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GEOLOGICAL SURVEY

Results of exploratory drilling for lignite in 1980,  
Fort Peck Indian Reservation,  
Daniels, Roosevelt, and Sheridan Counties, Montana

By

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Introduction

Thirty-four exploratory holes were drilled for lignite in the Fort Peck Indian Reservation during September and October, 1980. The drilling was done as part of the U.S. Geological Survey's program to assess the coal resources in the reservation. This preliminary report makes available the lithic descriptions and geophysical logs of the rocks penetrated in the exploratory holes. Previous reports by Hardie and Arndt (1981), and Arndt, Hardie, and Kehn (1982), reported on the results of exploratory drilling for lignite in the Fort Peck Indian Reservation in 1978 and 1979. Geologic interpretations resulting from this and other investigations in the reservation are not published here.

The Fort Peck Indian Reservation has been previously mapped by several investigators. Lignite beds that crop out in the reservation were described and located by Smith (1910). Colton and Bateman (1956) prepared a generalized geologic and structure contour map of the Fort Peck Indian Reservation. Witkind (1959) mapped and summarized the Quaternary geology of the southeastern part of the reservation; Colton (1962, 1963a, 1963b, and 1964) mapped the southwestern, west-central, and northern parts of the area covered in this report; and the Great Northern Railway Company (1966, now Burlington Northern, Inc.) investigated the Fort Kipp lignite deposit. Principal objectives of the investigations described in this report include a comprehensive study and the assessment of coal resources in the eastern part of the Fort Peck Indian Reservation, by integration and synthesis of preexisting information with new field studies and drilling information.

Funding for these investigations was provided by the U.S. Bureau of Indian Affairs. The investigations have proceeded with the authorization and cooperation of the Fort Peck Tribal Executive Board, Norman Hollow, Executive Chairman. Carl Fourstar, Director, Fort Peck Tribal Research Program, and Frances Eagleman, Realty Officer, U.S. Bureau of Indian Affairs, provided liaison with the U.S. Geological Survey and were most helpful in expediting the work.

The drilling described here was done by Gulbraa Drilling Company, Sidney, Montana, under contract to the U.S. Geological Survey. Geophysical logs of the drill holes were made by Strata Surveys, Steamboat Springs, Colorado, and Reich Geo-Physical, Billings, Montana, also under contract to the U.S. Geological Survey. Assistance in these investigations was provided by the following U.S. Geological Survey personnel: Bradley S. VanGosen and Jennifer P. Gard assisted in the siting and permitting of the exploratory holes; Roger B. Colton generously provided unpublished geologic data.

#### Location

The Fort Peck Indian Reservation occupies about 3,000 square miles in Daniels, Roosevelt, Sheridan, and Valley Counties, northeastern Montana (fig. 1). The Missouri River, a major feature in the area, forms the south boundary of the reservation (fig.2). The reservation extends eastward from Porcupine Creek to Big Muddy Creek. The north boundary is roughly parallel to lat 48°38' N. The reservation lies within the Northern Great Plains province and is comprised of rolling uplands that are dissected by the Missouri and Poplar Rivers and their tributaries. Principal towns in the reservation are located along the southern margin on U.S. Highway 2 and along the mainline of the Burlington Northern Railroad.

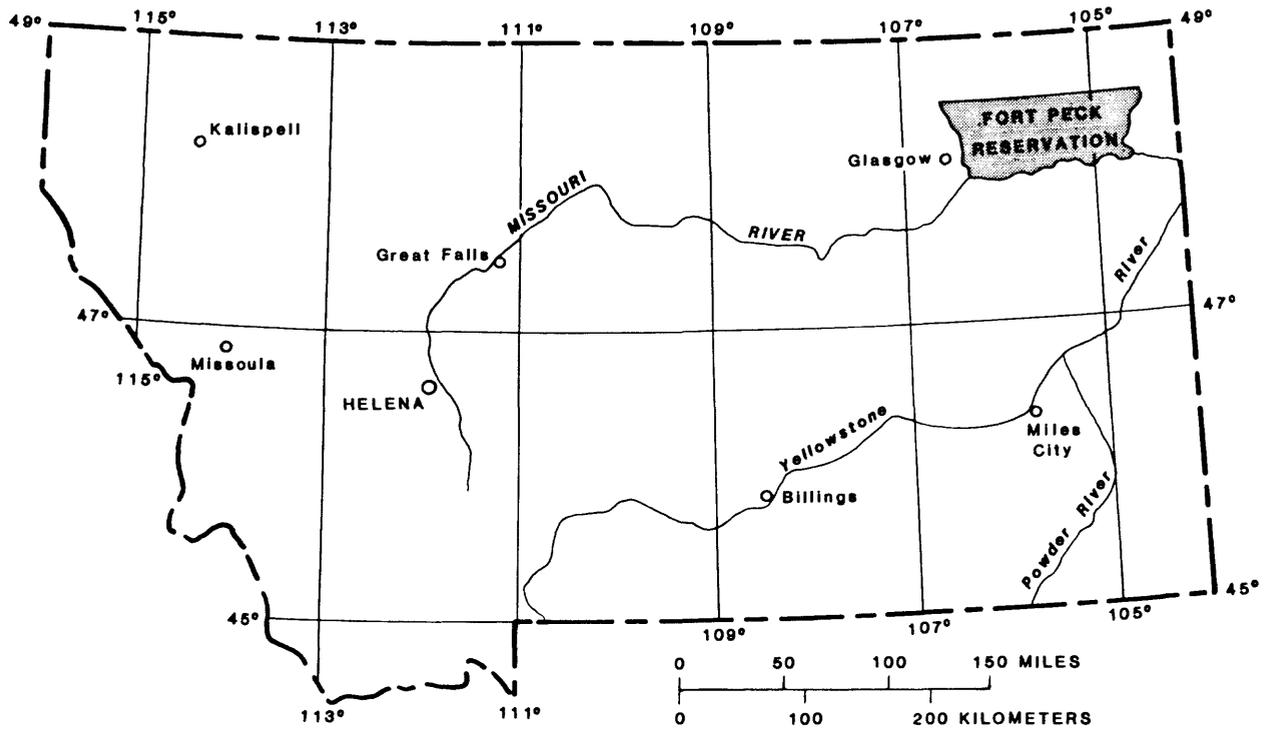


Figure 1.--Index map of Montana showing location of Fort Peck Indian Reservation.

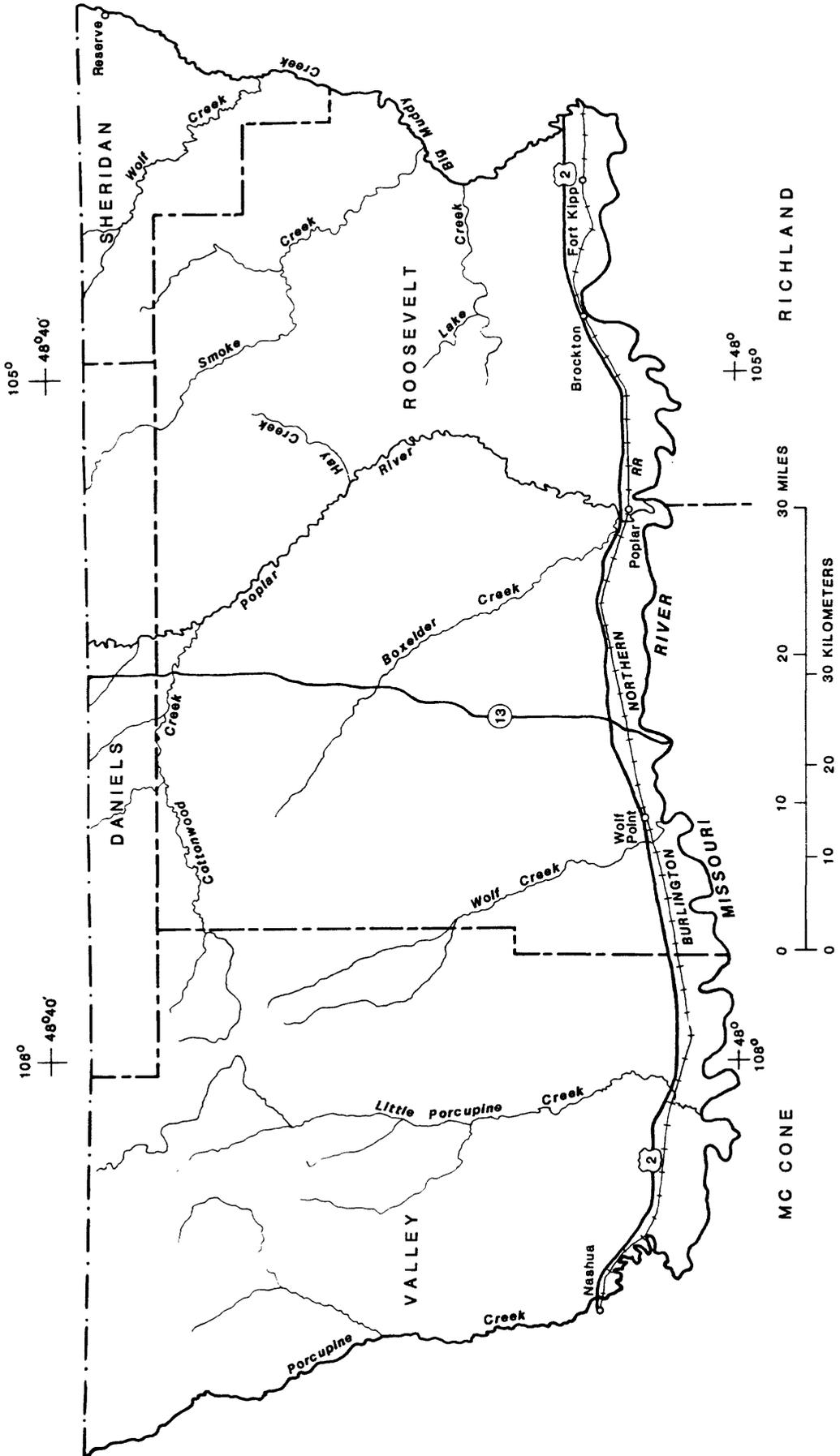


Figure 2.--Index map of Fort Peck Indian Reservation, northeastern Montana.

Most of the coal-bearing rocks underlying the reservation, the focus of these investigations, lie between the Poplar River and Big Muddy Creek and are included in the Fort Peck Indian Reservation lignite field of Smith (1910). The exploratory drilling described in this report tested the coal-bearing rocks underlying the east-central and northeastern parts of the Fort Peck Indian Reservation.

#### Geologic setting

Coal-bearing rocks in the Fort Peck Indian Reservation are in the Hell Creek Formation of Late Cretaceous age and the Fort Union Formation of Paleocene age. The Hell Creek Formation is mainly soft claystone and siltstone interbedded with ledge-forming sandstone, and also includes numerous but relatively thin and discontinuous beds of lignite. The formation is as much as 280 feet thick in the vicinity of the Fort Peck Indian Reservation. Somber gray claystone and siltstone predominate in the middle and upper parts of the formation, and brown sandstone dominates the lower part. Lignite beds in the formation are not known to exceed 3 feet in thickness in the reservation, and consequently, they are of little economic importance.

The Fort Union Formation conformably overlies the Hell Creek Formation. The contact between these formations is gradational and is arbitrarily placed at the base of the lowest mappable lignite bed (Colton and Bateman, 1956). Somber gray beds of the Hell Creek generally prevail below this horizon in subtle contrast with the overlying brighter yellow-hued beds comprising the Fort Union. Although the Fort Union Formation underlies most of the reservation east of the Poplar River, erosion has removed all but the lower few hundred feet of the formation in the vicinity of the Poplar River. In the study area the rocks of the Fort Union Formation dip gently eastward, and the thickest sequence of strata underlies the eastern part of the reservation.

The Fort Union Formation is as much as 1,050 feet thick in the eastern part of the Fort Peck Indian Reservation where it consists mainly of claystone, siltstone, and sandstone, and includes nine beds of lignite ranging from 2 to 14 feet in thickness, and numerous beds of lignite less than 2 feet thick. The formation is known to contain potentially recoverable lignitic coal at several localities in the eastern part of the reservation; however, the relationship of these known coal deposits to each other and to other recoverable coal deposits that may be present is not satisfactorily understood. Hopefully the current investigations will clarify these relationships.

Much of the coal-bearing sequence is buried under surficial deposits of Late Tertiary and Quaternary age. The surficial deposits include fluvial gravel deposits; glacial outwash, till, kame, and esker deposits; pond and lake deposits; alluvium and colluvium. Some of these deposits are thick and extensive, and conceal the underlying bedrock in areas of many square miles. Bedrock is exposed along some roadcuts and commonly along streambeds; however, extensive continuous rock exposures and exposures of coal are rare. Thus, it is necessary to resort to exploratory drilling in order to obtain adequate information to evaluate the coal-bearing sequence.

#### Coal exploratory drill holes

Thirty-four exploratory holes were drilled in the east-central and north-eastern parts of the Fort Peck Reservation in 1980 in order to obtain information on the quantity and distribution of coal beds in the Fort Union Formation. The 1978, 1979, and 1980 drill hole locations and the area in the eastern part of the reservation underlain by the coal-bearing Fort Union Formation are shown in figure 3. The stratigraphic intervals of the Fort Union and Hell Creek Formations tested by the 1980 drilling are shown in figures 4 and 5.

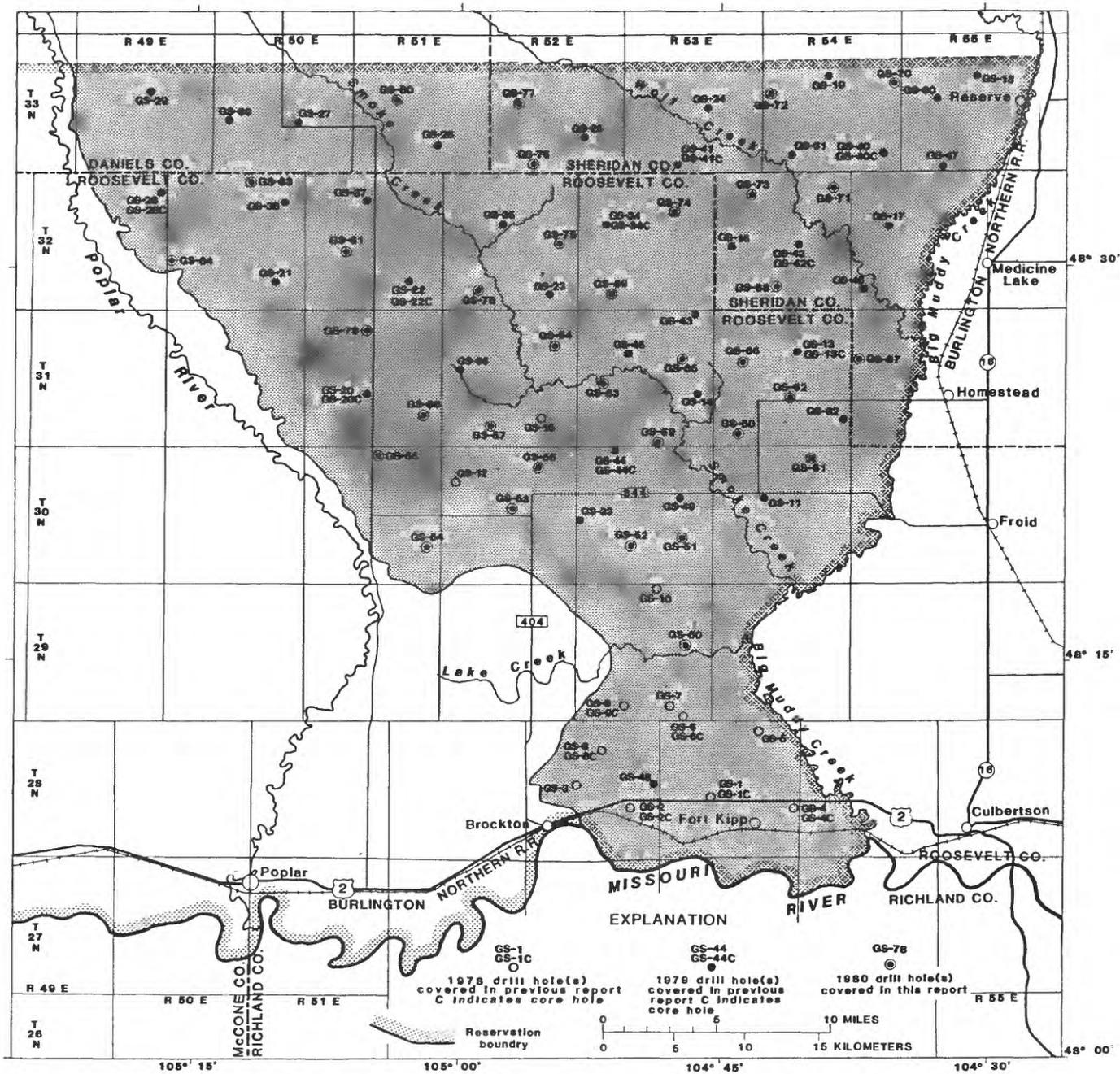
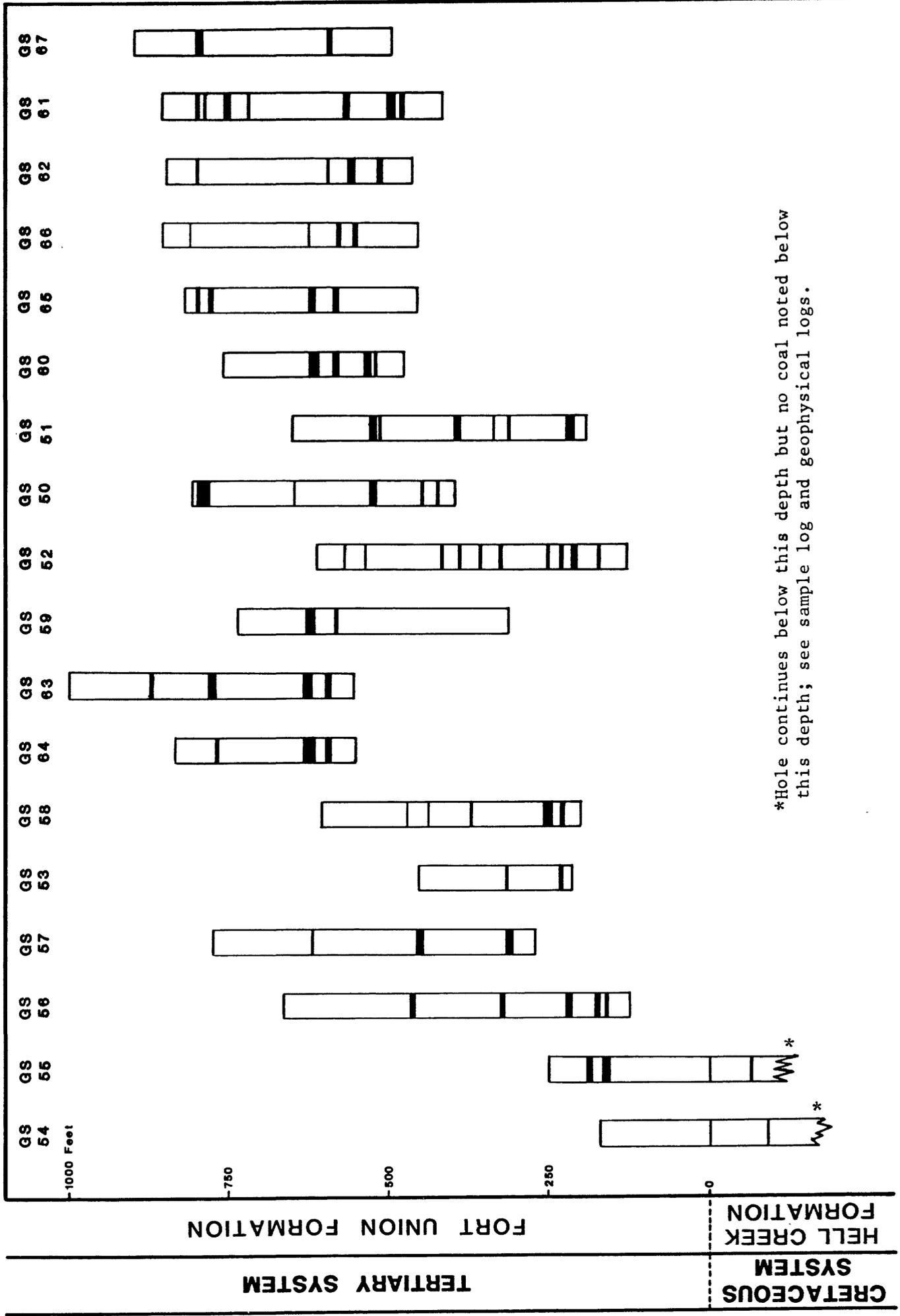


Figure 3.—Map showing locations of drill holes and area underlain by the Fort Union Formation (shaded) in the eastern part of the Fort Peck Indian Reservation, Montana.



\*Hole continues below this depth but no coal noted below this depth; see sample log and geophysical logs.

Figure 4.--Diagram showing stratigraphic intervals of the Fort Union and Hell Creek Formations penetrated by U.S. Geological Survey drill holes in the east-central part of the Fort Peck Indian Reservation during 1980. Dark bands indicate selected coal beds (coal thicknesses exaggerated).

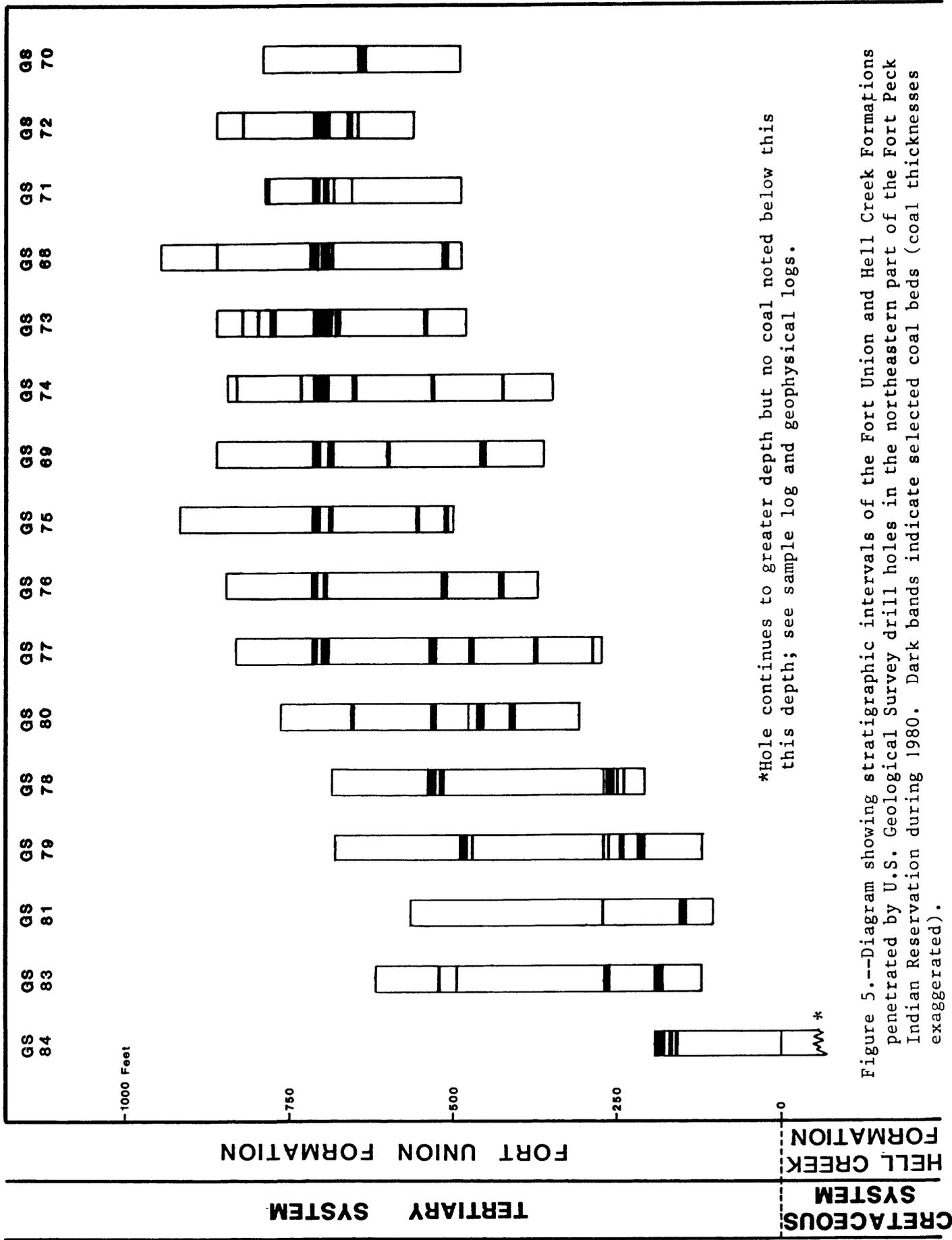


Figure 5.--Diagram showing stratigraphic intervals of the Fort Union and Hell Creek Formations penetrated by U.S. Geological Survey drill holes in the northeastern part of the Fort Peck Indian Reservation during 1980. Dark bands indicate selected coal beds (coal thicknesses exaggerated).

## Logs of drill holes

Sample logs of the coal exploratory holes described in this report were prepared from the field descriptions of the drill cuttings, and for selected holes by further examination of the drill cuttings under a microscope to determine the lithology of the strata tested. The geophysical logs were used to ascertain the tops and bottoms of stratigraphic units recognized from the examination of the drill cuttings.

Geophysical logs of the exploratory holes were made with a multiconductor logging tool. Natural-gamma, focused density, single-point resistance, and caliper logs, at a scale of 1 inch = 10 feet, were obtained at most locations. Natural-gamma and focused density (high resolution) logs, at an expanded scale of 1 inch = 5 feet, of selected coal beds and coal zones were made at most sites. It was not possible to make all of the logs noted above at some sites because of equipment failures or caving and blockage of holes. Logs made at the expanded scale are not reproduced in this report

## Coal quality

Coal samples were not collected for chemical analysis during the course of the 1980 exploratory drilling. Information on the quality of the coal in the area tested by the 1980 exploratory drilling is given in previous reports (Hardie and Arndt, 1981; Arndt, Hardie, and Kehn, 1982). These earlier reports contain the results of the chemical analysis of 37 coal samples collected from the Fort Union Formation in the eastern part of the Fort Peck Indian Reservation. The apparent rank of the coals that were analyzed is lignite A, according to specifications of the American Society for Testing and Materials (1978).

Conversion to metric units

Units of measurement used in this report are in the English system.

