

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Lithic Descriptions and Geophysical Logs of 83 U.S. Geological Survey
Coal Exploratory Holes in the Eastern Part of the Fort Peck Indian
Reservation, Daniels, Roosevelt, and Sheridan Counties, Montana

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Fort Peck Indian Reservation, Poplar, Montana

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

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COAL EXPLORATORY DRILL HOLES

Included here are the lithic descriptions and geophysical logs of 83 coal exploratory holes drilled by the U.S. Geological Survey in the eastern part of the Fort Peck Indian Reservation between 1978 and 1980. The drilling was done in order to obtain information on the quantity, quality, and distribution of lignite beds in the Fort Union Formation which underlies much of the eastern part of the reservation. The locations of the exploratory drill holes are shown in figure 1 of this report. Core holes were located within a few feet of 17 of the exploratory holes and selected intervals were cored to obtain fresh samples of coal for analysis not included in this report. The locations of core holes are also shown on figure 1 and cored intervals are indicated on the accompanying geophysical logs.

All drilling was done with medium-range truck-mounted rotary drills. Water and mud additives were used as a drilling medium. Samples of the drill cuttings, collected at 5-ft intervals, were examined and described in the field by the geologist monitoring the drilling.

LOGS OF THE DRILL HOLES

Sample logs of the coal exploratory holes described here 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 and cores were used to

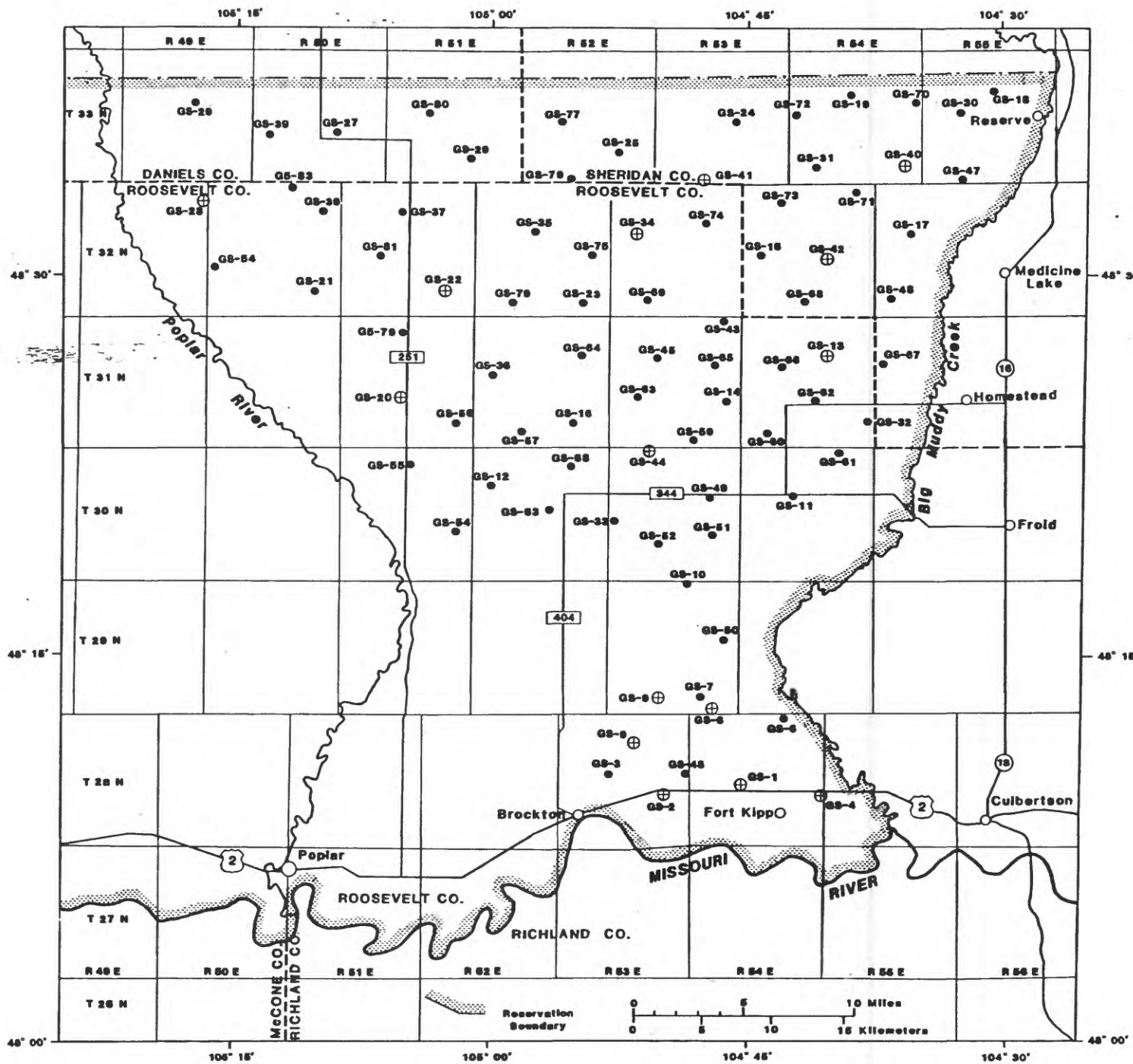


Figure 1.--Map showing locations of U.S. Geological Survey coal exploratory drill holes in the eastern part of the Fort Peck Indian Reservation, Montana. (•, exploratory drill hole; ⊕, exploratory drill hole and offset core hole; gs-1, drill hole identification number)

ascertain tops and bottoms of lithologic units recognized in the examination of the drill cuttings.

Geophysical logs of most 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 in. = 10 ft were obtained at most locations. At a few locations, a single-conductor logging tool was used, in which case the natural-gamma log was run going into the hole; a single-point resistance log was made on the trip out of the hole; and, density (gamma-gamma) and caliper logs were made on subsequent runs, both the density and caliper logs requiring a separate run in and out of the hole. Focused density (high-resolution) logs were made at an expanded scale of 1 in. = 5 ft of selected coal zones at most sites. It was not possible to make all five logs noted here at some sites because of equipment failures or caving and blockage of holes. At sites where the single-conductor logging tool was used, only the natural-gamma and density logs are reproduced in this report.

CONVERSION TO METRIC UNITS

Units of measurement used here are in the English system. Factors for conversion to the metric system are:

| <u>English system</u> | <u>Metric system</u> |
|-----------------------|------------------------|
| 1 inch----- | 2.54 centimeters |
| 1 foot----- | 0.3048 meter |
| 1 mile----- | 1.609 kilometers |
| 1 square mile----- | 2.59 square kilometers |

Sample log

Hole no.: GS-1 Date: 10-19-78 State: Montana County: Roosevelt
 Elev. (ground): 2225 ft Location: T. 28 N., R. 54 E., Sec. NW NW 21
 Total depth: 500 ft Drilling medium: mud Offset core hole: GS-1C

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-10 | Sand, silt, and clay, greenish-gray, unconsolidated |
| 10-15 | Claystone, light-gray |
| 15-20 | Siltstone, yellowish-gray, calcareous, argillaceous |
| 20-26 | Claystone, light-gray to yellowish-gray, calcareous |
| 26-43 | Siltstone, light-gray and grayish-orange-pink, calcareous |
| 43-58 | Claystone, dark-greenish-gray to light-gray, calcareous; carbonaceous claystone and coal laminations in upper part |
| 58-73 | Siltstone, light-olive-gray to grayish-orange, calcareous; thin carbonaceous claystone and coal laminations in upper part; grades to silty claystone between 63 and 68 ft |
| 73-79 | Claystone, light-gray to grayish-orange, calcareous |
| 79-85 | Siltstone, light-gray to grayish-orange, calcareous; slightly sandy in upper part; grades to claystone near base |
| 85-107 | Claystone, light-gray to grayish-yellow, silty, calcareous |
| 107-112 | Siltstone, medium-light-gray |
| 112-117.2 | Claystone, light-olive-gray, silty |
| 117.2-126 | Lignite, black; claystone parting from 124.8 to 125; see core sample D209957; ("D" Rider lignite bed) |
| 126-134.7 | Claystone, light-olive-gray, calcareous; scattered thin carbonaceous laminations |
| 134.7-143.7 | Lignite, black; abundant thin carbonaceous shale laminations in middle to upper part; see core sample D209958; ("D" lignite bed) |
| 143.7-163 | Claystone, medium-light-gray, silty, calcareous; interbedded with siltstone between 150 and 155 ft |
| 163-175 | Siltstone, greenish-gray to light-gray, calcareous |
| 175-176 | Lignite, black; ("CD" lignite bed) |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 176-190 | Claystone, light-gray, calcareous; grades to siltstone near base |
| 190-198 | Siltstone, light-gray |
| 198-206 | Claystone, brownish-gray, carbonaceous |
| 206-228 | Siltstone and silty claystone, light-gray to olive-gray; calcareous in upper part; includes scattered thin beds of carbonaceous shale and impure coal |
| 228-229.8 | Lignite, black; ("C" lignite bed) |
| 229.8-235 | Claystone, medium-light-gray to greenish-gray |
| 235-253 | Siltstone, medium-light-gray and yellowish-orange, locally sandy; scattered thin beds of coal and carbonaceous shale |
| 253-260 | Claystone, medium-dark- to dark-gray, calcareous |
| 260-276 | Siltstone and silty claystone, medium-light-gray and yellowish-orange, calcareous |
| 276-333 | Siltstone and silty sandstone, light-gray, calcareous; scattered thin beds of carbonaceous shale and coal |
| 333-348 | Claystone, light-gray to olive-gray, silty, calcareous; scattered thin beds of carbonaceous shale and coal |
| 348-370 | Siltstone and silty claystone, light-olive-gray, calcareous |
| 370-372 | Sandstone concretion, brownish-gray to olive-gray, calcareous, hard |
| 372-398 | Claystone, brownish-gray to greenish-gray, calcareous; very silty in middle and lower parts |
| 398-409 | Siltstone, greenish-gray to light-olive-gray; grades locally to sandstone; includes some interbedded silty claystone |
| 409-410 | Lignite, black |
| 410-475 | Siltstone, greenish-gray to brownish-gray, locally sandy, calcareous; includes interbedded brownish-gray silty claystone which is fairly abundant in middle to lower parts of interval; scattered calcareous sandstone concretions |
| 475-476 | Lignite, impure; ("B" lignite bed) |
| 476-481 | Claystone, brownish-gray, carbonaceous ("B" lignite bed) |

Sample log---Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 481-482 | Lignite, impure; ("B" lignite bed) |
| 482-500 | Siltstone and claystone, brownish-gray to greenish-gray; traces of carbonaceous shale and coal; scattered calcareous sandstone concretions |
| | Total depth 500 ft |

Hole no.: GS-1 Date: 10/19/78 State: Montana County: Roosevelt
 Elev. (ground); 2225 ft Location: T. 28 N., R. 54 E., Sec. NW NW 21
 Total depth: 500 ft Bit size: 5.5 in Logging speed: 15 ft/min
 Natural gamma: Time constant 4 Count range 50 cps
 Density (gamma-gamma ray): Time constant 4 Count range 1,000 cps

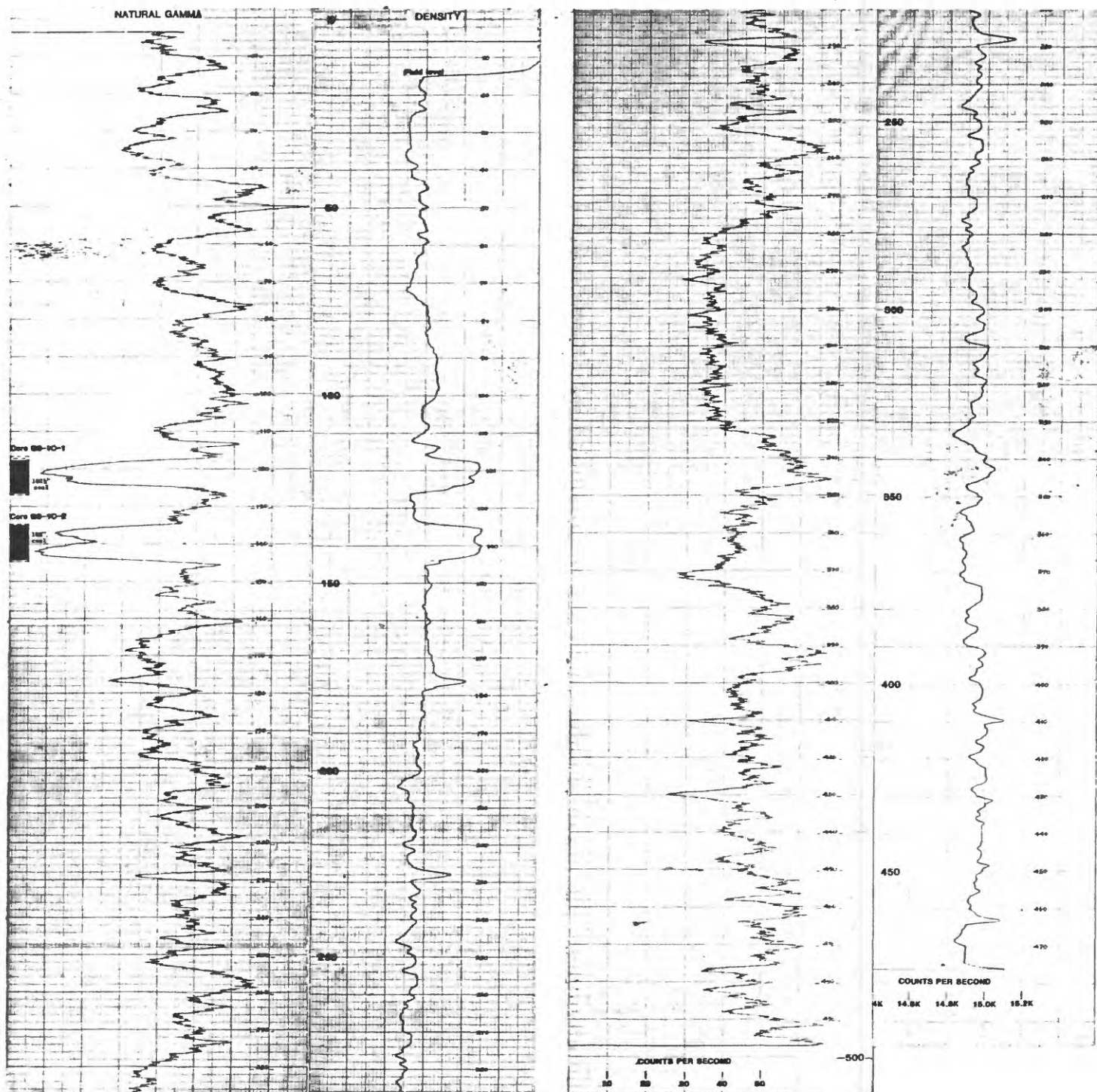


Figure 2.--Geophysical logs of hole GS-1.

Sample log

Hole no.: GS-2 Date: 10-10-78 State: Montana County: Roosevelt
 Elev. (ground): 2125 ft Location: T. 28 N., R. 53 E., Sec. NW SE 23
 Total depth: 380 ft Drilling medium: mud Offset core hole: GS-2C & GS-2C'

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-20 | Gravel, sand, and clay, yellowish-brown, unconsolidated |
| 20-26 | Claystone, grayish-orange-pink, calcareous; includes thin limonitic laminations |
| 26-28 | Lignite, black; ("B" lignite bed) |
| 28-29 | Carbonaceous shale; ("B" lignite bed) |
| 29-32 | Lignite, black; ("B" lignite bed) |
| 32-52 | Claystone, greenish-gray and grayish-orange, very silty, some iron-stained; includes carbonaceous shale between 38 and 42 ft |
| 52-74 | Siltstone, yellowish- to greenish-gray, calcareous; includes greenish-gray claystone between 61 and 65 ft |
| 74-83 | Claystone, light- to dark-greenish-gray; grades silty in middle of unit |
| 83-84.2 | Lignite, slightly impure |
| 84.2-104 | Siltstone, light-gray, sandy; grades to claystone in upper and lower parts |
| 104-107 | Carbonaceous shale and impure coal |
| 107-156 | Siltstone, greenish-gray, sandy, calcareous; grades to silty sandstone at base |
| 156-159 | Claystone, light-olive-gray, silty; includes thin streaks of coal |
| 159-160 | Lignite, impure ("AB" lignite bed) |
| 160-161 | Carbonaceous shale ("AB" lignite bed) |
| 161-164.8 | Lignite, black; grades impure in upper part ("AB" lignite bed) |
| 164.8-170 | Claystone, brownish-gray to light-olive-gray |
| 170-204 | Siltstone, greenish-gray to light-olive-gray, sandy, calcareous; includes calcareous sandstone concretion at 199 ft |
| 204-222 | Claystone, light-olive-gray, silty, locally carbonaceous |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|--|
| 222-236 | Siltstone, light-gray to light-olive-gray, calcareous; scattered calcareous sandstone concretions; grades to sandstone at base |
| 236-239 | Claystone, light-olive-gray |
| 239-240.5 | Lignite, black; ("AA" Rider lignite bed) |
| 240.5-243.7 | Siltstone, medium-gray, slightly sandy |
| 243.7-248.8 | Lignite, black, grades impure in upper part; see core samples numbered D-209953 and D-209954; ("AA" lignite bed) |
| 248.8-254 | Claystone, light-olive-gray; grades silty in lower part |
| 254-286 | Siltstone, light-gray to dark-greenish-gray, sandy, calcareous |
| 286-290 | Claystone, greenish-gray |
| 290-294.5 | Lignite, black; see core sample D-20995; ("A" Rider lignite bed) |
| 294.5-304.4 | Claystone, light-olive-gray to brownish-gray; includes scattered carbonaceous laminations |
| 304.4-311.9 | Lignite, black with moderate-brown mottling; grades impure in upper 5 inches; see core sample D-5209955; ("A" lignite bed) |
| 311.9-328 | Claystone and siltstone, light-gray to greenish-gray; claystone predominates |
| 328-350 | Siltstone, light-gray to greenish-gray, sandy, slightly calcareous; grades to claystone in middle of interval |
| 350-367 | Claystone, light-gray to greenish-gray, silty in lower part |
| 367-380 | Siltstone, light-gray to greenish-gray, sandy; geophysical logs indicate thin coal at 368 ft |
| Total depth 380 ft | |

Hole no.: GS-2 Date: 10/10/78 State: Montana County: Roosevelt
 Elev. (ground): 2125 ft Location: T. 28 N., R. 53 E., Sec. NW SE 23
 Total depth: 380 ft Bit size: 4.75 in Logging speed: 15 ft/min
 Natural gamma: Time constant 4 Count range 50 cps
 Density (gamma-gamma ray): Time constant 4 Count range 2,500 cps

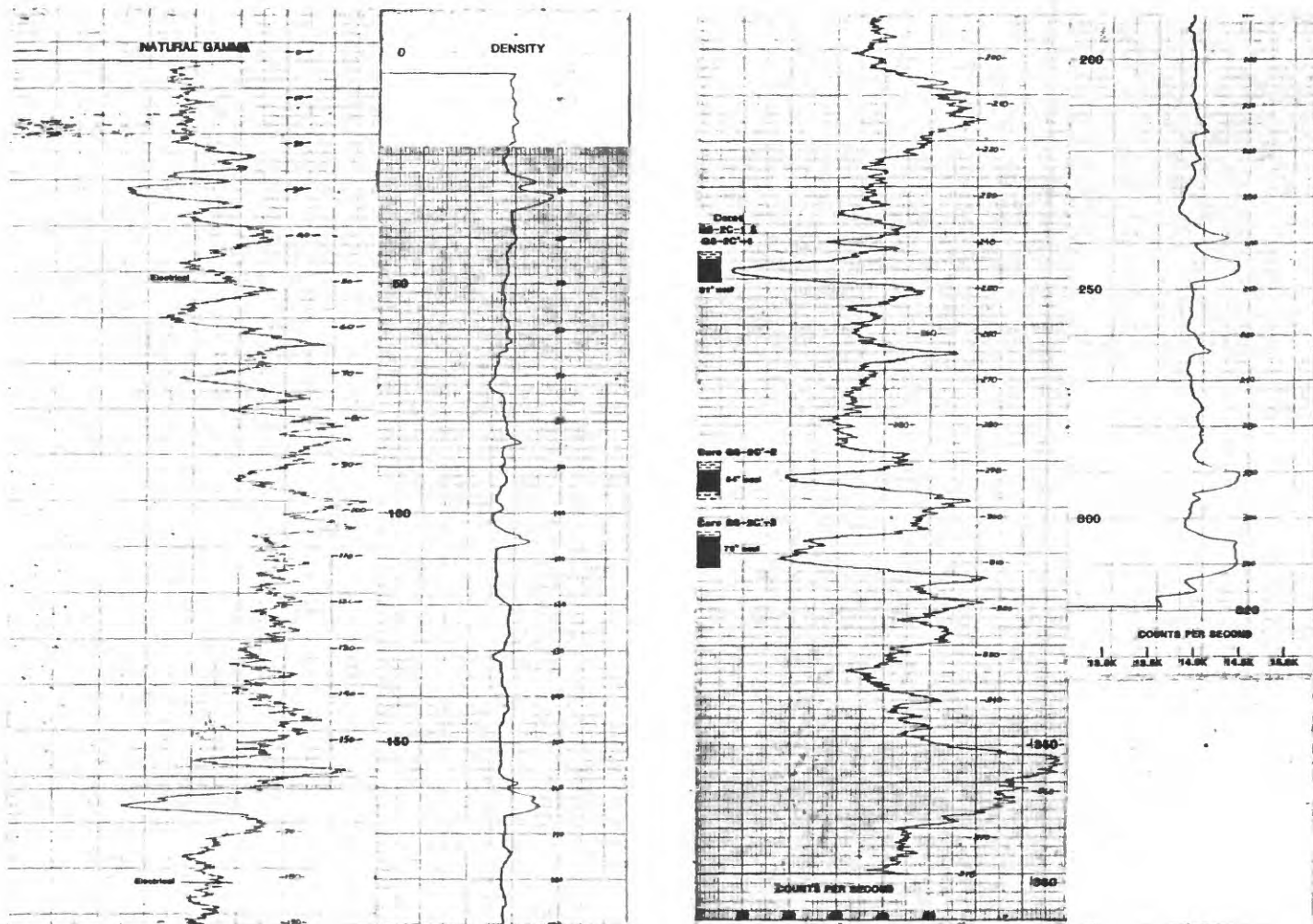


Figure 3.--Geophysical logs of hole GS-2.

Sample log

Hole no.: GS-3 Date: 10-14-78 State: Montana County: Roosevelt
 Elev. (ground): 2203 ft Location: T. 28 N., R. 53 E., Sec. SW SW 16
 Total depth: 300 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|--------------------|--|
| 0-10 | Sand and gravel, unconsolidated |
| 10-106 | Clay, sand, and gravel, unconsolidated; detrital coal fragments between 30 and 40 ft |
| 106-114 | Lignite, black; ("A" lignite bed) |
| 114-128 | Claystone, light-gray to greenish-gray, silty |
| 128-136 | Siltstone, light-gray, slightly calcareous, sandy |
| 136-163 | Claystone, light-gray to dark-greenish-gray and grayish-orange, silty; grades to sandy siltstone at base |
| 163-172 | Claystone, greenish-gray to dark-greenish-gray; grades to sandy siltstone between 165 and 168 ft |
| 172-181 | Siltstone, greenish-gray; includes some interbedded claystone |
| 181-182.5 | Lignite, black |
| 182.5-196.5 | Claystone, greenish-gray to dark-greenish-gray; includes thin beds of carbonaceous shale and coal between 188 and 192 ft |
| 196.5-198 | Lignite, black |
| 198-207 | Siltstone, dark-greenish-gray |
| 207-213 | Claystone, light-gray to greenish-gray, calcareous |
| 213-217 | Lignite, black; grades to impure coal and carbonaceous shale in upper part |
| 217-240 | Claystone, dark-greenish-gray; grades silty at base |
| 240-250.5 | Siltstone, medium-gray to greenish-gray, sandy, slightly calcareous |
| 250.5-252 | Lignite, impure; (base of Fort Union Formation) |
| 252-268 | Claystone, dark-greenish-gray, silty; (top of Hell Creek Formation) |
| 268-300 | Siltstone, greenish-gray, sandy |
| Total depth 300 ft | |

Hole no.: GS-3 Date: 10/15/78 State: Montana County: Roosevelt
Elev. (ground): 2203 ft Location: T. 28 N., R. 53 E., Sec. SW 16
Total depth: 300 ft Bit size: 5½ in Logging speed: 15 ft/min
Natural gamma: Time constant 4 Count range 50 cps
Density (gamma-gamma ray): Time constant 4 Count range 1,000 cps

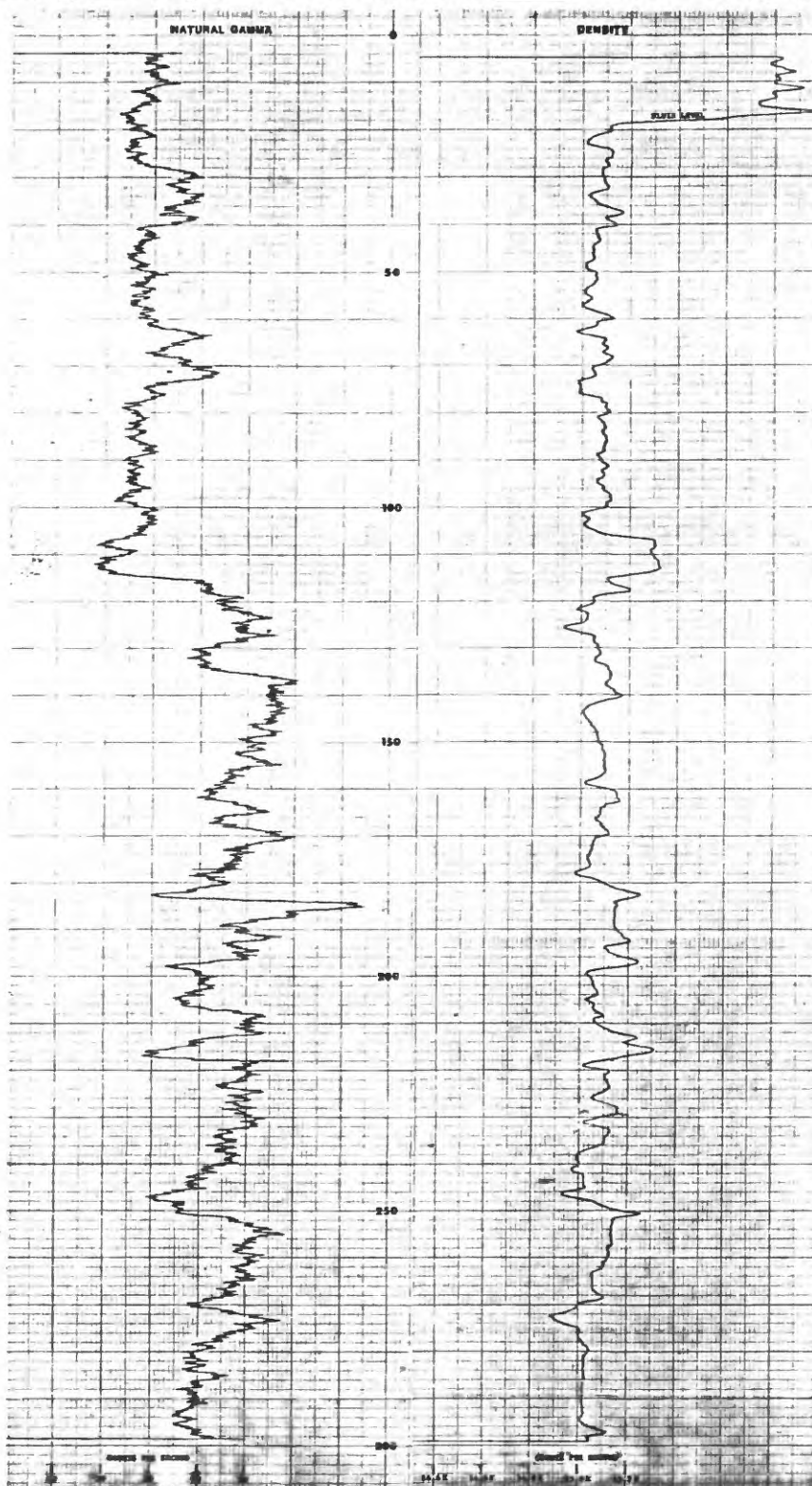


Figure 4.--Geophysical logs of hole GS-3.

Sample log

Hole no.: GS-4 Date: 10-20-78 State: Montana County: Roosevelt

Elev. (ground): 2090 ft Location: T. 28 N., R. 54 E., Sec. NE SE 24

Total depth: 300 ft Drilling medium: mud Offset core hole: GS-4C

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-22 | Gravel, sand, silt, and clay, yellowish-gray, unconsolidated |
| 22-28 | Sandstone, yellowish-gray, very fine grained, micaceous; traces of gypsum, magnetite, and pyrite |
| 28-34 | Claystone and siltstone, yellowish-gray to light-olive-gray |
| 34-47 | Sandstone, dusky-yellow, very fine grained, micaceous, calcareous; traces of magnetite and pyrite |
| 47-52 | Carbonaceous shale and impure coal, grayish-black to brownish-black |
| 52-60 | Sandstone, light-olive-gray to light-gray, very fine grained, silty, calcareous; trace amounts of pyrite, magnetite, and gypsum |
| 60-86 | Siltstone and claystone, medium-gray to greenish-gray; siltstone predominates in upper and lower parts of interval; thin, impure coal at 76 ft |
| 86-88 | Sandstone concretion, brownish-gray to olive-gray, calcareous, hard |
| 88-119 | Sandstone, light- to medium-gray, very fine grained, silty, calcareous; scattered thin calcareous concretions; trace amounts of magnetite, gypsum, muscovite, and chlorite(?) |
| 119-121 | Sandstone concretion; olive-gray, calcareous, hard |
| 121-150 | Claystone and siltstone, medium-light-gray to greenish-gray, locally sandy, calcareous |
| 150-152.4 | Claystone, light-olive-gray, silty |
| 152.4-156.2 | Lignite, black; grades slightly impure at top; includes claystone parting between 154.5 and 154.7 ft; see core samples D209959 and D209960; ("D" Rider lignite bed) |
| 156.2-162 | Claystone, light-olive-gray, silty |
| 162-168 | Siltstone, medium-light-gray, sandy, calcareous; includes thin calcareous sandstone concretion |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 168-175 | Claystone, medium-light-gray to brownish-gray, calcareous |
| 175-181 | Sandstone, light- to medium-light-gray, silty, calcareous |
| 181-188 | Claystone, light-gray to light-olive-gray, calcareous |
| 188-202.1 | Sandstone, medium-light-gray, very fine grained, silty, calcareous |
| 202.1-210.1 | Lignite, black with moderate-brown mottling; includes abundant carbonaceous shale laminae in upper part; grades slightly impure at base; see core sample D209961; ("D" lignite bed) |
| 210.1-215 | Claystone, greenish-gray, silty |
| 215-236 | Sandstone, light- to medium-gray, silty, calcareous; includes brownish-gray claystone between 223 and 227 ft |
| 236-238 | Claystone, brownish-gray to light-olive-gray |
| 238-241 | Lignite, black; ("CD" lignite bed) |
| 241-245 | Claystone, brownish-gray, carbonaceous |
| 245-290 | Sandstone, siltstone, and claystone, medium-light-gray to brownish-gray, calcareous; 5 to 8 ft thick units of silty sandstone separated by 3 to 5 ft thick units of silty claystone and siltstone; thin coal at 260 ft; calcareous concretions in basal 5 ft |
| 290-300 | Siltstone, light- to medium-gray, sandy, calcareous |
| | Total depth 300 ft |

Hole no.: GS-4 Date: 10/21/78 State: Montana County: Roosevelt
 Elev. (ground): 2090 ft Location: T. 28 N., R. 54 E., Sec. NE SE 24
 Total depth: 300 ft Bit size: 5.5 in Logging speed: 15 ft/min
 Natural gamma: Time constant 4 Count range 50 cps
 Density (gamma-gamma ray): Time constant 4 Count range 1,000 cps

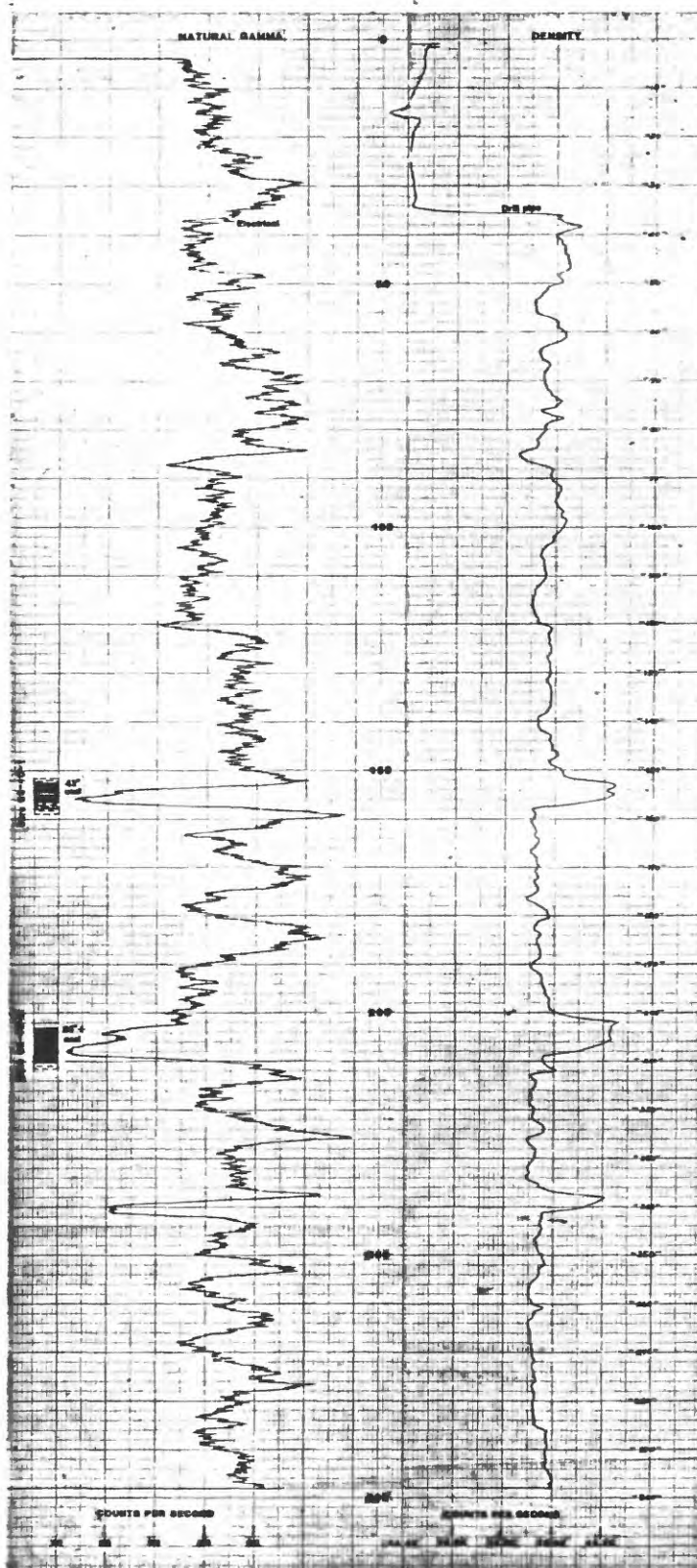


Figure 5.—Geophysical logs of hole GS-4.

Sample log

Hole no.: GS-5 Date: 10-27-78 State: Montana County: Roosevelt
 Elev. (ground): 2010 ft Location: T. 28 N., R. 54 E., Sec. NW NW 2
 Total depth: 220 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-63.5 | Gravel, sand, and clay, light-olive-gray, unconsolidated |
| 63.5-65.5 | Claystone, dark-yellowish-orange |
| 65.5-76 | Sandstone, dark-yellowish-orange, very fine grained, silty, micaceous, calcareous |
| 76-78 | Claystone, light-brownish-gray |
| 78-84 | Lignite, brownish-black; ("D" lignite bed) |
| 84-88 | Claystone, light-gray; grades to siltstone in lower part |
| 88-94 | Sandstone, dark-yellowish-orange, very fine grained |
| 94-99 | Claystone, light-gray |
| 99-109 | Siltstone and claystone, light-gray, locally sandy, calcareous |
| 109-116 | Claystone, light-gray, calcareous, grades silty in middle of unit |
| 116-126 | Sandstone, light-gray, very fine grained, micaceous |
| 126-132 | Claystone, light- to medium-gray, slightly silty |
| 132-143 | Sandstone, very light gray, very fine grained |
| 143-154 | Claystone, light-gray; interbedded with siltstone in upper part |
| 154-164 | Siltstone, light- to medium-gray; includes some interbedded claystone |
| 164-174 | Sandstone, light-gray, very fine grained, silty, argillaceous |
| 174-176.5 | Claystone, medium-dark-gray |
| 176.5-178 | Lignite, black; ("C" lignite bed) |
| 178-185 | Claystone, medium-gray to brownish-gray |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 185-190 | Sandstone, light-gray, very fine grained, silty |
| 190-205 | Claystone, light-olive-gray; grades to siltstone and sandstone between 195 and 202 ft |
| 205-216 | Sandstone and siltstone, light-gray to light-olive-gray |
| 216-220 | Claystone, greenish-gray to brownish-gray |
| | Total depth 220 ft |

Hole no.: GS-5 Date: 10/27/78 State: Montana County: Roosevelt
Elev. (ground): 2010 ft Location: T. 28 N., R. 54 E., Sec. NW NW 2
Total depth: 220 ft Bit size: 5.5 in Logging speed: 15 ft/min
Natural gamma: Time constant 4 Count range 50 cps
Density (gamma-gamma ray): Time constant 4 Count range 1,000 cps

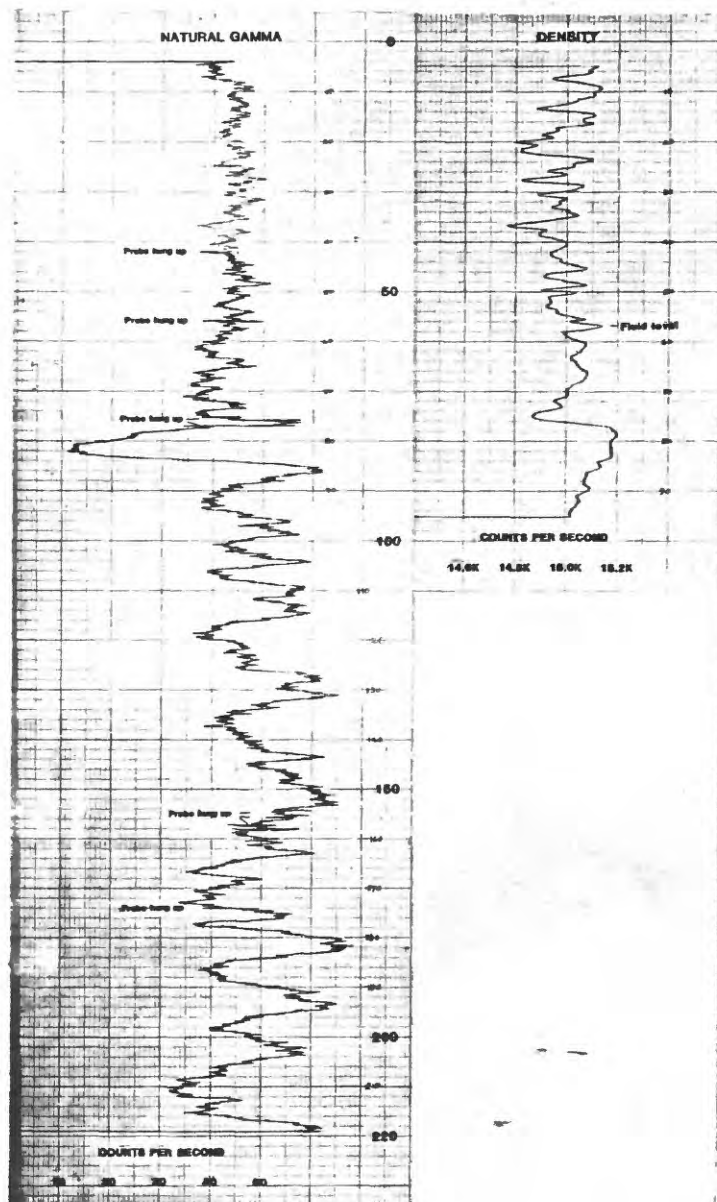


Figure 6.--Geophysical logs of hole GS-5.

Sample log

Hole no.: GS-6 Date: 10-28-78 State: Montana County: Roosevelt

Elev. (ground): 2161 ft Location: T. 29 N., R. 53 E., Sec. SE SE 35

Total depth: 415 ft Drilling medium: mud Offset core hole: GS-6C

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-9 | Gravel, sand, and clay, yellowish-gray, unconsolidated; several detrital coal fragments |
| 9-18 | Claystone, yellowish-gray to light-olive-gray; includes siltstone between 12 and 14 ft |
| 18-40 | Siltstone, yellowish-gray to light-olive-gray; includes some interbedded claystone; thin coal at 33 ft |
| 40-58 | Siltstone and sandstone, medium-light-gray, calcareous |
| 58-67.5 | Claystone, greenish-gray, slightly silty |
| 67.5-71.1 | Lignite, black; includes 2.5-in.-thick claystone parting in lower part; see core sample D209962; ("D" Rider lignite bed) |
| 71.1-80 | Claystone, greenish-gray |
| 80-91 | Sandstone and siltstone, medium-light-gray to yellowish-gray |
| 91-94.5 | Claystone, light-olive-gray, silty |
| 94.5-106.5 | Lignite, black with moderate-brown mottling; grades impure between 2.5 and 4.5 ft below top; includes 5 and 12-in.-thick claystone partings between 104 and 105.8 ft; see core samples D209963 and D209964; ("D" lignite bed) |
| 106.5-141 | Siltstone, light-gray to greenish-gray, calcareous; includes some interbedded olive-gray silty claystone; hard calcareous sandstone concretions between 113 and 114 ft, 132 and 134 ft, and 140 and 141 ft |
| 141-167 | Claystone, medium-gray to olive-gray, silty; includes some light- to medium-light-gray siltstone and scattered thin olive-gray calcareous sandstone concretions |
| 167-183 | Siltstone, light- to medium-gray, calcareous; interbedded with silty claystone in middle to lower parts |
| 183-198 | Sandstone and siltstone, medium-gray; very fine grained sandstone at base grading upward to silty sandstone and siltstone at top; interbedded with silty claystone in middle part |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|---|
| 198-200 | Claystone, brownish-gray, silty |
| 200-202 | Lignite, black; ("C" lignite bed) sandstone in middle part |
| 202-210 | Claystone, medium-light-gray, silty |
| 210-217 | Siltstone, light- to medium-light-gray, sandy; grades to silty sandstone in middle part |
| 217-240 | Silty claystone and siltstone, medium-light-gray to light- olive-gray; very silty claystone at top grading downward to siltstone |
| 240-304 | Sandstone and siltstone, light- to medium-gray, locally brownish-gray; scattered thin carbonaceous laminations; includes 3 to 4-ft-thick intervals of brownish-gray claystone between 251 and 254 ft and 276 and 280 ft; thin calcareous sandstone concretions between 290 and 300 ft |
| 304-312 | Claystone, medium-gray, slightly carbonaceous , silty |
| 312-329 | Sandstone, medium-light-gray, very fine grained, silty; scattered thin calcareous sandstone concretions |
| 329-334 | Claystone, medium-gray to brownish-gray, silty; includes thin coal at 333 ft |
| 334-338 | Siltstone, medium-light-gray, sandy |
| 338-342 | Claystone, brownish-gray, silty |
| 342-345 | Lignite, grayish-black; slightly pyritic; ("B" lignite bed) |
| 345-354 | Claystone, brownish-gray; grades silty at base |
| 354-415 | Sandstone, medium-light-gray to brownish-gray, very fine grained, silty; widely scattered thin carbonaceous laminations; very hard and dense calcareous sandstone concretion at base |
| Total depth 415 ft | |

Hole no.: GS-6 Date: 10/28/78 State: Montana County: Roosevelt
 Elev. (ground): 2161 ft Location: T. 29 N., R. 53 E., Sec. SE SE 35
 Total depth: 415 ft Bit size: 5.5 in Logging speed: 15 ft/min
 Natural gamma: Time constant 4 Count range 50 cps
 Density (gamma-gamma ray): Time constant 4 Count range 1,000 cps

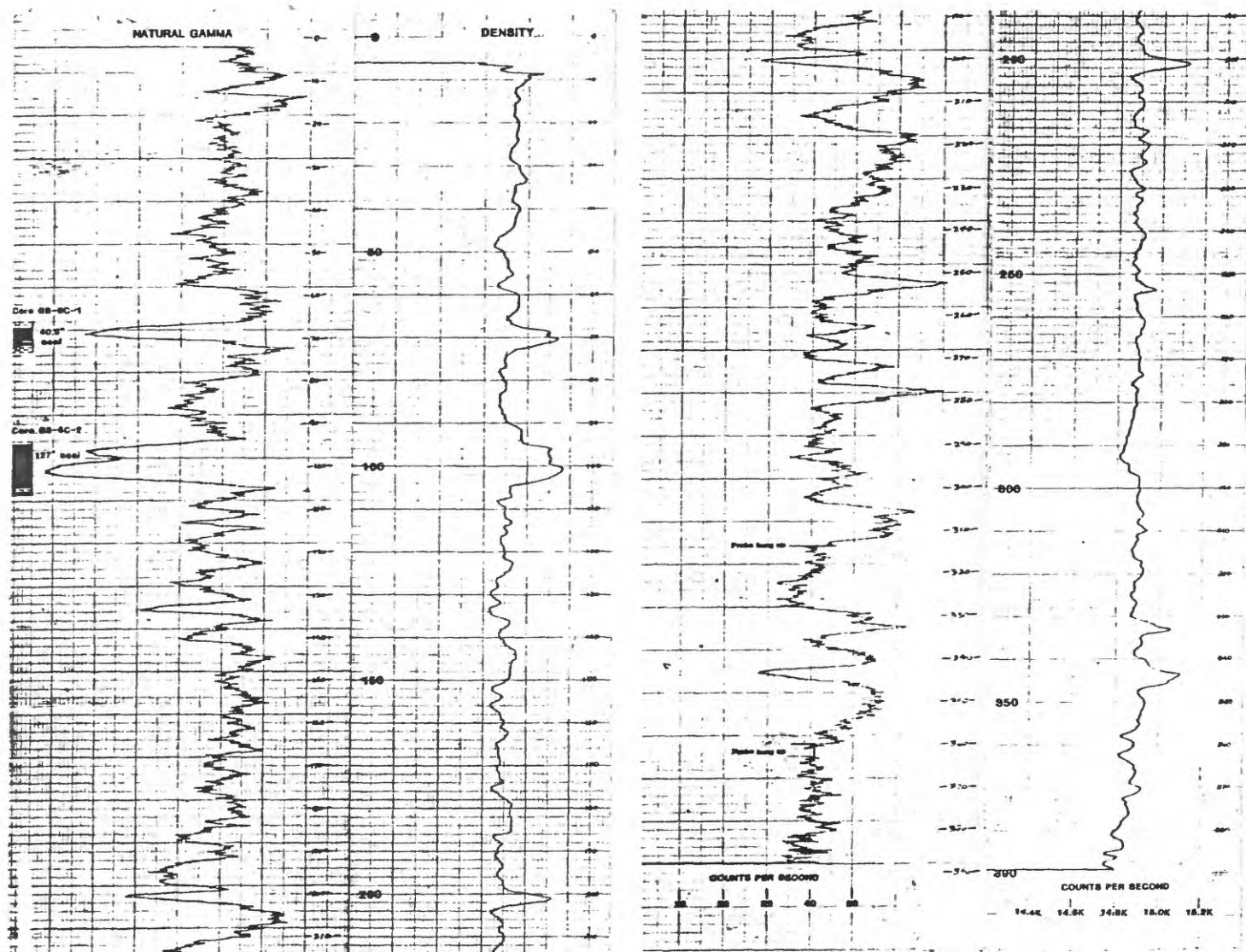


Figure 7.--Geophysical logs of hole GS-6.

Sample log

Hole no.: GS-7 Date: 10-30-78 State: Montana County: Roosevelt

Elev. (ground): 2239 ft Location: T. 29 N., R. 53 E., Sec. NW NW 35

Total depth: 260 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-6 | Gravel, sand, and clay, pale-yellowish-brown, unconsolidated |
| 6-13 | Siltstone, pale-brown to grayish-brown |
| 13-18 | Claystone, medium-gray to dark-yellowish-brown |
| 18-29 | Sandstone, greenish-gray to very pale orange, very fine grained, silty; traces of magnetite and chlorite(?); includes interbedded claystone between 22 and 24 ft |
| 29-36 | Siltstone and claystone, light-gray to light-olive-gray |
| 36-54 | Siltstone, light-gray to light-olive-gray, very sandy |
| 54-63 | Claystone and siltstone, medium-dark-gray to light-olive-gray; claystone predominates at top and base grading to silty claystone and siltstone in middle of unit; scattered thin carbonaceous beds |
| 63-66.5 | Lignite, black; ("D" Rider lignite bed) |
| 66.5-77 | Claystone, light-greenish-gray, very silty in upper part |
| 77-106 | Siltstone and silty sandstone, light- to medium-light-gray, calcareous |
| 106-114.5 | Lignite, black; grades impure between 108 and 110 ft; ("D" lignite bed) |
| 114.5-118 | Claystone, brownish-gray to medium-dark-gray |
| 118-128 | Sandstone, light-gray to light-olive-gray, very fine grained, silty |
| 128-155 | Siltstone, light-gray to yellowish-gray, sandy; includes some thinly interbedded silty claystone |
| 155-157.5 | Lignite, brownish-black, impure in upper part; ("CD" lignite bed) |
| 157.5-173 | Sandstone and siltstone, light-gray to brownish-gray; grades to claystone at top |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|--|
| 173-191 | Siltstone and silty claystone, medium-light-gray to greenish-gray; siltstone in upper part grading downward to silty claystone at base |
| 191-205 | Sandstone, light- to medium-light-gray, very fine grained, silty |
| 205-206 | Lignite, black |
| 206-208 | Claystone, brownish-gray, carbonaceous |
| 208-210 | Lignite, black; ("C" lignite bed) |
| 210-218 | Claystone and siltstone, medium-light-gray to brownish-gray; claystone at top and base grading to siltstone in middle of unit |
| 218-260 | Silty sandstone and siltstone, light-gray to brownish-gray; includes some thinly interbedded silty claystone |
| Total depth 260 ft | |

Hole no.: GS-7 Date: 10/30/78 State: Montana County: Roosevelt
 Elev. (ground): 2239 ft Location: T. 29 N., R. 53 E., Sec. NW NW 35
 Total depth: 260 ft Bit size: 5.5 in Logging speed: 15 ft/min
 Natural gamma: Time constant 4 Count range 50 cps
 Density (gamma-gamma ray): Time constant 4 Count range 1,000 cps

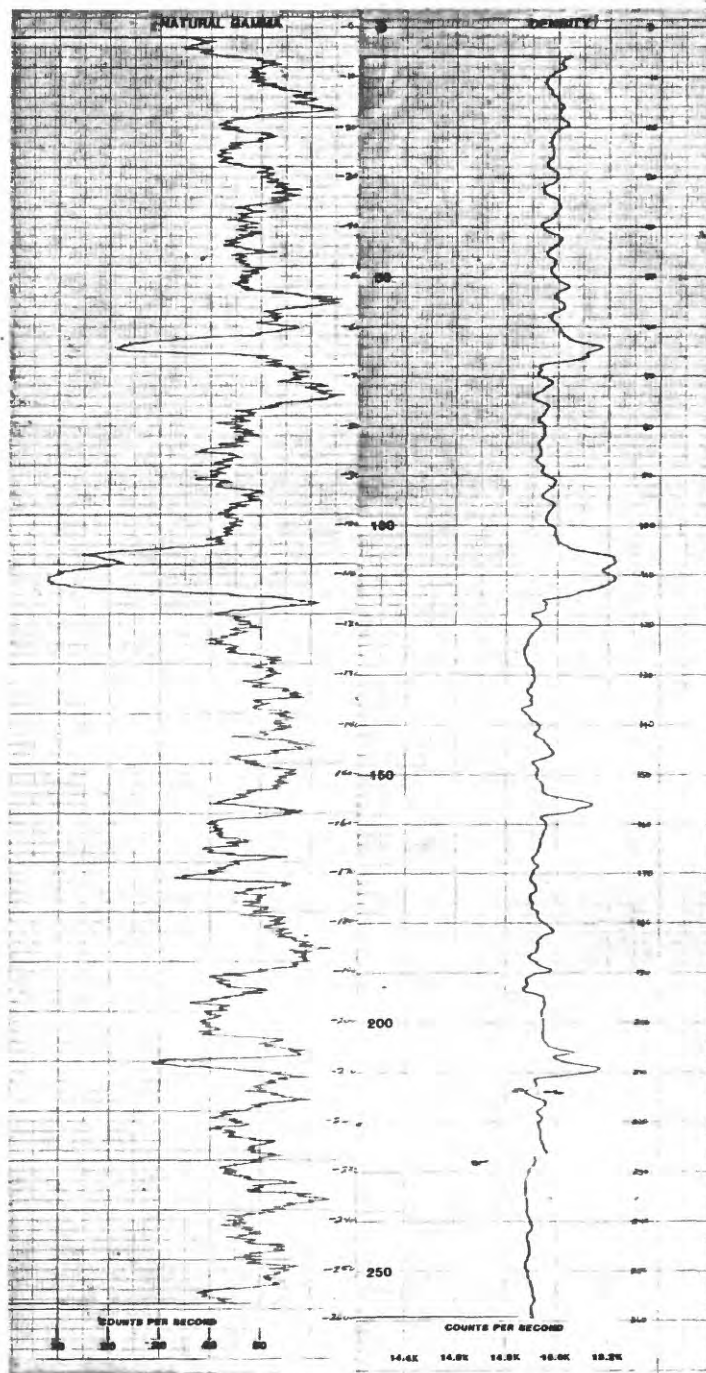


Figure 8.--Geophysical logs of hole GS-7.

Sample log

Hole no.: GS-8 Date: 10-16-78 State: Montana County: Roosevelt
 Elev. (ground): 2360 ft Location: T. 28 N., R. 53 E., Sec. SE NW 10
 Total depth: 320 ft Drilling medium: mud Offset core hole: GS-8C

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-7 | Fine gravel, sand, and clay, dark-yellowish-brown, unconsolidated |
| 7-28 | Claystone and siltstone, yellowish-gray, calcareous |
| 28-42 | Siltstone, yellowish-gray to grayish-yellow-green, sandy, micaceous, calcareous |
| 42-43.5 | Lignite, black |
| 43.5-65 | Claystone, light-gray to light-olive-gray, silty, finely micaceous; grades to siltstone between 50 and 55 ft |
| 65-83 | Siltstone, greenish-gray, calcareous; thin calcareous sandstone concretion at 66 ft |
| 83-87 | Claystone, light-olive-gray |
| 87-101 | Siltstone, greenish-gray, sandy, calcareous |
| 101-104 | Lignite, black; ("BC" lignite bed) |
| 104-111 | Claystone, medium-gray to brownish-gray |
| 111-115.5 | Siltstone, greenish-gray; grades to silty claystone at top |
| 115.5-116.5 | Lignite, black |
| 116.5-120 | Claystone, medium-gray |
| 120-156 | Siltstone and claystone, light- to medium-gray, calcareous; sandy siltstone and silty claystone predominate |
| 156-158.5 | Lignite, black |
| 158.5-178 | Siltstone, light- to medium-light-gray, locally sandy; grades to silty claystone at top and base |
| 178-184.2 | Lignite, black; see core samples D209965 and D209966; ("B" lignite bed) |
| 184.2-190 | Claystone, light-olive-gray; carbonaceous in upper part |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|---|
| 190-202 | Siltstone, medium-gray |
| 202-206 | Claystone, medium-dark-gray |
| 206-207.2 | Lignite, black |
| 207.2-215 | Claystone and siltstone, medium-gray to medium-dark-gray; claystone at top and base grading to siltstone in middle of unit |
| 215-233 | Siltstone, medium-gray to greenish-gray; grades sandy in lower part |
| 233-246 | Claystone, medium-gray; thin coal at 236 ft |
| 246-250 | Lignite and carbonaceous shale; impure coal at top and base separated by carbonaceous shale |
| 250-258 | Claystone, medium-gray, silty |
| 258-320 | Siltstone, medium-gray, very sandy; interbedded with claystone from 264 to 268 ft and 274 to 280 ft; calcareous sandstone concretion at 273 ft; grades to silty sandstone at base |
| Total depth 320 ft | |

Hole no.: GS-8 Date: 10/17/78 State: Montana County: Roosevelt
 Elev. (ground): 2360 ft Location: T. 28 N., R. 53 E., Sec. SE NW 10
 Total depth: 320 ft Bit size: 5.5 in Logging speed: 15 ft/min
 Natural gamma: Time constant 4 Count range 50 cps
 Density (gamma-gamma ray): Time constant 4 Count range 1,000 cps

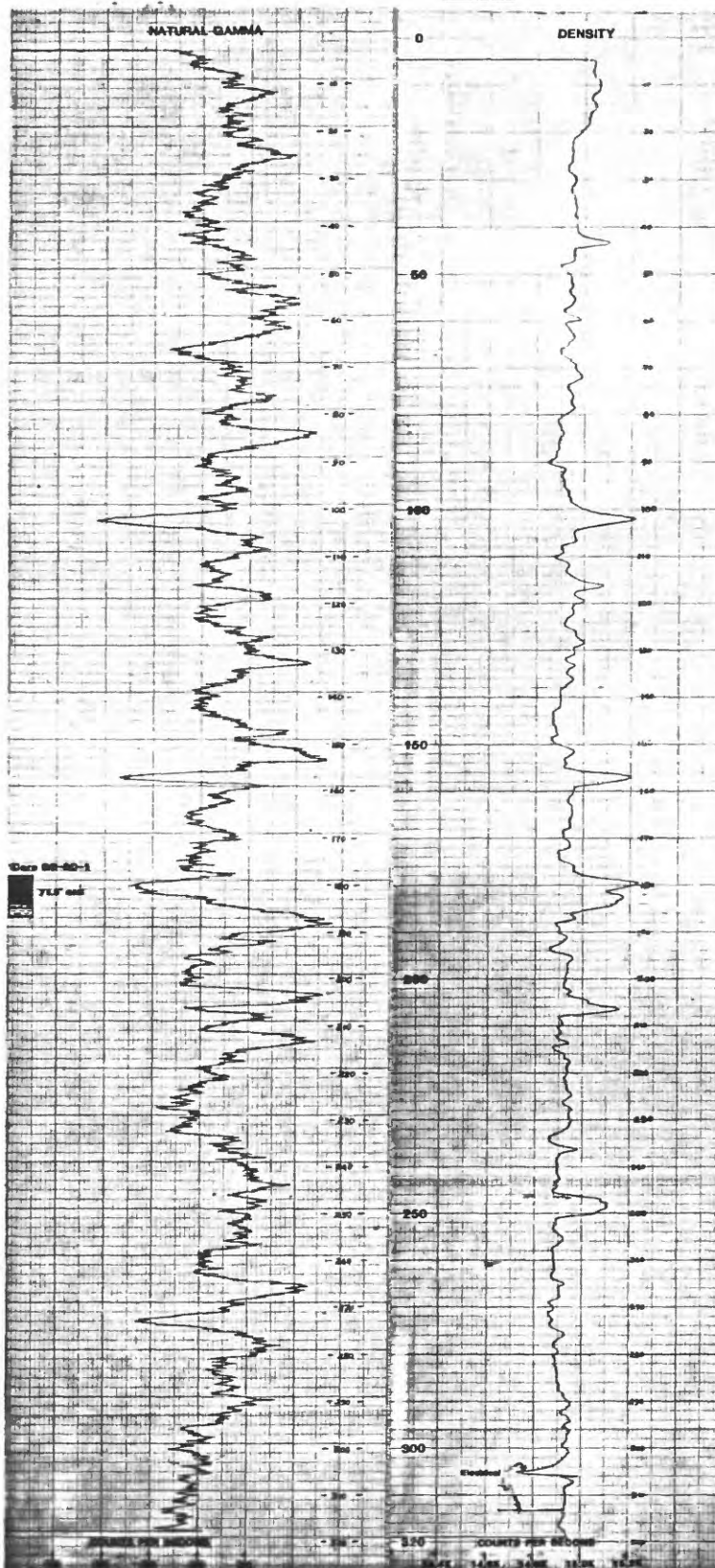


Figure 9.--Geophysical logs of hole GS-8.

