United States Department of the Interior

Geological Survey

Coal Exploratory Drilling during 1979 in Western Powder River County, Montana

by

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Introduction

In 1979, during August through November, the U. S. Geological Survey drilled 36 coal exploratory holes in the Moorhead and Birney-Broadus coal fields, western Powder River County, Montana (fig. 1). At seven locations several intervals were cored, in offset holes, to obtain samples of major coal beds (table 1). This drilling is part of a program, started in 1975, to evaluate the quantity and quality of coal in the northern Powder River Basin, and to clarify the correlation of coal beds among the Recluse, Wyoming, $1^{o} \times 1/2^{o}$ quadrangle, and the Birney and Broadus, Montana, $1^{o} \times 1/2^{o}$ quadrangles where coal resource investigations are now in progress (fig. 2). Previously, Hobbs and others (1977), Hobbs (1980), and Correia (1980), reported on the drilling in the Recluse geologic area, Campbell County, Wyoming; Hardie (1979) reported on a line of holes drilled northward into the Broadus area in Powder River County.

Geological study and drilling on this project were accomplished by U.S. Geological Survey equipment and personnel. Assistance in the field was provided by Robert Hobbs, Richard Babcock, Frank Spencer, Jim Boaz, and Linda Berlage. A special acknowledgement is given to project chief R. G. Hobbs. Geophysical logging was contracted to three companies; suites of geophysical logs consisting of natural gamma, calibrated density, resistivity and caliper were run on each of the holes. The geophysical logs were recorded at a vertical scale of 1 inch equals 10 feet and were reduced to approximately 1 inch equals 50 feet for publication. A lithologic description was made of samples of drill cuttings taken at 5 foot intervals. Depths and thicknesses were interpreted from geophysical logs. A strip log is provided for each of the geophysical logs showing generalized coal bed thicknesses; partings less than a foot in thickness have not been shown at this scale.

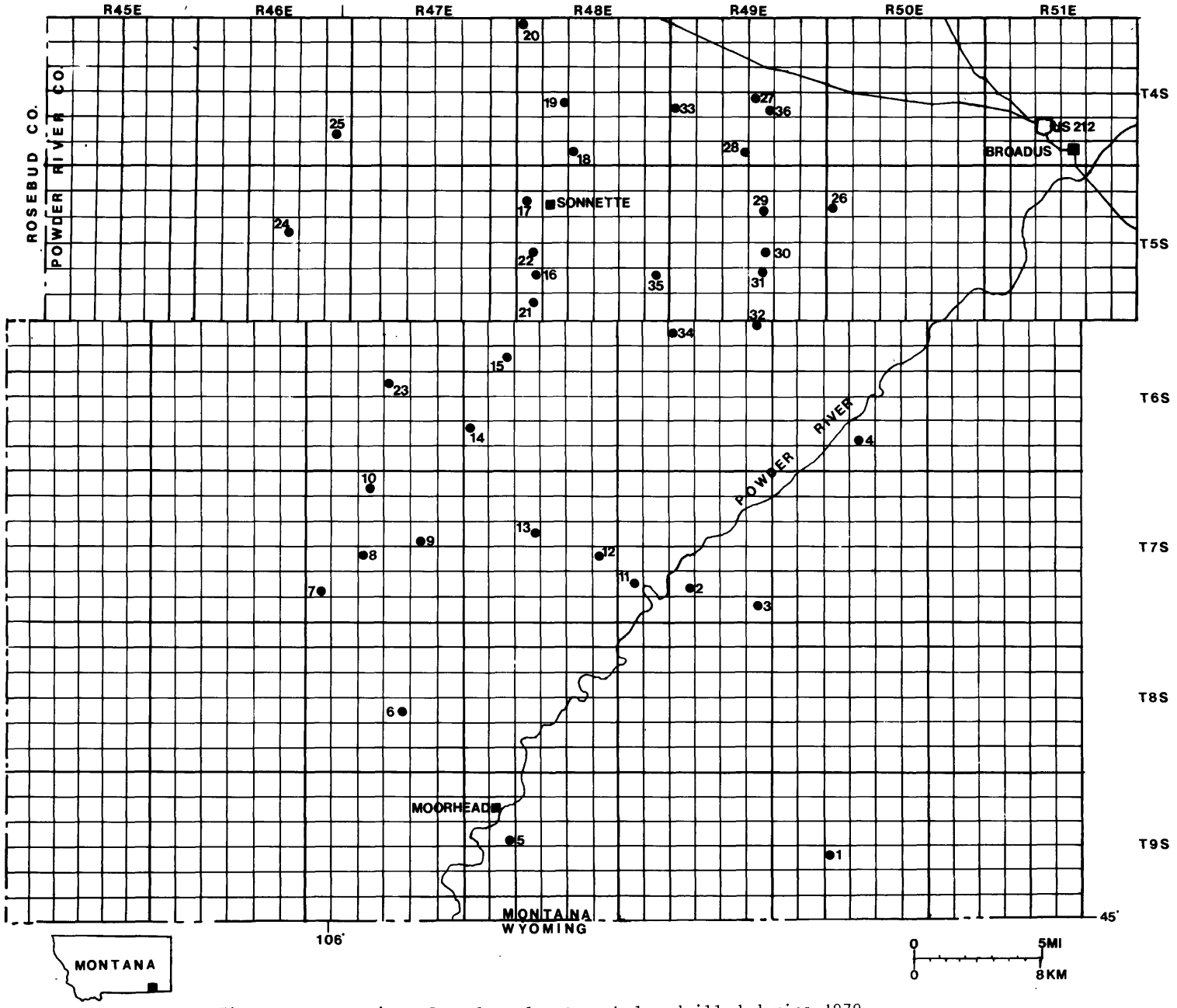


Fig. 1. -- Location of coal exploratory holes drilled during 1979

Table 1.--Drill hole location and other data

Well no.	Location	Surface elevation	Total depth	Cored interval	Remarks
MB-1C	300 fwl, 2150 fnl sec. 21, T. 9 S., R. 50 E	4020	126.6	19.5-65 90 -126.6	No log available, core hole offset to rotary hole 78BR5 in 1978.
MB-2	350 fel, 2200 fsl sec. 28, T. 7 S., R. 49 E	3325	465		Completed as water well
MB-3	880 fnl, 2450 fwl sec. 36, T. 7S., R. 49 E	3600	595		
MB-3C	900 fnl, 2450 fwl sec. 36, T. 7S., R. 49 E.	3600	175	135-175	
MB-4	300 fsl, 1350 fwl sec. 27, T. 6 S., R. 50 E.	3320	415		
MB-5	450 fel, 900 fsl sec. 17, T. 9 S., R. 48 E.	3690	615		
MB-6	1050 fel, 2500 fsl sec. 22, T. 8 S., R. 47 E.	4200	795		
MB-6C	1075 fel, 2500 sec. 22, T. 8 S., R 47 E.	4200	454	236-296.2 372-406.5	
MB-7	1200 fsl, 2000 fel sec. 30, T. 7 S., R. 47 E.	3790	535		
MB-8	100 fwl, 1100 fnl sec. 21, T. 7 S., R. 47 E.	3905	535		Completed as water well.
MB-9	450 fsl, 1650 fwl sec. 14, T. 7 S., R. 47 E.	4180	875		
MB-10	1000 fsl, 2650 fel sec. 4, T. 7 S., R. 47 E.	3960	535		
MB-11	1900 fel, 2000 fnl sec. 30, T. 7 S., R. 49 E.	3340	435		
MB-12	500 fwl 2100 fnl sec. 24, T. 7 S., R. 48 E.	3430	550		Completed as water well.
MB-13	550 fel, 2500 fnl sec. 16, T. 7 S., R. 48 E.	3560	375		Hole abandoned due to severe caving, - no log available moved to 13A.
MB-13A	600 fel, 2650 fnl sec. 16, T. 7 S., R. 48 E.	3580	605		

Table 1.--Drill hole location and other data--Continued

Well no.	Location	Surface elevation	Total depth	Cored interval	Remarks
MB-14	500 fwl, 650 fnl sec. 30, T. 6 S., R. 48 E.	4020	595		Hole caved below 350'.
MB-15	900 fel, 2100 fnl sec. 8, T. 6 S., R. 48 E.	4180	515		
MB-16	600 fnl, 900 fel sec. 30, T. 5 S., R. 48 E.	4100	555		
MB-17	1850 fwl, 1900 fnl sec. 7, T. 5 S., R. 48 E.	3905	515		
MB-18	500 fwl, 2000 fnl sec. 33, T. 4 S., R. 48 E.	3730	495		
MB-19	100 fel, 2400 fnl sec. 20, T. 4 S., R. 48 E.	3730	615		
MB-19C	150 fel, 2400 fnl sec. 20, T. 4 S., R. 48 E.	3730	426	60 - 90.2 399 - 424.5	
MB-20	650 fwl, 750 fnl sec. 6, T. 4 S., R. 48 E.	3565	690		
MB-21	1700 fnl, 1750 fel sec. 31, T. 5 S., R. 48 E.	4220	515		
MB-22	1400 fel, 1900 fnl sec. 19, T. 5 S., R. 48 E.	3960	455		
MB-22C	1450 fel, 1900 fnl sec. 19, T. 5 S., R. 48 E.	3960	421.6	32 - 43.3 79.8-106.4 172.2-186.9 395 -421.6	
MB-23	350 fwl, 2200 fnl sec. 15, T. 6 S., R. 47 E.	4080	760		
MB-24	1900 fel, 2150 fsl sec. 15, T. 5 S., R. 46 E.	3735	275		
MB-25	1600 fsl, 2200 fwl sec. 25, T. 4 S., R. 46 E.	3805	460		
MB-26	750 fwl, 1550 fsl sec. 7 T. 5 S., R. 50 E.	3705	615		

Table 1.--Drill hole location and other data--Continued

Well no.	Location	Surface elevation	Total depth	Cored interval	Remarks
MB-27	700 fwl, 1050 fnl sec. 22, T. 4 S., R. 49 E.	3435	370		Logger broke down. Log Available from 235′ - 367′.
MB-28	150 fel, 1850 fnl sec. 33, T. 4 S., R. 49 E.	3510	495		
MB-29	450 fsl, 2200 fel sec. 10, T. 5 S., R. 49 E.	3685	615		Hole caved - unable to log. No geophysical log run.
MB-30	1300 fel, 1950 fnl sec. 22, T. 5 S., R. 49 E.	3410	389		
MB-30C	1250 fel, 1950 fnl sec. 22, T. 5 S., R. 49 E.	3410	326.5	293-326.5	No log available.
MB-31	600 fnl, 2100 fel sec. 27, T. 5 S., R. 49 E.	3450	395		
MB-32	350 fnl, 1800 fwl sec. 1, T. 6 S., R. 49 E.	3425	395		
MB-33	750 fwl, 1100 fsl sec. 19, T. 4 S., R. 49 E.	3625	635		
MB-34	100 fwl, 2600 fnl sec. 4, T. 6 S., R. 49 E.	3560	515		
MB-35	1200 fnl, 1900 fwl sec. 25, T. 5 S., R. 48 E.	3725	299		
MB-36	200 fel, 1150 fsl sec. 22, T. 4 S., R. 49 E.	3435	555		

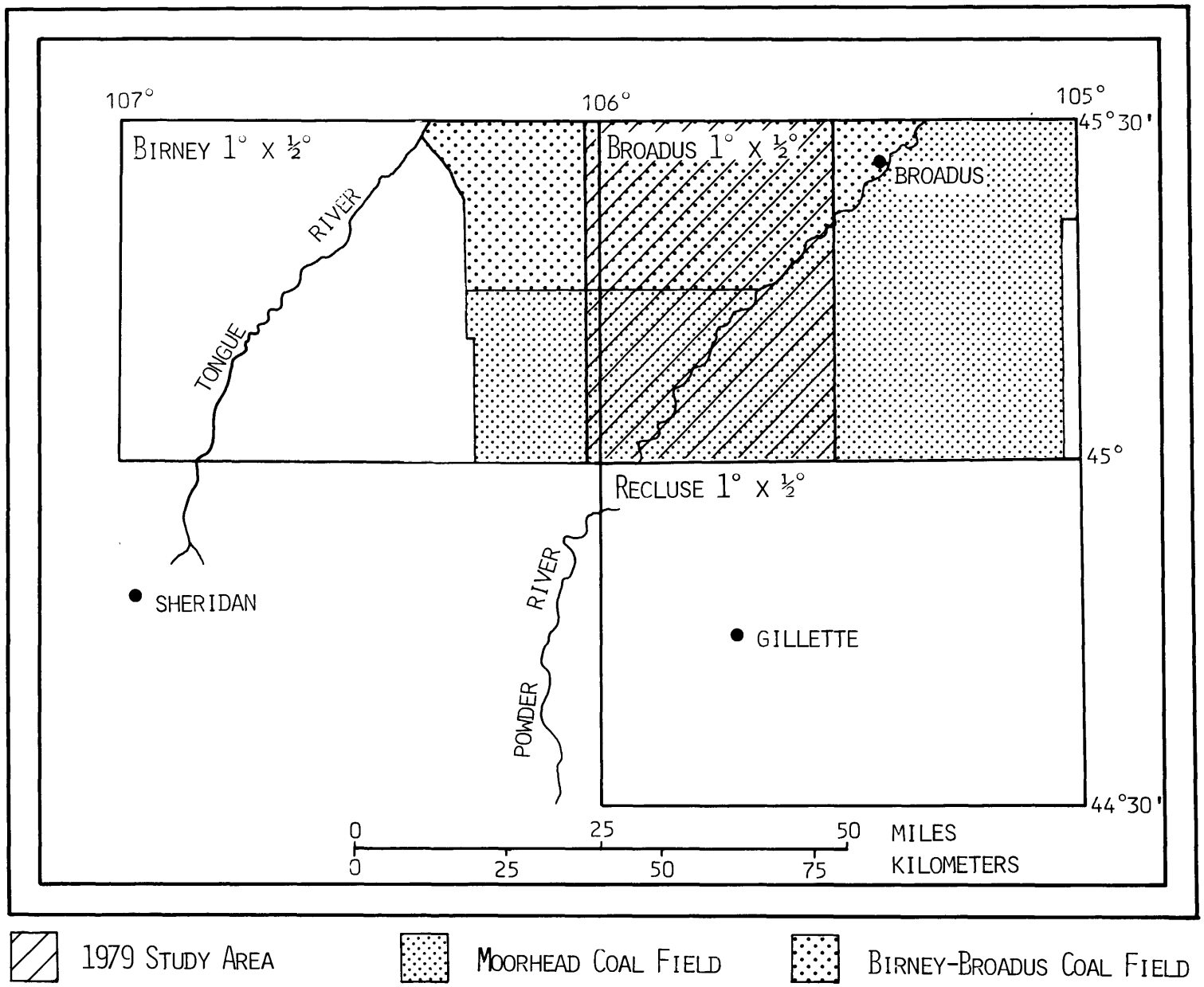


FIGURE 2. - INDEX MAP SHOWING LOCATIONS OF STUDY AREA, COAL FIELDS, AND 1° X ½° QUADRANGLES.

Cored intervals were described in the office and are presented with lithologic descriptions and geophysical logs in the appendix of this report.

In the course of drilling, assistance was provided to several Government agencies. The U. S. Department of Energy collected data for their National Uranium Resource Evaluation and Methane Desorption programs. Drill holes MB-2, MB-8, and MB-12 were completed as observation water wells for the U. S. Geological Survey and the U.S. Forest Service. Special rock core samples were collected for the Bureau of Land Management's overburden and U.S. Geological Survey's paleomagnetic studies.

Geologic Setting

The Moorhead and Birney-Broadus coal fields are located in the northern Powder River Basin where the Paleocene Fort Union Formation dips gently to the southwest.

In the study area the Fort Union Formation consists of two members: the lower member and the overlying Tongue River Member. Elsewhere in the basin, the lower member is differentiated into the Tullock and Lebo Shale Members.

The lower member does not crop out in the report area. A few miles to the east it is exposed on outcrop and is described as consisting of gray to dark gray shale with some interbedded sandstone, siltstone, and thin local coal beds (Bryson and Bass, 1973). Drill holes MB-26, MB-28, MB-30, MB-34 and MB-36 probably penetrated the lower member, but the location of the contact was not recognized because no sharp change in lithology was observed; consequently the lower member was not differentiated from the Tongue River Member in this report.

The Tongue River Member contains most of the coal in the Fort Union Formation. The coal-bearing rocks consist of sandstone, siltstone, shale, carbonaceous shale, and thin lenticular beds of argillaceous limestone. The rocks are poorly consolidated with the exceptions of calcareous sandstones and the argillaceous limestones. Coal beds that have burned on outcrop bake and fuse overlying rocks into brittle reddish rock called clinker that forms erosion-resistant buttes and ridges along major stream drainages.

References

Bryson, R. P. and Bass, N. W., 1973, Geology of Moorhead Coal Field, Powder River, Big Horn, and Rosebud Counties, Montana: U. S. Geological Survey Bulletin 1338, 116 p.

Correia, G. A., 1980, Preliminary results of 1978 coal assessment drilling in northern and western Recluse Geologic Analysis area, northern Campbell County and eastern Sheridan County, Wyoming: U. S. Geological Survey Open-File Report 80-80, 72 p.

Hardie, J. K., 1979, Preliminary report of coal exploration drilling in the Broadus area, Powder River County, Montana, during 1978: U. S. Geological Survey Open-File Report 79-965, 51 p.

Hobbs, R. G., 1980, 1976 coal exploratory drilling, core description, and coal analyses, Recluse Geologic Analysis area, northern Campbell County, Wyoming: U. S. Geological Survey Open-File Report 80-1160, 55 p.

Hobbs, R. G., Malotte, D. C., Sanchez, J. D., and Windolph, Jr., J. F., 1977, Core description logs, 1975 USGS drilling, Recluse area, northern Campbell County, Wyoming: U. S. Geological Survey Open-File Report 77-717, 46 p.

U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-1C Elev.(ft) 4020 Total Depth(ft) 126.6

Location 300 fwl 2150 fnl sec. 21 T. 9 S. R. 50 E.

County Powder River State Montana Quadrangle(7.5') Bay Horse

Cored: Yes x No Interval(s) 19.5' to 65' 90' to 126.6'

Date started 8/13/79 Date completed 8/16/79 Driller Arthur Clark

Geologist Correia Remarks: No geophysical log run.

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	5	5	Sandstone, light-olive, very fine grained, muddy
5	10	5	Shale, light-olive, silty
10	17	7	Sandstone, medium-gray, slightly carbonaceous, interbedded with shale
17	19.5	2.5	Shale, dark-brown, carbonaceous
			CORE DESCRIPTION
19.5	20.3	0.8	Siltstone, light-gray, muddy, oxidized at 19.9' with rootlets and gypsum
20.3	20.9	0.6	Claystone, blue-gray, interbedded with oxidized, very fine grained, sandstone
20.9	21.3	0.4	Sandstone, fine-grained, unconsolidated, with a clay and pyrite layer at 21.1'
21.3	23.3	2.0	Shale, dark-brown, carbonaceous, coal stringer at 22.3'; sand stringer at 22.5'
23.3	25.4	2.1	Mudstone, medium-gray, rootlets in top foot, sand stringer with pyrite nodules at 24.9'
25.4	27.6	2.2	Sandstone, medium-gray, interbedded with shale
27.6	28.3	0.7	Coal, pyrite lens at 27.7'
28.3	29.0	0.7	No recovery
29.0	31.4	2.4	Mudstone, medium-gray, carbonaceous top .3', silty toward base, carbonaceous streaks and pyrite at 30.8'
31.4	37.2	5.8	Sandstone, medium-light-gray, fine-grained; carbonaceous streaks, muddy, and pyrite nodules at 35.1'
37.2	38.0	0.8	No recovery
38.0	39.4	1.4	Sandstone, medium-gray, muddy towards base; carbonaceous at 38.3'
39.4	40.9	1.5	Shale, dark-brown, carbonaceous, sandy with pyrite nodules; coal stringer at top

Section MB-1C

Depth interval (feet) From	To	Thickness	Lithologic Description
40.9	65.0	14.1	No recovery
			END OF CORE DESCRIPTION
65	85	20	Sandstone, medium- to dark-gray, coarsens upward from very fine grained to coarse-grained
85	90	5	Shale, medium-gray, silty
			CORE DESCRIPTION
90	102.6	12.6	No recovery
102.6	106.6	4.0	Siltstone, medium-gray, muddy, with sand lenses and pyrite nodules throughout
106.6	116.1	9.5	Coal; burrowed at top, filled with sand and pyrite, badly fractured; pyrite lens at 106.9′ and nodules interspersed throughout
116.1	116.3	0.2	Shale, medium-dark-gray, carbonaceous
116.3	117.3	1.0	Coal, dull black, shaly at top
117.3	122.0	4.7	Coal, black, pyritic, minor cleat fracture at 119.0′
122.0	122.3	0.3	Shale, medium-brown, carbonaceous
122.3	123.9	1.6	Coal, dark-brown-black, woody, shaly
123.9	124.8	0.9	Shale, dark-brown, coaly
124.8	126.6	1.8	Mudstone, medium-gray, coal clasts, carbonaceous rootlets, sandy towards bottom

U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-2 Elev.(ft) 3325 Total Depth(ft) 465

Location 350 fel 2200 fsl sec. 28 T. 7 S. R. 49 E.

County Powder River State Montana Quadrangle (7.5′) Huckins School

Cored: Yes ____ No x Interval(s) ____

Date started 8/17/79 Date completed 8/17/79 Driller Arthur Clark

Geologist Linda Berlage Remarks: Completed as water observation well.

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	11	11	Alluvium, sandy and silty, light-brownish-yellow
11	17	6	Alluvium, clay, very light gray, silty
17	29	12	Sandstone, light-gray, very fine grained, silty, interbedded with siltstone, very light gray
29	39	10	Claystone, light-gray, carbonaceous with coaly streaks
39	52	13	Siltstone, light-gray
52	56	4	Coal, bony
56	86	30	Siltstone, medium- to dark-gray, clayey in part, argillaceous limestone 70′ -72′
86	94	8	Sandstone, dark-gray to medium-brown, very fine grained, silty
94	99	5	Coal
99	102	3	Shale, medium-gray
102	124	22	Siltstone, medium- to dark-gray, sandy at base
124	141	17	Shale, dark-gray
141	157	16	Sandstone, dark-gray, very fine grained, silty
157	163	6	Shale, dark-gray
163	192	29	Siltstone, medium- to dark-brown, carbonaceous in parts, clayey in places, coal 175′ to 177′ and at 191′
192	254	62	Siltstone, medium- to dark-gray, sandy, carbonaceous, coal streak at 227′
254	280	26	Sandstone, light-gray, very fine grained; interbedded with, light-to-medium-gray
280	288	8	Shale, light- to medium-gray
288	305	17	Siltstone, light- to medium-gray, interbedded with carbonaceous shale; coal stringer 291′ to 292′ and 296-297
305	312	7	Sandstone, light-gray, very fine grained

SECTION MB 2

Depth interval (feet) From	to	Thickness	Lithologic Description
312	322	10	Shale, light-gray, silty toward base
322	403	81	Sandstone, light- to medium-gray, very fine grained, shaley in part
403	425	22	Shale, medium- to dark-gray, carbonaceous, interbedded with light to medium-gray siltstone, coal stringer at 421′ to 423′
425	433	8	Siltstone, medium-gray
433	465	32	Shale, medium- to dark-gray, carbonaceous, interbedded with light- to medium-gray siltstone; pyrite nodules noted in cuttings

U.S. Geological Survey

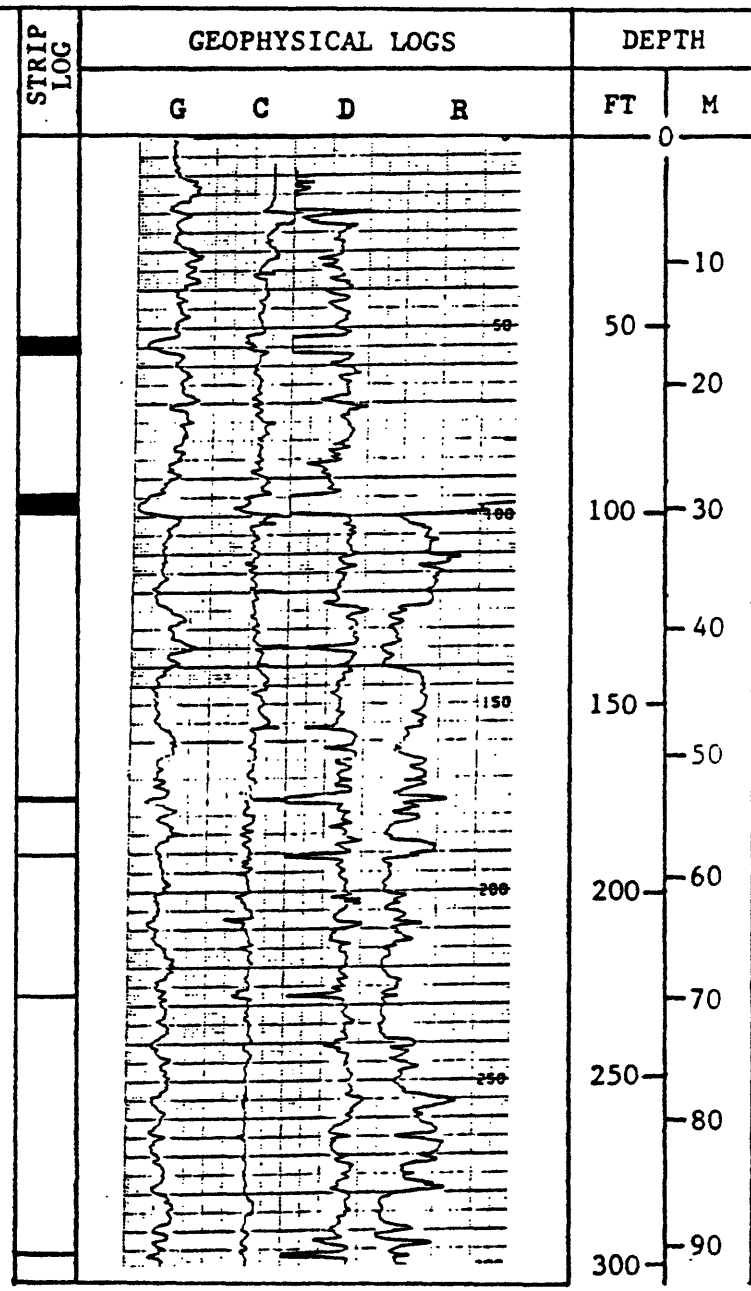
Hole Designation MB-2 Logged Depth 454 (ft

Geophysical Log Scales:

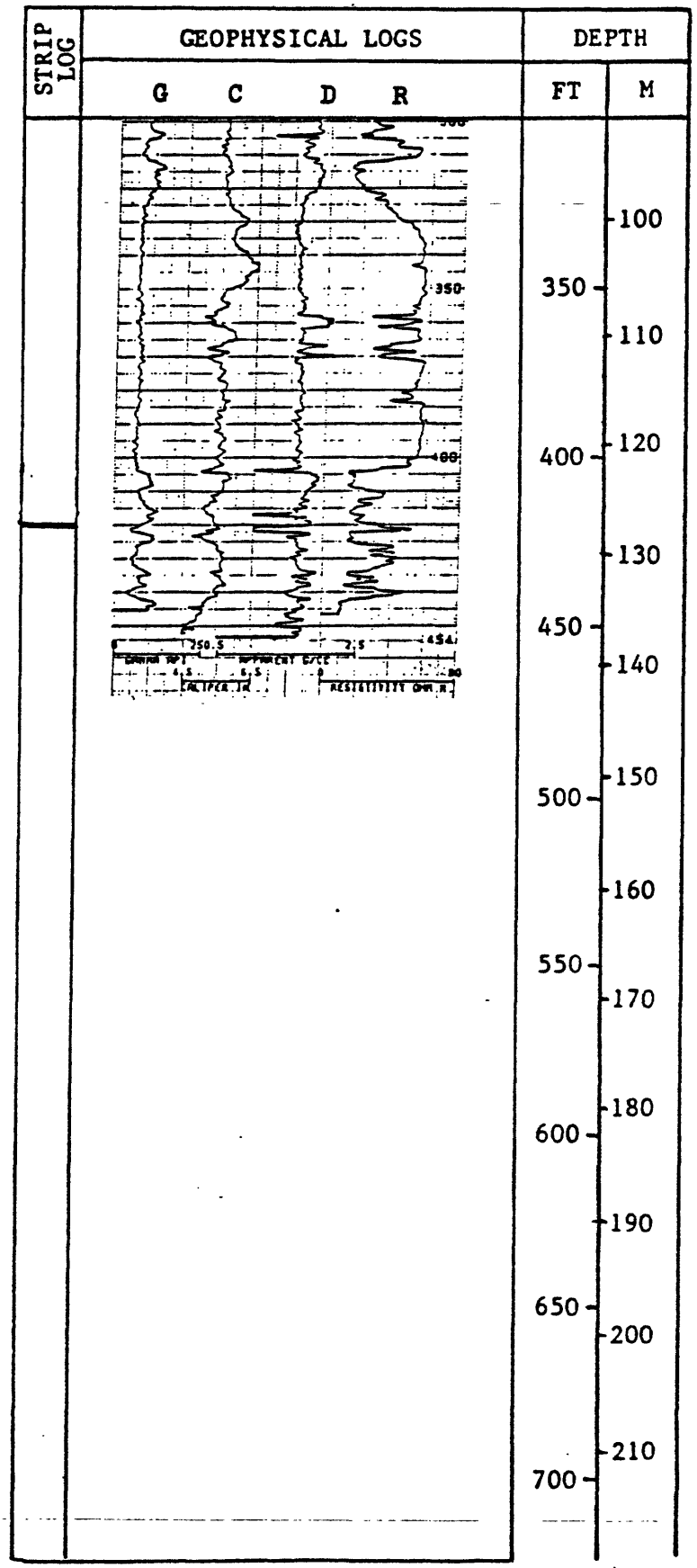
Gamma (G) 100 API units/in Density (D) .5 counts/sec/in

Resistivity (R) 20 ohms/in Caliper (C) 2 in/in

Remarks: 1 API unit = .618 counts per second



MB-2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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-3 & MB-3C Elev.(ft) 3600 Total Depth(ft) 595

Location 880 fnl 2450 fwl sec. 36 T. 7 S. R. 49 E.

County Powder River State Montana Quadrangle(7.5′) Huckins School

Cored: Yes x No Interval(s) 135′ - 175′

Date started 8/18/79 Date completed 8/18/79 Driller Arthur Clark

Geologist Mark Kirschbaum Remarks: Core description by George A. Correia.

Depth interval (feet) From	To	Thickness	Lithologic Description
0	5	5	Alluvium, yellow-brown, sandy
5	10	5	Alluvium, black, muddy, carbonaceous
10	21	11	Shale, red-brown, clayey, sandy, trace of sulfur
21	29	8	Shale, gray, clayey
29	34	5	Sandstone, gray, calcareous streaks
34	50	16	Siltstone, gray, clayey
50	73	23	Shale, gray, silty toward base, coal stringer 54′-56′
73	93	20	Siltstone, light-gray, with clayey streaks
93	116	23	Sandstone, medium-light-gray, fine- to very fine grained
116	135	19	Mudstone, light-gray, silty, limy streak at 125′
			CORE DESCRIPTION
135.0	139.3	4.3	Claystone, gray-green, shaly, carbonaceous
139.3	144.0	4.7	Coal, black
144.0	147.9	3.9	Coal, black, alternating shiny and dull bands, disseminated pyrite on fracture surfaces
147.9	149.3	1.4	Mudstone, medium-gray, coaly streak at 148.6′, silty toward bottom
149.3	150.6	1.3	Siltstone, medium-dark-gray, sandy streaks with pyrite nodules, carbonaceous
150.6	153.9	3.3	Sandstone, light-gray, fine-grain, pyrite nodules, slightly carbonaceous
153.9	156.0	2.1	Coal, black, shiny, pyrite on fractures, gypsum on fractures, top .3 ft of coal weathered
156.0	165.5	9.5	Coal, black, alternating dull and shiney bands, pyrite throughout, shaly at bottom

Depth interval (feet) From	To	Thickness	Lithologic Description
165.5	168.0	2.5	Sandstone, yellow-brown, with pyrite and organic material to 167.1′ then green-gray, fine-grain
168.0	172.9	4.9	Mudstone, gray-green, coaly at top, sandy pockets with pyrite nodules
172.9	175.0	2.1	Mudstone, gray-green, sandy, fine- to very fine grained, pyrite nodules
			END OF CORE DESCRIPTION
175	189	14	Shale, gray, silty toward base
189	242	53	Sandstone, light-gray, very fine grained
242	252	10	Mudstone, gray-brown
252	254	2	Shale, carbonaceous
254	256	2	Coal, black
256	262	6	Shale, black, carbonaceous, grades to siltstone toward bottom
262	328	66	Sandstone, light-gray, fine- to very fine grained, silty at top
328	336	8	Shale, light-gray, silty, pyrite nodules in cuttings
336	348	12	Siltstone, gray, coaly, clayey
348	351	3	Coal, black, bony
351	356	5	Shale, gray-brown, carbonaceous
356	393	37	Siltstone, gray, sandy toward base
393	399	6	Coal, black
399	423	24	Shale, gray-green, interbedded with sandstone
423	431	8	Siltstone, gray-green
431	440	9	Mudstone, light-gray, silty
440	489	49	Siltstone, light-gray, sandy, interbedded with light-gray shale; coal stringers at 468′ and 483′
489	509	20	Sandstone, gray, very fine grained, silty at top
509	528	19	Shale, dark-gray, silty and sandy in places
528	551	23	Siltstone, gray, with interbedded sandstone
551	561	10	Sandstone, gray, very fine grained
561	585	24	Shale, gray- to dark-gray, silty, carbonaceous shale noted in cuttings; coal stringer at 580′ - 582′
585	595	10	Shale, dark gray, with carbonaceous shale and bony coal streaks

U.S. Geological Survey

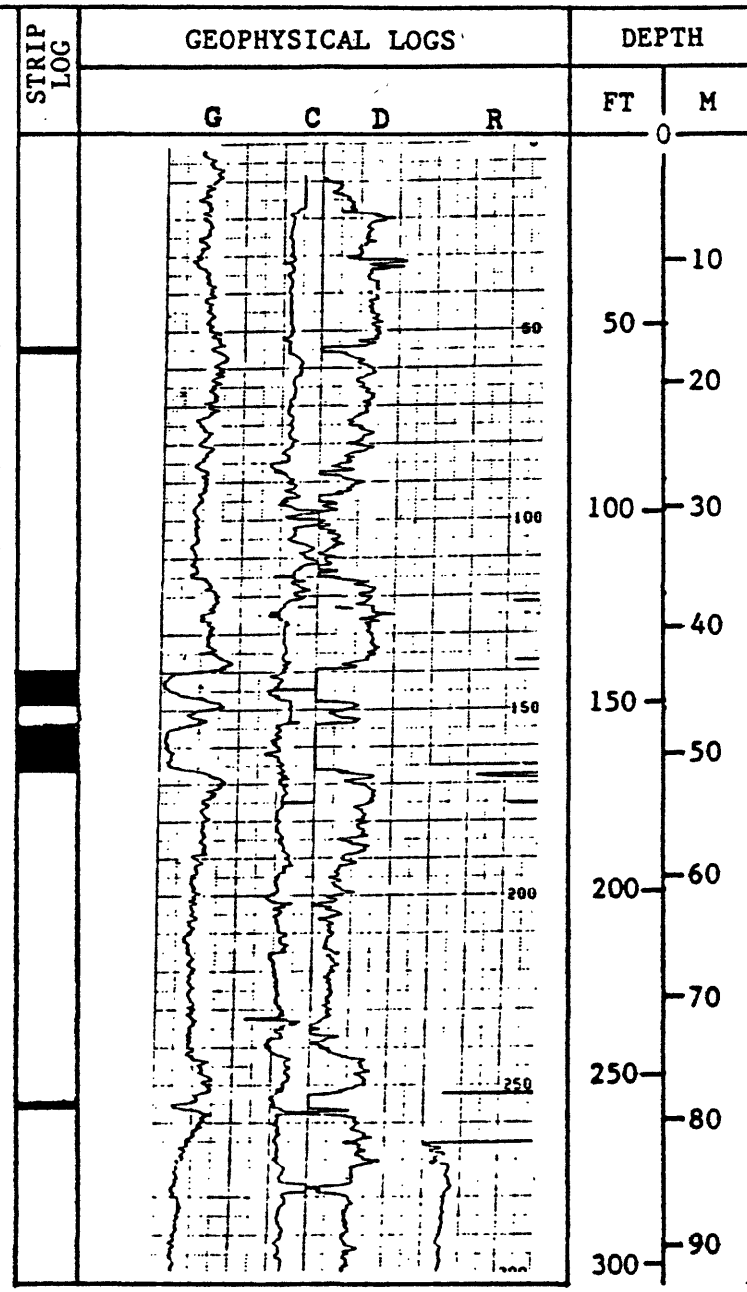
Hole Designation MB-3 Logged Depth 589 (ft)

Geophysical Log Scales:

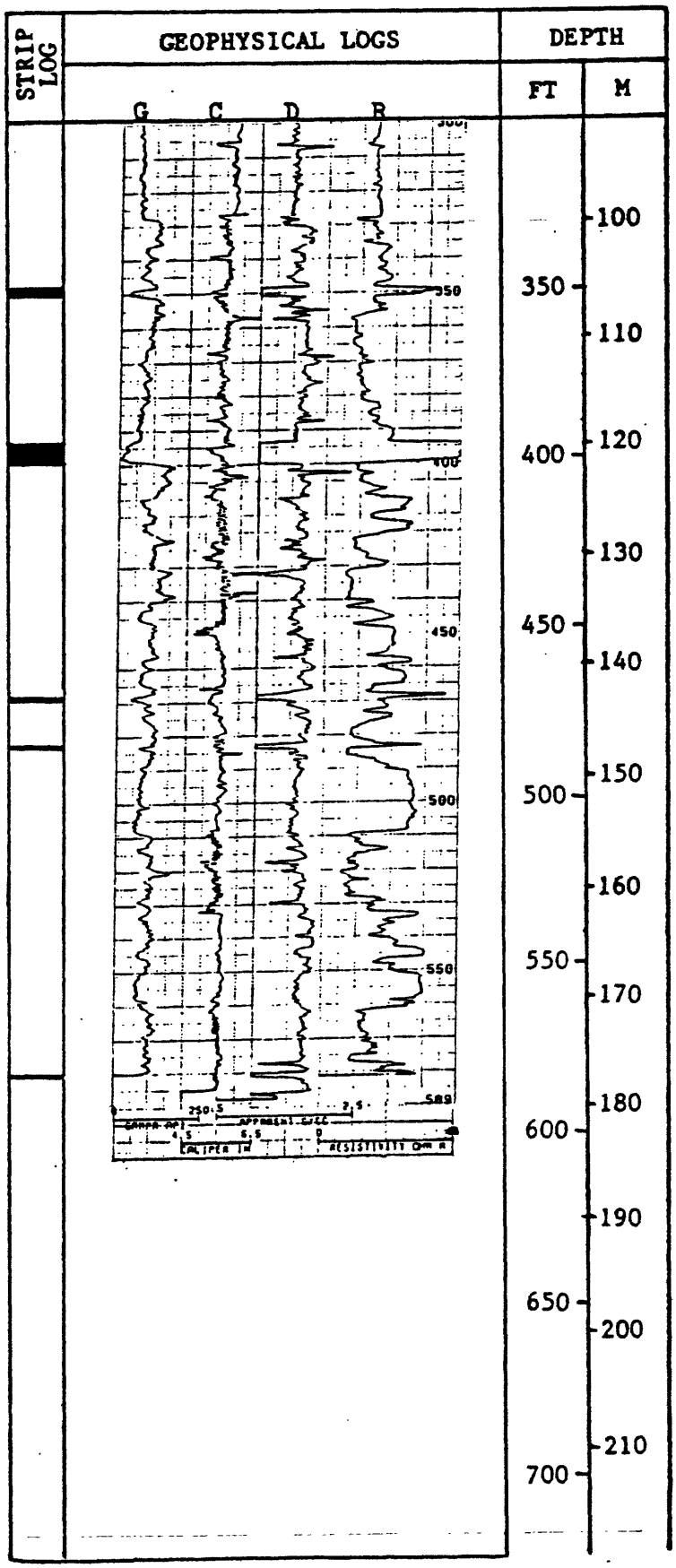
Gamma (G) 100 API units/in Density (D) .5 counts/sec/in

Resistivity (R) 10 ohms/in Caliper (C) 1 in/in

Remarks: 1 API unit = .618 counts per second



MB-3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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-4 Elev.(ft) 3320 Total Depth(ft) 415

Location 300 fsl 1350 fwl sec. 27 T. 6 S R. 50 E.

