

UNITED STATES DEPARTMENT OF THE INTERIOR
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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Open-File Report 82-538

1982

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

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

By Harold H. Arndt, John K. Hardie, and Thomas M. Kehn

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.

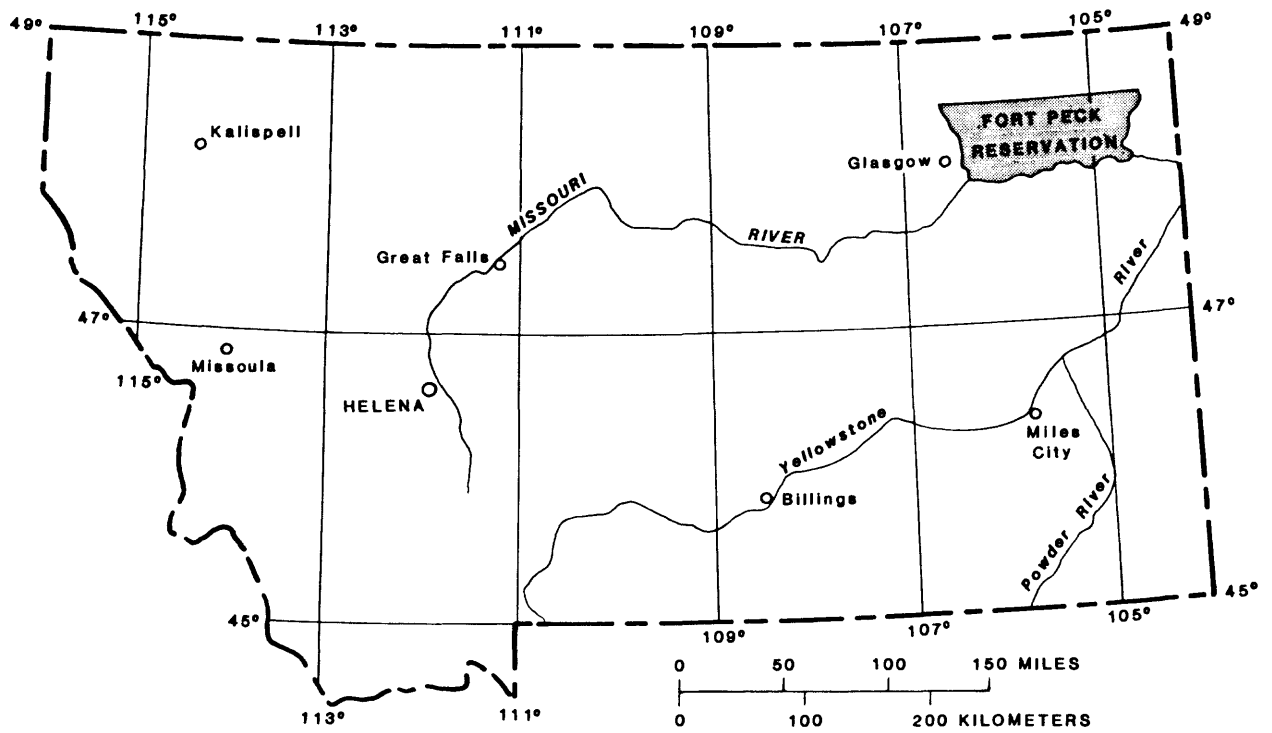


Figure 1.--Index map of Montana showing location of Fort Peck Indian Reservation.

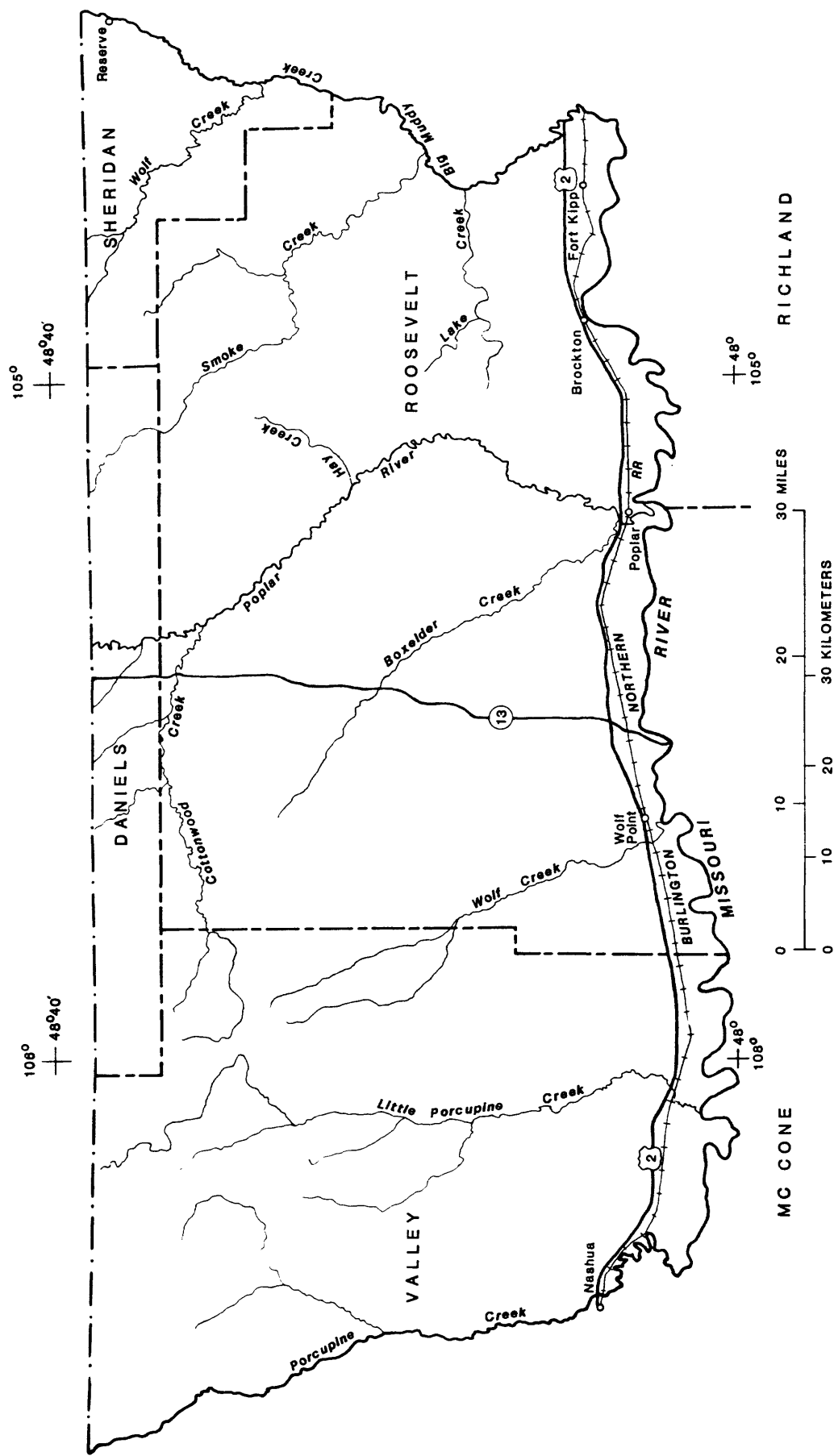


Figure 2.--Index map of Fort Peck Indian Reservation, northeastern Montana.

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.

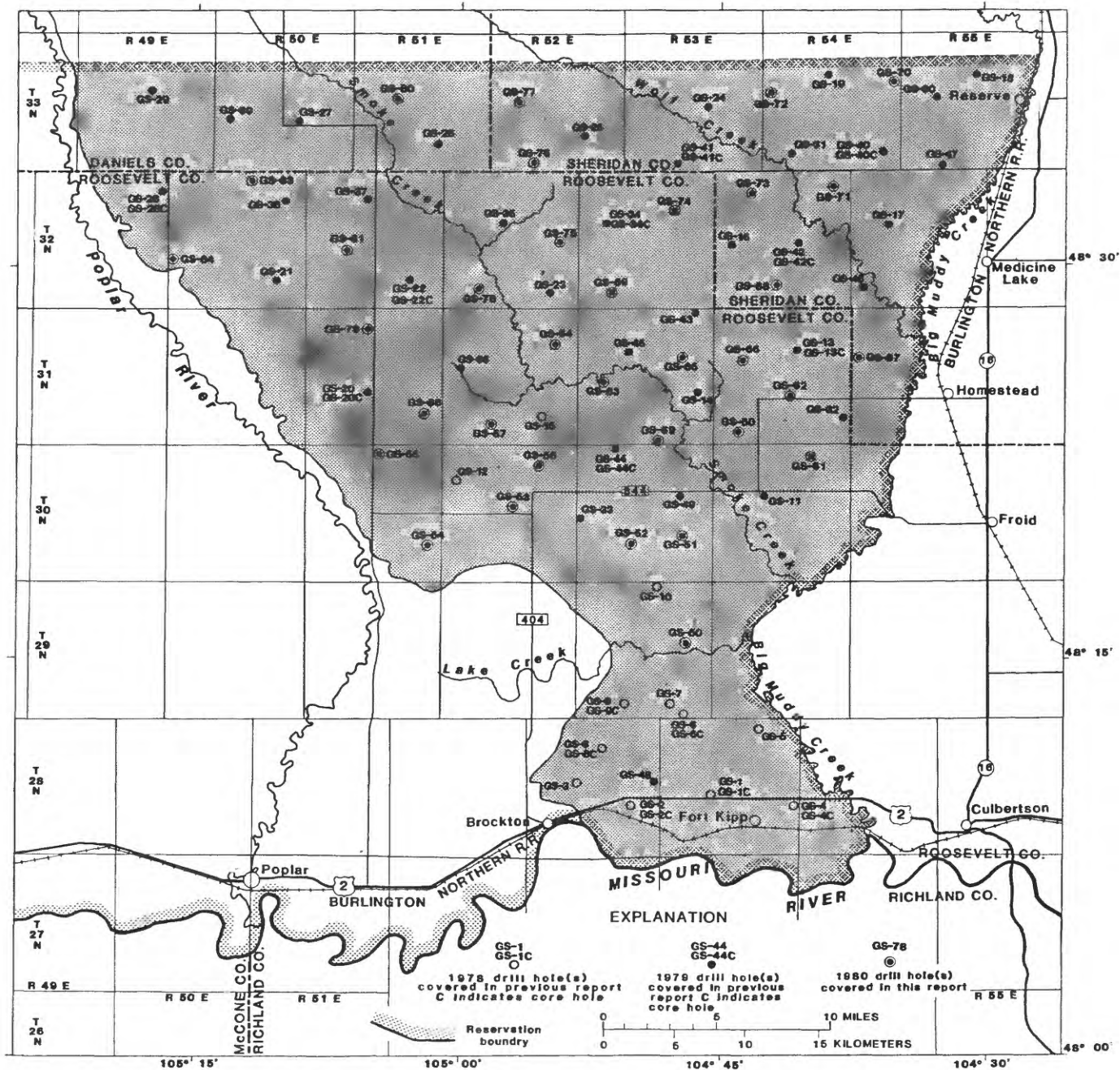
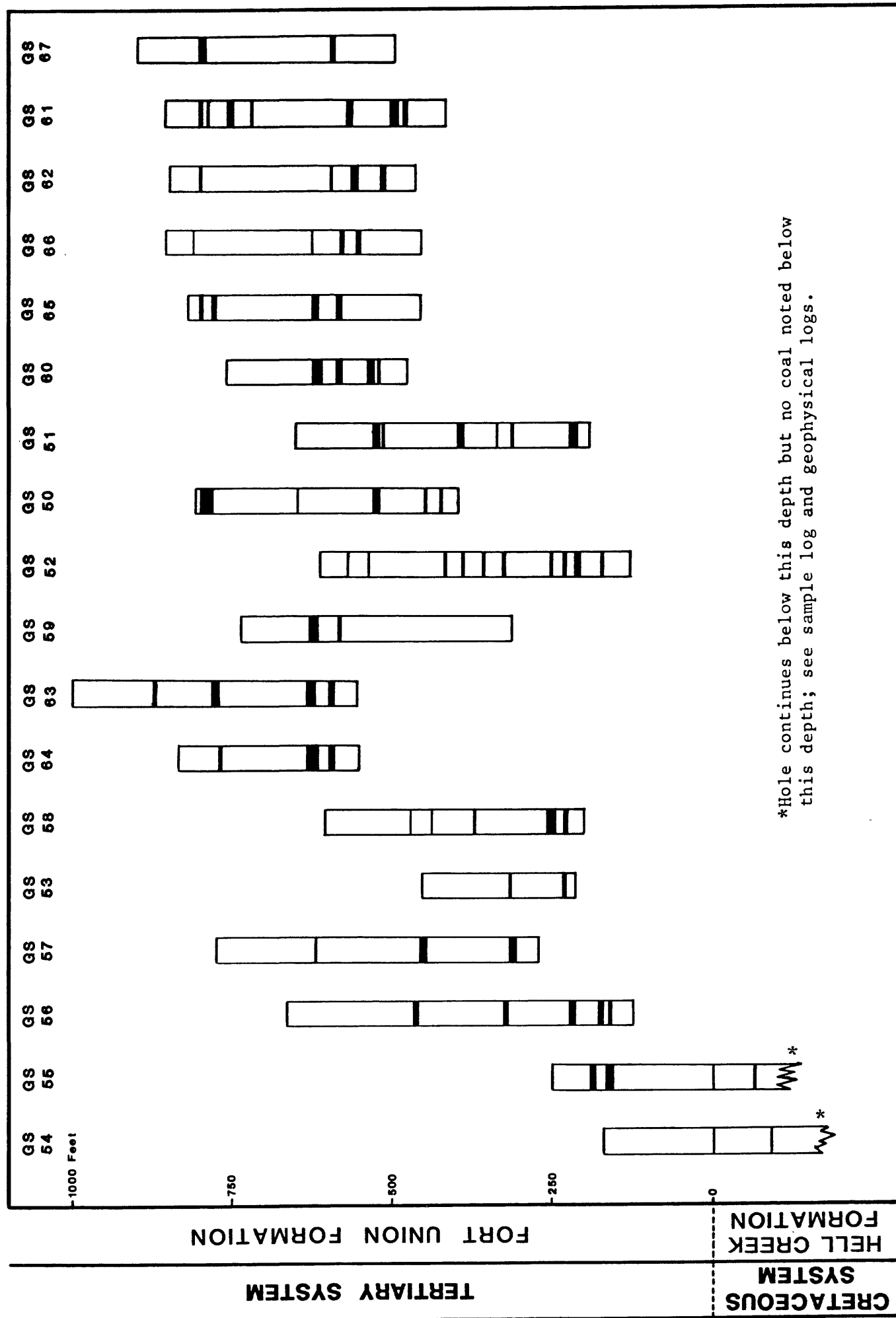


Figure 3.--Map showing locations of drill holes and area underlain by the Fort Union Formation (shaded) in the eastern part of the Fort Peck Indian Reservation, Montana.



*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).

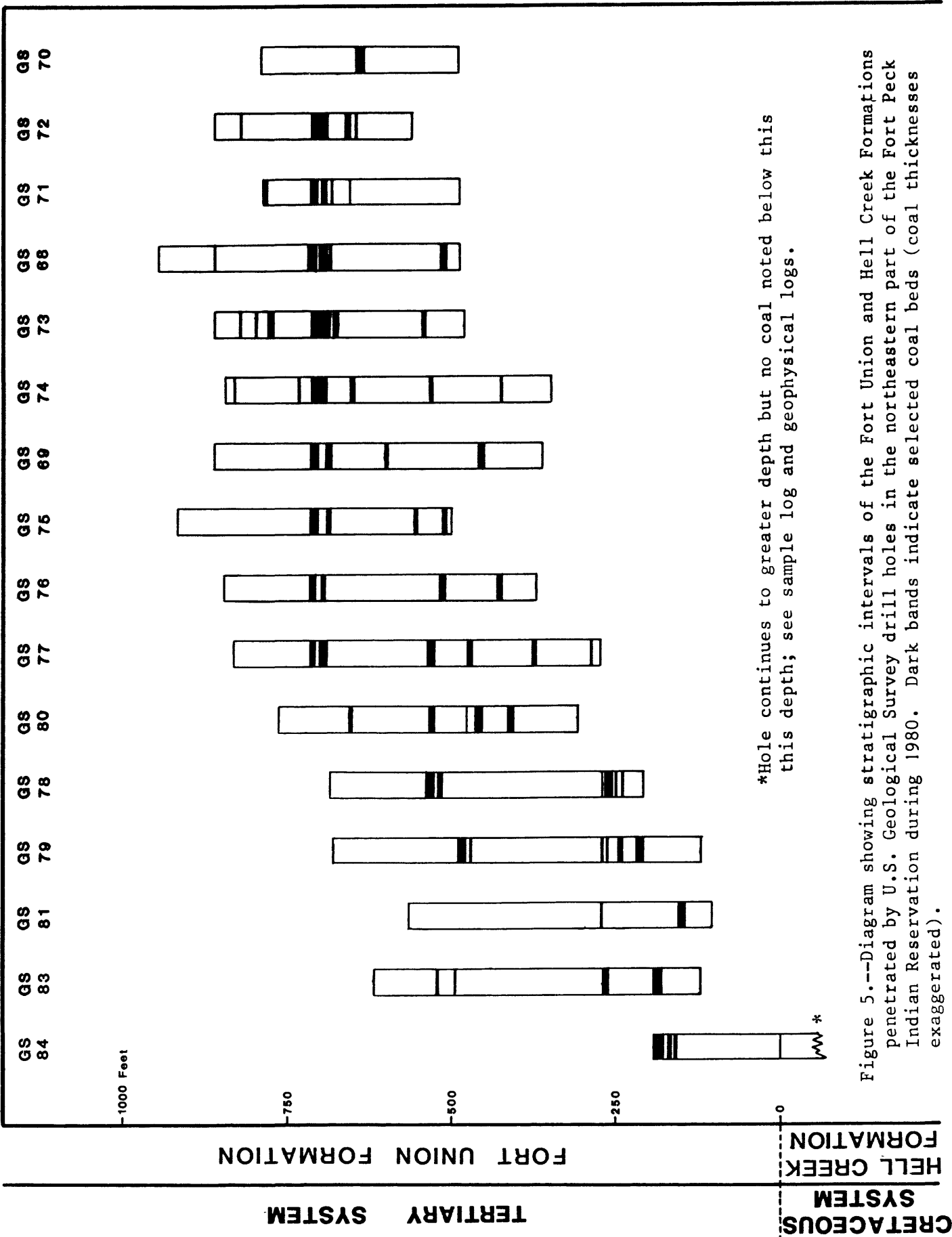


Figure 5.--Diagram showing stratigraphic intervals of the Fort Union and Hell Creek Formations penetrated by U.S. Geological Survey drill holes in the northeastern part of the Fort Peck Indian Reservation during 1980. Dark bands indicate selected coal beds (coal thicknesses exaggerated).

