

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Results of exploratory drilling for lignite in 1979,
Fort Peck Indian Reservation,
Daniels, Roosevelt, and Sheridan Counties, Montana

By

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

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

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Introduction

Thirty-seven exploratory holes and nine core holes were drilled for lignite in the Fort Peck Indian Reservation during July, August, and September, 1979. The drilling was done as part of the U.S. Geological Survey's program to assess the coal resources in the reservation. This preliminary report makes available the logs of the exploratory holes and the analyses of coal samples obtained from the core holes. A previous report by Hardie and Arndt (1981) reported on the results of exploratory drilling for lignite in the Fort Peck Indian Reservation during 1978. Geologic interpretations resulting from this and other investigations in the reservation are not published here.

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

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

The drilling described here was done by Gulbraa Drilling Company, Sidney, Montana, and Russell Drilling Company, Harvey, North Dakota, under contract to the U.S. Geological Survey. Geophysical logs of the drill holes were made by Roberts Geophysical Services, Council Bluffs, Iowa, and Digilog, Inc., Broomfield, Colorado, also under contract to the U.S. Geological Survey. Assistance in these investigations was provided by the following U.S. Geological Survey personnel: Ronald H. Affolter aided materially in the organization and preparation of the analytical data tables; Roger B. Colton generously provided unpublished geologic data.

Location

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

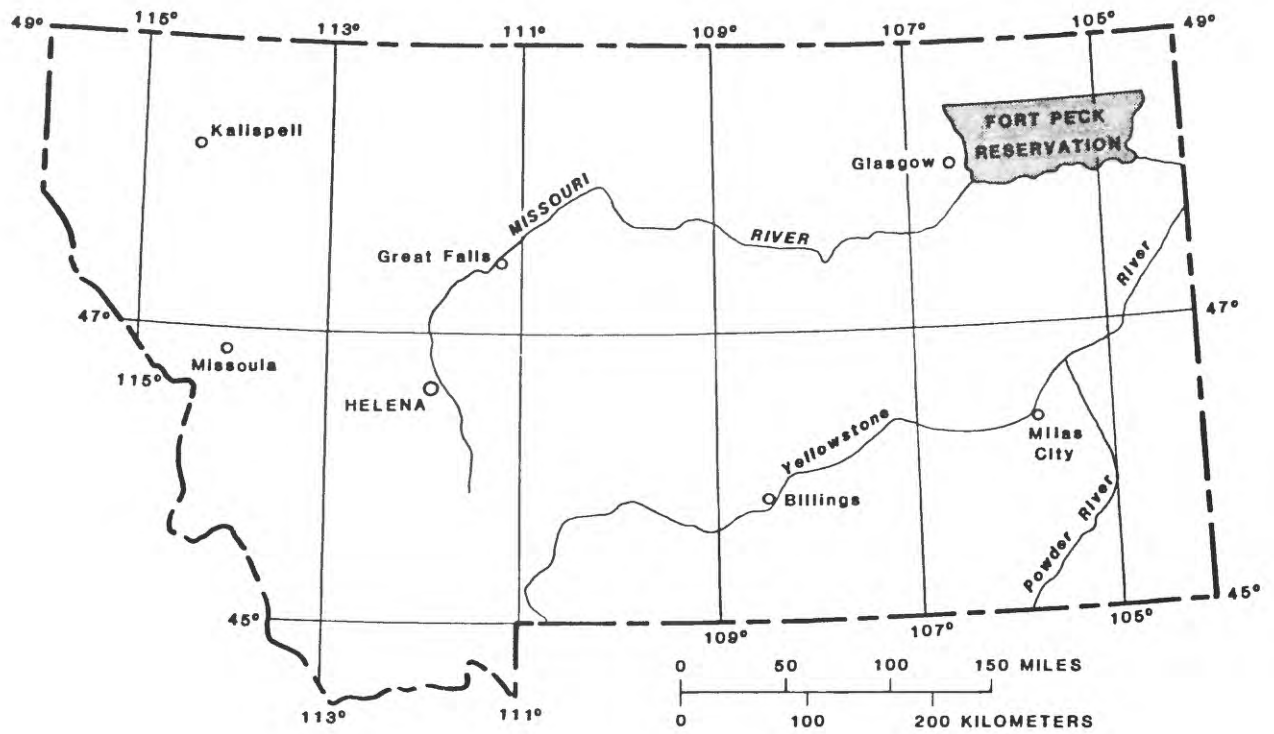


Figure 1.--Index map of Montana showing location of Fort Peck Indian Reservation.

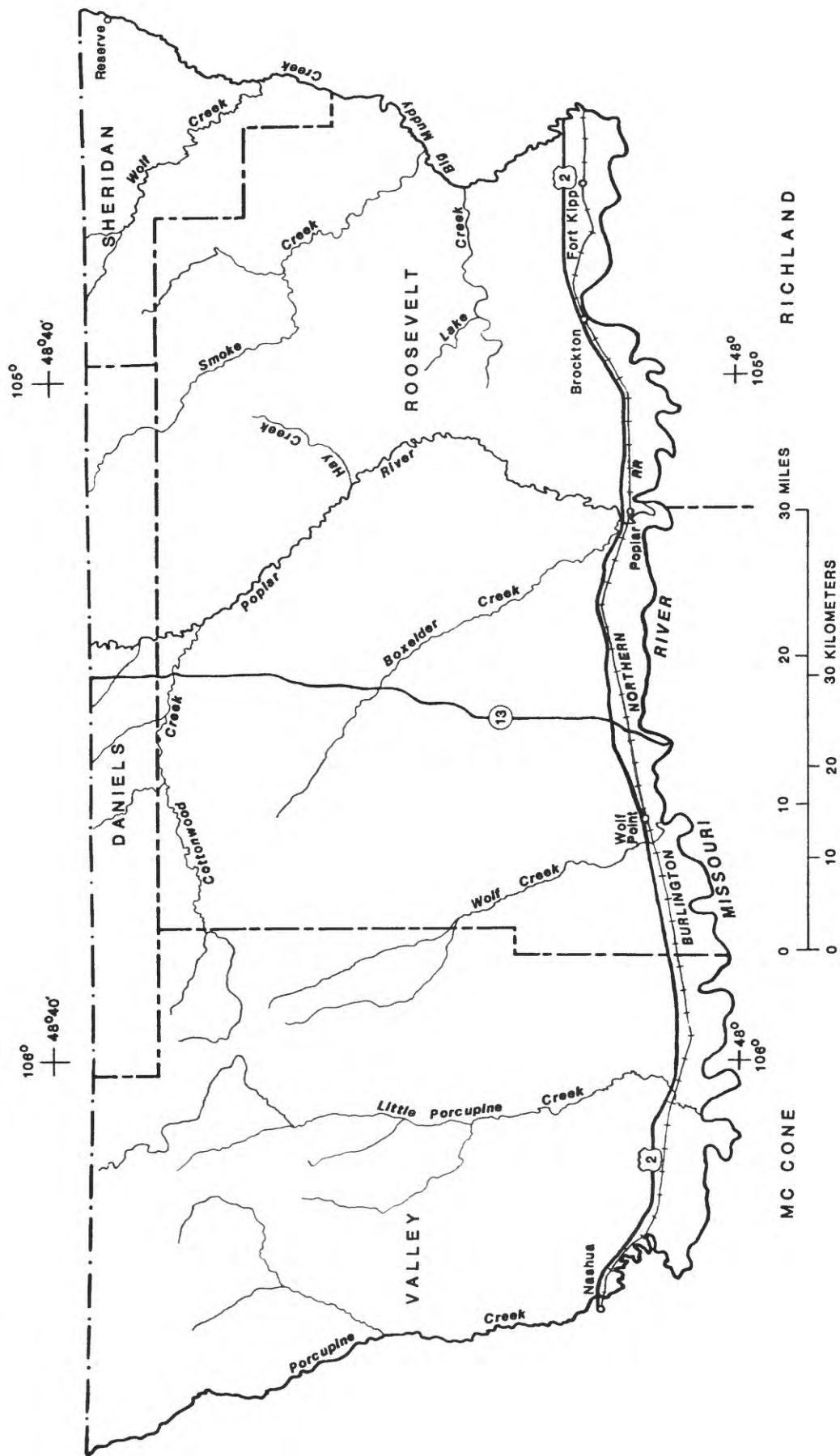


Figure 2.--Index map of Fort Peck Indian Reservation, northeastern Montana.

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

Geologic setting

Coal-bearing rocks in the Fort Peck Indian Reservation are in the Hell Creek Formation of Late Cretaceous age and the Fort Union Formation of Paleocene age. Much of the coal-bearing sequence is buried under Pleistocene glacial deposits. Bedrock is exposed along some roadcuts and commonly along streambeds; however, extensive continuous rock exposures are rare and it is necessary to resort to exploratory drilling at many localities in order to obtain information on the coal-bearing sequence.

The Hell Creek Formation is mainly soft claystone and siltstone interbedded with ledge-forming sandstone, and also includes fairly numerous but relatively thin and discontinuous beds of lignite. The formation is as much as 280 feet thick in the vicinity of the Fort Peck Indian Reservation. Somber gray claystone and siltstone predominate in the middle and upper parts of the formation, and brown sandstone dominates the lower part. Coals in the formation rarely exceed 3 feet in thickness; consequently, the formation is of little economic importance in the vicinity of the reservation.

The Fort Union Formation conformably overlies the Hell Creek Formation. The contact between these formations is gradational and is arbitrarily placed at the base of the lowest mappable lignite bed (Colton and Bateman, 1956). Somber gray beds of the Hell Creek generally prevail below this horizon in subtle contrast with the overlying brighter yellow-hued beds comprising the Fort Union.

The Fort Union Formation exceeds 1,000 feet in thickness in the eastern part of the Fort Peck Indian Reservation where it consists mainly of claystone, siltstone, and sandstone, and includes nine beds of lignite ranging from 2 to 14 feet in thickness, and numerous beds of lignite less than 2 feet thick. Although the formation underlies most of the reservation east of the Poplar River, erosion has removed all but the lower few hundred feet of the formation in the vicinity of the Poplar River. The formation dips gently eastward in the area of these investigations, and the thickest sequence of strata assigned to the Fort Union underlies the eastern part of the reservation. The Fort Union is known to contain potentially recoverable lignitic coal at several places in the eastern part of the reservation; however, the relationship of these known coal deposits to each other and to other recoverable deposits that may be present is little understood. Hopefully, the current investigations will eventually clarify these relationships.

Coal exploratory drill holes

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

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 were collected at 5-foot intervals and were described in the field. Cuttings from selected holes were later studied under a microscope in the office.

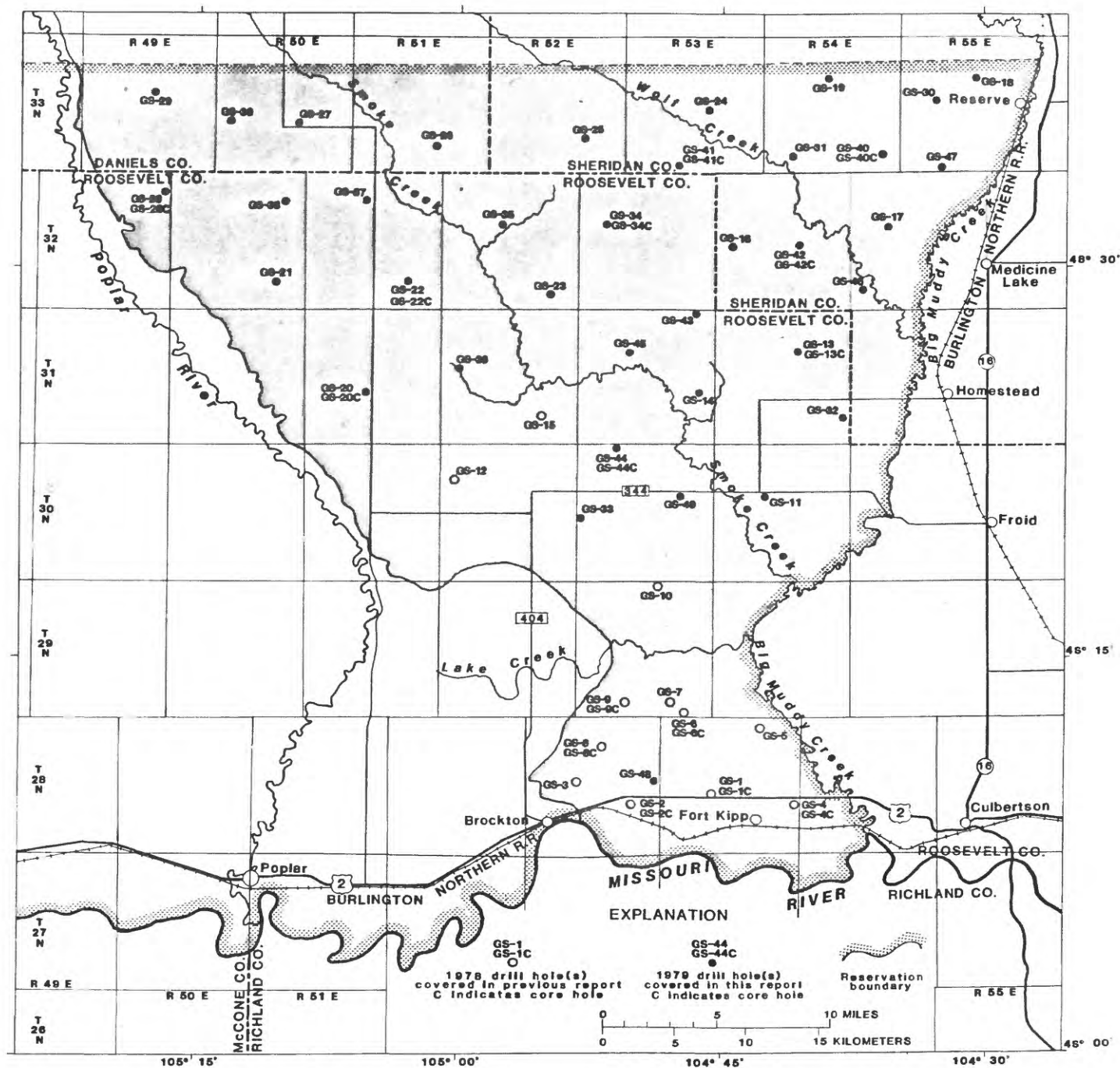


Figure 3.--Map showing locations of drill holes and area underlain by the Fort Union Formation (shaded) in the eastern part of the Fort Peck Indian Reservation, Montana.

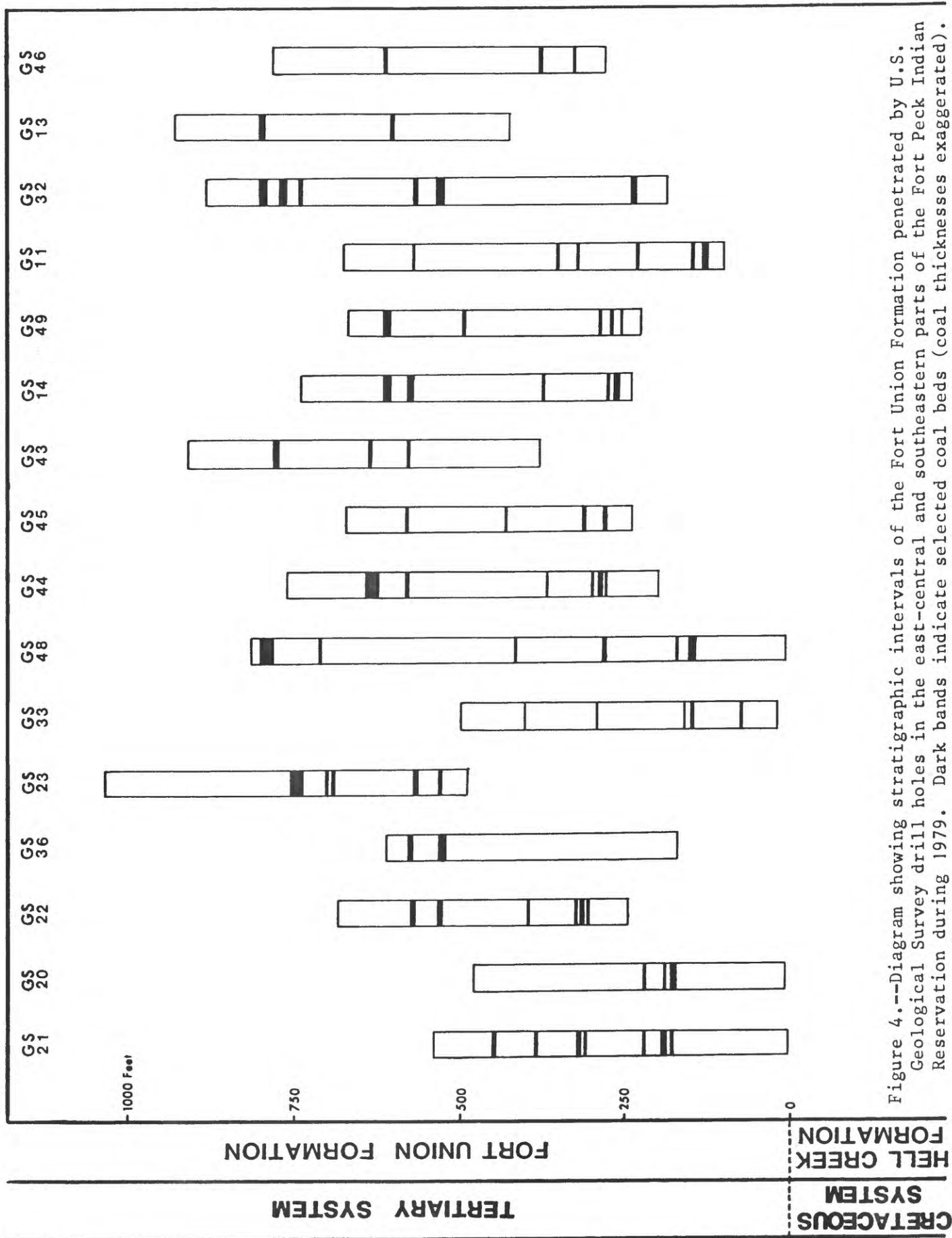


Figure 4.--Diagram showing stratigraphic intervals of the Fort Union Formation penetrated by U.S. Geological Survey drill holes in the east-central and southeastern parts of the Fort Peck Indian Reservation during 1979. Dark bands indicate selected coal beds (coal thicknesses exaggerated).

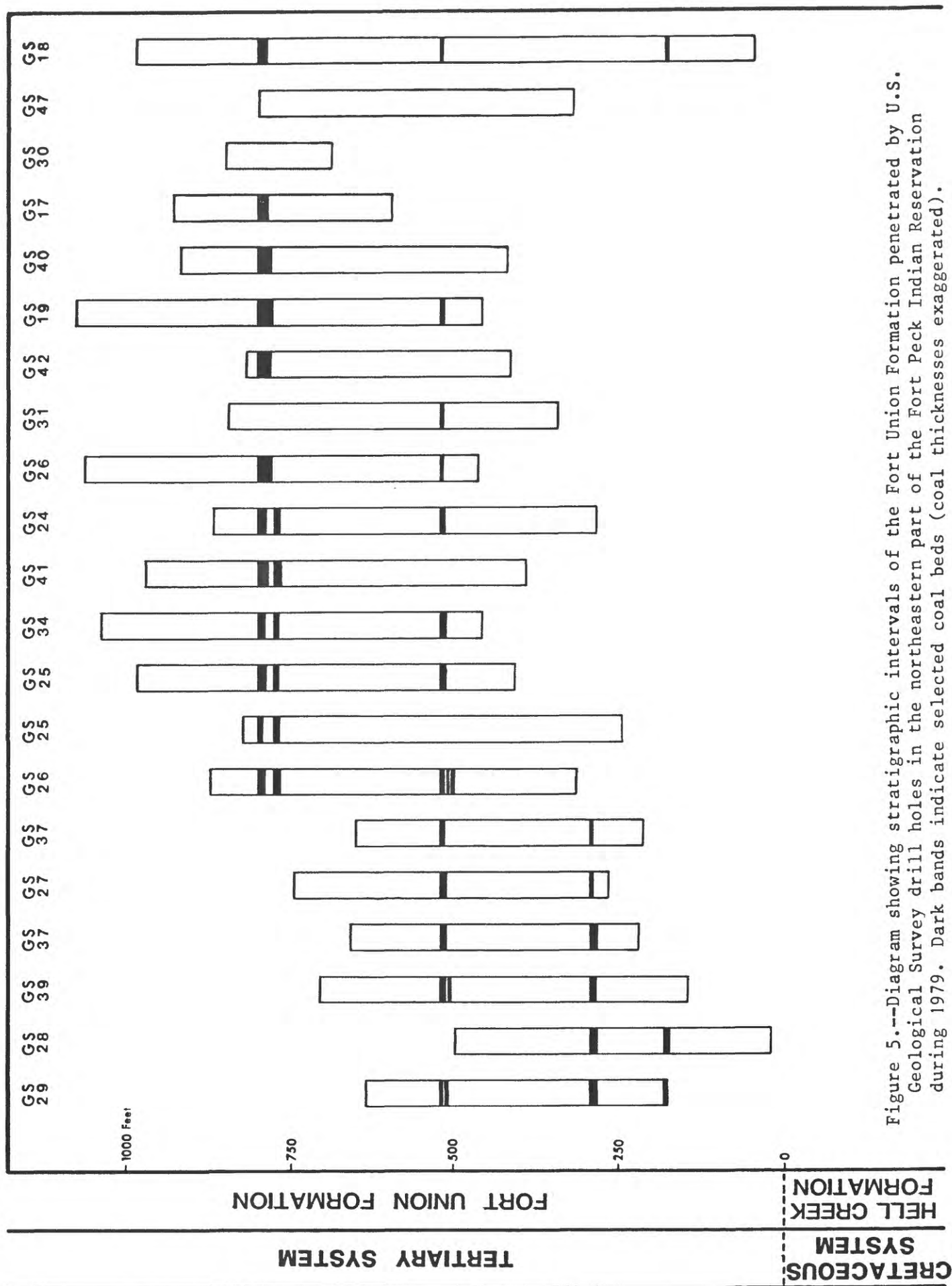


Figure 5.--Diagram showing stratigraphic intervals of the Fort Union Formation penetrated by U.S. Geological Survey drill holes in the northeastern part of the Fort Peck Indian Reservation during 1979. Dark bands indicate selected coal beds (coal thicknesses exaggerated).

Core holes were located within a few feet of nine of the 1979 exploratory drill holes (fig. 3). Selected intervals were cored to obtain fresh samples of coal for analysis. Cored intervals are indicated on the accompanying geophysical logs, and descriptions of the cores and samples taken are included with the sample and geophysical logs.

Logs of the drill holes

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

Geophysical logs of most of the exploratory holes were made with a multi-conductor logging tool. Natural-gamma, focused density, single-point resistance, and caliper logs at a scale of 1 inch = 10 feet were obtained at most locations. 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, each of the last two logs requiring a separate run in and out of the hole. Focused density (high-resolution) logs were made at an expanded scale of 1 inch = 5 feet 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. Also, the logs made at the expanded scale are not reproduced in this report.

