at 221.1 and 0.1 lens at 220.4. ANDERSON BED
233.2	235.0	1.8	Shale, gray

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Depth interval (feet)

From	To	Thick- ness	Core Description
469.0	470.3	1.3	Shale, carbonaceous, gray, plant fossils
470.3	483.0	12.7	Coal, vertical fractures, 0.03' shale, carbonaceous at 481.5; pyrite films at 481.5 DIETZ 3 BED
Note: Lower 1 foot of Dietz 3 coal not recovered (483.0-484.0)			
574.0	575.4	1.4	Shale, gray to dark gray
575.4	588.0	12.6	Coal, vertical fractures in lower two-thirds. CANYON BED
Note: Lower 12 feet of Canyon bed (588.0-600.0) not recovered because of excessive binding of core barrel			

U.S. GEOLOGICAL SURVEY  
Birney 1° x 1/2° quadrangle

Hole Birney 5A Elev. 3890 feet Total depth 906 feet  
 Location 600 ft FWL, 300 ft FNL, (NW 1/4 NW 1/4) Sec. 4, T. 9 S., R. 42 E.  
 County Big Horn State Montana Quadrangle Pine Butte School  
 Drilled by Drane Drilling Service Driller Allen Drane Hole size 5 inches  
 Date Started 9/11/78 Date Completed 9/25/78 Geologist W. C. Culbertson  
 Remarks Projected depth was 1100 feet. Hole lost at 906 because of excessive caving. Sample  
log modified by interpretation of geophysical log.

Depth interval (feet)

From	To	Thick- ness	Lithologic Description
0	20	20	Sand and clay with sparse pebbles
20	25	5	Shale, carbonaceous, yellowish brown
25	30	5	Siltstone and silt, shale, gray
30	35	5	Sandstone, fine grained, gray
35	38	3	Limestone, sandy, gray
38	48	10	Shale, gray, silty in upper part
48	54	6	Sandstone, very fine grained, light gray, clayey, and siltstone
54	57	3	Shale, carbonaceous, brownish gray
57	60	3	Sandstone, very fine grained
60	71	11	Shale, carbonaceous, dark brown - contains 1 foot coal at 66 ft
71	73	2	Shale, gray
73	77	4	Sandstone, very fine grained, gray
77	81	4	Shale, silty, gray
81	84	3	Shale, carbonaceous, dark brown
84	85	1	Coal
85	104	19	Shale, gray, silty in upper part
104	109	5	Sandstone very fine grained; and limy siltstone from 107 to 109
109	117	8	Sandstone, fine-grained, light gray to brownish gray
117	121	4	Shale, carbonaceous, brown with thin coal stringer at top
121	134	13	Sandstone, fine-grained gray with interbedded siltstone
134	141	7	Shale, carbonaceous, brownish gray
141	152	11	Sandstone, fine grained, clayey, gray grading down to siltstone
152	177	25	Shale, brownish gray to gray; carbonaceous with coal streaks from 151-159. Mollusk shells at 155 and 162
177	184	7	Sandstone, very fine grained, gray and siltstone
184	191	7	Shale, carbonaceous, dark brown to brownish gray, with coal streaks at 184
191	199	8	Sandstone, fine-grained, and siltstone, gray to tan
199	201	2	Shale, carbonaceous, dark brown
201	218	17	Coal - SMITH BED

Depth interval (feet)

From	To	Thick- ness	Lithologic Description
218	230	12	Shale, gray
230	260	30	Siltstone, gray and sandstone, very fine grained to fine grained. Limy hard siltstone from 241-244
260	266	6	Shale, carbonaceous, grayish brown
266	276	10	Siltstone, gray and silty shale
276	287	11	Sandstone, fine grained to very fine grained, light gray
287	289	2	Siltstone, limy, hard
289	309	20	Sandstone, fine grained, light gray interbedded with siltstone, shaly
309	357	48	Shale, silty, tan to yellowish brown
357	384	27	Coal - ANDERSON BED
384	388	4	Shale, carbonaceous
388	392	4	Coal
392	397	5	Shale, carbonaceous
397	406	9	Siltstone
406	409	3	Limestone, silty, gray
409	413	4	Sandstone, very fine grained, light gray
413	440	27	Shale, silty, olive gray to gray with interbedded siltstone
440	450	10	Sandstone, very fine grained, light gray to gray, clayey
450	475	25	Shale, carbonaceous, brownish gray
475	479	4	Coal
479	485	6	Shale, carbonaceous, brownish gray
485	489	4	Interbedded coal and carbonaceous shale
489	503	14	Sandstone, very fine grained and siltstone, light gray
503	505	2	Limestone, silty
505	521	16	Siltstone, gray and silty shale, gray to brownish gray
521	523	2	Coal
523	543	20	Shale, light gray to light olive gray
543	546	3	Sandstone, very fine grained, limy, hard gray
546	560	14	Sandstone, fine grained, gray
560	564	4	Limestone, silty
564	605	41	Shale, gray, silty shale, and siltstone, gray to olive gray
605	609	4	Limestone, sandy
609	630	21	Shale, gray and brownish gray with layers of siltstone
630	634	4	Shale, carbonaceous, grayish brown
634	636	2	Coal
636	638	2	Shale, carbonaceous
638	658	20	Coal, contains 1 ft shale from 642-643 ft - CANYON BED
658	682	24	Shale; carbonaceous in top 4 feet, grading down to gray shale and silty shale
682	685	3	Sandstone, fine grained, limy, hard
685	690	5	Shale, silty, gray
690	692	2	Siltstone, limy, hard
692	704	12	Siltstone, gray carbonaceous in part
704	722	18	Shale, gray and silty shale, gray
722	725	3	Siltstone, limy, hard
725	731	6	Sandstone, fine-grained, light gray

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Depth interval (feet)

From	To	Thick- ness	Lithologic Description
731	740	9	Shale, olive gray to brownish gray, grading down to silty shale
740	748	8	Sandstone, very fine to fine-grained; hard limy sandstone from 745-747
748	756	8	Shale, olive gray
756	768	12	Coal - COOK BED
768	771	3	Shale, carbonaceous, brownish gray
771	783	12	Siltstone, gray and silty shale, hard, limy siltstone from 774-776 and 781-783
783	802	19	Shale gray, with layers of siltstone
802	806	4	Coal - OTTER BED
806	824	18	Shale gray and silty shale
824	830	6	Limestone, sandy, gray
830	849	19	Interbedded shale and very fine grained sandstone
849	854	5	Coal
854	878	24	Shale, gray with layers of siltstone
878	887	9	Coal - UPPER WALL(?) BED
887	906	19	Probably shale and siltstone T.D.



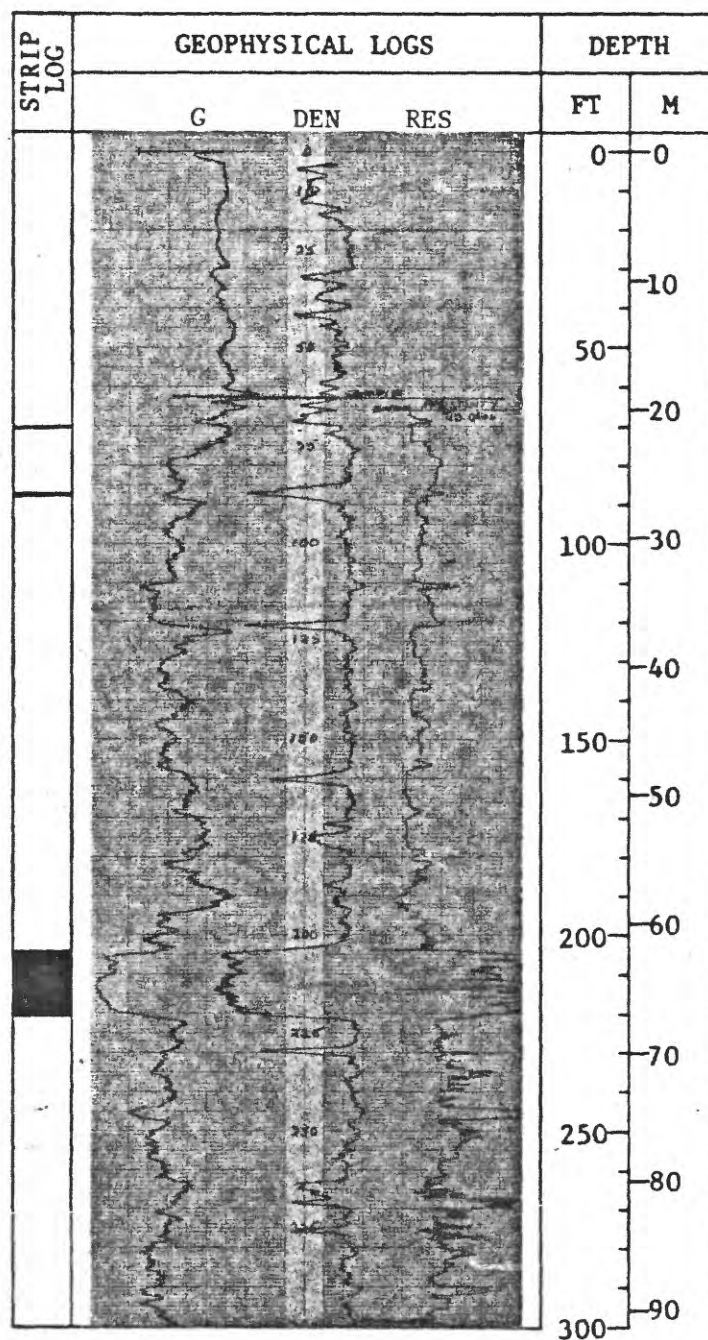
# U.S. Geological Survey

Hole name Birney 5A County Big Horn State Montana  
 Location 60 ft FWL, 300 ft FNL (NW $\frac{1}{4}$ NW $\frac{1}{4}$ ) Sec. 4 T. 9 S. R. 42 E.  
 Elevation 3890 ft Drilled depth 906 ft Logged depth 894 ft  
 Drilling medium mud Date logged 9/23/78