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

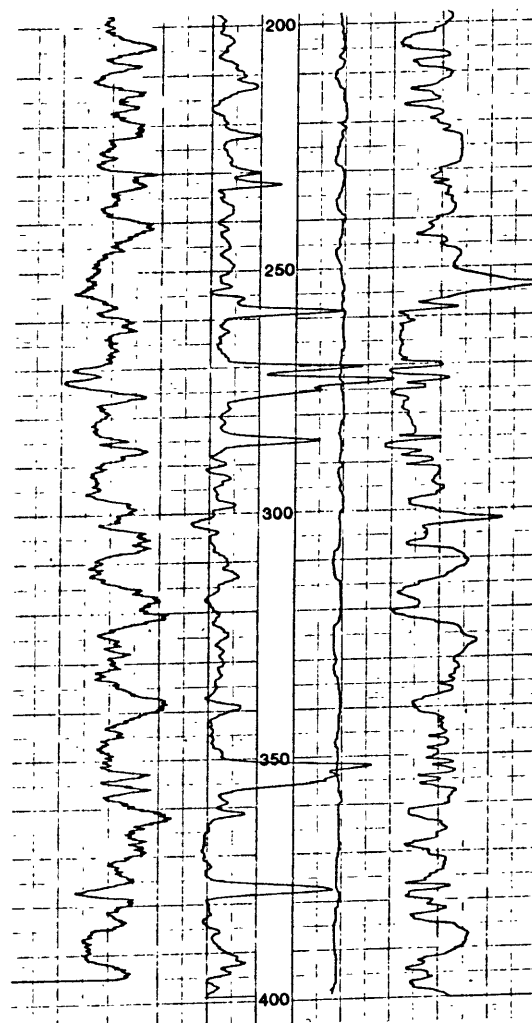
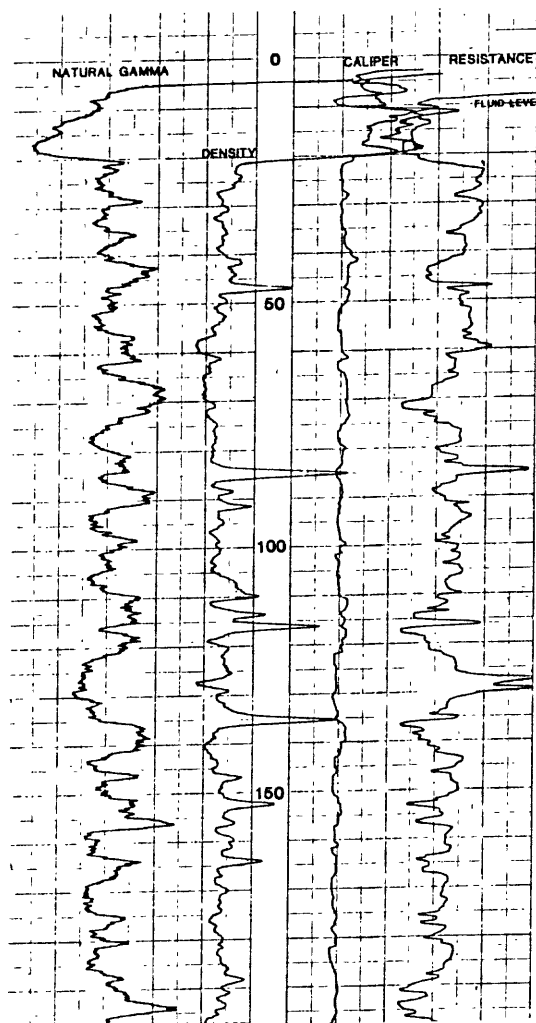


Figure 6.--Geophysical logs of hole GS-50

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

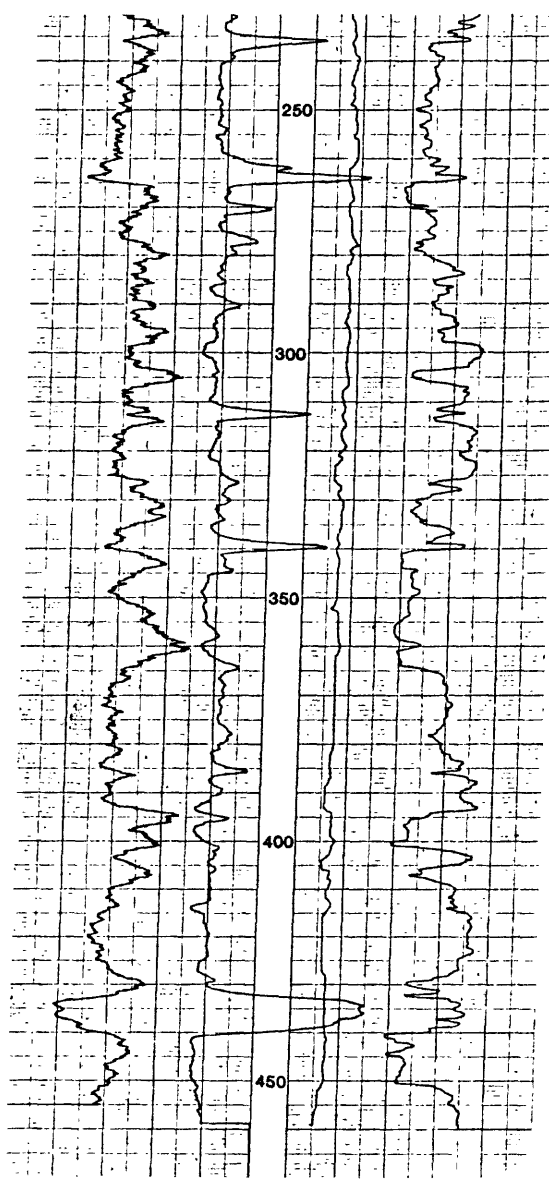
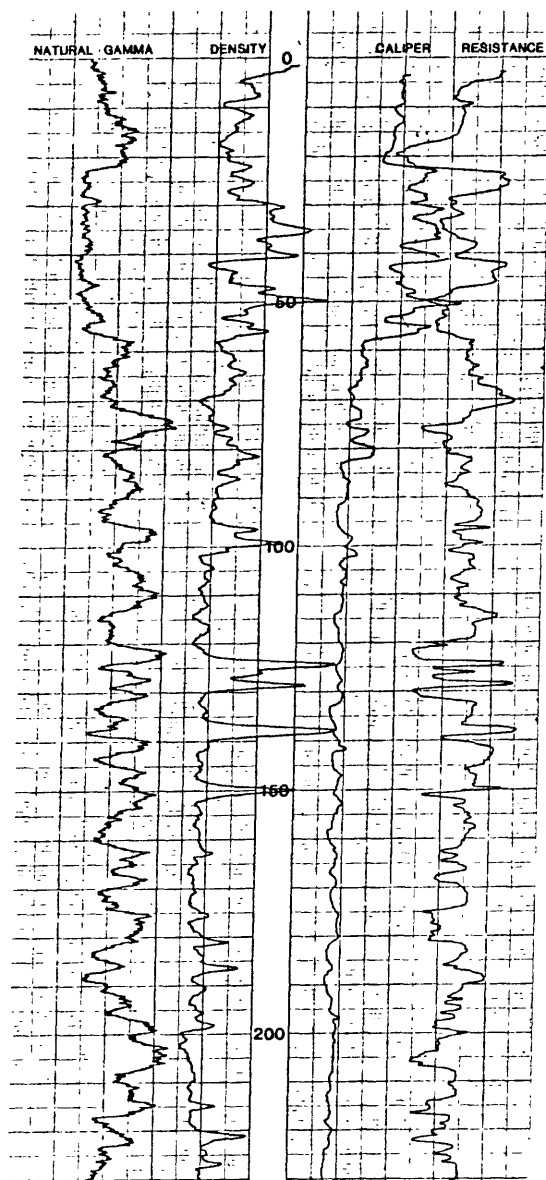