Sample log

Hole no.: GS-9 Date: 10-31-78 State: Montana County: Roosevelt

Elev. (ground): 2122 ft Location: T. 29 N., R. 53 E., Sec. NE NW 33

Total depth: 330 ft Drilling medium: mud Offset core hole: GS-9C

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-13 | Gravel, sand, and silt, dark-yellowish-brown, unconsolidated |
| 13-22 | Siltstone and claystone, light-olive-gray to grayish-yellow; siltstone in upper part grades downward to claystone in lower part; thin coal at 20 ft |
| 22-44 | Sandstone, light-olive-gray, very fine grained, silty; interbedded with claystone between 30 and 33 ft; calcareous sandstone concretion between 27 and 29 ft |
| 44-53 | Claystone, yellowish-gray to light-gray; calcareous sandstone concretion between 48 and 50 ft |
| 53-61 | Sandstone and siltstone, yellowish-gray to light-olive-gray; sandstone in upper part grades downward to siltstone in lower part |
| 61-64 | Claystone, dark-gray; includes thin impure coal |
| 64-69.5 | Lignite and carbonaceous shale, dark-gray to black; geophysical logs indicate 1.5 ft of lignite at top, 2.5 ft of carbonaceous shale and impure coal in middle, and 1.5 ft of impure lignite at base |
| 69.5-86 | Claystone and siltstone, light- to medium-gray and brownish-gray; silty claystone predominates; includes thin limestone concretions between 82 and 84 ft |
| 86-88 | Lignite, black |
| 88-92 | Claystone, medium-gray to brownish-gray |
| 92-121 | Siltstone and sandstone, medium-light-gray to medium-gray; includes a thin coal at 98 ft and thinly interbedded silty claystone between 105 and 112 ft |
| 121-127.5 | Lignite, black; grades impure in lower part; see description of core GS-9C-1; ("B" lignite bed) |
| 127.5-140 | Claystone, medium-light-gray to olive-gray, silty |
| 140-150 | Sandstone, medium-light-gray to light-olive-gray, very fine grained |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 150-170 | Claystone and siltstone, medium-light-gray to light-olive-gray, thinly interbedded |
| 170-187 | Sandstone and siltstone, medium-light-gray; sandstone predominates in upper part, siltstone in lower part |
| 187-197 | Claystone, medium-gray to brownish-gray, silty; thin calcareous sandstone concretion at 195 ft |
| 197-213 | Sandstone and siltstone, light-gray to brownish-gray; sandstone predominates in the upper part, siltstone in lower part; includes some scattered thin beds of medium-dark-gray claystone in middle to lower parts |
| 213-218 | Lignite and carbonaceous shale, black to brownish-gray; geophysical logs indicate 2 ft of lignite at top, 2 ft of carbonaceous shale and impure coal in middle, and about 1 ft of impure coal at base |
| 218-224 | Claystone, brownish-gray, silty |
| 224-247 | Sandstone and siltstone, medium-light-gray to medium-gray; siltstone at top grading downward to sandstone in middle and lower parts; hard calcareous sandstone concretion between 238 and 240 ft |
| 247-252 | Claystone, medium-dark-gray, silty; includes thin impure coal |
| 252-266 | Sandstone and siltstone, light- to medium-gray; siltstone predominates in upper and lower parts, sandstone in the middle part |
| 266-275.9 | Claystone, medium-dark-gray to brownish-black, silty; includes medium-dark-gray silty sandstone between 274 and 276 ft |
| 275.9-282.6 | Lignite, black; see core samples D209967 and D209968; ("AB" lignite bed) |
| 282.6-304 | Sandstone and siltstone, medium-gray to light-olive-gray; sandstone predominates in upper to middle parts, grading downward to siltstone in lower part; includes some thinly interbedded brownish-gray carbonaceous shale at 290 and 298 ft |
| 304-308 | Claystone, brownish-gray, silty |
| 308-315 | Siltstone, light-gray to brownish-gray; grades to sandstone at base |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 315-317 | Claystone, brownish-gray, carbonaceous |
| 317-319 | Lignite, black; ("AA" Rider lignite bed) |
| 319-330 | Claystone and siltstone, medium-light-gray to brownish-gray, thinly interbedded |
| | Total depth 330 ft |

Hole no.: GS-9 Date: 10/31/78 State: Montana County: Roosevelt
 Elev. (ground): 2122' Location: T. 29 N., R. 53 E., Sec. NE NW 33
 Total depth: 330 ft Bit size: 4 3/4 in Logging speed: 15 ft/min
 Natural gamma: Time constant 4 Count range 50 cps
 Density (gamma-gamma ray): Time constant 1 Count range 1,000 cps

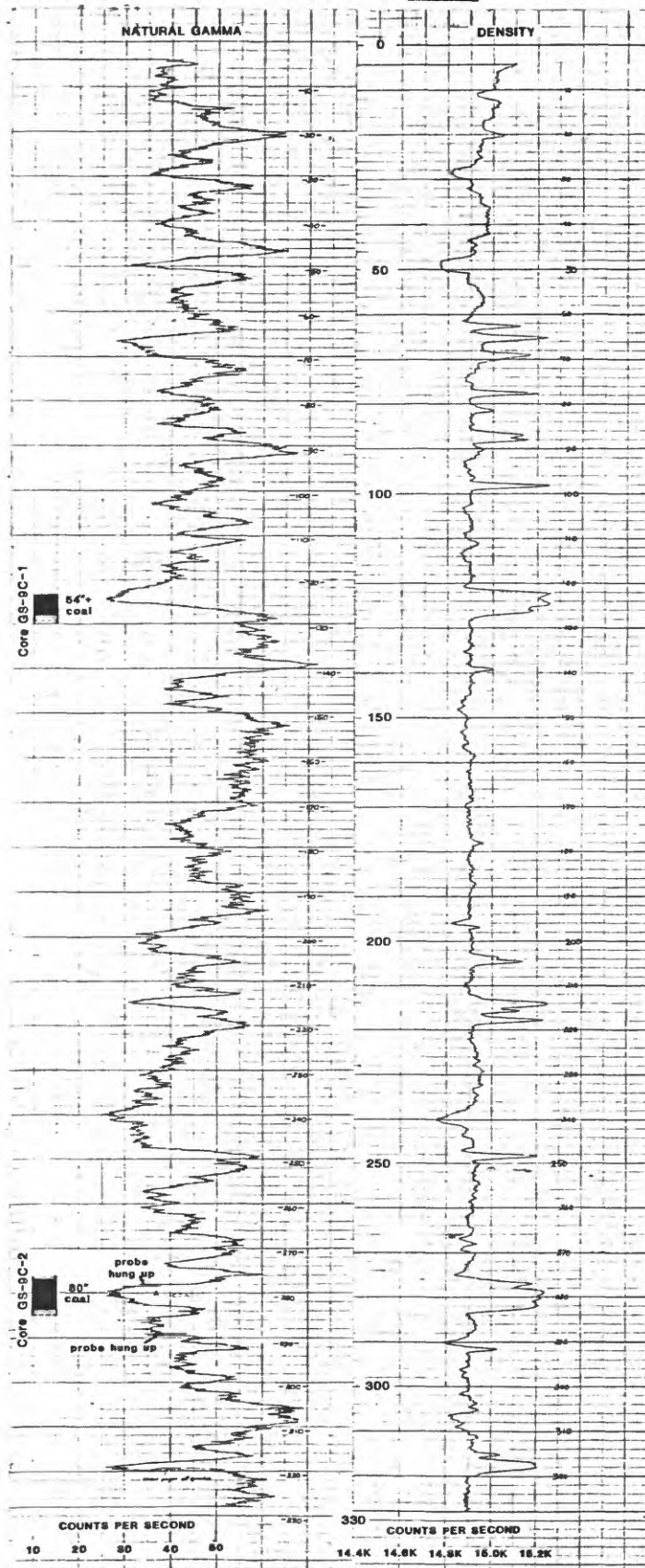


Figure 10.--Geophysical logs of hole GS-9.

Sample log

Hole no.: GS-10 Date: 11-2-78 State: Montana County: Roosevelt

Elev. (ground): 2027 ft Location: T. 29 N., R. 53 E., Sec. NW NE 3

Total depth: 260 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|--------------------|--|
| 0-15 | Sand, silt, and fine gravel, grayish-yellow, unconsolidated |
| 15-28 | Coarse gravel and sand, dark-yellowish-brown, unconsolidated |
| 28-42 | Claystone and siltstone, medium-light-gray to yellowish-gray; siltstone predominates in middle part; includes thin coal at 36 ft |
| 42-55 | Sandstone, grayish-yellow, silty, calcareous |
| 55-66 | Claystone, light-gray, calcareous; coal between 62 and 63 ft (Lower Smoke Creek lignite bed); grades silty in lower part |
| 66-150 | Sandstone and siltstone, light- to medium-light-gray; sandstone predominates at top and siltstone in lower part, remainder of unit is interbedded silty sandstone and siltstone; scattered thin calcareous concretions and several thin carbonaceous beds between 70 and 90 ft; includes some medium-gray silty claystone between 126 and 129 ft and at base |
| 150-152 | Lignite, black to brownish-black |
| 152-186 | Claystone, light- to medium-gray and brownish-gray, silty; includes some siltstone and numerous thin stringers of coal between 168 and 174 ft |
| 186-188.5 | Lignite, brownish-black, impure; ("B" lignite bed) |
| 188.5-200 | Sandstone, light-gray, very fine grained, silty; includes some medium-gray siltstone at top and between 194 and 197 ft |
| 200-227 | Claystone, very light gray to light-gray, silty; includes fairly abundant thinly interbedded siltstone and scattered thin carbonaceous layers |
| 227-229 | Lignite, black to brownish-black |
| 229-239 | Siltstone, medium-light-gray to light-gray, calcareous |
| 239-243 | Claystone, brownish-black to olive-black, carbonaceous |
| 243-260 | Siltstone, light- to medium-gray, sandy, calcareous; grades to very fine grained sandstone between 252 and 254 ft |
| Total depth 260 ft | |

Hole no.: GS-10 Date: 11/2/78 State: Montana County: Roosevelt
 Elev. (ground): 2027 ft Location: T. 29 N., R. 53 E., Sec. NW NE 3
 Total depth: 260 ft Bit size: 5½ in Logging speed: 15 ft/min
 Natural gamma: Time constant 4 Count range 50 cps
 Density (gamma-gamma ray): Time constant 4 Count range 1,000 cps

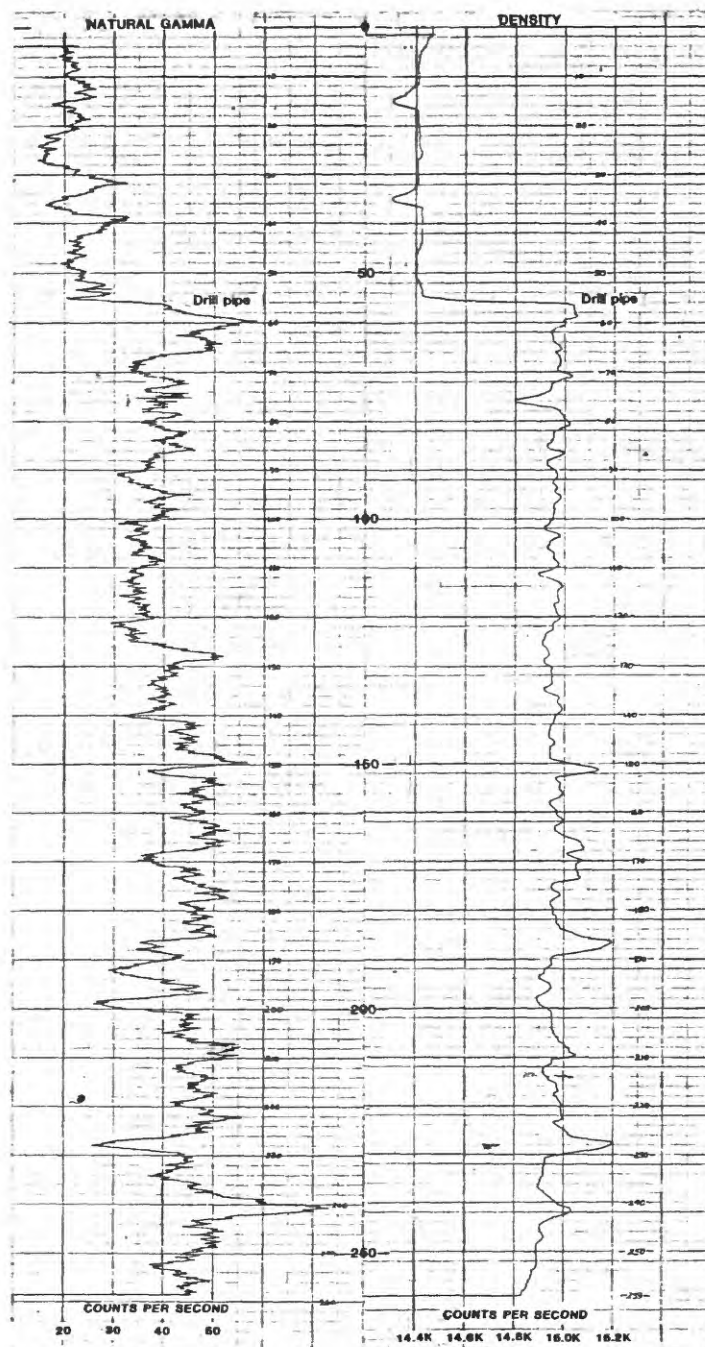


Figure 11.--Geophysical logs of hole GS-10.

Sample log

Hole no.: GS-11 Date: 8/9/79 State: Montana County: Roosevelt
 Elev. (ground): 2055 ft Location: T. 30 N., R. 54 E., Sec. NW NW 16
 Total depth: 561 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-5 | Sand and silt, light-olive-gray to brownish-gray, unconsolidated |
| 5-18 | Sand, silt, and clay, moderate-to dark-yellowish-brown, unconsolidated; sparsely scattered small pebbles |
| 18-45 | Sand, silt, and small rounded pebbles, dark-yellowish-brown, unconsolidated |
| 45-64 | Gravel and sand, unconsolidated; chiefly rounded pebbles of quartz, quartzite, and granitic rocks as much as 1.5 inches in diameter |
| 64-89 | Sandstone and siltstone, light-gray to yellowish-gray; very fine grained silty sandstone predominates in lower part |
| 89-90 | Lignite, black; (Lower Timber Coulee lignite bed) |
| 90-98 | Siltstone and claystone, light-to medium-gray |
| 98-160 | Sandstone, light-gray, very fine grained, silty; includes some thinly interbedded siltstone in upper and lower parts |
| 160-175 | Siltstone, and sandstone, light-gray; siltstone in upper part grades downward to sandstone at base |
| 175-184 | Siltstone and claystone, medium-light-gray |
| 184-185 | Lignite, grayish-black |
| 185-188 | Claystone, medium-light-gray |
| 188-282 | Sandstone and siltstone, light-to medium-gray; includes some widely scattered and thinly interbedded claystone; probable thin impure coals at 199, 209 and 213 ft; hard calcareous sandstone concretion at 238 ft |
| 282-312 | Siltstone and claystone, medium-light-gray; hard calcareous sandstone concretion between 305 and 307 ft |
| 312-319 | Sandstone, medium-light-gray, very fine grained, silty |
| 319-320.5 | Lignite, grayish-black to black; ("BC" lignite bed) |
| 320.5-334 | Claystone and siltstone, medium-gray to brownish-gray; includes some thinly interbedded carbonaceous shale |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|---|
| 334-335.5 | Lignite, grayish-black; ("BC" Leader lignite bed) |
| 335.5-363 | Silty claystone and siltstone thinly interbedded, medium-dark-gray; locally sandy |
| 363-370 | Sandstone, light-gray, very fine grained |
| 370-408 | Siltstone and silty claystone, light-gray to brownish-gray |
| 408-420 | Sandstone, light-gray, very fine grained, silty; trace of coal in lower part |
| 420-440 | Siltstone and silty claystone, medium-light-gray to brownish-gray; slightly carbonaceous in lower part |
| 440-441.5 | Lignite, grayish-black; ("B" lignite bed) |
| 441.5-444 | Carbonaceous claystone, brownish-gray |
| 444-470 | Sandstone and siltstone, light-to medium-gray |
| 470-490 | Siltstone and claystone, light-gray siltstone and interbedded greenish-gray to brownish-gray claystone |
| 490-514 | Sandstone, light-gray, very fine grained, silty |
| 514-527.5 | Siltstone and silty claystone, medium-light-gray to brownish-gray; includes impure lignite between 521.5-522.5 ft; grades to carbonaceous shale at base |
| 527.5-530 | Lignite, grayish-black; ("AB" lignite bed) |
| 530-531.5 | Carbonaceous shale and impure lignite, grayish-black to brownish-gray |
| 531.5-537 | Lignite, grayish-black to brownish-black; ("AB" lignite bed) |
| 537-561 | Siltstone and claystone, medium-light-gray, thinly interbedded |
| Total depth 561 ft | |

Hole No: GS-11 Date: 8-9-79 State: Montana County: Roosevelt
 Sec. NW NW 16 T. 30 N. R. 54 E. Elevation: 2055 ft Total Depth: 561 ft
 Logging Speed: 10 ft/min Natural Gamma: TC 3, Range 10 cps Density: TC 3,
 Range 200 cps Resistance: 10 ohms/in Caliper: Horizontal scale .2 in/in

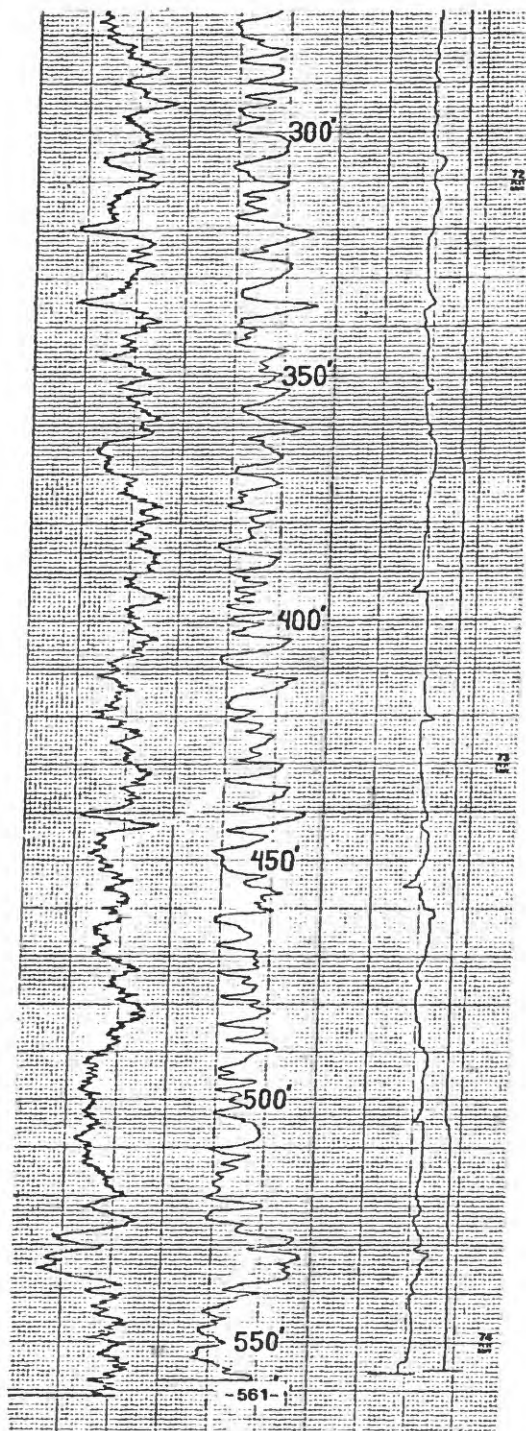
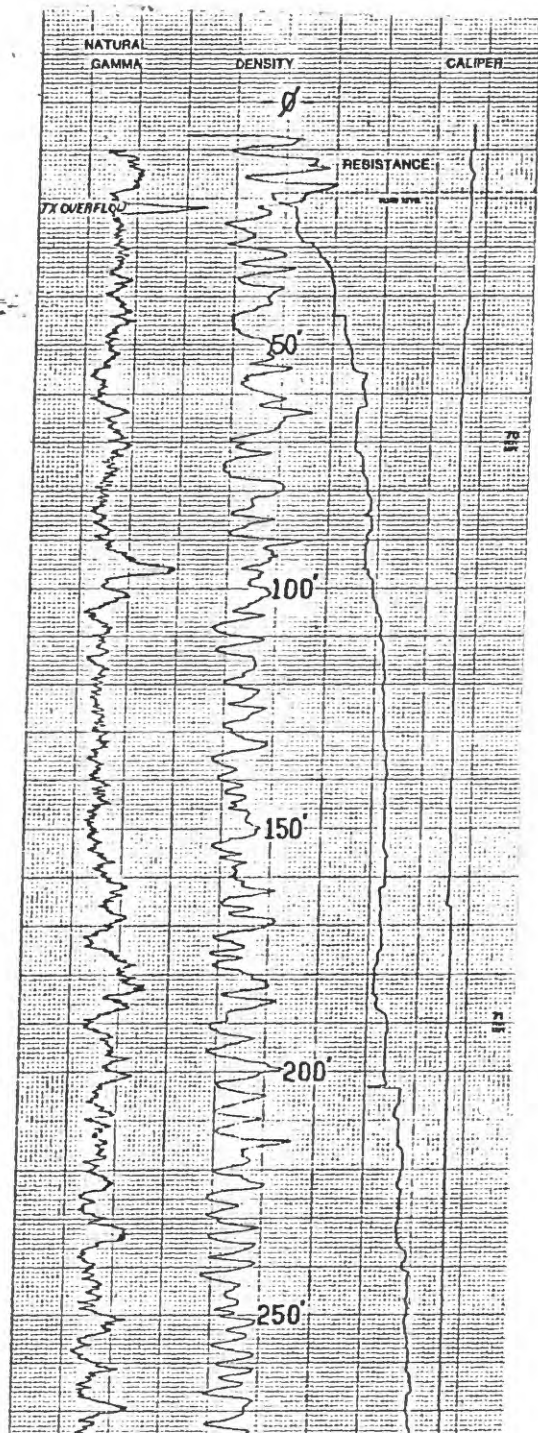


Figure 12.--Geophysical logs of hole GS-11

Sample log

Hole no.: GS-12 Date: 11-6-78 State: Montana County: Roosevelt

Elev. (ground): 2478 ft Location: T. 30 N., R. 52 E., Sec. NE SE 7

Total depth: 500 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-20 | Gravel, sand, and clay, pale-yellowish-brown, unconsolidated |
| 20-32 | Claystone, light-gray to light-olive-gray; grades to siltstone at top and base |
| 32-34 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 34-73 | Siltstone, grayish-orange and light-gray; scattered and thinly interbedded claystone; probable impure coal between 54.5 and 56.5 ft |
| 73-110 | Sandstone, light-gray, fine-grained; thin coal at 89 ft |
| 110-117.5 | Claystone, medium-gray, silty |
| 117.5-121.5 | Lignite and carbonaceous shale, dark-gray to black; geophysical logs indicate 10 in. of impure lignite at top, 20 in. of carbonaceous shale in middle, and about 18 in. of impure lignite at base |
| 121.5-143 | Siltstone, medium-gray; interbedded with claystone at top and between 131 and 133 ft; thin coal just above base |
| 143-155 | Siltstone and claystone, light- to medium-gray; siltstone in upper part grades downward to silty claystone in lower part |
| 155-200 | Sandstone and siltstone, light-gray; grades to siltstone at top and base, sandstone predominates elsewhere; includes silty claystone between 171 and 173 ft |
| 200-204 | Lignite, grayish-black to black; ("B" lignite bed) |
| 204-215 | Siltstone and claystone, light-gray; sandy siltstone in upper part grading downward to silty claystone at base |
| 215-217 | Lignite, brownish-black, slightly impure |
| 217-223 | Siltstone, light-gray, sandy |
| 223-227 | Claystone, light- to medium-gray, silty |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 227-271 | Sandstone and siltstone, light-gray; sandstone predominates in upper and lower parts; chiefly siltstone and sandy siltstone in middle part with some thinly interbedded silty claystone; thin calcareous concretion at 230 ft |
| 271-278 | Claystone, medium-gray; silty in upper part; impure coal between 273 and 274 ft |
| 278-294 | Siltstone and silty sandstone, light-gray, calcareous, very finely micaceous; includes thin silty claystone at base 3.5 ft of lignite in lower part; ("AB" Rider lignite bed) |
| 294-301 | Lignite, impure lignite, and carbonaceous shale, black to brownish-black; geophysical logs indicate about 3.5 ft of impure coal and carbonaceous shale in upper part, and about 3.5 ft of lignite in lower part; ("AB" Rider lignite bed) |
| 301-306 | Claystone, medium-gray to brownish-gray |
| 306-319 | Siltstone, silty sandstone, and claystone, light- to medium-gray; siltstone and silty sandstone in upper part grading downward to siltstone and silty claystone at base |
| 319-327 | Lignite and carbonaceous shale, black to grayish-black; geophysical logs indicate 3 ft of lignite at top, 2 ft of carbonaceous shale in middle of unit, and 3 ft of lignite in lower part; ("AB" lignite bed) |
| 327-376 | Siltstone and silty sandstone, light- to medium-gray; siltstone predominates with silty sandstone locally more abundant in middle to lower parts; includes sparse thinly interbedded silty claystone; scattered thin calcareous sandstone concretions between 345 and 365 ft |
| 376-378 | Lignite, grayish-black, slightly impure |
| 378-421 | Siltstone and sandstone, light-gray; siltstone in upper part grades downward to silty sandstone in middle, and to siltstone and silty claystone in lower part; thin impure coal at 388 ft |
| 421-428 | Lignite and carbonaceous shale, black to grayish-black; geophysical logs indicate 2.5 ft of lignite at top, 1.5 ft of carbonaceous shale in middle, and 3 ft of lignite in lower part; ("AA" lignite bed) |
| 428-459 | Claystone and siltstone, medium- to dark-gray; claystone in upper part grades downward to siltstone in middle, and to silty claystone in lower part |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 459-482 | Siltstone and sandstone, light- to medium-gray, thinly interbedded; grades to silty claystone at base |
| 482-484 | Carbonaceous shale and impure coal, black to grayish-black |
| 484-487 | Claystone, dark-gray |
| 487-490.5 | Lignite and carbonaceous shale, black to grayish-black; geophysical logs indicate about 1.5 ft of slightly impure lignite at top, about 1.0 ft carbonaceous shale in middle, and about 1.0 ft of impure lignite at base of unit; ("A" Rider lignite bed) |
| 490.5-500 | Siltstone and silty claystone, medium-gray, thinly interbedded |
| | Total depth 500 ft |

Hole no.: GS-12 Date: 11/6/78 State: Montana County: Roosevelt
 Elev. (ground): 2478 ft Location: T. 30 N., R. 52 E., Sec. SE 7
 Total depth: 500 ft Bit size: 5½ in Logging speed: 15 ft/min
 Natural gamma: Time constant 4 Count range 50 cps
 Density (gamma-gamma ray): Time constant 1 Count range 1,000 cps

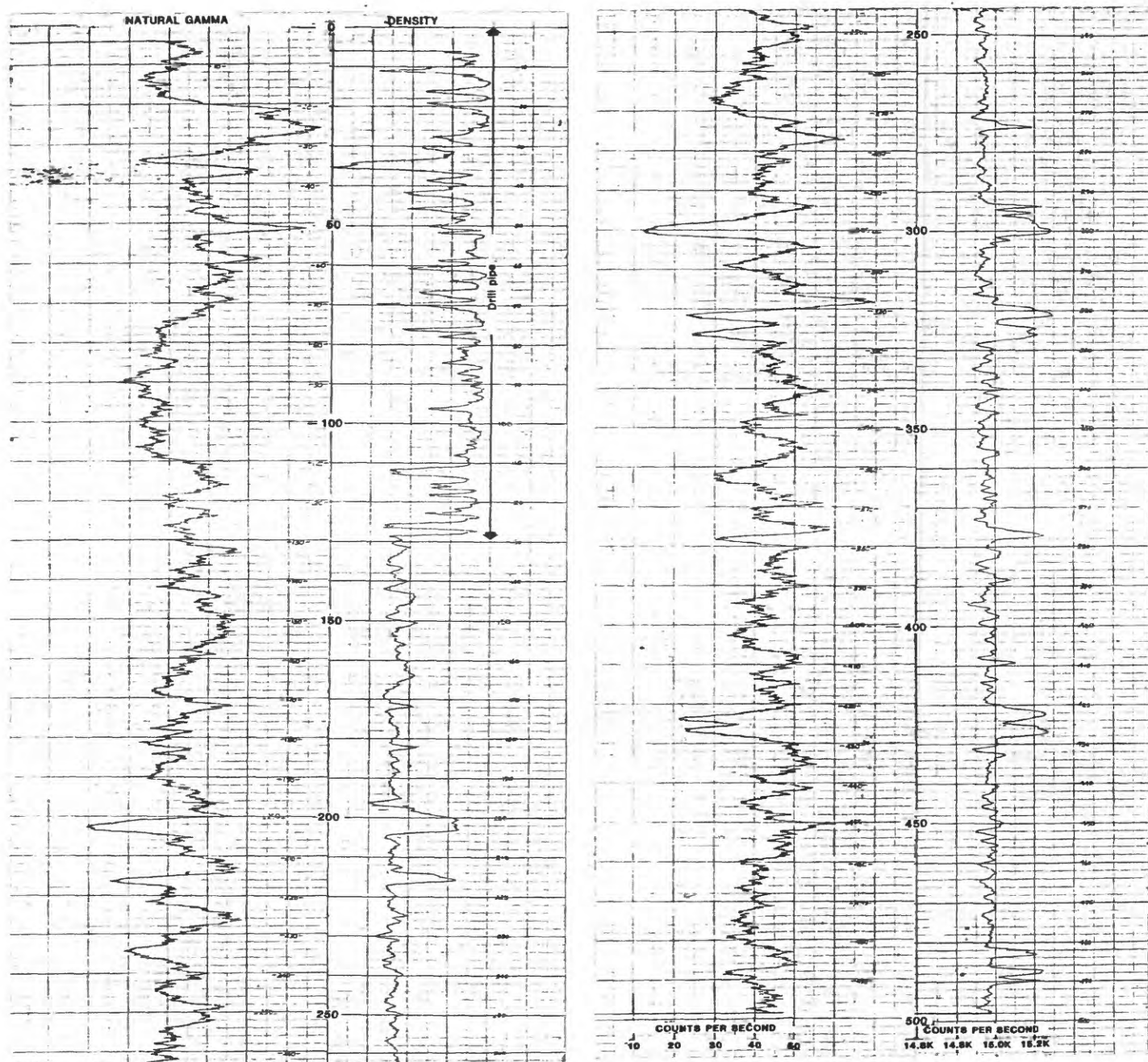


Figure 13.--Geophysical logs of hole GS-12.

Sample log

Hole no.: GS-13 Date: 8-15-79 State: Montana County: Roosevelt
 Elev. (ground): 2196 ft Location: T. 31 N., R. 54 E., Sec. SE SE 10
 Total depth: 503 ft Drilling medium: mud Offset core hole: GS-13C

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-10 | Sand, silt, and clay, dark-yellowish-brown, unconsolidated |
| 10-18 | Fine gravel, granules, and sand, unconsolidated |
| 18-112 | Sandstone, light-gray to moderate-yellowish-brown, very fine to fine-grained, scattered dark opaque grains, very finely micaceous; very poor cuttings return; hard, very light gray calcareous sandstone concretion at 66 ft |
| 112-117 | Claystone, greenish-gray |
| 117-119 | Lignite, grayish-black to brownish-black, impure; (Upper Timber Coulee lignite bed) |
| 119-131.5 | Claystone and siltstone, light-to medium-gray, slightly carbonaceous in upper and lower parts |
| 131.5-135.9 | Lignite, moderate-brown to black, grades impure in upper part; includes 3 inch thick claystone parting in upper part; see core sample D221130 description; (Lower Timber Coulee lignite bed) |
| 135.9-138.9 | Claystone, dark-greenish-gray to olive-gray; includes 4 inches of lignite in middle of interval; see core GS-13C-1 description |
| 138.9-158 | Sandstone, medium-light-gray, silty in lower part |
| 158-165 | Claystone, light-gray to olive-gray; grades to siltstone at top and base |
| 165-170 | Siltstone, greenish-gray |
| 170-253 | Sandstone and siltstone, light-gray to greenish-gray; includes some thinly interbedded claystone between 205 and 211 ft, and between 226 and 230 ft |
| 253-265 | Claystone, medium-light-gray, silty |
| 265-319 | Sandstone, very light gray to light-bluish-gray, very fine grained, silty |
| 319-322 | Carbonaceous claystone, brownish-gray |
| 322-324.5 | Lignite, black; (Lower Smoke Creek lignite bed) |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|---|
| 324.5-355 | Siltstone and sandstone, medium-light-gray; includes scattered thinly interbedded silty claystone |
| 355-357 | Lignite, black; ("BC" lignite bed) |
| 357-371 | Claystone and carbonaceous shale, light-gray to brownish-gray; includes impure lignite between 360-362 ft |
| 371-432 | Siltstone and sandstone, light-to medium-light-gray; includes some silty claystone between 380-384 ft, 392-396, ft and 413-416 ft |
| 432-440 | Claystone, light-olive-gray to brownish-gray, carbonaceous in middle part; grades silty at top and base |
| 440-447 | Sandstone, light-gray, very fine grained, silty |
| 447-475 | Siltstone, olive-gray; includes scattered thinly interbedded carbonaceous claystone; grades to sandstone at base |
| 475-503 | Sandstone, medium-gray to light-bluish-gray, very fine to fine-grained, salt and pepper texture |
| Total depth 503 ft | |

Hole No: GS-13 Date: 8-15-79 State: Montana County: Roosevelt
 Sec. SE SE 10 T. 31 N. R. 54 E. Elevation: 2196 ft Total Depth: 503 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 3, Range 10 cps Density: TC 3,
 Range 200 cps Resistance: 10 ohms/in Caliper: Horizontal scale 2 in/in

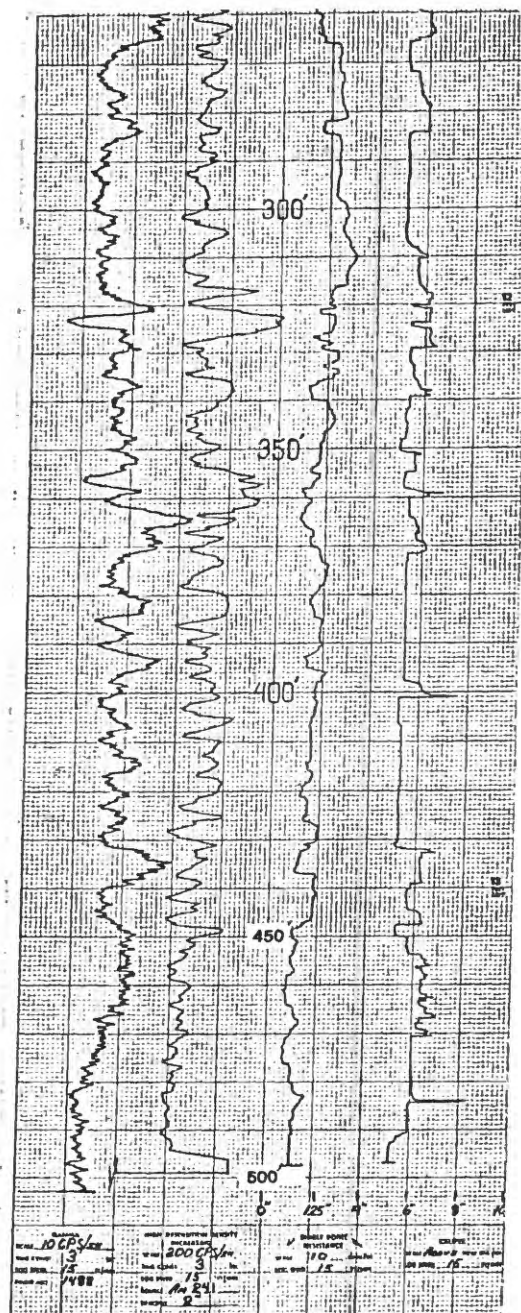
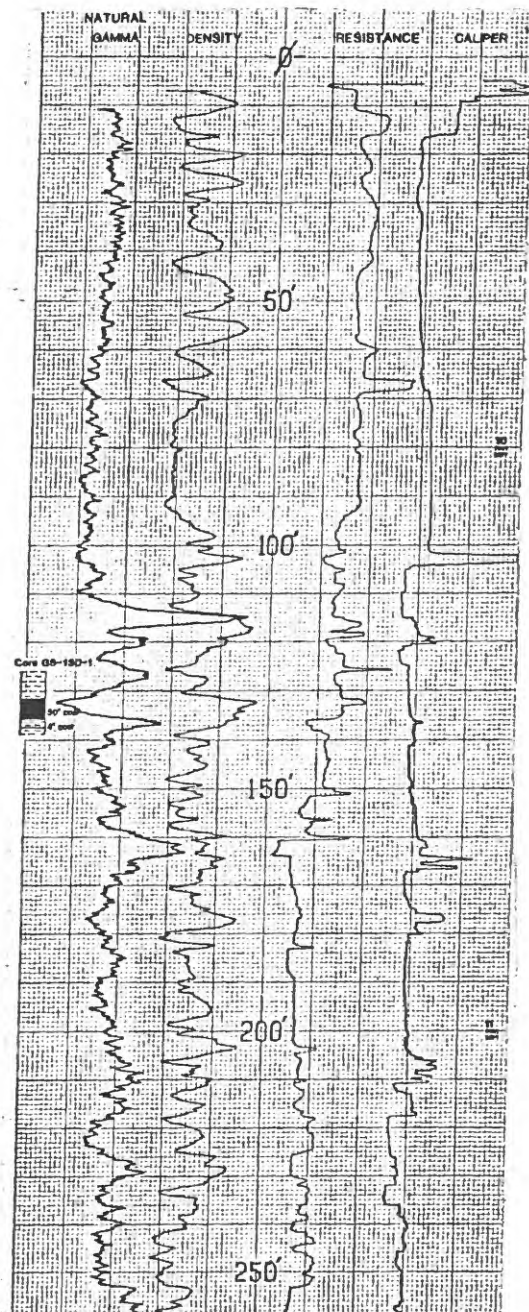


Figure 14.--Geophysical logs of hole GS-13

Sample log

Hole no.: GS-14 Date: 8-11-79 State: Montana County: Roosevelt

Elev. (ground): 2195 ft Location: T. 31 N., R. 53 E., Sec. SE SW 24

Total depth: 500 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-10 | Sand, silt, and clay, pale-yellowish-brown, unconsolidated; includes some scattered pebbles of granite and gneiss |
| 10-16 | Sandstone, yellowish-gray, very fine grained, silty; includes some brownish-gray claystone in middle of interval |
| 16-33 | Claystone and siltstone, yellowish-gray, locally sandy |
| 33-39 | Claystone, light-olive-gray, silty; includes traces of carbonaceous shale and impure lignite |
| 39-41 | Lignite, grayish-black to brownish-black, slightly impure; ("C" lignite bed) |
| 41-69.5 | Siltstone and silty claystone, medium-light-gray to greenish-gray, locally sandy |
| 69.5-71 | Lignite, grayish-black |
| 71-88 | Claystone and siltstone, medium-light-gray to greenish-gray; some brownish-gray carbonaceous shale between 80 and 85 ft |
| 88-124 | Sandstone and siltstone, light-to medium-gray and greenish-gray, very finely micaceous; very fine grained and silty sandstone; hard calcareous sandstone concretion from 93 to 94 ft; grades to slightly carbonaceous siltstone and claystone at base |
| 124-129 | Lignite, black; (Smoke Creek lignite bed) |
| 129-149 | Siltstone, medium-gray; includes some scattered thinly interbedded claystone; locally sandy |
| 149-160 | Claystone, medium-gray to brownish-gray, silty |
| 160-164 | Lignite, grayish-black to brownish-black; grades impure in lower part; (Lower Smoke Creek lignite bed) |
| 164-170 | Claystone, brownish-gray, silty |
| 170-190.5 | Sandstone and siltstone, medium-gray; chiefly very fine grained, finely micaceous sandstone with thinly interbedded siltstone |
| 190.5-192 | Lignite, grayish-black; ("BC" lignite bed) |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|--|
| 192-219 | Claystone, medium-gray, silty; grades to siltstone at top and base |
| 219-265 | Sandstone, medium-to light-gray, very fine grained, silty; some thinly interbedded silty claystone between 253 and 257 ft |
| 265-271 | Siltstone and claystone, medium-gray |
| 271-295 | Sandstone and siltstone, medium-gray, very finely micaceous; chiefly very fine grained sandstone with scattered thinly interbedded siltstone |
| 295-323 | Siltstone and claystone, medium-light-gray siltstone and brownish-gray claystone |
| 323-366 | Sandstone, light-to medium-light-gray, very fine grained, micaceous |
| 366-369 | Claystone, brownish-gray, silty |
| 369-370.5 | Lignite, grayish-black |
| 370.5-391 | Siltstone and sandstone, medium-light-gray, micaceous; chiefly sandy siltstone |
| 391-408 | Claystone and siltstone, medium-light-gray to brownish-gray; chiefly silty claystone in upper and lower parts grading to sandy siltstone in middle of interval |
| 408-434 | Siltstone and sandstone, light-to medium-light-gray; includes some thinly interbedded silty claystone in middle to lower parts |
| 434-462 | Siltstone and silty claystone, thinly interbedded, chiefly medium-light-gray with scattered brownish-gray and olive-gray, locally carbonaceous |
| 462-463 | Lignite, grayish-black |
| 463-474 | Claystone and siltstone, brownish-gray, slightly carbonaceous |
| 474-480 | Lignite, grayish-black to brownish-black; includes parting of impure coal and carbonaceous shale between 475.5 and 477 ft; ("AB" lignite bed) |
| 480-484 | Claystone, brownish-gray, silty, carbonaceous |
| 484-494 | Sandstone, medium-light-gray, very fine grained |
| 494-496 | Calcareous sandstone concretion, light-olive-gray, hard, dense |
| 496-500 | Siltstone-medium-light-gray |
| Total depth 500 ft | |

Hole No: GS-14 Date: 8-11-79 State: Montana County: Roosevelt
 Sec. SE SW 24 T. 31 N. R. 53 E. Elevation: 2195 ft Total Depth: 500 ft
 Logging Speed: 10 ft/min Natural Gamma: TC 3, Range 10 cps Density: TC 3,
 Range 200 cps Resistance: 10 ohms/in Caliper: Horizontal scale 2 in/in

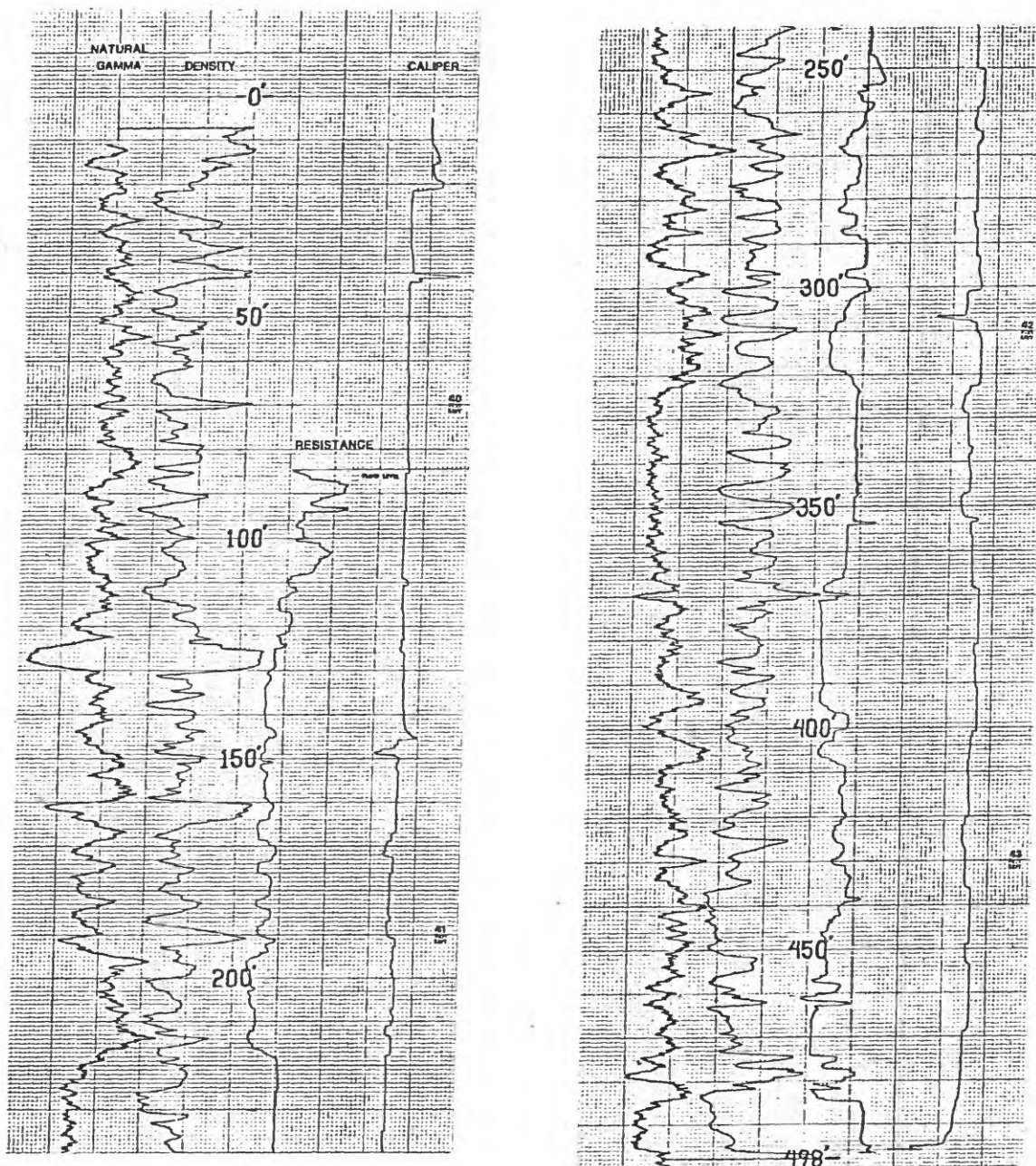


Figure 15.--Geophysical logs of hole GS-14

Sample log

Hole no.: GS-15 Date: 11-4-78 State: Montana County: Roosevelt
 Elev. (ground): 2375 ft Location: T. 31 N., R. 52 E., Sec. SE SW 26
 Total depth: 480 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-60 | Gravel, sand, silt, and clay, light-olive-gray to pale-yellowish-brown, unconsolidated |
| 60-76 | Sandstone and silty claystone, medium-light-gray to very pale orange; sandstone predominates at top and in lower part; grades to silty claystone in middle and at base |
| 76-100 | Claystone, yellowish-gray to medium-light-gray, silty |
| 100-106 | Siltstone and silty claystone, medium-gray; trace of coal in cuttings but no indication of coal in geophysical logs |
| 106-137 | Sandstone, yellowish-gray, very fine grained, silty; includes some thinly interbedded siltstone in upper part |
| 137-143 | Claystone, medium-gray to grayish-black; claystone in upper part grades downward to silty claystone |
| 143-144 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 144-159 | Siltstone, light-gray, calcareous; thin calcareous concretions at 146, 152, and 156 ft |
| 159-180 | Claystone, light- to medium-gray, silty; grades downward to siltstone at base |
| 180-193 | Siltstone, light-gray; grades downward to sandy siltstone at base |
| 193-215 | Sandstone, light-gray, very fine grained, silty |
| 215-236 | Claystone, medium- to dark-gray; includes thin impure coals at 217 and 223 ft; grades silty at top and in lower part |
| 236-250 | Sandstone, light-gray, very fine grained, silty; grades to siltstone at top and base; trace of coal in 245-250 ft cuttings sample |
| 250-265 | Siltstone and claystone; light- to medium-gray; siltstone in upper part grades downward to claystone in lower part; trace of coal in 250-255 ft cuttings sample |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 265-285 | Siltstone and sandstone, light- to medium-light-gray; siltstone in upper part grades downward to silty sandstone in lower part |
| 285-294 | Claystone, light- to medium-gray; grades silty and includes some thinly interbedded siltstone in middle part |
| 294-298 | Lignite, grayish-brown to black; trace of pyrite; ("B" lignite bed) |
| 298-337 | Siltstone and claystone, light- to medium-light-gray; siltstone in upper part grades downward to silty claystone; calcareous sandstone concretions between 316-318 ft, 326-327 ft, and 336-337 ft |
| 337-370 | Siltstone, light- to medium-gray, calcareous, finely micaceous; some thinly interbedded silty sandstone; thin coals at 354 ft and 369 ft |
| 370-390 | Claystone, medium-light-gray; very silty in upper part; includes bed of lignite between 379 and 380 ft |
| 390-400 | Siltstone and claystone, medium-light-gray; claystone at top grades downward to silty claystone and siltstone in lower part |
| 400-403 | Lignite, black; impure |
| 403-409 | Claystone, dusky-yellowish-brown, slightly carbonaceous |
| 409-429 | Siltstone, light-gray, calcareous; includes some thinly interbedded silty sandstone in lower part |
| 429-434 | Claystone, medium-gray; silty in upper part |
| 434-437 | Lignite, grayish-black to black; ("AB" Rider lignite bed) |
| 437-455 | Siltstone and claystone; light- to medium-gray; slightly carbonaceous claystone at top grades downward to siltstone in middle and lower parts |
| 455-460.5 | Lignite, grayish-black to black, slightly impure; ("AB" lignite bed) |
| 460.5-480 | Claystone and siltstone, medium-gray; thinly interbedded |
| | Total depth 480 ft |

Hole no.: GS-15 Date: 11/4/78 State: Montana County: Roosevelt
 Elev. (ground): 2375 ft Location: T. 31 N., R. 52 E., Sec. SW 26
 Total depth: 480 ft Bit size: 5½ in Logging speed: 15 ft/min
 Natural gamma: Time constant 4 Count range 50 cps
 Density (gamma-gamma ray): Time constant 1 Count range 1,000 cps

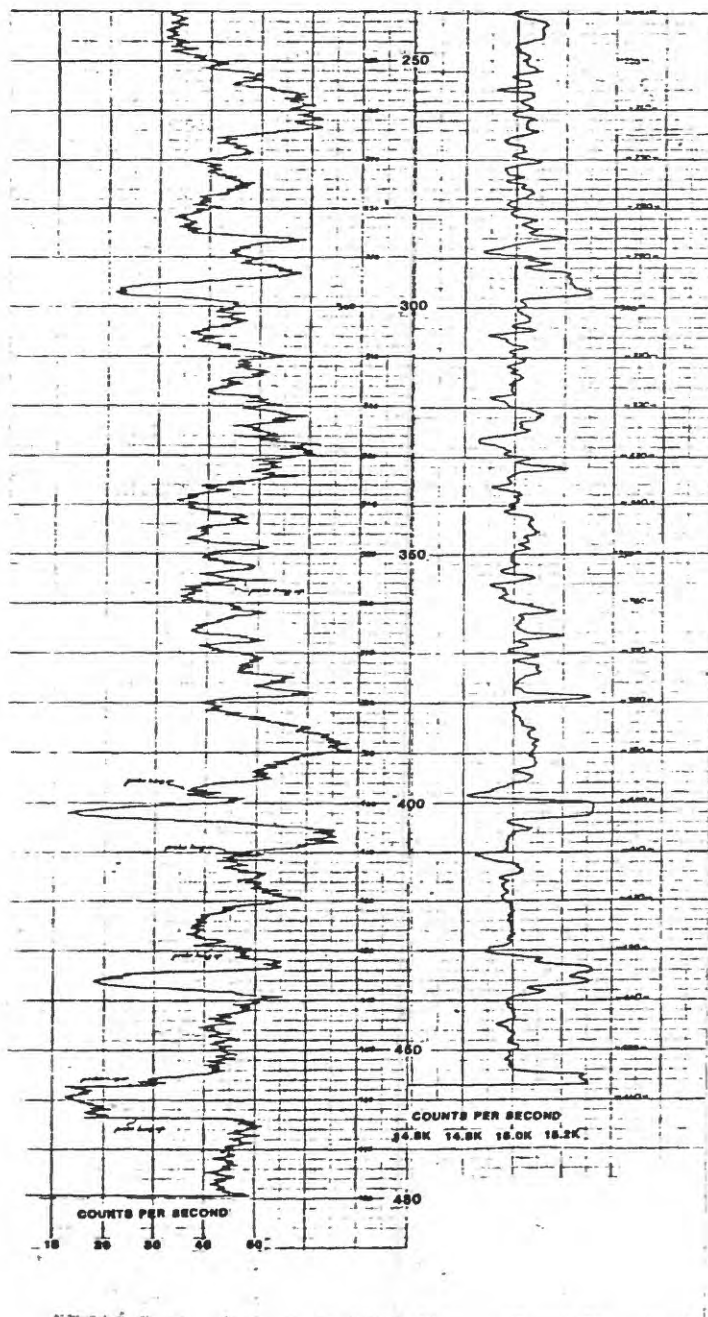
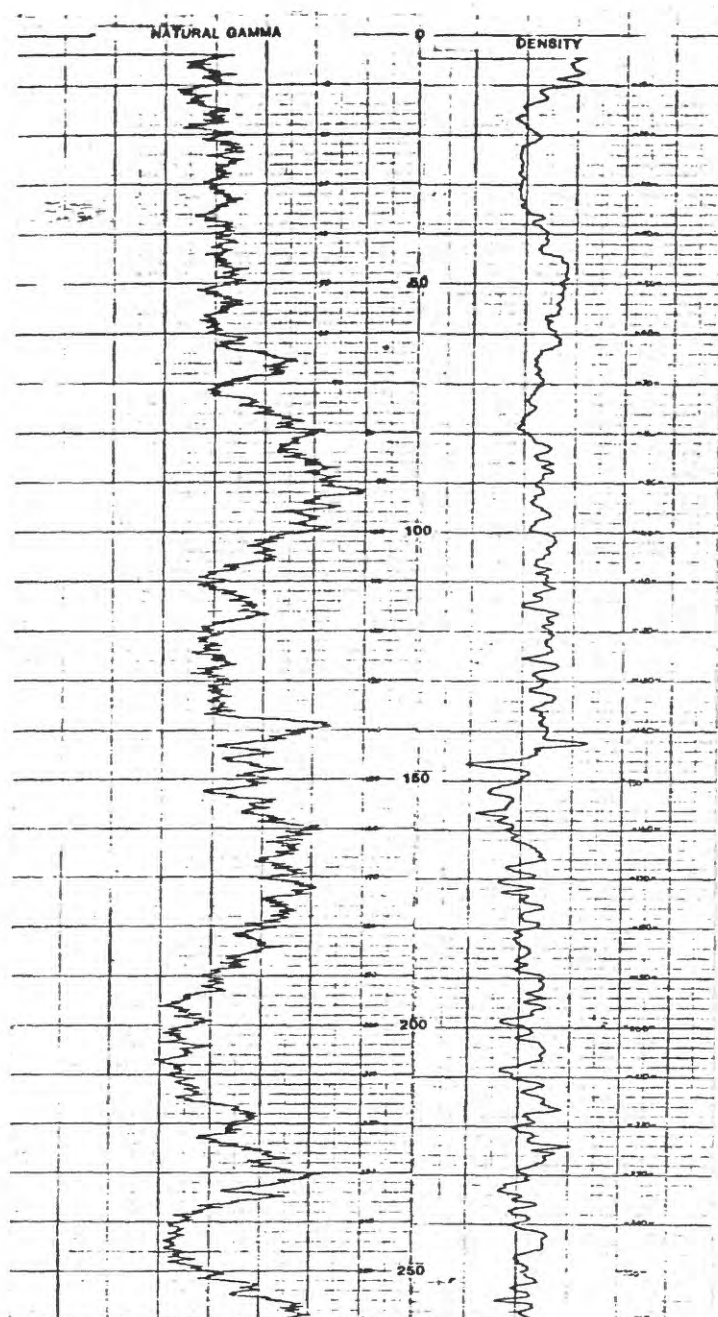


Figure 16.--Geophysical logs of hole GS-15.

Sample log

Hole no.: GS-16 Date: 8-22-79 State: Montana County: Sheridan
 Elev. (ground): 2485 ft Location: T. 32 N., R. 54 E., Sec. NE NE 19
 Total depth: 600 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-12 | Gravel, sand, and mud; unconsolidated |
| 12-58 | Siltstone, light-olive-gray to medium-bluish-gray; with interbedded sandstone |
| 58-84 | Sandstone, dark-yellowish-brown, fine-grained; 15 percent dark opaques; probable thin coal bed at base of interval |
| 84-87 | Claystone; probable thin coal bed at base of interval |
| 87-125 | Siltstone, light-olive-gray to medium-bluish-gray; with interbedded sandstone; probable coal bed 115 to 116 ft |
| 125-143 | Sandstone, light-olive-gray, very fine grained |
| 143-149 | Claystone, light-olive-gray |
| 149-150 | Lignite, black; (Local "R" lignite bed) |
| 150-191 | Siltstone, medium-bluish-gray; traces of organic debris; minor coal fragments |
| 191-219 | Claystone, medium-bluish-gray, slightly carbonaceous; with interbedded siltstone |
| 219-264 | Siltstone, light-gray to olive-gray; sandy near top of interval; coal beds 230 to 231 ft and 236 to 237 ft |
| 264-274 | Lignite, black; (Timber Coulee lignite bed) |
| 274-290 | Siltstone, greenish-gray; carbonaceous at base |
| 290-305 | Claystone, greenish-gray to dark-greenish-gray; carbonaceous at base; minor coal fragments |
| 305-402 | Sandstone, medium-bluish-gray, fine to very fine grained, argillaceous; probable coal bed 380 to 382 ft |
| 402-467 | Siltstone, greenish-gray to medium-light-gray; with thin interbedded sandstone and claystone; traces of coal and carbonaceous claystone scattered throughout interval |
| 467-470 | Lignite, black; (Lower Smoke Creek lignite bed) |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|---|
| 470-520 | Siltstone, light-olive-gray to greenish-gray to medium-light-gray, sandy; interbedded with carbonaceous claystone |
| 520-541 | Claystone, light-olive-gray to very light gray, silty, slightly carbonaceous; minor coal fragments |
| 541-546 | Siltstone, very light gray to light-olive-gray, sandy |
| 546-548 | Lignite, black; ("BC" lignite bed) |
| 548-570 | Siltstone, very light gray to light-olive-gray, sandy |
| 570-572 | Lignite, black |
| 572-583 | Siltstone, very light gray to light-olive-gray, sandy |
| 583-600 | Claystone, light-olive-gray to light-gray |
| Total depth 600 ft | |

Hole No: GS-16 Date: 8-22-79 State: Montana County: Sheridan
 Sec. NE NE 19 T. 32 N. R. 54 E. Elevation: 2485 ft Total Depth: 600 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 2 , Range 10 cps Density: TC 2 ,
 Range 200 cps Resistance: 10 ohms/in Caliper: Horizontal scale 2 in/in

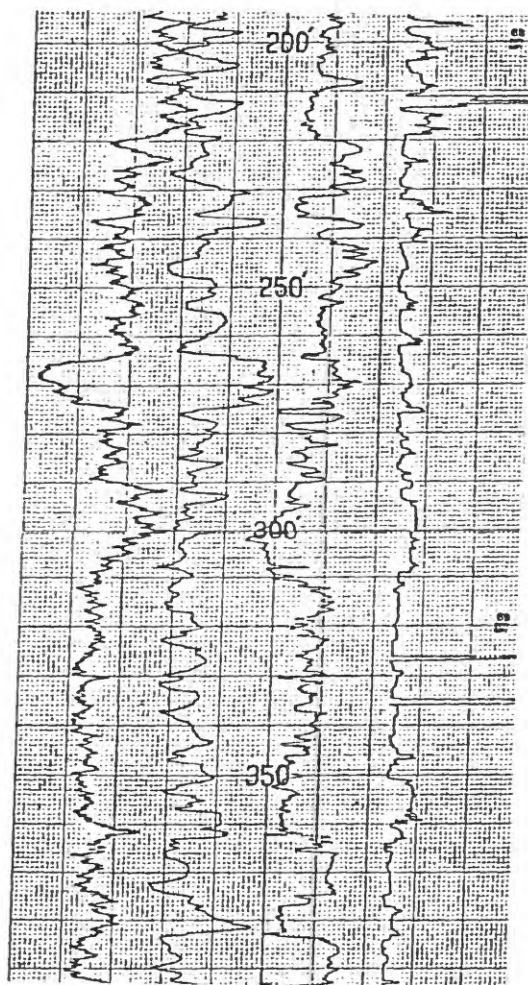
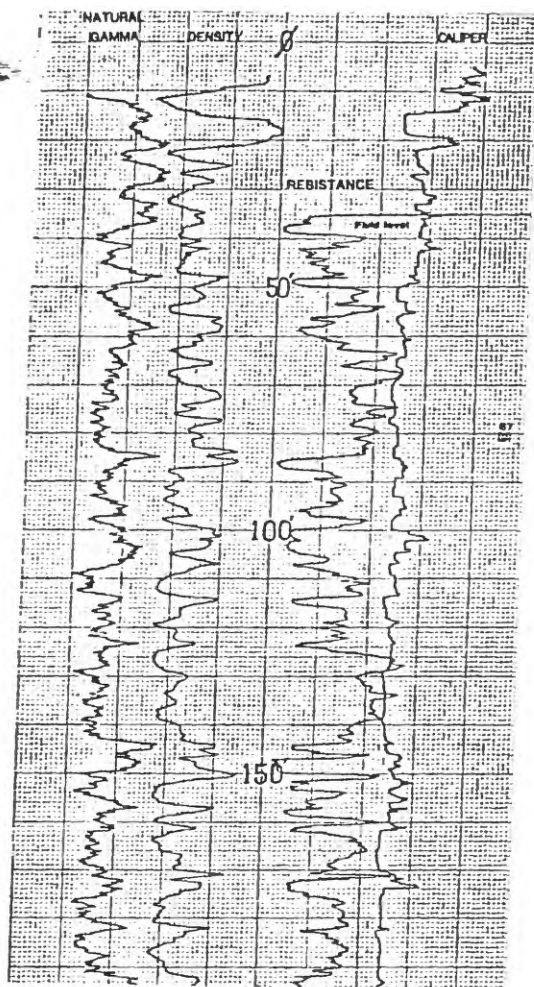


Figure 17.--Geophysical logs of hole GS-16

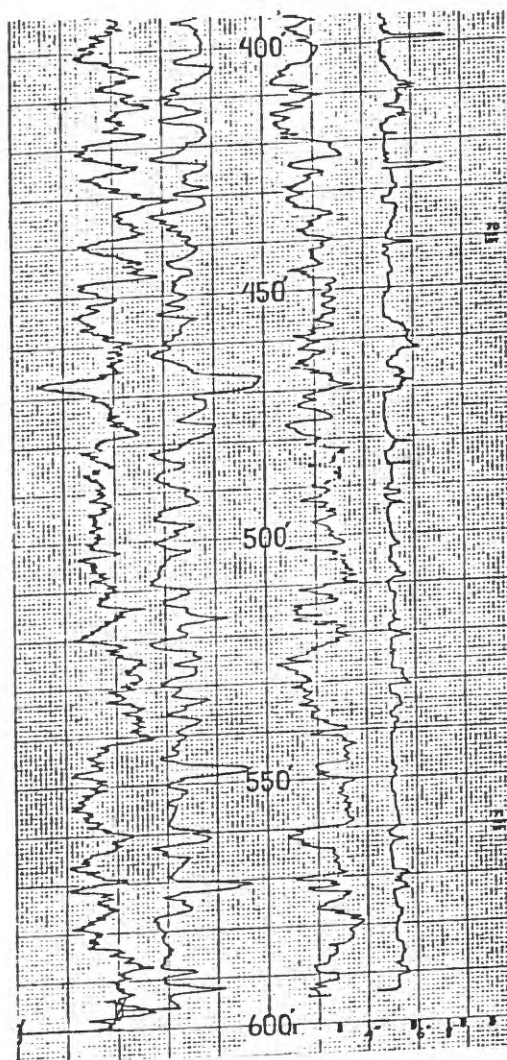


Figure 17.--Geophysical logs of hole GS-16--Continued

Sample log

Hole no.: GS-17 Date: 8-26-79 State: Montana County: Sheridan
 Elev. (ground): 2200 ft Location: T. 32 N., R. 55 E., Sec. SW NE 17
 Total depth: 328 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|--------------------|--|
| 0-17 | Sand, gravel, and mud; unconsolidated |
| 17-22 | Claystone, light-gray to medium-gray |
| 22-34 | Siltstone, olive-gray |
| 34-44 | Claystone, medium-gray to medium-dark-gray; traces of coal at base |
| 44-56 | Claystone, medium-dark-gray |
| 56-94 | Claystone, medium-gray, silty |
| 94-105 | Sandstone, medium-gray, very fine grained, silty |
| 105-108 | Lignite, black, impure; (Timber Coulee Rider lignite bed) |
| 108-123 | Claystone, light-gray; grades silty near base |
| 123-131 | Lignite, black; (Upper Timber Coulee lignite bed) |
| 131-157 | Claystone, very light gray, bentonitic(?) |
| 157-161 | Lignite, black; (Lower Timber Coulee lignite bed) |
| 161-169 | Siltstone, dark-brown |
| 169-172 | Lignite, impure; (Timber Coulee Leader lignite bed) |
| 172-185 | Claystone, dark-brown to medium-gray, silty; trace of coal at top |
| 185-222 | Sandstone, medium-gray; includes some interbedded silty claystone |
| 222-259 | Sandstone, medium-gray, very fine grained |
| 259-294 | Siltstone, light-gray to medium-gray; with interbedded sandstone; traces of coal at base |
| 294-316 | Sandstone, medium-gray to brownish-gray, very fine grained |
| 316-328 | Siltstone; poor sample return |
| Total depth 328 ft | |

Hole No: GS-17 Date: 8-26-79 State: Montana County: Sheridan
 Sec. SW NE 17 T. 32 N. R. 55 E. Elevation: 2200 ft Total Depth: 328 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 2, Range 10 cps Density: TC 2,
 Range 200 cps Resistance: 20 ohms/in Caliper: Horizontal scale 2 in/in