County Powder River State Montana Quadrangle(7.5′) Lonesome Peak

Cored: Yes ____ No x Interval(s) ____

Date started 8/20/79 Date completed 8/20/79 Driller Arthur Clark

Geologist Mark Kirschbaum Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	5	5	Alluvium, yellow-gray, sand with small chert granules
5	35	30	Alluvium, light-yellow, fine- to medium-grained, ironed stained
35	69	34	Sandstone, light-yellowish-brown, very fine to medium-grained, iron stained, coaly stringers
69	73	4	Siltstone, medium gray
73	84	11	Sandstone, light- to medium-gray, silty
84	102	18	Shale, medium-gray, silty
102	107	5	Coal, bony, interbedded with carbonaceous shale
107	137	30	Siltstone, dark- to medium-gray, clayey in parts, with calcareous sandstone stringers
137	138	1	Coal, black, shiny, sandy, with pyrite balls
138	145	7	Shale, medium-gray
145	149	4	Coal
149	226	77	Siltstone, medium- to dark-gray, clayey toward bottom, calcareous in places
226	238	12	Siltstone, dark-gray, clayey, pyrite balls at top, coal stringer at 237′
238	250	12	Sandstone, brown-gray, very fine grained
250	279	29	Siltstone, medium-gray, clayey or sandy in places, with a coal stringer at 268′
279	283	4	Sandstone, medium-gray, very fine grained, and light-gray siltstone, coal stringers
283	304	21	Siltstone, medium- to green-gray, some clay
304	395	91	Sandstone, medium- to dark-gray, fine- to medium-grained,calcareous in places, some pyrite
395	415	20	Shale, medium- to dark-gray, clayey, some fine-grained sandstone at top

U.S. Geological Survey

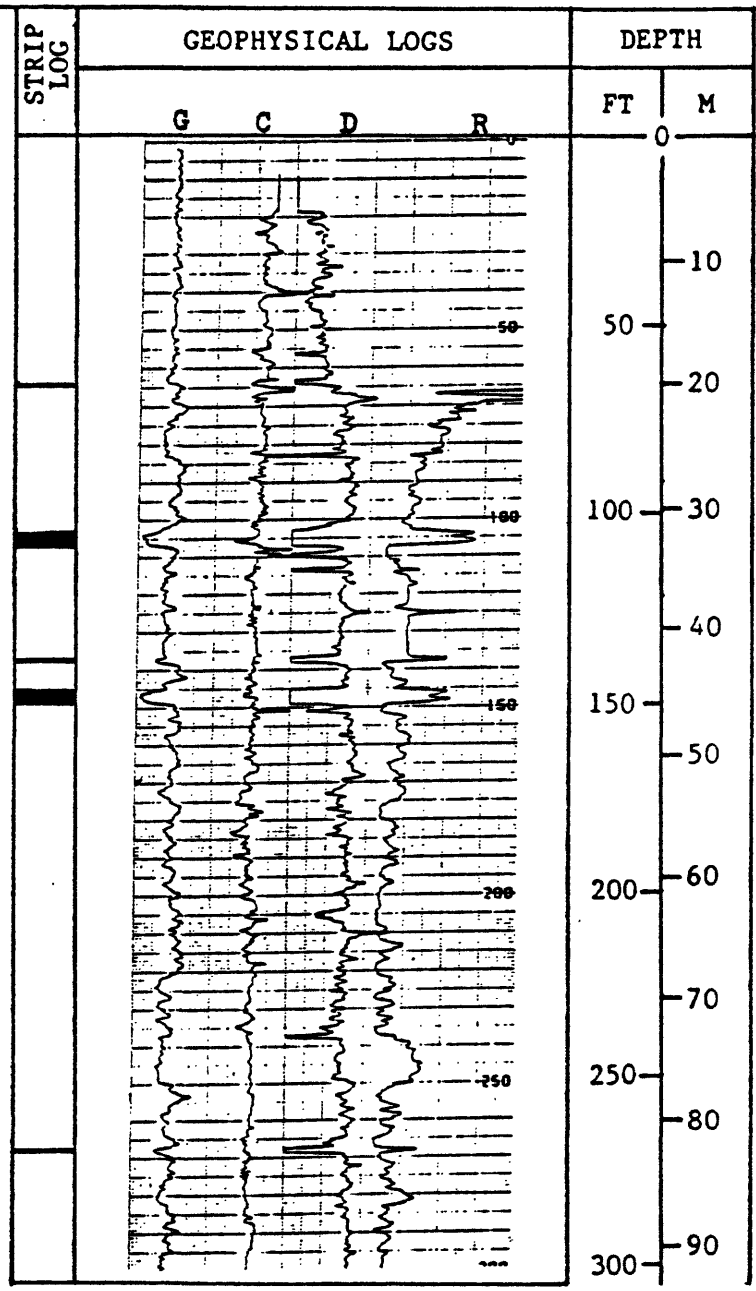
Hole Designation MB-4 Logged Depth 415 (ft)

Geophysical Log Scales:

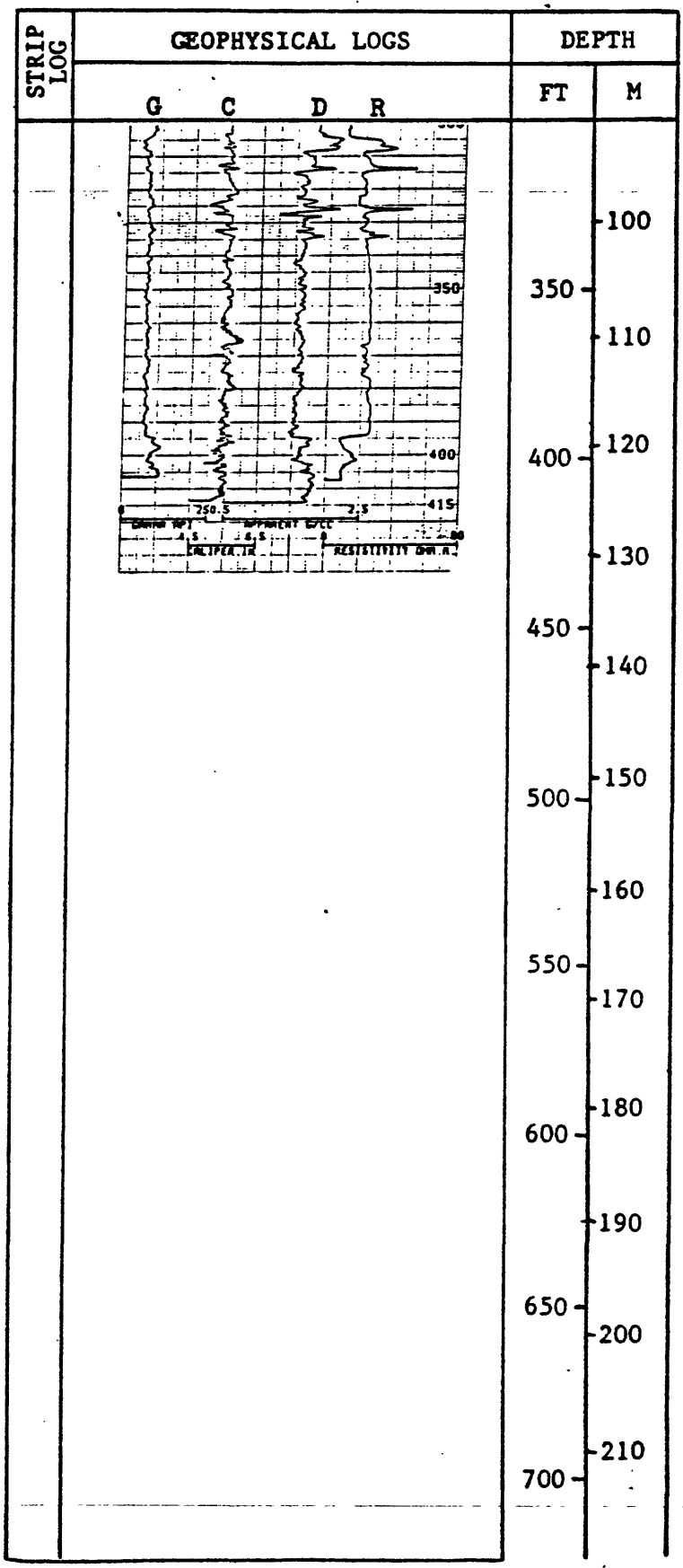
Gamma (G) 100 API units/in Density (D) .5 counts/sec/in

Resistivity (R) 20 ohms/in Caliper (C) 1 in/in

Remarks: 1 API units = .618 counts per second



MB-4


STRIP LOG
GEOPHYSICAL LOGS
G C D R
DEPTH
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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-5 Elev.(ft) 3690 Total Depth(ft) 615

Location 450 fel 900 fsl sec. 17 T. 9 S R. 48 E.

County Powder River State Montana Quadrangle(7.5)' Moorhead

Cored: Yes ____ No x Interval(s) ____

Date started 8/21/79 Date completed 8/22/79 Driller Arthur Clark

Geologist Mark Kirschbaum Remarks: Geophysical log to 547'

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	10	10	Alluvium
10	26	16	Siltstone, light-gray, iron stained
26	47	21	Sandstone, light-gray, very fine grained, calcareous cement, hard, iron stained
47	53	6	Shale, black, carbonaceous, coaly at bottom
53	61	8	Shale, light-blue-gray to light-gray, carbonaceous
61	95	34	Siltstone, medium- to dark-gray, interbedded with medium- to light-gray, shale
95	98	3	Sandstone, gray, fine-grained
98	101	3	Coal, shaly
101	114	13	Sandstone, light-gray, fine-grained, shaly streaks, iron stained
114	134	20	Shale, light- to medium-gray, silty at base
134	190	56	Sandstone, light-gray, fine- to very fine grained, calcareous, silty at top
190	199	9	Shale, medium-gray
199	205	6	Shale, medium-gray, silty
205	227	22	Shale, medium-gray, with interbedded siltstone
227	232	5	Coal
232	238	6	Claystone, gray
238	253	15	Siltstone, medium-gray, clayey
253	306	53	Sandstone, medium-gray, fine-grained, calcareous
306	334	28	Siltstone, medium-gray, trace carbonaceous shale in cuttings
334	339	5	Shale, medium-gray
339	353	14	Coal, black, shale parting 345'-346'
353	370	17	Shale, medium-gray, carbonaceous in parts, silty toward bottom
370	375	5	Coal
375	384	9	Siltstone, medium-gray

SECTION MB-5

Depth interval (feet)			
From	To	Thick-ness	Lithologic Description
384	389	5	Sandstone, medium-gray
389	404	15	Shale, dark-brown, silty at top
404	413	9	Sandstone, gray, clayey at base
413	416	3	Coal
416	465	49	Shale, medium-gray, silty, grading to light-gray siltstone toward bottom
465	508	43	Sandstone, medium-gray, very fine grained, calcareous at top
508	586	78	Shale, medium-gray, clayey, carbonaceous, coal beds at 511′-514′ and 562′-563′, sandstone at 522′ to 525′
586	593	7	Sandstone, medium-gray, calcareous
593	614	21	Shale, medium-gray, silty, traces of coal and carbonaceous shale

U.S. Geological Survey

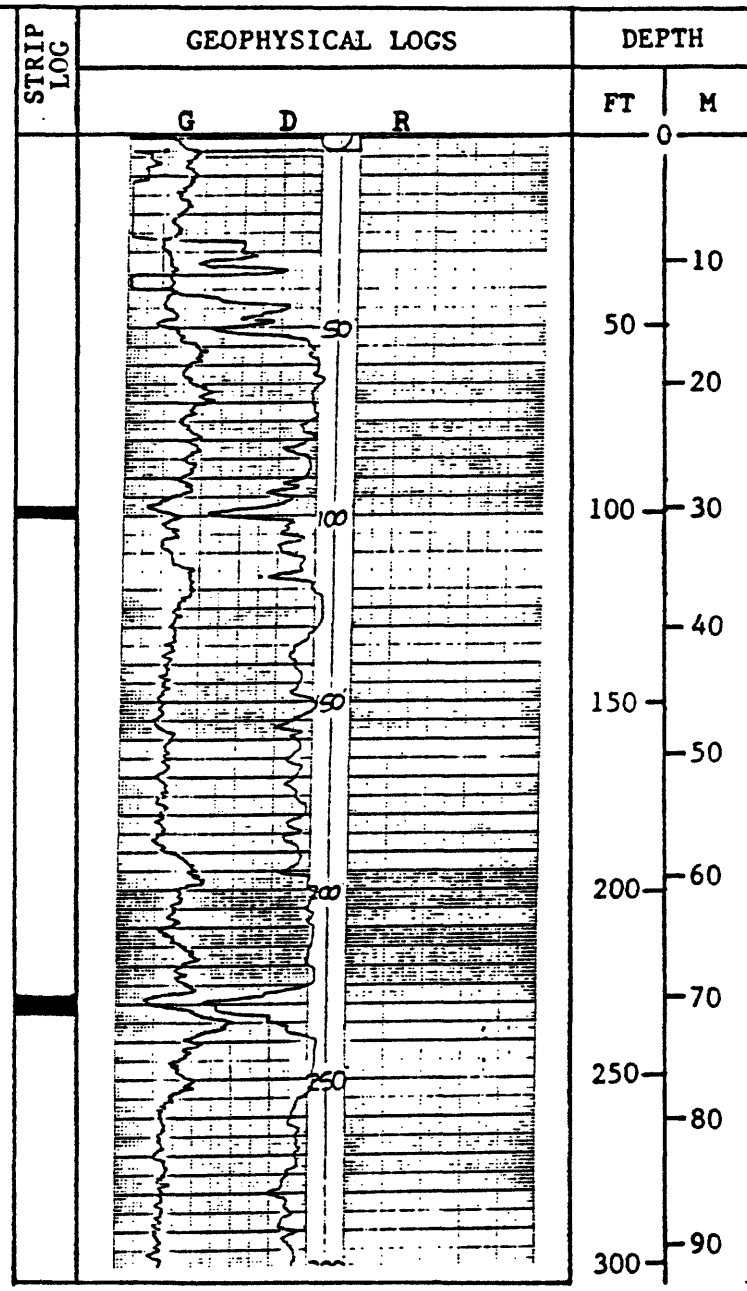
Hole Designation MB-5 Logged Depth 547 (ft)

Geophysical Log Scales:

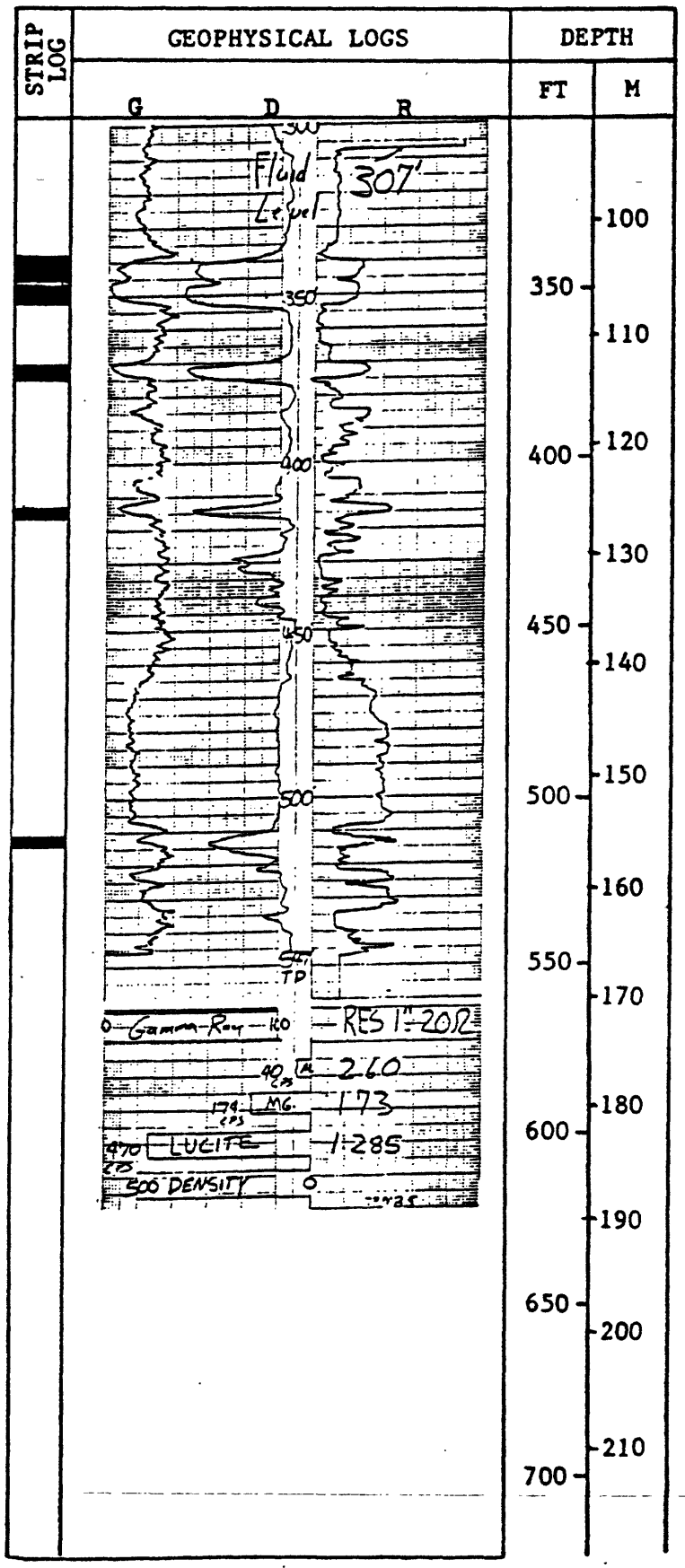
Gamma (G) 20 counts/sec/in Density (D) 100 counts/sec/in

Resistivity (R) 20 ohms/in Caliper (C) _____

Remarks: _____



MB-5


STRIP LOG
GEOPHYSICAL LOGS
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Fluid Level
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450
500
TD
Gamma-Ray
RES 1"=20Ω
2.60
MG.
1.73
LUCITE
1.285
DENSITY
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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-6 & MB-6C Elev.(ft) 4200 Total Depth(ft) 795

Location 1050 fel 2500 fsl sec. 22 T. 8 S. R. 47 E.

County Powder River State Montana Quadrangle(7.5′) Bradshaw Creek

Cored: Yes x No Interval(s) 236′ to 296.2′, 372′ to 406.5′

Date started 8/29/79 Date completed 9/1/79 Driller Arthur Clark

Geologist Frank Spencer Remarks: Core description by George A. Correia

Depth interval (feet) From	To	Thickness	Lithologic Description
0	1	1	Alluvial soil
1	7	6	Shale, carbonaceous, medium- to dark-brown, weathered
7	9	2	Coal
9	16	7	Shale, medium- to dark-gray
16	39	23	Sandstone, light-yellow-gray, very fine grained, clayey, calcareous streak at 26′
39	51	12	Shale, medium- to dark-gray at bottom, sandy
51	54	3	Sandstone, medium-dark-gray
54	93	39	Shale, medium-dark-gray, sandy, trace carbonaceous shale in cuttings at 76′
93	99	6	Coal, brown-black; shale parting 95′ to 96′
99	141	42	Sandstone, light- to medium-gray, fine-grained grading to shale, light- to medium-gray at the bottom
141	191	50	Siltstone, light- to medium-gray interbedded with shale, medium gray, sandy at the top
191	230	39	Sandstone, light- to medium-gray, very fine grained, grading to siltstone, medium- to dark-gray toward bottom
230	236	6	Shale, dark-brown, carbonaceous
			CORE DESCRIPTION
236	243.5	7.5	Shale, medium-dark-brown, carbonaceous, silty
243.5	248.6	5.1	Coal, brown, bony, woody
248.6	253.6	5.0	Coal, brown, bony, disseminated pyrite
253.6	264.5	10.9	Coal, brown, bony, woody
264.5	273.2	8.7	Coal, brown, bony, woody, disseminated pyrite
273.2	275.5	2.3	Sandstone, light-gray, very fine grained, clayey and shaly
275.5	295.1	19.6	Coal, brown, woody, shale at 279.8′ to 280.7′ with disseminated pyrite shale at 287.1′ to 289.8′

SECTION MB-6

Depth interval (feet) From	To	Thickness	Lithologic Description
295.1	295.8	0.7	Shale, dark-brown, carbonaceous
295.8	296.2	0.4	Sandstone, light-gray, coaly END OF CORE DESCRIPTION
296.2	316	19.8	Shale, medium-gray, carbonaceous towards top
316	362	46	Siltstone, light- to medium-gray, sandy, carbonaceous material in cuttings
362	372	10	Shale, medium- to dark-gray CORE DESCRIPTION
372.0	376.6	4.6	Shale, medium-dark-gray, carbonaceous
376.6	379.0	2.4	Sandstone, light- to medium-gray, fine- to very fine grained, coaly streaks
379.0	381.2	2.2	Coal, banded, woody, with vitrinite
381.2	385.3	4.1	Shale, medium-gray-brown, carbonaceous, sandy at top with coal streaks
385.3	386.0	0.7	Coal, brown, bony, shaly
386.0	388.0	2.0	Coal, brown, woody
388.0	403.5	14.5	Coal, dark-brown, woody with vitrinite streaks
403.5	406.5	3.0	Sandstone, light-gray, fine- to medium-grained, cherty END OF CORE DESCRIPTION
406.5	439	32.5	Siltstone, medium-gray, shaly with coal streak at 416′, calcareous, argillaceous limestone at 430′
439	450	11	Shale, light-gray, coaly shale at top
450	454	4	Siltstone, light-gray
454	460	6	Claystone, light-gray
460	489	29	Siltstone, light-to-medium gray, sandy
489	492	3	Shale, medium-gray
492	503	11	Sandstone, light- to medium-gray, fine to very fine grained, calcareous streaks
503	537	34	Shale, medium-gray, interbedded with light-gray, fine- to very fine grained sandstone, coal stringer 521′ to 523′
537	542	5	Shale, dark brown, carbonaceous, coal stringer
542	550	8	Coal, brown-black
550	557	7	Shale, medium-gray
557	559	2	Coal, shaly
559	599	40	Siltstone, light- to medium-gray, sandy at top, carbonaceous shale at the bottom
599	609	9	Shale, black to medium-gray, carbonaceous
609	611	2	Coal
611	632	21	Shale, gray, interbedded with light-gray siltstone
632	637	5	Shale, black, carbonaceous, bony coal from 634-636
637	660	23	Siltstone, medium-brown-gray, argillaceous limestone at 647′
660	668	8	Shale, medium-gray, carbonaceous at 669′

SECTION MB-6

Depth interval (feet) From	To	Thickness	Lithologic Description
668	672	4	Siltstone, medium-brown-gray, sandy
672	679	7	Shale, medium-brown-gray
679	684	5	Siltstone, medium-brown-gray, sandy
684	691	7	Shale, carbonaceous and bony coal
691	726	35	Shale, dark-gray, carbonaceous and silty in places.
726	736	10	Sandstone, light-gray
736	741	5	Shale, black, carbonaceous, coaly, silty at bottom
741	745	4	Coal
745	763	18	Shale, dark-gray, carbonaceous, coal at 750′, 757′ and 760′
763	775	12	Siltstone, light-gray, sandy at top
775	795	20	Siltstone, light-gray, coal from 776′ to 782, sandy at bottom

U.S. Geological Survey

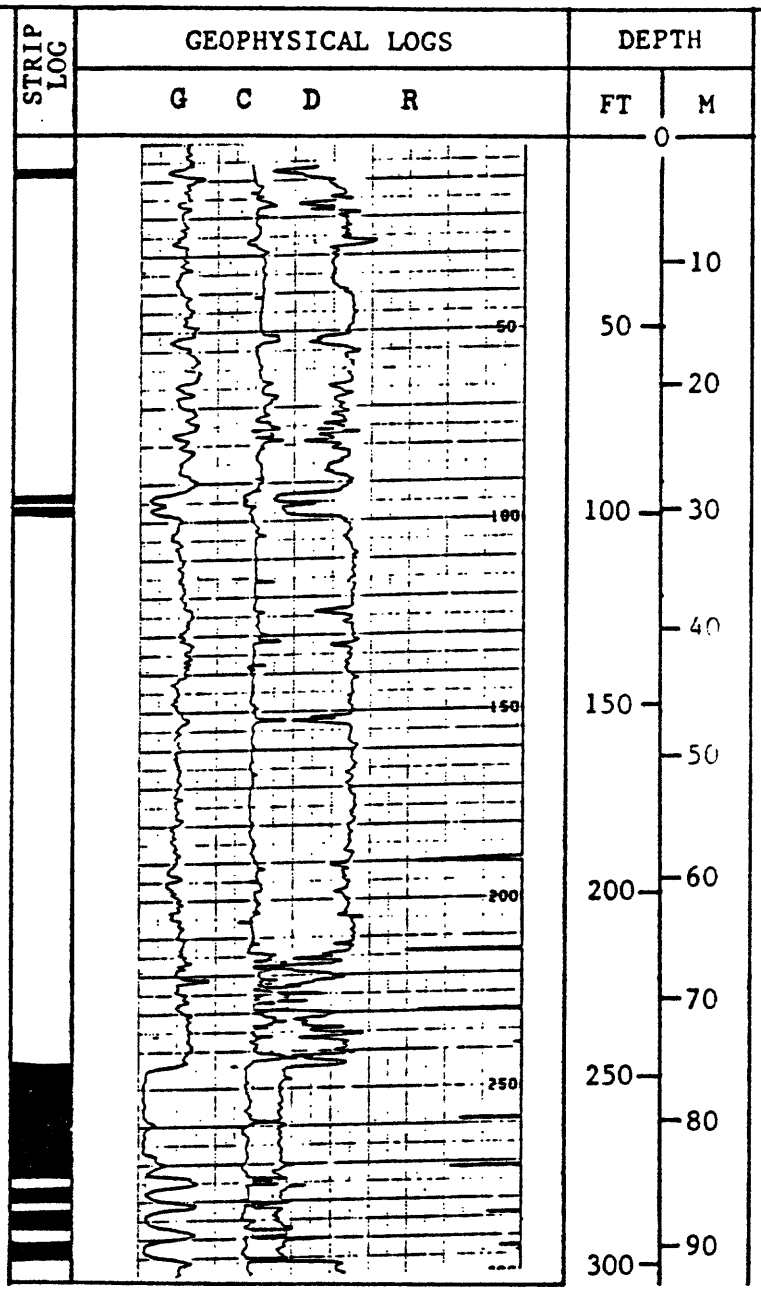
Hole Designation MB-6 Logged Depth 763 (ft)

Geophysical Log Scales:

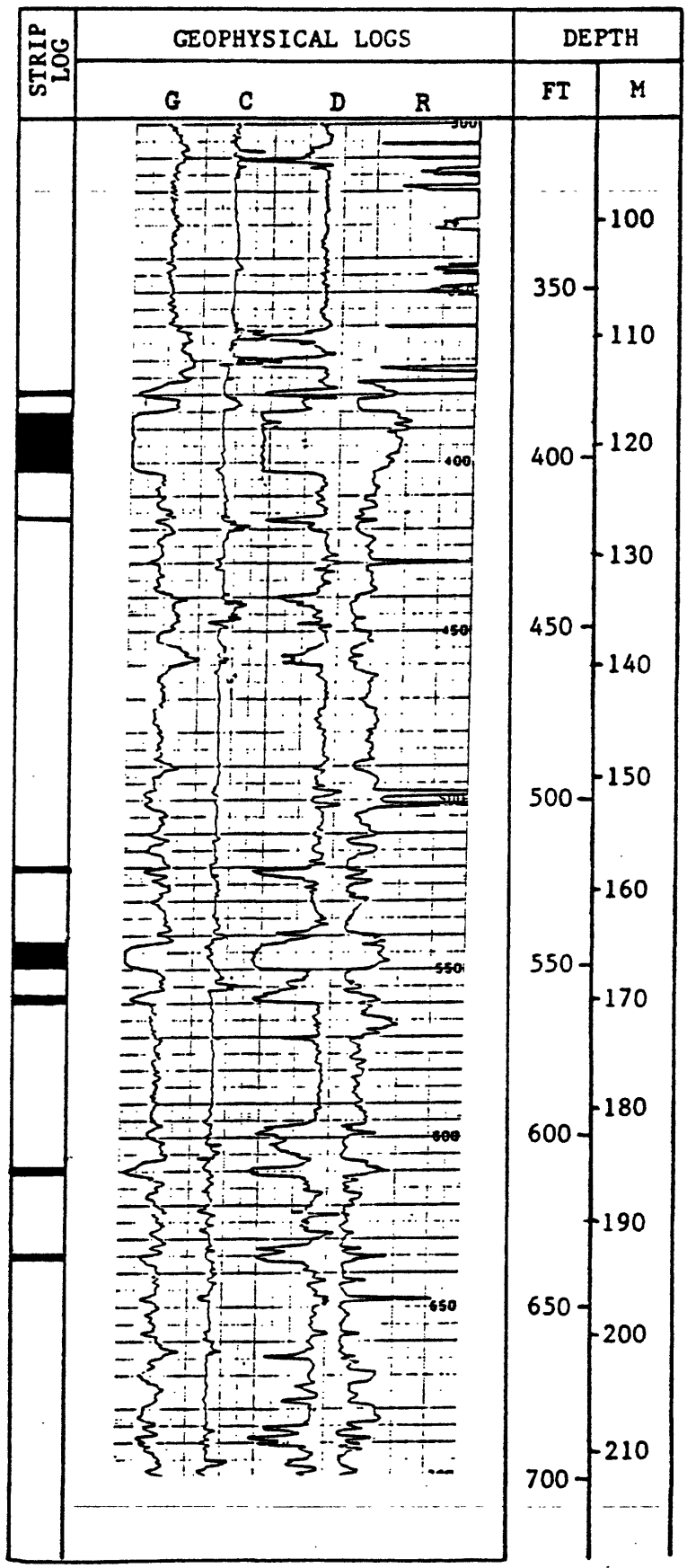
Gamma (G) 100 API units/in Density (D) .5 counts/sec/in

Resistivity (R) 20 ohms/in Caliper (C) 2 in/in

Remarks: 1 API unit = .618 counts per second



MB-6


STRIP LOG
GEOPHYSICAL LOGS
G
C
D
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DEPTH
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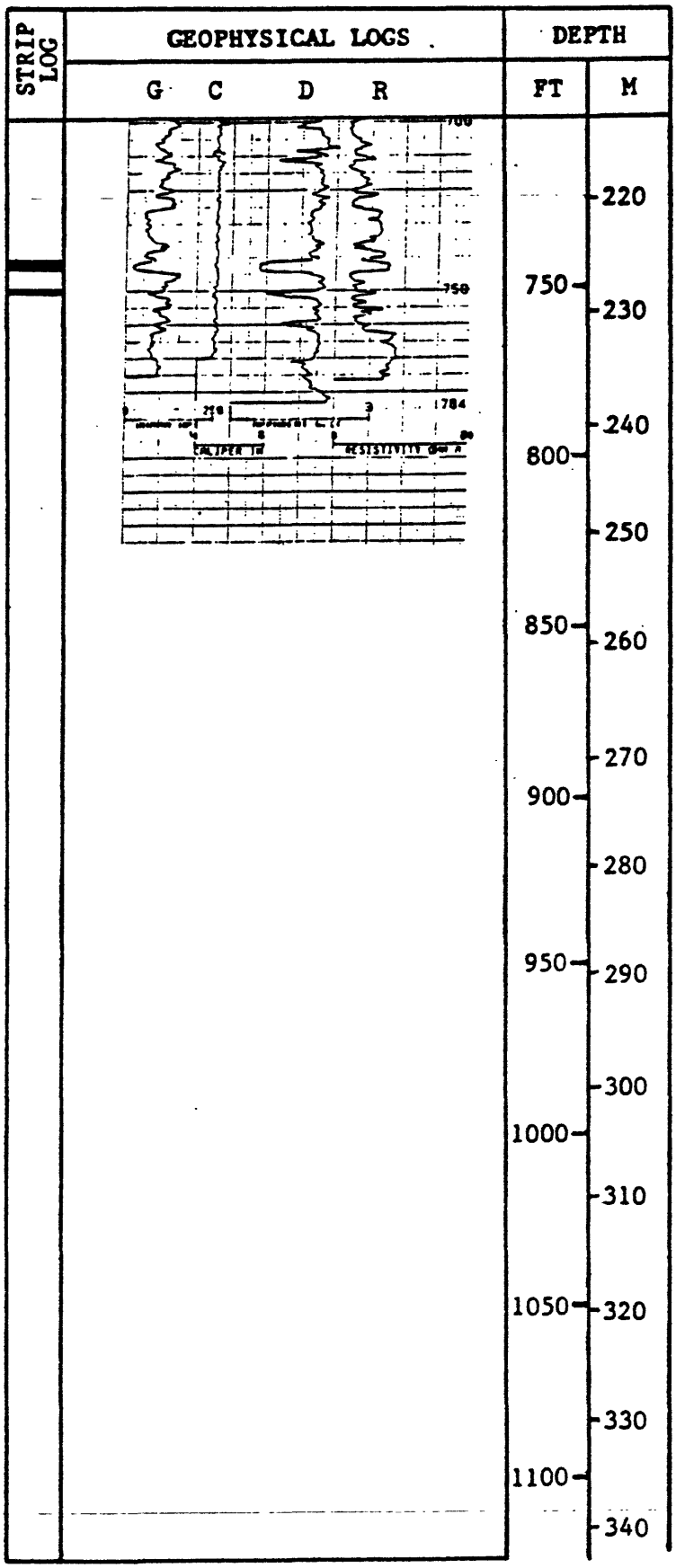
MB-6


STRIP LOG
GEOPHYSICAL LOGS
G C D R
DEPTH
FT
M
220
750
230
240
800
250
850
260
270
900
280
950
290
300
1000
310
1050
320
330
1100
340

U.S. Geological Survey

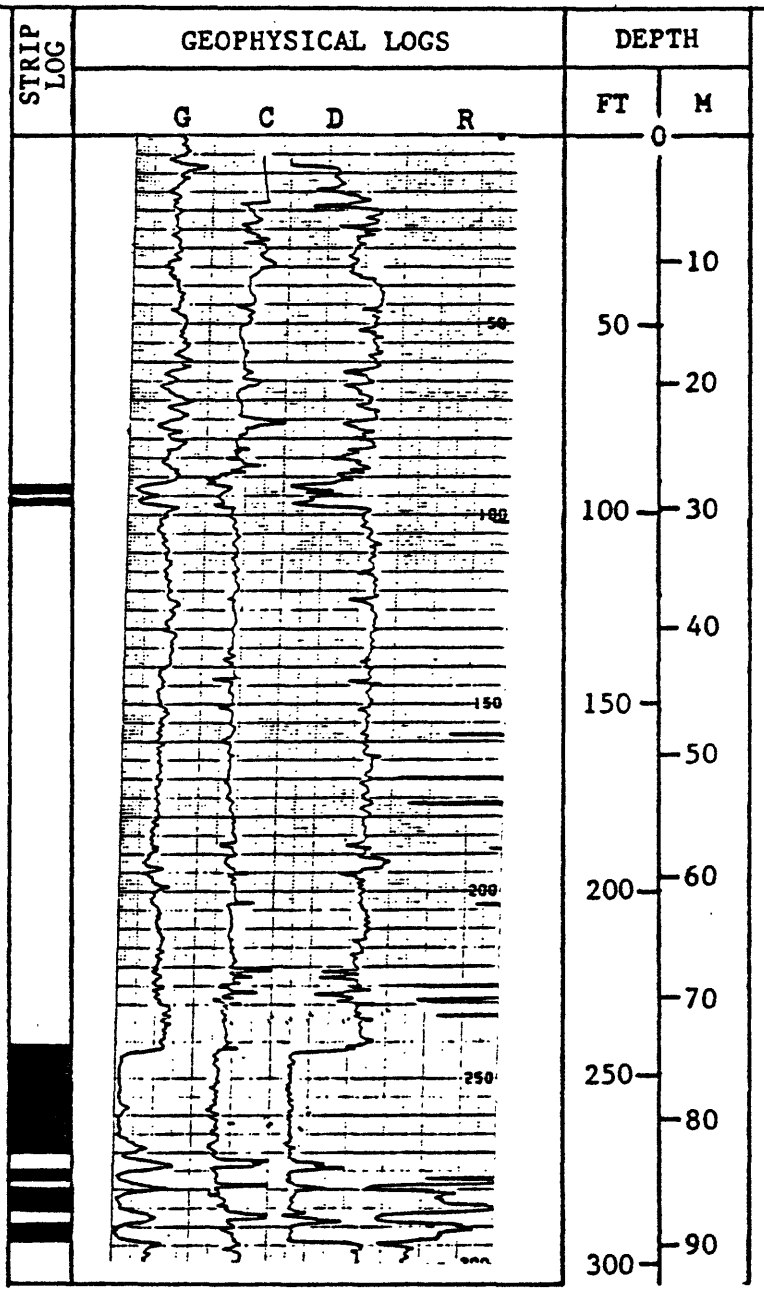
Hole Designation MB-6C Logged Depth 454 (ft)

Geophysical Log Scales:

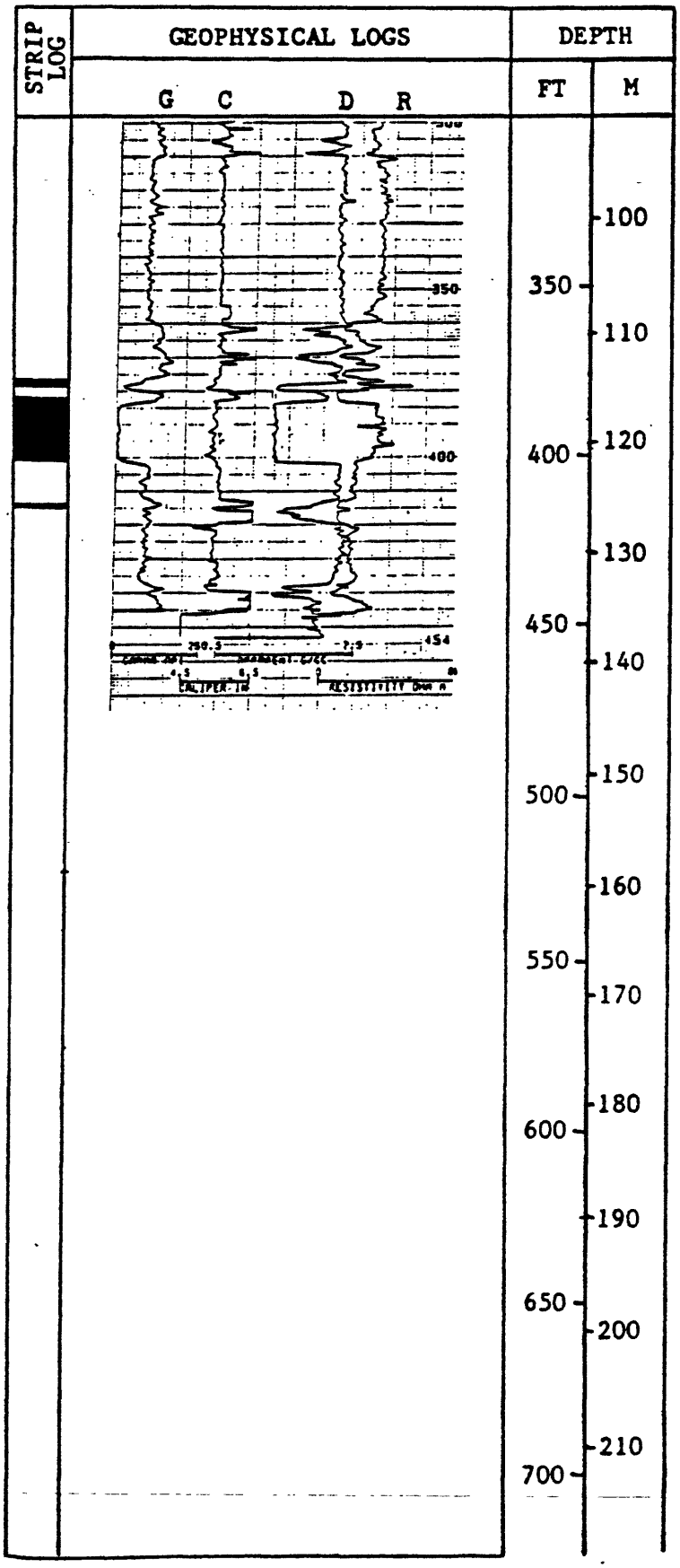
Gamma (G) 100 API units/in Density (D) .5 counts/sec/in

Resistivity (R) 20 ohm/in Caliper (C) 1 in/in

Remarks: 1 API unit = .618 counts per second



MB-6C


STRIP LOG
GEOPHYSICAL LOGS
G C D R
DEPTH
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600
650
700
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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-7 Elev.(ft) 3790 Total Depth(ft) 535

Location 1200 fsl 2000 fel sec. 30 T. 7 S. R. 47 E.

County Powder River State Montana Quadrangle(7.5′) Reanus Cone

Cored: Yes ____ No x Interval(s) ____

Date started 9/1/79 Date completed 9/2/79 Driller Arthur Clark

Geologist Frank Spencer Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	15	15	Alluvium, unconsolidated sand, light-yellow to brown with yellow clay
15	17	2	Sandstone, light-brown, fine- to medium-grained, silty
17	27	10	Sandstone, light-yellow-brown, silty, with iron stains, some clay
27	32	5	Shale, black, with coal stringer at 28′
32	36	4	Siltstone, light-gray, very fine grained
36	42	6	Siltstone, medium-gray, shaly toward bottom
42	44	2	Shale, medium-gray
44	55	11	Siltstone, medium-gray, with shale
55	59	4	Sandstone, light-gray, very fine grained, calcareous
59	70	11	Siltstone, light-gray to dark-gray, clayey
70	76	6	Shale, carbonaceous with coal stringer at top
76	90	14	Siltstone, medium-gray, shaly toward bottom
90	92	2	Shale, carbonaceous
92	98	6	Shale, medium-gray, silty
98	115	17	Coal, bony, woody, with siltstone parting from 105′ to 110′
115	148	33	Siltstone, light-gray, increasingly sandy towards bottom
148	154	6	Coal, bony, woody
154	188	34	Shale, light-gray, silty, interbedded with thin sandstone, light-gray
188	204	16	Sandstone, light-gray, very fine grained
204	209	5	Shale, black, carbonaceous, coal stringer at top
209	219	10	Sandstone, light-gray, very fine grained
219	226	7	Shale, light-gray
226	237	11	Siltstone, light-gray, sandy toward bottom
237	242	5	Coal, bony, woody, shaly
242	269	27	Siltstone, light-gray, sandy

Depth interval (feet)			
From	To	Thick-ness	Lithologic Description
269	272	3	Shale, carbonaceous, dark-gray
272	291	19	Siltstone, light-gray, sandy at bottom
291	300	9	Shale, medium-gray, carbonaceous, silty at top
300	316	16	Siltstone, medium-gray, clayey at top
316	339	23	Sandstone, dark-brown, very fine grained
339	349	10	Siltstone, medium-gray, clayey in places
349	358	9	Shale, dark-brown, carbonaceous at bottom, silty
358	372	14	Coal
372	380	8	Shale, medium-gray, silty,
380	390	10	Siltstone, medium-gray,
390	393	3	Shale, black, carbonaceous
393	401	8	Siltstone, medium-gray
401	420	19	Siltstone, light-gray, sandy
420	462	42	Sandstone, light- to medium-gray, fine-grained
462	467	5	Coal
467	470	3	Coal, shaly
470	477	7	Siltstone
477	498	21	Siltstone, medium-gray, sandy, interbedded with carbonaceous shale
498	500	2	Carbonaceous shale, dark-gray
500	507	7	Shale, medium-gray, silty
507	535	28	Sandstone, light-gray, very fine grained, silty, clayey in places

U.S. Geological Survey

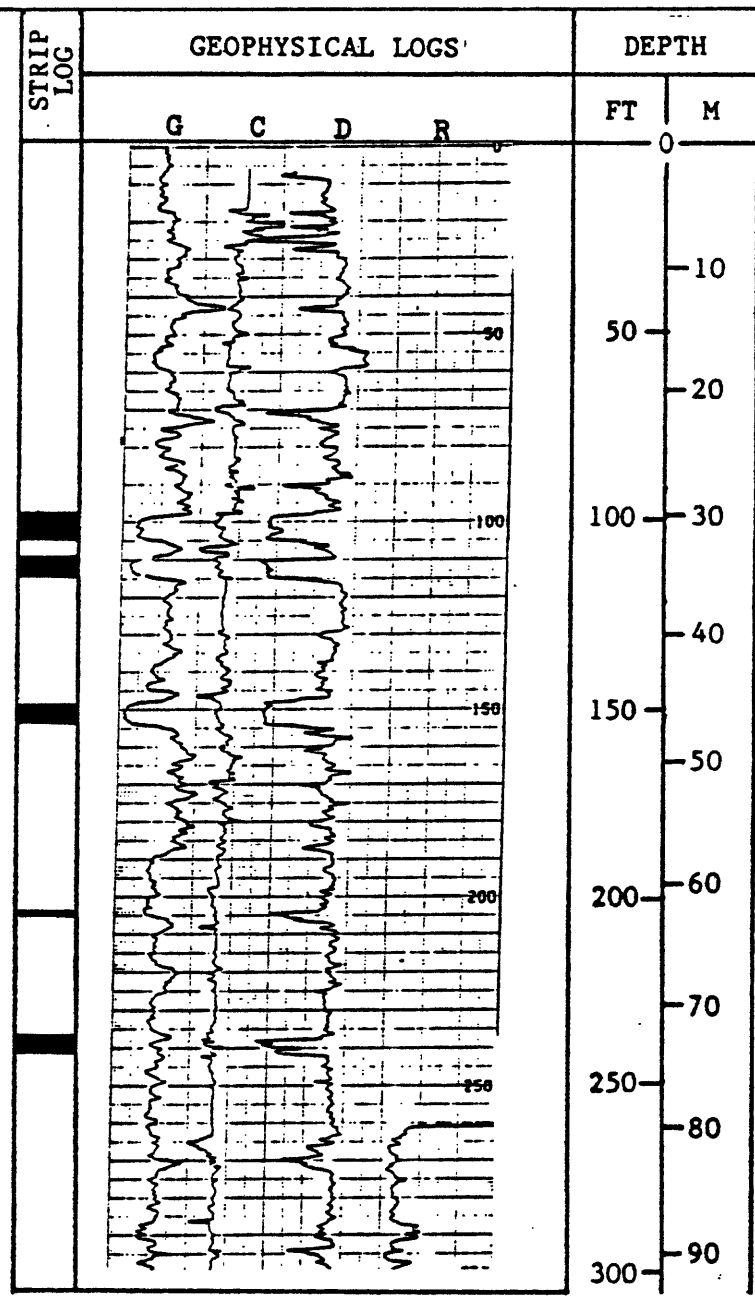
Hole Designation MB-7 Logged Depth 533 (ft)

Geophysical Log Scales:

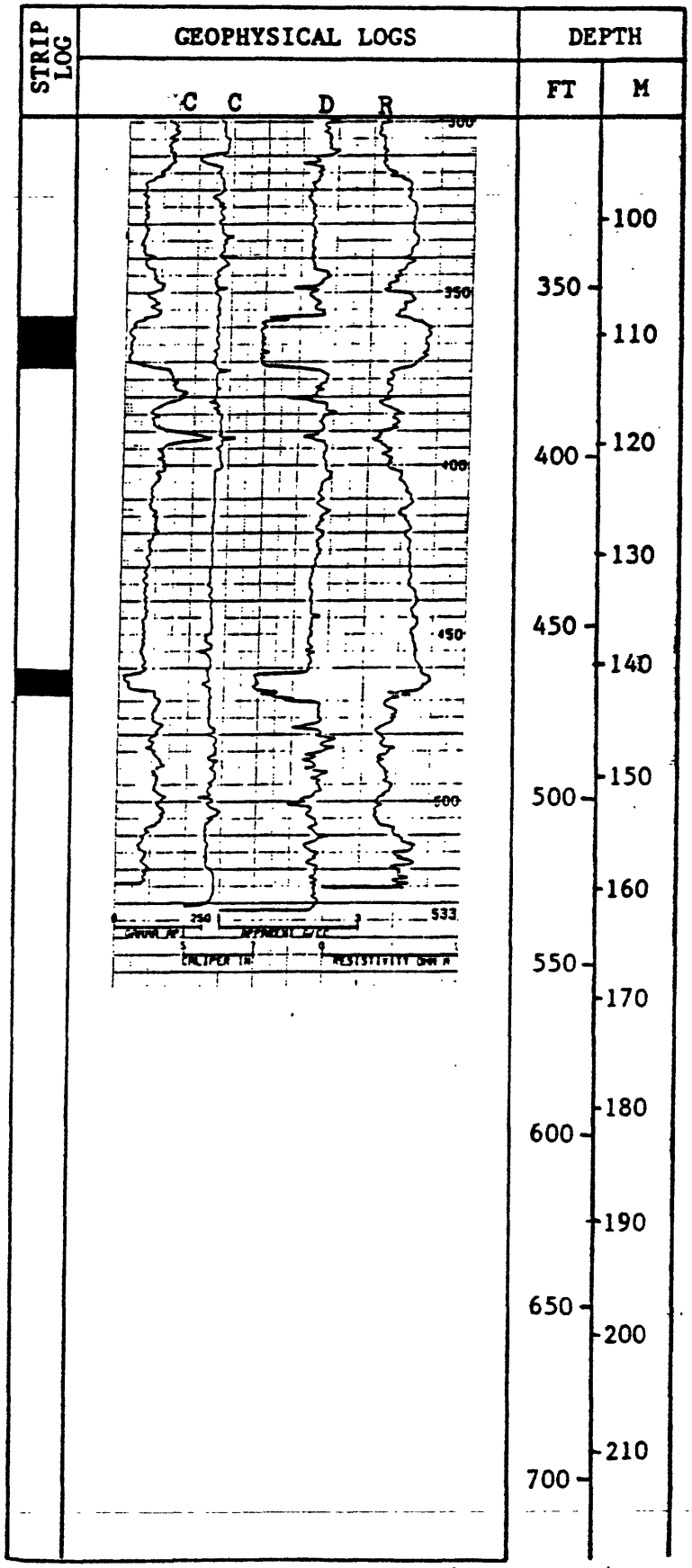
Gamma (G) 100 API units/in Density (D) .5 counts/sec/in

Resistivity (R) 2.5 ohms/in Caliper (C) 1 in/in

Remarks: 1 API unit = .618 counts per second



MB-7


STRIP LOG
GEOPHYSICAL LOGS
C C D R
DEPTH
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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-8 Elev.(ft) 3905 Total Depth(ft) 535

Location 100 fwl 1100 fnl sec. 21 T. 7 S. R. 47 E.