Figure 7.--Geophysical logs of hole GS-51

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

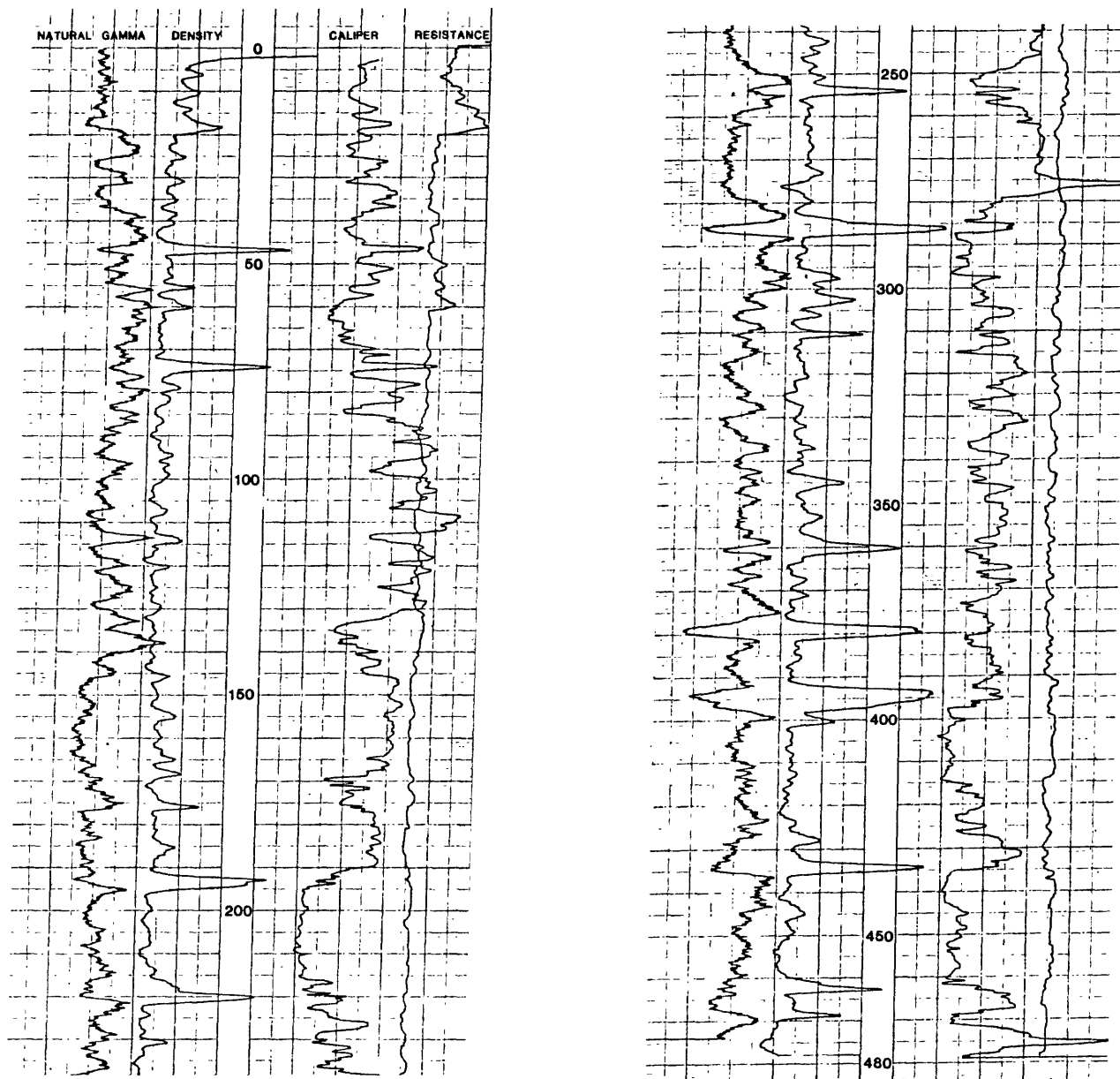


Figure 8.--Geophysical logs of hole GS-52

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

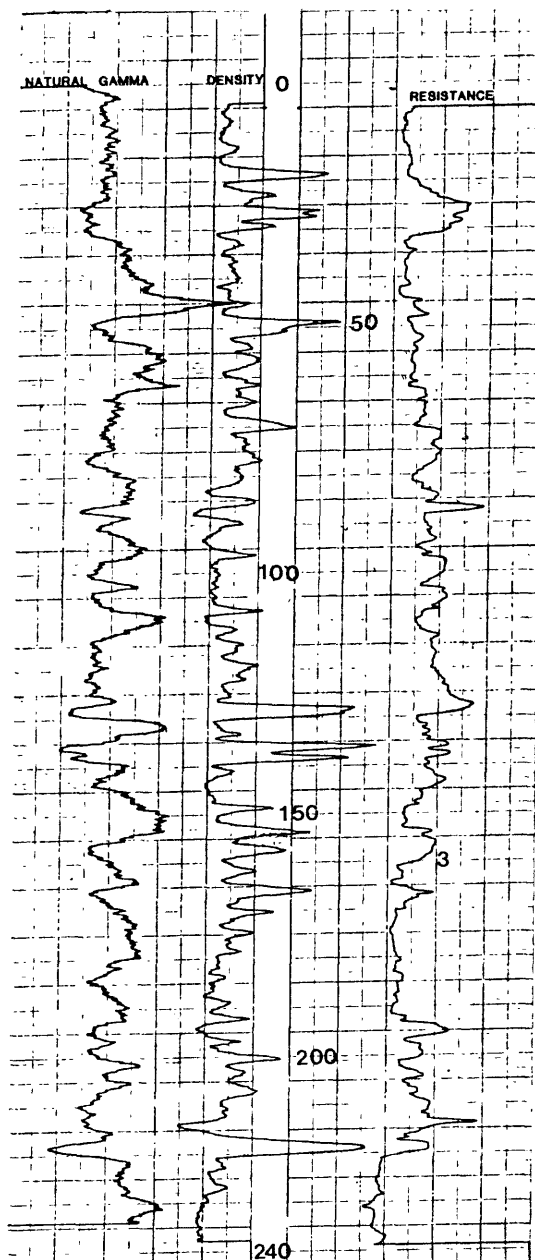


Figure 9.--Geophysical logs of hole GS-53

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

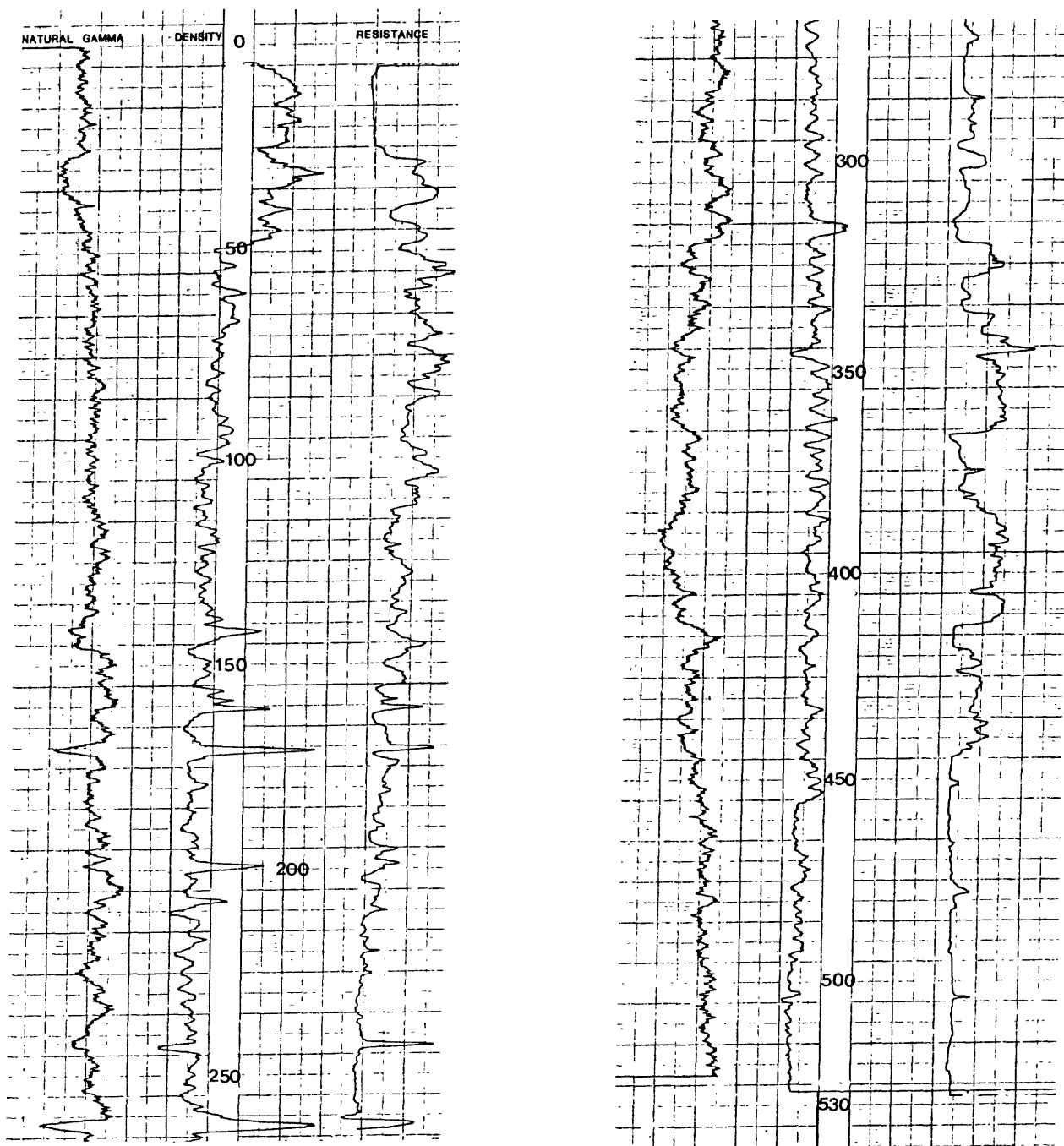


Figure 10.--Geophysical logs of hole GS-54

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

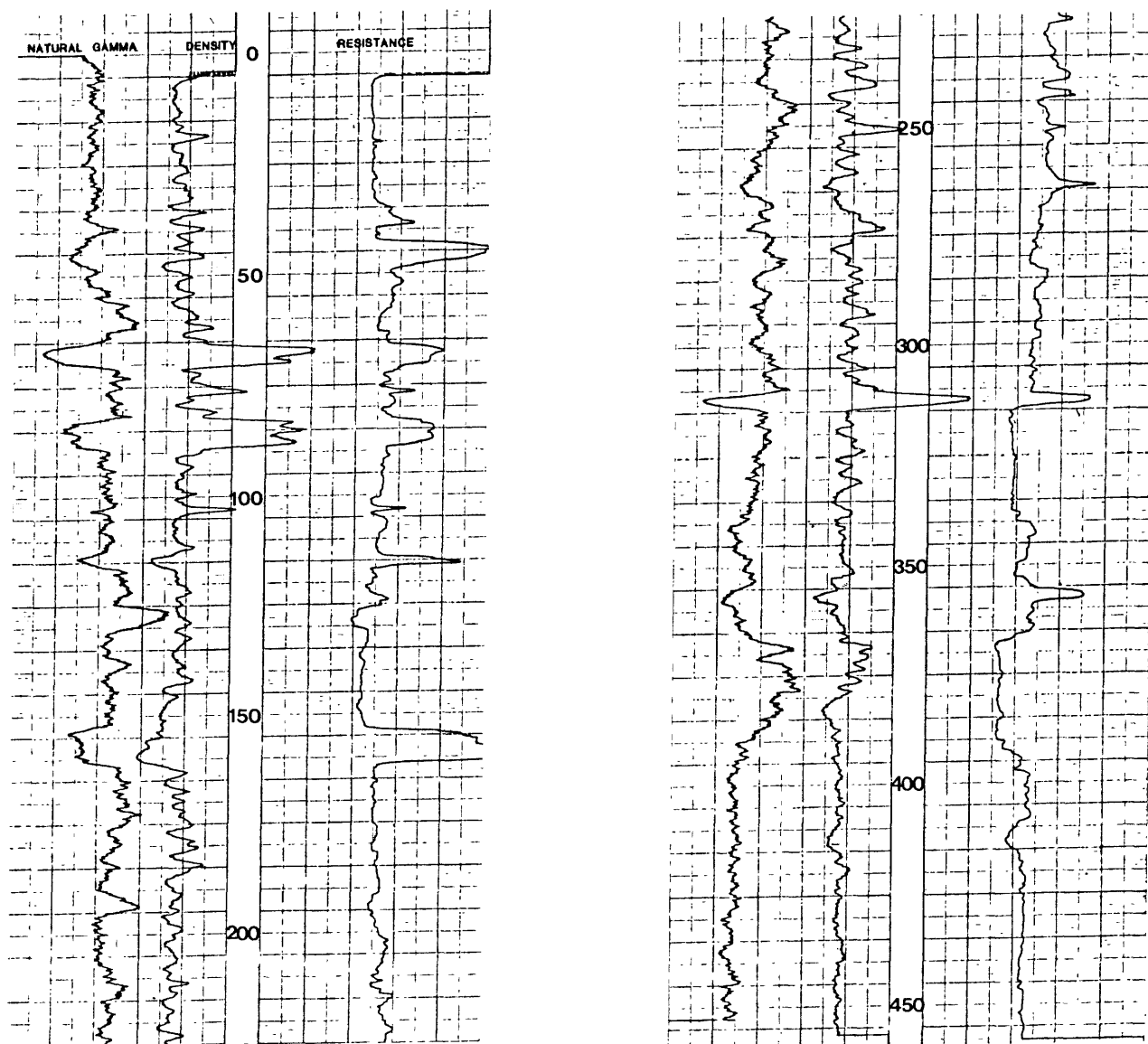


Figure 11.--Geophysical logs of hole GS-55

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 inter-bedded 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

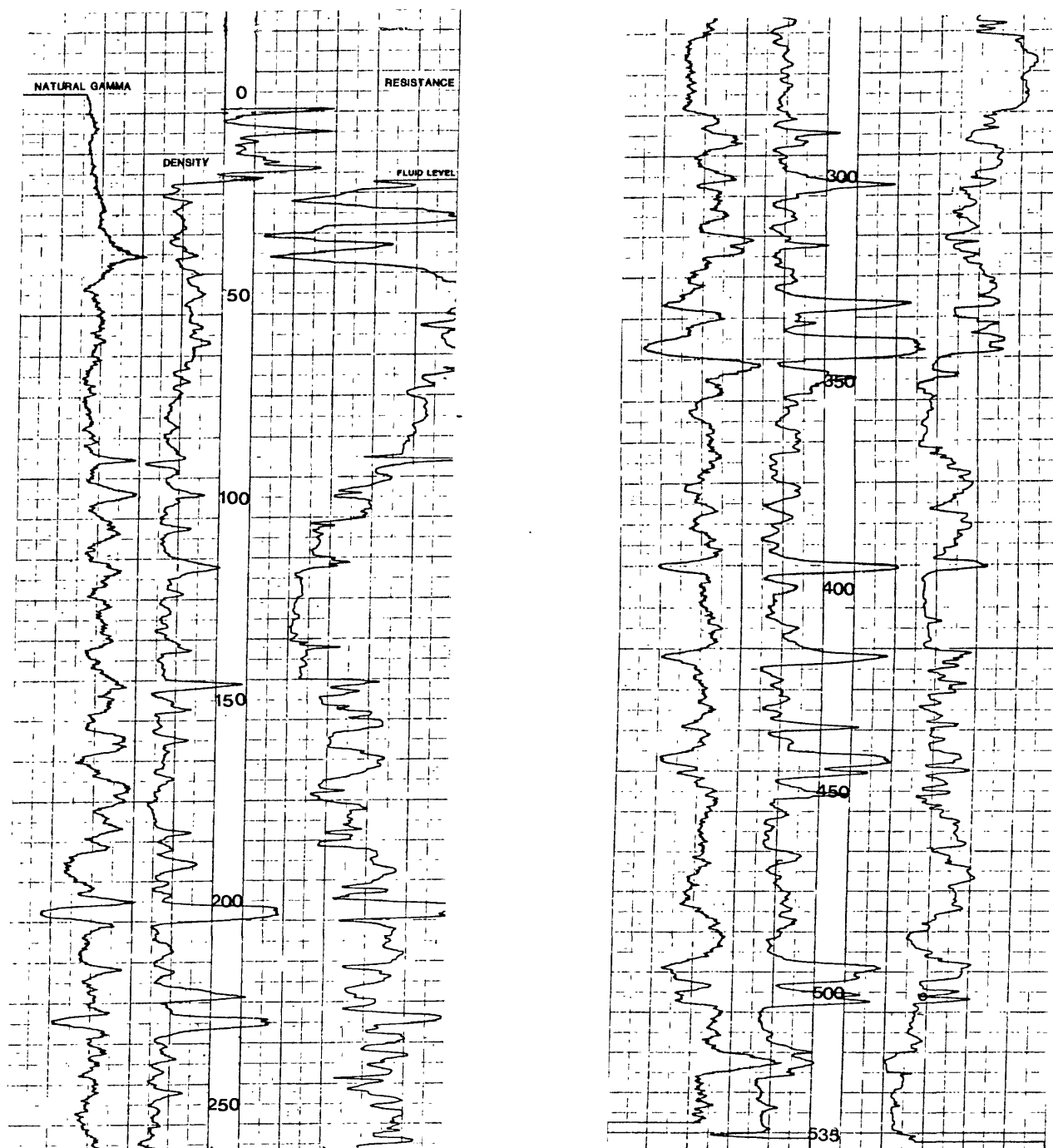


Figure 12.--Geophysical logs of hole GS-56

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

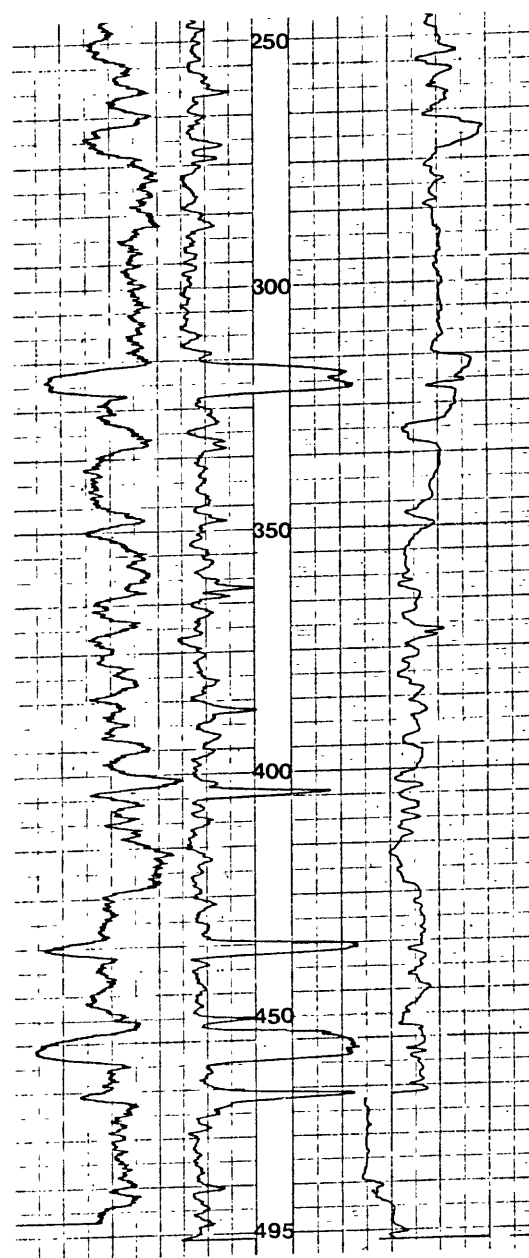
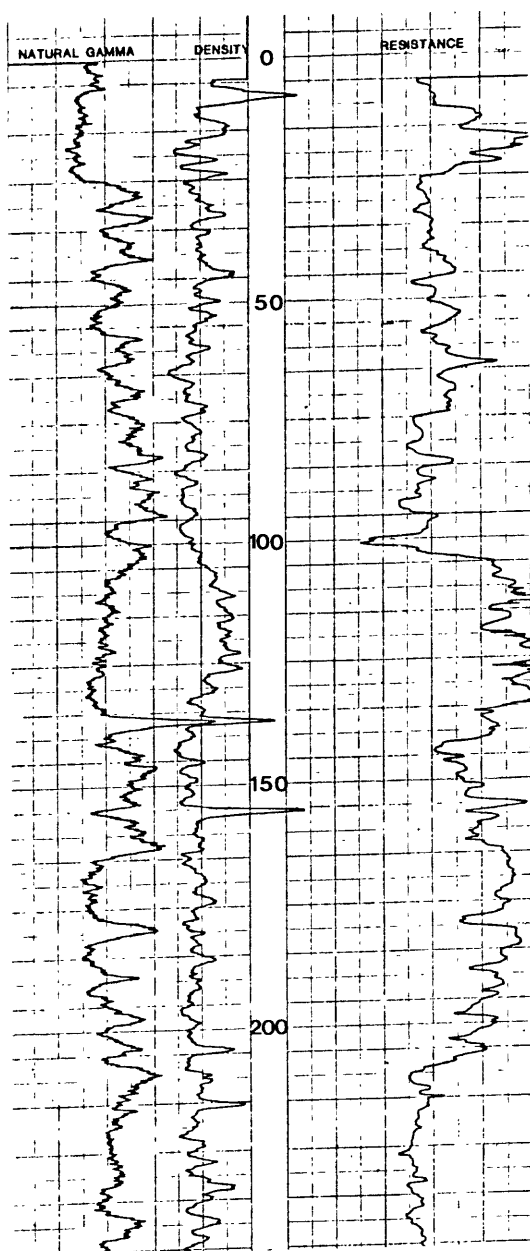


Figure 13.--Geophysical logs of hole GS-57

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

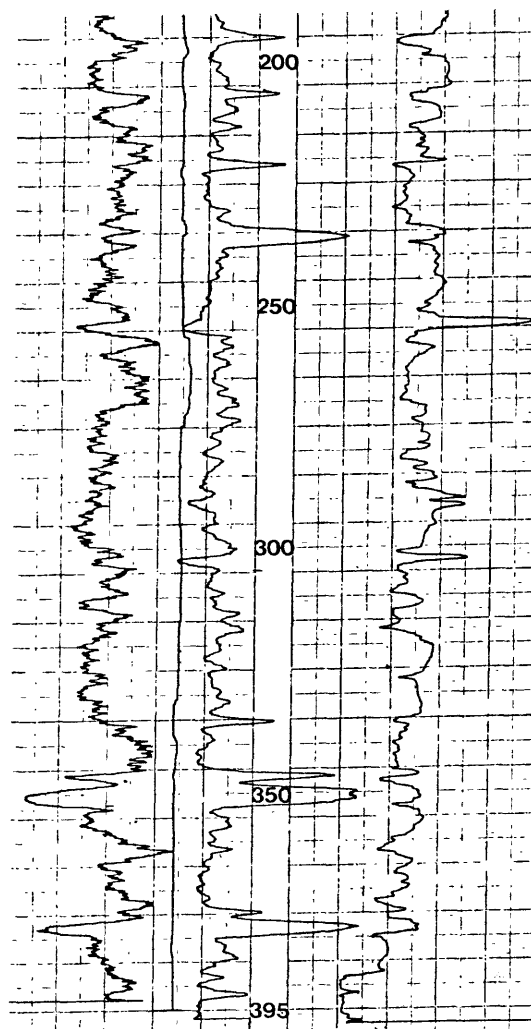
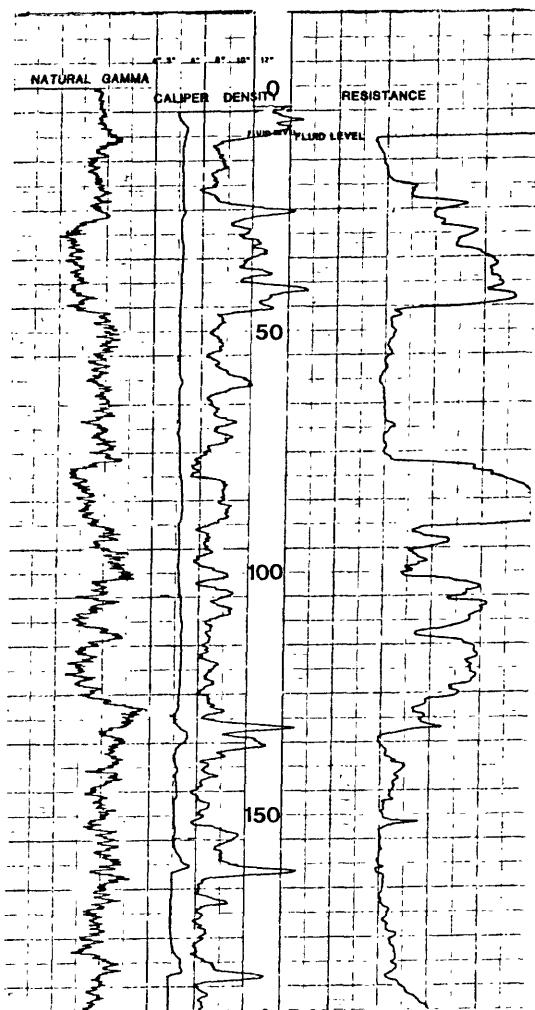