Factors for conversion to the metric system are:

<u>English system</u>	<u>Metric system</u>
1 foot-----	0.3048 meter
1 mile-----	1.609 kilometers
1 square mile-----	2.590 square kilometers
1 British thermal unit/pound-----	0.5556 kilogram-calories/kilogram

Sample log

Hole no.: GS-50 Date: 10-11-80 State: Montana County: Roosevelt

Elev. (ground): 1997 ft Location: T. 29 N., R. 53 E., Sec. NE SW 13

Total depth: 400 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-11	Sand and clay, light-brownish-gray, unconsolidated
11-20	Lignite, grayish-black to brownish-black; soft, oxidized
20-41	Siltstone and sandstone, light-brown to light-yellowish-brown; thinly interbedded; includes thin scattered beds of silty claystone
41-47	Claystone, light-bluish-gray to medium-bluish-gray
47-48	Lignite, brownish-black
48-55	Siltstone, light-bluish-gray; sandy in lower part
55-75	Claystone, medium-bluish-gray; sandy in middle of interval; traces of impure coal between 60 and 75 ft
75-80	Sandstone, medium-gray to greenish-gray, very fine grained
80-84.5	Siltstone, greenish-gray
84.5-85.5	Lignite, black
85.5-92	Claystone, medium-gray to greenish-gray, silty
92-109	Sandstone, medium-gray to greenish-gray, very fine grained
109-116	Siltstone, light-greenish-gray to greenish-gray; traces of coal in lower part
116-117	Lignite, black
117-122	Siltstone, greenish-gray
122-135	Sandstone, light-greenish-gray, very fine grained, silty; hard calcareous concretions between 127 and 130 ft
135-142	Claystone, medium-gray to greenish-gray, silty
142-258	Sandstone and siltstone, medium-gray to light-greenish-gray and light-olive-gray; thin to thick alternating sequences of very fine grained sandstone and sandy siltstone; includes some dark-gray carbonaceous shale between 155 and 157 ft and 193 and 195 ft, and impure coal and carbonaceous shale between 230 and 233 ft; calcareous sandstone concretion at 254 ft
258-259	Lignite, brownish-gray to brownish-black, impure

Sample log--Continued

Depth (feet)	Lithic description
259-269.5	Siltstone, light-olive-gray to olive-gray
269.5-274	Lignite, brownish-black to black, soft; grades to impure coal in middle to upper parts
274-277	Claystone, light-olive-gray
277-285	Sandstone, light-greenish-gray, silty
285-289	Claystone, olive-gray, silty in lower part
289-297	Sandstone, light-olive-gray, silty
297-308	Claystone and siltstone, light-olive-gray; thinly interbedded; includes hard calcareous concretion at 302 ft
308-315	Sandstone, light-olive-gray, very fine grained
315-323	Claystone, light-olive-gray to olive-gray, silty
323-351	Sandstone and siltstone, medium-light-gray; thinly interbedded; grades to silty claystone between 336 and 342 ft
351-355	Lignite, brownish-black to black; grades to carbonaceous shale and impure coal between 352 and 353.5 ft
355-376	Siltstone and silty claystone, medium-gray to light-olive-gray
376-378	Lignite, black
378-385	Claystone and siltstone, medium-gray
385-392	Sandstone, medium-gray, silty
392-400	Claystone, medium-gray, silty
	Total depth 400 ft

Hole no: GS-50    Date: 10-11-80    State: Montana    County: Roosevelt  
Sec. NE SW 13    T. 29 N.    R. 53 E.    Elevation: 1997 ft    Total depth: 400 ft  
Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 1,  
Range 100 cps    Resistance: uncalibrated    Caliper: Horizontal scale 2 in/in

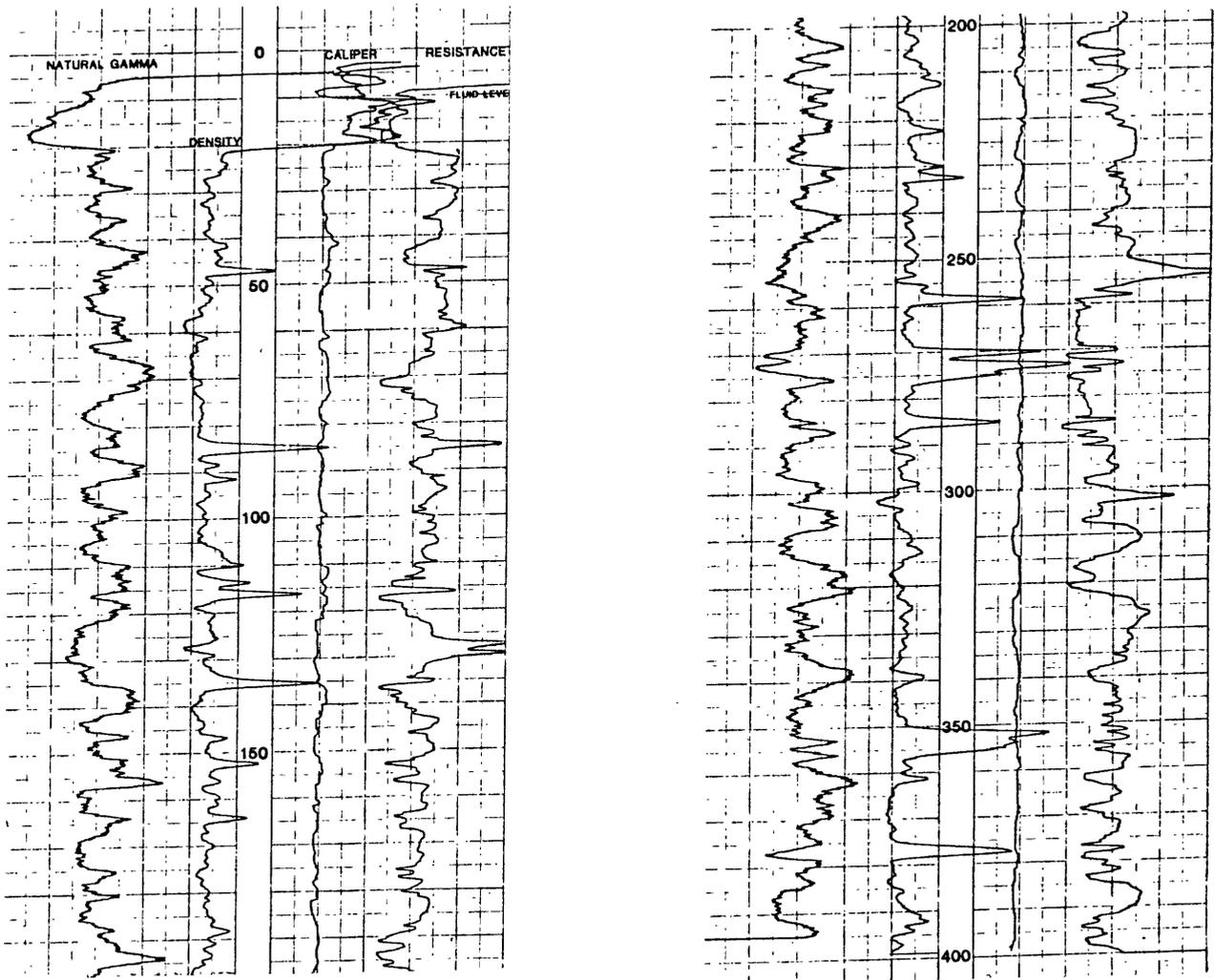


Figure 6.--Geophysical logs of hole GS-50

Sample log

Hole no.: GS-51 Date: 10-13-80 State: Montana County: Roosevelt  
 Elev. (ground): 2043 ft Location: T. 30 N., R. 53 E., Sec. SE SE 23  
 Total depth: 460 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-12	Sand and clay, light-brownish-gray, unconsolidated
12-57	Gravel and sand, light-brownish-gray to grayish-brown; contains rounded to subangular pebbles of quartz, quartzite, and granite as much as 2 inches in diameter
57-72	Siltstone and sandstone, light-brownish-gray to light-greenish-gray; hard calcareous concretion at 69 ft
72-120	Sandstone and siltstone, light-olive-gray; pyritic concretion at 78 ft; locally argillaceous
120-124	Claystone, dark-gray
124-125.5	Lignite, black
125.5-128	Carbonaceous shale and impure coal, dark-gray to black
128-129	Lignite, black
129-132	Claystone, light-greenish-gray
132-138	Sandstone and siltstone, light-greenish-gray to dark-gray
138-139.5	Lignite, black
139.5-152	Claystone and siltstone, medium-gray to light-olive-gray; grades to dark-gray carbonaceous shale at top and base; calcareous concretion at 143 ft
152-197	Siltstone and sandstone, medium-gray to light-olive-gray; thin to thick alternating sequences of very fine grained sandstone and siltstone; locally argillaceous
197-217	Claystone and siltstone, light-greenish-gray to light-olive-gray
217-235	Sandstone, medium-light-gray, very fine grained; silty in upper part; grades to carbonaceous siltstone at base
235-236	Lignite, black
236-261	Siltstone and sandstone, light-olive-gray; siltstone in upper part grading downward to silty sandstone in middle and lower parts
261-265	Lignite and carbonaceous shale; impure coal in upper part grades downward to carbonaceous shale in middle, and to relatively pure coal in lower part

Sample log--Continued

Depth (feet)	Lithic description
265-303	Siltstone and silty claystone, medium-gray to light-greenish-gray; sandy in upper part
303-307	Claystone, medium-gray
307-312	Siltstone, medium-gray
312-313	Lignite, black
313-315	Carbonaceous shale, grayish-black
315-326	Sandstone, light-greenish-gray, very fine grained, silty
326-335	Siltstone and silty claystone, medium-gray to greenish-gray; siltstone in upper part grading downward to silty claystone at base of interval
335-339	Sandstone, medium-gray, silty
339-340	Lignite, black
340-345	Claystone, medium-gray
345-355	Siltstone, medium-gray; sandy in upper part
355-363	Claystone, medium-gray; grades to siltstone at top and base
363-393	Sandstone, medium-light-gray, very fine grained
393-410	Claystone and siltstone, medium-gray to dark-greenish-gray; includes some dark-gray carbonaceous shale in upper part
410-425	Sandstone, greenish-gray to medium-light-gray, silty
425-433	Claystone, medium-dark-gray to dark-gray; grades to siltstone at top; carbonaceous at base
433-440	Lignite, brownish-black to black; probably impure in lower part
440-460	Claystone and siltstone, medium-gray to greenish-gray; slightly carbonaceous claystone at top grading downward to slightly sandy siltstone at base
	Total depth 460 ft

Hole no: GS-51    Date: 10-13-80    State: Montana    County: Roosevelt  
 Sec. SE SE 23    T. 30 N.    R. 53 E.    Elevation: 2043 ft    Total depth 460 ft  
 Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 2,  
 Range 105 cps    Resistance: uncalibrated    Caliper: Horizontal scale 2 in/in

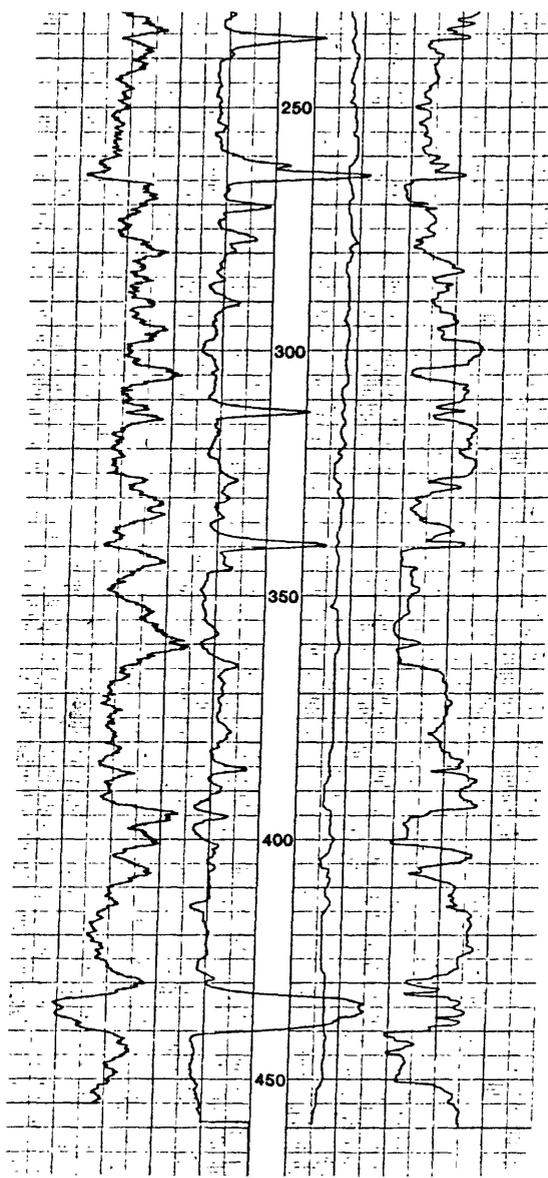
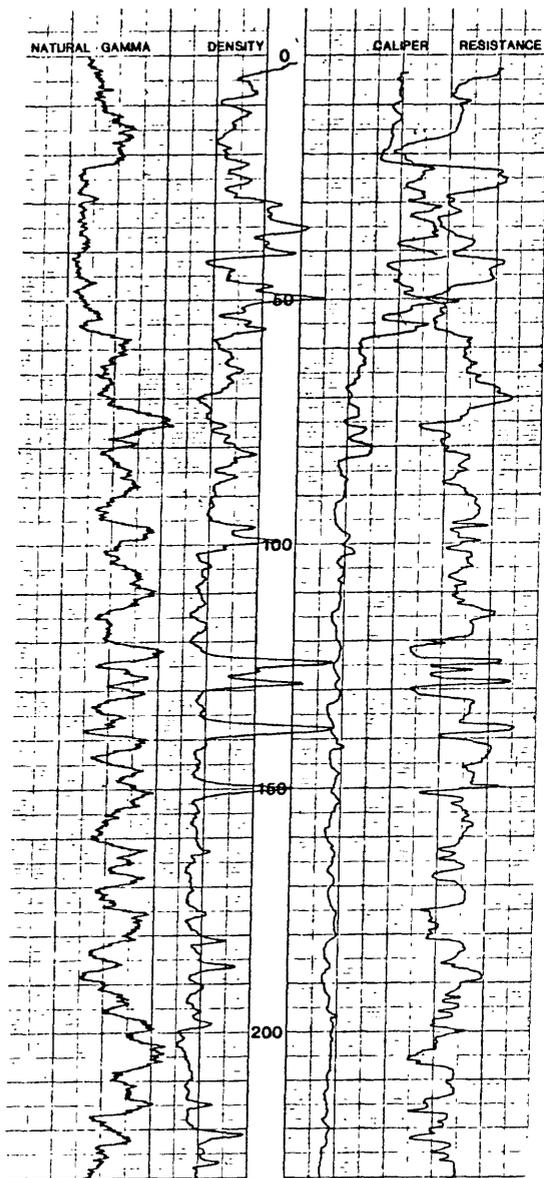


Figure 7.--Geophysical logs of hole GS-51

Sample log

Hole no.: GS-52 Date: 10-11-80 State: Montana County: Roosevelt  
 Elev. (ground): 2102 ft Location: T. 30 N., R. 53 E., Sec. NW NW 28  
 Total depth: 480 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-16	Sand, silt, and clay, light-brownish-gray to light-yellowish-brown, unconsolidated; includes scattered granules and small rounded pebbles of quartz, quartzite, and granite
16-18	Sandstone, light-yellowish-brown, silty
18-26	Claystone, light-greenish-gray
26-38	Sandstone, light-yellowish-brown, silty; argillaceous between 28 and 32 ft
38-46	Claystone, light-to medium-gray, silty
46-47	Lignite, black
47-74	Siltstone and silty claystone, medium-bluish-gray to dark-bluish-gray; siltstone predominates in upper and lower parts, claystone dominates in middle part
74-75	Lignite, black
75-88	Claystone and siltstone, medium-gray
88-130	Siltstone and silty sandstone, medium-light-gray to light-bluish-gray; locally argillaceous
130-145	Claystone, medium-gray to light-bluish-gray; grades to siltstone and very silty claystone in lower part
145-192	Sandstone, light-gray, very fine grained, silty; traces of coal and carbonaceous shale between 170 and 177 ft
192-194	Lignite, brownish-black to black; probably impure in lower part
194-197	Claystone, dark-gray, carbonaceous
197-219	Siltstone, medium-gray to light-greenish-gray, locally sandy
219-221	Lignite, brownish-black to black; probably impure in lower part
221-238	Claystone and siltstone, medium-gray to medium-dark-gray
238-250	Sandstone, medium-gray, very fine grained; grades to siltstone in lower part
250-253	Claystone, dark-gray, carbonaceous

Sample log--Continued

Depth (feet)	Lithic description
253-254.5	Lignite, brownish-black
254.5-258	Claystone, medium-gray to light-olive-gray
258-279	Sandstone, medium-light-gray, very fine grained; hard calcareous concretion at 276 ft
279-285	Claystone, medium-gray
285-287	Lignite, black
287-300	Claystone and siltstone, medium-gray to dark-gray; trace of coal in lower part
300-310	Siltstone, medium-dark-gray; includes some thinly interbedded silty claystone
310-311	Lignite, brownish-black
311-359.5	Siltstone and claystone, light-gray to medium-gray; sandy in upper part
359.5-361	Lignite, black
361-370	Claystone and siltstone, medium-dark-gray to dark-gray
370-378	Claystone, dark-gray, carbonaceous
378-380.5	Lignite, black
380.5-393	Claystone and siltstone, light-greenish-gray; claystone at top and base grading to siltstone in middle of interval
393-397.5	Lignite, brownish-black to black, hard
397.5-400	Claystone, dark-gray, carbonaceous
400-433.5	Siltstone, medium-gray to medium-dark-gray; includes some scattered thinly interbedded claystone
433.5-435.5	Lignite, brownish-black, impure
435.5-444	Claystone, medium-dark-gray
444-464	Siltstone, light-gray to medium-dark-gray; sandy in lower part; includes impure coal between 462 and 463 ft
464-468	Sandstone, light-gray, very fine grained

Sample log--Continued

Depth (feet)	Lithic description
468-472	Claystone, dark-gray, carbonaceous
472-480	Sandstone, medium-dark-gray, very fine grained; hard calcareous concretion at 475 ft
	Total depth 480 ft

Hole no: GS-52    Date: 10-11-80    State: Montana    County: Roosevelt  
 Sec. NW NW 28    T. 30 N.    R. 53 E.    Elevation: 2102 ft    Total depth 480 ft  
 Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 2,  
 Range 100 cps    Resistance: uncalibrated    Caliper: Horizontal scale 2 in/in

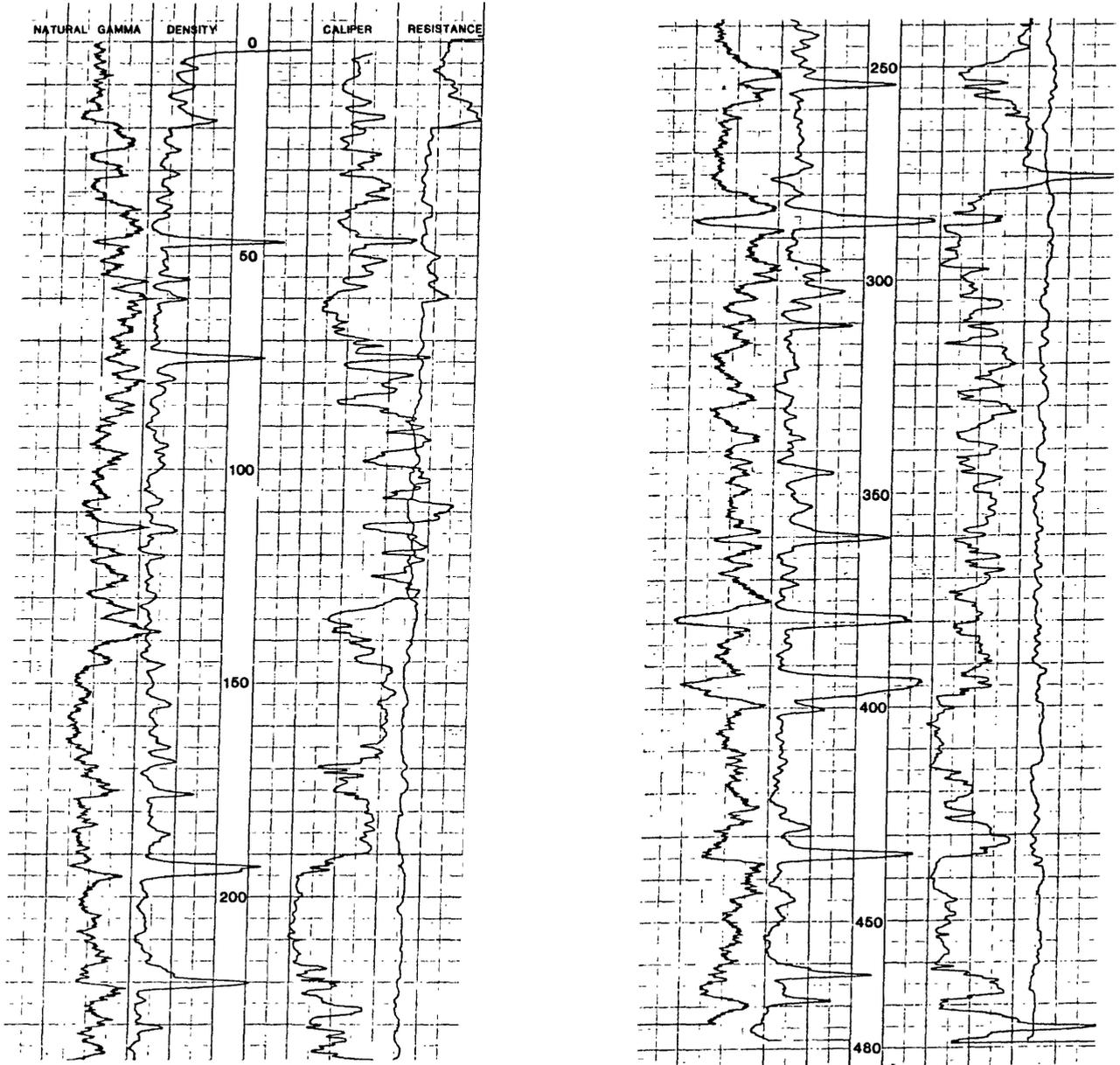


Figure 8.--Geophysical logs of hole GS-52

Sample log

Hole no.: GS-53      Date: 10-4-80      State: Montana      County: Roosevelt  
 Elev. (ground): 2272 ft      Location: T. 30 N., R. 52 E., Sec. SE SW 15  
 Total depth: 240 ft      Drilling medium: mud      Offset core hole: none

Depth (feet)	Lithic description
0-20	Sand, silt, and clay, dark-yellowish-brown, unconsolidated
20-31	Sand and gravel, dark-yellowish-brown to yellowish-gray; subangular to subrounded pebbles of quartz, quartzite, and granite as much as 1 inch in diameter
31-40	Siltstone, pale-yellowish-brown
40-49	Claystone, poor sample return
49-50	Lignite, black
50-63	Claystone, dark-gray and carbonaceous in upper part, pale-yellowish-brown in lower part
63-127	Sandstone and siltstone, very poor sample return; probably light-greenish-gray; hard calcareous concretion from 86 to 88 ft
127-129.5	Lignite, black
129.5-135	Claystone, medium-dark to light-brownish-gray
135-138.5	Lignite, brownish-black to black; grades impure in middle part
138.5-154	Claystone and siltstone, medium-dark-gray to dark-gray
154-155	Lignite, brownish-black, impure
155-165.5	Sandstone and siltstone, medium-dark-gray; siltstone predominates in lower part
165.5-166.5	Lignite, brownish-black, impure
166.5-180	Siltstone, medium-dark-gray; sandy in upper part
180-218	Sandstone, medium-gray, very fine grained, silty; includes scattered thinly interbedded siltstone; hard calcareous sandstone concretions at 195 and 214 ft
218-220	Lignite, black
220-240	Claystone and siltstone, medium-dark-gray
Total depth 240 ft	

Hole no: GS-53    Date: 10-4-80    State: Montana    County: Roosevelt  
Sec. SE SW 15    T. 30 N.    R. 52 E.    Elevation: 2272 ft    Total depth 240 ft  
Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 2,  
Range 105 cps    Resistance: uncalibrated    Caliper: no caliper log run

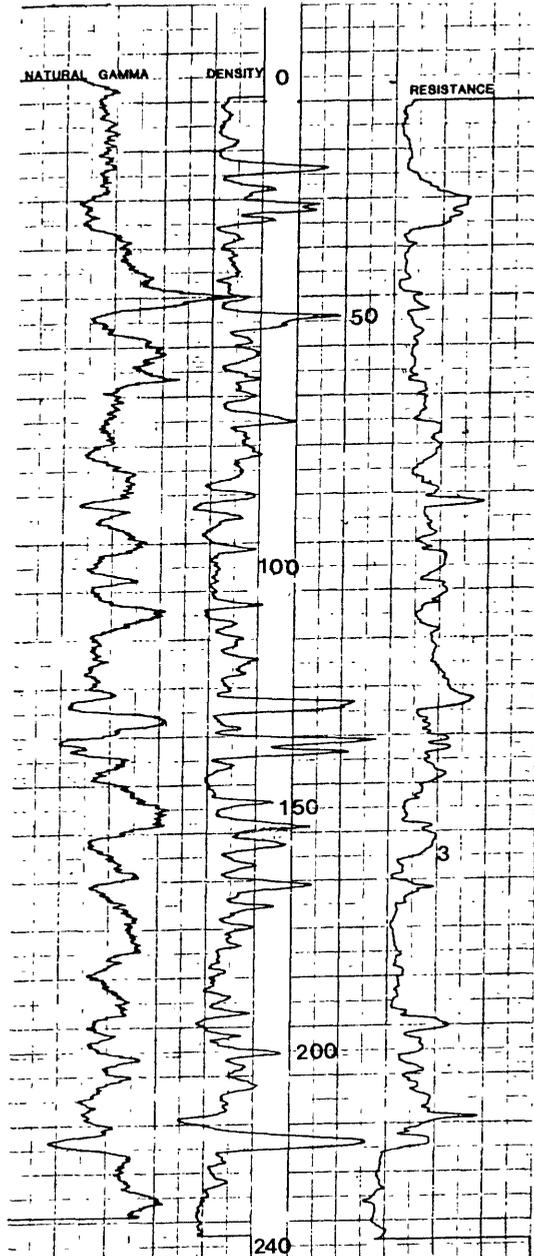


Figure 9.--Geophysical logs of hole GS-53

Sample log

Hole no.: GS-54 Date: 10-9-80 State: Montana County: Roosevelt

Elev. (ground): 2230 ft Location: T. 30 N., R. 51 E., Sec. NW SW 24

Total depth: 530 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-35	Sand, silt, and clay, pale-yellowish-brown to light-olive-gray, unconsolidated; includes scattered granules and small pebbles of quartz, quartzite, granite, and dolomite; sparse angular white dolomite pebbles as much as 3/4 inch in diameter; sparse detrital coal in upper 5 ft
35-45	Gravel, chiefly subangular to rounded pebbles and granules of quartz, some iron-stained, with abundant pebbles of granite, gneiss, quartzite, sandstone, and dolomite; pebbles as much as 1 inch in diameter but most are less than 0.5 inch
45-50	Sand and silt, yellowish-gray, unconsolidated
50-115	Siltstone and silty claystone, pale-yellowish-brown to yellowish-gray and very pale orange; thinly interbedded; very finely micaceous; sparse to locally abundant coarse grains and granules of quartz and feldspar; includes some scattered thin beds of very fine grained sandstone
115-140	Siltstone and silty claystone, yellowish-gray, finely micaceous
140-146	Sandstone, pale-yellowish-brown, very fine grained, silty
146-160	Claystone and siltstone, pale-yellowish-brown to yellowish-gray
160-170	Siltstone and claystone, light-brownish-gray to light-olive-gray, very finely micaceous; geophysical logs indicate thin impure coal at top of interval
170-171.2	Lignite, grayish-black
171.2-175	Claystone, light-gray to light-brownish-gray
175-190	Sandstone, light-gray, very fine grained, silty, very finely micaceous; includes some thinly interbedded siltstone and silty claystone
190-205	Claystone, brownish-gray, very finely micaceous; includes thin bed of light-greenish-gray very fine grained sandstone at 195 ft and thin impure coal at 199 ft
205-225	Siltstone, light-gray to medium-light-gray, very finely micaceous; includes some thinly interbedded light-brownish-gray to brownish-black carbonaceous shale

Sample log--Continued

Depth (feet)	Lithic description
225-261	Claystone and siltstone, light-gray to light-brownish-gray, very finely micaceous; includes scattered thin beds of light-gray very fine grained sandstone; hard calcareous sandstone concretion at 242 ft; grades to carbonaceous shale at base
261-262.5	Lignite, grayish-black to black
262.5-283	Siltstone and silty claystone, light-gray to light-olive-gray
283-313	Siltstone and silty sandstone, light-gray to light-olive-gray
313-319	Claystone and carbonaceous shale, light-brownish-gray to brownish-gray
319-365	Sandstone, light-gray to light-olive-gray, very fine grained, silty, finely micaceous; sparse flattened granules of light-greenish-gray claystone and rounded granules of quartz in lower 10 ft; includes scattered thin beds of light-olive-gray siltstone and silty claystone in upper part
365-385	Sandstone, very pale orange to very light gray, very fine grained, silty, finely micaceous, abundant dark opaque grains
385-412	Sandstone, yellowish-gray to light-olive-gray, very fine grained, silty, finely micaceous; scattered angular to rounded, medium to coarse quartz, feldspar, and dark opaque grains; scattered traces of carbonaceous shale and coal in cuttings throughout this interval
412-418	Claystone, light-brownish-gray to pale-yellowish-brown, silty
418-445	Sandstone, very light gray to light-gray and greenish-gray, very fine grained, silty, micaceous, abundant greenish-gray and dark opaque grains; includes some thinly interbedded siltstone and silty claystone
445-455	Siltstone and silty claystone, light-gray; scattered rounded, very coarse grains of slightly iron-stained quartz and 1/4 inch long angular fragment of pyritic sandstone noted in lower part of interval
455-496	Siltstone and silty claystone, light-olive-gray
496-530	Claystone, light-olive-gray to pale-yellowish-brown, silty; includes some scattered thinly interbedded siltstone
Total depth 530 ft	

Hole no: GS-54    Date: 10-9-80    State: Montana    County: Roosevelt  
Sec. NW NW 24    T. 30 N.    R. 51 E.    Elevation: 2230 ft    Total depth 530 ft  
Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 1,  
Range 100 cps    Resistance: uncalibrated    Caliper: no caliper log run