Conversion to metric units

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

Factors for conversion to the metric system are:

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

Sample log

Hole no.: GS-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
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
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
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
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
530-531.5	Carbonaceous shale and impure lignite, grayish-black to brownish-gray
531.5-537	Lignite, grayish-black to brownish-black
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

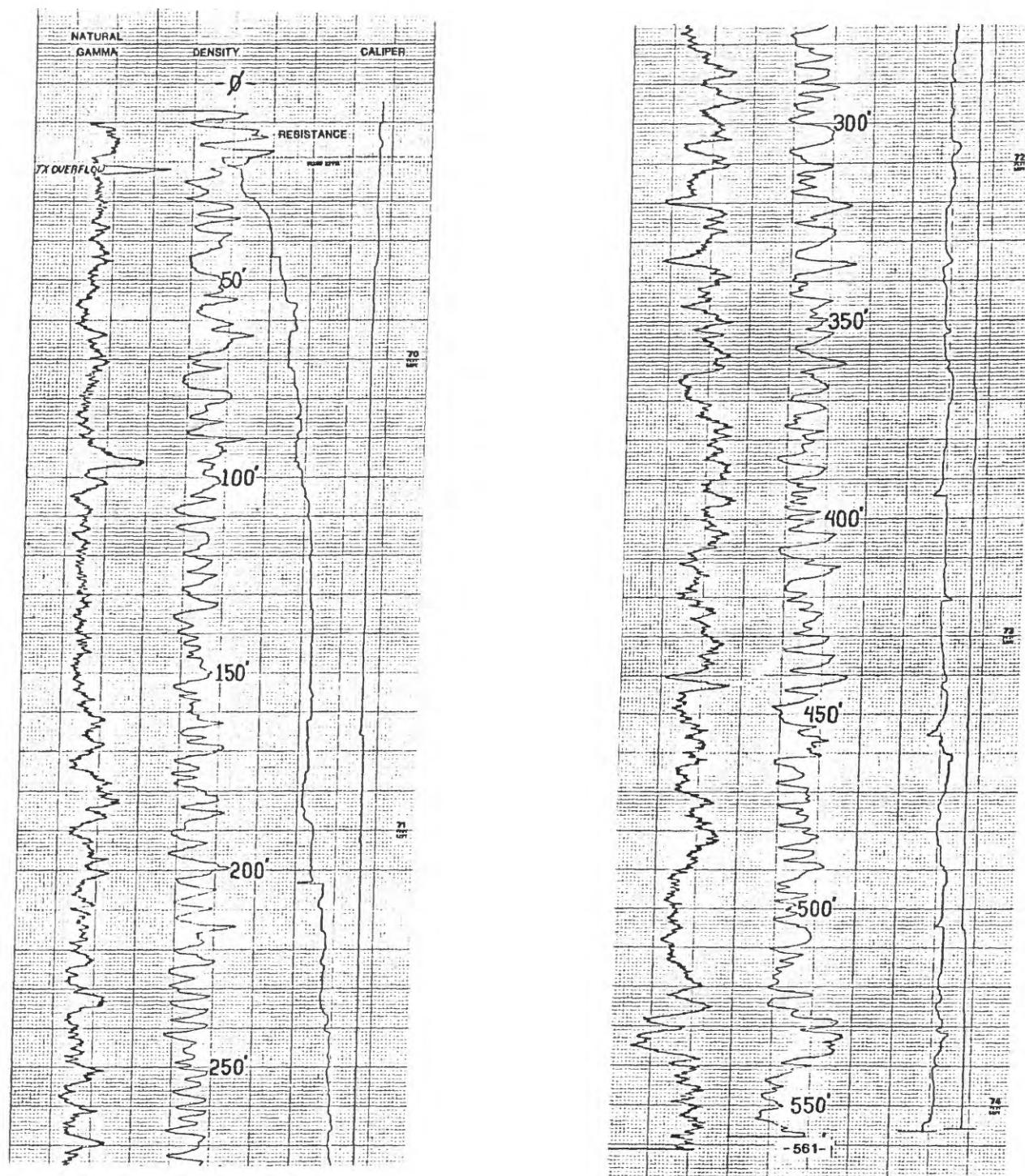


Figure 6.--Geophysical logs of hole GS-11

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
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 (fig. 8)
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 (fig. 8)
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

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
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

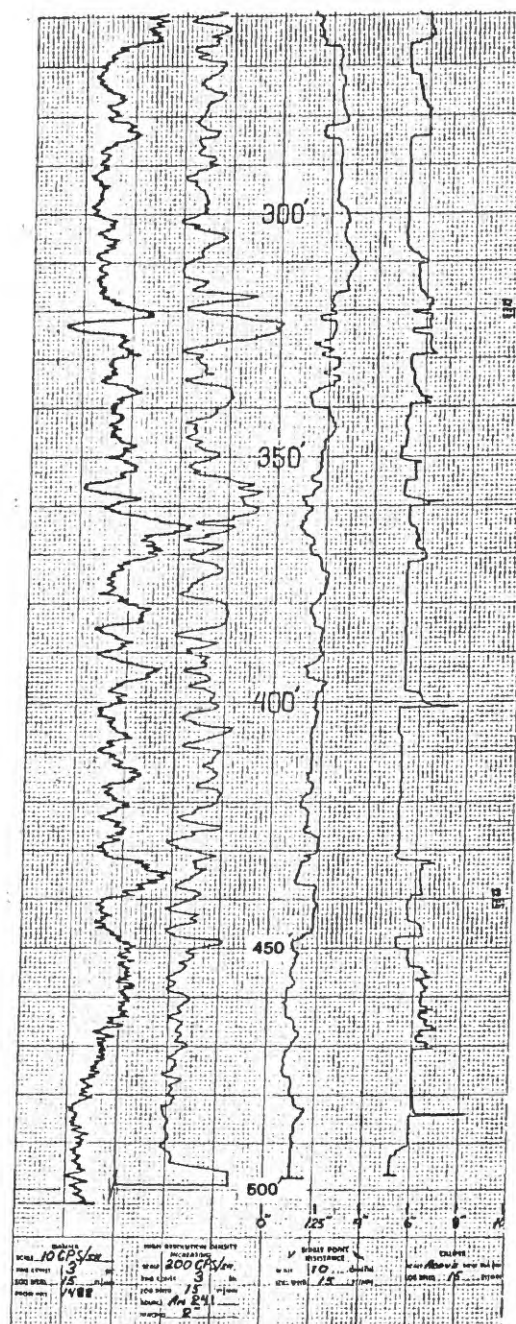
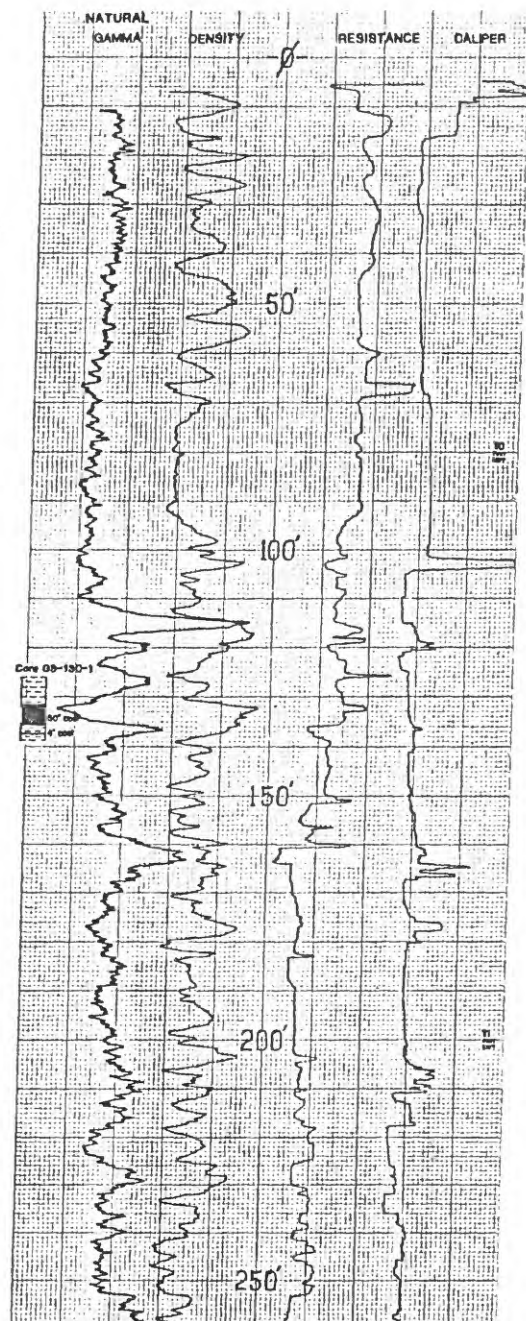


Figure 7.--Geophysical logs of hole GS-13

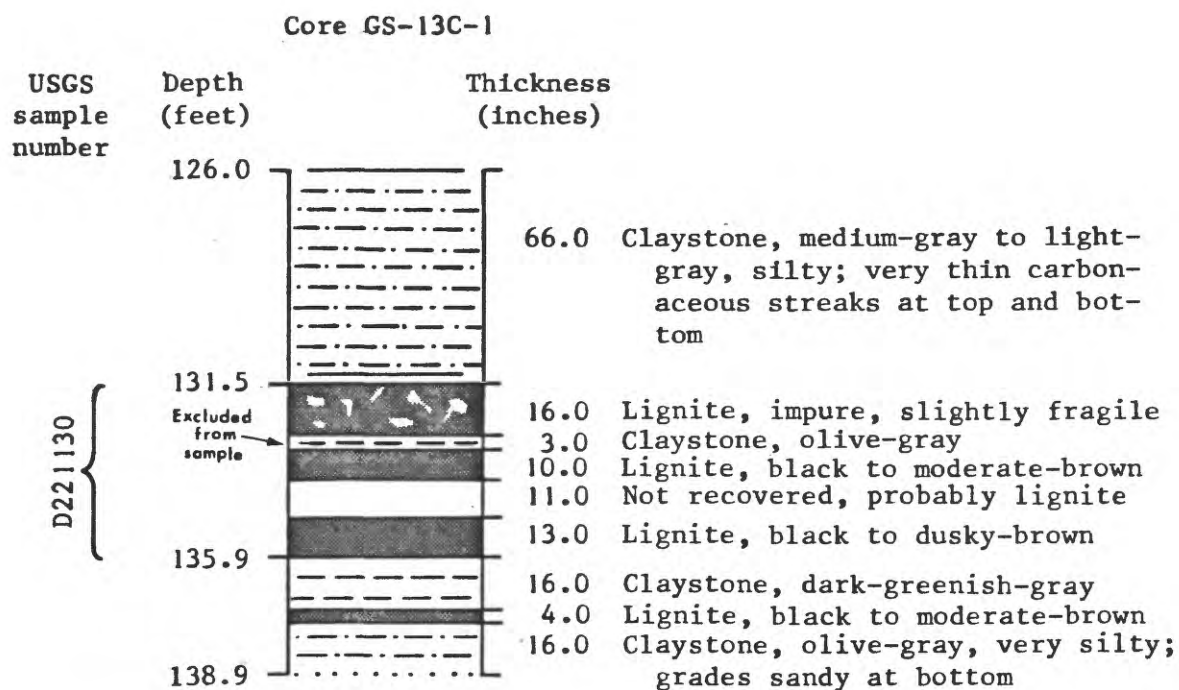


Figure 8.--Core and sample descriptions, core hole GS-13C, SE SE sec. 10, T. 31 N., R. 54 E., Roosevelt County, Montana.

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
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; includes 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
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
164-170	Claystone, brownish-gray, silty
170-190.5	Sandstone and siltstone, medium-gray; chiefly very fine grained, finely micaceous sandstone with scattered thinly interbedded siltstone
190.5-192	Lignite, grayish-black
192-219	Claystone, medium-gray, silty; grades to siltstone at top and base

Sample log--Continued

Depth (feet)	Lithic description
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
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

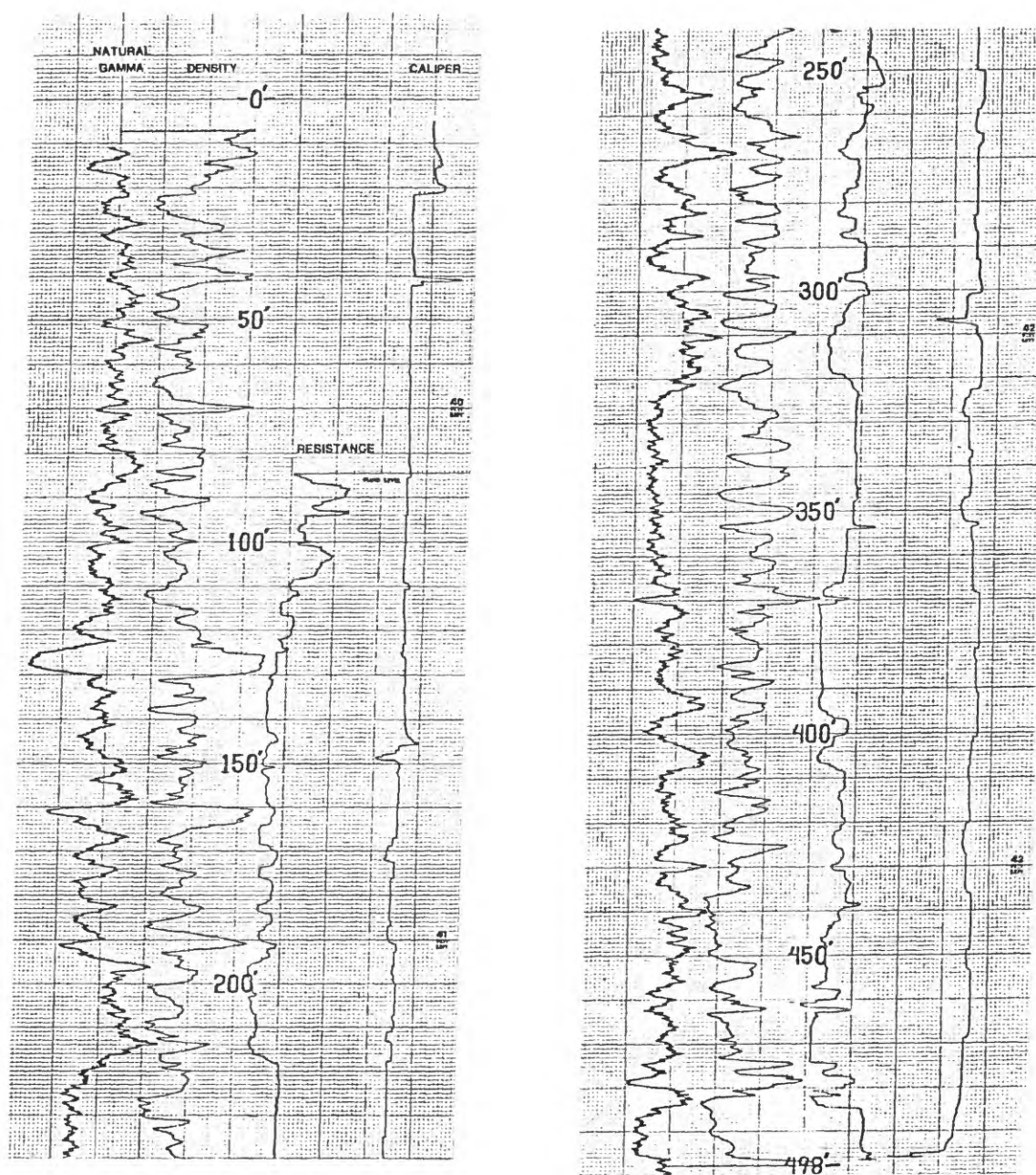


Figure 9.--Geophysical logs of hole GS-14

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
<hr/>	
0-12	Gravel, sand, and mud
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; traces of coal near top of interval
149-191	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
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
470-520	Siltstone, light-olive-gray to greenish-gray to medium-light-gray, sandy; with interbedded carbonaceous claystone

Sample log--Continued

Depth (feet)	Lithic description
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
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

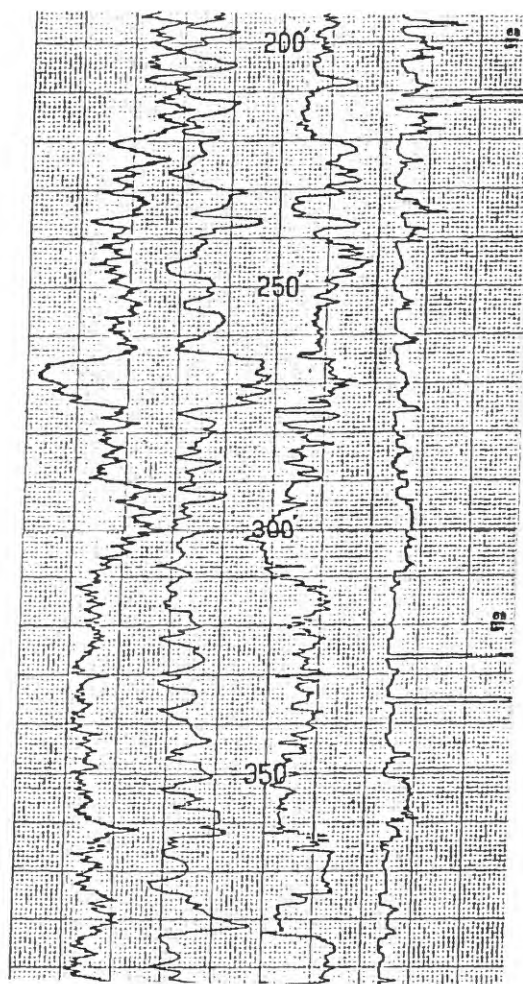
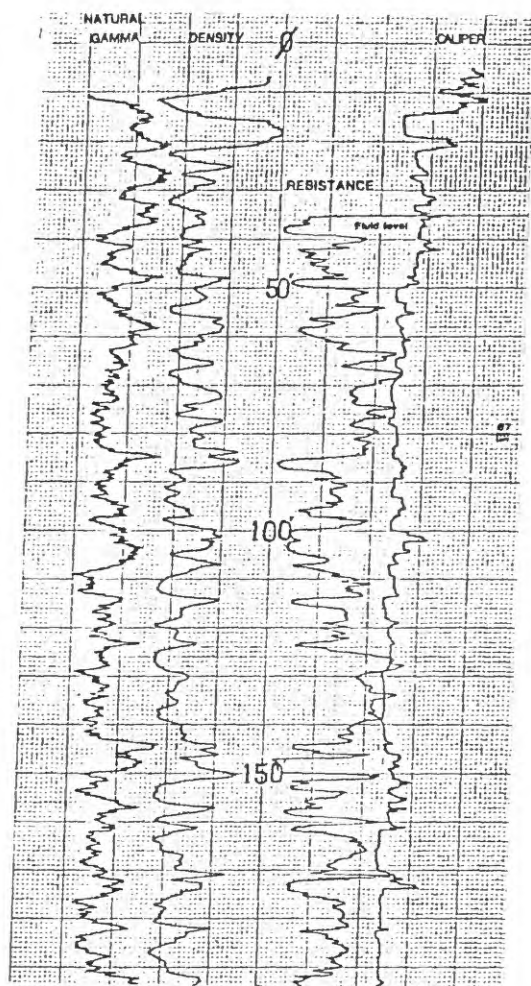


Figure 10.--Geophysical logs of hole GS-16

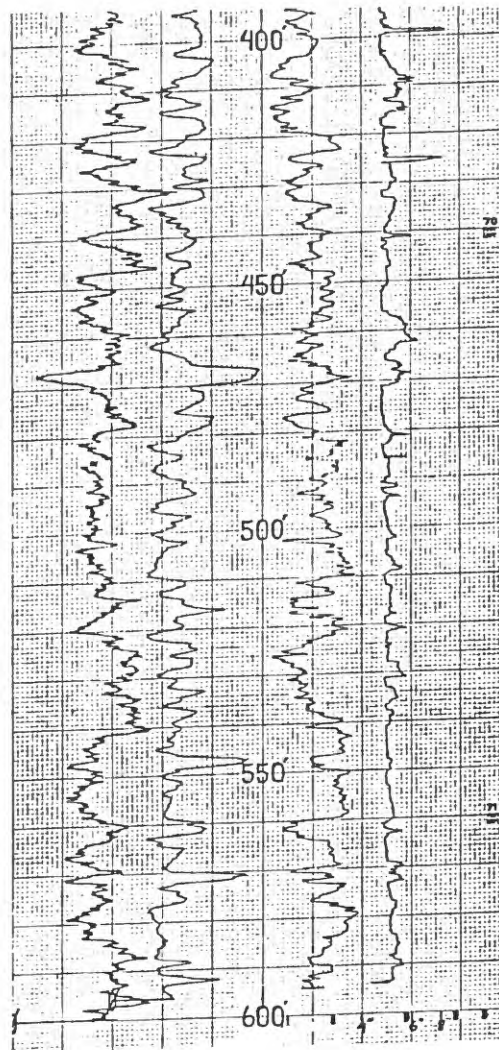


Figure 10.--Geophysical logs of hole GS-16--Continued

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
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
108-123	Claystone, light-gray; grades silty near base
123-131	Lignite, black
131-157	Claystone, very light gray, bentonitic(?)
157-161	Lignite, black
161-169	Siltstone, dark-brown
169-172	Lignite, impure (?)
172-185	Claystone, dark-brown to medium-gray, silty; trace of coal at top
185-222	Sandstone, medium-gray; includes interbedded silty claystone throughout interval
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

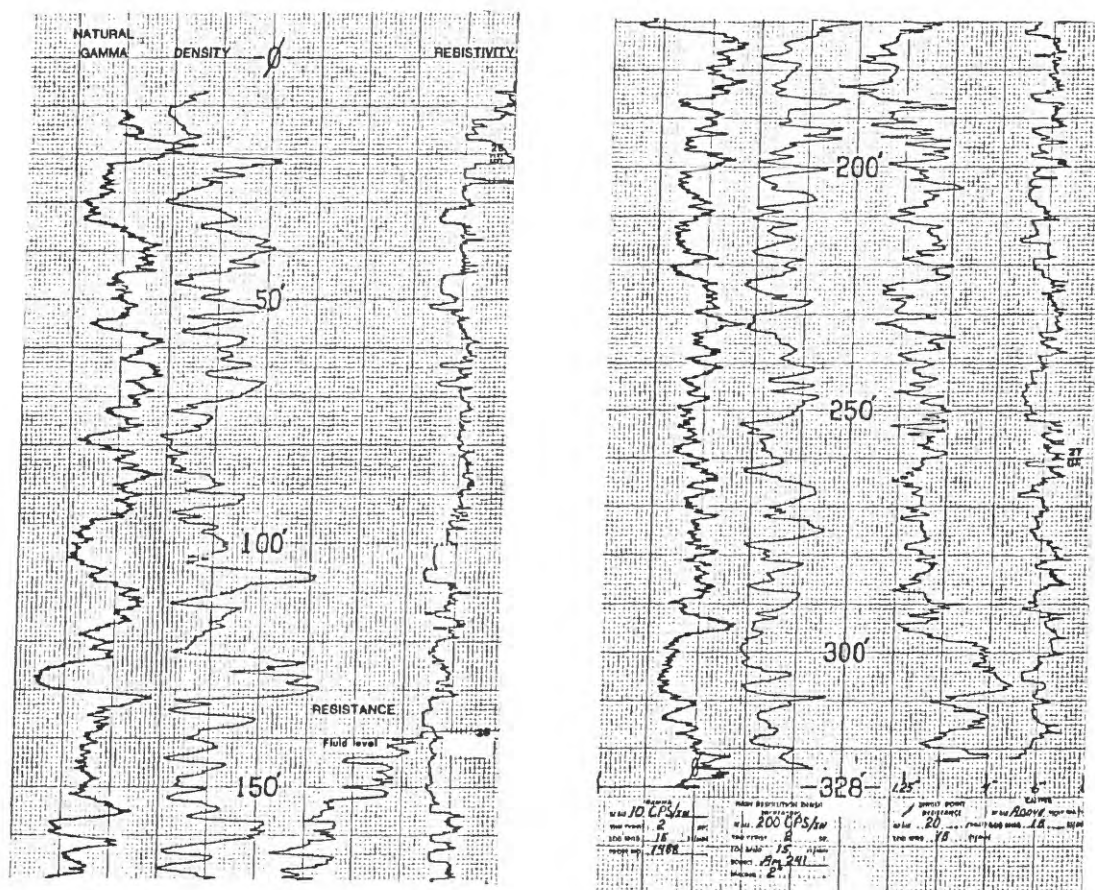


Figure 11.--Geophysical logs of hole GS-17

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
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
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
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
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
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
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; probable claystone parting 688 to 689 ft
690-772	Siltstone, olive-black to medium-dark-gray to medium-light-gray; with interbedded claystone; minor coal fragments
772-775	Lignite, black
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
906-940	Siltstone, medium-gray to olive-black; abundant coal fragments near base
	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

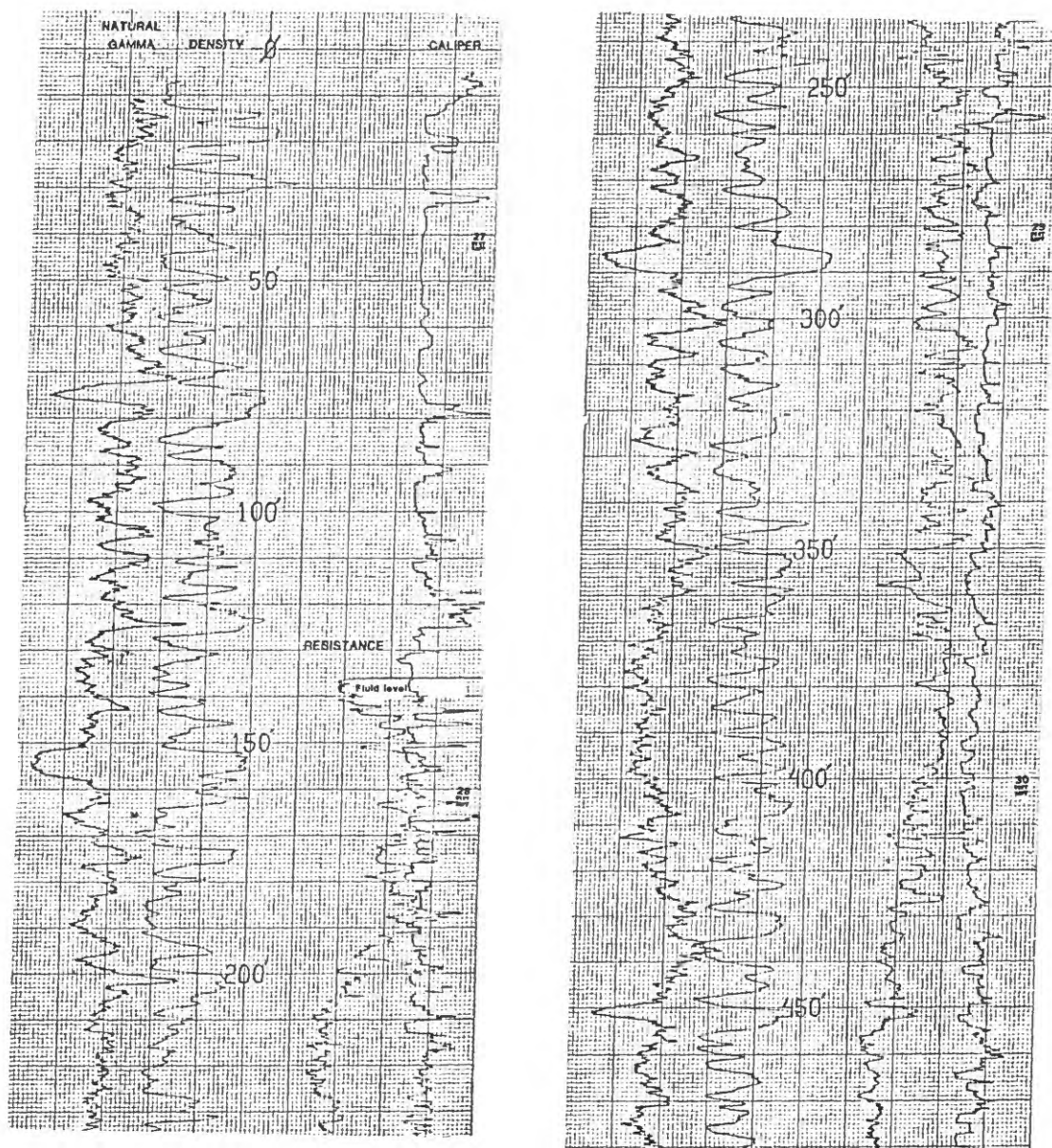


Figure 12.--Geophysical logs of hole GS-18

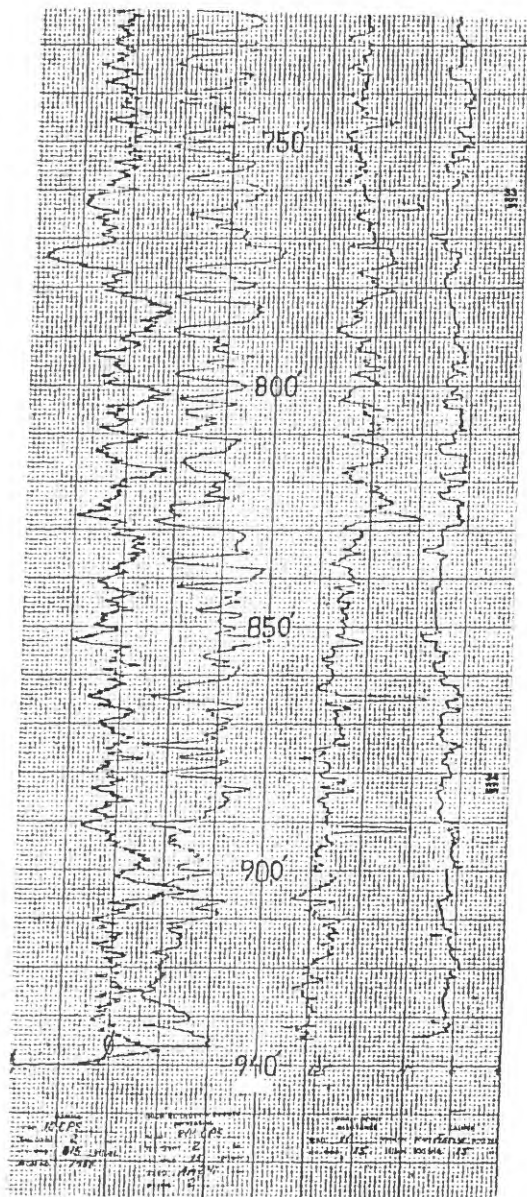
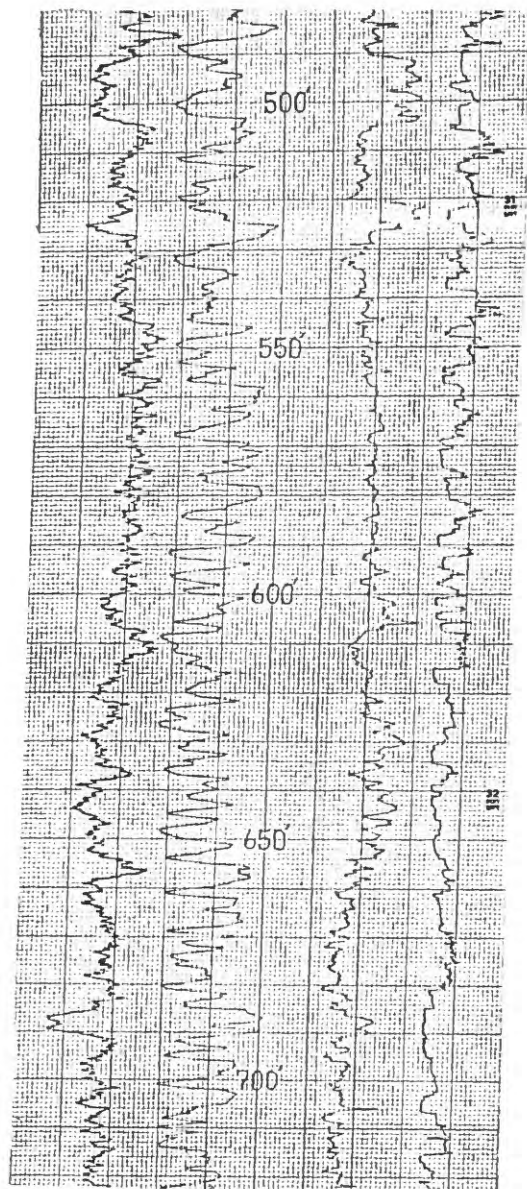