Figure 14.--Geophysical logs of hole GS-58

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

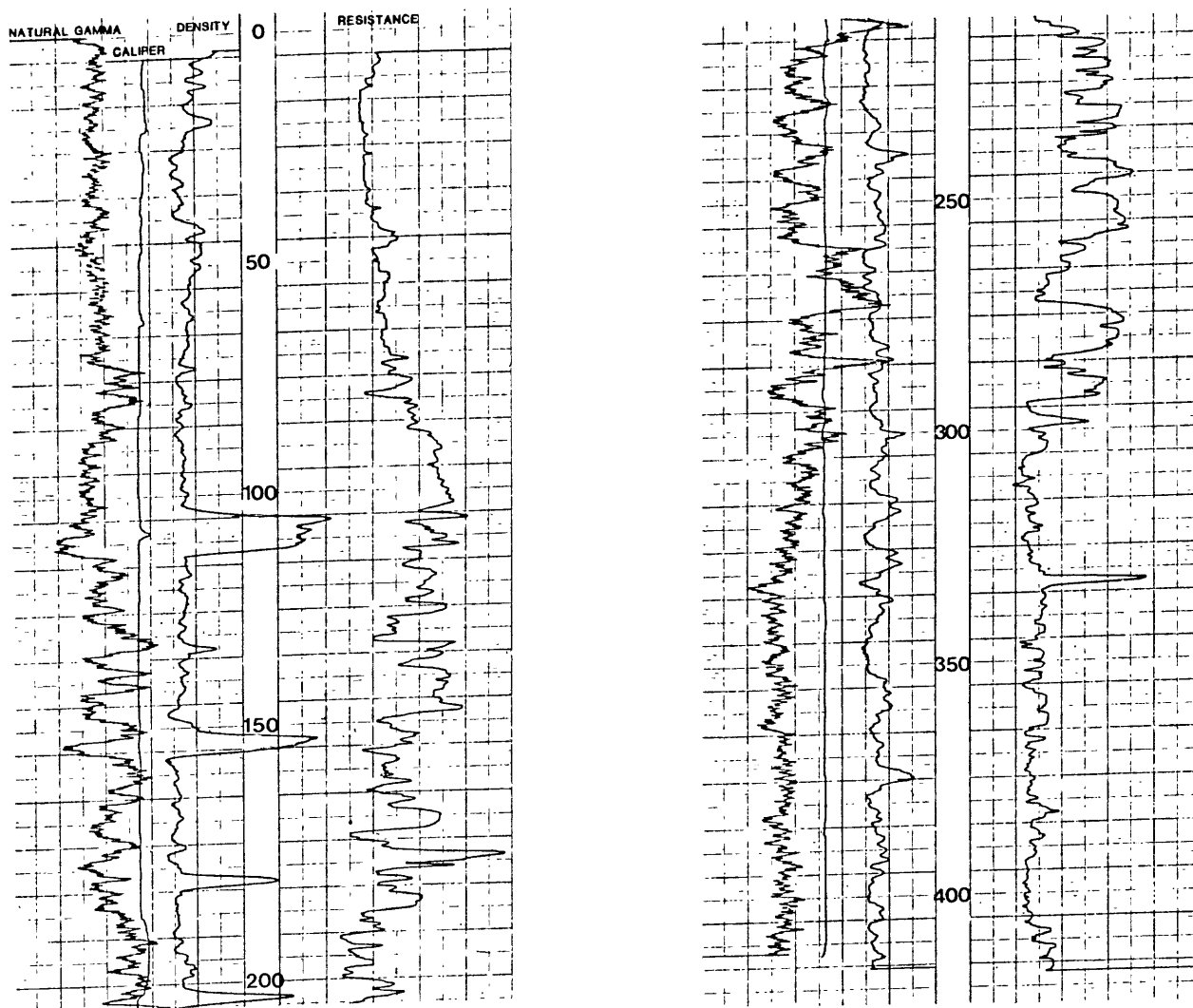


Figure 15.--Geophysical logs of hole GS-59

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

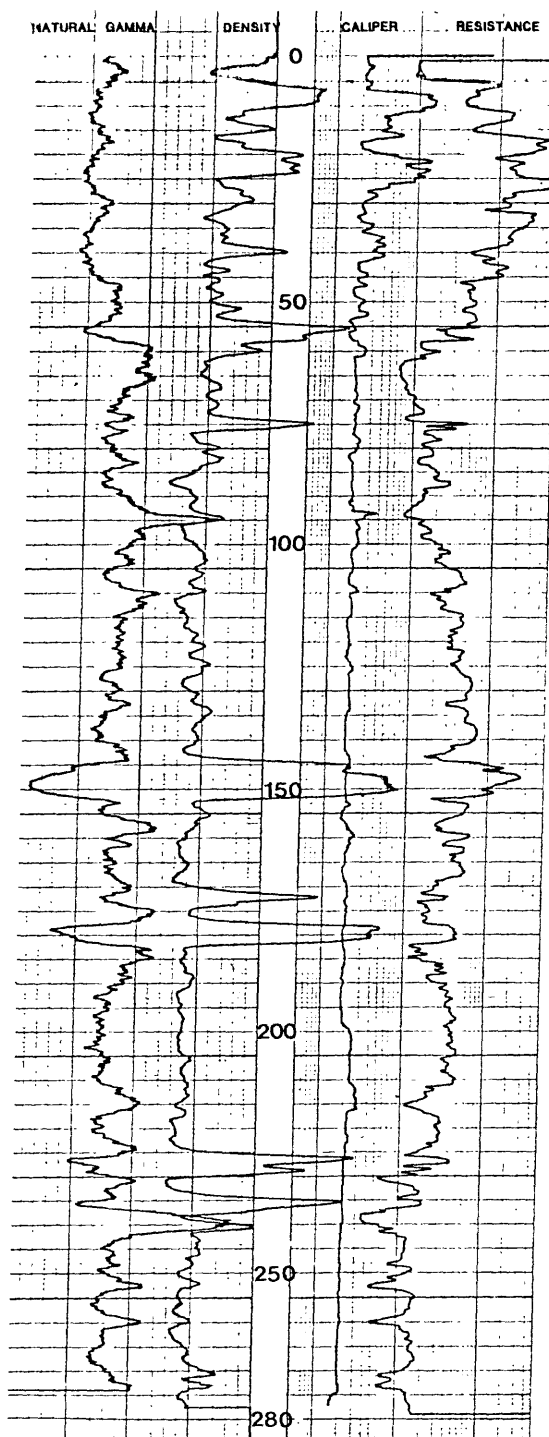


Figure 16.--Geophysical logs of hole GS-60

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

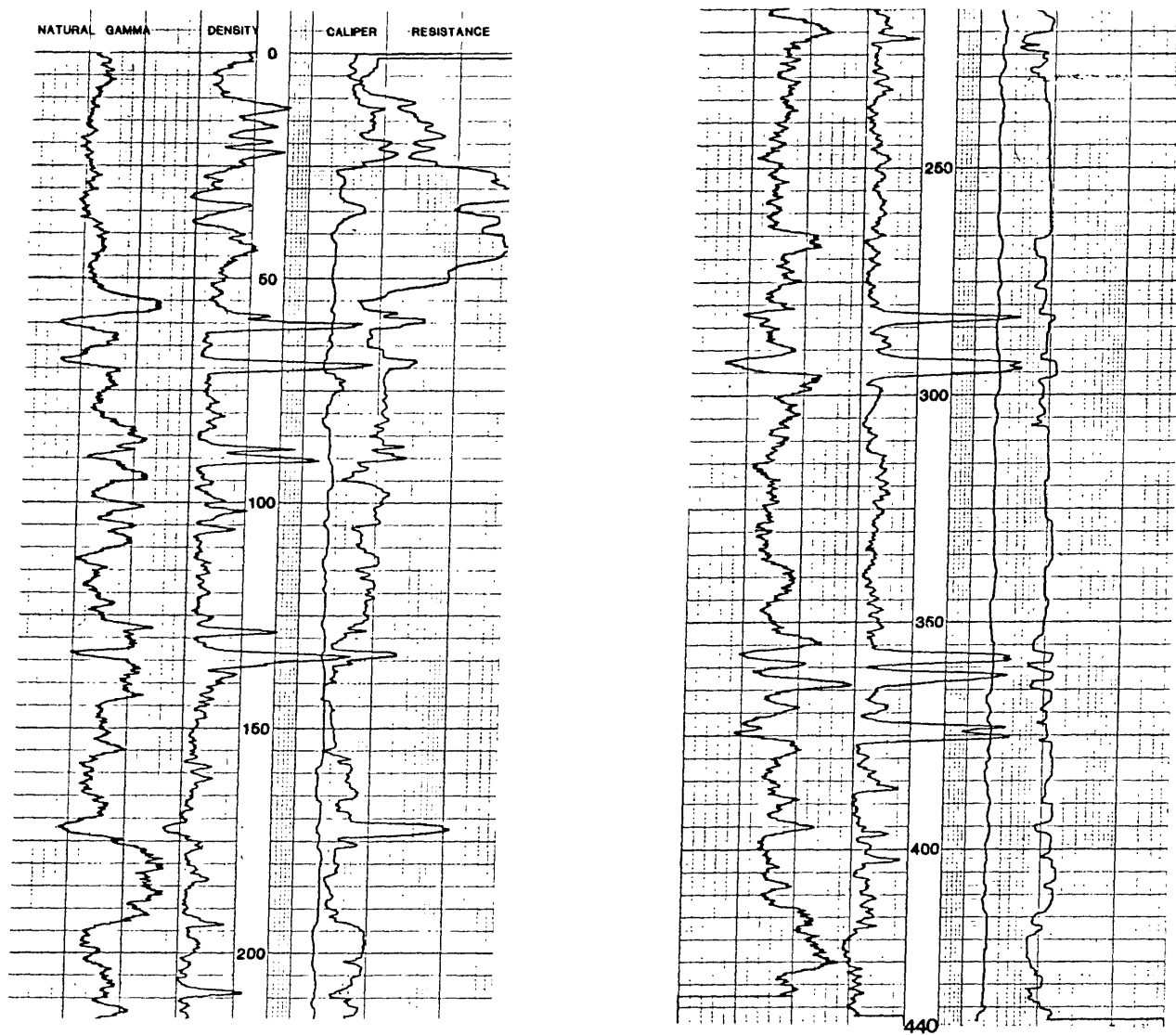


Figure 17.--Geophysical logs of hole GS-61

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 |
|-----------------|---|
| <hr/> | |
| 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

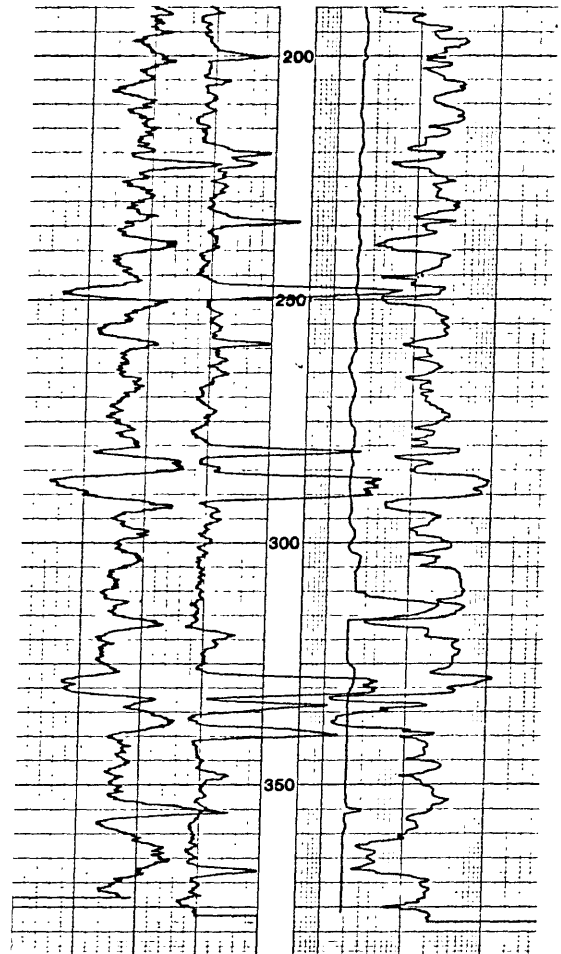
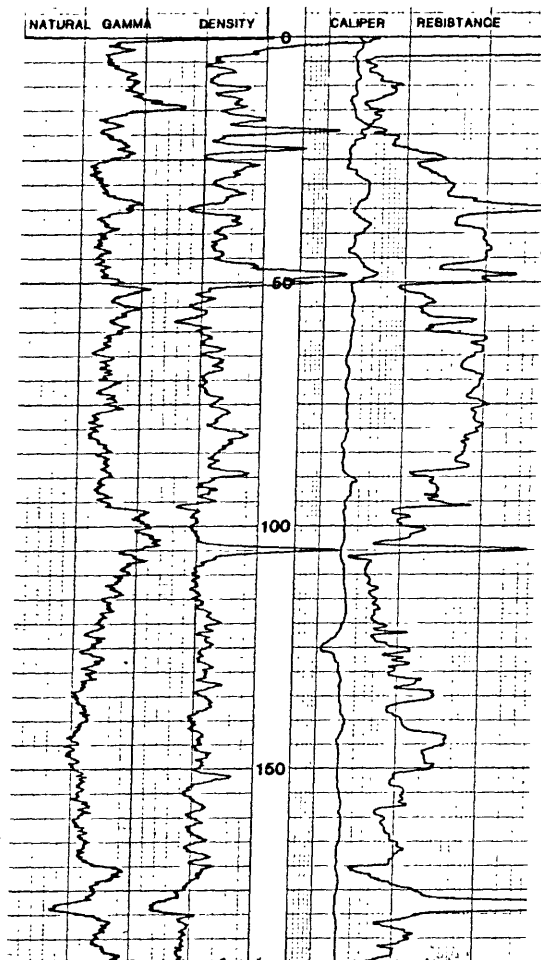