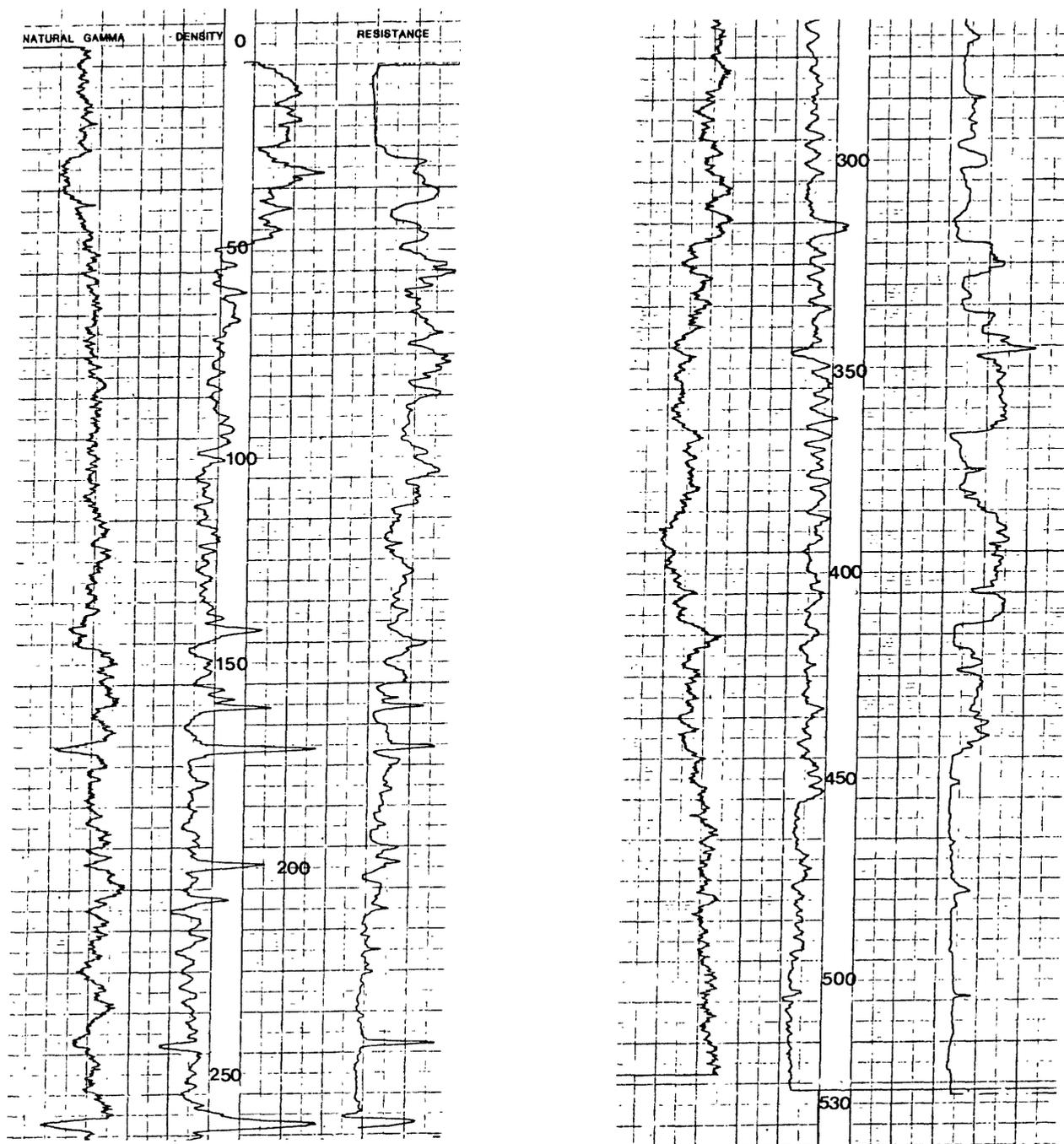


Figure 10.--Geophysical logs of hole GS-54

Sample log

Hole no.: GS-55 Date: 10-6-80 State: Montana County: Roosevelt  
 Elev. (ground): 2265 ft Location: T. 30 N., R. 51 E., Sec. NW SW 3  
 Total depth: 460 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-32	Silt and sand, light-olive-gray, unconsolidated
32-48	Silt, sand, and gravel, yellowish-gray, unconsolidated
48-66	Siltstone, yellowish-gray, sandy; grading to claystone near base
66-70	Lignite, black
70-83	Siltstone, light-gray to very light gray; probable coal 76 to 77 ft
83-89	Lignite, black
89-114	Siltstone, light-gray to very light gray; traces of carbonaceous claystone; coal bed 102 to 103 ft
114-116	Concretion, poor sample return
116-153	Siltstone, olive-gray; claystone parting 125 to 130 ft
153-161	Sandstone concretion; medium-light-gray, calcareous
161-210	Sandstone, light-gray, very fine grained, well sorted, angular, argillaceous; claystone parting 200 to 205 ft
210-250	Siltstone, medium-light-gray; grades to claystone at base
250-251.5	Lignite, grayish-black
251.5-265	Siltstone, medium-light-gray; grading sandy toward base; thin calcareous concretion at base
265-311	Siltstone, medium-gray to medium-dark-gray, sandy; with interbedded claystone
311-314	Lignite, black
314-356	Siltstone, greenish-gray
356-358	Concretion, poor sample return
358-367	Sandstone, medium-light-gray, very fine grained, argillaceous
367-400	Claystone, medium-light-gray
400-460	Sandstone, medium-light-gray, very fine grained
	Total depth 460 ft

Hole no: GS-55    Date: 10-6-80    State: Montana    County: Roosevelt  
Sec. NW SW 3    T. 30 N.    R. 51 E.    Elevation: 2265 ft    Total depth 460 ft  
Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 2,  
Range 105 cps    Resistance: uncalibrated    Caliper: no caliper log run

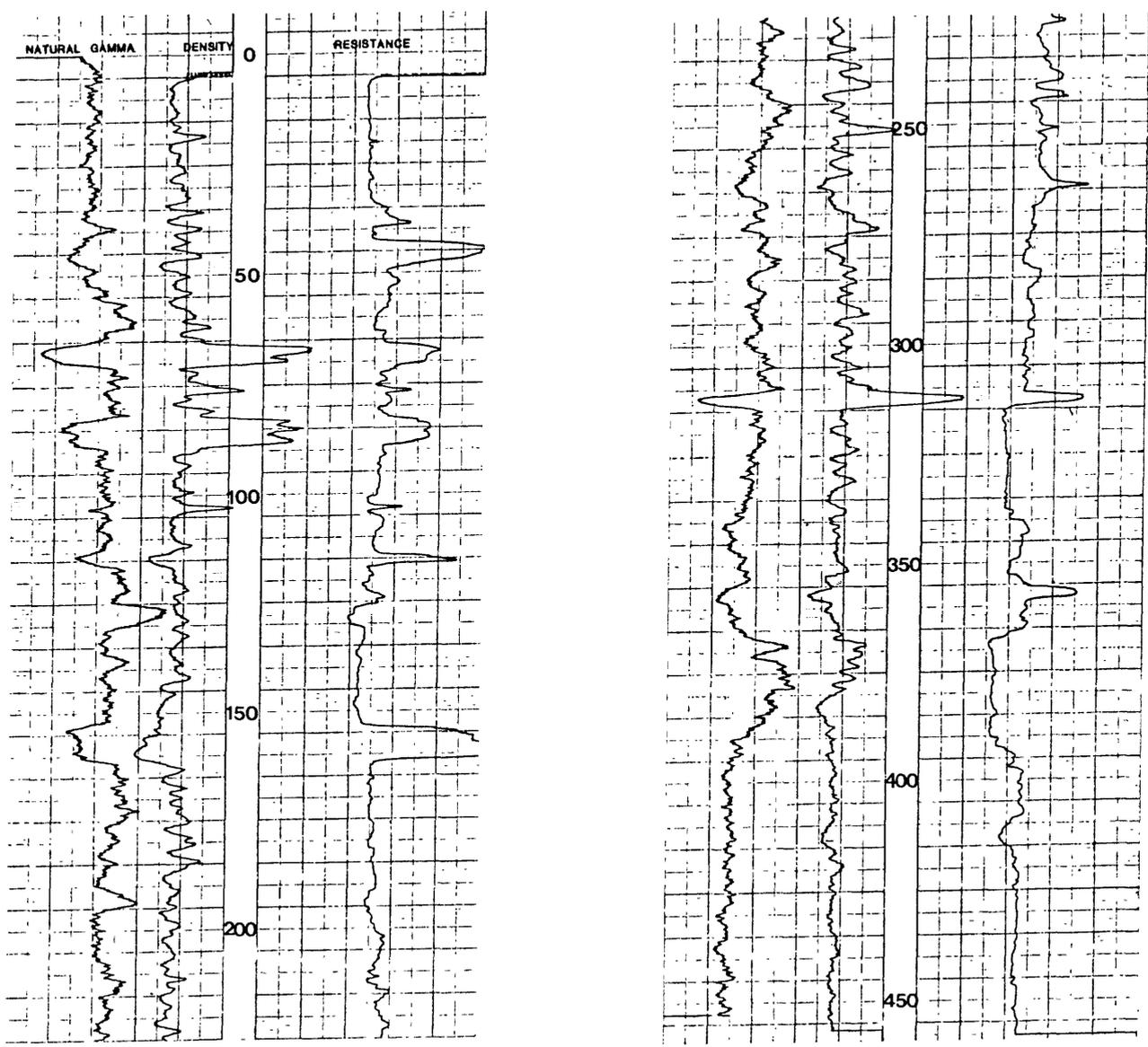


Figure 11.--Geophysical logs of hole GS-55

Sample log

Hole no.: GS-56 Date: 10-7-80 State: Montana County: Roosevelt  
 Elev. (ground): 2485 ft Location: T. 31 N., R. 51 E., Sec. SW SW 25  
 Total depth: 540 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-45	Silt, sand, and gravel, light-olive-gray, unconsolidated
45-90	Sandstone, grayish-orange to medium-light-gray, very fine grained
90-116	Sandstone, very light gray, very fine grained; with thin interbedded claystone
116-145	Siltstone, medium-light-gray; traces of organic debris
145-169	Siltstone, light-gray; claystone parting 158 to 163 ft
169-187	Claystone, light-gray
187-201	Sandstone, very light gray, very fine grained; interbedded with claystone at base
201-205	Lignite, black
205-228	Siltstone, light-gray; probable coal 222 to 224 ft
228-231	Lignite, black
231-266	Siltstone, light-gray to very light gray, sandy
266-284	Sandstone, light-gray, very fine grained
284-301	Claystone, light-gray to very light gray; silty 294 to 297 ft; probable coal 289 to 290 ft
301-303	Lignite, black
303-320	Siltstone, medium-gray to medium-light-gray; claystone parting at base; coal 317 to 318 ft
320-330	Siltstone, light-gray; grading sandy near base
330-333	Lignite, black
333-339	Claystone, medium-light-gray; silty at base
339-344	Lignite, black
344-350	Claystone, light-gray; coal 349 to 350 ft
350-367	Claystone, light-gray, silty
367-394	Siltstone, medium-light-gray; with interbedded claystone

Sample log--Continued

Depth (feet)	Lithic description
394-397	Lignite, black
397-416	Claystone, light-gray
416-419	Lignite, black
419-440	Siltstone, light-gray to medium-light-gray; coal bed 434 to 435 ft
440-446	Lignite, black
446-480	Sandstone, light-gray, very fine grained
480-492	Claystone, medium-gray
492-497	Lignite, black
497-500	Claystone, medium-gray
500-503	Lignite, black
503-540	Claystone, light-olive-brown to light-gray, silty
	Total depth 540 ft

Hole no: GS-56      Date: 10-7-80      State: Montana      County: Roosevelt  
 Sec. SW SW 25      T. 31 N.      R. 51 E.      Elevation: 2485 ft      Total depth 540 ft  
 Logging speed: 15 ft/min      Natural gamma: TC 2 , Range 25 cps      Density: TC 1 ,  
 Range 105 cps      Resistance: uncalibrated      Caliper: no caliper log run

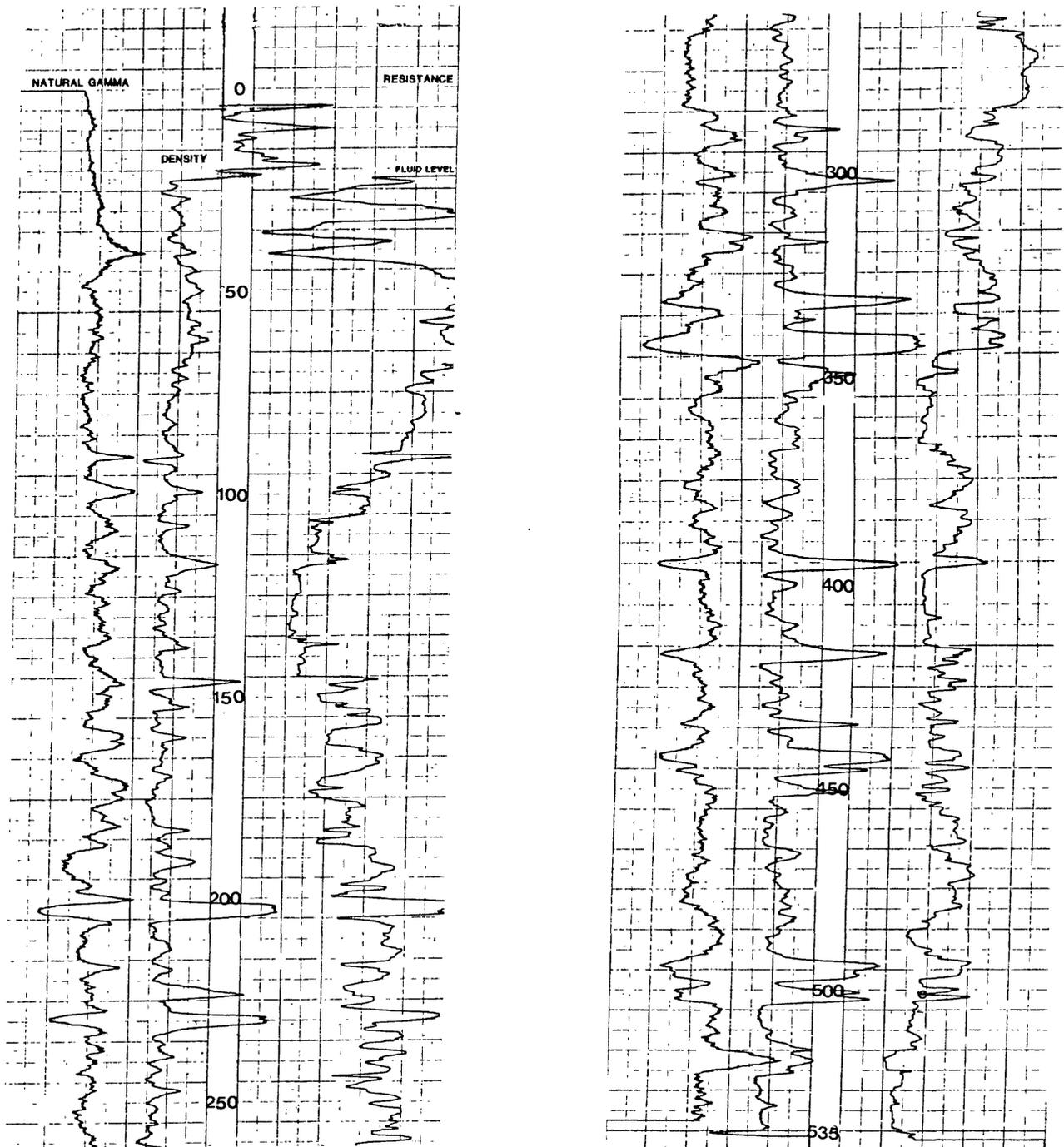


Figure 12.--Geophysical logs of hole GS-56

Sample log

Hole no.: GS-57 Date: 10-8-80 State: Montana County: Roosevelt  
 Elev. (ground): 2490 ft Location: T. 31 N., R. 52 E., Sec. NW NW 33  
 Total depth: 500 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-25	Silt, sand, and gravel, greenish-gray, unconsolidated
25-42	Claystone, moderate-yellow, silty
42-74	Sandstone, pale-greenish-yellow, very fine grained, silty
74-103	Siltstone, medium-light-gray; traces of carbonaceous claystone
103-142	Sandstone, yellowish-gray, very fine grained
142-164	Siltstone, very light gray, slightly sandy; coal 155 to 156 ft
164-206	Siltstone, medium-gray to very light gray, sandy; with interbedded claystone; slightly pyritic
206-254	Siltstone, greenish-gray to light-gray; some coal fragments
254-267	Sandstone, light-gray, very fine grained, silty; traces of magnetite, pyrite, and biotite
267-273	Claystone, greenish-gray
273-316	Siltstone, light-gray,
316-322	Lignite, black
322-351	Siltstone, medium-gray to yellowish-gray; traces of organic debris; claystone partings 328 to 333 ft and 346 to 349 ft
351-403	Siltstone, medium-gray to very light gray; thin interbedded sandstone and claystone; slightly carbonaceous
403-405	Lignite, black
405-414	Siltstone, medium-light-gray
414-423	Claystone, medium-light-gray
423-434	Siltstone, light-gray to medium-light-gray
434-437	Lignite, black
437-453	Siltstone, medium-light-gray; coal 450 to 451 ft
453-459	Lignite, black

Sample log--Continued

Depth (feet)	Lithic description
459-465	Siltstone, light-gray to medium-light-gray
465-467	Lignite, black
467-500	Siltstone, light-gray to medium-light-gray, slightly sandy
	Total depth 500 ft

Hole no: GS-57    Date: 10-8-80    State: Montana    County: Roosevelt  
Sec. NW NW 33    T. 31 N.    R. 52 E.    Elevation: 2490 ft    Total depth 500 ft  
Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 1,  
Range 100 cps    Resistance: uncalibrated    Caliper: no caliper log run

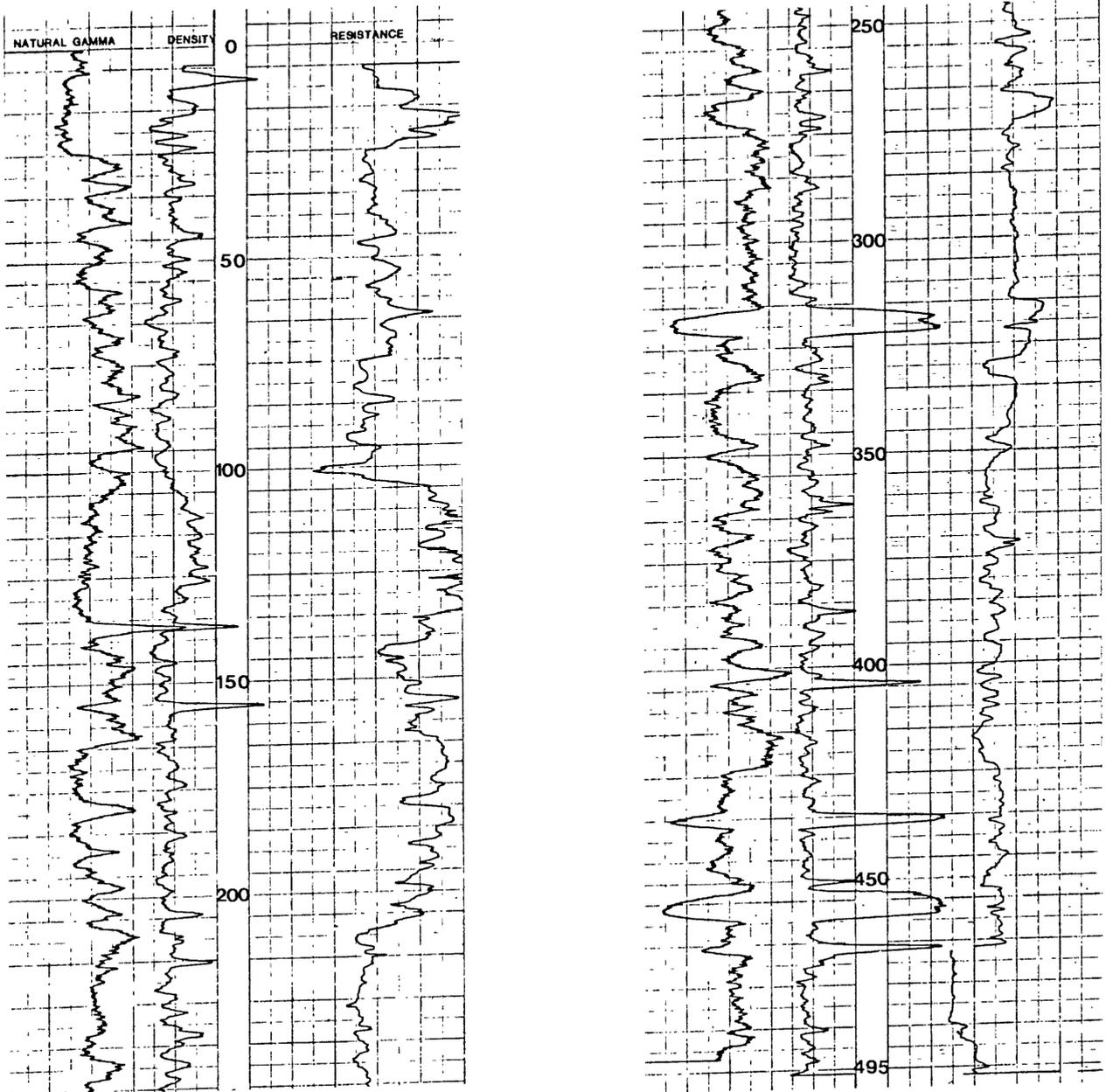


Figure 13.--Geophysical logs of hole GS-57

Sample log

Hole no.: GS-58 Date: 10-3-80 State: Montana County: Roosevelt  
 Elev. (ground): 2345 ft Location: T. 30 N., R. 52 E., Sec. SE SW 2  
 Total depth: 400 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-27	Silt, sand, and gravel, light-olive-gray, unconsolidated
27-46	Sandstone, yellowish-gray, very fine to medium-grained, poorly sorted; traces of magnetite, biotite, and copper(?)
46-77	Siltstone, yellowish-gray, sandy
77-91	Sandstone, yellowish-gray, fine-to very fine grained
91-101	Claystone, light-gray
101-131	Sandstone, very light gray, fine-to very fine grained
131-133	Lignite, black
133-183	Claystone, light-gray to dark-yellowish-orange
183-221	Siltstone, light-gray
221-222	Lignite, black
222-234	Claystone, very light gray
234-238	Lignite, black
238-249	Siltstone, medium-gray
249-270	Siltstone, light-gray
270-300	Claystone, medium-gray
300-317	Claystone, light-gray, silty; calcareous concretion 302 to 303 ft
317-335	Siltstone, light-gray, sandy
335-345	Claystone, medium-gray
345-347	Lignite, black
347-348	Claystone, medium-gray
348-352	Lignite, black
352-374	Siltstone, medium-light-gray
374-375	Lignite, black

Sample log--Continued

Depth (feet)	Lithic description
375-376	Claystone, light-gray to medium-light-gray
376-378	Lignite, black
378-388	Siltstone, medium-light-gray
388-400	Claystone, medium-light-gray; probable coal 391 to 392 ft
	Total depth 400 ft

Hole no: GS-58    Date: 10-3-80    State: Montana    County: Roosevelt  
 Sec. SE SW 2    T. 30 N.    R. 52 E.    Elevation: 2345 ft    Total depth: 400 ft  
 Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 2,  
 Range 105 cps    Resistance: uncalibrated    Caliper: log improperly run

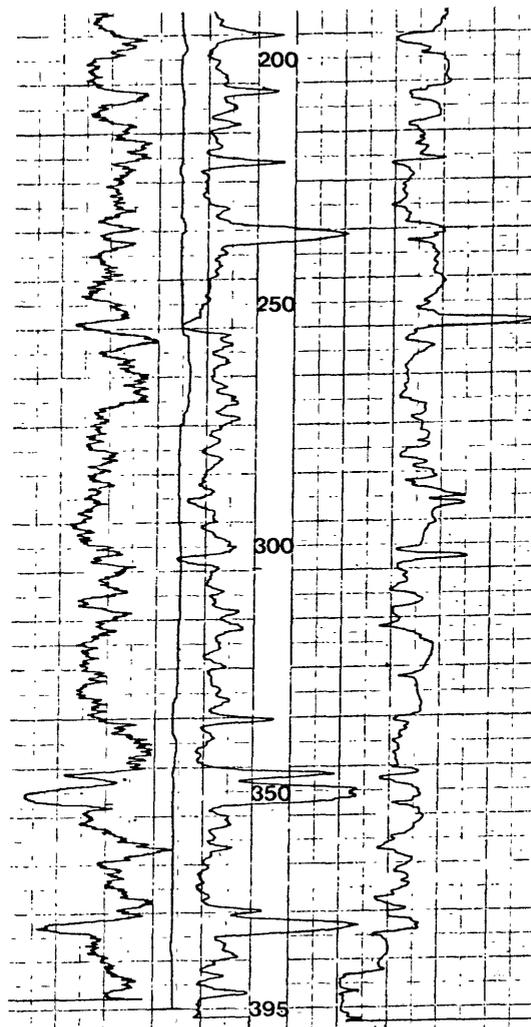
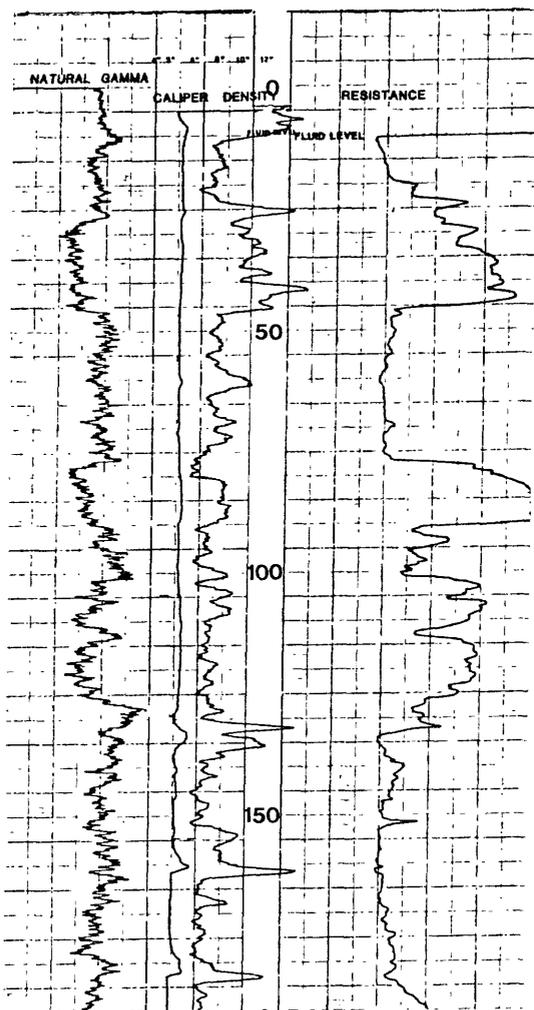


Figure 14.--Geophysical logs of hole GS-58

## Sample log

Hole no.: GS-59 Date: 10-14-80 State: Montana County: Roosevelt  
 Elev. (ground): 2115 ft Location: T. 31 N., R. 53 E., Sec. NE SE 34  
 Total depth: 420 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-40	Sand, silt, and clay, pale-yellowish-brown, unconsolidated
40-73	Sand and silt, light-olive-gray to greenish-gray
73-80	Claystone and siltstone, light-greenish-gray
80-105	Sandstone, light-greenish-gray, very fine grained, silty; includes abundant thinly interbedded siltstone
105-112	Lignite, brownish-black to black; impure in upper part
112-127	Siltstone, light-greenish-gray; includes scattered thinly interbedded claystone
127-142	Claystone, light-greenish-gray; includes thin impure coal at 133 ft
142-148	Sandstone, light-greenish-gray, very fine grained
148-152.5	Claystone, light-greenish-gray
152.5-155.5	Lignite, brownish-black to black; probably impure in lower part
155.5-163	Claystone, light-greenish-gray
163-182.5	Siltstone and claystone, light-greenish-gray; sandy in lower part
182.5-184	Lignite, brownish-black; probably impure
184-190	Siltstone, light-greenish-gray; grades to claystone at base
190-208	Claystone, light-greenish-gray to medium-gray; silty in lower part
208-209	Lignite, black
209-216	Claystone, medium-gray
216-259	Siltstone and sandstone, light-gray to medium-gray; siltstone predominates in upper part and very fine grained sandstone in lower part
259-274	Claystone, light-greenish-gray to brownish-gray; very silty in middle of interval
274-330	Siltstone, medium-gray to olive-gray, sandy; calcareous concretions at 287 and 299 ft; slightly carbonaceous between 295 and 305 ft

Sample log--Continued

Depth (feet)	Lithic description
330-420	Sandstone, medium-light-gray, very fine grained, silty; calcareous concretion at 332 ft
	Total depth 420 ft

Hole no: GS-59    Date: 10-14-80    State: Montana    County: Roosevelt  
Sec. NE SE 34    T. 31 N.    R. 53 E.    Elevation: 2115 ft    Total depth: 420 ft  
Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 1,  
Range 100 cps    Resistance: uncalibrated    Caliper: log improperly run