## Geophysical logs:

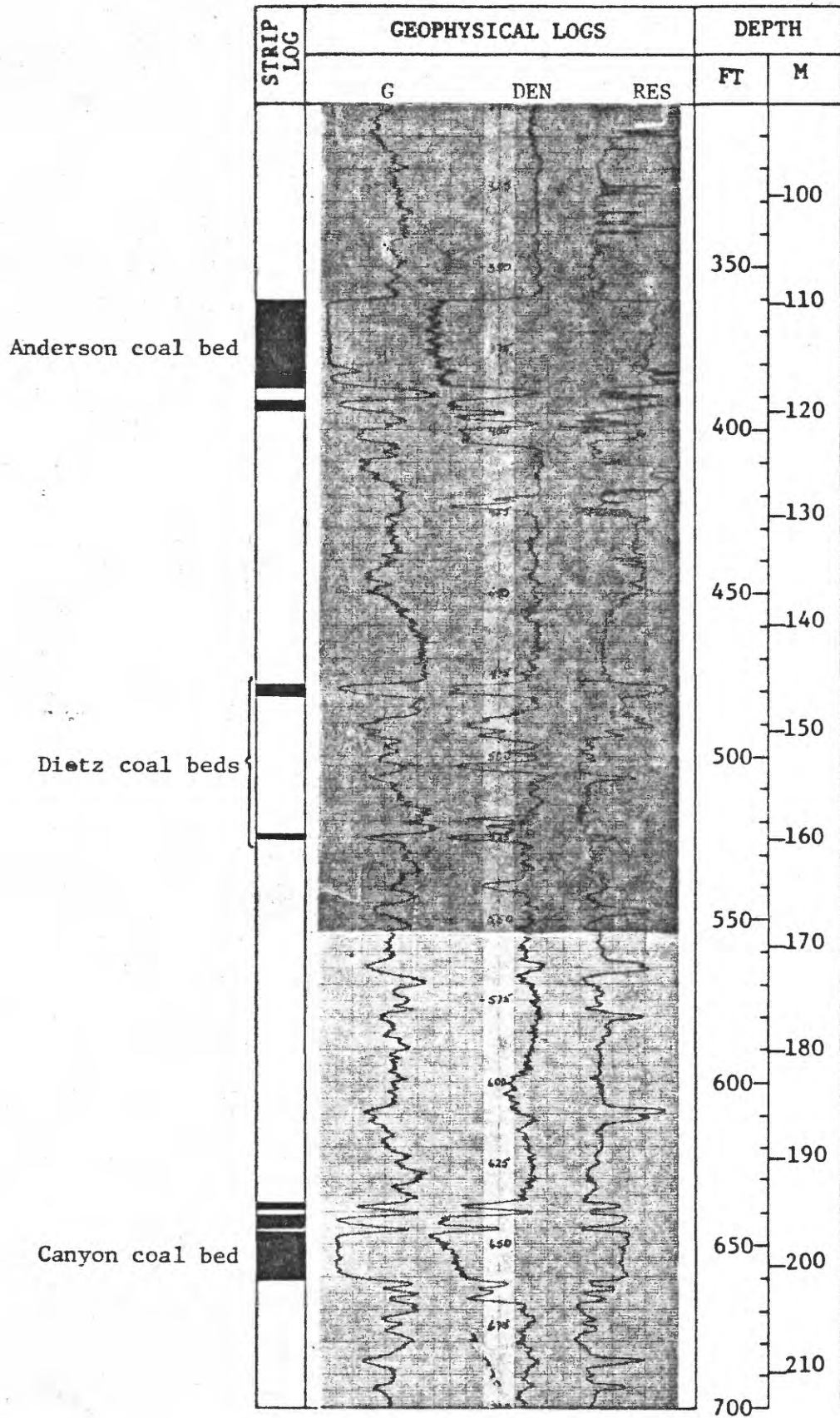
Gamma ray (G): T.C. 3 Scale 100 cps/in Logging speed 15 fpm  
 Density (DEN): T.C. 3 Scale                      Logging speed 15 fpm  
 Caliper (CAL): Scale                      Logging speed                      fpm  
 Resistance (RES): Scale 20 ohms/in Logging speed 15 fpm  
 Remarks: All logs recorded 3 feet low.

Smith coal bed



U.S. Geological Survey

Hole name Birney 5A continued





Hole name Birney 5A continued



U.S. GEOLOGICAL SURVEY  
Birney 1° x 1/2° quadrangle

Hole Birney 5B Elev. 3890 feet Total depth 219 feet  
 Location 600 ft FWL, 300 ft FNL (NW 1/4 NW 1/4) Sec. 4, T. 9 S., R. 42 E.  
 County Big Horn State Montana Quadrangle Pine Butte School  
 Drilled by Drane Drilling Service Driller Allen Drane Core size 2.4 inches  
 Date Started 9/25/78 Date Completed 9/26/78 Geologist W. C. Culbertson  
 Remarks Core started in coal, probably no more than 0.5 ft below top of coal bed. Hole is 6 ft west of Birney 5A

## Cored intervals (in feet)

Core No.	From	To	Length of Core Recovered	Core No.	From	To	Length of Core Recovered
1	201	209	8.0	2	209	219	10

## Depth interval (feet)

From	To	Thick-ness	Core Description
201.0	201.6	0.6	Coal, vertical fractures; framboidal pyrite on fracture plane. Lens of amber 0.2' x 0.08'
201.6	201.9	0.3	Shale, coaly, brownish black
201.9	204.4	2.5	Coal, framboidal pyrite on vertical fracture planes. Lens of pyrite from 201.9 to 202.0
204.4	204.8	0.4	Coal interbedded with thin layers of black coaly shale. Contains a 0.02' lens of yellowish brown siltstone at 204.7
204.8	209.0	4.2	Coal, as 201.9-204.4. At 207.5 is 0.06' lens of yellowish brown siltstone
209.0	212.0	3.0	Coal with sparse pyrite, contains small lenses of siltstone in in upper 0.5'
212.0	215.0	3.0	Coal with framboidal pyrite on vertical fracture planes. Contains blebs of amber at 214.3
215.0	217.0	2.0	Coal with sparse pyrite. Contains 4 lenses of siltstone and several blebs of amber
217.0	218.9	1.9	Coal with sparse pyrite. At 218.2 is a lens of siltstone and bleb of amber
218.9	219.0	0.1	Shale, clayey, gray

SMITH BED

U.S. GEOLOGICAL SURVEY  
Birney 1° x 1½° quadrangle

Hole Birney 6A Elev. 3600 feet Total depth 800 feet  
 Location 2800 ft FWL, 1900 ft FNL (SW 1/4 NE 1/4) Sec. 15, T. 8 S., R. 41 E.  
 County Big Horn State Montana Quadrangle Spring Gulch  
 Drilled by Drane Drilling Service Driller Allen Drane Hole size 5 inches  
 Date Started 8/25/78 Date Completed 8/29/78 Geologist W. C. Culbertson and T. Gaffke  
 Remarks Driller thinks unit at 122-153 may be water-bearing. Sample log modified by  
interpretation of geophysical log. No cuttings returned from 670-800 ft because of  
loss of circulation

Depth interval (feet)

From	To	Thick- ness	Lithologic Description
0	10	10	Shale, silty, gray to brown, carbonaceous 9-12
10	17	7	Sandstone, very fine grained, clayey, gray
17	24	7	Shale, silty, dark gray
24	28	4	Shale, carbonaceous with thin layer of coal
28	31	3	Siltstone and very fine grained sandstone, gray
31	37	6	Shale, carbonaceous with coal stringer
37	42	5	Shale, silty, and siltstone, light gray
42	49	7	Sandstone, fine-grained, limy, and limestone, silty
49	55	6	Sandstone, fine-grained
55	63	8	Shale, carbonaceous, brown; gray shale from 57-60
63	66	3	Sandstone, very fine grained
66	71	5	Shale, silty, and siltstone, gray
71	73	2	Shale, carbonaceous
73	112	39	Sandstone, very fine grained, and siltstone, gray with stringer of coal at 86
112	116	4	Shale, carbonaceous
116	118	2	Siltstone, gray
118	122	4	Shale, clay, gray
122	153	31	Siltstone and very fine grained sandstone
153	155	2	Shale, gray
155	160	5	Siltstone, gray, limy siltstone at 157
160	165	5	Shale, carbonaceous
165	185	20	Shale, silty, and siltstone, gray; with bed of silty limestone at 178-180
185	187	2	Coal
187	192	5	Shale, carbonaceous
192	210	18	Coal - CANYON BED
210	220	10	Shale, with coal stringers
220	226	6	Siltstone and shale, silty, gray
226	243	17	Sandstone, fine-grained, gray, limy from 237-243
243	293	50	Siltstone and very fine grained sandstone, gray

Depth interval (feet)

From	To	Thick- ness	Lithologic Description
293	304	11	Shale, silty, gray
304	313	9	Coal - COOK BED
313	318	5	Shale, carbonaceous and silty shale
318	337	19	Sandstone, very fine grained, gray
337	348	11	Shale, silty, gray
348	353	5	Coal - OTTER BED
353	363	10	Shale, carbonaceous
363	375	12	Siltstone, gray with stringers of limy siltstone
375	403	28	Sandstone, very fine grained, with thin interbeds of siltstone, limy in places
403	409	6	Sandstone, fine grained, limy, gray
409	415	6	Siltstone, clayey, gray
415	419	4	Shale, gray
419	440	21	Siltstone, gray and silty shale
440	515	75	Sandstone, fine grained and very fine grained, gray
515	532	17	Shale, silty and siltstone, gray
532	540	8	Coal - UPPER WALL BED
540	546	6	Shale carbonaceous
546	578	32	Coal, with shale from 556-557 - LOWER WALL BED
578	594	16	Sandstone?
594	598	4	Limestone, silty or sandy
598	666	68	Sandstone, fine-grained; limy sandstone at 645-646
666	670	4	Coal
670	678	8	Shale, silty
678	684	6	Limestone, silty
684	695	11	Sandstone?
695	706	11	Shale, with coal from 703-704
706	715	4	Sandstone?
715	720	5	Shale? with coal from 717-718
720	730	10	Siltstone?
730	748	18	Sandstone, fine grained
748	761	13	Shale, carbonaceous
761	800	39	Shale, gray and carbonaceous shale

T. D.

## U.S. Geological Survey

Hole name Birney 6A County Big Horn State Montana  
Location 2800 ft FWL, 1900 ft FNL (SW $\frac{1}{4}$ NE $\frac{1}{4}$ ) Sec. 15 T. 8 S. R. 41 E.  
Elevation 3600 ft Drilled depth 800 ft Logged depth 783 ft  
Drilling medium mud Date logged 8/29/78

Geophysical logs:

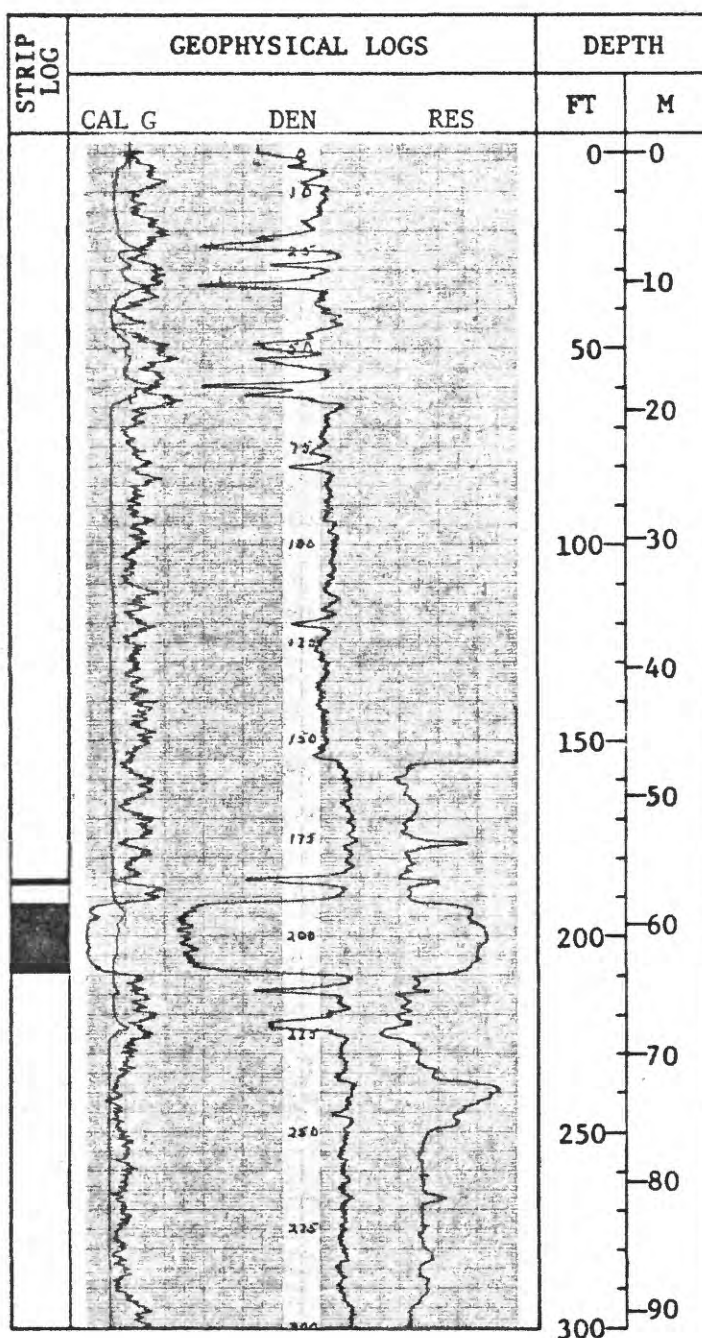
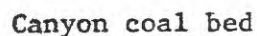
Gamma ray (G): T.C. 3 Scale 20 cps/in Logging speed 15 fpm

Density (DEN): T.C. 3 Scale                      Logging speed 15 fpm

Caliper (CAL):                      Scale 3.3 in/in Logging speed                      fpm

Resistance (RES): Scale 20 ohms/in Logging speed 15 fpm

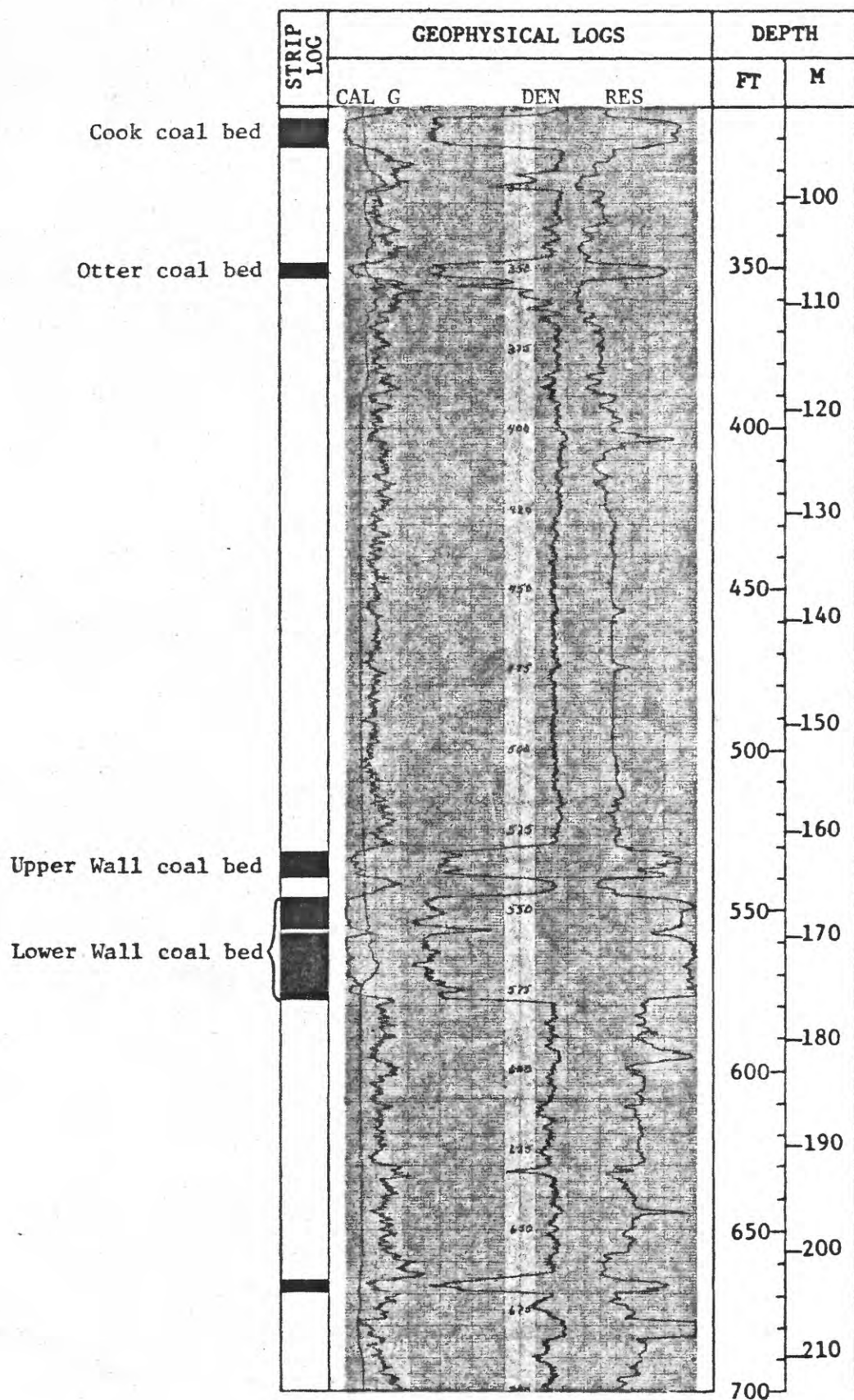
Remarks:





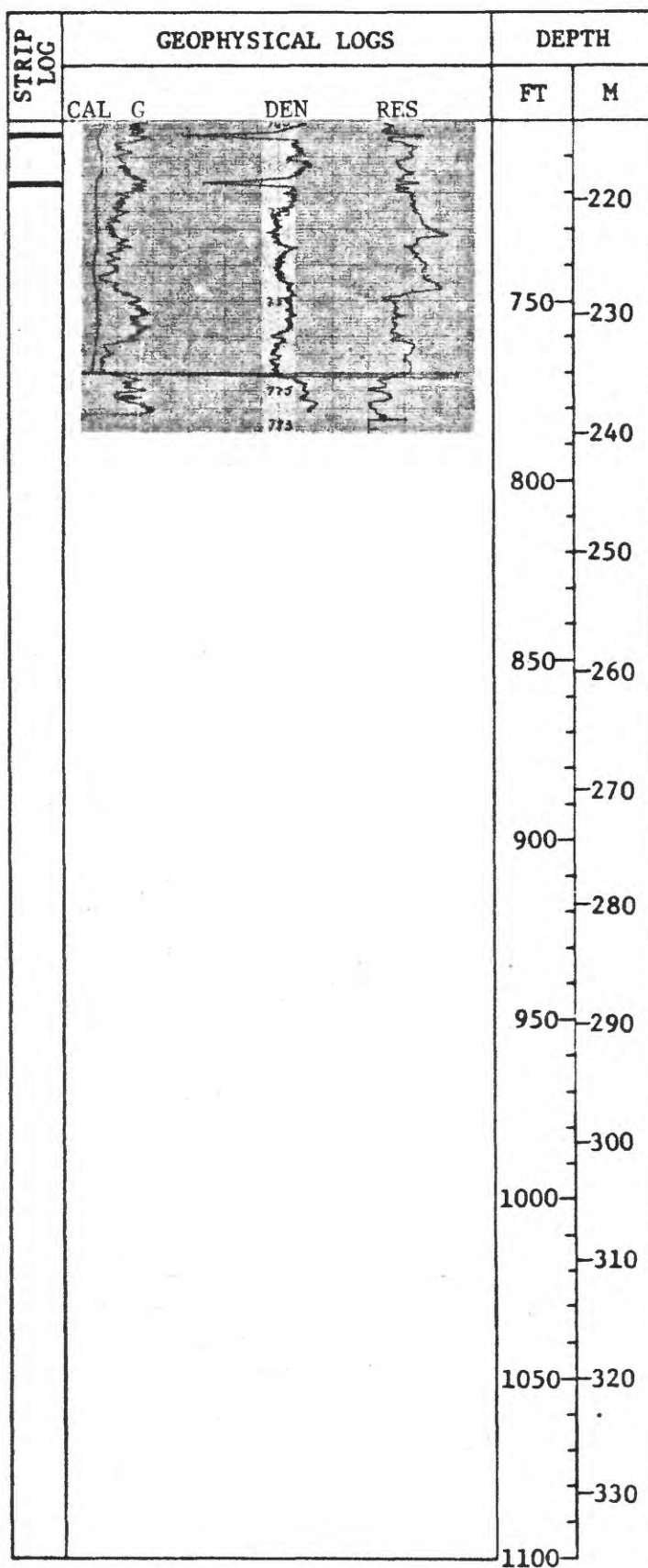
U.S. Geological Survey

Hole name Birney 6A continued



U.S. Geological Survey

Hole name Birney 6A continued



U.S. GEOLOGICAL SURVEY  
Birney 1° x 1/2° quadrangle

Hole Birney 7A Elev. 3535 feet Total depth 511 feet  
 Location 1500 ft FSL, 2900 ft FWL (NW 1/4 SE 1/4 Sec. 31, T. 7 S., R. 42 E.  
 County Rosebud State Mont. Quadrangle Spring Gulch  
 Drilled by Drane Drilling Services Driller Allen Drane Hole size 5 inches  
 Date Started 8/23/78 Date Completed 8/24/78 Geologist T. Gaffke, W.C. Culbertson  
 Remarks Driller thinks sandstone at 123-147 may be water bearing. No cuttings returned 408-511  
because of lost circulation.