Figure 18.--Geophysical logs of hole GS-62

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

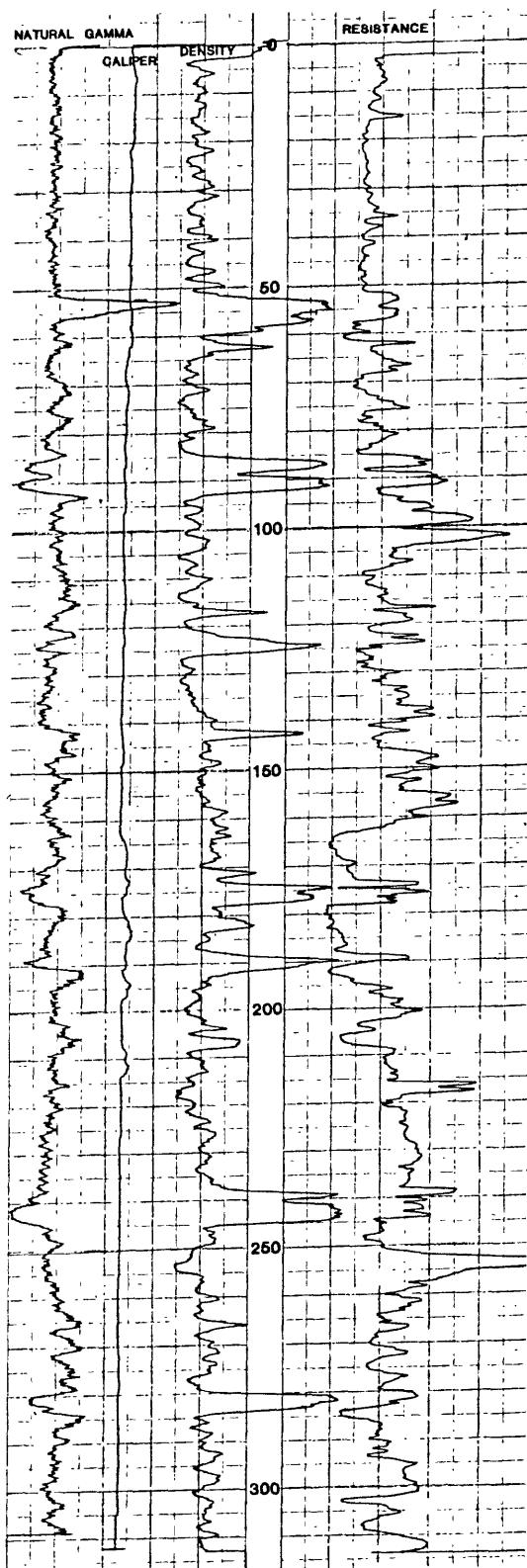


Figure 19.--Geophysical logs of hole GS-63

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

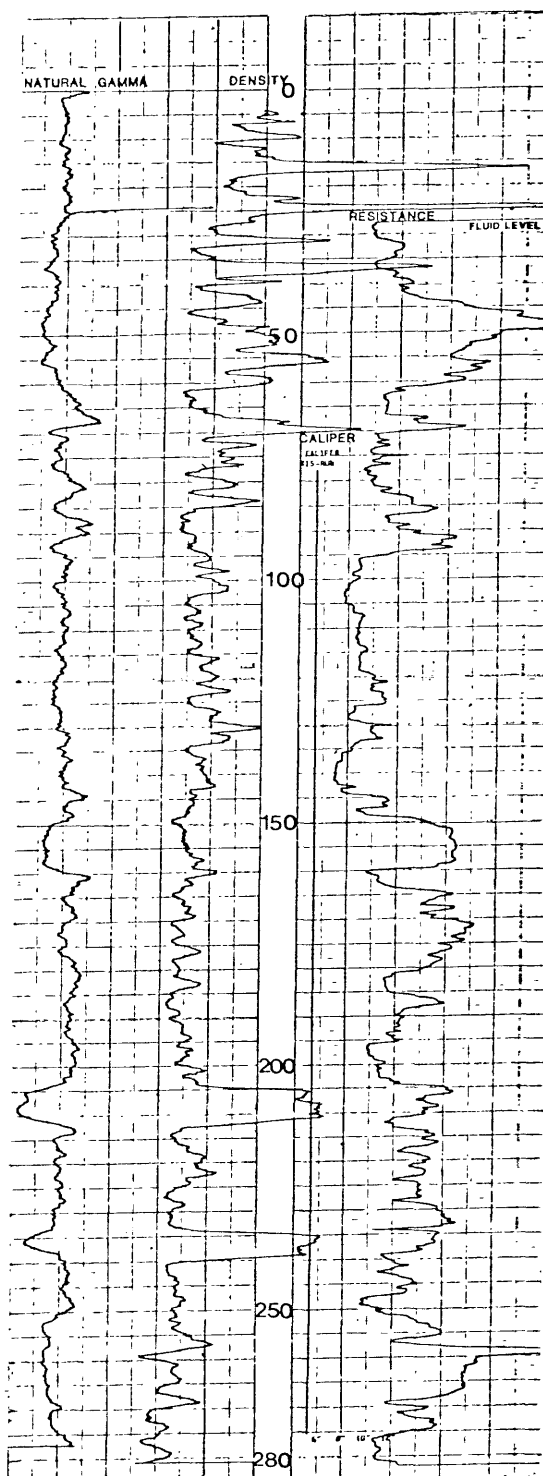


Figure 20.--Geophysical logs of hole GS-64

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

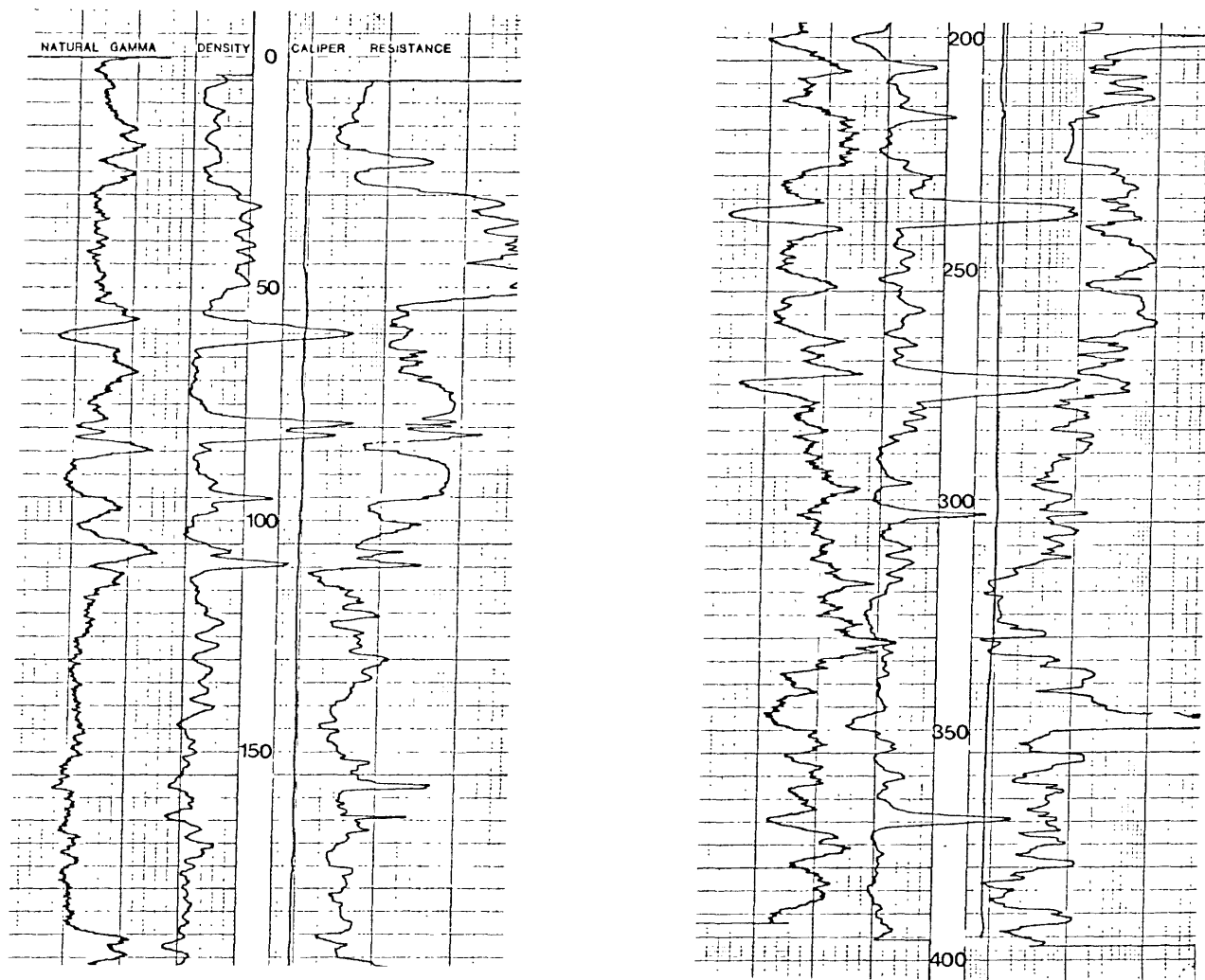


Figure 21.--Geophysical logs of hole GS-65

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

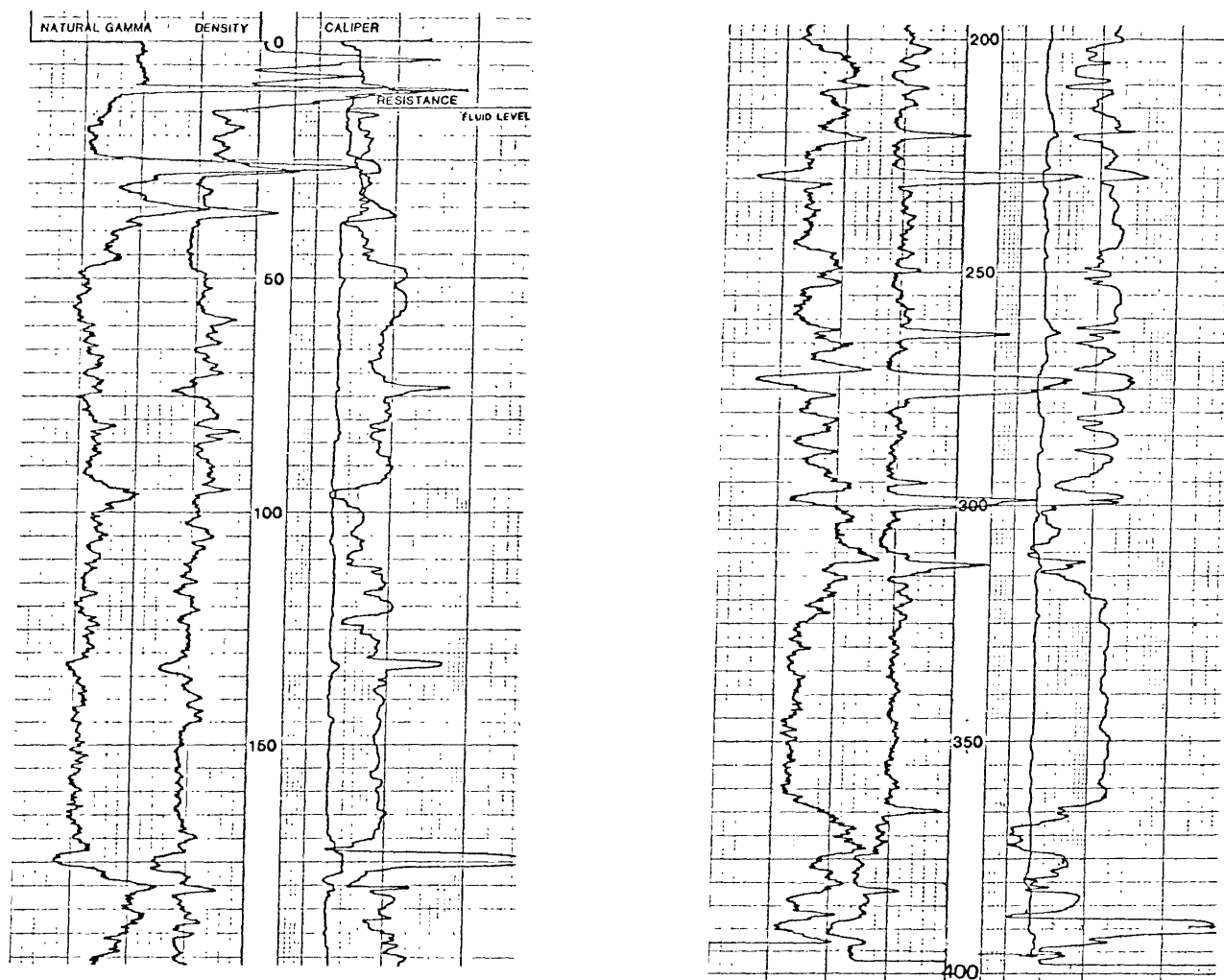


Figure 22.--Geophysical logs of hole GS-66

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

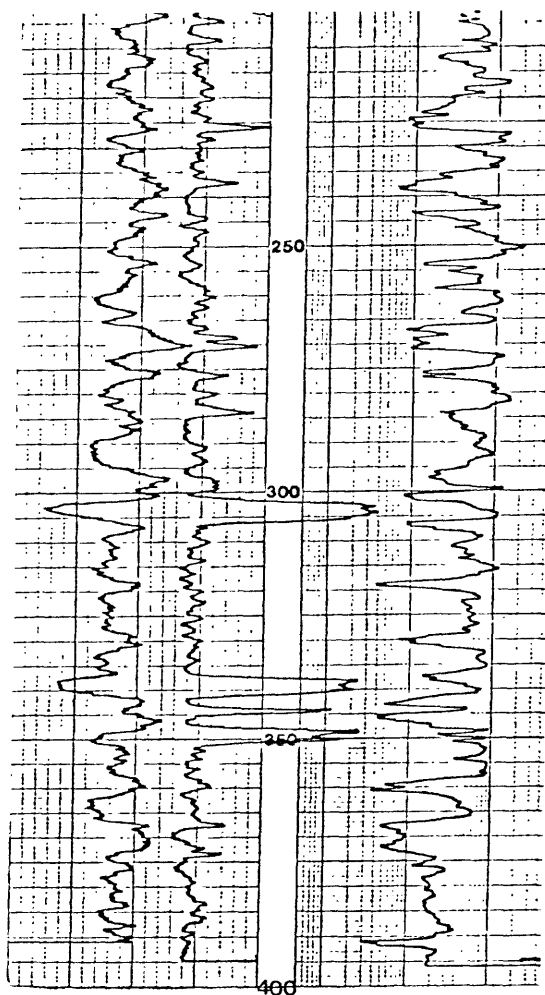
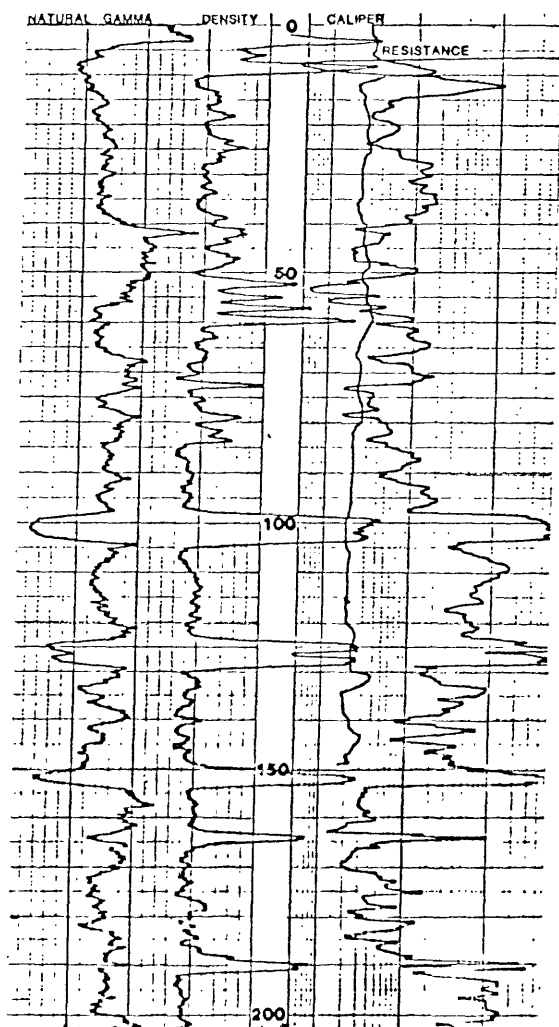