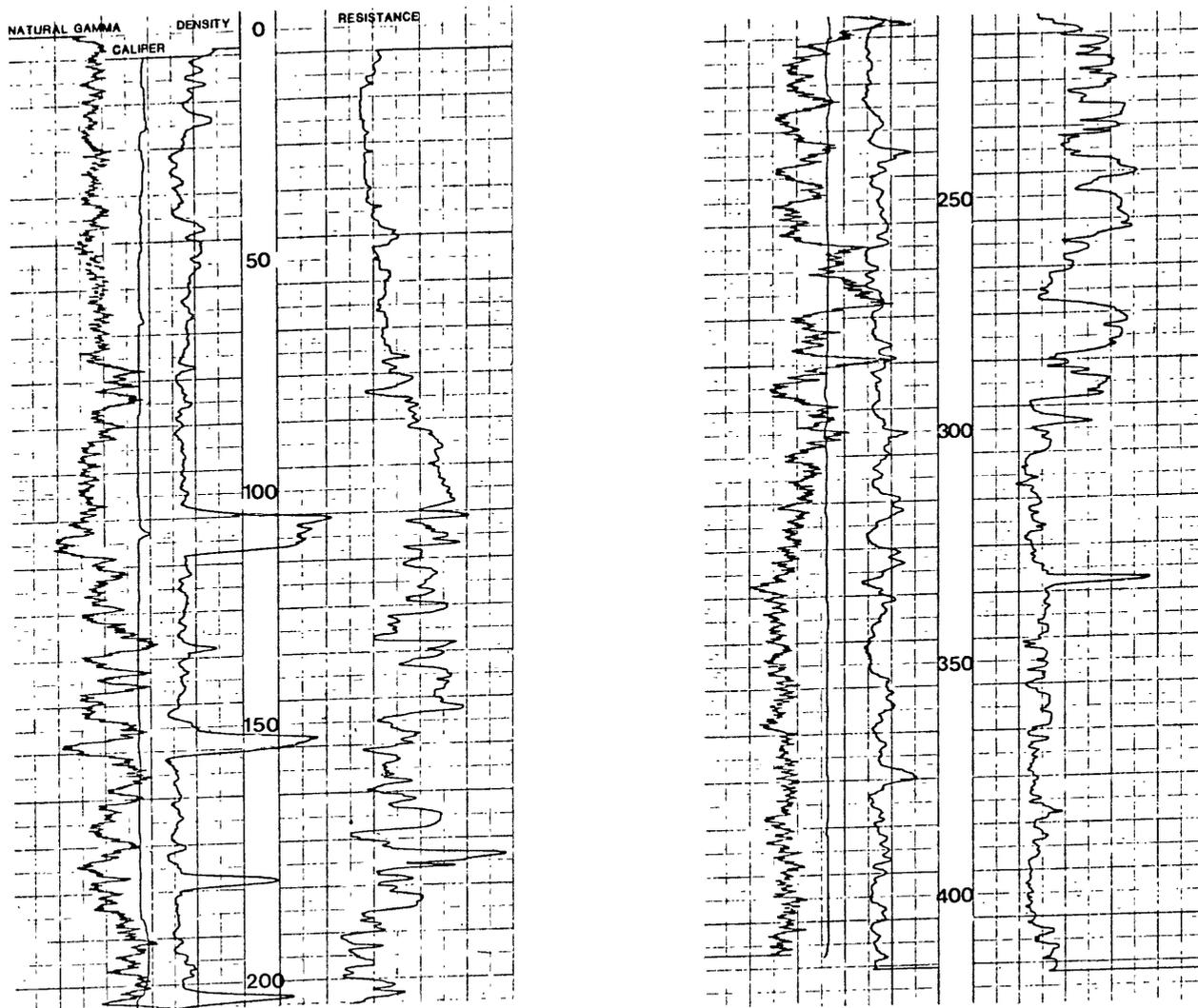


Figure 15.--Geophysical logs of hole GS-59

Sample log

Hole no.: GS-60 Date: 10-16-80 State: Montana County: Roosevelt  
 Elev. (ground): 2108 ft Location: T. 31 N., R. 54 E., Sec. SW NW 32  
 Total depth: 280 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-45	Gravel, sand, silt, and clay, dark-yellowish-brown to brown; scattered subrounded to subangular pebbles of quartz, quartzite, and granite as much as 1.25 inches in diameter
45-55	Siltstone, light-greenish-gray
55-58	Lignite, brownish-black to black; impure in middle to lower parts
58-67	Claystone, greenish-gray
67-74.5	Siltstone, greenish-gray; sandy in lower part
74.5-75.5	Lignite, black
75.5-92	Siltstone and sandstone, light-greenish-gray
92-97	Claystone, light-greenish-gray
97-126	Siltstone, light-greenish-gray; includes some thinly interbedded claystone in upper part
126-140	Sandstone, light-greenish-gray, very fine grained, silty
140-145	Claystone, light-greenish-gray, silty
145-152	Lignite, black
152-178	Siltstone and claystone, light-gray to light-greenish-gray; includes impure coal between 172 and 173 ft
178-181.5	Lignite, brownish-black to black
181.5-186	Claystone, light-greenish-gray
186-226	Siltstone, light-greenish-gray to greenish-gray, sandy; grades to claystone between 212 and 217 ft and at base
226-229.5	Lignite, brownish-black to black; impure in lower part
229.5-235	Claystone and siltstone, greenish-gray
235-236.5	Lignite, black
236.5-243	Claystone, light-greenish-gray
243-280	Siltstone, greenish-gray, sandy; some thinly interbedded claystone
	Total depth 280 ft

Hole no: GS-60    Date: 10-16-80    State: Montana    County: Roosevelt  
Sec. SW NW 32    T. 31 N.    R. 54 E.    Elevation: 2108 ft    Total depth 280 ft  
Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 1,  
Range 100 cps    Resistance: uncalibrated    Caliper: Horizontal scale 1 in/in

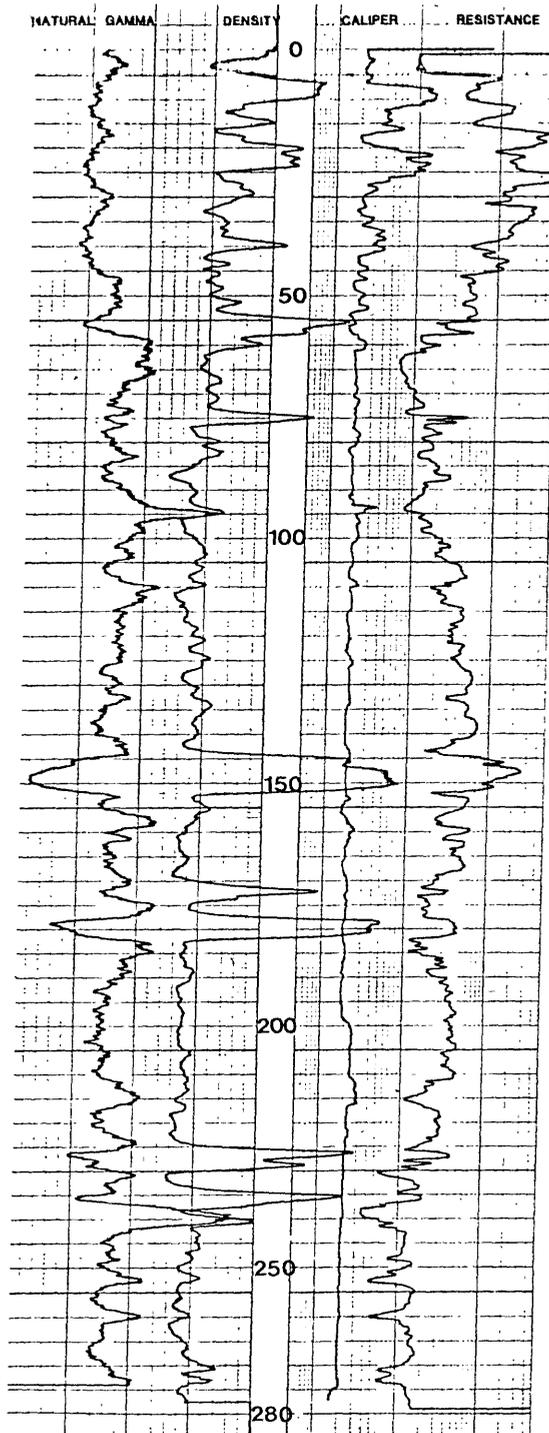


Figure 16.--Geophysical logs of hole GS-60

Sample log

Hole no.: GS-61      Date: 10-18-80      State: Montana      County: Roosevelt  
 Elv. (ground): 2082 ft      Location: T. 30 N., R. 54 E., Sec. NE NW 2  
 Total depth: 440 ft      Drilling medium: mud      Offset core hole: none

Depth (feet)	Lithic description
0-38	Gravel, sand, silt, and clay, dark-yellowish-brown to brown; scattered subrounded to subangular pebbles of quartz, quartzite, and granite as much as 1 inch in diameter
38-54	Sandstone, pale-yellowish-brown, very fine to medium-grained
54-58	Claystone, light-greenish-gray
58-61.5	Lignite, brownish-black to black
61.5-67.5	Claystone and siltstone, light-greenish-gray to medium-gray
67.5-69.5	Lignite, black
69.5-82	Siltstone and sandstone, light-greenish-gray; grades to silty claystone at top and base
82-87	Claystone, light-greenish-gray
87-90.5	Lignite, brownish-black to black; middle to upper parts impure
90.5-95	Claystone, dark-yellowish-brown; silty in upper part
95-110	Siltstone and claystone, light-greenish-gray; siltstone predominates in upper part, chiefly claystone in lower part
110-127	Sandstone, light-greenish-gray, very fine grained; grades to siltstone at base
127-133	Claystone, light-greenish-gray; thin impure coal at 128 ft
133-134.5	Lignite, black
134.5-144	Claystone, light-greenish-gray
144-156	Siltstone, light-greenish-gray to light-olive-gray
156-171	Sandstone, light-greenish-gray; grades to siltstone in lower part
171-174	Sandstone, calcareous concretion, light-gray, hard
174-193	Claystone, light-greenish-gray, silty in lower part
193-203	Sandstone, light-greenish-gray, silty
203-245	Siltstone, light-bluish-gray to light-greenish-gray; includes some thinly interbedded claystone in upper part; sandy at base

Sample log--Continued

Depth (feet)	Lithic description
245-264	Sandstone, light-greenish-gray, silty
264-269	Claystone, light-greenish-gray
269-292	Siltstone, light-greenish-gray; includes coal between 282 and 283 ft; grades to silty claystone at base
292-295	Lignite, black
295-300	Claystone, light-greenish-gray
300-353	Siltstone and sandstone, light-greenish-gray; thinly interbedded silty sandstone and siltstone
353-357	Claystone, light-greenish-gray
357-363	Lignite, brownish-black to black; includes about 22 inches of carbonaceous shale and impure coal in middle of unit
363-372	Claystone and siltstone, light-greenish-gray; siltstone predominates in middle of unit
372-375.5	Lignite, brownish-black to black; grades to impure coal in middle of unit
375.5-380	Claystone, medium-dark-gray, carbonaceous
380-413	Siltstone and sandstone, medium-gray to light-greenish-gray; siltstone predominates in upper part and silty sandstone dominates in lower part
413-427	Claystone, light-greenish-gray; silty in upper part
427-440	Siltstone, light-greenish-gray
	Total depth 440 ft

Hole no: GS-61    Date: 10-18-80    State: Montana    County: Roosevelt  
Sec. NE NW 2    T. 30 N.    R. 54 E.    Elevation: 2082 ft    Total depth: 440 ft  
Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 1,  
Range 100 cps    Resistance: uncalibrated    Caliper: Horizontal scale 1 in/in

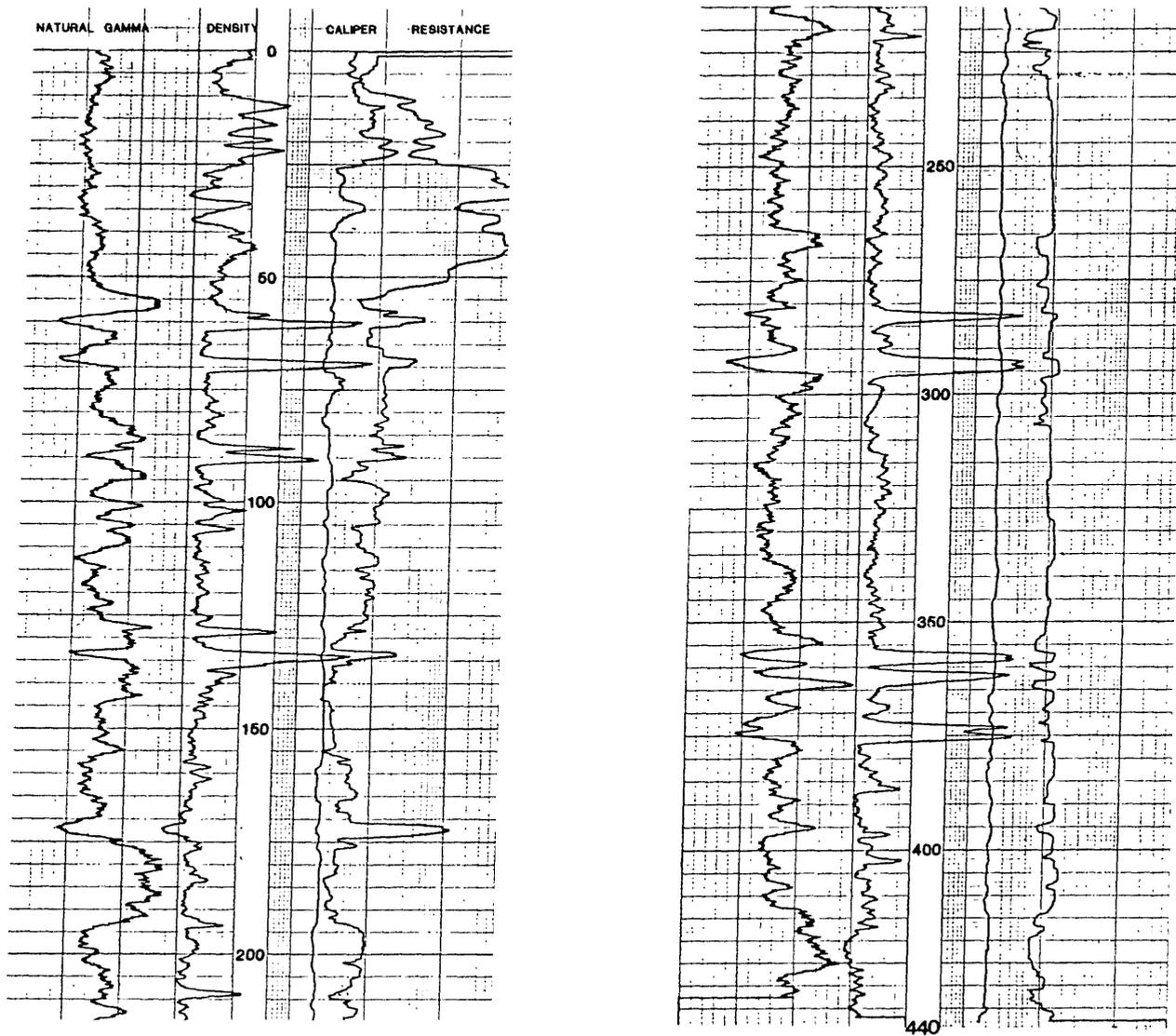


Figure 17.--Geophysical logs of hole GS-61

Sample log

Hole no.: GS-62 Date: 10-19-80 State: Montana County: Roosevelt

Elev. (ground): 2122 ft Location: T. 31 N., R. 54 E., Sec. SW SW 22

Total depth: 380 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-14	Sand, silt, and clay, pale-yellowish-brown to dark-yellowish-brown, unconsolidated
14-16	Claystone, light-brownish-gray
16-19	Carbonaceous shale and impure coal, dark-gray to brownish-black
19-20	Lignite, black
20-25	Siltstone and silty claystone, light-brown
25-48	Sandstone, light-brownish-gray, very fine grained; hard calcareous concretion at 35 ft
48-50.5	Lignite, brownish-black to black; impure in lower part
50.5-96	Sandstone, light-greenish-gray to light-bluish-gray, very fine grained, silty; calcareous concretions at 58 ft and at base of unit
96-105	Claystone, light-greenish-gray
105-106	Lignite, black
106-120	Siltstone, light-greenish-gray; grades to claystone at top and to silty sandstone at base
120-170	Sandstone, light-greenish-gray, very fine grained, abundant dark opaque grains
170-190	Siltstone, light-greenish-gray; grades to silty claystone at top; hard calcareous sandstone concretion between 178 and 180 ft
190-205	Claystone, light-greenish-gray, silty; trace of coal and carbonaceous shale between 200 and 205 ft
205-247	Siltstone, light-greenish-gray, sandy; includes some scattered thinly interbedded claystone; traces of impure coal and carbonaceous shale between 220 and 225 ft; thin coal at 234 ft
247-249	Lignite, black
249-281	Siltstone and claystone, light-greenish-gray; chiefly siltstone grading to silty claystone and claystone in upper part
281-282	Lignite, black
282-286	Claystone, light-olive-gray

Sample log--Continued

Depth (feet)	Lithic description
286-290.5	Lignite, brownish-black to black; probably impure in lower part
290.5-318	Siltstone and claystone, light-olive-gray to light-greenish-gray; chiefly siltstone with scattered thinly interbedded claystone; grades to claystone at top
318-327.5	Sandstone, light-brownish-gray, silty; grades to siltstone at base
327.5-331	Lignite, black
331-339.5	Claystone, light-olive-gray to dark-gray, carbonaceous; includes thin impure coal at 334 ft
339.5-340.5	Lignite, brownish-black to black
340.5-354	Siltstone, light-olive-gray
354-369	Claystone, light-greenish-gray; silty in upper part
369-380	Siltstone, light-greenish-gray
	Total depth 380 ft

Hole no: GS-62    Date: 10-19-80    State: Montana    County: Roosevelt  
Sec. SW SW 22    T. 31 N.    R. 54 E.    Elevation: 2122 ft    Total depth: 380 ft  
Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 1,  
Range 100 cps    Resistance: uncalibrated    Caliper: Horizontal scale 1 in/in

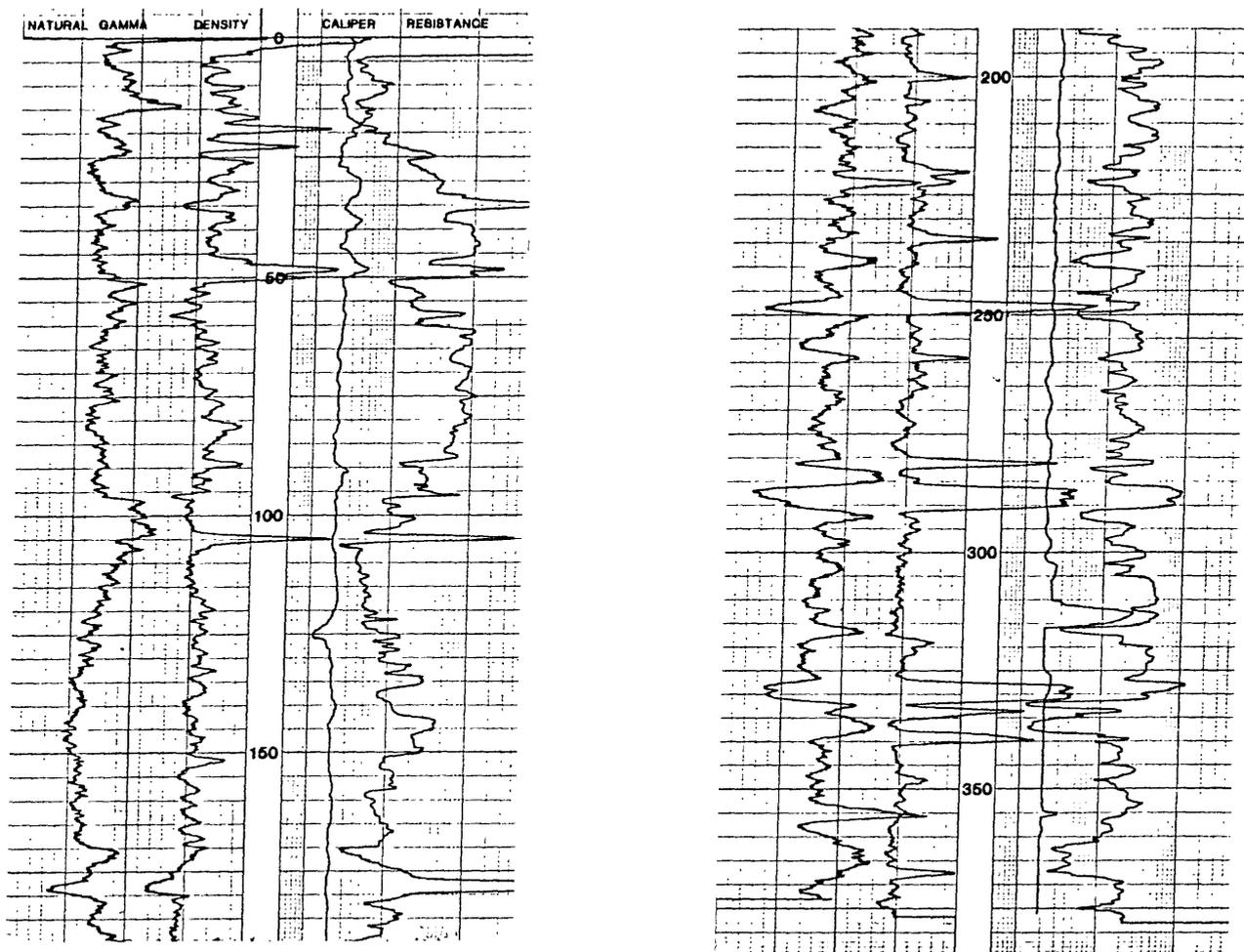


Figure 18.--Geophysical logs of hole GS-62

Sample log

Hole no.: GS-63    Date: 10-1-80    State: Montana    County: Roosevelt  
 Elev. (ground): 2342 ft    Location: T. 31 N., R. 53 E., Sec. NE SW 20  
 Total depth: 320 ft    Drilling medium: mud    Offset core hole: none

Depth (feet)	Lithic description
0-15	Sand, silt, and clay, dark-yellowish-brown, unconsolidated; sparsely scattered iron-stained pebbles
15-20	Gravel and sand, dark-yellowish-brown sand and very pale orange to dark-reddish-brown pebbles; about 60 percent gravel and 40 percent sand; unconsolidated
20-40	Sand, silt, and clay, dark-yellowish-brown, unconsolidated
40-53	Gravel and sand, chiefly dark-reddish-brown subrounded pebbles as much as 1 inch in diameter; unconsolidated
53-58	Lignite, brownish-black to grayish-black, oxidized
58-63	Siltstone, greenish-gray; includes thin impure coal at base
63-86	Sandstone and siltstone, greenish-gray; very fine grained sandstone
86-92	Lignite, brownish-black to black; includes about 1 ft of carbonaceous shale and impure coal in middle of unit
92-122	Siltstone, greenish-gray to dark-greenish-gray; sandy in lower part; includes thin coal at 117 ft; grades to claystone at top and base of unit
122-124	Lignite, brownish-black
124-174	Siltstone and sandstone, greenish-gray; very fine grained sandstone thinly interbedded with siltstone; thin coals at 142 and 171 ft
174-177	Lignite, brownish-black to black
177-189	Sandstone, greenish-gray, very fine grained, silty in upper part
189-190.5	Lignite, brownish-black
190.5-195	Claystone, dark-gray carbonaceous
195-225	Siltstone, light-greenish-gray; calcareous concretions from 216 to 218 ft
225-239	Sandstone, light-greenish-gray, silty
239-245	Lignite, brownish-black to black

Sample log--Continued

Depth (feet)	Lithic description
245-260	Sandstone, light-gray to greenish-gray, very fine grained; calcareous concretion between 253 and 255 ft
260-280	Siltstone and claystone, greenish-gray; sandy siltstone thinly interbedded with silty claystone
280-283.5	Lignite, brownish-black to black; grades impure in lower part
283.5-287	Claystone, dark-greenish-gray
287-320	Siltstone, light-greenish-gray
	Total depth 320 ft

Hole no: GS-63    Date: 10-1-80    State: Montana    County: Roosevelt  
Sec. NE SW 20    T. 31 N.    R. 53 E.    Elevation: 2342 ft    Total depth 320 ft  
Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 2,  
Range 105 cps    Resistance: uncalibrated    Caliper: log improperly run

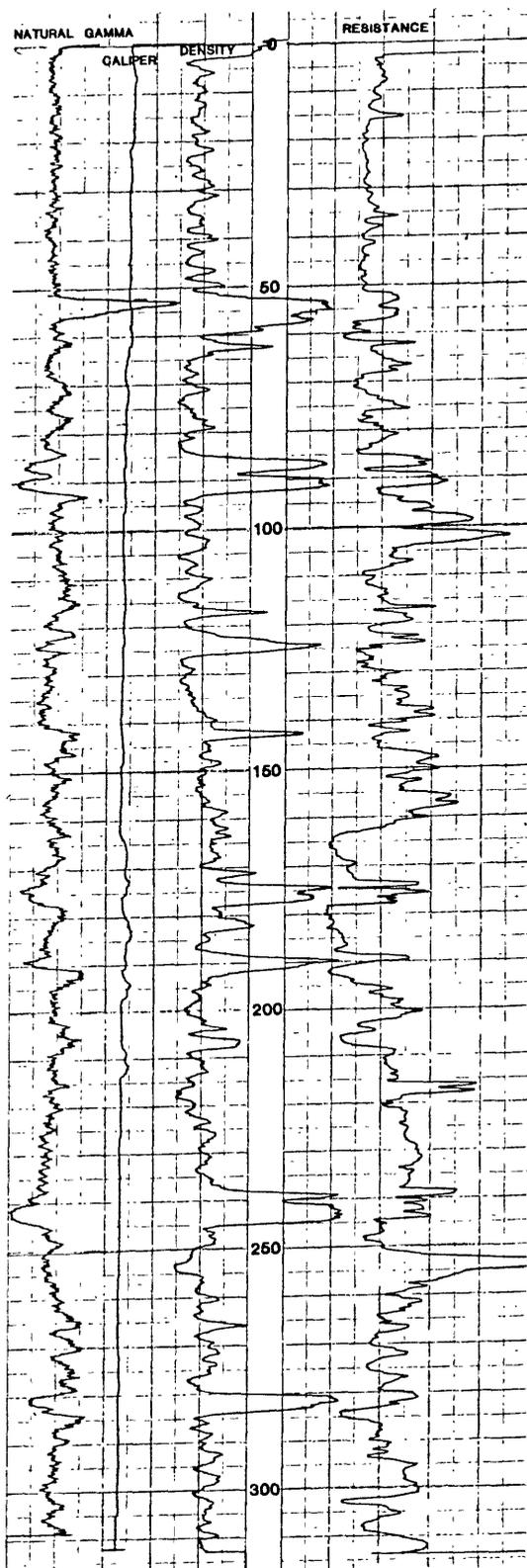


Figure 19.--Geophysical logs of hole GS-63

Sample log

Hole no.: GS-64    Date: 9-30-80    State: Montana    County: Roosevelt  
 Elev. (ground): 2375 ft    Location: T. 31 N., R. 52 E., Sec. SE SE 11  
 Total depth: 282 ft    Drilling medium: mud    Offset core hole: none

Depth (feet)	Lithic description
0-61	Silt, sand, and gravel, yellowish-gray to light-olive-gray, unconsolidated
61-68	Siltstone, light-gray
68-70	Lignite, black
70-94	Siltstone, light-gray
94-149	Siltstone, light-gray, very sandy; probable coal 130 to 131 ft
149-160	Sandstone, very light gray to light-gray, very fine grained
160-185	Siltstone, very light gray to bluish-white, slightly sandy; argillaceous at top and base
185-205	Claystone, bluish-white
205-212	Lignite, black
212-234	Siltstone, light-gray, slightly sandy
234-239	Lignite, black
239-251	Claystone, light-gray
251-269	Sandstone, light-gray to very light gray, very fine grained
269-282	Siltstone, white to very light gray
	Total depth 282 ft

Hole no: GS-64    Date: 9-30-80    State: Montana    County: Roosevelt  
 Sec. SE SE 11    T. 31 N.    R. 52 E.    Elevation: 2375 ft    Total depth 282 ft  
 Logging speed: 15 ft/min    Natural gamma: TC 2 , Range 25 cps    Density: TC 2 ,  
 Range 105 cps    Resistance: uncalibrated    Caliper: log improperly run

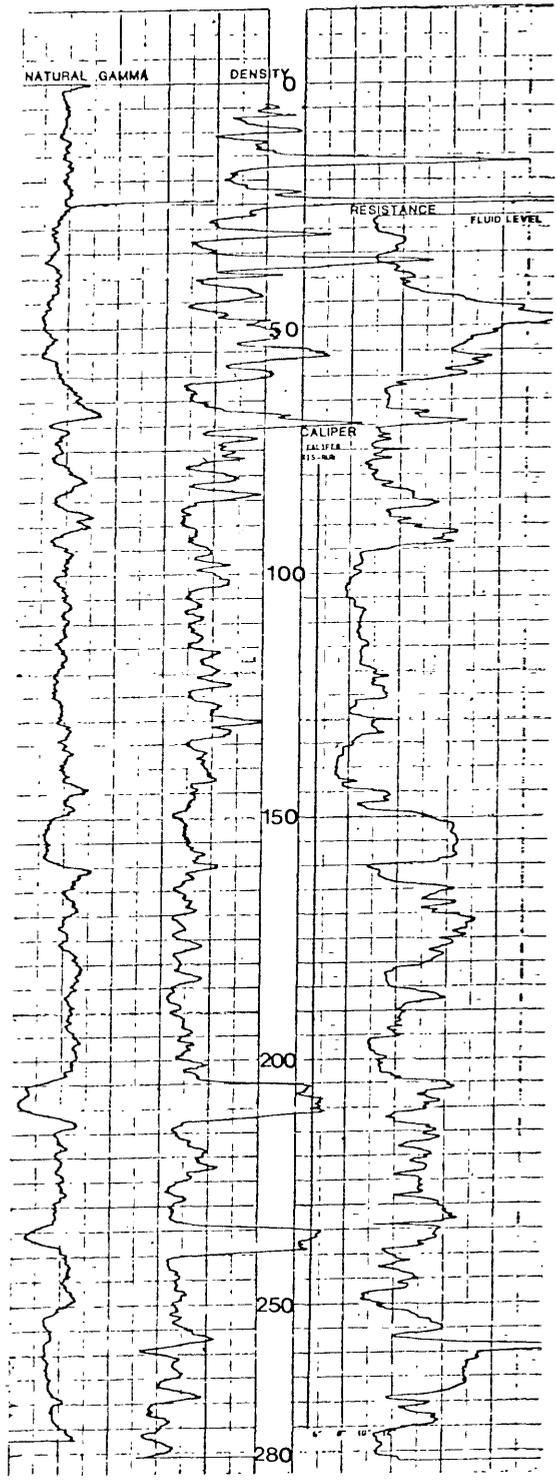


Figure 20.--Geophysical logs of hole GS-64

Sample log

Hole no.: GS-65 Date: 10-15-80 State: Montana County: Roosevelt  
 Elev. (ground): 2322 ft Location: T. 31 N., R. 53 E., Sec. NE NE 14  
 Total depth: 400 ft Drilling medium: mud Offset core hole: none