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Depth interval (feet)

From	To	Thick- ness	Lithologic Description
0	11	11	Alluvium
11	12	1	Sandstone, fine grained, gray
12	28	16	Shale, silty gray
28	40	12	Sandstone, very fine grained, gray
40	45	5	Shale, gray
45	57	12	Coal, with 1 foot shale at 54-55 - CANYON BED
57	62	5	Shale, gray carbonaceous in upper 1 foot
62	70	8	Siltstone, gray; limy siltstone at 67-68
70	74	4	Sandstone, very fine grained
74	85	11	Siltstone, gray; limy siltstone 83-84
85	119	34	Sandstone, very fine grained, gray; limy sandstone at 94-95, 105-107; some thin shale layers
119	123	4	Sandstone, fine grained, limy
123	147	24	Sandstone, fine-grained, gray
147	156	9	Coal with carbonaceous shale at 152-154 - COOK BED
156	167	11	Shale, carbonaceous, with gray shale and coal stringers
167	170	3	Coal
170	180	10	Shale, carbonaceous to 178, gray 178-180
180	184	4	Siltstone, limy and silty shale
184	198	14	Sandstone, fine grained with silty shale at 188-190
198	203	5	Siltstone, clayey, light gray
203	212	9	Sandstone, fine grained, limy, gray
212	220	8	Sandstone, very fine grained, light gray
220	224	4	Siltstone and silty shale
224	227	3	Coal, with thin shale parting - OTTER BED
227	235	8	Shale, carbonaceous, brown
235	240	5	Siltstone, gray; limy siltstone at 236-238
240	252	12	Shale, gray; carbonaceous from 240-242
252	256	4	Siltstone, gray
256	260	4	Shale, carbonaceous with coal stringers
260	267	7	Shale, gray and tan



Depth interval (feet)

From	To	Thick- ness	Lithologic Description
267	269	2	Sandstone, fine grained
269	282	13	Shale, carbonaceous; silty shale from 274-277
282	292	10	Shale, gray
292	313	21	Siltstone and very fine grained sandstone, gray
313	353	40	Shale, silty and siltstone, gray
353	359	6	Sandstone, very fine grained
359	361	2	Shale, brownish gray
361	368	7	Sandstone, very fine grained, and siltstone, gray
368	402	34	Coal - WALL BED
402	408	6	Sandstone, very fine grained
408	440	32	Sandstone
440	443	3	Shale
443	447	4	Coal
447	454	7	Shale
454	462	8	Sandstone
462	464	2	Coal
464	468	4	Shale
468	492	24	Siltstone and sandstone
492	496	4	Sandy limestone
496	508	12	Shale
508	511	3	Unknown

# U.S. Geological Survey

Hole name Birney 7A County Rosebud State Montana  
 Location 1500 ft FSL, 2900 ft FWL (NW $\frac{1}{4}$ SE $\frac{1}{4}$ ) Sec. 31 T. 7 S. R. 42 E.  
 Elevation 3535 ft Drilled depth 511 ft Logged depth 508 ft  
 Drilling medium mud Date logged 8/24/78

## Geophysical logs:

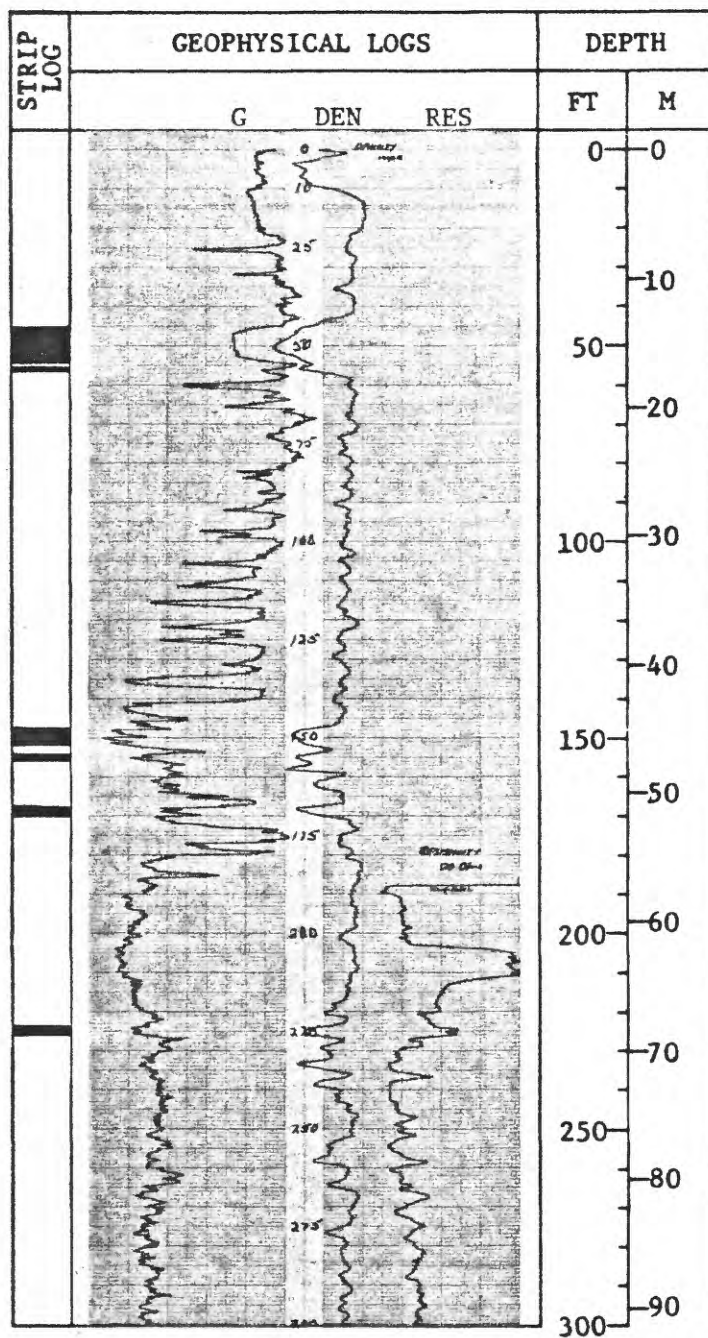
Gamma ray (G): T.C. 3 Scale 20 cps/in Logging speed 15 fpm  
 Density (DEN): T.C. 3 Scale                      Logging speed 15 fpm  
 Caliper (CAL): Scale                      Logging speed                      fpm  
 Resistance (RES): Scale 20 ohms/in Logging speed 15 fpm

Remarks: Gamma ray log defective from 0 to fluid level at 188 feet.

Canyon coal bed

Cook coal bed

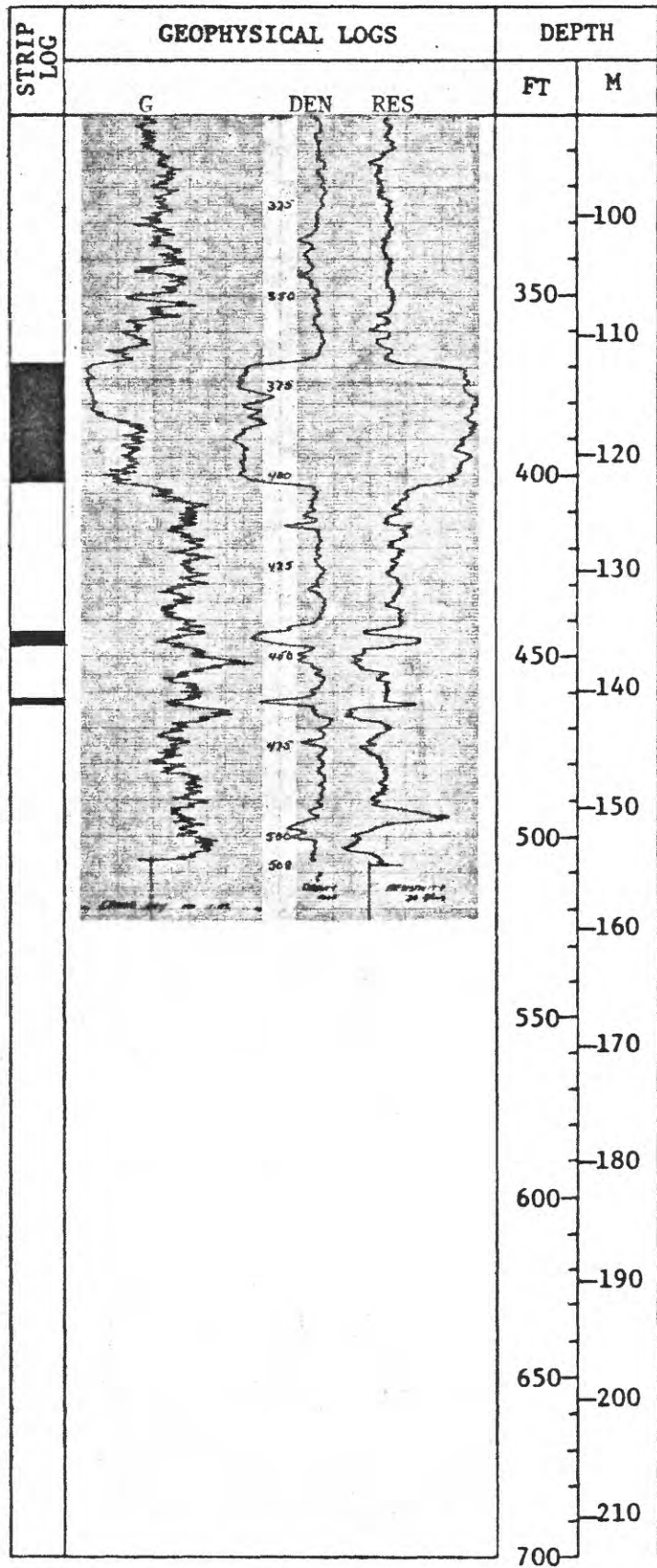
Otter coal bed



U.S. Geological Survey

Hole name Birney 7A continued

Wall coal bed



U.S. GEOLOGICAL SURVEY  
Birney 1° x 1/2° quadrangle

Hole Birney 8A Elev. 3530 feet Total depth 247 feet  
 Location 1700 ft FEL, 800 ft FNL (NW 1/4 NE 1/4) Sec. 20, T. 8 S., R. 43 E.  
 County Big Horn State Montana Quadrangle Stroud Creek  
 Drilled by Drane Drilling Service Driller Allen Drane Hole size 5 inches  
 Date Started 9/9/78 Date Completed 9/9/78 Geologist W. C. Culbertson  
 Remarks Hole lost because circulation could not be restored below depth 133. 132-187 probably  
water-bearing. Sample log of 133-243 based on interpretation of geophysical logs