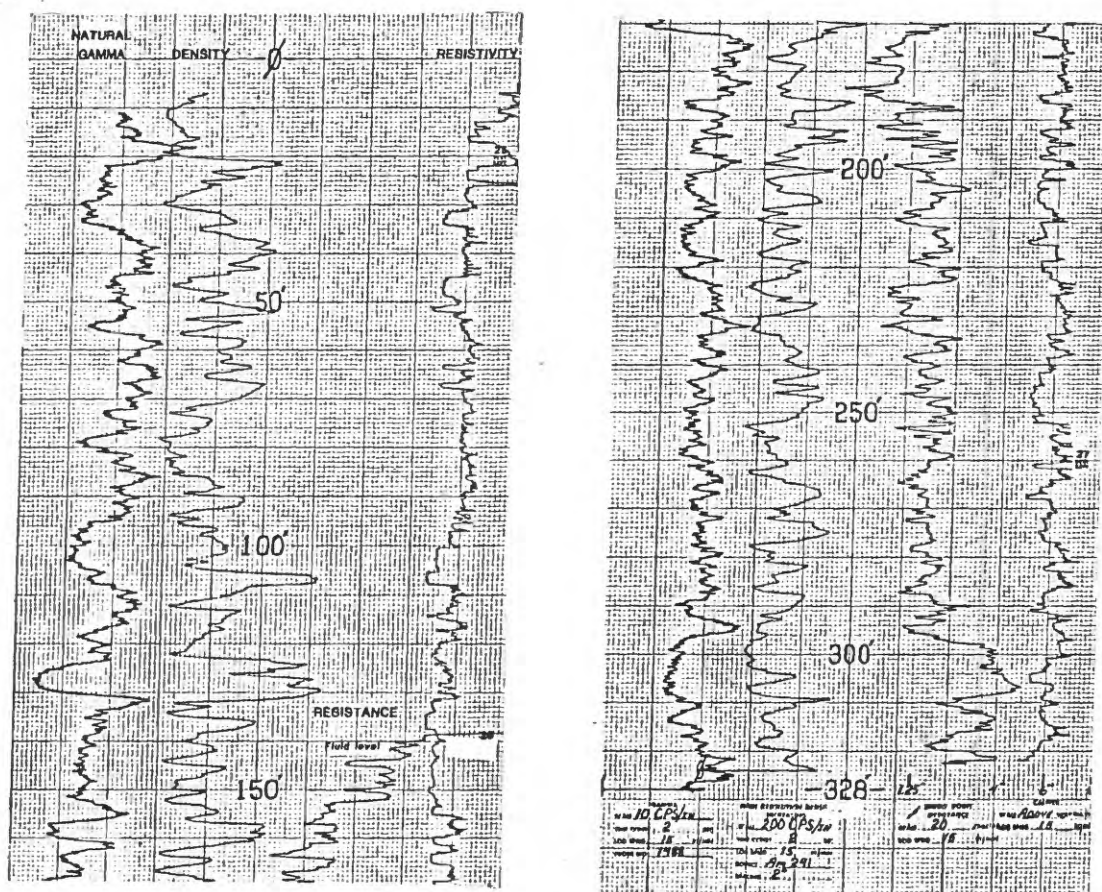


Figure 18.--Geophysical logs of hole GS-17

Sample log

Hole no.: GS-18 Date: 9-8-79 State: Montana County: Sheridan

Elev. (ground): 2255 ft Location: T. 33 N., R. 55 E., Sec. SW SW 10

Total depth: 940 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-5 | Sand, pale-brown to dark-yellowish-brown, unconsolidated |
| 5-61 | Siltstone, light-olive-gray to yellowish-gray; with interbedded sandstone; traces of coal near middle of interval |
| 61-73 | Claystone, light-olive-gray; grades sandy near top of interval |
| 73-76 | Lignite, black; (Local "R" lignite bed) |
| 76-125 | Siltstone, medium-light-gray; with interbedded claystone and sandstone; probable thin coal bed at base |
| 125-152 | Siltstone, medium-light-gray; probable thin concretion 130 ft; probable coal bed 145 to 146 ft |
| 152-158 | Lignite, black; (Upper Timber Coulee lignite bed) |
| 158-202 | Siltstone, medium-light-gray; probable coal beds 162 to 163 ft and 173 to 175 ft |
| 202-285 | Sandstone, medium-light-gray to grayish-blue-green, silty, very fine grained; with interbedded claystone; probable concretion 255 to 258 ft |
| 285-290 | Lignite, black; (Reserve lignite bed) |
| 290-336 | Claystone, medium-light-gray, silty; with interbedded sandstone; traces of coal near base |
| 336-360 | Claystone, medium-light-gray; silty near top of interval; coal bed 344 to 345 ft |
| 360-426 | Sandstone, medium-light-gray, very fine grained, silty; with interbedded siltstone; traces of coal at top and base of interval |
| 426-450 | Siltstone, medium-light-gray, sandy |
| 450-453 | Lignite, black, impure; ("BC" lignite bed) |
| 453-503 | Siltstone, medium-light-gray to light-gray; with interbedded sandstone; minor coal fragments |
| 503-525 | Siltstone, medium-light-gray, sandy |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|--|
| 525-528 | Lignite, black, impure; ("B" lignite bed ?) |
| 528-600 | Siltstone, medium-light-gray; with interbedded claystone; traces of coal near middle of interval |
| 600-685 | Siltstone, medium-light-gray to olive-black, sandy; with thin interbedded claystone; traces of coal near base |
| 685-690 | Lignite, black; ("AA" lignite bed ?) |
| 690-772 | Siltstone, olive-black to medium-dark-gray to medium-light-gray; with interbedded claystone; minor coal fragments |
| 772-775 | Lignite, black, impure; ("A" lignite bed ?) |
| 775-789 | Claystone, medium-light-gray; grades silty near top of interval; becoming shaley and carbonaceous near base |
| 789-852 | Siltstone, medium-light-gray, sandy; with interbedded claystone; traces of coal scattered throughout interval; probable sandstone concretion 826 to 828 ft |
| 852-854 | Lignite, black |
| 854-894 | Siltstone, medium-light-gray, sandy; with interbedded claystone; traces of coal scattered throughout interval; probable sandstone concretions (hard) 864 to 865 ft and 891 to 892 ft |
| 894-905 | Claystone, medium-light-gray, slightly silty |
| 905-906 | Lignite, black; (base of Fort Union Formation) |
| 906-940 | Siltstone, medium-gray to olive-black; abundant coal fragments near base; (top of Hell Creek Formation) |
| Total depth 940 ft | |

Hole No: GS-18 Date: 9-8-79 State: Montana County: Sheridan
 Sec. SW SW 10 T. 33 N. R. 55 E. Elevation: 2255 ft Total Depth: 940 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 2, Range 10 cps Density: TC 2,
 Range 200 cps Resistance: 10 ohms/in Caliper: Horizontal scale 2 in/in

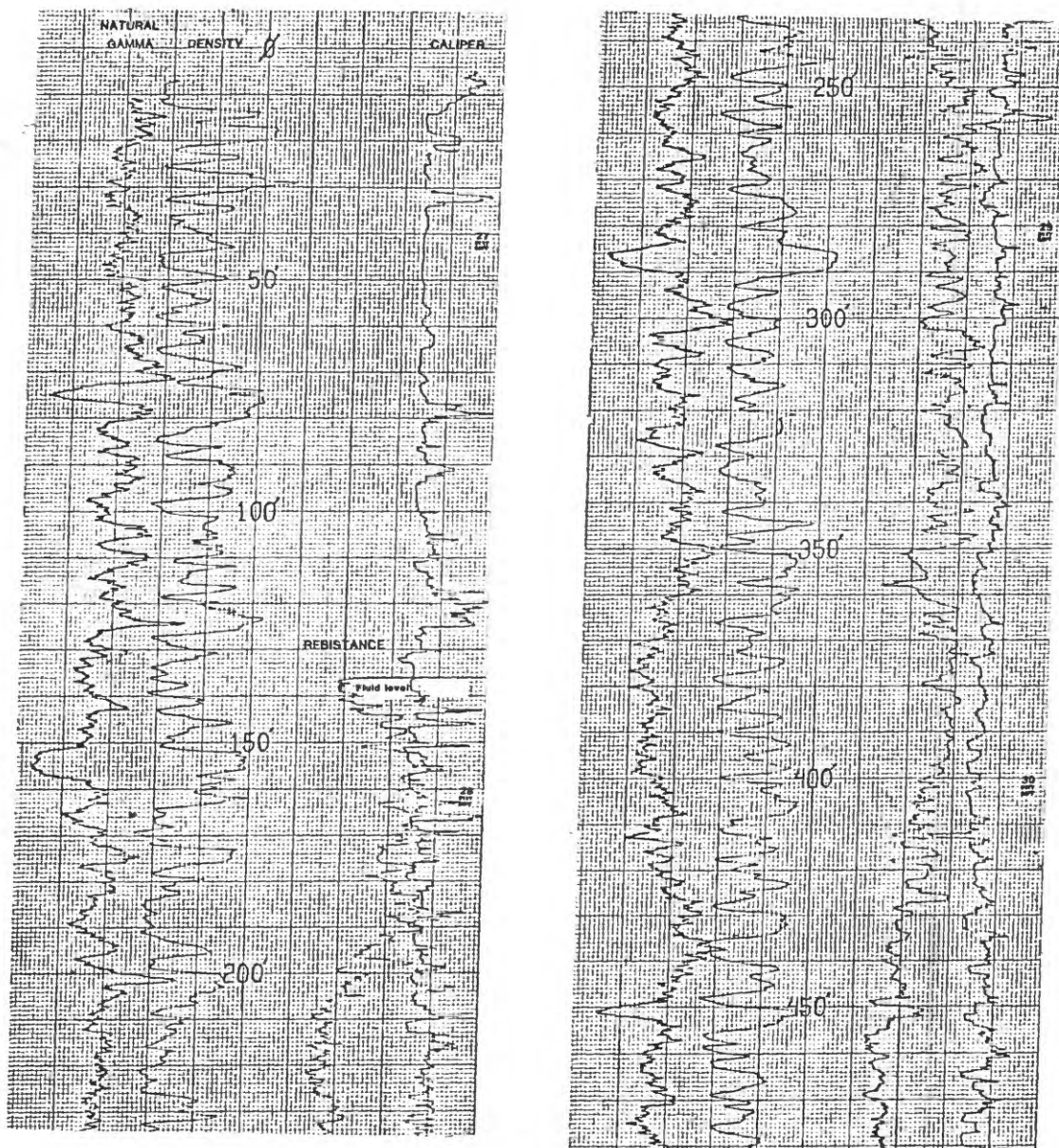


Figure 19.--Geophysical logs of hole GS-18

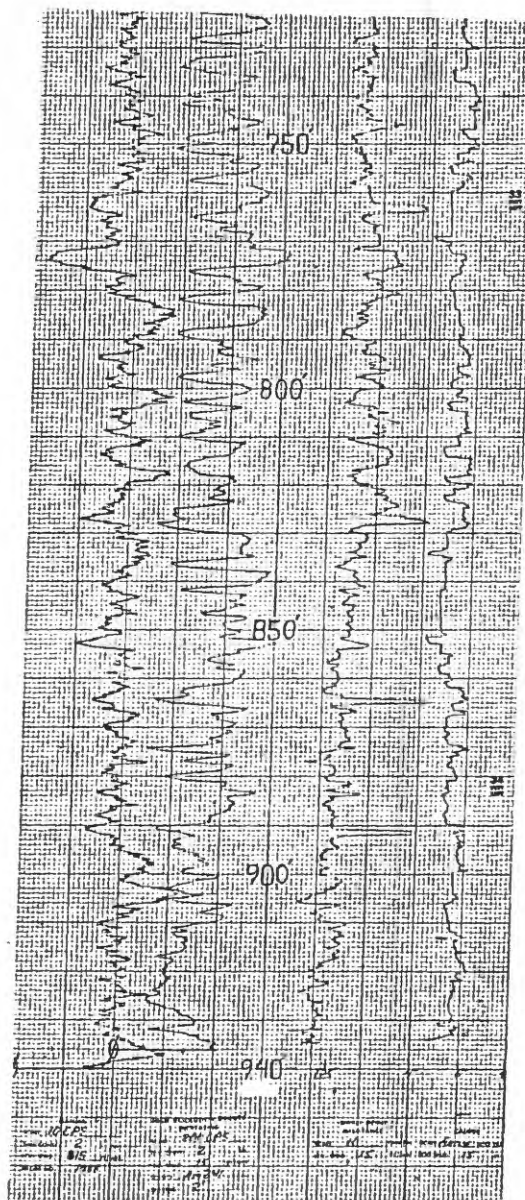
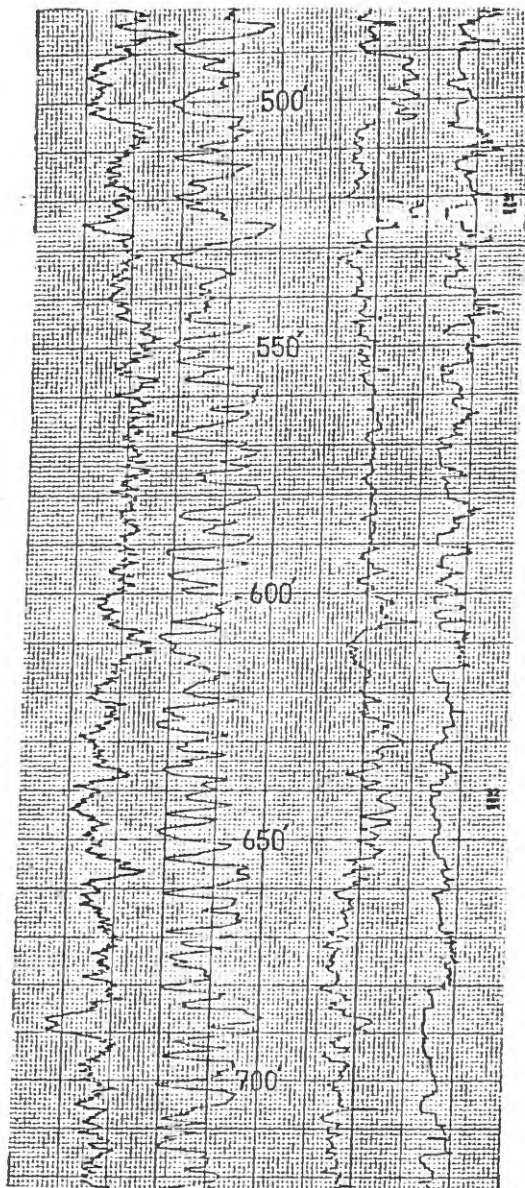


Figure 19.--Geophysical logs of hole GS-18--Continued

Sample log

Hole no.: GS-19 Date: 9-5-79 State: Montana County: Sheridan

Elev. (ground): 2370 ft Location: T. 33 N., R. 54 E., Sec. SE SE 9

Total depth: 621 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-11 | Sand and gravel, brownish-gray |
| 11-29 | Claystone, light-olive-gray to pale-yellowish-brown, silty |
| 29-91 | Sandstone, yellowish-gray to grayish-orange, very fine grained |
| 91-117 | Siltstone, light-olive-gray to medium-gray to greenish-gray, sandy; minor coal fragments |
| 117-147 | Siltstone, greenish-gray to medium-gray to medium-light-gray; with interbedded sandstone; minor coal fragments |
| 147-151 | Lignite, black; (Local "R" lignite bed) |
| 151-155 | Claystone, brownish-gray |
| 155-157 | Lignite, black |
| 157-168 | Claystone, light-gray, silty; minor coal fragments |
| 168-253 | Sandstone, light-gray to medium-light-gray, very fine grained; traces of carbonaceous debris in middle of interval |
| 253-264 | Lignite, black; (Upper Timber Coulee lignite bed) |
| 264-296 | Siltstone, light-olive-gray to medium-light-gray; probable coal bed 273 to 274 ft |
| 296-299 | Lignite, black; (Lower Timber Coulee lignite bed) |
| 299-320 | Claystone, light-olive-gray to medium-light-gray, silty |
| 320-323 | Lignite, black, impure; (Timber Coulee Leader lignite bed) |
| 323-351 | Siltstone, light-olive-gray to medium-light-gray, sandy; grades to claystone at top of interval; minor coal fragments |
| 351-382 | Siltstone, medium-light-gray to light-olive-gray; minor coal fragments |
| 382-450 | Siltstone, medium-light-gray to light-olive-gray, slightly sandy; with thin interbedded claystone; traces of coal near middle of interval |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 450-479 | Siltstone, light-olive-gray to medium-light-gray, slightly sandy; slightly carbonaceous near top of interval |
| 479-543 | Claystone, light-olive-gray to medium-light-gray, silty; coal bed 502 to 503 ft |
| 543-558 | Siltstone, light-olive-gray, argillaceous |
| 558-561 | Lignite, black; ("BC" lignite bed) |
| 561-594 | Claystone, light-olive-gray; grades silty near top of interval; probable coal bed 593 to 594 ft |
| 594-621 | Claystone, olive-gray; silty near base; coal bed 611 to 612 ft |
| | Total depth 621 ft |

Hole No: GS-19 Date: 9-5-79 State: Montana County: Sheridan
 Sec. SE SE 9 T. 33 N. R. 54 E. Elevation: 2370 ft Total Depth: 621 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 2 , Range 10 cps Density: TC 2 ,
 Range 200 cps Resistance: 10 ohms/in Caliper: Horizontal scale 2 in/in

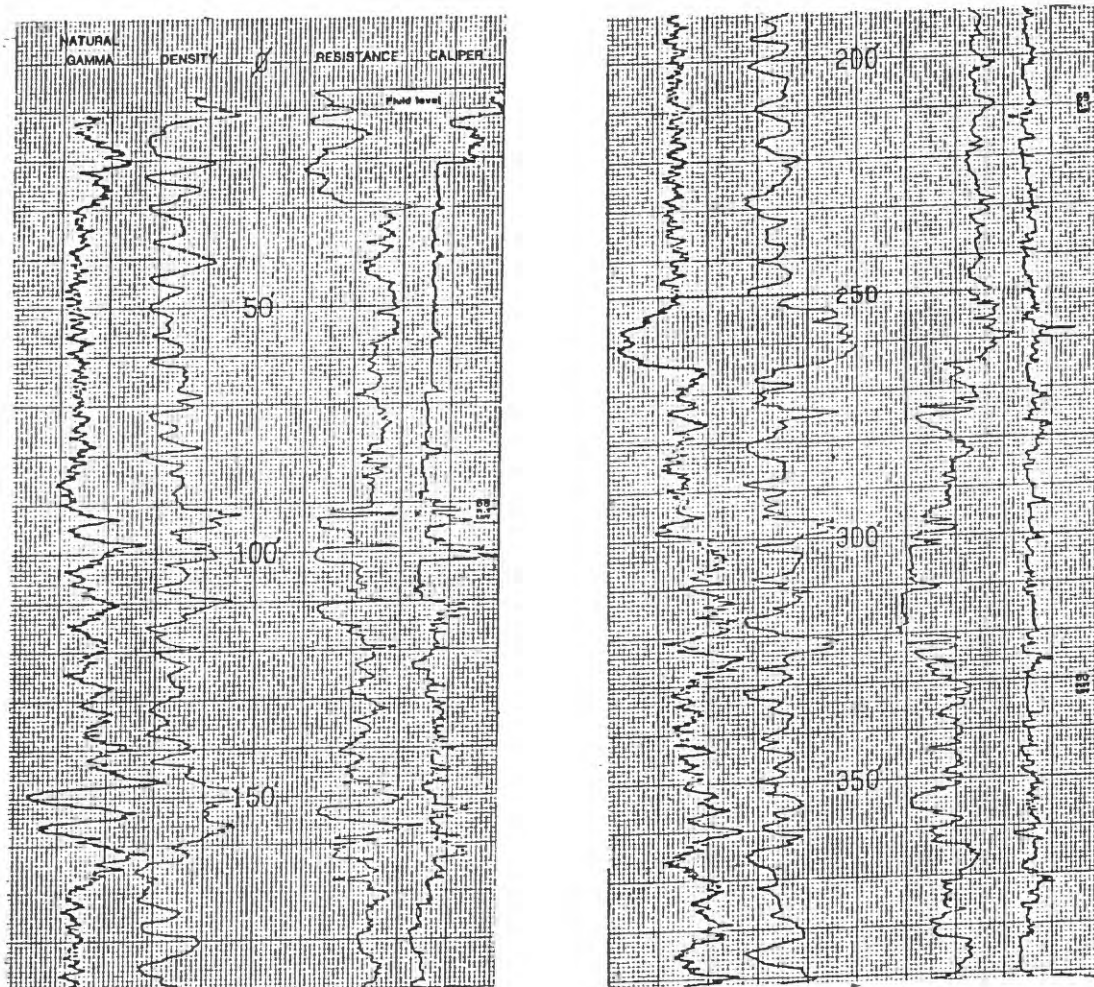


Figure 20.--Geophysical logs of hole GS-19



Sample log

Hole no.: GS-20 Date: 7-19-79 State: Montana County: Roosevelt
 Elev. (ground): 2370 ft Location: T. 31 N., R. 51 E., Sec. NE SE 21
 Total depth: 480 ft Drilling medium: mud Offset core hole: GS-20C

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-22 | Sand, clay, and gravel, light-olive-gray, unconsolidated |
| 22-37 | Gravel, 30 percent silt and clay, unconsolidated |
| 37-57 | Siltstone, medium-light-gray; (coal 53 to 54 ft) |
| 57-67 | Sandstone, medium-light-gray; grades to claystone at base; grades silty near top of interval |
| 67-69 | Lignite, black; ("AB" lignite bed) |
| 69-93 | Siltstone, dark-gray, grades sandy near base; traces of carbonaceous debris scattered throughout interval |
| 93-130 | Sandstone, medium-gray, very fine grained |
| 130-161 | Siltstone, medium-gray; slightly carbonaceous near top |
| 161-176 | Sandstone, olive-gray, very fine grained, silty |
| 176-183 | Siltstone, light-olive-gray |
| 183-185 | Lignite, black; ("A" Rider lignite bed) |
| 185-208 | Siltstone, light-olive-gray to medium-gray, interbedded sandstone near base; probable thin coal at top of interval |
| 208-217.1 | Claystone, medium-light-gray; grades to grayish-black carbonaceous claystone at base |
| 217.1-218.3 | Lignite, black, see sample description D221131; ("A" lignite bed) |
| 218.3-218.8 | Claystone, dark-yellowish-brown; ("A" lignite bed) |
| 218.8-222.1 | Lignite, black see sample description D221131; ("A" lignite bed) |
| 222.1-239 | Siltstone, medium-gray to light-olive-gray; traces of organic debris; with thin interbedded sandstone; grades to pale-olive claystone at top of interval |
| 239-304 | Claystone, light-olive-gray, slightly silty; traces of carbonaceous claystone scattered throughout interval |
| 304-327 | Siltstone, medium-gray to light-olive-gray and medium-dark-gray |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 327-354 | Claystone, olive-gray, slightly carbonaceous; grades silty near base |
| 354-368 | Siltstone, light-olive-gray to dark-gray |
| 368-373 | Claystone, dark-gray, silty, slightly carbonaceous; grades to siltstone near base |
| 373-374 | Shale, carbonaceous; (base of Fort Union Formation) |
| 374-395 | Sandstone, medium-light-gray to light-olive-gray, very fine grained, silty, slightly carbonaceous, probable thin coal bed at base of interval; (top of Hell Creek Formation) |
| 395-429 | Sandstone, very light gray to light-gray, very fine grained, silty; grades to claystone at top of interval |
| 429-453 | Siltstone, greenish-gray, slightly carbonaceous |
| 453-468 | Sandstone, very light gray |
| 468-480 | Claystone, very light gray, silty, slightly carbonaceous |
| | Total depth 480 ft |

Hole No: GS-20 Date: 7-19-79 State: Montana County: Roosevelt
 Sec. NE SE 21 T. 31 N. R. 51 E. Elevation: 2370 ft Total Depth: 480 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 4 , Range 50 cps Density: TC 4 ,
 Range 20,000 cps Resistance: N/A ohms/in Caliper: Horizontal scale N/A in/in

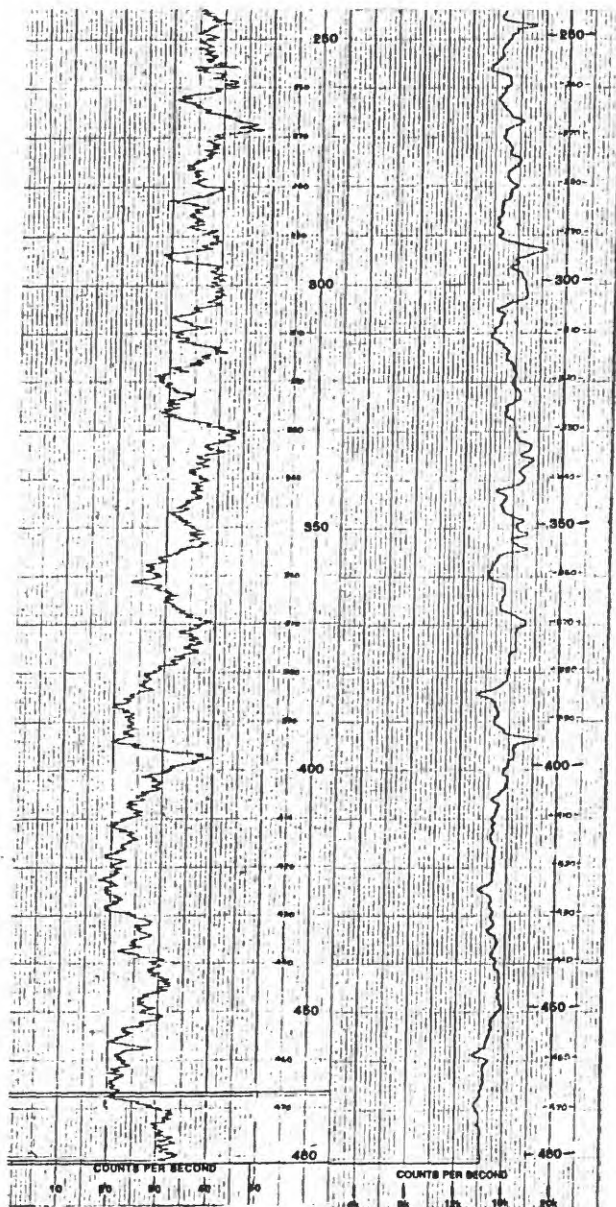
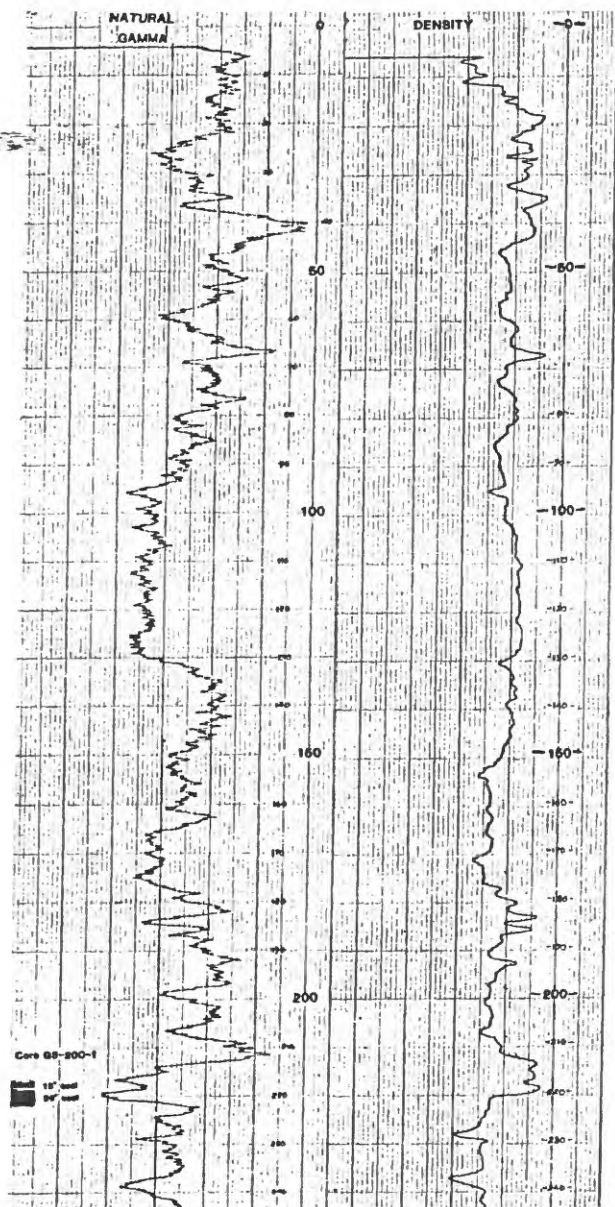


Figure 21.--Geophysical logs of hole GS-20

Sample log

Hole no.: GS-21 Date: 7-26-79 State: Montana County: Roosevelt
 Elev. (ground): 2645 ft Location: T. 32 N., R. 50 E., Sec. SE SE 26
 Total depth: 540 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-49 | Sand and gravel, yellowish-gray, unconsolidated |
| 49-58 | Claystone, olive-gray, slightly carbonaceous |
| 58-78 | Siltstone, olive-gray; grades sandy near base |
| 78-80 | Lignite, black; ("B" lignite bed) |
| 80-113 | Sandstone, olive-gray, very fine grained; silty near base; traces of carbonaceous claystone |
| 113-118 | Shale, medium-gray to olive-gray, silty |
| 118-134 | Sandstone, medium-gray to olive-gray, very fine grained, very silty; scattered fragments of sandstone concretions |
| 134-141 | Shale, medium-light-gray to olive-gray |
| 141-143 | Lignite, black |
| 143-158 | Sandstone, meins, abundant feldspar, scattered grains of dark- gray organic material |
| 158-165 | Claystone, medium-gray |
| 165-173 | Sandstone, medium-gray, very fine grained, silty |
| 173-178 | Claystone, olive-gray, slightly silty |
| 178-196 | Siltstone, olive-gray; traces of carbonaceous shale |
| 196-205 | Siltstone, olive-gray; grades to claystone near base |
| 205-214 | Siltstone, olive-gray, sandy; traces of carbonaceous claystone |
| 214-218 | Claystone, olive-gray |
| 218-220 | Lignite, black; ("AB" lignite bed) |
| 220-223 | Claystone, olive-gray |
| 223-225 | Lignite, black; ("AB" lignite bed) |
| 225-239 | Claystone, olive-gray; grades to siltstone near base |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|---|
| 239-269 | Siltstone, light-olive-gray; thin interbedded claystone at base |
| 269-277 | Sandstone, medium-gray, very fine grained, slightly micaceous, slightly carbonaceous |
| 277-310 | Siltstone, olive-gray; with interbedded carbonaceous claystone |
| 310-313 | Lignite, black; ("AA" lignite bed) |
| 313-344 | Sandstone, olive-gray, very fine grained; with interbedded siltstone |
| 344-348 | Lignite, black; ("A" Rider lignite bed) |
| 348-360 | Sandstone, bluish-gray, fine to medium-grained, silty; coal bed 359 to 360 ft |
| 360-374 | Siltstone, olive-gray, sandy, slightly carbonaceous |
| 374-380 | Claystone, olive-gray |
| 380-388 | Sandstone, olive-gray, very fine grained |
| 388-396 | Siltstone, olive-gray |
| 396-410 | Sandstone, light-olive-gray, very fine grained, silty |
| 410-423 | Siltstone, moderate-yellow to dark-yellowish-gray to medium-dark-gray |
| 423-439 | Siltstone, light-olive-gray to light-olive-brown, sandy; minor coal fragments |
| 439-451 | Siltstone, olive-gray to medium-gray, sandy |
| 451-452 | Lignite, black |
| 452-478 | Claystone, olive-gray to bluish-gray; very silty near top |
| 478-492 | Siltstone, medium-gray to olive-gray, sandy; with interbedded silty claystone |
| 492-526 | Sandstone, olive-gray to bluish-gray, very fine grained; 10 percent dark opaques; grades silty near top of interval |
| 526-527 | Carbonaceous shale, brownish-gray; (approximate base of Fort Union Formation) |
| 525-540 | Shale, olive-gray to dark-yellowish-brown |
| Total depth 540 ft | |

Hole No: GS-21 Date: 7-26-79 State: Montana County: Roosevelt
 Sec. SE SE 26 T. 32 N. R. 50 E. Elevation: 2645 ft Total Depth: 540 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 4 , Range 50 cps Density: TC 1 ,
 Range 20,000 cps Resistance: N/A ohms/in Caliper: Horizontal scale N/A in/in

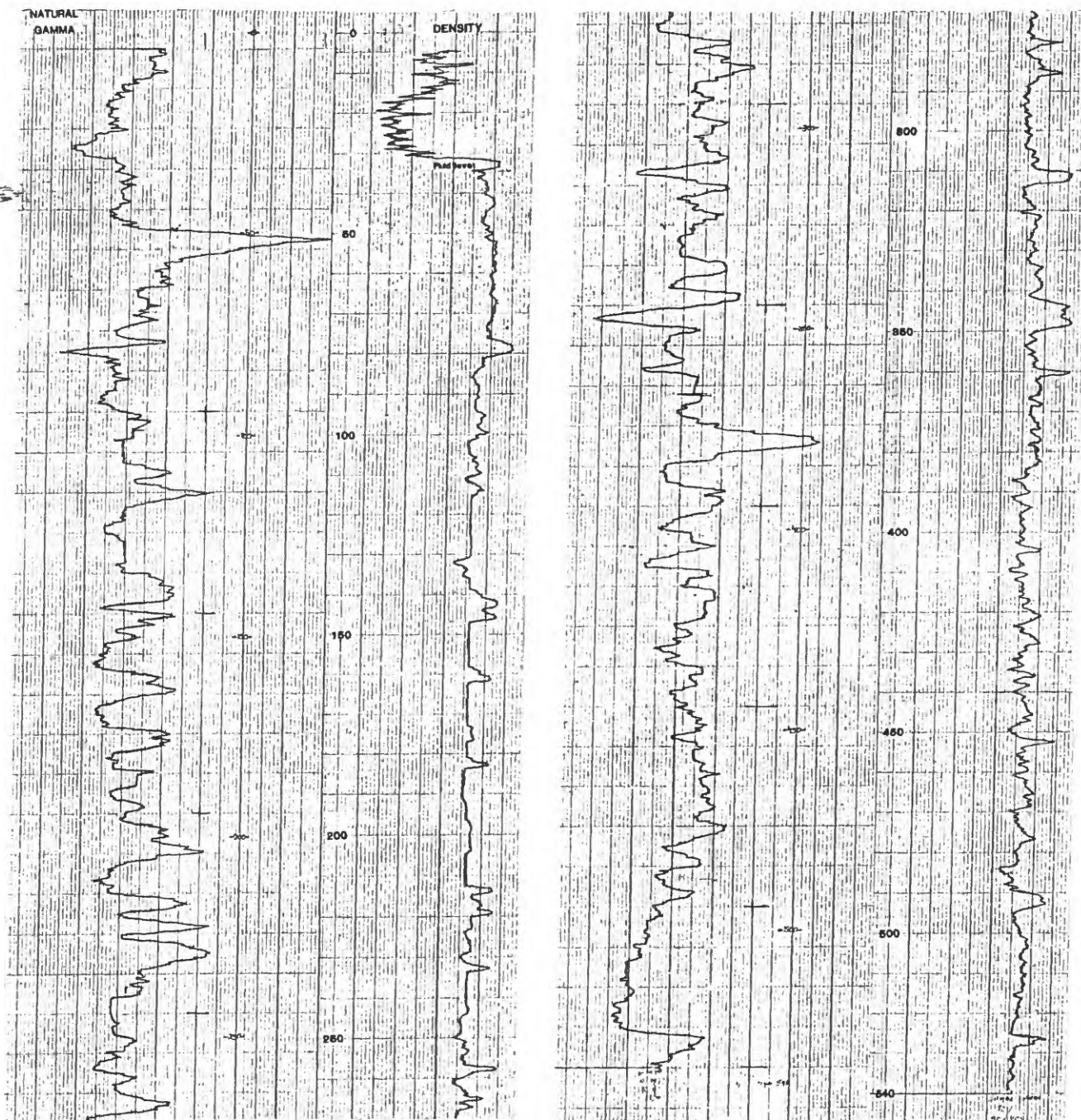


Figure 22.--Geophysical logs of hole GS-21

Sample log

Hole no.: GS-22 Date: 8-4-79 State: Montana County: Roosevelt

Elev. (ground): 2645 ft Location: T. 32 N., R. 51 E., Sec. SW SE 26

Total depth: 440 ft Drilling medium: mud Offset core hole: GS-22C

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-13 | Sand, mud, and gravel, yellowish-brown, unconsolidated |
| 13-50 | Gravel, unconsolidated |
| 50-68 | Siltstone, yellowish-brown, sandy |
| 68-92 | Siltstone, light-olive-gray, very fine grained; with interbedded claystone |
| 92-112.2 | Claystone, medium-gray to light-olive-gray to greenish-gray |
| 112.2-117.1 | Lignite, see sample description D221125; (Smoke Creek lignite bed) |
| 117.1-124 | Claystone, greenish-gray; grades silty near middle of interval |
| 124-150 | Sandstone; grades to claystone at base |
| 150-154.4 | Lignite, see sample description D221126; (Lower Smoke Creek lignite bed) |
| 154.4-156 | Claystone, light-greenish-gray; includes 2.5 inches of lignite in lower part; see core GS-22C-2 description |
| 156-160 | Siltstone, light-greenish-gray, sandy |
| 160-173 | Claystone, medium-gray |
| 173-177 | Sandstone concretion |
| 177-192 | Siltstone, light-gray, very sandy |
| 192-209 | Siltstone, light-gray; grades to claystone at top and base |
| 209-230 | Sandstone, light-gray, very fine grained; siltstone parting 218 to 224 ft |
| 230-252 | Siltstone, light-gray; minor coal fragments; grades argillaceous at top and base of interval |
| 252-269 | Sandstone; poor sample return |
| 269-275 | Claystone, greenish-gray, very silty |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 275-277 | Lignite, black |
| 277-325 | Claystone, greenish-gray to olive-gray, silty; traces of coal at top of interval |
| 325-335 | Claystone, greenish-gray to olive-gray |
| 335-351 | Siltstone, light-greenish-gray; grades to very fine grained sandstone at base and argillaceous siltstone near top of interval |
| 351-360.5 | Claystone, light-gray |
| 360.5-367.1 | Lignite; claystone parting 362.4 to 362.9 ft; see sample descriptions D221127 and D221128; ("AB" lignite bed) |
| 367.1-371.1 | Claystone, sandy |
| 371.1-374 | Lignite; see sample description D221129; ("AB" lignite bed) |
| 374-375.2 | Claystone, medium-light-gray; sandy at base |
| 375.2-401 | Siltstone; poor sample return |
| 401-416 | Claystone, light-gray |
| 416-423 | Sandstone, light-gray |
| 423-431 | Claystone, light-gray |
| 431-440 | Sandstone, greenish-gray, very fine grained |
| | Total depth 440 ft |

Hole No: GS-22 Date: 8/4/79 State: Montana County: Roosevelt
 Sec. SW SE 26 T. 32 N. R. 51 E. Elevation: 2645 ft Total Depth: 440 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 4 , Range 50 cps Density: TC 1 ,
 Range 10,000 cps Resistance: 10 ohms/in Caliper: Horizontal scale N/A in/in

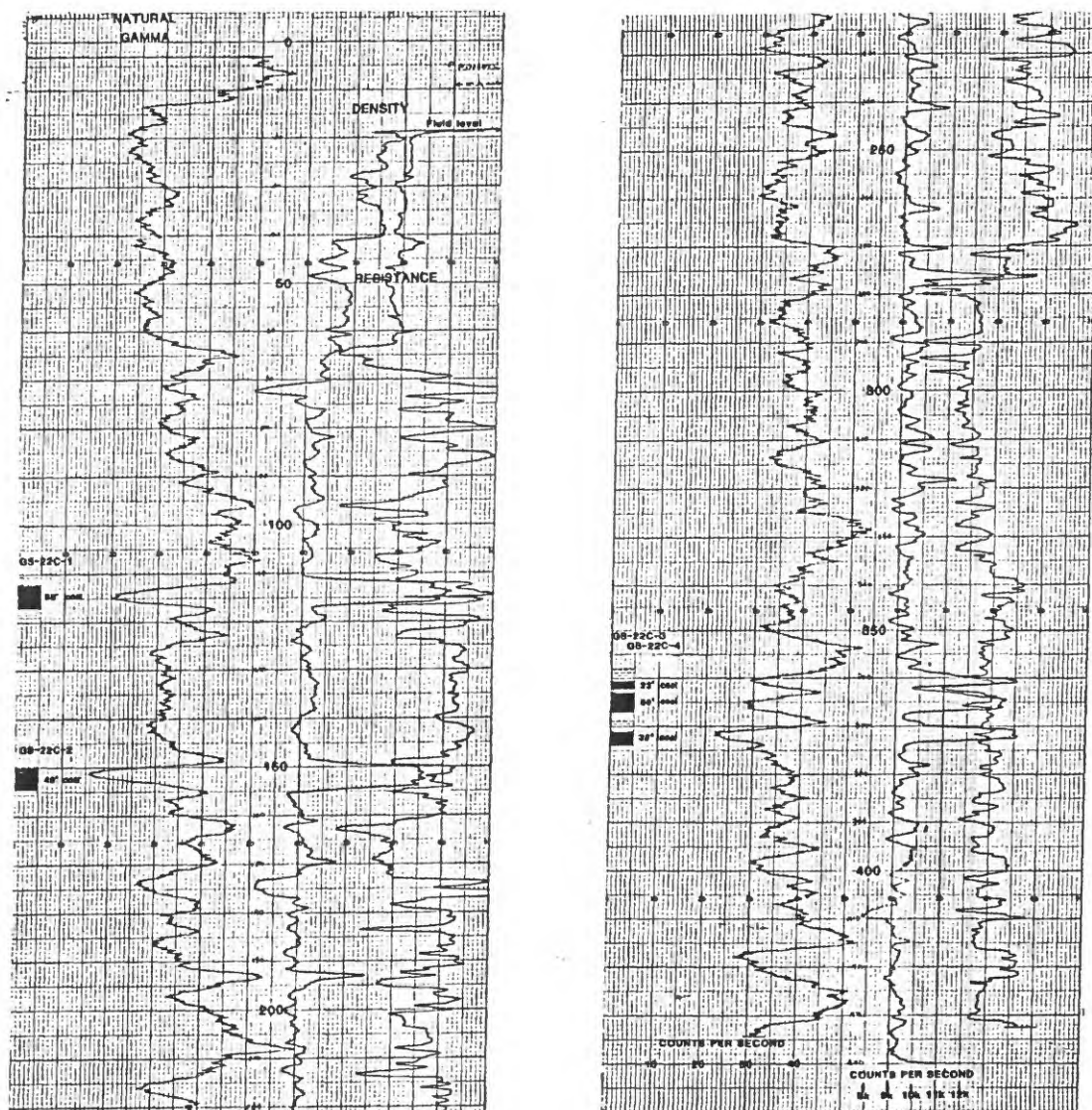


Figure 23.--Geophysical logs of hole GS-22

Sample log

Hole no.: GS-23 Date: 7-25-79 State: Montana County: Roosevelt

Elev. (ground): 2535 ft Location: T. 32 N., R. 52 E., Sec. SE NE 35

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

| Depth (feet) | Lithic description |
|-------------------|--|
| 0-20 | Sand, silt, and gravel, light-olive-gray, unconsolidated |
| 20-56 | Gravel and sand, unconsolidated |
| 56-122 | Siltstone, dusky-yellow; with thin interbedded claystone |
| 122-144 | Claystone, light-olive-gray to pale-blue; interbedded with siltstone near middle of interval |
| 144-167 | Siltstone, medium-blue-gray, sandy |
| 167-201 | Claystone, pale-blue; traces of carbonaceous debris |
| 201-253 | Siltstone, light-bluish-gray, sandy |
| 253-266 | Claystone, light-bluish-gray; grades silty near base |
| 266-296 | Siltstone, light-bluish-gray; scattered thin sandstone concretions; interbedded claystone at middle and base of interval |
| 296-304 | Lignite, black; (Upper Timber Coulee lignite bed) |
| 304-334 | Siltstone, light-olive-gray; interbedded claystone at top of interval |
| 334-336 | Lignite, black; (Lower Timber Coulee lignite bed) |
| 336-338 | Claystone, brownish-gray |
| 338-341 | Lignite, black; (Lower Timber Coulee lignite bed) |
| 341-354 | Claystone, light-olive-gray |
| 354-361 | Siltstone, light-gray to light-olive-gray |
| 361-382 | Claystone, light-gray; with thin sandstone concretions in upper part of interval |
| 382-384 | Lignite, black; (Timber Coulee Leader lignite bed) |
| 384-399 | Siltstone, olive-gray to light-gray to grayish-orange; minor coal fragments |
| 399-408 | Claystone, medium-dark-gray; carbonaceous in lower part |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 408-459 | Siltstone, olive-gray to medium-light-gray; carbonaceous near base; with interbedded claystone |
| 459-463 | Lignite, black; (Smoke Creek lignite bed) |
| 463-480 | Claystone, medium-gray; interbedded siltstone in lower half of interval |
| 480-482 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 482-494 | Claystone, medium-gray; grades silty at base |
| 494-508 | Siltstone, medium-gray to medium-bluish-gray; argillaceous near middle of interval |
| 508-527 | Claystone, medium-gray, silty |
| 527-540 | Claystone, medium-gray; grades to siltstone at base |
| | Total depth 540 ft |

Hole No: GS-23 Date: 7-25-79 State: Montana County: Roosevelt
 Sec. SE NE 35 T. 32 N. R. 52 E. Elevation: 2535 ft Total Depth: 540 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 4 , Range 50 cps Density: TC 1 ,
 Range 20,000 cps Resistance: N/A ohms/in Caliper: Horizontal scale N/A in/in

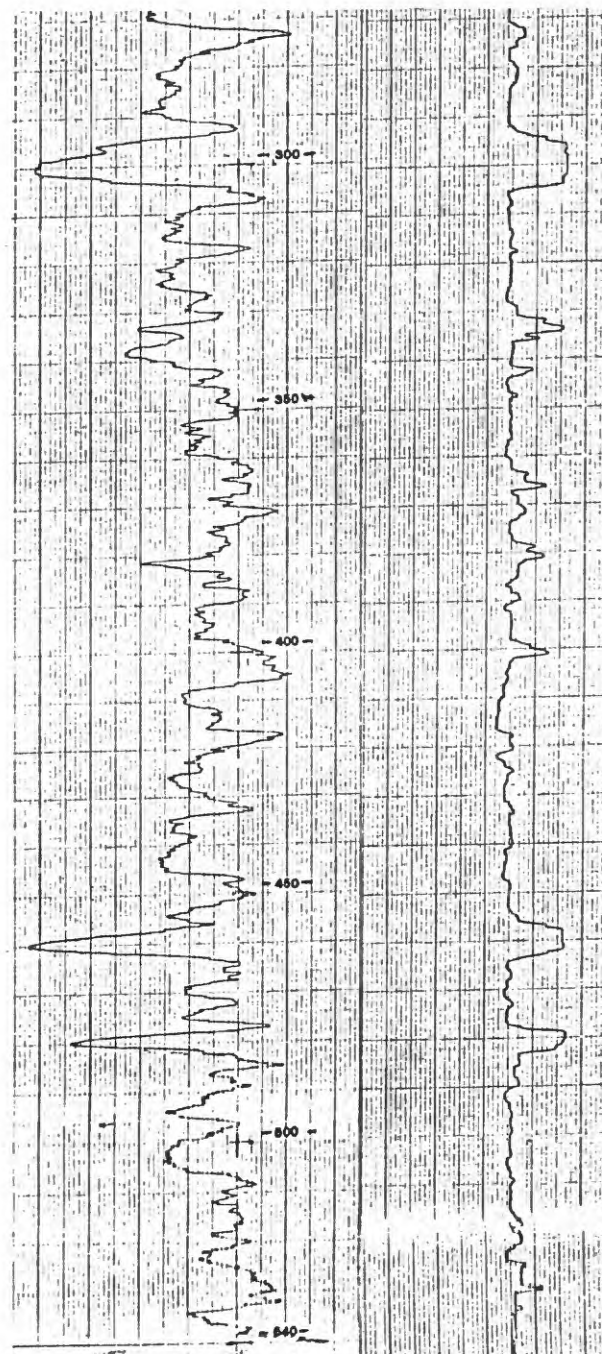
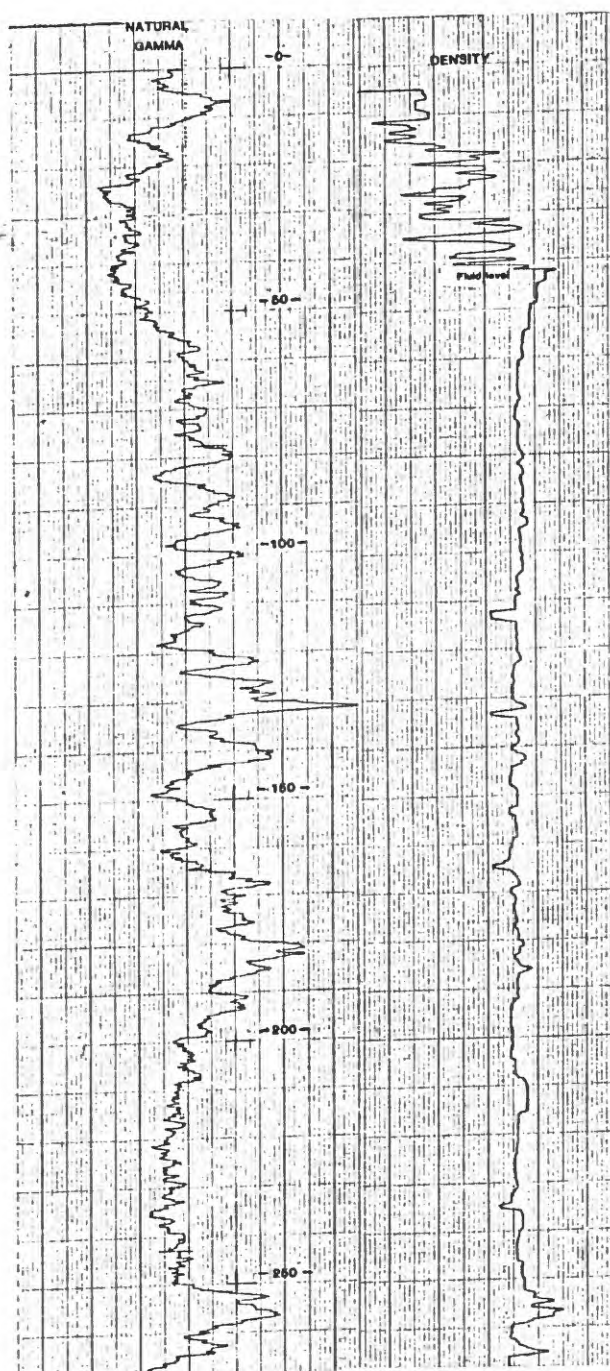


Figure 24.--Geophysical logs of hole GS-23

Sample log

Hole no.: GS-24 Date: 8-14-79 State: Montana County: Sheridan
 Elev. (ground): 2295 ft Location: T. 33 N., R. 53 E., Sec. NW NE 22
 Total depth: 576 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-19 | Sand, mud, and gravel, unconsolidated |
| 19-28 | Sandstone, yellowish-gray, very fine grained |
| 28-31 | Lignite, dirty; (Timber Coulee Rider lignite bed) |
| 31-38 | Siltstone, dusky-brown |
| 38-45 | Lignite, black; (Upper Timber Coulee lignite bed) |
| 45-61 | Sandstone, light-gray, very fine grained, silty; grades to siltstone near top of interval |
| 61-64 | Lignite, black; (Lower Timber Coulee lignite bed) |
| 64-77 | Sandstone, greenish-gray, very fine grained, silty |
| 77-85 | Sandstone, greenish-gray, very fine grained |
| 85-102 | Claystone, greenish-gray; grades silty at top of interval |
| 102-106 | Lignite, black; (Timber Coulee Leader lignite bed) |
| 106-118 | Claystone, greenish-gray ; grades silty near base |
| 118-120 | Lignite, black |
| 120-147 | Sandstone, greenish-gray, very fine grained; interbedded claystone at top and base of interval |
| 147-175 | Siltstone, greenish-gray, sandy; with thin interbedded claystone; grades to silty claystone at base |
| 175-176 | Lignite, black |
| 176-186 | Claystone, light-greenish-gray |
| 186-221 | Siltstone, greenish-gray, sandy; with interbedded claystone |
| 221-224 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 224-231 | Claystone, greenish-gray |
| 231-248 | Siltstone, greenish-gray |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 248-275 | Sandstone, greenish-gray, very silty; claystone parting 258 to 262 ft |
| 275-291 | Claystone, greenish-gray; silty near middle of interval |
| 291-322 | Sandstone, white to greenish-gray, fine to very fine grained; claystone parting 299 to 303 ft |
| 322-347 | Claystone, greenish-gray; slightly silty at middle of interval |
| 347-349 | Lignite, black; ("BC" lignite bed) |
| 349-395 | Siltstone, greenish-gray; grades sandy near base; probable coal bed 379 to 381 ft |
| 395-398 | Lignite, black, impure |
| 398-407 | Siltstone, medium-gray |
| 407-421 | Sandstone, greenish-gray, very fine grained |
| 421-423 | Lignite, black ("B"(?) lignite bed) |
| 423-455 | Claystone, greenish-gray, grades silty near base; probable coal beds 448 to 450 ft and 453 to 454 ft |
| 455-464 | Siltstone, medium-gray, slightly sandy |
| 464-467 | Lignite, black, impure |
| 467-481 | Siltstone, greenish-gray |
| 481-487 | Claystone, medium-gray, very silty |
| 487-513 | Sandstone, medium-gray, very fine grained; with abundant coal fragments at base of interval; interbedded with claystone 491 to 496 ft and 500 to 504 ft |
| 513-529 | Claystone, medium-gray; grades silty near base |
| 529-533 | Lignite, black, impure; ("AA" lignite bed ?) |
| 533-550 | Claystone, medium-gray; silty at top of interval; probable coal bed 539 to 540 ft |
| 550-576 | Siltstone, medium-gray |
| | Total depth 576 ft |

Hole GS-24 Date: 8-14-79 State: Montana County: Sheridan
 Sec. NW NE 22 T. 33 N. R. 53 E. Elevation: 2295 ft Total Depth: 576 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 4 , Range 50 cps Density: TC 2 ,
 Range 10,000 cps Resistance: 10 ohms/in Caliper: Horizontal scale N/A in/in

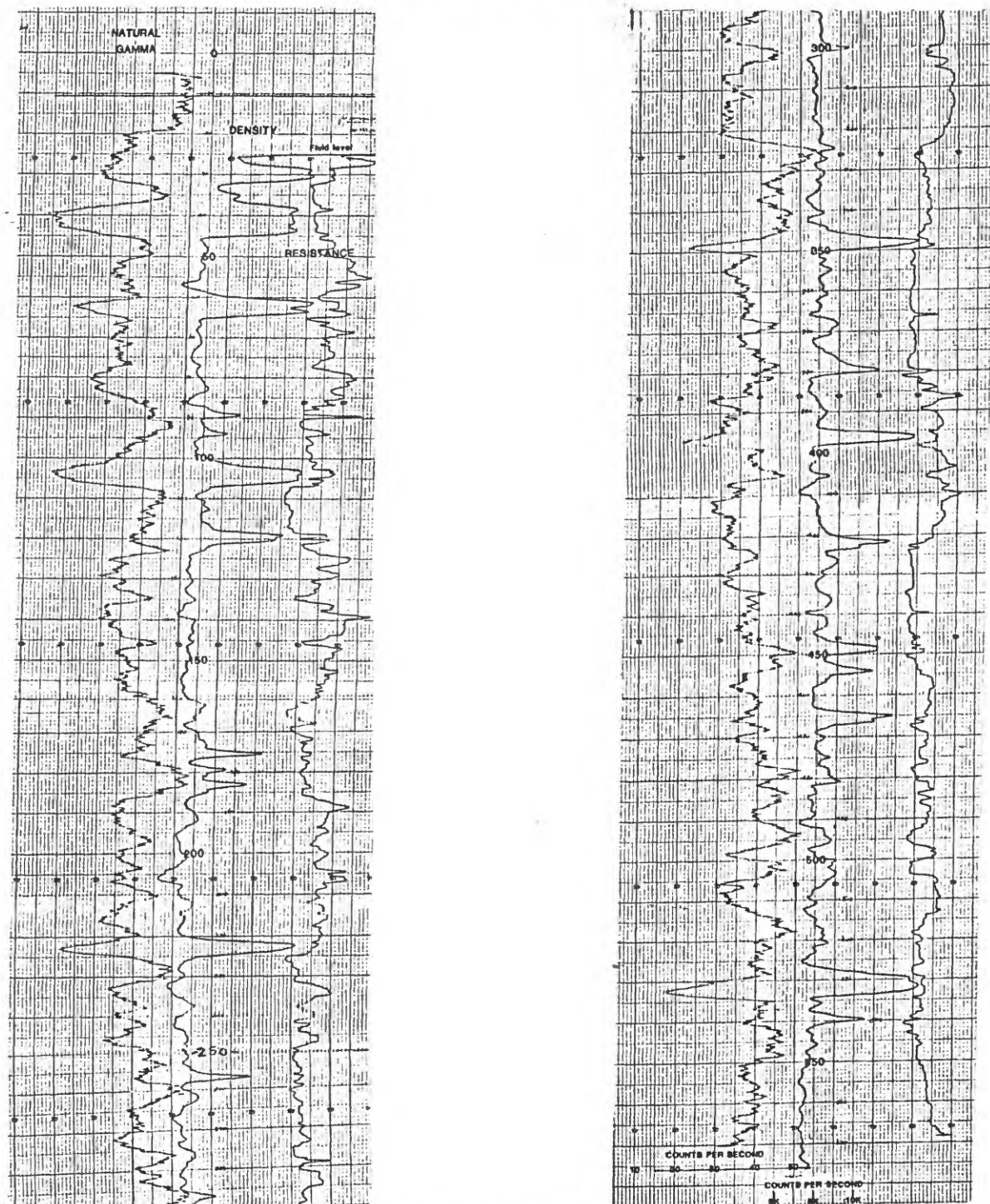


Figure 25.--Geophysical logs of hole GS-24

Sample log

Hole no.: GS-25 Date: 8-11-79 State: Montana County: Sheridan
 Elev. (ground): 2615 ft Location: T. 33 N., R. 52 E., Sec. NW SW 26
 Total depth: 576 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-16 | Sand, mud, and gravel, unconsolidated |
| 16-24 | Gravel, unconsolidated |
| 24-31 | Claystone, light-gray |
| 31-75 | Siltstone, olive-gray to greenish-gray; grades to very fine grained sandstone at top of interval; abundant coal fragments at base |
| 75-100 | Siltstone, yellowish-brown, very sandy; interbedded claystone at top and base of interval; abundant coal fragments at base |
| 100-159 | Sandstone, yellowish-brown, very fine grained; grades silty near top of interval; interbedded claystone 117 to 120 ft and 156 to 159 ft |
| 159-162 | Lignite, black, impure; (Timber Coulee Rider lignite bed) |
| 162-187 | Claystone, light-to medium-gray and greenish-gray; grades sandy near top of interval |
| 187-194 | Lignite, black; (Upper Timber Coulee lignite bed) |
| 194-205 | Sandstone, light-to medium-gray |
| 205-208 | Lignite, black; (Lower Timber Coulee lignite bed) |
| 208-216 | Claystone, medium-gray |
| 216-256 | Siltstone, light-gray to medium-gray, sandy |
| 256-277 | Claystone, medium-gray, very silty |
| 277-295 | Sandstone, light-gray to medium-gray, very fine grained; interbedded claystone 282 to 287 ft |
| 295-315 | Siltstone, light-gray to greenish-gray |
| 315-361 | Claystone, light-gray to greenish-gray, silty |
| 361-372 | Sandstone, light-gray |
| 372-378 | Siltstone, light-gray to greenish-gray |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 378-381 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 381-424 | Sandstone, greenish-gray to light-gray, very fine grained |
| 424-433 | Claystone, medium-gray to greenish-gray, silty |
| 433-452 | Sandstone, light-greenish-gray, very fine grained; abundant coal fragments at top of interval |
| 452-466 | Claystone, light-gray; abundant coal fragments at top of interval; grades silty near top and base |
| 466-469 | Lignite, black, impure; ("BC" lignite bed) |
| 469-481 | Claystone, light-gray; silty at top of interval |
| 481-488 | Sandstone, light-gray, silty |
| 488-501 | Claystone, light-gray; grades silty near top and base of interval |
| 501-547 | Sandstone, light-gray to light-brownish-gray; silty from 510 to 517 ft and 523 to 532 ft |
| 547-557 | Claystone, light-gray |
| 557-576 | Siltstone, light-gray |
| | Total depth 576 ft |

Hole No: GS-25 Date: 8-11-79 State: Montana County: Sheridan
 Sec. NW SW 26 T. 33 N. R. 52 E. Elevation: 2615 ft Total Depth: 576 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 4 , Range 50 cps Density: TC 2 ,
 Range 10,000 cps Resistance: 10 ohms/in Caliper: Horizontal scale N/A in/in