Depth feet)	Lithic description
0-28	Silt and clay, grayish-brown, unconsolidated
28-54	Sand, silt, and clay, dark-yellowish-brown to light-greenish-gray
54-59	Claystone, light-yellowish-brown
59-62	Lignite; lost circulation, no sample return
62-70	Claystone(?) and siltstone(?), poor sample return
70-79	Siltstone, light-greenish-gray; sandy in lower part
79-83	Lignite, brownish-black to black; impure in middle part
83-87	Claystone, light-greenish-gray
87-95	Sandstone, light-greenish-gray, very fine grained
95-109	Claystone and siltstone, greenish-gray; claystone in upper and lower parts grading to slightly sandy siltstone in middle part
109-110	Lignite, black
110-125	Siltstone, light-greenish-gray; argillaceous in upper part, sandy in lower part
125-189	Sandstone, light-gray to light-greenish-gray, very fine grained; fine-to medium-grained between 155 and 165 ft; fairly abundant dark opaque grains; thin calcareous concretions at 158 and 164 ft
189-228	Claystone, light-greenish-gray to dark-brownish-gray; thin calcareous concretions at 200, 209, and 219 ft; trace of coal and carbonaceous shale between 215 and 220 ft
228-237	Siltstone, light-greenish-gray
237-240.5	Lignite, black
240.5-274	Sandstone, light-greenish-gray, silty; grades to claystone in lower part
274-278	Lignite, black
278-315	Siltstone, light-greenish-gray to greenish-gray; includes scattered thinly interbedded silty claystone; thin coal at 303 ft

Sample log--Continued

Depth (feet)	Lithic description
315-335	Claystone, greenish-gray
335-350	Siltstone, light-greenish-gray to greenish-gray; grades to silty sandstone in lower part
350-369	Claystone and siltstone, light-greenish-gray to greenish-gray
369-371	Lignite, black
371-390	Claystone, greenish-gray, silty in lower part
390-400	Siltstone, light-greenish-gray
	Total depth 400 ft

Hole no: GS-65    Date: 10-15-80    State: Montana    County: Roosevelt  
Sec. NE NE 14    T. 31 N.    R. 53 E.    Elevation: 2322 ft    Total depth: 400 ft  
Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 1,  
Range 100 cps    Resistance: uncalibrated    Caliper: log improperly run

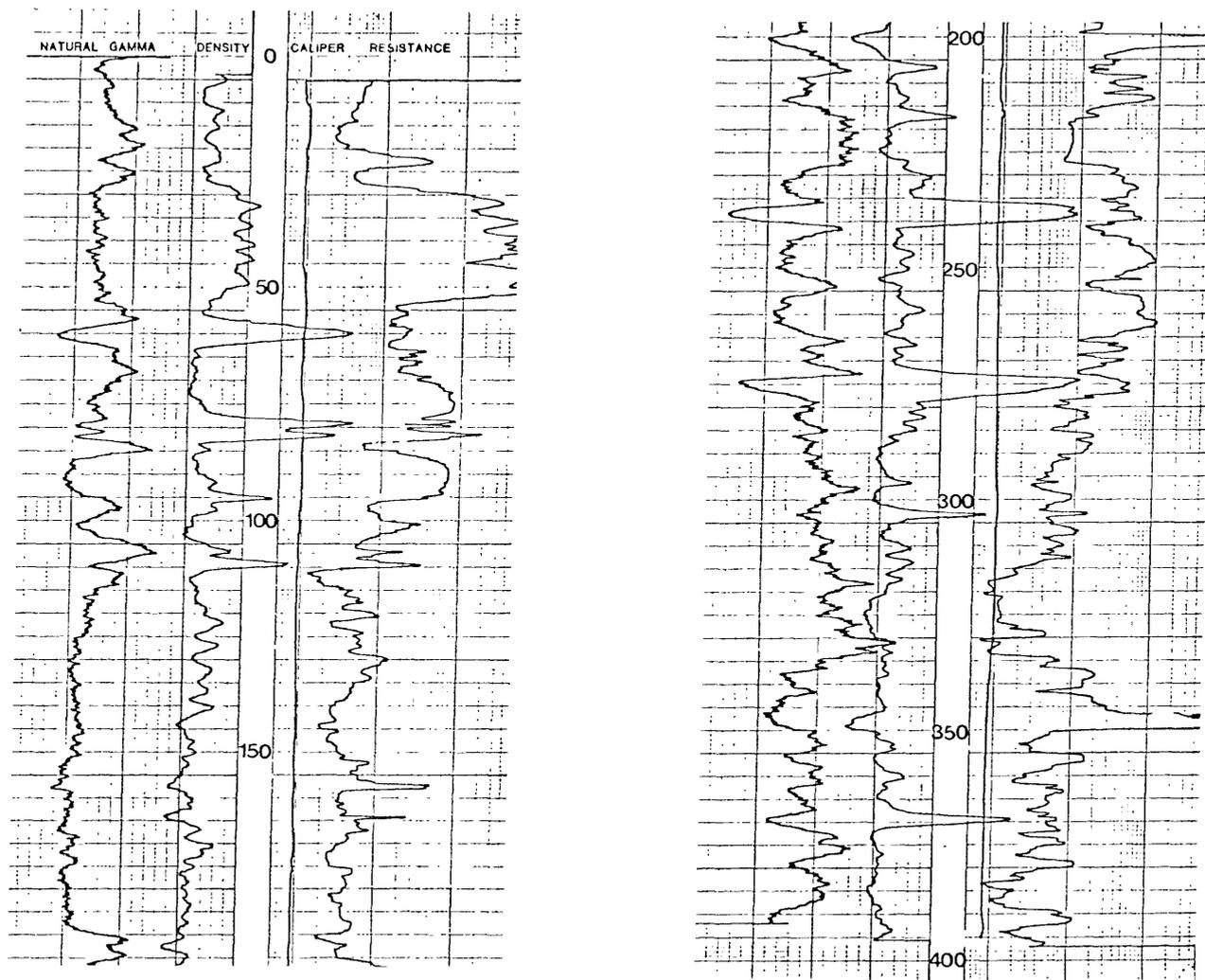


Figure 21.--Geophysical logs of hole GS-65

Sample log

Hole no.: GS-66    Date: 10-20-80    State: Montana    County: Roosevelt  
 Elev. (ground): 2208 ft    Location: T. 31 N., R. 54 E., Sec. SE NE 17  
 Total depth: 400 ft    Drilling medium: mud    Offset core hole: none

Depth (feet)	Lithic description
0-25	Sand, silt, and clay, pale-yellowish-brown to dark-yellowish-brown, unconsolidated
25-47	Siltstone and claystone, light-greenish-gray to grayish-brown; claystone predominates in upper part and siltstone dominates in lower part; trace of coal in cuttings from 25 to 30 ft; thin coal at 38 ft
47-173	Sandstone, light-gray to light-greenish-gray and light-olive-gray, very fine grained; silty between 60 and 130 ft; argillaceous and slightly carbonaceous between 95 and 100 ft; thin scattered calcareous concretions between 70 and 85 ft; hard calcareous concretion at 132 ft
173-176	Sandstone, calcareous concretion, light-olive-gray; hard, dense
176-228.5	Claystone, light-greenish-gray; grades to siltstone in middle part and at base; carbonaceous between 210 and 215 ft
228.5-230.5	Lignite, black
230.5-245	Siltstone, light-greenish-gray
245-253	Claystone, light-greenish-gray, silty; thin impure coal at 250 ft
253-263	Siltstone, light-greenish-gray; grades to claystone at base
263-264	Lignite, brownish-black, impure
264-272	Claystone and siltstone, light-olive-gray
272-275.5	Lignite, brownish-black to black; impure in lower part
275.5-298	Siltstone and claystone, light-greenish-gray to light-olive-gray; alternating thin to thick sequences of siltstone and claystone
298-300	Lignite, black
300-320	Claystone, light-greenish-gray, silty; thin impure coal at 312 ft
320-363	Sandstone, light-gray, very fine to fine-grained; silty in upper part
363-374	Claystone, light-olive-gray; thin impure coal at 365 ft

Sample log--Continued

Depth (feet)	Lithic description
374-400	Siltstone, light-olive-gray; includes scattered thinly interbedded claystone; hard calcareous concretion from 388 to 392 ft
	Total depth 400 ft

Hole no: GS-66    Date: 10-20-80    State: Montana    County: Roosevelt  
Sec. SE NE 17    T. 31 N.    R. 54 E.    Elevation: 2208 ft    Total depth: 400 ft  
Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 1,  
Range 100 cps    Resistance: uncalibrated    Caliper: Horizontal scale 1 in/in

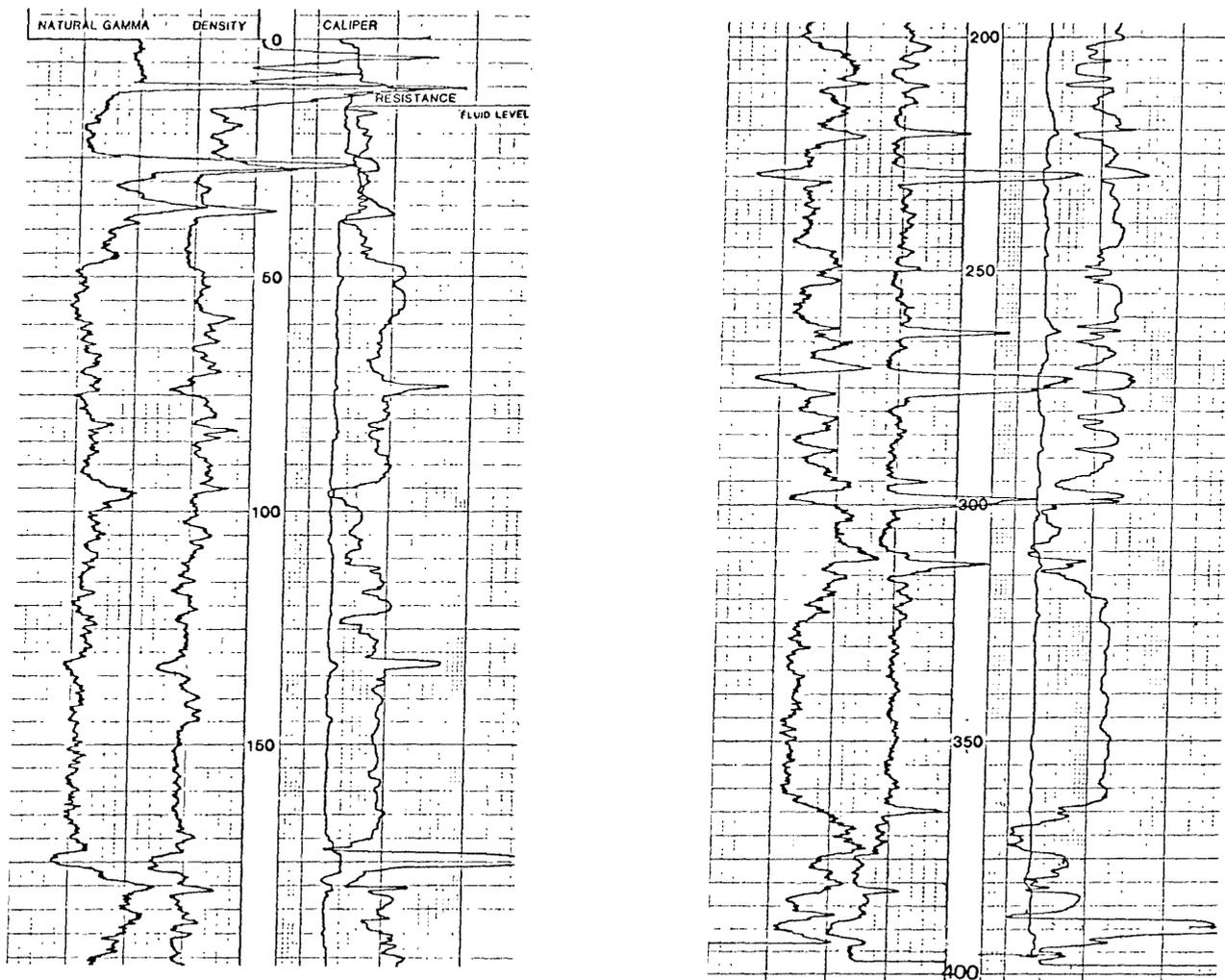


Figure 22.--Geophysical logs of hole GS-66

Sample log

Hole no.: GS-67 Date: 10-19-80 State: Montana County: Sheridan  
 Elev. (ground): 2050 ft Location: T. 31 N., R. 55 E., Sec. NE NW 18  
 Total depth: 400 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-5	Sand, silt, and clay, dark-yellowish-brown, unconsolidated
5-41	Gravel, sand, silt, and clay, dark-yellowish-brown, unconsolidated; includes scattered subrounded pebbles of quartz, quartzite, gneiss, granite, and sandstone as much as 1 inch in diameter; pebbles are most abundant between 5 and 20 ft
41-52	Claystone, pale-yellowish-brown to light-olive-gray, silty
52-57	Carbonaceous shale and impure coal, brownish-gray to brownish-black
57-60	Lignite(?) indicated in density log, possible impure coal indicated in natural-gamma and resistance logs; poor sample return
60-65	Sandstone, light-greenish-gray, very fine grained
65-75	Claystone, light-olive-gray, silty; includes thin coal at 73 ft
75-99	Siltstone, light-olive-gray, sandy
99-104	Lignite, black
104-124	Siltstone and sandstone, light-bluish-gray; grades to silty claystone at top and at base
124-129	Lignite, brownish-black to black; about 10 inches of impure coal in middle of unit
129-151	Siltstone and sandstone, light-olive-gray; silty in upper part, sandy in lower part; includes some thinly interbedded claystone in upper part
151-153.5	Lignite, black
153.5-163.5	Claystone, light-olive-gray
163.5-165	Lignite, brownish-black
165-172	Claystone, light-olive-gray
172-200	Siltstone, light-greenish-gray, sandy; includes some impure coal at 190 ft
200-302	Claystone and siltstone, light-greenish-gray to light-olive-gray; thin to thick alternating sequences of claystone and siltstone; locally sandy between 250 and 300 ft
302-306	Lignite, brownish-black to black

Sample log-- Continued

Depth (feet)	Lithic description
306-338	Siltstone, light-greenish-gray; includes some scattered thinly interbedded claystone; grades to claystone at top
338-341	Lignite, brownish-black to black
341-348.5	Claystone, light-gray; includes coal between 344 and 345 ft
348.5-351	Lignite, black
351-400	Siltstone, light-gray; interbedded with claystone between 357 and 362 ft and between 367 and 373 ft
	Total depth 400 ft

Hole no: GS-67    Date: 10-19-80    State: Montana    County: Sheridan  
Sec. NE NW 18    T. 31 N.    R. 55 E.    Elevation: 2050 ft    Total depth: 400 ft  
Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 1,  
Range 100 cps    Resistance: uncalibrated    Caliper: Horizontal scale 1 in/in

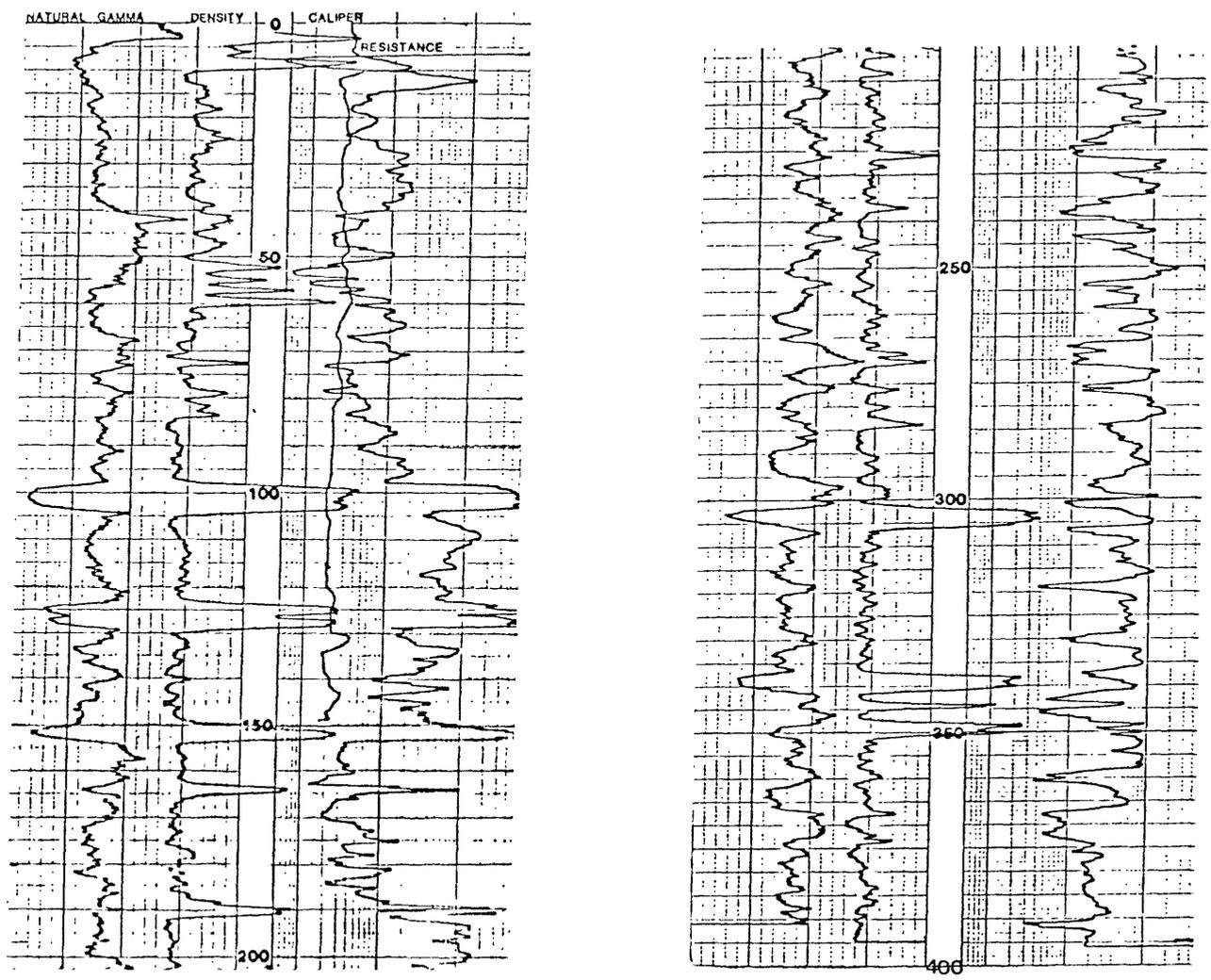


Figure 23.--Geophysical logs of hole GS-67

Sample log

Hole no.: GS-68 Date: 10-20-80 State: Montana County: Sheridan  
 Elev. (ground): 2347 ft Location: T. 32 N., R. 54 E., Sec. NE NE 33  
 Total depth: 460 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-10	Sand, silt, and clay, dark-yellowish-brown, unconsolidated
10-25	Siltstone and sandstone, pale-yellowish-brown; thinly interbedded siltstone and silty sandstone
25-30	Claystone, pale-yellowish-brown, silty
30-40	Sandstone and siltstone, pale-yellowish-brown; calcareous concretion at 33 ft
40-84.5	Siltstone and silty claystone, yellowish-brown to light-greenish-gray; dark-brownish-gray carbonaceous shale between 60 and 65 ft
84.5-86	Lignite, black
86-108	Sandstone and siltstone, light-greenish-gray; thinly interbedded very fine grained sandstone and siltstone
108-109	Lignite, black
109-113	Claystone, greenish-gray
113-120	Sandstone, light-greenish-gray, very fine grained
120-182.5	Siltstone and claystone, light-greenish-gray; alternating thin to thick sequences of siltstone and claystone; siltstone predominates in the upper part and claystone is dominate in lower part
182.5-230	Sandstone, light-greenish-gray, very fine grained; grades to siltstone at top and to silty claystone at base
230-235	Lignite, black
235-237	Carbonaceous shale, medium-dark-gray to brownish-black
237-241.5	Lignite, brownish-black to black; grades to impure coal in middle of unit
241.5-264	Siltstone and sandstone, light-greenish-gray; silty at top and base, sandy in middle
264-266	Lignite, brownish-black to black; impure from 264 to 265 ft
266-270	Claystone, brownish-gray to brownish-black, carbonaceous
270-275	Siltstone, light-brownish-gray to brownish-gray, slightly carbonaceous

Sample log--Continued

Depth (feet)	Lithic description
275-276	Lignite, brownish-black, impure
276-341	Siltstone, light-greenish-gray to light-olive-gray; scattered thinly interbedded claystone; calcareous concretion at 314 ft
341-349	Claystone, light-olive-gray, silty
349-360	Siltstone, light-greenish-gray
360-412	Sandstone and siltstone, light-greenish-gray; very fine grained silty sandstone predominates in upper part and siltstone dominates in lower part; thin, hard calcareous concretions at 387, 394, and 404 ft
412-419	Claystone, light-olive-gray to medium-gray
419-423.5	Lignite, brownish-black to black
423.5-435	Claystone, medium-gray to olive-gray, silty, slightly carbonaceous
435-460	Siltstone, light-greenish-gray, sandy; includes some scattered thinly interbedded claystone
	Total depth 460 ft

Hole no: GS-68    Date: 10-20-80    State: Montana    County: Sheridan  
Sec. NE NE 33    T. 32 N.    R. 54 E.    Elevation: 2347 ft    Total depth: 460 ft  
Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 1,  
Range 100 cps    Resistance: uncalibrated    Caliper: Horizontal scale 1 in/in

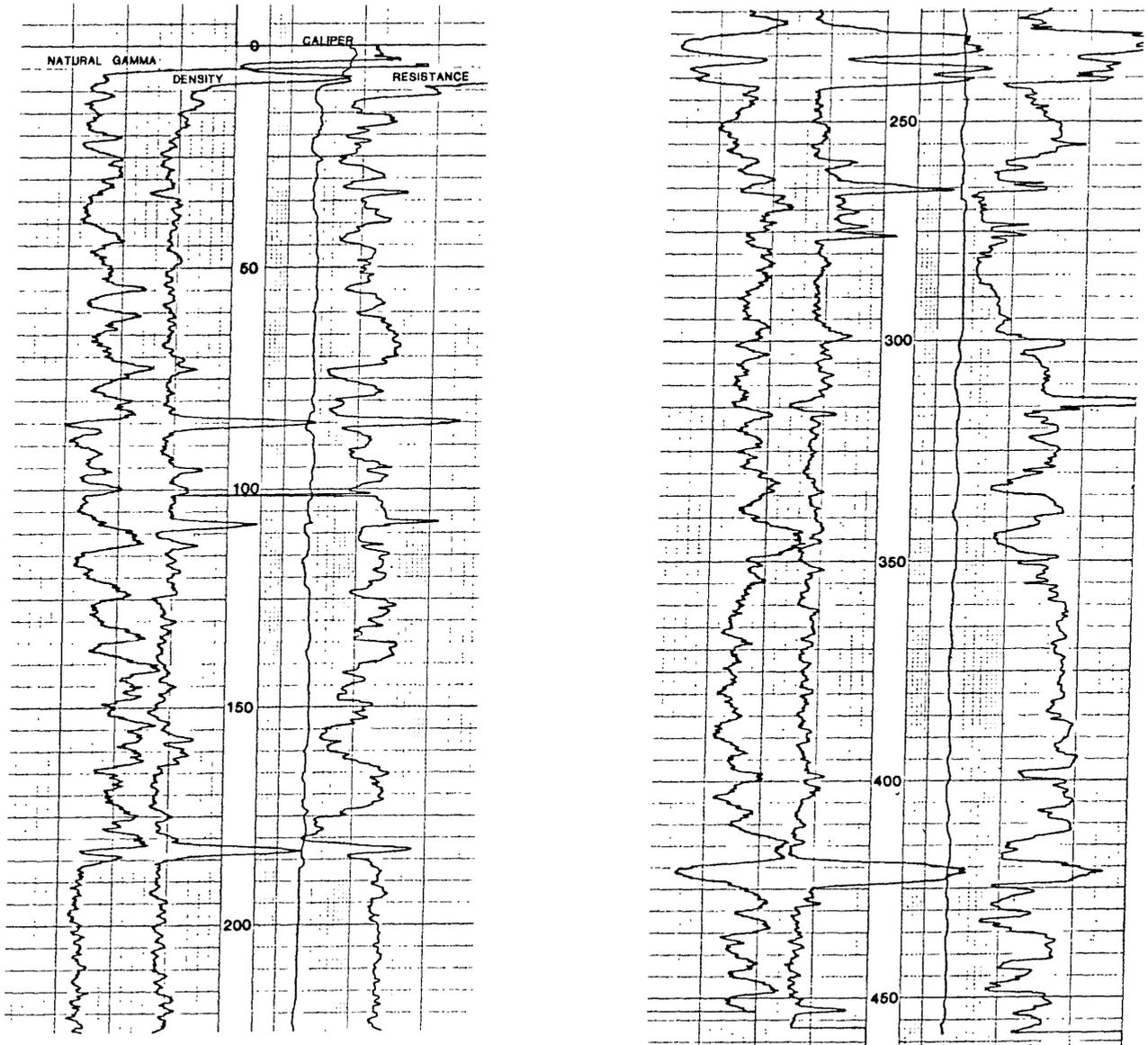


Figure 24.--Geophysical logs of hole GS-68

Sample log

Hole no.: GS-69 Date: 10-21-80 State: Montana County: Roosevelt  
 Elev. (ground): 2328 ft Location: T. 32 N., R. 53 E., Sec. NW NE 32  
 Total depth: 500 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-35	Sand, silt, and clay, dark-yellowish-brown to brown, unconsolidated; includes scattered subrounded to subangular pebbles of quartz, quartzite, and granite as much as 1 inch in diameter
35-61	Claystone and siltstone, light-greenish-gray
61-64	Impure coal and carbonaceous shale, brownish-gray to brownish-black
64-86	Siltstone, light-greenish-gray; sandy in upper part
86-97	Claystone, light-olive-gray; silty in upper part
97-145	Siltstone and sandstone, light-greenish-gray; alternating thin to thick sequences of very fine grained sandstone and siltstone; sandstone predominates in upper part and siltstone dominates in lower part
145-150	Claystone, light-olive-gray, silty
150-155	Claystone, olive-gray to olive-black, carbonaceous
155-158	Lignite, black
158-160	Carbonaceous shale and impure coal, brownish-gray to brownish-black
160-175	Sandstone, light-olive-gray, very fine grained; grades to siltstone at base
175-184	Claystone, light-olive-gray, silty in lower part
184-188	Lignite, black
188-223	Siltstone and sandstone, light-olive-gray to light-bluish-gray; thin alternating sequences of silty sandstone and siltstone; hard calcareous sandstone concretion from 207 to 209 ft
223-230	Claystone, light-olive-gray, silty in lower part
230-240	Siltstone, light-olive-gray
240-248	Claystone, brownish-gray to brownish-black, carbonaceous; includes thin impure coal at top
248-263	Siltstone and sandstone, medium-light-gray to light-olive-gray; siltstone in upper part grades downward to silty sandstone in lower part

Sample log--Continued

Depth (feet)	Lithic description
263-265	Lignite, black
265-269	Claystone, brownish-gray to light-olive-gray, slightly carbonaceous
269-291	Sandstone, light-greenish-gray, very fine grained
291-296	Claystone, brownish-gray to brownish-black, carbonaceous, silty; includes thin coal at top of unit
296-341	Siltstone, light-greenish-gray to light-olive-gray, locally sandy; calcareous concretion at 320 ft
341-346	Calcareous sandstone concretion, light-gray, hard
346-355	Claystone, light-olive-gray to olive-gray; grades to siltstone at base
355-397	Siltstone and claystone, light-olive-gray; alternating thin to thick sequences of siltstone and claystone; thin coal at 369 ft
397-404	Claystone, brownish-gray to olive-gray, carbonaceous; includes thin coal at top of unit
404-406	Carbonaceous shale and impure coal, brownish-black to brownish-gray
406-408.5	Lignite, black
408.5-412	Claystone, olive-gray; grades to siltstone at base
412-425	Siltstone and claystone, light-olive-gray
425-478	Sandstone, light-greenish-gray to light-olive-gray, very fine grained
478-480	Claystone, brownish-gray, carbonaceous
480-481	Lignite, brownish-black
481-483	Carbonaceous shale, dark-gray to brownish-black
483-484	Lignite, black
484-486	Claystone, light-olive-gray
486-492	Sandstone, light-greenish-gray, silty
492-500	Siltstone and claystone, light-olive-gray
	Total depth 500 ft