Figure 23.--Geophysical logs of hole GS-67

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

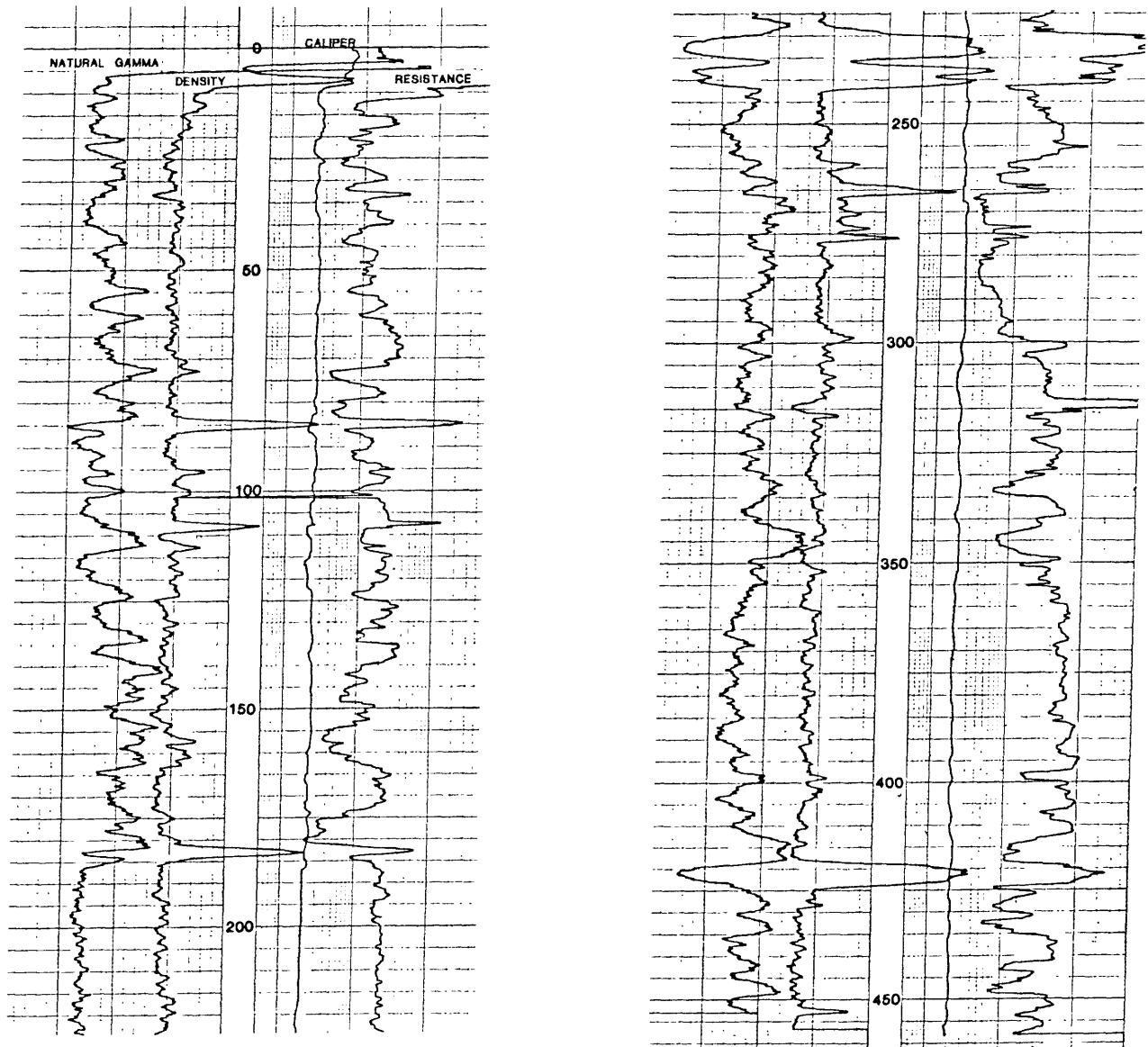


Figure 24.--Geophysical logs of hole GS-68

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

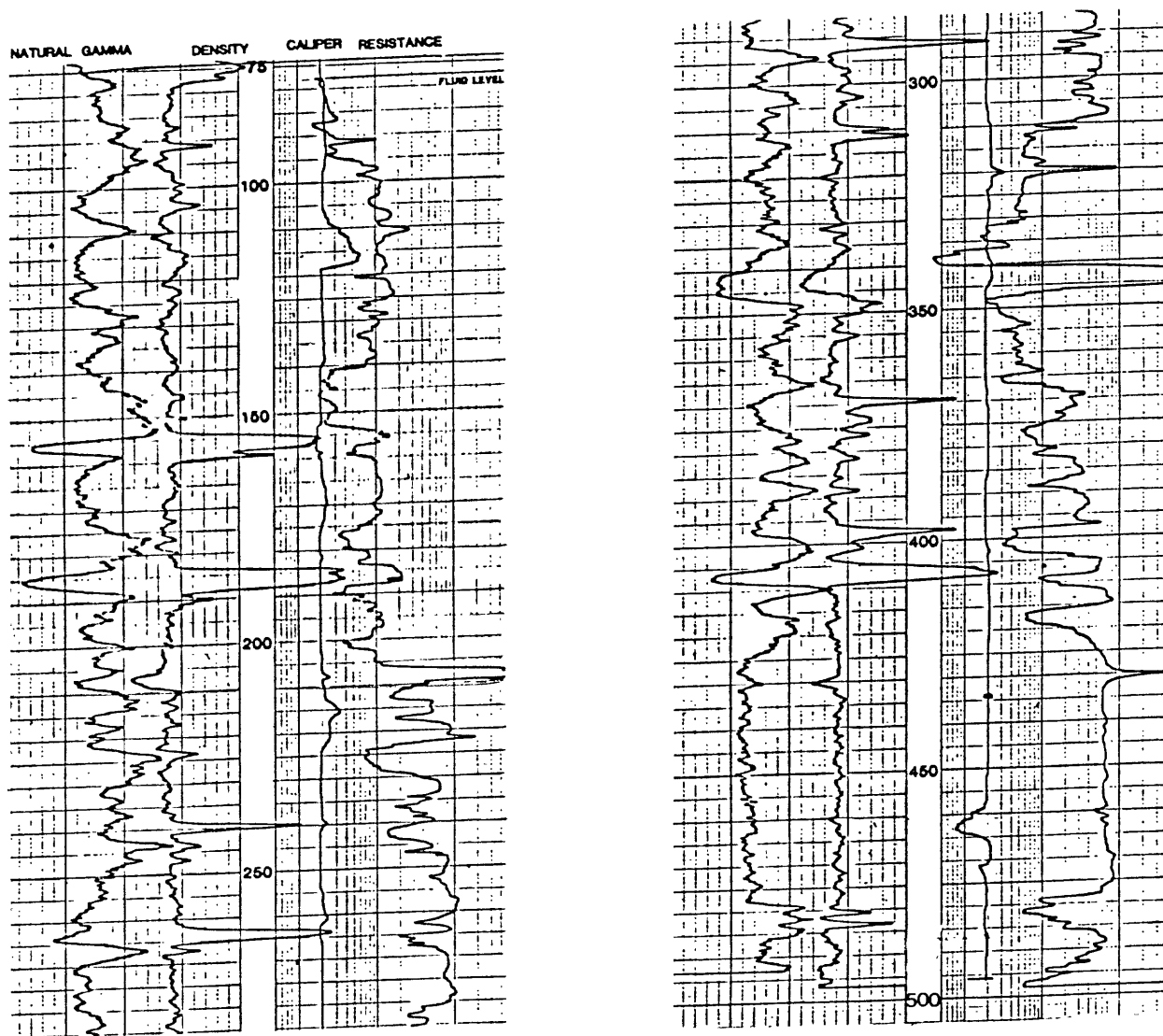


Figure 25.--Geophysical logs of hole GS-69

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

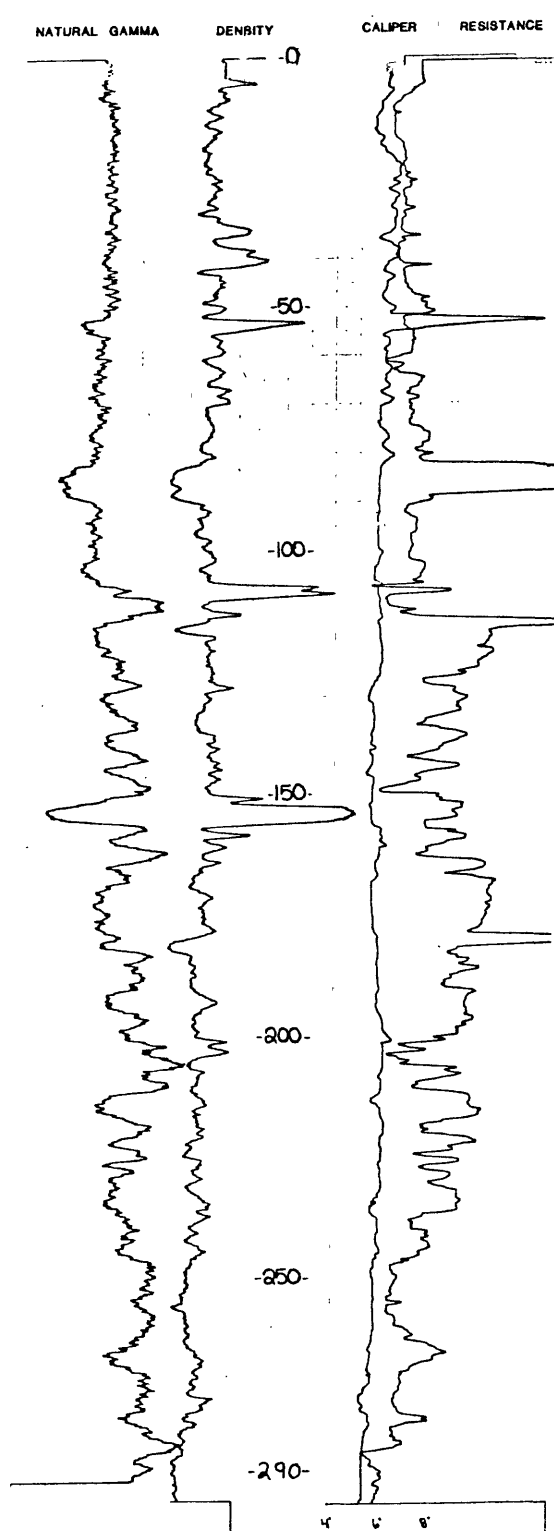


Figure 26.--Geophysical logs of hole GS-70

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

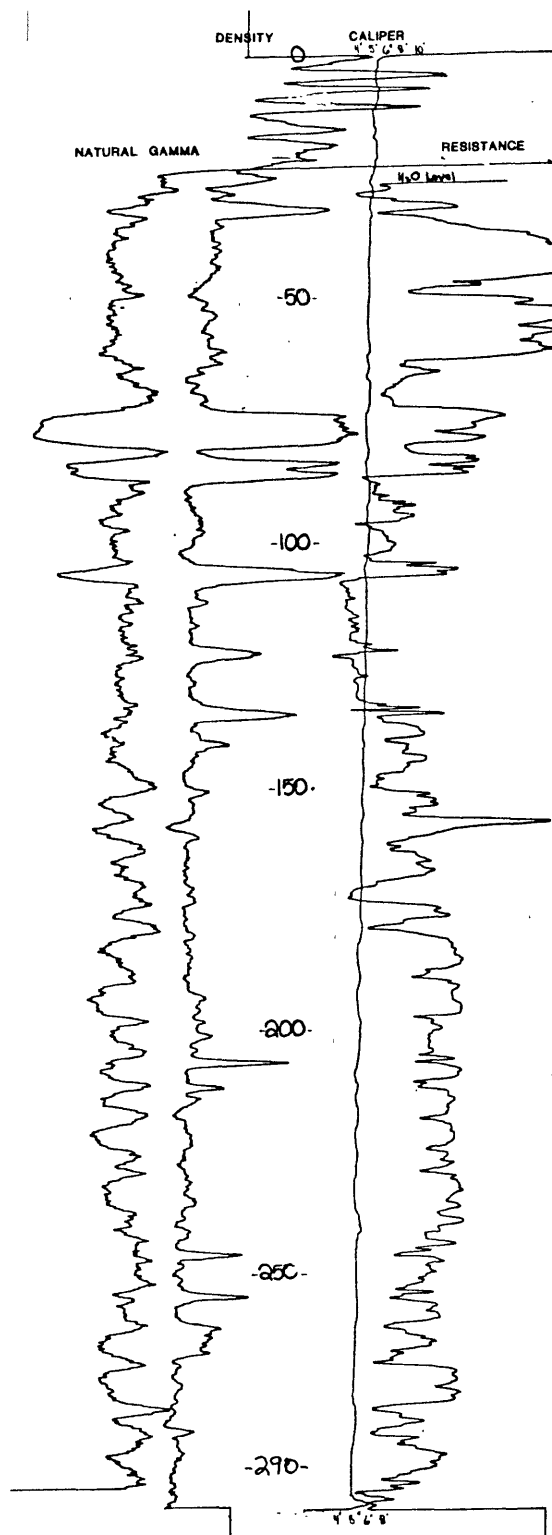


Figure 27.--Geophysical logs of hole GS-71

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

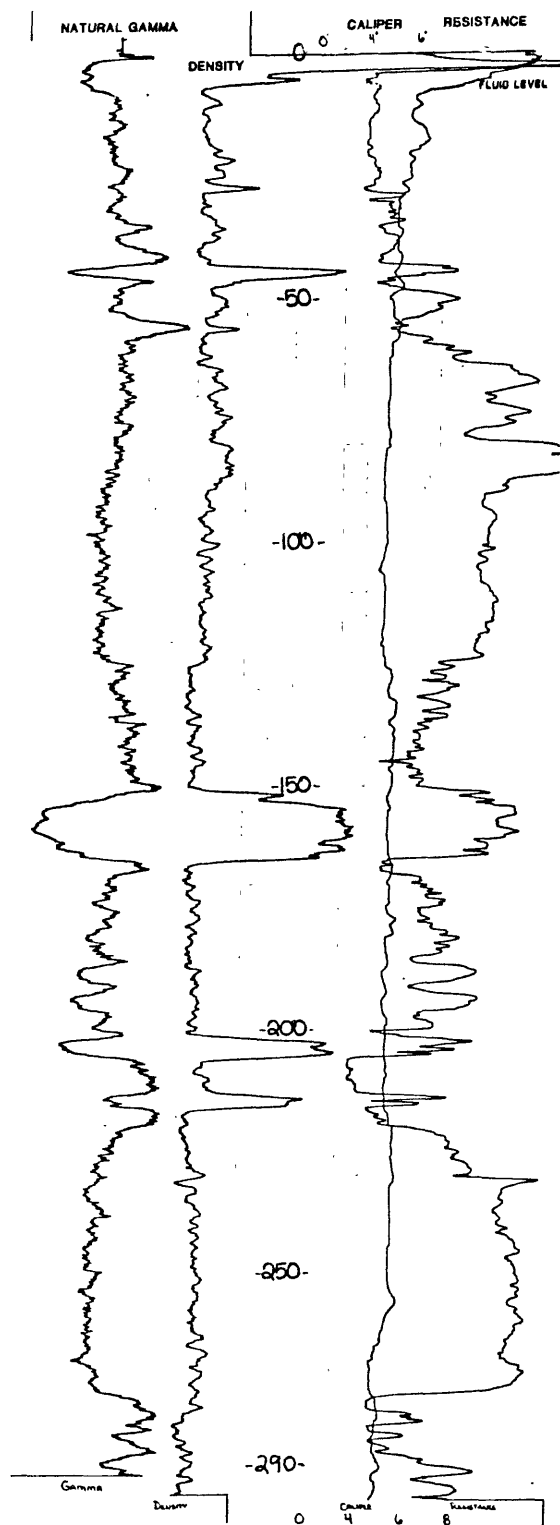


Figure 28.--Geophysical logs of hole GS-72

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