Figure 12.--Geophysical logs of hole GS-18--Continued

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
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
264-296	Siltstone, light-olive-gray to medium-light-gray; probable coal bed 273 to 274 ft
296-299	Lignite, black
299-320	Claystone, light-olive-gray to medium-light-gray, silty
320-323	Lignite, black
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
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

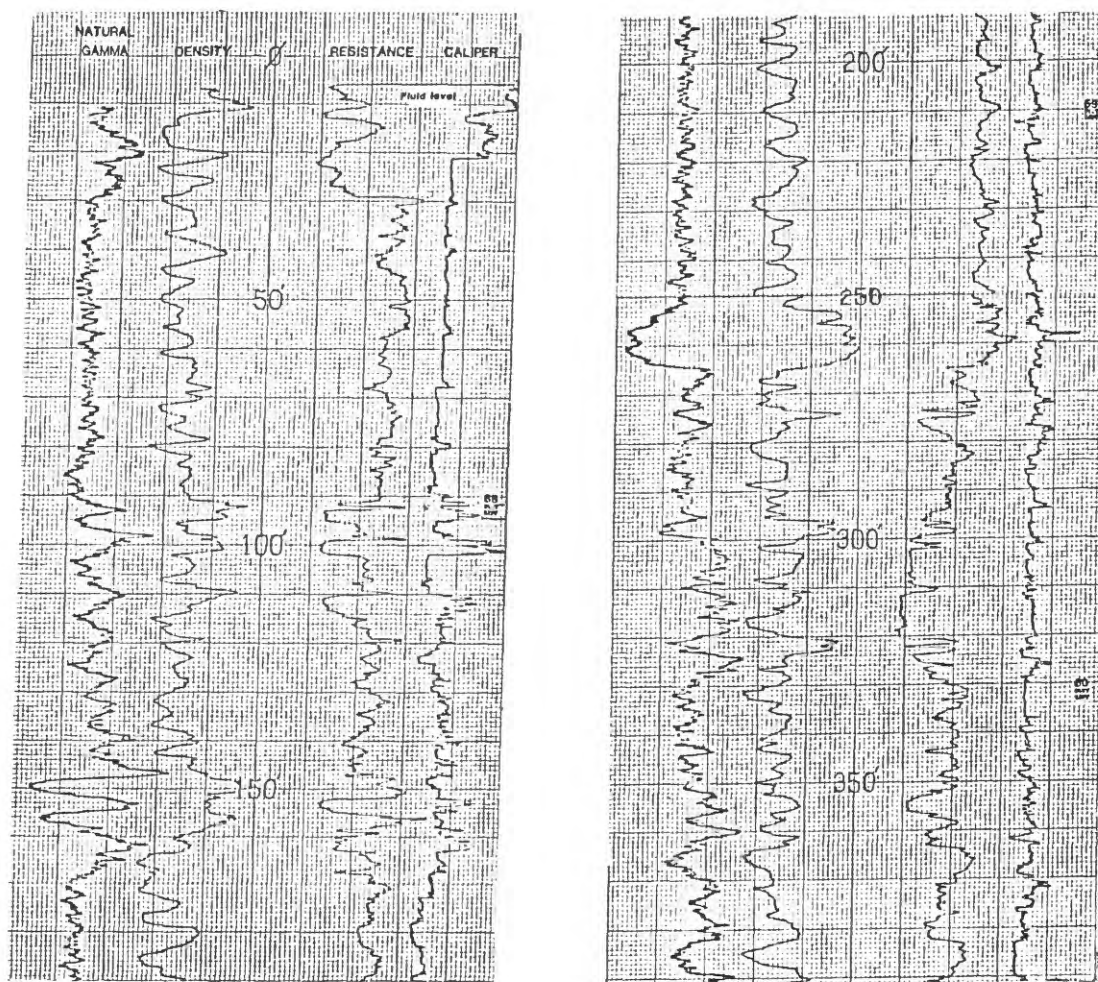


Figure 13.--Geophysical logs of hole GS-19

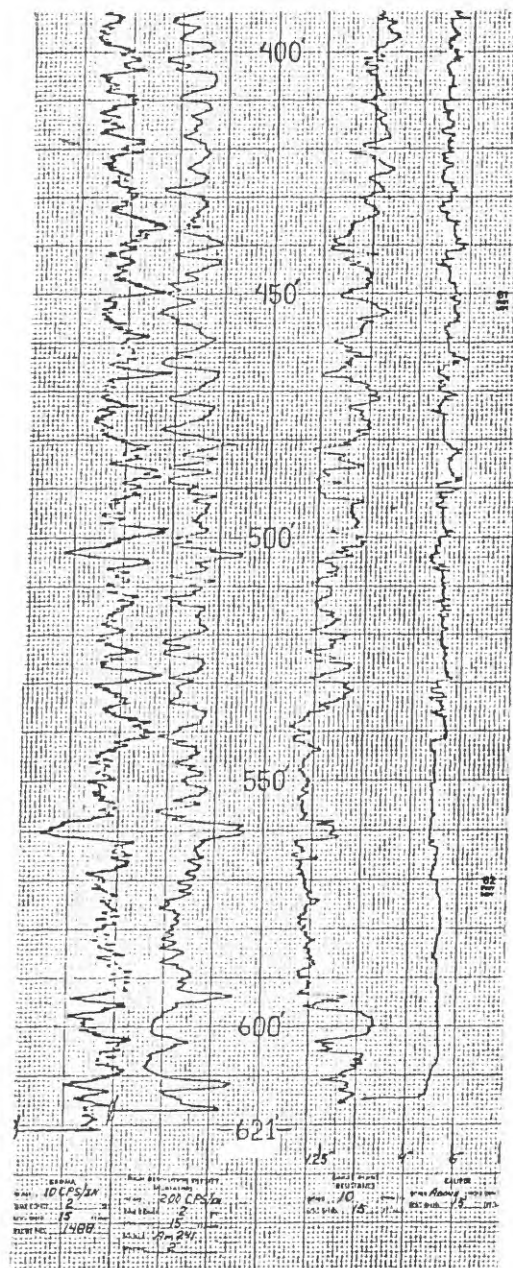


Figure 13.--Geophysical logs of hole GS-19--Continued

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
22-37	Gravel, 30 percent silt and clay
37-57	Siltstone, medium-light-gray; probable coal bed 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
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
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 (fig. 15)
218.3-218.8	Claystone, dark-yellowish-brown
218.8-222.1	Lignite, black see sample description D221131 (fig. 15)
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 to 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
368-378	Claystone, dark-gray, silty, slightly carbonaceous; grades to siltstone near base
378-395	Sandstone, medium-light-gray to light-olive-gray, very fine grained, silty, slightly carbonaceous, probable thin coal bed at base of interval
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

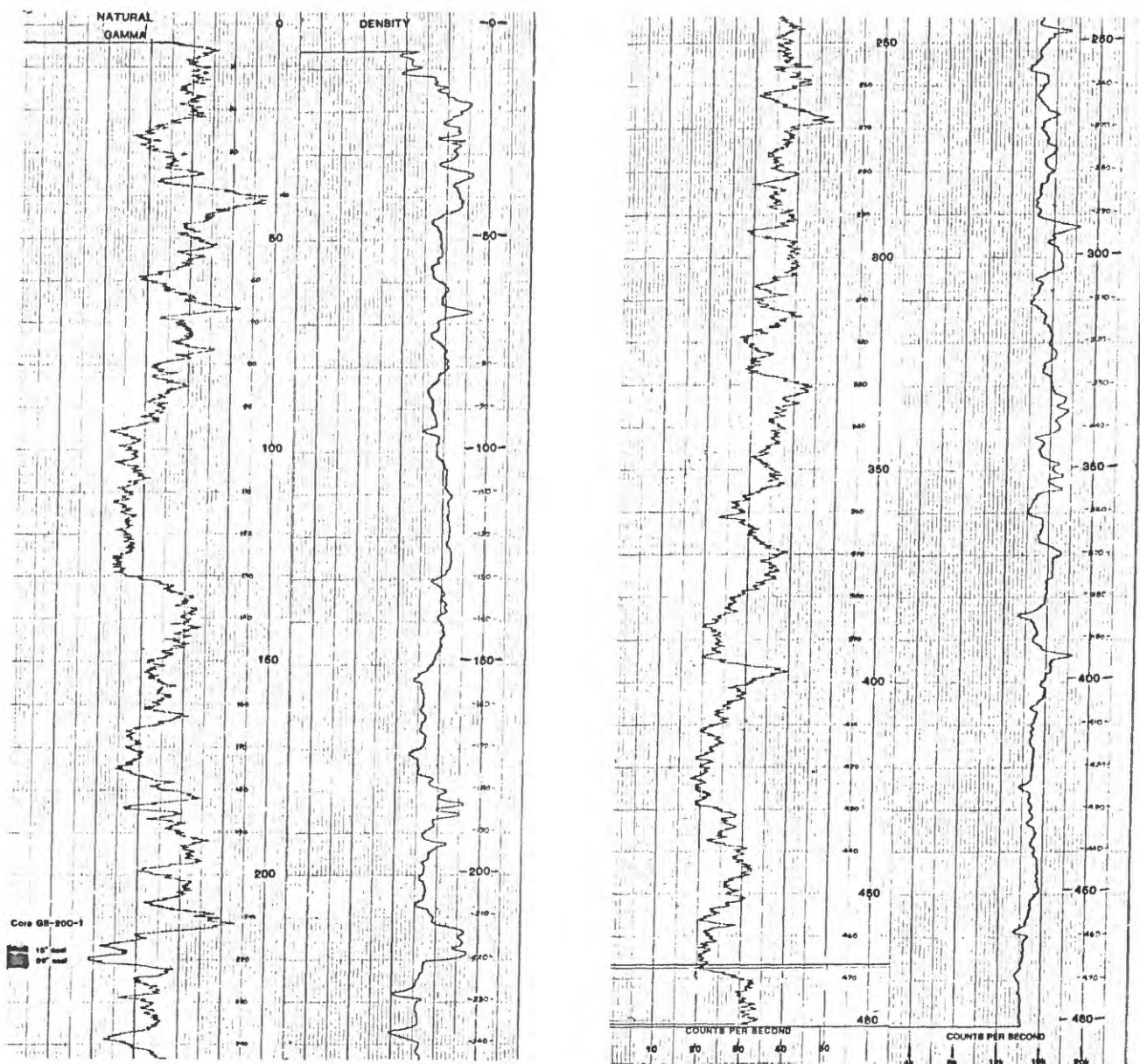


Figure 14.--Geophysical logs of hole GS-20

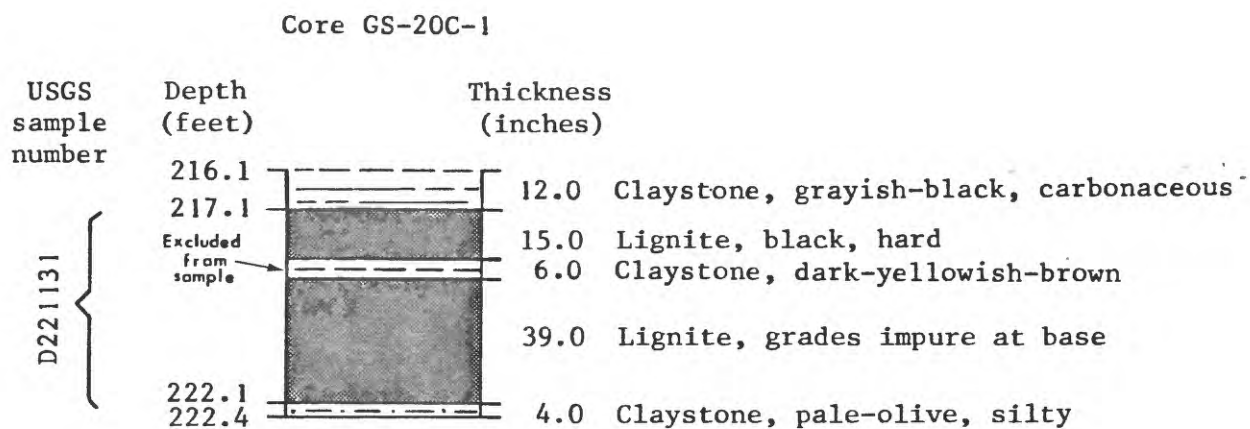


Figure 15.--Core and sample descriptions, core hole GS-20C, NE SE sec. 21,
T. 31 N., R. 51 E., Roosevelt County, Montana.

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
<hr/>	
0-49	Sand and gravel, yellowish-gray
49-58	Claystone, olive-gray, slightly carbonaceous
58-78	Siltstone, olive-gray; grades sandy near base
78-80	Lignite, black
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, medium-light-gray, very fine grained; grades argill- aceous near top of interval
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
220-223	Claystone, olive-gray
223-225	Lignite, black
225-239	Claystone, olive-gray; grades to siltstone near base
239-269	Siltstone, light-olive-gray; thin interbedded claystone at base

Sample log--Continued

Depth (feet)	Lithic description
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
313-344	Sandstone, olive-gray, very fine grained; with interbedded siltstone
344-348	Lignite, black
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 of interval
478-492	Siltstone, medium-gray to olive-gray, sandy; with interbedded silty claystone
492-525	Sandstone, olive-gray to bluish-gray, very fine grained; 10 percent dark opaques; grades silty near top of interval
525-540	Shale, olive-gray to dark-yellowish-brown; traces of carbonaceous debris
	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

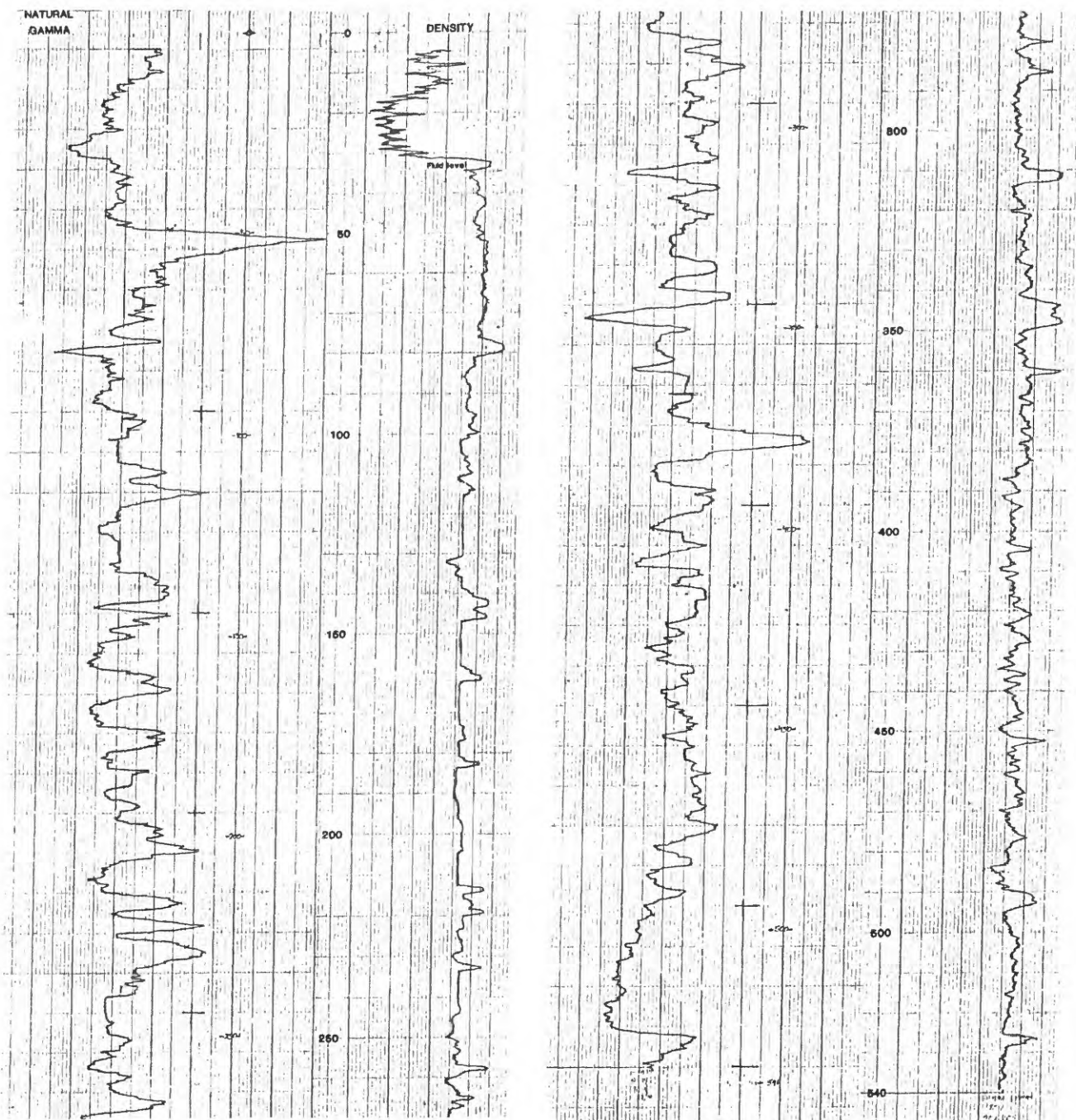


Figure 16.--Geophysical logs of hole GS-21

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
13-50	Gravel
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 (fig. 18)
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 (fig. 18)
154.4-156	Claystone, light-greenish-gray; includes 2.5 inches of lignite in lower part; see core GS-22C-2 description (fig. 18)
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
275-277	Lignite, black
277-325	Claystone, greenish-gray to olive-gray, silty; traces of coal at top of interval

Sample log--Continued

Depth (feet)	Lithic description
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 (fig. 19)
367.1-371.1	Claystone, sandy
371.1-374	Lignite, see sample description D221129 (fig. 19)
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

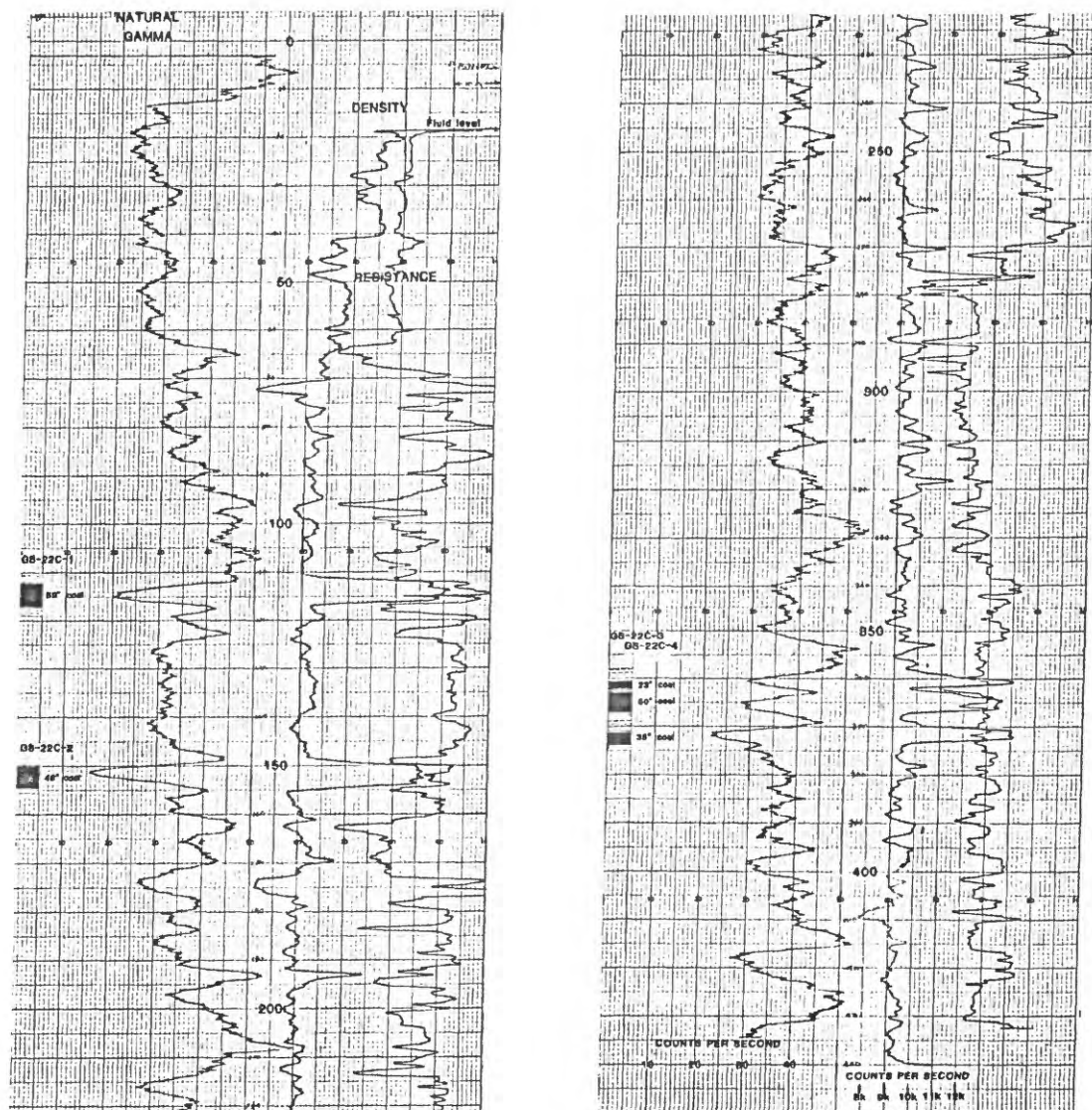


Figure 17.--Geophysical logs of hole GS-22

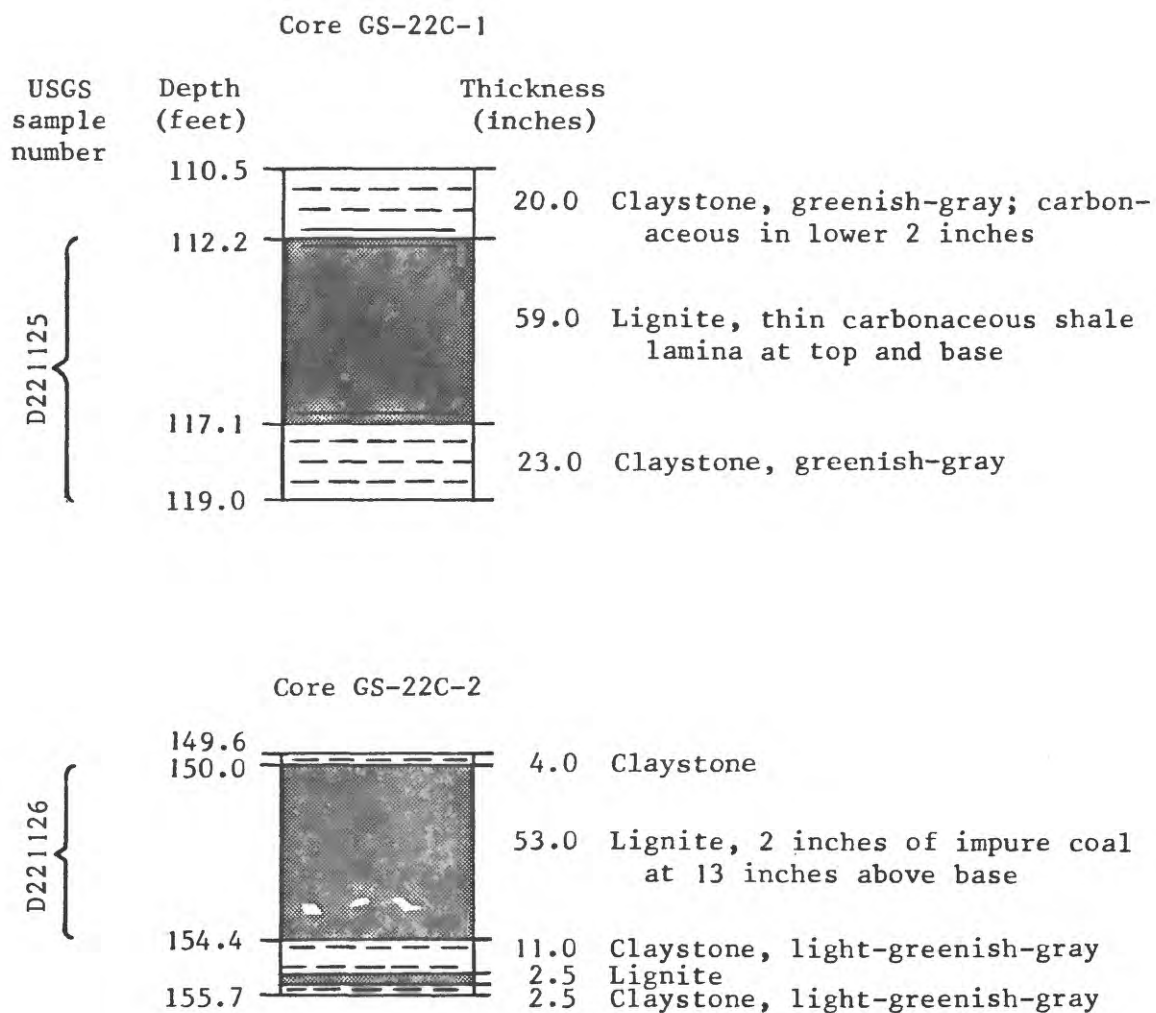


Figure 18.--Core and sample descriptions, core hole GS-22C, SW SE sec. 26, T. 32 N., R. 51 E., Roosevelt County, Montana.