Depth interval (feet)

From	To	Thick- ness	Lithologic Description
0	5	5	Sandstone, fine-grained, limy, olive gray
5	13	8	Shale, gray, with coal streaks at 7-9 feet
13	16	4	Limestone, silty, gray
17	24	7	Shale, silty and siltstone, clayey, gray
24	28	4	Shale, carbonaceous, dark gray
28	34	6	Siltstone, and very fine grained sandstone
34	37	3	Shale, carbonaceous with coal streaks
37	59	22	Shale and silty shale, gray to light gray. Traces of coal and carbonaceous shale at 47 to 49
59	64	5	Siltstone, gray; limy at 59-60 and 63-64
64	68	4	Shale, gray
68	73	5	Siltstone and silty shale, gray
73	76	3	Coal - COX BED
76	82	6	Shale, carbonaceous
82	87	5	Shale, gray and brown; coal(?) at 86-87
87	96	9	Sandstone, very fine grained, limy in part, light gray. Trace of coal at 93
96	101	5	Limestone, sandy
101	124	23	Siltstone, gray
124	137	13	Shale, carbonaceous, with coal streaks
137	187	50	Sandstone, fine grained, poorly consolidated
187	206	19	Shale
206	225	19	Coal - CANYON BED
225	227.5	2.5	Shale
227.5	229	1.5	Coal
229	240	11	Siltstone
240	243	3	Shale

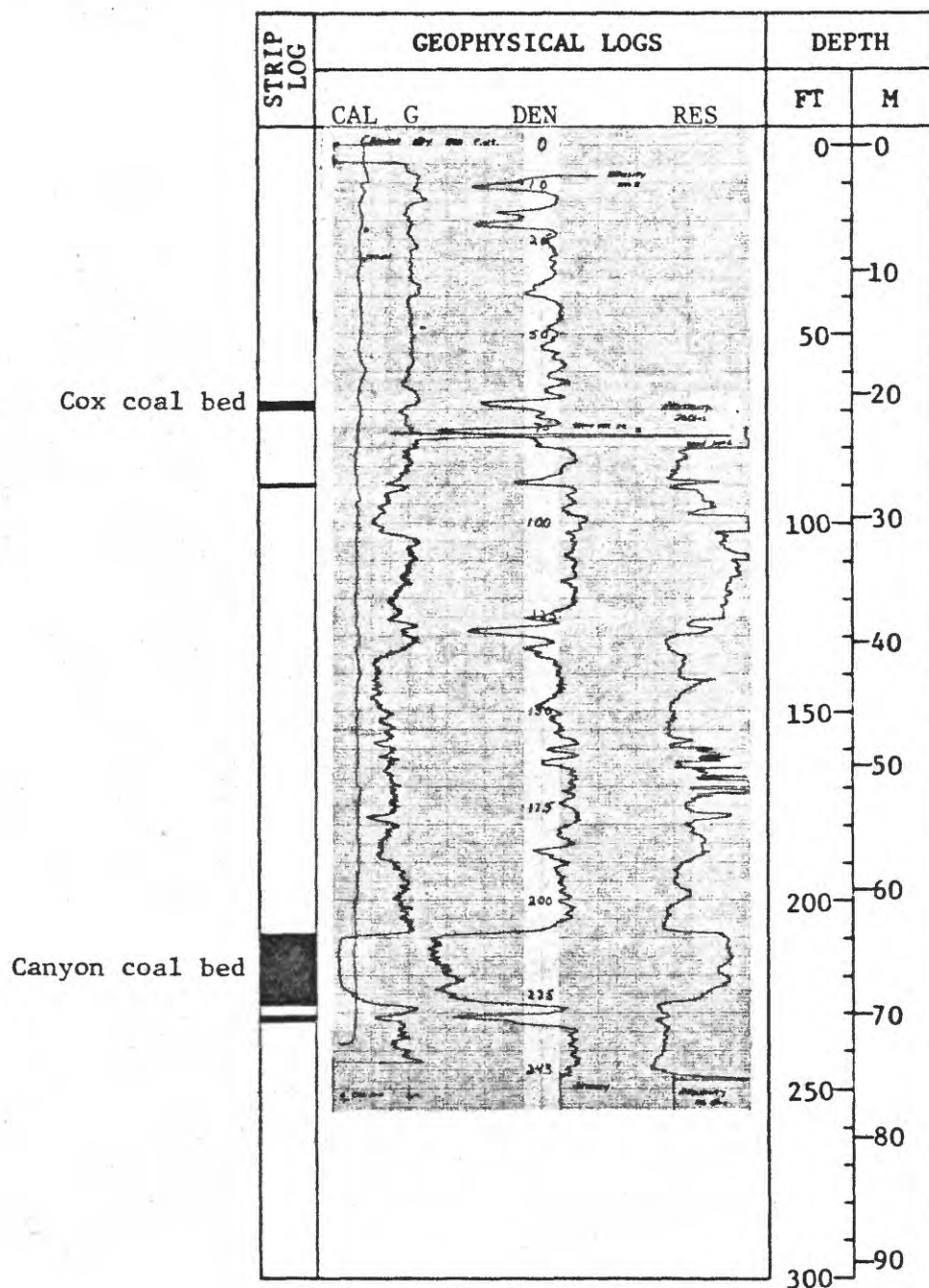
## U.S. Geological Survey

Hole name Birney 8A County Big Horn State Montana  
Location 1700 ft FEL, 800 ft FNL (NW $\frac{1}{4}$ NE $\frac{1}{4}$ ) Sec. 20 T. 8 S. R. 43 E.  
Elevation 3530 ft Drilled depth 247 ft Logged depth 244 ft  
Drilling medium mud Date logged 9/10/78

Geophysical logs:

Gamma ray (G):	T.C. <u>3</u>	Scale <u>100 cps/in</u>	Logging speed <u>15</u>	fpm
Density (DEN):	T.C. <u>3</u>	Scale _____	Logging speed <u>15</u>	fpm
Caliper (CAL):		Scale <u>3.3 in/in</u>	Logging speed _____	fpm
Resistance (RES):		Scale <u>20 ohms/in</u>	Logging speed <u>15</u>	fpm

Remarks:



U.S. GEOLOGICAL SURVEY  
Birney 1° x 1½° quadrangle

Hole BIRNEY 8-B Elev. 3520 feet Total depth 617 feet  
 Location 90 ft FNL, 700 ft FWL (NW 1/4 NW 1/4) Sec. 20, T. 8 S., R. 43 E.  
 County Big Horn State Montana Quadrangle Stroud Creek  
 Drilled by Drane Drilling Service Driller Allen Drane Hole size 5 inches  
 Date Started 9/26/78 Date Completed 9/28/78 Geologist W. C. Culbertson  
 Remarks Hole lost at 617 feet because of lost circulation problem

## Depth interval (feet)

From	To	Thick- ness	Lithologic Description
0	5	5	Soil and sandy alluvium
5	32	27	Siltstone and silty shale, gray
32	34	2	Shale, carbonaceous and coal streaks
34	47	13	Shale, silty, and siltstone, gray
47	51	4	Limestone, silty, gray
51	63	12	Shale, silty, and siltstone, gray
63	65	2	Coal - COX BED
65	80	15	Siltstone and silty shale, gray
80	92	12	Shale, gray
92	93	1	Coal
93	101	8	Siltstone and silty shale, gray
101	106	5	Sandstone, fine grained, light gray
106	111	5	Limestone, sandy, very fine grained, gray
111	125	14	Sandstone, very fine grained, and siltstone, gray; limy siltstone from 117-118
125	135	10	Shale, gray, and silty shale
135	139	4	Siltstone and very fine grained sandstone, gray
139	142	3	Coal, probably poor quality
142	152	10	Shale, carbonaceous, olive gray
152	164	12	Siltstone and fine grained sandstone
164	171	7	Shale, silty, gray and brown carbonaceous shale
171	177	6	Sandstone, fine grained, olive gray
177	182	5	Siltstone, and silty shale, gray
182	193	11	Shale, carbonaceous, brown
193	210	17	Coal - CANYON BED
210	213	3	Shale, carbonaceous, brown, and gray shale
213	226	13	Sandstone, fine grained, light gray
226	235	9	Shale, silty, and siltstone, with 1 foot coal at 227-228
235	241	6	Limestone, silty and limy siltstone, gray
241	262	21	Shale, silty and gray shale
262	285	23	Sandstone, fine grained, light gray interbedded with gray shale. Sandy limestone at 266-268
285	294	9	8.5 ft coal. - WHITE BED
294	296	2	Shale, carbonaceous, brown



Depth interval (feet)

