UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Coal exploratory holes drilled in 1980 in the Birney 1° x ½° quadrangle, Powder River and Big Horn Counties, Montana

By

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Open-File Report 81-1329

1981

Introduction

In 1980 the U.S. Geological Survey conducted a drilling program for the purpose of evaluating the coal resources of the eastern part of the Birney 1° x ½° quadrangle in Powder River and Big Horn Counties, Montana. This program supplements the 1978-1979 drilling program for the central part of the Birney quadrangle (Culbertson and others, 1980). Nine holes were drilled in the Otter Creek area (fig.1) to depths ranging from 655 to 935 feet (200 to 285 m) and a suite of geophysical logs were run in each hole to identify the thickness and depth of the coalbeds. An offset hole was drilled about 20 feet (6m) from Otter 7 to core the Roland coal bed of Baker (1929). At Otter 9 the initial hole was abandoned at 320 feet (98 m). A second hole was drilled to 755 feet (230 m), using data from first hole to locate and core the Cook and Otter coal beds. The holes were drilled with U.S. Geological Survey equipment and personnel, and the geophysical logs were run by a contractor.

For each hole, a lithologic log was prepared by examining samples of rock cuttings that were caught at 5-foot (1.5 m) intervals. Subsequently the lithologic log was modified to reflect the thickness and depth of identifiable rock and coal units shown on the geophysical log. In two holes, Otter 5 and Otter 7, the hole partially caved before geophysical logging, so it was not possible to get the logging tool to the bottom of the hole. In these holes the thickness and depth of the lowermost coal beds were derived from reports by the driller as to what depths the drill entered and exited the coal bed, supplemented by examination of the cuttings returned.

The geophysical logs were recorded at a vertical scale of 1 inch equals 10 feet, but were reduced to 1 inch equal 50 feet for publication. The lithologic log and the reduced geophysical logs for each hole are shown in the balance of this report.

Geologic Setting

Most of the coal beds occur in 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 thin lenticular beds of silty or sandy limestone. Most of these rocks are poorly indurated and have weathered to slopes, but the beds of limestone or limy sandstone locally form resistant ledges and benches. Where the thick coal beds have burned at the outcrop, the overlying rocks have been baked or fused into clinker, a reddish resistant rock that is locally called "scoria" or "red shale." Thick masses of clinker cap many of the peaks and upland surfaces in this area.

Overlying the Fort Union Formation is the Wasatch Formation of Eocene age, which also consists of sandstone, siltstone, shale and coal. In this area it differs from the Fort Union principally in that it contains more and thicker beds of carbonaceous shale, more zones of molluscan fossils, and fewer light-colored sandstones and siltstones. The contact with the Fort Union is placed at the top of the Roland coal bed of Baker (1929).

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 southwesterly direction. The regional dip is modified by a few low-amplitude flexures.

Coal beds

Figure 1 illustrates the names, thicknesses, and correlations of the coal beds penetrated in each of the nine holes. Collectively these holes include all the known coal beds underlying this area. The coal beds range in thickness from 1 to 32 feet (0.3 to 9.8 m), although coal beds thinner than 2 feet are not shown on figure 1. The rank of the coal beds is sub-bituminous C, or possibly lignite A. Analyses of the major coal beds probably would show, on an as-received basis, a heating value of 7500 to 8800 Btu per pound, a sulfur content of 0.5 percent or less and an ash content of about 5 percent (see Matson and Blumer, 1973).

References

Baker, A. A., 1929, The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Montana: U.S. Geological Survey Bulletin 806-B, p. 15-67.

Culbertson, W. C., Gaffke, T. M., and Correia, G., 1980, Coal exploratory holes drilled in 1978-79 in the Birney 1^{o} x $1/2^{o}$ quadrangle, Big Horn and Rosebud Counties, Montana for coal beds in the Tongue River Member of the Paleocene Fort Union Formation: U.S. Geological Survey Open-File Report 80-55, 68 p.

Matson, R.E., and Blumer, J. W., 1973, Quality and reserves of strippable coal, selected deposits, southeastern Montana: Montana Bur. Mines and Geology Bull. 91, 135 p.

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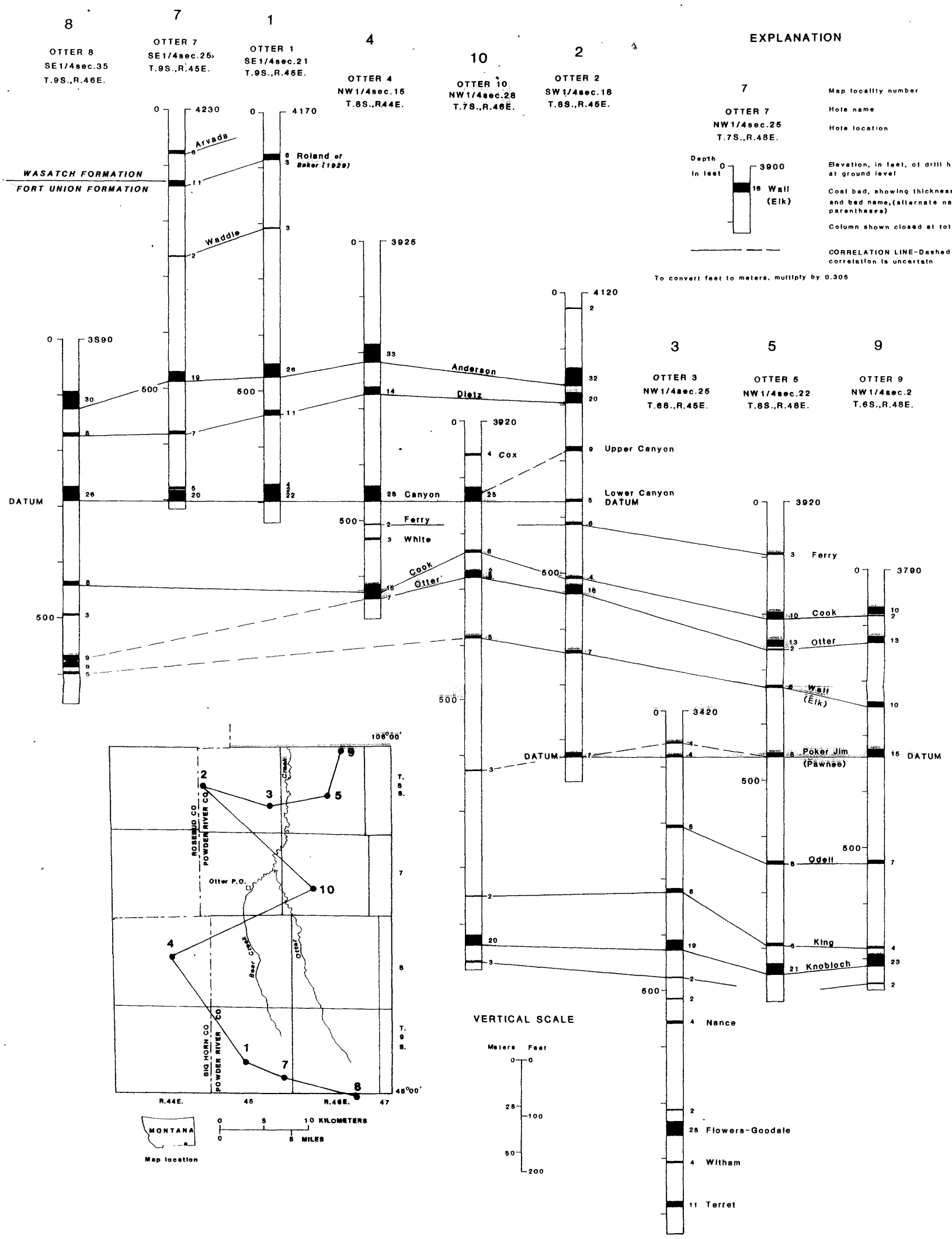


Figure 1.--Index map and correlation diagram for 1980 Otter coal exploratory drill holes,Big Horn and Powder River Counties, Montana

U.S. GEOLOGICAL SURVEY
Birney 1° x ½° quadrangle

Hole Otter #1 Elev. 4170 feet Total depth 736 feet

Location 1800 FEL, 1400 FSL (NW 1/4, SE 1/4) Sec. 21, T. 9 S., R. 45 E.

County Powder River State Mont. Quadrangle Bear Creek School 7 ½'

Drilled by U.S.Geological Survey Driller A. Clark Hole size 5 inches

Date Started 8/26/80 Date Completed 8/27/80 Geologist F. Spencer

Remarks Lithology from 5 ft samples, modified by H. I. Saperstone and W. C. Culbertson to conform with geophysical logs to depth 718

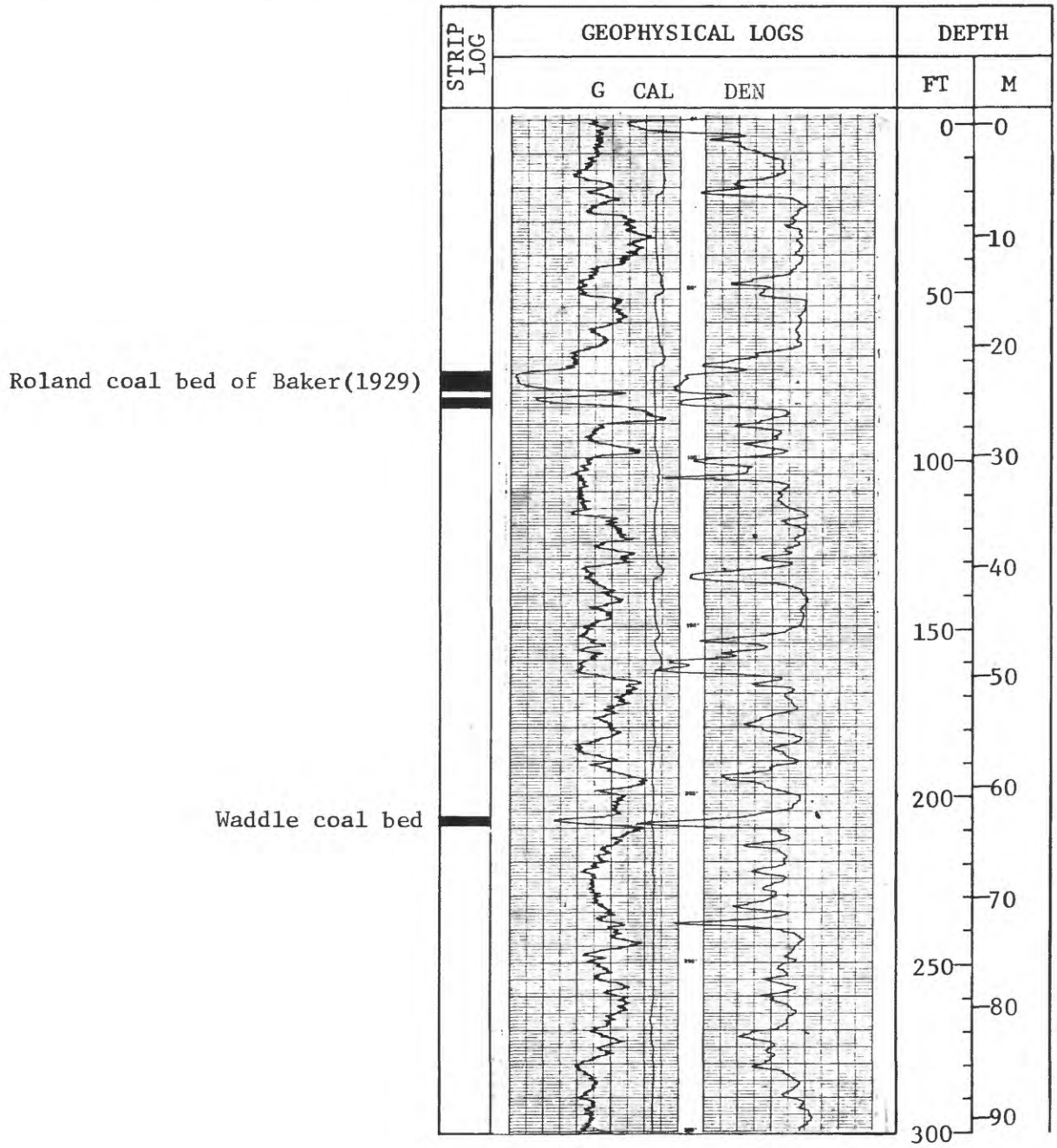
Depth interval (feet) From	To	Thickness	Lithologic Description
0	5	5	Alluvium; medium-brown sandy loam
5	10	5	Alluvium; medium yellow-gray, sandy clay
10	28	18	Sandstone, very fine grained, light yellow-gray, to light yellow-brown , unconsolidated, subangular grains of quartz
28	31	3	Shale; dark-brown, carbonaceous with shell fragments
31	40	9	Shale; dark-gray, silty in part, carbonaceous w/shell fragments
40	43	3	Siltstone; medium-gray, clayey in part
43	52	9	Sandstone, very fine grained, light-to medium-gray with subangular quartz grains
52	62	10	Siltstone, sandy, medium gray
62	74	12	Sandstone, very fine grained, silty in part, medium brown gray to light-gray, subangular quartz grains
74	80	6	Coal, dull brown } ROLAND BED OF BAKER (1929)
80	82	2	Shale, carbonaceous, dark-brown } ROLAND BED OF BAKER (1929)
82	85	3	Coal } ROLAND BED OF BAKER (1929)
85	89	4	Siltstone, clayey, carbonaceous
89	97	8	Sandstone, very fine grained, light-gray
97	99	2	Shale, carbonaceous
99	118	19	Sandstone, very fine grained, light-gray with thin very calcareous interbeds, angular quartz grains
118	160	42	Sandstone, very fine grained, silty, light to medium brownish-gray
160	165	5	Sandstone, fine grained to very fine grained with abundant carbonaceous debris and subangular quartz grains
165	183	18	Siltstone, medium-gray, sandy in part
183	192	9	Sandstone, medium-gray, very fine grained, silty in part
192	197	5	Shale, carbonaceous, dark-brown
197	200	3	Sandstone, medium brownish-gray, very fine grained, very silty in part, with carbonaceous debris
200	206.5	6.5	Siltstone, light brownish-gray, clayey in part

Depth interval (feet) From	To	Thickness	Lithologic Description
206.5	209	2.5	Coal, brown — WADDLE BED
209	212	3	Siltstone, light gray, sandy in part
212	217	5	Sandstone, light gray, very fine grained
217	222	5	Siltstone, light gray
222	237	15	Sandstone, light gray, very fine grained
237	247	10	Siltstone, light to medium gray, sandy in part
247	271	24	Sandstone, light to medium gray, very fine grained
271	279	8	Siltstone, medium gray, sandy in part
279	307	28	Sandstone, light to medium gray, silty in part with subangular quartz grains
307	310	3	Limestone, sandy
310	317	7	Sandstone, light to medium gray
312	327	15	Siltstone, medium gray
327	332	5	Sandstone, light to medium gray, very fine grained with subangular quartz grains
332	346	14	Siltstone, medium gray, sandy in part
346	361	15	Sandstone, medium gray, very fine grained, silty with subangular quartz grains
361	366	5	Siltstone, medium gray, sandy
366	371	5	Sandstone, medium gray, very fine grained silty, with subangular quartz grains
371	376	5	Siltstone, medium gray sandy
376	392	16	Sandstone, medium gray, very fine-grained to fine grained
392	402	10	Siltstone, medium gray
402	437	35	Siltstone medium gray with carbonaceous shale streaks (coaly)
437	451	14	Shale, dark brown, carbonaceous
451	477	26	Coal, brown — ANDERSON BED
477	486	9	Shale, carbonaceous, banded
486	492	6	Siltstone, medium gray, sandy
492	497	5	Siltstone
497	502	5	Sandstone, medium gray, very fine grained
502	533.5	31.5	Siltstone, medium brownish gray
533.5	544	10.5	Coal, brown — DIETZ BED
544	551	7	Shale, carbonaceous, dark brown with coal streaks
551	559	8	Siltstone, medium gray, sandy
559	604	45	Sandstone, medium gray, very fine grained, silty
604	625	21	Sandstone, light to medium gray, fine grained to medium grained
625	640	15	Siltstone, light gray
640	666	26	Sandstone, light gray, very fine grained
666	670	4	Coal
670	672	2	Shale, dark brown — CANYON BED
672	674	2	Coal
674	676	2	Shale, dark brown
676	698	22	Coal

Depth interval (feet)			
From	To	Thick-ness	Lithologic Description
698	711	13	Siltstone, light gray
711	714	3	Shale, carbonaceous, dark gray
714	736	22	Siltstone, light gray

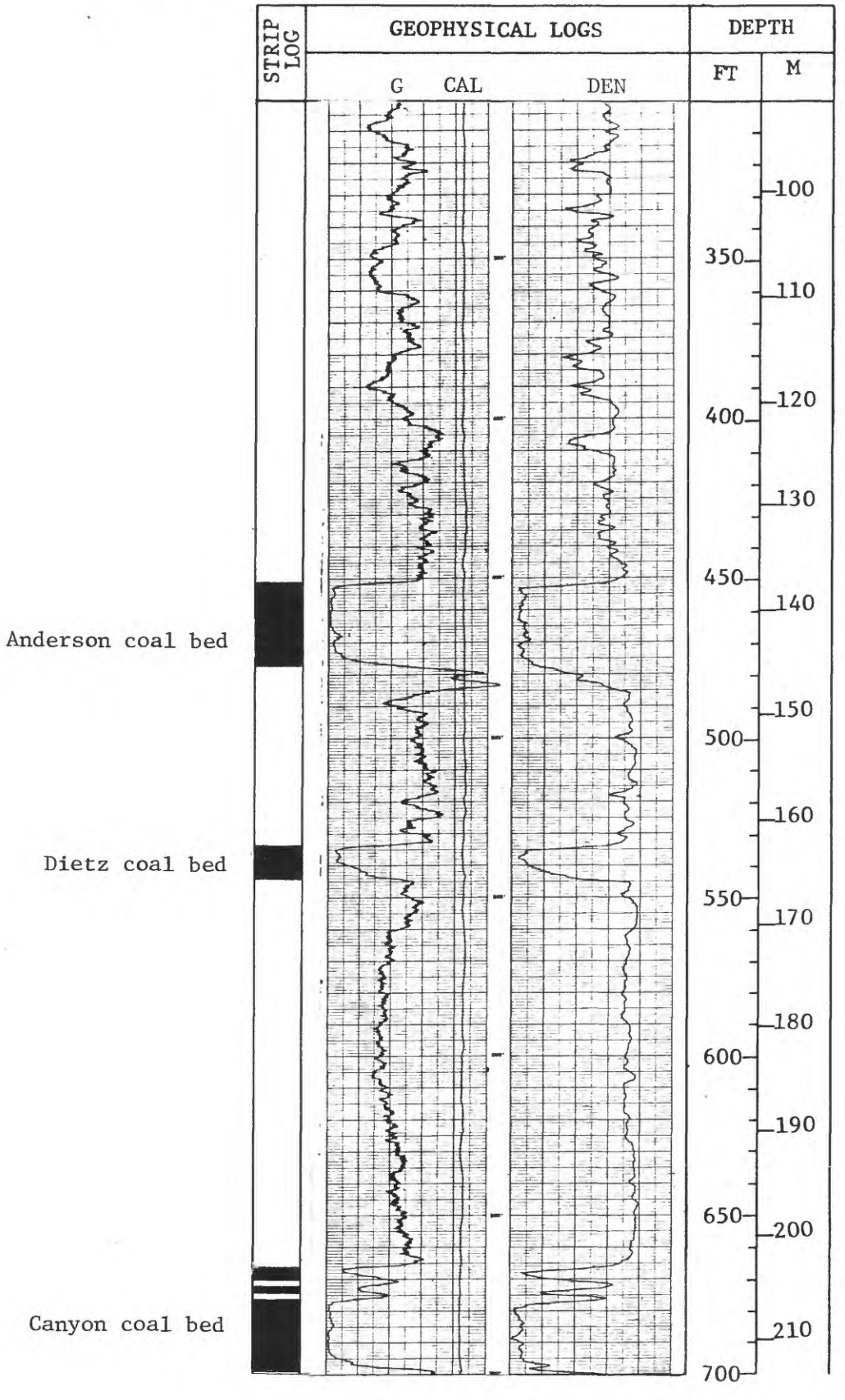
U.S. Geological Survey
Birney 1° x 1/2° Quadrangle