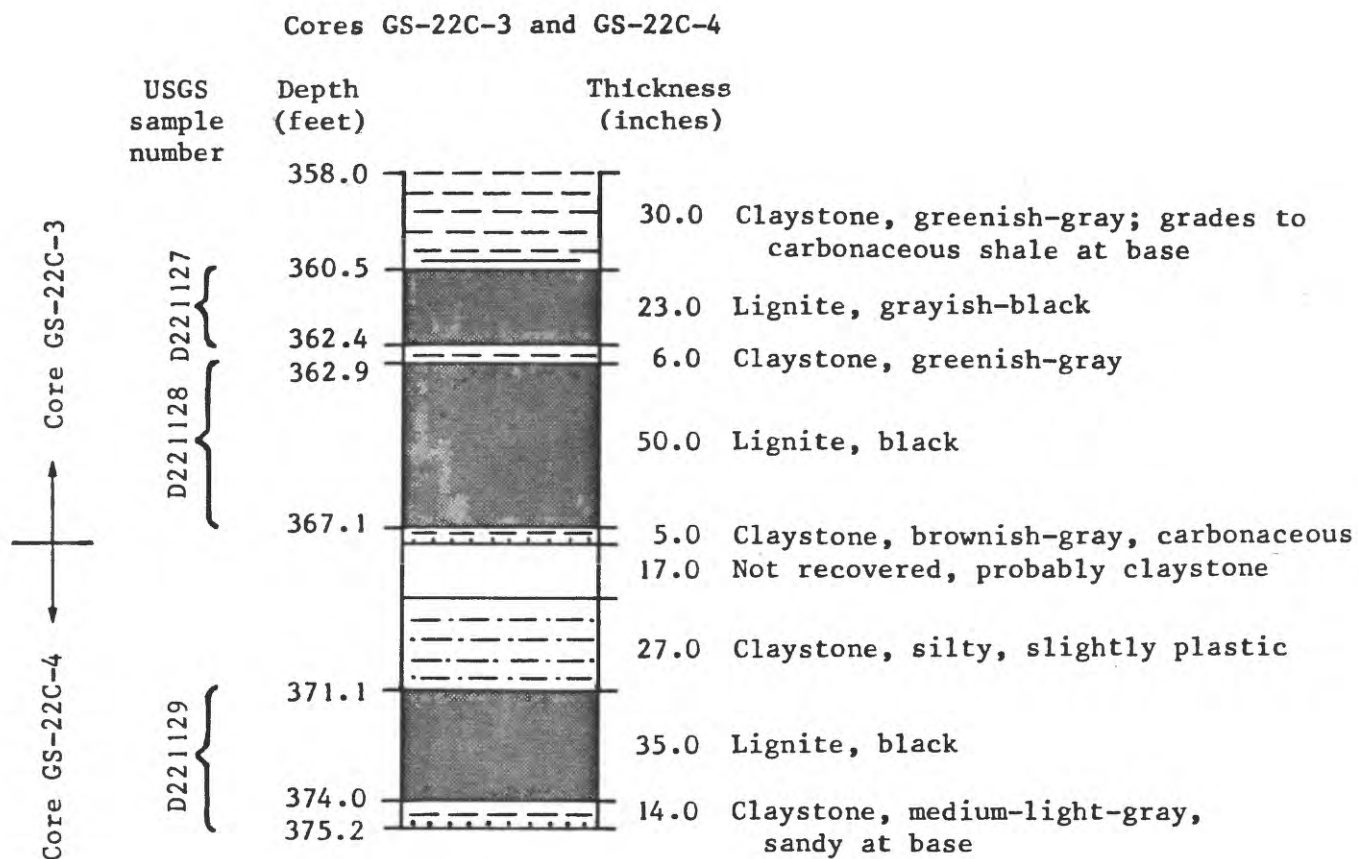


Figure 19.--Core and sample descriptions, core hole GS-22C, SW SE sec. 26, T. 32 N., R. 51 E., Roosevelt County, Montana.

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
20-56	Gravel and sand
56-122	Siltstone, dusky-yellow; with thin interbedded claystone
122-144	Claystone, light-olive-gray to pale-blue; interbedded siltstone near center 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
304-334	Siltstone, light-olive-gray; interbedded claystone at top of interval
334-336	Lignite, black
336-338	Claystone, brownish-gray
338-341	Lignite, black
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
384-399	Siltstone, olive-gray to light-gray to grayish-orange; minor coal fragments
399-408	Claystone, medium-dark-gray; carbonaceous near base

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
463-480	Claystone, medium-gray; interbedded siltstone in lower half of interval
480-482	Lignite, black
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

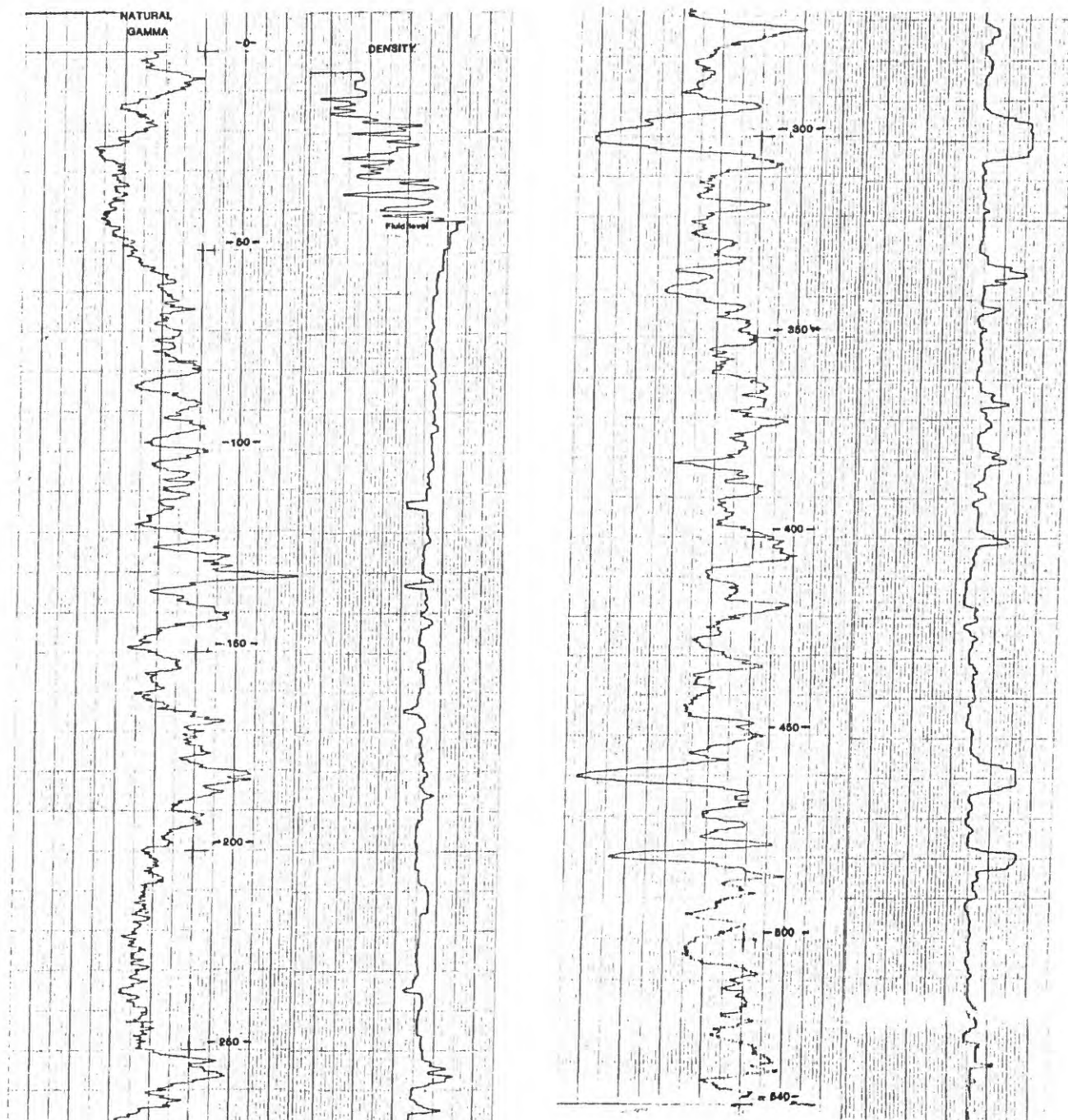


Figure 20.--Geophysical logs of hole GS-23

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
19-28	Sandstone, yellowish-gray, very fine grained
28-31	Lignite, oxidized
31-38	Siltstone, dusky-brown
38-44	Lignite, black
44-61	Sandstone, light-gray, very fine grained, silty; grades to siltstone near top of interval
61-64	Lignite, black
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
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
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
349-395	Siltstone, greenish-gray; grades sandy near base; probable coal bed 379 to 381 ft
395-398	Lignite, black
398-407	Siltstone, medium-gray
407-421	Sandstone, greenish-gray, very fine grained
421-423	Lignite, black
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
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
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

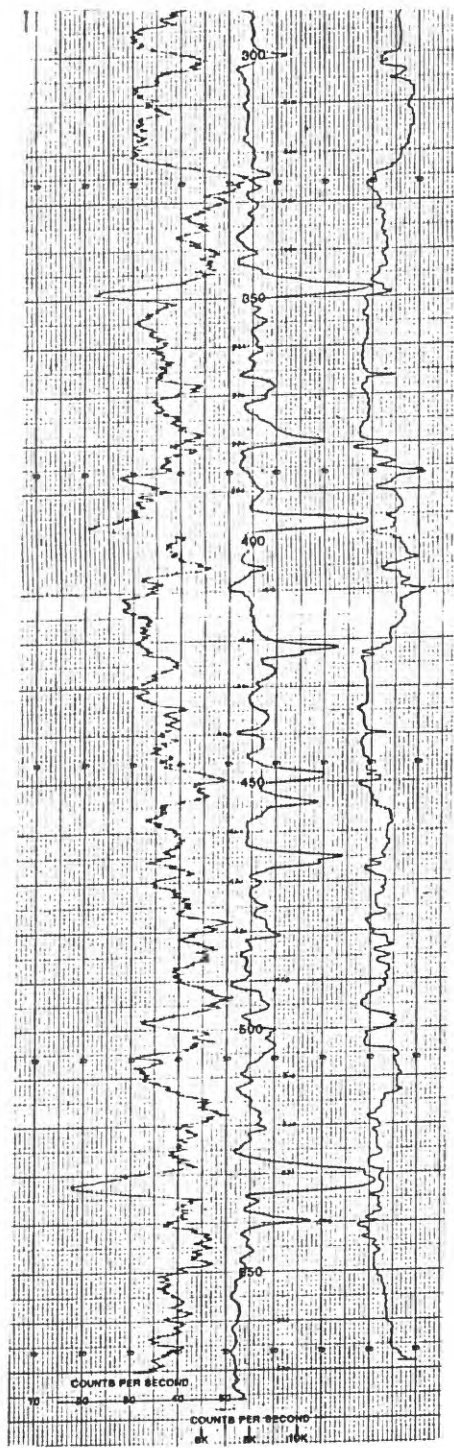
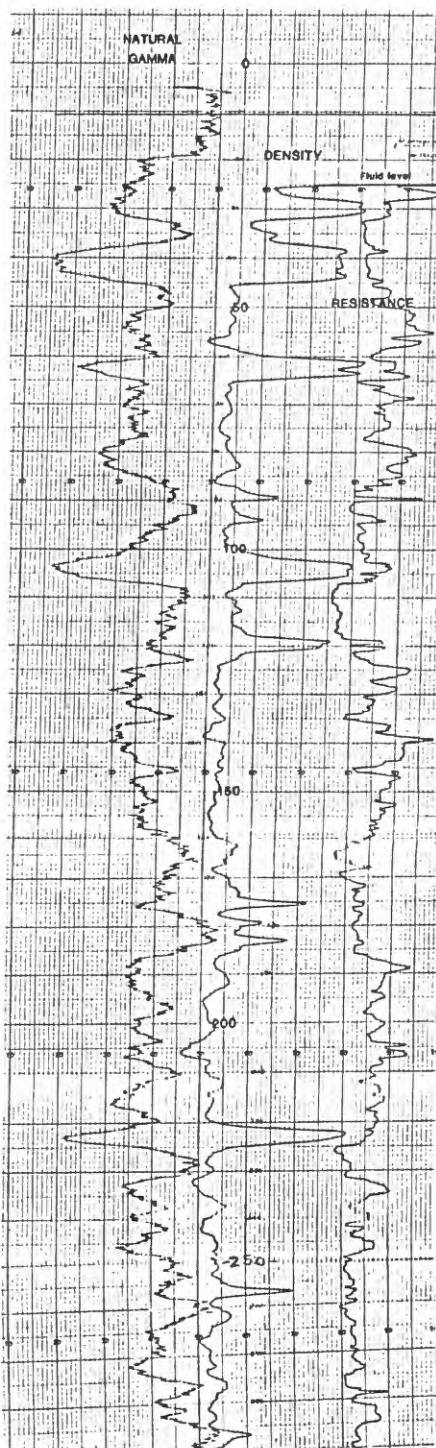


Figure 21.--Geophysical logs of hole GS-24

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
16-24	Gravel
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
162-187	Claystone, light-to medium-gray and greenish-gray; grades sandy near top of interval
187-194	Lignite, black
194-205	Sandstone, light-to medium-gray
205-208	Lignite, black
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
378-381	Lignite, black

Sample log--Continued

Depth (feet)	Lithic description
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
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

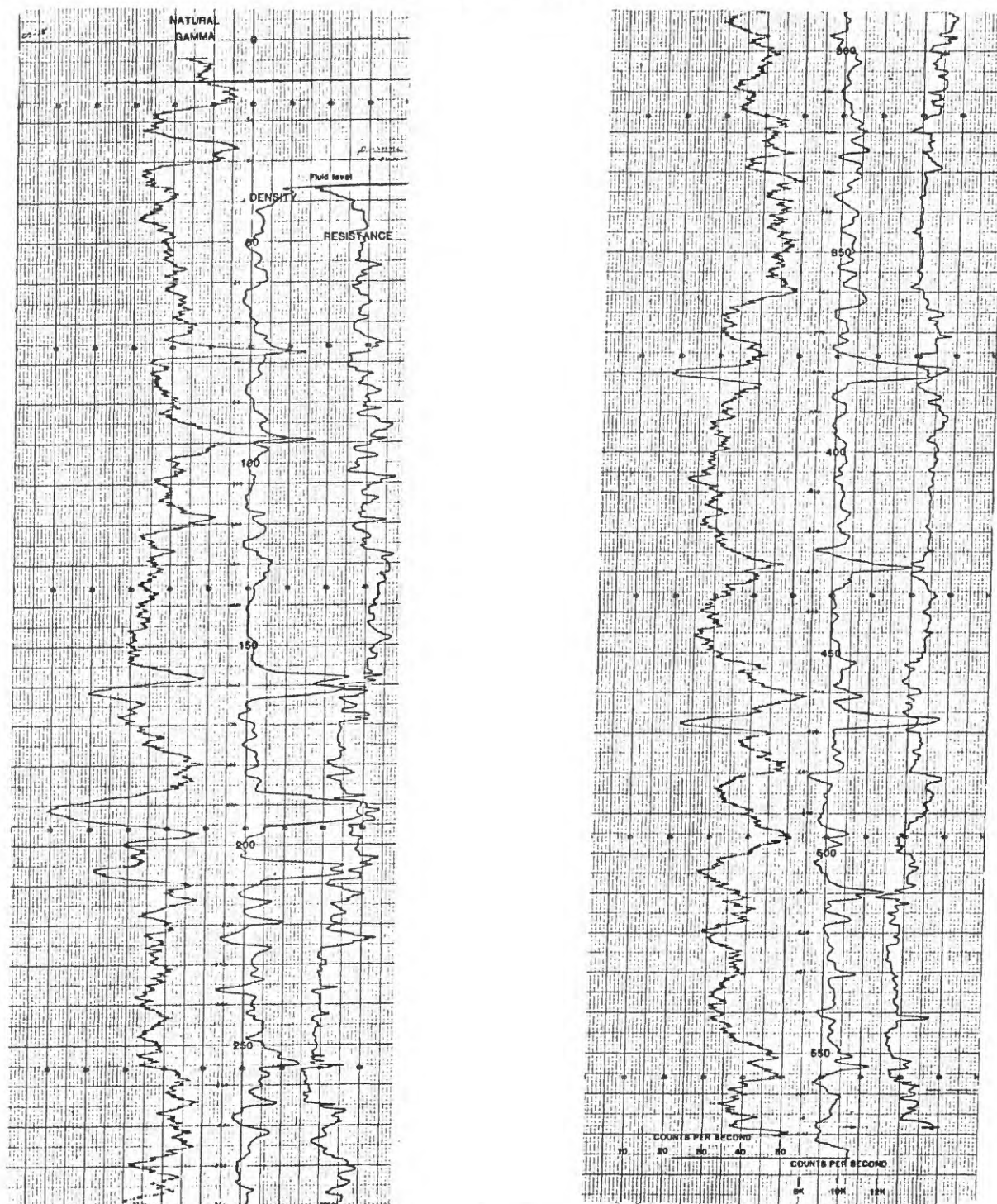


Figure 22.--Geophysical logs of hole GS-25

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
32-41	Sand, brownish-gray, silty
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
91-107	Claystone, medium-gray; interbedded sandstone 98 to 102 ft
107-114	Sandstone, medium-gray, very fine grained
114-117	Lignite, black
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
293-311	Claystone, olive-gray; silty near middle of interval

Sample log--Continued

Depth (feet)	Lithic description
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
357-361	Claystone, coal bed 359 to 360 ft
361-364	Lignite, black
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; probable coal 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

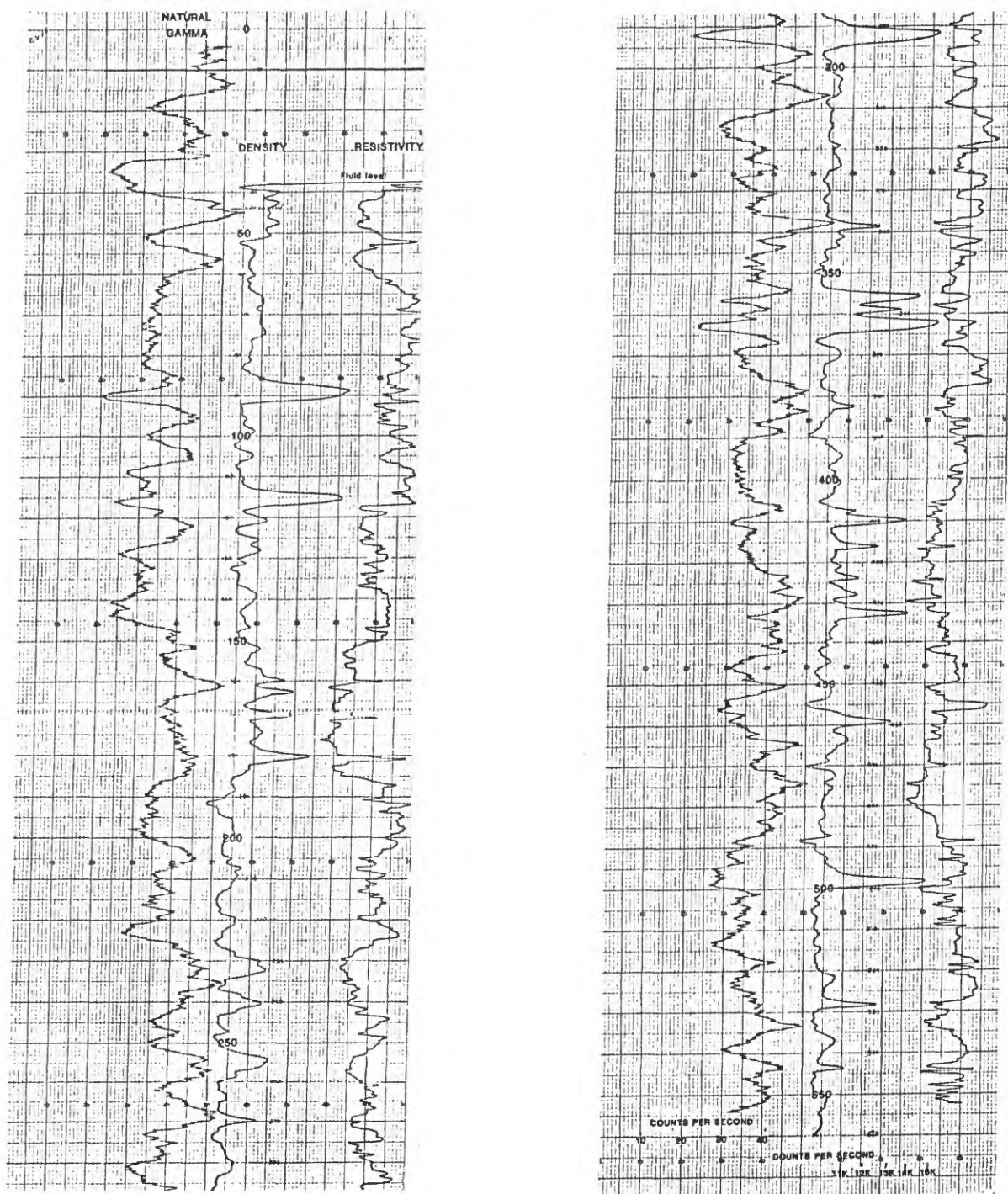


Figure 23.--Geophysical logs of hole GS-26

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
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
172-218	Siltstone, light-gray; with interbedded claystone
218-220	Lignite, black
220-232	Siltstone, light-gray
232-236	Lignite; claystone parting 233 to 234 ft
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
320-341	Claystone, very light gray
341-430	Sandstone, light-gray to greenish-gray, very fine grained; claystone parting 385 to 391 ft and 411 to 418 ft; probable coal bed 429 to 430 ft

Sample log--Continued

Depth (feet)	Lithic description
430-458	Siltstone, olive-gray
458-460	Lignite
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