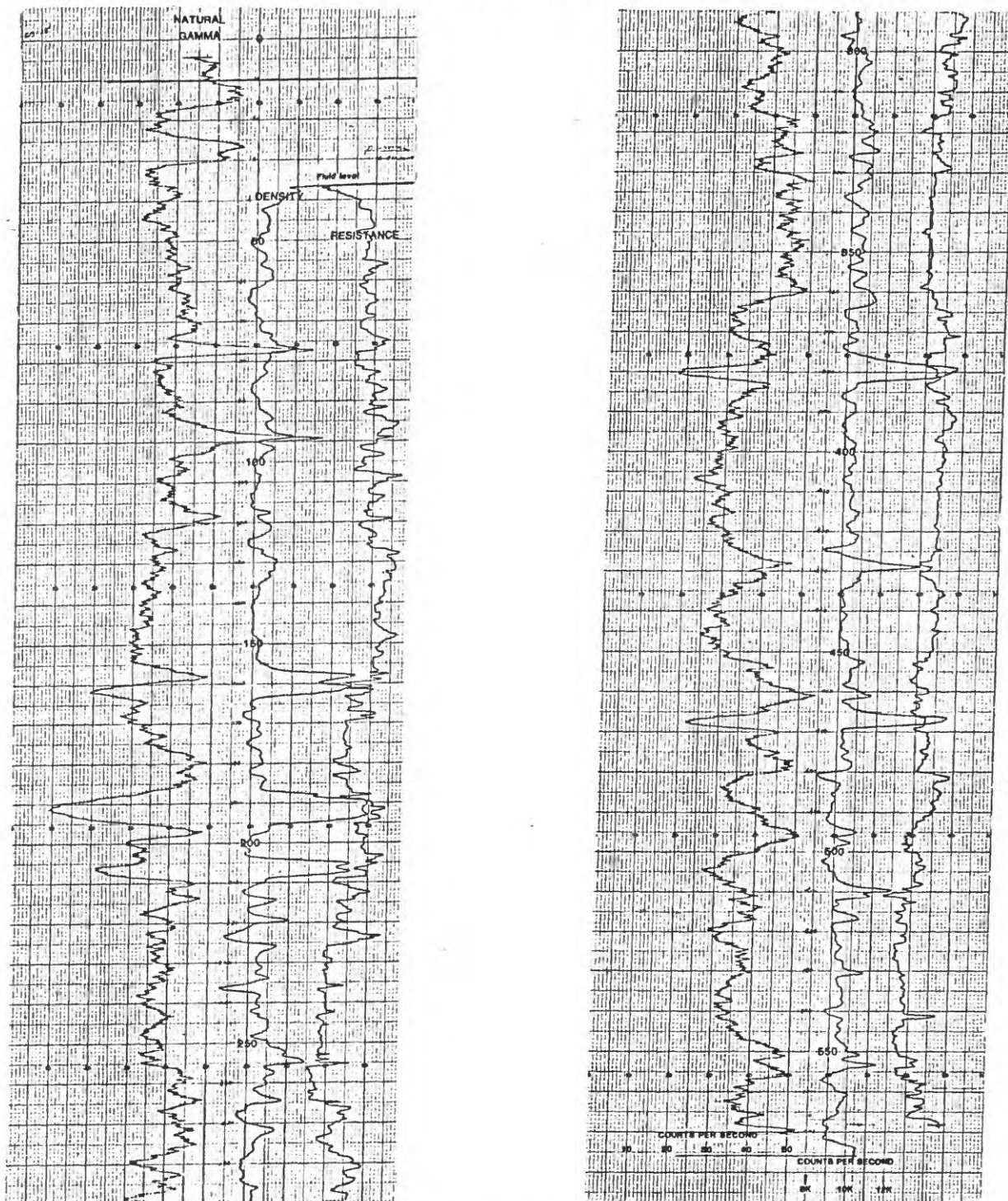


Figure 26.--Geophysical logs of hole GS-25

Sample log

Hole no.: GS-26 Date: 8-10-79 State: Montana County: Daniels

Elev. (ground): 2575 ft Location: T. 33 N., R. 51 E., Sec. SE SE 27

Total depth: 560 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-32 | Sand, mud, and gravel, brownish-gray, unconsolidated |
| 32-41 | Sand and silt, brownish-gray, unconsolidated |
| 41-59 | Claystone, medium-gray, silty; interbedded sandstone 48 to 53 ft |
| 59-88 | Sandstone, olive-gray, very fine grained; grades silty near top of interval; claystone parting 84 to 88 ft |
| 88-91 | Lignite, black; (Upper Timber Coulee lignite bed) |
| 91-107 | Claystone, medium-gray; interbedded sandstone 98 to 102 ft |
| 107-114 | Sandstone, medium-gray, very fine grained |
| 114-117 | Lignite, black; (Lower Timber Coulee lignite bed) |
| 117-127 | Claystone, medium-gray |
| 127-147 | Sandstone, medium-gray |
| 147-158 | Siltstone, light-gray |
| 158-163 | Claystone; probable coal beds 159 to 160 ft and 162 to 163 ft |
| 163-186 | Claystone, light-gray; probable coal beds 168 to 170 ft and 180 to 181 ft |
| 186-220 | Siltstone, light-gray, sandy; abundant coal fragments in upper half of interval; argillaceous near middle of interval |
| 220-225 | Sandstone, light-gray, very fine grained |
| 225-243 | Claystone, light-gray |
| 243-252 | Siltstone, light-gray, sandy |
| 252-272 | Claystone, light-gray; silty near middle of interval |
| 272-290 | Siltstone, light-gray; sandy near middle of interval |
| 290-293 | Lignite, black; (Lower Smoke Creek lignite bed) |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|---|
| 293-311 | Claystone, olive-gray; silty near middle of interval |
| 311-336 | Siltstone, olive-gray; sandy at top of interval |
| 336-355 | Siltstone, olive-gray; grades to claystone at top and base of interval |
| 355-357 | Lignite, black; ("BC" lignite bed) |
| 357-361 | Claystone; ("BC" lignite bed 359 to 360 ft) |
| 361-364 | Lignite, black; ("BC" lignite bed) |
| 364-376 | Sandstone, olive-gray, very fine grained; interbedded claystone at top of interval |
| 376-389 | Claystone, olive-gray |
| 389-408 | Sandstone, olive-gray, very fine grained; interbedded claystone at base |
| 408-411 | Lignite, black |
| 411-421 | Siltstone, olive-gray |
| 421-443 | Claystone, olive-gray; ("B" lignite bed 432 to 433 ft) |
| 443-463 | Siltstone, olive-gray, sandy; sandstone concretion 455 to 457 ft; probable coal bed 459 to 460 ft |
| 463-487 | Claystone, olive-gray |
| 487-515 | Sandstone, olive-gray; coal bed 497 to 499 ft |
| 515-560 | Siltstone, olive-gray; probable coal bed 528 to 529 ft; interbedded claystone 530 to 535 ft and 542 to 544 ft; coal fragments at base of interval |
| Total depth 560 ft | |

Hole No: GS-26 Date: 8-10-79 State: Montana County: Daniels
 Sec. SE SE 27 T. 33 N. R. 51 E. Elevation: 2575 ft Total Depth: 560 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 4 , Range 50 cps Density: TC 2 ,
 Range 10,000 cps Resistance: 10 ohms/in Caliper: Horizontal scale N/A in/in

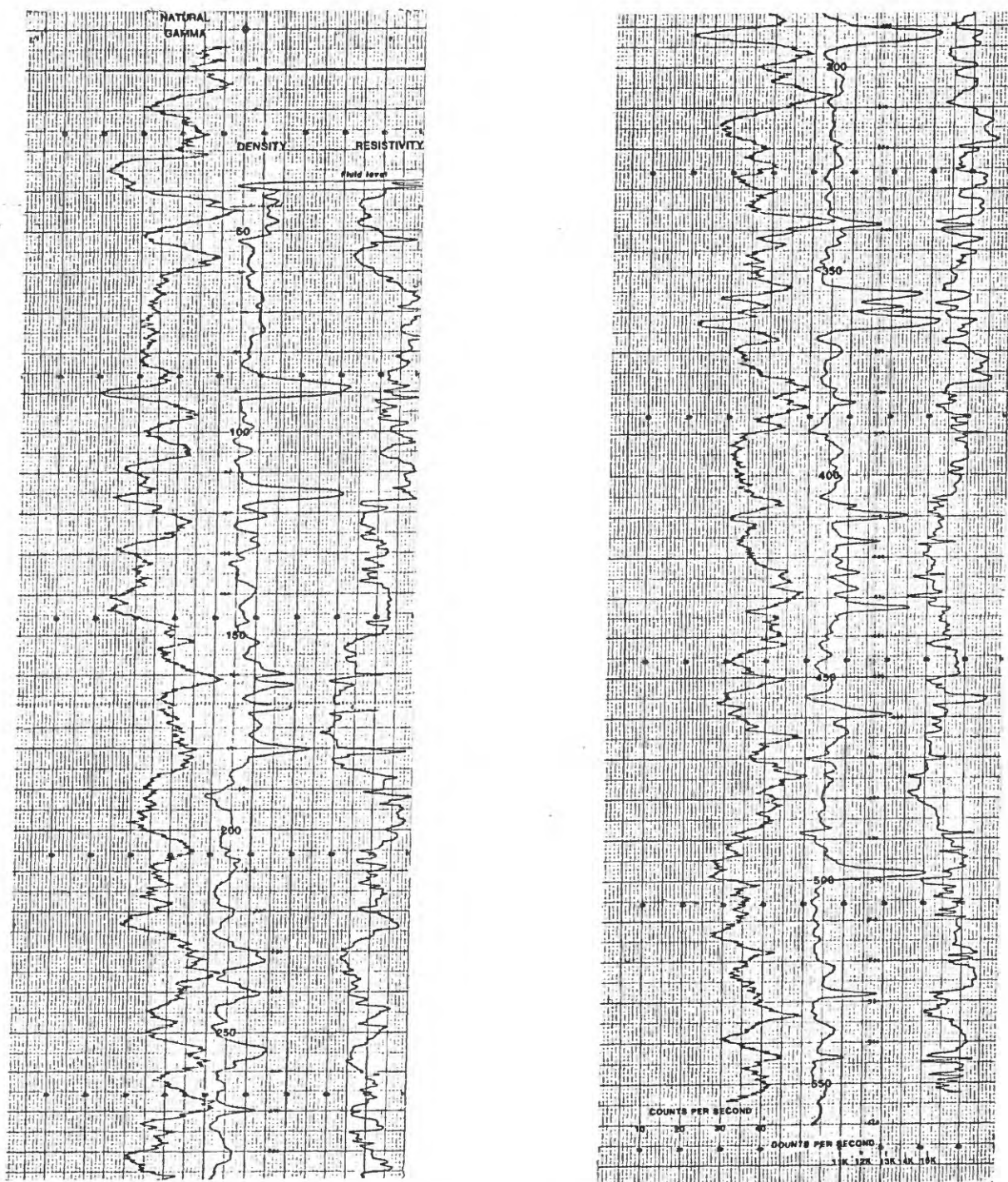


Figure 27.--Geophysical logs of hole GS-26

Sample log

Hole no.: GS-27 Date: 8-9-79 State: Montana County: Daniels

Elev. (ground): 2620 ft Location: T. 33 N., R. 50 E., Sec. SE SE 22

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

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-71 | Sand and gravel, unconsolidated |
| 71-76 | Claystone, greenish-gray |
| 76-100 | Sandstone, greenish-gray, very fine grained; interbedded claystone 81 to 83 ft and 87 to 91 ft |
| 100-114 | Claystone, greenish-gray |
| 114-134 | Claystone, light-gray |
| 134-165 | Sandstone, olive-gray, very fine grained; interbedded siltstone near middle of interval; coal bed 141 to 142 ft |
| 165-170 | Siltstone, light-gray |
| 170-172 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 172-218 | Siltstone, light-gray; with interbedded claystone |
| 218-220 | Lignite, black |
| 220-232 | Siltstone, light-gray |
| 232-236 | Lignite, impure; ("BC" lignite bed) |
| 236-244 | Claystone, light-gray |
| 244-301 | Sandstone, light-gray |
| 301-306 | Lignite, grades impure near base |
| 306-315 | Siltstone, light-gray; grades to claystone near base; coal bed 314 to 315 ft |
| 315-317 | Claystone |
| 317-320 | Lignite, black, impure; ("B" lignite bed) |
| 320-341 | Claystone, very light gray |
| 341-430 | Sandstone, light-gray to greenish-gray, very fine grained; interbedded with claystone from 385 to 391 ft and 411 to 418 ft; thin coal at 429 ft |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 430-458 | Siltstone, olive-gray |
| 458-460 | Lignite; ("AB" lignite bed) |
| 460-470 | Claystone, olive-gray |
| 470-480 | Siltstone, olive-gray; grades to claystone near base; probable coal bed 478 to 479 ft |
| | Total depth 480 ft |

Hole No: GS-27 Date: 8-9-79 State: Montana County: Daniels
 Sec. SE SE 22 T. 33 N. R. 50 E. Elevation: 2620 ft Total Depth: 480 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 4 , Range 50 cps Density: TC 2 ,
 Range 10,000 cps Resistance: 10 ohms/in Caliper: Horizontal scale N/A in/in

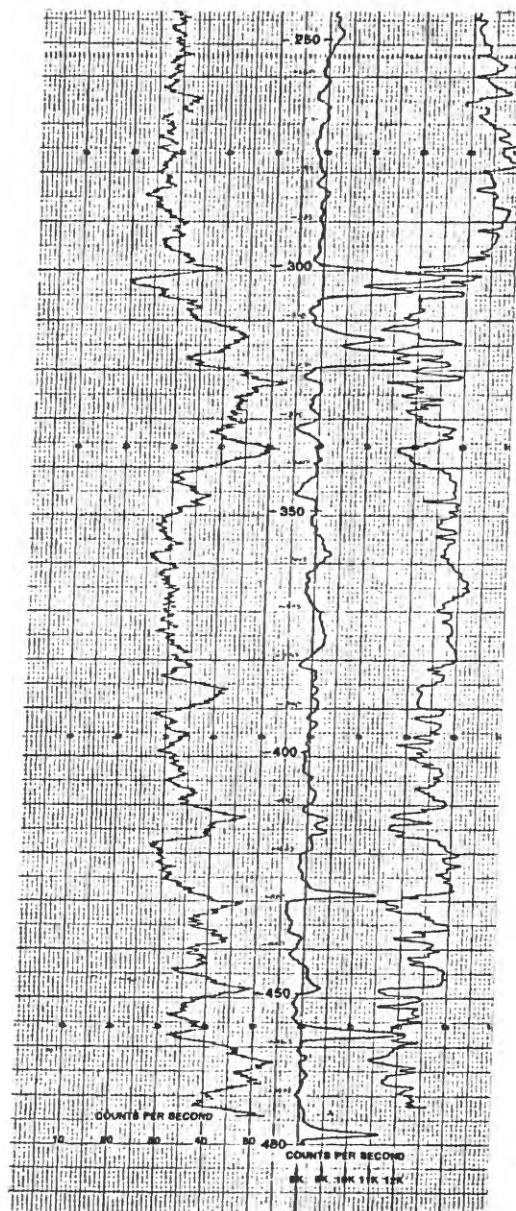
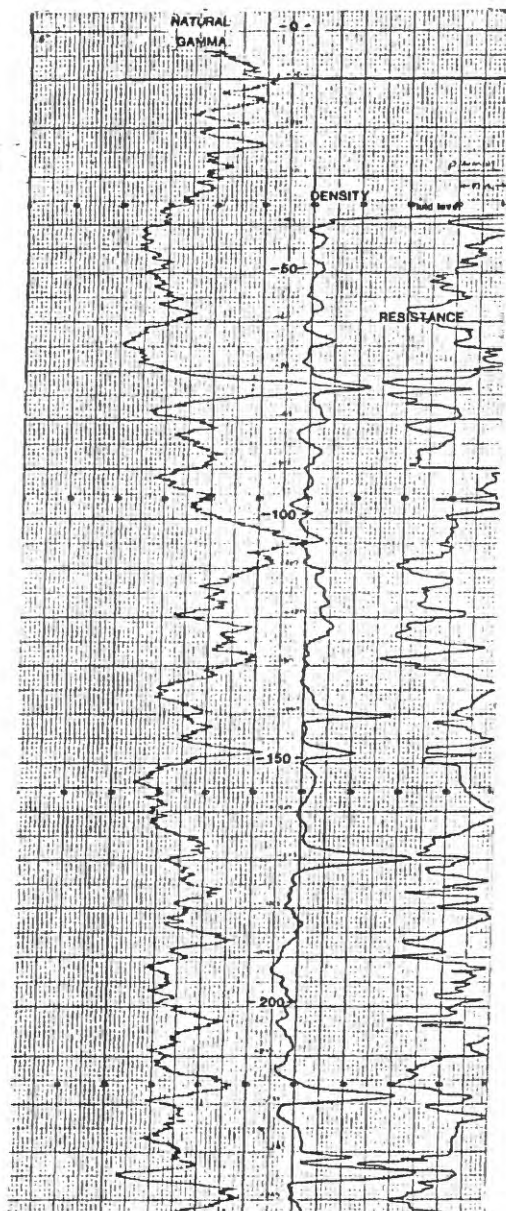


Figure 28.--Geophysical logs of hole GS-27

Sample log

Hole no.: GS-28 Date: 7-27-79 State: Montana County: Roosevelt

Elev. (ground): 2645 ft Location: T. 32 N., R. 49 E., Sec. SE SE 1

Total depth: 480 ft Drilling medium: mud Offset core hole: GS-28C

| Depth (feet) | Lithic description |
|---------------------|--|
| 0-32 | Sand, mud, and gravel, yellowish-brown, unconsolidated |
| 32-73 | Sand and gravel, unconsolidated |
| 73 73-77 | Claystone, pale-yellowish-brown |
| 77-92 | Sandstone, medium-gray to medium-dark-gray, very fine grained, argillaceous, silty; traces of coal and carbonaceous shale at top of interval |
| 92-99 | Shale, grayish-black, carbonaceous; minor coal fragments |
| 99-152 | Sandstone, light-gray, very fine grained, silty; minor coal fragments; argillaceous near top of interval |
| 152-165.6 | Claystone, light-gray to olive-gray and greenish-gray, silty slightly sandy; with thin interbedded carbonaceous claystone |
| 165.6-168 | Lignite, black; see sample description D221132 |
| 168-186 | Sandstone, light-gray, very fine grained; traces of coal at top of interval |
| 186-197 | Claystone, medium-gray; grades to siltstone near base |
| 197-199 | Lignite, black |
| 199-206 | Sandstone, greenish-gray, very fine grained; argillaceous at top and base |
| 206-211.7 | Lignite, see sample description D221133; ("AB" lignite bed) |
| 211.7-220 | Sandstone, light-gray, very fine grained; interbedded olive-gray claystone at top of interval |
| 220-227 | Claystone, light-gray; grades sandy at top and base |
| 227-230 | Lignite, impure |
| 230-251 | Claystone, medium-gray to light-gray, silty; grades sandy at top and base |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|---|
| 251-278 | Sandstone, light-gray, very fine grained, silty; argillaceous at top; traces of coal near base |
| 278-284 | Claystone, medium-gray |
| 284-301 | Siltstone, medium-light-gray; with thin interbedded sandstone |
| 301-309 | Sandstone, light-gray, very fine grained |
| 309-325.7 | Claystone, medium-light-gray to greenish-gray, silty; scattered organic debris at base |
| 325.7-332.1 | Lignite; with interbedded claystone 330.2 to 331.1 ft; see sample descriptions D221134 and D221135; ("A" Rider lignite bed) |
| 332.1-339 | Siltstone, medium-light-gray, sandy |
| 339-381 | Siltstone, medium-light-gray to light-gray; traces of organic debris scattered throughout interval |
| 381-389 | Claystone, medium-gray |
| 389-416 | Sandstone, pinkish-gray, very fine grained; probable coal beds 391 to 392 ft and 400 to 401 ft |
| 416-458 | Sandstone, pinkish-gray to medium-light-gray, very fine grained; with some thinly interbedded siltstone |
| 458-480 | Sandstone, pinkish-gray to yellowish-gray, very fine grained; traces of organic debris at base |
| Total depth 480 ft | |

Hole No: GS-28C Date: 8-3-79 State: Montana County: Roosevelt
 Sec. SE SE 1 T. 32 N. R. 49 E. Elevation: 2645 ft Total Depth: 480 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 4 , Range 50 cps Density: TC 2 ,
 Range 10,000 cps Resistance: 10 ohms/in Caliper: Horizontal scale N/A in/in

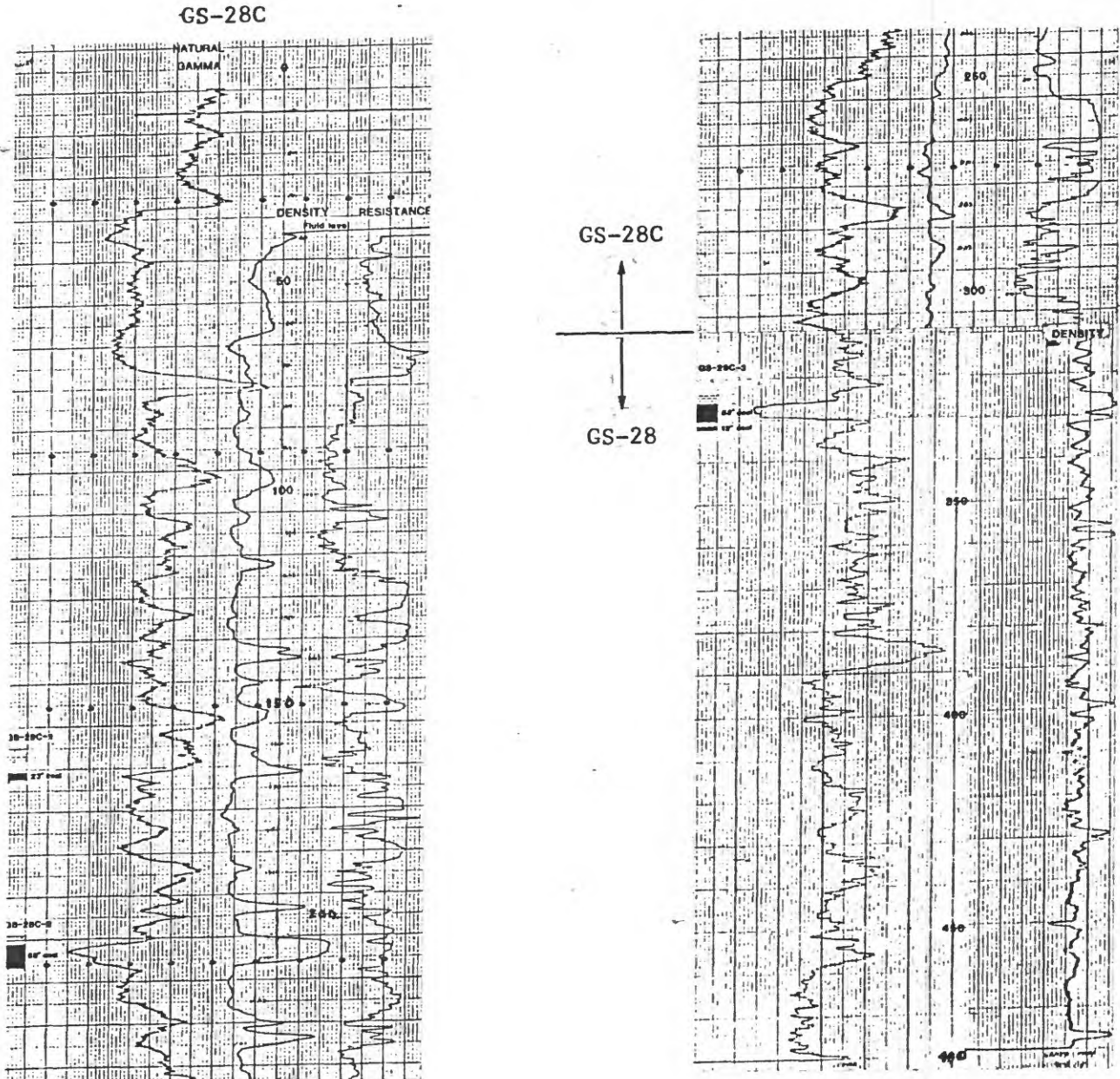


Figure 29.--Geophysical logs of holes GS-28 and GS-28C

Sample log

Hole no.: GS-29 Date: 8-4-79 State: Montana County: Daniels

Elev. (ground): 2735 ft Location: T. 33 N., R. 49 E., Sec. SE NW 15

Total depth: 466 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-36 | Sand and gravel, unconsolidated |
| 36-45 | Sandstone, very fine grained |
| 45-67 | Siltstone, olive-gray |
| 67-90 | Claystone, greenish-gray; grades silty near top and argillaceous near base |
| 90-106 | Siltstone, olive-gray, sandy ; interbedded claystone at top and base |
| 106-121 | Sandstone, olive-gray, very fine grained |
| 121-161 | Siltstone, light-to dark-gray; grades to claystone at top and base; ("BC" lignite bed 141 to 143 ft) |
| 161-200 | Siltstone, dark-gray; probable coal bed 176 to 177 ft |
| 200-211 | Claystone, dark-gray; minor coal fragments |
| 211-251 | Sandstone, dark-gray, very fine grained |
| 251-268 | Siltstone, dark-gray; with thin interbedded claystone |
| 268-322 | Siltstone, light-gray; sandy near top of interval; grades argillaceous toward base; coal bed 304 to 305 ft |
| 322-351 | Sandstone, olive-gray, very fine grained; with thin interbedded claystone |
| 351-356 | Lignite, grades impure in middle of interval; ("AB" lignite bed) |
| 356-370 | Claystone, medium-gray |
| 370-371 | Lignite, black |
| 371-388 | Siltstone, dark-gray |
| 388-399 | Claystone, dark-gray; coal bed 395 to 396 ft |
| 399-411 | Siltstone, dark-gray; minor coal fragments |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 411-414 | Lignite, black; ("AA" lignite bed) |
| 414-439 | Claystone, dark-gray; siltstone parting 432 to 435 ft |
| 439-446 | Siltstone, dark-gray, sandy |
| 446-449 | Lignite, impure |
| 449-466 | Siltstone, dark-gray |
| | Total depth 466 ft |

Hole No: GS-29 Date: 8-4-79 State: Montana County: Daniels
 Sec. SE NW 15 T. 33 N. R. 49 E. Elevation: 2735 ft Total Depth: 466 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 1 , Range 50 cps Density: TC 4 ,
 Range 10,000 cps Resistance: 10 ohms/in Caliper: Horizontal scale N/A in/in

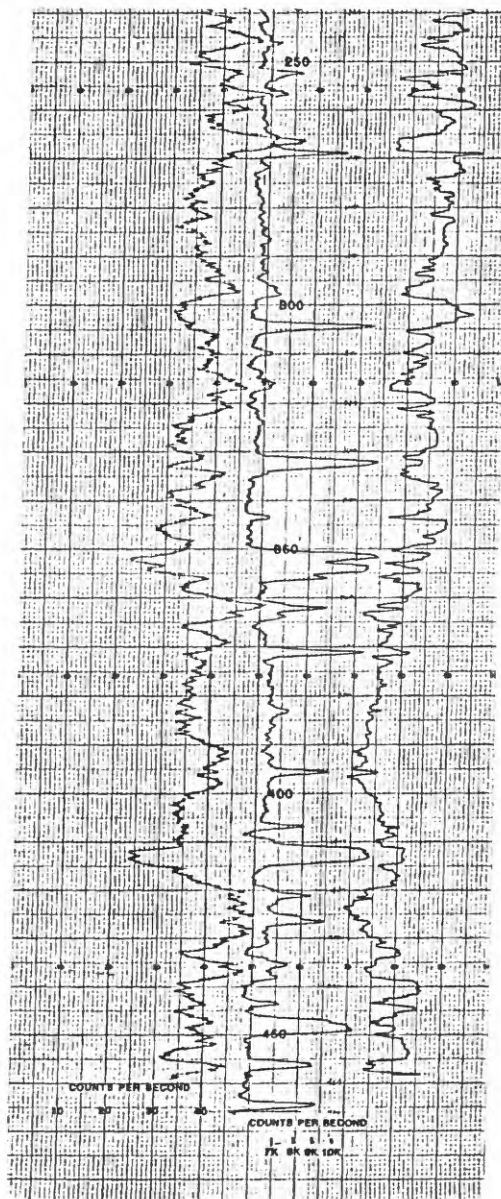
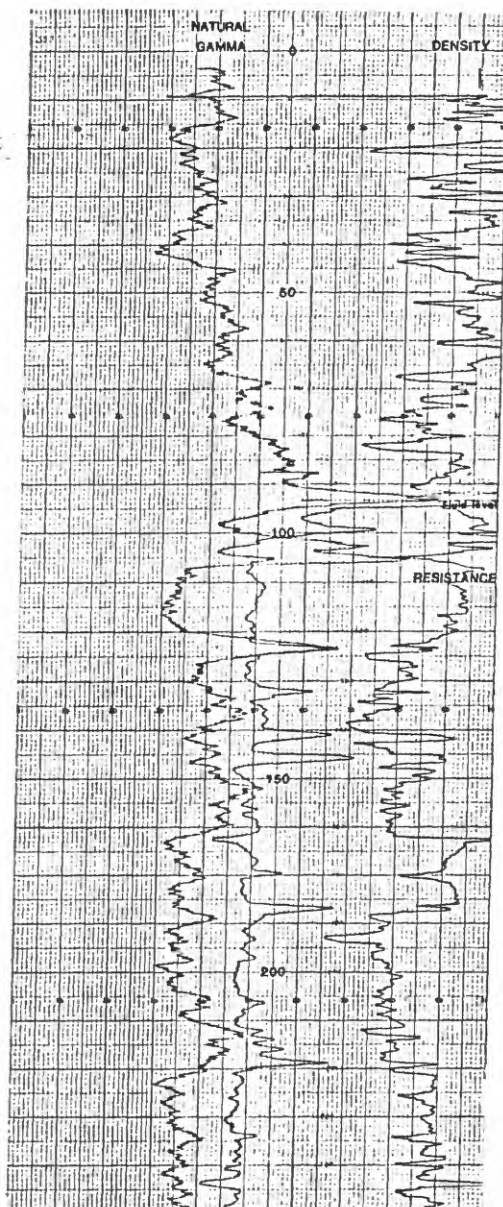


Figure 30.--Geophysical logs of hole GS-29

Sample log

Hole no.: GS-30 Date: 9-6-79 State: Montana County: Sheridan
Elev. (ground): 2115 ft Location: T. 33 N., R. 55 E., Sec. SW SE 17
Total depth: 156 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|--------------------|--|
| 0-25 | Sand with sparse scattered granules and pebbles, olive-gray to dark-yellowish-brown, unconsolidated |
| 25-39 | Sand and silt, dark-yellowish-brown, unconsolidated |
| 39-130 | Sand, silt, and clay, light-olive-gray to olive-gray, unconsolidated; sparse detrital coal fragments at base |
| 130-156 | Gravel, rounded pebbles of quartz, quartzite, and granite as much as 1 inch in diameter, unconsolidated |
| Total depth 156 ft | |

Hole No: GS-30 Date: 9-6-79 State: Montana County: Sheridan
 Sec. SW SE 17 T. 33 N. R. 55 E. Elevation: 2115 ft Total Depth: 156 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 2 , Range 10 cps Density: TC 2 ,
 Range 200 cps Resistance: 10 ohms/in Caliper: Horizontal scale 2 in/in

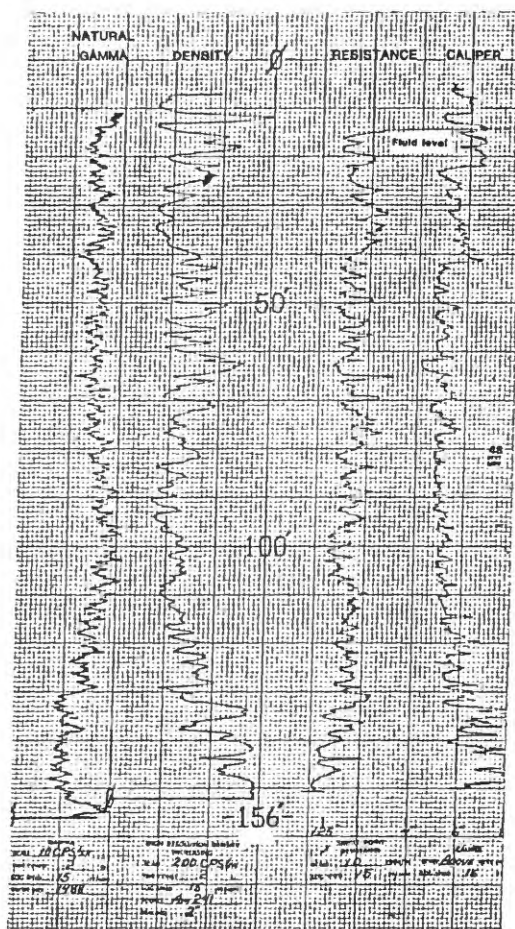


Figure 31.--Geophysical logs of hole GS-30

Sample log

Hole no.: GS-31 Date: 8-28-79 State: Montana County: Sheridan

Elev. (ground): 2140 ft Location: T. 33 N., R. 54 E., Sec. NW NW 32

Total depth: 500 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|--------------------|--|
| 0-13 | Sand and gravel, medium-brown, unconsolidated |
| 13-76 | Sandstone, medium-brown to medium-gray, silty, very fine grained |
| 76-106 | Claystone, medium-gray, very silty; traces of coal at base of interval |
| 106-141 | Siltstone, medium-gray to light-gray; with thinly interbedded claystone; calcareous sandstone concretion 118 to 120 ft; traces of coal at top and base of interval |
| 141-156 | Claystone, light-gray |
| 156-174 | Siltstone, light-gray; calcareous sandstone concretion 169 to 170 ft |
| 174-201 | Claystone, medium-gray to light-gray, slightly silty; traces of coal at top and base of interval |
| 201-236 | Siltstone, greenish-gray to light-gray to medium-gray; (Lower Smoke Creek lignite bed 201 to 202 ft) |
| 236-244 | Claystone, light-gray to medium-gray |
| 244-316 | Siltstone, medium-gray; (coal bed 274 to 275 ft and "BC" lignite bed 312 to 313 ft) |
| 316-407 | Sandstone, light-gray, fine to very fine grained |
| 407-438 | Claystone, light-gray; silty in upper part |
| 438-450 | Sandstone, light-gray, very fine grained, silty |
| 450-465 | Claystone, light-greenish-gray, silty; thin calcareous sandstone concretion at top of interval |
| 465-469 | Lignite, black; ("AA" lignite bed) |
| 469-500 | Siltstone, light-brownish-gray, sandy; probable calcareous sandstone concretion at 496 ft |
| Total depth 500 ft | |

Hole No: GS-31 Date: 8-28-79 State: Montana County: Sheridan
 Sec. NW NW 32 T. 33 N. R. 54 E. Elevation: 2140 ft Total Depth: 500 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 2, Range 10 cps Density: TC 2,
 Range 200 cps Resistance: 5 ohms/in Caliper: Horizontal scale 2 in/in

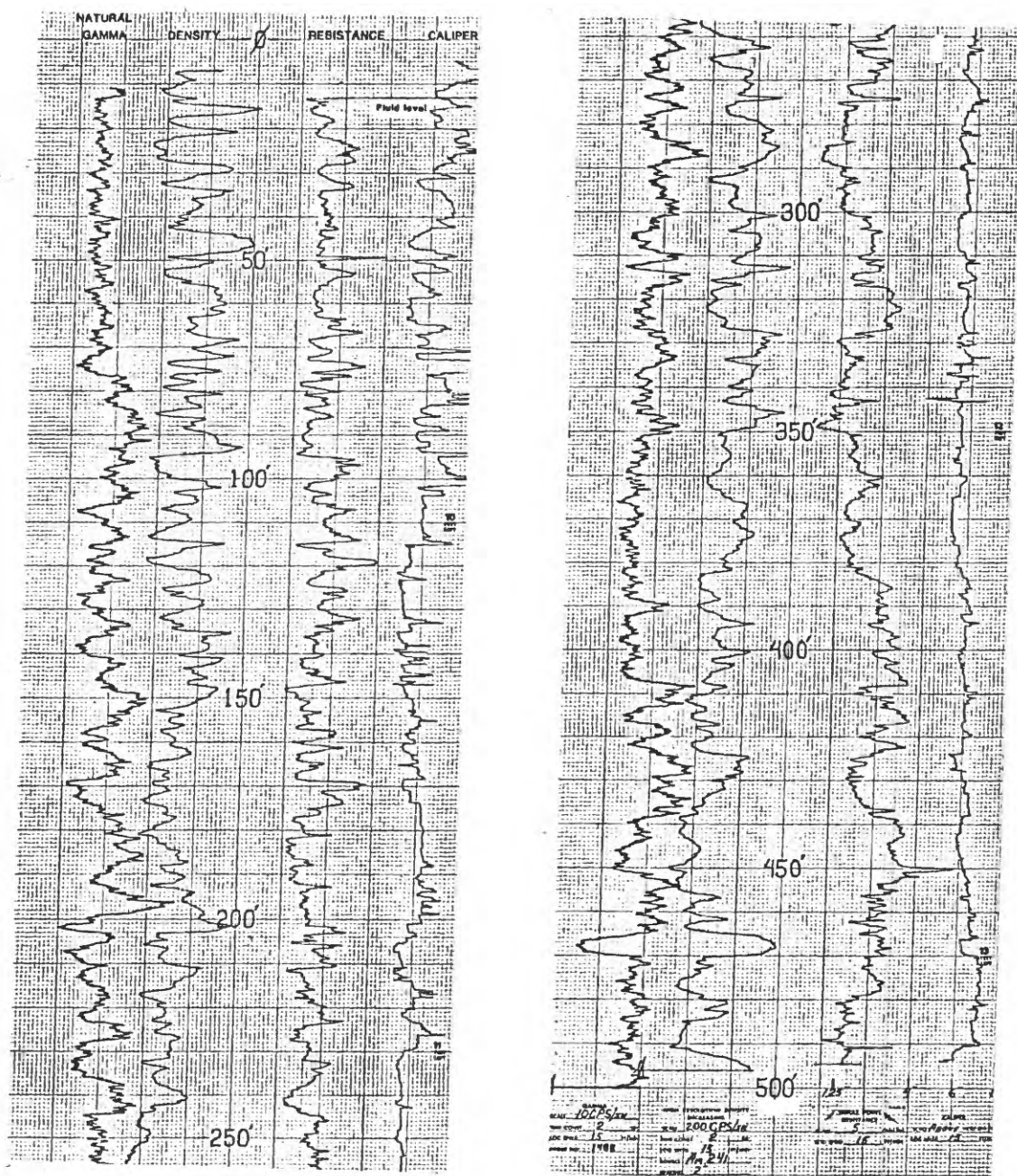


Figure 32.--Geophysical logs of hole GS-31

Sample log

Hole no.: GS-32 Date: 8-14-79 State: Montana County: Roosevelt

Elev. (ground): 2068 ft Location: T. 31 N., R. 54 E., Sec. SW SE 25

Total depth: 703 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-15 | Sand, silt, and clay, olive-gray, unconsolidated; contains scattered pebbles and granules |
| 15-30 | Gravel, sand and silt, olive-gray to yellowish-gray; pebbles and granules of quartz, granite, gneiss, and dolomite |
| 30-62 | Claystone and siltstone, light-olive-gray to dusky-yellow, very finely micaceous; traces of carbonaceous shale and impure coal in lower part; sandy at base |
| 62-63.5 | Lignite, brownish-black, impure |
| 63.5-78 | Siltstone, medium-light-gray, sandy; includes some medium-gray claystone in middle of interval; grades downward to sandstone in lower part |
| 78-85 | Claystone, medium-light-gray, silty; contains scattered thin carbonaceous lamina |
| 85-91 | Lignite, grayish-black to brownish-black; grades impure between 87.5 and 89.5 ft; (Upper Timber Coulee lignite bed) |
| 91-93 | Claystone, medium-light-gray |
| 93-103 | Sandstone, light-gray, very fine grained |
| 103-114 | Siltstone, light-gray; includes some thinly interbedded claystone in lower part |
| 114-117.5 | Lignite, grayish-black to brownish-black; grades impure in upper part; (Lower Timber Coulee lignite bed) |
| 117.5-124 | Siltstone and claystone, medium-light-gray siltstone in upper part, greenish-gray claystone in lower part |
| 124-147 | Sandstone, medium-gray, very fine grained, micaceous; grades to medium-dark-gray siltstone at base |
| 147-149 | Lignite, grayish-black; (Timber Coulee Leader lignite bed) |
| 149-169 | Siltstone, medium-light-gray; includes thinly interbedded clay- at top and base of interval |
| 169-183 | Sandstone, medium-bluish-gray, very fine to medium-grained |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 183-200 | Siltstone and silty claystone, medium-light-gray; siltstone predominates in upper part of interval, claystone in lower part; includes coal between 194 and 195 ft |
| 200-224 | Sandstone, medium-light-gray, very fine grained; includes some thinly interbedded siltstone between 207 and 210 ft, and 216 and 220 ft |
| 224-284 | Siltstone, medium-light-gray to medium-gray; includes thinly interbedded medium-gray claystone between 239 and 243 ft, and 257 and 262 ft |
| 284-307 | Sandstone, medium-light-gray to medium-bluish-gray, very fine grained; includes impure coal from 299 to 300 ft; grades to light-olive-gray siltstone at base |
| 307-310.5 | Lignite, grayish-black; (Lower Smoke Creek lignite bed) |
| 310.5-313 | Claystone, brownish-gray |
| 313-328 | Sandstone, light-gray, very fine grained |
| 328-340 | Siltstone, medium-light-gray to light-olive-gray, sandy; scattered thin carbonaceous lamina |
| 340-346 | Sandstone, medium-light-gray, very fine grained, silty |
| 346-352 | Lignite, grayish-black to brownish-black; grades slightly impure in middle and lower parts; ("BC" lignite bed) |
| 352-356 | Claystone, light-olive-gray, silty in lower part |
| 356-411 | Sandstone and siltstone, chiefly light-gray very fine grained sandstone with scattered thinly interbedded medium-light-gray siltstone; hard, dense calcareous sandstone concretions at 388 and 397 ft |
| 411-456 | Siltstone and silty claystone, thinly interbedded, very light gray to light-olive-gray; grades to silty sandstone between 445 and 450 ft |
| 456-457 | Lignite, grayish-black |
| 457-475 | Siltstone, medium-gray to light-olive-gray |
| 475-479 | Lignite, grayish-black to brownish-black; includes impure coal and carbonaceous shale between 477 and 478 ft; ("B" lignite bed) |
| 479-502 | Siltstone, light-olive-gray; includes some thinly interbedded silty claystone; sandy in upper part |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 502-509 | Sandstone, medium-gray, very fine grained |
| 509-530 | Siltstone, light-olive-gray; includes some thinly interbedded claystone in middle and lower parts |
| 530-592 | Siltstone, light-olive-gray; sandy in upper part and at base; hard, dense calcareous sandstone concretion at 542 ft; includes some thinly interbedded claystone in middle to lower parts |
| 592-599 | Claystone, light-olive-gray |
| 599-601 | Lignite, grayish-black; ("AB" lignite bed) |
| 601-647 | Claystone and siltstone, light-olive-gray claystone predominates in upper part and at base of interval and medium-light-gray siltstone in middle part; hard, dense calcareous sandstone concretion at 625 ft |
| 647-652 | Lignite, grayish-black to brownish-black; includes impure coal and carbonaceous shale between 649 and 650 ft; ("AA" lignite bed) |
| 652-675 | Siltstone and claystone, light-gray to greenish-gray siltstone predominates in upper part and light-olive-gray claystone in lower part |
| 675-703 | Siltstone, light-gray to light-olive-gray; includes some thinly interbedded greenish-gray very fine grained sandstone between 680 and 690 ft; grades to silty claystone at base |
| | Total depth 703 ft |

Hole No: GS-32 Date: 8-14-79 State: Montana County: Roosevelt
 Sec. SW SE 25 T. 31 N. R. 54 E. Elevation: 2068 ft Total Depth: 703 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 3, Range 10 cps Density: TC 3,
 Range 200 cps Resistance: 10 ohms/in Caliper: Horizontal scale 2 in/in

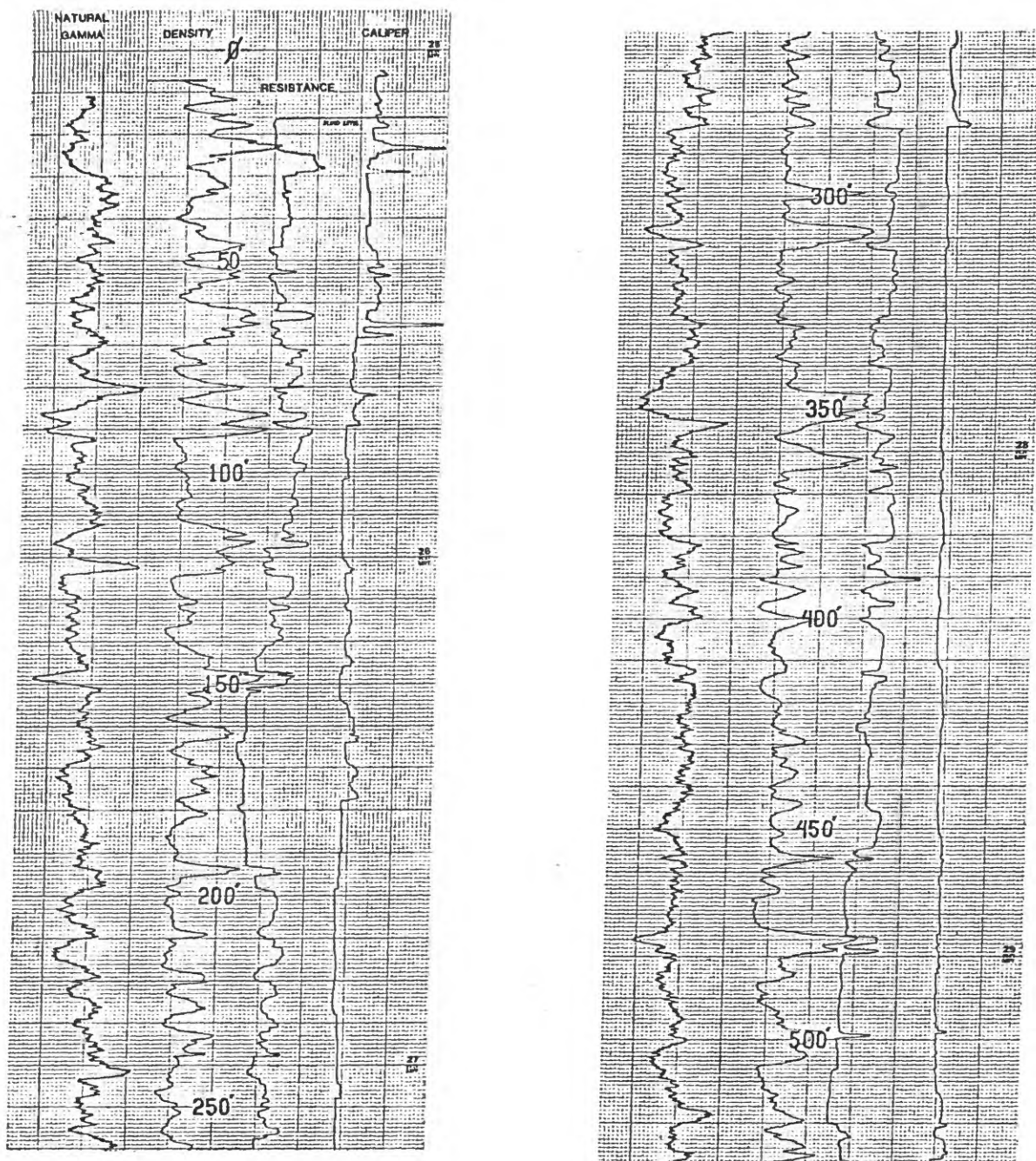


Figure 33.--Geophysical logs of hole GS-32

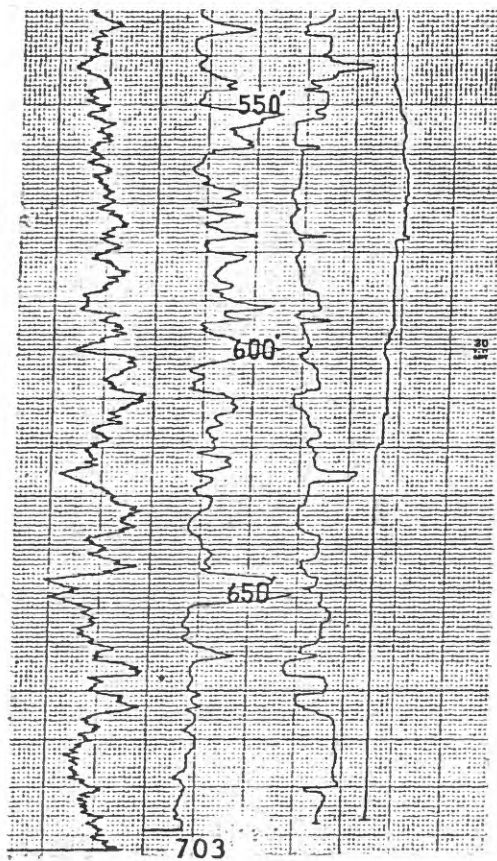


Figure 33.--Geophysical logs of hole GS-32--Continued

Sample log

Hole no.: GS-33 Date: 7-17-79 State: Montana County: Roosevelt
 Elev. (ground): 2155 ft Location: T. 30 N., R. 53 E., Sec. NW NW 19
 Total depth: 480 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-25 | Clay, silt, and sand, unconsolidated, yellowish-gray; includes abundant very coarse grains and granules of quartz, quartzite, granite, and gneiss; sparse detrital coal fragments in lower part |
| 25-60 | Gravel, sand, and silt, unconsolidated, yellowish-green and pale-yellowish-brown; chiefly well-rounded to subangular pebbles of white and grayish-pink quartz and quartzite, with abundant rounded pebbles of granite, gneiss, and sandstone as much as 1.25 inches in diameter |
| 60-86 | Siltstone and claystone, very light gray to light-gray; some thinly interbedded silty sandstone; sparse to locally abundant traces of coal in cuttings from upper part of interval |
| 86-92 | Carbonaceous shale, brownish-gray to brownish-black; some interbedded light-gray claystone |
| 92-116 | Siltstone and claystone, light-gray; slightly sandy siltstone predominates grading locally to silty claystone; probable thin coal at 104 ft |
| 116-122 | Carbonaceous shale and claystone, brownish-gray to medium-gray; includes some impure coal |
| 122-153 | Siltstone and silty claystone, light-gray; includes thinly interbedded carbonaceous shale and coal between 135 and 140 ft; grades to brownish-gray silty sandstone at base |
| 153-159 | Carbonaceous shale with traces of coal |
| 159-185 | Siltstone and silty claystone, light-gray; includes some brownish-gray to brownish-black carbonaceous shale and impure coal between 163 and 169 ft; probable thin impure coal at 175 ft |
| 185-199 | Sandstone, very light gray, very fine grained; includes some light-gray siltstone; fairly abundant coal in cuttings from 185 to 190 ft |
| 199-212 | Claystone, very light gray to light-gray, silty; grades to medium-dark-gray and brownish-gray carbonaceous shale between 205 and 210 ft; probable thin coal at 212 ft |
| 212-213 | Coal, black; ("AB" lignite bed) |
| 213-236 | Siltstone and silty claystone, very light gray to light-olive-gray; grades to silty sandstone at base and to claystone at top |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 236-245 | Claystone, yellowish-gray to light-olive-gray; silty in lower part |
| 245-258 | Sandstone, very light gray, very fine grained; includes some thinly interbedded siltstone |
| 258-261 | Carbonaceous shale, brownish-gray to brownish-black |
| 261-263 | Lignite, brownish-black to black; ("AA" Rider lignite bed) |
| 263-267 | Carbonaceous shale, brownish-gray |
| 267-275 | Siltstone and silty sandstone, very light gray to yellowish-gray |
| 275-279 | Carbonaceous shale, medium-gray to brownish-gray |
| 279-281.5 | Lignite, brownish-black to black |
| 281.5-290 | Carbonaceous shale, brownish-gray to brownish-black; includes some thin layers of coal and thinly interbedded light-gray silty claystone |
| 290-297.5 | Claystone, brownish-gray to olive-gray at top, light-gray in lower part; grades silty in lower part |
| 297.5-299 | Lignite, brownish-black, impure |
| 299-326 | Claystone, light-gray to brownish-gray and light-olive-gray, silty |
| 326-339 | Siltstone, very light gray to yellowish-gray, very finely micaceous; grades to silty claystone in lower part |
| 339-344 | Carbonaceous shale, medium-dark-to dark-gray |
| 344-350 | Lignite and carbonaceous shale, brownish-black to black; 1.0 ft of lignite at top and 1.0 ft of lignite at base, separated by 4.0 ft of carbonaceous shale; ("A" Rider lignite bed) |
| 350-355 | Siltstone and silty claystone, light-gray to brownish-gray |
| 355-357 | Lignite, black; ("A" lignite bed) |
| 357-360 | Carbonaceous shale, medium-dark-gray to dark-gray |
| 360-381 | Claystone, light-gray to light-olive-gray, silty; includes scattered thin beds of siltstone and very fine grained sandstone; probable thin impure coal at 369 ft |
| 381-391 | Claystone, light-to medium-dark-gray, slightly silty; carbonaceous in upper part; may include thin impure coal at 383 ft |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 391-401 | Sandstone, light-to very light gray, fine-to very fine grained; subangular, salt and pepper texture; chiefly feldspar and quartz with sparse very fine mica, fairly abundant green grains, and scattered grains of detrital coal, in clay matrix |
| 401-409 | Claystone, medium-gray to brownish-gray; includes some pyritic carbonaceous shale and trace of coal |
| 409-427 | Sandstone, very light gray, very fine grained; includes some brownish-gray silty claystone between 417 and 421 ft |
| 427-433 | Carbonaceous shale, brownish-black, pyritic |
| 433-435 | Lignite, brownish-black, impure |
| 435-453 | Claystone, light-gray to yellowish-gray, silty, very finely micaceous; includes some thinly interbedded very light gray siltstone |
| 453-458 | Carbonaceous shale, brownish-black; trace of coal |
| 458-480 | Claystone and siltstone, light-brownish-gray and light-olive-gray; includes some brownish-gray carbonaceous shale between 462 and 467 ft |
| | Total depth 480 ft |

Hole No: GS-33 Date: 7-17-79 State: Montana County: Roosevelt
 Sec. NW NW 19 T. 30 N. R. 53 E. Elevation: 2155 ft Total Depth: 480 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 4, Range 50 cps Density: TC 4,
 Range 20,000cps Resistance: N/A ohms/in Caliper: Horizontal scale N/A in/in

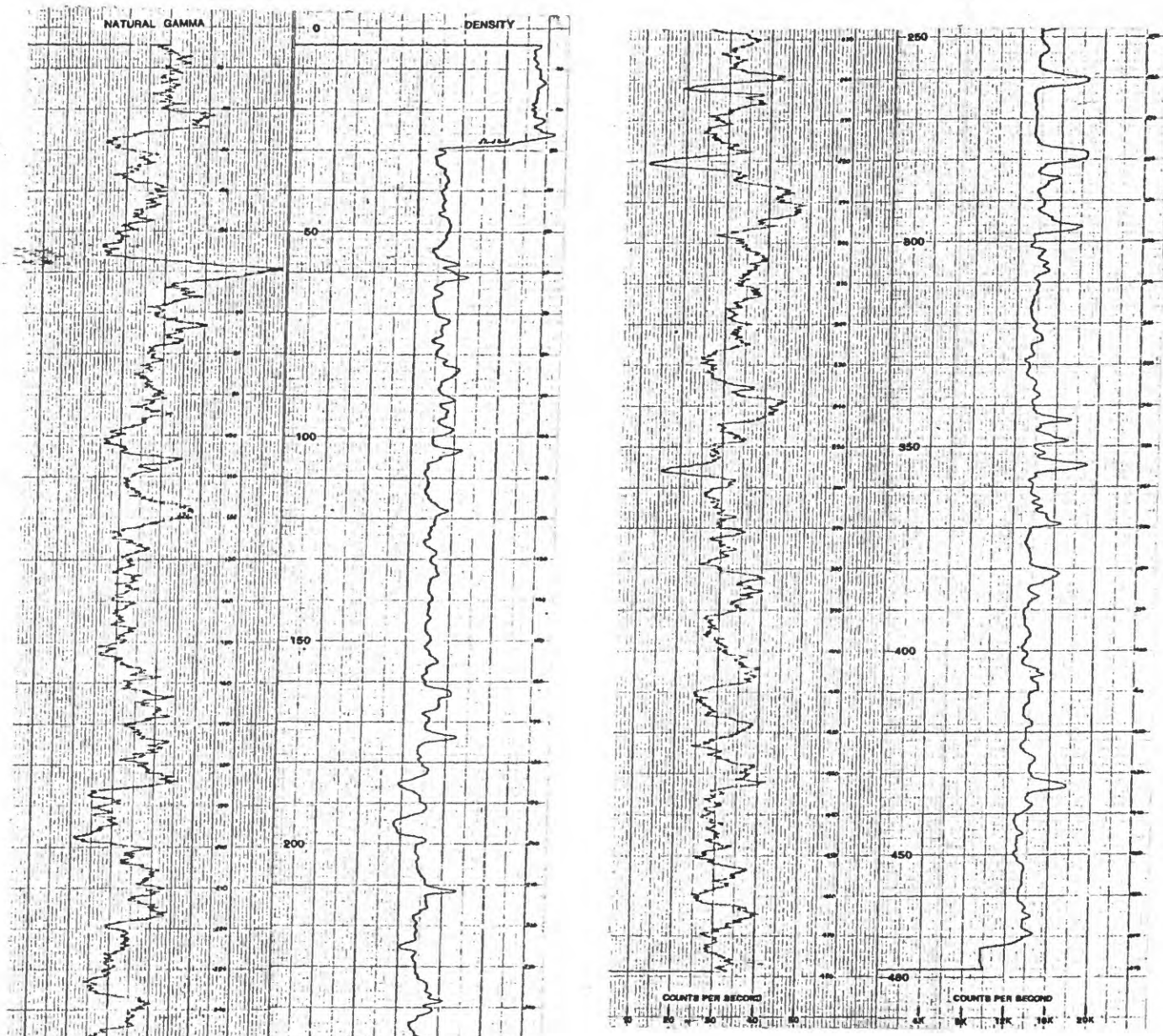


Figure 34.--Geophysical logs of hole GS-33

Sample log

Hole no.: GS-34 Date: 8-11-79 State: Montana County: Roosevelt
 Elev. (ground): 2585 ft Location: T. 32 N., R. 53 E., Sec. NW NW 17
 Total depth: 580 ft Drilling medium: mud Offset core hole: GS-34C

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-13 | Sand, silt, and mud, light-gray, unconsolidated |
| 13-31 | Gravel, unconsolidated |
| 31-50 | Siltstone, yellowish-gray |
| 50-74 | Sandstone, very pale orange, very fine grained |
| 74-85 | Claystone, greenish-gray |
| 85-109 | Sandstone, olive-gray, very fine grained |
| 109-141 | Siltstone, very pale orange; interbedded sandstone at base and interbedded claystone throughout remaining interval |
| 141-150 | Claystone, yellowish-gray |
| 150-182 | Sandstone, yellowish-gray, very fine grained |
| 182-208 | Siltstone, light-gray; grades to sandstone near base |
| 208-228.1 | Siltstone, greenish-gray; grades to claystone at base; coal bed 225.9 to 226.3 ft |
| 228.1-233.2 | Lignite, see sample description D221136; (Upper Timber Coulee lignite bed) |
| 233.2-244 | Claystone, greenish-gray; grades sandy near top of interval |
| 244-247.5 | Lignite, see sample description D221137; (Lower Timber Coulee lignite bed) |
| 247.5-277 | Siltstone, greenish-gray; interbedded claystone at top and base; sandstone parting 261 to 266 ft |
| 277-305 | Claystone, greenish-gray, silty |
| 305-310 | Lignite, impure; (Timber Coulee Leader lignite bed) |
| 310-341 | Sandstone, light-gray; claystone partings 310 to 314 ft, 326 to 330 ft, and 336 to 341 ft |
| 341-362 | Sandstone, greenish-gray, silty |

Sample log---Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 362-383 | Claystone, greenish-gray, silty; several coal fragments |
| 383-390 | Sandstone, light-gray |
| 390-422 | Claystone, greenish-gray; traces of coal near base |
| 422-433 | Sandstone, greenish-gray; grades to claystone at base |
| 433-437 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 437-477 | Siltstone, greenish-gray, sandy; traces of coal throughout interval |
| 477-485 | Claystone, greenish-gray |
| 485-492 | Siltstone, greenish-gray; coal bed 491 to 492 ft |
| 492-509 | Claystone, light-gray; grades sandy near base |
| 509-520 | Siltstone, light-gray |
| 520-522 | Lignite, black; ("BC" lignite bed) |
| 522-534 | Claystone, medium-light-gray |
| 534-541 | Siltstone, light-gray |
| 541-544 | Lignite, impure |
| 544-554 | Claystone, light-greenish-gray, silty |
| 554-572 | Claystone, light-gray |
| 572-580 | Sandstone |
| | Total depth 580 ft |

Hole No: GS-34 Date: 8-11-79 State: Montana County: Roosevelt
 Sec. NW NW 17 T. 32 N. R. 53 E. Elevation: 2585 ft Total Depth: 580 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 4 , Range 50 cps Density: TC 2 ,
 Range 10,000 cps Resistance: 20 ohms/in Caliper: Horizontal scale N/A in/in

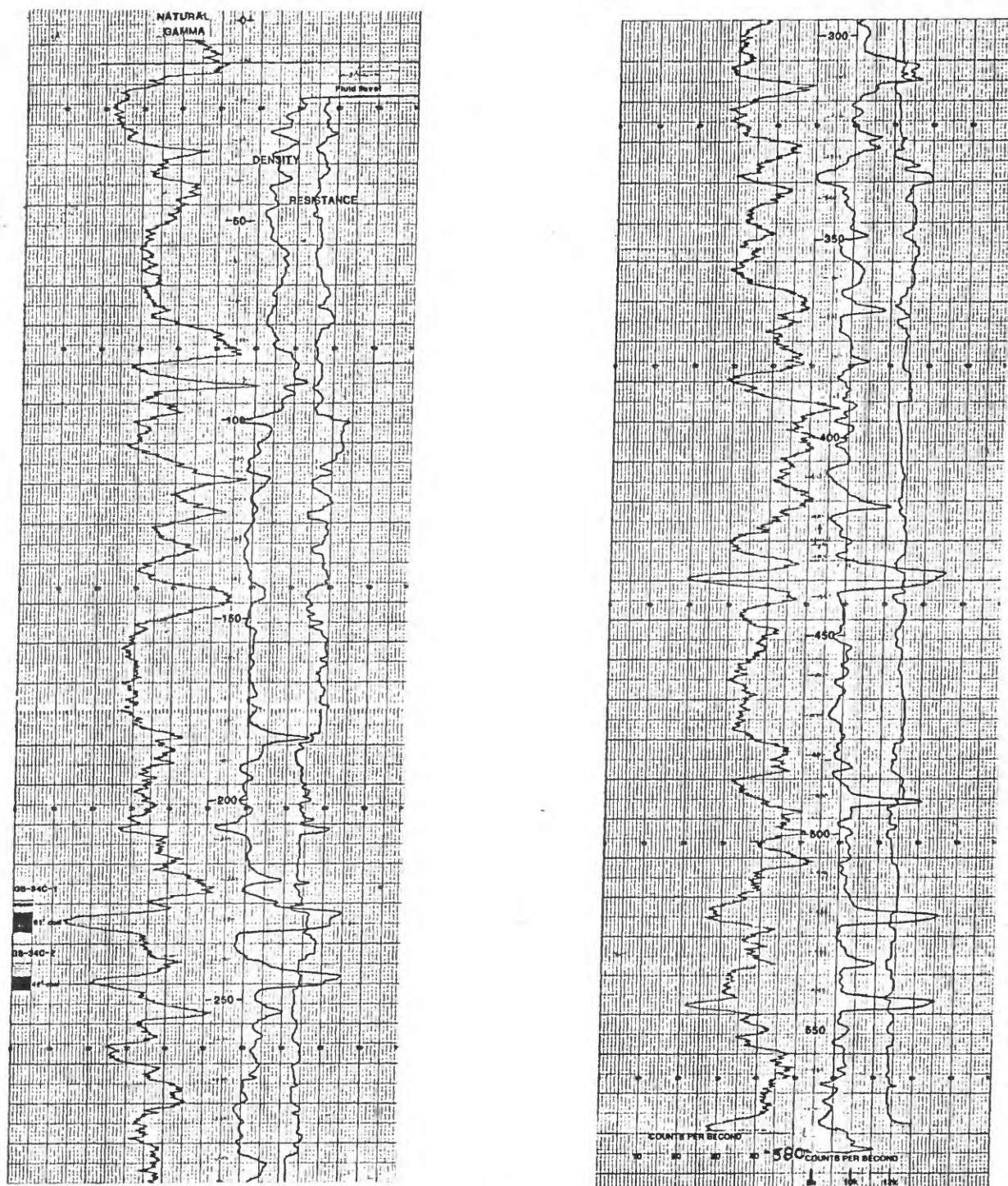


Figure 35.--Geophysical logs of hole GS-34

Sample log

Hole no.: GS-35 Date: 8-13-79 State: Montana County: Roosevelt
 Elev. (ground): 2420 ft Location: T. 32 N., R. 52 E., Sec. NW NE 16
 Total depth: 576 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-14 | Sand, mud, and gravel, unconsolidated |
| 14-19 | Siltstone, yellowish-brown |
| 19-23 | Lignite, black; (Upper Timber Coulee lignite bed) |
| 23-37 | Claystone, light-gray; silty near base |
| 37-57 | Siltstone, light-gray; interbedded claystone at base |
| 57-60 | Lignite, black; (Lower Timber Coulee lignite bed) |
| 60-63 | Claystone, brownish-gray |
| 63-66 | Lignite, black; (Lower Timber Coulee lignite bed) |
| 66-85 | Sandstone, greenish-gray, very fine grained; interbedded claystone near middle of interval |
| 85-111 | Claystone, greenish-gray, silty |
| 111-115 | Lignite, impure; (Timber Coulee Leader lignite bed) |
| 115-125 | Siltstone, greenish-gray, sandy; coal from 124 to 125 ft |
| 125-155 | Siltstone, greenish-gray; grades to claystone at top and base of interval |
| 155-178 | Sandstone, greenish-gray, very fine grained; grades to claystone near base |
| 178-181 | Sandstone, greenish-gray, very fine grained |
| 181-212 | Claystone, greenish-gray; (Smoke Creek lignite bed 189 to 190 ft) |
| 212-215 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 215-246 | Siltstone, greenish-gray, sandy; with interbedded claystone |
| 246-265 | Claystone, light-gray, silty; traces of coal near middle of interval |
| 265-280 | Claystone, greenish-gray |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 280-281 | Lignite, black |
| 281-300 | Claystone, light-greenish-gray; grades silty near base |
| 300-330 | Sandstone, greenish-gray; argillaceous near middle of interval; traces of coal near top of interval |
| 330-373 | Siltstone, greenish-gray; thin calcareous sandstone concretions near top of interval |
| 373-405 | Claystone, medium-gray to greenish-gray, silty |
| 405-418 | Siltstone, medium-gray; claystone parting 410 to 415 ft |
| 418-456 | Claystone, medium-gray, silty |
| 456-459 | Lignite, black |
| 459-463 | Claystone |
| 463-466 | Lignite, black |
| 466-480 | Sandstone, light-gray, very fine grained; interbedded claystone at top of interval |
| 480-518 | Claystone, medium-gray; grades silty toward top of interval; coal 507 to 509 ft |
| 518-527 | Siltstone, light-gray |
| 527-544 | Claystone, light-gray; several coal fragments |
| 544-553 | Sandstone, light-gray, very fine grained |
| 553-576 | Claystone, dark-gray |
| | Total depth 576 ft |