Hole name Otter 1 County Powder River State Montana
Location NW¼SE¼ Sec. 21 T. 9 S. R. 45 E.
Elevation 4170 ft Drilled depth 736 ft Logged depth 718 ft
Drilling medium air and foam Date logged 8/27/80
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 50 cps/in Logging speed 15 fpm
Density (DEN): T.C. 2 Scale 1000 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 2 in/in Logging speed fpm
Resistance (RES): Scale Logging speed fpm
Remarks:



U.S. Geological Survey

Hole name Otter 1 continued



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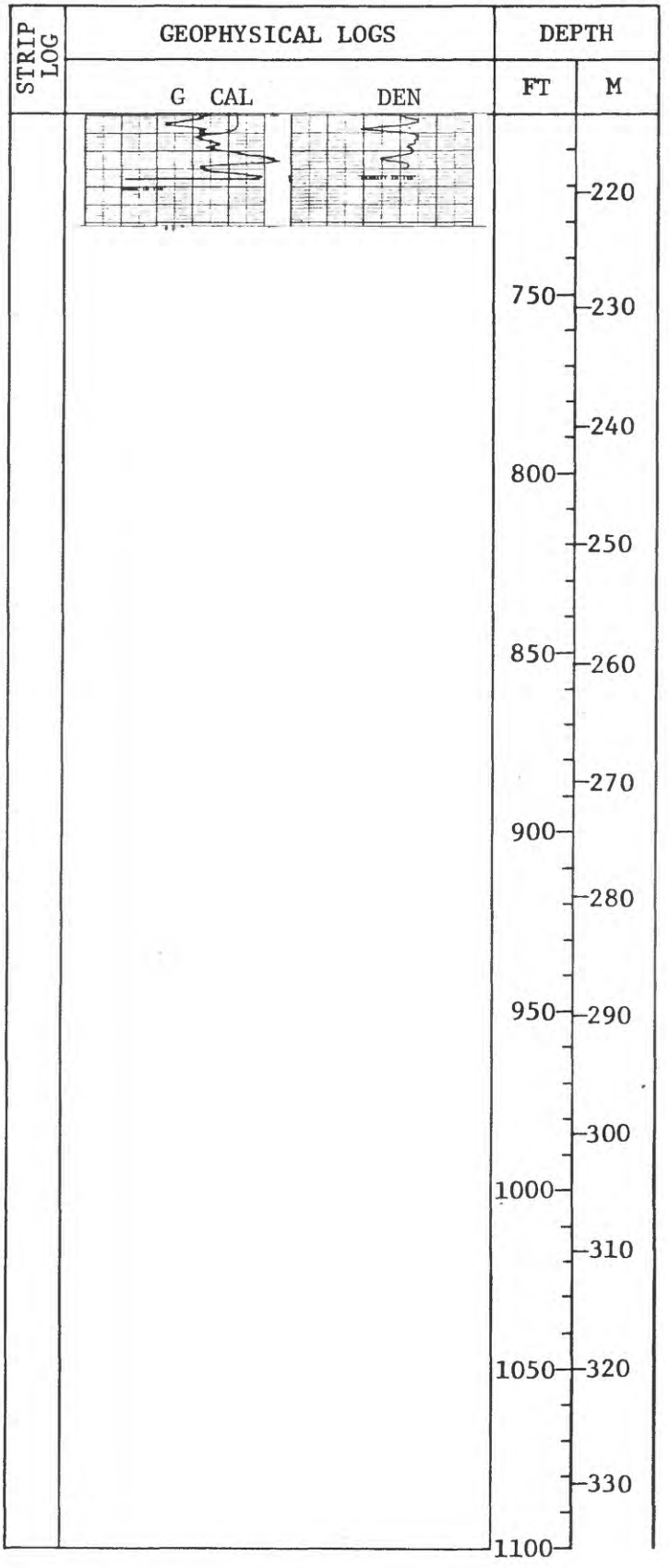
Hole name Otter 1 continued



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

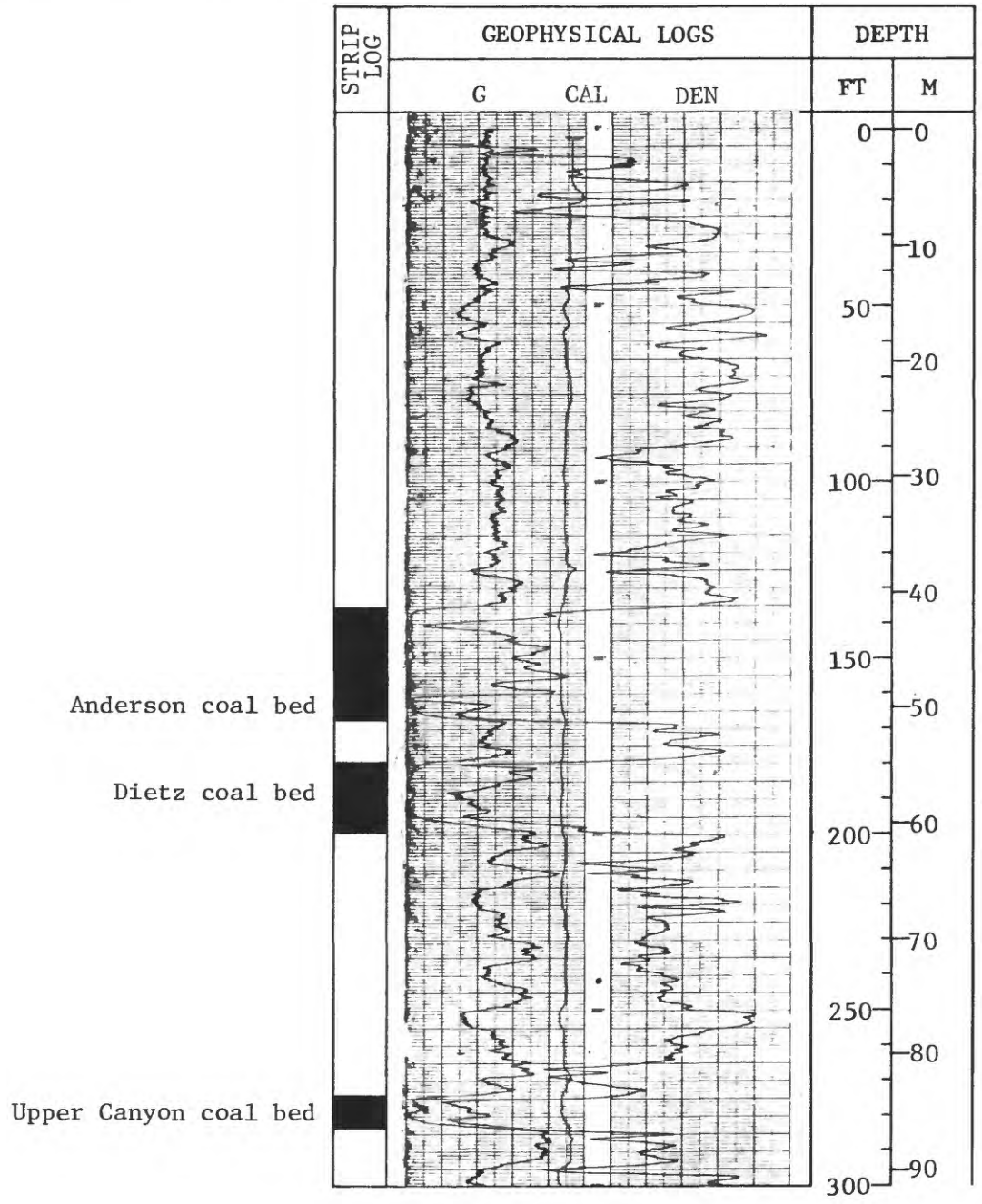
Hole Otter #2 Elev. 4120 feet Total depth 875 feet
Location 1000 FWL, 200 FSL (SW 1/4, SW 1/4) Sec. 18, T. 6 S., R. 45 E.
County Powder River State Mont. Quadrangle Poker Jim Butte 7 1/2'
Drilled by U.S.Geological Survey Driller A. Clark Hole size 5 inches
Date Started 8/30/80 Date Completed 8/30/80 Geologist F. Spencer
Remarks Lithology from 5 ft samples, modified by H. I. Saperstone and W. C. Culbertson to conform with geophysical logs to depth 843

Depth interval (feet) From	To	Thickness	Lithologic Description
0	5	5	Alluvium, medium brown silt
5	10	5	Alluvium, silt, light yellow, iron-stained
10	23	13	Siltstone, light yellow, weathered
23	25	2	Coal, weathered, powdery
25	31	6	Sandstone, light to medium gray, very fine grained
31	49	18	Siltstone, medium gray, sandy
49	59	10	Sandstone, medium gray, very fine grained to fine grained
59	77	18	Siltstone, medium brown gray, sandy
77	87	10	Sandstone, medium gray, fine grained to medium grained
87	94	7	Siltstone, medium gray
94	124	30	Shale, dark brown, carbonaceous, silty
124	135	11	Shale, dark brown, carbonaceous, with coal stringers
135	167	32	Coal ANDERSON BED
167	179	12	Shale, carbonaceous, dark brown with siltstone interbeds
179	199	20	Coal DIETZ BED
199	204	5	Shale, carbonaceous dark, brownish gray with thin bedded siltstone
204	213	9	Siltstone, dark brownish gray
213	222	9	Sandstone, medium gray interbedded with light gray sandy limestone
222	236	14	Sandstone, medium gray, very fine grained, interbedded with light gray calcareous, very fine grained sand
236	264	28	Siltstone, medium brownish gray
264	269	5	Siltstone, medium brownish gray interbedded with carbonaceous shale
269	274	5	Shale, carbonaceous, dark brown
274	283	9	Coal UPPER CANYON BED
283	293	10	Siltstone, dark brown, interbedded with dark brown carbonaceous shale
293	297	4	Sandstone, medium gray, very fine grained, calcareous in part
297	301	4	Limestone, sandy

Depth interval (feet) From	To	Thickness	Lithologic Description
301	305	4	Siltstone, medium brownish gray
305	312	7	Sandstone, medium to light gray, very fine grained
312	317	5	Siltstone, medium gray
317	368	51	Siltstone, medium brownish gray
368	373	5	Coal — LOWER CANYON BED
373	379	6	Sandstone, light to medium gray, very fine grained, calcareous
379	389	10	Siltstone, medium gray
389	401	12	Sandstone medium brown gray, very fine grained
401	408	7	Siltstone, medium brown gray, sandy
408	414	6	Coal — FERRY BED
414	418	4	Shale, medium gray, silty
418	502	84	Siltstone, medium brown gray, sandy, locally very calcareous
502	505	3	Shale, carbonaceous, dark brown, silty in part
505	509	4	Coal — COOK BED
509	515	6	Siltstone, medium to dark gray, carbonaceous
515	521	6	Shale, silty in part, carbonaceous
521	537	16	Coal — OTTER BED
537	607	70	Siltstone, medium to dark brownish gray, sandy in part
607	621	14	Sandstone, medium gray, very fine grained, silty in part
621	630	9	Siltstone, medium gray
630	636	6	Shale, carbonaceous. dark brown with interbedded siltstone
636	643	7	Coal — WALL BED
643	653	10	Shale, carbonaceous, dark brown with interbedded dark brown siltstone
653	670	17	Siltstone, medium to dark olive gray, sandy
670	701	31	Siltstone, brownish gray, sandy
701	710	9	Sandstone, light gray, calcareous
710	732	22	Siltstone, dark brown, interbedded with dark brown carbonaceous shale
732	750	18	Siltstone, medium brownish gray, sandy
750	754	4	Sandstone, medium gray, very fine grained calcareous in part with some granular black chert
754	778	24	Siltstone, light olive gray, sandy interbedded with carbonaceous shale
778	795	17	Siltstone, medium gray, interbedded with medium gray shale
795	815	20	Sandstone, medium gray, very fine grained
815	824	9	Sandstone light to medium gray, very fine grained, silty
824	828	4	Coal
828	829	1	Shale, carbonaceous, coaly } POKER JIM BED
829	832	3	Coal
832	840	8	Sandstone, medium gray, very fine grained
840	870	30	Siltstone, medium gray, sandy
870	871	1	Coal
871	875	4	Siltstone, medium gray, with carbonaceous debris

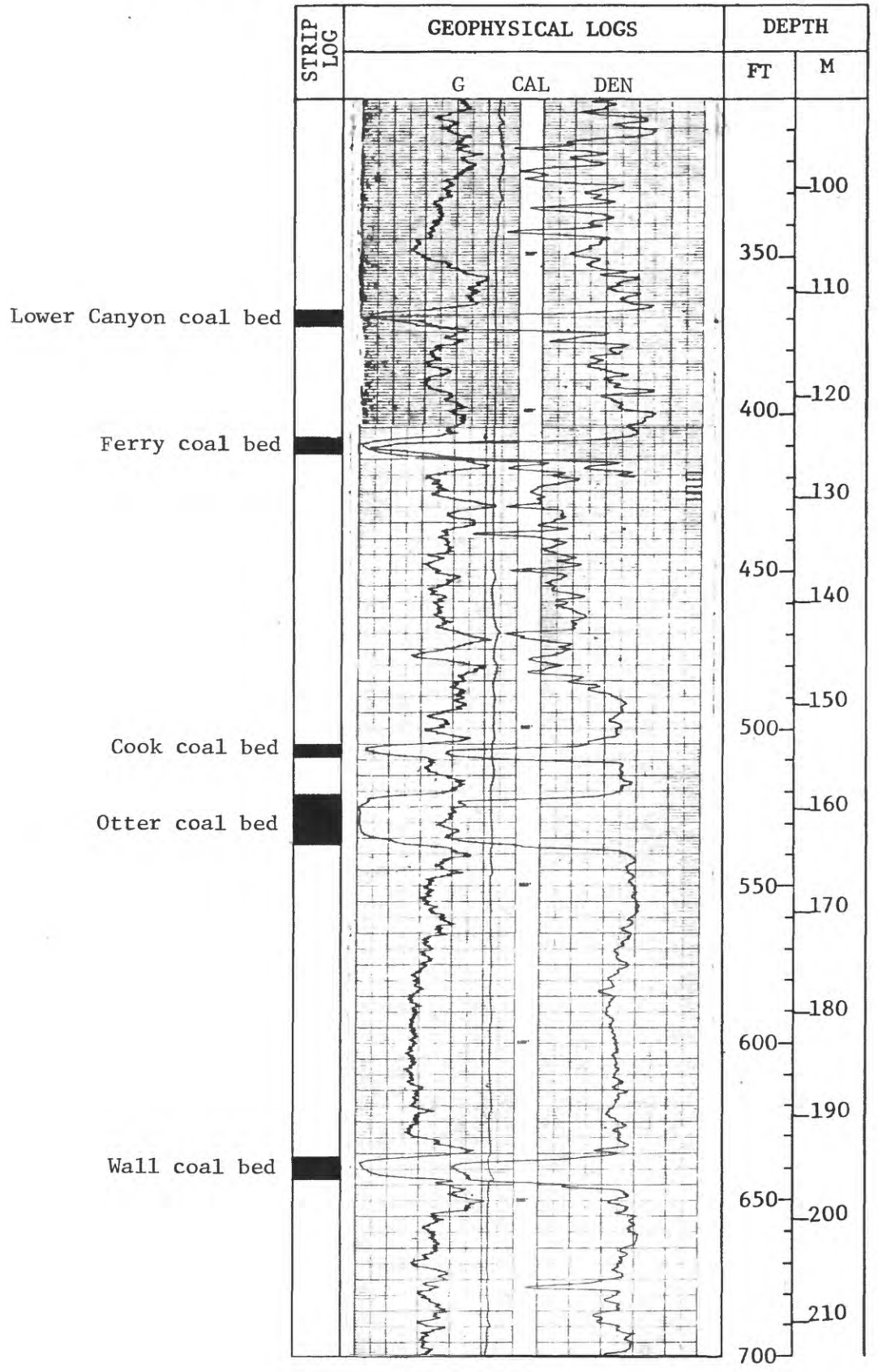
U.S. Geological Survey
Birney 1° x 1/2° Quadrangle

Hole name Otter 2 County Powder River State Montana
Location SW¼SW¼ Sec. 18 T. 6 S. R. 45 E.
Elevation 4120 ft Drilled depth 875 ft Logged depth 843 ft
Drilling medium air and foam Date logged 8/30/80
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 25 cps/in Logging speed 15 fpm
Density (DEN): T.C. 2 Scale 1000 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 2 in/in Logging speed fpm
Resistance (RES): Scale Logging speed fpm
Remarks:



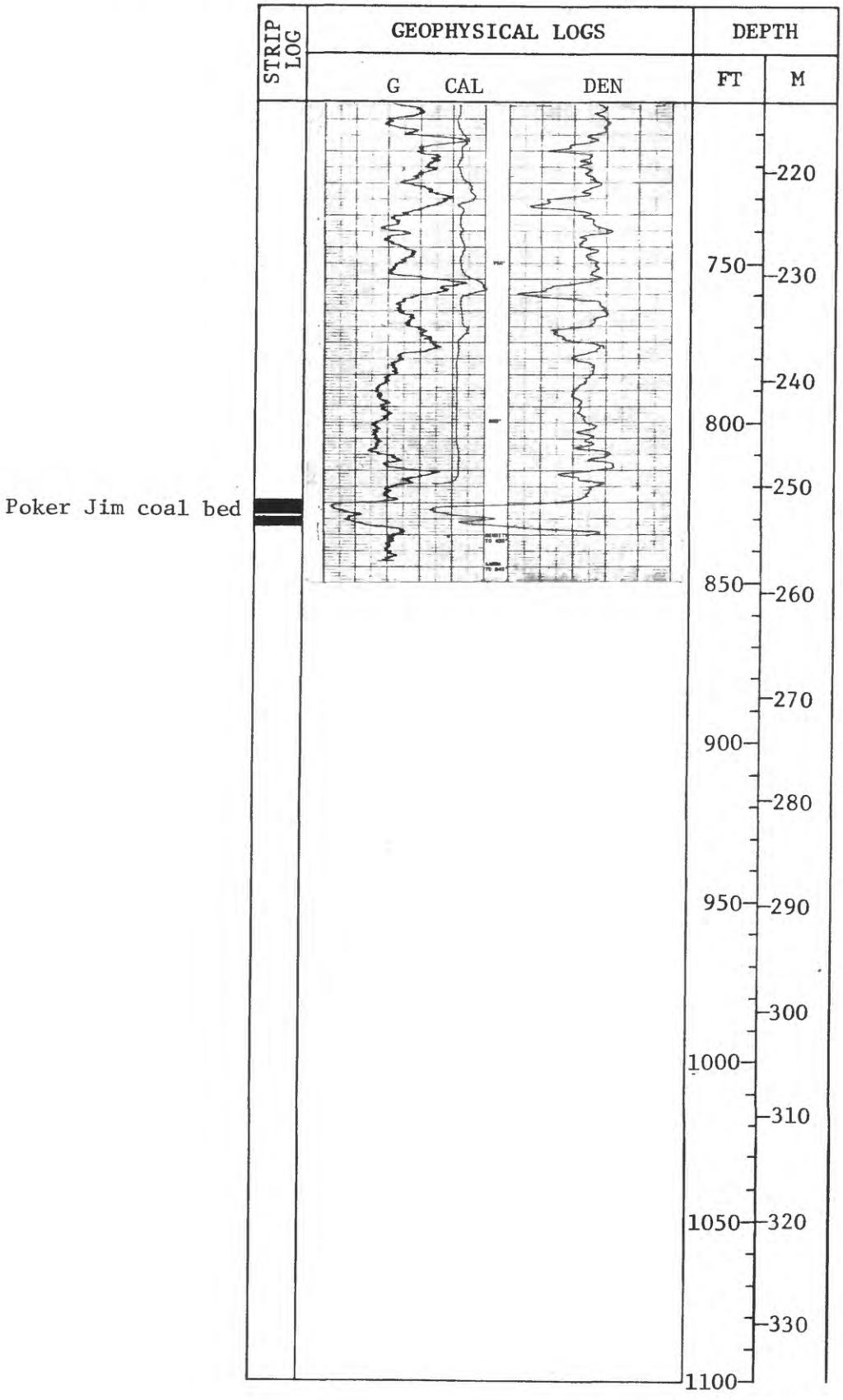
U.S. Geological Survey

Hole name Otter 2 continued



U.S. Geological Survey

Hole name Otter 2 continued



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

Hole Otter #3 Elev. 3420 feet Total depth 935 feet

Location 1700 ft FWL, 200 ft FNL (NE 1/4 NW 1/4) Sec. 25, T. 6 S., R. 45 E.

County Powder River State Mont. Quadrangle Fort Howes

Drilled by U.S. Geological Survey Driller Arthur Clark Hole size 5 inches

Date Started 8/29/80 Date Completed 8/29/80 Geologist F. Spencer

Remarks Lithology from 5-foot samples, modified to conform with geophysical log interpretation by H. I. Saperstone. and W. C. Culbertson.

Depth interval (feet) From	To	Thickness	Lithologic Description	
0	18	18	Alluvium, unconsolidated sand, medium yellowish brown	
18	23	5	Sandstone, weathered	
23	34	11	Clay, light yellowish gray with weathered coal	
34	38	4	Shale, carbonaceous, dark brown	
38	56	18	Sandstone, dark gray, very fine grained, slightly carbonaceous	
56	57.5	1.5	Coal	
57.5	58	0.5	Shale, carbonaceous, dark brown	UPPER POKER JIM BED
58	60	2	Coal	
60	62	2	Shale, carbonaceous, dark brown	
62	77	15	Sandstone, light to medium gray, very fine grained, silty with angular to subangular quartz grains	
77	80.5	3.5	Shale, medium gray	
80.5	84	3.5	Coal	LOWER POKER JIM BED
84	90	6	Shale, carbonaceous	
90	97	7	Siltstone, medium gray with carbonaceous shale interbeds	
97	102	5	Shale, dark gray with carbonaceous shale	
102	112	10	Siltstone, medium gray	
112	117	5	Shale, medium gray, sandy	
117	134	17	Siltstone, medium to dark gray, interbedded with medium gray shale	
134	139	5	Shale, carbonaceous, dark brown	
139	144	5	Siltstone, medium gray interbedded with thin dark gray shale	
144	153	9	Sandstone, medium gray with very fine grained angular quartz	
153	154	1	Coal	
154	174	20	Shale, carbonaceous, dark brown	
174	179	5	Siltstone, light to medium gray, sandy in part	
179	196	17	Siltstone, dark brownish gray with interbedded carbonaceous shale	
196	197	1	Coal	
197	200	3	Siltstone, medium gray	
200	204	4	Shale, carbonaceous, dark brown	
204	209	5	Coal	ODELL BED
209	221	12	Siltstone, medium gray	

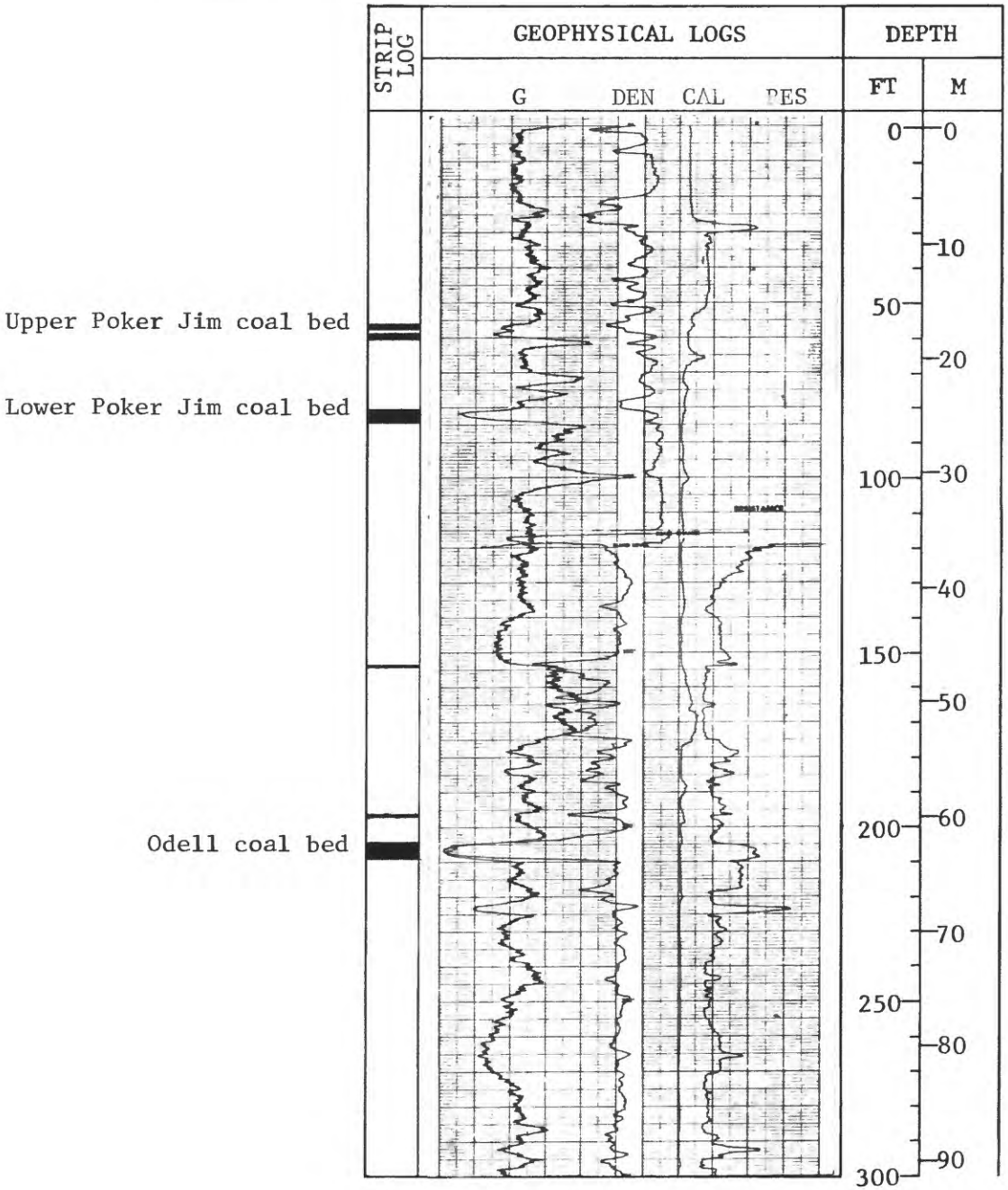
Depth interval (feet) From	To	Thickness	Lithologic Description
221	224	3	Limestone, medium to light gray, sandy
224	252	28	Siltstone, medium gray to light gray
252	257	5	Sandstone, light to medium gray, very fine grained, with subangular to angular quartz grains
257	261	4	Sandstone, medium gray, fine grained, angular quartz grains
261	265	4	Sandstone, medium gray, fine grained to medium grained
265	271	6	Sandstone, medium gray, fine grained to very fine grained
271	277	6	Siltstone, medium gray
277	291	14	Shale, carbonaceous, dark brown
291	294	3	Sandstone, medium gray, very fine grained, limy
294	298	4	Shale, carbonaceous, dark brown
303	317	14	Sandstone, light to medium gray, very fine grained with angular quartz and black chert
317	325	8	Coal KING BED
325	333	8	Siltstone, medium gray, sandy
333	341	8	Sandstone, light gray, very fine grained
341	358	17	Sandstone, light gray, very fine grained to fine grained with black chert
358	373	15	Siltstone, medium brownish gray, sandy
373	390	17	Sandstone, light to medium gray, fine grained; medium grained at base, with subrounded quartz grains and black chert
390	399	9	Shale, carbonaceous, interbedded with medium gray shale
399	407	8	Siltstone, medium brownish gray interbedded with carbonaceous shale
407	411	4	Shale, carbonaceous, dark brown
411	430	19	Coal KNOBLOCH BED
430	437	7	Siltstone, medium brown
437	441	4	Shale, carbonaceous, dark brown with medium brown siltstone
441	448	7	Siltstone, light gray, sandy
448	453	5	Sandstone, light to medium gray, fine grained with subrounded quartz and black chert
453	468	15	Siltstone, light to medium gray
468	476	8	Shale, carbonaceous, dark brown
476	477.5	1.5	Coal
477.5	486	8.5	Shale, carbonaceous, dark brown, interbedded with siltstone
486	491	5	Siltstone, medium brownish gray with interbedded carbonaceous shale
491	492	1	Coal
492	497	5	Shale, gray, silty
497	504	7	Siltstone, light gray, sandy
504	506	2	Shale, medium gray
506	514	8	Siltstone, light gray, sandy
514	516	2	Coal, black, bright
516	524	8	Shale, carbonaceous, dark brown, with siltstone interbeds
524	532	8	Siltstone, medium to dark gray

Depth interval (feet) From	To	Thickness	Lithologic Description	
532	540	8	Sandstone, light to medium gray, very fine grained to fine grained with subrounded quartz grains	
540	549	9	Siltstone, light gray	
549	556	7	Shale, carbonaceous	
556	560	4	Coal, bright	NANCE BED
560	564	4	Shale, carbonaceous, dark brown	
564	581	17	Siltstone, dark brownish gray to medium gray, interbedded with thin carbonaceous shale	
581	588	7	Shale, medium gray	
588	598	10	Sandstone, light gray, very fine grained	
598	602	4	Siltstone, light gray	
602	669	67	Sandstone, light to medium gray, fine grained with subrounded quartz grains	
669	702	33	Sandstone, medium gray, fine grained to very fine grained with subrounded quartz grains and light yellow clay streaks	
702	704	2	Shale, carbonaceous, dark brown	
704	705	1	Coal	
705	708	3	Shale, carbonaceous, dark brown	
708	711	3	Sandstone, light gray, very fine grained	
711	713	2	Siltstone, medium gray	
713	715	2	Coal	
715	726	11	Siltstone, medium gray	
726	734	8	Shale, medium gray	
734	750	16	Coal, bright, brittle	FLOWERS-GOODALE BED
750	751	1	Shale, carbonaceous, dark brown	
751	760	9	Coal bright	
760	780	20	Siltstone, medium gray, interbedded with carbonaceous shale	
780	786	6	Sandstone, light to medium gray, very fine grained	
786	793	7	Siltstone, medium gray, and shale, medium gray	
793	798	5	Sandstone, light to medium gray, very fine grained	
798	805	7	Shale, carbonaceous, dark brown interbedded with siltstone	
805	809	4	Coal	WITHAM BED
809	811	2	Shale, carbonaceous	
811	823	12	Siltstone, medium gray	
823	832	9	Shale, medium gray	
832	841	9	Sandstone, light gray, very fine grained	
841	847	6	Siltstone, light to medium gray with interbedded carbonacesous shale	
847	853	6	Sandstone, light gray, very fine grained	
853	866	13	Siltstone, light to medium gray, and medium gray shale	
866	874	8	Siltstone, medium gray	
874	878	4	Shale, carbonaceous, dark brown	
878	889	11	Coal	TERRET BED
889	897	8	Shale, silty, brownish gray	
897	922	25	Siltstone, medium gray	

Depth interval (feet) From	To	Thickness	Lithologic Description
922	923	1	Coal
923	927	4	Sandstone, light to medium gray, fine grained to medium grained with subrounded quartz grains
927	935	8	Sandstone, light medium gray, very fine grained to fine grained

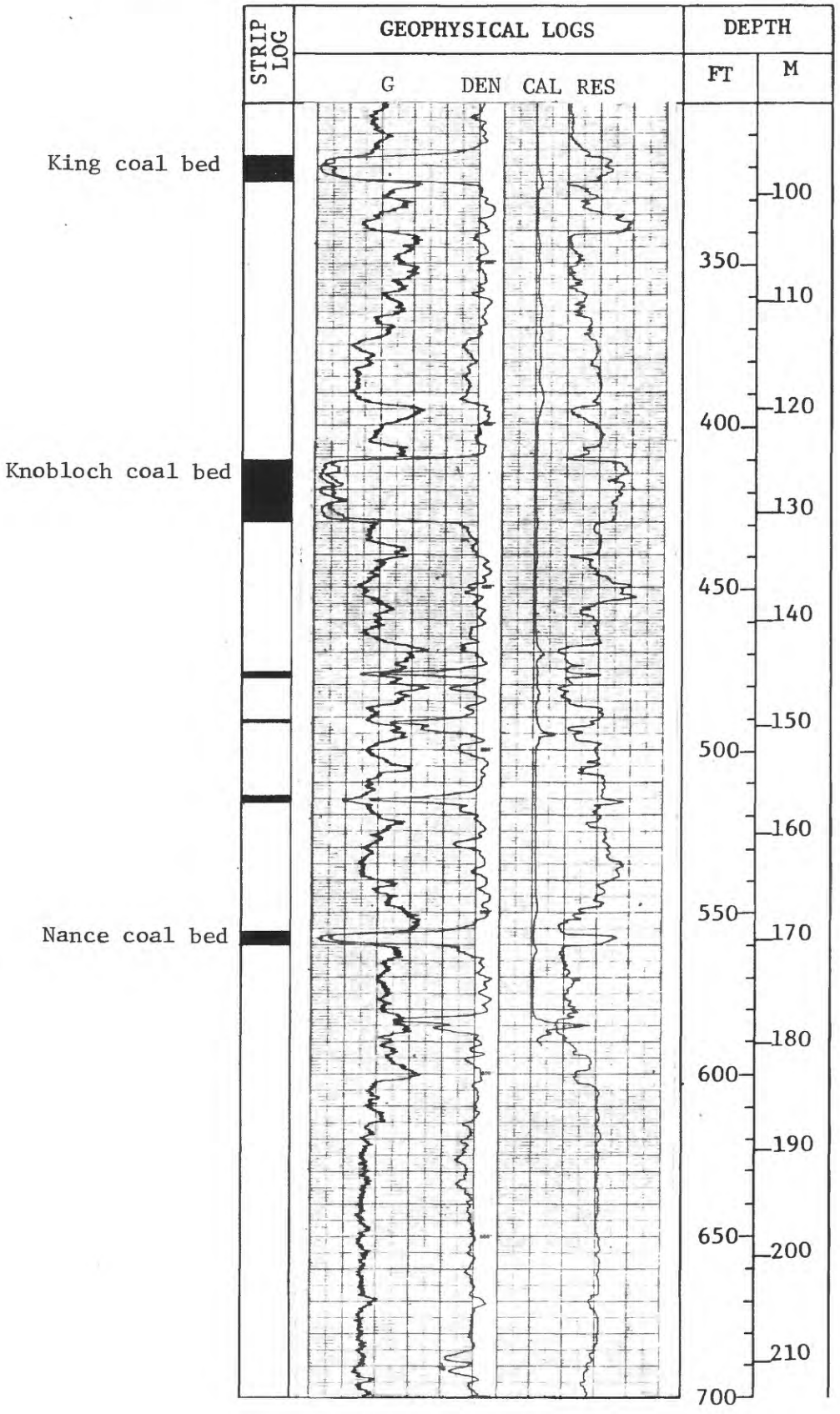
U.S. Geological Survey
Birney 1° x 1/2° Quadrangle

Hole name Otter 3 County Powder River State Montana
Location NE¼NW¼ Sec. 25 T. 6 S. R. 45 E.
Elevation 3420 ft Drilled depth 935 ft Logged depth 927 ft
Drilling medium air and foam Date logged 8/29/80
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 25 cps/in Logging speed 15 fpm
Density (DEN): T.C. 2 Scale 154 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 2 in/in Logging speed fpm
Resistance (RES): Scale Logging speed fpm
Remarks:



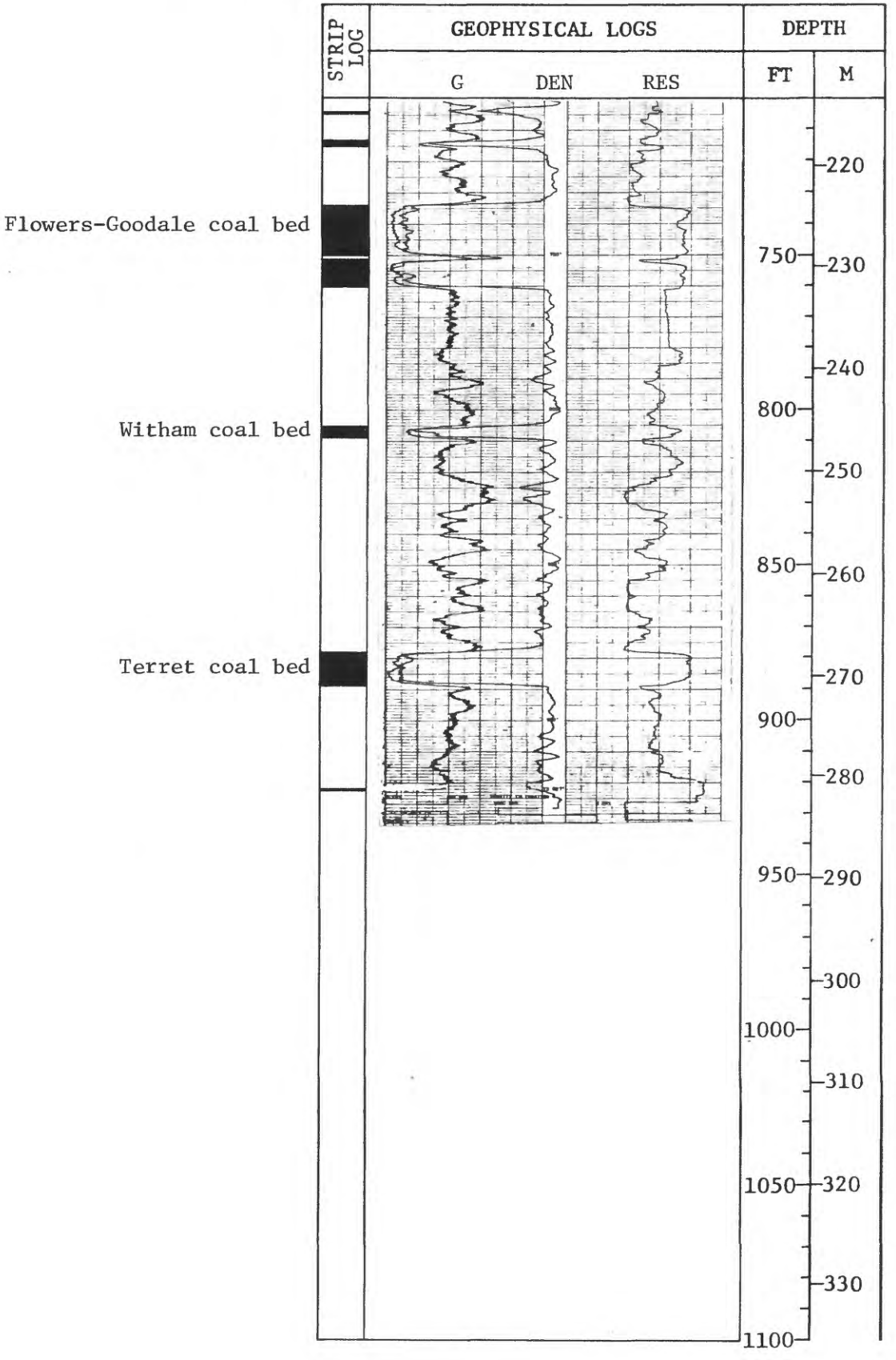
U.S. Geological Survey

Hole name Otter 3 continued



U.S. Geological Survey

Hole name Otter 3 continued



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

Hole Otter #4 Elev. 3925 feet Total depth 675 feet

Location 900 FWL, 2300 FNL (SW 1/4, NW 1/4) Sec. 15 , T. 8 S., R. 44 E.

County Big Horn State Mont. Quadrangle Hamilton Draw 7 1/2'

Drilled by U.S.Geological Survey Driller Larry Kojak Hole size 5 inches

Date Started 8/29/80 Date Completed 8/30/80 Geologist W.C. Culbertson

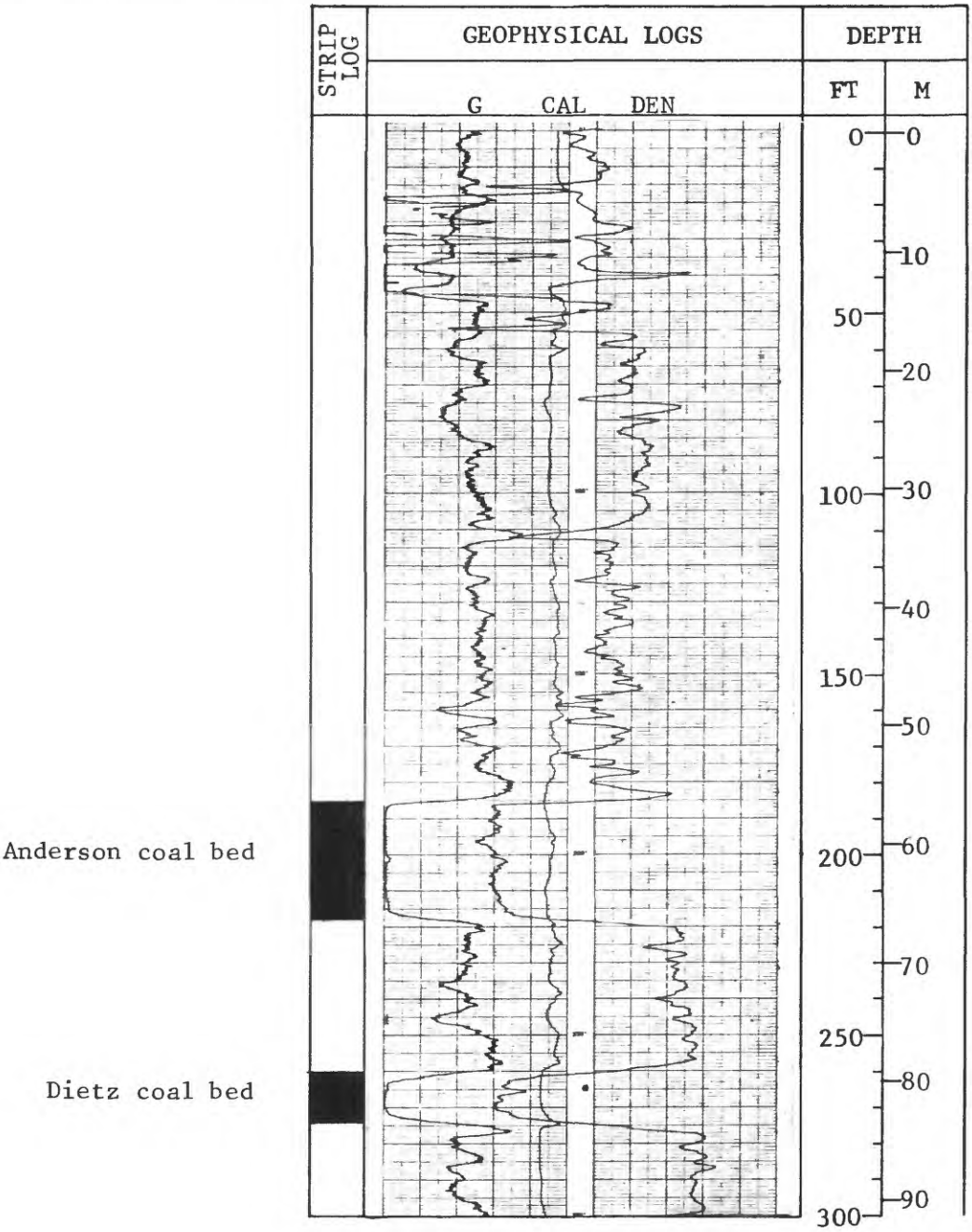
Remarks Lithology from 5 ft samples, modified by H. I. Saperstone and W. C. Culbertson conform with geophysical logs. Encountered water at 35 feet.

Depth interval (feet) From	To	Thickness	Lithologic Description
0	22	22	Colluvium-sand, fine grained, yellowish-brown
22	35	13	Sandstone, clayey, very fine grained, light olive-gray
35	43	8	Sandstone, very fine grained, gray to yellowish-gray
43	47	4	Siltstone, clayey, yellowish-brown
47	52	5	Shale, medium-gray, silty, few carbonaceous limestone fragments
52	63	11	Shale, carbonaceous, brownish gray
63	76	13	Shale, carbonaceous, olive-gray, fragments of sandy limestone
76	86	10	Sandstone, fine grained, medium-gray, calcareous in part
86	95	9	Shale, medium-gray
95	100	5	Sandstone, fine grained, medium-gray
100	132	32	Siltstone, medium light-gray, clayey in part
132	134	2	Shale, carbonaceous, dark-brown
134	143	9	Siltstone, clayey, dark-gray
143	152	9	Shale, dark gray, silty at top
152	158	6	Siltstone, clayey, light-gray
158	170	12	Sandstone, medium light-gray, fine grained
170	178	8	Shale, gray, with carbonaceous brownish-black shale interbeds
178	185	7	Shale, carbonaceous, brownish-gray
185	218	33	Coal ANDERSON BED
218	235	17	Shale, carbonaceous, dark-gray
235	244	9	Siltstone, light-gray
244	247	3	Sandstone, medium light-gray, very fine grained
247	250	3	Siltstone, carbonaceous, medium-gray
250	260	10	Shale, medium - gray
260	274	14	Coal DIETZ BED
274	288	14	Shale, carbonaceous, brownish-gray
288	295	7	Shale, medium light - gray
295	300	5	Siltstone, very light - gray

Depth interval (feet) From	To	Thickness	Lithologic Description
300	304	4	Shale, carbonaceous, brownish gray
304	310	6	Shale light brownish gray
310	315	5	Shale medium gray
315	320	5	Shale carbonaceous, brownish - gray
320	335	15	Siltstone, medium to light gray
335	340	5	Sandstone, fine grained with abundant dark accessory minerals, medium gray
340	349	9	Siltstone, clayey, medium light gray
349	360	11	Sandstone, medium to medium light gray, very fine grained, with piece of petrified wood
360	363	3	Limestone, sandy, medium light gray
363	375	12	Sandstone, very fine grained, light gray with siltstone interbeds
375	385	10	Siltstone, carbonaceous, clayey, medium gray to dark gray
385	405	20	Siltstone, medium gray
405	412	7	Shale, medium light gray, silty
412	423	11	Shale, light brownish gray
423	427	4	Siltstone, light gray
427	431	4	Shale, carbonaceous, dark brown; coaly streaks and light gray siltstone interbeds
431	438	7	Shale, carbonaceous, dark brown with coaly streaks
438	466	28	Coal CANYON BED
466	505	39	Shale, gray, clayey, carbonaceous in part, with petrified wood fragments
505	507	2	Coal FERRY BED
507	519	12	Shale, carbonaceous, light brownish gray
519	531	12	Siltstone, clayey, medium gray
531	534	3	Coal WHITE BED
534	548	14	Shale, carbonaceous, dark gray
548	553	5	Siltstone, light gray
553	570	17	Shale dark gray, carbonaceous
570	574	4	Siltstone, light gray
574	602	28	Shale, carbonaceous, brownish-gray to dark brown with coal streaks
602	613	11	Shale, carbonaceous, brownish-gray
613	628	15	Coal COOK BED
628	632	4	Shale, carbonaceous, brownish gray
632	639	7	Coal OTTER BED
639	670	31	Shale, carbonaceous, brownish gray
670	675	5	Siltstone, light gray, calcareous in part

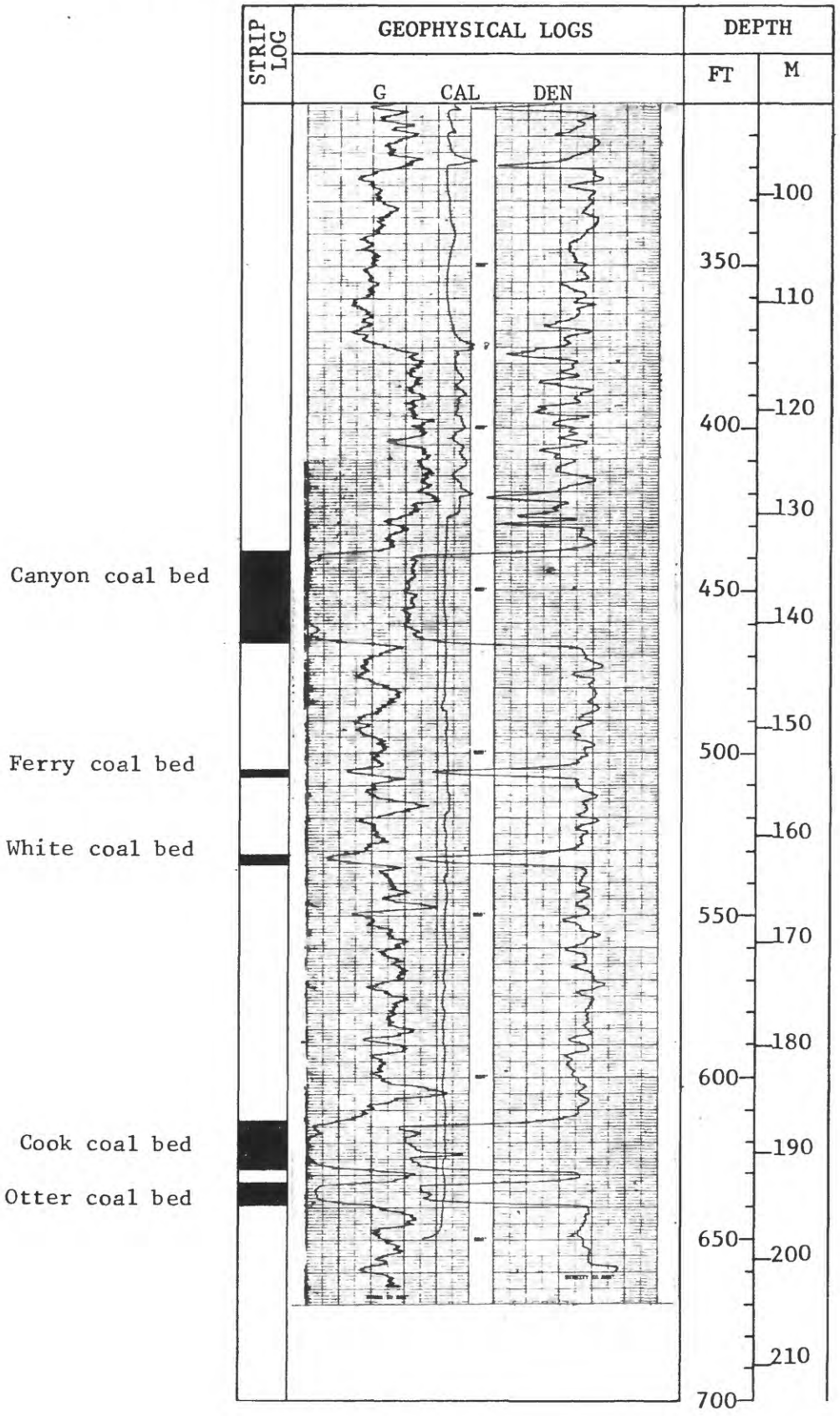
U.S. Geological Survey
Birney 1° x 1/2° Quadrangle

Hole name Otter 4 County Big Horn State Montana
Location SW¼NW¼ Sec. 15 T. 8 S. R. 44 E.
Elevation 3925 ft Drilled depth 675 ft Logged depth 664 ft
Drilling medium air and foam Date logged 8/30/80
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 25 cps/in Logging speed 15 fpm
Density (DEN): T.C. 2 Scale 1000 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 2 in/in Logging speed fpm
Resistance (RES): Scale Logging speed fpm
Remarks:



U.S. Geological Survey

Hole name Otter 4 continued



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

Hole Otter #5 Elev. 3920 feet Total depth 895 feet

Location 2100 FWL, 1200 FNL (SE 1/4, NW 1/4) Sec. 22 , T. 6 S., R. 46 E.