County Powder River State Montana Quadrangle(7.5') Sayle

Cored: Yes ____ No x Interval(s) ____

Date started 9/2/79 Date completed 9/3/79 Driller Arthur Clark

Geologist Frank Spencer Remarks: Completed as observation water well.

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	1	1	Alluvium
1	5	4	Coal and shale, carbonaceous, oxidized
5	25	20	Sandstone, light-yellow, fine- to very fine grained, iron stained, grading to siltstone at bottom
25	30	5	Shale, dark-brown, carbonaceous, coal stringer at top
30	44	14	Sandstone, light-yellow, fine- to very fine grained quartz, angular to sub-angular, silty, badly washed out in spots
44	49	5	Shale, black, carbonaceous, coaly
49	54	5	Sandstone, fine- to very fine grained, angular to subangular, micaceous, silty
54	58	4	Coal, dark-brown
58	70	12	Shale, dark-brown, carbonaceous
70	84	14	Coal, dark-brown, woody
84	109	25	Siltstone, medium-gray, fine- to medium-grained sand, shaly 92′ to 97′
109	112	3	Shale, dark-brown, carbonaceous, badly washed out
112	129	17	Siltstone, dark-brown, shaly and washed out 120′ to 122′
129	151	22	Sandstone, light-gray, medium- to very fine grained, quartz, subangular, calcareous cement, hard
151	159	8	Sandstone, light-gray, large percentage of coaly material
159	202	43	Sandstone, light-gray, very fine- to coarse-grain, silty in spots, calcareous, black chert grains at top
202	205	3	Sandstone, light-brown, fine- to medium-grain, coaly, calcareous
205	229	24	Siltstone, light- to medium-gray, calcareous, sandy in part, concretionary and hard 215′ to 217′, shaly coal streak 227′
229	254	25	Shale, medium-gray to dark-brown, carbonaceous, interbedded with siltstone, light- to medium-gray, sandy, calcareous concretions
254	269	15	Coal, black
269	283	14	Shale, light-gray, carbonaceous, silty

SECTION MB-8

Depth interval (feet) From	To	Thickness	Lithologic Description
283	292	9	Coal, black
292	306	14	Shale, light-gray, silty
306	309	3	Limestone, argillaceous
309	314	5	Siltstone, medium-gray
314	317	3	Limestone, argillaceous
317	327	10	Shale, medium- to light-gray, silty, carbonaceous
327	342	15	Siltstone, light-gray, sandy
342	345	3	Coal, black, shaly
345	382	37	Sandstone, light-yellow, very fine grained, grading to light-gray, clayey sandstone
382	387	5	Sandstone, light-gray, fine- to medium-grained, calcareous cement, hard
387	393	6	Shale, black, carbonaceous, coaly, silty
393	421	28	Siltstone, light-gray, calcareous
421	449	28	Sandstone, light- to medium-gray, very fine grained, calcareous, carbonaceous shale stringers
449	489	40	Siltstone, medium-gray, interbedded carbonaceous shale, calcareous sandy concretions
489	503	14	Coal, black
503	535	32	Siltstone, light-gray, calcareous sandy concretions

U.S. Geological Survey

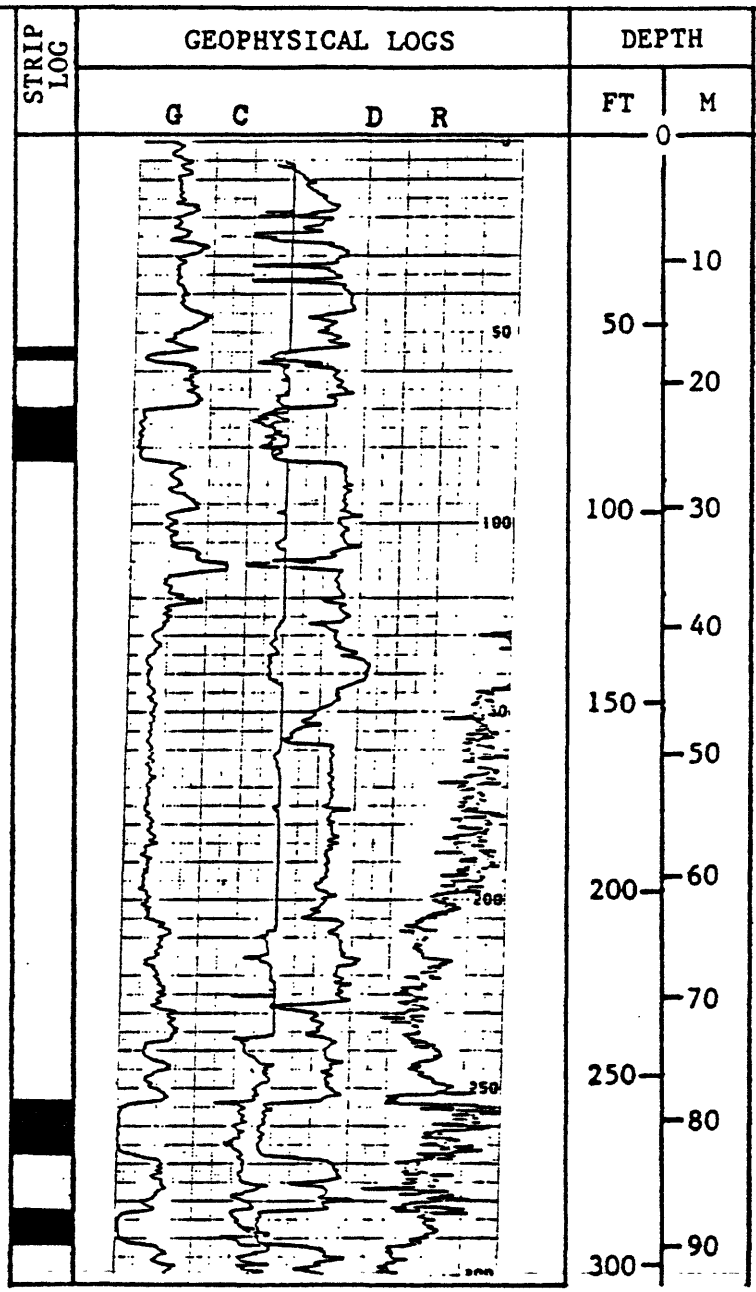
Hole Designation MB-8 Logged Depth 515 (ft)

Geophysical Log Scales:

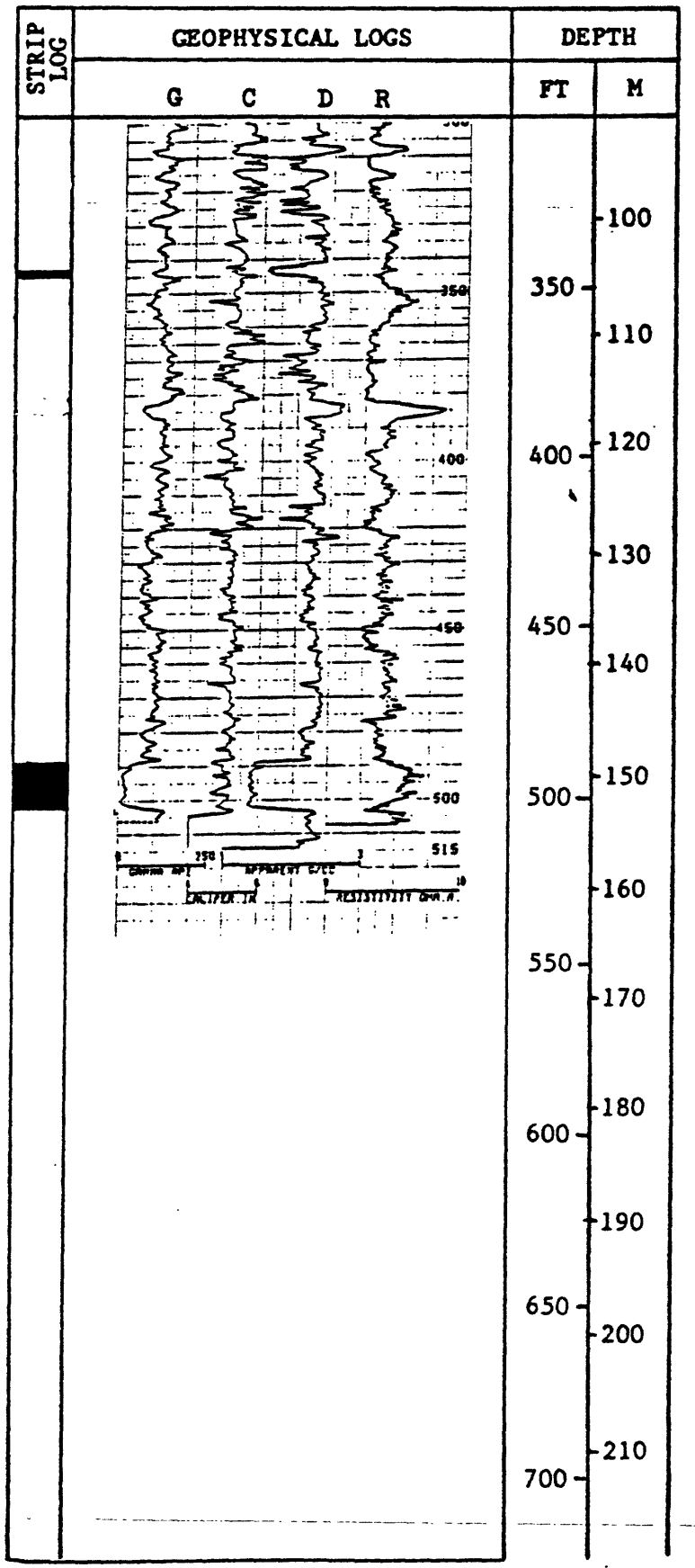
Gamma (G) 100 API units/in Density (D) .5 counts/in

Resistivity (R) 2.5 ohms/in Caliper (C) 1 in/in

Remarks: 1 API unit = .618 counts per second



MB-8


STRIP LOG
GEOPHYSICAL LOGS
G C D R
DEPTH
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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-9 Elev.(ft) 4180 Total Depth(ft) 875

Location 450 fsl 1650 fwl sec. 14 T. 7 S. R. 47 E.

County Powder River State Montana Quadrangle(7.5′) Sayle

Cored: Yes ____ No x Interval(s) ____

Date started 10/15/79 Date completed 10/15/79 Driller Arthur Clark

Geologist Mark Kirschbaum Remarks: Hole caved below 761′: caliper arm did not open until 600′

Depth interval (feet)

From	To	Thickness	Lithologic Description
1	10	10	Alluvium, sand, very pale orange to gray-orange, fine-grained
10	24	14	Sandstone, light-olive-gray, fine-grained
24	47	23	Shale, light to- medium-gray, silty
47	51	4	Coal
51	66	15	Siltstone, light-gray, clayey
66	71	5	Shale, coaly
71	90	19	Coal, black, shale parting 83′ to 87′
90	100	10	Shale, light-gray, interbedded with light-gray siltstone
100	182	82	Siltstone, medium- to light-gray, shaly in places, calcareously cemented 108′ to 112′
182	186	4	Coal
186	200	14	Shale, black, carbonaceous, interbedded with coal at 190′ to 192′
200	207	7	Shale, medium-light-gray, silty toward bottom
207	212	5	Coal
212	217	5	Shale, light-gray, clayey
217	220	3	Coal, shaly
220	264	44	Shale, light-gray, interbedded with light-gray siltstone
264	270	6	Sandstone, light-gray, very fine grained, shaly toward bottom
270	272	2	Coal
272	281	9	Siltstone, light-gray, shaly at top
281	289	8	Shale, brown-gray
289	305	16	Coal
305	312	7	Shale, brown-gray, washed out
312	321	9	Siltstone, light-gray, washed out
321	329	8	Sandstone, light-gray, very fine grained
329	339	10	Siltstone, light-gray

SECTION MB-9

Depth interval (feet) From	To	Thickness	Lithologic Description
339	356	17	Shale, brown-gray, silty, washed out
356	383	27	Siltstone, medium- to light-gray, shaley
383	407	24	Shale, light- to medium-gray, washed out
407	430	23	Sandstone, medium-light-gray, shale stringers, carbonaceous
430	449	19	Mudstone, medium-light-gray, interbedded with medium-light-gray sandstone
449	453	4	Shale, brown-gray, carbonaceous, sandy towards bottom
453	482	29	Coal, black, shale parting 470′ to 473′
482	489	7	Shale, black, carbonaceous
489	634	145	Siltstone, light- to medium-dark-gray, sandy, interbedded with shale, light-gray
634	691	57	Sandstone, light-gray, very fine grained
691	705	14	Coal
705	714	9	Shale, brown-gray, clayey, coal stringers
714	762	48	Siltstone, light- to medium-gray, sandy (very fine grained) toward bottom
762	783	21	Shale, medium-gray, clayey
783	816	33	Coal
816	875	59	Shale, light- to medium-gray, hard calcareous lenses, silty at top, clayey toward bottom

U.S. Geological Survey

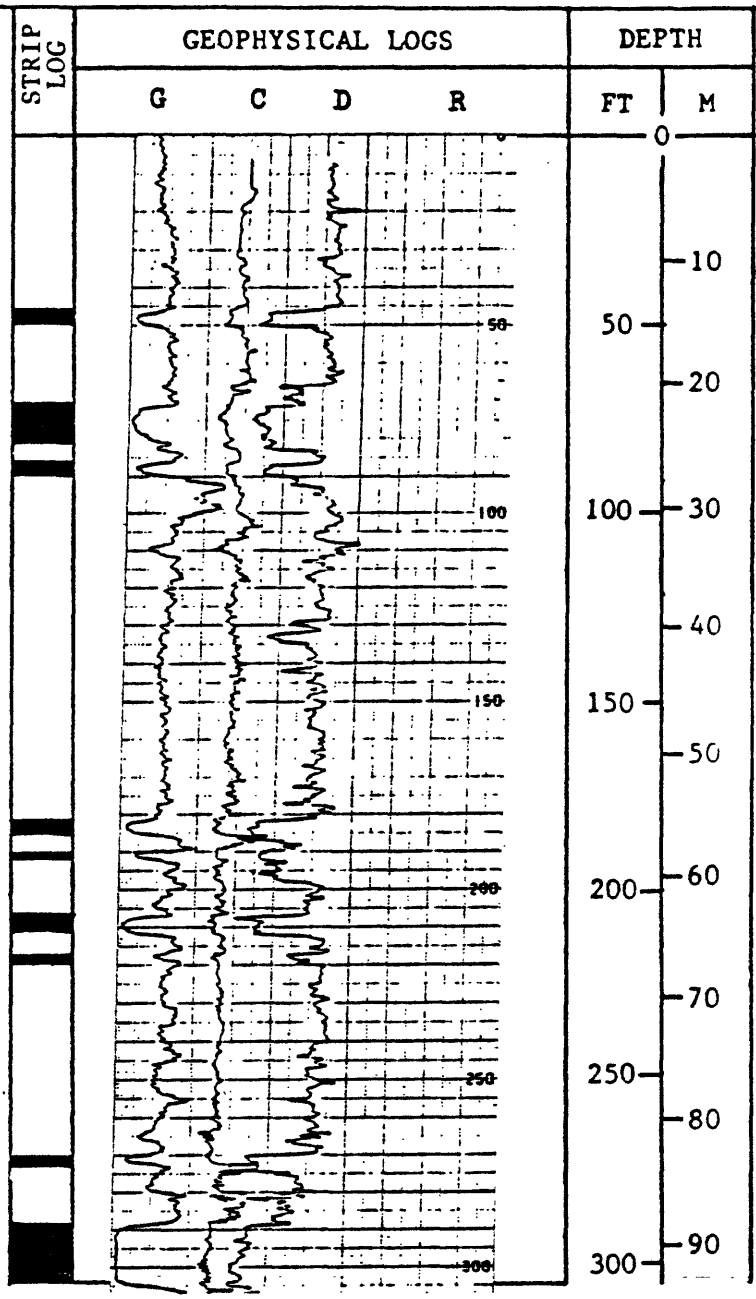
Hole Designation MB-9 Logged Depth 761 (ft)

Geophysical Log Scales:

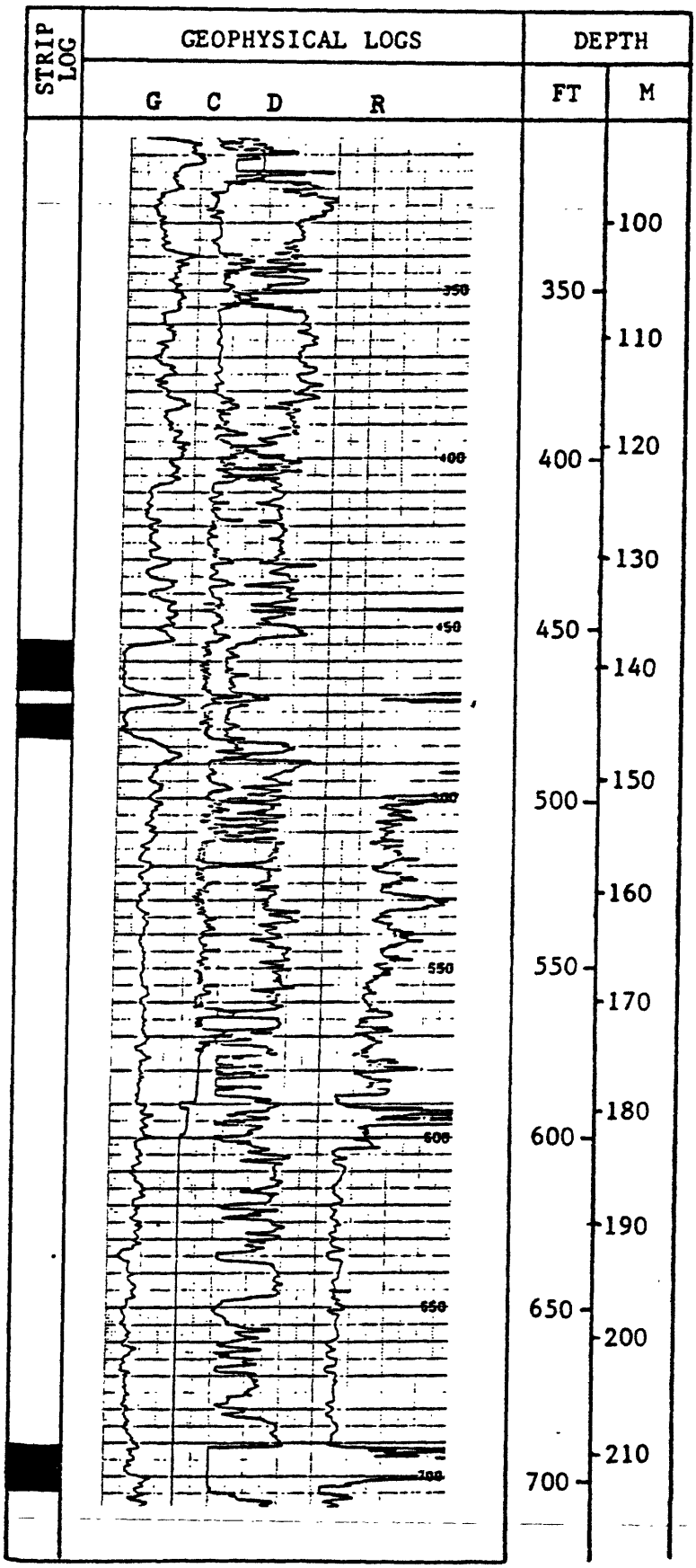
Gamma (G) 100 API units/in Density (D) .5 counts/sec/in

Resistivity (R) 20 ohms/in Caliper (C) 2 in/in

Remarks: 1 API unit = .618 counts per second



MB-9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MB-9

STRIP LOG	GEOPHYSICAL LOGS	DEPTH	
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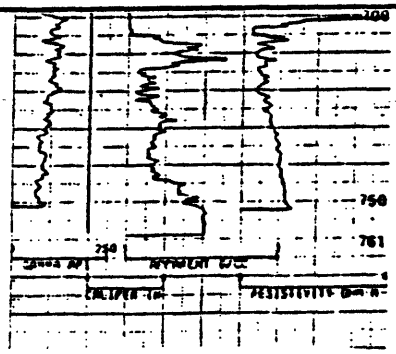


U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-10 Elev.(ft) 3960 Total Depth(ft) 535

Location 1000 fsl 2650 fel sec. 4 T. 7 S. R. 47 E.

County Powder River State Montana Quadrangle(7.5′) Phillips Butte

Cored: Yes ____ No x Interval(s) ____

Date started 9/11/79 Date completed 9/11/79 Driller Arthur Clark

Geologist Mark Kirschbaum Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	14	14	Alluvium, sand, yellowish-brown, fine- to very fine grained
14	37	23	Sandstone, yellow- brown to dark-yellow-orange, fine- to very fine grained, calcareous
37	42	5	Shale, dark-brown
42	71	29	Siltstone, light-gray, sandy in spots, with dark-brown shale at 56′ to 58′
71	73	2	Shale, brown-black, carbonaceous
73	76	3	Coal
76	84	8	Shale, brown-black, carbonaceous
84	102	18	Coal, shaly at bottom
102	114	12	Sandstone, light-gray, very fine grained, grading downward to medium-gray siltstone
114	117	3	Shale, light-gray
117	133	16	Sandstone, light-gray, very fine grained, interbedded with shale
133	136	3	Sandstone, medium-gray, calcareously cemented, hard
136	150	14	Siltstone, light-gray, sandy toward bottom
150	156	6	Sandstone, light-gray, very fine grained, silty
156	159	3	Shale, light-gray
159	168	9	Siltstone, medium-light-gray, sandy
168	191	23	Shale, medium-light-gray, silty
191	239	48	Sandstone, light-gray, very fine grained, silty at top, shale stringer at 226′
239	267	28	Siltstone, light- to medium-gray, shaly
267	298	31	Coal, shale parting 283′ to 286′
298	360	62	Siltstone, light- to medium-gray, clayey in part, sandy toward bottom, calcareously cemented and hard 334′ to 335′, coal stringers at 306′ and 350′

SECTION MB-10

Depth interval (feet) From	To	Thickness	Lithologic Description
360	431	71	Sandstone, light- to medium-gray, interbedded with siltstone, bony coal from 378′ to 380′ and 398′ to 400′
431	438	7	Shale, medium-gray
438	444	6	Sandstone, light-gray, very fine grained, calcareously cemented and very hard
444	475	31	Sandstone, light- to medium-gray, medium-grained, some interbedded with siltstone
475	492	17	Sandstone, light-gray, silty in part
492	535	43	Siltstone, light-gray

U.S. Geological Survey

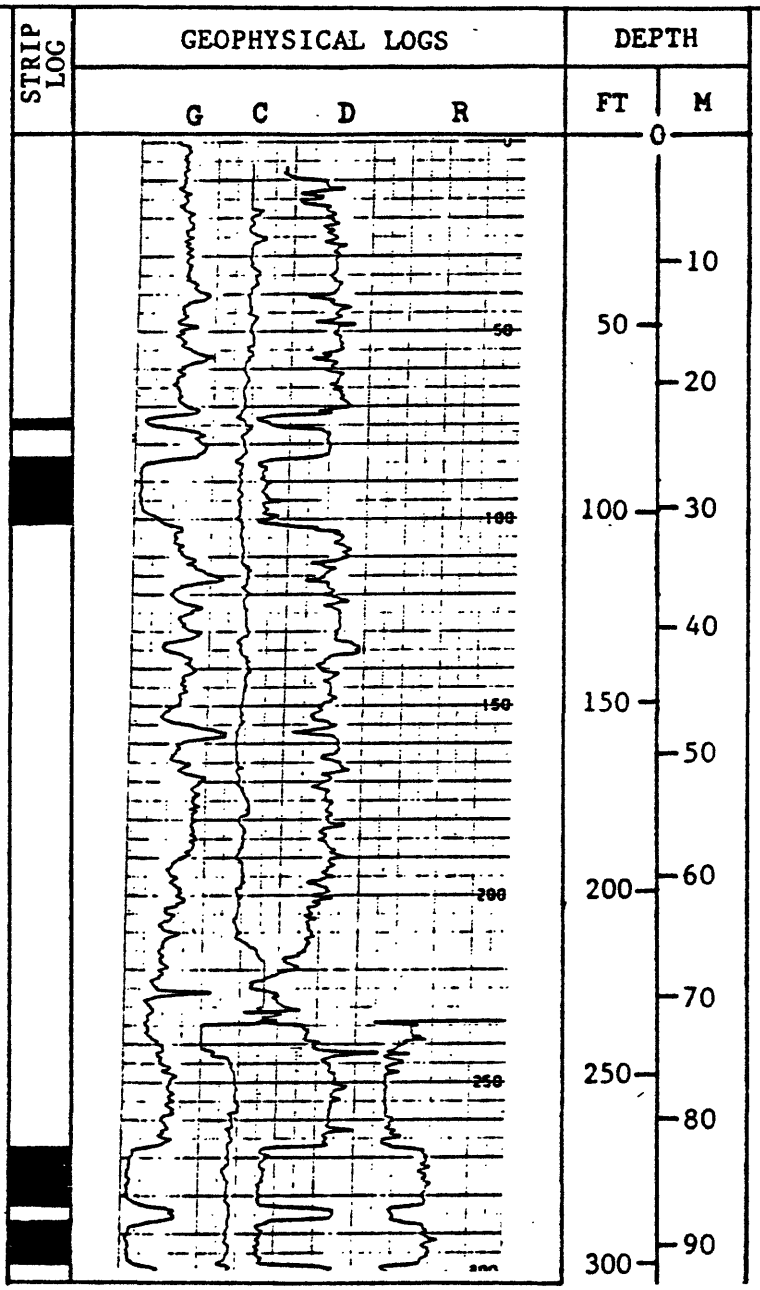
Hole Designation MB-10 Logged Depth 529 (ft)

Geophysical Log Scales:

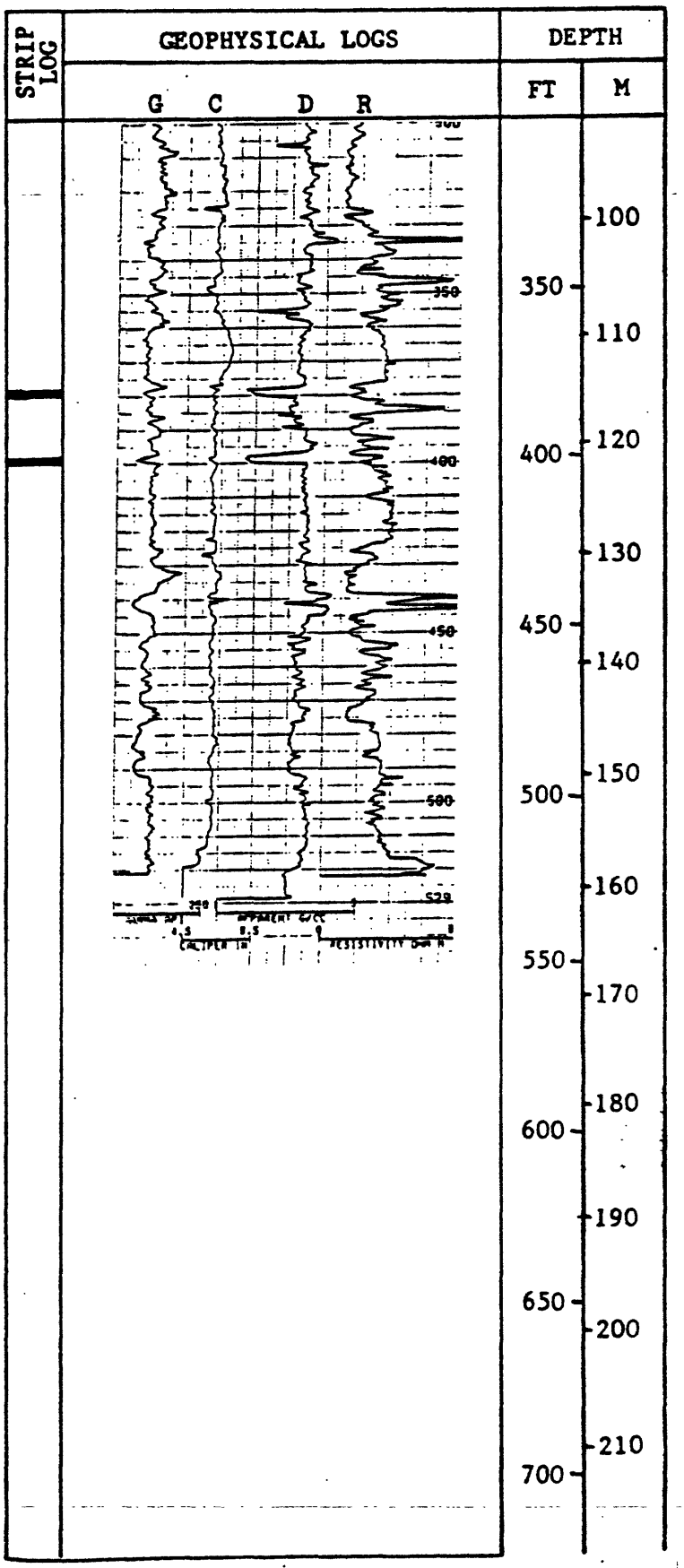
Gamma (G) 100 API units/in Density (D) .5 counts/sec/in

Resistivity (R) 20 ohms/in Caliper (C) 2 in/in

Remarks: 1 API unit = .618 counts per second



MB-10


STRIP LOG
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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-11 Elev.(ft) 3340 Total Depth(ft) 435

Location 1900 fel 2000 fnl sec. 30 T. 7 S. R. 49 E.

County Powder River State Montana Quadrangle (7.5′) Bloom Creek

Cored: Yes ____ No x Interval(s) ____

Date started 9/1/79 Date completed 9/1/79 Driller Steve Grant

Geologist Mark Kirschbaum Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	14	14	Alluvium, sand, light-brown, with clinker chips
14	22	8	Sandstone, light-olive-brown, very fine grained, calcareous at bottom
22	45	23	Siltstone, light- to medium-gray, interbedded with shale, black, carbonaceous, coaly, 30′ to 33′
45	81	36	Shale, medium-dark-gray, grading silty toward the bottom
81	91	10	Coal, black, shaly top and bottom
91	113	22	Sandstone, medium-gray, very fine grained, silty, coaly stringer at 94′
113	123	10	Shale, medium-dark-gray, silty
123	130	7	Coal, black, shale parting at bottom
130	142	12	Siltstone, medium-dark-gray, calcareous, sandy toward bottom
142	146	4	Sandstone, light-gray, fine-grained, calcareously cemented and hard
146	175	29	Sandstone, light- to medium-gray, very fine grained
175	179	4	Siltstone, light-gray
179	185	6	Coal, black
185	212	27	Shale, light- to medium-gray, silty, interbedded with sandy, medium-gray siltstone
212	225	13	Sandstone, medium gray, very fine grained, calcareously cemented and hard 214′ to 218′
225	237	12	Shale, medium-gray, silty at top, carbonaceous
237	251	14	Siltstone, medium-gray, silty at top
251	256	5	Coal, black, shale parting at 252′ to 253′
256	276	20	Siltstone, medium-gray, shaly
276	281	5	Coal, black, shale parting at 278′ to 279′
281	301	20	Sandstone, light-gray, very fine grained, silty toward bottom
301	341	40	Sandstone, medium-light-gray, very fine grained, silty in places
341	354	13	Shale, medium- to medium-dark-gray, silty

SECTION MB-11

Depth interval (feet)			
From	To	Thick-ness	Lithologic Description
354	360	6	Sandstone, light-gray, very fine grained, silty
360	362	2	Coal
362	385	23	Siltstone, medium-dark-gray, sandy at top
385	435	50	Sandstone, light- to medium-gray, fine- to very fine grained, silty

U.S. Geological Survey

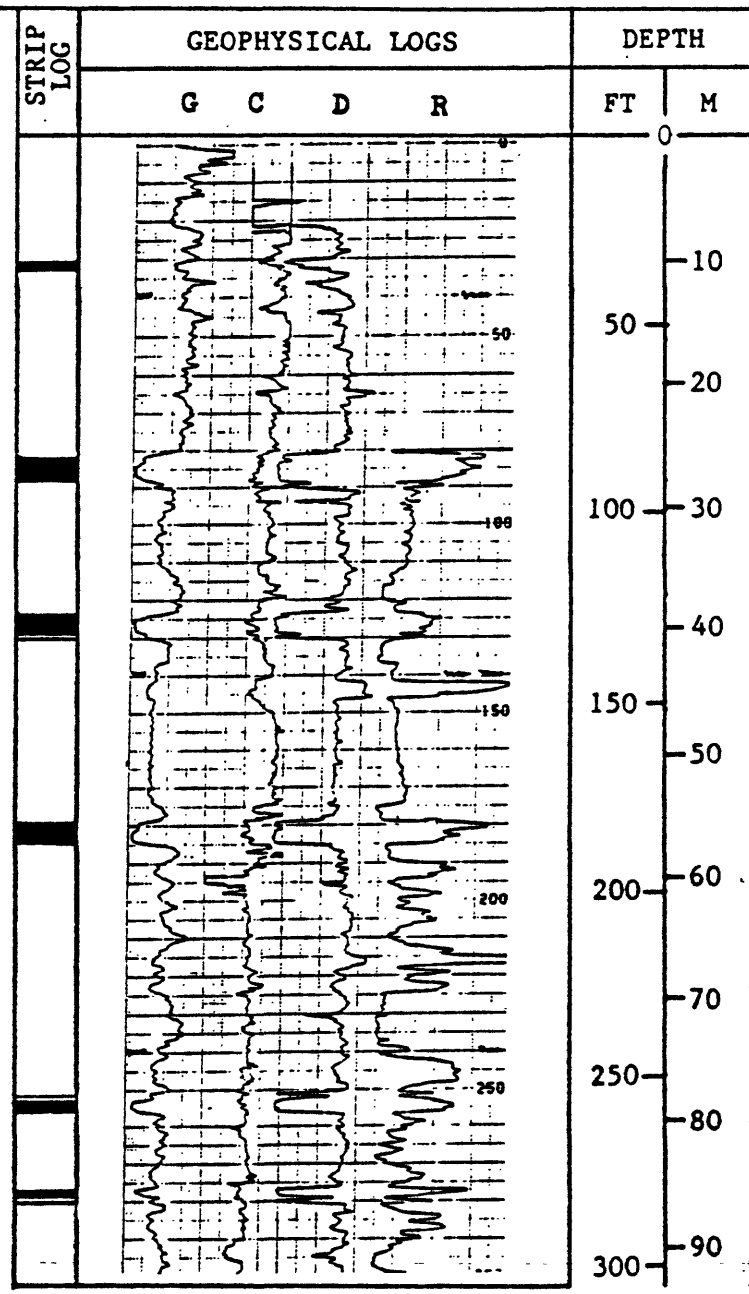
Hole Designation MB-11 Logged Depth 433 (ft)

Geophysical Log Scales:

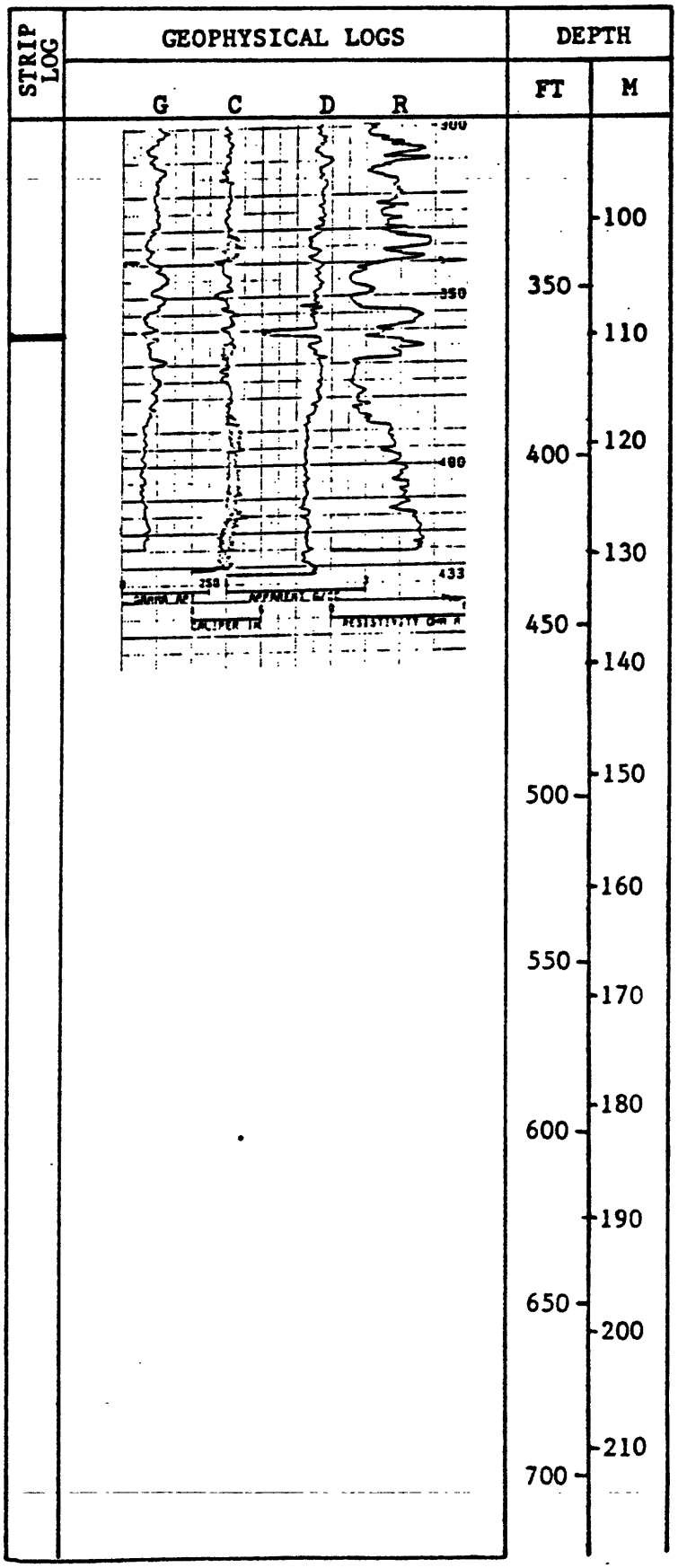
Gamma (G) 100 API units/in Density (D) .5 counts/sec/in

Resistivity (R) 20 ohms/in Caliper (C) 2 in/in

Remarks: 1 API unit = .618 counts per second



MB-11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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-12 Elev.(ft) 3430 Total Depth(ft) 550

Location 500 fwl 2100 fnl sec. 24 T. 7 S. R. 48 E.