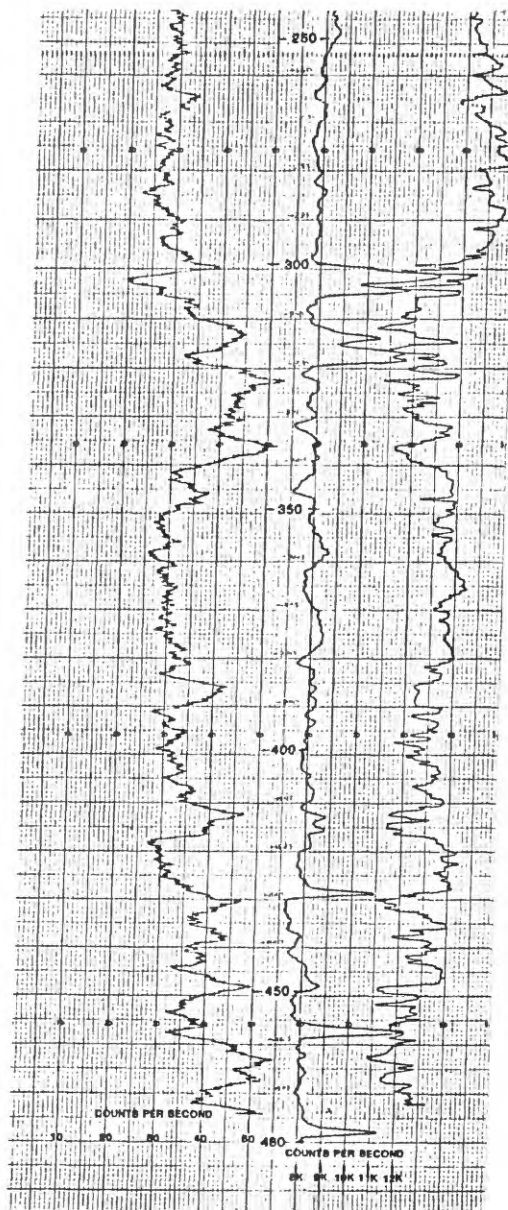
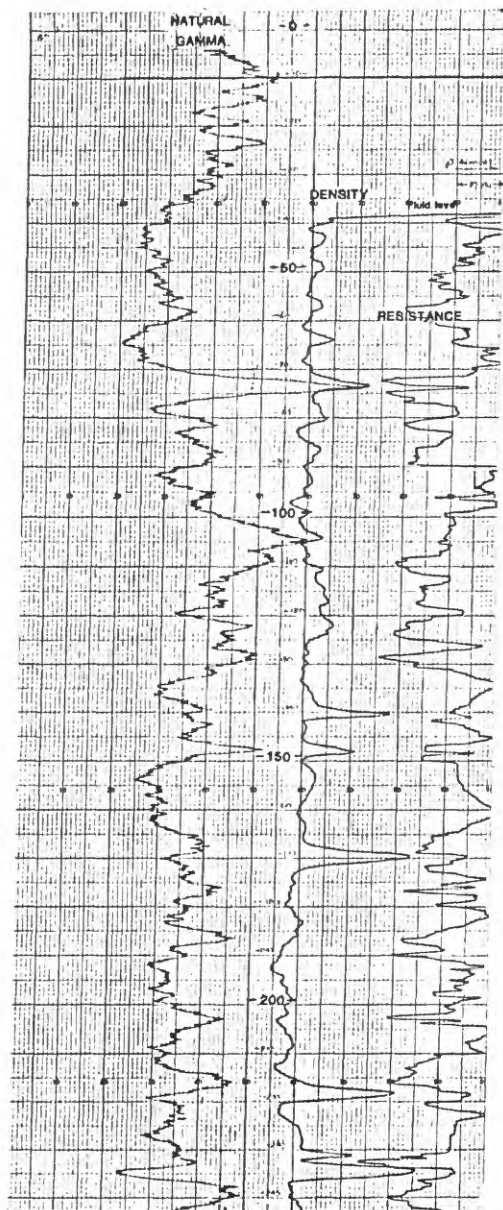


Figure 24.--Geophysical logs of hole GS-27

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
32-73	Sand and gravel
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, see sample description D221132 (fig. 26)
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 (fig. 26)
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
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 (fig. 26)
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

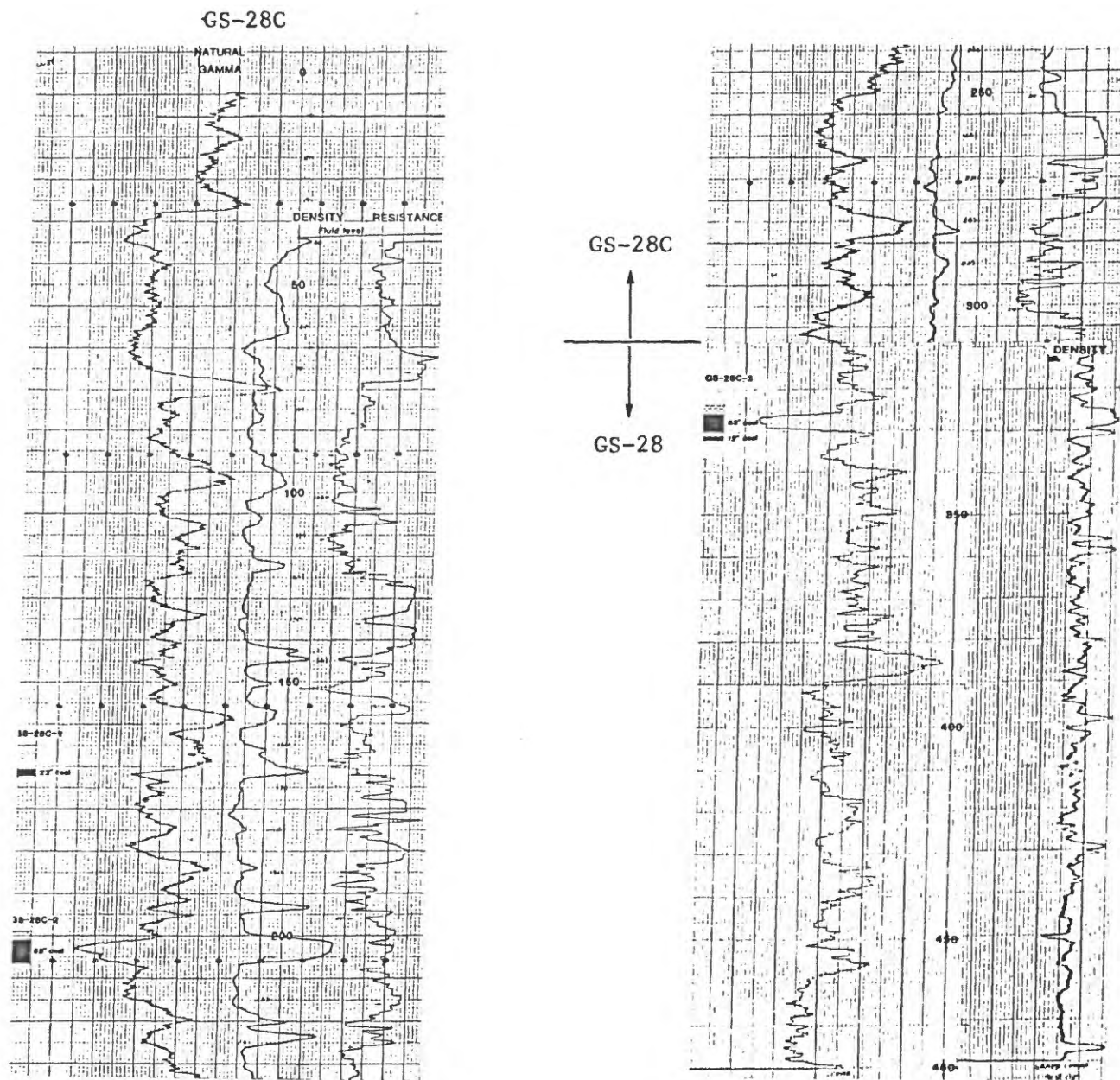


Figure 25.--Geophysical logs of holes GS-28 and GS-28C

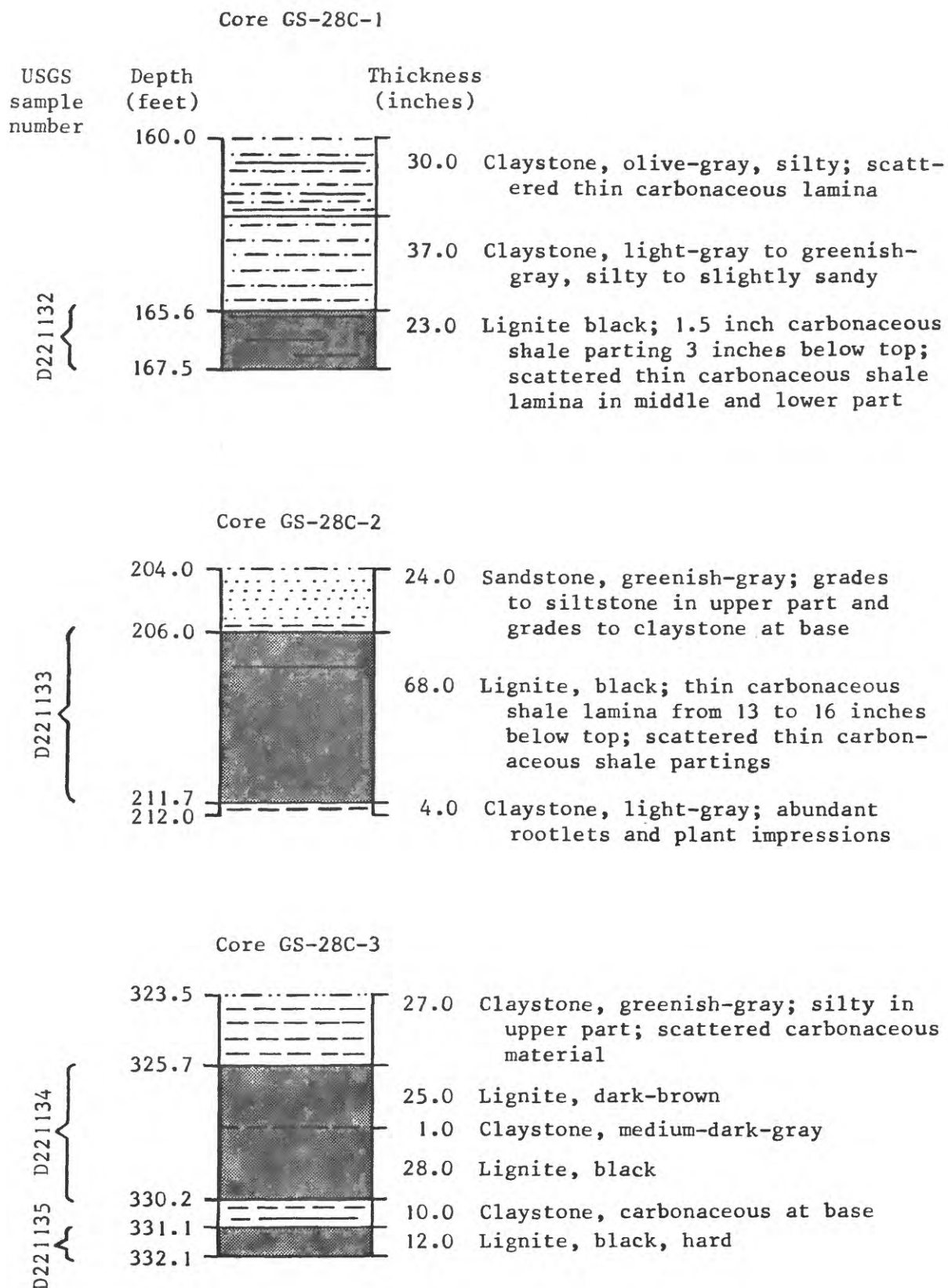


Figure 26.--Core and sample descriptions, core hole GS-28C, SE SE sec. 1, T. 32 N., R. 49 E., Roosevelt County, Montana

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; abundant coal fragments in upper half of interval; grades to claystone at top and base
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
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
411-414	Lignite, black
414-439	Claystone, dark-gray; siltstone parting 432 to 435 ft

Sample log--Continued

Depth (feet)	Lithic description
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

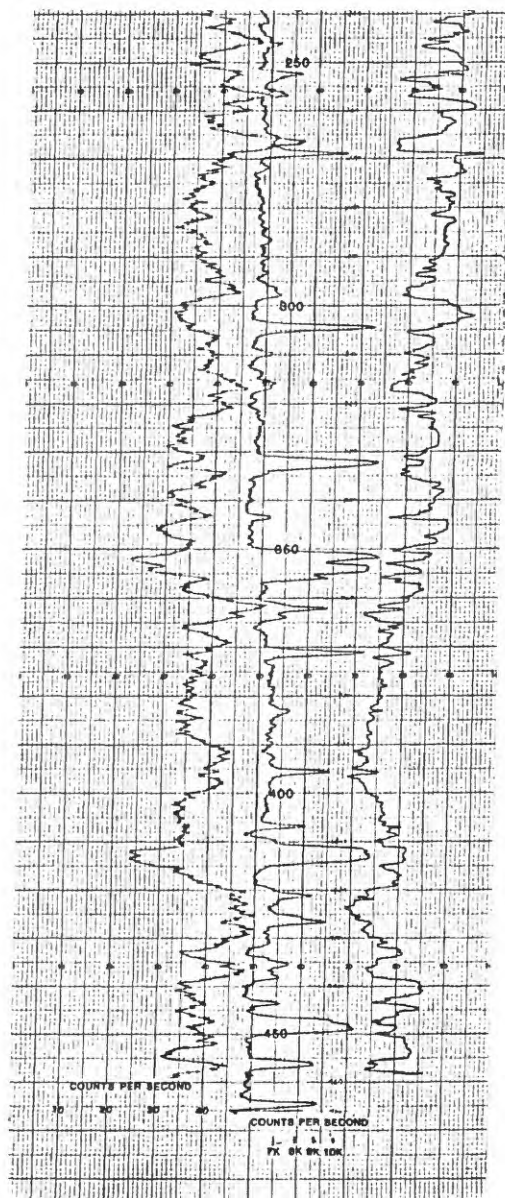
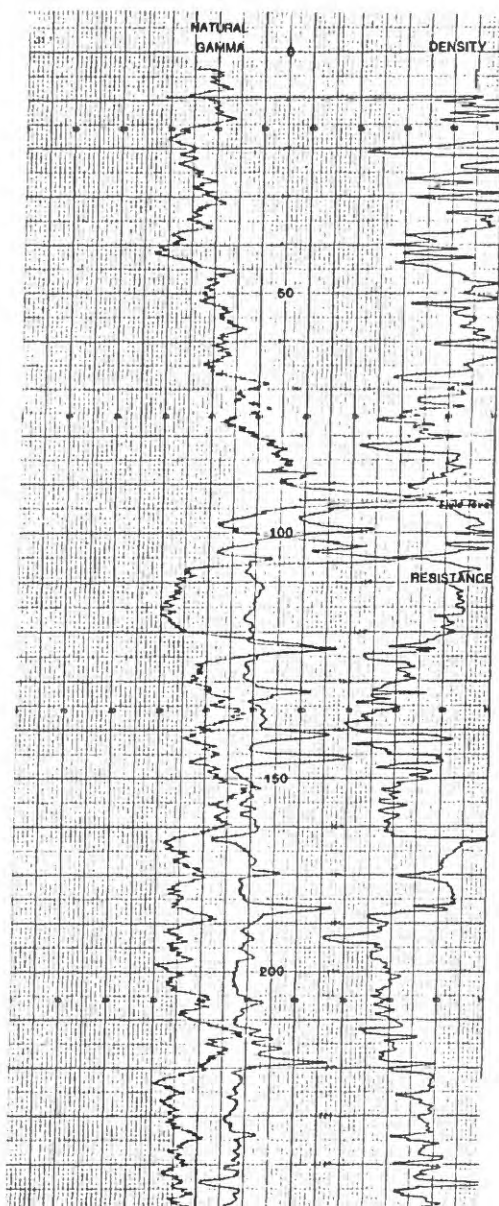


Figure 27.--Geophysical logs of hole GS-29

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

25-39 Sand and silt, dark-yellowish-brown

39-130 Sand, silt, and clay, light-olive-gray to olive-gray; sparse detrital coal fragments at base

130-156 Gravel, rounded pebbles of quartz, quartzite, and granite as much as 1 inch in diameter

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

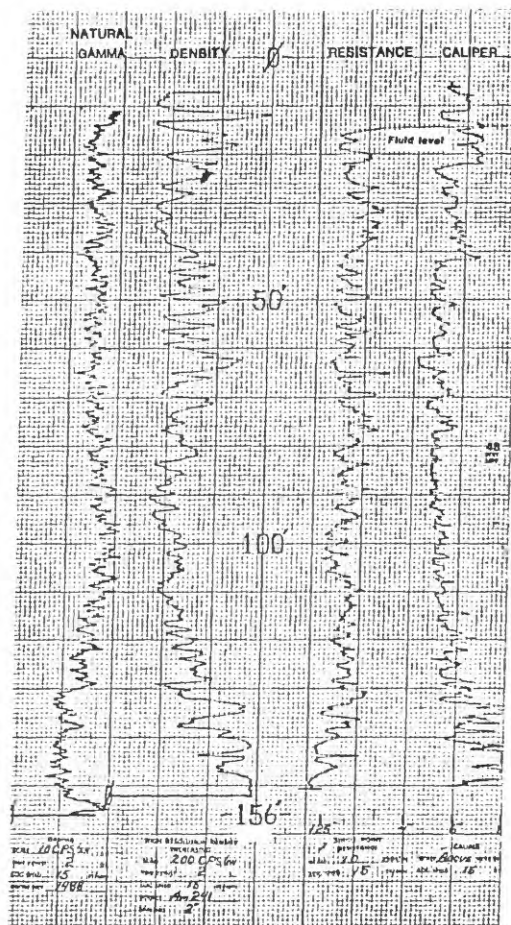


Figure 28.--Geophysical logs of hole GS-30

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
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; coal bed 201 to 202 ft
236-244	Claystone, light-gray to medium-gray
244-316	Siltstone, medium-gray; coal beds 274 to 275 ft and 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
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

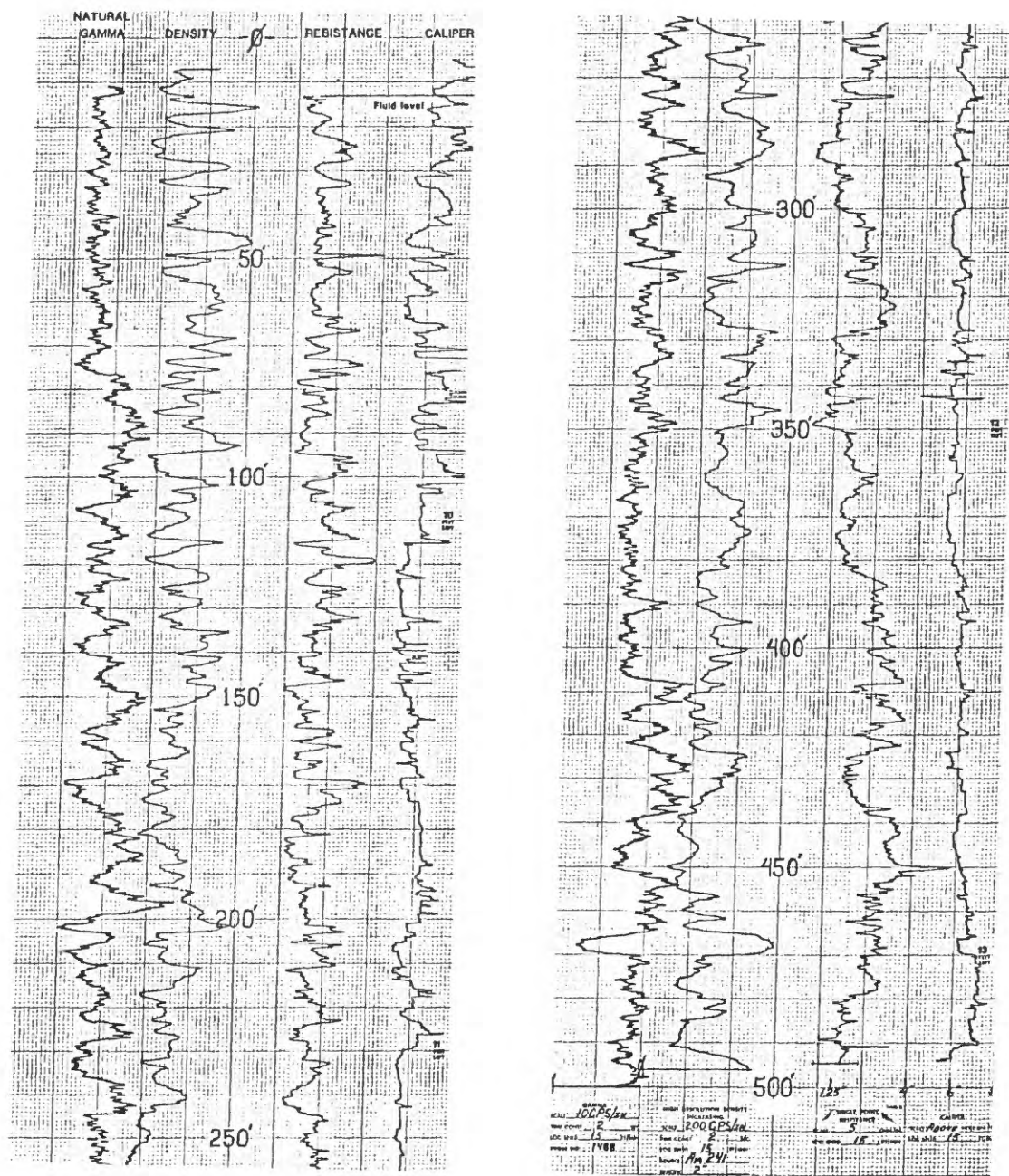


Figure 29.--Geophysical logs of hole GS-31

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
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
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
147-150	Lignite, grayish-black
150-169	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 probable thin coal at 194 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 thin impure coal at 299 ft; grades to light-olive-gray siltstone at base
307-310.5	Lignite, grayish-black
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
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
479-502	Siltstone, light-olive-gray; includes some thinly interbedded silty claystone; sandy in upper part
502-509	Sandstone, medium-gray, very fine grained

Sample log--Continued

Depth (feet)	Lithic description
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
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
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

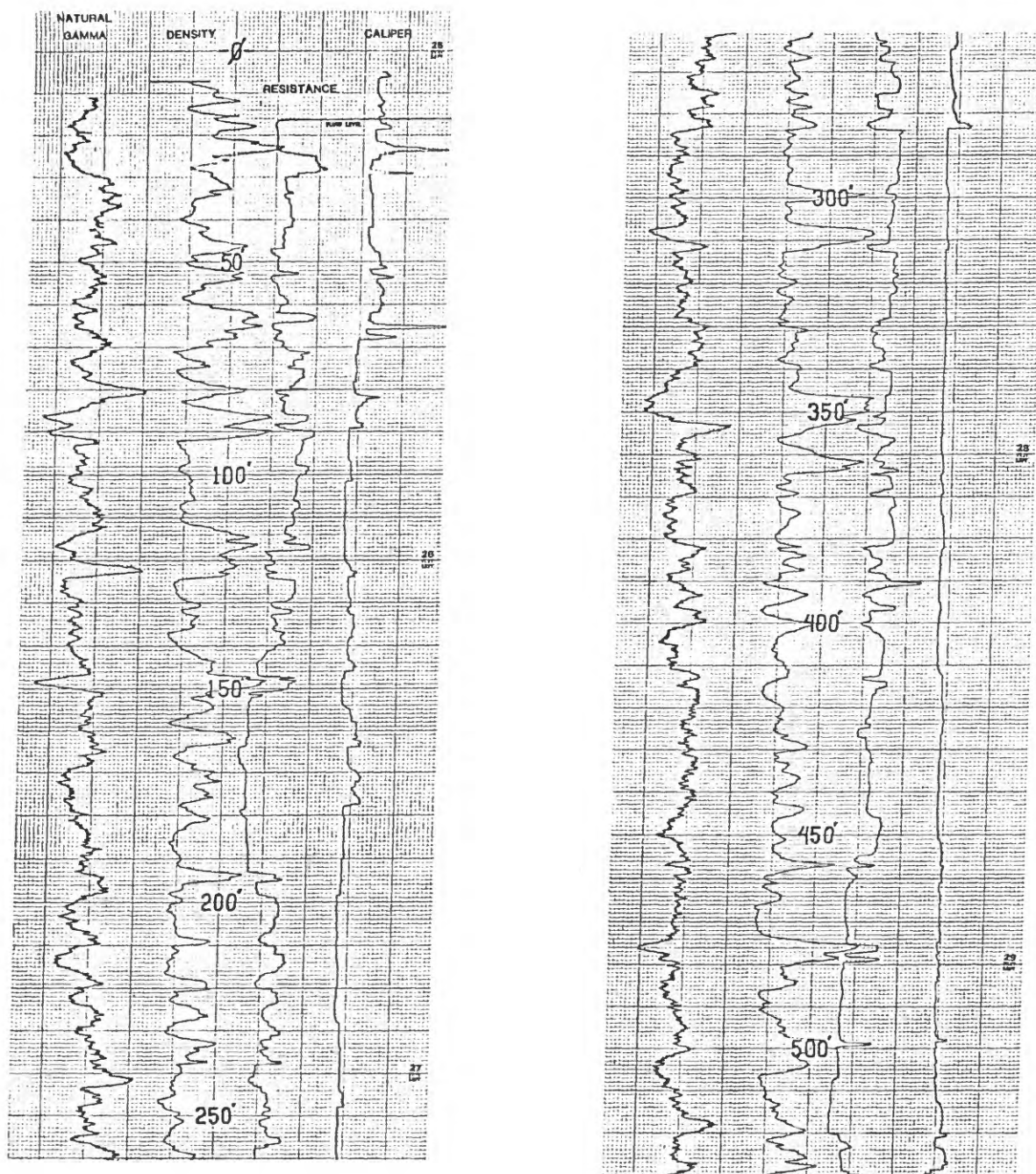


Figure 30.--Geophysical logs of hole GS-32

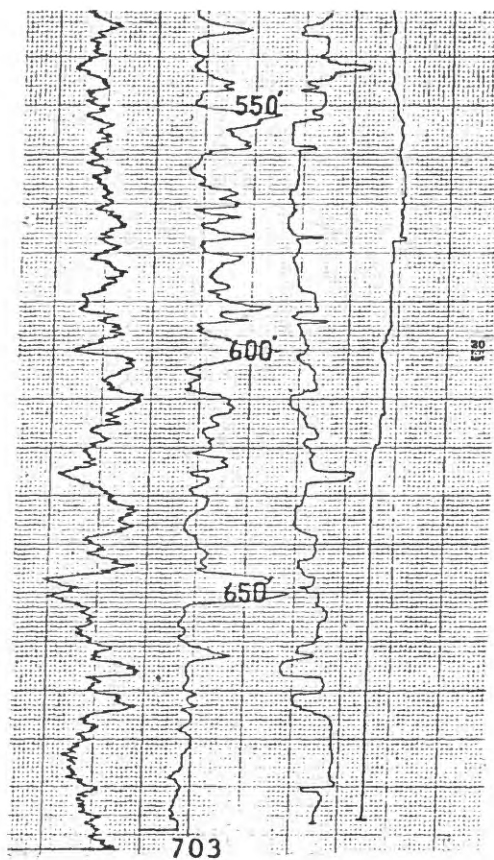


Figure 30.--Geophysical logs of hole GS-32--Continued

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
199-218	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
218-236	Siltstone and silty claystone, very light gray to light-olive-gray; grades to silty sandstone at base
236-245	Claystone, yellowish-gray to light-olive-gray; silty in lower part

Sample log--Continued

Depth (feet)	Lithic description
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
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
344-345	Lignite, brownish-black, impure
345-355	Siltstone and silty claystone, light-gray to brownish-gray; probable thin impure coal at 349 ft
355-357	Lignite, black
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
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