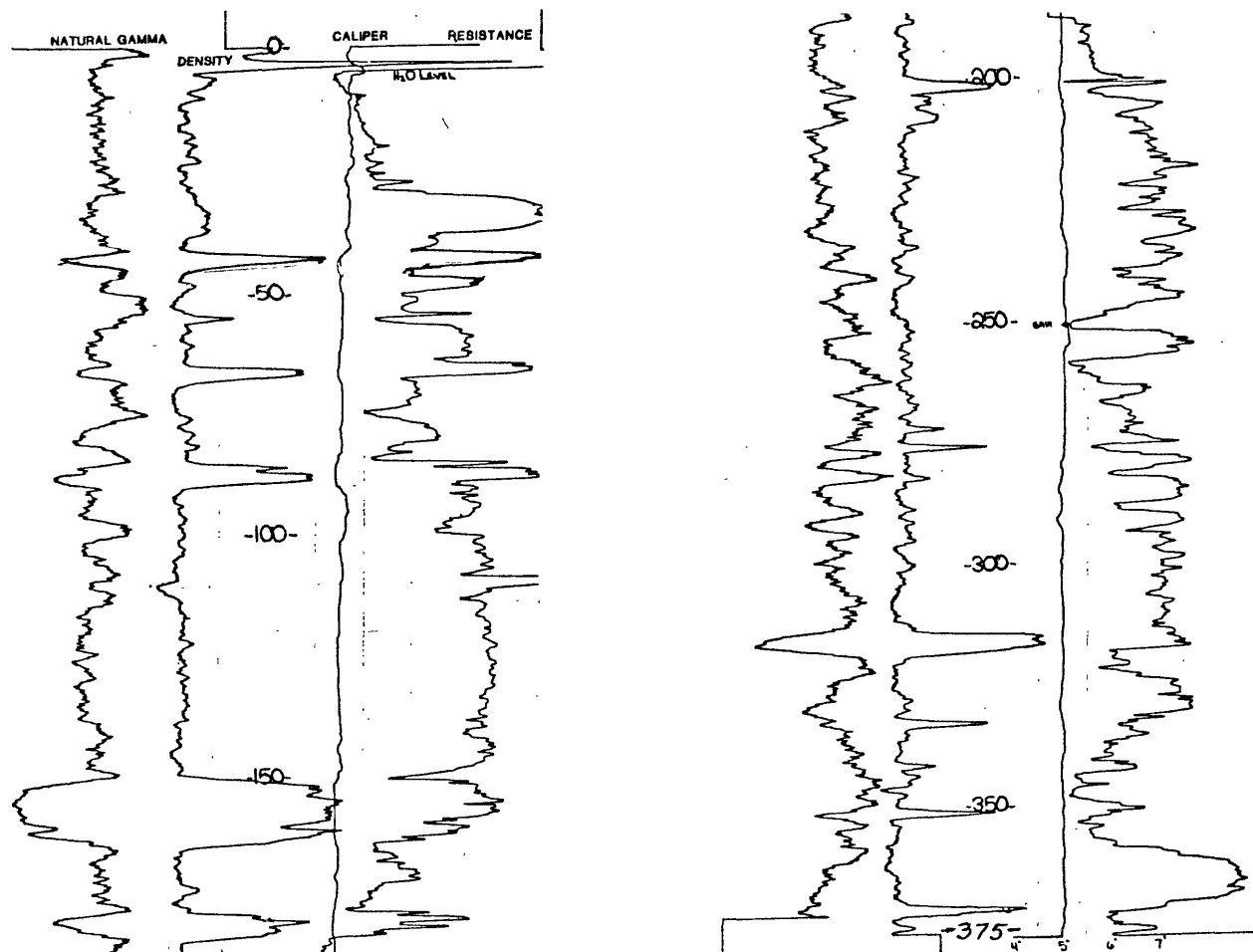


Figure 29.--Geophysical logs of hole GS-73

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

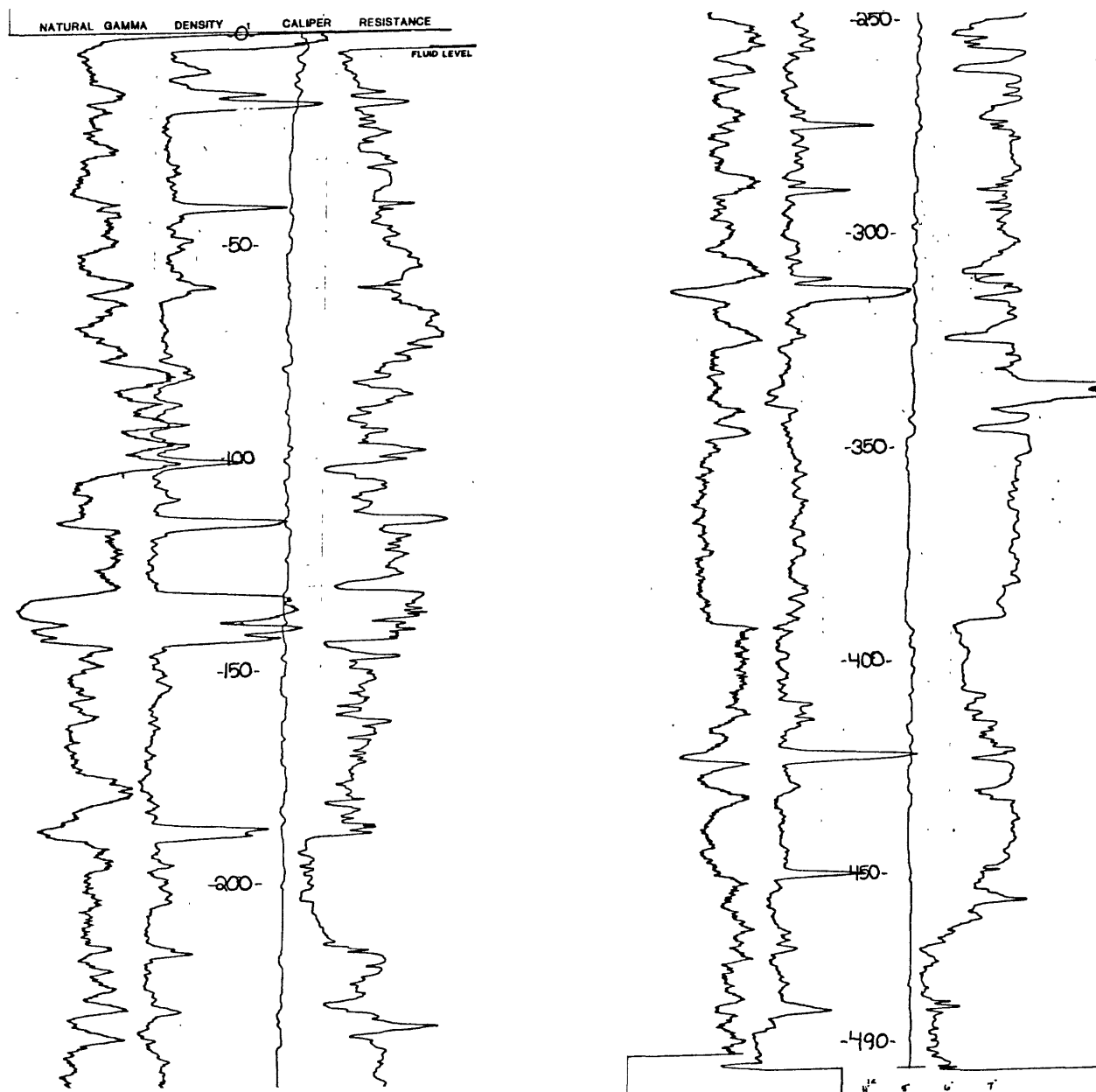


Figure 30.--Geophysical logs of hole GS-74

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

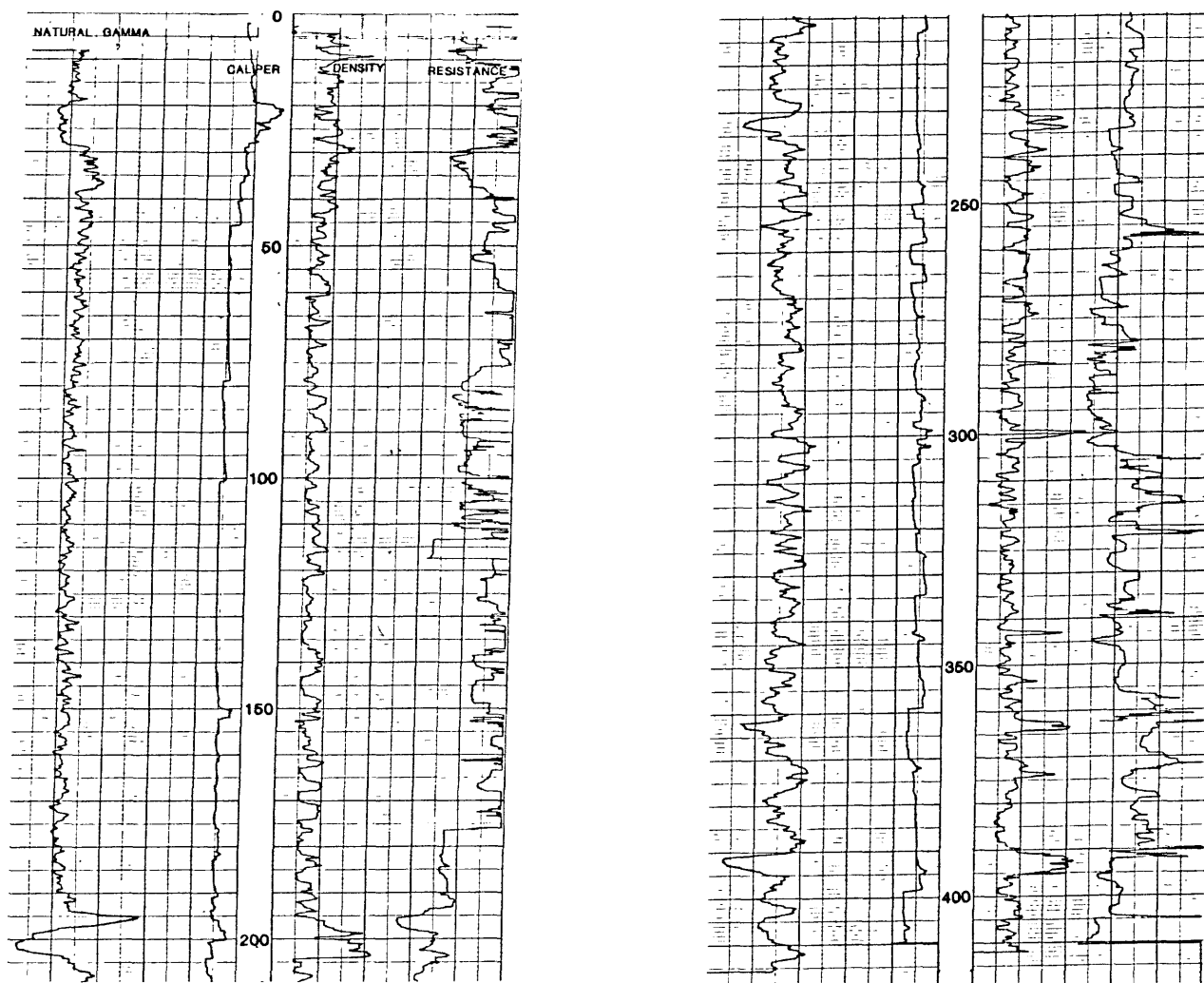


Figure 31.--Geophysical logs of hole GS-75

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

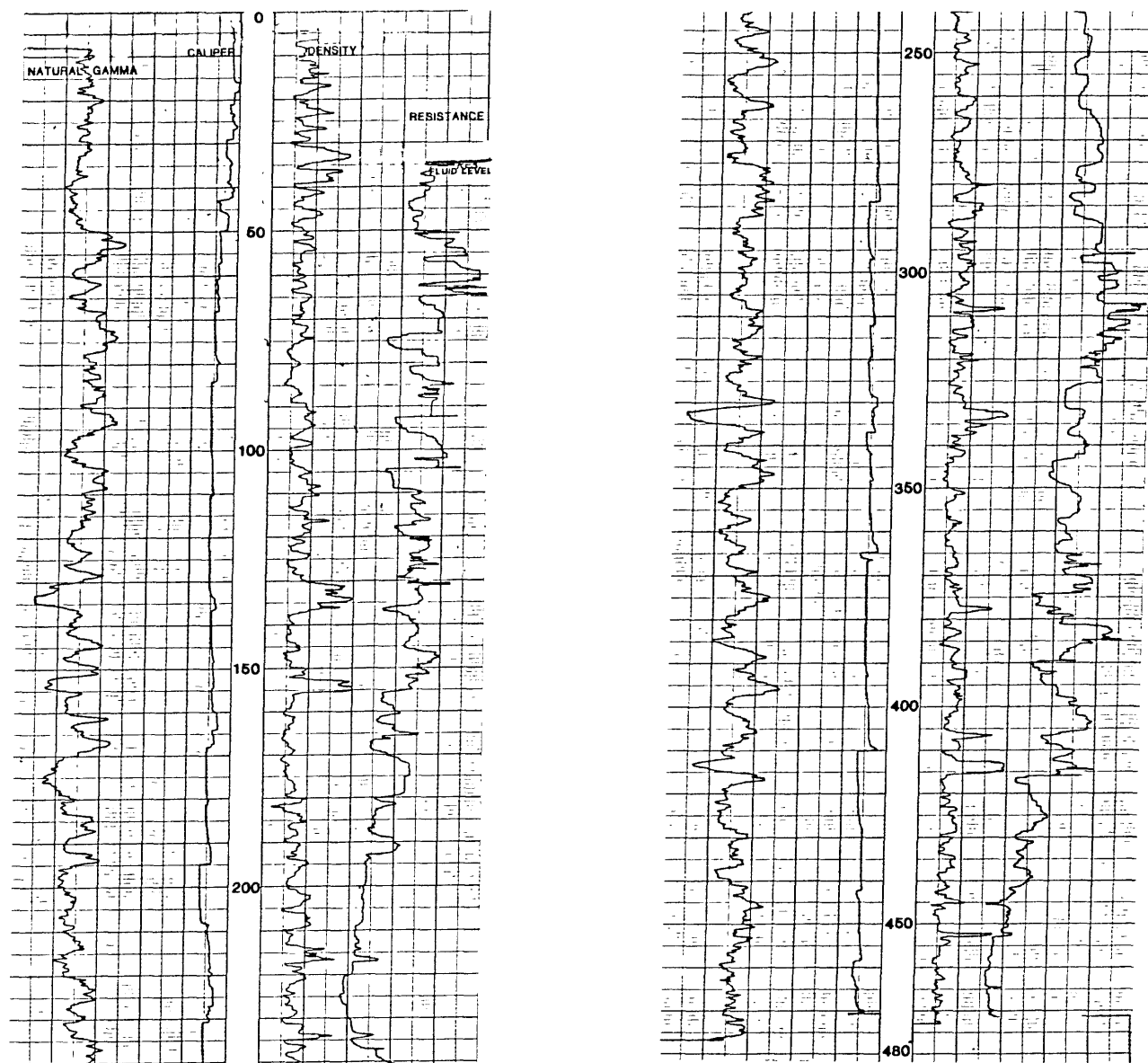


Figure 32.--Geophysical logs of hole GS-76

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

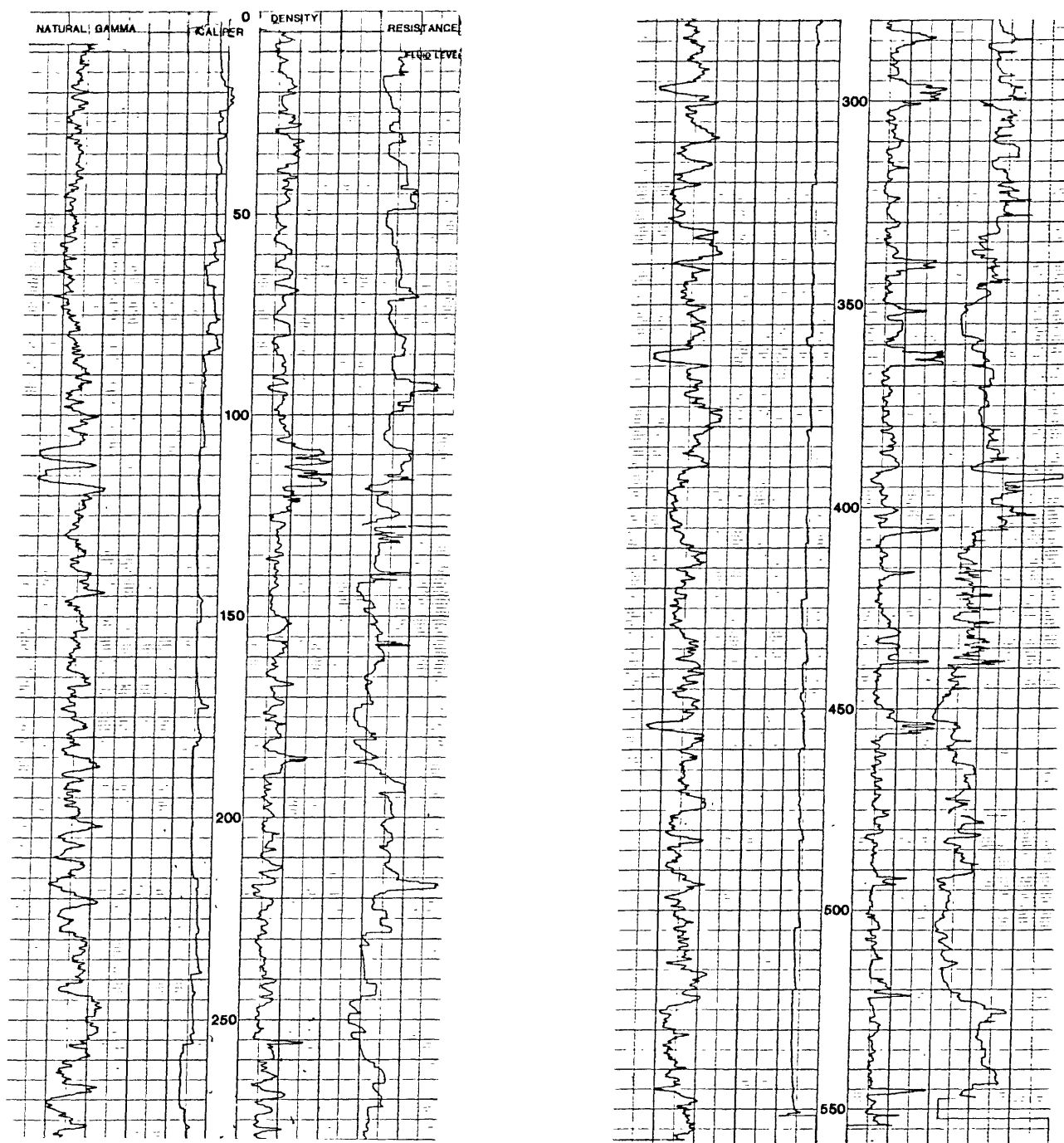


Figure 33.--Geophysical logs of hole GS-77

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

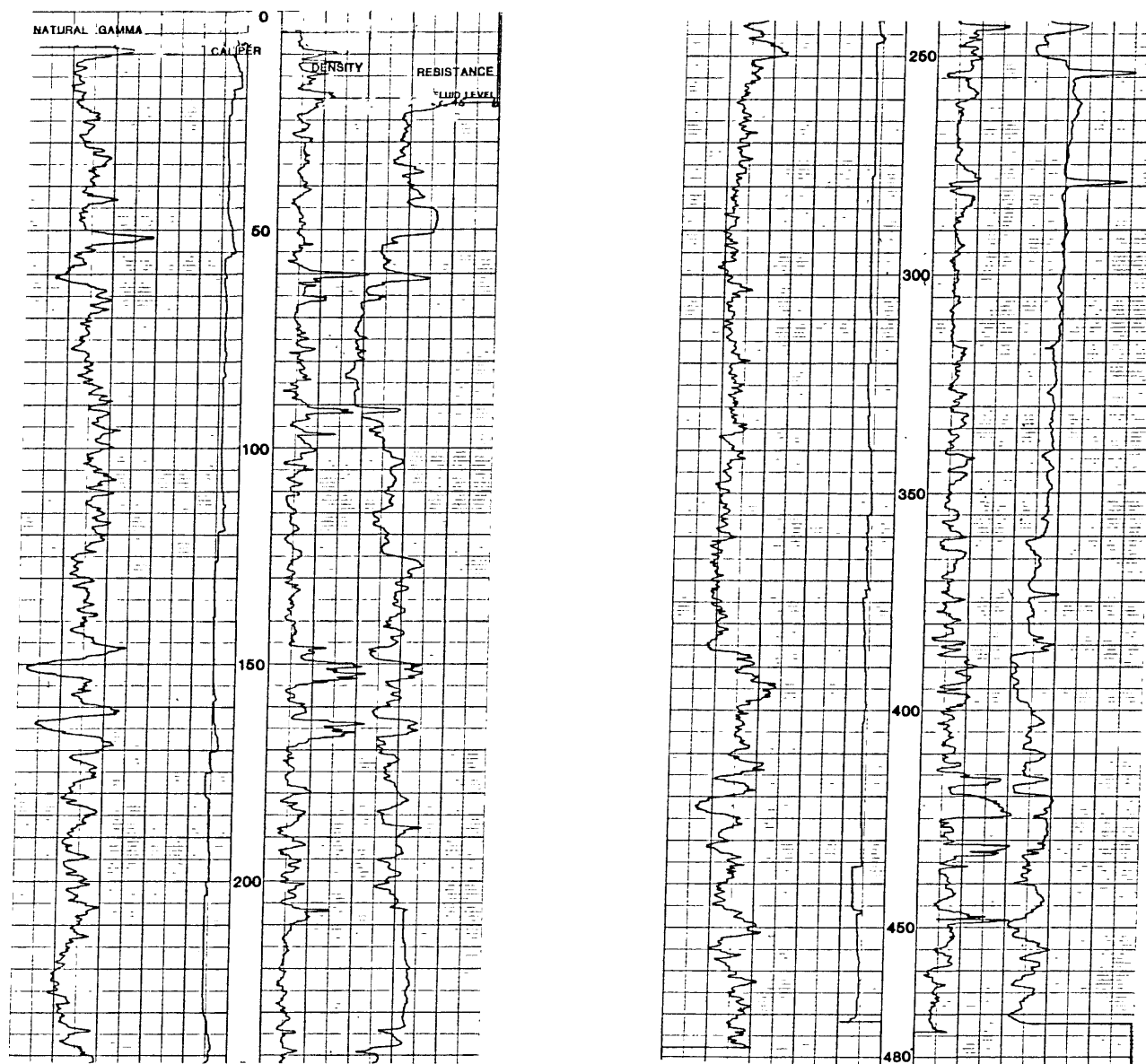