Hole no: GS-69    Date: 10-21-80    State: Montana    County: Roosevelt  
 Sec. NW NE 32    T. 32 N.    R. 53 E.    Elevation: 2328 ft    Total depth: 500 ft  
 Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 1,  
 Range 100 cps    Resistance: uncalibrated    Caliper: Horizontal scale 1 in/in

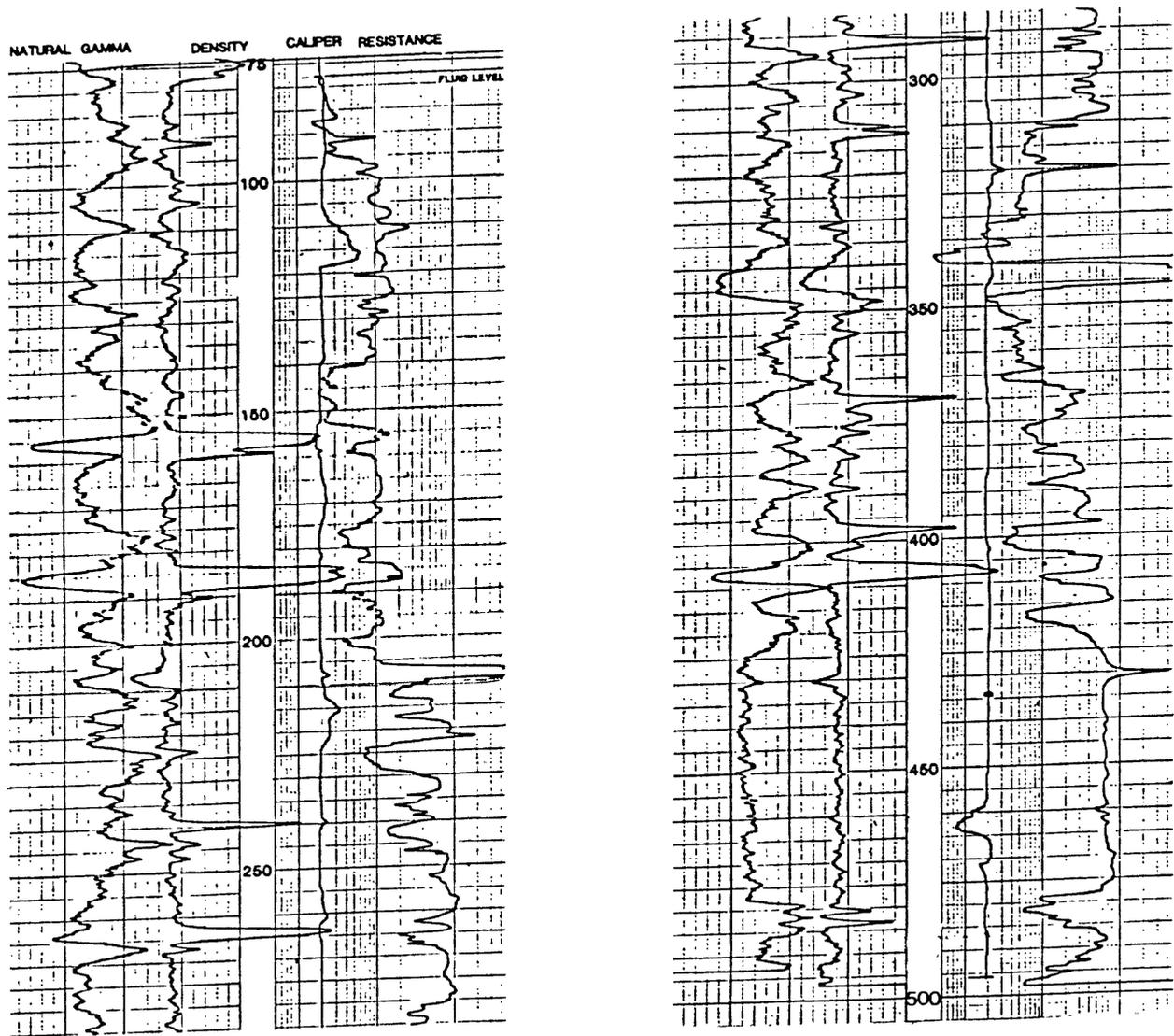


Figure 25.--Geophysical logs of hole GS-69

Sample log

Hole no.: GS-70 Date: 10-28-80 State: Montana County: Sheridan

Elev. (ground): 2175 ft Location: T. 33 N., R. 54 E., Sec. NE NE 13

Total depth: 300 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-60	Silt, sand, and gravel, light-olive-gray, unconsolidated
60-82	Sandstone, light-gray, very fine grained, silty; 5 percent dark opaques
82-88	Sandstone concretion, light-gray to very light gray, calcareous
88-108	Sandstone, light-gray to very light gray, very fine grained
108-109	Lignite, black
109-114	Siltstone, light-greenish-gray
114-126	Sandstone, light-bluish-gray, medium-to very fine grained, poorly sorted
126-150	Siltstone, yellowish-gray, carbonaceous; with interbedded claystone
150-155	Lignite, black
155-182	Siltstone, light-gray to yellowish-gray, argillaceous; carbonaceous near base; calcareous concretion 179 to 181 ft
182-190	Siltstone, light-gray; 20 percent coal fragments in cuttings
190-201	Sandstone, light-gray to medium-light-gray; trace of coal
201-211	Claystone, light-gray to light-olive-gray; about 20 percent carbonaceous claystone
211-237	Siltstone, light-gray to light-olive-gray; traces of carbonaceous claystone at top of interval; with interbedded claystone
237-268	Claystone, light-olive-gray to medium-dark-gray; abundant coal fragments at top of interval; grades silty near top and base
268-300	Siltstone, medium-light-gray; carbonaceous in middle and at base of unit
	Total depth 300 ft

Hole no: GS-70    Date: 10-28-80    State: Montana    County: Sheridan  
Sec. NE NE 13    T. 33 N.    R. 54 E.    Elevation: 2175 ft    Total depth 300 ft  
Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 2,  
Range 105 cps    Resistance: uncalibrated    Caliper: Horizontal scale 2 in/in

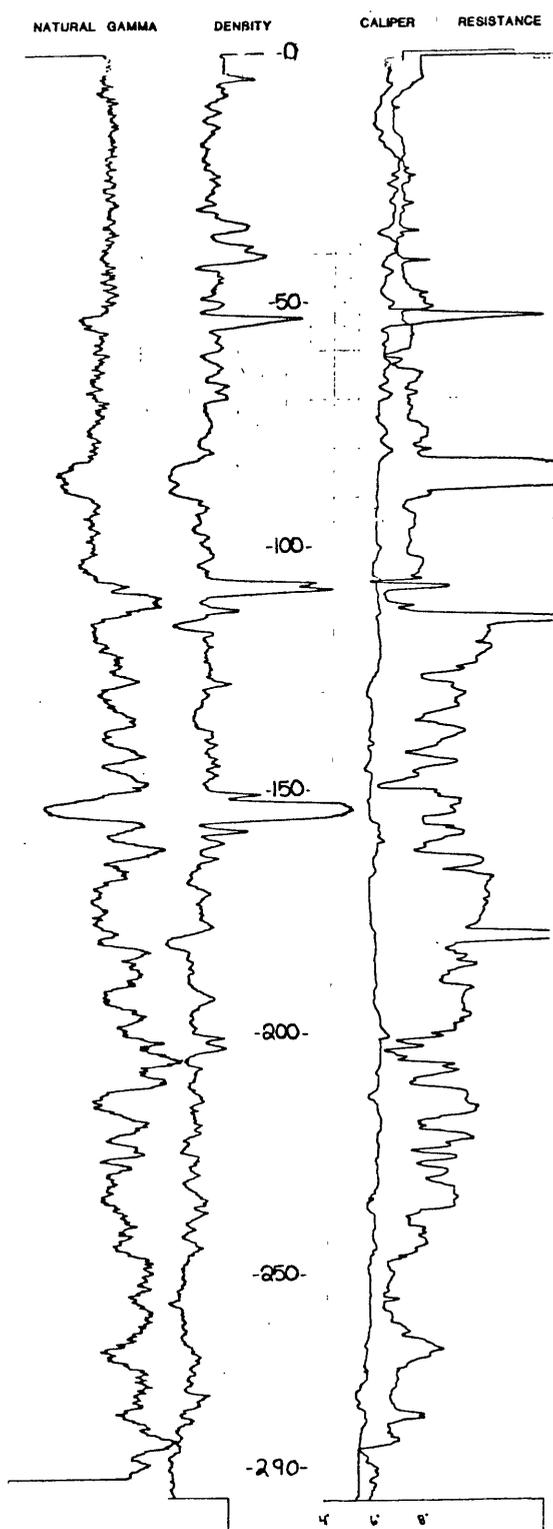


Figure 26.--Geophysical logs of hole GS-70

Sample log

Hole no.: GS-71 Date: 10-27-80 State: Montana County: Sheridan

Elev. (ground): 2170 ft Location: T. 32 N., R. 54 E., Sec. SW NW 1

Total depth: 300 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-17	Silt, sand, and gravel, olive-gray to light-olive-gray, unconsolidated
17-31	Claystone, light-olive-gray
31-33	Lignite, black
33-63	Sandstone, yellowish-gray, very fine grained, micaceous
63-74	Claystone, light-gray to yellowish-gray, slightly silty
74-80	Lignite, black
80-83	Claystone, light-gray
83-86	Lignite, black
86-105	Claystone, light-gray
105-107	Lignite, black
107-134	Siltstone, pale-green
134-136	Lignite, black
136-200	Claystone, light-gray; with interbedded siltstone; traces of carbonaceous claystone and coal near middle of interval; calcareous sandstone concretion 156 to 159 ft
200-242	Claystone, light-gray; with interbedded siltstone; probable coal 207 to 208 ft; traces of carbonaceous claystone and coal near middle of interval
242-262	Claystone, light-gray, slightly silty; with interbedded carbonaceous claystone, probable coals 246 to 247 ft and 254 to 255 ft
262-266	Shale, grayish-black, carbonaceous; minor coal fragments
266-300	Claystone, light-gray; traces of coal near middle of interval
Total depth 300 ft	

Hole no: GS-71    Date: 10-27-80    State: Montana    County: Sheridan  
Sec. SW NW 1    T. 32 N.    R. 54 E.    Elevation: 2170 ft    Total depth 300 ft  
Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 2,  
Range 105 cps    Resistance: uncalibrated    Caliper: log improperly run

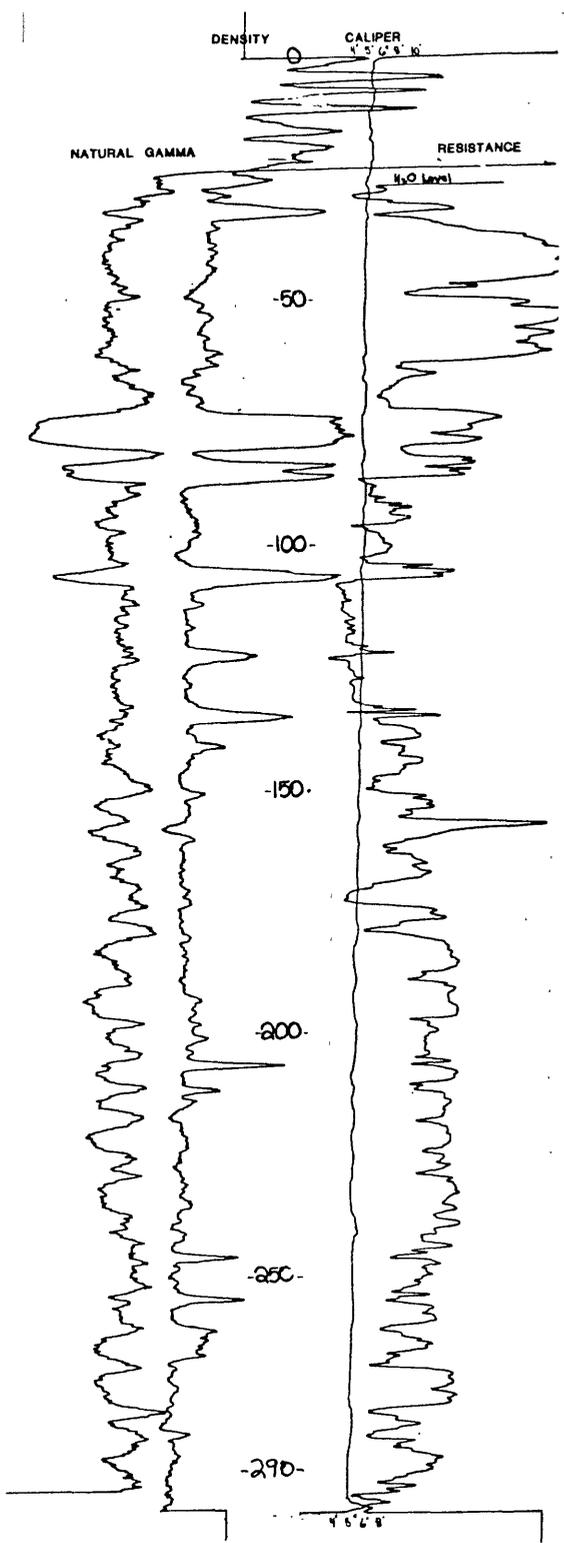


Figure 27.--Geophysical logs of hole GS-71

Sample log

Hole no.: GS-72 Date: 10-28-80 State: Montana County: Sheridan  
 Elev. (ground): 2330 ft Location: T. 33 N., R. 54 E., Sec. SE SW 18  
 Total depth: 300 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-7	Sand and gravel, pale-yellowish-brown, unconsolidated
7-28	Siltstone, light-olive-gray; traces of carbonaceous claystone in lower part; coal 26 to 27 ft
28-43	Siltstone, yellowish-gray to grayish-orange; traces of carbonaceous claystone in lower part
43-45	Lignite, black
45-57	Sandstone, yellowish-gray; slightly micaceous and pyritic; traces of organic debris
57-64	Claystone, pale-yellowish-orange to very light gray
64-80	Siltstone, yellowish-gray to dark-yellowish-orange; with interbedded siltstone
80-124	Sandstone, yellowish-gray, very fine grained
124-152	Claystone, very light gray; grades silty near top of interval
152-165	Lignite, black
165-186	Siltstone, very light gray; grades to claystone at top of interval
186-202	Siltstone, light-olive-gray; with interbedded claystone
202-206	Lignite, black
206-213	Claystone, light-gray, slightly silty; traces of organic debris
213-215	Lignite, black
215-220	Claystone, light-gray
220-230	Siltstone, light-gray, sandy
230-275	Sandstone, yellowish-gray, very fine grained
275-289	Claystone, very light gray; with interbedded siltstone
289-300	Siltstone, yellowish-gray
	Total depth 300 ft

Hole no: GS-72    Date: 10-28-80    State: Montana    County: Sheridan  
 Sec. SE SW 18    T. 33 N.    R. 54 E.    Elevation: 2330 ft    Total depth 300 ft  
 Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 2,  
 Range 105 cps    Resistance: uncalibrated    Caliper: Horizontal scale 2 in/in

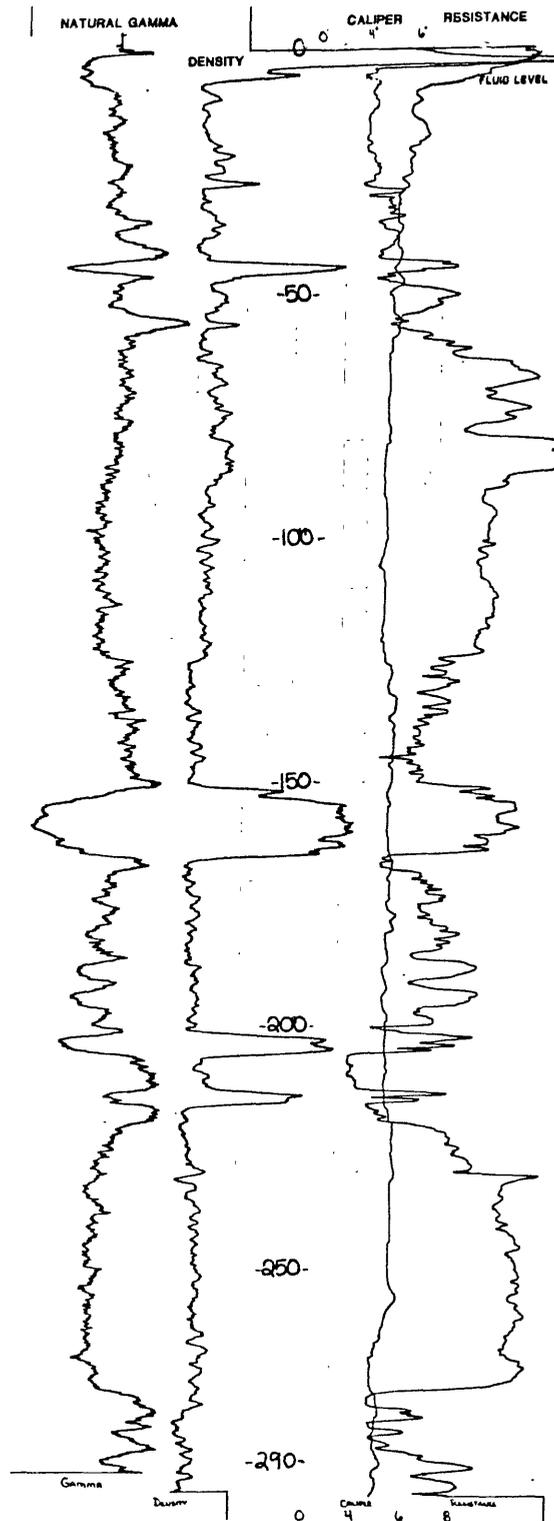


Figure 28.--Geophysical logs of hole GS-72

Sample log

Hole no.: GS-73 Date: 10-27-80 State: Montana County: Sheridan  
 Elev. (ground): 2285 ft Location: T. 32 N., R. 54 E., Sec. SE SE 5  
 Total depth: 380 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-30	Silt, sand, and gravel, light-olive-gray, unconsolidated
30-43	Sandstone, yellowish-gray, very fine grained, silty; grades to claystone at base
43-45	Lignite, black
45-50	Sandstone, yellowish-gray, very fine grained; interbedded with claystone 45 to 47 ft
50-57	Claystone, light-gray
57-65	Sandstone, yellowish-gray, very fine grained, silty
65-67	Lignite, black
67-75	Siltstone, light-gray; interbedded with claystone at base
75-85	Siltstone, light-gray, sandy; traces of organic debris; interbedded with carbonaceous claystone at base
85-89	Lignite, black
89-97	Sandstone, very light gray, very fine grained, silty
97-100	Claystone, light-gray
100-151	Sandstone, very light gray to yellowish-gray, very fine grained, silty
151-163	Lignite, black
163-178	Siltstone, light-gray
178-182	Lignite, black
182-187	Claystone, light-gray
187-200	Siltstone, light-gray, sandy
200-202	Lignite, black
202-247	Siltstone, light-gray to yellowish-gray; with interbedded claystone
247-263	Siltstone, olive-gray to light-olive-gray; interbedded with claystone at top and base of interval

Sample log--Continued

Depth (feet)	Lithic description
263-293	Siltstone, light-bluish-gray; grades to claystone near top of interval; with interbedded claystone
293-314	Siltstone, light-bluish-gray to yellowish-gray
314-318	Lignite, black
318-324	Claystone, poor sample return
324-332	Sandstone, yellowish-gray, very fine grained
332-333	Lignite, black
333-358	Claystone, medium-gray to light-gray; traces of carbonaceous claystone; coal 351 to 352 ft
358-371	Sandstone, light-gray, very fine grained; probable coal 370 to 371 ft
371-380	Claystone, light-olive-gray
	Total depth 380 ft

Hole no: GS-73    Date: 10-27-80    State: Montana    County: Sheridan  
 Sec. SE SE 5    T. 32 N.    R. 54 E.    Elevation: 2285 ft    Total depth: 380 ft  
 Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 2,  
 Range 105 cps    Resistance: uncalibrated    Caliper: log improperly run

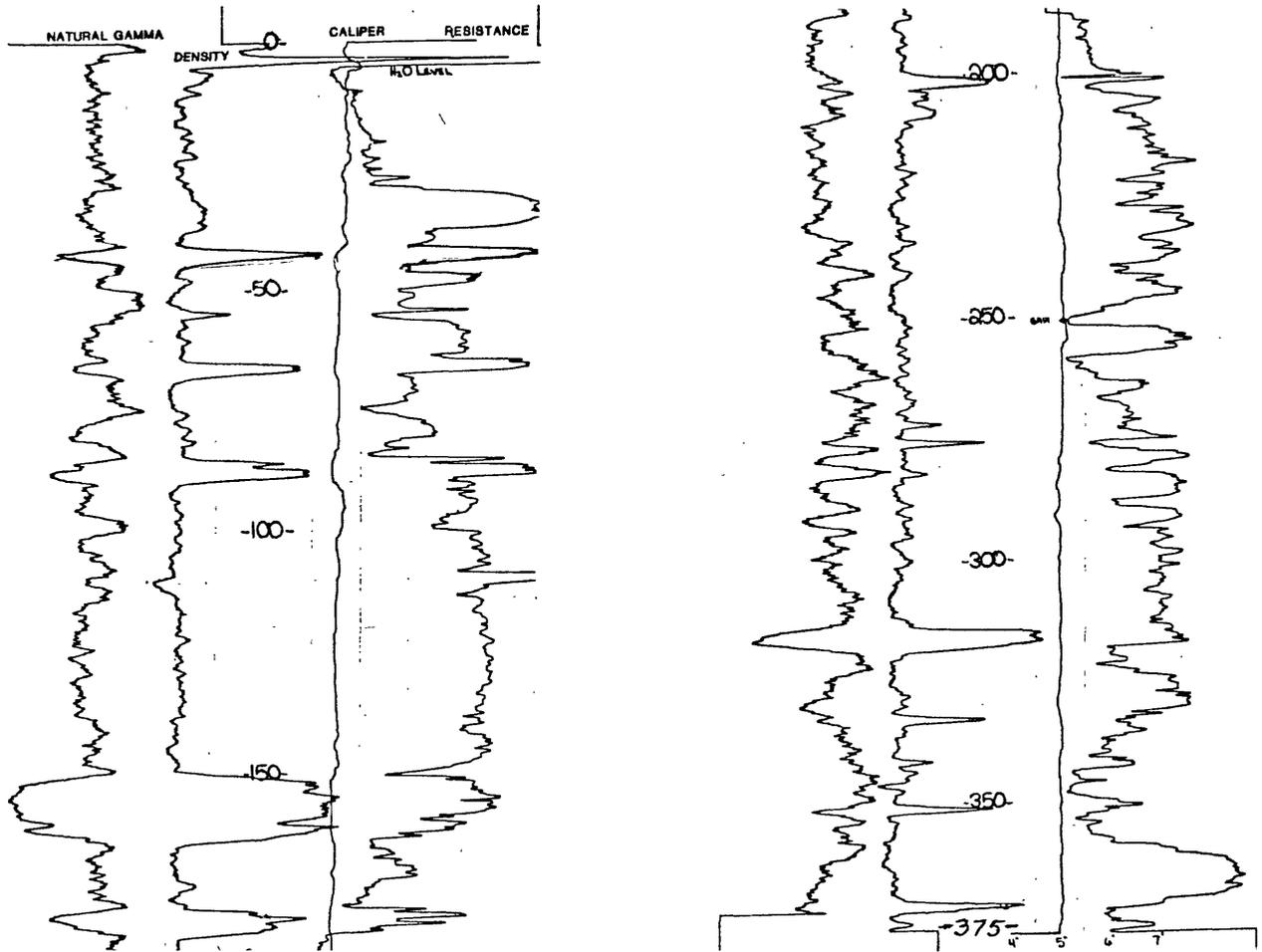


Figure 29.--Geophysical logs of hole GS-73

Sample log

Hole no.: GS-74 Date: 10-24-80 State: Montana County: Roosevelt  
 Elev. (ground): 2430 ft Location: T. 32 N., R. 53 E., Sec. NE SW 11  
 Total depth: 500 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-12	Silt, sand, and gravel, light-olive-gray; unconsolidated
12-16	Claystone, light-olive-gray; probable coal 14 to 15 ft
16-18	Lignite, black
18-40	Siltstone, yellowish-gray to very light gray and dark-yellowish-orange, sandy; traces of organic debris
40-41	Lignite, black
41-51	Siltstone, very light gray; partially iron-stained
51-77	Claystone, very light gray, very silty; carbonaceous at base
77-103	Claystone, very light gray; with interbedded carbonaceous claystone
103-114	Claystone, very light gray, silty
114-116	Lignite, black
116-131	Claystone, light-gray to very light gray
131-142	Lignite, black
142-186	Siltstone, light-gray to very light gray; claystone parting 174 to 181 ft
186-189	Lignite, black
189-214	Siltstone, light-gray to light-bluish-gray, sandy; about 15 percent carbonaceous claystone
214-250	Siltstone, light-gray to yellowish-gray, sandy; interbedded claystone in upper part; scattered traces of coal and carbonaceous claystone; probable calcareous concretion 234 to 236 ft
250-257	Shale, brownish-black, carbonaceous
257-305	Siltstone, medium-light-gray to light-gray and light-greenish-gray; probable thin coals at 274 and 290 ft; scattered traces of carbonaceous claystone and shale
305-312	Claystone; medium-light-gray; includes coal between 310 and 311 ft

Sample log--Continued

Depth (feet)	Lithic description
312-315	Lignite, black
315-391	Sandstone, light-gray to very light gray, very fine grained; calcareous concretion 335 to 339 ft; traces of coal 365 to 370 ft
391-421	Claystone, medium-light-gray; silty in lower part
421-423	Lignite, black
423-449	Siltstone, very light gray
449-450	Lignite, black
450-500	Claystone, light-gray to very light gray, slightly silty; probable coal 482 to 483 ft
	Total depth 500 ft

Hole no: GS-74    Date: 10-24-80    State: Montana    County: Roosevelt  
 Sec. NE SW 11    T. 32 N.    R. 53 E.    Elevation: 2430 ft    Total depth 500 ft  
 Logging speed: 15 ft/min    Natural gamma: TC 2, Range 25 cps    Density: TC 2,  
 Range 105 cps    Resistance: uncalibrated    Caliper: log improperly run