Hole No: GS-35 Date: 8-13-79 State: Montana County: Roosevelt
 Sec. NW NE 16 T. 32 N. R. 52 E. Elevation: 2420 ft Total Depth: 576 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 4 , Range 50 cps Density: TC 2 ,
 Range 10,000 cps Resistance: 10 ohms/in Caliper: Horizontal scale N/A in/in

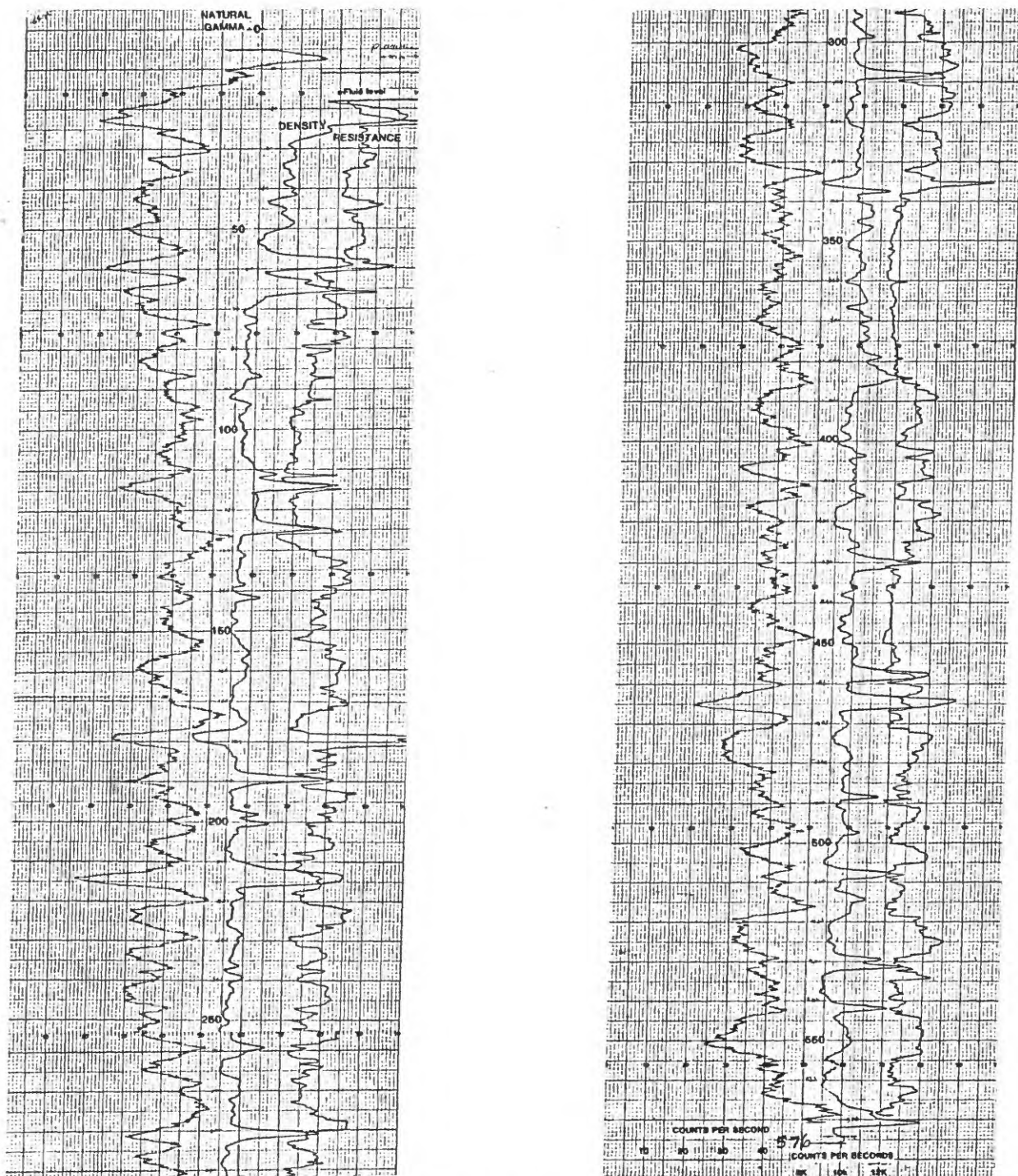


Figure 36.--Geophysical logs of hole GS-35

Sample log

Hole no.: GS-36 Date: 7-22-79 State: Montana County: Roosevelt
 Elev. (ground): 2530 ft Location: T. 31 N., R. 52 E., Sec. NE SE 18
 Total depth: 440 ft Drilling medium: air Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-16 | Silt, sand, and gravel, light-olive-gray, unconsolidated |
| 16-28 | Siltstone, grayish-yellow to yellowish-gray, very sandy |
| 28-39 | Siltstone, light-olive-brown; grades to grayish-black carbonaceous shale at base |
| 39-43 | Lignite, black; (Smoke Creek lignite bed) |
| 43-55 | Claystone, light-olive-gray |
| 55-63 | Siltstone, dark-yellowish-brown to light-olive-gray; grades to claystone at base |
| 63-68 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 68-105 | Claystone, light-olive-gray to medium-light-gray, sandy; with interbedded sandy siltstone |
| 105-150 | Siltstone, olive-gray to medium-blue to light-olive-gray; with interbedded claystone; calcareous concretion from 136 to 138 ft |
| 150-196 | Sandstone, light-olive-gray, very fine grained |
| 196-207 | Claystone, olive-gray to light-olive-gray |
| 207-220 | Sandstone, light-olive-gray, very fine grained, silty |
| 220-261 | Siltstone, light-olive-gray, sandy; traces of coal near top of interval |
| 261-269 | Sandstone, light-bluish-gray |
| 269-303 | Siltstone, olive-gray; with traces of coal near base |
| 303-344 | Claystone, light-olive-gray; grades sandy at top of interval |
| 344-376 | Siltstone, light-bluish-gray; traces of coal at top and base of interval; grades sandy at base |
| 376-394 | Claystone, light-olive-gray to pale-olive-gray; abundant coal fragments scattered throughout interval; includes sandstone between 380 and 384 ft |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 394-415 | Sandstone, light-olive-gray to dark-yellowish-orange; scattered coal fragments |
| 415-426 | Siltstone, light-olive-gray; scattered coal fragments |
| 426-440 | Claystone, light-olive-gray, silty |
| | Total depth 440 ft |

Hole No: GS-36 Date: 7-22-79 State: Montana County: Roosevelt
 Sec. NE SE 18 T. 31 N. R. 52 E. Elevation: 2530 ft Total Depth: 440 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 4 , Range 50 cps Density: TC 1 ,
 Range 20,000 cps Resistance: N/A ohms/in Caliper: Horizontal scale N/A in/in

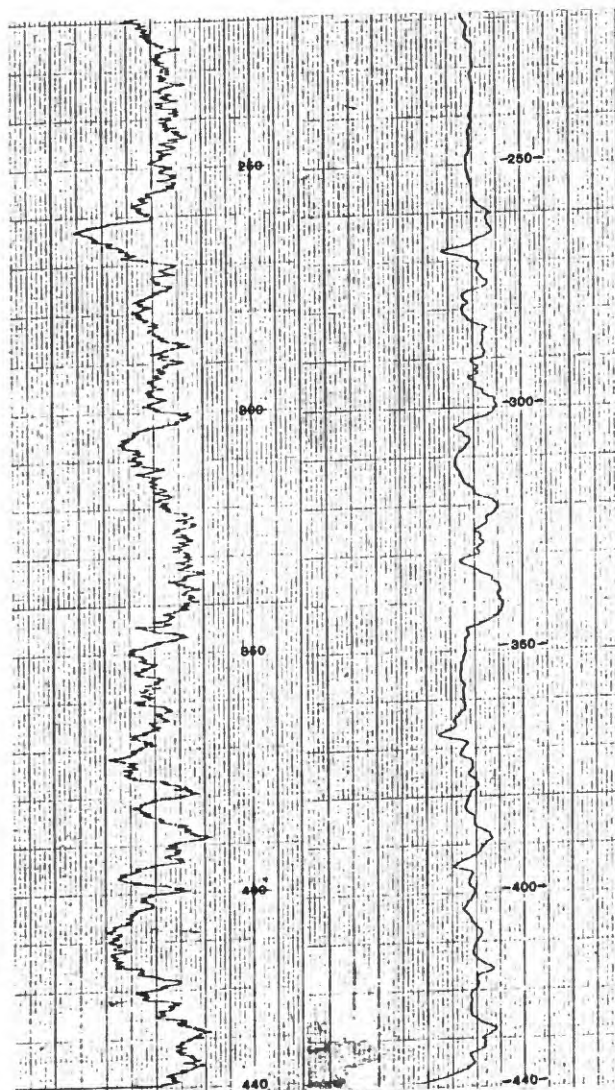
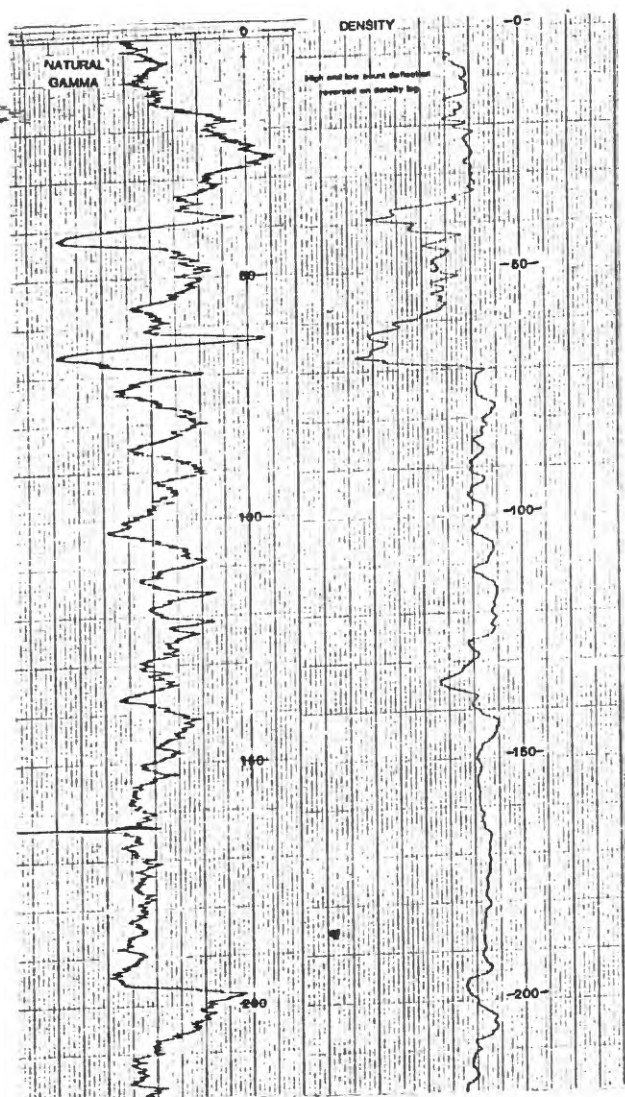


Figure 37.--Geophysical logs of hole GS-36

Sample log

Hole no.: GS-37 Date: 7-29-79 State: Montana County: Roosevelt
 Elev. (ground): 2480 ft Location: T. 32 N., R. 51 E., Sec. NW NE 9
 Total depth: 446 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-16 | Gravel and sand, brownish-gray to yellowish-gray, unconsolidated |
| 16-37 | Claystone, medium-gray to light-gray, silty; sandy at base; minor coal fragments |
| 37-52 | Siltstone, light-gray; grades to claystone at top of interval |
| 52-71 | Sandstone, light-gray to light-bluish-gray, very fine grained; probable coal 54 to 56 ft |
| 71-82 | Siltstone, light-gray to light-bluish-gray |
| 82-85 | Lignite, black; ("BC" lignite bed) |
| 85-96 | Claystone, light-gray |
| 96-128 | Siltstone, light-gray to very light gray; sandy at top and base of interval |
| 128-150 | Claystone, light-gray; with interbedded carbonaceous claystone; ("B" lignite bed 142 to 143 ft) |
| 150-169 | Siltstone, medium-gray, very sandy |
| 169-171 | Lignite, black |
| 171-179 | Siltstone, light-to medium-gray; minor coal fragments; grades to claystone at top |
| 179-197 | Siltstone, light-gray, sandy; traces of coal near top of interval |
| 197-265 | Sandstone, bluish-gray to light-gray, very fine grained; traces of coal near base; traces of coal and carbonaceous shale near top of interval |
| 265-273 | Claystone, bluish-gray; coal from 265 to 266 ft and 269 to 270 ft |
| 273-278 | Lignite, impure |
| 278-302 | Claystone, light-gray to medium-gray |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|--|
| 302-304 | Lignite, black; ("AB" lignite bed) |
| 304-328 | Claystone, brownish-gray; grades silty near top of interval |
| 328-330 | Lignite, black |
| 330-362 | Siltstone, light-gray, sandy; traces of carbonaceous shale and coal at base |
| 362-380 | Claystone, light-gray; sandstone parting 367 to 370 ft; ("AA" lignite bed 370 to 371 ft) |
| 380-408 | Siltstone, light-gray to medium-gray |
| 408-425 | Sandstone, medium-gray, very fine grained |
| 425-446 | Claystone, medium-gray to brownish-gray; sandy near middle of interval; minor coal fragments |
| Total depth 446 ft | |

Hole No: GS-37 Date: 7-29-79 State: Montana County: Roosevelt
 Sec. NW NE 9 T. 32 N. R. 51 E. Elevation: 2480 ft Total Depth: 446 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 4 , Range 50 cps Density: TC 2 ,
 Range 10,000 cps Resistance: 20 ohms/in Caliper: Horizontal scale N/A in/in

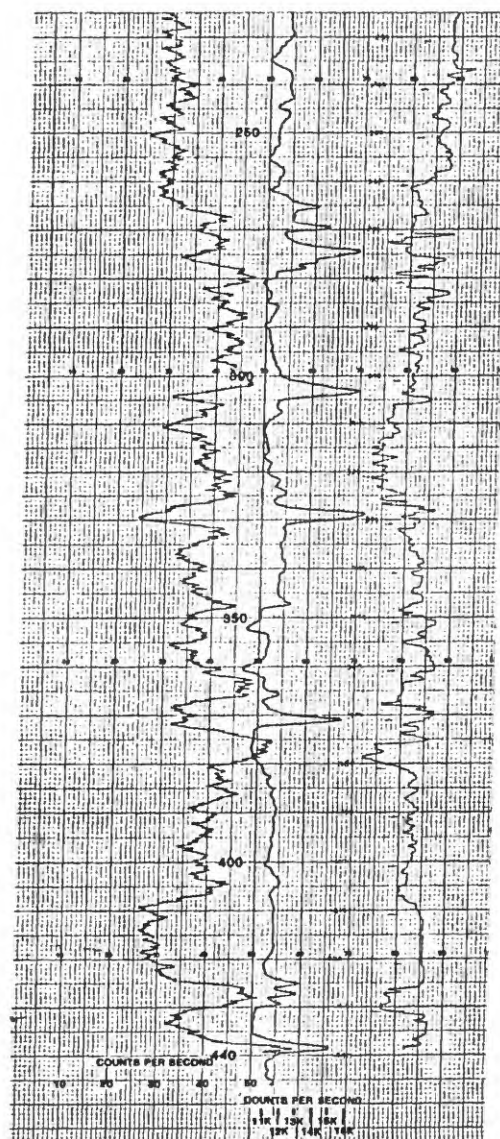
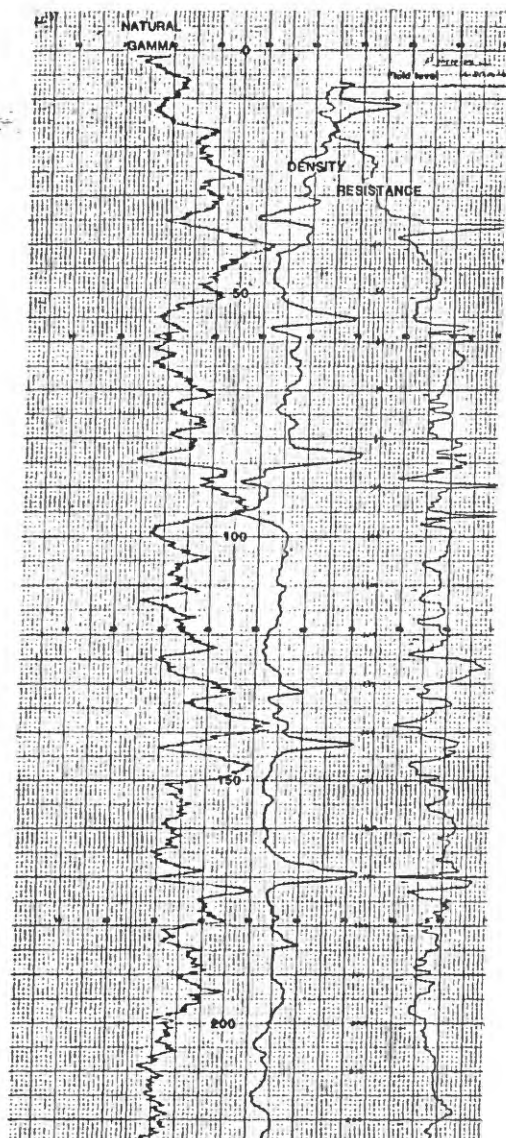


Figure 38.--Geophysical logs of hole GS-37

Sample log

Hole no.: GS-38 Date: 7-28-79 State: Montana County: Roosevelt
 Elev. (ground): 2635 ft Location: T. 32 N., R. 50 E., Sec. NW NW 12
 Total depth: 440 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-18 | Gravel, unconsolidated |
| 18-58 | Silt, sand, and gravel, yellowish-gray, unconsolidated |
| 58-89 | Siltstone, light-gray to light-olive-gray; with thin interbedded claystone; grades argillaceous at top and base of interval |
| 89-92 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 92-111 | Siltstone, light-gray to light-olive-gray, sandy; interbedded claystone at top of interval; minor coal fragments |
| 111-127 | Claystone, light-gray to light-olive-gray, silty |
| 127-129 | Limestone, light-gray |
| 129-142 | Siltstone, light-to medium-gray; grades to claystone at top and base of interval |
| 142-149 | Sandstone, light-gray, medium-to fine-grained |
| 149-155 | Siltstone, light-gray; traces of carbonaceous shale and coal |
| 155-158 | Lignite, black; ("BC" lignite bed) |
| 158-185 | Siltstone, light-gray; with thin interbedded carbonaceous shale |
| 185-196 | Claystone, light-gray, silty |
| 196-215 | Siltstone, light-gray; grades to claystone at top and base of interval |
| 215-232 | Sandstone, light-gray |
| 232-242 | Claystone, light-gray; organic debris scattered throughout interval |
| 242-262 | Siltstone, light-gray, slightly sandy |
| 262-274 | Sandstone, light-gray, very fine grained; several coal fragments |
| 274-295 | Siltstone, light-gray; grades to claystone near top of interval |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 295-298 | Lignite, black, impure |
| 298-313 | Claystone, light-gray, silty |
| 313-327 | Siltstone, light-gray ; grades to claystone at base |
| 327-353 | Siltstone, light-gray to very light gray, sandy; interbedded sandstone at top of interval; probable coal bed 345 to 346 ft |
| 353-366 | Claystone, light-olive-gray, micaceous; grades silty at top of interval; ("AB" lignite bed 363 to 364 ft) |
| 366-370 | Lignite, black; ("AB" lignite bed) |
| 370-388 | Siltstone, olive-gray; grades to claystone at top of interval; coal from 372 to 373 ft |
| 388-390 | Lignite, black |
| 390-406 | Sandstone, light-gray to medium-gray; coal from 395 to 396 ft |
| 406-428 | Siltstone, light-gray to medium-gray; minor coal fragments |
| 428-440 | Claystone, light-gray to medium-gray, silty |
| | Total depth 440 ft |

Hole No: GS-38 Date: 7-28-79 State: Montana County: Roosevelt
 Sec. NW NW 12 T. 32 N. R. 50 E. Elevation: 2635 ft Total Depth: 440 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 4 , Range 50 cps Density: TC 1 ,
 Range 20,000 cps Resistance: N/A ohms/in Caliper: Horizontal scale N/A in/in

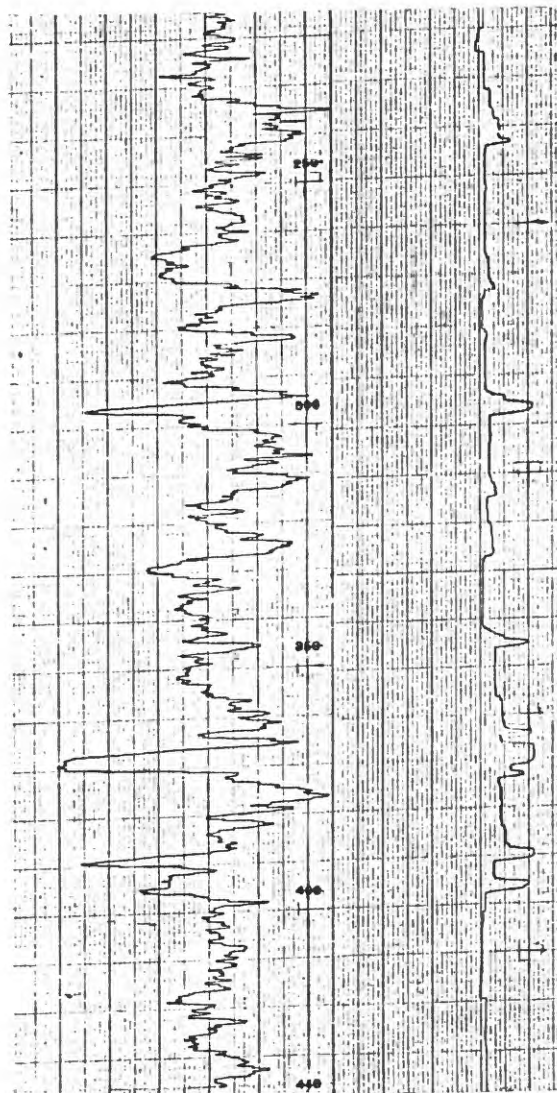
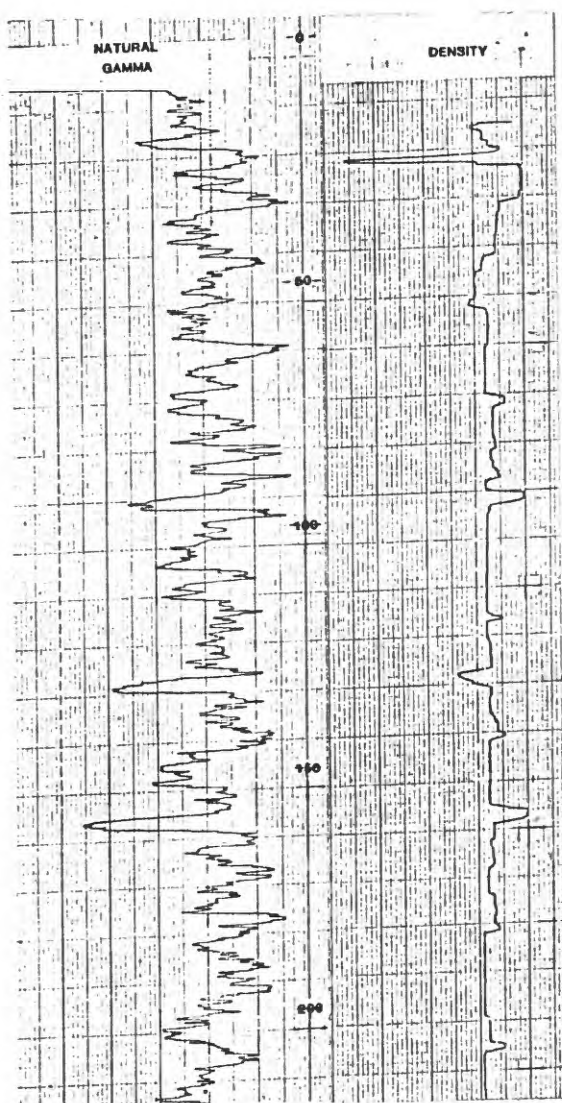


Figure 39.--Geophysical logs of hole GS-38

Sample log

Hole no.: GS-39 Date: 8-8-79 State: Montana County: Daniels
 Elev. (ground): 2680 ft 'Location: T. 33 N., R. 50 E., Sec. SE SE 19
 Total depth: 560 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-24 | Sand, gravel, and clay, light-olive-gray, unconsolidated |
| 24-34 | Gravel, unconsolidated |
| 34-56 | Sandstone, yellowish-brown, very fine grained, silty |
| 56-68 | Claystone, olive-gray, silty |
| 68-113 | Siltstone, light-olive-gray to olive-gray, argillaceous; probable coal from 94 ft to 96 ft |
| 113-133 | Sandstone, olive-gray, very fine grained; interbedded claystone 113 ft to 119 ft and 126 ft to 129 ft |
| 133-177 | Claystone, light-gray to medium-gray, some thinly interbedded siltstone; (Lower Smoke Creek lignite bed 150 to 152 ft) |
| 177-200 | Siltstone, light-gray; grades sandy near base; coal bed 191 ft to 192 ft |
| 200-202 | Lignite, black; ("BC" lignite bed) |
| 202-244 | Claystone, light-to greenish-gray; grades silty near base; probable coal beds 204 ft to 205 ft and 215 ft to 216 ft |
| 244-277 | Sandstone, yellowish-brown, very fine grained; probable coal bed 262 ft to 263 ft |
| 277-280 | Lignite, black, impure; ("B" lignite bed) |
| 280-293 | Claystone, greenish-gray to olive-gray |
| 293-315 | Siltstone, greenish-gray; coal bed 306 to 307 ft |
| 315-330 | Claystone, medium-gray |
| 330-353 | Siltstone, light-gray to medium-gray; probable coal bed 336 ft to 338 ft |
| 353-362 | Claystone, light-gray to medium-gray |
| 362-387 | Sandstone, light-gray, very fine grained |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 387-415 | Claystone, medium-gray; includes coal from from 408 to 409 ft |
| 415-418 | Lignite, black; ("AB" lignite bed) |
| 418-438 | Claystone, greenish-gray to olive-gray; grades silty at top and base of interval |
| 438-477 | Siltstone, olive-gray; probable coal beds 441 ft to 442 ft and 467 ft to 469 ft |
| 477-483 | Lignite, black; ("AA" lignite bed) |
| 483-509 | Claystone, greenish-gray to light-gray; abundant coal fragments |
| 509-560 | Claystone, light-gray, silty; several thin coal beds (less than 2 ft thick) in upper half of interval |
| | Total depth 560 ft |

Hole No: GS-39 Date: 8-8-79 State: Montana County: Daniels
 Sec. SE SE 19 T. 33 N. R. 50 E. Elevation: 2680 ft Total Depth: 560 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 4 , Range 50 cps Density: TC 2 ,
 Range 10,000 cps Resistance: 20 ohms/in Caliper: Horizontal scale N/A in/in

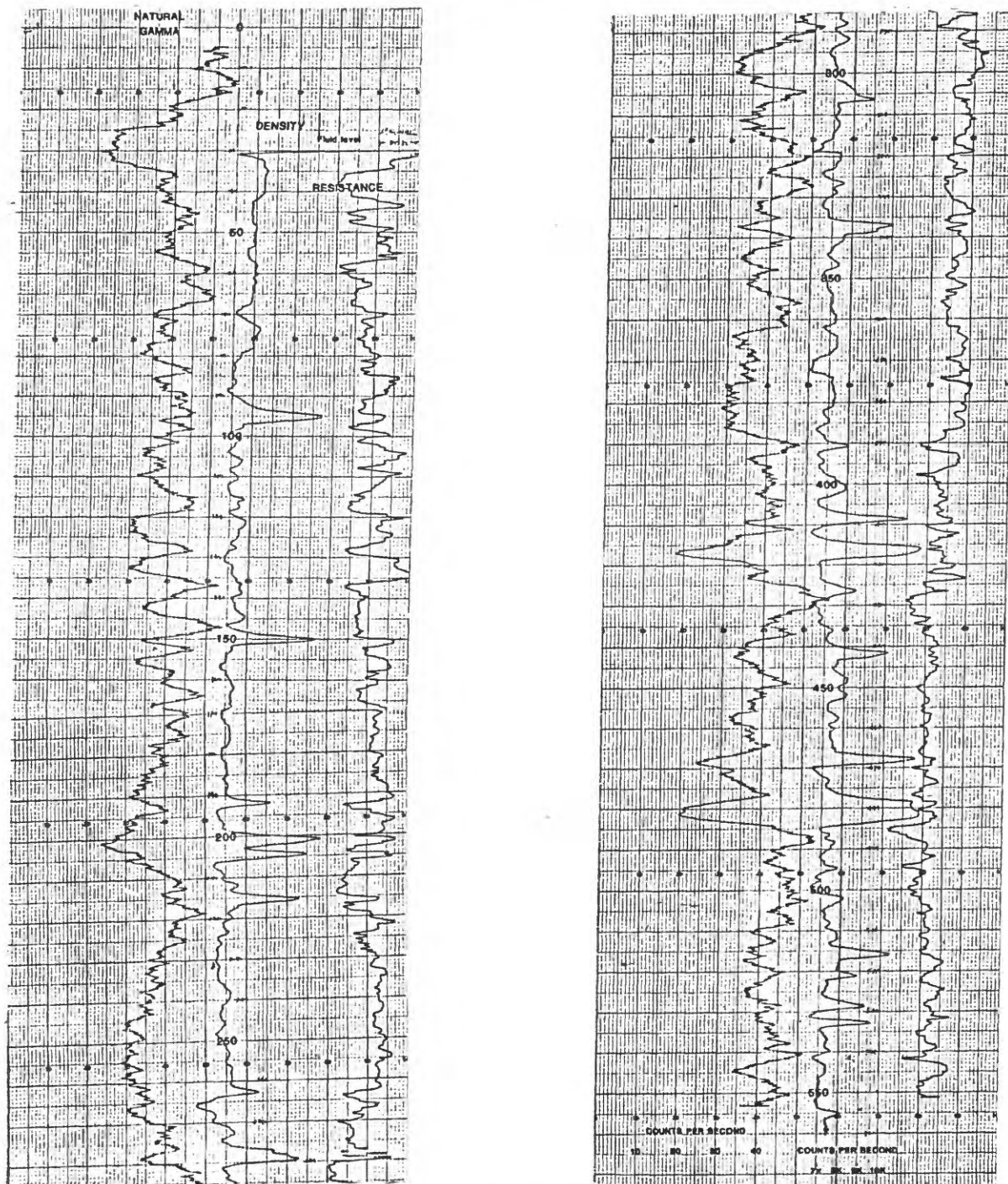


Figure 40.--Geophysical logs of hole GS-39

Sample log

Hole no.: GS-40 Date: 8-29-79 State: Montana County: Sheridan

Elev. (ground): 2210 ft Location: T. 33 N., R. 54 E., Sec. NW NW 36

Total depth: 500 ft Drilling medium: mud Offset core hole: GS-40C

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-16 | Sand, clay, and gravel, olive-gray, unconsolidated |
| 16-44 | Siltstone, olive-gray to greenish-gray to yellowish-gray, sandy; includes some interbedded claystone |
| 44-46 | Lignite, black |
| 46-76 | Siltstone, olive-gray to medium-light-gray; with interbedded claystone |
| 76-102 | Sandstone, light-gray, very fine grained, silty |
| 102-113.6 | Claystone, light-olive-gray, silty; grades to carbonaceous shale at base |
| 113.6-116 | Lignite, see sample description D221139; (Timber Coulee Rider lignite bed) |
| 116-119.6 | Claystone, light-olive-gray; grades carbonaceous at base |
| 119.6-132 | Lignite; claystone parting 130 to 130.7 ft; see sample description D221140; (Upper Timber Coulee lignite bed) |
| 132-144.2 | Claystone, light-olive-gray; grades to very fine grained sandstone at base |
| 144.2-147.9 | Lignite, see sample description D221141; (Lower Timber Coulee lignite bed) |
| 147.9-163 | Claystone, olive-gray, silty; grades carbonaceous at top of interval |
| 163-209 | Siltstone, light-olive-gray to greenish-gray, sandy; with interbedded claystone; traces of coal near top of interval |
| 209-255 | Sandstone; (Reserve lignite bed 236 to 237 ft) |
| 255-275 | Sandstone, light-gray to olive-gray, very fine grained; probable calcareous sandstone concretion 254 to 256 ft |
| 275-299 | Siltstone, olive-gray to brownish-gray; traces of coal at top and base of interval |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 299-317 | Sandstone, olive-gray, very fine grained; grades argillaceous near base; probable calcareous sandstone concretion 307 to 309 ft |
| 317-362 | Claystone, olive-gray, silty; grades sandy near base |
| 362-366 | Lignite, black, impure; ("BC" lignite bed) |
| 366-404 | Claystone, olive-gray, silty; with interbedded siltstone |
| 404-420 | Sandstone, light-gray, silty |
| 420-458 | Siltstone, medium-gray to olive-gray, sandy |
| 458-500 | Sandstone, medium-gray to olive-gray; traces of coal at top of interval; ("B" lignite bed 465 to 466 ft) |
| | Total depth 500 ft |

Hole No: GS-40 Date: 8-29-79 State: Montana County: Sheridan
 Sec. NW NW 36 T. 33 N. R. 54 E. Elevation: 2210 ft Total Depth: 500 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 2, Range 10 cps Density: TC 2,
 Range 200 cps Resistance: 5 ohms/in Caliper: Horizontal scale 2 in/in

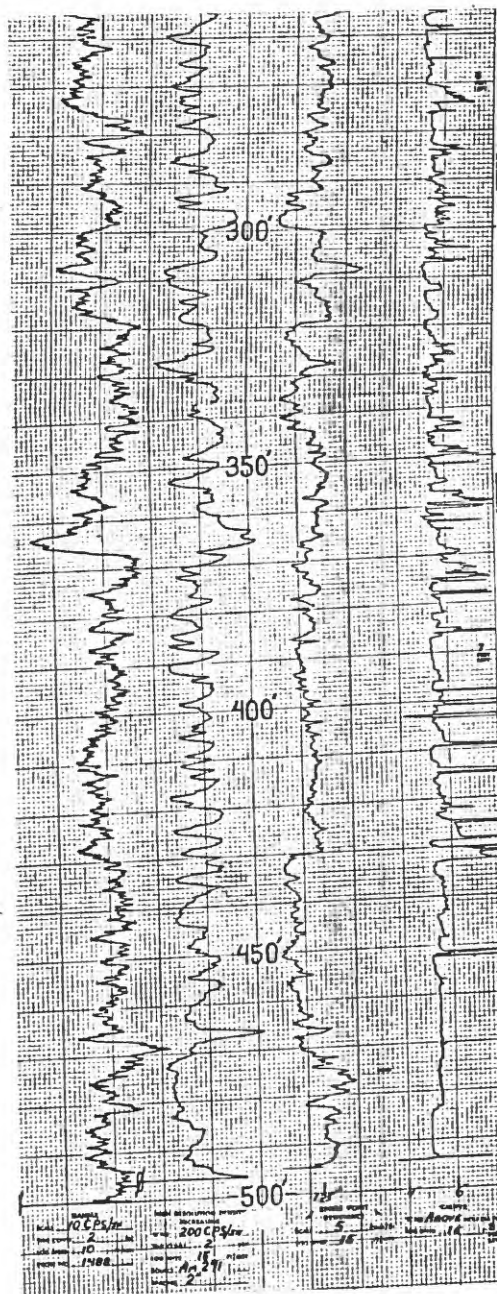
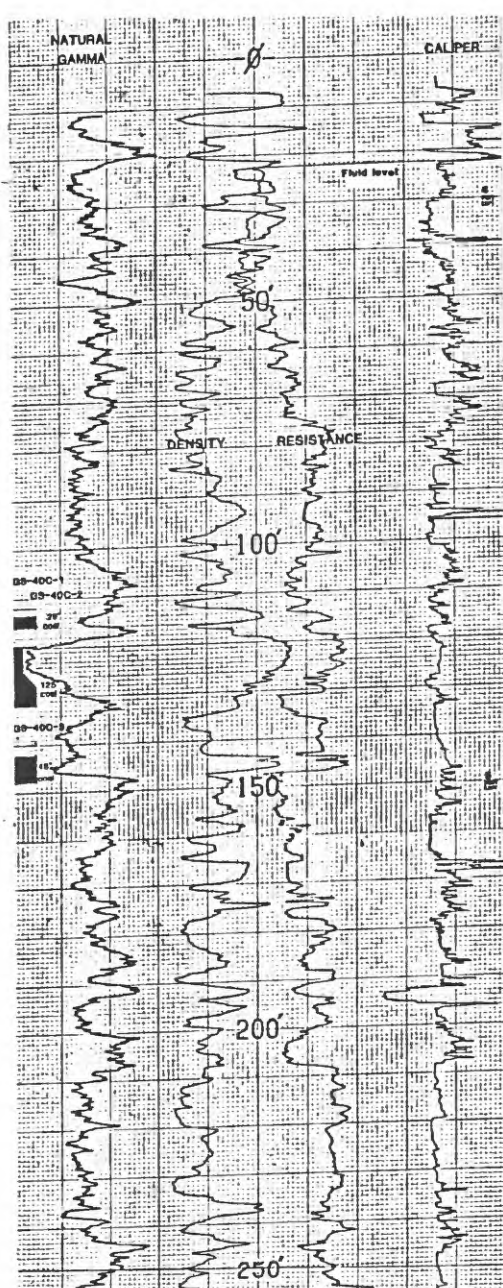


Figure 41.--Geophysical logs of hole GS-40

Sample log

Hole no.: GS-41 Date: 8-14-79 State: Montana County: Sheridan
 Elev. (ground): 2430 ft Location: T. 33 N., R. 53 E., Sec. SW SW 33
 Total depth: 580 ft Drilling medium: mud Offset core hole: GS-41C

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-17 | Sand and clay, yellowish-brown; unconsolidated |
| 17-37 | Sandstone, greenish-gray to yellowish-brown, very fine grained |
| 37-48 | Claystone, greenish-gray; pyritic at base |
| 48-51.3 | Lignite, see sample description D221142; (Local "R" lignite bed) |
| 51.3-69 | Claystone, light-gray to greenish-gray, very silty |
| 69-71 | Lignite, black |
| 71-100 | Claystone, light-gray to greenish-gray, very silty |
| 100-121 | Claystone, greenish-gray; coal bed 109 to 110 ft |
| 121-133 | Siltstone, greenish-gray; probable coal bed 129 to 130 ft |
| 133-135 | Lignite, black; (Timber Coulee Rider lignite bed) |
| 135-161.3 | Claystone, greenish-gray; with interbedded siltstone; grades to carbonaceous claystone at base |
| 161.3-169.7 | Lignite, see sample description D221143; (Upper Timber Coulee lignite bed) |
| 169.7-170.5 | Claystone, medium-gray, rooted |
| 170.5-175.3 | Lignite, claystone parting 172.8 to 173.2 ft; see sample description D221144; (Lower Timber Coulee lignite bed) |
| 175.3-187 | Sandstone, greenish-gray; dark-gray interbedded claystone at top of interval |
| 187-201 | Claystone, greenish-gray |
| 201-215 | Siltstone, greenish-gray; thin interbedded claystone at base |
| 215-218 | Lignite, black; (Timber Coulee Leader lignite bed) |
| 218-231 | Claystone, light-gray to greenish-gray; silty at top |
| 231-238 | Sandstone, greenish-gray, very fine grained |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|--|
| 238-279 | Sandstone, light-gray to greenish-gray, very fine grained; grades to siltstone at top; scattered interbedded siltstone |
| 279-298 | Claystone, greenish-gray |
| 298-329 | Sandstone, greenish-gray, very fine grained; interbedded claystone near top of interval; coal bed 306 to 307 ft |
| 329-339 | Claystone, greenish-gray |
| 339-343 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 343-378 | Sandstone, medium-gray, very fine grained |
| 378-417 | Claystone, medium-gray, silty; probable coal bed 387 to 389 ft |
| 417-442 | Sandstone, moderate-brown to greenish-gray, very fine grained; grades silty near top of interval |
| 442-506 | Claystone, greenish-gray; with interbedded siltstone; scattered coal fragments |
| 506-515 | Sandstone, light-to medium-gray |
| 515-517 | Lignite, black |
| 517-528 | Sandstone, light-to medium-gray |
| 528-543 | Claystone, light-to medium-gray; scattered coal fragments |
| 543-553 | Sandstone, light-to medium-gray |
| 553-580 | Claystone, greenish-gray, silty |
| Total depth 580 ft | |

Hole No: GS-41 Date: 8-14-79 State: Montana County: Sheridan
 Sec. SW SW 33 T. 33 N. R. 53 E. Elevation: 2430 ft Total Depth: 580 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 4 , Range 50 cps Density: TC 2 ,
 Range 10,000 cps Resistance: 10 ohms/in Caliper: Horizontal scale N/A in/in

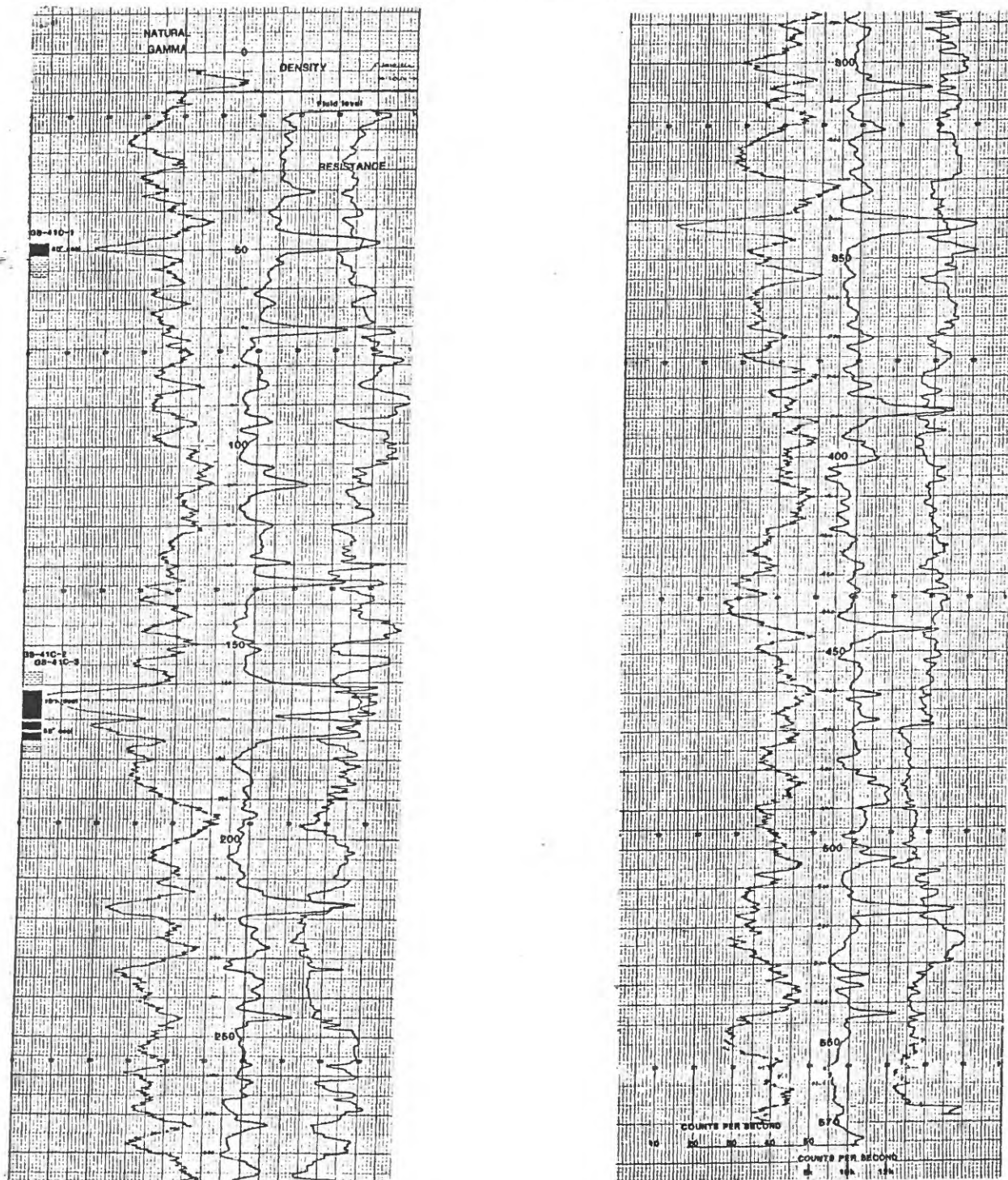


Figure 42.--Geophysical logs of hole GS-41

Sample log

Hole no.: GS-42 Date: 8-23-79 State: Montana County: Sheridan

Elev. (ground): 2160 ft Location: T. 32 N., R. 54 E., Sec. SE NE 22

Total depth: 400 ft Drilling medium: mud Offset core hole: GS-42C

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-11 | Sand, clay, and gravel, brownish-gray, unconsolidated |
| 11-28.7 | Sandstone, medium-yellow to dark-yellowish-orange, very fine grained; grades to silty carbonaceous claystone at base |
| 28.7-39.5 | Lignite; claystone parting 37 to 37.4 ft; see sample description D221145; (Timber Coulee lignite bed) |
| 39.5-60 | Siltstone, light-gray to medium-dark-gray |
| 60-61.5 | Lignite, black; (Timber Coulee Leader lignite bed) |
| 61.5-80 | Siltstone, medium-bluish-gray, sandy; grades to claystone at top |
| 80-94 | Siltstone, dark-greenish-gray to greenish-gray; scattered coal fragments |
| 94-110 | Siltstone, light-gray to medium-light-gray; carbonaceous at base |
| 110-128 | Sandstone, light-gray to medium-light-gray |
| 128-165 | Siltstone, light-gray to medium-light-gray to olive-gray; carbonaceous at top of interval; concretion 149 to 154 ft |
| 165-187 | Siltstone, light-gray to medium-dark-gray to greenish-gray, sandy, micaceous; with traces of organic debris; traces of coal near top of interval; calcareous sandstone concretion 181 to 187 ft |
| 187-197 | Claystone, olive-gray to light-olive-gray, silty, slightly carbonaceous |
| 197-209 | Siltstone, medium-gray to medium-bluish-gray, sandy, micaceous; carbonaceous at base |
| 209-213 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 213-262 | Siltstone, greenish-gray to medium-light-gray to olive-gray, micaceous; traces of coal at middle of interval |
| 262-315 | Sandstone, olive-gray to medium-gray; scattered thinly interbedded siltstone and carbonaceous claystone; includes coal from 274 to 275 ft |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 315-366 | Siltstone, olive-gray to light-gray to greenish-gray; traces of organic debris scattered throughout interval; coal bed 362 to 363 ft |
| 366-400 | Siltstone, light-olive-gray to medium-light-gray; thin interbedded claystone |
| | Total depth 400 ft |

Hole No: GS-42 Date: 8-23-79 State: Montana County: Sheridan
 Sec. SE NE 22 T. 32 N. R. 54 E. Elevation: 2160 ft Total Depth: 400 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 2, Range 10 cps Density: TC 2,
 Range 200 cps Resistance: 10 ohms/in Caliper: Horizontal scale 2 in/in

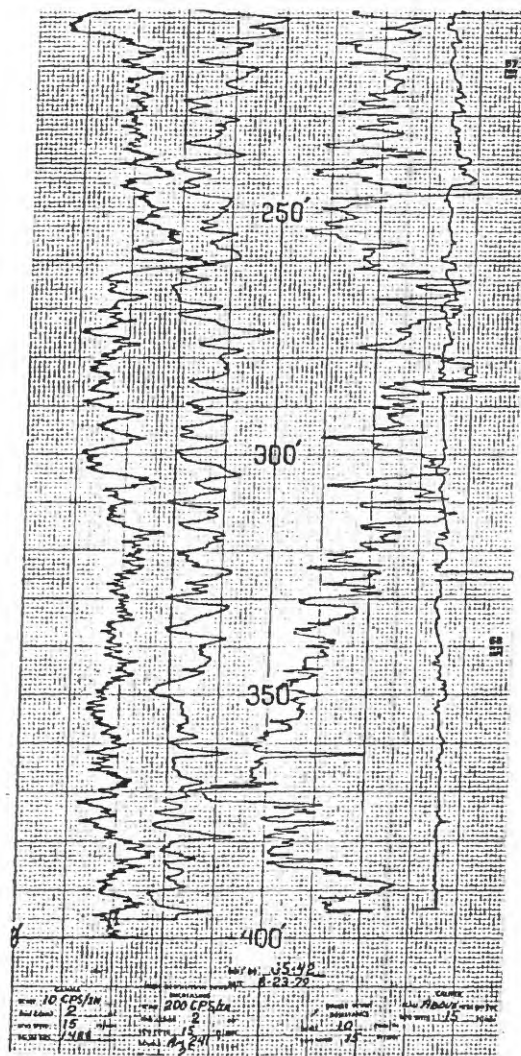
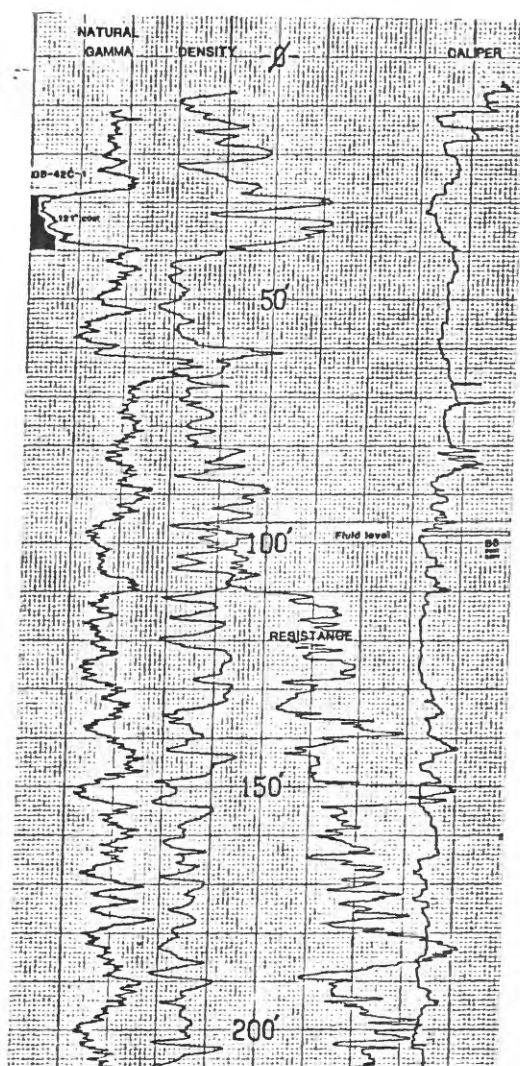


Figure 43.--Geophysical logs of hole GS-42

Sample log

Hole no.: GS-43 Date: 8-21-79 State: Montana County: Roosevelt
 Elev. (ground): 2395 ft Location: T. 31 N., R. 53 E., Sec. NW NW 1
 Total depth: 525 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-13 | Sand, silt, and clay, olive-gray, unconsolidated; includes sparse scattered pebbles of quartz, quartzite, granite, and dolomite |
| 13-110 | Sandstone and siltstone, medium-to light-gray, very fine grained sandstone thinly interbedded with light-olive-gray to medium-gray siltstone |
| 110-115 | Claystone, grayish-black, carbonaceous |
| 115-127 | Claystone and siltstone, medium-light-gray; carbonaceous in lower part |
| 127-131 | Lignite, grayish-black to brownish-black; somewhat impure in lower 2 ft; (Lower Timber Coulee lignite bed) |
| 131-148 | Siltstone and claystone, chiefly medium-light-gray siltstone interbedded with medium-bluish-gray carbonaceous claystone in upper and middle parts of interval |
| 148-159 | Sandstone and siltstone, light-to medium-dark-gray |
| 159-167 | Claystone and siltstone, medium-dark-gray to light-olive-gray |
| 167-168.5 | Lignite, grayish-black; (Timber Coulee Leader lignite bed) |
| 168.5-189 | Siltstone, medium-dark-gray |
| 189-239 | Sandstone, medium-light-gray to medium-bluish-gray, very fine grained, silty, finely micaceous |
| 239-268 | Siltstone and claystone, light-to medium-light-gray; scattered thin carbonaceous lamina |
| 268-278.5 | Sandstone and siltstone, light-to medium-light-gray; sandy at top and base, silty in middle part |
| 278.5-280 | Lignite, grayish-black; (Smoke Creek lignite bed) |
| 280-320 | Siltstone, light-to medium-light-gray; includes some thinly interbedded brownish-gray carbonaceous claystone in upper part; grades downward to very fine grained sandstone in lower part |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|---|
| 320-328 | Claystone, medium-light-gray to brownish-gray; slightly carbonaceous in lower part |
| 328-332 | Lignite, grayish-black to brownish-gray; grades impure in lower 2 ft; (Lower Smoke Creek lignite bed) |
| 332-334 | Claystone, medium-light-gray to brownish-gray; carbonaceous |
| 334-370 | Siltstone, very light gray to medium-light-gray; includes some thinly interbedded medium-bluish-gray claystone; locally sandy; hard, dense calcareous sandstone concretion at 359 ft |
| 370-453 | Sandstone and siltstone, light-gray very fine grained sandstone, medium-light-gray to light-olive-gray siltstone; alternating sandy and silty sequences; calcareous sandstone concretion at 384 ft; thin coal at 417 ft |
| 453-472 | Siltstone and claystone, brownish-gray carbonaceous claystone predominates in upper part of interval, medium-light-gray siltstone in middle and lower parts |
| 472-498 | Sandstone and siltstone; chiefly medium-light-gray very fine grained sandstone with some thinly interbedded greenish-gray siltstone; calcareous sandstone concretion at 495 ft |
| 498-525 | Siltstone, dark-greenish-gray to medium-gray, locally sandy; includes some thinly interbedded claystone at 510 and 515 ft; calcareous sandstone concretion at 523 ft |
| Total depth 525 ft | |

Hole No: GS-43 Date: 8-21-79 State: Montana County: Roosevelt
 Sec. NW NW 1 T. 31 N. R. 53 E. Elevation: 2395 ft Total Depth: 525 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 2, Range 10 cps Density: TC 2,
 Range 200 cps Resistance: 10 ohms/in Caliper: Horizontal scale 2 in/in

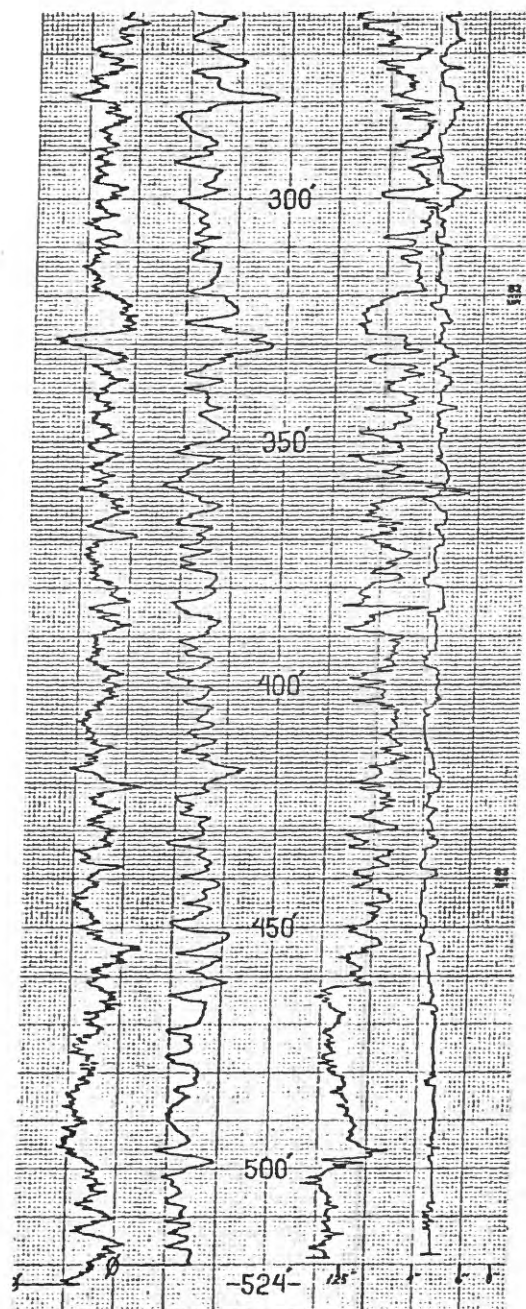
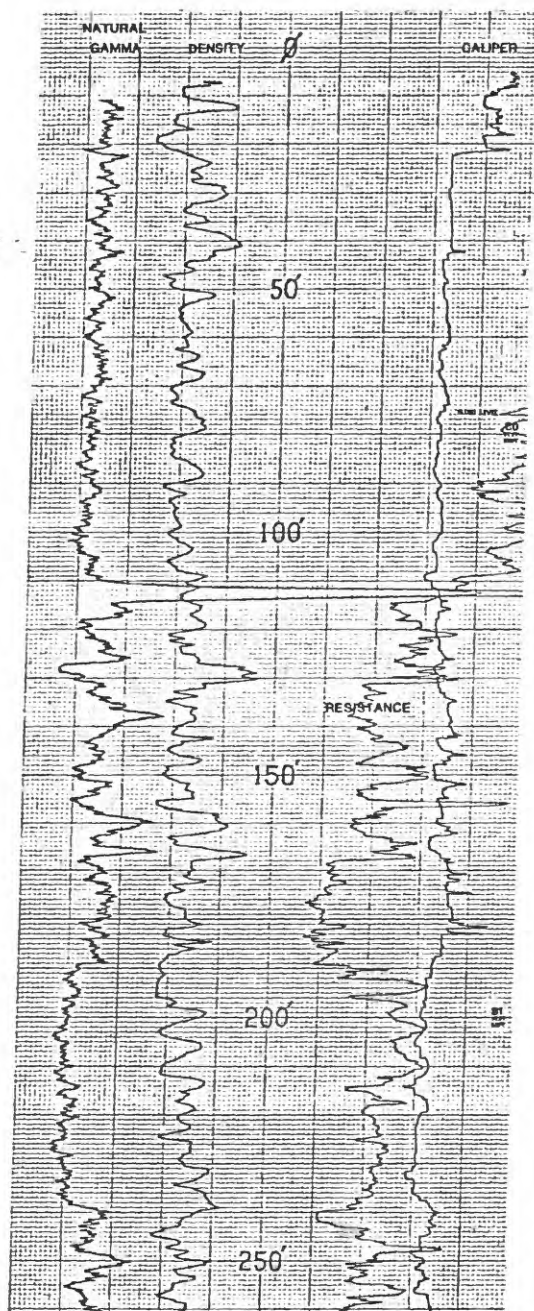


Figure 44.--Geophysical logs of hole GS-43

Sample log

Hole no.: GS-44 Date: 8/8/79 State: Montana County: Roosevelt
 Elev. (ground): 2221 ft Location: T. 30 N., R. 53 E., Sec. NE NE 5
 Total depth: 560 ft Drilling medium: mud Offset core hole: GS-44C

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-9 | Sand, silt, and clay, yellowish-gray to dusky-yellow, unconsolidated |
| 9-28 | Siltstone, medium-light-gray to yellowish-gray; includes some interbedded dark-gray carbonaceous claystone between 15 and 19 ft; grades to very fine grained sandstone at base of interval |
| 28-42 | Claystone, medium-light-gray to olive-gray; scattered thin carbonaceous lamina; impure coal and silty carbonaceous shale between 32 and 34 ft |
| 42-52 | Siltstone, medium-light-gray to brownish-gray, scattered thin carbonaceous lamina; grades to very fine grained sandstone at base of interval |
| 52-57 | Claystone, olive-gray to brownish-gray, silty, carbonaceous |
| 57-58.5 | Lignite, brownish-black, impure; ("C" lignite bed) |
| 58.5-77 | Claystone, medium-gray to medium-dark-gray, slightly silty, slightly carbonaceous |
| 77-88.5 | Siltstone and sandstone, medium-gray siltstone in upper part grading downward to light-gray very fine grained sandstone in lower part |
| 88.5-90.5 | Lignite, grayish-black to brownish-black, slightly impure |
| 90.5-97 | Claystone, greenish-gray to very light gray |
| 97-111 | Siltstone, greenish-gray to medium-light-gray, sandy |
| 111-121.5 | Claystone, medium-gray, carbonaceous, very silty |
| 121.5-130 | Lignite, grayish-black; see core sample D221138; (Smoke Creek lignite bed) |
| 130-139 | Siltstone, medium-gray |
| 139-178.5 | Claystone and siltstone, light-gray to brownish-gray and greenish-gray; thinly interbedded alternating sequences of claystone and siltstone; scattered thin carbonaceous lamina; calcareous siltstone concretion at 170 ft |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 178.5-180.5 | Lignite, grayish-black; (Lower Smoke Creek lignite bed) |
| 180.5-185 | Claystone, medium-light-gray to brownish-gray |
| 185-215 | Siltstone and claystone, light-gray to greenish-gray; alternating sequences of siltstone and claystone; calcareous siltstone concretions at 196 and 212 ft |
| 215-245 | Sandstone, light-gray, very fine to medium-grained |
| 245-260 | Claystone, medium-light-gray to greenish-gray; includes thin impure coal at 253 ft; grades to siltstone at base |
| 260-262 | Lignite, brownish-black, impure |
| 262-266 | Claystone, medium-light-gray |
| 266-274 | Sandstone, light-gray, silty |
| 274-285 | Claystone, medium-light-gray; includes some scattered dark-gray carbonaceous shale |
| 285-293 | Sandstone, light-gray, silty |
| 293-392 | Silty claystone and siltstone, brownish-gray to greenish-gray claystone thinly interbedded with light-gray siltstone; impure coal and carbonaceous shale from 320 to 325 ft and 330 to 335 ft |
| 392-393.5 | Lignite, brownish-black |
| 393.5-398 | Claystone, brownish-gray to medium-light-gray |
| 398-415 | Siltstone and silty sandstone, light-gray |
| 415-438 | Claystone and siltstone, light-gray to brownish-gray; chiefly silty claystone grading to slightly sandy siltstone in middle of interval and at base |
| 438-446 | Sandstone, light-gray, very fine grained, silty |
| 446-459 | Claystone, light-gray to brownish-gray, silty in upper part |
| 459-462 | Lignite, grayish-black to brownish-black, impure; ("AB" Rider lignite bed) |
| 462-471 | Claystone, brownish-gray to medium-light-gray, slightly carbonaceous |
| 471-474 | Lignite, grayish-black; ("AB" lignite bed) |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 474-479.5 | Claystone and carbonaceous shale, medium-light-gray to brownish-gray |
| 479.5-481 | Lignite, grayish-black; ("AB" Leader lignite bed) |
| 481-507 | Claystone, medium-light-gray to brownish-gray, silty; locally carbonaceous; calcareous siltstone concretion at 501 ft |
| 507-525 | Siltstone and silty sandstone, light-gray |
| 525-537 | Siltstone and silty claystone, thinly interbedded light-to medium-light-gray |
| 537-538 | Lignite, black; ("AA" lignite bed) |
| 538-541 | Siltstone, light-gray |
| 541-560 | Claystone, medium-light-gray, silty |