County Powder River State Mont. Quadrangle Goodspeed 7 1/2'

Drilled by U.S.Geological Survey Driller A. Clark Hole size 5 1/8 inches

Date Started 8/31/80 Date Completed 8/31/80 Geologist F. Spencer

Remarks Lithology from 5 ft samples, modified by H I Saperstone and W. C. Culbertson to conform with geophysical logs to depth 742

Depth interval (feet)

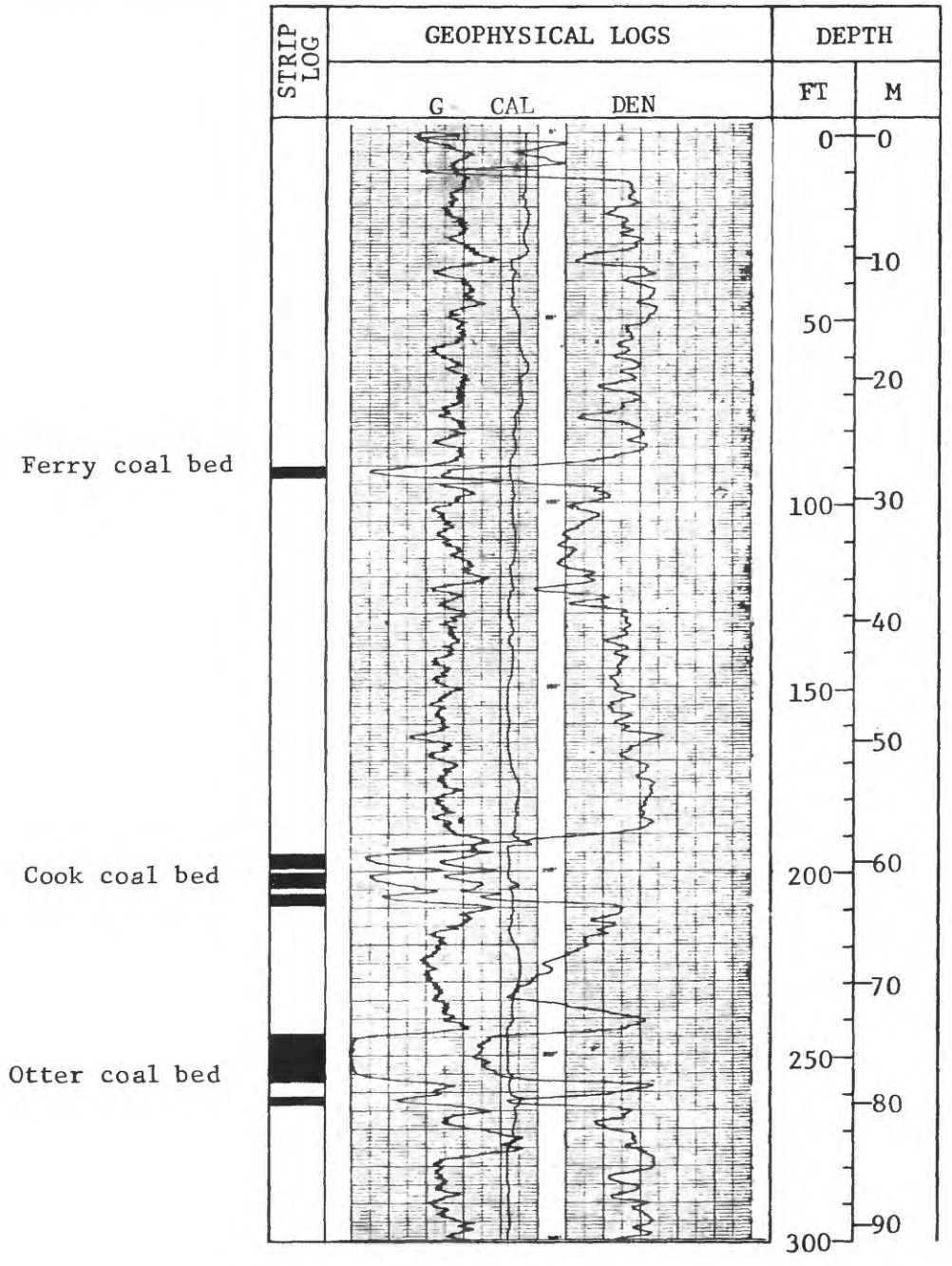
From	To	Thickness	Lithologic Description
0	5	5	Alluvium, sandy clay, yellowish orange with light yellow sandstone fragments
5	9	4	Alluvium, sandy clay, medium gray interbedded with light yellow sandstne fragments
9	12	3	Sandstone, light yellow orange (iron-stained), calcareous
12	20	8	Shale, medium gray
20	25	5	Sandstone, medium yellowish gray, very fine grained
25	36	11	Siltstone
36	39	3	Sandstone, light yellowish brown, very fine grained, calcareous in part
39	45	6	Siltstone, medium gray
45	51	6	Shale, carbonaceous interbedded with siltstone, medium brownish gray
51	57	6	Shale, medium to dark gray
57	61	4	Sandstone, light yellowish-orangey, iron stained ,very fine grained
61	66	5	Siltstone, medium brown
66	90	24	Shale, carbonaceous, dark brown, silty in part
90	93	3	Coal FERRY BED
93	95	2	Shale carbonaceous
95	100	5	Sandstone, light gray, very fine grained to fine grained, with sub-angular quartz grains
100	119	19	Sandstone, medium gray, fine grained
119	122	3	Shale, dark gray, interbedded with carbonaceous shale
122	131	9	Siltstone, medium gray, sandy of base
131	162	31	Sandstone light to medium gray, very fine grained with angular quartz grains
162	164	2	Limestone, sandy
164	191	31	Sandstone, light to medium gray, very fine grained with angular quartz grains
191	195	4	Shale, gray

Depth interval (feet) From	To	Thickness	Lithologic Description
195	199	4	Coal, dull dirty
199	200	1	Shale, carbonaceous
200	204	4	Coal, dull — COOK BED
204	206	2	Shale, carbonaceous
206	209	3	Coal, dull, dirty
209	220	11	Siltstone, medium gray
220	238	18	Siltstone, medium gray, sandy
238	242	4	Sandstone, light to medium gray, very fined grained
242	244	2	Shale, carbonaceous, dark brown
244	257	13	Coal
257	258	1	Siltstone, medium gray — OTTER BED
258	261	3	Sandstone, medium gray, very fine grained
261	263	2	Coal
263	265	2	Shale, carbonaceous, dark brownish black
265	270	5	Siltstone, medium gray, sandy
270	277	7	Shale, medium gray
277	287	10	Sandstone, light gray, very fine grained, calcareous
287	289	2	Siltstone, medium gray
289	294	5	Sandstone, light gray to medium gray, very fine grained, calcareous
294	314	20	Siltstone, light gray
314	327	13	Siltstone, light to medium gray
327	333	6	Coal — WALL BED
333	349	16	Shale, carbonaceous, dark brown with coaly streaks
349	411	62	Siltstone, medium gray, sandy
411	413	2	Siltstone light gray, very calcareous
413	431	18	Sandstone, light gray to medium gray, very fine grained
431	452	21	Siltstone, medium gray, interbedded with light gray very fine grained, calcareous sandstone
452	460	8	Coal — POKER JIM BED
460	473	13	Siltstone, light to medium gray, interbedded with light gray, very fine grained, calcareous sandstone
473	479	6	Sandstone, medium gray, very fine grained to fine grained
479	487	8	Siltstone, medium to dark gray
487	502	15	Siltstone, medium gray, clayey, interbedded with very fine grained calcareous sandstone
502	514	12	Siltstone, light to medium gray, sandy
514	519	5	Shale, carbonaceous with coal stringers
519	535	16	Siltstone, sandy
535	560	25	Siltstone , interbedded with carbonaceous shale
560	592	32	Sandstone, light to medium gray, very fine grained, interbedded with medium gray siltstone
592	598	6	Siltstone, medium gray
598	605	7	Sandstone, light to, medium gray, very fine grained, silty
605	626	21	Siltstone, medium gray, sandy in part

Depth interval (feet) From	To	Thickness	Lithologic Description
626	633	7	Shale, carbonaceous, interbedded with dark brown siltstone
633	643	10	Siltstone, medium gray, sandy
643	649	6	Coal ODELL BED
649	655	6	Shale, carbonaceous, interbedded with siltstone
655	660	5	Siltstone, dark brownish gray
660	680	20	Sandstone medium gray to dark gray, very fine grained, silty
680	685	5	Siltstone, medium gray, interbedded with light gray sandstone, very fine grained, calcareous in part
685	690	5	Siltstone, medium gray, interbedded with carbonaceous shale
690	695	5	Siltstone, dark brown, interbedded with carbonaceous shale
695	709	14	Sandstone, medium gray, very fine grained to fine grained
709	717	8	Siltstone, medium brown interbedded with medium gray sandstone, very fine grained
717	725	8	Sandstone, medium gray, fine grained with subrounded to rounded quartz grains
725	755	30	Sandstone, very fine grained with calcareous fragments
755	760	5	Sandstone, medium fray, fine grained to very fine grained with subrounded quartz grains
760	770	10	Shale, carbonaceous with coal fragments, silty in part
770	790	20	Siltstone, medium gray
790	795	5	Coal KING BED
795	800	5	Siltstone, medium gray, sandy in part
800	826	26	Siltstone, medium gray
826	847	21	Coal (Coal thickness as reported by driller) KNOBLOCH BED
847	865	18	Siltstone, medium brownish gray
865	870	5	Sandstone, medium olive gray, very fine grained
870	875	5	Siltstone
875	895	20	No Sample - probably siltstone, sandy

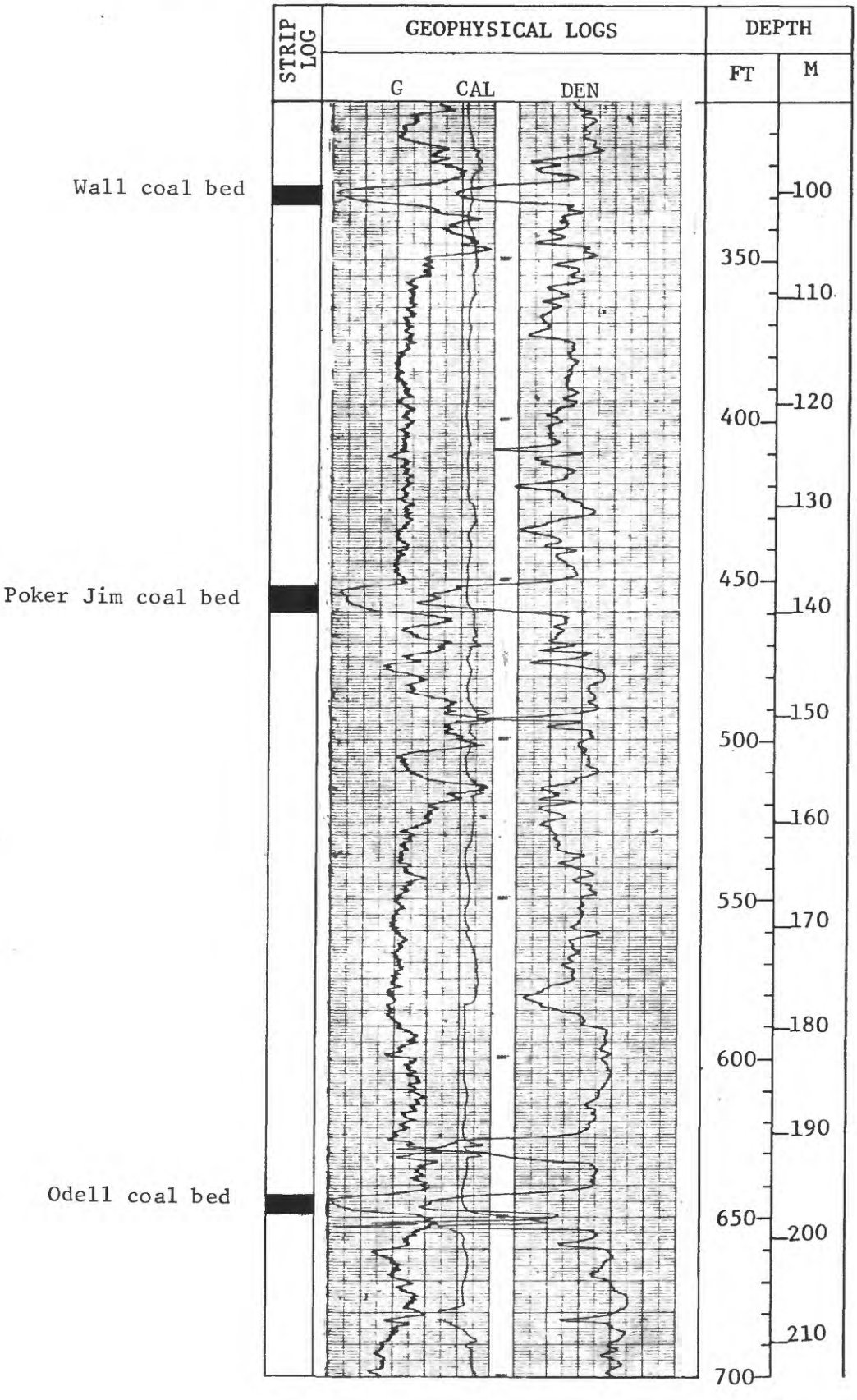
U.S. Geological Survey
Birney 1° x 1/2° Quadrangle

Hole name Otter 5 County Powder River State Montana
Location SE¼NW¼ Sec. 22 T. 6 S. R. 46 E.
Elevation 3920 ft Drilled depth 895 ft Logged depth 742 ft
Drilling medium air and foam Date logged 8/31/80
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 25 cps/in Logging speed 15 fpm
Density (DEN): T.C. 2 Scale 1000 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 2 in/in Logging speed fpm
Resistance (RES): Scale Logging speed fpm
Remarks:



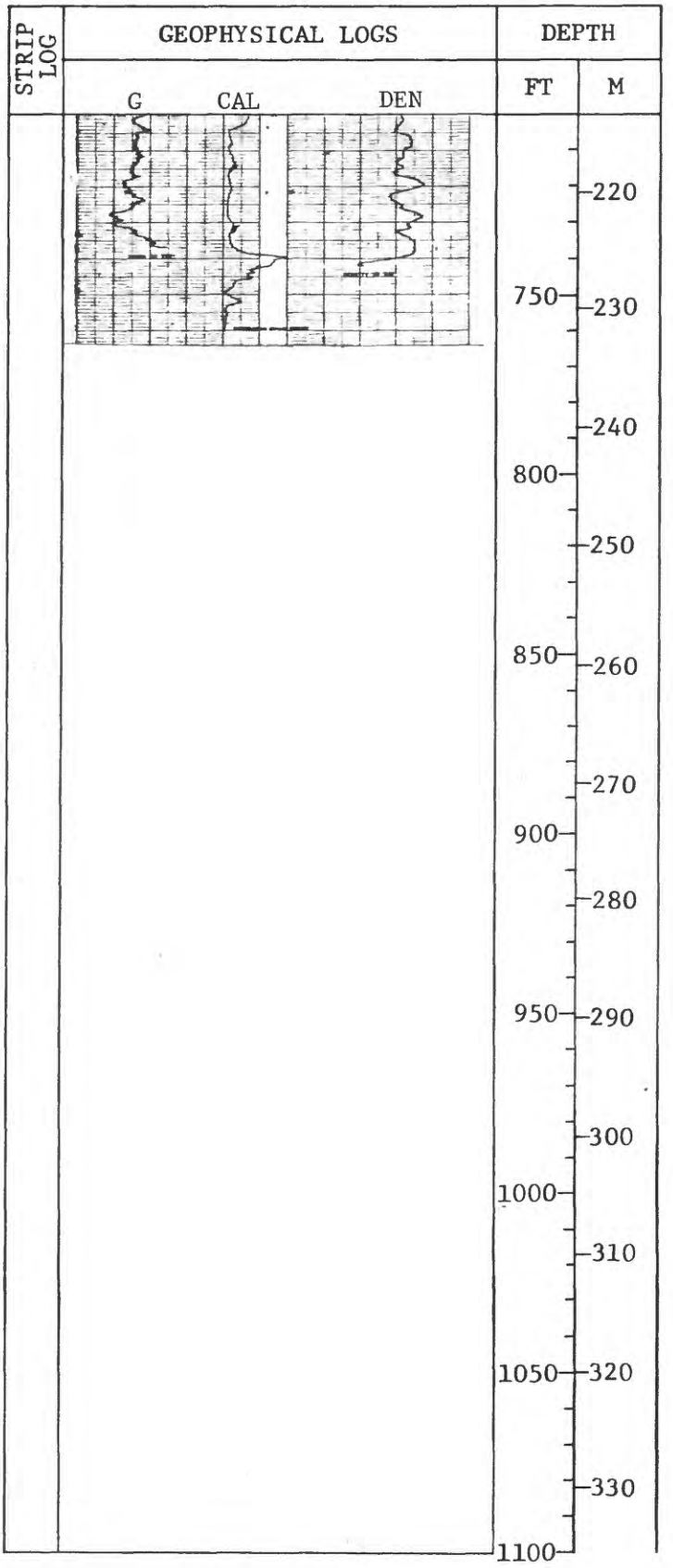
U.S. Geological Survey

Hole name Otter 5 continued



U.S. Geological Survey

Hole name Otter 5 continued



U.S. GEOLOGICAL SURVEY
Birney 1° x ½° quadrangle

Hole Otter #7 Elev. 4230 feet Total depth 715 feet
Location 200 FSL, 2200 FEL (SW 1/4, SE 1/4) Sec. 25, T. 9 S., R. 45 E.
County Powder River State Mont. Quadrangle Bear Creek School 7 ½'
Drilled by U.S.Geological Survey Driller A. Clark Hole size 5 inches
Date Started 8/18/80 Date Completed 8/18/80 Geologist F. Spencer
Remarks Combined log; Lithology from core 125.4-138.4, Rest of Lithology from 5 ft samples, modified by H. I. Saperstone and W. C. Culbertson to conform with geophysical logs to depth 615

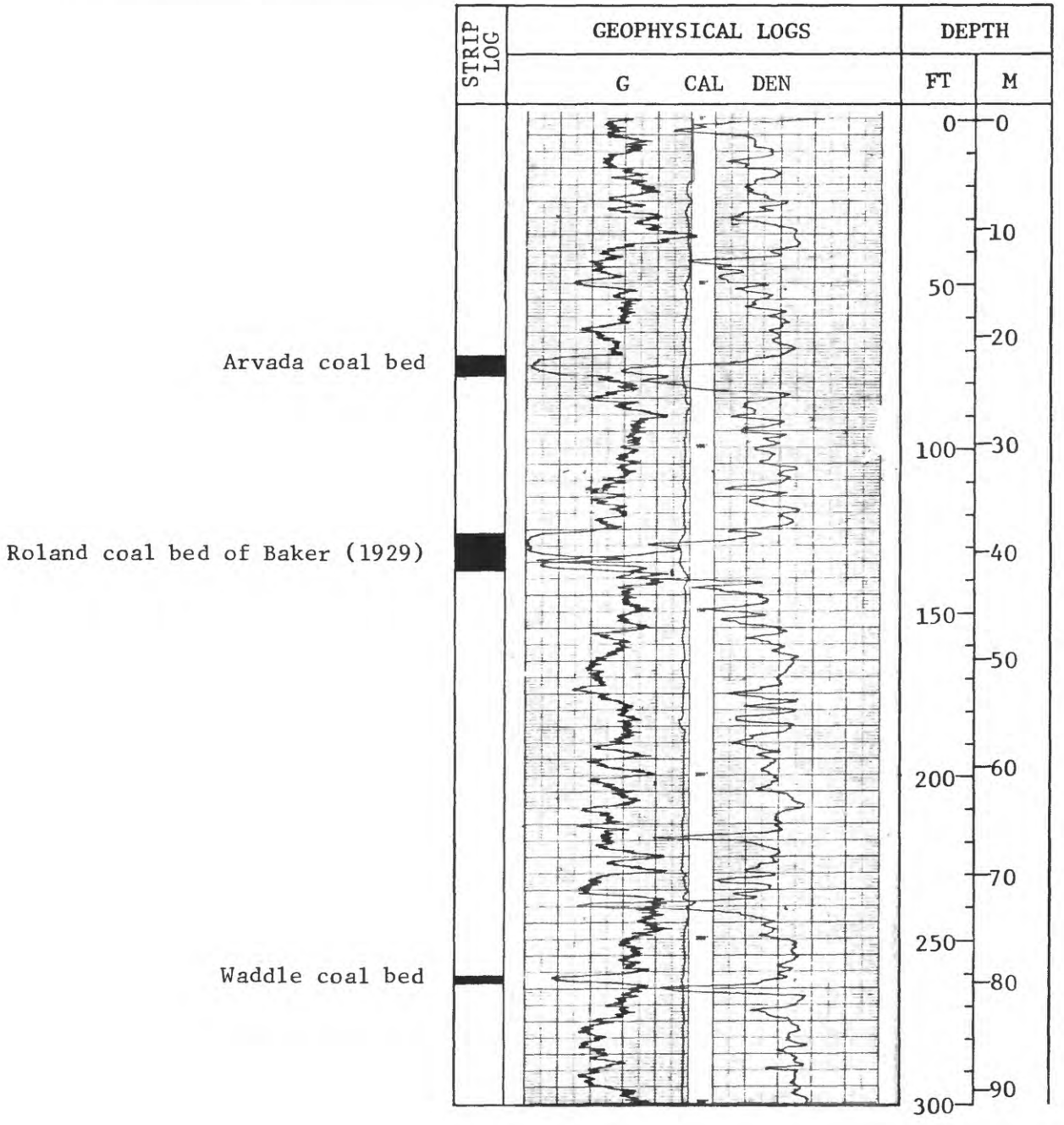
Depth interval (feet) From	To	Thickness	Lithologic Description
0	6	6	Shale, gray, clayey
6	11	5	Shale, medium gray with light gray sandstone, fine grained, friable
11	15	4	Shale, carbonaceous, brownish gray with thin layer fossiliferous (mollusk shell fragments), limy, fine grained sandstone
15	20	5	Sandstone, light olive gray, very fine grained to fine grained, very friable
20	23	3	Shale, medium gray to olive black, clayey
23	34	11	Sandstone, medium light gray, fine grained, very friable
34	38	4	Shale, carbonaceous, brownish black
38	51	13	Sandstone, fine-grained, medium light gray to light yellowish brown, unconsolidated
51	63	12	Shale, carbonaceous, dark brown with medium gray clayey shale
63	72	9	Shale, sandy in part, medium gray, with brownish-gray carbonaceous shale
72	78	6	Coal ARVADA BED
78	89	11	Sandstone, medium light gray, fine grained, unconsolidated
89	111	20	Shale, medium light gray, silty
111	125.4	14.4	Shale, clayey, light brownish gray, with fragments of mollusk shells at base
			Top of Core Interval
125.4	125.8	0.4	Siltstone, medium gray
125.8	126.0	0.2	Mollusk shell fragments in a mixture of siltstone and dark brown carbonaceous shale