Figure 34.--Geophysical logs of hole GS-78

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

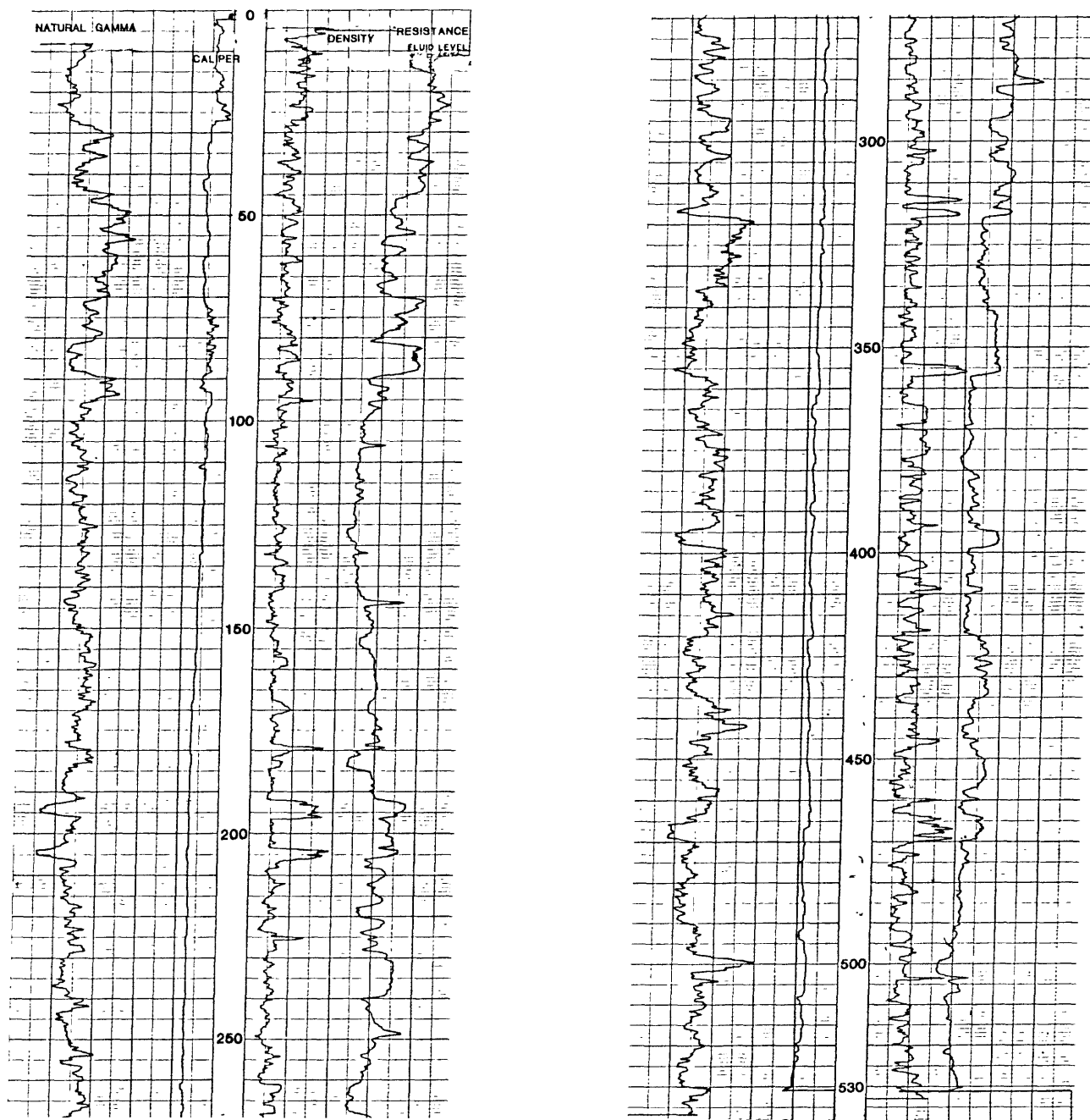


Figure 35.--Geophysical logs of hole GS-79

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

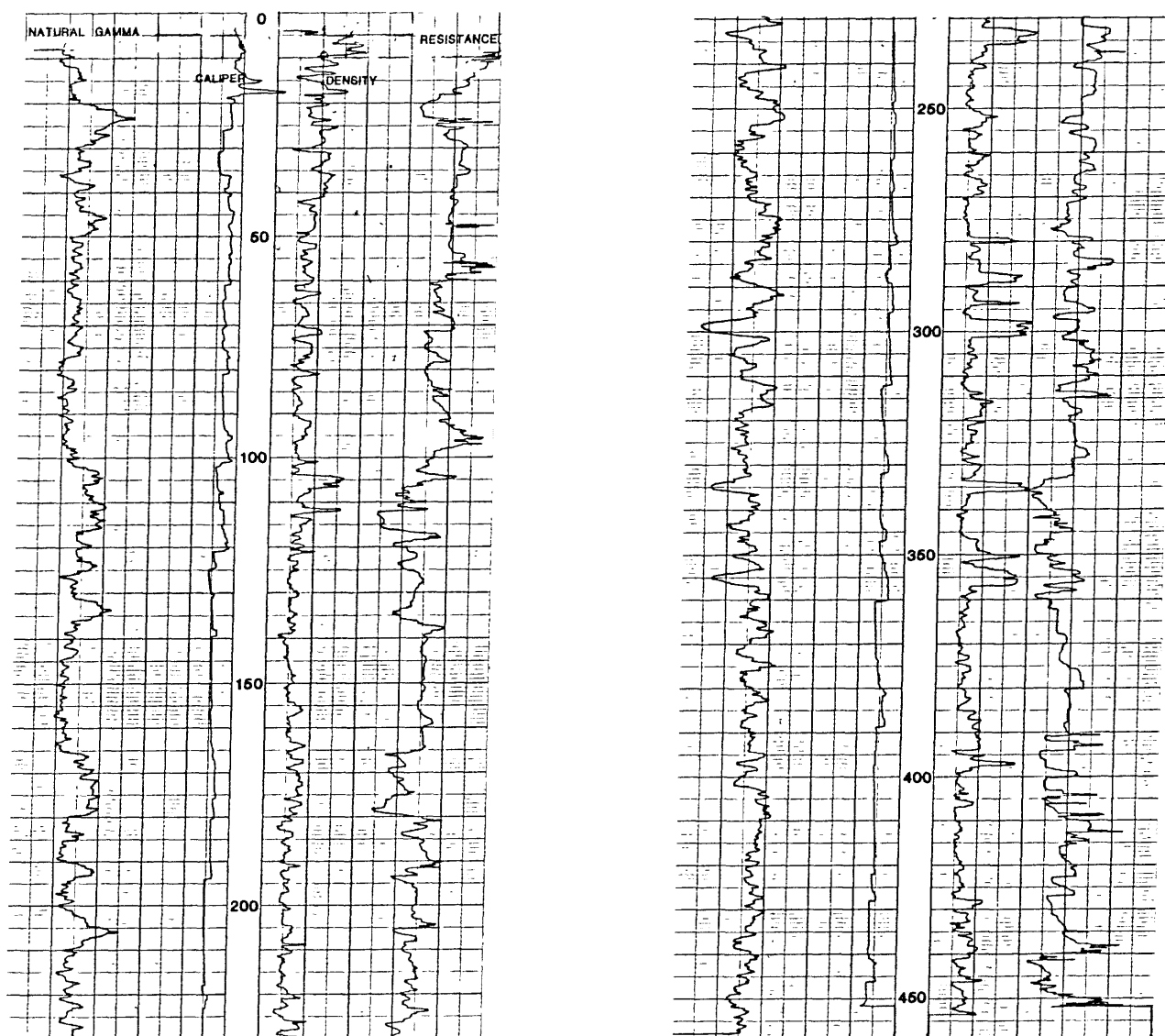


Figure 36.--Geophysical logs of hole GS-80

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

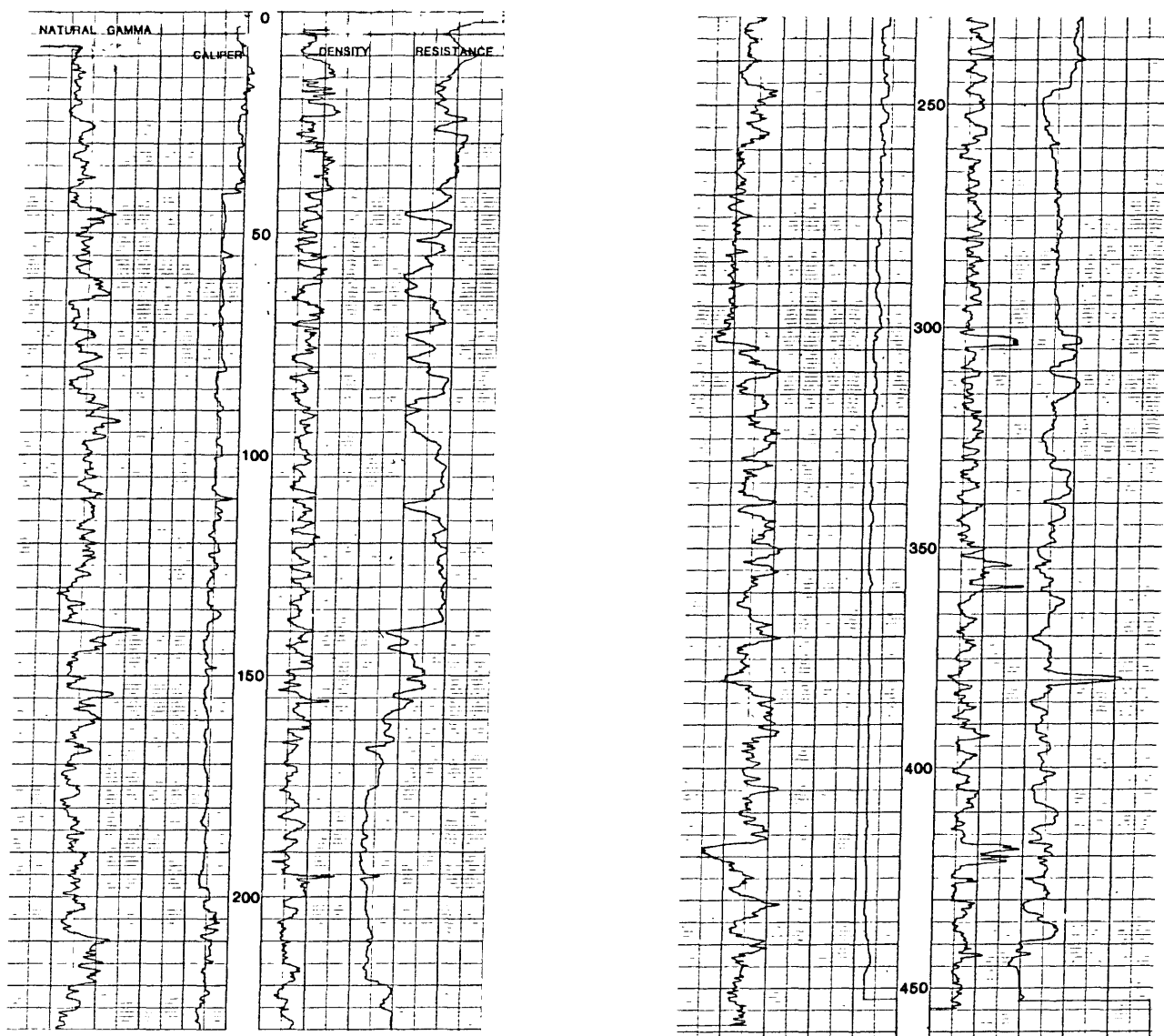


Figure 37.--Geophysical logs of hole GS-81

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

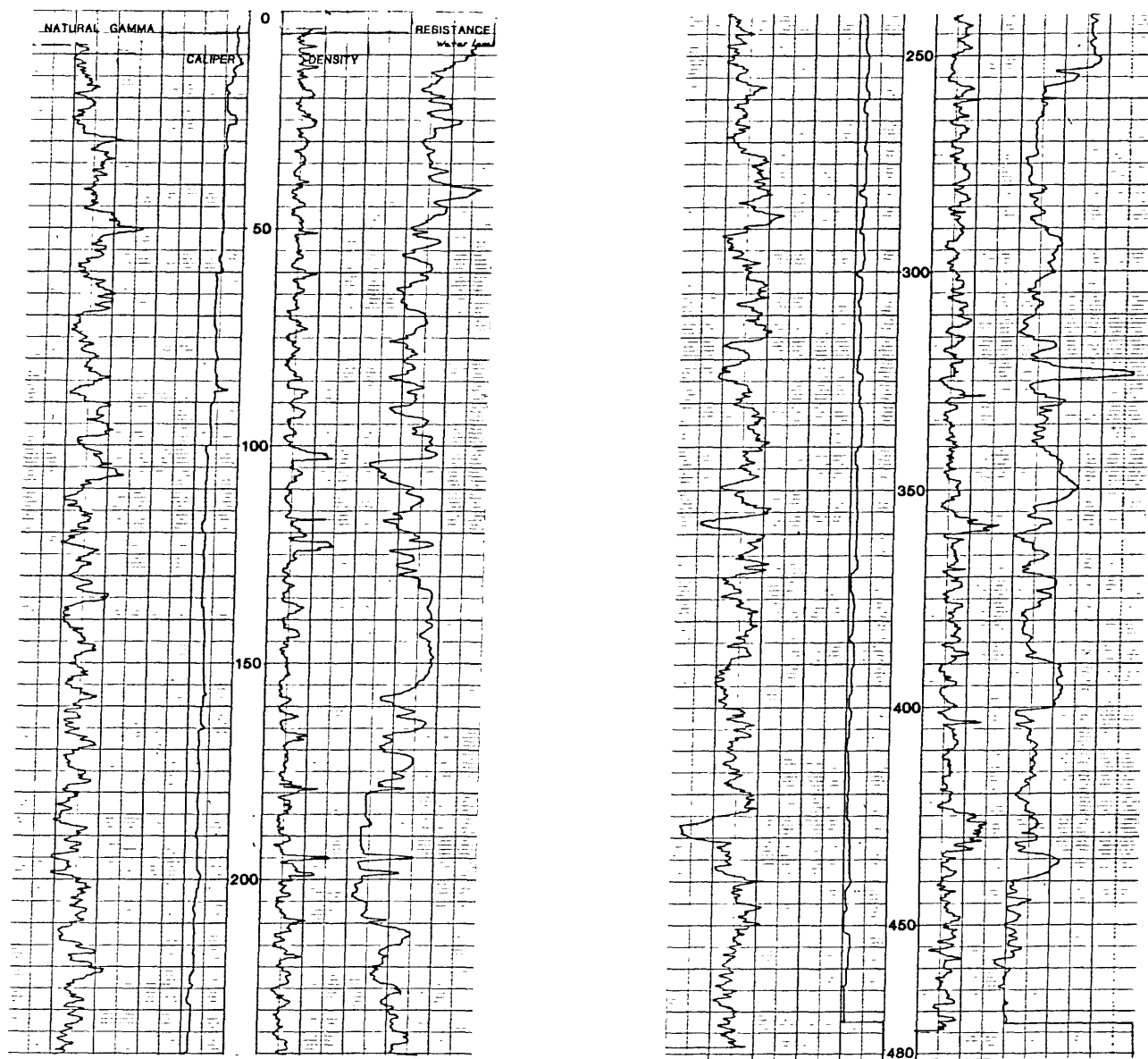


Figure 38.--Geophysical logs of hole GS-83

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

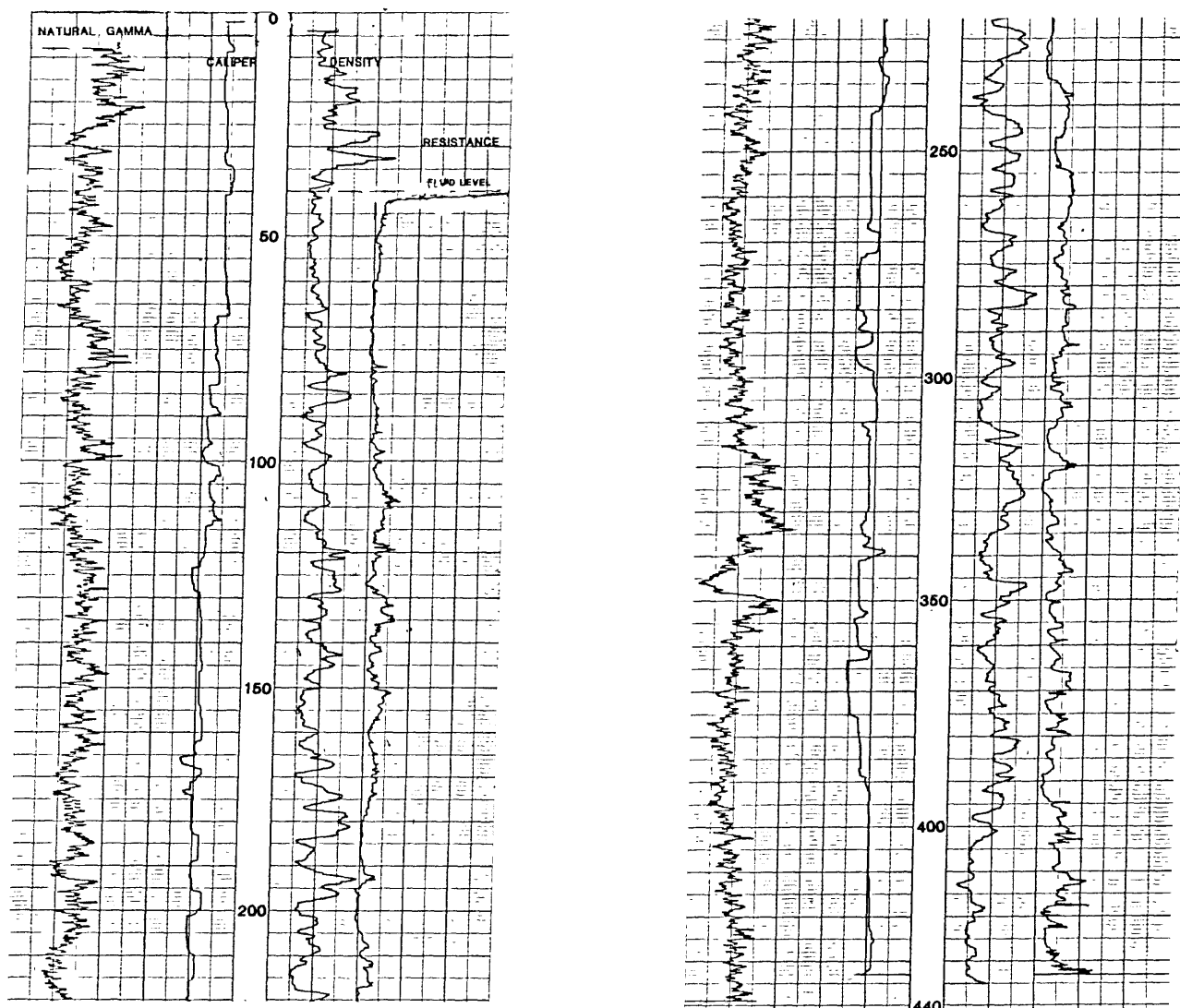


Figure 39.--Geophysical logs of hole GS-84

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