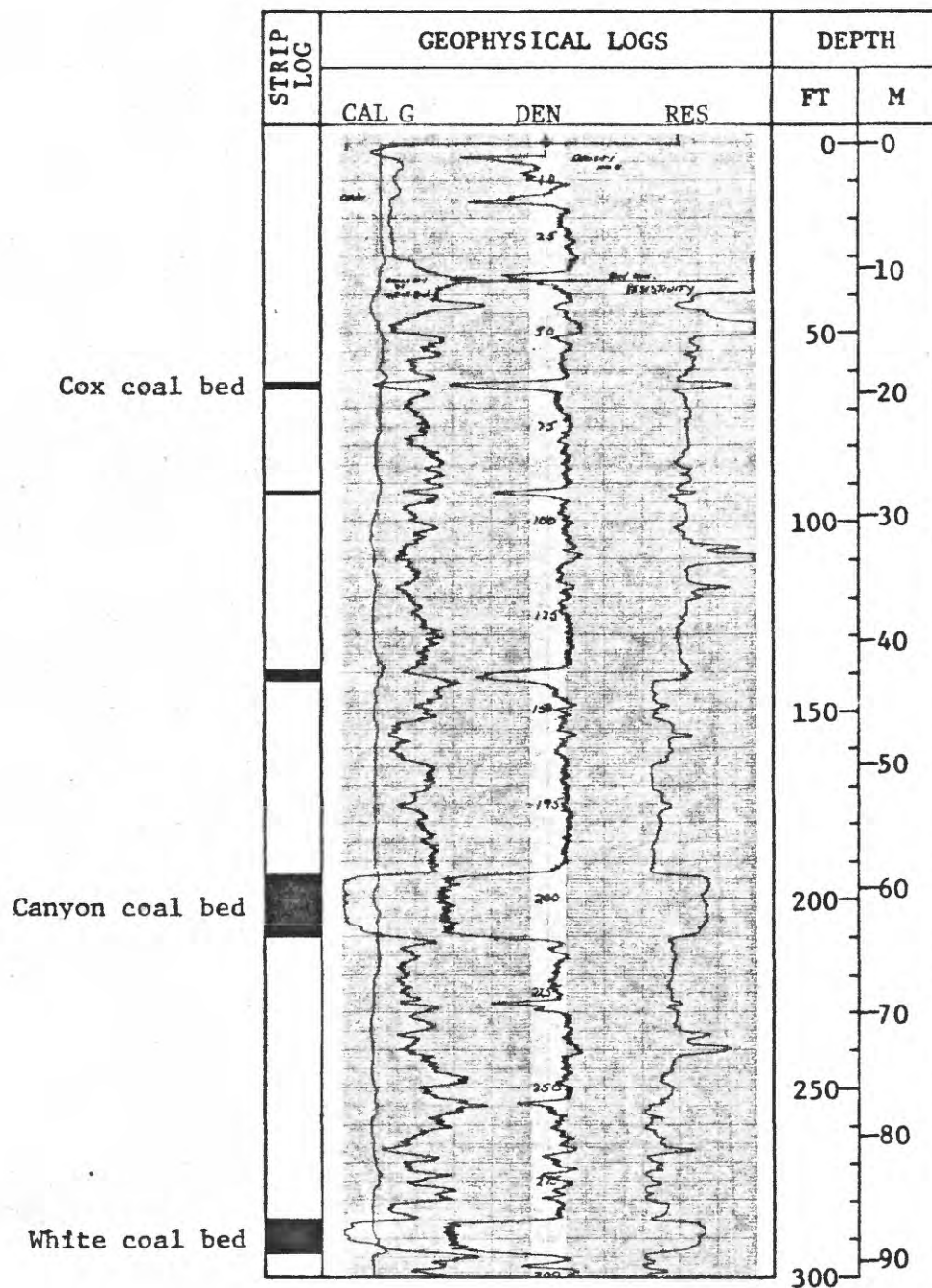
From	To	Thick- ness	Lithologic Description
296	313	17	Sandstone, fine grained, and siltstone
313	328	15	Shale, gray
328	337	9	Sandstone, fine grained, and siltstone
337	348	11	Shale, carbonaceous, and siltstone
348	360	12	Coal; shaly from 353-354, and 358-359 - COOK BED
360	364	4	Shale, carbonaceous, brown
364	380	16	Siltstone, gray and silty shale
380	399	19	Sandstone, fine grained, and siltstone
399	405	6	Coal - OTTER BED
405	411	6	Shale, gray
411	414	3	Limestone, silty
414	423	9	Shale, gray
423	450	27	Sandstone, fine grained and siltstone
450	455	5	Shale
455	459	4	Coal
459	475	16	Shale gray with minor siltstone
475	478	3	Coal
478	520	42	Siltstone and fine-grained sandstone
520	525	5	Shale, gray
525	533	8	Coal WALL BED
533	564	31	Silty shale and siltstone
564	571	7	Shale, carbonaceous
571	574	3	2.5 ft coal
574	577	3	Shale, gray
577	578	1	Coal
578	586	8	Shale, gray
586	607	21	Sandstone, fine grained, and siltstone

# U.S. Geological Survey

Hole name Birney 8B County Big Horn State Montana  
 Location 90 ft FNL, 700 ft FWL (NW $\frac{1}{4}$ NW $\frac{1}{4}$ ) Sec. 20 T. 8 S. R. 43 E.  
 Elevation 3520 ft Drilled depth 617 ft Logged depth 607 ft  
 Drilling medium air to 418 ft, mud T.D. Date logged 9/28/78

## Geophysical logs:

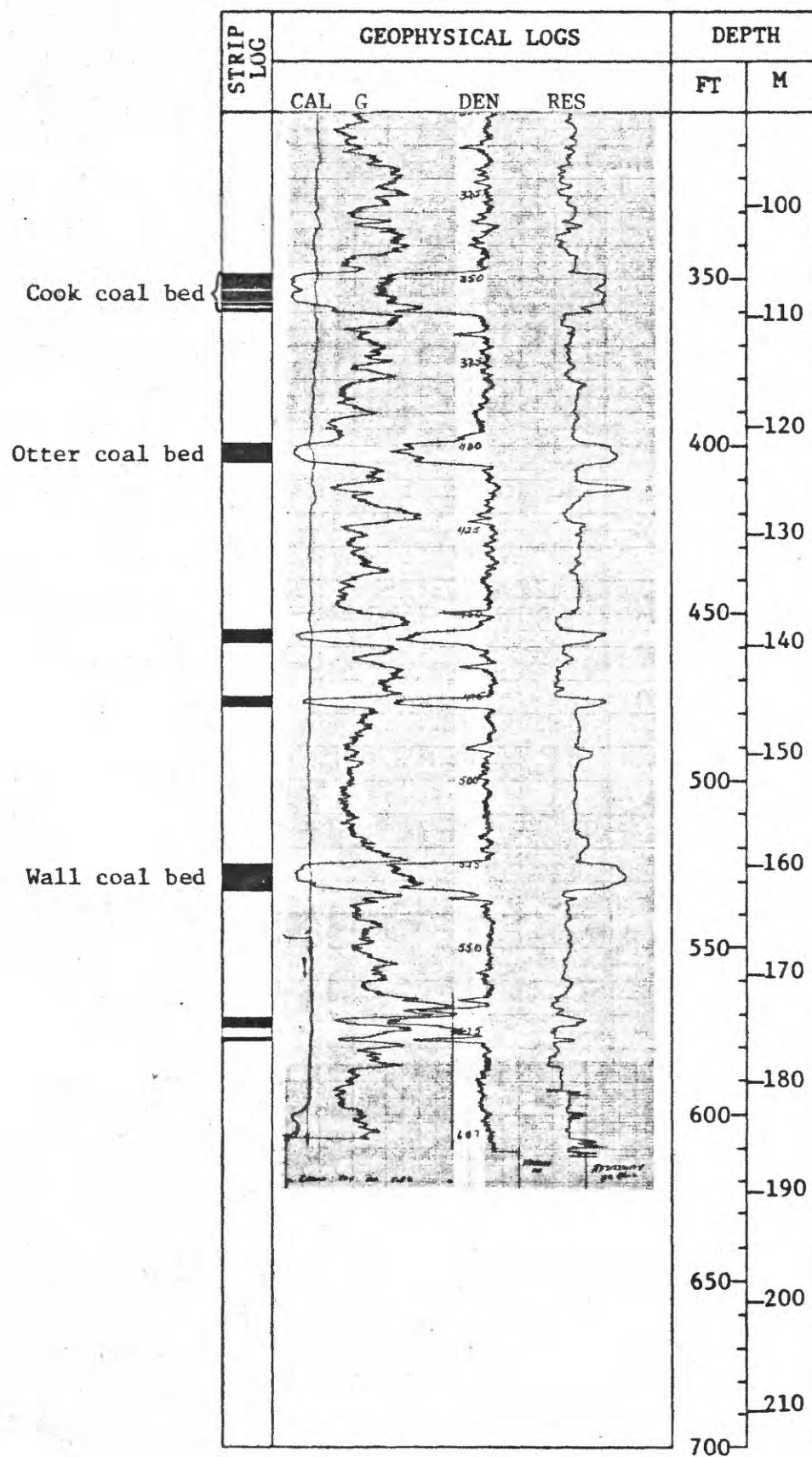
Gamma ray (G): T.C. 3 Scale 100 cps/in Logging speed 15 fpm  
 Density (DEN): T.C. 3 Scale 100 cps/in Logging speed 15 fpm  
 Caliper (CAL): Scale 3.3 in/in Logging speed 15 fpm  
 Resistance (RES): Scale 20 ohms/in Logging speed 15 fpm  
 Remarks: \_\_\_\_\_





U.S. Geological Survey

Hole name Birney 8B continued



U.S. GEOLOGICAL SURVEY  
Birney 1° x 1/2° quadrangle

Hole Birney #9 Elev. 3950 feet Total depth 720 feet  
 Location 900 ft FWL, 2100 ft FNL (SW 1/4 NW 1/4) Sec. 25, T. 7 S., R. 44 E.  
 County Rosebud State Mont. Quadrangle Hamilton Draw  
 Drilled by Navajo Drilling Driller Gene Abbott Hole size 5 inches  
 Date Started 1/19/79 Date Completed 1/24/79 Geologist George Correia  
 Remarks Samples taken at 5-foot intervals. Geophysical logs used to modify sample description.  
Lost circulation at 420. Poor returns from 420-720.