County Powder River State Montana Quadrangle(7.5′) Bloom Creek

Cored: Yes ____ No x Interval(s) ____

Date started 9/2/79 Date completed 9/2/79 Driller Steve Grant

Geologist Mark Kirschbaum Remarks: Completed as water well

Depth interval (feet) From	To	Thickness	Lithologic Description
0	9	9	Alluvium, sandy, yellowish-brown, fine-grained
9	15	6	Sandstone, yellow-brown, oxidized, clayey toward bottom
15	24	9	Coal, bony, shaly at top
24	43	19	Sandstone, medium-gray, very fine grained, silty
43	71	28	Shale, medium-gray, interbedded with light-olive-gray siltstone
71	86	15	Siltstone, brown-gray, trace carbonaceous, shale in cuttings
86	101	15	Sandstone, medium-gray, very fine grained, silty
101	103	2	Coal
103	132	29	Sandstone, light-brown-gray, very fine grained, interbedded with light-gray siltstone, clayey, coaly streak at 109′
132	135	3	Coal
135	160	25	Sandstone, medium-gray, very fine grained, interbedded with light-gray shale
160	169	9	Shale, medium-gray, coal stringer 164′-166′
169	189	20	Siltstone, light- to medium-gray, shaley
189	208	19	Sandstone, light-gray, very fine grained, silty
208	236	28	Siltstone, light- to medium-gray, sandy
236	245	9	Coal
245	262	17	Siltstone, light-gray, clayey, coal streak at 250′
262	288	26	Sandstone, light-gray, fine- to very fine grained, calcareous and hard at 266′, silty
288	298	10	Sandstone, light-gray, very fine grained
298	305	7	Coal
305	326	21	Shale, light-gray, silty, calcareous and hard at 314′
326	334	8	Coal
334	344	10	Sandstone, light-gray, very fine grained
344	352	8	Shale, light-gray, silty

SECTION MB-12

Depth interval (feet) From	To	Thickness	Lithologic Description
352	377	25	Sandstone, light-gray, very fine grained
377	401	24	Siltstone, light- to medium-gray, interbedded with very fine grained sandstone, coal streak from 392′ to 393′
401	407	6	Coal
407	428	21	Siltstone, light-gray, clayey toward bottom
428	432	4	Coal
432	442	10	Sandstone, light-gray, silty
442	450	8	Shale, medium-gray, silty
450	471	21	Siltstone, light-gray, clayey towards bottom
471	485	14	Sandstone, light-gray, silty
485	495	10	Shale, medium-gray, silty
495	500	5	Sandstone, medium-gray
500	511	11	Shale, medium-gray, silty
511	514	3	Coal
514	550	46	Siltstone, light- to medium-gray, clayey

U.S. Geological Survey

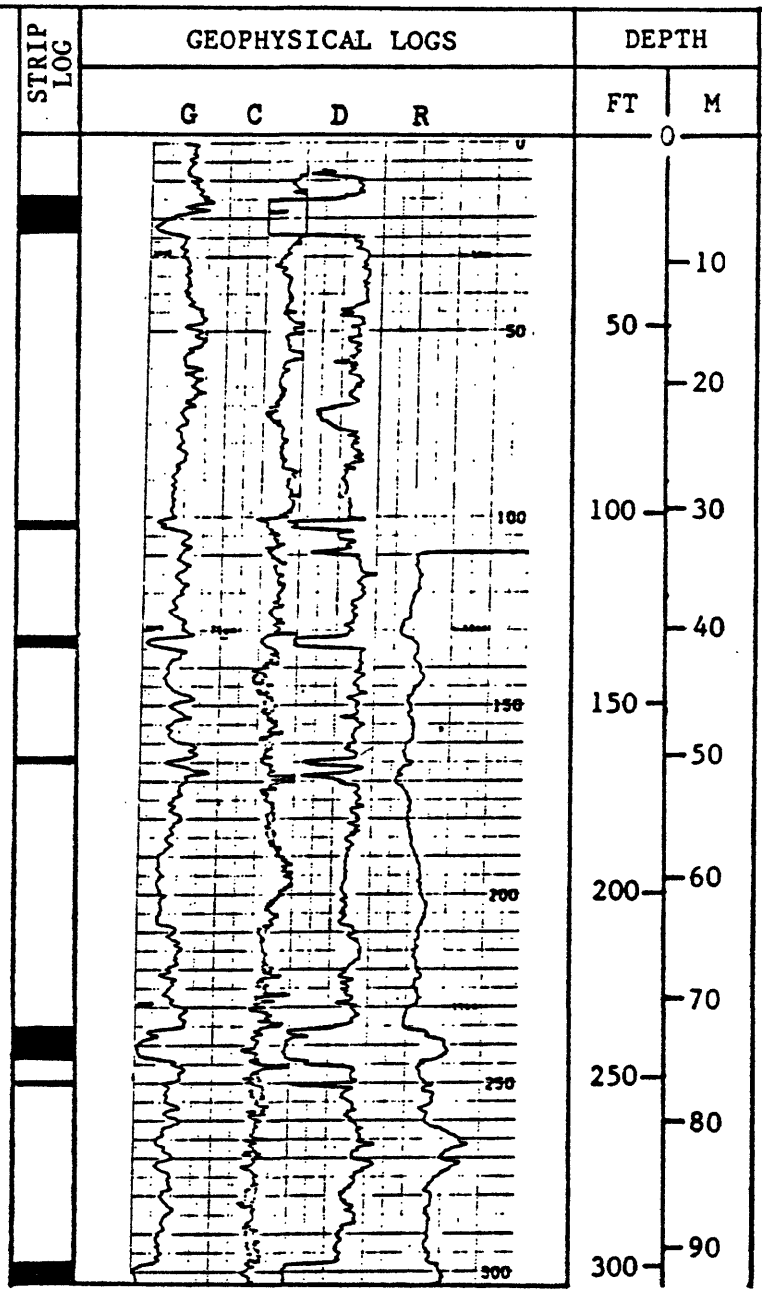
Hole Designation MB-12 Logged Depth 545 (ft)

Geophysical Log Scales:

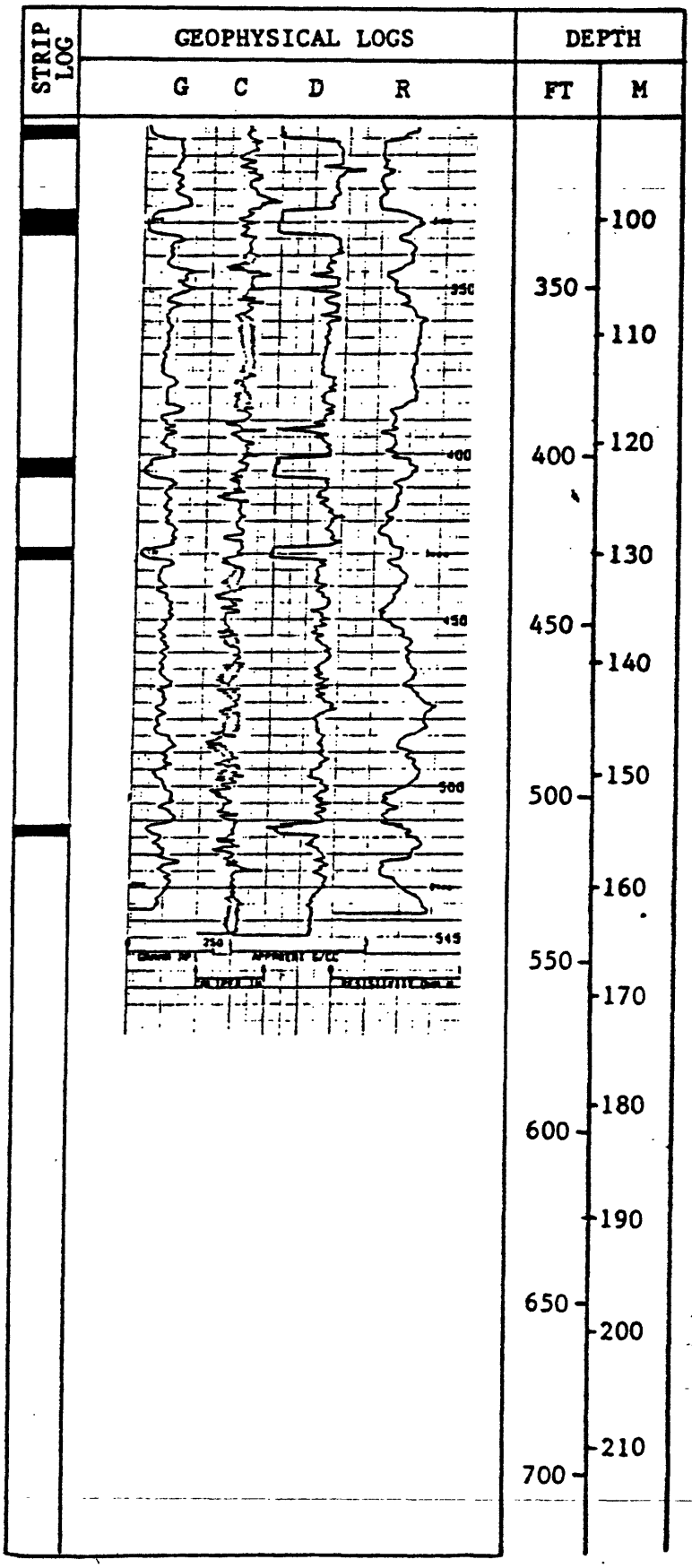
Gamma (G) 100 API units/in Density (D) .5 counts/sec/in

Resistivity (R) 2.5 ohms/in Caliper (C) 2 in/in

Remarks: 1 API unit = .618 counts per second



MB-12


STRIP LOG
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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-13A Elev.(ft) 3580 Total Depth(ft) 605

Location 600 fel 2650 fnl sec. 16 T. 7 S. R. 48 E.

County Powder River State Montana Quadrangle(7.5′) Bloom Creek

Cored: Yes ____ No x Interval(s) ____

Date started 9/13/79 Date completed 9/13/79 Driller Arthur Clark

Geologist Mark Kirschbaum Remarks: Hole 13 abandoned due to surface caving and moved to 13 A

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	5	5	Soil, yellow-gray
5	54	49	Sandstone, yellow-gray to very pale orange, fine grain, badly washed 38′ to 54′
54	63	9	Shale, medium-gray
63	75	12	Siltstone, medium-gray
75	91	16	Shale, medium-light-gray, silty top
91	99	8	Coal, parting at 95-96′
99	125	26	Shale, medium-gray to gray-brown, silty
125	160	35	Coal, black, shale streak at 147′
160	226	66	Siltstone, medium-light to medium-gray, sandy in places
226	233	7	Shale, medium-light-gray, clayey
233	244	11	Coal, black, bony 233′ to 235′, shale parting 235′ to 237′
244	256	12	Siltstone, medium-gray, clayey at top
256	274	18	Shale, medium-light-gray, silty
274	279	5	Siltstone, medium-light-gray
279	291	12	Shale, medium-gray; carbonaceous, brown-black toward bottom
291	346	55	Shale, medium-gray to olive-gray with interbedded medium-light-gray siltstone
346	362	16	Sandstone, olive-gray, very fine grained
362	368	6	Coal, black, bony top 1′, shale parting from 263′ to 265′
368	389	21	Shale, medium-light-gray, silty
389	391	2	Coal
391	406	15	Shale, medium-gray
406	408	2	Sandstone, medium-light-gray, very fine grained, calcareous
408	431	23	Siltstone, medium-gray, clayey
431	437	6	Sandstone, medium-gray
437	444	7	Shale, medium-gray

SECTION MB-13A

Depth interval (feet)			
From	To	Thick-ness	Lithologic Description
444	456	12	Coal, black, shale parting 448′ to 450′
456	464	8	Shale, medium-light-gray, coaly at 459′
464	466	2	Coal, bony
466	499	33	Sandstone, light-gray, silty, with some interbedded light-gray shale
499	507	8	Coal
507	514	7	Shale, medium-gray, carbonaceous
514	525	11	Sandstone, medium-gray, very fine grained, calcareous and hard at 524′
525	542	17	Shale, medium-gray, carbonaceous and coaly streaks
542	559	17	Siltstone, medium-gray
559	584	25	Coal, black, bony top 1′, shale partings 560′ to 562′ and 568′ to 571′
584	588	4	Shale, light-gray
588	605	17	Siltstone, light-gray, sandy at top

U.S. Geological Survey

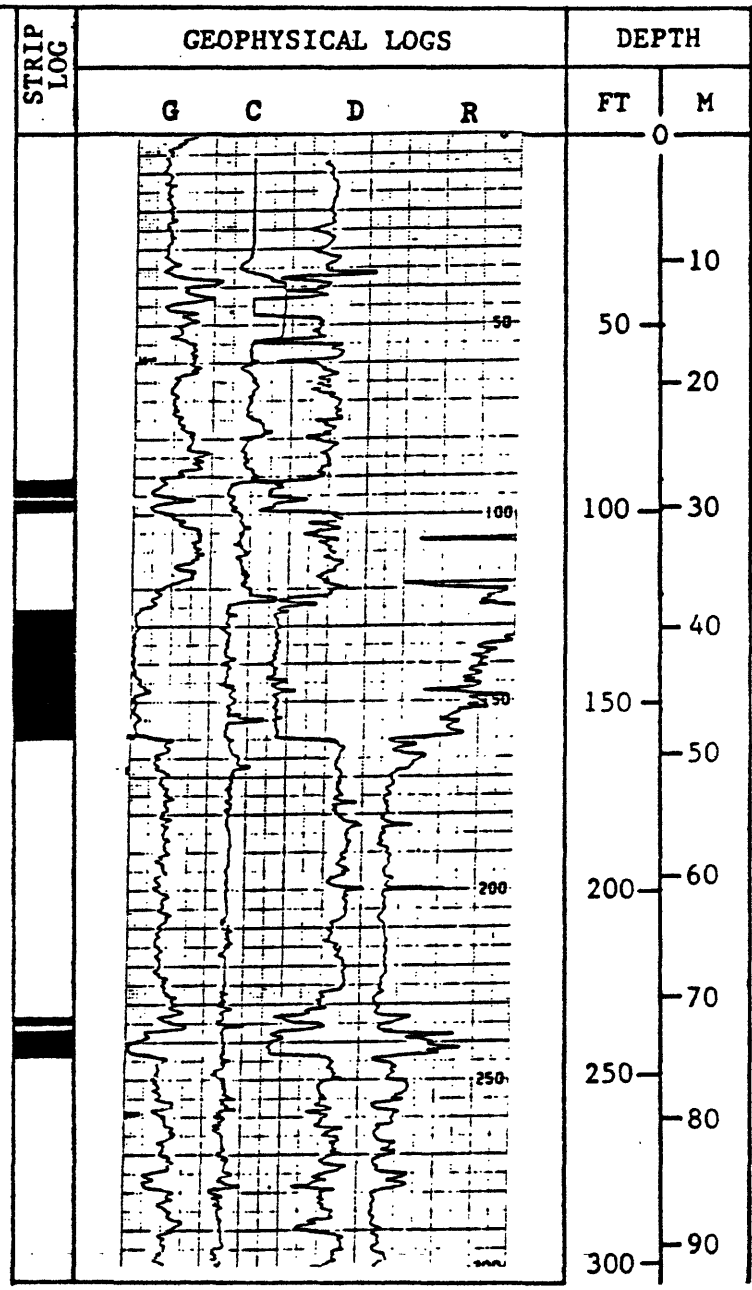
Hole Designation MB-13A Logged Depth 607 (ft)

Geophysical Log Scales:

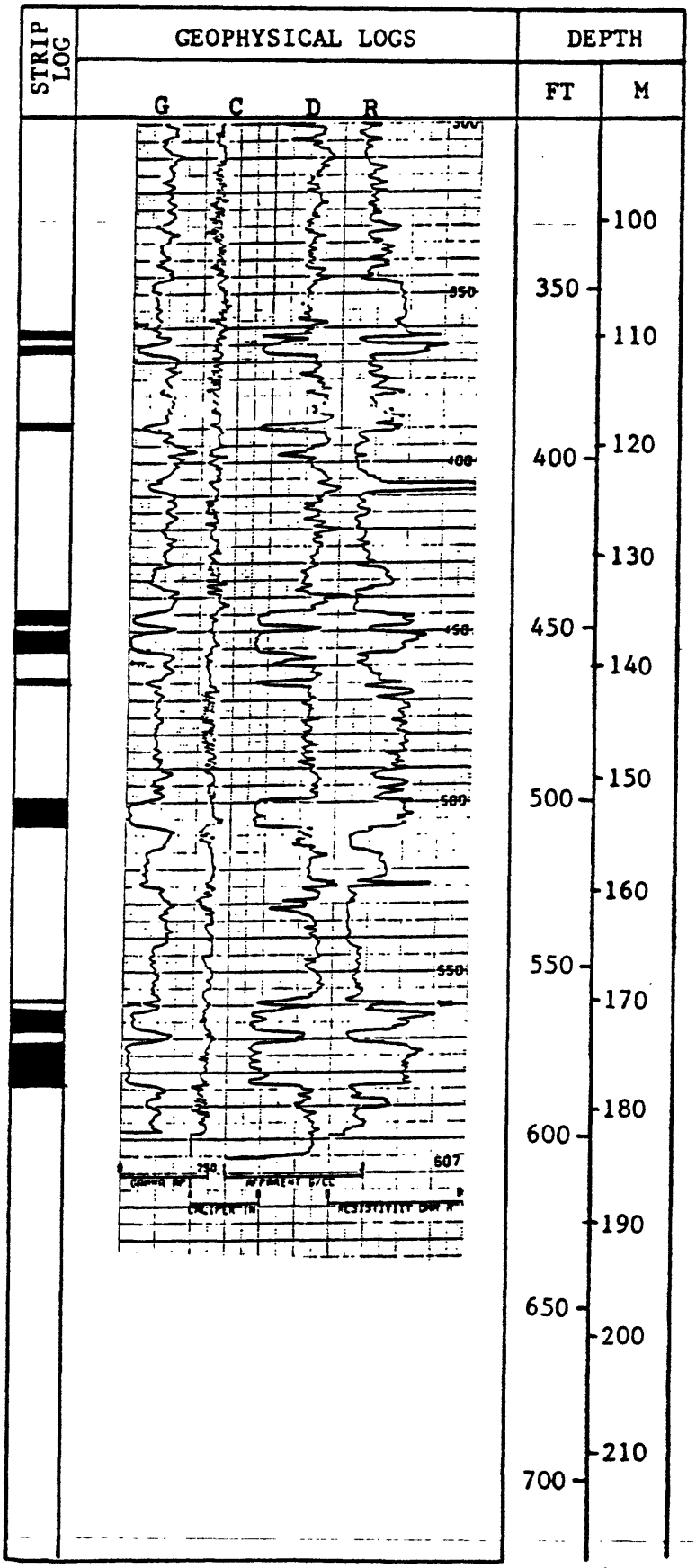
Gamma (G) 100 API units/in Density (D) .5 counts/sec/in

Resistivity (R) 20 ohms/in Caliper (C) 2 in/in

Remarks: 1 API unit = .618 counts per second



MB-13A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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-14 Elev.(ft) 4020 Total Depth(ft) 595

Location 500 fwl 650 fnl sec. 30 T. 6 S. R. 48 E.

County Powder River State Montana Quadrangle(7.5′) Phillips Butte

Cored: Yes ____ No x Interval(s) ____

Date started 9/13/79 Date completed 9/15/79 Driller Steve Grant

Geologist Mark Kirschbaum Remarks: Hole caved below 350′

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	11	11	Alluvium, silt, grayish-yellow to light-olive-brown
11	15	4	Coal, highly oxidized
15	24	9	Siltstone, brown-gray to light-yellow-brown, leached, clayey
24	30	6	Mudstone, medium-light-gray
30	44	14	Sandstone, light-olive-gray to very light gray, very fine grained, silty at top, well cemented and hard in places
44	49	5	Shale, light-gray
49	52	3	Coal, shaly
52	61	9	Siltstone, light-medium-gray
61	88	27	Siltstone, medium-gray, sandy
88	90	2	Coal, shale, carbonaceous
90	103	13	Shale, medium- to light-gray, sandy at top
103	116	13	Coal
116	133	17	Shale, light-gray, silty
133	156	23	Siltstone, medium-light-gray, clayey
156	195	39	Shale, medium- to medium-dark-gray interbedded with light-gray siltstone
195	206	11	Sandstone, light-olive-gray, very fine grained
206	220	14	Siltstone, olive-gray to light-olive-gray, clayey
220	228	8	Mudstone, medium-gray
228	286	58	Sandstone, light olive-gray to medium-light-gray, very fine grained, silty with interbedded medium gray shale
286	305	19	Coal, some carbonaceous shale
305	328	23	Siltstone, light-to medium-gray, clayey
328	340	12	Coal

SECTION MB-14

Depth interval (feet)			
From	To	Thick-ness	Lithologic Description
340	442	102	Siltstone, medium-gray to medium-dark-gray, interbedded with medium-light-gray to medium-gray shale, with medium-light-gray, very fine grained sandstone, calcareous, hard from 368′ to 376′; coal stringer at 441′
442	564	122	Sandstone, light- to medium-dark-gray, very fine grained
564	595	31	Siltstone, olive-gray, clayey

U.S. Geological Survey

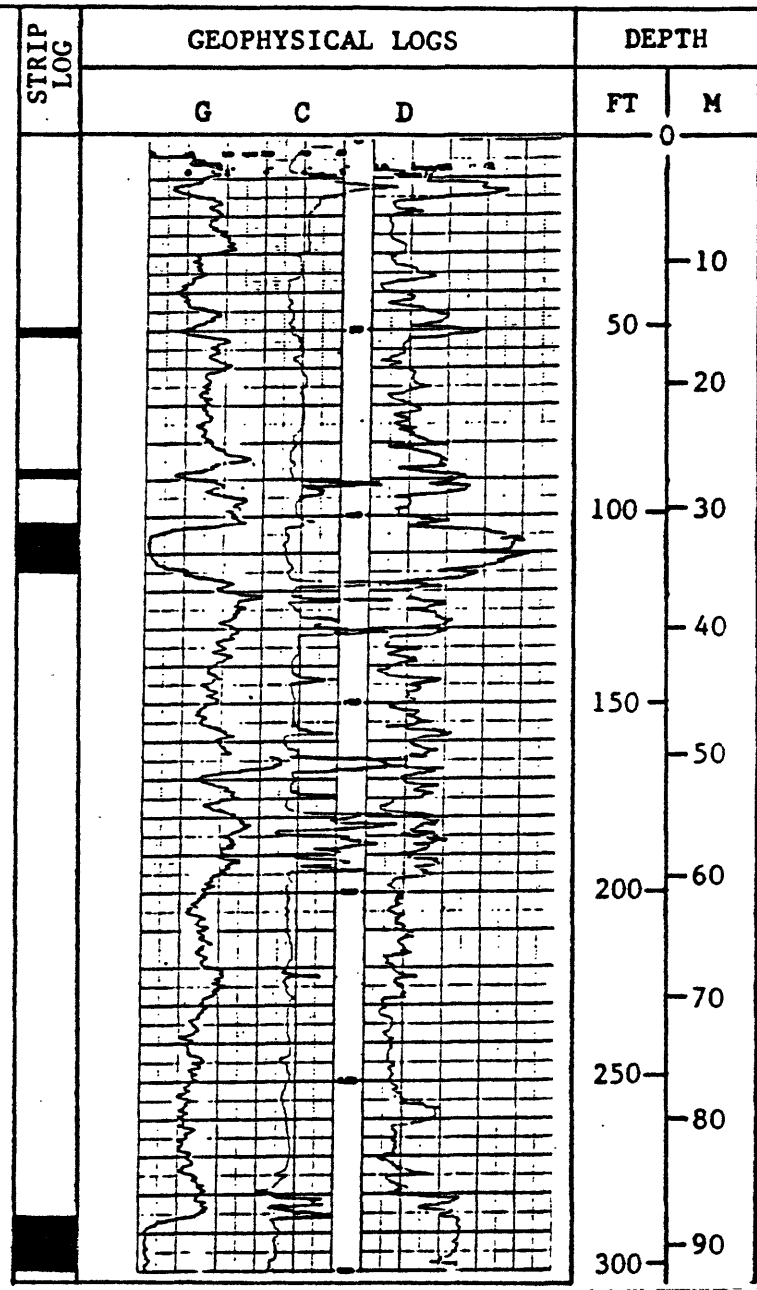
Hole Designation MB-14 Logged Depth 350 (ft)

Geophysical Log Scales:

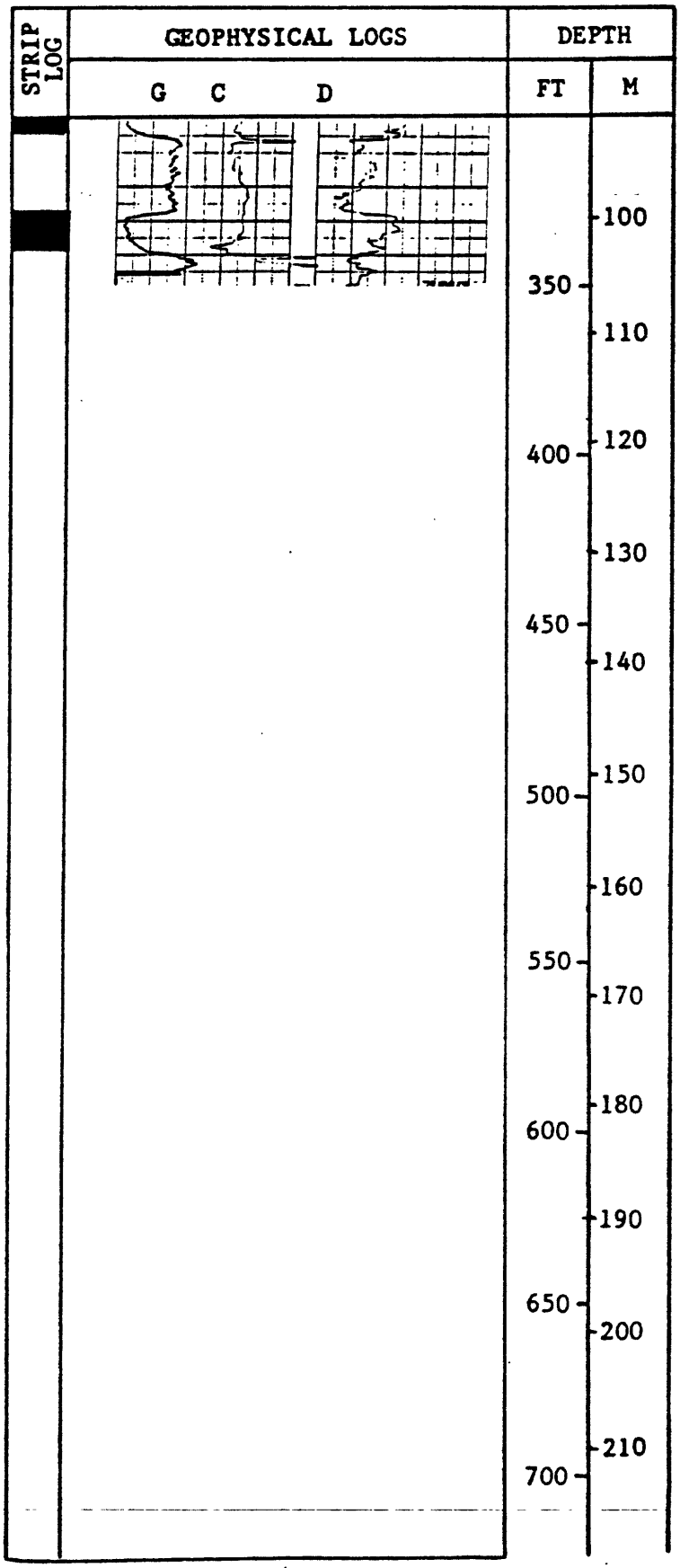
Gamma (G) 10 counts/sec/in Density (D) .53 counts/sec/in

Resistivity (R) _____ Caliper (C) 2 in/in

Remarks: The density log is plotted with increasing density to the left



MB-14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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-15 Elev.(ft) 4180 Total Depth(ft) 515

Location 900 fel 2100 fnl sec. 8 T. 6 S. R. 48 E.

County Powder River State Montana Quadrangle(7.5′) Hodson Flats

Cored: Yes ____ No x Interval(s) ____

Date started 9/15/79 Date completed 9/15/79 Driller Arthur Clark

Geologist Mark Kirschbaum Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	5	5	Alluvium, gray-yellow
5	14	9	Alluvium, yellow-brown
14	26	12	Sandstone, light-brown to yellow-gray, very fine grained, silty
26	42	16	Siltstone, light-gray
42	49	7	Sandstone, light-brown, very fine grained, silty
49	53	4	Shale, dark-gray, some silt
53	55	2	Coal
55	58	3	Carbonaceous shale
58	61	3	Coal
61	85	22	Siltstone, medium-light-gray to medium-gray, clayey
85	94	9	Shale, medium-gray, coal stringer
94	100	6	Sandstone, light-gray, very fine grained
100	103	3	Coal
103	146	43	Sandstone, light-blue-gray to light-gray, very fine grained, clayey in places
146	183	37	Shale, medium-gray, silty, with coal at 146′ to 148′ and 181′ to 182′
183	195	12	Shale, brown-black, silty
195	204	9	Coal
204	254	50	Interbedded shale, medium-light-gray, and medium-gray to medium-dark-gray, siltstone, numerous washouts
254	273	19	Sandstone, medium-gray, very fine grained
273	336	63	Shale, light-to-medium gray with clay at 324′; silty in places; trace coal in cuttings at 277′
336	420	84	Sandstone, medium-light-gray, very fine grained, silty
420	449	29	Siltstone, light- to medium-light-gray, clayey toward bottom
449	489	40	Coal, shale parting from 471′ to 476′
489	497	8	Shale, medium-light-gray
497	515	18	Shale, medium-gray, silty

U.S. Geological Survey

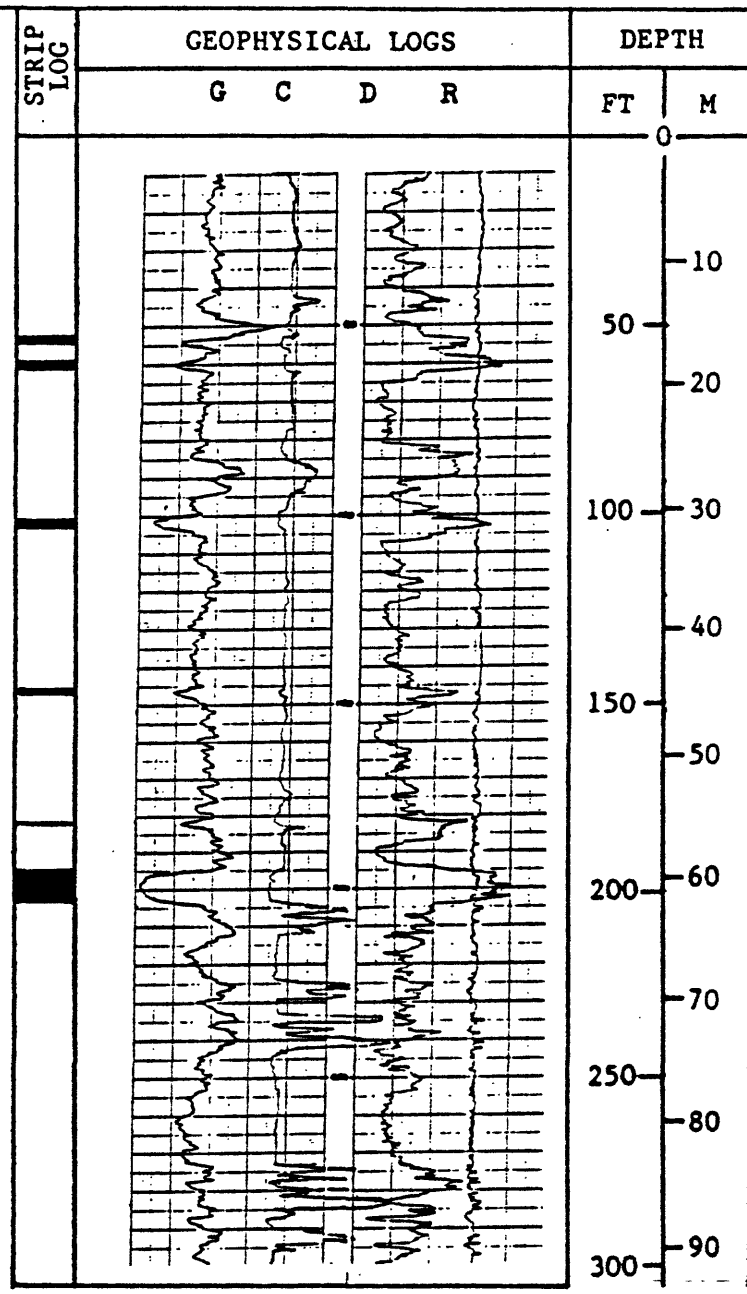
Hole Designation MB-15 Logged Depth 514 (ft)

Geophysical Log Scales:

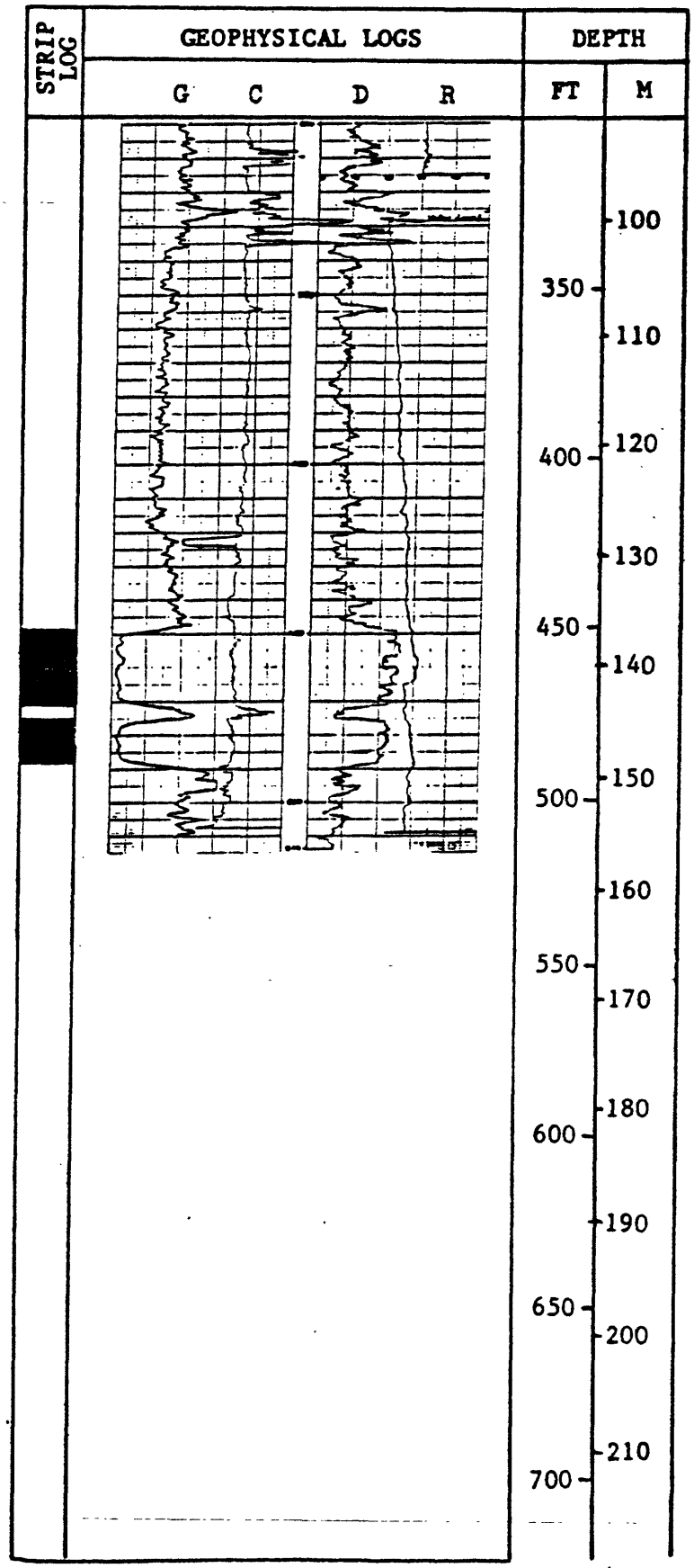
Gamma (G) 10 API units Density (D) .53 counts/sec/in

Resistivity (R) Dry 200 ohms/in Wet 10 ohms/in Caliper (C) 2 in/in

Remarks: Dry resistivity run until 330'. Density log plotted with increasing density to the left. 1 API unit = .618 counts per second



MB-15


STRIP LOG
GEOPHYSICAL LOGS
G C D R
DEPTH
FT
M
350
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550
600
650
700
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110
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180
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200
210

U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-16 Elev.(ft) 4100 Total Depth(ft) 555

Location 600 fnl 900 fel sec. 30 T. 5 S. R. 48 E.

County Powder River State Montana Quadrangle(7.5') Hodson Flats

Cored: Yes ____ No x Interval(s) ____

Date started 9/18/79 Date completed 9/18/79 Driller Steve Grant

Geologist Mark Kirschbaum Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	5	5	Alluvium, dark-yellow-orange sand to yellow-brown clay
5	10	5	Alluvium, sand and clay, yellow-brown to gray-brown
10	12	2	Alluvium, sand, yellow-orange
12	19	7	Coal, highly oxidized, carbonaceous shale parting from 16' to 17'
19	30	11	Sandstone, yellow-brown to yellow-gray, very fine grained, clayey
30	44	14	Shale, medium-light to medium-gray, trace carbonaceous shale
44	48	4	Coal
48	60	12	Shale, medium-dark-gray to brown-black
60	64	4	Coal, bony
64	75	11	Shale, medium-light-gray
75	78	3	Coal, shale, carbonaceous
78	87	9	Shale, medium-gray, silty
87	92	5	Sandstone, light-gray, very fine grained, calcareous, hard
92	95	3	Mudstone, medium-gray, silty
95	96	1	Sandstone, light-gray, very fine grained, calcareous, hard
96	125	29	Sandstone, green-gray to medium-gray, very fine grained, clayey
125	138	13	Siltstone, medium-dark-gray, clayey
138	147	9	Coal
147	156	9	Shale, medium-gray, silty
156	160	4	Shale, medium-dark-gray
160	200	40	Shale, medium-light to medium-dark-gray, silty
200	219	19	Coal
219	236	17	Siltstone, medium-light-gray, sandy
236	304	68	Sandstone, medium-light-gray, very fine grained, grading silty to top
304	315	11	Coal
315	326	11	Shale, medium-dark-gray, silty towards bottom
326	347	21	Sandstone, very light to light-gray, grading shaly to base
347	365	18	Sandstone, light- to medium-gray grading silty to base

SECTION MB-16

Depth interval (feet)			
From	To	Thick-ness	Lithologic Description
365	415	50	Sandstone, medium-gray, very fine grained, silty at top
415	445	30	Siltstone, light gray, interbedded with medium-light- to medium-gray, shale
445	473	28	Shale, brown-gray to brown-black, silty
473	502	29	Sandstone, light-gray, very fine grained, silty
502	523	21	Coal
523	555	32	Siltstone, medium-light- to medium-gray, clayey

U.S. Geological Survey

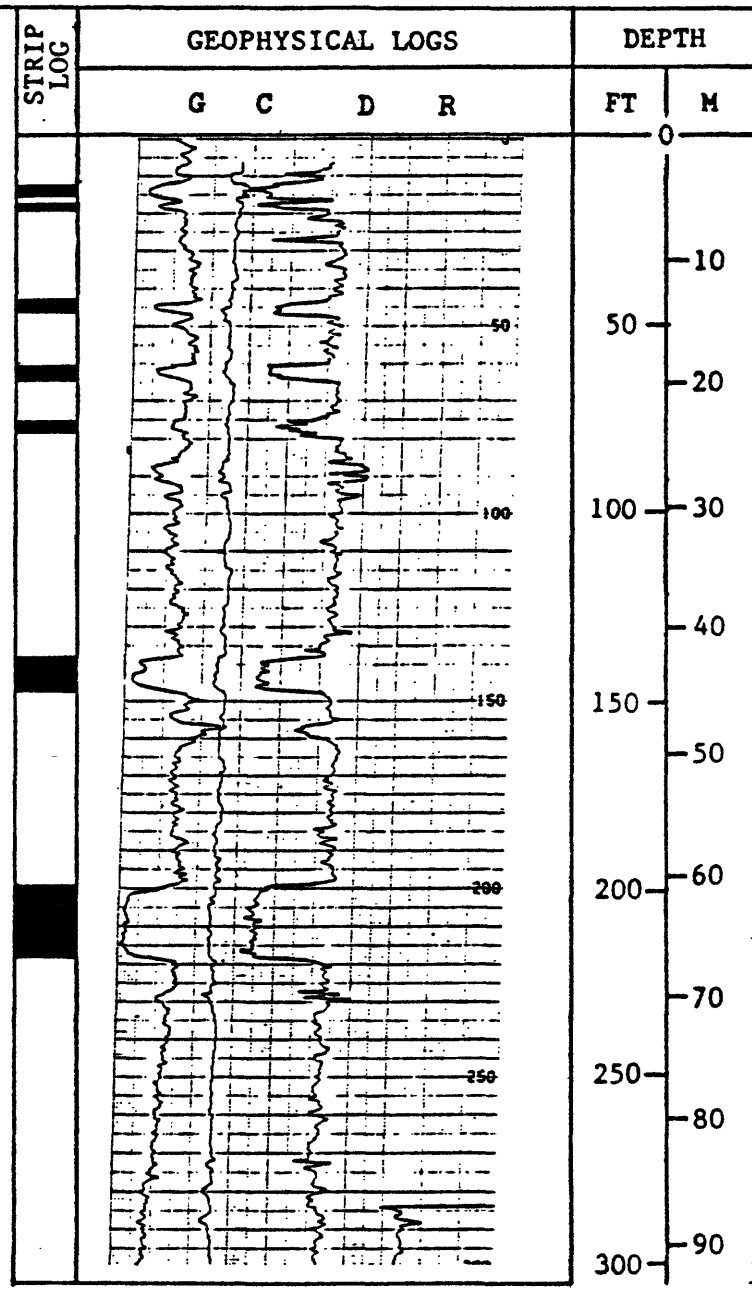
Hole Designation MB-16 Logged Depth 546 (ft)

Geophysical Log Scales:

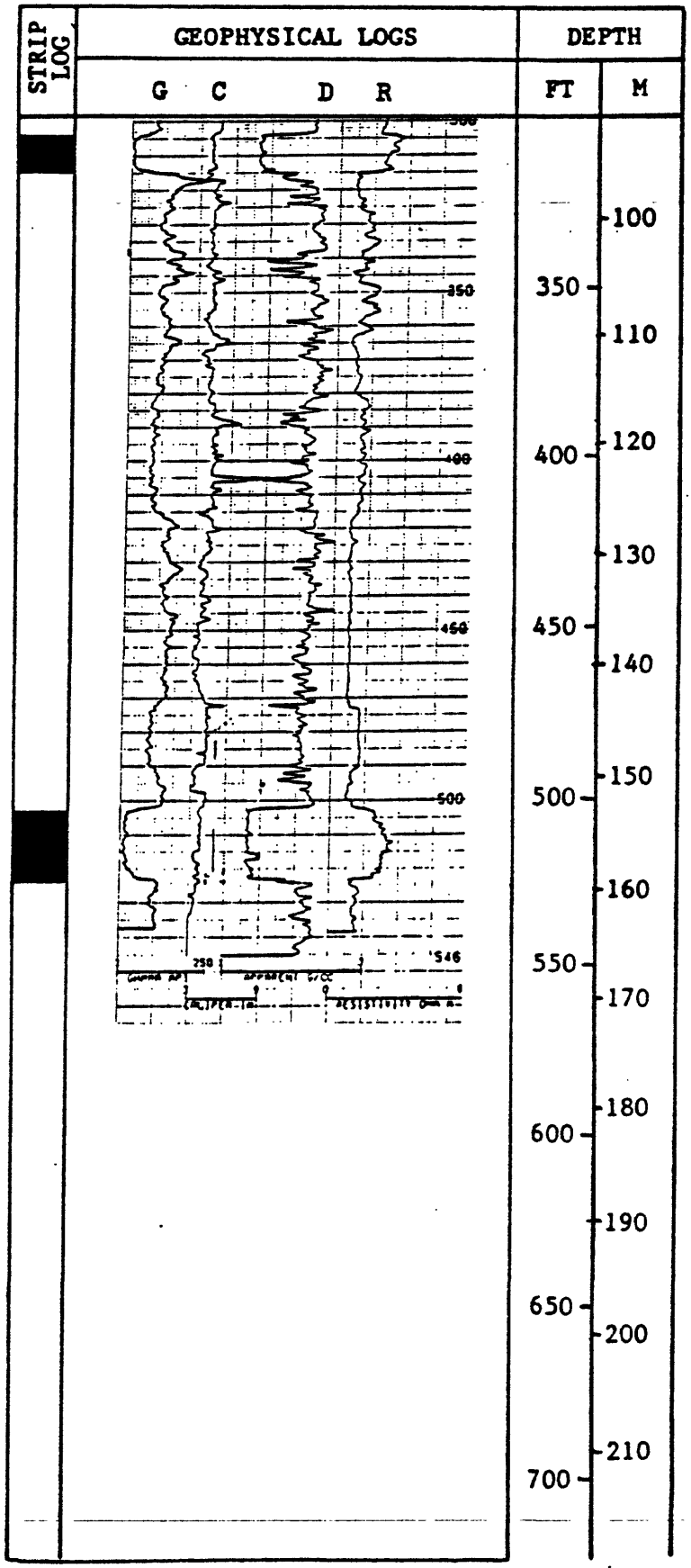
Gamma (G) 100 API units Density (D) .5 counts/sec/in

Resistivity (R) 20 ohms/in Caliper (C) 3 in/in

Remarks: 1 API unit = .618 counts per second



MB-16


STRIP LOG
GEOPHYSICAL LOGS
G C D R
DEPTH
FT
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650
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160
170
180
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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-17 Elev.(ft) 3905 Total Depth(ft) 515

Location 1850 fwl 1900 fnl sec. 7 T. 5 S. R. 48 E.