Depth interval (feet) From	To	Thickness	Lithologic Description
126.0	137.2	11.2	Coal, dark brown to black, dull with bright banding, impure coal from 133.1 to 133.2. Pyrite and gypsum crystals on fracture plane from 131.7 to 134.7 ROLAND BED OF BAKER (1929)
137.2	137.3	0.1	Shale, carbonaceous, dark brown
137.3	137.5	0.2	Shale, medium gray
137.5	138.4	0.9	Siltstone, light gray
			End of Core
138.4	142	3.6	Shale, carbonaceous, dark brownish gray
142	156	14	Shale, silty, medium gray with clayey fine-grained sandstone
156	173	17	Sandstone, light to medium gray, very fine grained, angular to subangular quartz grains.
173	175	2	Limestone, sandy, medium gray
175	190	15	Siltstone, medium gray interbedded with very fine grained sandstone, several hard calcareous layers
190	210	20	Sandstone, medium gray to medium brownish gray, very fine grained, with interbedded siltstone
210	223	13	Siltstone, medium grayish brown, interbedded with carbonaceous shale
223	230	7	Shale, carbonaceous, dark brown, with brownish gray siltstone
230	237	7	Siltstone, dark brown, sandy, carbonaceous
237	248	11	Shale, dark brown, sandy, carbonaceous
248	261	13	Siltstone, medium gray, sandy
261	263	2	Coal WADDLE BED
263	271	8	Shale carbonaceous, dark gray
271	275	4	Shale, medium gray
275	278	3	Siltstone, light gray
278	294	16	Sandstone, very fine grained, light gray, with calcareous lenses
294	306	12	Shale, silty, brownish gray
306	310	4	Shale, carbonaceous, dark brown
310	323	13	Siltstone, light to medium gray
323	337	14	Shale, dark brown to dark gray, carbonaceous, with coal stringer near base
337	360	23	Siltstone, light gray
360	375	15	Siltstone, light gray, sandy
375	378	3	Siltstone, medium gray, sandy
378	384	6	Sandstone, fine grained, light gray with subangular to angular quartz grains
384	395	11	Siltstone, light gray
395	404	9	Shale, medium to dark gray
404	416	12	Shale, light to medium gray
416	420	4	Shale, dark gray
420	431	11	Shale, medium gray

Depth interval (feet) From	To	Thickness	Lithologic Description
431	443	12	Siltstone, light gray interbedded with medium gray shale
443	454	11	Shale, gray, slightly carbonaceous
454	469	15	Shale, dark brown, carbonaceous
469	488	19	Coal ANDERSON BED
488	515	27	Shale, carbonaceous, dark brown
515	545	30	Shale, brownish gray to medium dark gray
545	565	20	Shale, medium brown
565	575	10	Shale, medium gray
575	582	7	Coal DIETZ BED
582	586	4	Shale, medium gray
586	591	5	Siltstone, medium gray
591	596	5	Sandstone, medium gray, very fine grained
596	606	10	Siltstone, medium gray
606	611	5	Shale, medium gray sandy
611	645	34	Sandstone, medium gray, very fine grained
645	650	5	Note (No samples) - probably poorly cemented sandstone
650	655	5	Sandstone, medium gray, very fine grained
655	665	10	Shale, dark brownish gray
665	670	5	Shale, gray sandy
670	675	5	Shale, medium gray, with carbonaceous dark brown shale at base, with coal stringers
675	680	5	Coal
680	682	2	Shale, carbonaceous dark brown } CANYON BED Note: Coal interval reported by driller
682	702	20	Coal
702	715	13	Sandstone, light brownish gray, very fine grained

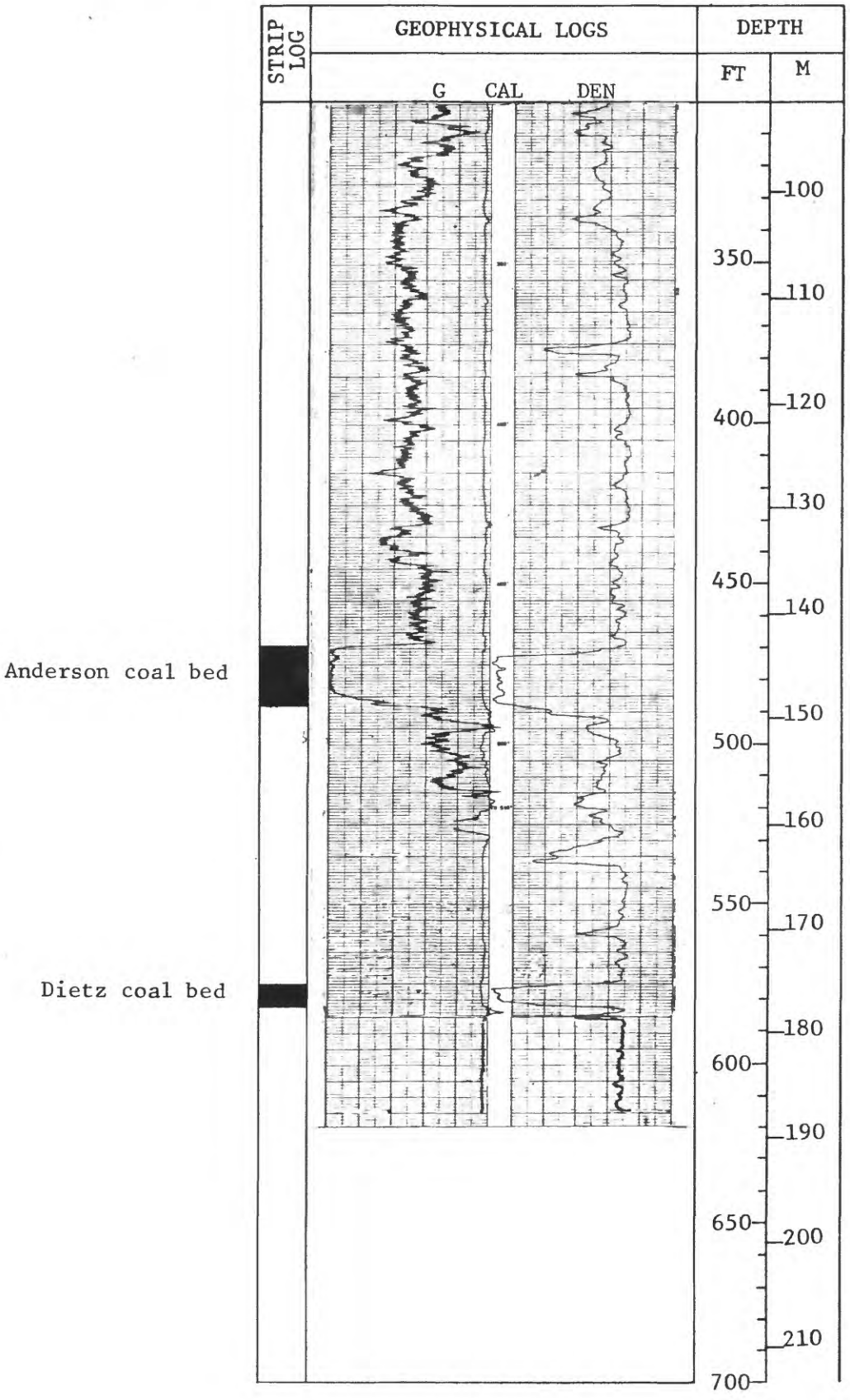
U.S. Geological Survey
Birney 1° x 1/2° Quadrangle

Hole name Otter 7 County Powder River State Montana
Location SW¼SE¼ Sec. 25 T. 9 S. R. 45 E.
Elevation 4230 ft Drilled depth 715 ft Logged depth 615 ft
Drilling medium air and foam Date logged 8/18/80
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 25 cps/in Logging speed 15 fpm
Density (DEN): T.C. 2 Scale 1000 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 2 in/in Logging speed fpm
Resistance (RES): Scale Logging speed fpm
Remarks:



U.S. Geological Survey

Hole name Otter 7 continued



U.S. GEOLOGICAL SURVEY
Birney 1° x ½° quadrangle

Hole Otter #8 Elev. 3890 feet Total depth 655 feet
Location 1600 FSL, 1700 FEL (SW 1/4, SE 1/4) Sec. 35, T. 9 S., R. 46 E.
County Powder River State Mont. Quadrangle Cabin Creek NE 7½'
Drilled by U.S.Geological Survey Driller A. Clark Hole size 5 inches
Date Started 8/26/80 Date Completed 8/26/80 Geologist F. Spencer
Remarks Lithology from 5 ft samples, modified by H. I. Saperstone and W. C. Culbertson to conform with geophysical logs to depth 634

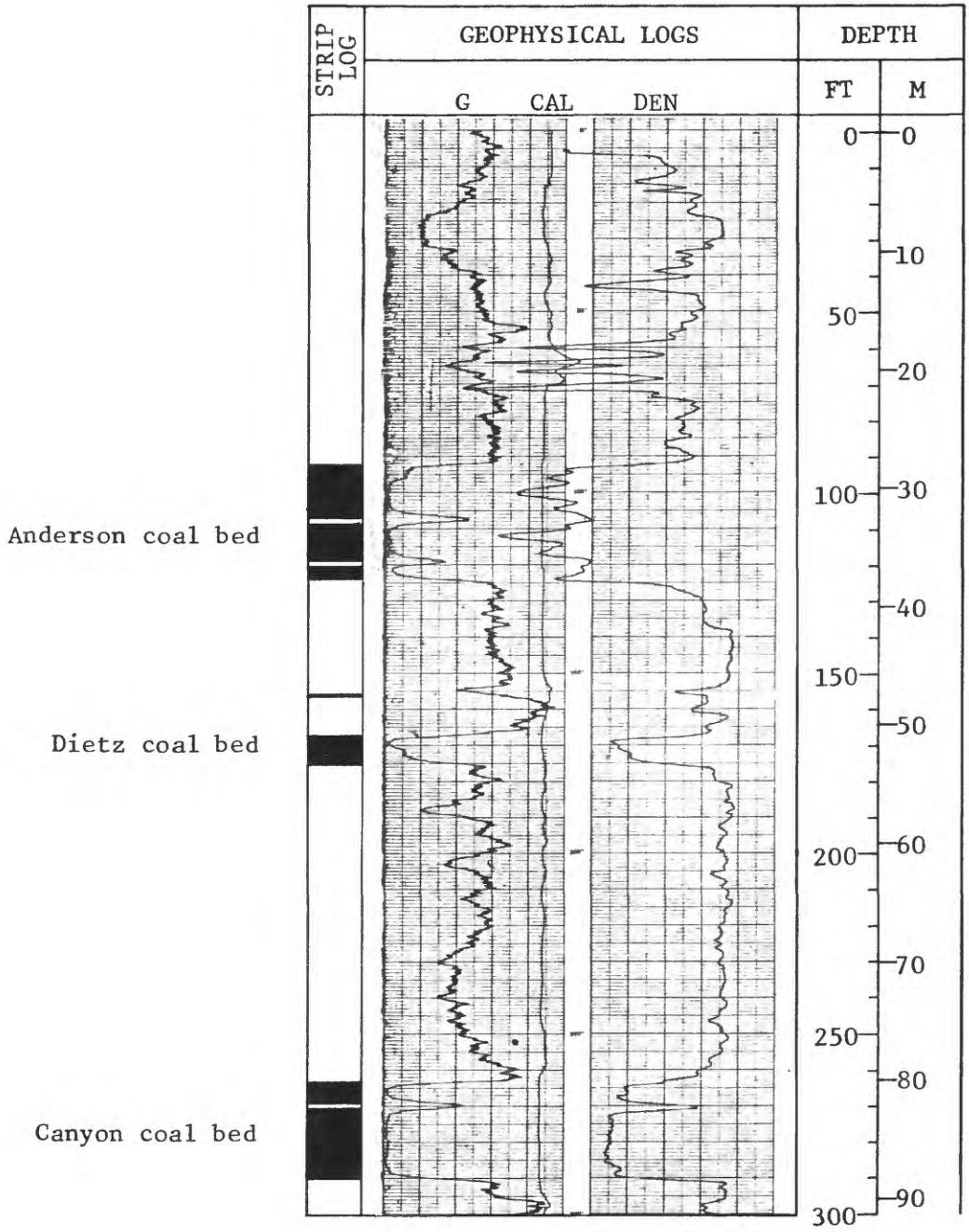
Depth interval (feet) From	To	Thickness	Lithologic Description
0	5	5	Claystone, light yellowish brown
5	10	5	Claystone, medium brownish gray, silty in part, shaley in part
10	16	6	Shale, medium to dark gray
16	22	6	Shale, light to medium gray, silty
22	25	3	Siltstone, medium gray, sandy
25	34	9	Sandstone, light to medium gray, fine grained with thin beds of very fine grained calcareous sandstone
34	41	7	Sandstone, medium gray, fine grained with subangular grains of quartz and black chert
41	56	15	Siltstone, dark gray
56	61	5	Sandstone, dark to medium gray, fine grained
61	64	3	Siltstone, dark brownish gray
64	71	7	Sandstone, medium gray, fine grained with subangular quartz grains and black chert
71	80	9	Siltstone, brownish gray, clayey, interbedded with medium gray sandstone, fine grained
80	85	5	Siltstone, dark brownish gray, shaly and sandy
85	92	7	Shale, carbonaceous dark brownish gray, silty
92	107	15	Coal, black, dull
107	108	1	Shale, carbonaceous
108	119	11	Coal, black, dull } ANDERSON BED
119	120	1	Shale, carbonaceous
120	124	4	Coal, black dull
124.0	155	31	Siltstone, medium dark gray to medium gray
155	156	1	Coal
156	167	11	Siltstone, medium dark gray
167	175	8	Coal, black, dull DIETZ BED
175	185	10	Siltstone, medium gray
185	190	5	Siltstone, light medium gray, very calcareous
190	200	10	Siltstone, medium dark gray, fissile

Depth interval (feet) From	To	Thick-ness	Lithologic Description
200	205	5	Sandstone, medium gray, very fine grained, silty
205	210	5	Siltstone, medium gray, sandy
210	225	15	Siltstone, medium gray
225	229	4	Siltstone, medium gray, sandy
229	247	18	Sandstone, medium gray, very fine grained, silty
247	258	11	Siltstone, medium gray
258	263	5	Shale, carbonaceous, dark gray
263	269	6	Coal, black } CANYON BED
269	270	1	Shale, carbonaceous } CANYON BED
270	290	20	Coal, black } CANYON BED
290	310	20	Siltstone, medium gray, shaly with carbonaceous shale
310	319	9	Shale, medium gray, sandy
319	329	10	Shale, medium gray
329	332	3	Shale, carbonaceous, dark gray
332	338	6	Shale, carbonaceous, with coal stringers
338	350	12	Siltstone, medium gray
350	358	8	Sandstone, medium gray, very fine grained, calcareous
358	363	5	Siltstone, medium gray
363	368	5	Siltstone, medium brownish-gray
368	393	25	Siltstone, medium brownish-gray, sandy
393	400	7	Siltstone, medium brownish-gray, interbedded with sandstone, medium grained; and calcareous sandstone, very fine grained
400	405	5	Siltstone, medium gray
405	411	6	Siltstone, medium gray, sandy
411	415	4	Shale, dark brownish gray, slightly carbonaceous
415	423	8	Shale, carbonaceous, dark brown
423	434	11	Shale, carbonaceous, dark brown with a coal stringer near top
434	442	8	Coal, black, dull COOK BED
442	446	4	Shale, carbonaceous
446	450	4	Siltstone, medium gray
450	491	41	Siltstone, light to medium gray, sandy in part
491	494	3	Coal LOCAL BED
494	500	6	Siltstone, light to medium gray, carbonaceous
500	504	4	Shale, dark brown, carbonaceous, silty in part
504	509	5	Siltstone, light to medium gray
509	520	11	Siltstone, medium brownish gray, sandy
520	530	10	Siltstone, medium brownish gray, with thin very fine grained sandstone interbeds, calcareous in part
530	535	5	Siltstone, light to medium brownish gray
535	538	3	Siltstone, medium brownish gray interbedded with carbonaceous shale