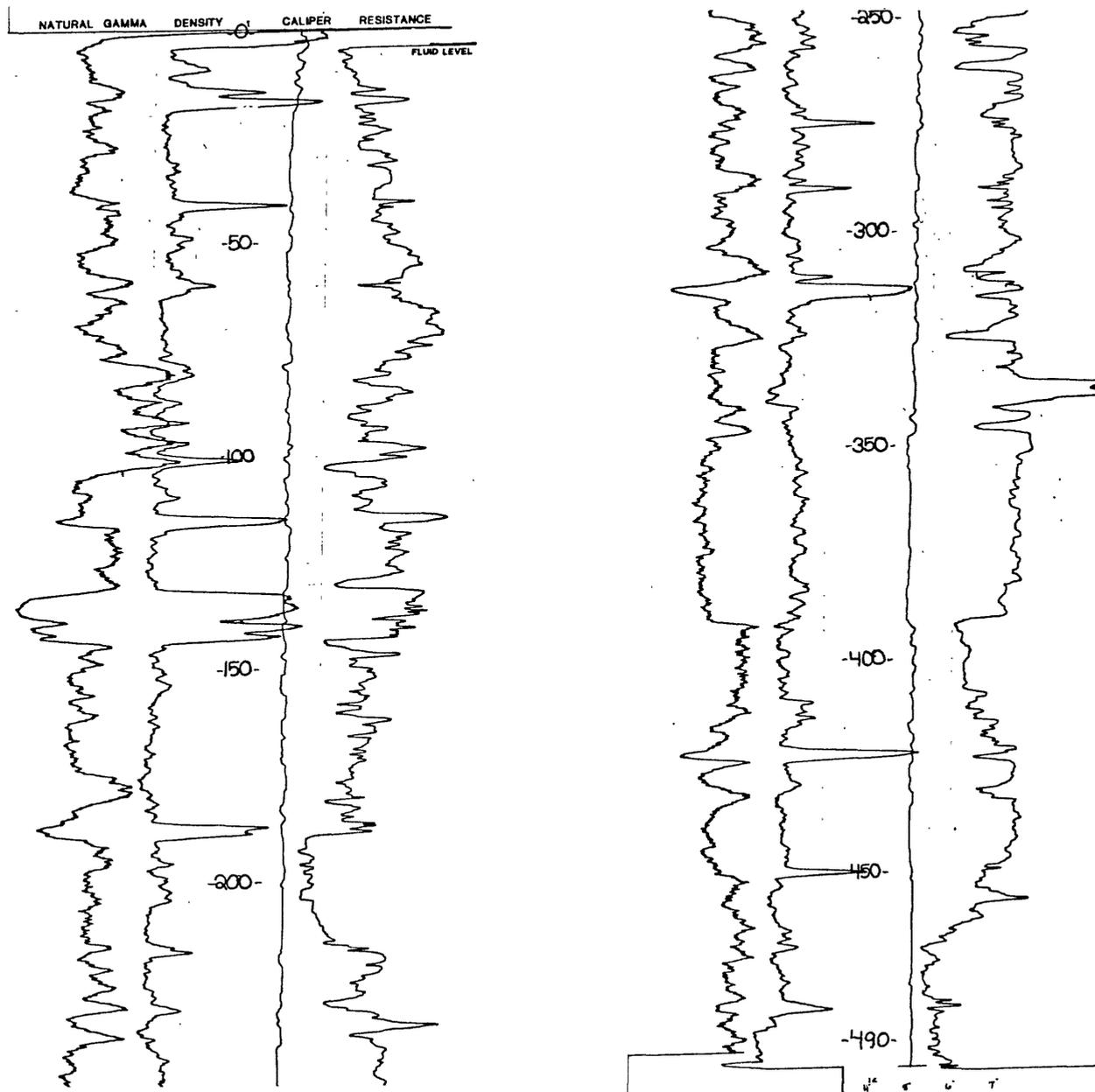


Figure 30.--Geophysical logs of hole GS-74

Sample log

Hole no.: GS-75    Date: 9-27-80    State: Montana    County: Roosevelt

Elev. (ground): 2465 ft    Location: T. 32 N., R. 52 E., Sec. NW NW 24

Total depth: 420 ft    Drilling medium: mud    Offset core hole: none

Depth (feet)	Lithic description
0-29	Silt, sand, and gravel, light-olive-gray, unconsolidated
29-38	Siltstone, white; with 40 percent slightly coaly carbonaceous shale and claystone
38-194	Sandstone, very light gray, yellowish-gray, light-olive-gray, and pale-yellowish-orange, fine-to very fine grained, silty; partially iron-stained
194-198	Claystone, poor sample return
198-204	Lignite; probable claystone parting 199 to 200 ft
204-214	Claystone, very light gray, silty
214-231	Siltstone, olive-gray to light-olive-gray, sandy
231-234	Lignite, black; probable claystone parting 232 to 233 ft
234-305	Claystone, light-to very light gray, silty; probable coals 284 to 285 ft and 300 to 301 ft
305-322	Siltstone, very light gray to medium-light-gray, sandy; traces of carbonaceous claystone; some interbedded claystone
322-356	Siltstone, light-gray; thin coal 343 to 344 ft
356-362	Siltstone, light-gray to very light gray, sandy
362-364	Lignite, black
364-391	Siltstone and claystone; light-gray to very light gray, sandy; probable coal 373 to 374 ft
391-395	Lignite, black
395-420	Siltstone, light-gray to very light gray
	Total depth 420 ft

Hole no: GS-75      Date: 9-27-80      State: Montana      County: Roosevelt  
 Sec. NW NW 24      T. 32 N.      R. 52 E.      Elevation: 2465 ft      Total depth 420 ft  
 Logging speed: 15 ft/min      Natural gamma: TC 2, Range 12 cps      Density: TC 1,  
 Range 170 cps      Resistance: 15 ohms/in      Caliper: Horizontal scale 4 in/in

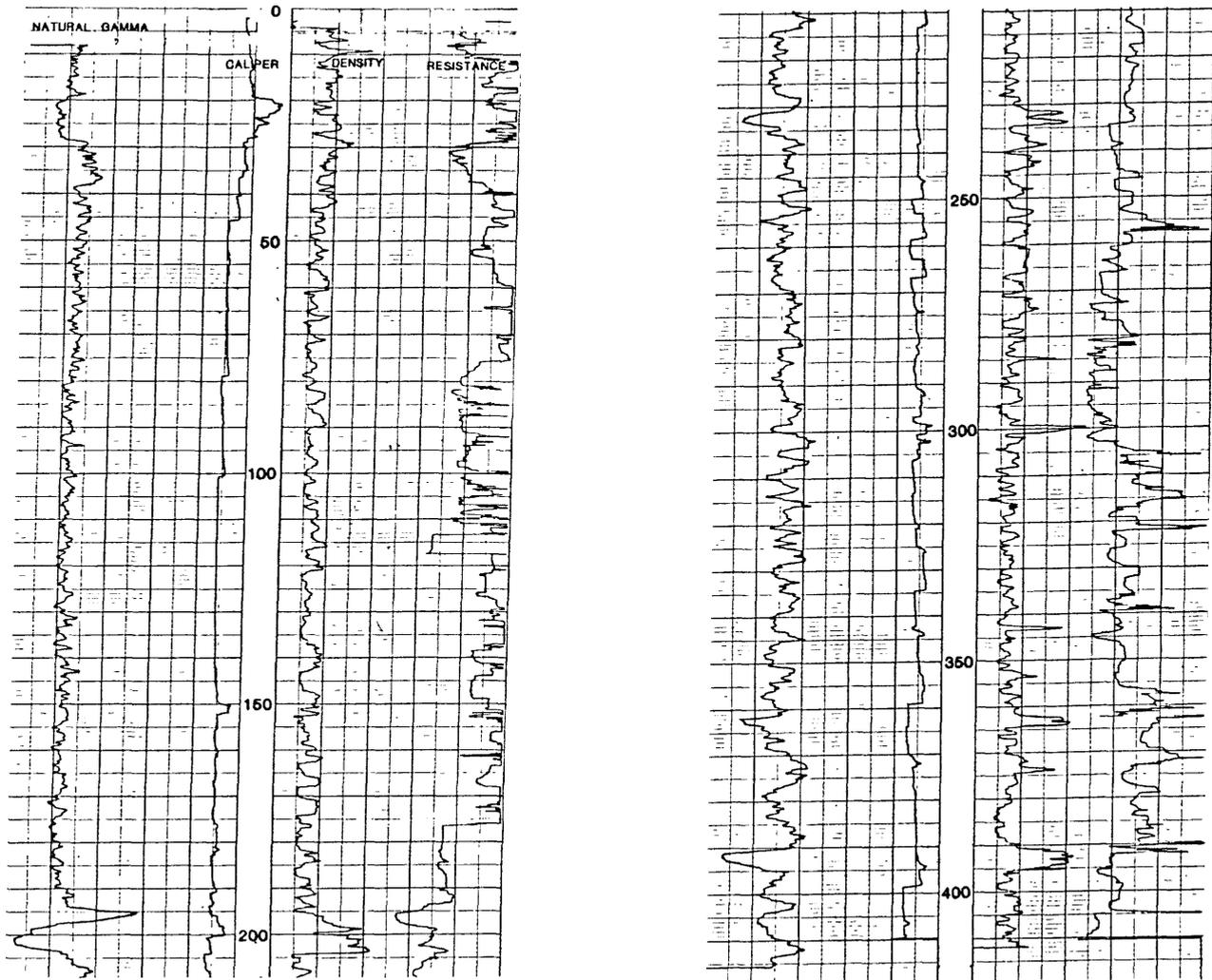


Figure 31.--Geophysical logs of hole GS-75

Sample log

Hole no.: GS-76 Date: 9-26-80 State: Montana County: Sheridan

Elev. (ground): 2585 ft Location: T. 33 N., R. 52 E., Sec. SW SW 33

Total depth: 480 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-50	Silt, sand, and gravel, light-olive-gray, unconsolidated
50-68	Claystone, grayish-orange, slightly silty
68-77	Claystone, light-gray to yellowish-gray; traces of coal throughout interval
77-92	Siltstone, light-gray; traces of light-brownish-gray and pale-yellowish-orange claystone; traces of organic debris
92-131	Claystone, light-to very light gray, slightly silty
131-136	Lignite, black
136-153	Claystone, light-gray
153-156	Lignite, black
156-169	Claystone, light-gray
169-182	Sandstone, yellowish-gray to light-olive-gray, very fine grained
182-195	Claystone, light-gray; carbonaceous near middle of interval; some interbedded sandstone in lower part
195-214	Siltstone, light-gray, sandy
214-217	Lignite, black; impure in upper part
217-240	Claystone, light-gray; some interbedded siltstone; carbonaceous in upper part; impure coal 234 to 235 ft
240-275	Sandstone, yellowish-gray, very fine grained; claystone parting 250 to 253 ft; scattered carbonaceous claystone with traces of coal near middle of interval
275-288	Siltstone, light-gray
288-325	Sandstone, light-gray; silty at top and base; includes coal 308 to 309 ft
325-331	Claystone, medium-dark-gray; silty in upper part; carbonaceous at base
331-335	Lignite, black
335-349	Claystone; grades silty near top of interval

Sample log--Continued

Depth (feet)	Lithic description
349-412	Siltstone, light-gray to yellowish-gray, sandy; claystone partings between 374 to 381 ft and 390 to 395 ft; coals 377 to 378 ft and 406 to 407 ft
412-415	Lignite, black
415-453	Siltstone, light-gray; grades to claystone near base; probable coals 444 to 445 ft and 452 to 453 ft
453-480	Claystone, greenish-gray to light-greenish-gray, silty
	Total depth 480 ft

Hole no: GS-76      Date: 9-26-80      State: Montana      County: Sheridan  
 Sec. SW SW 33      T. 33 N.      R. 52 E.      Elevation: 2585 ft      Total depth 480 ft  
 Logging speed: 15 ft/min      Natural gamma: TC 2, Range 12 cps      Density: TC 1,  
 Range 170 cps      Resistance: 15 ohms/in      Caliper: Horizontal scale 4 in/in

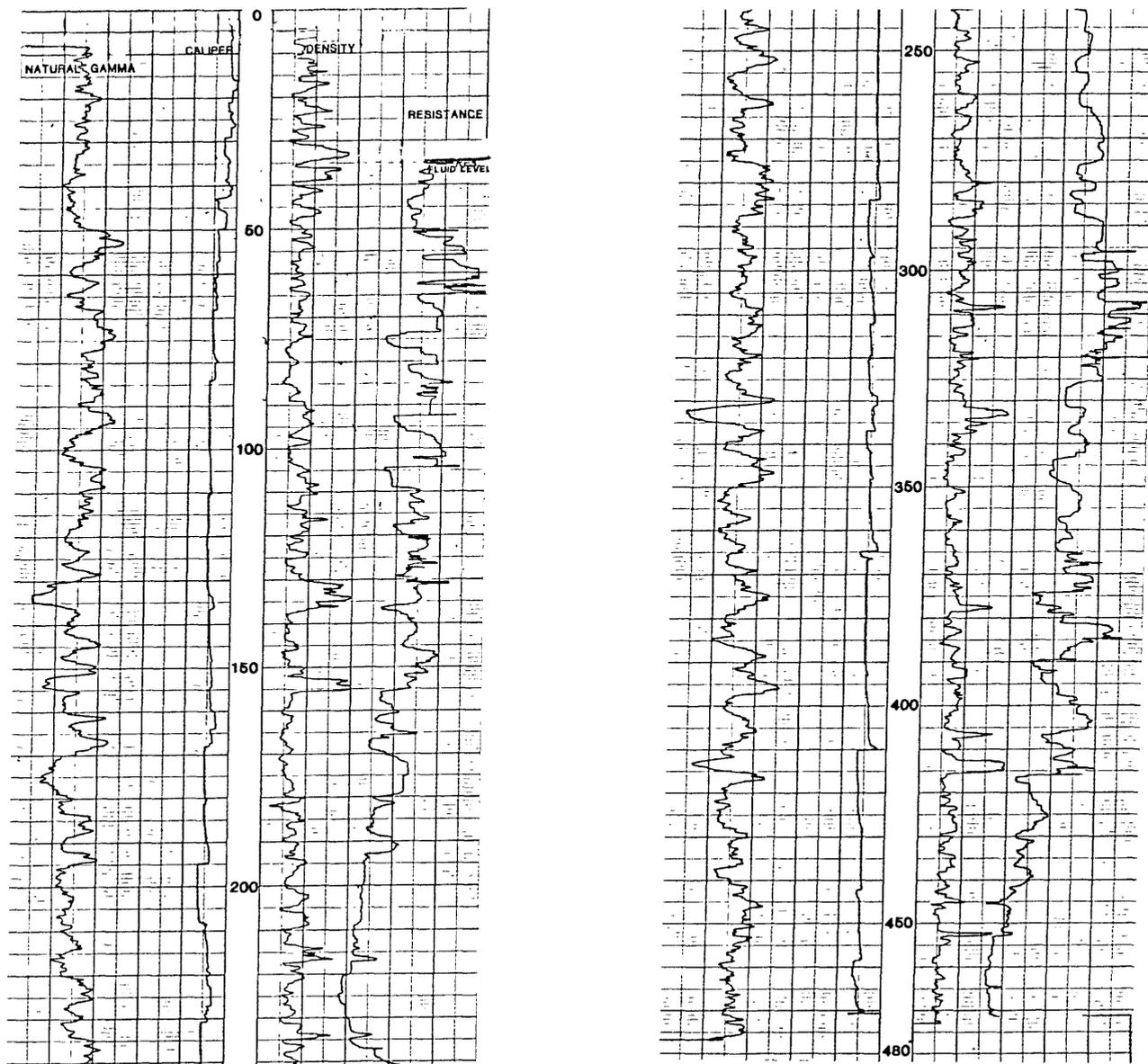


Figure 32.--Geophysical logs of hole GS-76

Sample log

Hole no.: GS-77 Date: 9-25-80 State: Montana County: Sheridan  
 Elev. (ground): 2520 ft Location: T. 33 N., R. 52 E., Sec. NE NE 20  
 Total depth: 560 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-32	Silt, sand, and gravel, pale-yellowish-brown, unconsolidated
32-85	Silt, sand, and gravel, light-olive-gray to pale-yellowish-brown, unconsolidated; trace of detrital(?) coal in lower part
85-109	Claystone, light-to medium-light-gray; interbedded with carbonaceous shale at top and base; trace of coal just below top of unit; calcareous sandstone concretion 92 to 94 ft
109-112	Lignite, black
112-114	Claystone, medium-gray
114-118	Lignite, black
118-155	Claystone, greenish-gray to medium-gray, silty; traces of carbonaceous claystone near middle of interval
155-188	Sandstone, light-bluish-gray to light-gray, very fine grained, silty; 5 percent dark opaques; slightly pyritic; includes some interbedded claystone; abundant fragments of carbonaceous shale and coal in cuttings from base of unit
188-228	Claystone, light-gray; abundant coal fragments near top of interval; calcareous concretion 216 to 218 ft
228-244	Siltstone, light-gray; traces of carbonaceous claystone
244-260	Claystone, light-gray to medium-light-gray; traces of carbonaceous claystone; coal 255 to 256 ft
260-296	Sandstone, light-olive-gray, very fine grained, silty, minor iron-stains; coal fragments in lower half of interval; traces of carbonaceous shale and claystone scattered throughout interval
296-301	Lignite, black; probably impure at base
301-331	Sandstone, light-olive-gray to light-gray, very fine grained; some interbedded siltstone in upper half of interval; traces of carbonaceous claystone near base
331-339	Claystone, light-olive-gray to light-gray
339-341	Lignite, black
341-362	Siltstone, light-gray; coal 351 to 352 ft

Sample log--Continued

Depth (feet)	Lithic description
362-365	Lignite, black
365-392	Claystone, light-gray; traces of carbonaceous claystone near base
392-406	Sandstone, light-gray to bluish-gray, very fine grained; calcareous concretion 392 to 394 ft; coal 405 to 406 ft
406-439	Sandstone, light-olive-gray to light-gray, very fine grained, silty; traces of organic debris; coals 426 to 427 ft and 438 to 439 ft
439-453	Siltstone, light-olive-gray to light-gray
453-456	Lignite, brownish-black; probably impure
456-492	Sandstone, light-gray, very fine grained; traces of coal near middle of interval
492-523	Claystone, light-olive-gray to light-gray; abundant coal fragments at top and base of interval
523-544	Sandstone, light-gray to light-olive-gray; traces of carbonaceous shale at base
544-560	Claystone, light-bluish-gray, silty; coal 545 to 546 ft
	Total depth 560 ft

Hole no: GS-77      Date: 9-25-80      State: Montana      County: Sheridan  
 Sec. NE NE 20      T. 33 N.      R. 52 E.      Elevation: 2520 ft      Total depth 560 ft  
 Logging speed: 15 ft/min      Natural gamma: TC 2, Range 12 cps      Density: TC 1,  
 Range 170 cps      Resistance: 15 ohms/in      Caliper: Horizontal scale 4 in/in

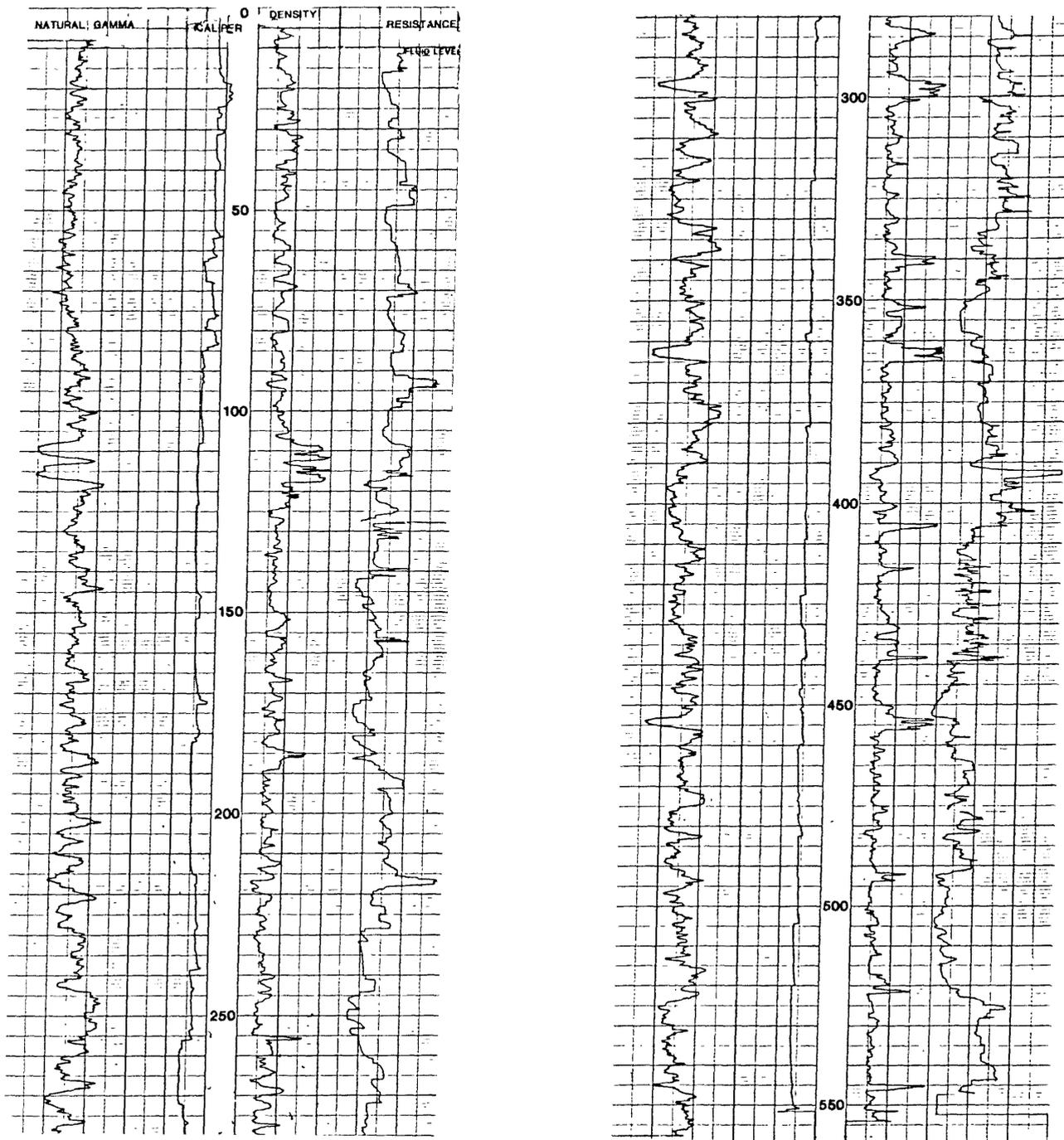


Figure 33.--Geophysical logs of hole GS-77

Sample log

Hole no.: GS-78    Date: 9-23-80    State: Montana    County: Roosevelt  
 Elev. (ground): 2460 ft    Location: T. 32 N., R. 52 E., Sec. SW NE 32  
 Total depth: 480 ft    Drilling medium: mud    Offset core hole: none

Depth (feet)	Lithic description
0-9	Sandstone, grayish-yellow, very fine grained, silty
9-22	Claystone, light-olive-gray; with thinly interbedded carbonaceous claystone; trace of coal
22-44	Siltstone, yellowish-gray, very sandy, slightly pyritic and micaceous
44-51	Sandstone, very pale orange, very fine grained, silty, slightly micaceous
51-62	Siltstone, light-olive-gray; grades sandy near base; traces of carbonaceous claystone; coal 60 to 61 ft
62-93	Claystone, medium-to medium-dark-gray; slightly silty in upper part of interval; traces of carbonaceous shale near middle of interval; coal 91 to 92 ft
93-124	Claystone, medium-to very light gray; traces of carbonaceous claystone near middle of interval; thin coal at 97 ft
124-149	Siltstone, light-gray to yellowish-gray, micaceous
149-154	Lignite, black
154-163	Claystone, very light gray
163-167	Lignite, black
167-209	Siltstone, light-gray to very light gray and yellowish-gray; probable thin coal at 206 ft
209-243	Sandstone, very light gray to yellowish-gray, very fine grained; grades silty near top and base; abundant coal fragments throughout interval
243-244	Lignite, black
244-255	Claystone, light-gray; calcareous concretion 254 to 255 ft
255-386	Sandstone, very light gray to yellowish-gray, very fine grained; calcareous concretion 278 to 279 ft
386-398	Claystone, light-olive-gray; traces of carbonaceous claystone
398-416	Claystone, light-gray

Sample log--Continued

Depth (feet)	Lithic description
416-418	Lignite, black
418-420	Claystone, medium-gray
420-425	Lignite, black
425-431	Claystone, light-gray, sandy near base
431-433	Lignite, black
433-447	Sandstone, light-gray, very fine grained
447-449	Lignite, black
449-480	Claystone, light-to very light gray
	Total depth 480 ft

Hole no: GS-78    Date: 9-23-80    State: Montana    County: Roosevelt  
 Sec. SW NE 32    T. 32 N.    R. 52 E.    Elevation: 2460 ft    Total depth 480 ft  
 Logging speed: 15 ft/min    Natural gamma: TC 2, Range 12 cps    Density: TC 1,  
 Range 170 cps    Resistance: 15 ohms/in    Caliper: Horizontal scale 4 in/in

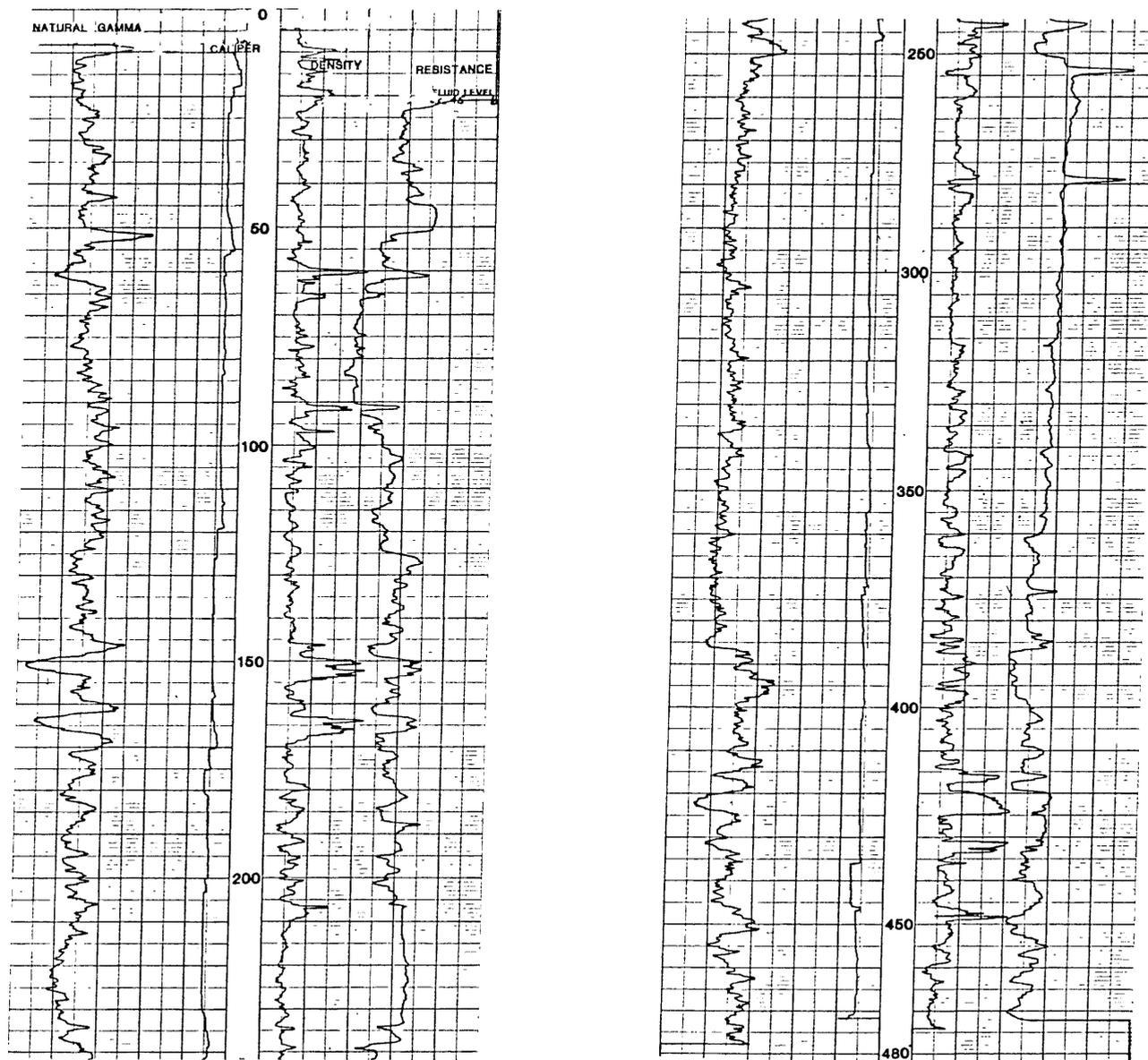


Figure 34.--Geophysical logs of hole GS-78

Sample log

Hole no.: GS-79 Date: 9-22-80 State: Montana County: Roosevelt

Elev. (ground): 2645 ft Location: T. 31 N., R. 51 E., Sec. NE SE 4

Total depth: 540 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-27	Silt, sand, and gravel, light-olive-gray, unconsolidated; gravel most abundant in lower part
27-45	Claystone, yellowish-gray to light-greenish-gray; slightly silty; some iron-stains; traces of organic debris; includes about 20 percent carbonaceous claystone at base
45-70	Claystone, yellowish-gray to light-olive-gray; traces of coal and carbonaceous shale throughout interval
70-89	Siltstone, yellowish-gray to light-gray and olive-gray; sandy at base; traces of organic debris; includes about 20 percent carbonaceous claystone at base
89-94	Claystone, light-gray
94-151	Siltstone, light-gray to medium-light-gray, sandy; traces of carbonaceous claystone at top and base; probable coal 95 to 96 ft; thin calcareous concretions at 106 and 144 ft
151-192	Sandstone, very light gray, very fine grained, silty; coal between 179 to 180 ft
192-196	Lignite, black
196-204	Sandstone, very light gray, very fine grained, silty
204-206	Lignite, black
206-240	Sandstone, very light gray, very fine grained
240-268	Siltstone, very light gray, sandy; interbedded with carbonaceous claystone near top of interval
268-313	Siltstone, medium-light-gray; scattered interbedded claystone; about 20 percent carbonaceous claystone and shale near base
313-315	Lignite, black
315-316	Claystone, medium-light-gray
316-318	Lignite, black
318-354	Sandstone, light-to very light gray, calcareous; grades to silty pyritic claystone near top of interval

Sample log--Continued

Depth (feet)	Lithic description
354-357	Lignite, brownish-black; impure in upper part
357-420	Siltstone, light-gray to light-olive-gray; scattered interbedded claystone; carbonaceous near top of interval; sandy between 364 and 375 ft; sandstone between 394 and 399 ft; probable impure coal at 408 ft
420-464	Siltstone, medium-light-gray to very light gray; claystone parting 436 to 444 ft; coals 445 to 446 and 459 to 460 ft
464-470	Lignite, black
470-540	Siltstone, light-olive-gray; silty near top of interval; scattered interbedded claystone; coal 503 to 504 ft
	Total depth 540 ft

Hole no: GS-79      Date: 9-22-80      State: Montana      County: Roosevelt  
 Sec. NE SE 4      T. 31 N.      R. 51 E.      Elevation: 2645 ft      Total depth 540 ft  
 Logging speed: 15 ft/min      Natural gamma: TC 2, Range 12 cps      Density: TC 1,  
 Range 170 cps      Resistance: 15 ohms/in      Caliper: Horizontal scale 4 in/in