County Powder River State Montana Quadrangle(7.5) Sonnette

Cored: Yes ____ No x Interval(s) ____

Date started 9/27/79 Date completed 9/27/79 Driller Steve Grant

Geologist Frank Spencer Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	5	5	Alluvium, sand, light-yellow-gray, medium- to fine grained
5	10	5	Alluvium, sand, medium-yellow-brown, very fine grained to fine grain
10	65	55	Sandstone, light-yellow-gray to medium-gray, very fine grained to fine-grained, silty, silty toward base
65	75	10	Coal, woody, shale at top
75	77	2	Shale
77	82	5	Sandstone, light- to medium-gray, very fine grained, silty
82	84	2	Coal stringer
84	101	17	Shale, light-gray, silty
101	112	11	Coal, bony, woody
112	115	3	Shale
115	127	12	Siltstone, light-gray
127	131	4	Shale, carbonaceous
131	158	27	Siltstone, light- to medium-gray, sandy, with shaley coal stringers at 141′ and 145′
158	180	22	Sandstone, light-gray, very fine grained, silty, clayey
180	200	20	Sandstone, medium brown-gray, medium- to coarse-grained, with calcareous streaks
200	260	60	Sandstone, light- to medium-gray, cherty, silty
260	262	2	Coal stringer
262	288	26	Siltstone, light-gray, clayey
288	304	16	Interbedded shaley coal and shale
304	317	13	Siltstone, light-gray, sandy
317	340	23	Coal
340	378	38	Sandstone, light- to medium-gray, very fine to medium-grained, silty
378	406	28	Siltstone, medium-gray, sandy
406	409	3	Coal

SECTION MB-17

Depth interval (feet)			
From	To	Thick-ness	Lithologic Description
409	419	10	Shale, dark-brown, silty, carbonaceous
419	444	25	Sandstone, medium-gray, very fine grained to medium-grained
444	451	7	Shale
451	462	11	Coal
462	471	9	Shale, medium-gray, silty
471	490	19	Siltstone, medium-gray
490	494	4	Shale, medium-gray
494	515	21	Siltstone, medium-gray, sandy toward base

U.S. Geological Survey

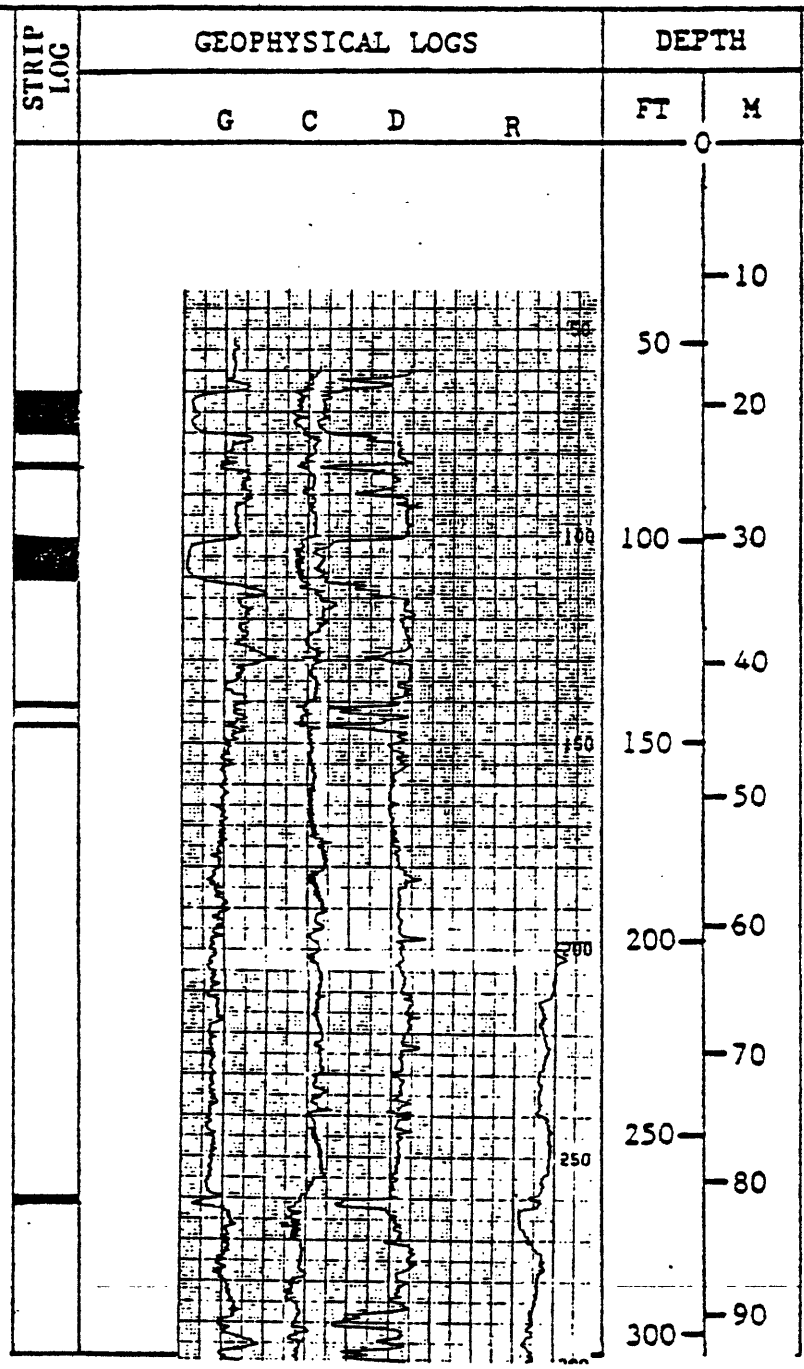
Hole Designation MB-17 Logged Depth 480 (ft)

Geophysical Log Scales:

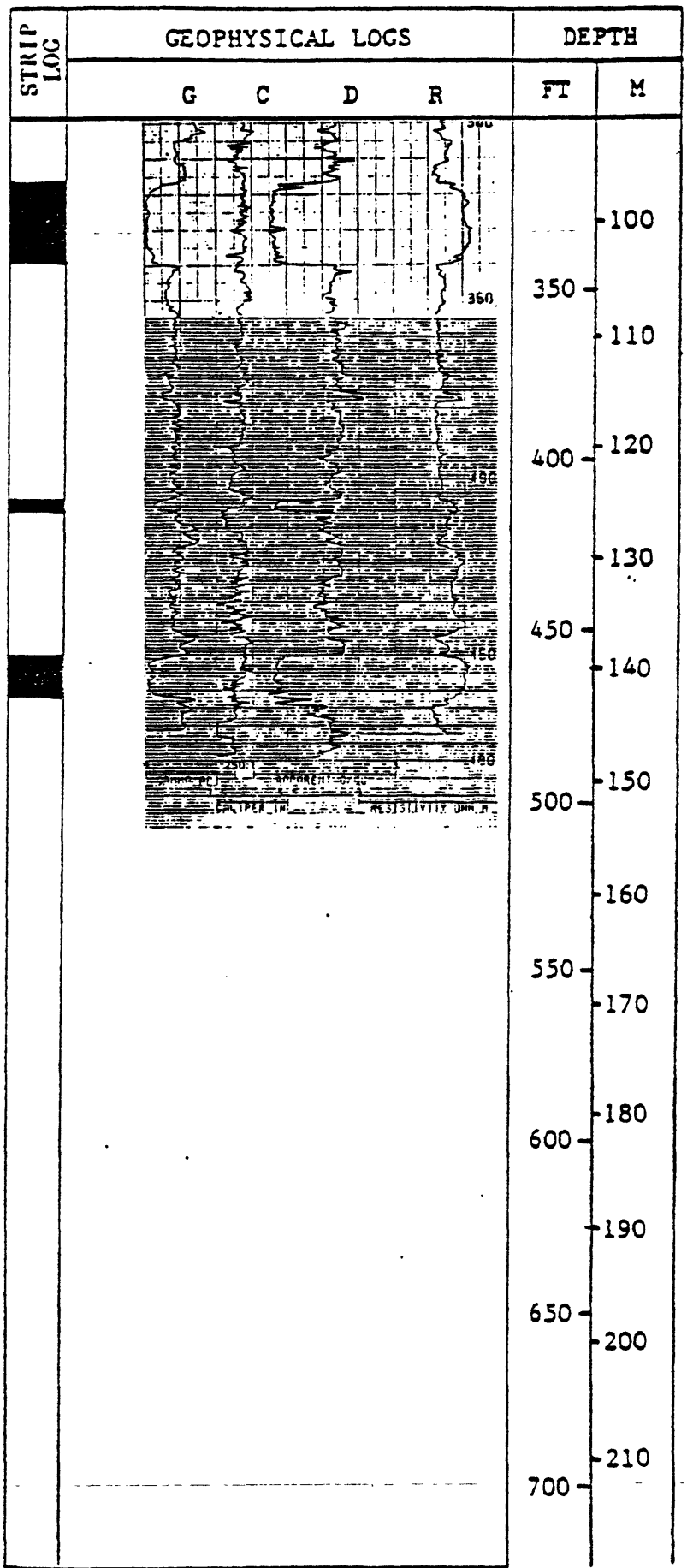
Gamma (G) 100 API units/in Density (D) .5 counts/sec/in

Resistivity (R) 2.5 ohms/in Caliper (C) 1.5 in/in

Remarks: 1 API unit = .618 counts per second



MB-17


STRIP LOG
GEOPHYSICAL LOGS
G C D R
DEPTH
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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-18 Elev.(ft) 3730 Total Depth(ft) 495

Location 500 fwl 2000 fnl sec. 33 T. 4 S. R. 48 E.

County Powder River State Montana Quadrangle(7.5') Sonnette

Cored: Yes ____ No x Interval(s) ____

Date started 10/15/79 Date completed 10/24/79 Driller Steve Grant

Geologist Mark Kirschbaum Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	5	5	Soil, clay, yellow-orange to gray-brown
5	10	5	Soil, clay, light-olive-gray
10	15	5	Soil, clay, medium-gray
15	29	14	Shale, medium-gray
29	36	7	Carbonaceous shale, coal at 30′
36	39	3	Shale, clayey, medium-gray
39	41	2	Shale, carbonaceous, coaly
41	44	3	Mudstone, light-gray, clayey, silty
44	55	11	Siltstone, medium-light-gray, sandy
55	61	6	Mudstone, olive-gray
61	83	22	Coal
83	143	60	Sandstone, light-olive-gray, very fine grained, silty
143	146	3	Coal, bony and carbonaceous shale
146	153	7	Mudstone, green-gray, clayey
153	164	11	Siltstone, light-gray, silty
164	171	7	Shale, carbonaceous, coal 167′-169′
171	175	4	Shale, brown-black
175	186	11	Mudstone, medium-light- to medium-gray, silty
186	190	4	Coal
190	213	23	Siltstone, medium- to medium-light-gray, clayey
213	226	13	Mudstone, brown-gray, coal stringers
226	235	9	Sandstone, medium-gray, very fine grained
235	240	5	Siltstone, medium gray

SECTION MB-18

Depth interval (feet) From	To	Thickness	Lithologic Description
240	260	20	Shale, olive-gray to brown-gray
260	265	5	Mudstone, brown-black
265	270	5	Mudstone, olive-gray, and, medium-gray, very fine grained sandstone
270	300	30	Shale, medium-gray to green-gray
300	310	10	Siltstone, medium-light-gray
310	320	10	Shale, medium-light-gray
320	325	5	Siltstone, medium-light-gray
325	330	5	Shale, medium-light-gray
330	332	2	Siltstone, medium-light-gray, calcareous, hard
332	345	13	Shale, medium-gray
345	367	22	Coal
367	375	8	Carbonaceous shale and medium-gray, very fine grained sandstone
375	380	5	Carbonaceous shale and mudstone
380	400	20	Mudstone, brown-gray
400	405	5	Mudstone, dark-green-gray
405	410	5	Siltstone, light-gray
410	420	10	Siltstone, medium-light-gray, and sandstone, light-gray, very fine grained, calcareous, hard
420	437	17	Sandstone, medium-gray, very fine grained, clayey
437	439	2	Coal
439	459	20	Siltstone, light-gray, sandy
459	462	3	Coal
462	470	8	Siltstone, green-gray, clayey
470	475	5	Siltstone, light-olive-gray
475	480	5	Siltstone, light-gray, and sandstone, light-gray, very fine grained, calcareous, hard
480	495	15	Siltstone, light-gray, coal stringer

U.S. Geological Survey

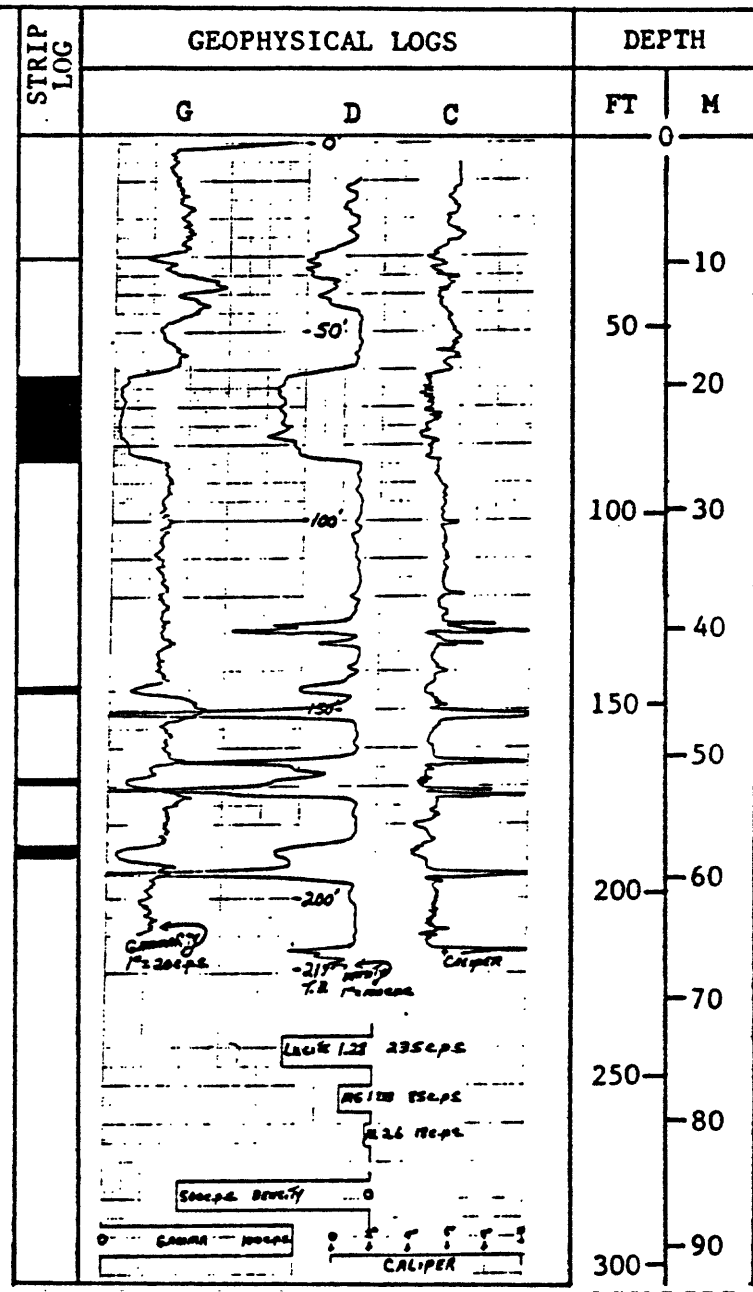
Hole Designation MB-18 Logged Depth 219 (ft)

Geophysical Log Scales:

Gamma (G) 20 counts/sec/in Density (D) 100 counts/sec/in

Resistivity (R) _____ Caliper (C) 2 in/in

Remarks: _____



U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-19 & MB-19C Elev.(ft) 3730 Total Depth(ft) 615

Location 100 fel 2400 fnl sec. 20 T. 4 S. R. 48 E.

County Powder River State Montana Quadrangle(7.5') Sonnette

Cored: Yes x No Interval(s) 60' to 90.2', 399' to 424.5'

Date started 10/26/79 Date completed 10/26/79 Driller Arthur Clark

Geologist Mark Kirschbaum Remarks: Core description by George A. Correia

Depth interval (feet) From	To	Thickness	Lithologic Description
0	4	4	Soil, yellow-brown
4	9	5	Siltstone, yellow-gray
9	15	6	Shale, yellow-orange, clayey
25	35	10	Siltstone, yellow-gray, with stringers of mudstone, yellow-orange, clayey
35	43	8	Mudstone, light- to medium-light-gray, clayey
43	48	5	Shale, light-gray, coaly streak at 46'
48	60	12	Shale, light-gray, silty, shell fragments, clayey
			CORE DESCRIPTION
60.0	61.3	1.3	Claystone, light-gray, silty toward bottom
61.3	62.4	1.1	Claystone, gray, silty, sand pockets, sharp contact with coal
62.4	75.2	12.8	Coal, black, hard, dull with bright streaks, conchoidal fracture, slicken side on top .6', clay streaks with gypsum crystals on fractures 71.8' to 72.3', gypsum and pyrite (disseminated) at 72.6', moisture on fresh fractures 72.3' to 73.0'
75.2	75.8	0.6	Shale, light brown, carbonaceous with rootlets and plant material, coal streak at base
75.8	78.1	2.3	Shale, gray, carbonaceous streaks - coal clasts - small streaks of coal to 76.5', scattered rootlets 76.5' to 77.8', slightly carbonaceous 77.8' to 78.1'
78.1	78.5	.4	Coal, black, hard, 60% shiny, clay pockets
78.5	79.1	.6	Shale, olive-brown, carbonaceous
79.1	79.6	.5	Shale, medium gray, carbonaceous on bedding planes, grades basal .2' into coal
79.6	89.4	9.8	Coal, black, hard, dull with shiny bands, conchoidal fracturing, clay streaks at 85.6', 86.3', and 87.6', disseminated pyrite and gypsum 86.2' to 86.4' on fractures, sharp basal contact with siltstone below

Depth interval (feet) From	To	Thickness	Lithologic Description
89.4	90.2	.8	Siltstone, medium-light-gray, clayey, shaly top .1′, gypsum, scattered rootlets
			END OF CORE DESCRIPTION
90.2	122	31.8	Shale, medium-light-gray, silty
122	129	7	Siltstone, light-gray, slightly sandy
129	152	23	Shale, light-gray, silty
152	155	3	Coal, black, bony
155	158	3	Claystone, very light gray
158	162	4	Coal, black, bony
162	167	5	Shale, medium-light-gray, carbonaceous at top, silty
167	193	26	Siltstone, medium-light-gray, sandy at bottom
193	211	18	Sandstone, light-gray, very fine grained, calcareous and hard at 195′
211	219	8	Shale, medium-light-gray
219	222	3	Coal
222	228	6	Shale, medium-dark-gray, carbonaceous, silty
228	256	28	Siltstone, light-gray, sandy, coaly from 238′ - 240′
256	262	6	Shale, brown-black, carbonaceous in part
262	286	24	Siltstone, medium- to light-gray
286	289	3	Shale, medium-gray
289	298	9	Shale, olive-gray, silty, carbonaceous with some coaly material
298	338	40	Mudstone, medium- to olive-gray, silty, shaly with coaly streak 321′ to 322′, clay streak at bottom
338	383	45	Sandstone, light-gray, very fine grained, silty toward bottom
383	399	16	Shale, light- to medium-light-gray, silty
			CORE DESCRIPTION
399.0	399.4	.4	Claystone, medium-gray, silty, sharp basal contact with coal
399.4	420.4	21.0	Coal, black, dull with shiny bands, fractured 399.4′ to 403.3′, medium hard, crumbles when fractured 399.4 to 407.8, badly broken with clay streaks 412.5′ to 413.4′
420.4	422.2	1.8	Claystone, medium-gray, slightly silty, carbonized rootlets, coal lense bottom .1′
422.2	424.5	2.3	Sandstone, medium-light-gray, fine grain, subrounded, mostly quartz
			END OF CORE DESCRIPTION
424.5	446	22.5	Siltstone, medium-to medium-light-gray
446	454	8	Sandstone, medium-light-gray, very fine grained
454	461	7	Shale, medium-light-gray, silty
461	468	7	Coal
468	475	7	Siltstone, very-light-gray
475	485	10	Shale, medium-light-gray, silty
485	514	29	Sandstone, medium-light-gray, silty
514	522	8	Coal
522	564	42	Shale, light- to medium-gray, silty
564	575	11	Sandstone, medium-light-gray, silty
575	615	40	Shale, medium-light-to light-gray, silty

U.S. Geological Survey

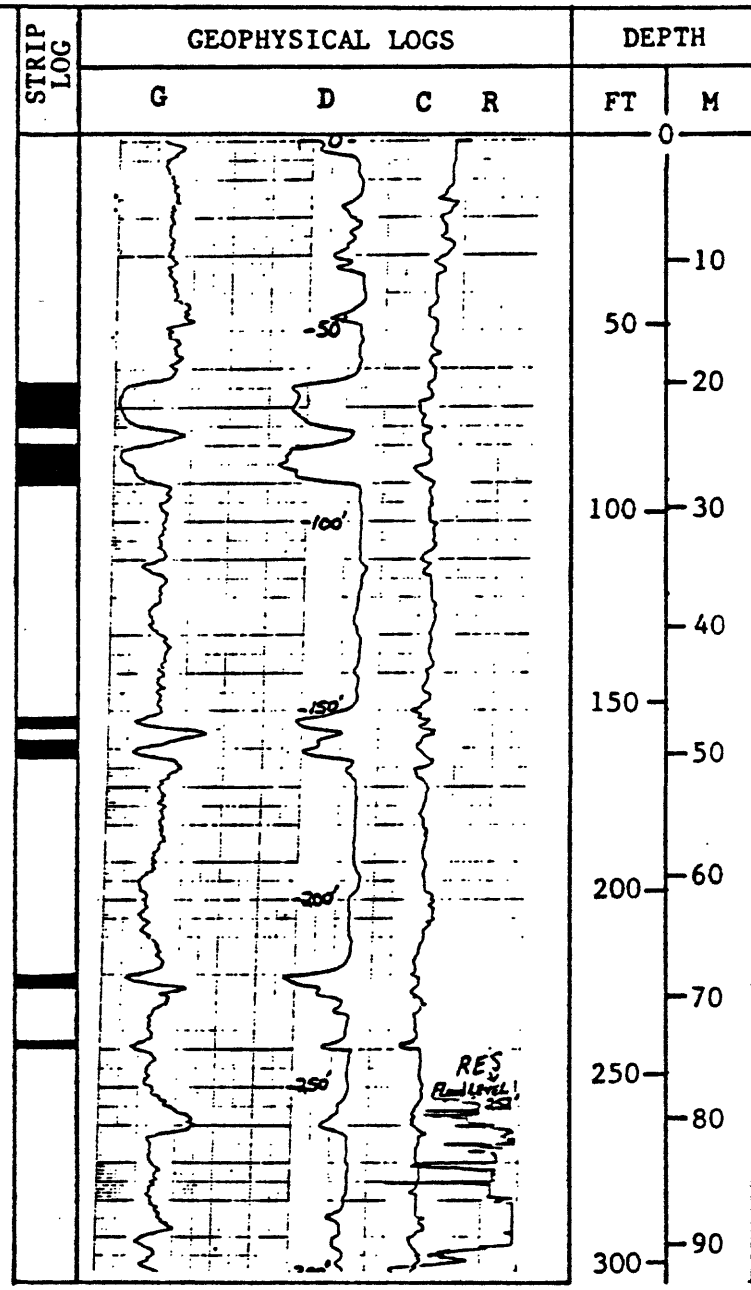
Hole Designation MB-19 Logged Depth 610 (ft)

Geophysical Log Scales:

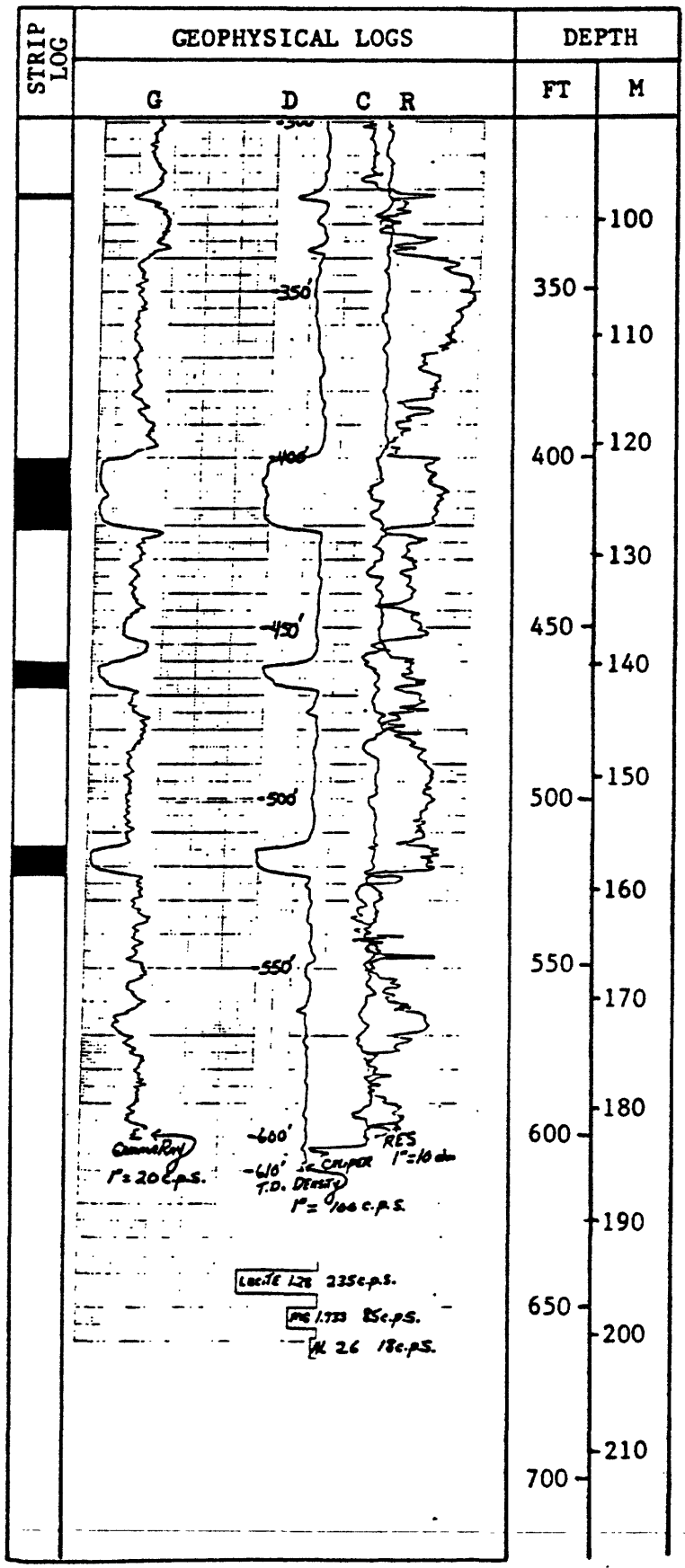
Gamma (G) 20 counts/sec/in Density (D) 100 counts/sec/in

Resistivity (R) 10 ohms Caliper (C) 2 in/in

Remarks:



MB-19


STRIP LOG
GEOPHYSICAL LOGS
G
D
C
R
DEPTH
FT
M
350'
400'
450'
500'
550'
600'
610'
T.D.
Gamma Ray
1"=20 c.p.s.
Density
1"=100 c.p.s.
Caliper
RES
1"=10 ohm
Locate L28 235 c.p.s.
FDC 1733 85 c.p.s.
AL 26 18 c.p.s.
100
110
120
130
140
150
160
170
180
190
200
210
350
400
450
500
550
600
650
700

U.S. Geological Survey

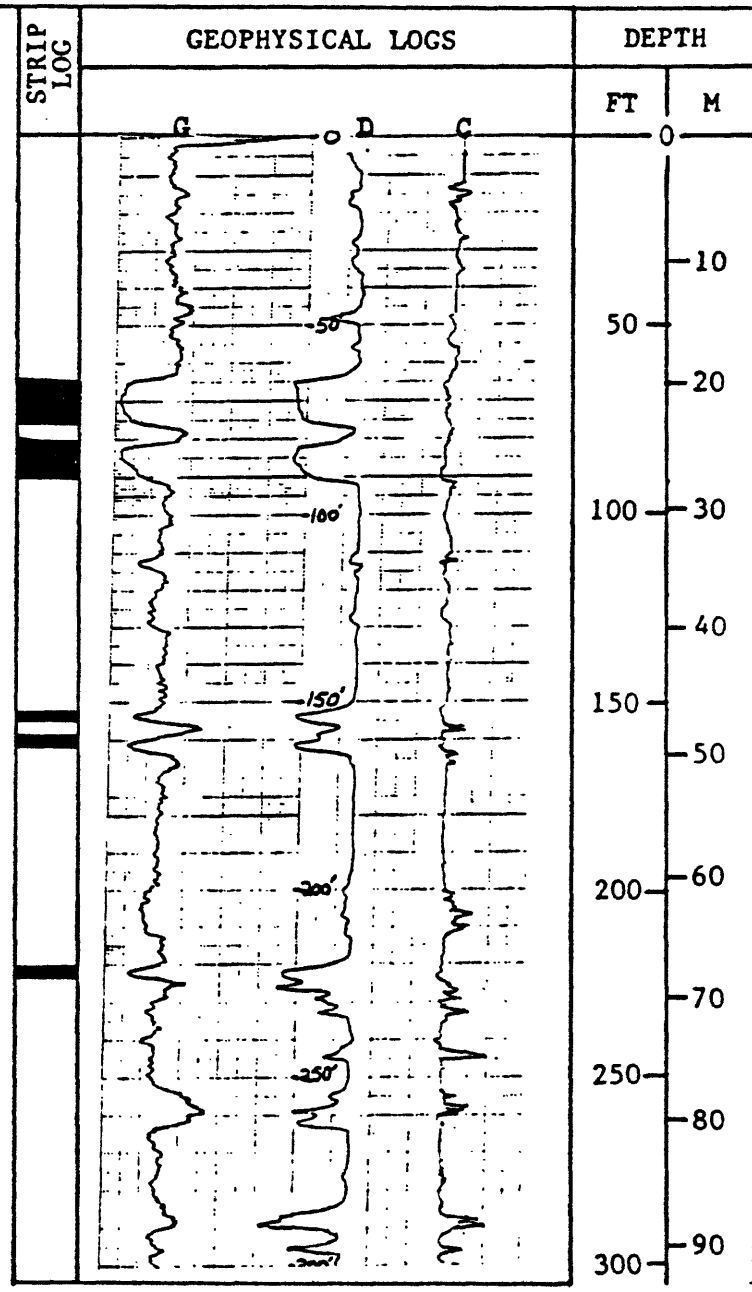
Hole Designation MB-19C Logged Depth 426 (ft)

Geophysical Log Scales:

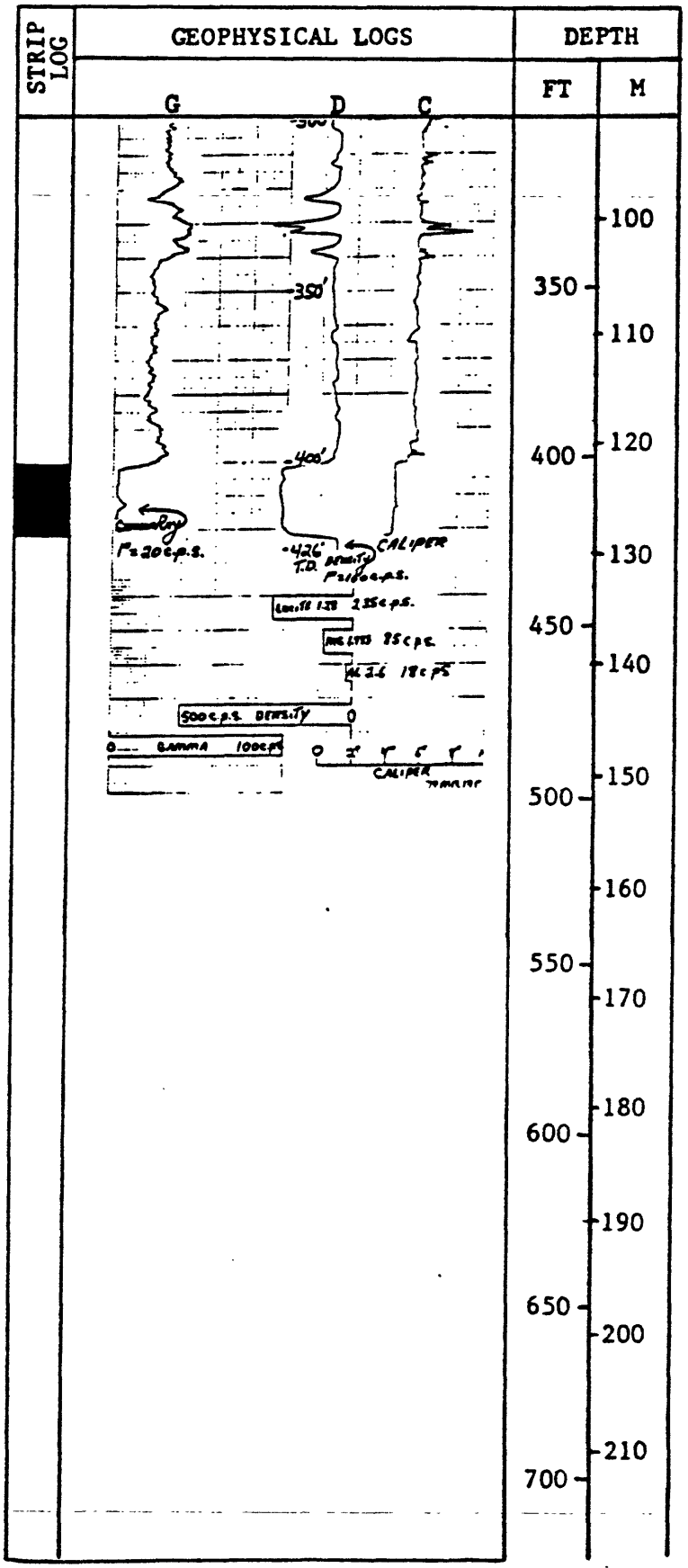
Gamma (G) 20 counts/sec/in Density (D) 100 counts/sec/in

Resistivity (R) _____ Caliper (C) 2 in/in

Remarks: _____



MB-19C


STRIP LOG
GEOPHYSICAL LOGS
G
D
C
DEPTH
FT
M
350'
400'
426' T.D.
CALIPER
500 c.p.s. DENSITY
GAMMA 100 c.p.s.
CALIPER
100
350
110
400
120
130
450
140
150
500
160
550
170
180
600
190
650
200
210
700

U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-20 Elev.(ft) 3565 Total Depth(ft) 690

Location 650 fwl 750 fnl sec. 6 T. 4 S. R. 48 E.

County Powder River State Montana Quadrangle(7.5') Samuelson Ranch

Cored: Yes x No Interval(s)

Date started 10/29/79 Date completed 10/29/79 Driller Arthur Clark

Geologist Mark Kirschbaum Remarks:

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	5	5	Soil, light-olive-gray
5	14	9	Mudstone, very-light-gray to yellow-gray
14	30	16	Sandstone, yellow-gray, very fine grained
30	36	6	Shale, medium-gray
36	43	7	Shale, light- to medium-light-gray, coaly at bottom
43	50	7	Shale, medium-light-gray, silty
50	80	30	Siltstone, medium-light-to medium-gray, sandy
80	81	1	Coal, bony
81	87	6	Claystone, light-gray
87	90	3	Shale, carbonaceous, clayey
90	118	28	Siltstone, green-gray to medium-gray
118	126	8	Claystone, medium-dark-gray
126	257	131	Mudstone, light-gray, interbedded with gray siltstone, sandy in places
257	290	33	Siltstone, medium-light-gray, clayey
290	311	21	Coal with shale parting from 300'-302'
311	319	8	Shale, brown-gray
319	328	9	Coal, shaley ? at top
328	356	28	Shale, medium-light-gray to brown-gray, with some tan, very fine grained, well cemented sandstone
356	358	2	Coal
358	395	37	Siltstone, light- to medium-light-gray, clayey in places
395	466	71	Sandstone, light-green-gray to tan to green-gray, very fine grained, well cemented in places, silty at top
466	473	7	Coal with olive-gray shale stringer at 469'
473	493	20	Shale, olive-gray to brown-gray
493	497	4	Shale, brown-gray, carbonaceous in part
497	539	42	Siltstone, light-gray

SECTION MB-20

Depth interval (feet)			
From	To	Thick-ness	Lithologic Description
539	543	4	Coal and carbonaceous shale
543	609	66	Shale, light- to medium-light-gray, silty, with coal stringers
609	631	22	Sandstone, medium-light-gray, very fine grained
631	634	3	Coal
634	644	10	Shale, light-gray, silty
644	653	9	Sandstone, light-gray
653	655	2	Carbonaceous shale, coal, hard
655	663	8	Shale, medium-light-gray, clayey
663	668	5	Coal
668	675	7	Shale, light-gray
675	690	15	Sandstone, light-gray, very fine grained

U.S. Geological Survey

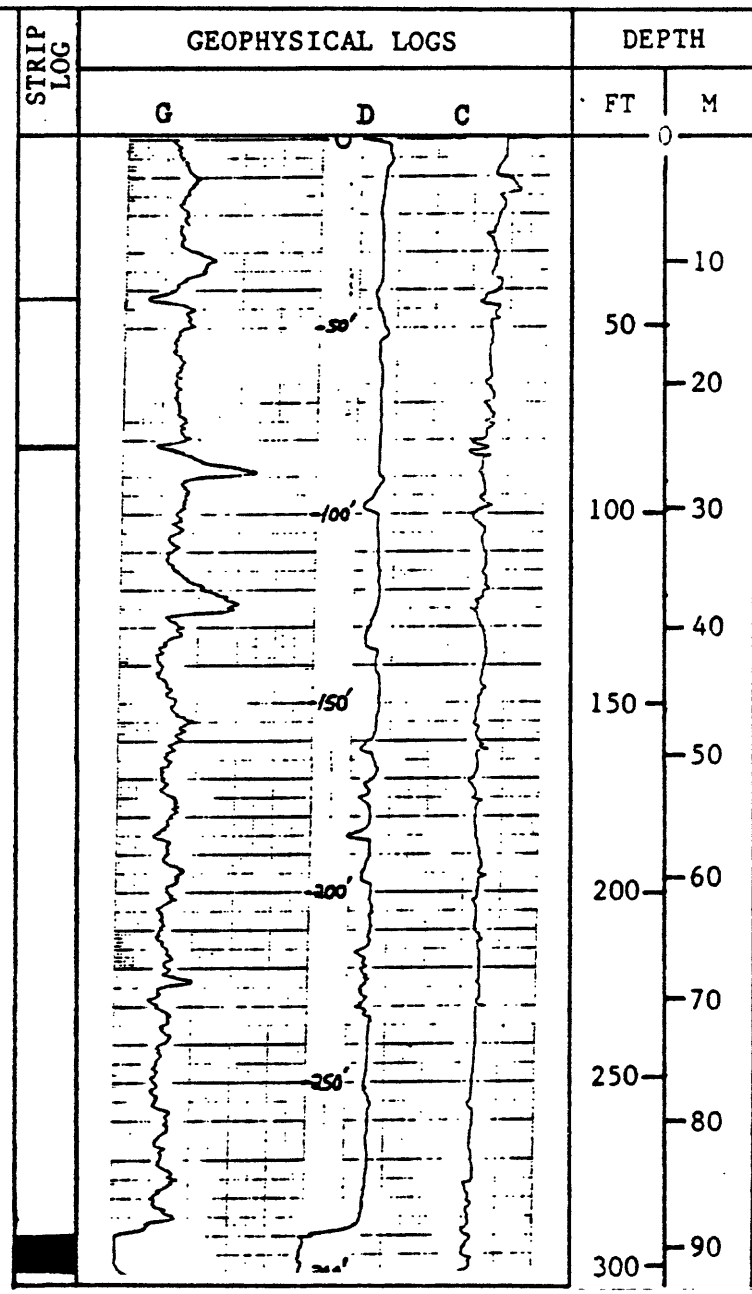
Hole Designation MB-20 Logged Depth 685 (ft)

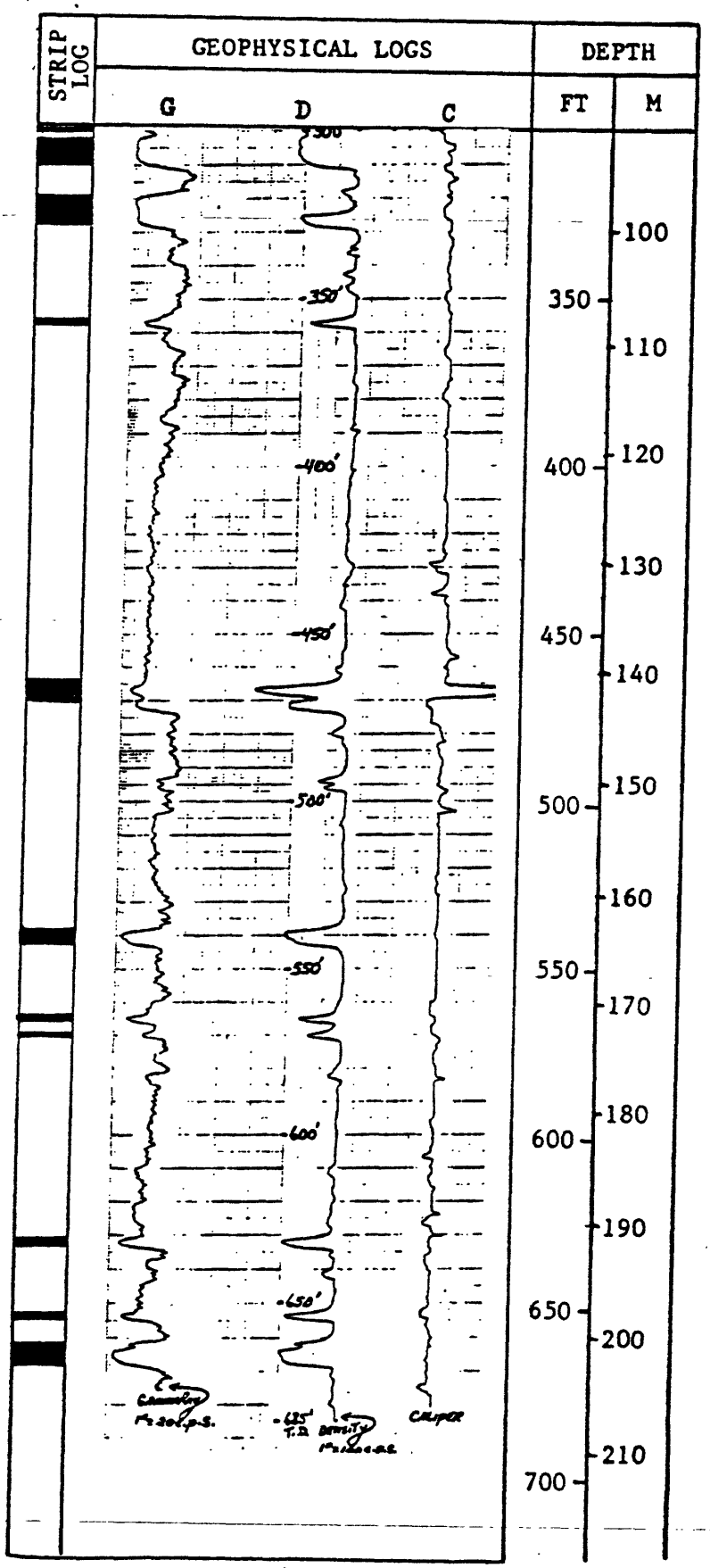
Geophysical Log Scales:

Gamma (G) 20 counts/sec/in Density (D) 100 counts/sec/in

Resistivity (R) Caliper (C) 2 in/in

Remarks:




STRIP LOG
GEOPHYSICAL LOGS
G
D
C
DEPTH
FT
M
300'
350'
400'
450'
500'
550'
600'
650'
635'
T.D.
CALIPER
100
110
120
130
140
150
160
170
180
190
200
210
350
400
450
500
550
600
650
700

U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-21 Elev.(ft) 4220 Total Depth(ft) 515

Location 1700 fnl 1750 fel sec. 31 T. 5 S. R. 48 E.