Total depth 560 ft

Hole No: GS-44 Date: 8-8-79 State: Montana County: Roosevelt
 Sec. NE NE 5 T. 30 N. R. 53 E. Elevation: 2221 ft Total Depth: 560 ft
 Logging Speed: 15 ft/min. Natural Gamma: TC 4, Range 50 cps Density: TC 2,
 Range 10,000cps Resistance: 50 ohms/in Caliper: Horizontal scale N/A in/in

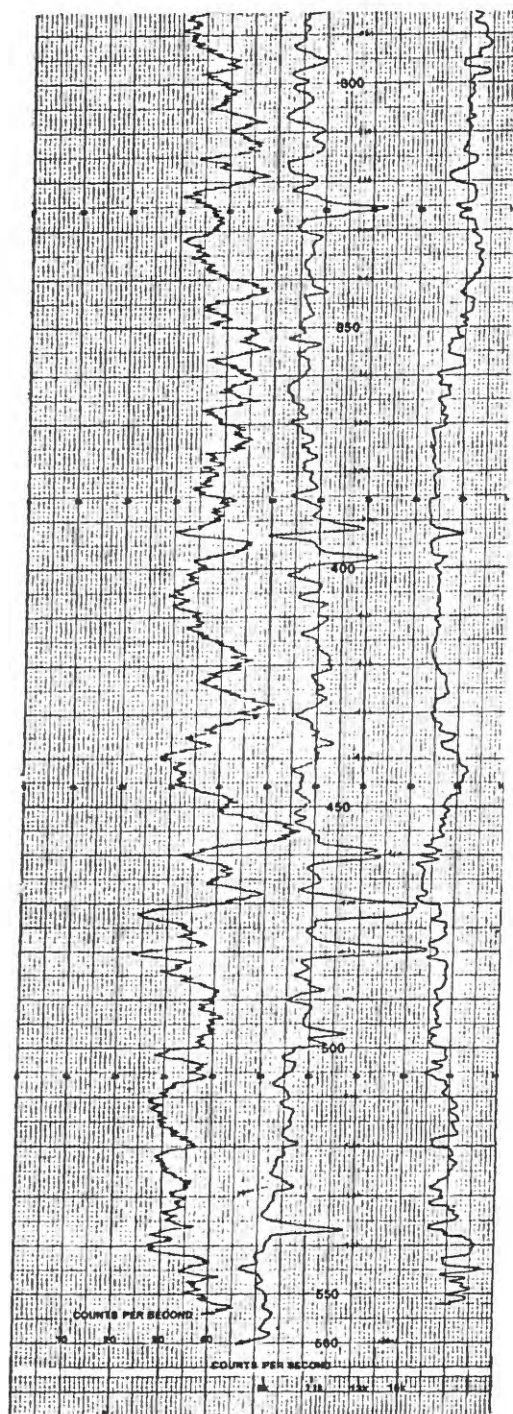
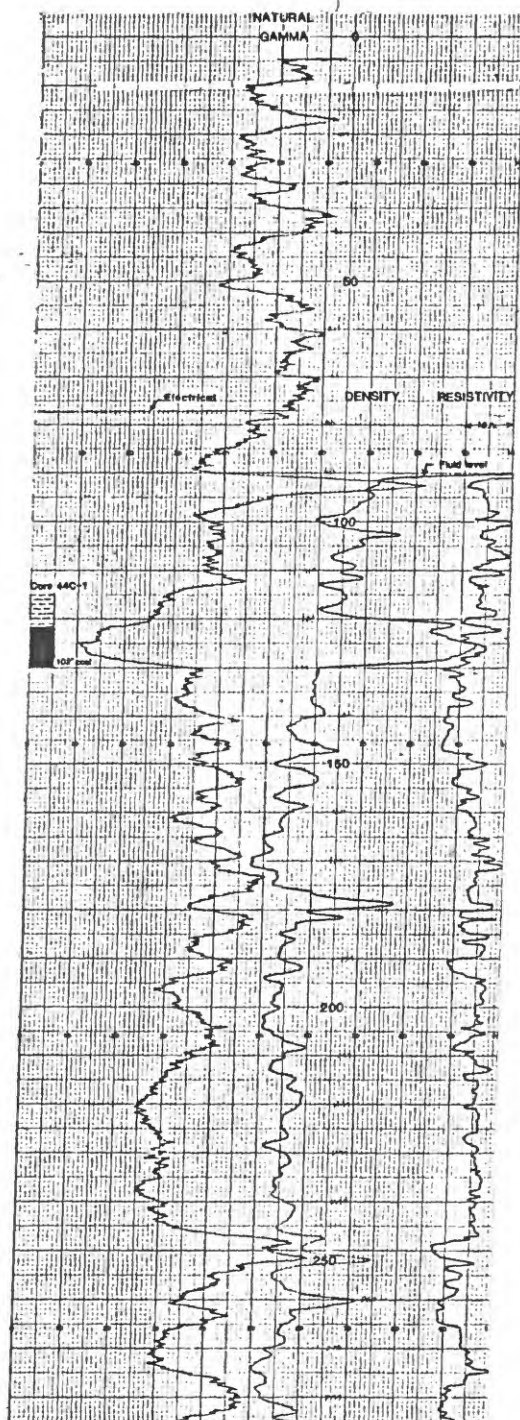


Figure 45.--Geophysical logs of hole GS-44

Sample log

Hole no.: GS-45 Date: 8-10-79 State: Montana County: Roosevelt
 Elev. (ground): 2132 ft Location: T. 31 N., R. 53 E., Sec. SW SW 9
 Total depth: 435 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-30 | Sand and silt with scattered small pebbles and granules of quartz, quartzite, and granite, pale-yellowish-brown, unconsolidated |
| 30-55 | Gravel and coarse sand, brownish-gray to pale-yellowish-brown, unconsolidated; contains granules and rounded flat pebbles as much as 1.5 inches in diameter of quartz, quartzite, granite, and gneiss |
| 55-70 | Siltstone, dusky-brown to medium-gray, sandy |
| 70-78 | Carbonaceous shale, medium-to dark-gray |
| 78-93 | Siltstone, medium-gray; thin coal at 84 ft |
| 93-95 | Lignite, grayish-black; (Smoke Creek lignite bed) |
| 95-100 | Claystone, brownish-gray, carbonaceous |
| 100-120 | Siltstone, medium-gray, sandy |
| 120-135 | Claystone, medium-gray, silty in upper part |
| 135-137 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 137-145 | Sandstone and siltstone, light-gray |
| 145-155 | Claystone, medium-gray, very silty |
| 155-200 | Siltstone and sandstone, medium-light-gray to brownish-gray; includes some thinly interbedded silty claystone between 167 and 175 ft; hard calcareous sandstone concretions at 158 and 181 ft; trace of coal at 196 ft |
| 200-209 | Claystone, medium-dark-gray, silty |
| 209-215 | Siltstone, medium-gray |
| 215-243 | Claystone, medium-light-gray to medium-dark-gray, very silty |
| 243-246 | Lignite, grayish-black, impure; ("B" lignite bed) |
| 246-274 | Siltstone and silty claystone, medium-gray siltstone thinly interbedded with brownish-gray to greenish-gray claystone |

Sample log--Continued

| Depth (feet) | Lithic Description |
|--------------------|--|
| 274-312 | Sandstone, medium-light-gray, very fine grained, silty |
| 312-358 | Siltstone and silty sandstone, medium-light-gray to medium-dark-gray; includes scattered thinly interbedded medium-dark-gray silty claystone |
| 358-359.5 | Lignite, grayish-black |
| 359.5-363 | Claystone, brownish-gray, silty |
| 363-371 | Sandstone, medium-light-gray, very fine grained, silty |
| 371-380 | Siltstone, medium-gray to brownish-gray |
| 380-393 | Claystone, medium-gray, silty |
| 393-394.5 | Lignite, grayish-black |
| 394.5-416 | Siltstone, medium-gray to medium-dark-gray, sandy |
| 416-435 | Sandstone, medium-light-gray, very fine grained, silty; very hard calcareous sandstone concretion between 432 and 435 ft |
| Total depth 435 ft | |

Hole No: GS-45 Date: 8-10-79 State: Montana County: Roosevelt
 Sec. SW SW 9 T. 31 N. R. 53 E. Elevation: 2132 ft Total Depth: 435 ft
 Logging Speed: 10 ft/min Natural Gamma: TC 3, Range 10 cps Density: TC 3,
 Range 200 cps Resistance: 10 ohms/in Caliper: Horizontal scale 2 in/in

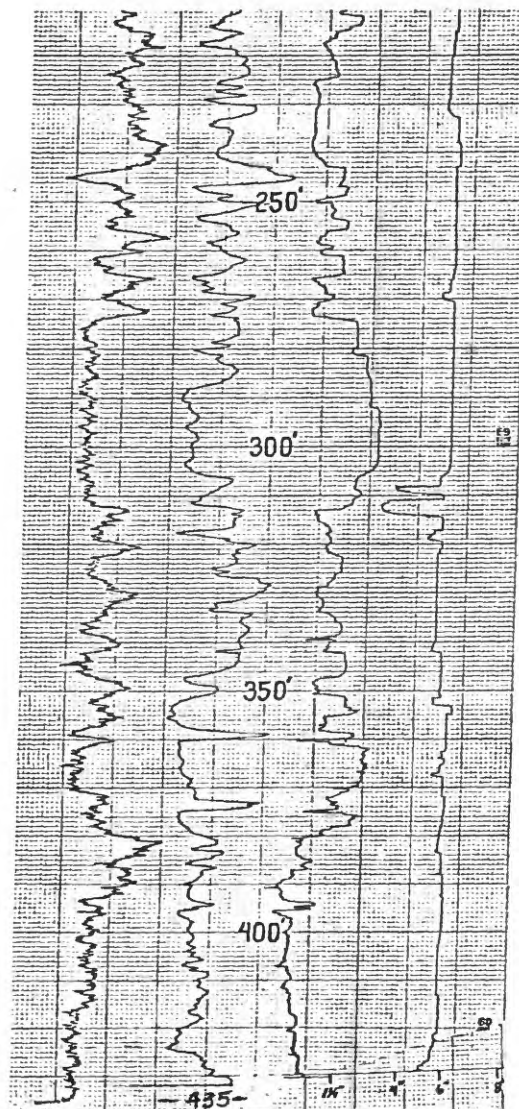
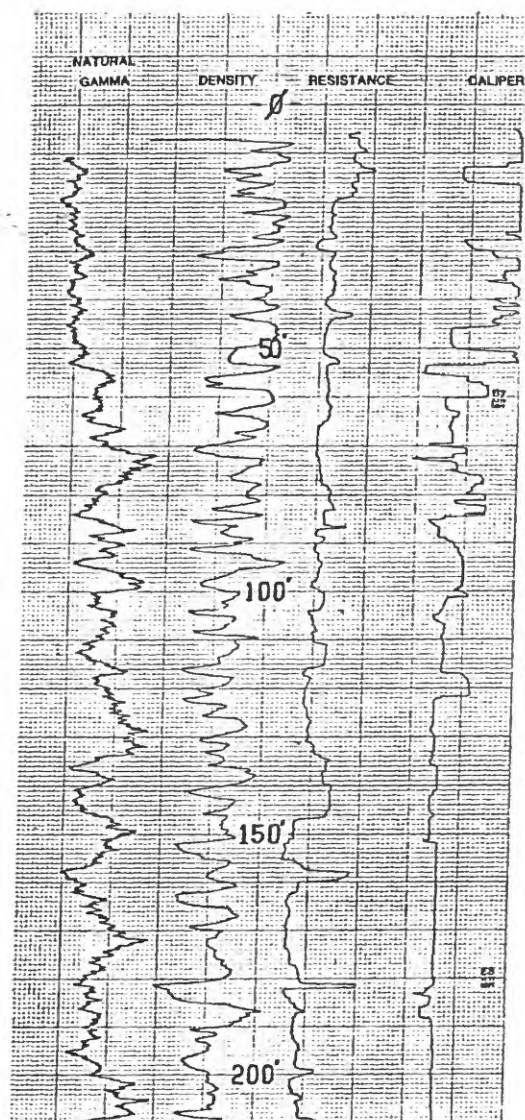


Figure 46.--Geophysical logs of hole GS-45

Sample log

Hole no.: GS-46 Date: 8-25-79 State: Montana County: Sheridan
 Elev. (ground): 2038 ft Location: T. 32 N., R. 55 E., Sec. NW NE 31
 Total depth: 500 ft Drilling medium: mud Offset core hole: none

Depth
(feet)

Lithic description

| | |
|-----------|---|
| 0-10 | Sand, silt, clay, dark-yellowish-brown, unconsolidated |
| 10-19 | Gravel and sand, unconsolidated; rounded pebbles as much as 1.25 inches in diameter |
| 19-60 | Siltstone(?), poor sample return, lost circulation; interval appears to contain chiefly medium-dark-gray siltstone |
| 60-61 | Lignite, indicated by drillers log and trace of impure coal in cuttings |
| 61-165 | Siltstone and claystone, light-to medium-gray; alternating thin sequences of siltstone and claystone; sandy siltstone dominates in middle to lower parts; calcareous siltstone concretion from 99 to 101 ft; thin coal at 159 ft; grades to light-bluish-gray silty claystone at base |
| 165-168.5 | Lignite, grayish-black to brownish-black; (Lower Smoke Creek lignite bed) |
| 168.5-178 | Claystone, light-greenish-gray to light-gray; silty in lower part |
| 178-190 | Siltstone, light-gray to light-bluish-gray |
| 190-197 | Claystone, medium-gray, silty |
| 197-199 | Lignite, grayish-black; ("BC" lignite bed) |
| 199-205 | Claystone, medium-gray, silty |
| 205-206 | Lignite, black; ("BC" Leader lignite bed) |
| 206-215 | Claystone, medium-gray |
| 215-310 | Siltstone, medium-gray to light-gray; sandy in upper part; includes scattered thinly interbedded dark-gray carbonaceous claystone in middle and lower parts; calcareous siltstone concretion at 245 ft; thin coals at 269, 290, and 304 ft; grades to sandstone at base |
| 310-364 | Sandstone, light-gray, very fine to fine-grained |
| 364-401 | Siltstone and silty claystone, light-to medium-dark-gray; thin coal at 375 ft |

Sample log--Continued

| Depth (feet) | Lithic Description |
|-----------------|---|
| 401-403.5 | Lignite, grayish-black to brownish-black |
| 403.5-447 | Claystone, medium-light-gray to dark-gray and brownish-gray, silty; scattered thin carbonaceous lamina; thin coal at 435 ft |
| 447-449 | Limestone, light-gray, very finely crystalline |
| 449-458 | Claystone, light-gray, silty |
| 458-460 | Lignite, grayish-black; ("AB" lignite bed) |
| 460-484 | Claystone, light-gray, silty |
| 484-500 | Siltstone, light-gray |
| | Total depth 500 ft |

Hole No: GS-46 Date: 8-25-79 State: Montana County: Sheridan
 Sec. NW NE 31 T. 32 N. R. 55 E. Elevation: 2038 ft Total Depth: 500 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 2, Range 10 cps Density: TC 2,
 Range 200 cps Resistance: 20 ohms/in Caliper: Horizontal scale 2 in/in

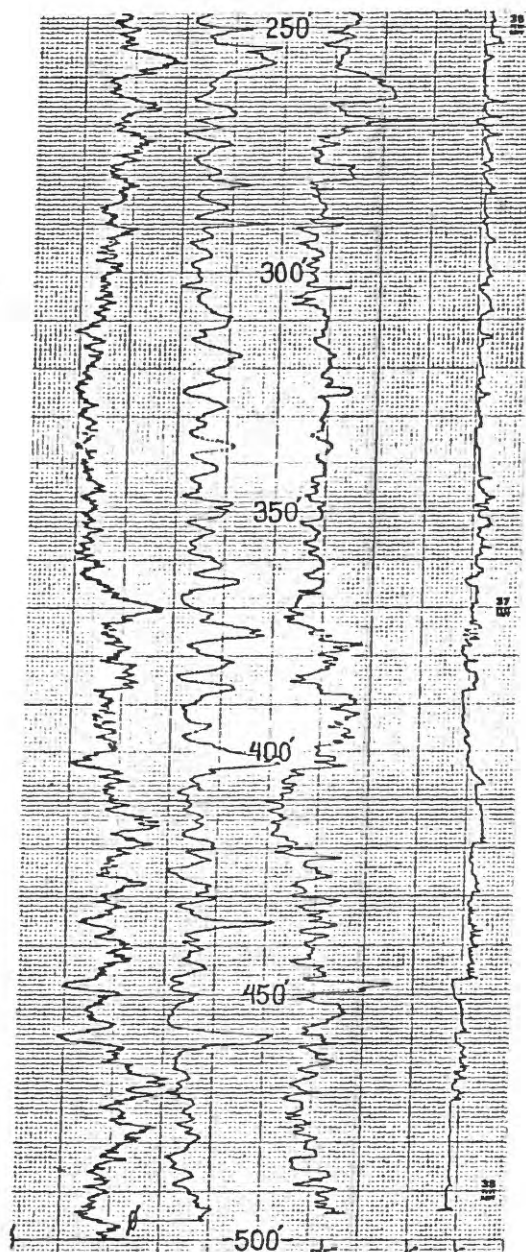
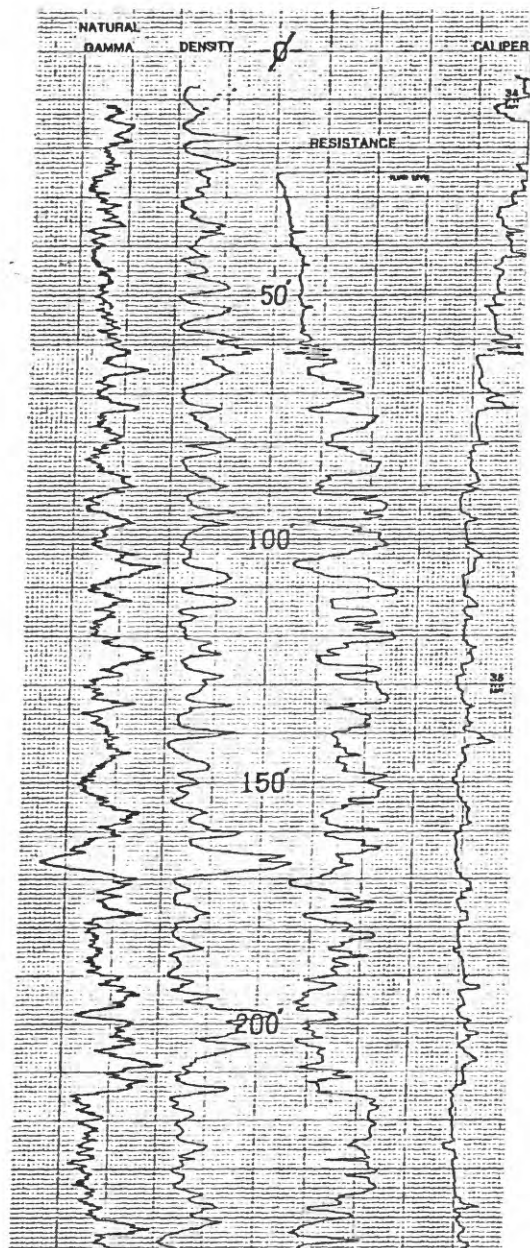


Figure 47.--Geophysical logs of hole GS-46

Sample log

Hole no.: GS-47 Date: 8-29-79 State: Montana County: Sheridan
 Elev. (ground): 2055 ft Location: T. 33 N., R. 55 E., Sec. SE SE 32
 Total depth: 477 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-22 | Sand, gravel, and clay, light-olive-gray, unconsolidated |
| 22-48 | Siltstone, reddish-brown to yellowish-brown; lignite 47 to 48 ft |
| 48-50 | Claystone, greenish-gray to olive-gray |
| 50-55 | Lignite, black; (Lower Timber Coulee lignite bed) |
| 55-57 | Claystone, light-gray |
| 57-59 | Lignite, black |
| 59-81 | Siltstone, greenish-gray to olive-gray |
| 81-84 | Lignite, impure |
| 84-103 | Sandstone, olive-gray, very fine grained |
| 103-132 | Siltstone, olive-gray |
| 132-136 | Lignite, black; (Reserve lignite bed) |
| 136-188 | Siltstone, light-gray to medium-gray to olive-gray; with interbedded sandstone; scattered coal fragments |
| 188-200 | Claystone, olive-gray, sandy |
| 200-211 | Sandstone, olive-gray, very fine grained, silty |
| 211-248 | Siltstone, olive-gray; grades sandy near base; traces of coal near base |
| 248-298 | Sandstone, olive-gray, very fine grained; grades to coarse-grained sandstone near base; grades silty near top of interval; probable calcareous sandstone concretion 296 to 298 ft |
| 298-320 | Siltstone, olive-gray to medium-gray; grades argillaceous near top and base of interval |
| 320-376 | Siltstone, brownish-gray to greenish-gray; some interbedded sandstone; coal bed 339 to 340 ft |
| 376-378 | Lignite, black |

Sample log--Continued

| Depth (feet) | Lithic Description |
|--------------------|--|
| 378-383 | Claystone, olive-gray |
| 383-385 | Lignite, black |
| 385-420 | Claystone, medium-gray to light-gray to olive-gray, silty |
| 420-435 | Siltstone, olive-gray |
| 435-459 | Claystone, brownish-gray; grades silty near top of interval; coal bed 446 to 447 ft |
| 459-477 | Siltstone, olive-gray; calcareous sandstone concretion at base of interval |
| Total depth 477 ft | |

Hole No: GS-47 Date: 8-29-79 State: Montana County: Sheridan
 Sec. SE SE 32 T. 33 N. R. 55 E. Elevation: 2055 ft Total Depth: 477 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 2 , Range 10 cps Density: TC 2 ,
 Range 200 cps Resistance: 10 ohms/in Caliper: Horizontal scale 2 in/in

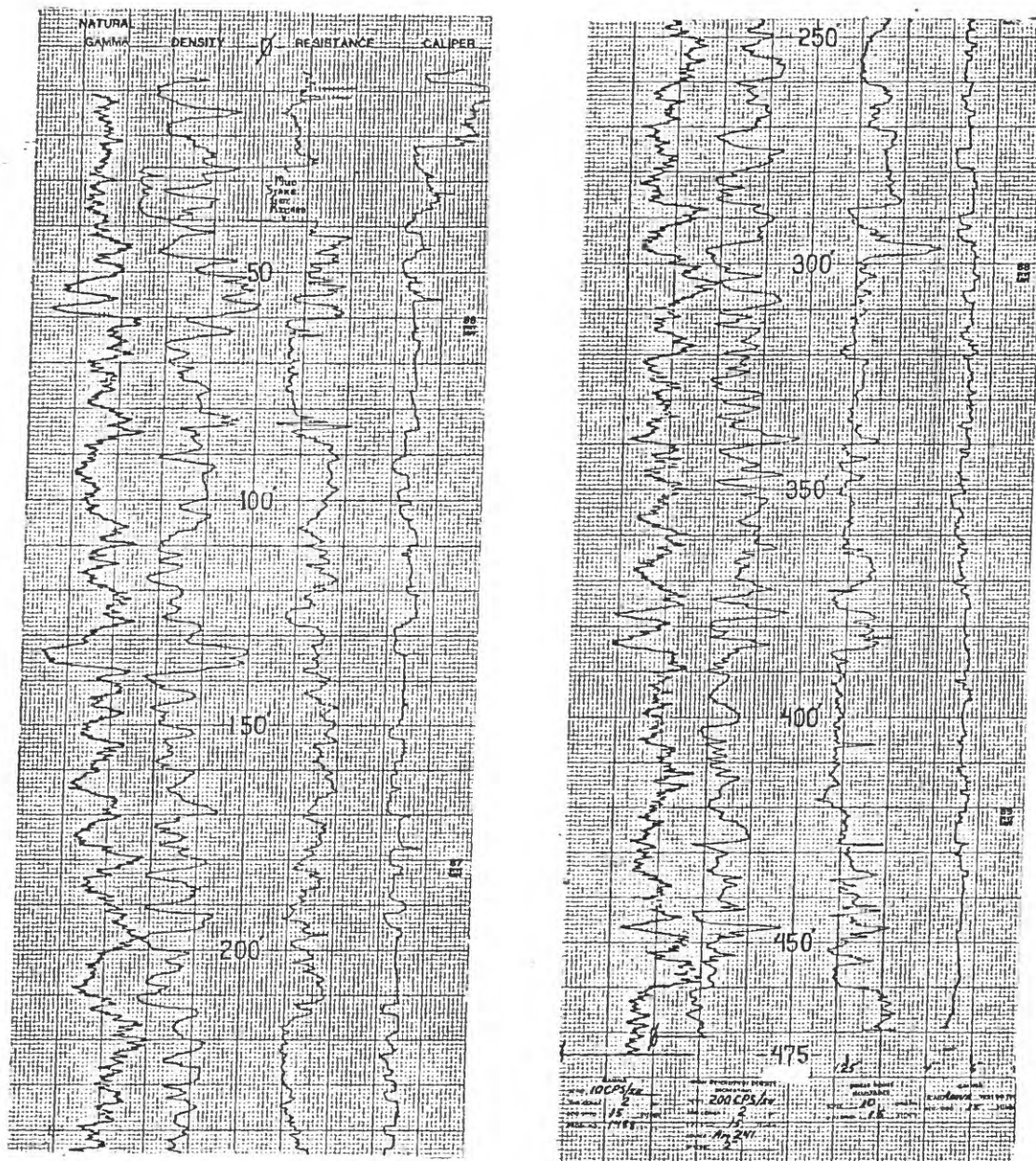


Figure 48.--Geophysical logs of hole GS-47

Sample log

Hole no.: GS-48 Date: 9-11-79 State: Montana County: Roosevelt
 Elev. (ground): 2332 ft Location: T. 28 N., R. 53 E., Sec. NE NE 13
 Total depth: 797 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-11 | Sand, silt, and clay, unconsolidated, pale-yellowish-brown; abundant rounded coarse grains and granules of quartz, feldspar, and granite; several angular to subrounded pebbles of granite, quartz, and dolomite as much as 1.25 inches in diameter |
| 11-14 | Sandstone, pale-yellowish-brown, very fine grained |
| 14-22 | Lignite, brownish-black to black; oxidized in upper part; grades impure between 16 and 17.5 ft; ("D" lignite bed) |
| 22-24 | Claystone, very light gray to light-brownish-gray |
| 24-38 | Siltstone and silty sandstone, very light gray |
| 38-56 | Claystone, light-olive-gray to greenish-gray and yellowish-gray to pinkish-gray; grades silty and slightly sandy between 42 and 46 ft |
| 56-74 | Siltstone, yellowish-gray; includes some very fine grained, very finely micaceous yellowish-gray sandstone in middle to lower parts and yellowish-gray to pale orange claystone from 68 to 70 ft |
| 74-85 | Claystone, yellowish-gray to pinkish-gray, silty; trace of brownish-black carbonaceous shale in upper part |
| 85-95 | Siltstone, pale-yellowish-brown to light greenish-gray; includes some thinly interbedded very fine sandstone with abundant very fine mica and greenish-gray grains |
| 95-108 | Siltstone and silty claystone, yellowish-gray to pinkish-gray |
| 108-111 | Sandstone, very light gray to pinkish-gray, very fine grained, silty, very finely micaceous, finely disseminated organic material |
| 111-112.5 | Claystone, light-gray to light-olive-gray |
| 112.5-115.5 | Lignite, grayish-black; impure in upper part; ("C" lignite bed) |
| 115.5-122 | Claystone, light-brownish-gray, scattered organic material; includes some light-gray siltstone in middle part |
| 122-132 | Siltstone and sandstone, yellowish-gray siltstone in upper part grading downward to light gray sandstone |

Sample log--Continued

| Depth (feet) | Lithic Description |
|-----------------|--|
| 132-145 | Claystone, yellowish-gray to light-brownish-gray, silty |
| 145-150 | Sandstone and siltstone, very light gray |
| 150-155 | Claystone, very light gray to light-olive-gray, silty |
| 155-191 | Sandstone and siltstone, thinly interbedded, light-gray to yellowish-gray; includes scattered traces of light-brownish-gray to dark-yellowish-brown carbonaceous shale; hard calcareous sandstone concretions at 161 and 166 ft; traces of coal between 175 and 185 ft |
| 191-205 | Claystone, white to yellowish-gray, locally very silty |
| 205-220 | Siltstone, very light gray to yellowish-gray; some thinly interbedded light-gray claystone and brownish-gray carbonaceous shale; trace of coal between 205 and 210 ft |
| 220-240 | Sandstone and siltstone, thinly interbedded, white to very light gray to light-brownish |
| 240-245 | Claystone, light-gray |
| 245-272 | Siltstone, light-gray to yellowish-gray, locally sandy; includes yellowish-gray to light-brownish-gray claystone between 250 and 253 ft and 262 and 267 ft; scattered traces of coal |
| 272-274 | Lignite, grayish-black; ("BC" lignite bed) |
| 274-295 | Siltstone and claystone, light-gray to light-olive-gray; claystone in upper part grading downward to siltstone in lower part |
| 295-310 | Sandstone and siltstone, yellowish-gray to light-olive-gray; siltstone and silty sandstone in upper part grading downward to very fine grained sandstone in lower part |
| 310-333 | Sandstone, light-olive-gray to light-gray, very fine to medium grained; angular light and dark grains, abundant feldspar, clay matrix |
| 333-371 | Sandstone, light-gray to light-olive-gray, very fine grained to fine grained, silty; includes some thinly interbedded yellowish-gray siltstone |
| 371-393 | Siltstone, light-gray to yellowish-gray; includes some thinly interbedded claystone in upper and lower parts; calcareous sandstone concretion at 377 ft |
| 393-397 | Lignite, grayish-black; impure in lower part; ("B" lignite bed) |

Sample log--Continued

| Depth (feet) | Lithic Description |
|-----------------|---|
| 397-409 | Claystone, brownish-gray to yellowish-gray; includes some thinly interbedded yellowish-gray siltstone |
| 409-416 | Sandstone, light-gray, fine-to medium-grained, poorly sorted, angular grains, abundant feldspar, scattered grains of dark-gray organic material |
| 416-425 | Claystone, chiefly yellowish-gray, some brownish-gray |
| 425-440 | Siltstone, yellowish-gray to very pale orange, finely micaceous |
| 440-480 | Siltstone and claystone, yellowish-gray to light-olive-gray; thinly interbedded; traces of carbonaceous shale and coal |
| 480-488 | Claystone and carbonaceous shale, yellowish-gray to brownish-gray; trace of coal |
| 488-505 | Claystone and siltstone, light-gray siltstone in upper part grading downward to yellowish-gray claystone in middle and lower parts; abundant brownish-gray to brownish-black carbonaceous shale in lower part |
| 505-520 | Siltstone and sandstone, very light gray to yellowish-gray |
| 520-524 | Carbonaceous shale, brownish-gray; coal from 521 to 522 ft |
| 524-527 | Lignite, grayish-black; ("AB" lignite bed) |
| 527-530 | Claystone, light-brownish-gray to brownish-gray, silty |
| 530-542 | Sandstone, yellowish-gray to very pale orange, very fine grained, silty, micaceous |
| 542-552 | Claystone, light-gray to yellowish-gray; includes some brownish-gray carbonaceous shale and trace of coal |
| 552-582 | Siltstone and silty claystone, yellowish-gray to grayish-orange; sparsely scattered very light gray silty sandstone |
| 582-585.5 | Lignite, grayish-black; ("AA" lignite bed) |
| 585.5-594 | Claystone, yellowish-gray to pale-yellowish-brown, silty |
| 594-615 | Sandstone, light-gray to very light gray, very fine grained, silty, micaceous, salt and pepper texture |
| 615-639 | Siltstone, yellowish-gray to very pale orange, locally sandy |
| 639-642 | Lignite, grayish-black; ("A" Rider lignite bed) |

Sample log--Continued

| Depth (feet) | Lithic Description |
|--------------------|---|
| 642-658 | Claystone and siltstone, thinly interbedded, pale-yellowish-brown to yellowish-gray; includes some brownish-black carbonaceous shale in lower part |
| 658-665 | Lignite, grayish-black to brownish-black; grades impure in upper part and at base; ("A" lignite bed) |
| 665-674 | Siltstone and silty claystone, light-gray to yellowish-gray; sandy in lower part |
| 674-681 | Claystone, yellowish-gray to light-olive-gray; traces of carbonaceous shale and coal |
| 681-695 | Siltstone, yellowish-gray to light-olive-gray and brownish-gray; includes some thinly interbedded silty claystone |
| 695-703 | Sandstone, light gray to yellowish-gray, very fine grained, silty |
| 703-709 | Claystone, light-brownish-gray; includes some brownish-gray carbonaceous shale |
| 709-710.5 | Lignite, grayish-black to black |
| 710.5-715 | Claystone and carbonaceous shale, brownish-gray |
| 715-735 | Siltstone, pale-yellowish-brown to yellowish-gray; includes calcareous sandstone concretion at 717 ft and thinly interbedded light-brownish-gray claystone in upper part; grades sandy in lower part |
| 735-758.5 | Sandstone, very light gray to yellowish-gray; very fine grained and silty in upper part, fine-grained in middle to lower parts; subangular, salt and pepper texture; finely micaceous, abundant feldspar, scattered dark opaque grains, fine detrital coal, clay matrix |
| 758.5-759.5 | Lignite, grayish-blue to grayish-black |
| 759.5-763 | Carbonaceous shale, brownish-gray to brownish-black |
| 763-764.5 | Lignite, grayish-black |
| 764.5-796 | Siltstone and silty claystone, pale-yellowish-brown to brownish-gray and light-olive-gray; grades sandy in middle and lower parts |
| 796-797 | Sandstone concretion, calcareous, light-olive-gray, hard, dense |
| Total depth 797 ft | |

Hole No: GS-48 Date: 9-11-79 State: Montana County: Roosevelt
 Sec. NE SE 13 T. 28 N. R. 53 E. Elevation: 2332 ft Total Depth: 797 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 2, Range 10 cps Density: TC 2,
 Range 200 cps Resistance: 5 ohms/in Caliper: Horizontal scale 2 in/in

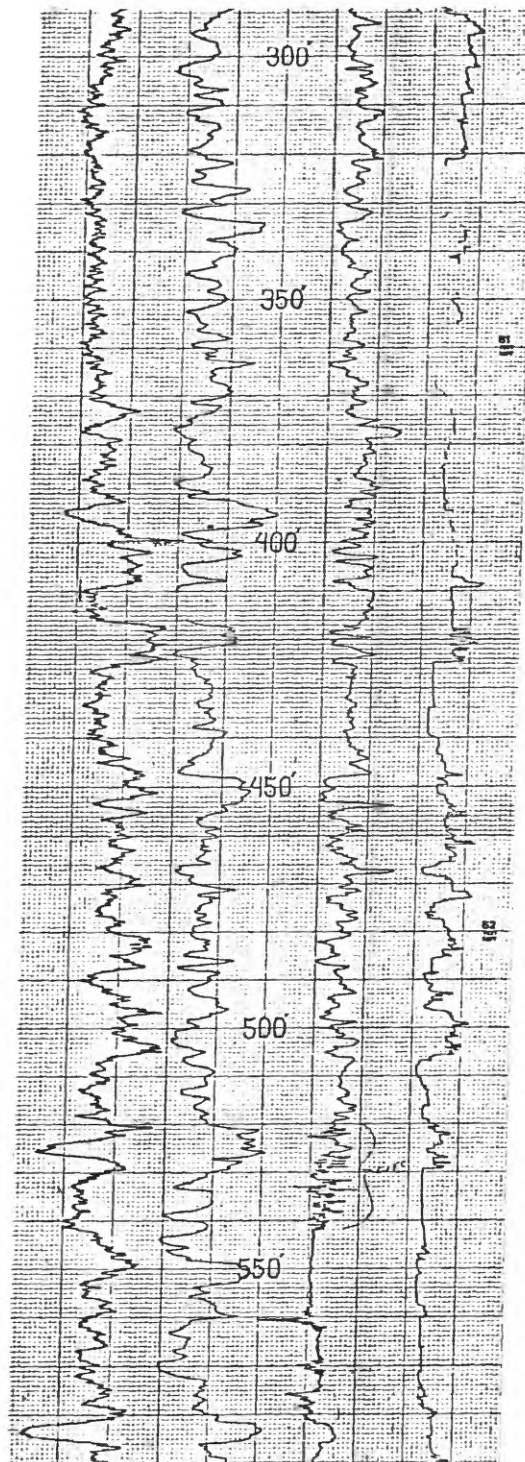
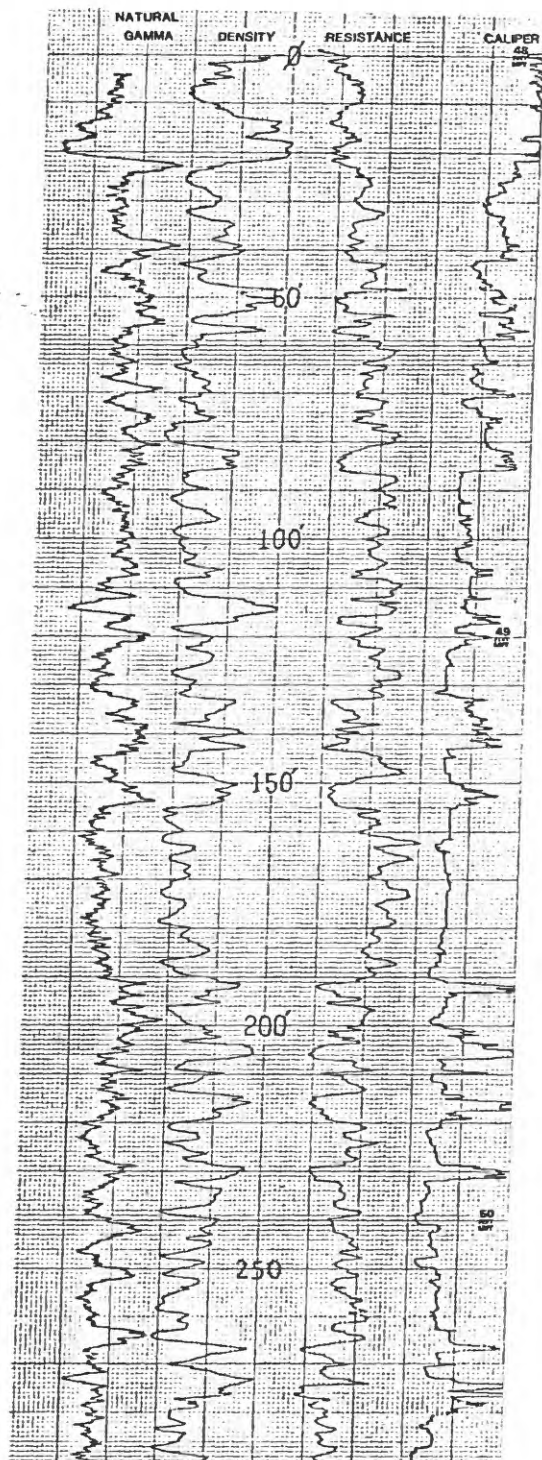


Figure 49.--Geophysical logs of hole GS-48



Sample log

Hole no.: GS-49 Date: 9-13-79 State: Montana County: Roosevelt
 Elev. (ground): 2099 ft Location: T. 30 N., R. 53 E., Sec. NE NW 14
 Total depth: 440 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-15 | Sand and silt, pale-yellowish-brown to dark-yellowish-brown, unconsolidated; sparse granules and small pebbles of quartz, quartzite, and granite |
| 15-37 | Gravel and coarse sand, unconsolidated; angular to well-rounded pebbles as much as 2 inches in diameter |
| 37-45 | Sandstone, pale-yellowish-brown, very fine grained |
| 45-47 | Claystone, medium-light-gray |
| 47-54 | Lignite, grayish-black; (Smoke Creek lignite bed) |
| 54-84 | Siltstone and silty sandstone, light-gray |
| 84-87 | Claystone, light-olive-gray, slightly silty |
| 87-141 | Sandstone, light-gray to medium-light-gray; includes widely scattered and thinly interbedded siltstone and silty claystone |
| 141-155 | Siltstone and claystone, greenish-gray; siltstone predominates in upper and middle parts, grading downward to claystone in lower part |
| 155-158 | Lignite(?), geophysical logs indicate impure coal in this interval; no trace of coal in cuttings; ("BC" lignite bed ?) |
| 158-173 | Siltstone, medium-light-gray |
| 173-174.5 | Lignite, brownish-black, impure |
| 174.5-181 | Claystone, greenish-gray, silty; trace of coal in lower part |
| 181-219 | Siltstone, medium-light-gray to greenish-gray; includes some scattered thinly interbedded silty claystone |
| 219-230 | Sandstone, medium-light-gray, very fine grained, silty; hard calcareous sandstone concretion at base |
| 230-280 | Siltstone and silty sandstone, medium-light-gray to light-gray; includes thinly interbedded medium-gray to olive-gray claystone between 245 and 258 ft |

Sample log--Continued

| Depth (feet) | Lithic Description |
|-----------------|---|
| 280-290 | Siltstone and claystone, light-greenish-gray to olive-gray |
| 290-300 | Claystone and carbonaceous shale, olive-gray to olive-black grades to siltstone at base |
| 300-310 | Siltstone, medium-gray; calcareous siltstone concretion at 301 ft |
| 310-313 | Lignite(?), geophysical logs indicate impure coal in this interval; no trace of coal in cuttings |
| 313-324 | Siltstone, medium-dark-gray to olive-gray |
| 324-335 | Sandstone, medium-light-gray, very fine grained, silty; includes some thinly interbedded olive-gray siltstone in middle of interval |
| 335-355 | Claystone, olive-gray to brownish-gray, silty |
| 355-372 | Sandstone, medium-light-gray to medium-gray, very fine grained, silty |
| 372-398 | Claystone and siltstone, medium-light-gray siltstone thinly interbedded with olive-gray claystone; calcareous siltstone concretion at 382 ft; coal from 385 to 386.5 ft |
| 398-399.5 | Lignite, brownish-black; ("AB" Rider lignite bed) |
| 399.5-412 | Siltstone and claystone, medium-light-gray |
| 412-413.5 | Lignite, brownish-black; ("AB" lignite bed) |
| 413.5-422 | Claystone, medium-gray to olive-gray |
| 422-440 | Siltstone and silty sandstone, medium-light-gray |
| | Total depth 440 ft |

Hole No: GS-49 Date: 9-13-79 State: Montana County: Roosevelt
 Sec. NE NW 14 T. 30 N. R. 53 E. Elevation: 2099 ft Total Depth: 440 ft
 Logging Speed: 15 ft/min Natural Gamma: TC 2, Range 10 cps Density: TC 2,
 Range 200 cps Resistance: 10 ohms/in Caliper: Horizontal scale 2 in/in

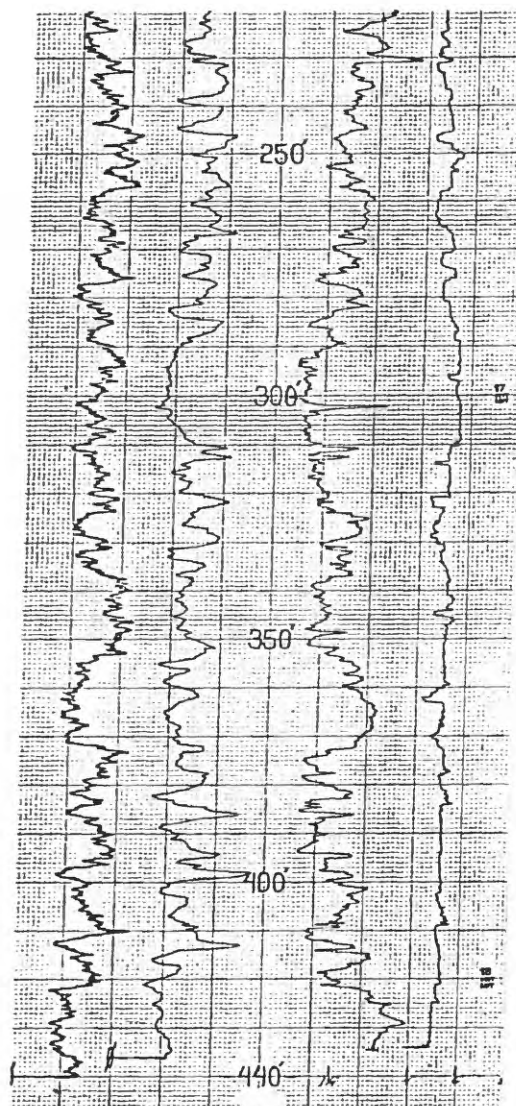
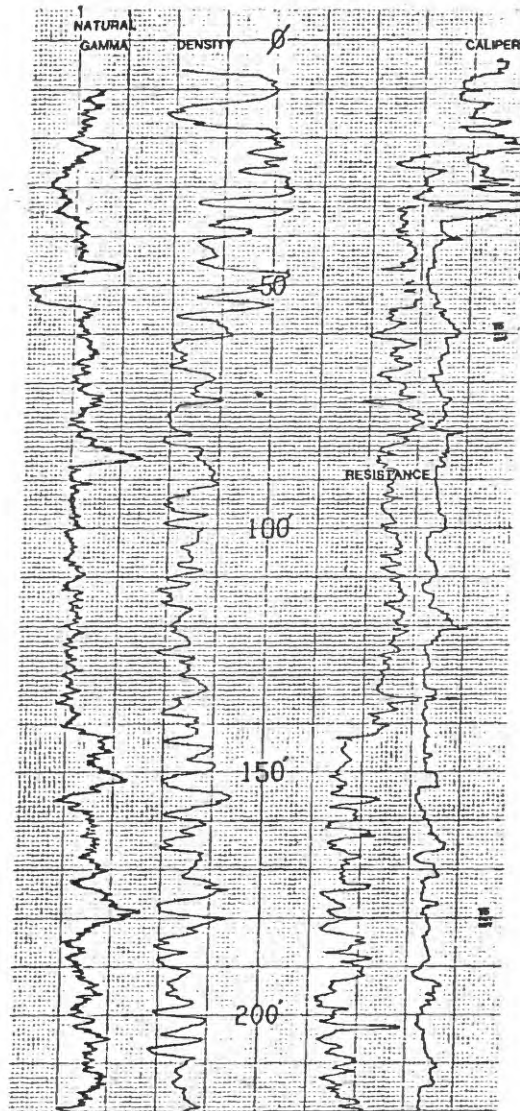


Figure 50.--Geophysical logs of hole GS-49

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; ("D" lignite bed) |
| 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 |
| 116-117 | Lignite, black; ("C" lignite bed) |
| 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 |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 258-259 | Lignite, brownish-gray to brownish-black, impure |
| 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; ("BC" lignite bed) |
| 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; ("B" lignite bed) |
| 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

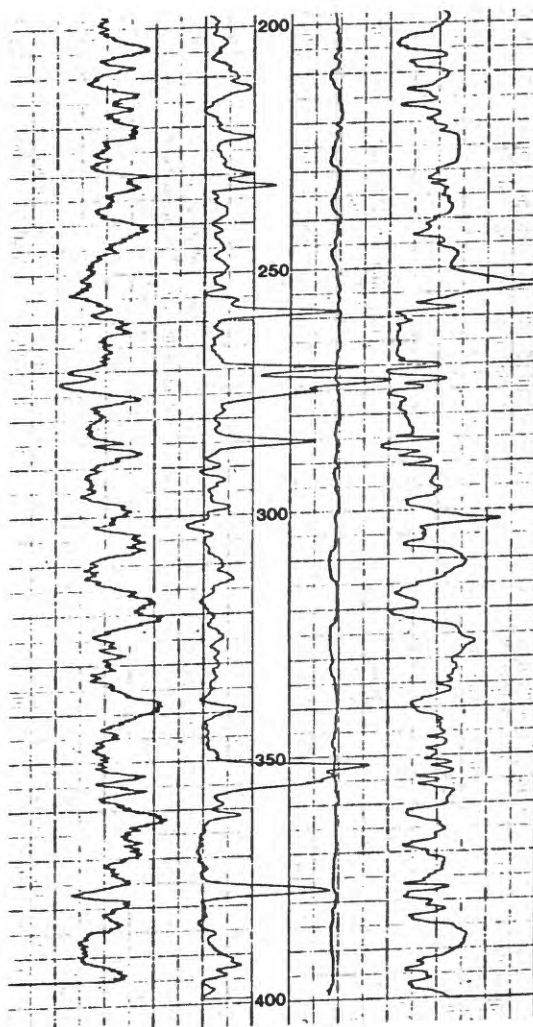
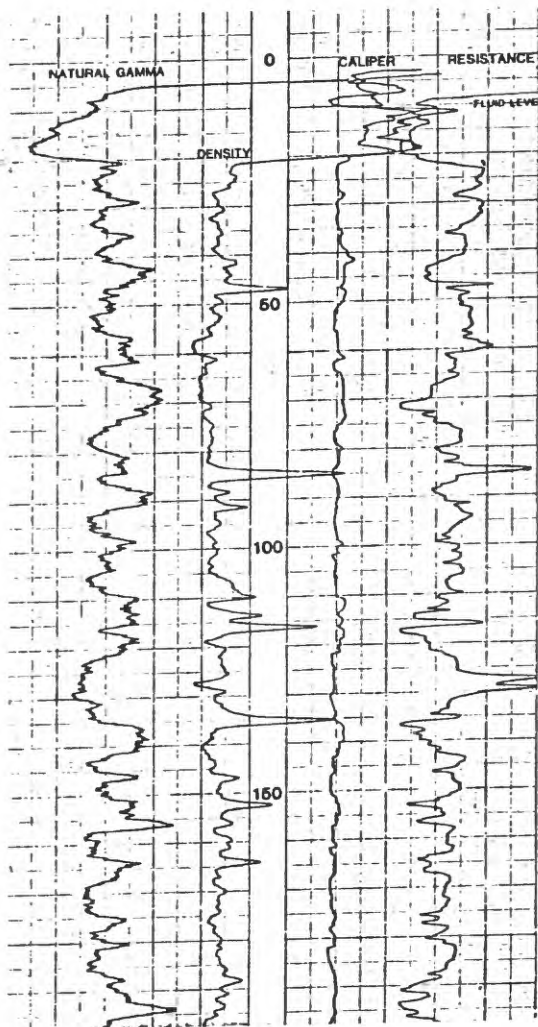


Figure 51.--Geophysical logs of hole GS-50

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 |
|-----------------|---|
| <hr/> | |
| 0-12 | Sand and clay, light-brownish-gray, unconsolidated |
| 12-57 | Gravel and sand, light-brownish-gray to grayish-brown, unconsolidated; 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; (Lower Smoke Creek lignite bed) |
| 125.5-128 | Carbonaceous shale and impure coal, dark-gray to black |
| 128-129 | Lignite, black; (Lower Smoke Creek Leader lignite bed) |
| 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 |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|---|
| 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; ("B" lignite bed) |
| 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; ("AB" lignite bed) |
| 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

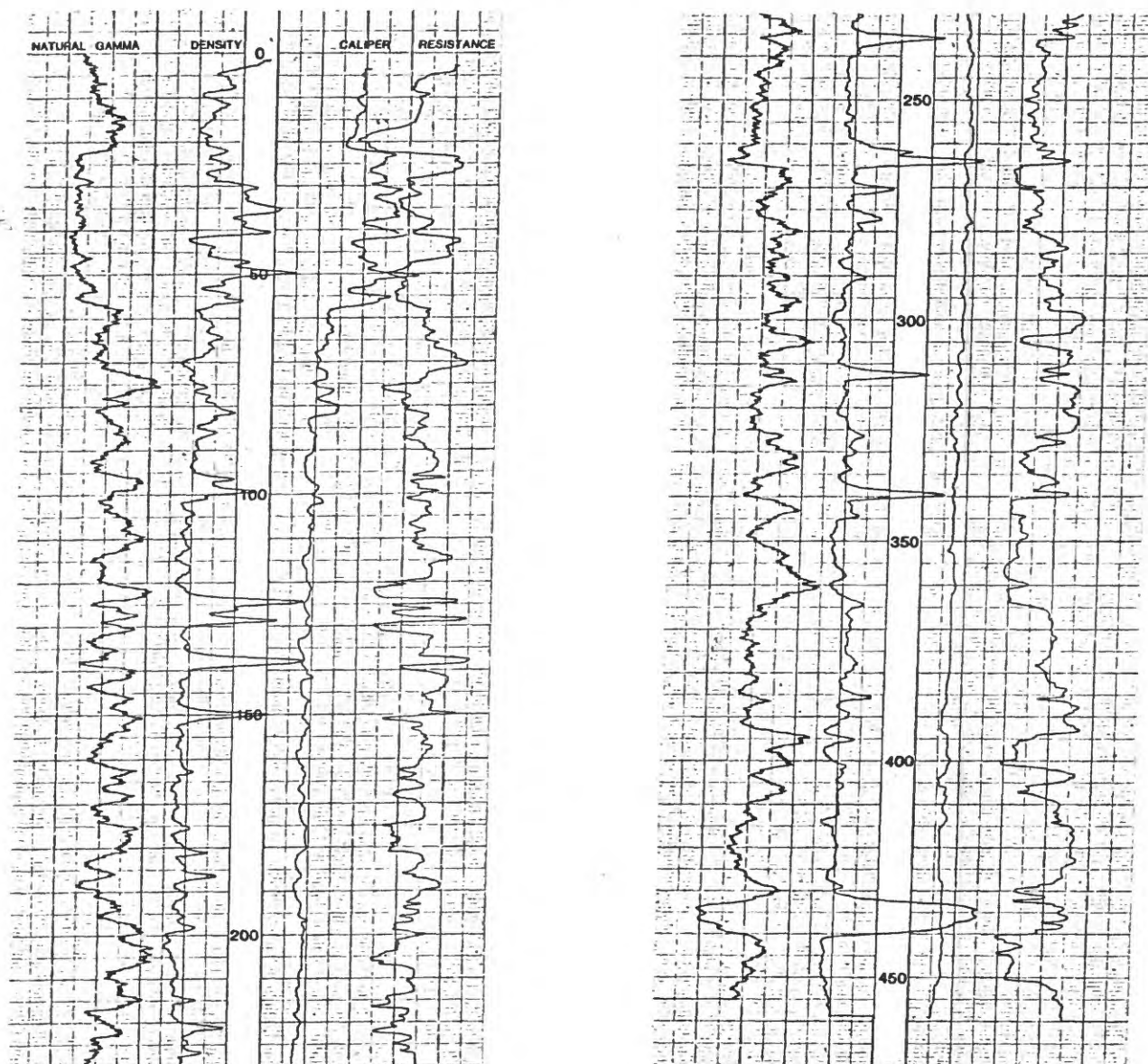


Figure 52.--Geophysical logs of hole GS-51

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 |
| 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; (Lower Smoke Creek lignite bed) |
| 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; ("B" lignite bed) |
| 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 |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 250-253 | Claystone, dark-gray, carbonaceous |
| 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; ("AB" Rider lignite bed) |
| 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; ("AB" lignite bed) |
| 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; ("AA" lignite bed) |
| 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 |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|---|
| 464-468 | Sandstone, light-gray, very fine grained |
| 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

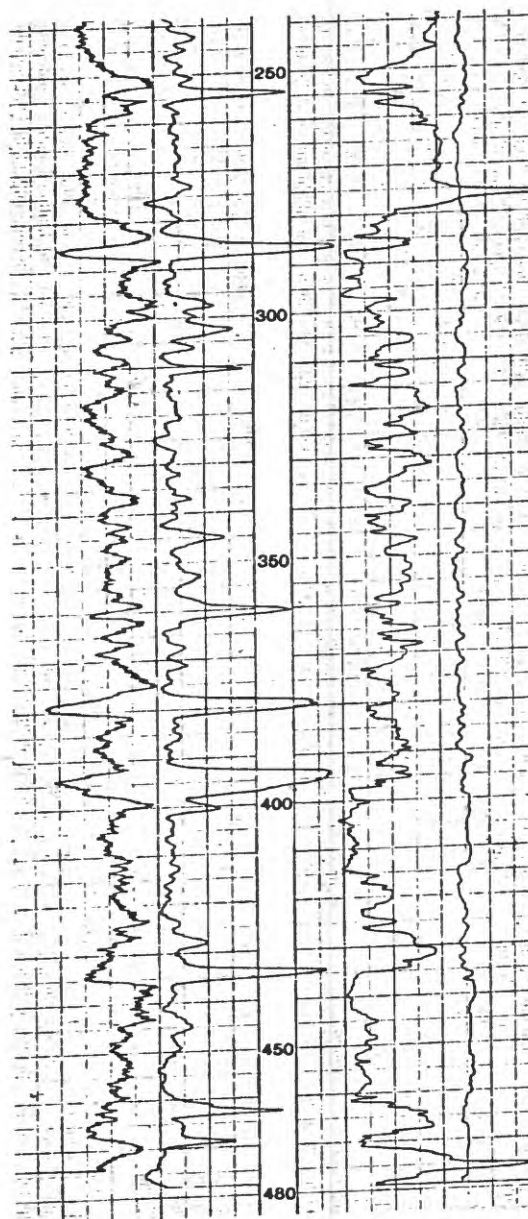
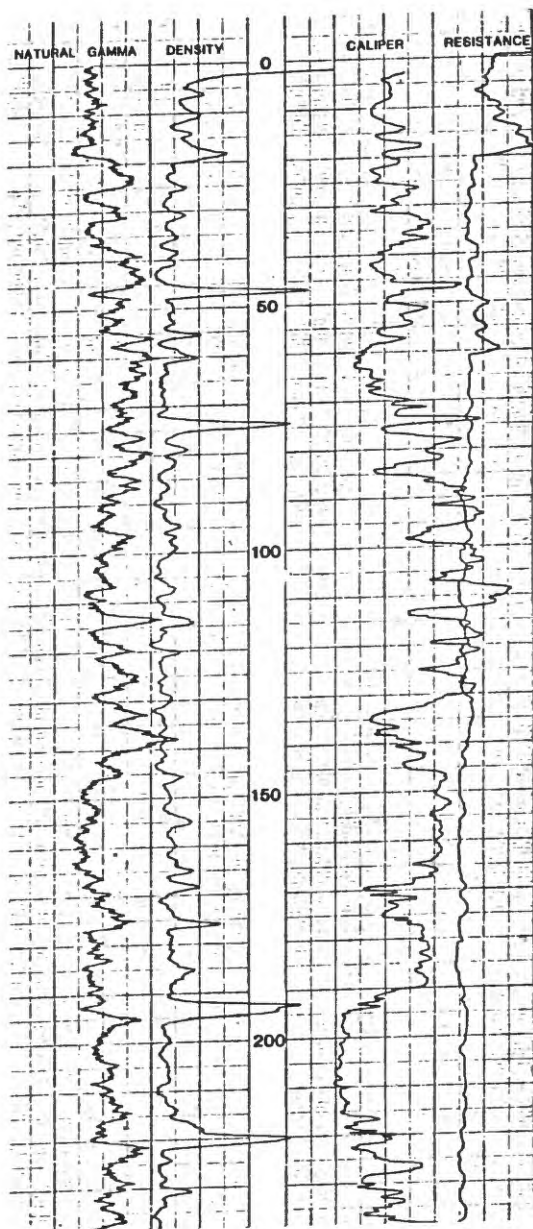


Figure 53.--Geophysical logs of hole GS-52

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, unconsolidated; 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; ("AB" Rider lignite bed) |
| 129.5-135 | Claystone, medium-dark to light-brownish-gray |
| 135-138.5 | Lignite, brownish-black to black; grades impure in middle part; ("AB" lignite bed) |
| 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 |
| 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; ("AA" lignite bed) |
| 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

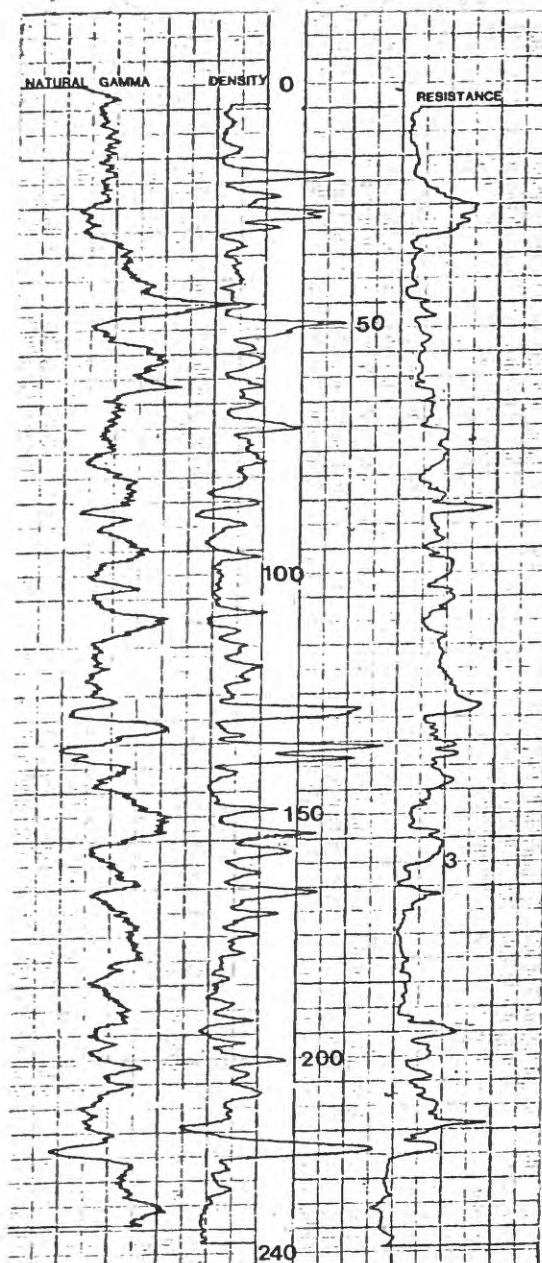


Figure 54.—Geophysical logs of hole GS-53

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, unconsolidated; 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 |
| 190-199 | Claystone, brownish-gray, very finely micaceous; includes thin bed of light-greenish-gray very fine grained sandstone at 195 ft |
| 199-200 | Lignite, black; (base of Fort Union Formation) |
| 200-205 | Claystone, greenish-gray; (top of Hell Creek Formation) |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|---|
| 205-225 | Siltstone, light-gray to medium-light-gray, very finely micaceous; includes some thinly interbedded light-brownish-gray to brownish-black carbonaceous shale |
| 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 |
| 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; (base of Hell Creek Formation) |
| 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; (Fox Hills Formation) |
| 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; (top of Bearpaw Shale) |
| 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