Sample log--Continued

Depth (feet)	Lithic description
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

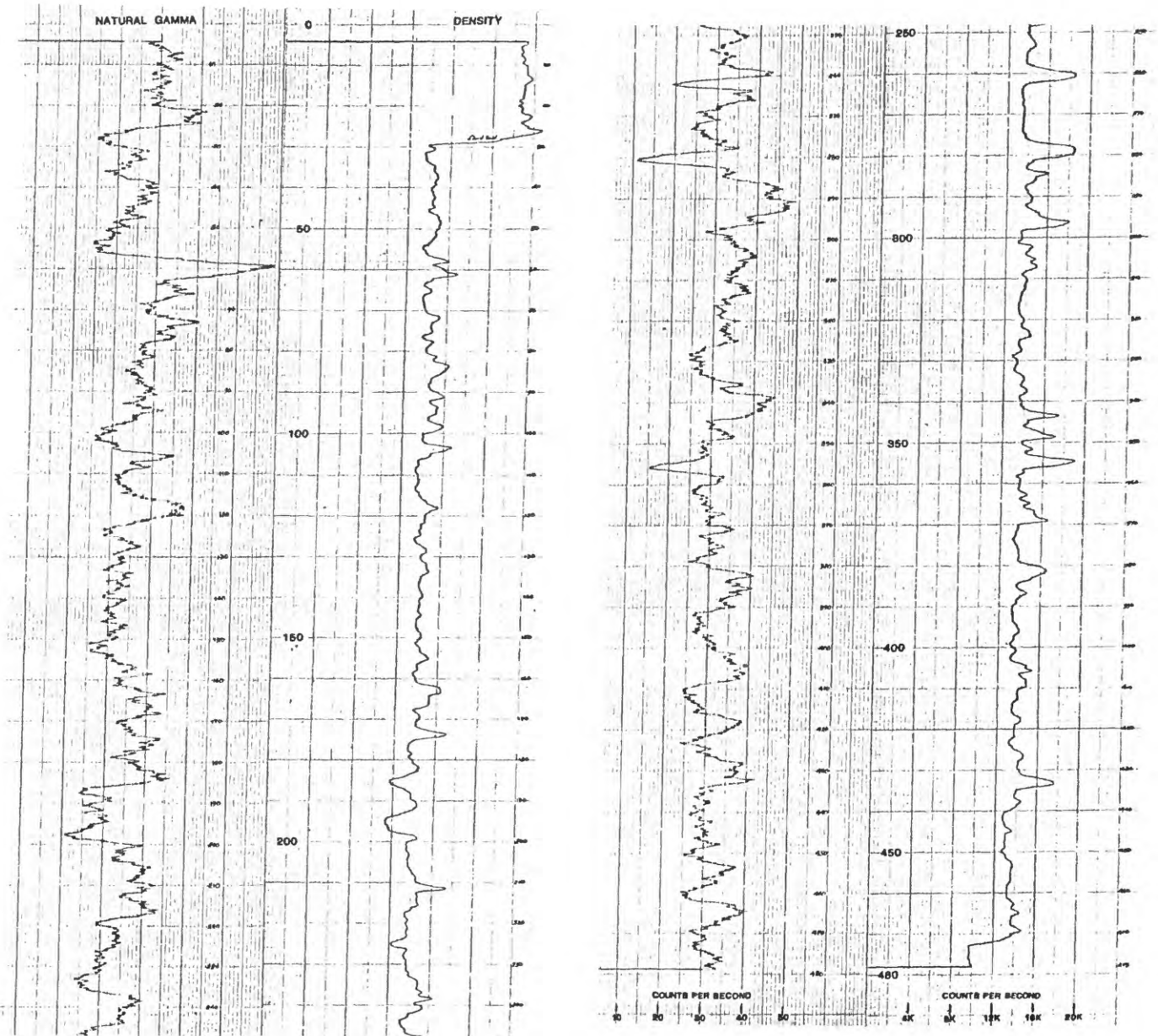


Figure 31.--Geophysical logs of hole GS-33

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
13-31	Gravel
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 (fig. 33)
233.2-244	Claystone, greenish-gray; grades sandy near top of interval
244-247.5	Lignite, see sample description D221137 (fig. 33)
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(?)
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
362-383	Claystone, greenish-gray, silty; minor coal fragments
383-390	Sandstone, light-gray

Sample log--Continued

Depth (feet)	Lithic description
390-422	Claystone, greenish-gray; traces of coal near base
422-433	Sandstone, greenish-gray; grades to claystone at base
433-437	Lignite, black
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
522-534	Claystone, medium-light-gray
534-541	Siltstone, light-gray
541-544	Lignite
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

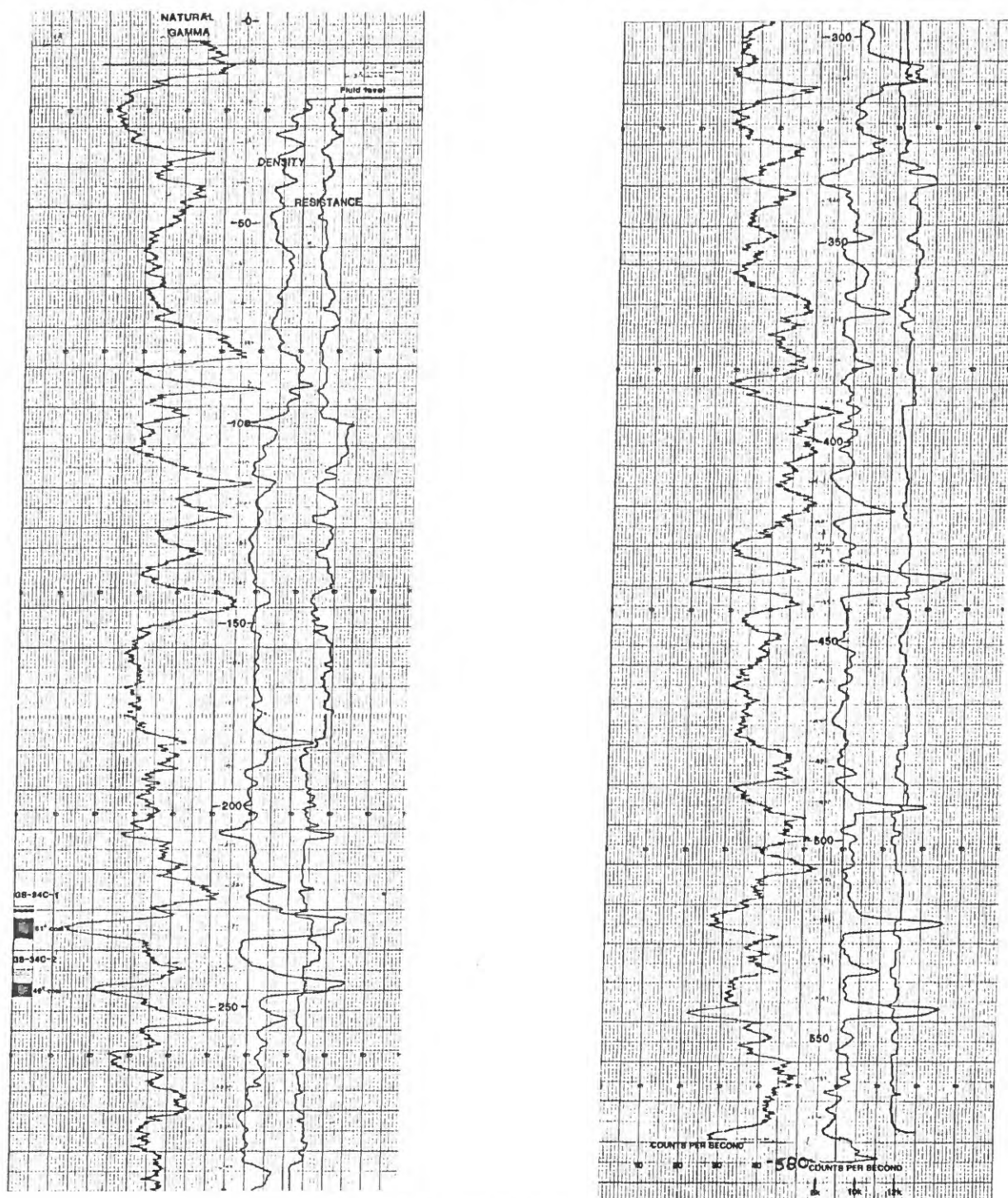


Figure 32.--Geophysical logs of hole GS-34

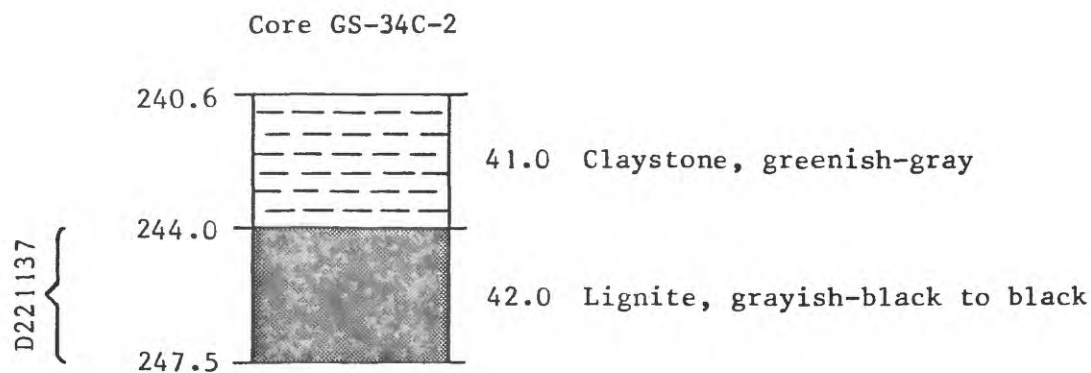
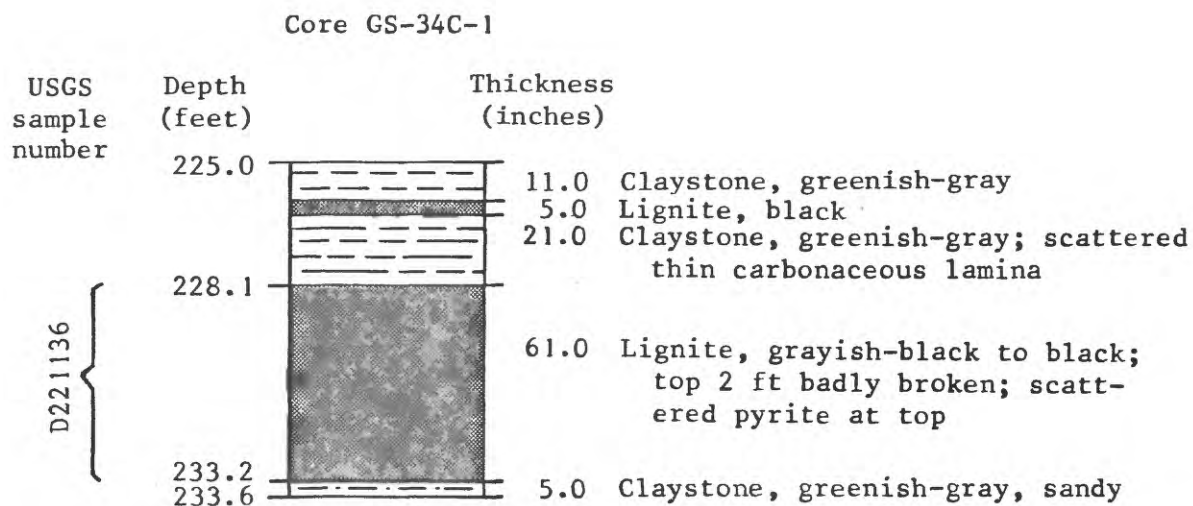


Figure 33.--Core and sample descriptions, core hole GS-34C, NW NW sec. 17, T. 32 N., R. 53 E., Roosevelt County, Montana.

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
14-19	Siltstone, yellowish-brown
19-23	Lignite, black
23-37	Claystone, light-gray; silty near base
37-57	Siltstone, light-gray; interbedded claystone at base
57-60	Lignite, black
60-63	Claystone
63-66	Lignite, black
66-85	Sandstone, greenish-gray, very fine grained; interbedded claystone near middle of interval
85-111	Claystone, greenish-gray, silty
111-115	Lignite, impure(?)
115-125	Siltstone, greenish-gray, sandy; coal bed 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; coal bed 189 to 190 ft
212-215	Lignite, black
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
280-281	Lignite, black

Sample log--Continued

Depth (feet)	Lithic description
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; minor 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

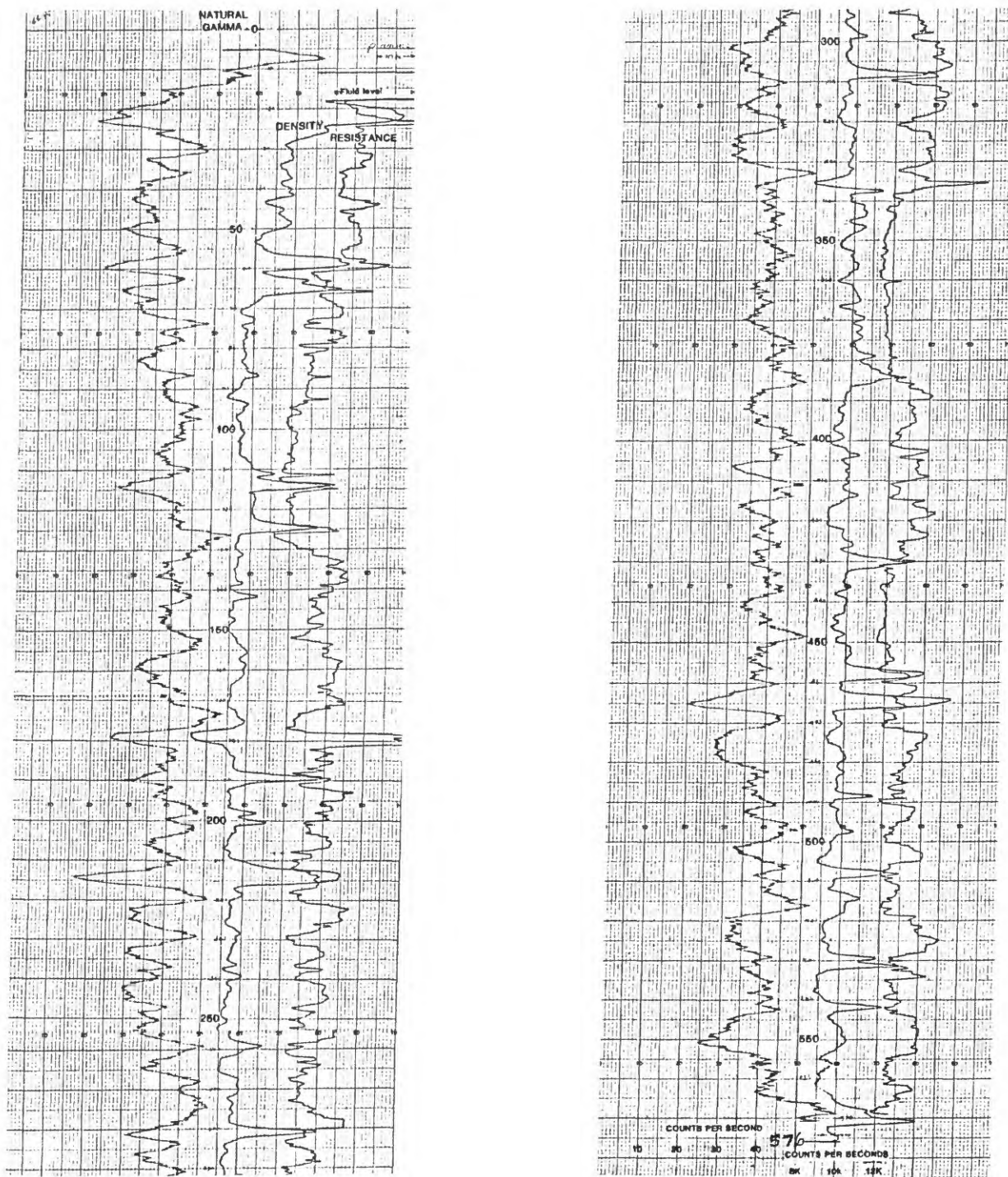


Figure 34.--Geophysical logs of hole GS-35

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
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
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
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 sandstone concretion 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; sandstone parting 380 to 384 ft

Sample log--Continued

Depth (feet)	Lithic description
394-415	Sandstone, light-olive-gray to dark-yellowish-orange; minor coal fragments
415-426	Siltstone, light-olive-gray; minor 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

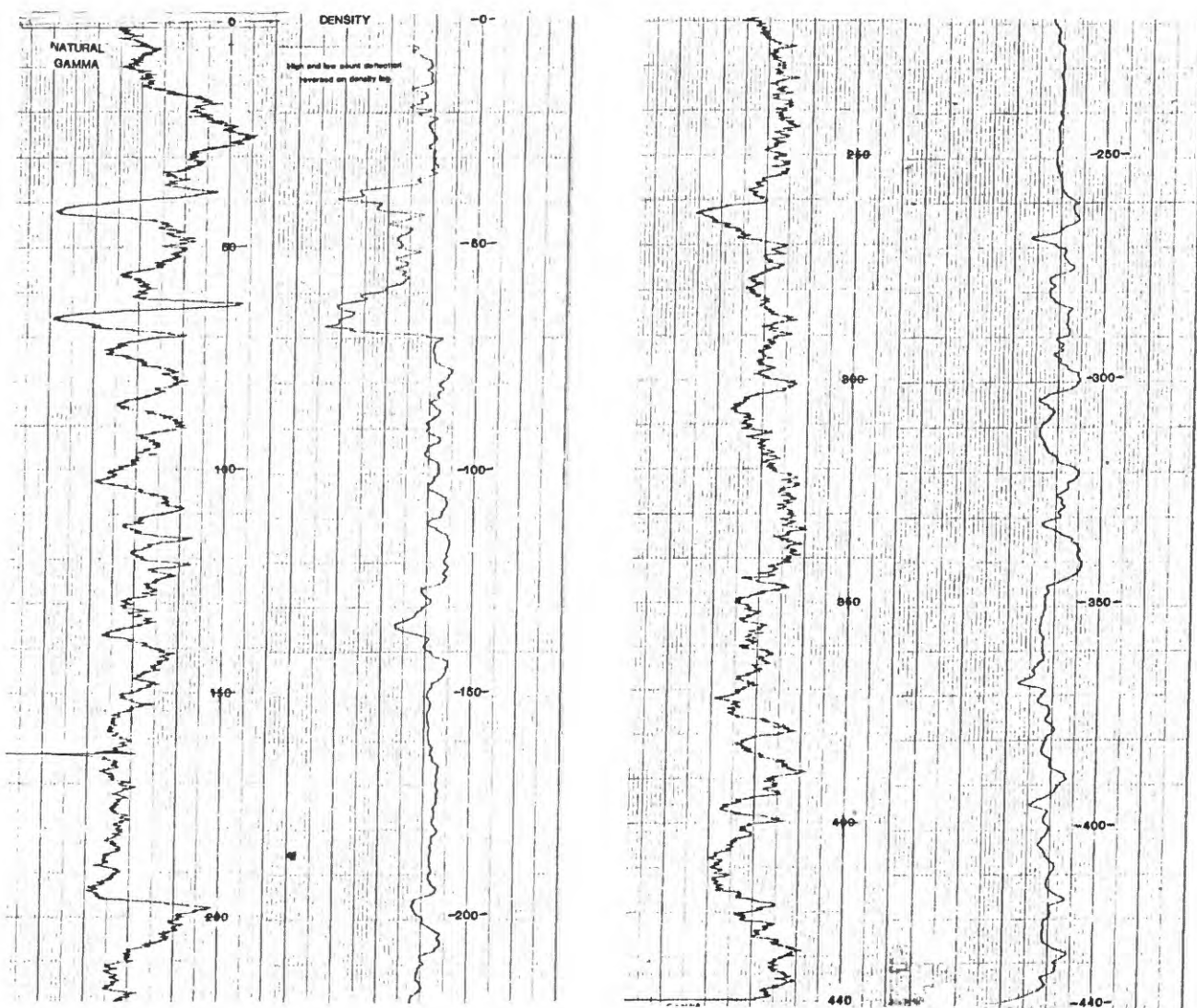


Figure 35.--Geophysical logs of hole GS-36

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
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
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; probable coal 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
302-304	Lignite, black

Sample log--Continued

Depth (feet)	Lithic description
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; coal 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

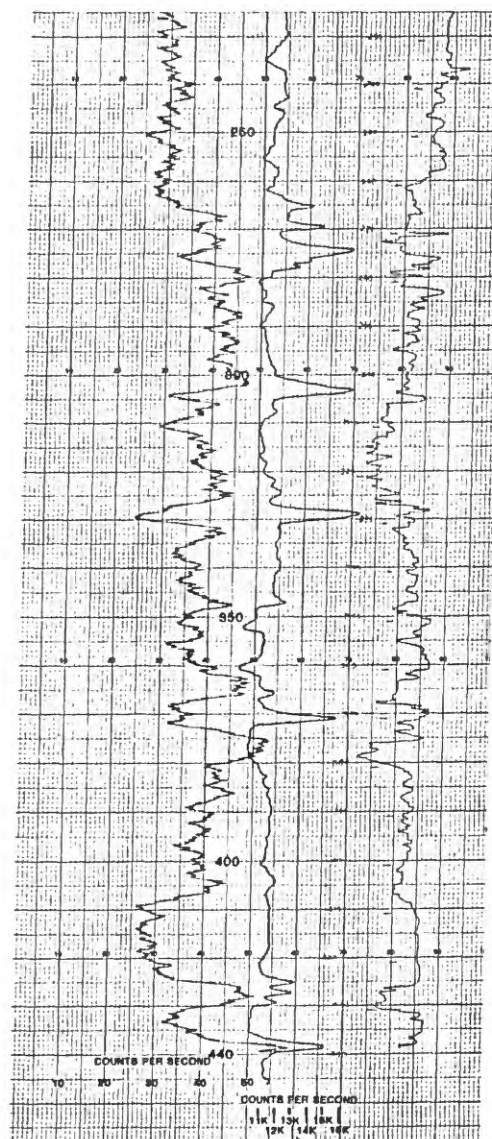
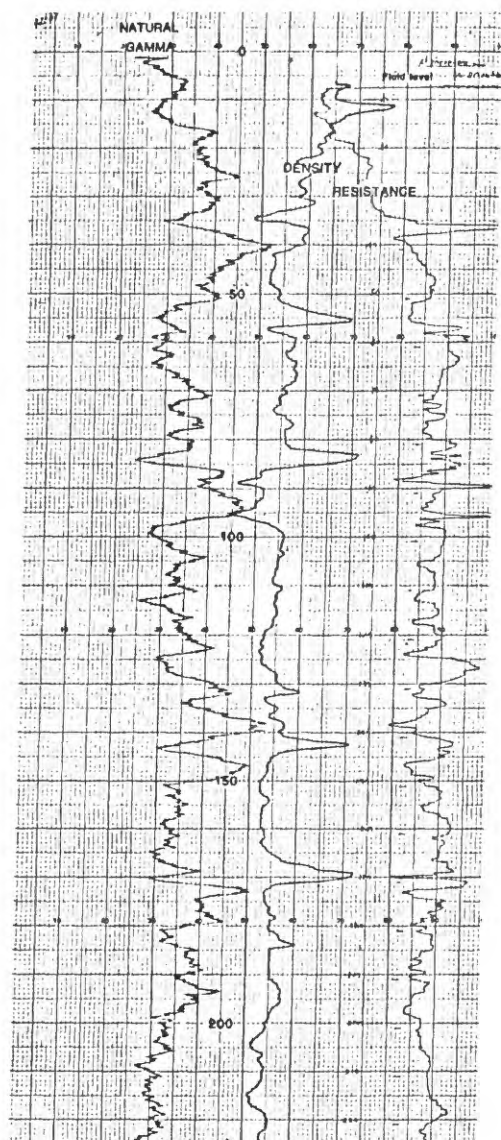


Figure 36.--Geophysical logs of hole GS-37

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
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
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; minor coal fragments
274-295	Siltstone, light-gray; grades to claystone near top of interval
295-298	Lignite, black

Sample log--Continued

Depth (feet)	Lithic description
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; coal from 363 to 364 ft
366-370	Lignite, black
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