Depth interval (feet) From	To	Thickness	Lithologic Description
538	548	10	Shale, carbonaceous with coal stringers
548	564	16	Siltstone, medium gray, coaly towards base
564	573	9	Coal OTTER BED
573	576	3	Shale, carbonaceous
576	585	9	Coal
585	592	7	Siltstone, dark to medium gray WALL BED
592	597	5	Coal
597	604	7	Shale, carbonaceous
604	607	3	Sandstone, medium gray, very fine grained
607	616	9	Siltstone, medium gray
616	620	4	Shale, medium gray
620	625	5	Sandstone, very fine grained, light brownish gray
625	630	5	Siltstone, medium brownish gray, sandy in part
630	653	23	Siltstone, medium brownish gray, interbedded with carbonaceous shale

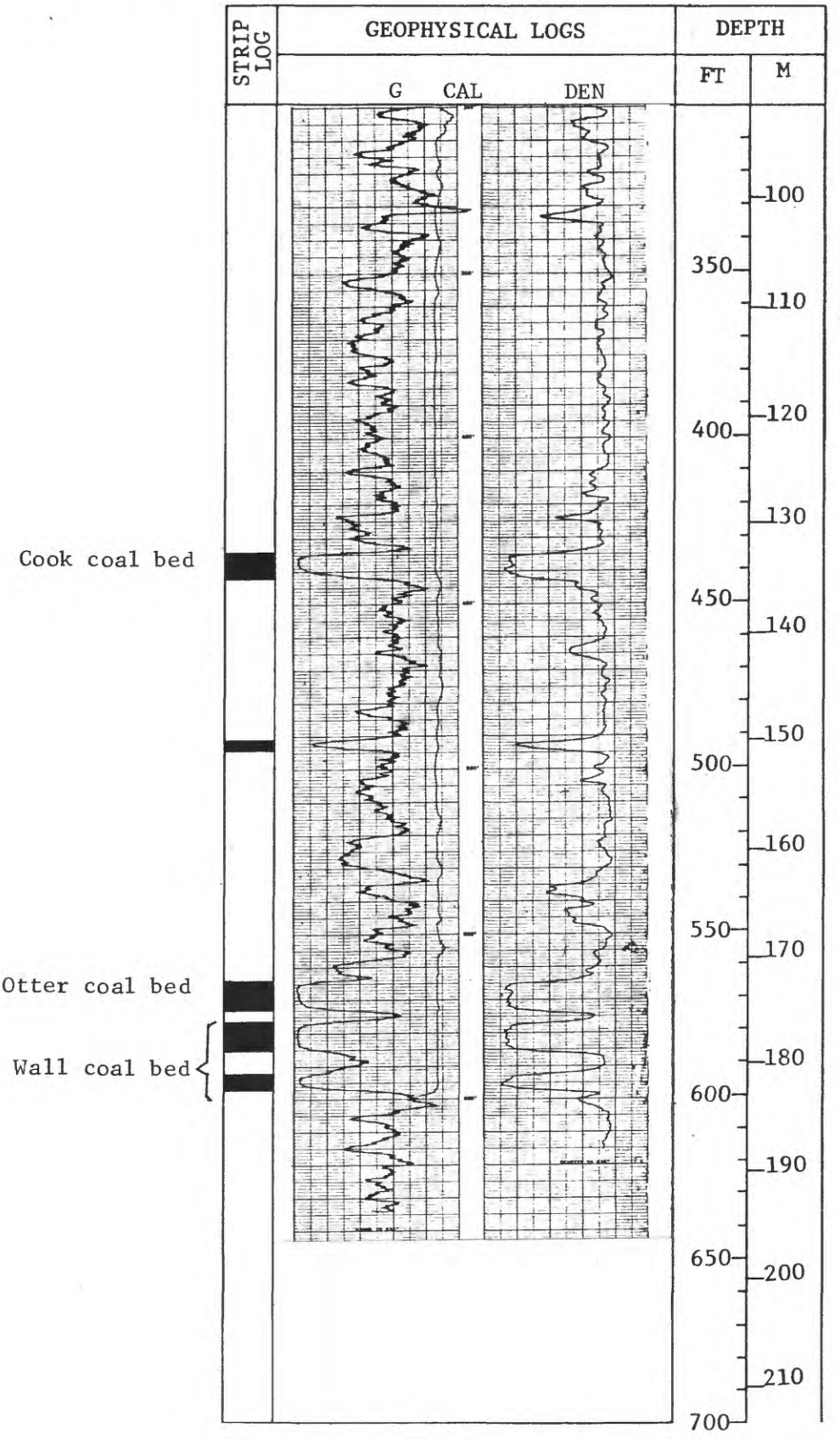
U.S. Geological Survey
Birney 1° x 1/2° Quadrangle

Hole name Otter 8 County Powder River State Montana
Location SW¼SE¼ Sec. 35 T. 9 S. R. 46 E.
Elevation 3890 ft Drilled depth 655 ft Logged depth 634 ft
Drilling medium air and foam Date logged 8/26/80
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 25 cps/in Logging speed 15 fpm
Density (DEN): T.C. 2 Scale 1000 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 2 in/in Logging speed fpm
Resistance (RES): Scale Logging speed fpm
Remarks:



U.S. Geological Survey

Hole name Otter 8 continued



U.S. GEOLOGICAL SURVEY
Birney 1° x ½° quadrangle

Hole Otter #9 Elev. 3790 feet Total depth 755 feet

Location 100 FWL, 1700 FNL (SW 1/4, NW 1/4) Sec. 2 , T. 6 S., R. 46 E.

County Powder River State Mont. Quadrangle Goodspeed Butte 7 ½'

Drilled by U.S.Geological Survey Driller A. Clark Hole size 5 inches

Date Started 9/9/80 Date Completed 9/10/80 Geologist F. Spencer & W.C. Culbertson

Remarks Composite of a core and sample log. In sample log, lithology from 5 ft samples, modified by H. I. Saperstone and W. C. Culbertson to conform with geophysical logs to depth 745

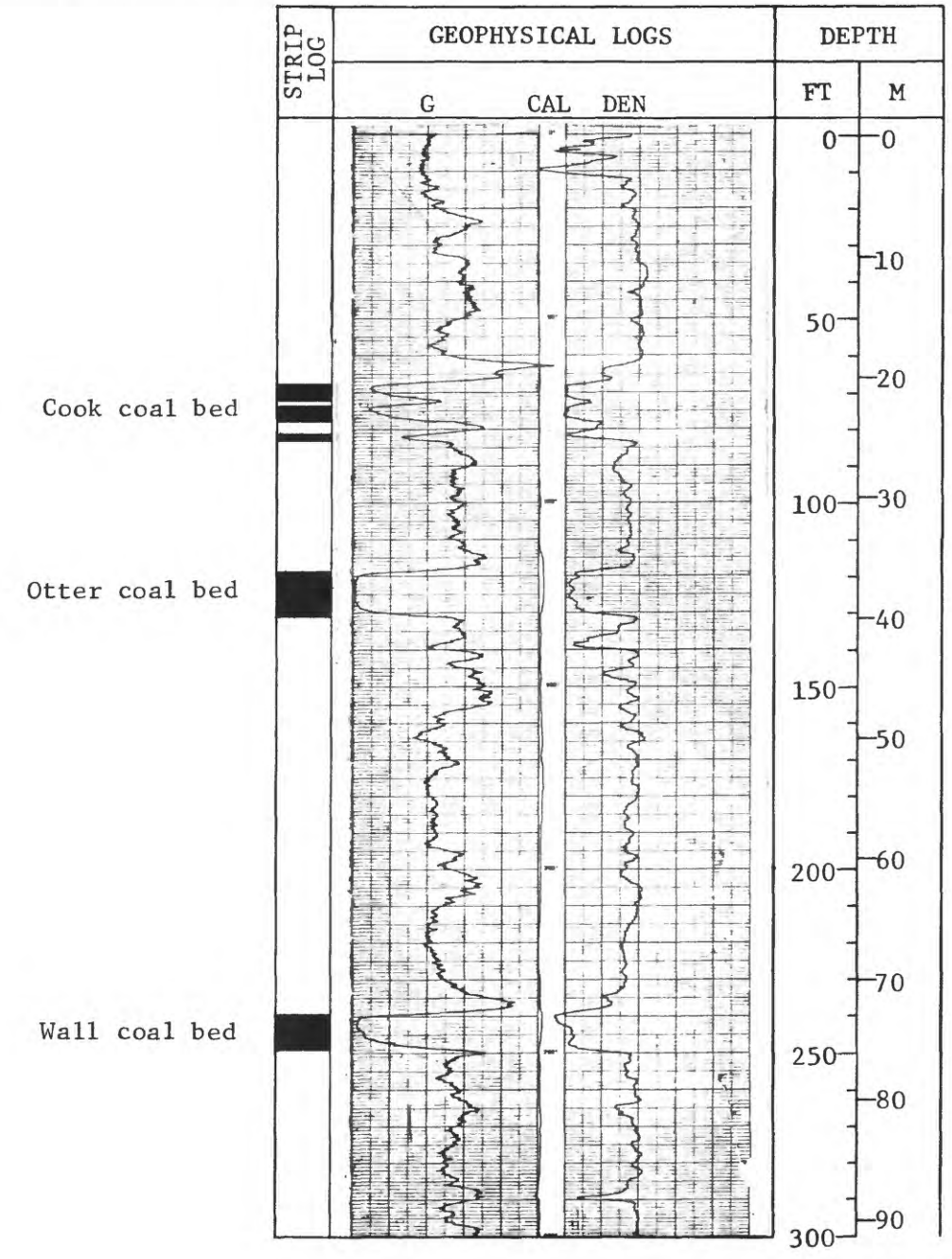
Depth interval (feet) From	To	Thickness	Lithologic Description	
0	5	5	Siltstone, yellowish brown	
5	7	2	Limestone, sandy, light gray	
7	21	14	Sandstone, fine grained, medium light gray to yellowish brown, poorly consolidated.	
21	27	6	Shale, yellowish brown	
27	33	6	Sandstone, fine grained, yellowish brown, friable	
33	41	8	Siltstone, yellowish brown to light gray	
41	55	14	Shale, silty, light olive gray	
			Begin Core Description	
55.0	55.2	0.2	Sandstone, very fine grained, light gray	
55.2	57.4	2.2	Siltstone, medium gray	
57.4	61.9	4.5	Sandstone, very fine to fine grained, medium gray	
61.9	63.2	1.3	Siltstone, medium gray, carbonaceous at base	
63.2	66.7	3.5	Shale, carbonaceous, with coaly stringers; near top are mollusk shell fragments as much as 3/8 inch thick	
66.7	67.0	0.3	Core lost, probably coal	COOK BED
67.0	72.0	5.0	Coal	
72.0	72.9	0.9	Shale, carbonaceous and coaly	
72.9	77.9	5.0	Coal	
77.9	79.7	1.8	Shale, carbonaceous, sandy at base	
			End of core description	
79.7	81	1.3	Shale, carbonaceous, brownish black	
81	83	2	Coal	
83	87	4	Sandstone, fine grained, light gray, poorly cemented	
87	92	5	Shale, light gray	
92	102	10	Shale, medium gray	
102	108	6	Siltstone, medium light gray	
108	114	6	Shale, silty, medium light gray	
			Begin core description	

Depth interval (feet) From	To	Thickness	Lithologic Description
114.0	117.2	3.2	Shale, medium gray, with coal stringers
117.2	118.5	1.3	Shale, dark to medium gray carbonaceous with mollusk shell fragments near base
118.5	131.0	12.5	Coal, dark brown to black OTTER BED
131.0	132.3	1.3	Shale, medium gray
132.3	135.8	3.5	Sandstone, medium gray, very fine grained, clayey at base
135.8	137.0	1.2	Sandstone, medium gray
			End Core Description
137	140	3	Siltstone, light gray, limy
140	156	16	Shale, brownish gray to medium gray, interbedded with siltstone
156	162	6	Shale, silty, light gray to yellowish brown
162	202	40	Sandstone, very fine grained, light gray, poorly cemented
202	210	8	Shale, silty, medium gray
210	220	10	Siltstone, medium light gray, clayey in part
220	230	10	Sandstone, very fine grained, light gray
230	235	5	Shale, silty, light gray
235	239	4	Shale, carbonaceous, brownish gray
239	249	10	Coal WALL BED
249	260	11	Shale, medium gray to medium light gray, silty in part
260	267	7	Siltstone, light gray
267	272	5	Sandstone, very fine grained light gray
272	276	4	Siltstone, light brownish gray
276	286	10	Sandstone, fine grained to very fine grained light gray, poorly cemented
286	301	15	Siltstone, carbonaceous, brownish gray, interbedded with light gray shale
301	310	9	Siltstone, light gray
310	320	10	Sandstone, light gray; very fine grained, silty in part
320	324	4	Shale, medium gray, carbonaceous at base
324	339	15	Coal POKER JIM BED
339	343	4	Shale, carbonaceous
343	353	10	Siltstone, medium gray, sandy
353	360	7	Sandstone, medium gray, very fine grained
360	366	6	Siltstone, medium gray
366	409	43	Sandstone, medium gray very fine grained
409	414	5	Siltstone, medium gray, sandy
414	465	51	Sandstone, light to medium gray very fine grained
465	470	5	Siltstone, medium gray, sandy
470	485	15	Sandstone, medium gray, very fine grained, silty
485	490	5	Siltstone, medium gray, sandy
490	500	10	Siltstone, light gray, sandy
500	507	7	Sandstone, light gray, very fine grained
507	512	5	Siltstone, light gray, sandy
512	522	10	Shale, medium gray

Depth interval (feet) From	To	Thickness	Lithologic Description
522	529	7	Coal — ODELL BED
529	533	4	Shale, medium gray, carbonaceous
533	536	3	Sandstone, medium gray, very fine grained
536	538	2	Shale, medium gray with fracture-filled pyrite
538	545	7	Sandstone, medium to light gray
545	547	2	Siltstone with coal stringers
547	594	47	Sandstone medium gray, very fine grained; silty, calcareous in lower part
594	600	6	Siltstone medium gray
600	610	10	Sandstone, medium gray, very fine grained
610	616	6	Siltstone
616	621	5	Shale, carbonaceous, dark brown
621	644	23	Shale, carbonaceous, dark gray, interbedded with medium to dark brown siltstone
644	651	7	Sandstone, medium to light gray, very fine grained
651	655	4	Siltstone, medium gray
655	673	18	Sandstone, medium gray, very fine grained to fine grained towards base
673	675	2	Siltstone, medium gray
675	679	4	Coal — KING BED
679	689	10	Shale, carbonaceous
689	712	23	Coal — KNOBLOCH BED
712	722	10	Sandstone, medium brownish gray, very fine grained to fine grained
722	731	9	Siltstone, medium gray
731	741	10	Sandstone, medium gray, very fine grained
741	743	2	Coal
743	752	9	Shale, carbonaceous, dark brown
752	755	3	Siltstone, medium brownish gray

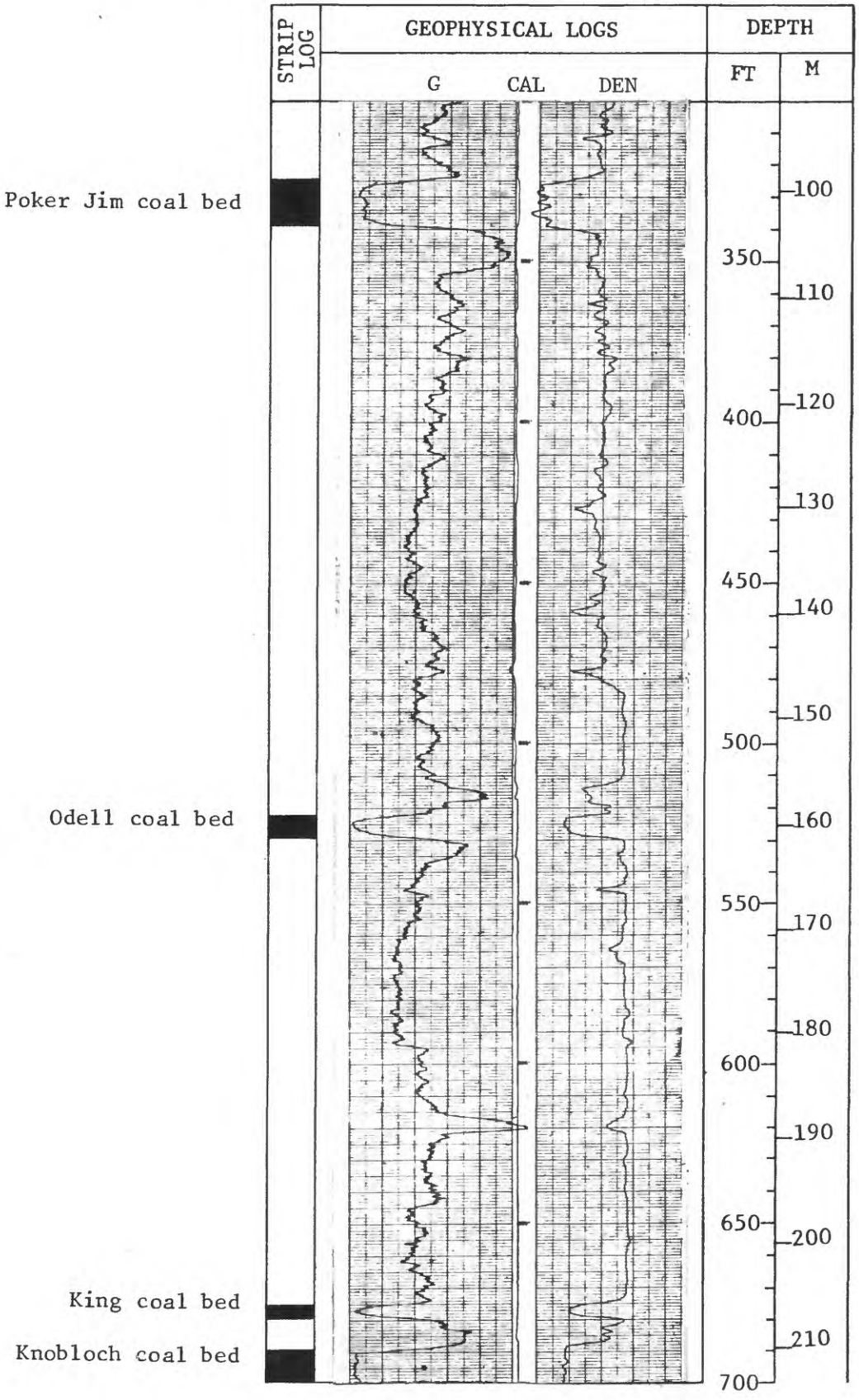
U.S. Geological Survey
Birney 1° x 1/2° Quadrangle

Hole name Otter 9 County Powder River State Montana
Location SW¼NW¼ Sec. 2 T. 6 S. R. 46 E.
Elevation 3790 ft Drilled depth 755 ft Logged depth 745 ft
Drilling medium air and foam Date logged 9/10/80
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 25 cps/in Logging speed 15 fpm
Density (DEN): T.C. 2 Scale 125 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 4 in/in Logging speed fpm
Resistance (RES): Scale Logging speed fpm
Remarks:



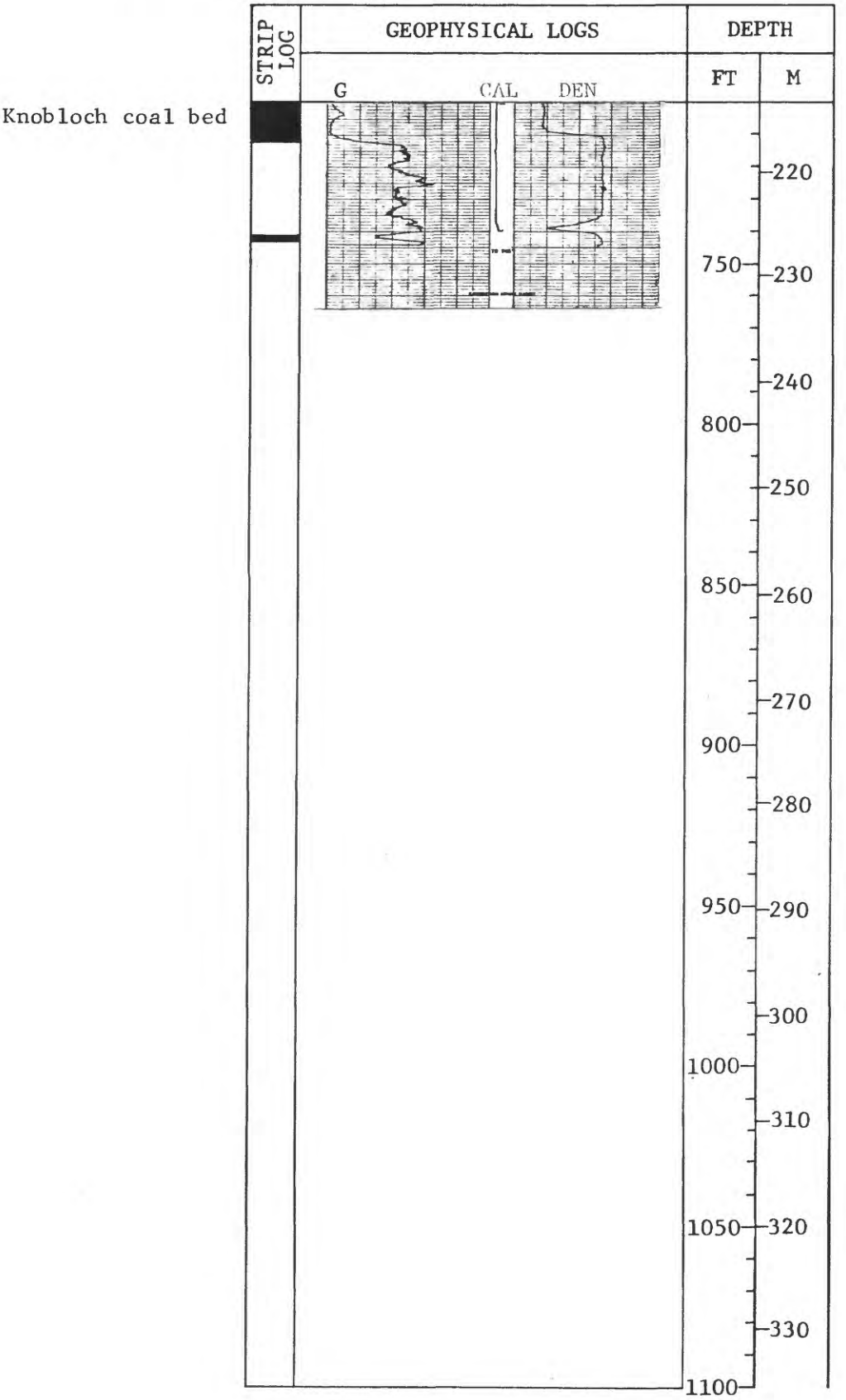
U.S. Geological Survey

Hole name Otter 9 continued



U.S. Geological Survey

Hole name Otter 9 continued



U.S. GEOLOGICAL SURVEY
Birney 1° x ½° quadrangle

Hole Otter #10 Elev. 3920 feet Total depth 985 feet

Location 1400 ft fnl, 300 ft fwl (SW ¼, NW ¼) Sec. 28, T. 7 S., R. 46 E.

County Powder River State Montana Quadrangle Reanus Cone 7 ½'

Drilled by U.S.Geological Survey Driller S. Grant & S. Roberts Hole size 5 inches

Date Started 8/27/80 Date Completed 8/28/80 Geologist T. Moore & F. Spencer

Remarks Lithology from 5 ft samples, modified by H. I. Saperstone and W. C. Culbertson to conform with geophysical logs to depth 971

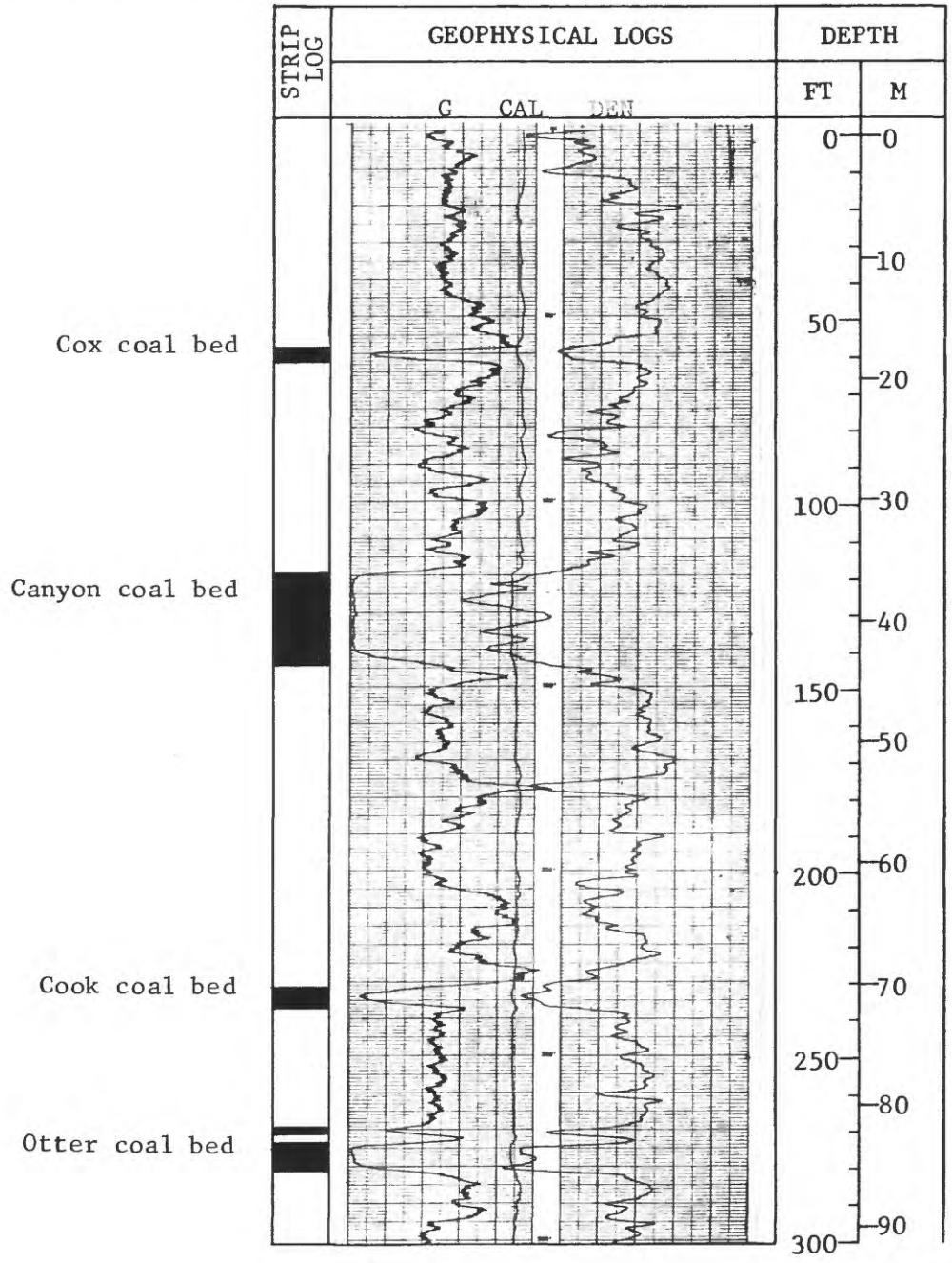
Depth interval (feet) From	To	Thickness	Lithologic Description
0	5	5	Sandstone, medium gray, very fine grained
5	20	15	Siltstone, light-medium gray, sandy
20	22	2	Siltstone, light-medium gray, shaly
22	25	3	Sandstone, brownish-tan, shaly
25	28	3	Sandstone, medium gray, very fine grained, calcareous in part
28	45	17	Sandstone, brownish-tan, very fine grained
45	50	5	Siltstone, dark brownish-tan
50	52	2	Siltstone, medium dark-gray, with some carbonaceous shale
52	58	6	Shale, medium dark-gray, carbonaceous
58	62	4	Coal COX BED
62	73	11	Shale, carbonaceous, medium to dark brownish-gray, sandy in part
73	82	9	Shale, medium gray, sandy
82	88	6	Siltstone, medium brown
88	92	4	Sandstone, light brownish-gray, fine grained with chert
92	100	8	Siltstone, medium gray
100	114	14	Siltstone, medium brownish gray, shaly, sandy
114	119	5	Shale, carbonaceous, medium-dark brownish-gray
119	144	25	Coal, black, dull CANYON BED
144	148	4	Shale, carbonaceous, dark brownish gray
148	150	2	Shale, medium gray
150	171	21	Siltstone, medium-light gray, shaley towards base
171	178	7	Shale, carbonaceous, dark brownish-gray
178	189	11	Shale, medium-dark gray
189	204	15	Siltstone, medium gray, shaly
204	215	9	Shale, carbonaceous, dark brownish gray interbedded with medium dark gray shale
215	225	10	Siltstone, medium gray, carbonaceous
225	231	6	Shale, carbonaceous, dark brownish gray with coal stringers
231	237	6	Coal, dull, black COOK BED
237	269	32	Siltstone medium gray

Depth interval (feet) From	To	Thick-ness	Lithologic Description	
269	271	2	Coal	OTTER BED
271	273	2	Shale, medium gray	
273	281	8	Coal	
281	295	14	Shale, carbonaceous, medium gray	
295	340	45	Siltstone, medium gray	
340	345	5	Shale, dark gray	
345	350	5	Shale, very carbonaceous, dark brownish-gray interbedded with coal stringers	
350	362	12	Siltstone light to medium gray, sandy	
362	383	21	Siltstone, shaly, medium gray	
383	388	5	Coal	WALL BED
388	390	2	Shale, carbonaceous, dark gray	
390	404	14	Siltstone, light gray, sandy	
404	425	21	Siltstone dark brown carbonceous	
425	428	3	Shale, carbonaceous, dark brown	
428	441	13	Siltstone, light to medium gray, sandy	
441	444	3	Shale, carbonaceous, dark brown with coal stringers	
444	456	12	Sandstone, medium to dark gray, very fine grained with carbonaceous shale streaks	
456	460	4	Siltstone, light gray, sandy	
460	465	5	Siltstone, dark brownish gray with carbonaceous shale	
465	475	10	Siltstone, medium gray, sandy	
475	482	7	Siltstone, medium gray	
482	486	4	Shale, carbonaceous, dark brown	
486	494	8	Siltstone, medium gray	
494	506	12	Shale, carbonaceous, dark brown, with a coal stringer	
506	565	59	Siltstone, light gray, sandy	
565	571	6	Sandstone, light yellowish gray, very fine-grained	
571	581	10	Siltstone, light gray, sandy	
581	594	13	Siltstone, light gray, interbedded with carbonaceous dark brown shale with abundant coal stringers	
594	600	6	Shale, carbonaceous, with thin light-gray siltstone beds	
600	605	5	Siltstone, light gray	
605	615	10	Siltstone, medium gray	
615	625	10	Sandstone, light gray, very fine grained, silty	
625	628	3	Coal, bright	POKER JIM BED
628	644	16	Siltstone, medium gray with carbonaceous shale	
644	690	46	Siltstone, medium gray, light greenish gray, and brownish gray, sandy in part	
690	715	25	Sandstone, medium gray, very fine to fine grained, with subangular quartz grains	
715	719	4	Shale, dark grayish-brown, slightly carbonaceous	
719	732	13	Siltstone, light to medium gray	
732	737	5	Shale, medium gray, silty in part	
737	759	22	Siltstone, medium gray	

Depth interval (feet) From	To	Thickness	Lithologic Description
759	762	3	Shale, medium gray
762	768	6	Siltstone, medium gray
768	772	4	Sandstone, medium gray, very fine grained
772	795	23	Siltstone, medium gray, shaley
795	812	17	Sandstone, medium to light gray, very fine grained to fine grained with black chert
812	817	5	Sandstone, medium gray, fine grained with black chert and sub-angular quartz grains
817	830	13	Siltstone, medium gray
830	839	9	Shale, carbonaceous, dark brown
839	844	5	Siltstone, light yellowish gray
844	849	5	Siltstone, medium brownish gray
849	851	2	Coal KING BED
851	860	9	Siltstone, medium brown
860	864	4	Siltstone, medium gray
864	878	14	Siltstone, medium gray, interbedded with light gray calcareous sandstone lenses
878	885	7	Siltstone, medium gray, interbedded with sandstone
885	890	5	Siltstone, medium gray
890	901	11	Siltstone, medium brownish gray
901	908	7	Shale, dark gray
908	916	8	Siltstone, dark gray interbedded with very fine grained sandstone
916	920	4	Shale, carbonaceous, dark brown
920	940	20	Coal KNOBLOCH BED
940	957	17	Siltstone, medium gray
957	961	4	Sandstone, medium gray, very fine grained
961	967	6	Siltstone, light to medium gray
967	970	3	Coal
970	976	6	Shale, carbonaceous
976	981	5	Siltstone, light brownish gray
981	985	4	Siltstone, light medium gray

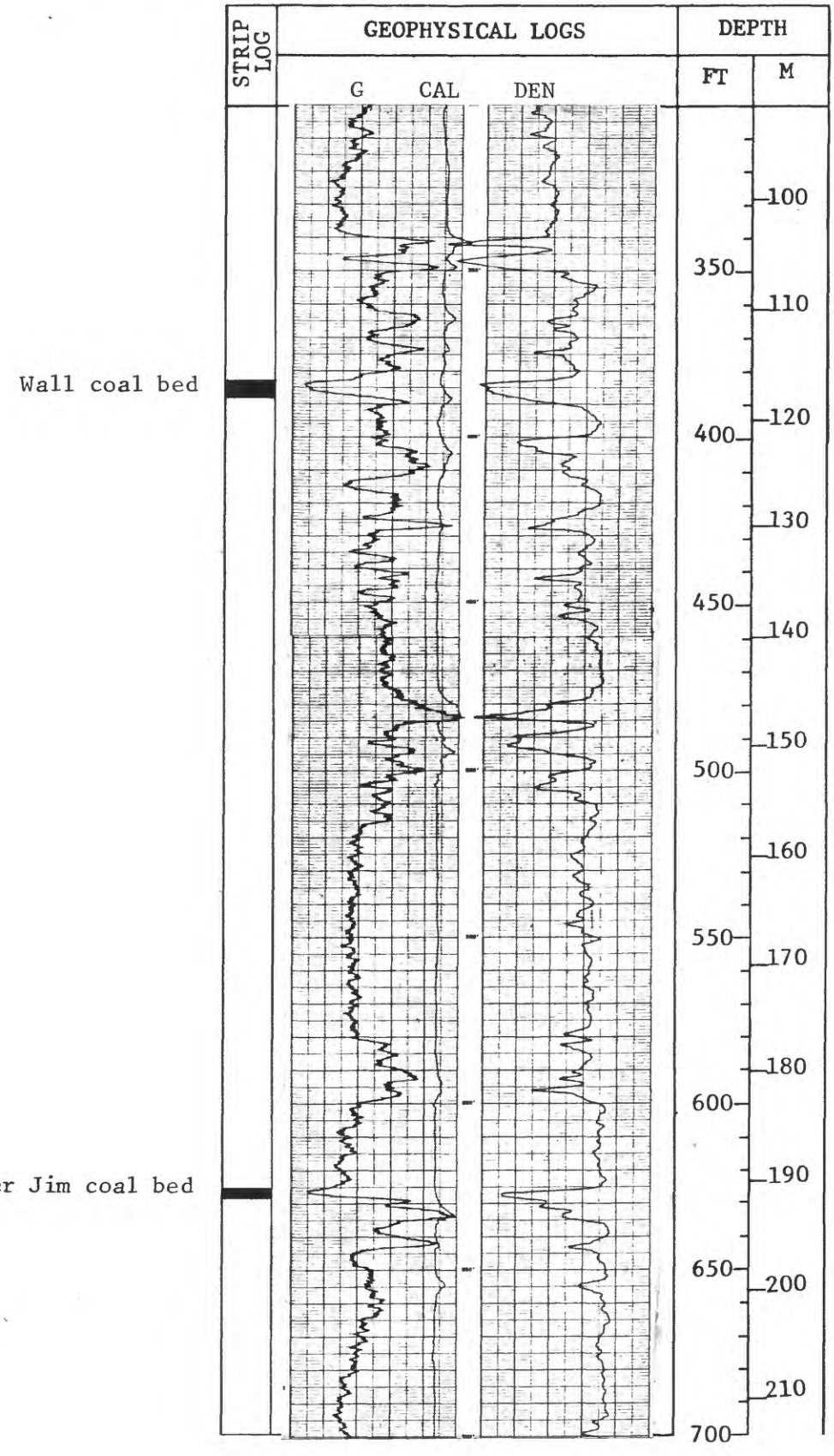
U.S. Geological Survey
Birney 1° x 1/2° Quadrangle

Hole name Otter 10 County Powder River State Montana
Location SW¼NW¼ Sec. 28 T. 7 S. R. 46 E.
Elevation 3920 ft Drilled depth 985 ft Logged depth 971 ft
Drilling medium air and foam Date logged 8/28/80
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 25 cps/in Logging speed 15 fpm
Density (DEN): T.C. 2 Scale 1000 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 2 in/in Logging speed fpm
Resistance (RES): Scale Logging speed fpm
Remarks:



U.S. Geological Survey

Hole name Otter 10 continued



U.S. Geological Survey

Hole name Otter 10 continued