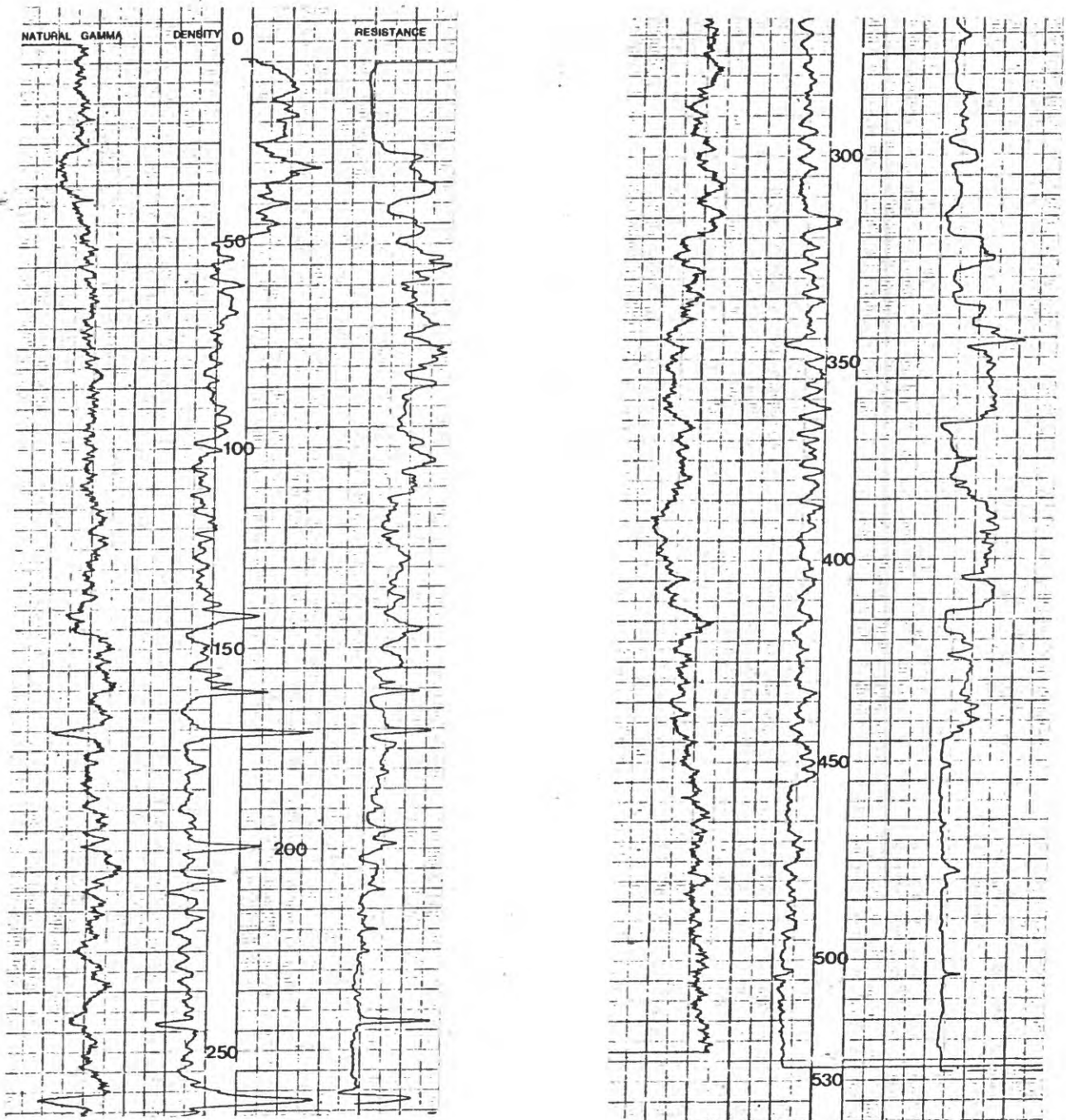


Figure 55.--Geophysical logs of hole GS-54

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; ("A" Rider lignite bed) |
| 70-83 | Siltstone, light-gray to very light gray; probable coal 76 to 77 ft |
| 83-89 | Lignite, black; ("A" lignite bed) |
| 89-114 | Siltstone, light-gray to very light gray; traces of carbonaceous claystone; coal bed 102 to 103 ft |
| 114-116 | Sandstone 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; (base of Fort Union Formation) |
| 251.5-265 | Siltstone, medium-light-gray; grading sandy toward base; thin calcareous concretion at base; (top of Hell Creek Formation) |
| 265-311 | Siltstone, medium-gray, sandy; interbedded with claystone |
| 311-314 | Lignite, black, impure |
| 314-356 | Siltstone, greenish-gray |
| 356-358 | Sandstone 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

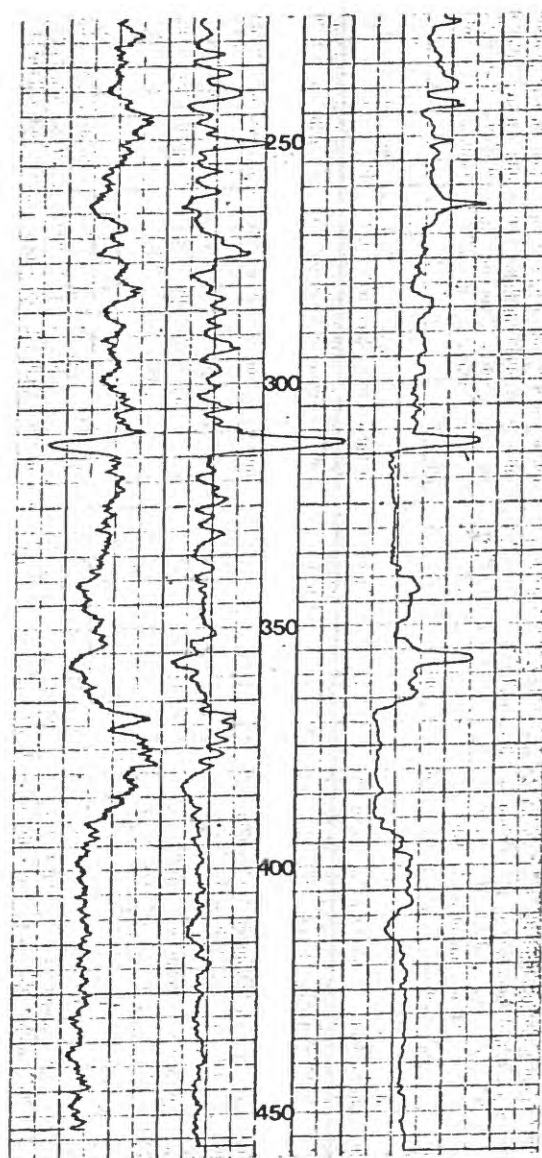
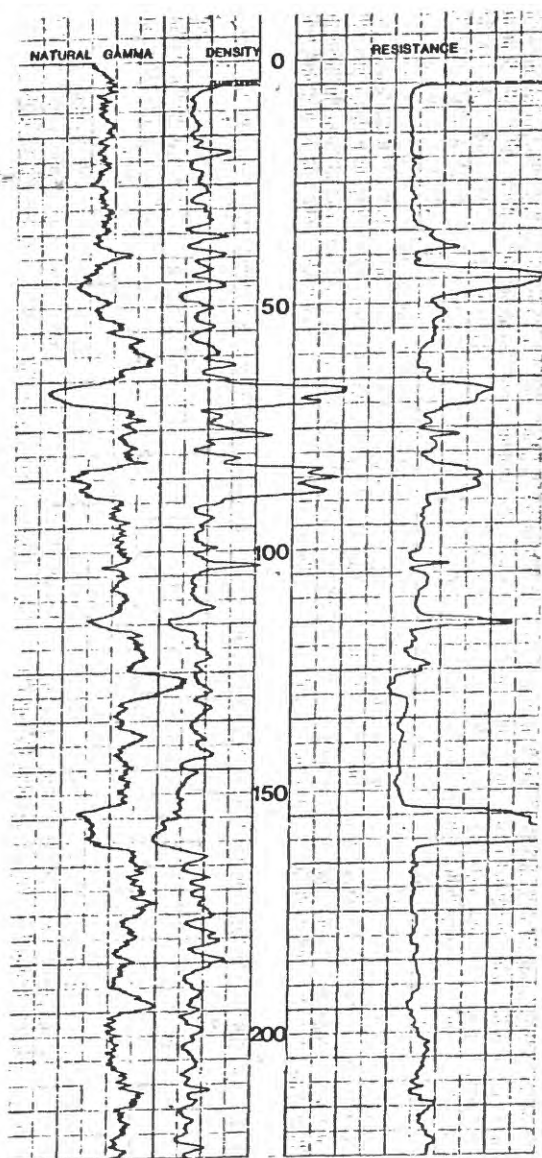


Figure 56.--Geophysical logs of hole GS-55

Sample log

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

| Depth (feet) | Lithic description |
|-----------------|--|
| 0-45 | Silt, sand, and gravel, light-olive-gray, unconsolidated |
| 45-90 | Sandstone, grayish-orange to medium-light-gray, very fine grained |
| 90-116 | Sandstone, very light gray, very fine grained; with thin interbedded claystone |
| 116-145 | Siltstone, medium-light-gray; traces of organic debris |
| 145-169 | Siltstone, light-gray; claystone parting 158 to 163 ft |
| 169-187 | Claystone, light-gray |
| 187-201 | Sandstone, very light gray, very fine grained; interbedded with claystone at base |
| 201-205 | Lignite, black; ("B" lignite bed) |
| 205-228 | Siltstone, light-gray; probable coal 222 to 224 ft |
| 228-231 | Lignite, black, impure |
| 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; grades to claystone 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; ("AB" lignite bed) |
| 344-350 | Claystone, light-gray; coal 349 to 350 ft |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 350-367 | Claystone, light-gray, silty |
| 367-394 | Siltstone, medium-light-gray; with interbedded claystone |
| 394-397 | Lignite, black, impure |
| 397-416 | Claystone, light-gray |
| 416-419 | Lignite, black, impure |
| 419-440 | Siltstone, light-gray to medium-light-gray; coal bed 434 to 435 ft |
| 440-446 | Lignite, black; ("AA" lignite bed) |
| 446-480 | Sandstone, light-gray, very fine grained |
| 480-492 | Claystone, medium-gray |
| 492-497 | Lignite, black; ("A" Rider lignite bed) |
| 497-500 | Claystone, medium-gray |
| 500-503 | Lignite, black; ("A" lignite bed) |
| 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

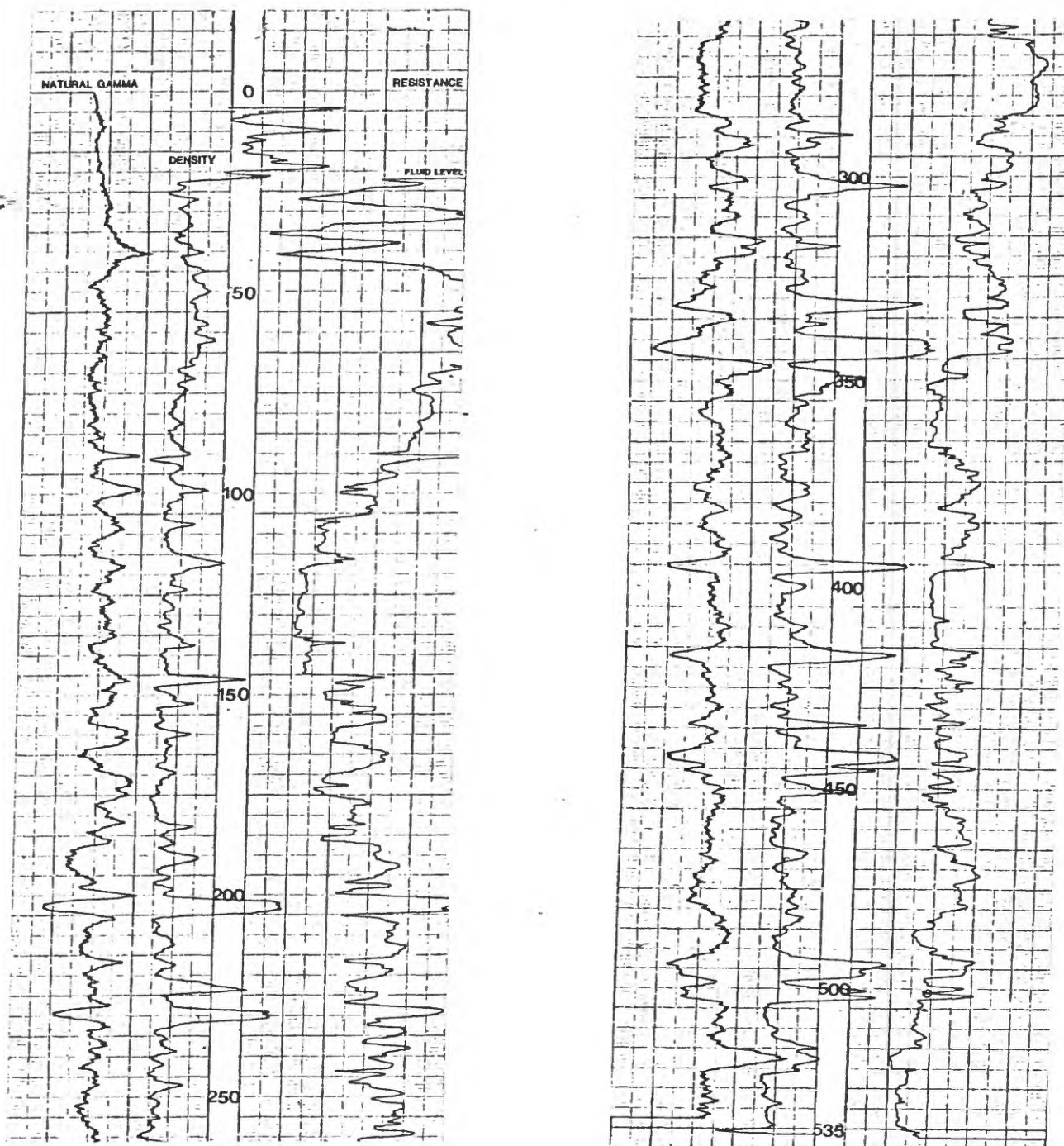


Figure 57.--Geophysical logs of hole GS-56

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; (Lower Smoke Creek lignite bed 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; ("B" lignite bed) |
| 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 |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 437-453 | Siltstone, medium-light-gray; coal 450 to 451 ft |
| 453-459 | Lignite, black; ("AB" lignite bed) |
| 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

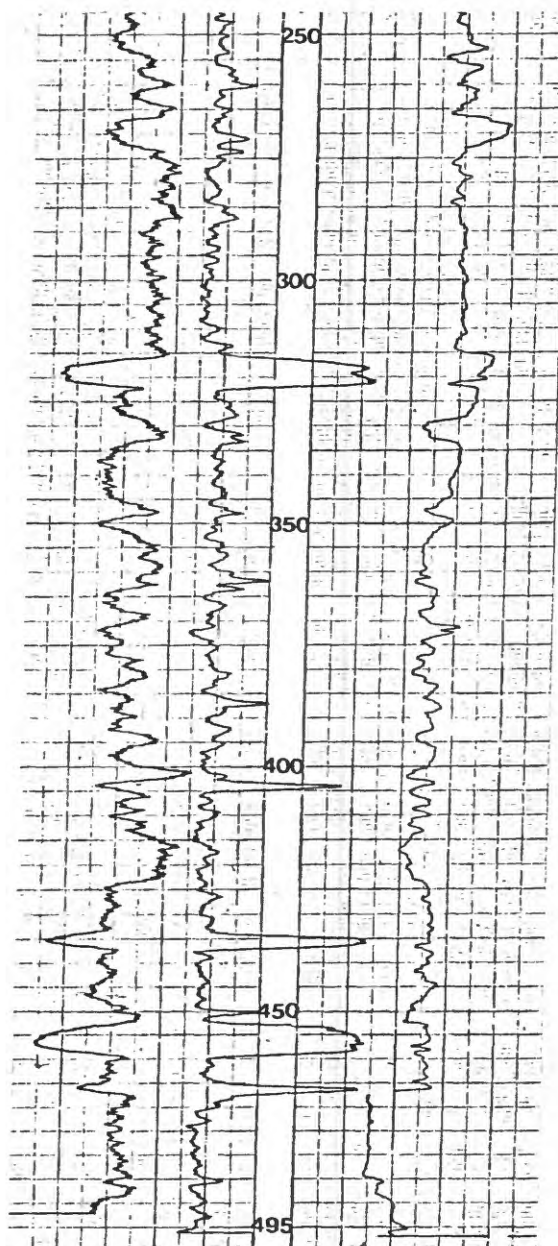
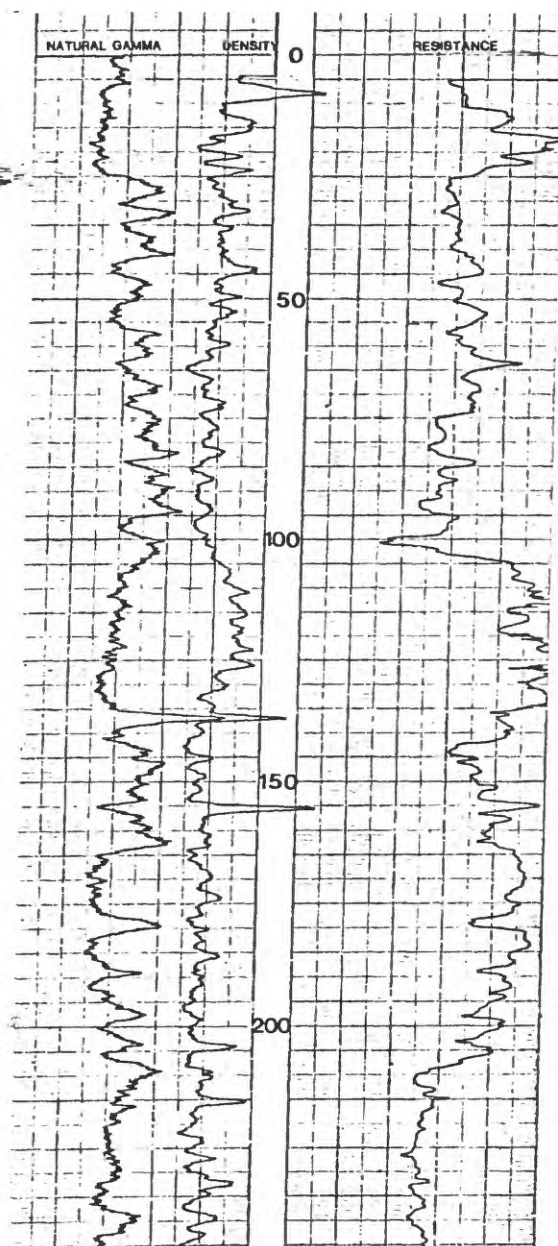


Figure 58.--Geophysical logs of hole GS-57

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; ("B" lignite bed) |
| 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; ("AB" Rider lignite bed) |
| 347-348 | Claystone, medium-gray; ("AB" Rider lignite bed) |
| 348-352 | Lignite, black; ("AB" Rider lignite bed) |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 352-374 | Siltstone, medium-light-gray |
| 374-375 | Lignite, black; ("AB" lignite bed) |
| 375-376 | Claystone, light-gray to medium-light-gray |
| 376-378 | Lignite, black; ("AB" lignite bed) |
| 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

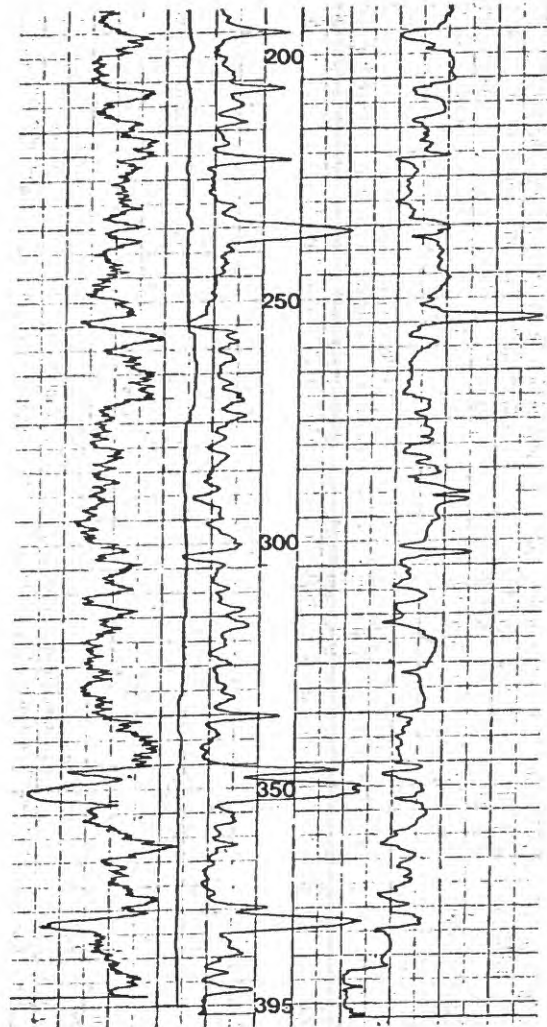
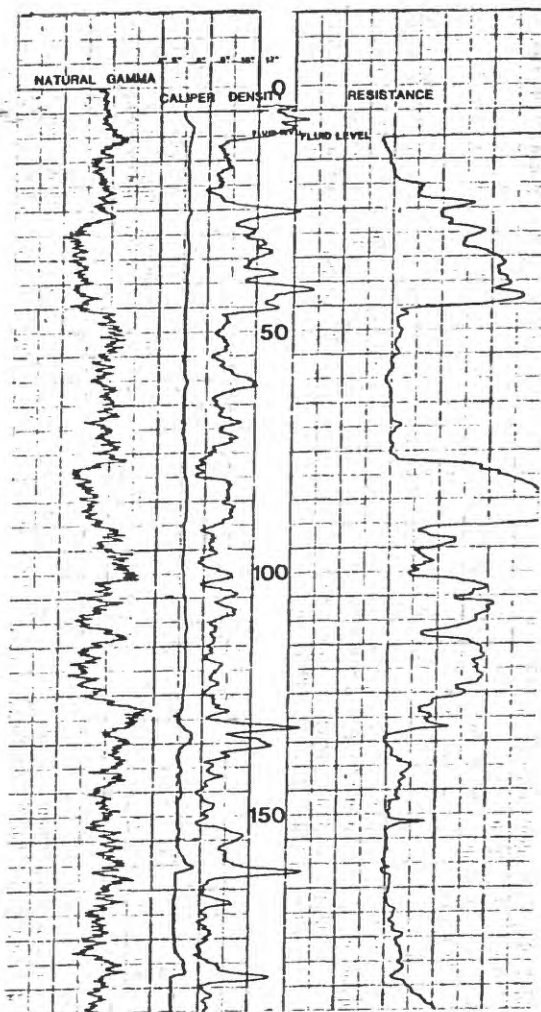


Figure 59.--Geophysical logs of hole GS-58

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; (Smoke Creek lignite bed) |
| 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; (Lower Smoke Creek lignite bed) |
| 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; ("BC" lignite bed) |
| 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 |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|---|
| 274-330 | Siltstone, medium-gray to olive-gray, sandy; calcareous concretions at 287 and 299 ft; slightly carbonaceous between 295 and 305 ft |
| 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

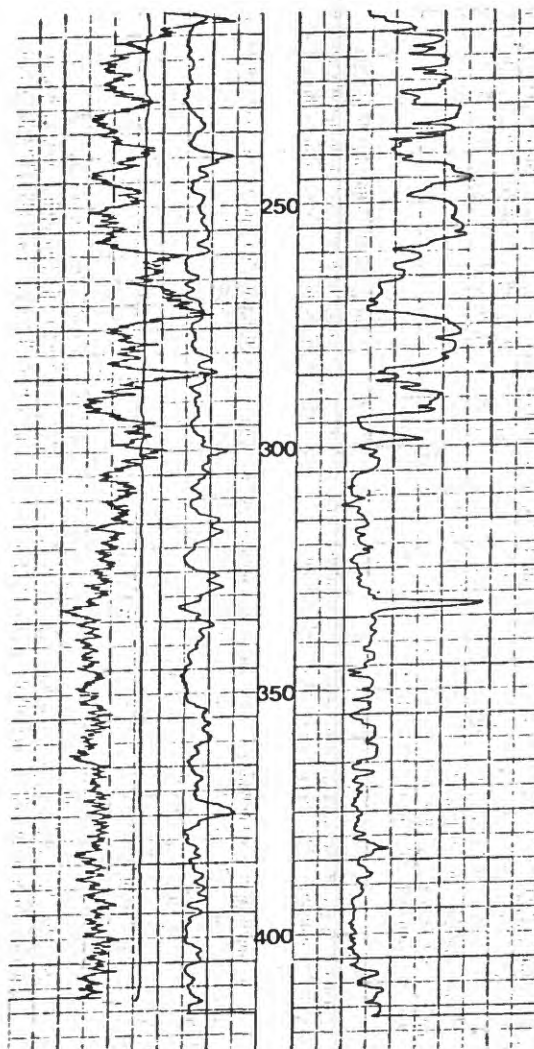
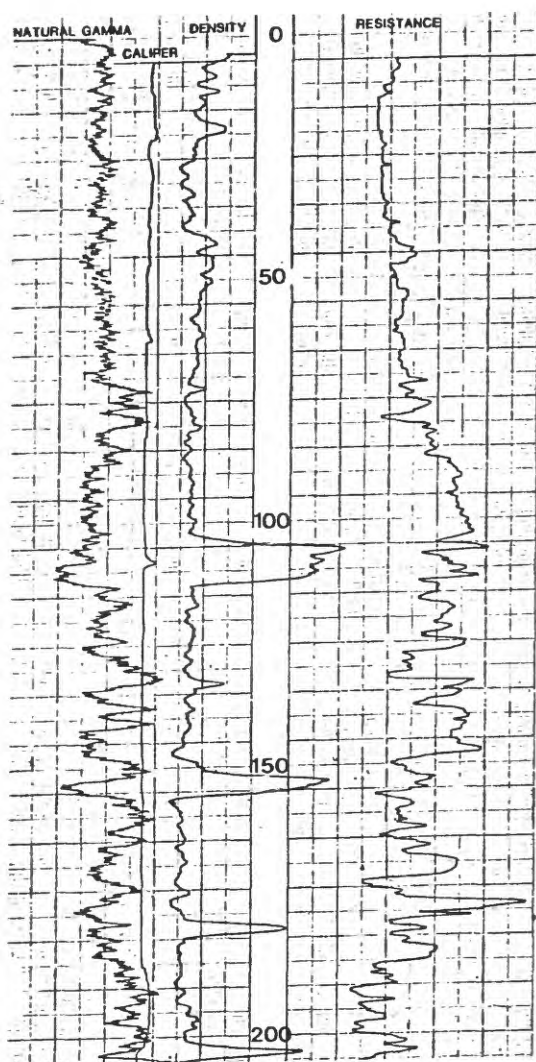


Figure 60.--Geophysical logs of hole GS-59

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; ("C" lignite bed) |
| 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; (Smoke Creek lignite bed) |
| 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; (Lower Smoke Creek lignite bed) |
| 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; ("BC" lignite bed) |
| 229.5-235 | Claystone and siltstone, greenish-gray |

Sample log--continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 235-236.5 | Lignite, black; ("BC" Leader lignite bed) |
| 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

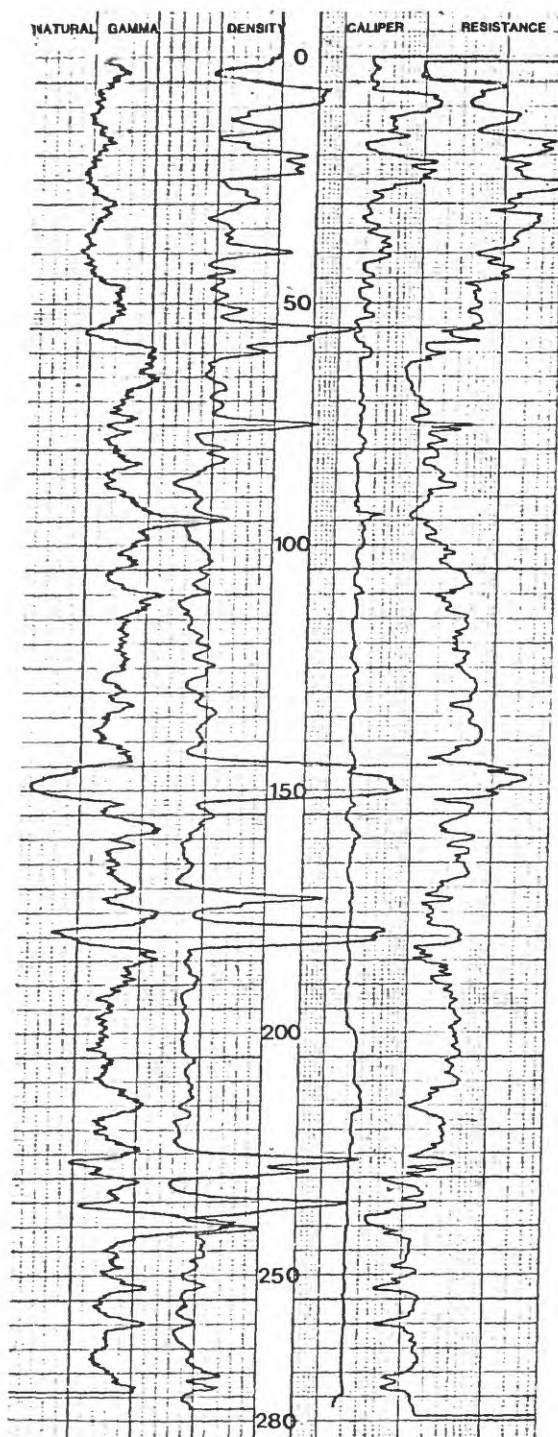


Figure 61.--Geophysical logs of hole GS-60

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, unconsolidated; 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; (Upper Timber Coulee lignite bed) |
| 61.5-67.5 | Claystone and siltstone, light-greenish-gray to medium-gray; (Upper Timber Coulee lignite bed) |
| 67.5-69.5 | Lignite, black; (Upper Timber Coulee lignite bed) |
| 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; (Lower Timber Coulee lignite bed) |
| 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; (Timber Coulee Leader lignite bed) |
| 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 |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|---|
| 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 |
| 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; (Lower Smoke Creek lignite bed) |
| 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; ("BC" lignite bed) |
| 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; ("BC" Leader lignite bed) |
| 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

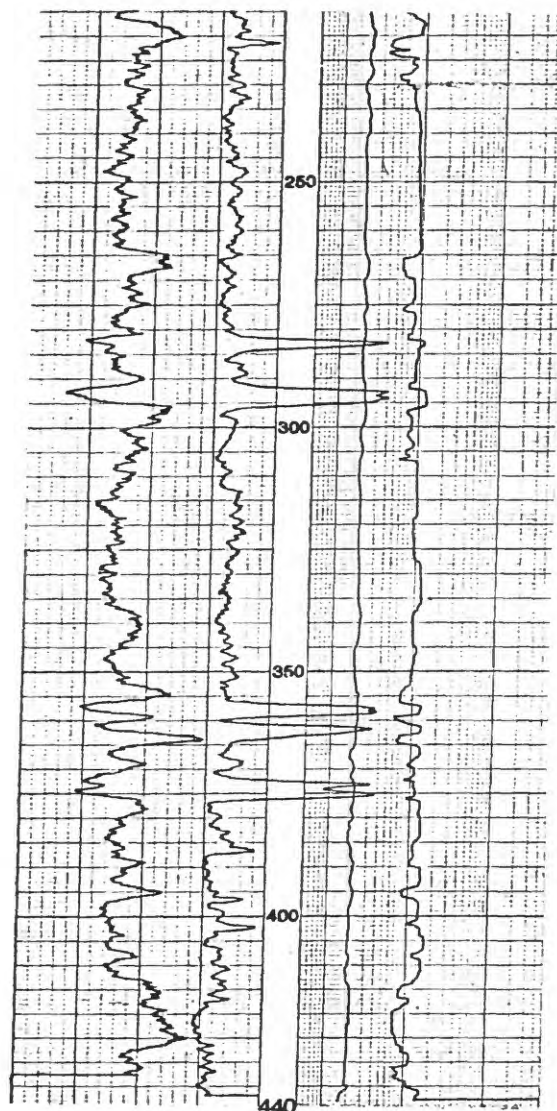
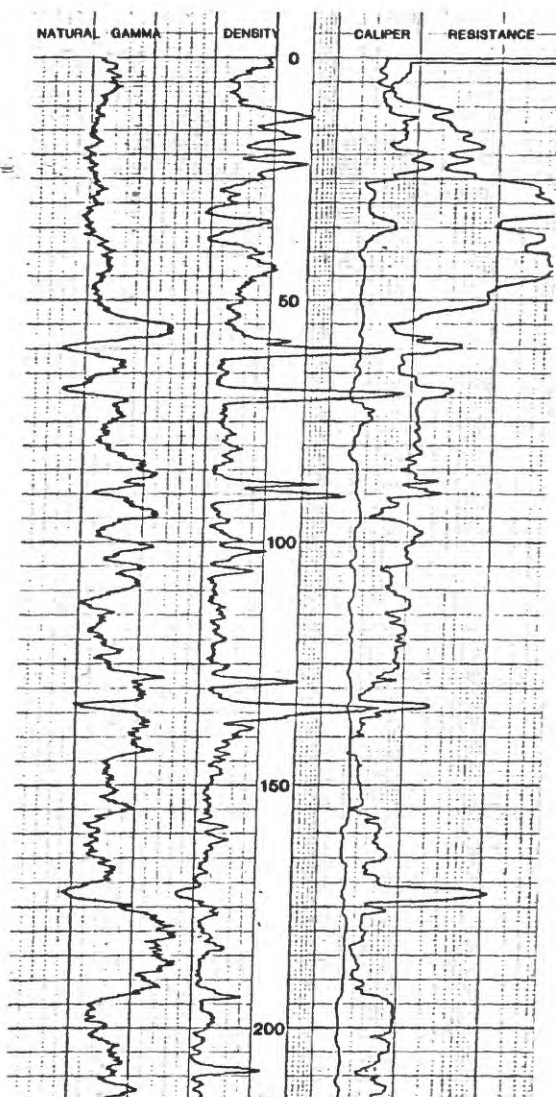


Figure 62.--Geophysical logs of hole GS-61

Sample log

Hole no.: GS-62 Date: 10-19-80 State: Montana County: Roosevelt
 Elev. (ground): 2122 ft Location: T. 31 N., R. 54 E., Sec. SW SW 22
 Total depth: 380 ft Drilling medium: mud Offset core hole: none

| Depth (feet) | Lithic description |
|-----------------|---|
| 0-14 | Sand, silt, and clay, pale-yellowish-brown to dark-yellowish-brown, unconsolidated |
| 14-16 | Claystone, light-brownish-gray |
| 16-19 | Carbonaceous shale and impure coal, dark-gray to brownish-black |
| 19-20 | Lignite, black |
| 20-25 | Siltstone and silty claystone, light-brown |
| 25-48 | Sandstone, light-brownish-gray, very fine grained; hard calcareous concretion at 35 ft |
| 48-50.5 | Lignite, brownish-black to black; impure in lower part; (Upper Timber Coulee lignite bed) |
| 50.5-96 | Sandstone, light-greenish-gray to light-bluish-gray, very fine grained, silty; calcareous concretions at 58 ft and at base |
| 96-105 | Claystone, light-greenish-gray |
| 105-106 | Lignite, black; (Timber Coulee Leader lignite bed) |
| 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; (Smoke Creek lignite bed) |
| 249-281 | Siltstone and claystone, light-greenish-gray; chiefly siltstone grading to silty claystone and claystone in upper part |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 281-282 | Lignite, black |
| 282-286 | Claystone, light-olive-gray |
| 286-290.5 | Lignite, brownish-black to black; probably impure in lower part; (Lower Smoke Creek lignite bed) |
| 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; ("BC" lignite bed) |
| 331-333.5 | Claystone, light-olive-gray to dark-gray, carbonaceous; ("BC" lignite bed) |
| 333.5-334.5 | Lignite, black; ("BC" lignite bed) |
| 334.5-339.5 | Claystone, dark-gray |
| 339.5-340.5 | Lignite, brownish-black to black; ("BC" Leader lignite bed) |
| 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

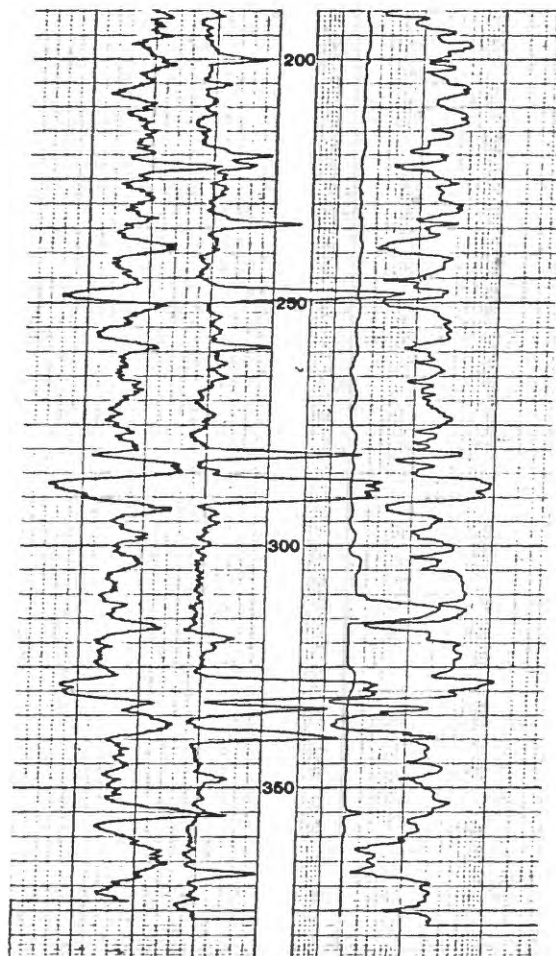
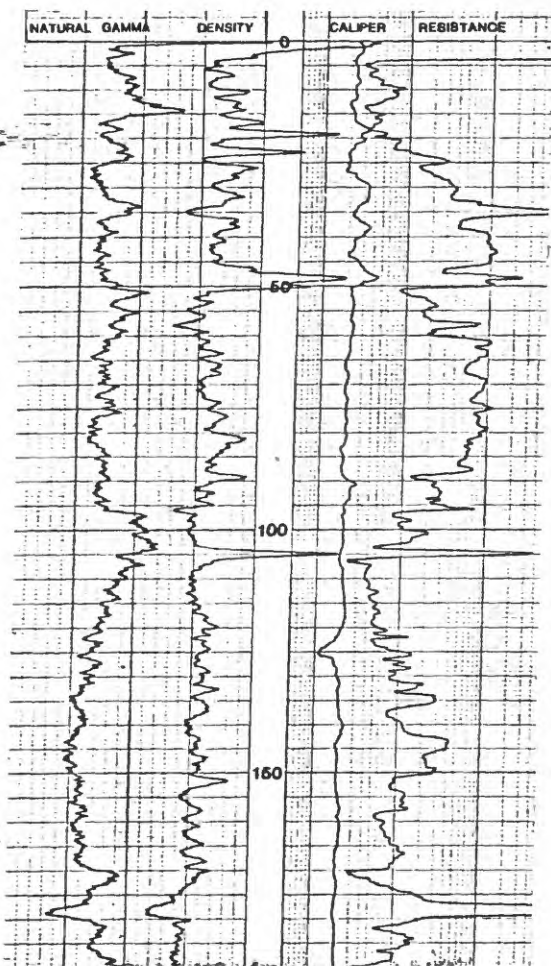


Figure 63.--Geophysical logs of hole GS-62

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; (Upper Timber Coulee lignite bed) |
| 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; (Lower Timber Coulee lignite bed) |
| 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; (Timber Coulee Leader lignite bed) |
| 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, impure; ("C" lignite bed) |
| 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 |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 225-239 | Sandstone, light-greenish-gray, silty |
| 239-245 | Lignite, brownish-black to black; grades impure in upper part; (Smoke Creek lignite bed) |
| 245-260 | Sandstone, light-gray to greenish-gray, very fine grained; calcar- eous 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; (Lower Smoke Creek lignite bed) |
| 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

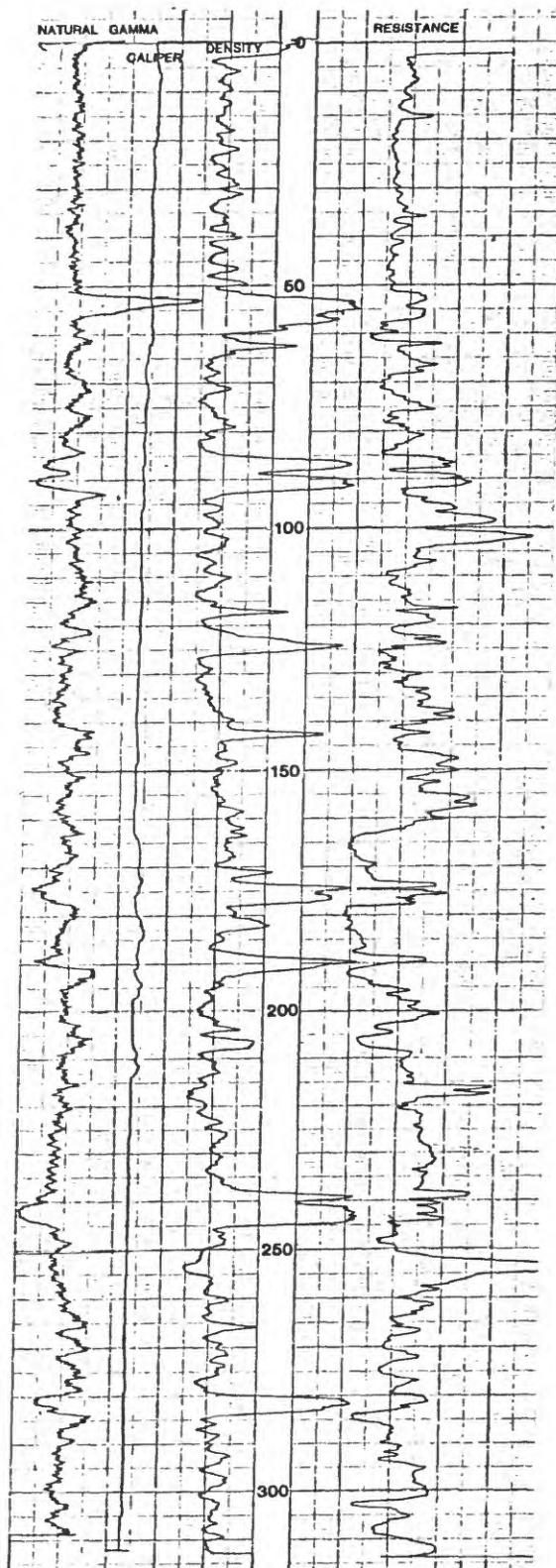


Figure 64.--Geophysical logs of hole GS-63

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; (Lower Timber Coulee lignite bed) |
| 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; (Smoke Creek lignite bed) |
| 212-234 | Siltstone, light-gray, slightly sandy |
| 234-239 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 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

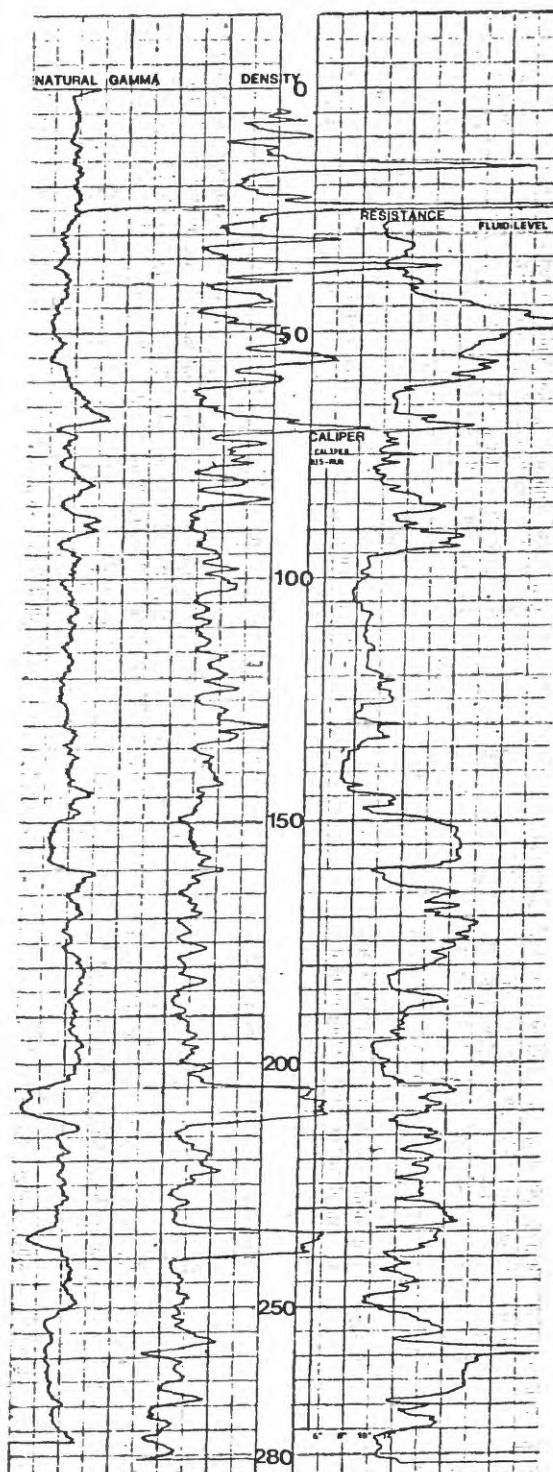


Figure 65.--Geophysical logs of hole GS-64

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; (Upper Timber Coulee lignite bed) |
| 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; (Lower Timber Coulee lignite bed) |
| 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; (Timber Coulee Leader lignite bed) |
| 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; (Smoke Creek lignite bed) |
| 240.5-274 | Sandstone, light-greenish-gray, silty; grades to claystone in lower part |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 274-278 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 278-302.5 | Siltstone, light-greenish-gray to greenish-gray; includes scattered thinly interbedded silty claystone |
| 302.5-303.5 | Lignite, black; ("BC" lignite bed) |
| 303.5-315 | Siltstone, light-greenish-gray |
| 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

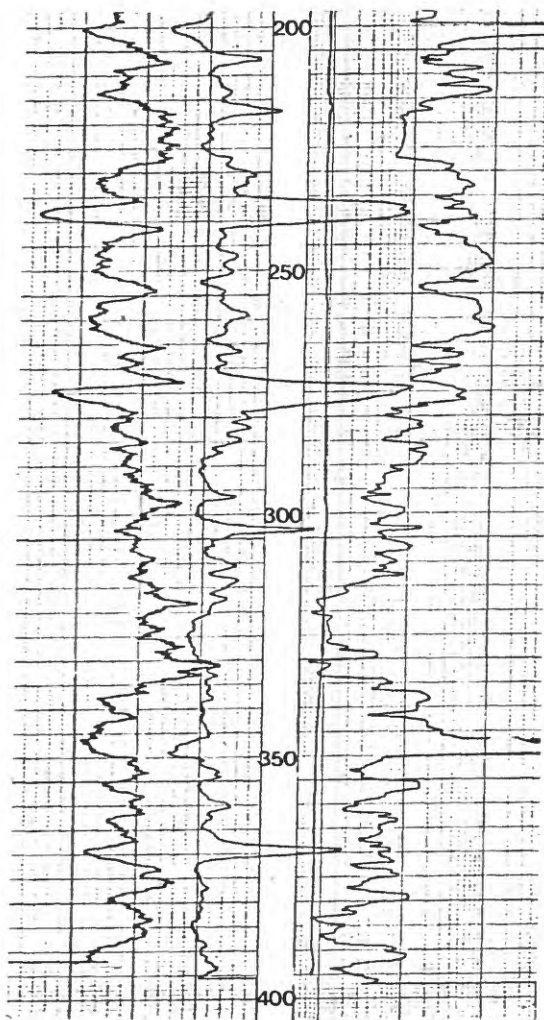
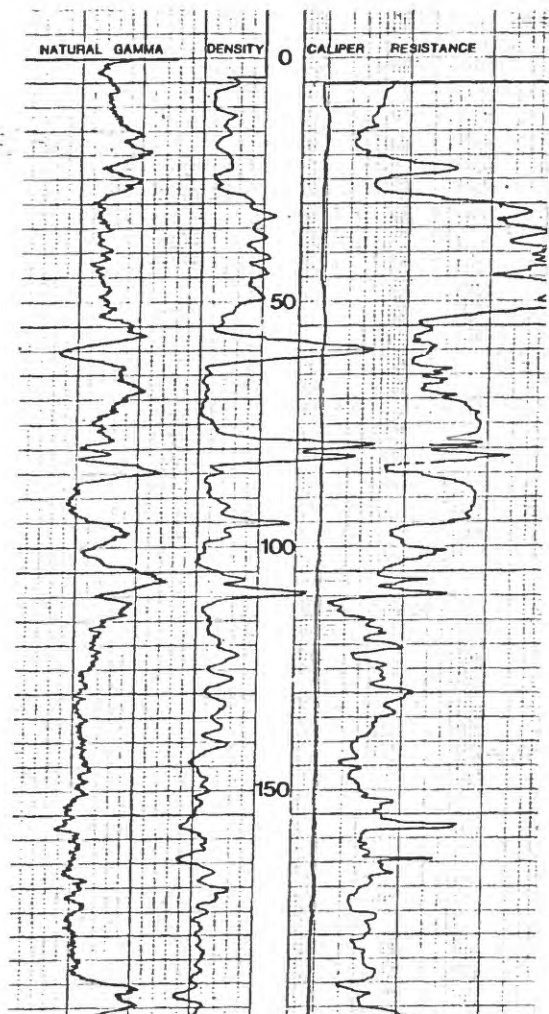


Figure 66.--Geophysical logs of hole GS-65

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 |
| 25-37 | Claystone, light-greenish-gray to grayish-brown |
| 37-38 | Lignite, black; (Upper Timber Coulee lignite bed) |
| 38-47 | Siltstone, light-greenish-gray |
| 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; (Smoke Creek lignite bed) |
| 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; (Lower Smoke Creek lignite bed) |
| 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; ("BC" lignite bed) |
| 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 |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 363-374 | Claystone, light-olive-gray; thin impure coal at 365 ft |
| 374-400 | Siltstone, light-olive-gray; includes scattered thinly inter-bedded 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

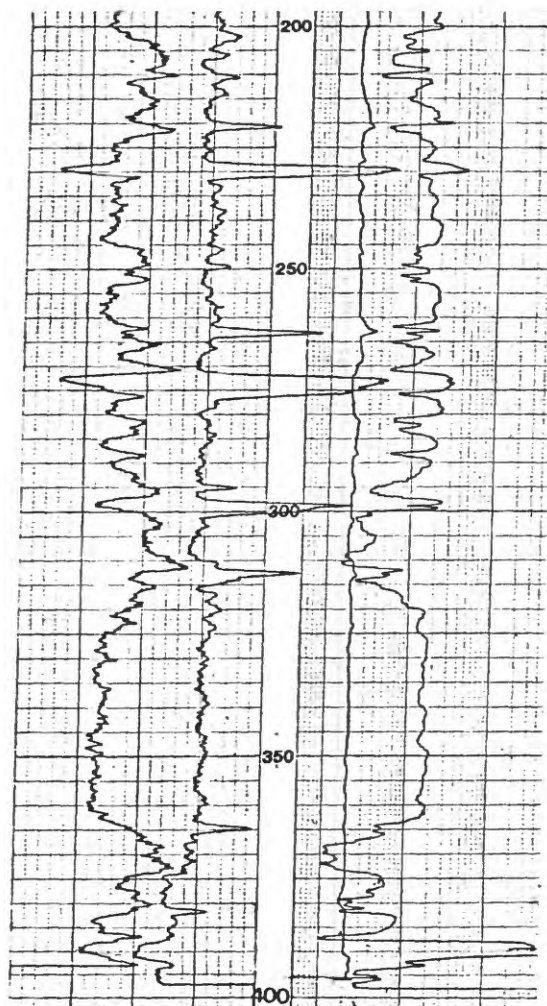
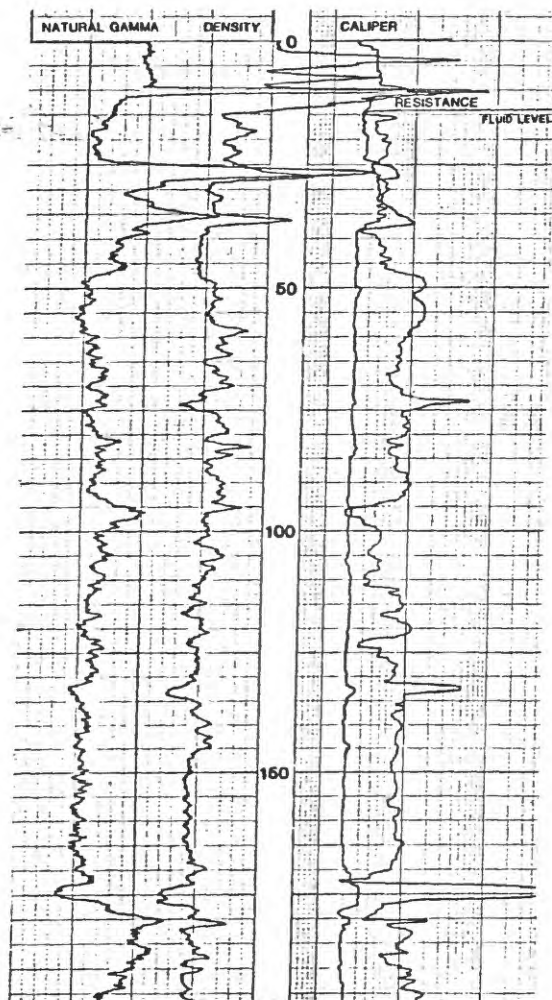


Figure 67.--Geophysical logs of hole GS-66

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; coal from 73 to 74 ft |
| 75-99 | Siltstone, light-olive-gray, sandy |
| 99-104 | Lignite, black; (Upper Timber Coulee lignite bed) |
| 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; (Lower Timber Coulee lignite bed) |
| 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 | Lignite, black; (Timber Coulee Leader lignite bed) |
| 153-163.5 | Claystone, light-olive-gray |
| 163.5-165 | Lignite, brownish-black |
| 165-172 | Claystone, light-olive-gray |
| 172-190 | Siltstone, light-greenish-gray, sandy |

Sample log-- Continued

| Depth (feet) | Lithic description |
|--------------------|--|
| 190-191 | Lignite, brownish-black; ("C" lignite bed) |
| 191-200 | Siltstone, light-greenish-gray |
| 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; (Lower Smoke Creek lignite bed) |
| 306-338 | Siltstone, light-greenish-gray; includes some scattered thinly interbedded claystone; grades to claystone at top |
| 338-341 | Lignite, brownish-black to black; ("BC" lignite bed) |
| 341-348.8 | Claystone, light-gray; includes coal between 344 and 345 ft |
| 348.8-351 | Lignite, black; ("BC" Leader lignite bed) |
| 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

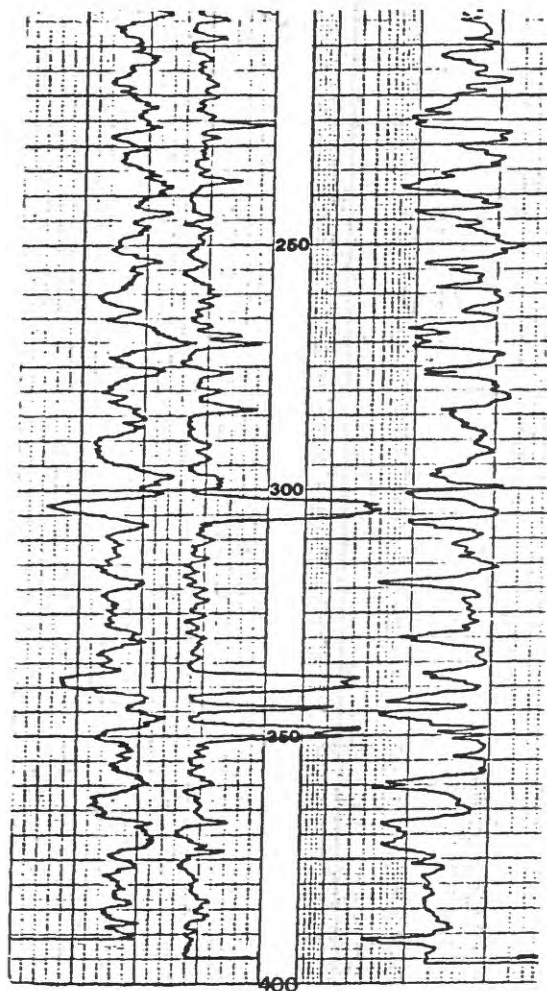
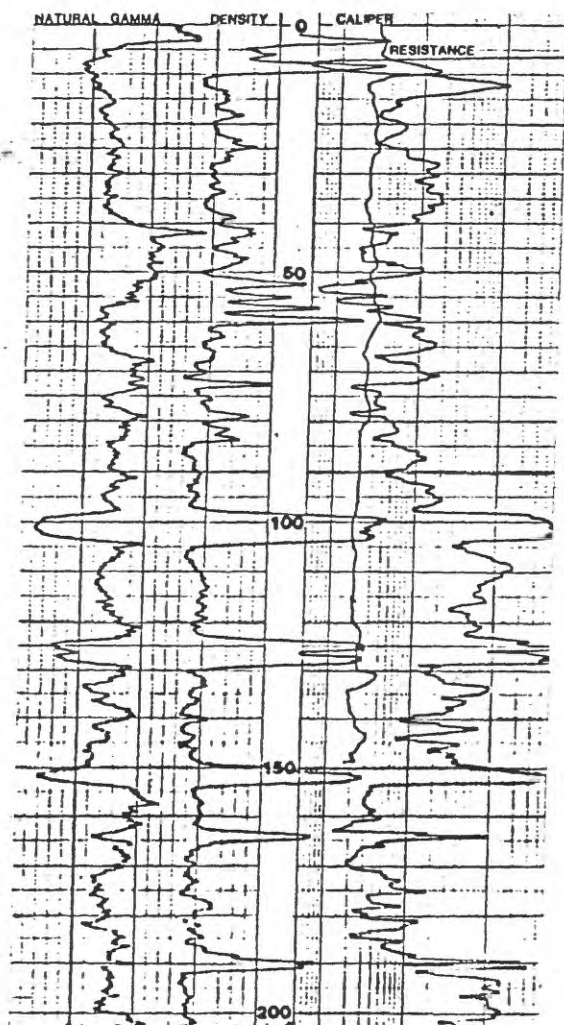


Figure 68.--Geophysical logs of hole GS-67

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 |
| 120-185 | 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; includes thin coal at 182.5 ft |
| 185-230 | Sandstone, light-greenish-gray, very fine grained; grades to siltstone at top and to silty claystone at base |
| 230-235 | Lignite, black; (Timber Coulee lignite bed) |
| 235-237.3 | Carbonaceous shale, medium-dark-gray to brownish-black; (Timber Coulee lignite bed) |
| 237.3-241.5 | Lignite, brownish-black to black; includes 0.8 ft of impure coal in middle of unit; (Timber Coulee lignite bed) |
| 241.5-264 | Siltstone and sandstone, light-greenish-gray; silty at top and base, sandy in middle |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|--|
| 264-266 | Lignite, brownish-black to black; impure from 264 to 265 ft; (Timber Coulee lignite bed) |
| 266-270 | Claystone, brownish-gray to brownish-black, carbonaceous |
| 270-275 | Siltstone, light-brownish-gray to brownish-gray, slightly carbonaceous |
| 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; (Lower Smoke Creek lignite bed) |
| 423.5-435 | Claystone, medium-gray to olive-gray, silty, 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

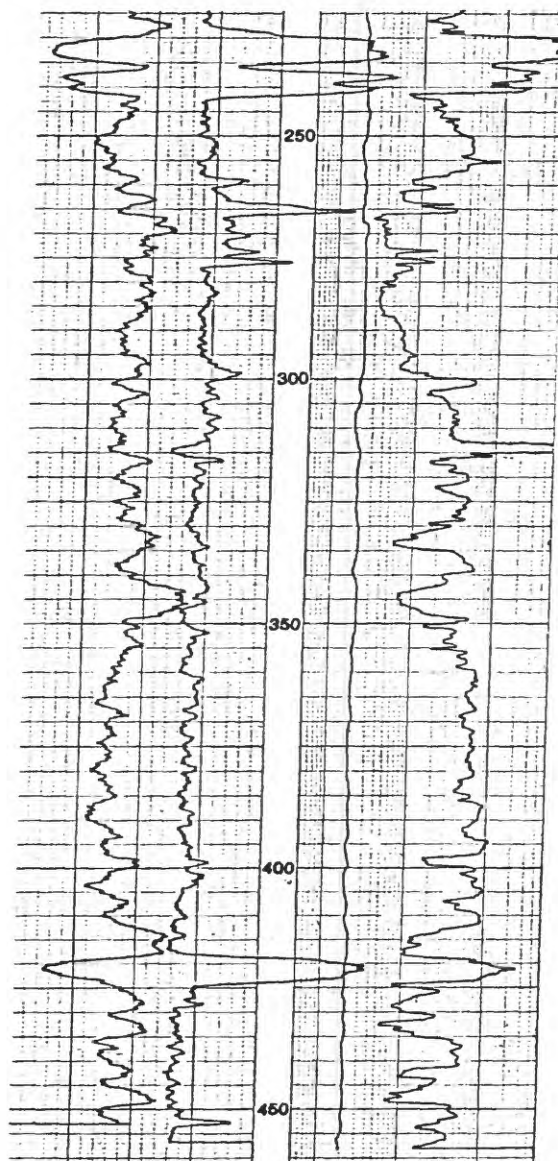
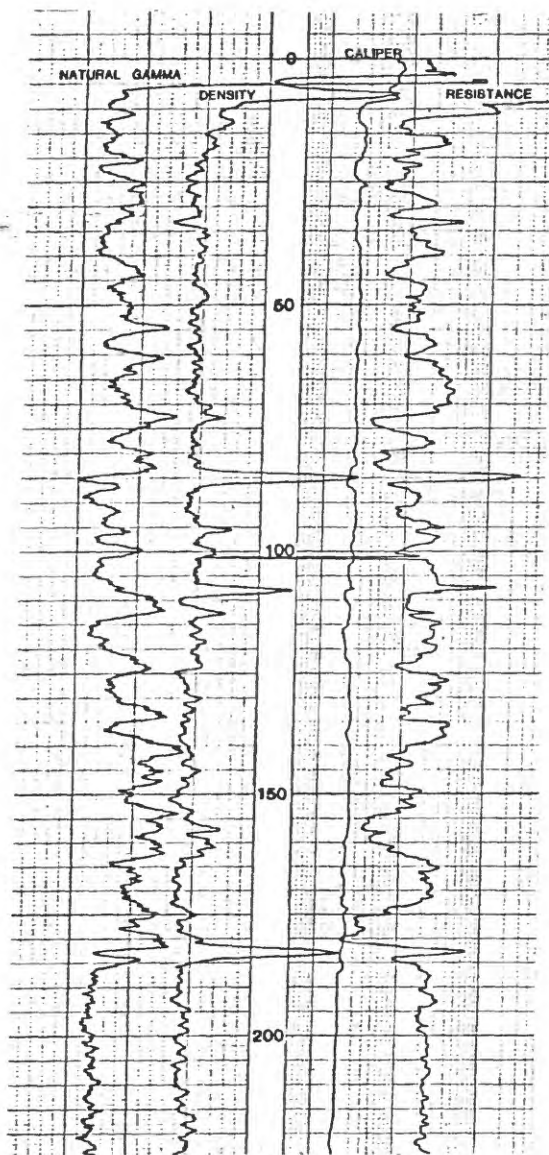