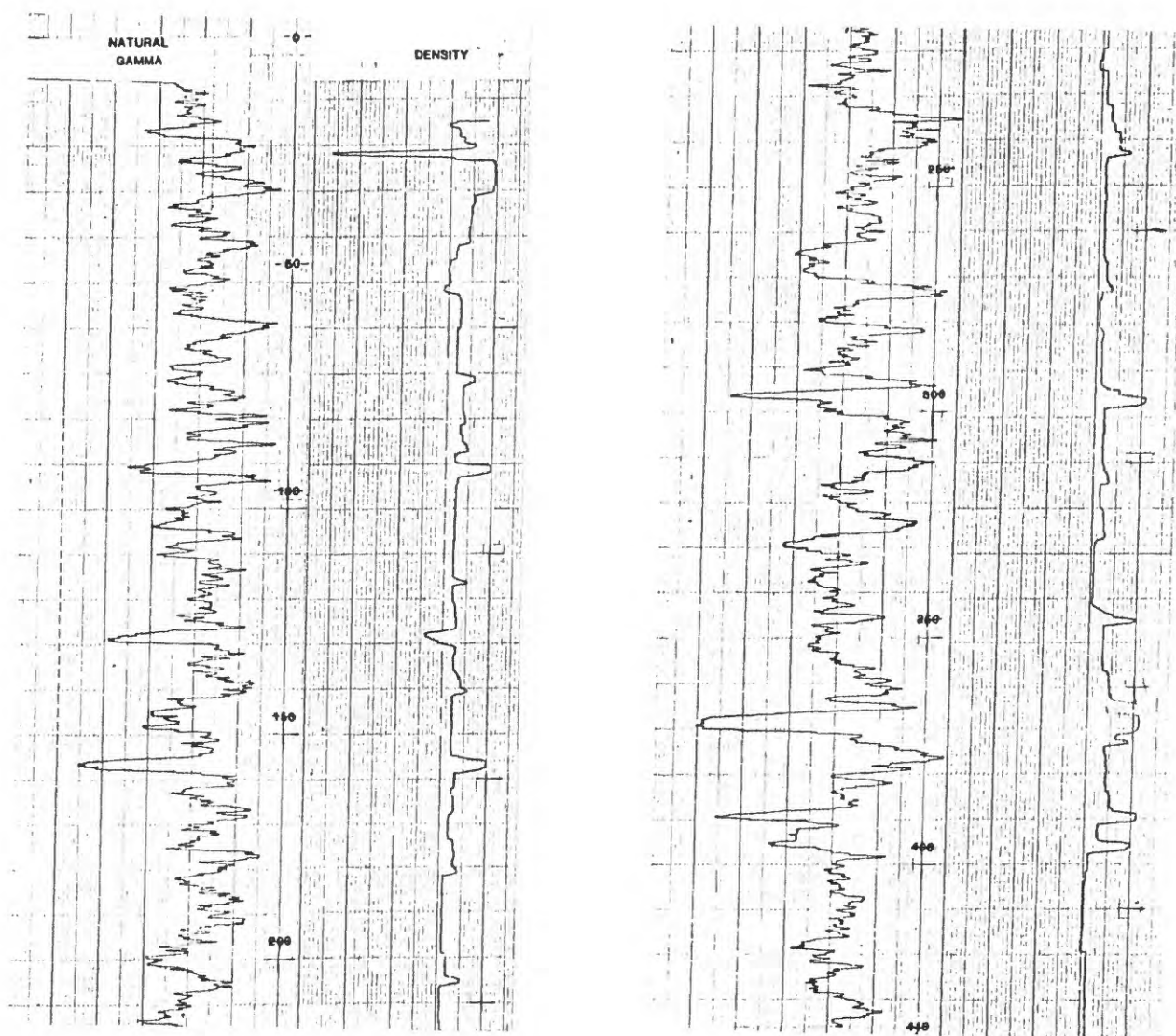


Figure 37.--Geophysical logs of hole GS-38

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; coal 150-152; scattered coal fragments; some thinly interbedded siltstone
177-200	Siltstone, light-gray; grades sandy near base; coal bed 191 ft to 192 ft
200-202	Lignite, black
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
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
387-415	Claystone, medium-gray; coal bed 408 ft to 409 ft
415-418	Lignite, black

Sample log--Continued

Depth (feet)	Lithic description
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
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) 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

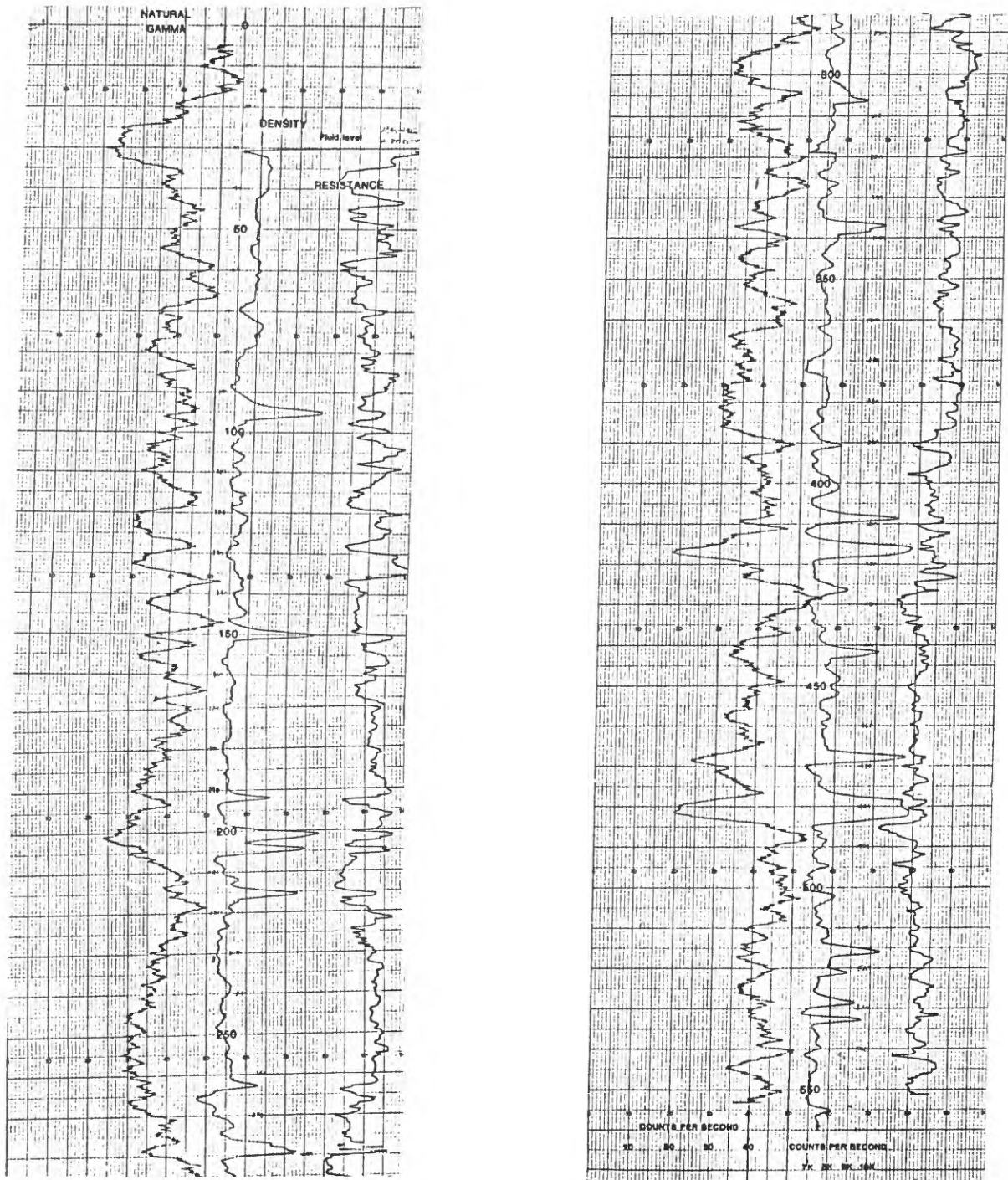


Figure 38.--Geophysical logs of hole GS-39

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 (fig. 40)
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 (fig. 40)
132-144.2	Claystone, light-olive-gray; grades to very fine grained sandstone at base
144.2-147.9	Lignite, see sample description D221141 (fig. 40)
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; probable thin coal bed near base
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
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

Sample log--Continued

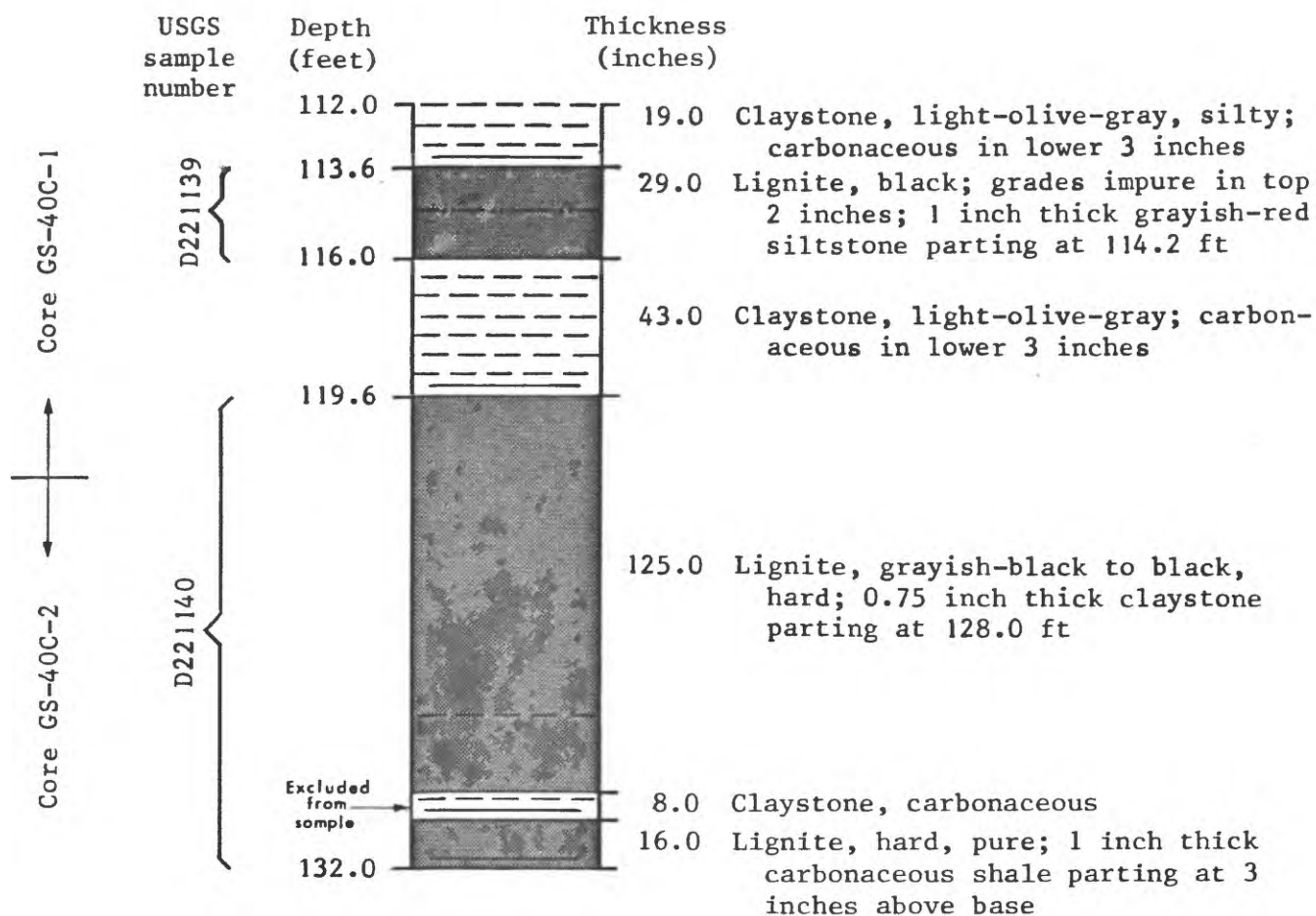
Depth (feet)	Lithic description
362-366	Lignite, black
366-404	Claystone, olive-gray, silty; with interbedded siltstone
404-420	Sandstone, light-gray, silty
420-458	Siltstone, medium-gray to olive-gray, sandy
458-500	Sandstone, medium-gray to olive-gray; traces of coal at top of interval; coal bed 465 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 39.--Geophysical logs of hole GS-40

Cores GS-40C-1 and GS-40C-2



Core GS-40C-3

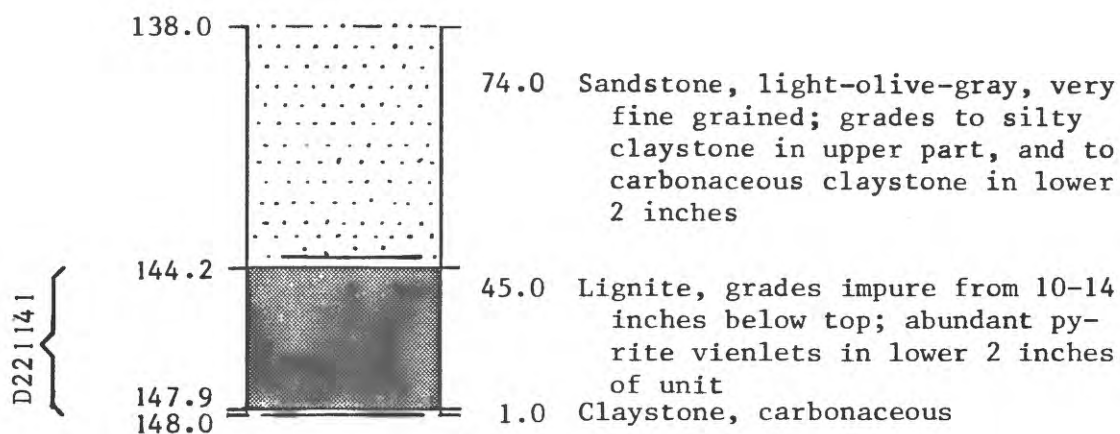


Figure 40.--Core and sample descriptions, core hole GS-40C, NW NW sec. 36, T. 33 N., R. 54 E. Sheridan County, Montana.

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
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 (fig. 42)
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
135-161.3	Claystone, greenish-gray; with interbedded siltstone; grades to carbonaceous claystone at base
161.3-169.7	Lignite, see sample description D221143 (fig. 42)
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 (fig. 42)
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
218-231	Claystone, light-gray to greenish-gray; silty at top
231-238	Sandstone, greenish-gray, very fine grained
238-279	Sandstone, light-gray to greenish-gray, very fine grained; grades to siltstone at top; scattered interbedded siltstone

Sample log--Continued

Depth (feet)	Lithic description
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
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; minor 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; minor 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

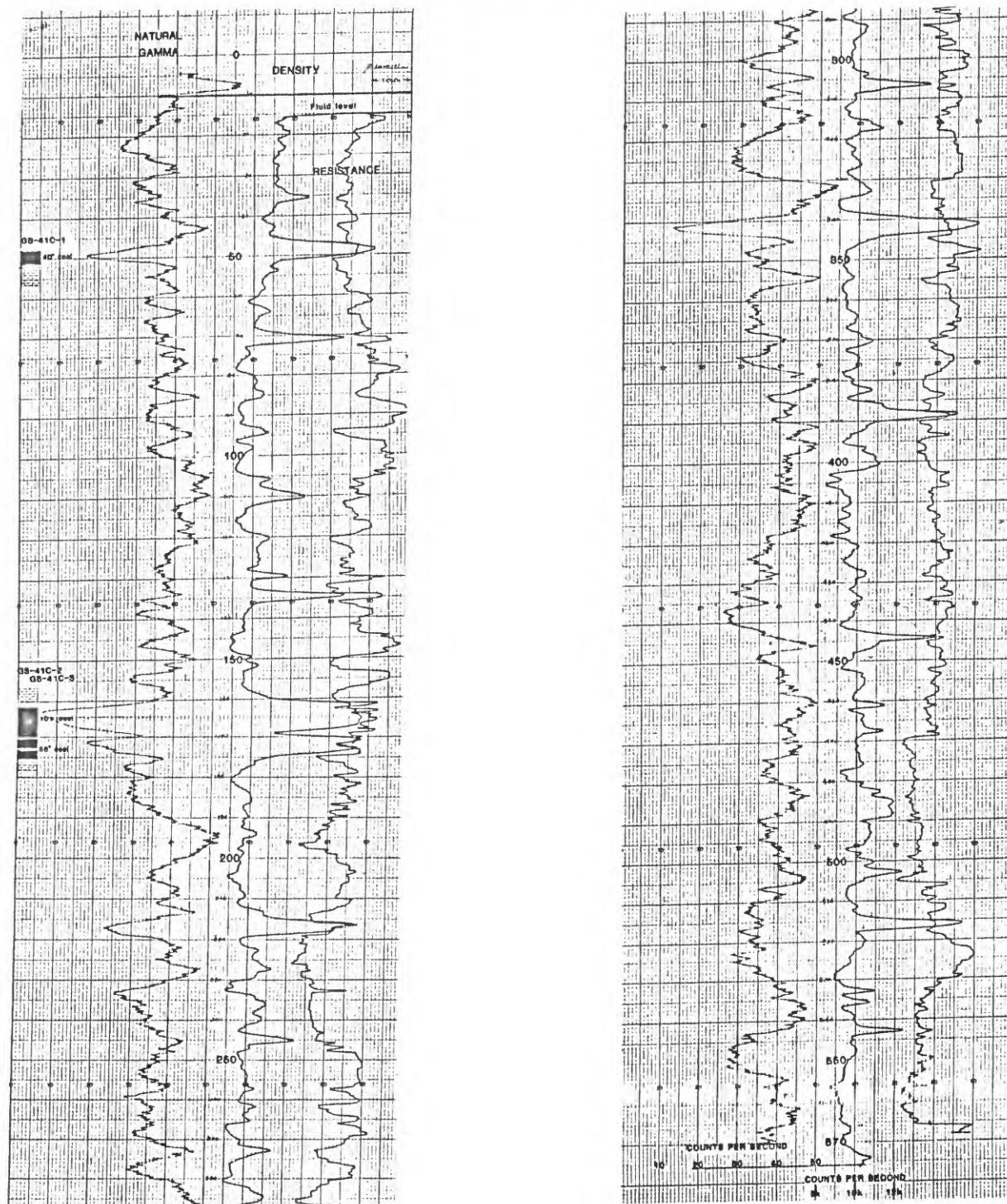
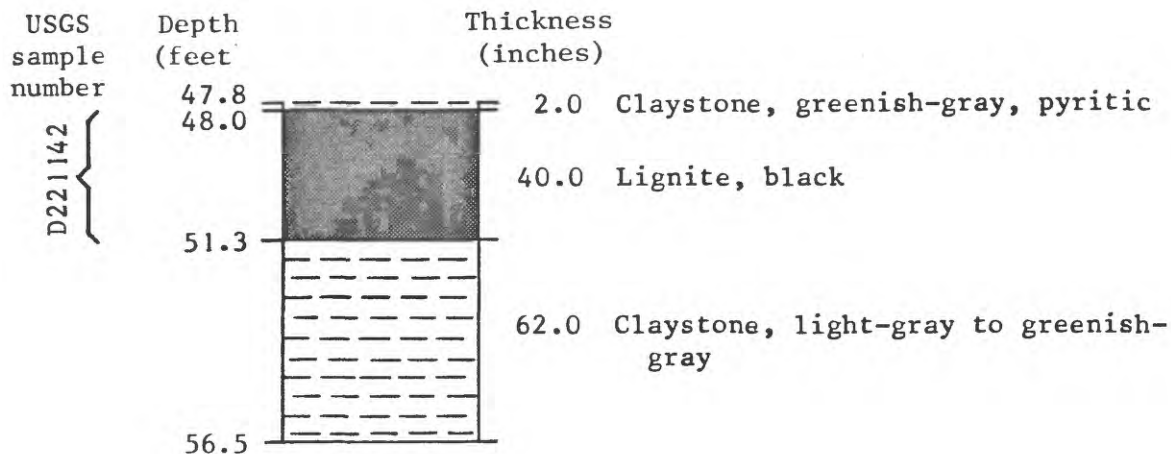


Figure 41.--Geophysical logs of hole GS-41

Core GS-41C-1



Cores GS-41C-2 and GS-41C-3

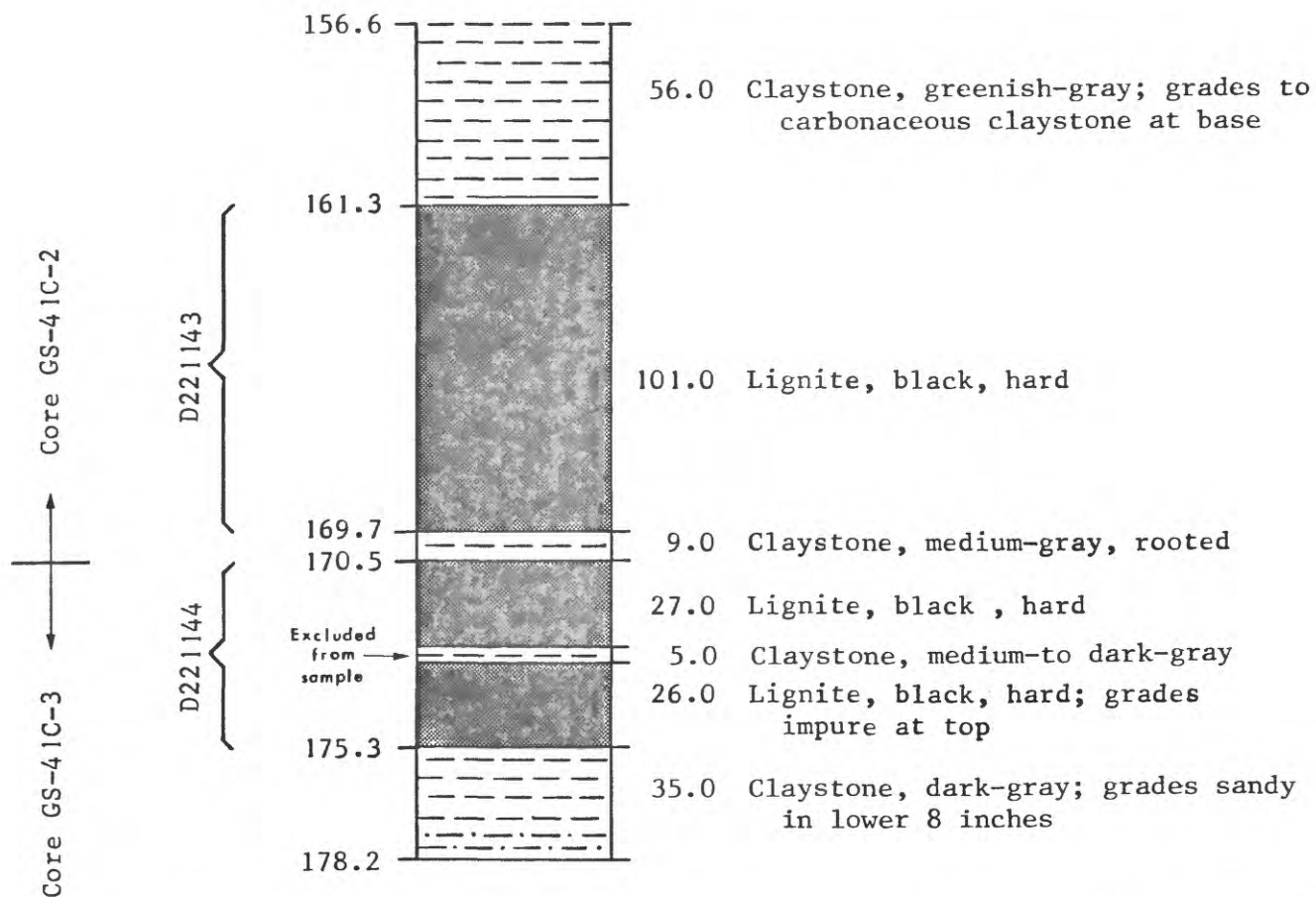


Figure 42.--Core and sample descriptions, core hole GS-41C, SW SW sec. 33, T. 33 N., R. 53 E., Sheridan County, Montana.

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 (fig. 44)
39.5-60	Siltstone, light-gray to medium-dark-gray
60-61.5	Lignite, black
61.5-80	Siltstone, medium-bluish-gray, sandy; grades to claystone at top of interval
80-94	Siltstone, dark-greenish-gray to greenish-gray; minor coal fragments
94-110	Siltstone, light-gray to medium-light-gray; slightly 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
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; sparse coal fragments; thin interbedded siltstone and carbonaceous claystone; 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

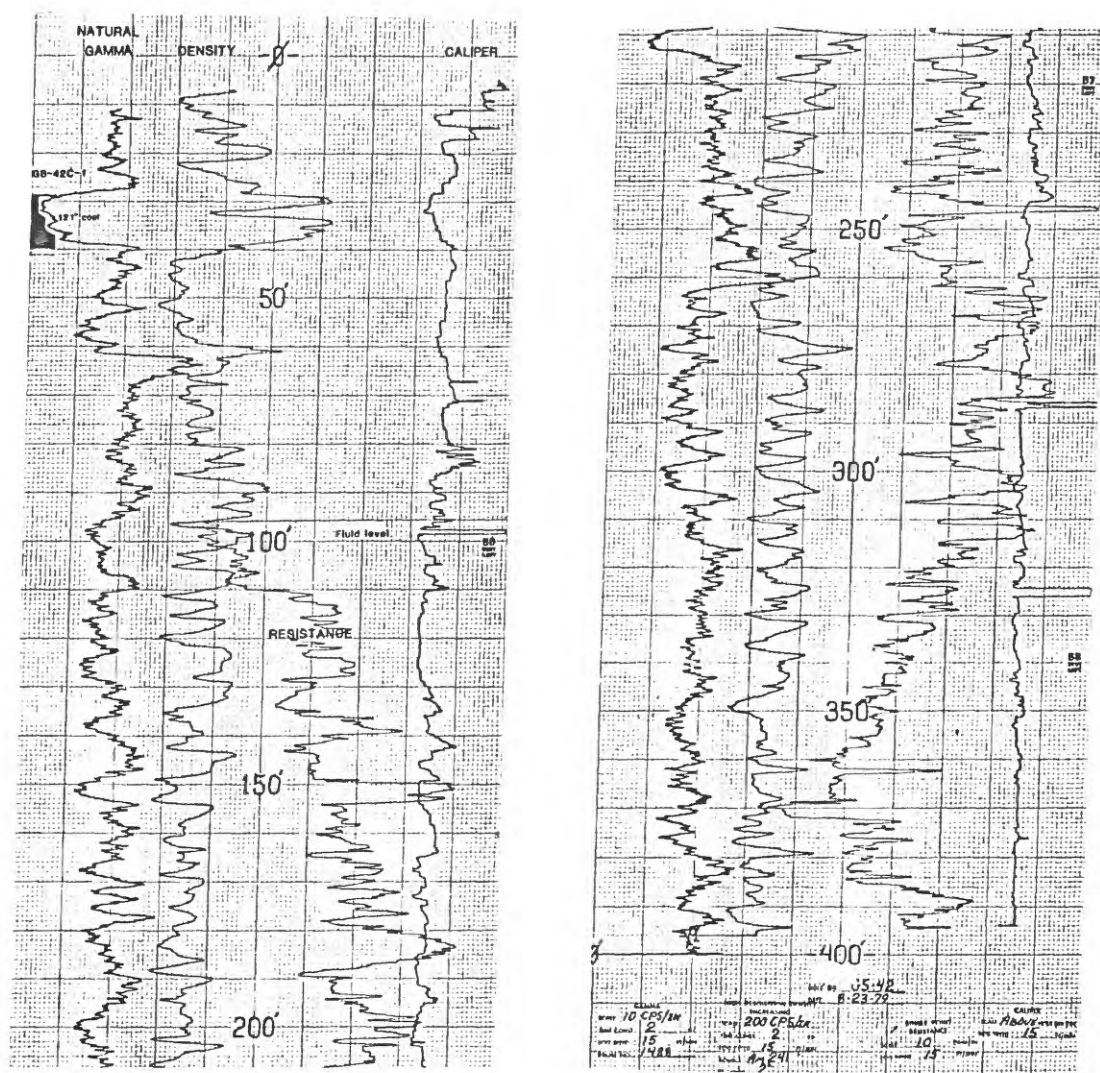


Figure 43.--Geophysical logs of hole GS-42

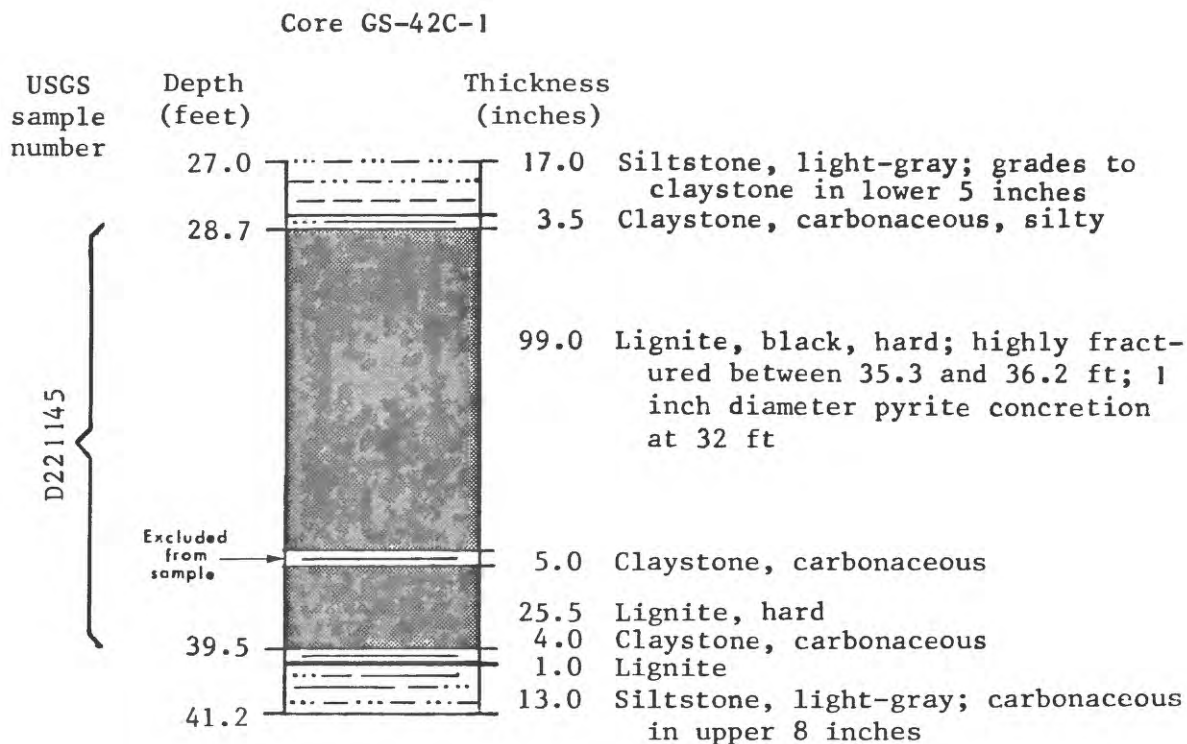


Figure 44.--Core and sample descriptions, core hole GS-42C, SE NE sec. 22, T. 32 N., R. 54 E., Sheridan County, Montana.