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Depth interval (feet)

From	To	Thick- ness	Lithologic Description
0	10	10	Soil
10	54	44	Shale, dark gray, sticky, slightly silty
54	70	16	Sandstone, gray, very fine grained uncemented
70	75	5	Shale, dark gray
75	107	32	Coal - ANDERSON BED
107	113	6	Shale, gray
113	115	2	Limestone, silty, gray
115	167	52	Sandstone, fine grained, very friable, clayey
167	184	17	Shale, dark gray
184	199	15	Coal - DIETZ BED
199	210	11	Siltstone, light gray
210	220	10	Shale, carbonaceous, dark gray
220	255	35	Siltstone, light gray, clayey, with silty limestone lens at 243-245
255	278	23	Shale, carbonaceous, dark gray
278	312	34	Siltstone, dark gray, clayey, carbonaceous in part
312	327	15	Shale, carbonaceous dark gray
327	356	29	Coal
356	360	4	Shale, dark gray
360	364	4	Limestone, sandy, gray
364	380	16	Sandstone, very fine grained, clayey, gray
380	410	30	Shale gray, possibly with 1 foot coal(?) at 381-382
410	427	17	Siltstone, clayey grading down to sandstone, fine grained
427	433	6	Shale, carbonaceous, with about 1 1/2 ft coal at 429 feet
433	515	82	Mostly shale, gray, and shale, silty with minor siltstone
515	537	22	Coal, with 1 foot shale at 529-530 - COOK-OTTER BED
537	545	8	Shale, carbonaceous
545	621	76	Mostly siltstone or fine grained sandstone
621	624	3	Coal
624	643	19	Shale, carbonaceous, and minor siltstone
643	648	5	Impure coal bed - 2.5 ft coal, 1.0 ft shale, 1.5 ft coal WALL? BED
648	659	11	Shale, carbonaceous, with 1 foot coal at 641-652

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<u>Depth interval (feet)</u>			
From	To	Thick- ness	Lithologic Description
<hr/>			
659	686	27	Siltstone and silty shale
686	689	3	Coal
689	717	28	Shale, gray, with minor siltstone

U.S. Geological Survey  
Branch of Coal Resources

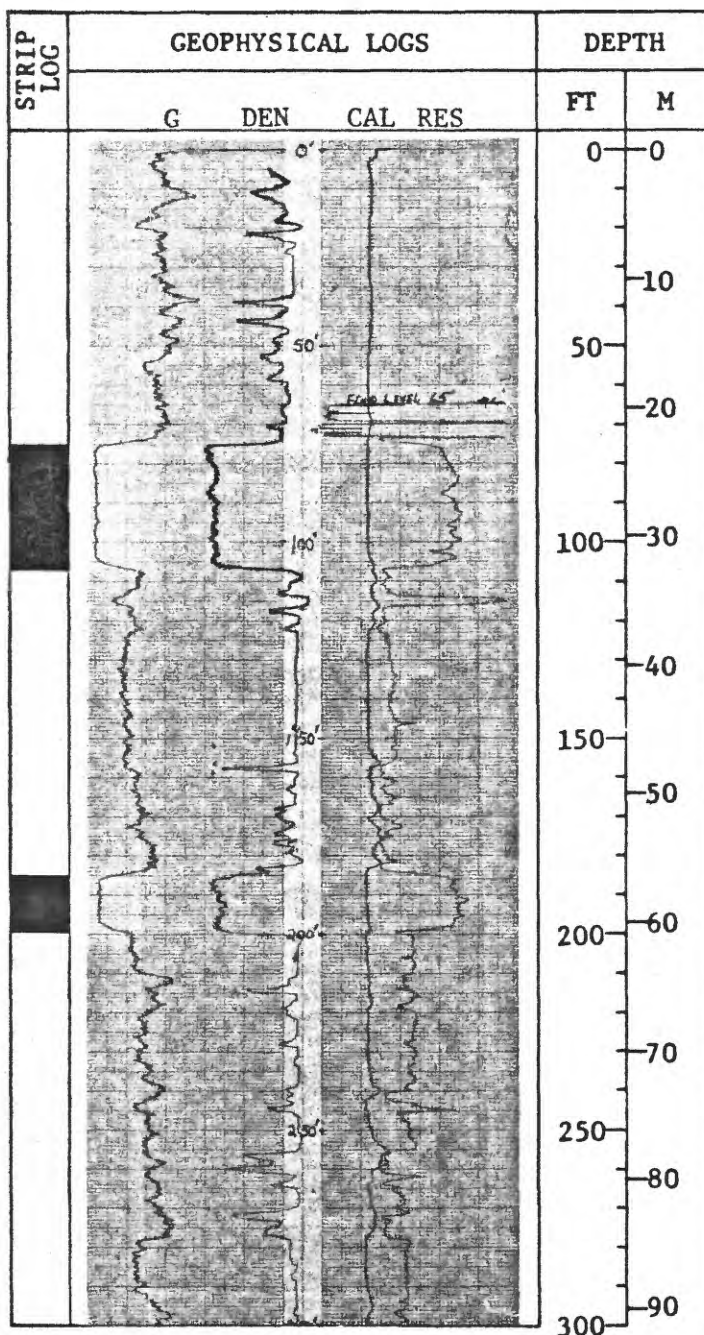
Hole name Birney 9 County Rosebud State Montana  
Location 900 ft FWL, 2100 ft FNL (SW<sup>1</sup>/<sub>4</sub> NW<sup>1</sup>/<sub>4</sub>) Sec. 25 T. 7 S R. 44 E.  
Elevation 3950 ft Drilled depth 720 ft Logged depth 717 ft  
Drilling medium mud Date logged 1/24/79

**Geophysical logs:**

Gamma ray (G): T.C. 2 Scale 50 cps/in Logging speed 15 fpm  
Density (DEN): T.C. 2 Scale 100 cps/in Logging speed 15 fpm  
Caliper (CAL): Scale 5 in/in Logging speed 15 fpm  
Resistance (RES): Scale 20 ohms/in Logging speed 15 fpm  
Remarks: \_\_\_\_\_

Anderson coal bed

Dietz coal bed



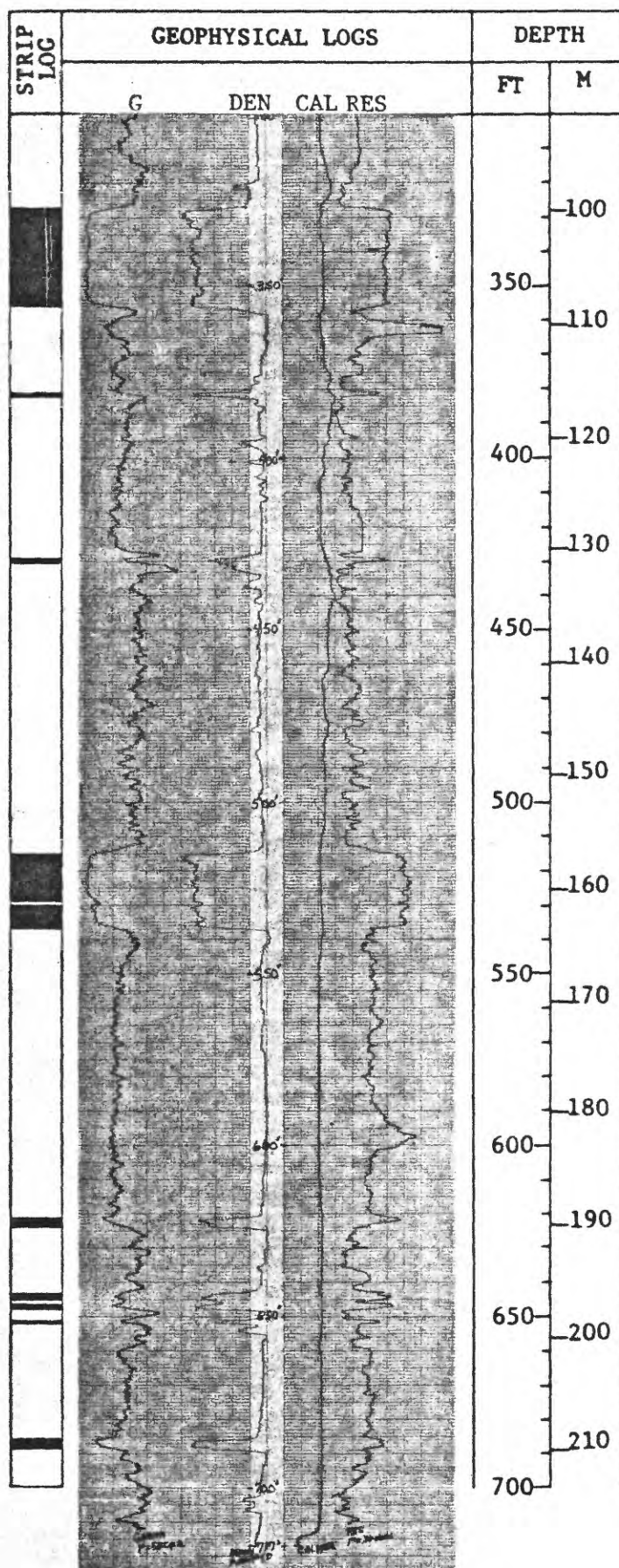
# U.S. Geological Survey

Hole name Birney 9 continued

Canyon coal bed

Cook coal bed  
Otter coal bed

Wall coal bed





U.S. GEOLOGICAL SURVEY  
Birney 1° x 1/2° quadrangle

Hole Birney 10 Elev. 3620 feet Total depth 800 feet  
 Location 2400 ft FWL, 1100 ft FNL (SE 1/4 NE 1/4 NW 1/4) Sec. 2, T. 8 S., R. 43 E.  
 County Big Horn State Montana Quadrangle Stroud Creek  
 Drilled by Navajo Drilling Co. Driller Gene Abbott Hole size 5 inches  
 Date Started 1/24/79 Date Completed 1/25/79 Geologist Geo. Correia & W. C. Culbertson  
 Remarks Sample log modified by interpretation of geophysical logs.