Figure 69.--Geophysical logs of hole GS-68

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; (Upper Timber Coulee lignite bed) |
| 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; (Lower Timber Coulee lignite bed) |
| 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 |
| 240-241 | Lignite, brownish-black, impure; (Timber Coulee Leader lignite bed) |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 241-248 | Claystone, brownish-gray to brownish-black, carbonaceous |
| 248-263 | Siltstone and sandstone, medium-light-gray to light-olive-gray; siltstone in upper part grades downward to silty sandstone in lower part |
| 263-265 | Lignite, black |
| 265-269 | Claystone, brownish-gray to light-olive-gray, 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 |
| 355-369 | Siltstone and claystone, light-olive-gray; alternating thin to thick sequences of siltstone and claystone |
| 369-370 | Lignite, black; (Smoke Creek lignite bed) |
| 370-397 | Siltstone and claystone, light-olive-gray |
| 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; (Lower Smoke Creek lignite bed) |
| 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 |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 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

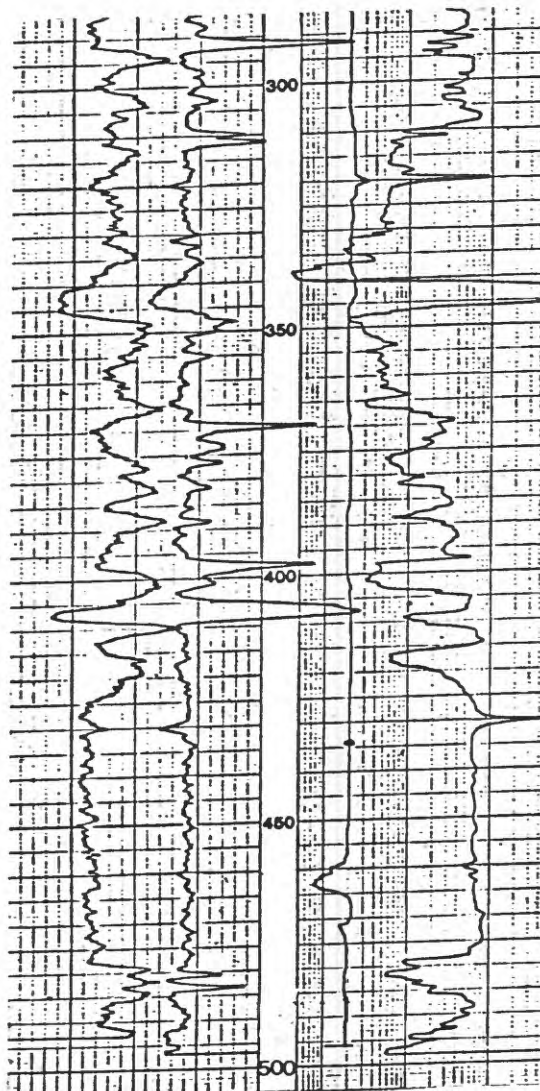
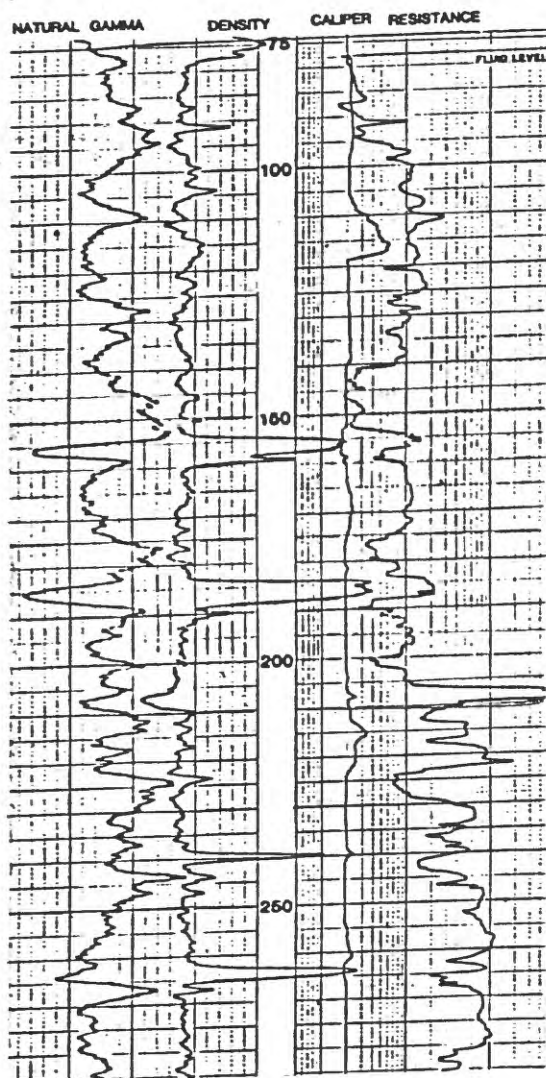


Figure 70.--Geophysical logs of hole GS-69

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; (Upper Timber Coulee lignite bed) |
| 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; (Lower Timber Coulee lignite bed) |
| 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

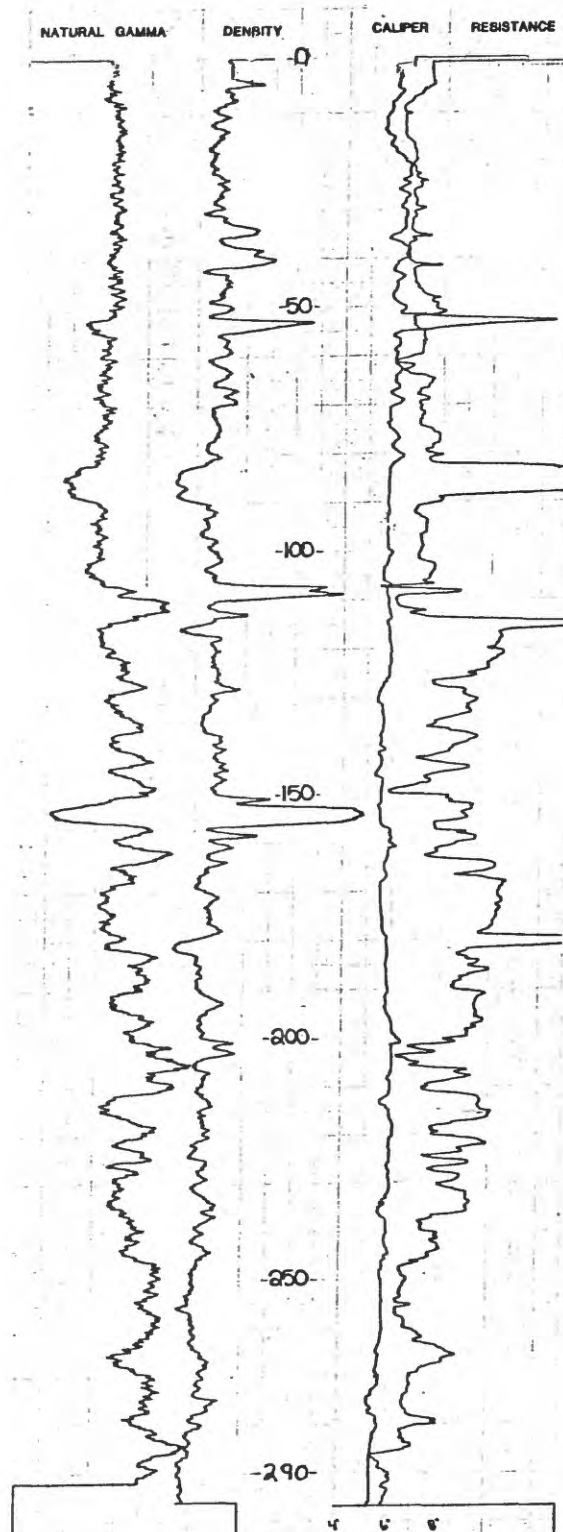


Figure 71.--Geophysical logs of hole GS-70

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; (Timber Coulee Rider lignite bed) |
| 33-63 | Sandstone, yellowish-gray, very fine grained, micaceous |
| 63-74 | Claystone, light-gray to yellowish-gray, slightly silty |
| 74-80 | Lignite, black; (Upper Timber Coulee lignite bed) |
| 80-83 | Claystone, light-gray |
| 83-86 | Lignite, black; (Lower Timber Coulee lignite bed) |
| 86-105 | Claystone, light-gray |
| 105-107 | Lignite, black; (Timber Coulee Leader lignite bed) |
| 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 coal 246 to 247 ft; (Lower Smoke Creek lignite bed 254 to 255 ft) |
| 262-266 | Shale, grayish-black, carbonaceous |
| 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

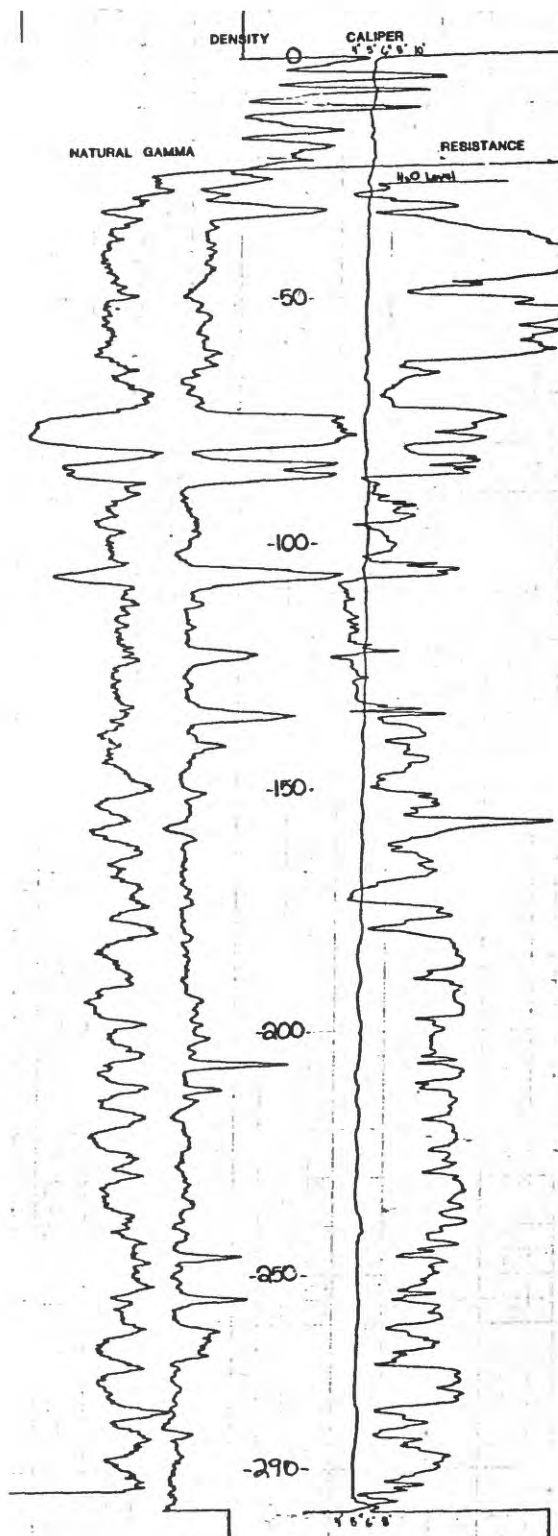


Figure 72.--Geophysical logs of hole GS-71

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; (Local "R" lignite bed) |
| 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; (Upper Timber Coulee lignite bed) |
| 165-186 | Siltstone, very light gray; grades to claystone at top |
| 186-202 | Siltstone, light-olive-gray; with interbedded claystone |
| 202-206 | Lignite, black; (Lower Timber Coulee lignite bed) |
| 206-213 | Claystone, light-gray, slightly silty; traces of organic debris |
| 213-215 | Lignite, black; (Timber Coulee Leader lignite bed) |
| 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; some 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

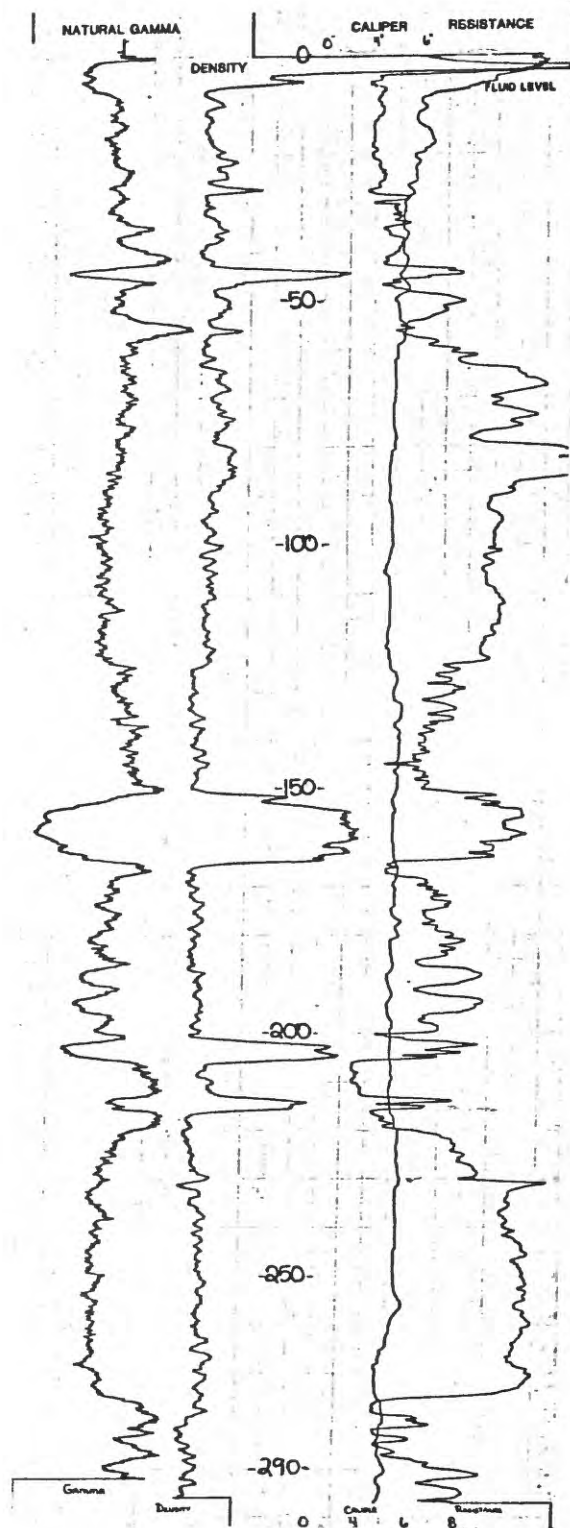


Figure 73.—Geophysical logs of hole GS-72

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; (Local "R" lignite bed) |
| 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, impure; (Timber Coulee Rider lignite bed) |
| 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; (Timber Coulee lignite bed) |
| 163-178 | Siltstone, light-gray |
| 178-182 | Lignite, black; (Timber Coulee Leader lignite bed) |
| 182-187 | Claystone, light-gray |
| 187-200 | Siltstone, light-gray, sandy |
| 200-202 | Lignite, black |
| 202-247 | Siltstone, light-gray to yellowish-gray; includes some interbedded claystone |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 247-263 | Siltstone, olive-gray to light-olive-gray; interbedded with claystone at top and base of interval |
| 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; (Lower Smoke Creek lignite bed) |
| 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

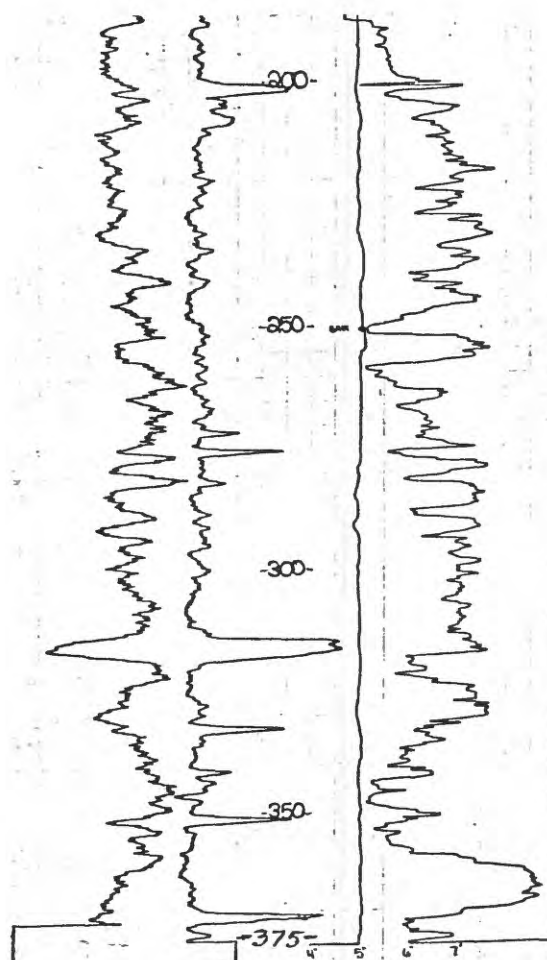
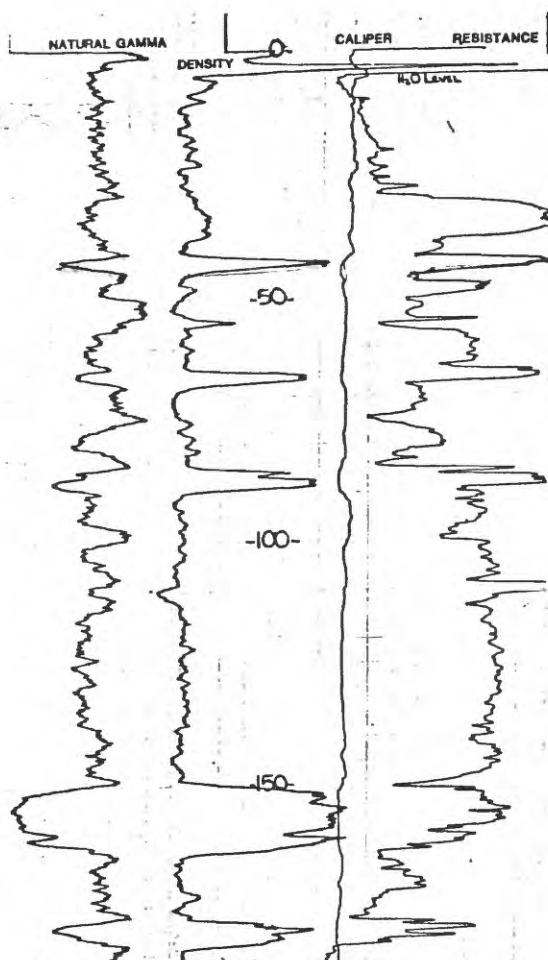


Figure 74.--Geophysical logs of hole GS-73

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; (Local "R" lignite bed) |
| 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; (Timber Coulee lignite bed) |
| 142-186 | Siltstone, light-gray to very light gray; claystone parting 174 to 181 ft |
| 186-189 | Lignite, black; (Timber Coulee Leader lignite bed) |
| 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 |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 305-312 | Claystone, medium-light-gray; includes coal between 310 and 311 ft |
| 312-315 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 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; ("BC" lignite bed) |
| 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

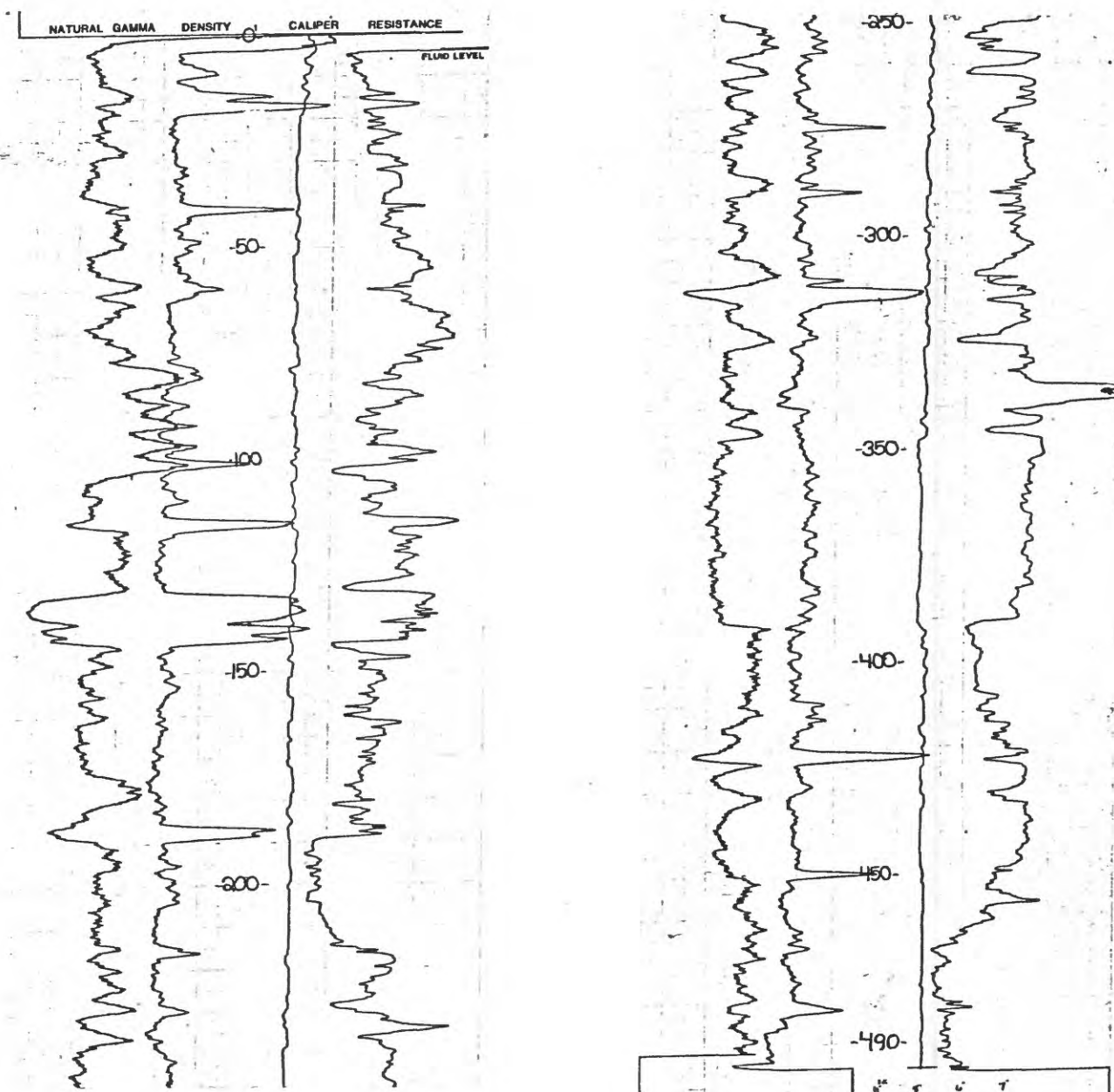


Figure 75.--Geophysical logs of hole GS-74

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, impure; (Upper Timber Coulee lignite bed) |
| 204-214 | Claystone, very light gray, silty |
| 214-231 | Siltstone, olive-gray to light-olive-gray, sandy |
| 231-234 | Lignite, black; (Lower Timber Coulee lignite bed) |
| 234-305 | Claystone, light-to very light gray, silty; probable coal 284 to 285 ft; (Timber Coulee Leader lignite bed 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; (Smoke Creek lignite bed) |
| 364-391 | Siltstone and claystone; light-gray to very light gray, sandy; probable coal 373 to 374 ft |
| 391-395 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 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

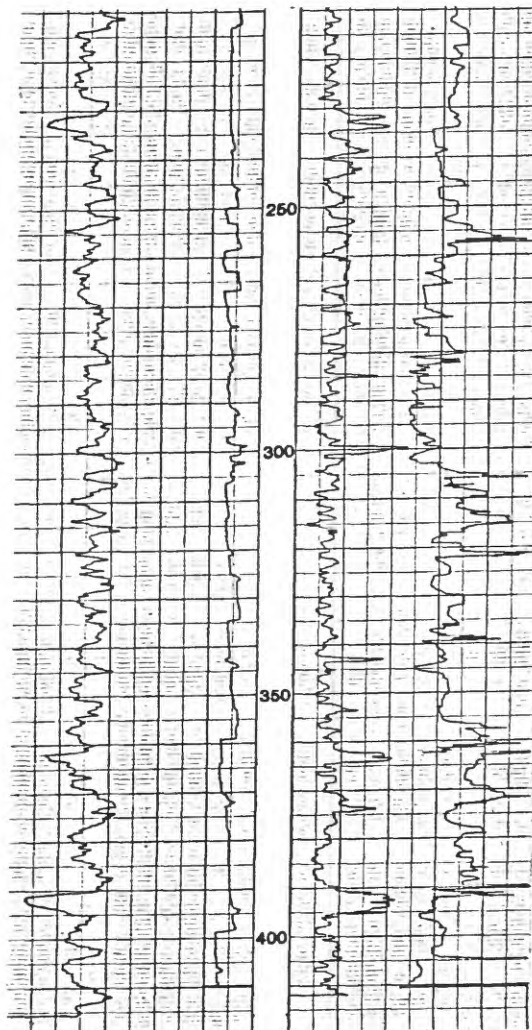
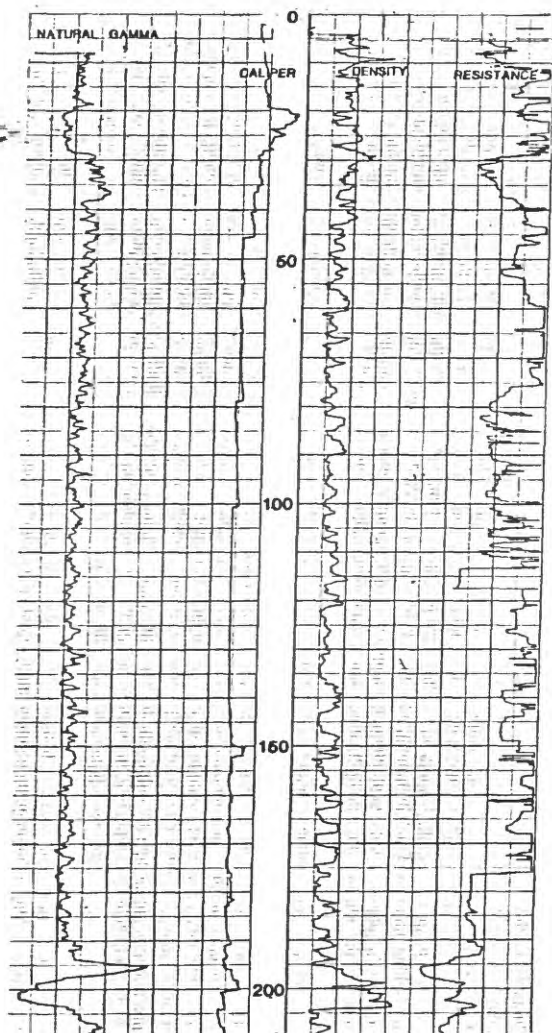


Figure 76.--Geophysical logs of hole GS-75

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 |
| 50-68 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; (Upper Timber Coulee lignite bed) |
| 136-153 | Claystone, light-gray |
| 153-156 | Lignite, black; (Lower Timber Coulee lignite bed) |
| 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; (Timber Coulee Leader lignite bed) |
| 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 |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 331-335 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 335-349 | Claystone; grades silty near top of interval |
| 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; ("BC" lignite bed) |
| 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

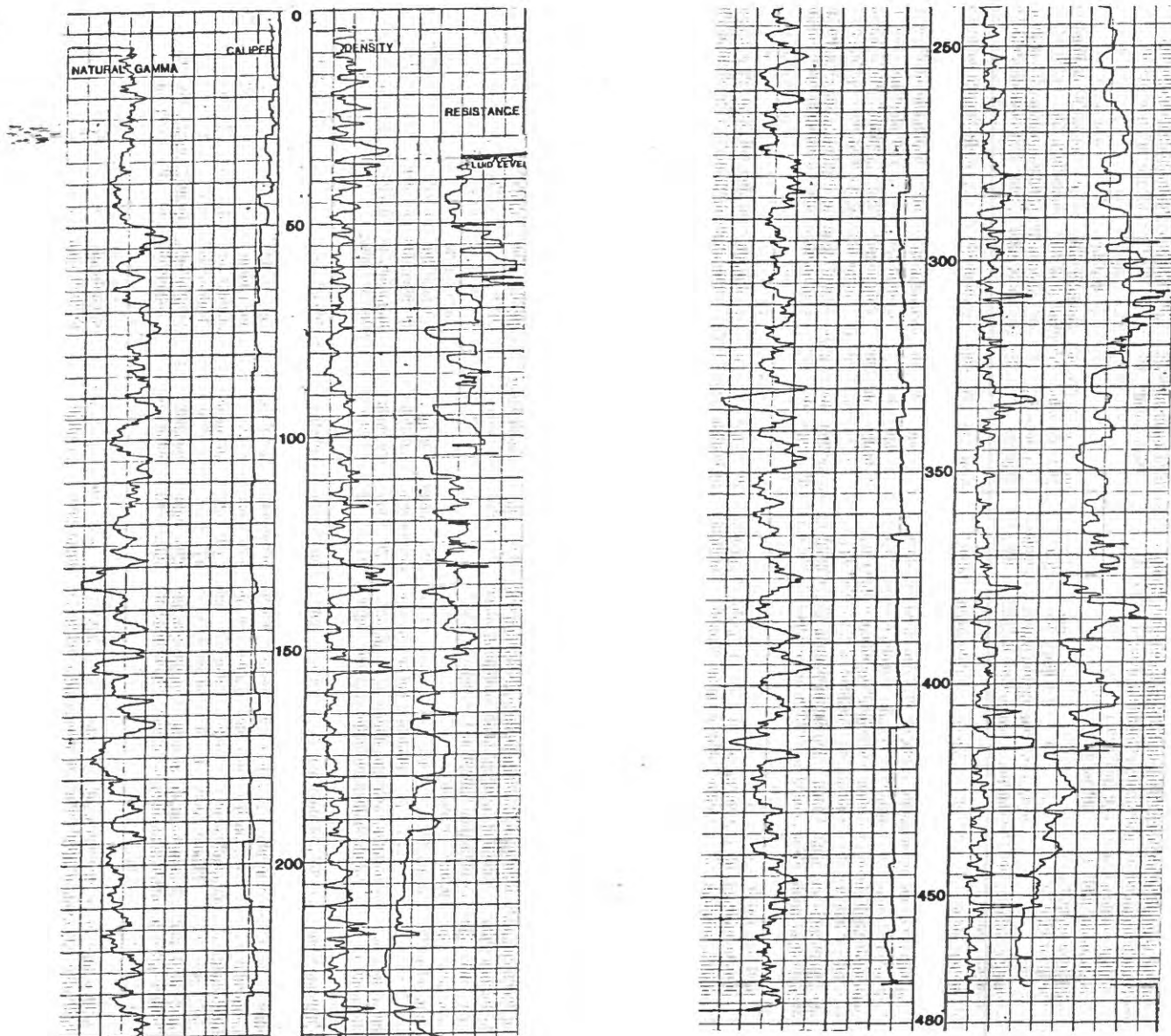


Figure 77.--Geophysical logs of hole GS-76

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 |
| 85-108 | 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 |
| 108-112 | Lignite, black; (Upper Timber Coulee lignite bed) |
| 112-114 | Claystone, medium-gray |
| 114-118 | Lignite, black; (Lower Timber Coulee lignite bed) |
| 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; some ironstains; coal fragments in lower half of interval; traces of carbonaceous shale and claystone scattered throughout interval |
| 296-301 | Lignite, black; probably impure at base; (Lower Smoke Creek lignite bed) |
| 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 |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|--|
| 339-341 | Lignite, black |
| 341-362 | Siltstone, light-gray; coal 351 to 352 ft |
| 362-365 | Lignite, black; ("BC" lignite bed) |
| 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; coal from 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; ("B" lignite bed) |
| 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

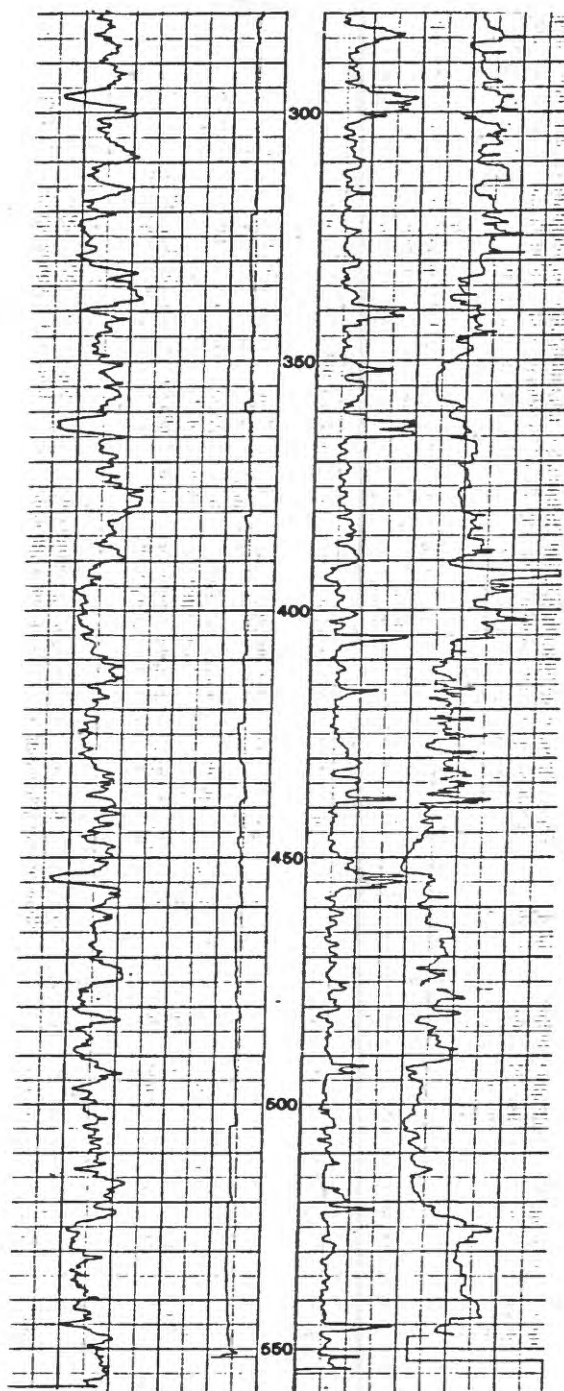
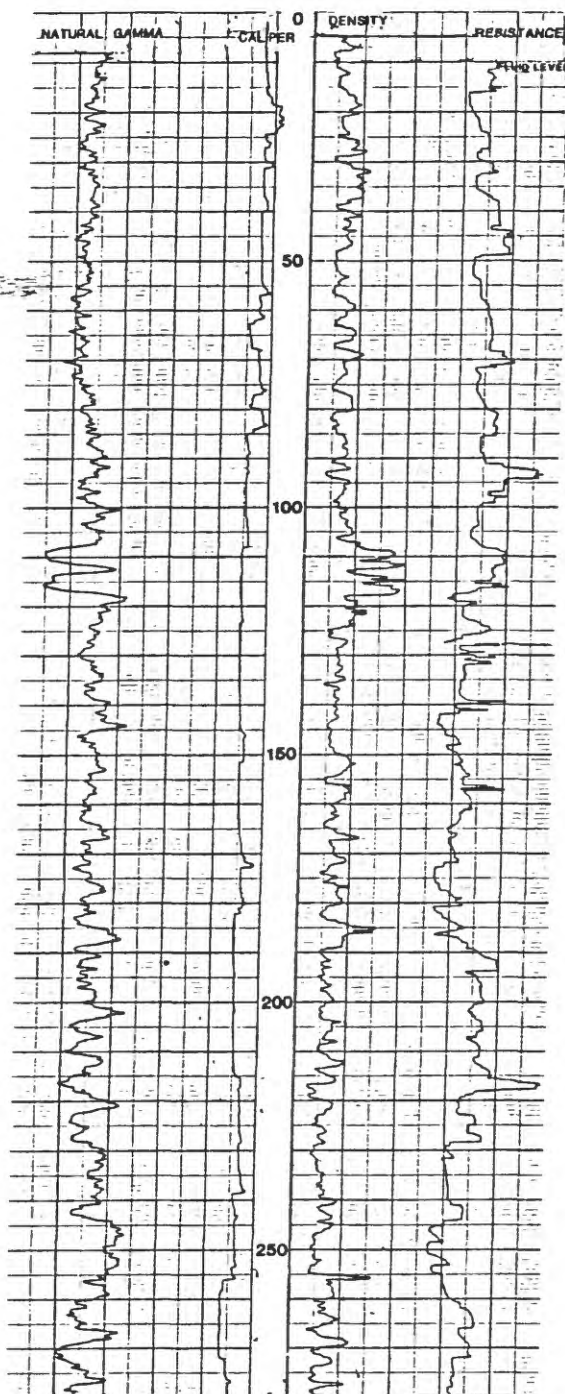


Figure 78.—Geophysical logs of hole GS-77

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; (Smoke Creek lignite bed) |
| 154-163 | Claystone, very light gray |
| 163-167 | Lignite, black; (Lower Smoke Creek lignite bed) |
| 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 |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 386-398 | Claystone, light-olive-gray; traces of carbonaceous claystone |
| 398-416 | Claystone, light-gray |
| 416-418 | Lignite, black; ("AB" lignite bed) |
| 418-420 | Claystone, medium-gray; |
| 420-425 | Lignite, black; ("AB" lignite bed) |
| 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

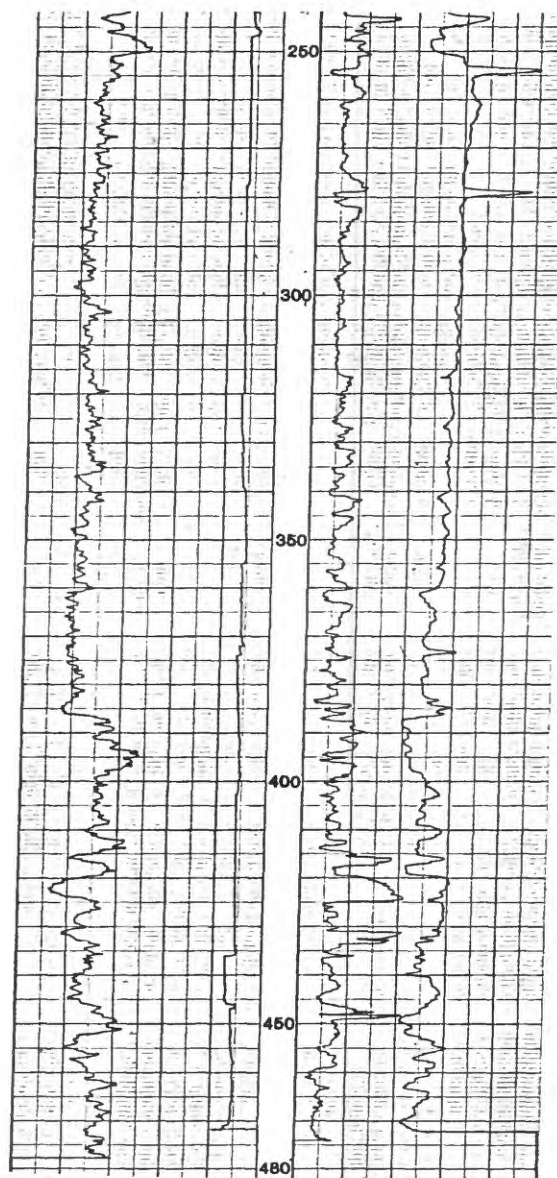
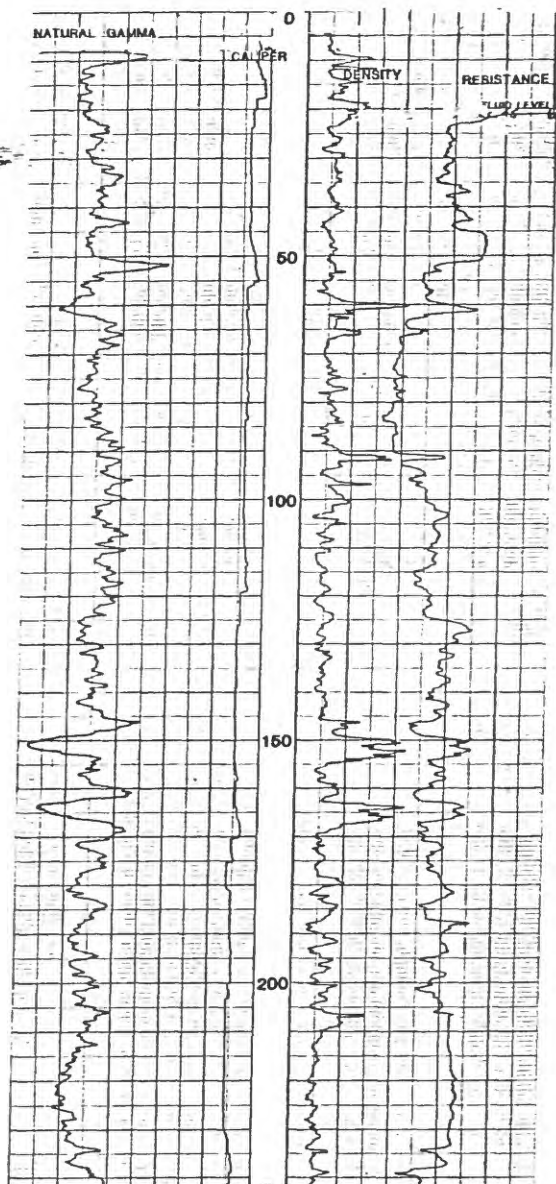


Figure 79.--Geophysical logs of hole GS-78

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; ("B" lignite bed) |
| 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; ("AB" lignite bed) |
| 315-316 | Claystone, medium-light-gray |
| 316-318 | Lignite, black; ("AB" lignite bed) |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 318-354 | Sandstone, light-to very light gray, calcareous; grades to silty pyritic claystone near top of interval |
| 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; includes claystone from 436 to 444 ft and coal from 445 to 446 and 459 to 460 ft |
| 464-470 | Lignite, black; ("A" Rider lignite bed) |
| 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

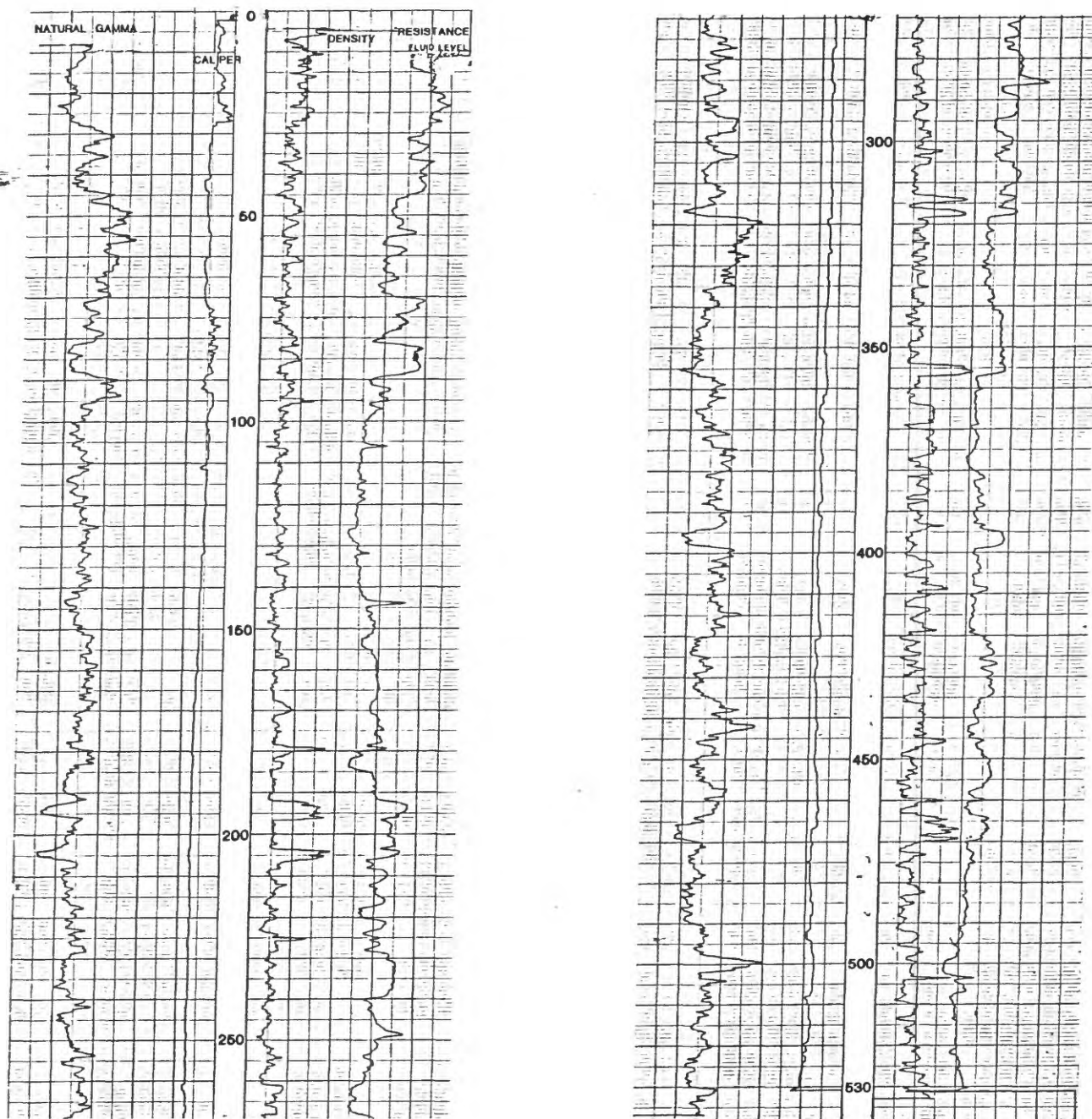


Figure 80.--Geophysical logs of hole GS-79

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, impure; (Timber Coulee Leader lignite bed) |
| 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; (Lower Smoke Creek lignite bed) |
| 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; ("BC" lignite bed) |
| 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 |

Sample log--Continued

| Depth (feet) | Lithic description |
|-----------------|---|
| 353-357 | Lignite, black, impure; ("B" lignite bed) |
| 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

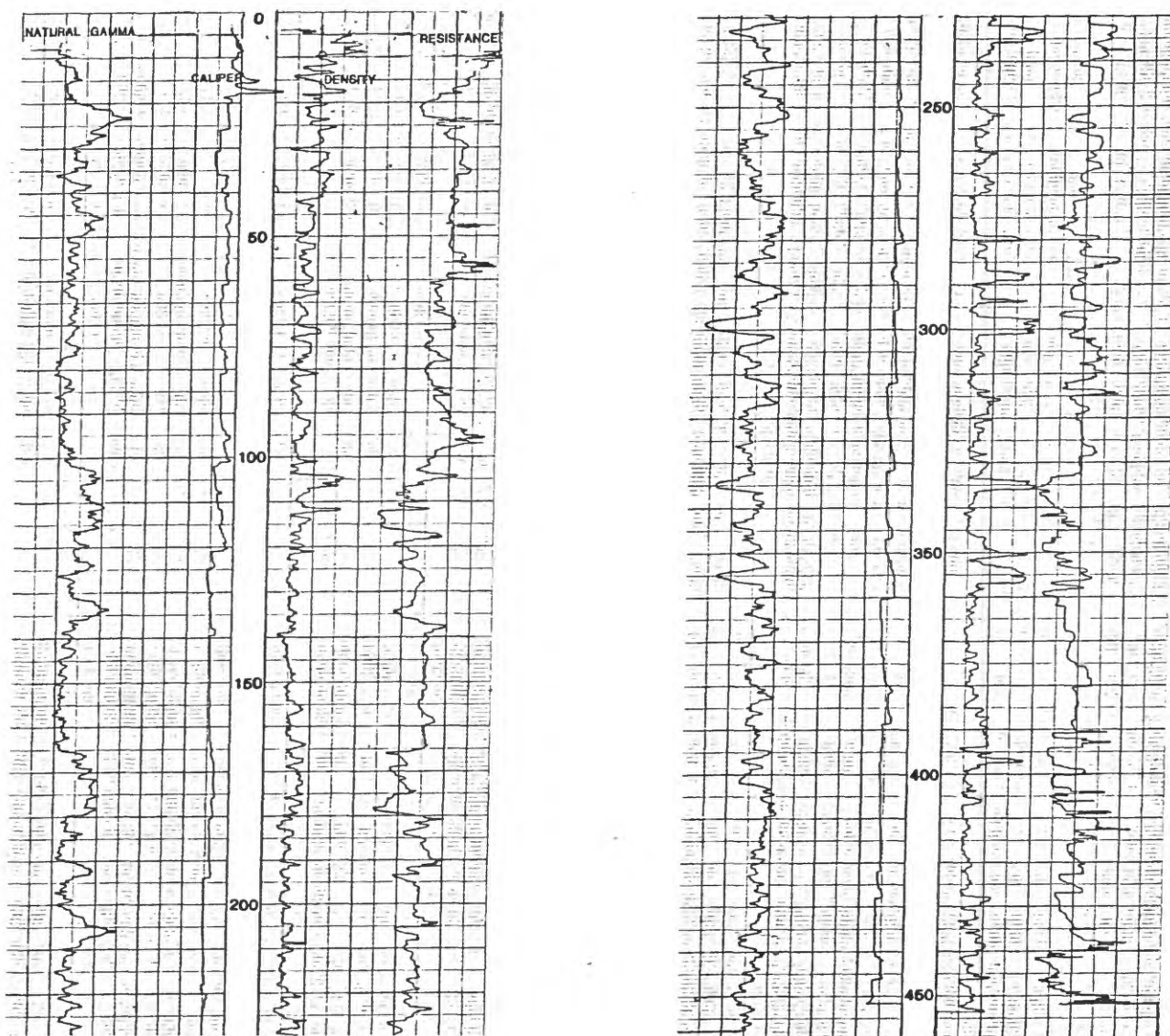


Figure 81.--Geophysical logs of hole GS-80

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; some interbedded claystone |
| 86-97 | Claystone, white; traces of carbonaceous claystone |
| 97-139 | Sandstone, yellowish-gray, very fine grained; trace of coal |
| 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; traces of coal and carbonaceous claystone; ("B" lignite bed 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; sparse interbedded siltstone; ("AB" lignite bed 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; ("AA" lignite bed) |
| 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 |

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

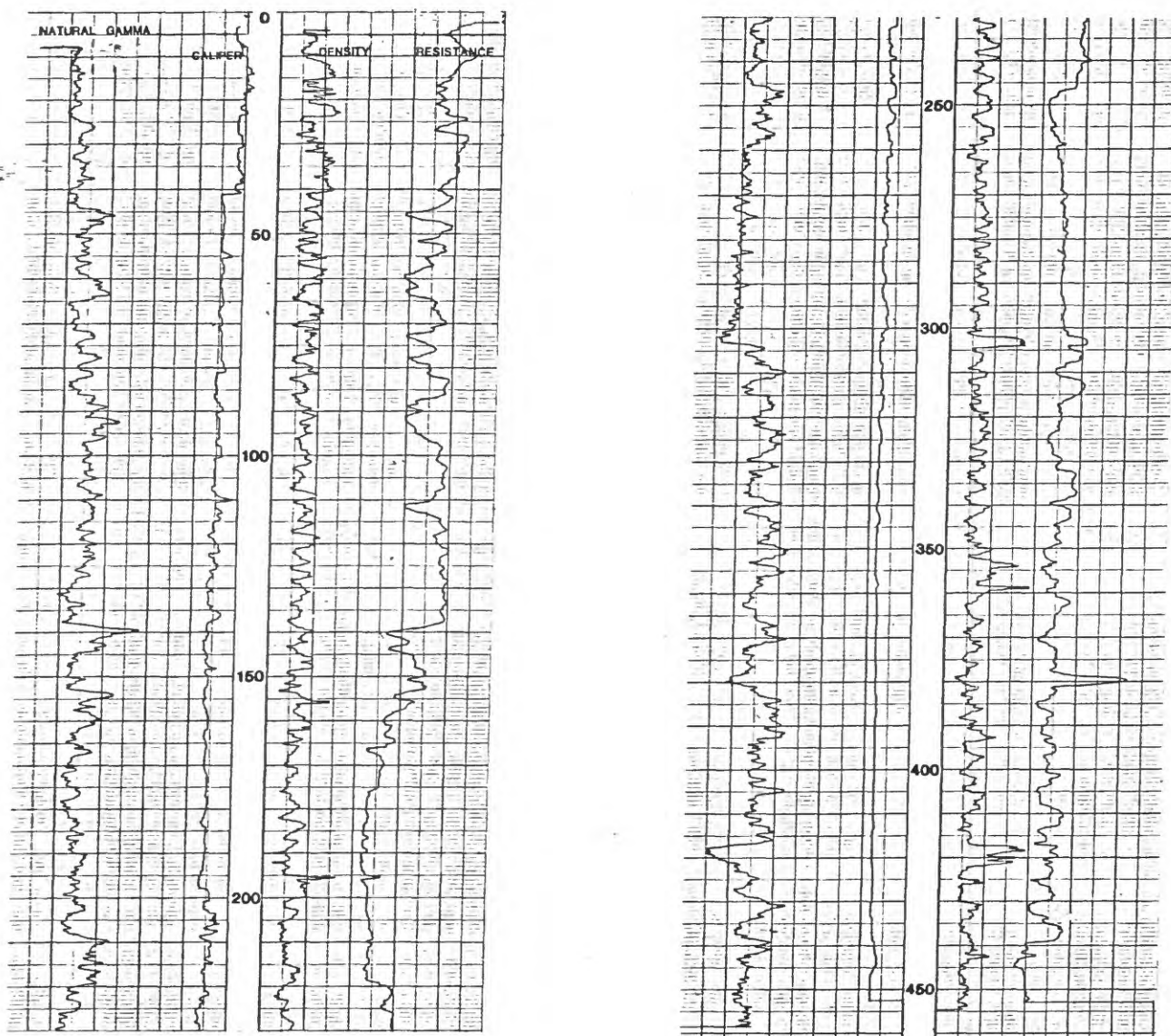


Figure 82.--Geophysical logs of hole GS-81

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; (Lower Smoke Creek lignite bed) |
| 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 coal at 179; ("BC" lignite bed 199 to 200 ft) |
| 210-256 | Sandstone, very light gray, very fine grained; some coal fragments at top of interval; grades 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 |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|---|
| 341-356 | Siltstone, medium-light-gray, sandy; interbedded with claystone at base |
| 356-359 | Lignite, black, impure |
| 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; ("AB" lignite bed) |
| 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

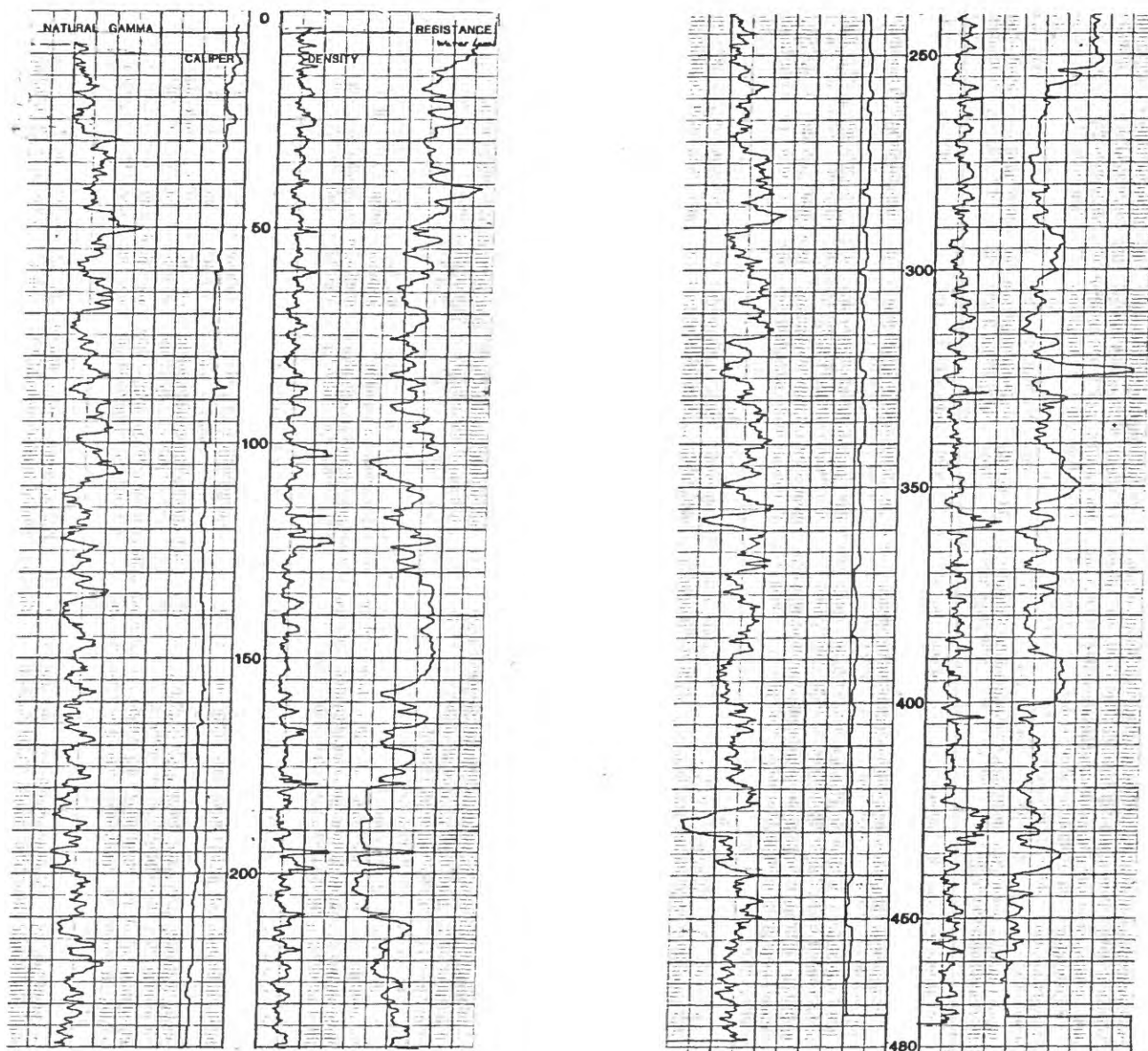


Figure 83.--Geophysical logs of hole GS-83

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 |
|-----------------|--|
| 0-2 | Silt, sand, and gravel, unconsolidated |
| 2-5 | Lignite, black; ("A" Rider lignite bed) |
| 5-26 | Claystone, light-olive-gray to light-gray; with grayish-yellow sandstone from 16 to 21 ft; few concretion fragments 15 to 20 ft |
| 26-29 | Lignite, black; ("A" lignite bed) |
| 29-32 | Claystone, medium-gray |
| 32-34 | Lignite, black; ("A" lignite bed) |
| 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 |

Sample log--Continued

| Depth (feet) | Lithic description |
|--------------------|--|
| 192-193 | Lignite, black; (base of Fort Union Formation) |
| 193-218 | Claystone, light-olive-gray; silty near middle of interval; trace of carbonaceous shale at base; (top of Hell Creek Formation) |
| 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; (base of Hell Creek Formation) |
| 402-440 | Claystone, light-gray to very light gray; (top of Fox Hills Formation) |
| 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

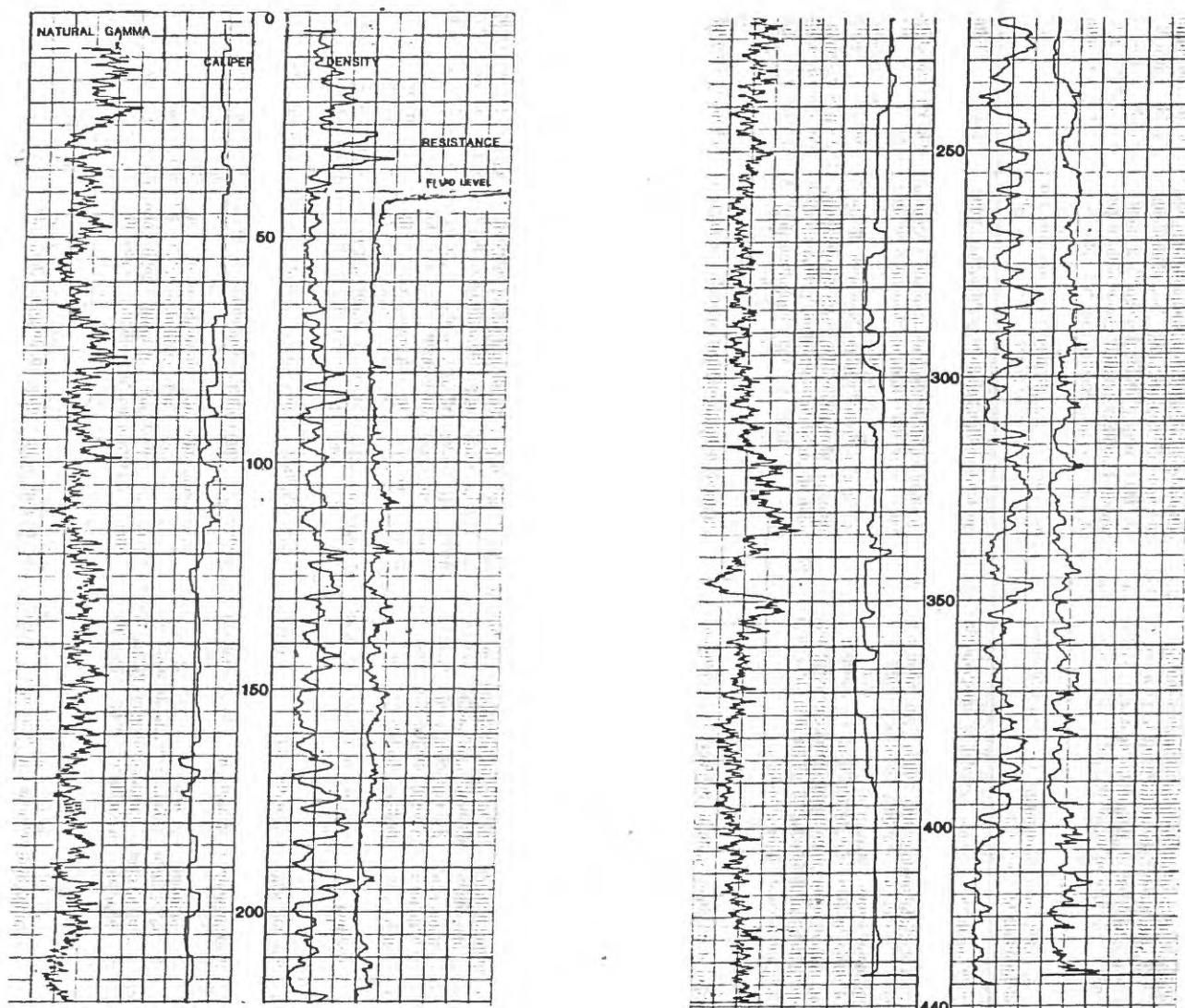


Figure 84.--Geophysical logs of hole GS-84