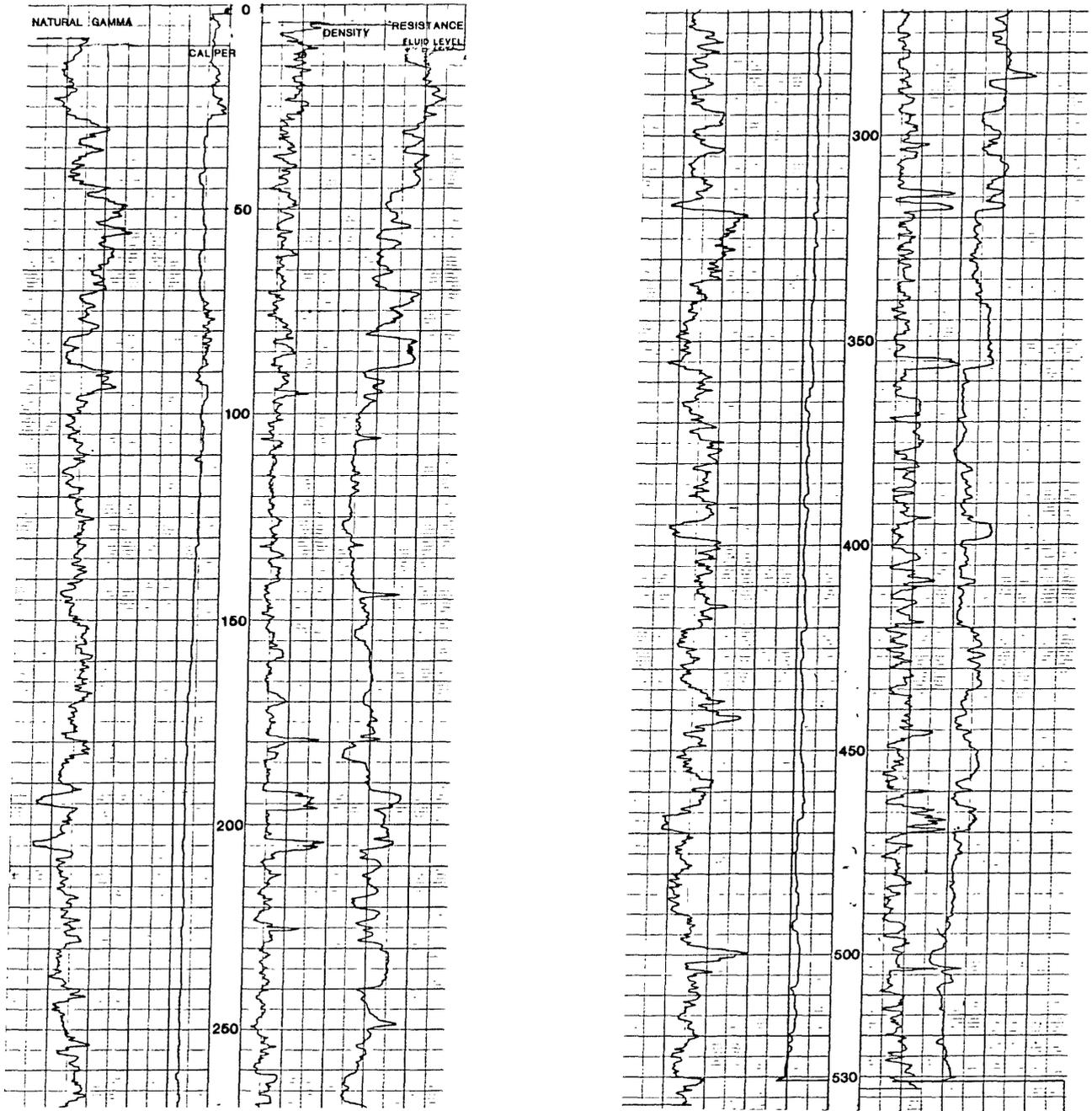


Figure 35.--Geophysical logs of hole GS-79

Sample log

Hole no.: GS-80    Date: 9-24-80    State: Montana    County: Daniels  
 Elev. (ground): 2565 ft    Location: T. 33 N., R. 51 E., Sec. SE SE 17  
 Total depth: 460 ft    Drilling medium: mud    Offset core hole: none

Depth (feet)	Lithic description
0-18	Silt, sand, and gravel, light-olive-gray, unconsolidated
18-28	Claystone, light-greenish-gray; about 30 percent carbonaceous claystone in lower part
28-77	Sandstone, yellowish-gray to grayish-orange; very fine grained, silty; traces of coal in upper half of interval
77-104	Sandstone, light-gray, very fine grained; thinly interbedded with claystone at base
104-107	Lignite, black
107-136	Siltstone, very light gray to yellowish-gray; scattered interbedded claystone; thin coal at 112 ft
136-166	Sandstone, very light gray, very fine grained
166-180	Claystone, very light gray; trace of coal at top of interval
180-232	Siltstone, light-gray to very light gray; scattered interbedded claystone; slightly carbonaceous in upper part of interval
232-236	Lignite, black
236-271	Sandstone, very light gray, very fine grained, silty; claystone parting 248 to 253 ft; trace of coal near base
271-287	Claystone, light-gray, silty; coal 279 to 280 ft
287-289	Lignite, black
289-297	Claystone; sandy near middle of interval; coal 293 to 294 ft
297-301	Lignite, black
301-334	Sandstone, very light gray, very fine grained; claystone parting 312 to 317 ft
334-336	Lignite, black
336-353	Siltstone, light-gray; scattered interbedded sandstone; coal 350 to 351 ft
353-357	Lignite, black

Sample log--Continued

Depth (feet)	Lithic description
357-402	Siltstone, light-gray, sandy; with interbedded claystone; coal 397 to 398 ft
402-417	Claystone, light-olive-gray, silty in lower part
417-460	Siltstone and sandstone, light-olive-gray; siltstone in upper part grading downward to silty sandstone in lower part
	Total depth 460 ft

Hole no: GS-80    Date: 9-24-80    State: Montana    County: Daniels  
Sec. SE SE 17    T. 33 N.    R. 51 E.    Elevation: 2565 ft    Total depth 460 ft  
Logging speed: 15 ft/min    Natural gamma: TC 2, Range 12 cps    Density: TC 1,  
Range 170 cps    Resistance: 15 ohms/in    Caliper: Horizontal scale 4 in/in

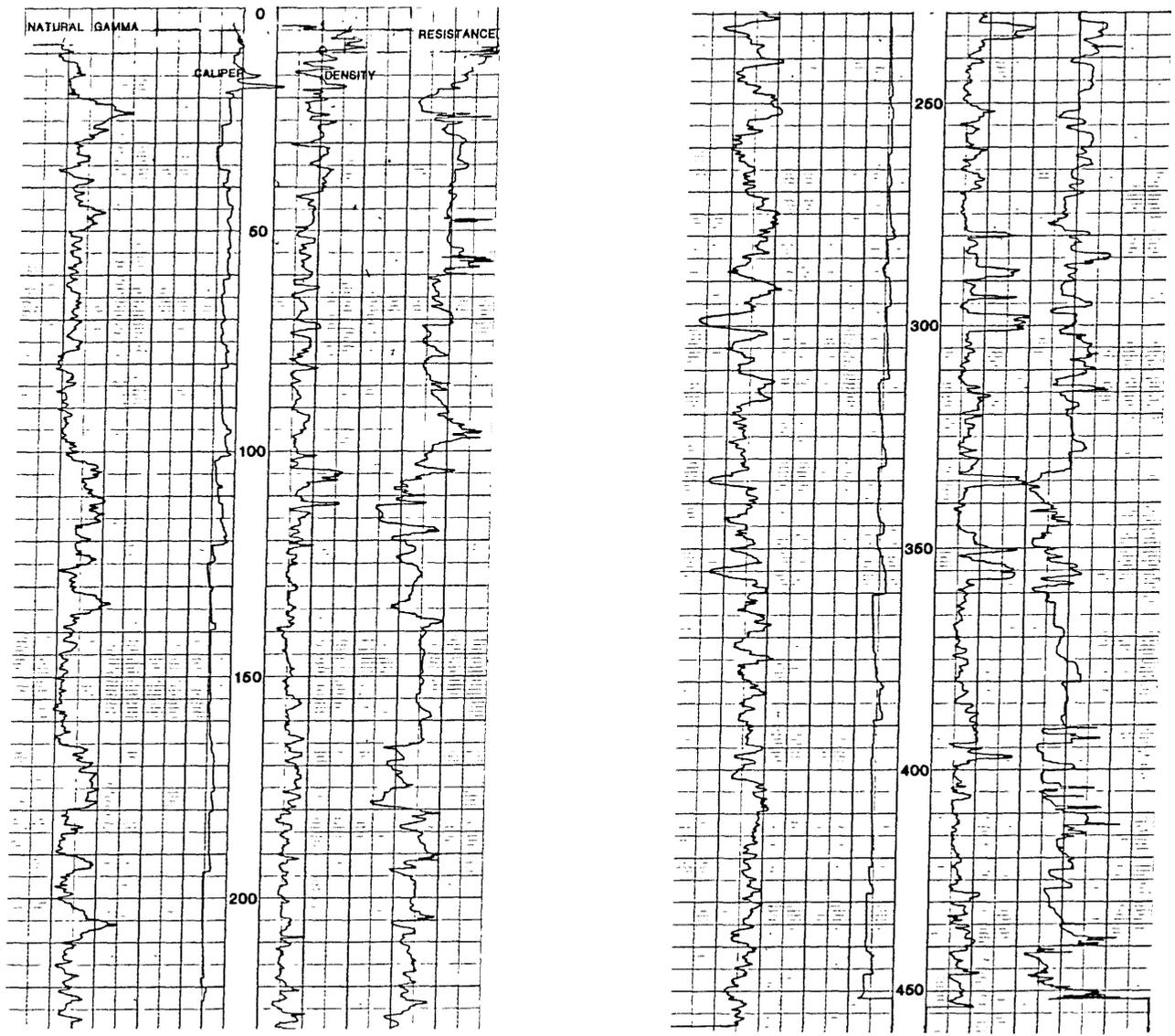


Figure 36.--Geophysical logs of hole GS-80

Sample log

Hole no.: GS-81 Date: 9-21-80 State: Montana County: Roosevelt  
 Elev. (ground): 2645 ft Location: T. 32 N., R. 51 E., Sec. NE NE 20  
 Total depth: 460 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-27	Silt, sand, and gravel, light-olive-gray, unconsolidated
27-57	Sandstone, yellowish-gray, very fine grained; interbedded with claystone in lower half of interval
57-64	Claystone, light-olive-brown to dark-yellowish-orange
64-86	Sandstone, very fine grained; interbedded with claystone near middle of interval
86-97	Claystone, white; traces of carbonaceous claystone
97-139	Sandstone, yellowish-gray, very fine grained; minor coal fragments
139-168	Siltstone, light-gray to light-olive-gray; grades to claystone at top and near base of interval; trace of coal at top and coal from 155 to 156 ft
168-209	Siltstone, medium-light-gray to yellowish-gray; scattered traces of coal and carbonaceous claystone; coal from 195 to 196 ft
209-220	Siltstone, medium-gray, sandy; abundant organic debris
220-246	Sandstone, light-gray, fine-to very fine grained, silty
246-302	Sandstone, light-bluish-gray, fine-to very fine grained, poorly sorted, calcareous; 15 percent dark opaque grains
302-304	Lignite, black
304-356	Claystone, light-olive-gray to greenish-gray; scattered interbedded siltstone; coal from 353 to 354 ft; carbonaceous at base
356-383	Siltstone, light-olive-gray to greenish-gray; traces of organic debris at top of interval; coal from 359 to 360 ft; calcareous concretion 379 to 381 ft
383-417	Claystone, light-olive-gray to light-gray, silty
417-421	Lignite, black
421-439	Siltstone, light-olive-gray, sandy; scattered interbedded claystone; probable coal from 425-426 ft
439-460	Claystone, light-olive-gray, sandy; abundant coal fragments at top of interval
Total depth 460 ft	

Hole no: GS-81      Date: 9-21-80      State: Montana      County: Roosevelt  
 Sec. NE NE 20      T. 32 N.      R. 51 E.      Elevation: 2645 ft      Total depth 460 ft  
 Logging speed: 15 ft/min      Natural gamma: TC 2, Range 12 cps      Density: TC 1,  
 Range 170 cps      Resistance: 15 ohms/in      Caliper: Horizontal scale 4 in/in

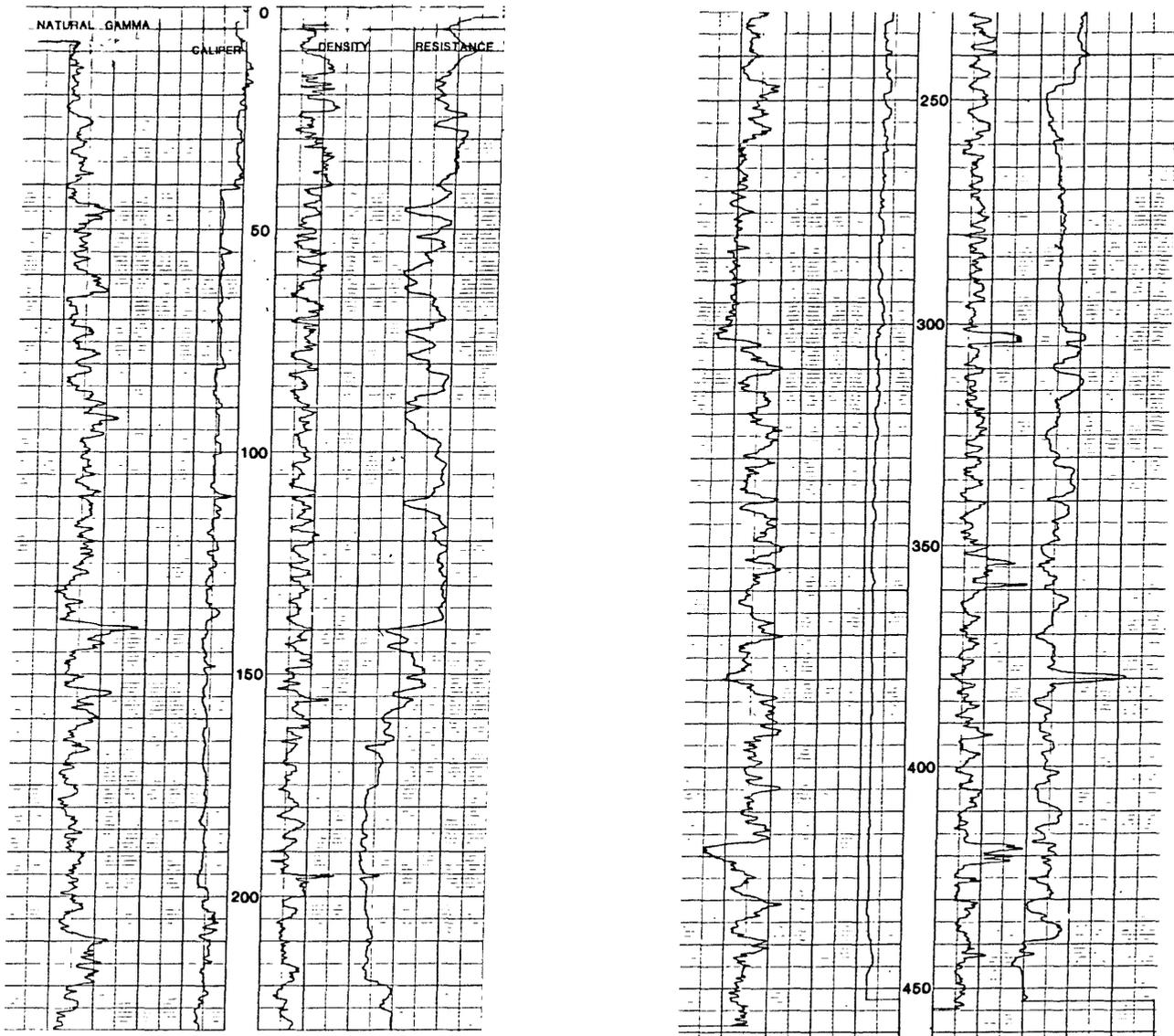


Figure 37.--Geophysical logs of hole GS-81

Sample log

Hole no.: GS-83    Date: 9-18-80    State: Montana    County: Roosevelt

Elev. (ground): 2660 ft    Location: T. 32 N., R. 50 E., Sec. NE NE 3

Total depth: 480 ft    Drilling medium: mud    Offset core hole: none

Depth (feet)	Lithic description
0-29	Silt, sand, and gravel, light-olive-gray, unconsolidated; gravel increases in abundance near base
29-46	Claystone, yellowish-gray to greenish-gray, silty; traces of of carbonaceous claystone at top of interval
46-69	Siltstone, dusky-yellow to moderate-yellow; calcareous concretion fragments near top of interval; slightly carbonaceous at base; agrillaceous at top and base
69-101	Claystone, greenish-gray to dusky-yellow; silty near base; traces of carbonaceous claystone throughout interval
101-103	Lignite, black
103-122	Siltstone, light-bluish-gray; minor coal fragments scattered throughout interval
122-124	Lignite, black
124-130	Claystone, greenish-gray
130-158	Sandstone, greenish-gray to light-olive-gray, very fine grained, silty; with interbedded siltstone; minor coal fragments at base
158-178	Siltstone, greenish-gray, sandy; interbedded claystone throughout interval
178-210	Siltstone, medium-gray to medium-dark-gray, very sandy; traces of carbonaceous claystone; probable thin coals at 179, 195, and 199 ft
210-256	Sandstone, very light gray, very fine grained; minor coal fragments at top of interval; grading silty near top of interval
256-291	Claystone, medium-gray; carbonaceous at base; sandy with minor coal fragments in upper half of interval
291-316	Claystone, light-olive-gray; slightly carbonaceous; sandy near top
316-341	Claystone, light-olive-gray; sandy at top of interval; calcareous concretion 322 to 324 ft
341-356	Siltstone, medium-light-gray, sandy; interbedded with claystone at base
356-359	Lignite, black

Sample log--Continued

Depth (feet)	Lithic description
359-376	Siltstone, light-olive-gray; with interbedded claystone throughout interval
376-389	Claystone, light-olive-gray
389-401	Sandstone, light-gray, very fine grained
401-424	Siltstone, medium-light-gray
424-431	Lignite, brownish-black to black; impure in upper part
431-439	Sandstone, very light gray, very fine grained
439-480	Claystone, light-gray, silty
	Total depth 480 ft

Hole no: GS-83      Date: 9-18-80      State: Montana      County: Roosevelt  
 Sec. NE NE 3      T. 32 N.      R. 50 E.      Elevation: 2660 ft      Total depth 480 ft  
 Logging speed: 15 ft/min      Natural gamma: TC 2, Range 12 cps      Density: TC 1,  
 Range 208 cps      Resistance: 15 ohms/in      Caliper: Horizontal scale 4 in/in

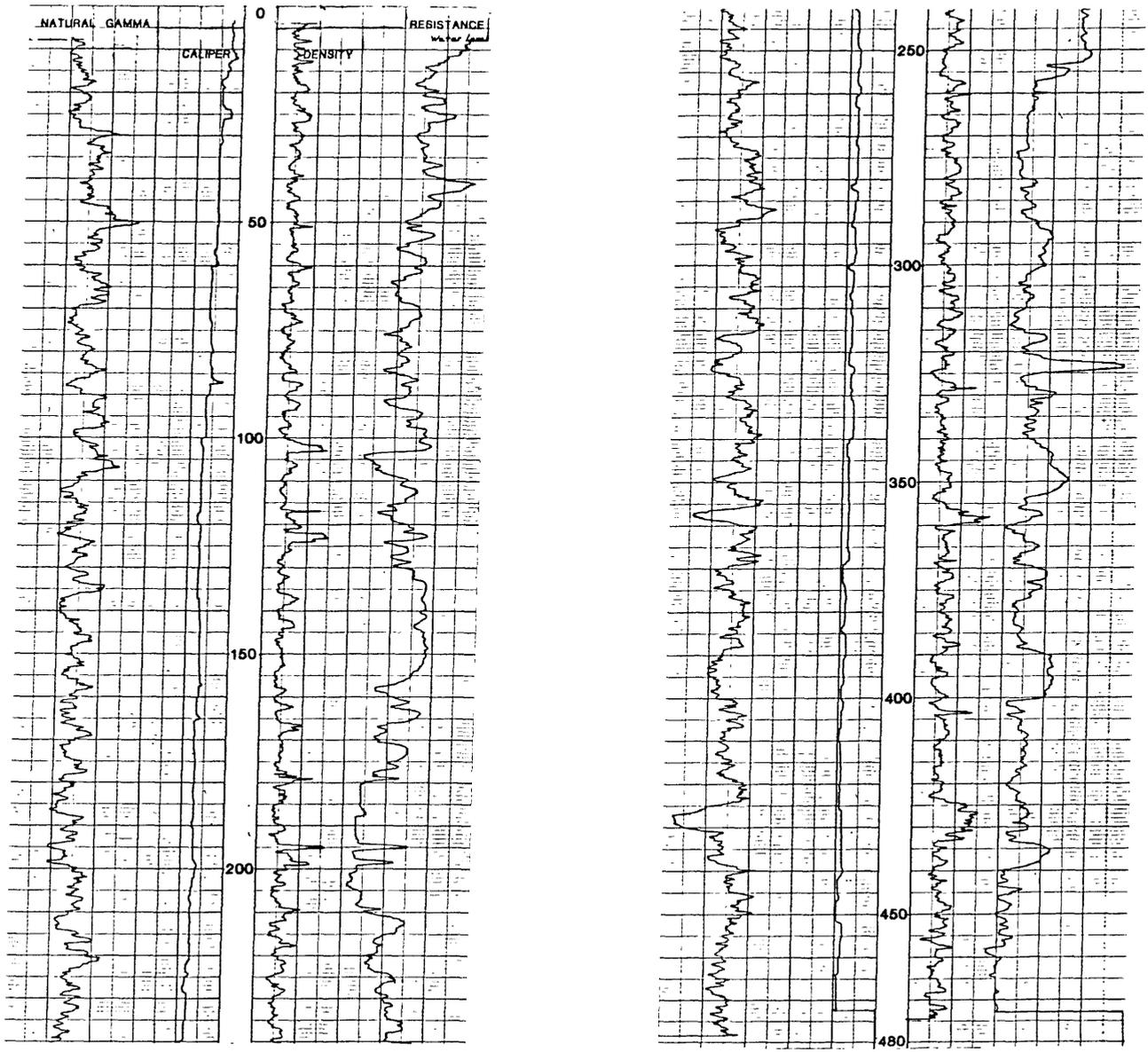


Figure 38.--Geophysical logs of hole GS-83

Sample log

Hole no.: GS-84 Date: 9-15-80 State: Montana County: Roosevelt

Elev. (ground): 2440 ft Location: T. 32 N., R. 50 E., Sec. NE SW 19

Total depth: 440 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-5	Silt, sand, and gravel, unconsolidated; about 30 percent oxidized coal fragments
5-26	Claystone, light-olive-gray to light-gray; with grayish-yellow sandstone parting 16 to 21 ft; few concretion fragments 15 to 20 ft
26-29	Lignite, black
29-32	Claystone, medium-gray
32-34	Lignite, black
34-51	Claystone, medium-gray to light-olive-gray; traces of carbonaceous shale; interbedded with sandstone at top of interval
51-67	Sandstone, light-gray to very light gray, very fine grained, well sorted; 10 percent dark opaque grains
67-80	Siltstone, light-to medium-light-gray; scattered carbonaceous claystone
80-81	Lignite, black
81-110	Siltstone, light-gray to medium-light-gray; traces of organic debris; sandy at top and base
110-119	Claystone, medium-light-gray
119-122	Shale, olive-black, carbonaceous
122-155	Sandstone, greenish-gray; with thin interbedded claystone, siltstone, and carbonaceous shale throughout interval; traces of organic debris at base
155-164	Sandstone, yellowish-gray, very fine grained, well sorted, iron-stained; 10-15 percent dark opaque grains; traces of carbonaceous shale
164-192	Sandstone, yellowish-gray to light-olive-gray, very fine grained; well sorted; 10 percent dark opaque grains; scattered thinly interbedded claystone; fine-grained in lower part
192-193	Lignite, black
193-218	Claystone, light-olive-gray; silty near middle of interval; traces of carbonaceous shale at base

Sample log--Continued

Depth (feet)	Lithic description
218-228	Sandstone, light-bluish-gray, very fine grained, silty
228-242	Claystone, light-olive-gray; traces of carbonaceous shale
242-263	Sandstone, light-gray to medium-light-gray, very fine grained
263-285	Sandstone, light-bluish-gray, fine-to very fine grained; about 20 percent dark opaque grains; silty at top of interval
285-334	Sandstone, light-bluish-gray, fine-to very fine grained; scattered interbedded siltstone
334-346	Claystone, light-olive-gray, silty
346-349	Sandstone, light-gray, very fine grained
349-380	Siltstone, light-olive-gray to olive-gray; sandy near middle of interval
380-402	Sandstone, light-bluish-gray, very fine grained
402-440	Claystone, light-gray to very light gray
	Total depth 440 ft

Hole no: GS-84 Date: 9-15-80 State: Montana County: Roosevelt  
Sec. NE SW 19 T. 32 N. R. 50 E. Elevation: 2440 ft Total depth: 440 ft  
Logging speed: 15 ft/min Natural gamma: TC 1, Range 15 cps Density: TC 1,  
Range 165 cps Resistance: 30 ohms/in Caliper: Horizontal scale 3 in/in

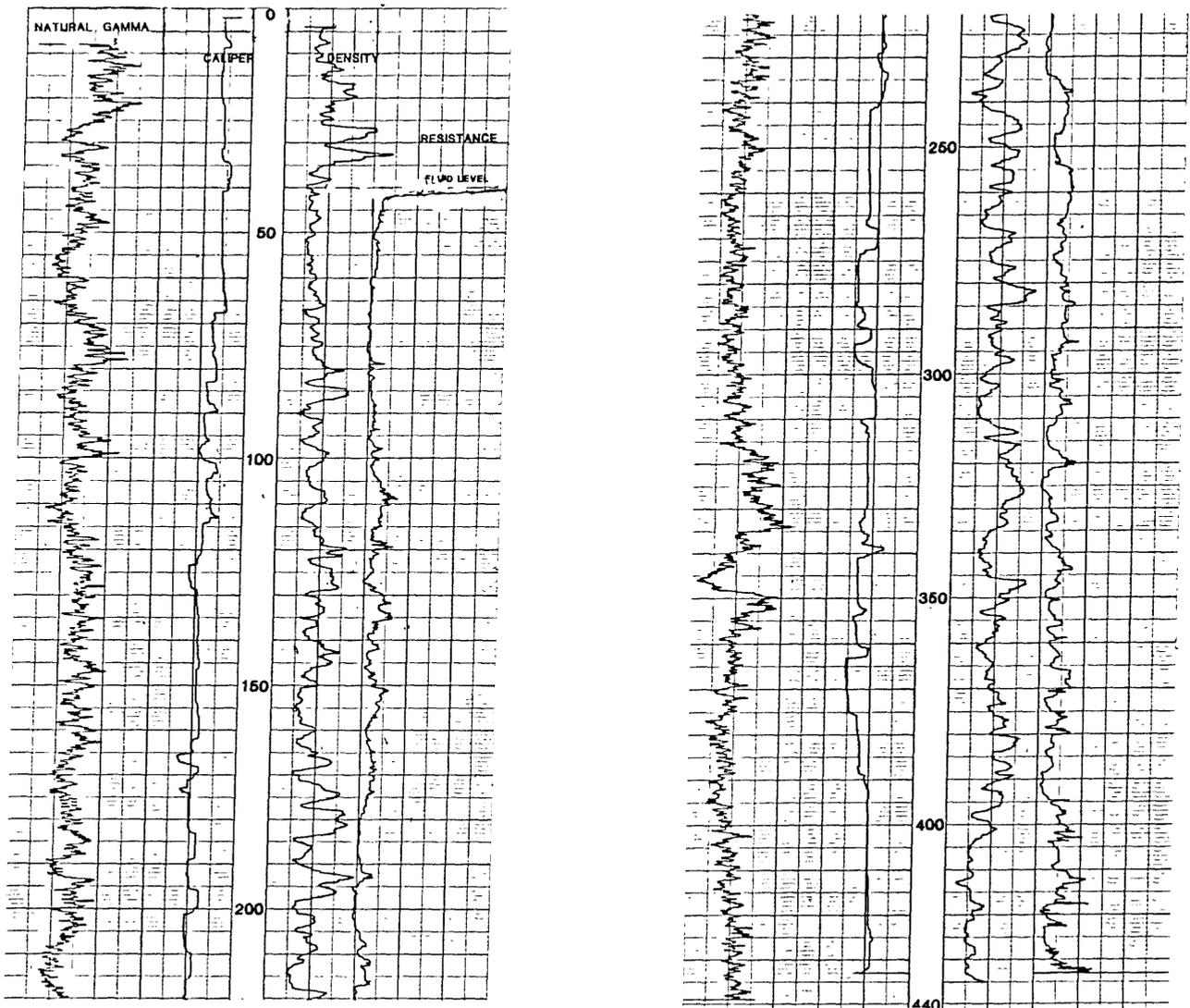


Figure 39.--Geophysical logs of hole GS-84

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