County Powder River State Montana Quadrangle(7.5′) Hodson Flats

Cored: Yes ____ No x Interval(s) ____

Date started 10/14/79 Date completed 10/14/79 Driller Steve Grant

Geologist Mark Kirschbaum Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	5	5	Soil, sand, medium-gray
5	15	10	Soil, sand, yellow-orange
15	20	5	Soil, sand, gray-yellow
20	45	25	Sandstone, medium-yellow to gray-yellow, very fine grained, silty
45	60	15	Siltstone, light-gray
60	70	10	Shale, brown-gray
70	79	9	Coal, bony
79	99	20	Sandstone, light- to medium-light-gray, silty
99	101	2	Coal, bony, and carbonaceous shale
101	132	31	Shale, light-olive-gray to medium-gray, silty toward base
132	162	30	Sandstone, brown-gray to medium-dark-gray, silty
162	171	9	Coal, bony, shale parting from 166′ to 168′
171	182	11	Siltstone, medium-light-gray, clayey
182	200	18	Siltstone, medium-gray to brown-gray, sandy
200	205	5	Shale, medium-gray to brown-gray
205	209	4	Coal, bony, and carbonaceous shale
209	223	14	Shale, brown-gray to brown-black
223	232	9	Coal, with carbonaceous shale parting at 227′
232	279	47	Shale, medium-light to medium-gray, silty
279	283	4	Coal
283	334	51	Siltstone, medium-light to medium-gray, clayey in places
334	417	83	Sandstone, medium-light to medium-gray, very fine grained, silty in part
417	454	37	Coal, with mudstone parting from 439′ to 441′
454	470	16	Mudstone, medium-light-gray
470	482	12	Siltstone, green-gray, sandy, clayey
482	500	18	Shale, light- to medium-light-gray, with coal stringers
500	504	4	Sandstone, medium-gray, very fine grained
504	515	11	Shale, medium- to medium-light-gray, slightly silty

U.S. Geological Survey

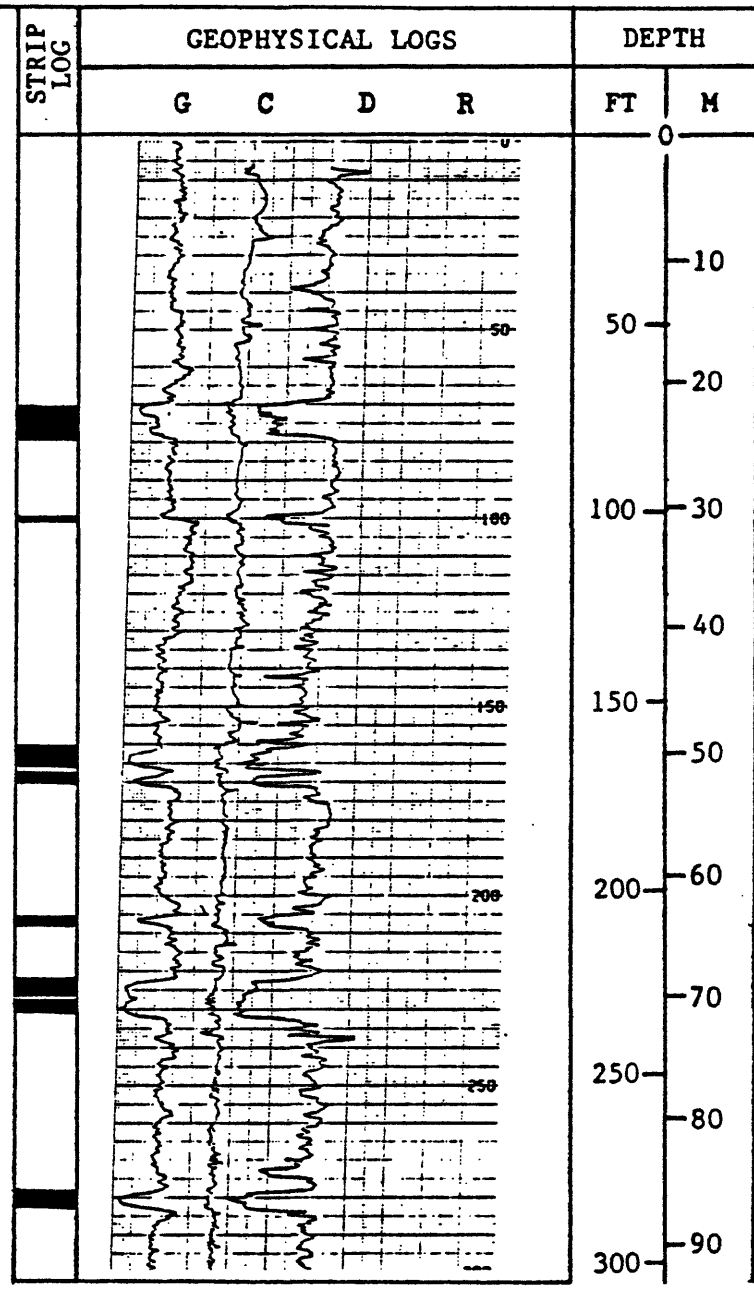
Hole Designation MB-21 Logged Depth 514 (ft)

Geophysical Log Scales:

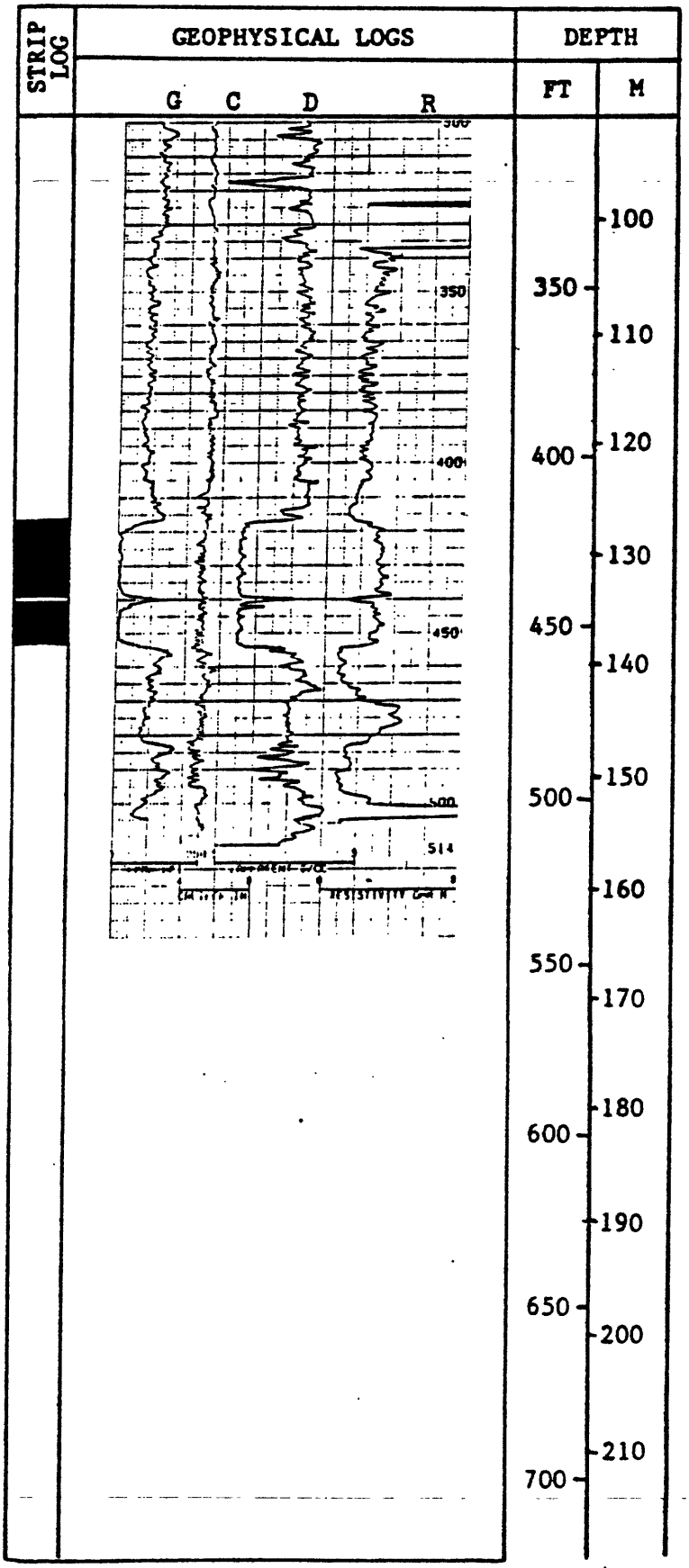
Gamma (G) 100 API units/in Density (D) .5 counts/sec/in

Resistivity (R) 20 ohms/in Caliper (C) 2 in/in

Remarks: 1 API unit = .618 counts per second



MB-21


STRIP LOG
GEOPHYSICAL LOGS
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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-22 & MB22C Elev.(ft) 3960 Total Depth(ft) 455

Location 1400 fel 1900 fnl sec. 19 T. 5 S. R. 48 E.

County Powder River State Montana Quadrangle(7.5) Sonnette

Cored: Yes x No Intervals 32.0 to 43.3, 79.8 to 106.4, 172.8 to 186.9, 395 to 421.6

Date started 9/28/79 Date completed 9/28/79 Driller Steve Grant

Geologist Frank Spencer Remarks: Core description George A. Correia

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	5	5	Alluvium, clay, medium-yellowish-brown
10	21	11	Siltstone, yellow-brown, sandy, calcareous and hard at 10′, clayey at bottom
21	32	11	Sandstone, medium-yellow-brown, very fine-grained
			CORE DESCRIPTION
32.0	32.6	0.6	Coal, black, mostly vitrinite, clay on fractures, oxidation first .2′
32.6	37.8	5.2	Coal, black, 75% dull, hard, conchoidal fracture pyrite rosettes between 43.1′ and 44.8′
37.8	39.5	1.7	Coal, black, alternating bands of shaly coal and hard dull coal, gypsum on fractures
39.5	43.3	3.8	Coal, black, 75% dull, conchoidal fractures
			END OF CORE DESCRIPTION
43.3	51	7.7	Shale, medium-gray, carbonaceous at top, silty
51	59	8	Siltstone, medium-gray
59	66	7	Shale, medium-gray
66	79.8	13.8	Siltstone, medium-gray, clayey top and bottom, carbonaceous at top
			CORE DESCRIPTION
79.8	84.5	4.7	Claystone, medium-gray, slightly silty, carbonaceous on bedding planes, coaly 81.6 to 81.8
84.5	93.3	8.8	Coal, black, alternating dull clean and dull dirty bands, hard, conchoidal, fractures, shaly 84.5′ to 84.9′, small clay streaks 90.9′ to 91.8′
93.3	95.1	1.8	Coal, black, dull, very hard, large conchoidal fractures
95.1	97.7	2.6	Coal, black, dull clean and dull dirty bands, scattered clay pockets, gypsum on fractures, disseminated pyrite 96.2′
97.7	100.5	2.8	Coal, black, dull with some shiny bands, dirty, scattered gypsum, scattered clay pockets

SECTION MB-22

Depth interval (feet) From	To	Thickness	Lithologic Description
100.5	105.1	4.6	Coal, black, dull with shiny streaks, gypsum on fractures, diseminated pyrite band at 100.8′
105.1	106.4	1.3	Claystone, dark-gray, carbonaceous, scattered gypsum crystals
			END OF CORE DESCRIPTION
106.4	108	1.6	Claystone, dark-gray, carbonaceous
108	135	27	Shale, medium-gray, interbedded with medium-gray siltstone
135	172.8	37.8	Sandstone, medium-gray, medium- to coarse-grain, calcareous at top, grades toward bottom to siltstone, badly washed out
			CORE DESCRIPTION
172.8	173.5	0.7	Siltstone, medium-gray, carbonaceous bands, clayey, sandy in spots, sharp basal contact with coal
173.5	176.0	2.5	Coal, black, shaly, 60% dull, scattered clay pockets
176.0	185.5	9.5	Coal, black, hard, 80% dull, conchoidal fracture, some gypsum on fractures, resin pockets toward bottom
185.5	186.2	0.7	Shale, dark-gray, carbonaceous
186.2	186.9	0.6	Coal, black, very shaly, sandy
			END OF CORE DESCRIPTION
186.9	196	9.1	Claystone, light-gray, silty toward bottom, coaly streaks
196	217	21	Siltstone, light-gray, sandy
217	227	10	Shale, black-brown, carbonaceous, coaly streaks
227	354	127	Siltstone, light- to medium-gray, interbedded with light- to medium-gray, very fine to medium-grain, sandstone stringers of shale, carbonaceous, coaly material, and hard calcareous lenses
354	384	30	Sandstone, medium-to dark-gray, very fine grained, clayey, carbonaceous toward bottom
384	395	11	Shale, medium- to dark-gray
			CORE DESCRIPTION
395.0	395.9	0.9	Sandstone, dark-gray, fine-grained, claystone stringers, carbonaceous
395.9	407.7	11.8	Coal, black, hard, alternating dull and shiny bands, conchoidal fracturing, sandy streaks and resin pockets top .2′
407.7	420.1	12.4	Coal, black, hard, dull and shiny bands, conchoidal fracturing, cleat fractures 414.6 to 419.4′, clay streak 417.8′, shaly, 419.4′ to 420.1′
420.1	420.5	0.4	Claystone, medium-gray, carbonaceous, scattered coal clasts
420.5	421.6	1.1	Siltstone, medium-gray, rootlets
			END OF CORE DESCRIPTION
421.6	455	33.4	Siltstone, medium-gray, calcareous, sandy

U.S. Geological Survey

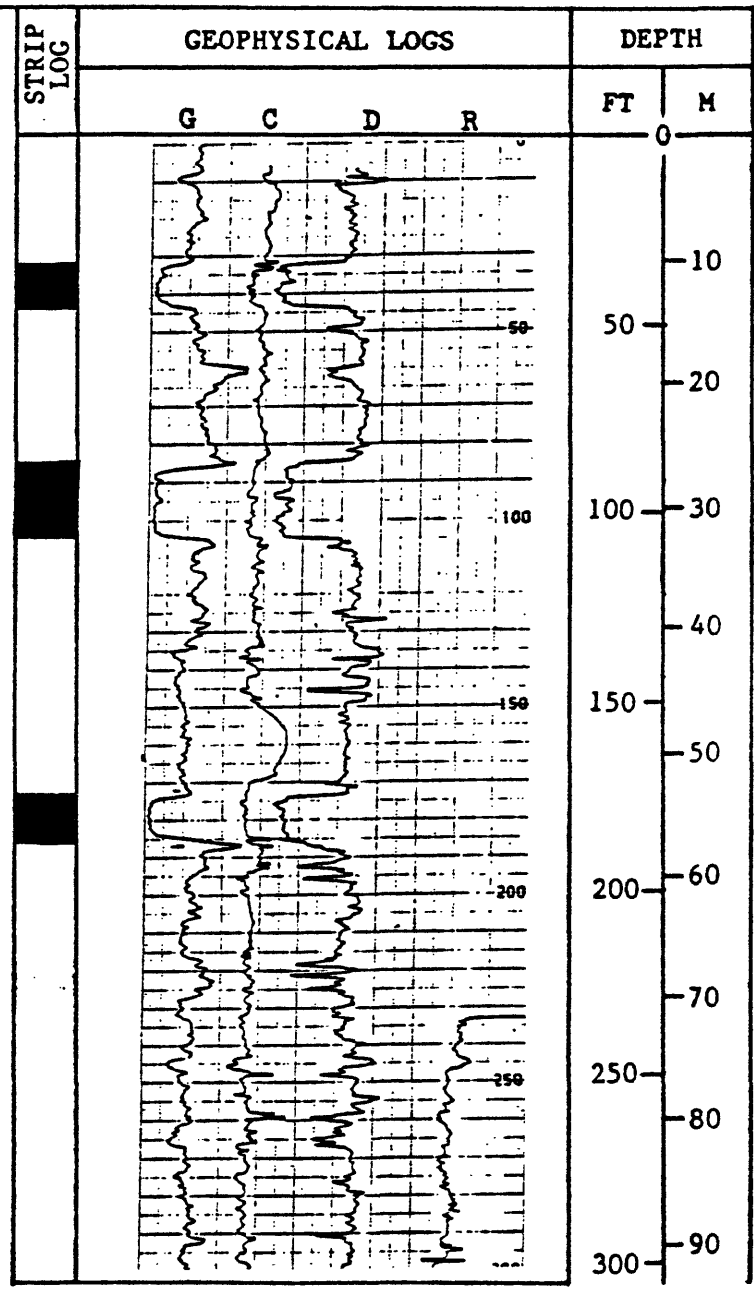
Hole Designation MB-22 Logged Depth 451 (ft)

Geophysical Log Scales:

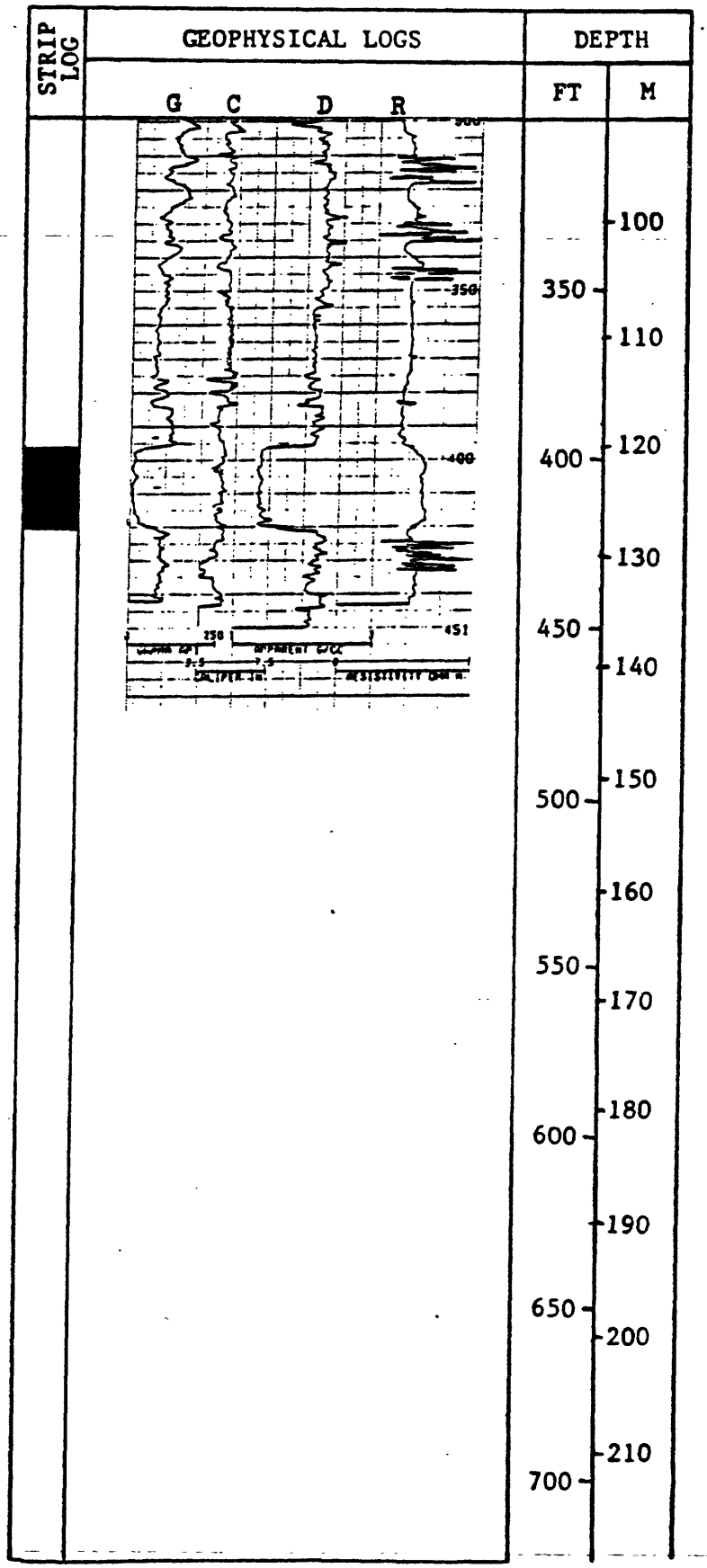
Gamma (G) 100 API units/in Density (D) .5 counts/sec/in

Resistivity (R) 2.5 ohms/in Caliper (C) 2 in/in

Remarks: 1 API unit = .618 counts per second



MB-22


STRIP LOG
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U.S. Geological Survey

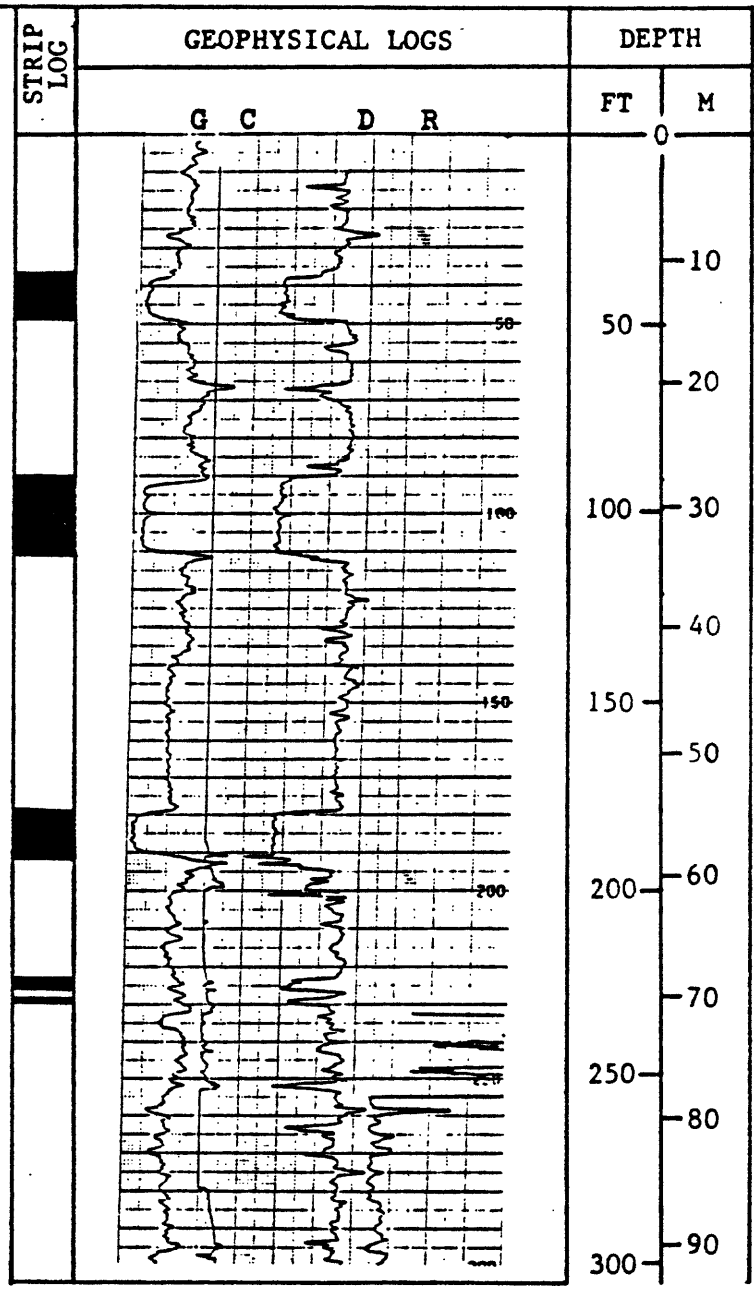
Hole Designation MB-22C Logged Depth 425 (ft)

Geophysical Log Scales:

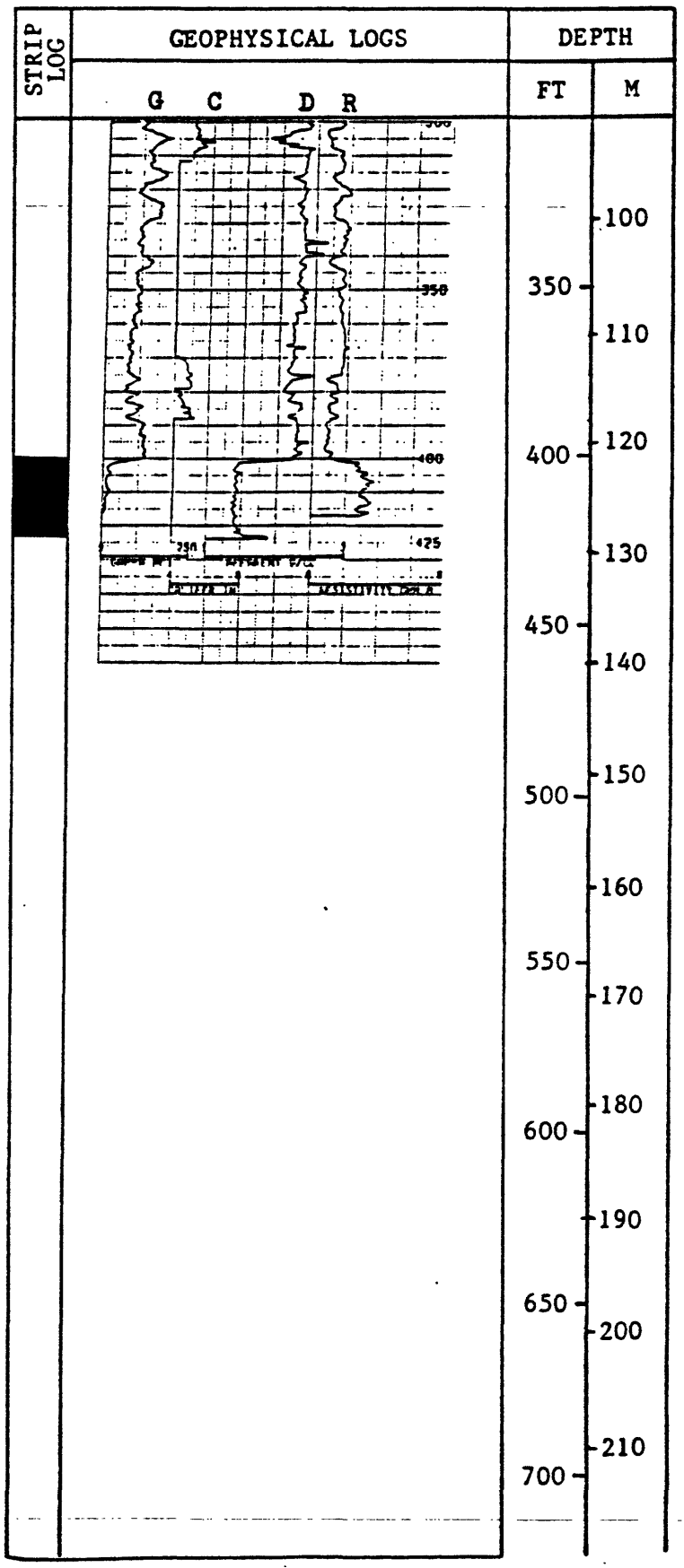
Gamma (G) 100 API units/in Density (D) .5 counts/sec/in

Resistivity (R) 20 ohms/in Caliper (C) 2 in/in

Remarks: 1 API unit = .618 counts per second



MB-22 C


STRIP LOG
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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-23 Elev.(ft) 4080 Total Depth(ft) 760

Location 350 fwl 2200 fnl sec. 15 T. 6 S. R. 47 E.

County Powder River State Montana Quadrangle(7.5′) Phillips Butte

Cored: Yes ____ No x Interval(s) ____

Date started 10/24/79 Date completed 10/25/79 Driller Arthur Clark

Geologist Mark Kirschbaum Remarks: ____

Depth interval (feet) From	To	Thickness	Lithologic Description
0	5	5	Soil, gray-yellow to light-olive-gray
5	19	14	Shale, light-olive-gray to medium-light-gray, silty
19	21	2	Shale, carbonaceous
21	31	10	Shale, medium-light-gray to light-olive-brown, silty, carbonaceous shale 24′ to 26′
31	33	2	Sandstone, medium-gray to light-brown, very fine grained, well cemented, calcareous
33	46	13	Siltstone, medium-gray, sandy
46	59	13	Shale, medium-gray to brown-gray to brown-black
59	65	6	Shale, medium-gray
65	79	14	Mudstone and siltstone, medium-gray, interbedded
79	83	4	Coal, black
83	102	19	Siltstone, light- to medium-gray
102	104	2	Coal, black
104	133	29	Siltstone, medium-light-gray, sandy
133	136	3	Coal, black
136	146	10	Shale, medium-gray
146	154	8	Coal, black
154	160	6	Shale, light-blue-gray, silty
160	164	4	Shale, light-blue-gray
164	190	26	Siltstone, light-gray, sandy, and light-gray shale
190	197	7	Shale, brown-gray
197	231	34	Shale, light-gray to green-gray, silty
231	240	9	Sandstone, medium-light-gray
240	252	12	Shale, medium-light-gray
252	260	8	Sandstone, medium-gray
260	280	20	Siltstone, light-gray, clayey

SECTION MB-23

Depth interval (feet) From	To	Thickness	Lithologic Description
280	286	6	Shale, light-gray
286	292	6	Siltstone, light-gray
292	294	2	Shale, light-gray
294	313	19	Siltstone, medium-light-gray
313	316	3	Shale, medium-light-gray
316	372	56	Siltstone, light- to medium-gray
372	384	12	Shale, medium-light-gray, silty at bottom
384	402	18	Coal, black
402	407	5	Claystone, medium-light-gray
407	418	11	Coal, black
418	436	18	Siltstone, light-gray to brown-gray clayey top and bottom
436	439	3	Shale, brown-gray
439	511	72	Interbedded shale, medium-light-gray to brown-gray, and siltstone, light-gray to medium-light-gray, sandy in places
511	514	3	Coal
514	521	7	Shale, light-gray to brown-gray
521	543	22	Sandstone, light-gray, silty at top
543	574	31	Shale, light-gray to medium-light-gray
574	576	2	Sandstone, light-gray
576	583	7	Siltstone, light-gray, to light-gray shale towards bottom
583	623	40	Siltstone, light-to medium-light-gray, clayey in places
623	668	45	Sandstone, light-gray to brown-gray, silty towards bottom
668	692	24	Coal, with shale parting from 684′ to 686′
692	737	45	Shale, olive-gray to medium-gray, sandy
737	755	18	Shale, medium-light to medium-gray
755	760	5	Siltstone, light-gray

U.S. Geological Survey

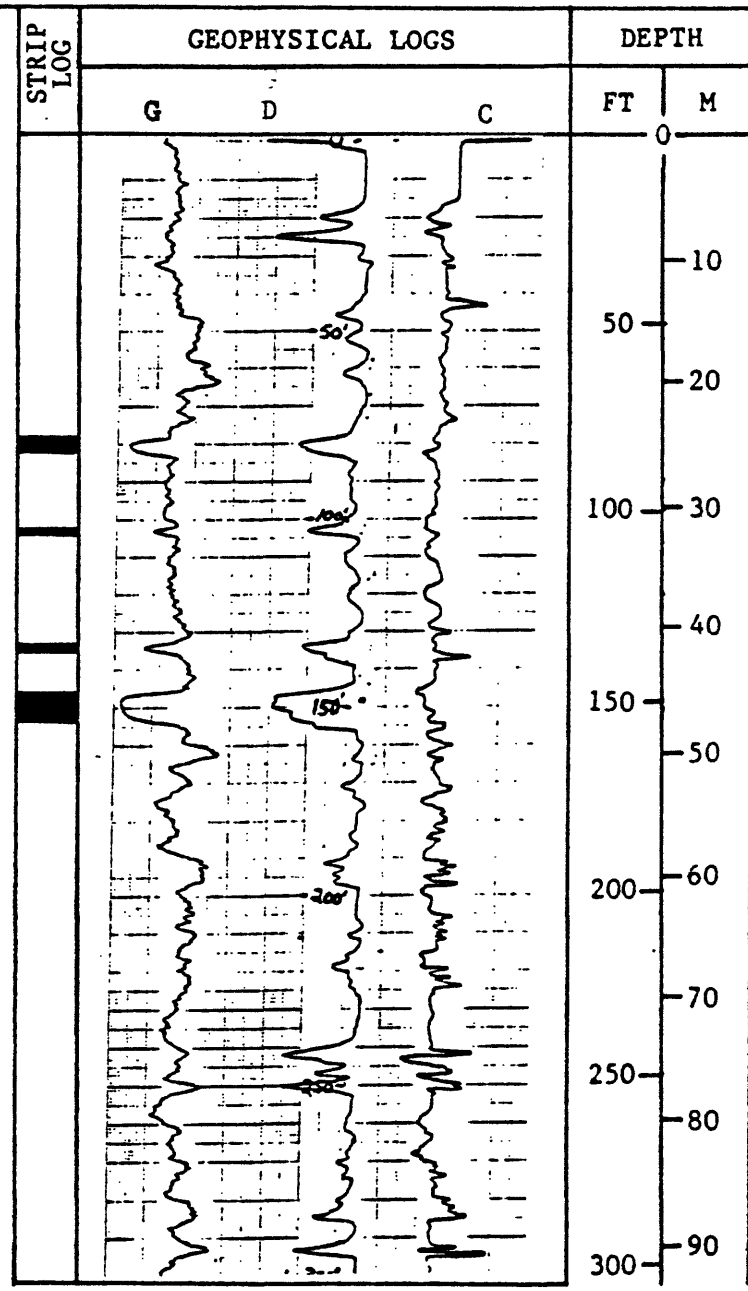
Hole Designation MB-23 Logged Depth 737 (ft)

Geophysical Log Scales:

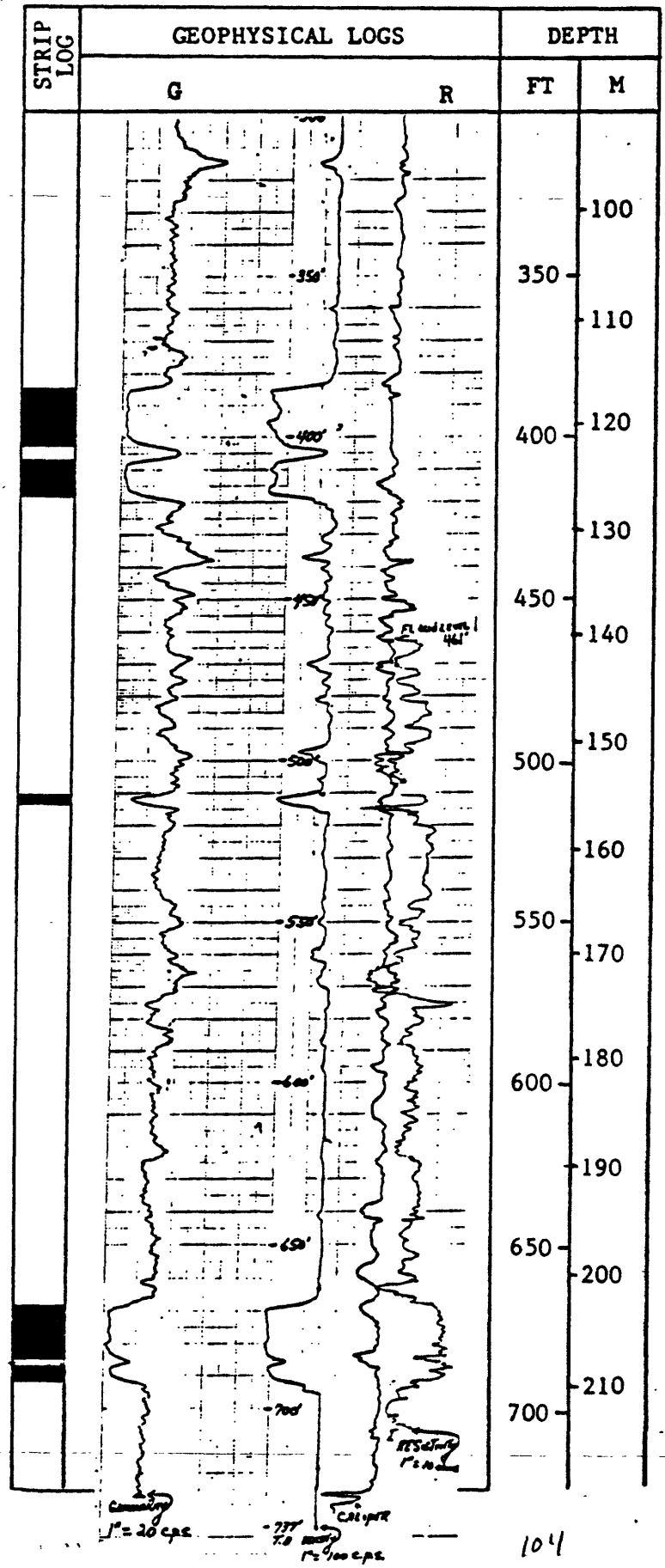
Gamma (G) 20 counts/sec/in Density (D) 100 counts/sec/in

Resistivity (R) 10 ohms/in Caliper (C) 2 in/in

Remarks:



MB-23


STRIP LOG
GEOPHYSICAL LOGS
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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-24 Elev.(ft) 3735 Total Depth(ft) 275

Location 1900 fel 2150 fsl sec. 15 T. 5 S. R. 46 E.

County Powder River State Montana Quadrangle(7.5') Yager Butte

Cored: Yes ____ No x Interval(s) ____

Date started 10/27/79 Date completed 10/27/79 Driller Steve Grant

Geologist Mark Kirschbaum Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	5	5	Soil, yellow-brown
5	20	15	Siltstone, yellow-brown, and yellow-brown mudstone
20	50	30	Sandstone, light-gray to yellow-gray, fine-grained
50	80	30	Interbedded siltstone, light-olive-gray, and medium-light-gray to yellow-orange shale
80	102	22	Siltstone, medium-light-gray, grading to medium-light-gray, very fine grained, sandstone toward bottom
102	121	19	Sandstone, medium-light-gray, very-fine-grained
121	136	15	Coal, bony
136	143	7	Shale, light-gray, carbonaceous at top
143	157	14	Siltstone, light-to medium-light-gray, clayey
157	170	13	Coal, bony
170	206	36	Shale, medium-gray, silty toward bottom
206	260	54	Sandstone, medium-light-gray, fine-grained
260	275	15	Shale, medium-gray, sandy

U.S. Geological Survey

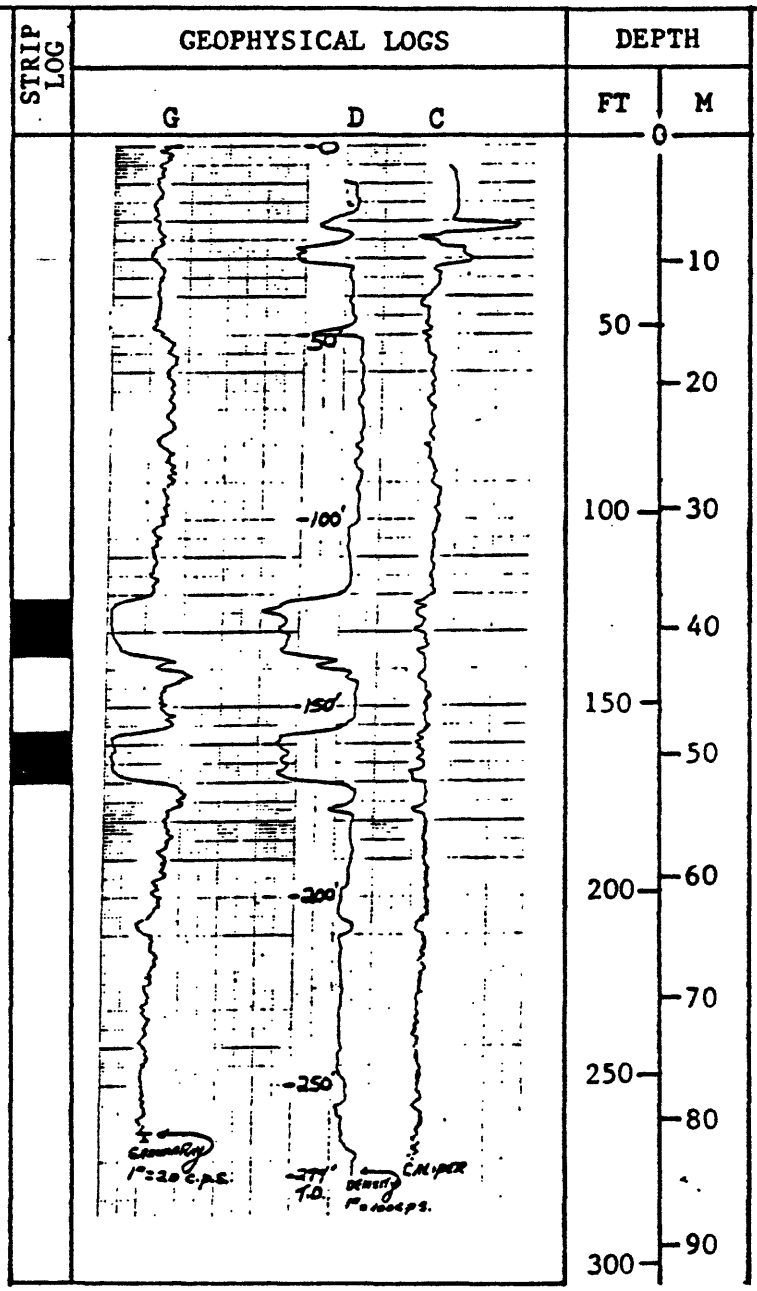
Hole Designation MB-24 Logged Depth 274 (ft)

Geophysical Log Scales:

Gamma (G) 20 counts/sec/in Density (D) 100 counts/sec/in

Resistivity (R) _____ Caliper (C) 2 in/in

Remarks: _____



U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-25 Elev.(ft) 3805 Total Depth(ft) 460

Location 1600 fsl 2200 fwl sec. 25 T. 4 S. R. 46 E.