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Depth interval (feet)

From	To	Thick- ness	Lithologic Description
0	20	20	Sand, clay, and clinker gravel, reddish (Terrace deposit)
20	35	15	Shale, silty, gray
35	52	17	Shale, gray to brown
52	57	5	4.5 ft coal with small shale parting in middle - COX BED
57	59	2	Shale, carbonaceous, grayish brown
59	75	16	Siltstone, gray, clayey and silty shale. Coal at 72-73
75	105	30	Sandstone, brownish gray, very fine grained, clayey
105	109	4	Limestone, sandy, gray
109	122	13	Shale, brown, carbonaceous, possibly 1 foot coal at 112-113 ft
122	140	18	Sandstone, very fine to fine ground, gray, slightly clayey
140	157	17	Shale, gray, and silty shale
157	165	8	Sandstone, fine grained, gray clayey
165	177	12	Shale, carbonaceous, brown
177	199	22	Coal - CANYON BED
199	201	2	Shale, carbonaceous, brown
201	240	39	Sandstone, fine grained interbedded with gray shale and siltstone
240	242	2	Limestone, sandy, gray
242	249	7	Shale, gray with minor siltstone
249	252	3	About 2.5 ft coal
252	272	20	Alternating beds of shale, gray to brown, and sandstone, fine grained, gray
272	277	5	Coal bed: 1.5 coal, 1.0 shale, 3.0 coal
277	280	3	Shale, carbonaceous, brown
280	287	7	Sandstone, gray, fine grained
287	300	13	Shale, carbonaceous, brown
300	314	14	Coal - COOK BED
314	323	9	Shale, gray
323	329	6	Coal - OTTER BED
329	340	11	Shale, gray and brown
340	346	6	Siltstone, gray, and sandstone, very fine grained
346	349	3	Limestone, sandy, gray
349	365	16	Shale, gray, silty
365	383	18	Siltstone, gray
383	392	9	Shale, carbonaceous, brown; may be 1 ft coal at 383-384

Depth interval (feet)

From	To	Thick- ness	Lithologic Description
392	407	15	Siltstone, gray
407	411	4	Shale, brown, carbonaceous
411	422	11	Siltstone, gray
422	449	27	Alternating beds of shale, gray; and gray fine grained sandstone; possibly 1 foot coal bed at 440-441 and 442-443
449	456	7	Coal - WALL BED
456	459	3	Shale, carbonaceous, brown
459	480	21	Shale, silty, gray; and gray shale
480	520	40	Sandstone, fine- to medium-grained, gray to brownish gray
520	560	40	Shale, gray, and sandstone, very fine grained. Possibly 1 foot coal at 531-532
560	562	2	Limestone, silty, gray
562	595	33	Shale, gray
595	620	25	Siltstone, gray, and sandstone, fine grained
620	651	31	Shale, gray and brown, with minor siltstone
651	660	9	Coal - BREWSTER-ARNOLD BED
660	665	5	Shale, carbonaceous, brown
665	680	15	Sandstone, fine grained, gray
680	692	12	Shale, gray
692	730	38	Siltstone gray-grading down to sandstone, fine grained; 2 ft limy sandstone at 727-729
730	738	8	Shale, gray
738	755	17	Siltstone and fine grained sandstone
755	798	43	Shale gray and silty shale

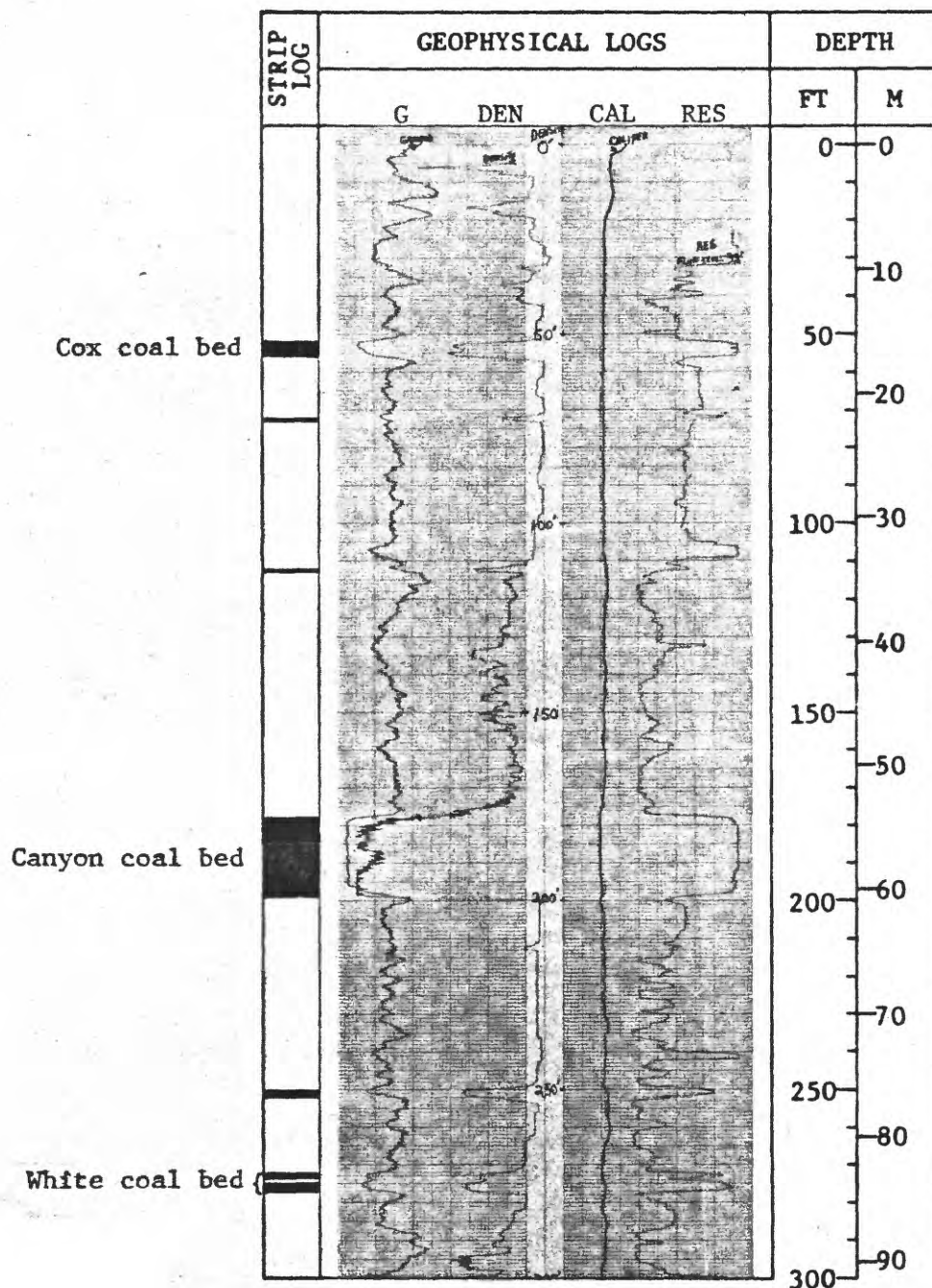
# U.S. Geological Survey

Hole name Birney 10 County Big Horn State Montana  
 Location 2400 ft FWL, 1100 ft FNL (SE $\frac{1}{4}$  NE $\frac{1}{4}$  NW $\frac{1}{4}$ ) Sec. 2 T. 8 S. R. 43 E.  
 Elevation 3620 ft Drilled depth 800 ft Logged depth 798 ft  
 Drilling medium mud Date logged 1/25/79

## Geophysical logs:

Gamma ray (G): T.C. 2 Scale 50 cps/in Logging speed 15 fpm  
 Density (DEN): T.C. 2 Scale 100 cps/in Logging speed 15 fpm  
 Caliper (CAL): Scale 5 in/in Logging speed 15 fpm  
 Resistance (RES): Scale 20 ohms/in Logging speed 15 fpm

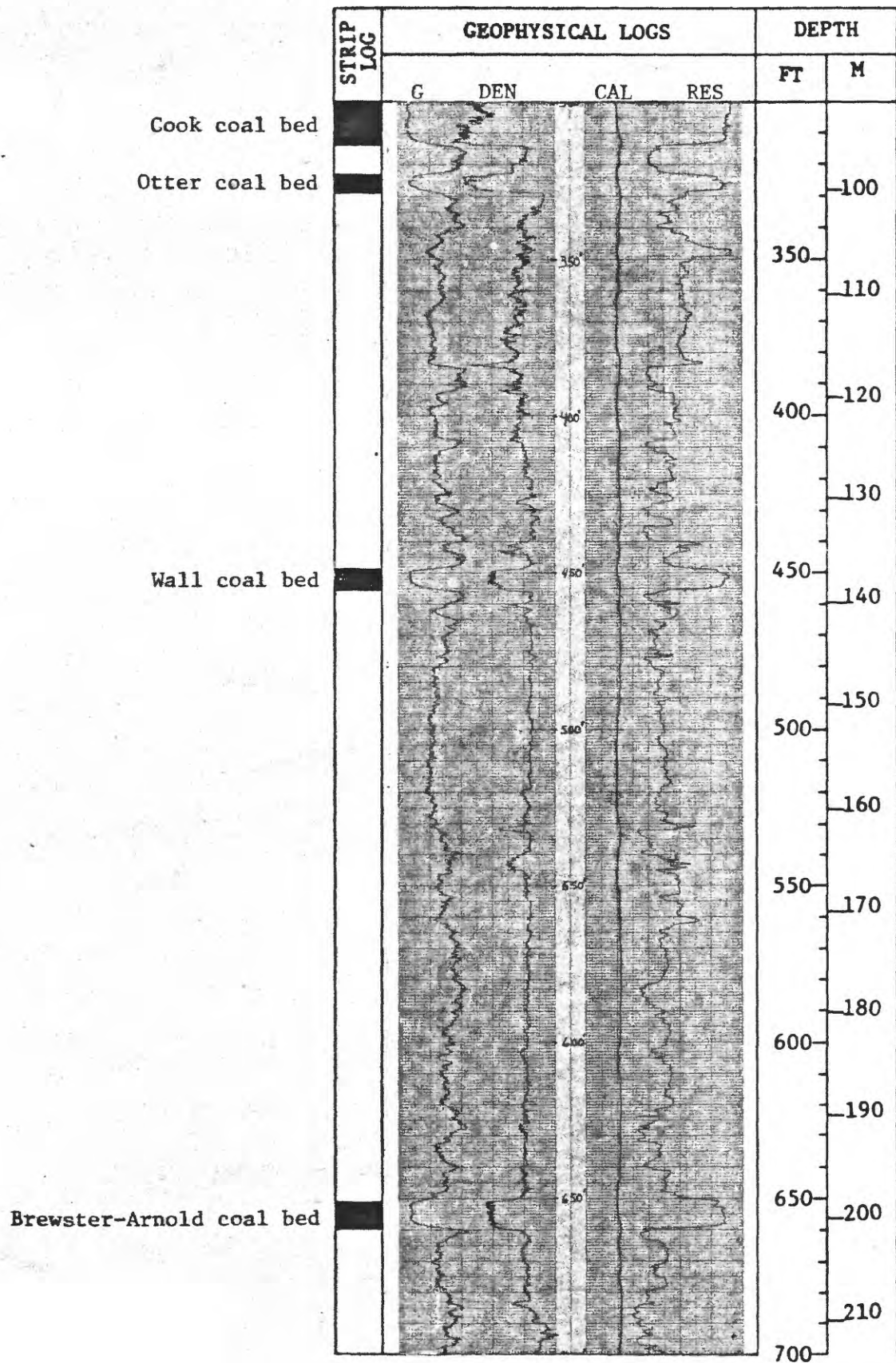
Remarks: \_\_\_\_\_





U.S. Geological Survey

Hole name Birney 10 continued



Hole name Birney 10 continued