County Powder River State Montana Quadrangle(7.5′) Yager Butte

Cored: Yes ____ No x Interval(s) ____

Date started 10/25/79 Date completed 10/26/79 Driller Steve Grant

Geologist Mark Kirschbaum Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	5	5	Soil, silt, pale-brown
5	28	23	Shale, yellow-gray to dark yellow-orange, silty
28	39	11	Siltstone, yellow-gray to light-gray
39	58	19	Siltstone, light-gray to medium-dark-gray, clayey
58	73	15	Interbedded shale, light-to medium-dark-gray, and light- to medium-light-gray siltstone
73	105	32	Shale, medium-to medium-light-gray, silty toward bottom
105	115	10	Coal, bony
115	152	37	Interbedded siltstone, medium-light- to medium-gray, and shale, light-gray to medium-light-gray
152	176	24	Sandstone, medium-light-gray, silty in part
176	195	19	Shale, medium-light to medium-gray, silty
195	216	21	Coal
216	218	2	Carbonaceous shale
218	220	2	Coal
220	225	5	Shale, medium-light-gray
225	235	10	Siltstone, medium-light-gray, hard
235	239	4	Shale, medium-light-gray
239	252	13	Coal
252	282	30	Shale, medium-gray to brown-black, silty in part with carbonaceous shale at top, bony coal from 256′ to 257′
282	320	38	Siltstone, medium-gray, sandy
320	329	9	Sandstone, medium-light-gray, very fine grained, well-cemented
329	338	9	Shale, medium-gray
338	340	2	Coal
340	382	42	Shale, light-gray, silty, with carbonaceous shale from 365′ to 368′
382	385	3	Shale, light-gray; shale, carbonaceous
385	389	4	Coal
389	404	15	Siltstone, light-gray
404	459	55	Siltstone, medium-gray, sandy

U.S. Geological Survey

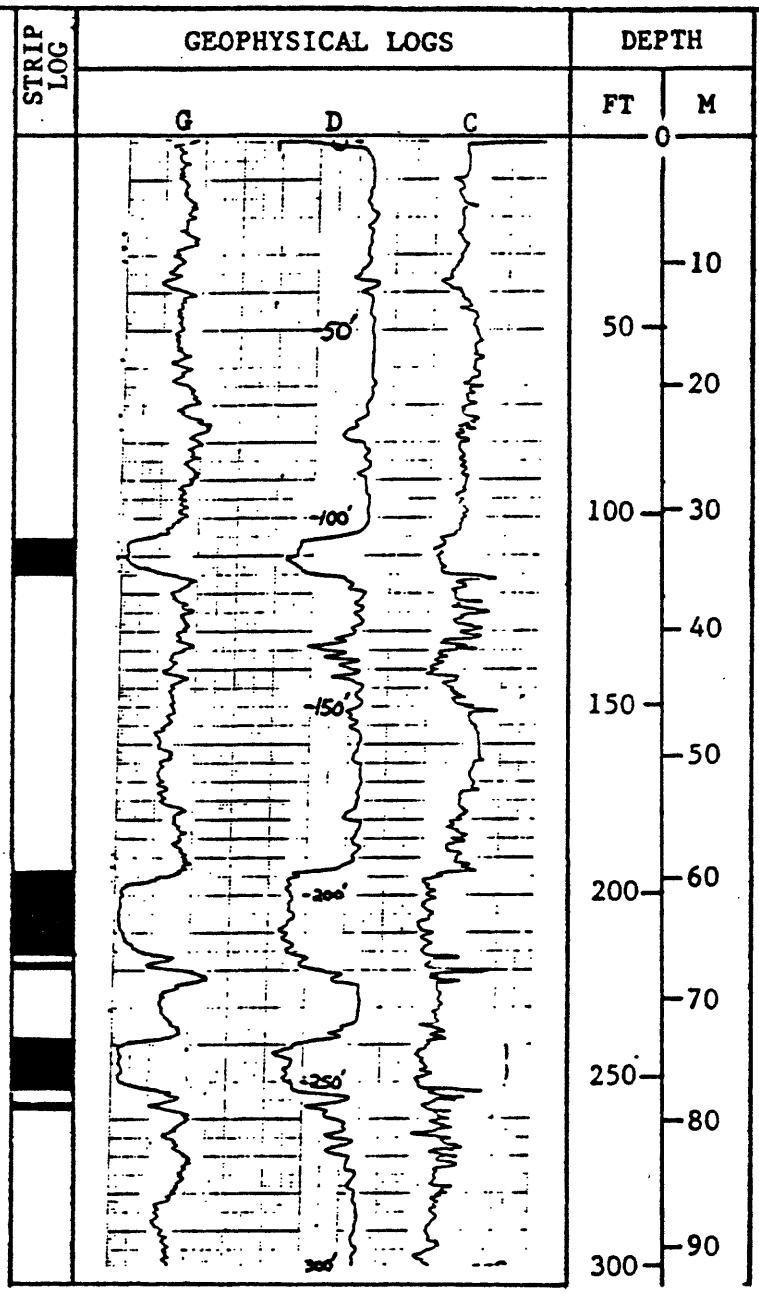
Hole Designation MB-25 Logged Depth 459 (ft)

Geophysical Log Scales:

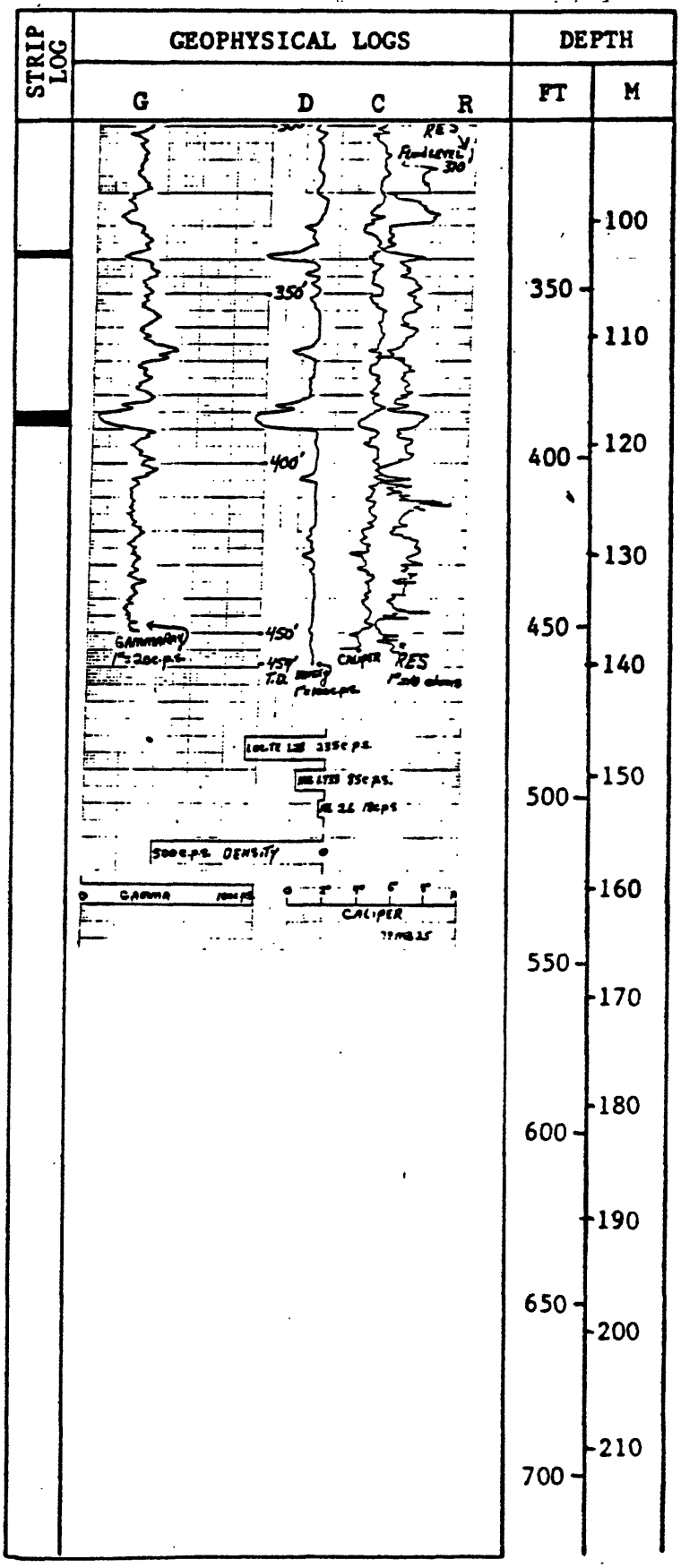
Gamma (G) 20 counts/sec/in Density (D) 100 counts/sec/in

Resistivity (R) 10 ohms/in Caliper (C) 2 in/in

Remarks:



MB-25


STRIP LOG
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U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-26 Elev.(ft) 3705 Total Depth(ft) 615

Location 750 fwl 1550 fsl sec. 7 T. 5 S. R. 50 E.

County Powder River State Montana Quadrangle(7.5') Epsie NE

Cored: Yes ____ No x Interval(s) ____

Date started 11/9/79 Date completed 11/10/79 Driller Arthur Clark

Geologist Jim Boaz Remarks: ____

Depth interval (feet)

From	To	Thick-ness	Lithologic Description
0	10	10	Soil, brown, sandy, clay, gray with yellow streaks, clinker pieces, red
10	12	2	Shale, brown
12	53	41	Siltstone, gray-green, trace coal in cuttings
53	71	18	Sandstone, gray-green to gray, clayey
71	80	9	Shale, gray
80	104	24	Siltstone, brown-gray
104	131	27	Siltstone, brown-gray to dark-gray, sandy
131	134	3	Coal
134	161	27	Shale, green-gray to gray
161	164	3	Coal
164	173	9	Shale, gray-green
173	187	14	Sandstone, light-gray, silty
187	190	3	Shale, light-gray
190	231	41	Siltstone, light-gray to gray, clayey
231	234	3	Coal
234	268	34	Shale, gray, silty
268	271	3	Coal
271	274	3	Siltstone, gray
274	276	2	Shale, gray
276	347	71	Interbedded siltstone, gray, and shale, trace coal in cuttings
347	351	4	Coal
351	357	6	Shale, brown-gray, silty
357	361	4	Shale, gray
361	397	36	Siltstone, gray, interbedded with shale, gray
397	400	3	Coal
400	407	7	Shale, gray
407	438	31	Siltstone, gray, clayey

SECTION MB-26

Depth interval (feet)			
From	To	Thick-ness	Lithologic Description
438	441	3	Coal
441	471	30	Siltstone, brown-gray, with carbonaceous shale stringer
471	523	52	Shale, brown-gray
523	541	18	Coal
541	615	74	Sandstone, fine-grained, silty at top

U.S. Geological Survey

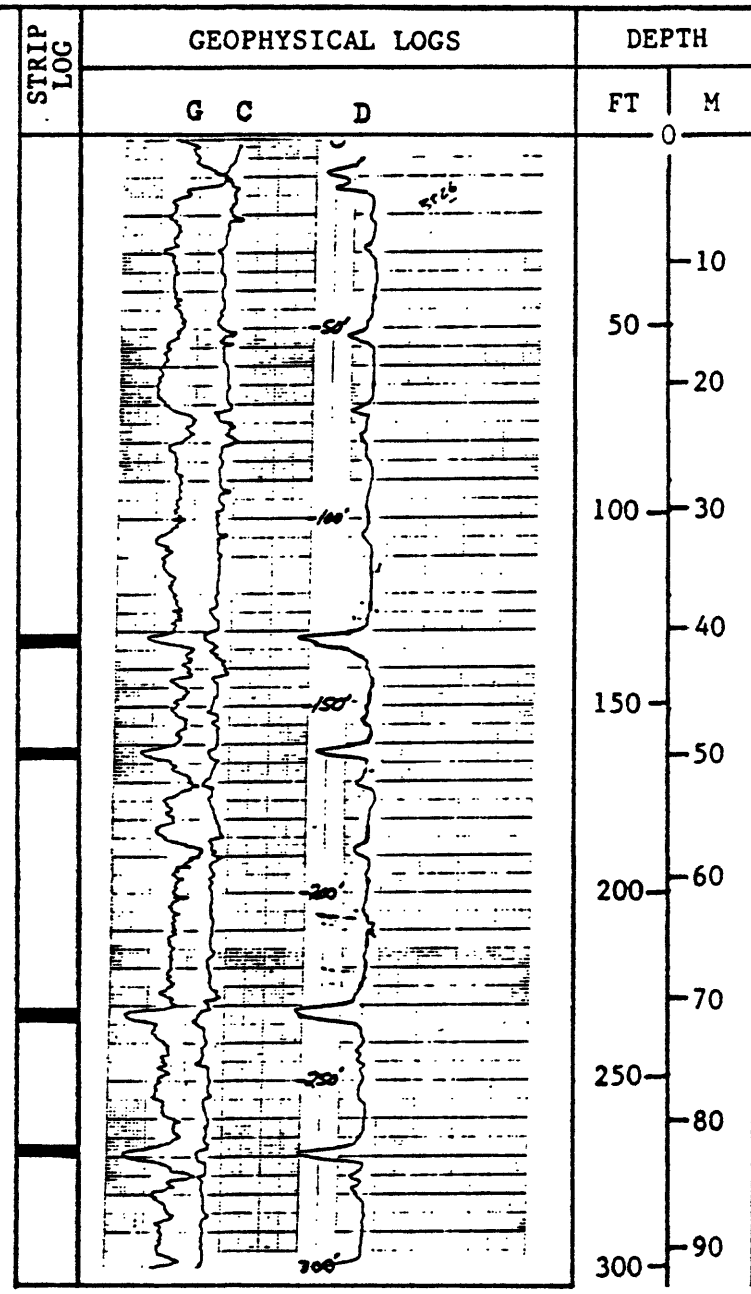
Hole Designation MB-26 Logged Depth 611 (ft)

Geophysical Log Scales:

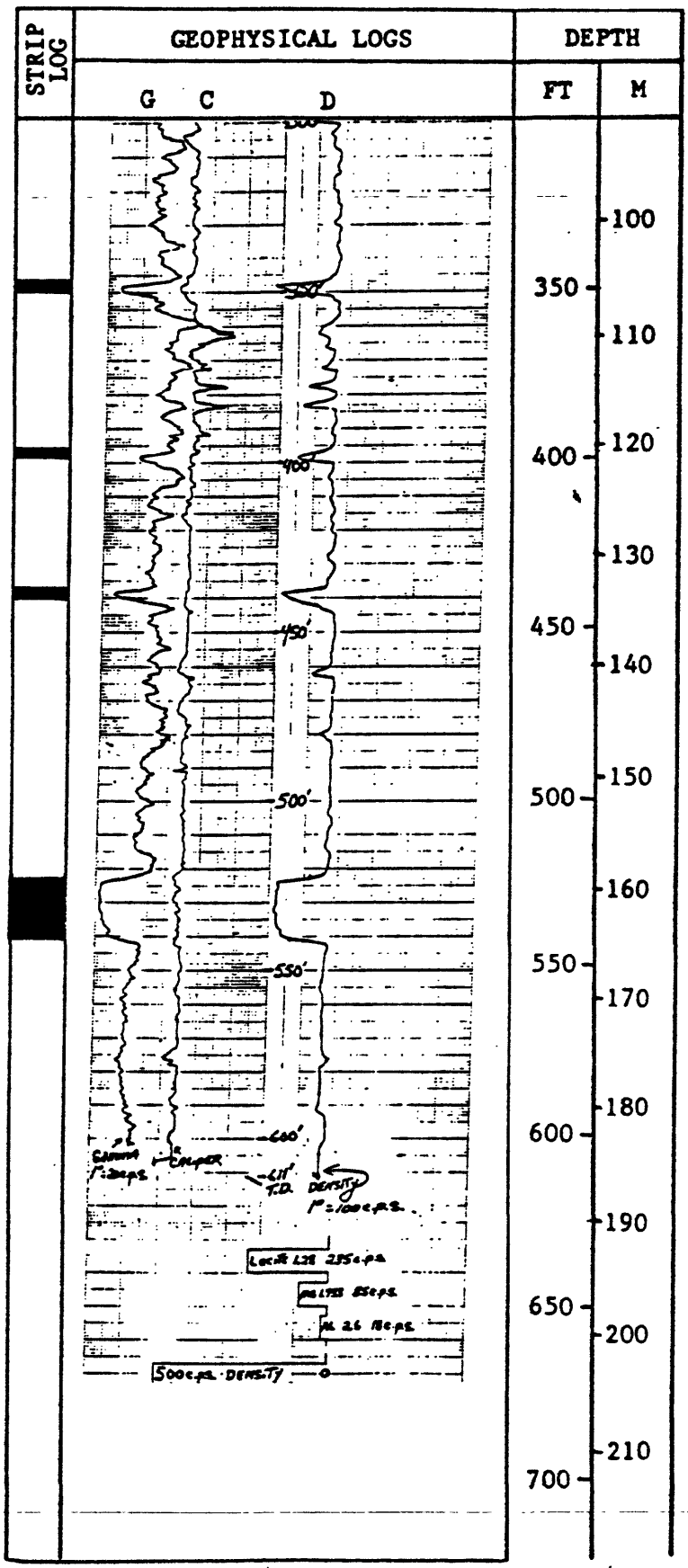
Gamma (G) 20 counts/sec/in Density (D) 100 counts/sec/in

Resistivity (R) _____ Caliper (C) 2 in/in

Remarks: _____



MB-26


STRIP LOG
GEOPHYSICAL LOGS
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DENSITY
500 c.p.s. DENSITY

U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-27 Elev.(ft) 3435 Total Depth(ft) 370

Location 700 fwl 1050 fnl sec. 22 T. 4 S. R. 49 E.

County Powder River State Montana Quadrangle(7.5′) Epsie

Cored: Yes ____ No x Interval(s) ____

Date started 11/11/79 Date completed 11/11/79 Driller Arthur Clark

Geologist Jim Boaz Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	15	15	Soil, orange-gray, sand and clay mixture
15	26	11	Sandstone, gray, fine-grained
26	32	6	Coal
35	40	5	Shale, gray
40	49	9	Sandstone, gray, fine-grained, silty
49	52	3	Coal, bony
52	55	3	Sandstone, yellow-gray
55	57	2	Coal
57	70	13	Shale, dark- to light-gray
70	105	35	Sandstone, gray, fine-grained
105	110	5	Shale, gray, silty and sandy
110	145	35	Sandstone, gray
145	165	20	Shale, green-gray
165	170	5	Sandstone, fine-grained
170	180	10	Shale, gray
180	192	12	Sandstone, fine-grained
192	200	8	Coal
200	245	45	Shale, green-gray, hard sandstone at approximately 213′
245	255	10	Sandstone
255	265	10	Shale, green-gray
265	277	12	Sandstone
277	298	21	Shale, sandy
298	325	27	Coal, parting at 321′
325	335	10	Shale, dark-brown-gray
335	370	35	Shale, green-gray, sandy towards bottom

U.S. Geological Survey

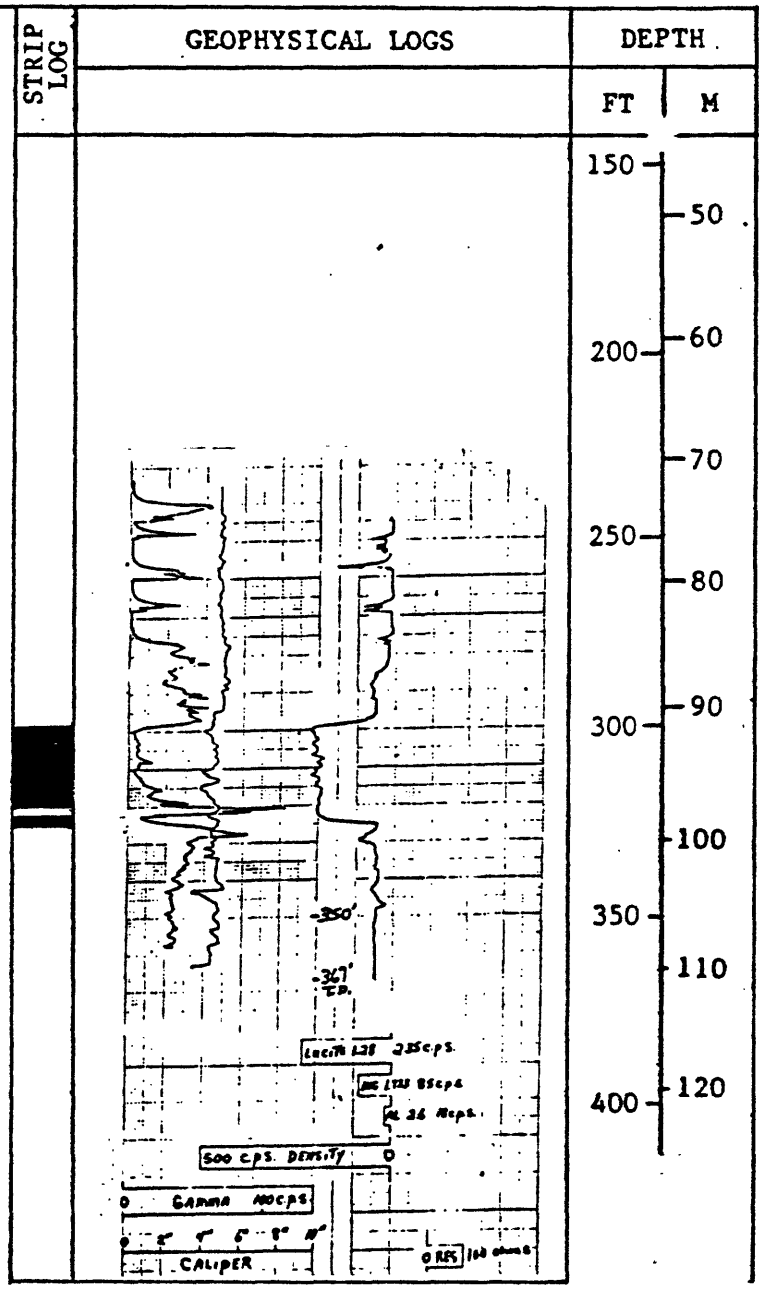
Hole Designation MB-27 Logged Depth 230 to 367 (ft)

Geophysical Log Scales:

Gamma (G) 20 counts/sec/in Density (D) 100 counts/in

Resistivity (R) _____ Caliper (C) 2 in/in

Remarks: Equipment failure; no log available above 240 feet



U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-28 Elev.(ft) 3510 Total Depth(ft) 495

Location 150 fel 1850 fnl sec. 33 T. 4 S. R. 49 E.

County Powder River State Montana Quadrangle(7.5′) Epsie

Cored: Yes ____ No x Interval(s) ____

Date started 11/5/79 Date completed 11/5/79 Driller Arthur Clark

Geologist Jim Boaz Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	10	10	Soil, mixed clinker, sand, gravel
10	27	17	Shale, brown to dark-brown
27	29	2	Coal
29	45	16	Siltstone, green-gray, sandy
45	63	18	Shale, green-gray
63	100	37	Siltstone, green-gray, increasingly sandy towards bottom
100	111	11	Sandstone, fine-grained
111	113	2	Coal, bony
113	124	11	Siltstone, green-gray, clayey
124	190	66	Sandstone
190	194	4	Coal
194	209	15	Sandstone, fine-grained, silty
209	254	45	Siltstone, light-gray to green-gray, sandy in places, interbedded with light-gray shale
254	290	36	Interbedded sandstone, fine-grained, and siltstone, green-gray
290	293	3	Coal
293	362	69	Interbedded sandstone, fine-grained, and light-gray shale and siltstone, coal stringer at 325′
362	390	28	Sandstone, fine-grained, silty
390	400	10	Sandstone, fine-grained
400	427	27	Coal
427	495	68	Sandstone, fine-grained

U.S. Geological Survey

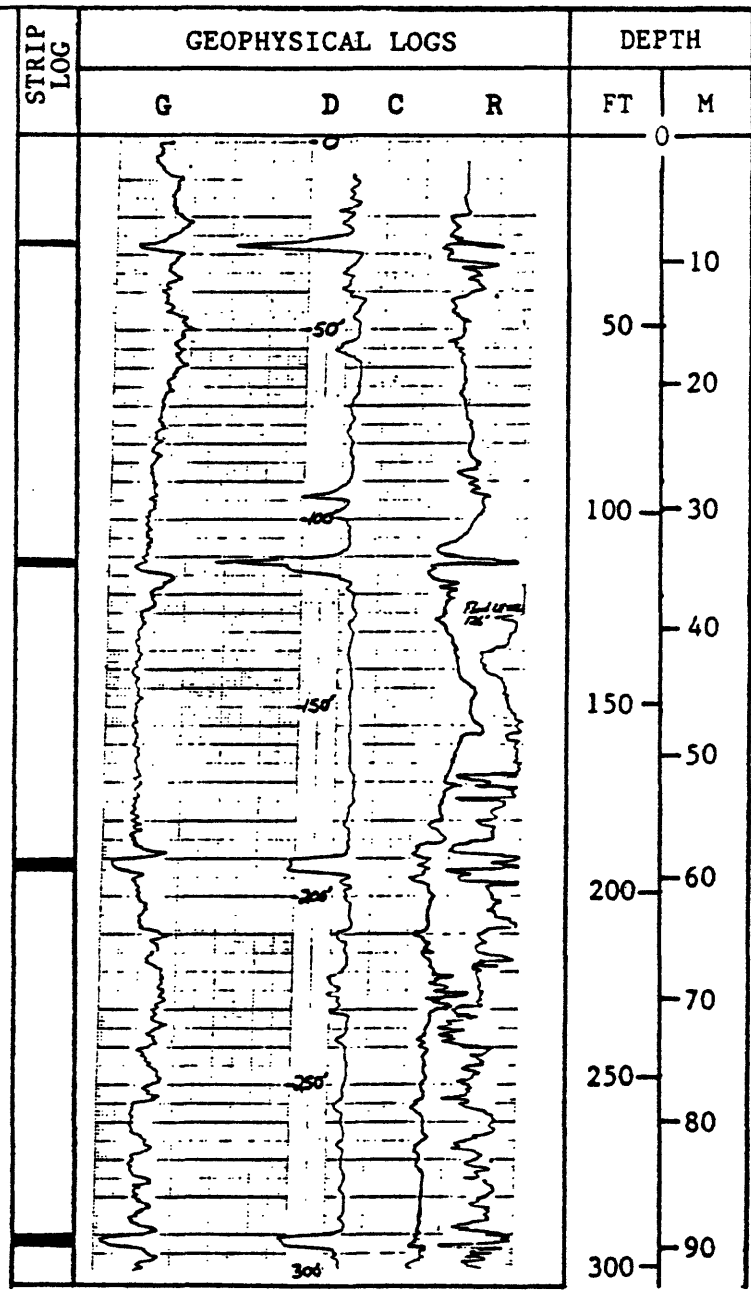
Hole Designation MB-28 Logged Depth 490 (ft)

Geophysical Log Scales:

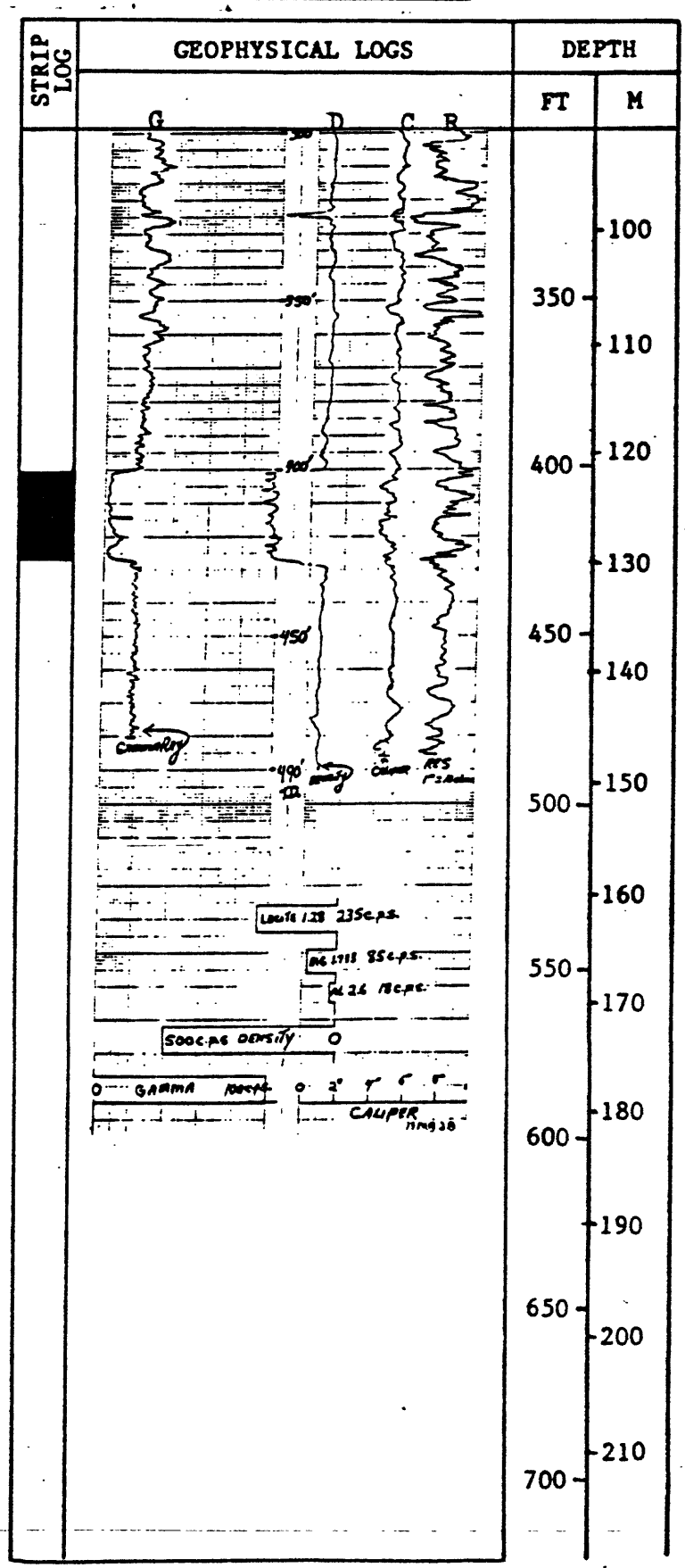
Gamma (G) 20 counts/sec/in Density (D) 100 counts/sec/in

Resistivity (R) 10 ohms/in Caliper (C) 2 in/in

Remarks:



MB-28


STRIP LOG
GEOPHYSICAL LOGS
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DEPTH
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GAMMA
CALIPER

U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-29 Elev.(ft) 3685 Total Depth(ft) 615

Location 450 fsl 2200 fel sec. 10 T. 5 S. R. 49 E.

County Powder River State Montana Quadrangle(7.5′) Epsie

Cored: Yes ____ No x Interval(s) ____

Date started 11/7/79 Date completed 11/8/79 Driller Arthur Clark

Geologist Jim Boaz Remarks: Hole caved, no geophysical log

Depth interval (feet) From	To	Thickness	Lithologic Description
0	5	5	Soil, orange, clinker pieces, yellow-gray, very fine grained, clayey sand
5	25	20	Sandstone, yellow-orange, very fine grained, silty
25	30	5	Coal, black, dull, medium-soft
30	115	85	Shale, medium- to dark-gray, sand at bottom, coaly at 45′
115	141	26	Sandstone, gray, fine-grained, silty, clay
141	145	4	Coal, black
145	167	22	Shale, medium-gray, silty
167	195	28	Sandstone, gray, fine-grained, silty, shale streak 175′
195	210	15	Shale, light-gray, silty
210	280	70	Sandstone, light- to dark-gray, fine-grained, shaly at top and bottom
280	308	28	Shale, light-gray, silty
308	320	12	Coal, black, shaly
320	370	50	Shale, light-gray, silty, interbedded with light-gray, fine-grained, silty, sandstone
370	375	5	Coal, black
375	478	103	Shale, dark-gray, silty
478	530	52	Sandstone, gray, very fine grained, silty, shaly at bottom
530	575	45	Shale, gray
575	600	25	Coal, black, hard
600	615	15	Shale, brown-gray, medium-hard, silty

U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-30 Elev.(ft) 3410 Total Depth(ft) 389

Location 1300 fel 1950 fnl sec. 22 T. 5 S. R. 49 E.

County Powder River State Montana Quadrangle(7'5) Epsie

Cored: Yes x No Interval(s) 293' to 326.5'

Date started 11/6/79 Date completed 11/6/79 Driller Arthur Clark

Geologist Jim Boaz Remarks: Core description by George A. Correia

Depth interval (feet) From	To	Thickness	Lithologic Description
0	13	13	Soil, dark brown, clay, silt, sand, organics
13	18	5	Sand, yellow-orange, fine
18	21	3	Coal, hard, shiny
21	52	31	Siltstone, light-gray to gray, and light-gray shale
52	55	3	Coal
55	103	48	Siltstone, green-gray, shaley in places, with coal stringers at 61' and 79'
103	107	4	Coal
107	140	33	Shale, green-gray to light-gray, clayey
140	177	37	Siltstone, light-gray, sandy, clayey at 150'
177	203	26	Siltstone, light-gray, with coal stringer, clayey
203	242	39	Sandstone, fine-grained
242	261	19	Siltstone, green-gray, and sand, fine-grained
261	267	6	Sandstone, fine-grained
267	277	10	Shale, green-gray
277	291	14	Sandstone, fine-grained, coaly at bottom
291	293	2	Shale, brown-gray
			CORE DESCRIPTION
293.0	294.0	1	Siltstone, medium gray, clayey, coal streaks (woody) at 293.2, 293.4, 293.9, and 294.0, soft sediment deformation prominent, pyrite balls at 293.8
294.0	295.8	1.8	Claystone, medium-dark-gray, carbonaceous, coal streak 294.5 to 294.7, sharp basal contact with underlying coal, .5 foot loss
295.8	304.0	8.2	Coal, black, dull with shiny bands, fractured 295.8 to 298.1, heavily desseminated pyrite in fractures, clay streak 297.1 to 297.3, conchoidal fracturing below 298.1, disseminated pyrite on fractures 300.4 to 302.2 feet
304.0	313.9	9.9	Coal, black, hard, dull with shiny streaks, conchoidal fracturing, sharp basal contact

SECTION MB-30

Depth interval (feet) From	To	Thickness	Lithologic Description
313.9	315.3	1.4	Claystone, medium-gray, carbonaceous and shaly top .1', (woody with rootlets)
315.3	322.7	7.4	Coal, black, dull with shiny streaks, cleat fracturing throughout, conchoidal fracturing, clay streak at 321.4 and 322.0, resin on fractures at 322.4
322.7	323.3	.6	Claystone, medium-gray, carbonaceous and shaly from 322.7 to 322.8, rootlets below with woody streak at 323.0
323.3	326.5	3.2	Siltstone, medium-light-gray, clayey, rootlets from 323.5 to 324.1
			END OF CORE DESCRIPTION
326.5	376	49.5	Shale, green-gray
376	378	2	Coal
378	389	11	Siltstone, green-gray

U.S. Geological Survey

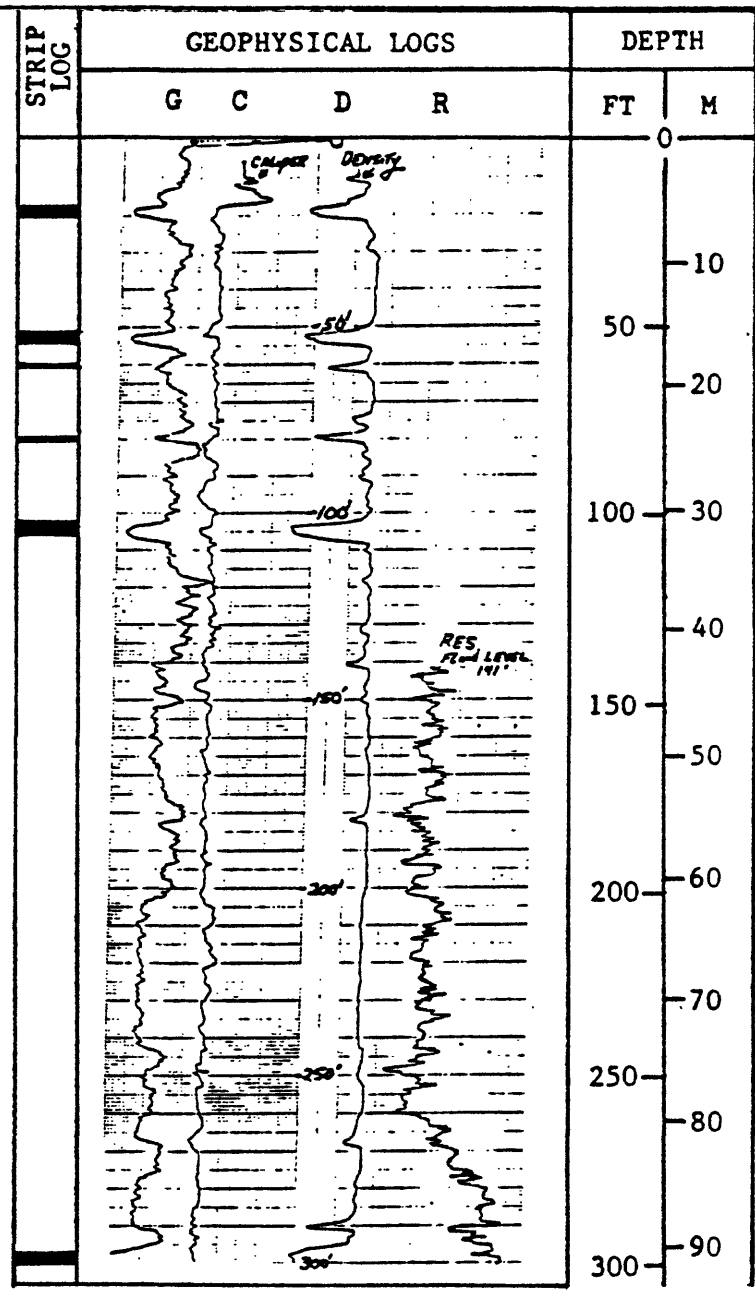
Hole Designation MB-30 Logged Depth 389 (ft)

Geophysical Log Scales:

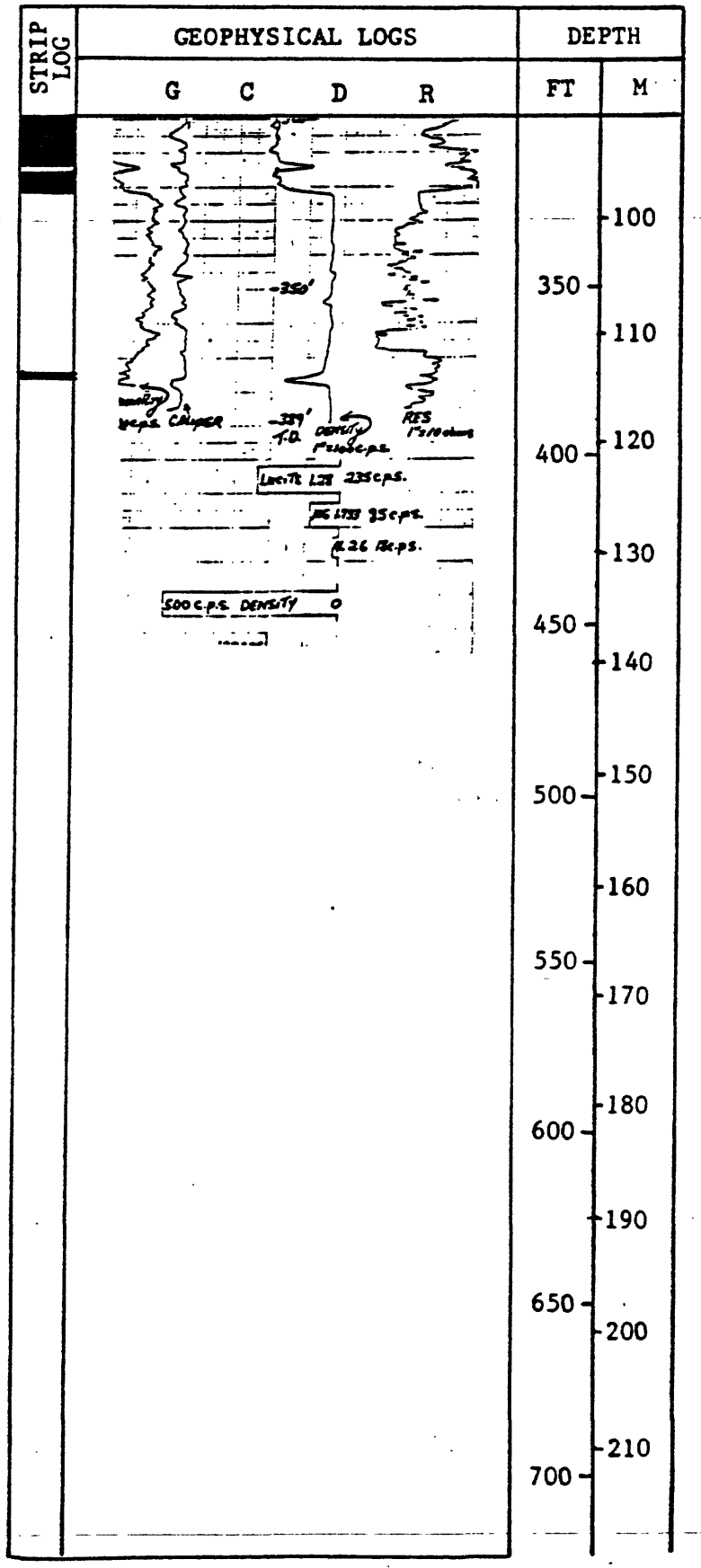
Gamma (G) 20 counts/sec/in Density (D) 100 counts/sec/in

Resistivity (R) 10 ohms/in Caliper (C) 2 in/in

Remarks:



MB-30


STRIP LOG
GEOPHYSICAL LOGS
G C D R
DEPTH
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-350'
-389'
T.D.
CALIPER
RES
Loc. Tk. L28 235 c.p.s.
500 c.p.s. DENSITY 0

U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-31 Elev.(ft) 3450 Total Depth(ft) 395

Location 600 fnl 2100 fel sec. 27 T. 5 S. R. 49 E.

County Powder River State Montana Quadrangle(7.5′) Yarger Butte

Cored: Yes ____ No x Interval(s) ____

Date started 11/7/79 Date completed 11/7/79 Driller Steve Grant

Geologist Jim Boaz Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	5	5	Soil, sand, yellow-gray, fine, silty, clayey
5	15	10	Shale, brown-gray, clayey
15	20	5	Shale, brown-gray, and gravel, subrounded to rounded, with sandstone and mudstone
20	32	12	Siltstone, dark-yellow to gray, coaly
32	35	3	Coal, very soft
35	58	23	Siltstone, gray, and light-gray to gray shale
58	62	4	Coal, soft
62	120	58	Shale, gray, silty, sandy in places, with coal stringer at 67′ and coal from 92′-94′ and 112′-114′
120	124	4	Coal
124	158	34	Shale, green-gray, silty toward bottom, coal stringer at 156′
158	165	7	Sandstone, gray fine-grained
165	171	6	Shale, gray
171	187	16	Sandstone, gray, fine-grained
187	210	23	Shale, dark-gray, silty
210	301	91	Sandstone, gray, fine, shaly in places
301	307	6	Shale, gray
307	317	10	Siltstone, gray
317	326	9	Shale, gray, coaly
326	334	8	Sandstone, gray, fine-grained
334	338	4	Shale, gray
338	355	17	Coal
355	368	13	Siltstone, green-gray
368	380	12	Coal
380	395	15	Sandstone, fine-grained

U.S. Geological Survey

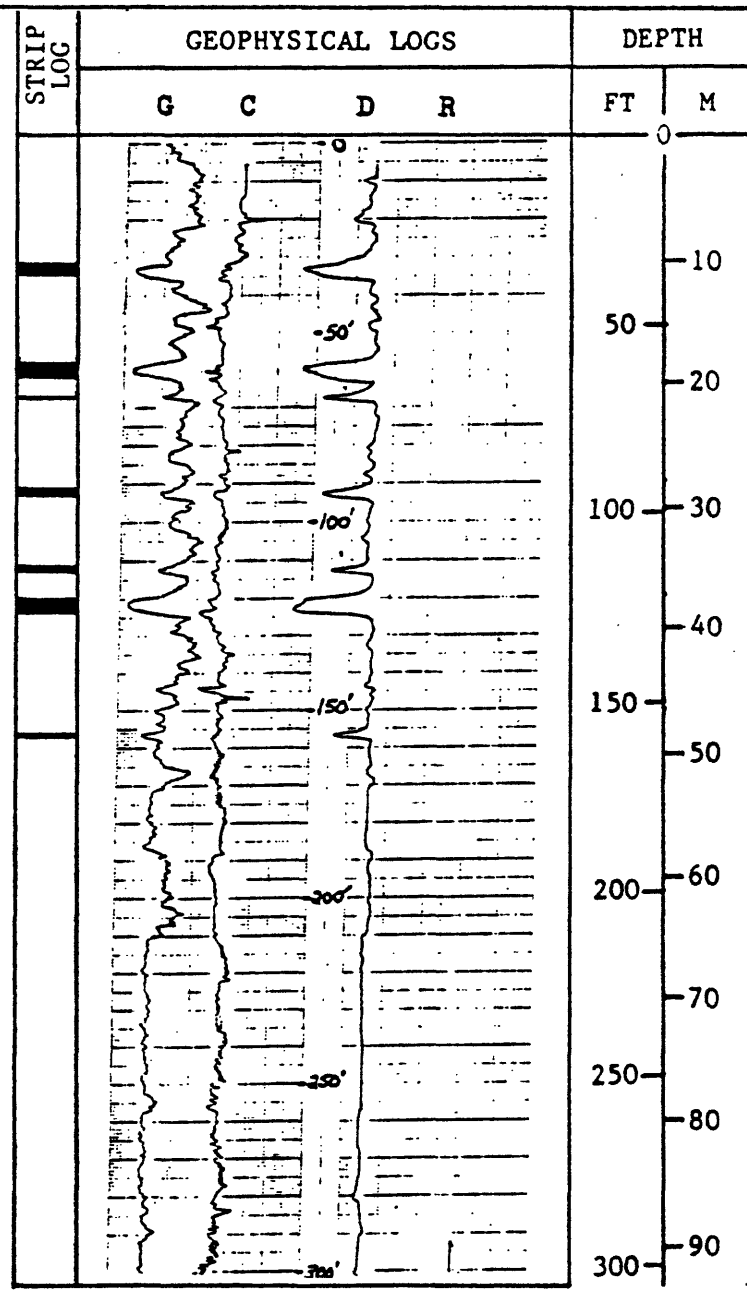
Hole Designation MB-31 Logged Depth 376 (ft)

Geophysical Log Scales:

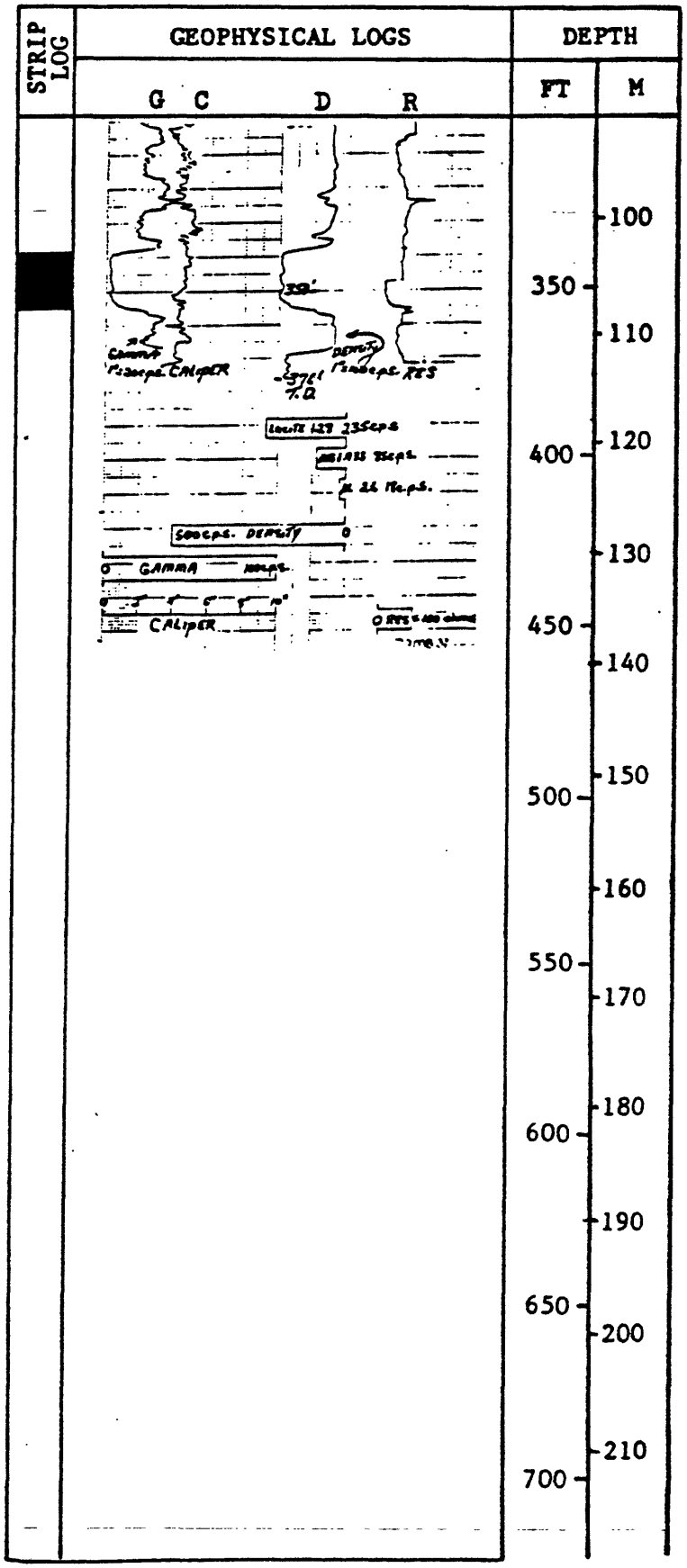
Gamma (G) 20 counts/sec/in Density (D) 100 counts/sec/in

Resistivity (R) 100 ohms/in Caliper (C) 2 in/in

Remarks:



MB-31


STRIP LOG
GEOPHYSICAL LOGS
G C D R
DEPTH
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170
180
190
200
210
GAMMA
CALIPER

U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-32 Elev.(ft) 3425 Total Depth(ft) 395

Location 350 fnl 1800 fwl sec. 1 T. 6 S. R. 49 E.

County Powder River State Montana Quadrangle(7.5) Yarger Butte

Cored: Yes ____ No x Interval(s) ____

Date started 11/8/79 Date completed 11/9/79 Driller Steve Grant

Geologist Jim Boaz Remarks: Natural Gamma logged through steel.

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	5	5	Soil, sand, clinker, yellow to orange
5	10	5	Sandstone, yellow-gray, fine, silty, and gray shale
10	38	28	Sandstone, yellow-gray to orange-gray, fine-grained, silty
38	55	17	Sandstone, gray, fine-grained
55	85	30	Sandstone, orange-gray, fine-grained, with coaly stringers
85	87	2	Coal stringer
87	106	19	Shale, gray
106	111	5	Coal
111	155	44	Interbedded sandstone, fine-grained, and shale or siltstone, light-gray to gray, with bony coal at 151′ to 153′
155	160	5	Coal
160	175	15	Shale, light-gray to light-green-gray
175	234	59	Shale, green-gray to gray, silty in places, with coal stringer at 218′
234	283	49	Sandstone, fine, silty or shaly in places
283	310	27	Interbedded siltstone, gray to light gray, and sandstone, fine-grained
310	332	22	Sandstone, dark-green-gray, fine-grained
332	333	1	Coal stringer
333	338	5	Interbedded sandstone, fine-grained, and shale, dark-gray
338	352	14	Coal
352	374	22	Shale, dark-green-gray
374	395	21	Sandstone, fine-grained

U.S. Geological Survey

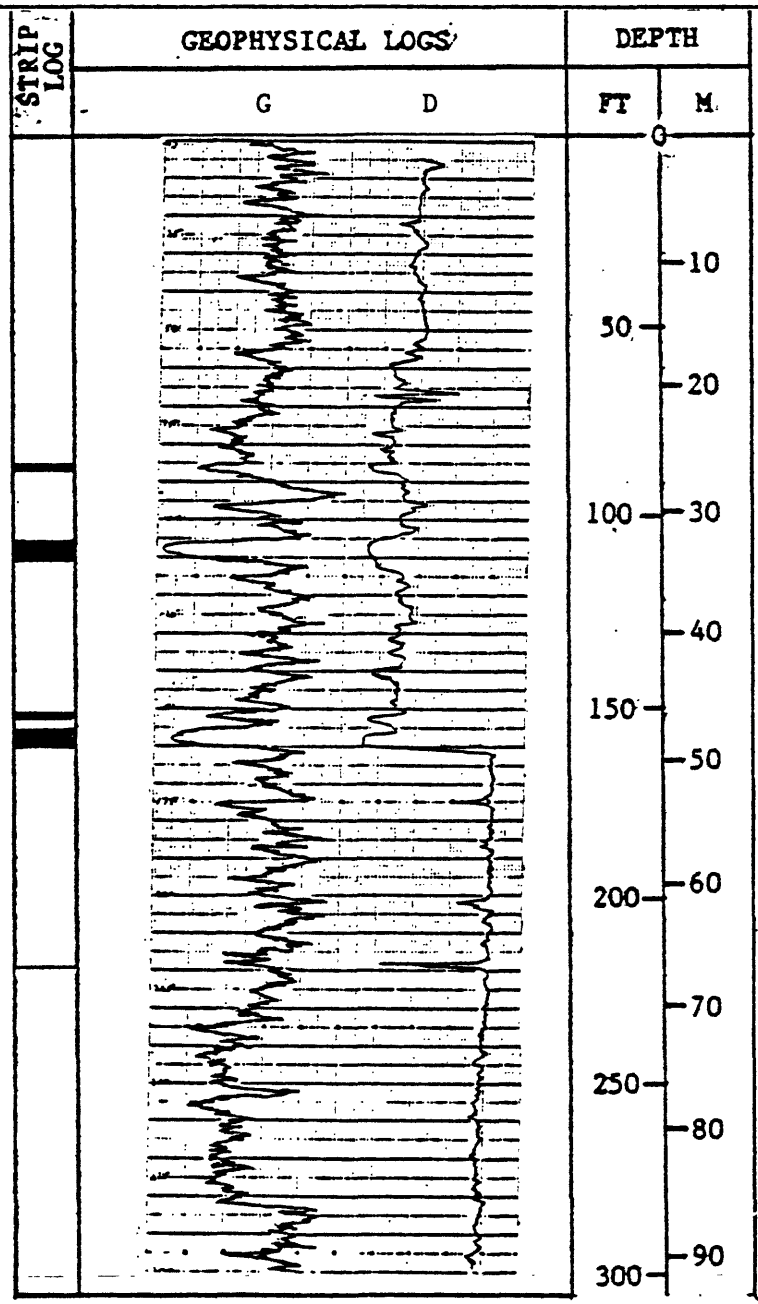
Hole Designation MB-32 Logged Depth 395 (ft)

Geophysical Log Scales:

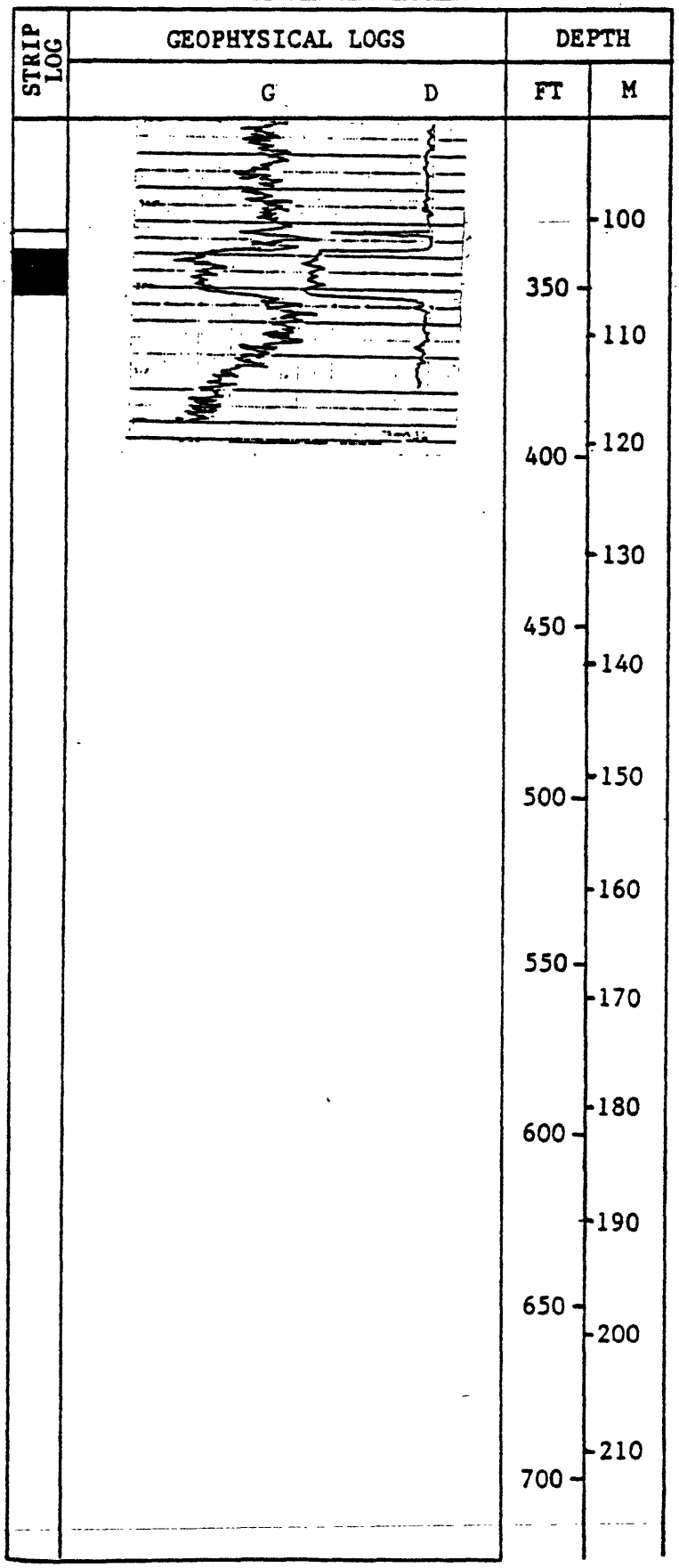
Gamma (G) 50 counts/sec/in Density (D) 10 counts/sec/in

Resistivity (R) _____ Caliper (C) _____

Remarks: _____



MB-32


STRIP LOG
GEOPHYSICAL LOGS
G
D
DEPTH
FT
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350
110
400
120
130
450
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550
170
180
600
190
650
200
210
700

U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-33 Elev.(ft) 3625 Total Depth(ft) 635

Location 750 fwl 1100 fsl sec. 19 T. 4 S. R. 49 E.

County Powder River State Montana Quadrangle(7.5′) Epsie

Cored: Yes ____ No x Interval(s) ____

Date started 10/30/79 Date completed 10/30/79 Driller Arthur Clark

Geologist Jim Boaz Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	21	21	Sand, fine- to medium-grained, silica, micaceous
21	27	6	Shale, light- to dark-gray
27	29	2	Sandstone, light-gray
29	46	17	Shale, medium-gray
46	50	4	Coal, dull black, hard
50	62	12	Shale, dark-gray
62	76	14	Siltstone, medium-gray
76	87	11	Shale, medium-gray
87	89	2	Coal
89	112	23	Siltstone, medium-gray
112	156	44	Shale, medium-gray, silty
156	159	3	Claystone, light-green-gray
159	180	21	Siltstone medium-gray
180	183	3	Shale, medium-gray
183	190	7	Siltstone, dark-gray-green
190	195	5	Shale, medium-gray
195	215	20	Sandstone, dark-gray-green
215	256	41	Shale, dark-gray-green, and dark-gray-green siltstone
256	271	15	Coal, dull black, with siltstone(?) parting from 262′ to 264′
271	282	11	Shale, green-gray
282	290	8	Siltstone, light-green-gray, sandy
290	319	29	Shale, light-green-gray to dark-brown-gray, clayey; coal stringers
319	336	17	Siltstone, green-gray to gray-brown, with coal stringers
336	367	31	Shale, gray-brown, silty
367	373	6	Coal and siltstone(?) parting at 370′
373	385	12	Sandstone, brown, silty
385	428	43	Siltstone, gray, clayey in places
428	514	86	Sandstone, gray, silty towards bottom, washout 483′ to 485′

SECTION MB-33

Depth interval (feet)			
From	To	Thick-ness	Lithologic Description
514	518	4	Coal
518	562	44	Shale, dark-gray, clayey
562	580	18	Siltstone, light-gray, clayey at bottom
580	614	34	Coal, with siltstone(?) parting from 604′ to 607′
614	635	21	Siltstone, dark-gray

U.S. Geological Survey

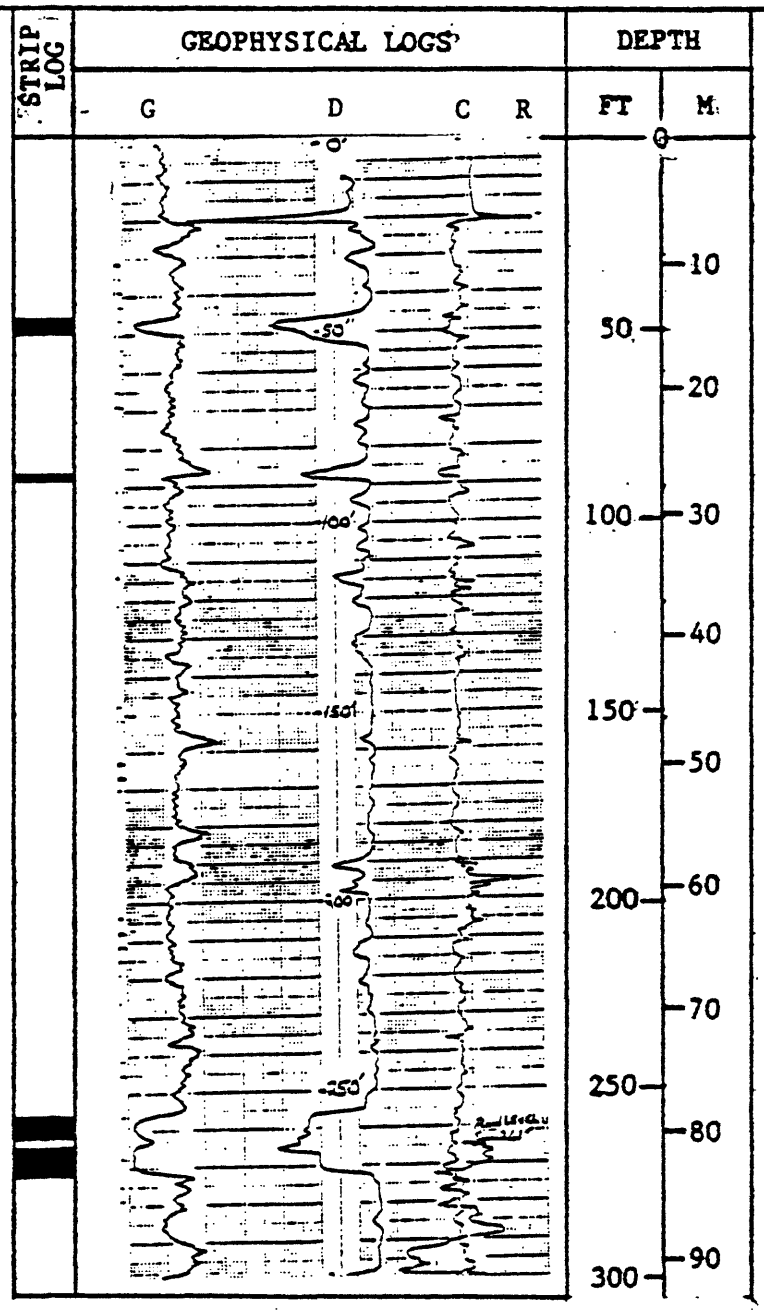
Hole Designation MB-33 Logged Depth 626 (ft)

Geophysical Log Scales:

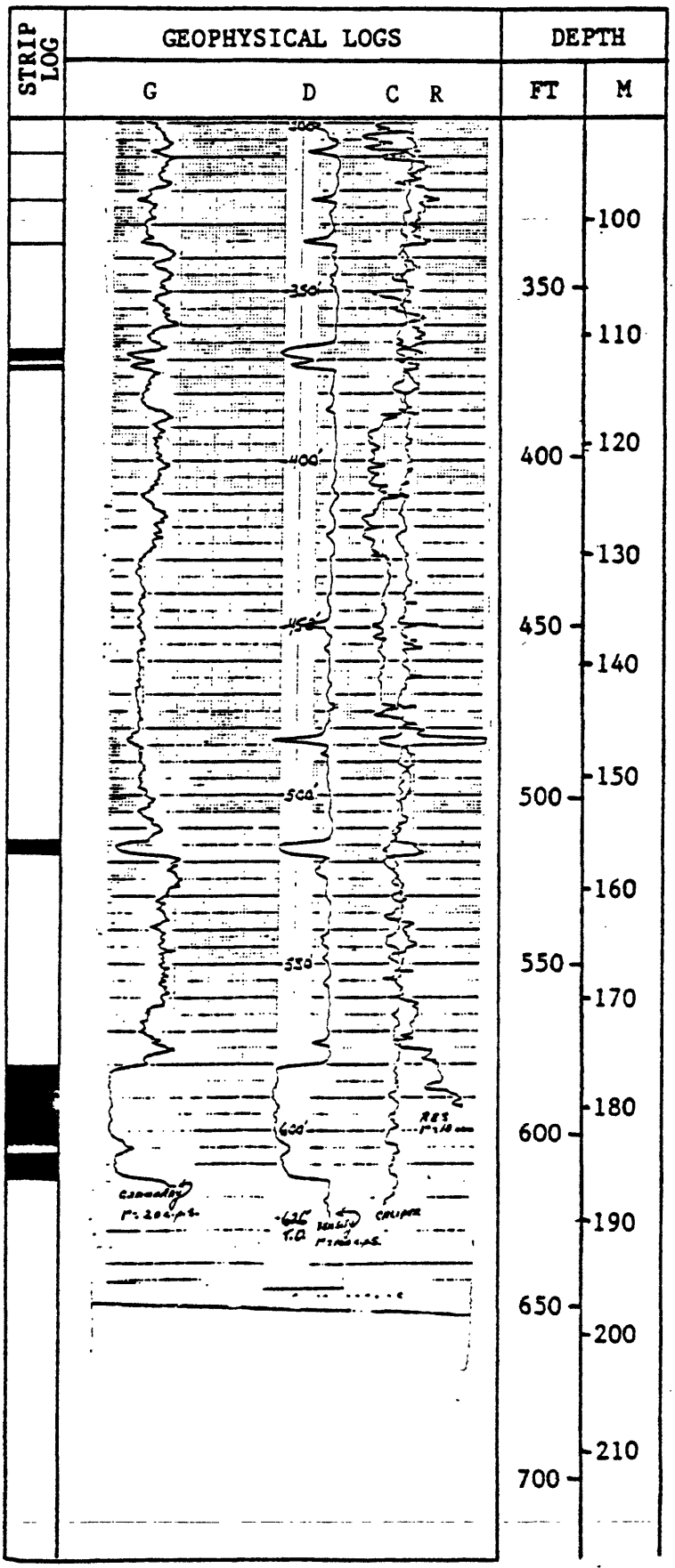
Gamma (G) 20 counts/sec/in Density (D) 100 counts/sec/in

Resistivity (R) 10 ohms/in Caliper (C) 2. in/in

Remarks:



MB-33


STRIP LOG
GEOPHYSICAL LOGS
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DEPTH
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350'
400'
450'
500'
550'
600'
100
110
120
130
140
150
160
170
180
190
200
210
350
400
450
500
550
600
650
700

U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-34 Elev.(ft) 3560 Total Depth(ft) 515

Location 100 fwl 2600 fnl sec. 4 T. 6 S. R. 49 E.

County Powder River State Montana Quadrangle(7.5') Yarger Butte

Cored: Yes ____ No x Interval(s) ____

Date started 11/9/79 Date completed 11/10/79 Driller Steve Grant

Geologist Jim Boaz Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	27	27	Soil, brown, red clinker pieces
27	58	31	Siltstone, dark-gray, clayey near top
58	84	26	Shale, dark-brown-gray
84	88	4	Coal
88	99	11	Shale, dark-gray, silty
99	113	14	Siltstone, gray
113	132	19	Shale, gray- to dark-gray, coal stringer at 113′
132	133	1	Coal stringer
133	190	57	Shale, gray, silty
190	235	45	Siltstone, gray- to dark-gray, with sandstone lenses, coal stringer at top
235	243	8	Coal
243	255	12	Siltstone, dark-gray, with some coal near top, clayey at bottom
255	311	56	Siltstone, brown-gray to dark-gray, sandy in places
311	334	23	Sandstone, fine-grained, silty
334	343	9	Coal, shale parting from 335′ to 337′
343	353	10	Shale, dark-gray to gray
353	358	5	Coal
358	390	32	Siltstone, gray, clayey in places
390	396	6	Coal, with shale parting at 392′
396	447	51	Siltstone, gray, sandy, clayey in places
447	459	12	Siltstone, gray, sandy, with trace coal in cuttings
459	515	56	Sandstone, dark-green-gray to dark brown-gray, fine-grained

U.S. Geological Survey

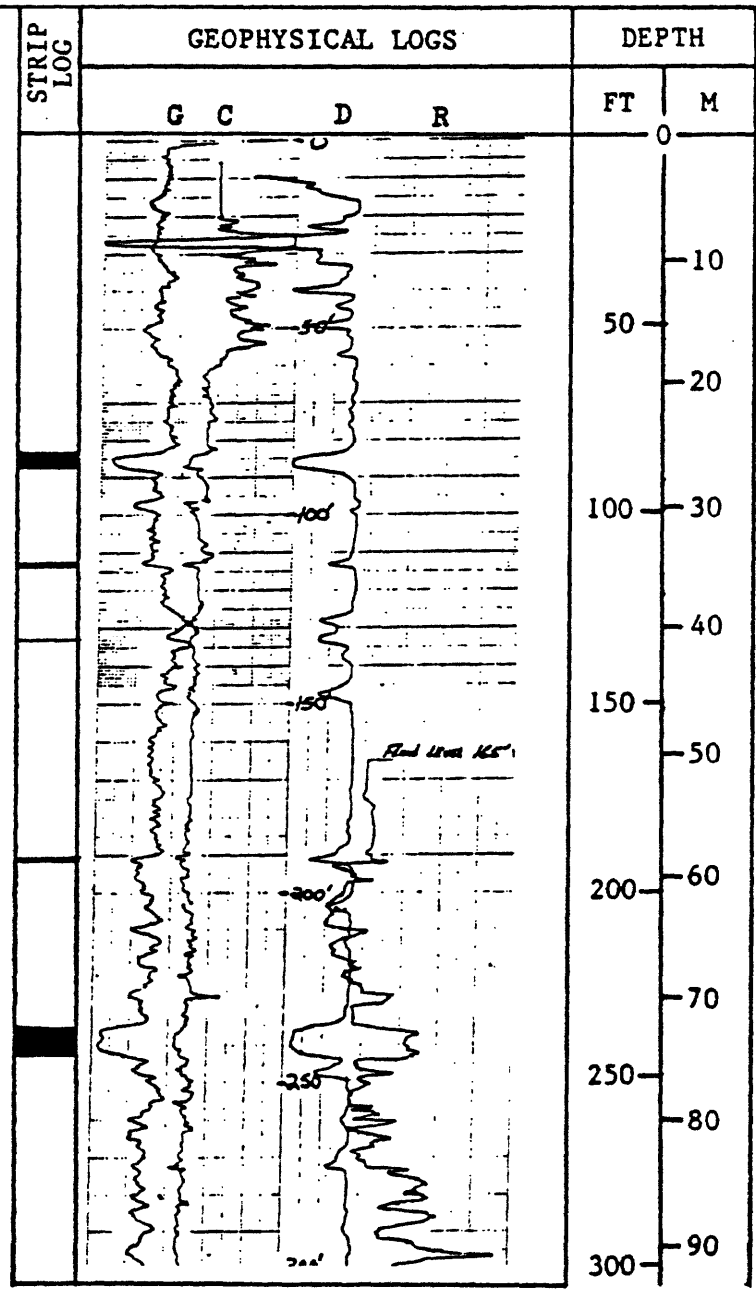
Hole Designation MB-34 Logged Depth 512 (ft

Geophysical Log Scales:

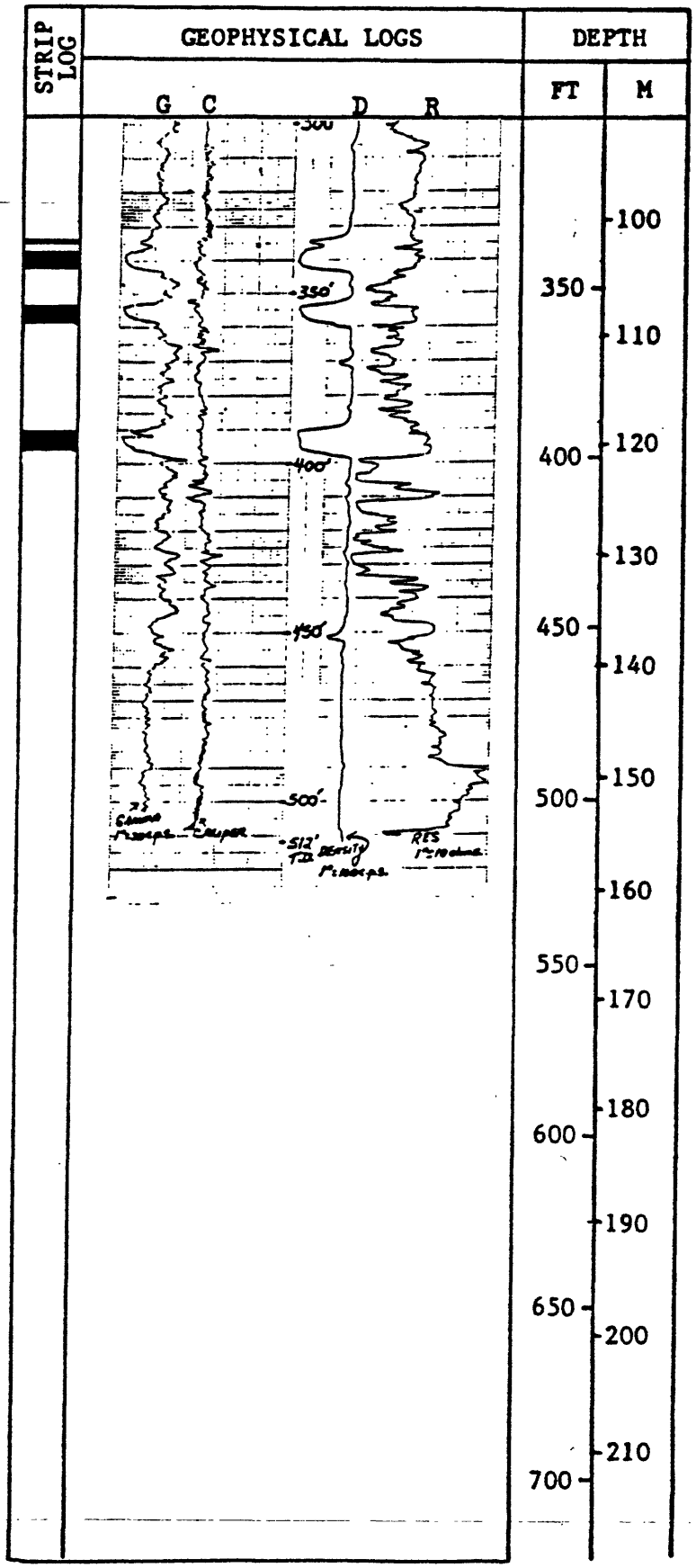
Gamma (G) 20 counts/sec/in Density (D) 100 counts/sec/in

Resistivity (R) 10 ohms/in Caliper (C) 2 in/in

Remarks:



MB-34


STRIP LOG
GEOPHYSICAL LOGS
G C D R
DEPTH
FT
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300
350'
400'
450'
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512'
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110
120
130
140
150
160
170
180
190
200
210
350
400
450
500
550
600
650
700

U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-35 Elev.(ft) 3725 Total Depth(ft) 299

Location 1200 fnl 1900 fwl sec. 25 T. 5 S. R. 48 E.

County Powder River State Montana Quadrangle(7.5′) Yarger Butte

Cored: Yes ____ No x Interval(s) ____

Date started 11/12/79 Date completed 11/12/79 Driller Steve Grant

Geologist Jim Boaz Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	31	31	Soil, brown, gravel to clay
31	56	25	Shale, gray to dark-brown-gray, sandy, clayey in places
56	71	15	Siltstone, gray
71	88	17	Shale, gray
88	110	22	Coal
110	134	24	Shale, gray to dark-gray, silty in places, with sandstone stringer from 127′ to 128′
134	167	33	Siltstone, gray, sandy toward bottom, clayey in places
167	169	2	Coal
169	187	18	Siltstone, gray, clayey at bottom
187	189	2	Coal
189	215	26	Siltstone, gray, clayey at top, with very hard sandstone stringer, orange-gray, very fine grained
215	221	6	Sandstone, gray
221	227	6	Siltstone, gray
227	231	4	Coal
231	243	12	Siltstone, gray to dark-gray
243	261	18	Shale, gray, silty
261	299	38	Shale, gray, clayey, with sandstone stringer at 264′

U.S. Geological Survey

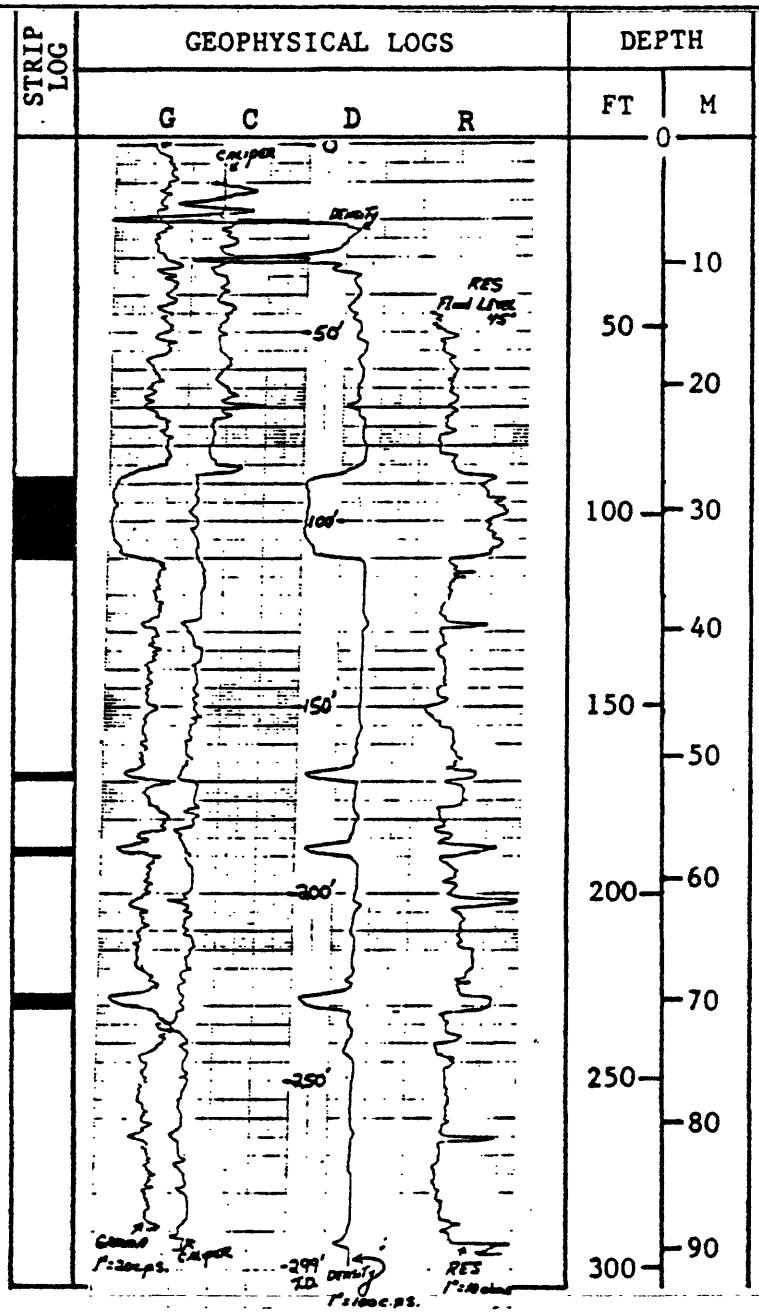
Hole Designation MB-35 Logged Depth 299 (ft)

Geophysical Log Scales:

Gamma (G) 20 counts/sec/in Density (D) 100 counts/sec/in

Resistivity (R) 10 ohms/in Caliper (C) 2 in/in

Remarks:



U. S. Geological Survey

Moorhead Broadus Drilling Project

Hole Designation MB-36 Elev.(ft) 3435 Total Depth(ft) 555

Location 200 fel 1150 fsl sec. 22 T. 4 S. R. 49 E.

County Powder River State Montana Quadrangle(7.5′) Epsie

Cored: Yes ____ No x Interval(s) ____

Date started 11/13/79 Date completed 11/13/79 Driller Arthur Clark

Geologist Jim Boaz Remarks: ____

Depth interval (feet)

From	To	Thickness	Lithologic Description
0	30	30	Sand, orange-gray to yellow-gray, fine-grained, silty, clayey at bottom
30	32	2	Coal
32	42	10	Shale, dark-brown-gray to very dark gray
42	67	25	Siltstone, gray
67	71	4	Coal
71	103	32	Siltstone, gray, clayey in places
103	105	2	Coal
105	136	31	Shale, light-green-gray to gray, silty toward bottom
136	161	25	Shale, gray
161	195	34	Siltstone, gray, sandy
195	205	20	Sandstone, gray
205	220	15	Siltstone, gray, clayey in places
220	225	5	Coal
225	252	27	Siltstone, green-gray, sandy
252	275	23	Shale, green-gray
275	315	40	Shale, green-gray, silty
315	338	23	Coal
338	378	40	Siltstone, gray-green, less clay at bottom
378	475	97	Sandstone, fine-grained
475	495	20	Shale
495	519	24	Sandstone, fine-grained
519	555	36	Sandstone, gray, fine-grained, and gray shale

U.S. Geological Survey

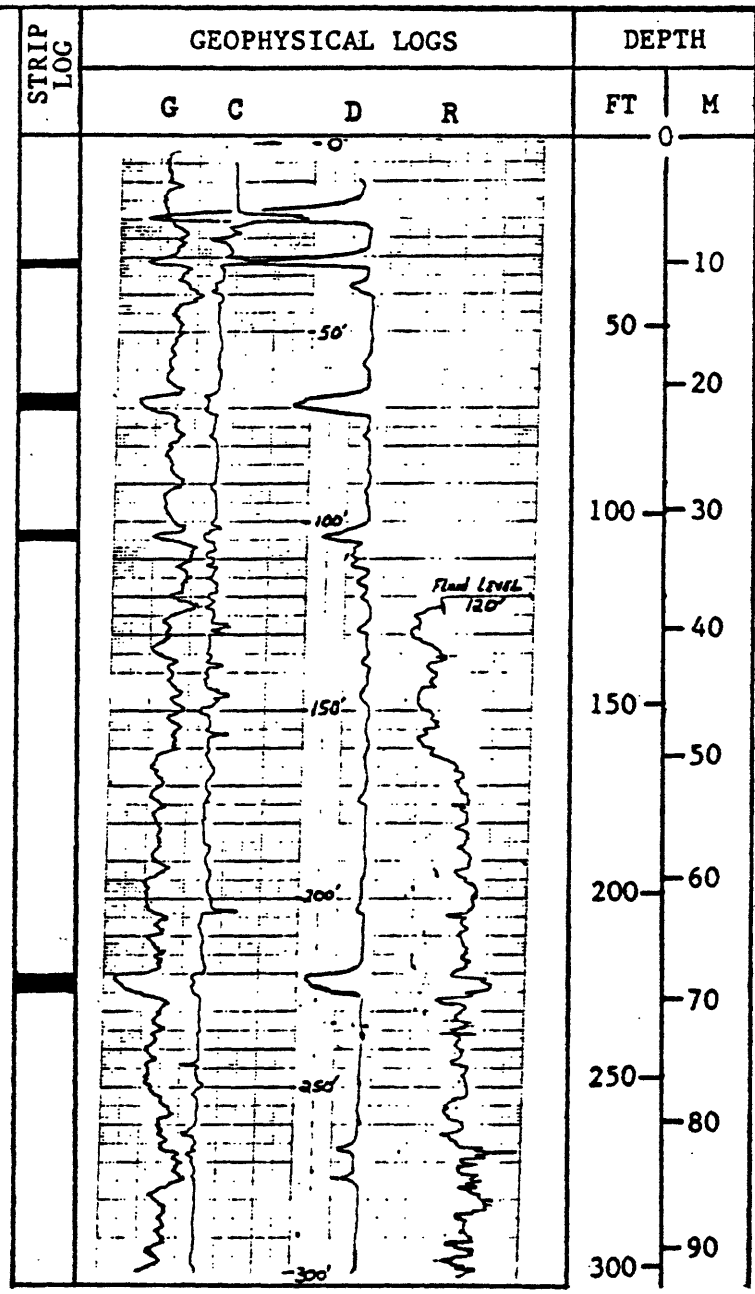
Hole Designation MB-36 Logged Depth 554 (f

Geophysical Log Scales:

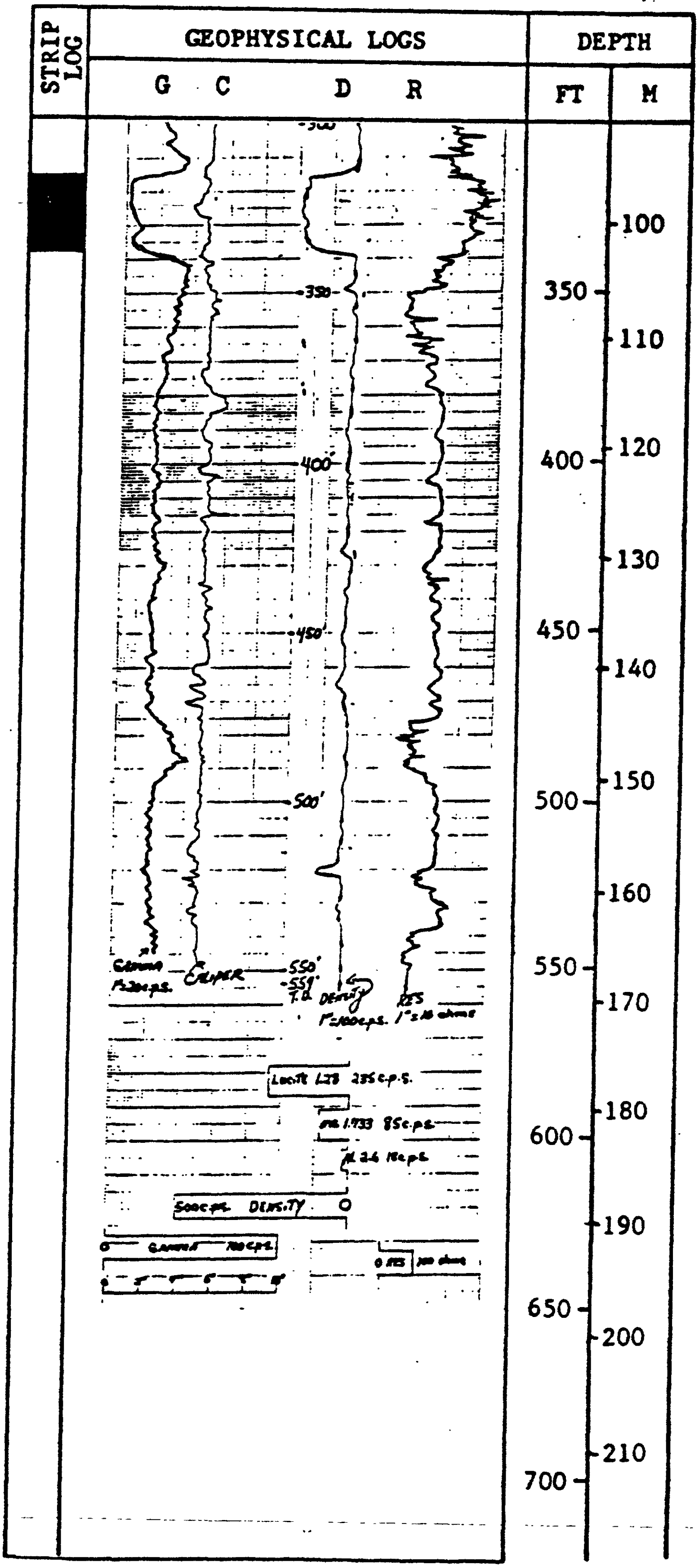
Gamma (G) 20 counts/sec/in Density (D) 100 counts/sec/in

Resistivity (R) 10 ohms/in Caliper (C) 2 in/in

Remarks:



MB-36


STRIP LOG
GEOPHYSICAL LOGS
G C D R
DEPTH
FT
M
350
400
450
500
550
600
650
700
100
110
120
130
140
150
160
170
180
190
200
210
CALIPER
DENSITY
RES