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
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
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
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
320-328	Claystone, medium-light-gray to brownish-gray; slightly carbonaceous in lower part

Sample log--Continued

Depth (feet)	Lithic description
328-332	Lignite, grayish-black to brownish-gray; grades impure in lower 2 ft
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

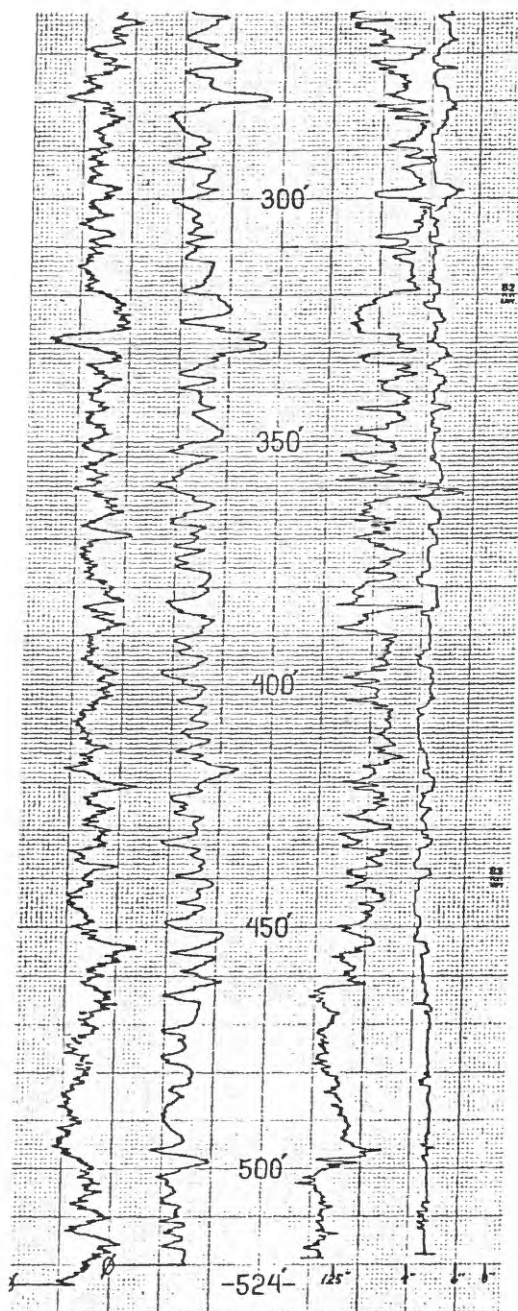
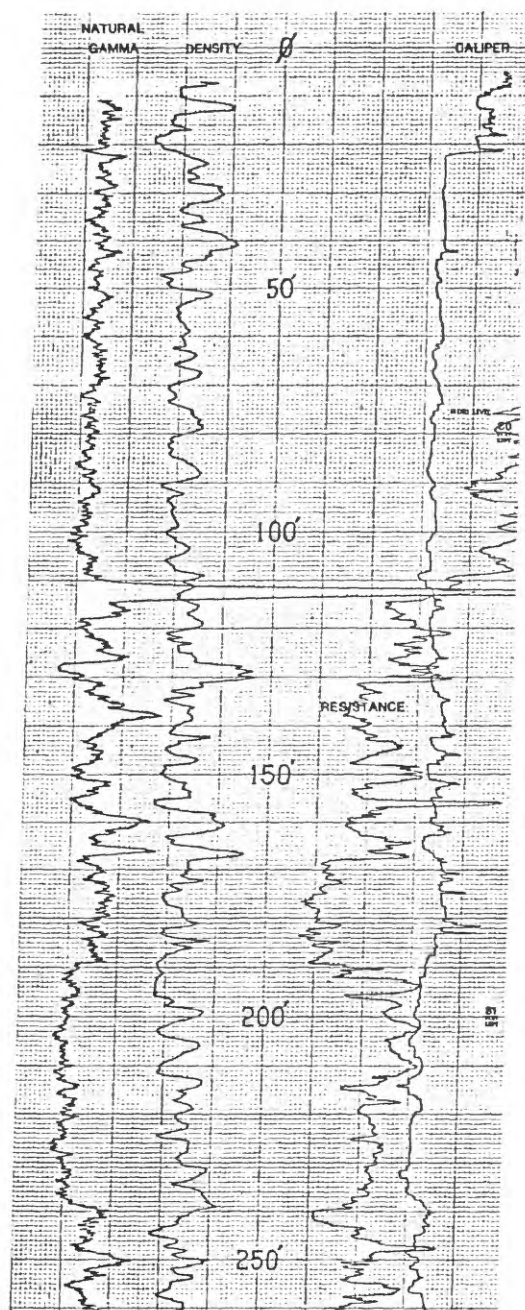


Figure 45.--Geophysical logs of hole GS-43

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
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; see core GS-44C-1 description (fig. 47)
121.5-130	Lignite, grayish-black; see core and sample descriptions, core hole GS-44C (fig. 47)
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
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
462-471	Claystone, brownish-gray to medium-light-gray, slightly carbonaceous
471-474	Lignite, grayish-black
474-479.5	Claystone and carbonaceous shale, medium-light-gray to brownish-gray

Sample log--Continued

Depth (feet)	Lithic description
479.5-481	Lignite, grayish-black
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
525-541	Siltstone and silty claystone, thinly interbedded light-to medium-light-gray; thin coal at 537 ft
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

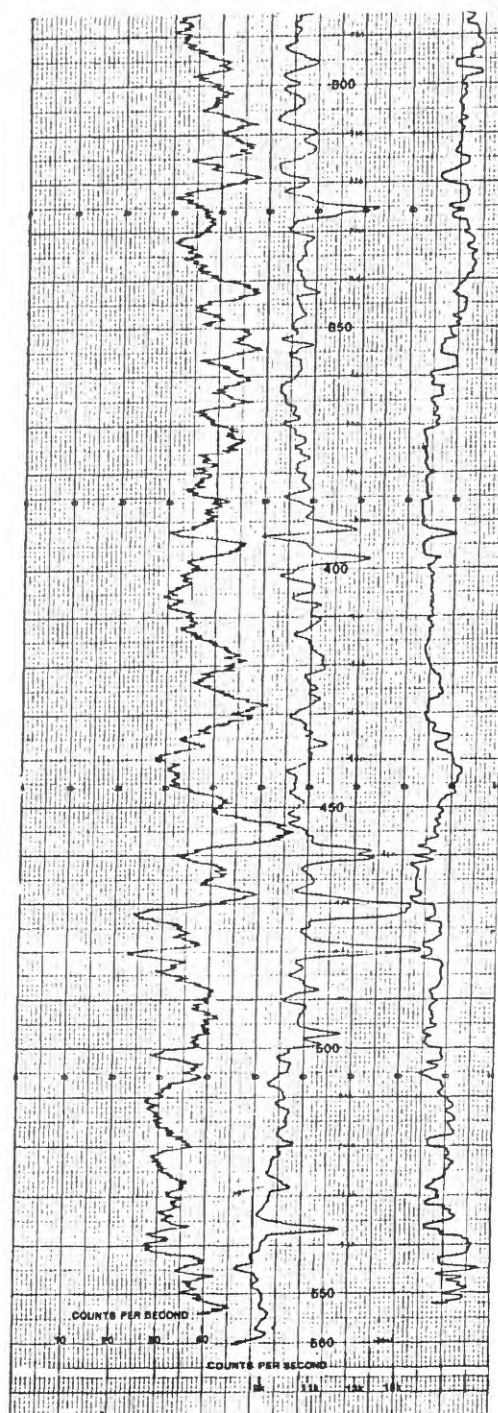
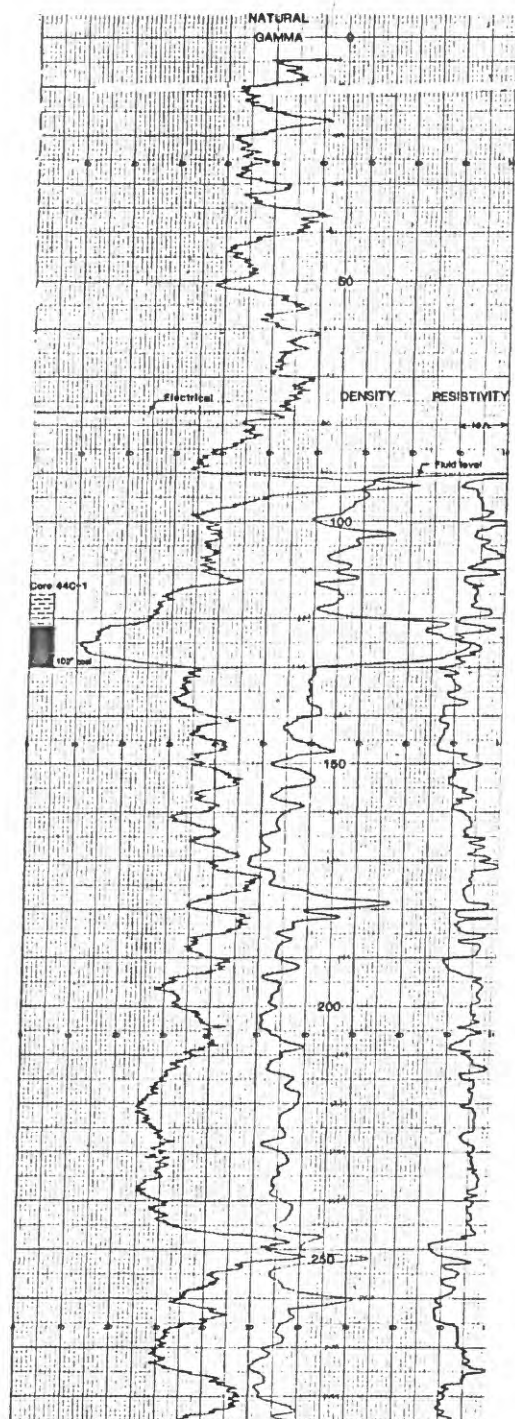


Figure 46.--Geophysical logs of hole GS-44

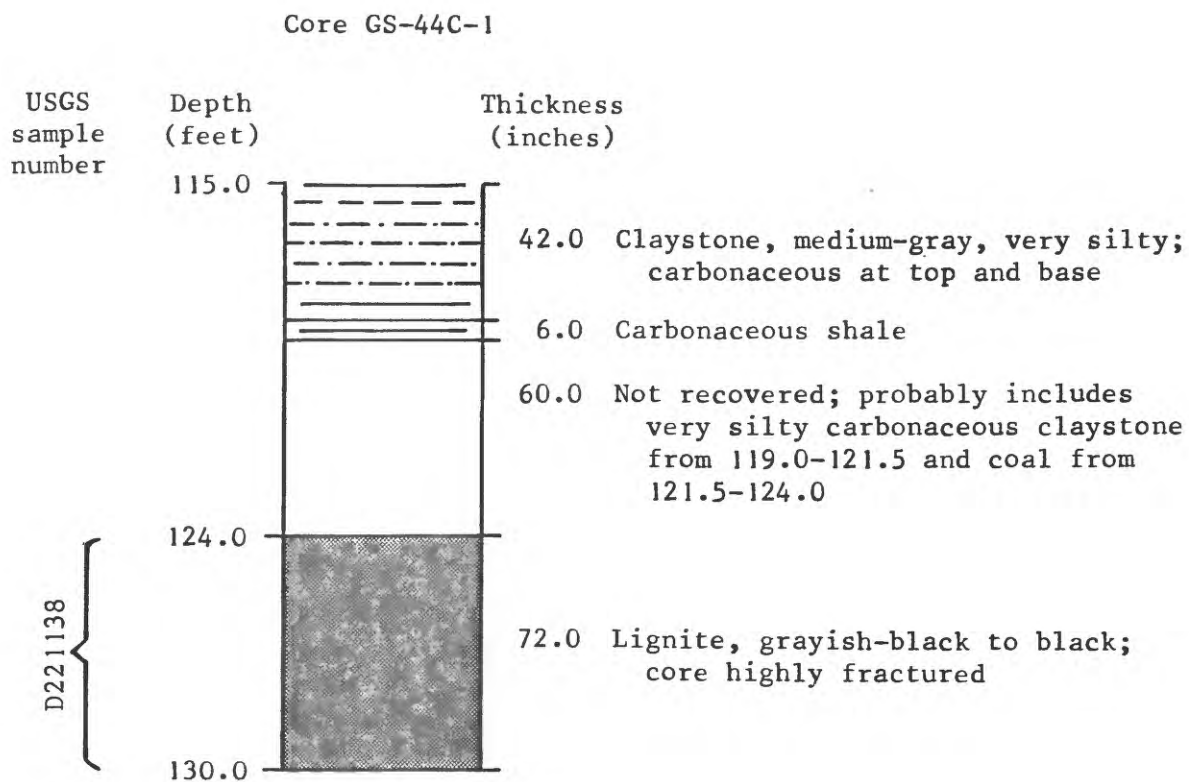


Figure 47.--Core and sample descriptions, core hole GS-44C, NE NE sec. 5, T. 30 N., R. 53 E., Roosevelt County, Montana

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; 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
95-100	Claystone, brownish-gray, carbonaceous
100-120	Siltstone, medium-gray, sandy
120-134	Claystone, medium-gray, silty in upper part
134-145	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
246-274	Siltstone and silty claystone, medium-gray siltstone thinly interbedded with brownish-gray to greenish-gray claystone
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

Sample log--Continued

Depth (feet)	Lithic description
358-359.5	Lignite, grayish-black
359.5-363	Claystone, brownish-gray, silty
362-371	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

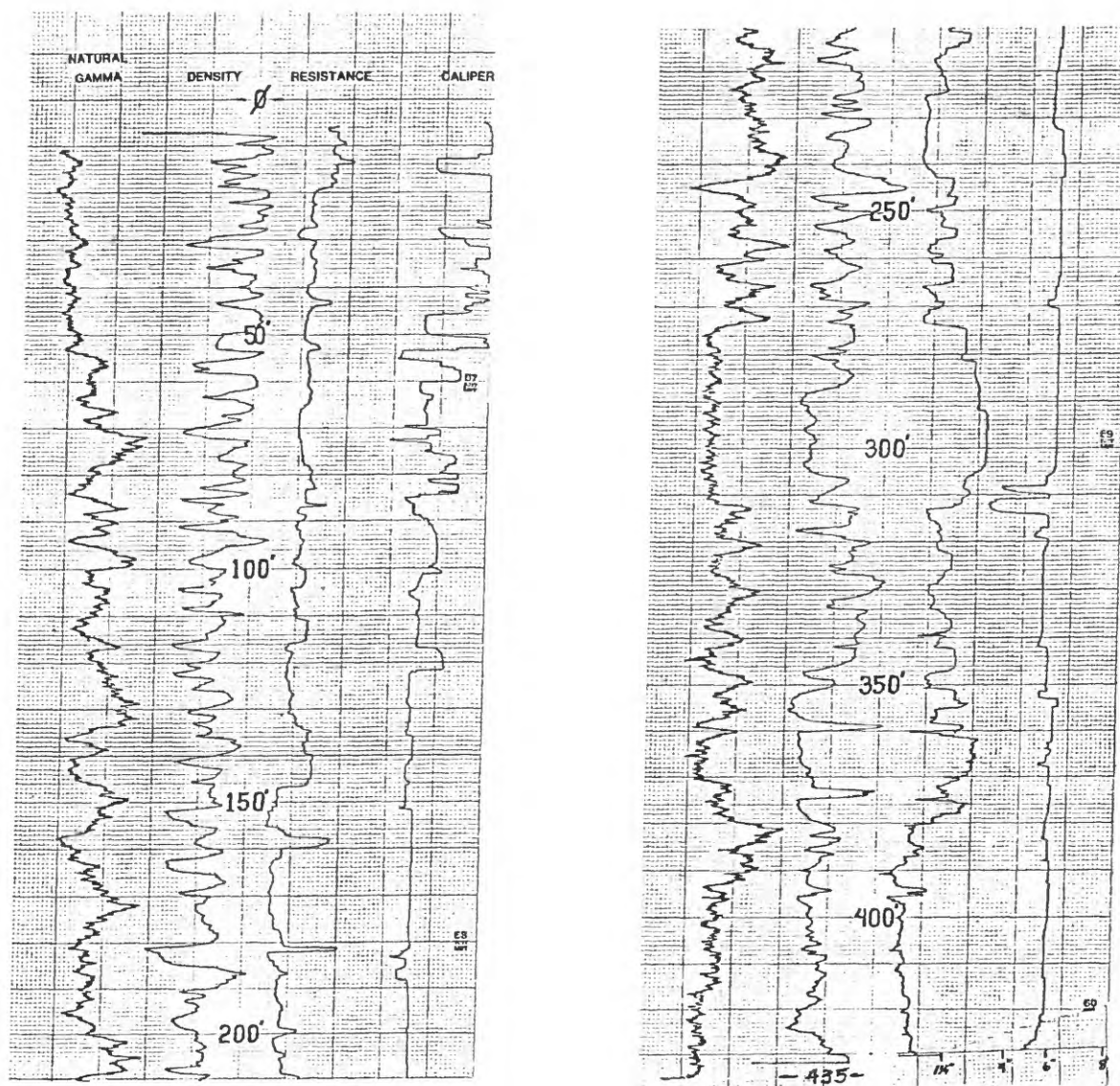


Figure 48.--Geophysical logs of hole GS-45

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, and clay, dark-yellowish-brown, unconsolidated
10-19	Gravel and sand, rounded pebbles as much as 1.25 inch 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
168.5-178	Claystone, light-greenish-gray to light-gray; very silty in lower part
178-190	Siltstone, light-gray to light-bluish-gray
190-197	Claystone, medium-gray, silty
197-199	Lignite, grayish-black
199-215	Claystone, medium-gray, silty; thin coal at 205 ft
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
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

Sample log--Continued

Depth (feet)	Lithic description
447-449	Limestone, light-gray, very finely crystalline
449-458	Claystone, light-gray, silty
458-460	Lignite, grayish-black
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

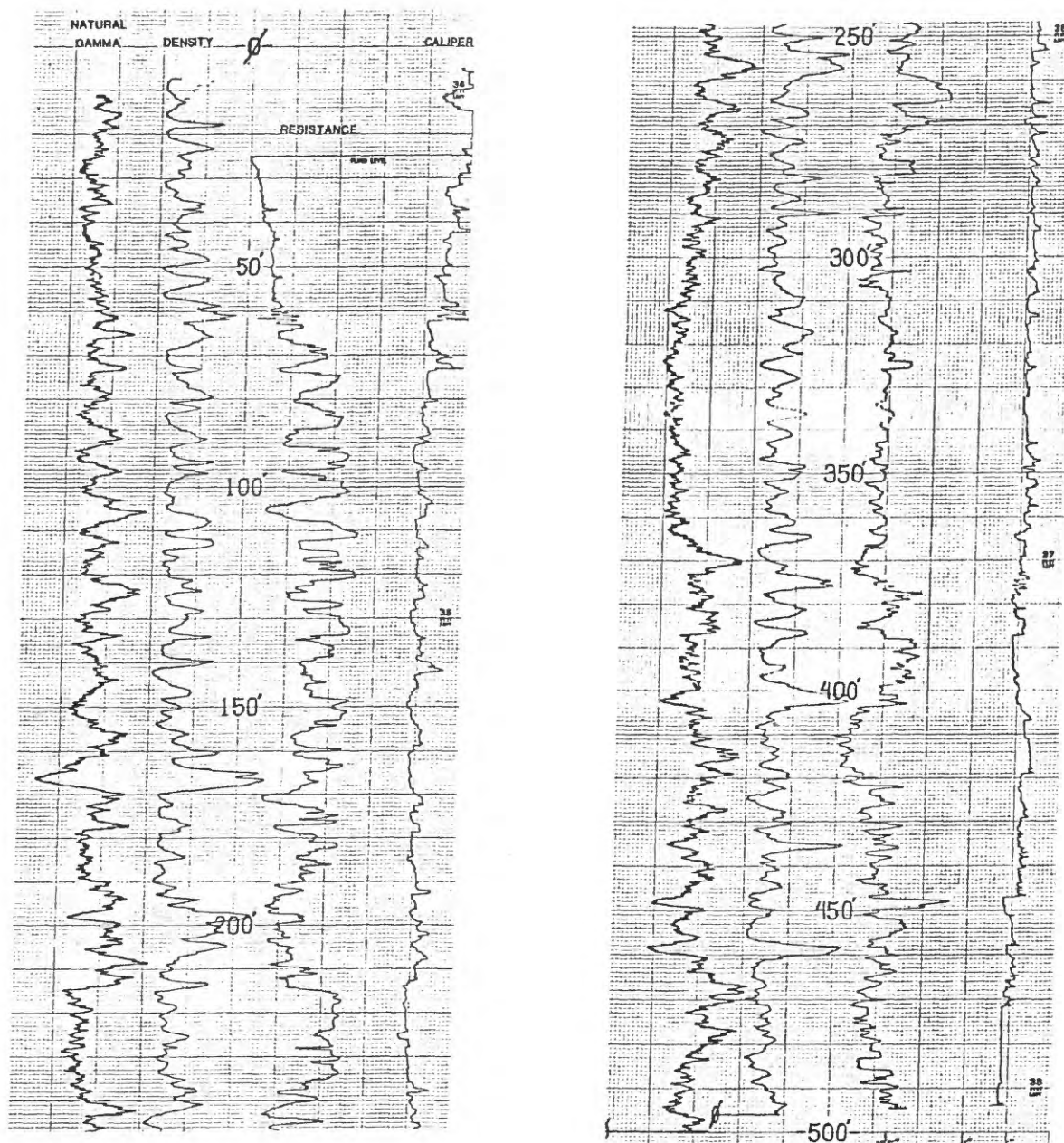


Figure 49.--Geophysical logs of hole GS-46

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
22-48	Siltstone, reddish-brown to yellowish-brown;
47-48	Lignite, black
48-50	Claystone, greenish-gray to olive-gray
50-55	Lignite, black
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
136-188	Siltstone, light-gray to medium-gray to olive-gray; with interbedded sandstone; minor 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; with 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 50.--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 SE 13
 Total depth: 797 ft Drilling medium: mud Offset core hole: none

Depth (feet)	Lithic description
0-11	Sand, slit, 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 inch 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
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 very 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 grained 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
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
132-145	Claystone, yellowish-gray to light-brownish-gray; silty in upper part

Sample log--Continued

Depth (feet)	Lithic description
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; includes some 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
274-295	Siltstone and claystone, light-gray to light-olive-gray; silty 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 sand-concretion at 377 ft
393-397	Lignite, grayish-black
397-409	Claystone, brownish-gray to yellowish-gray; includes some thinly interbedded yellowish-gray siltstone

Sample log--Continued

Depth (feet)	Lithic description
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, very 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; includes coal from 521 to 522 ft
524-527	Lignite, grayish-black
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 and very pale orange; sparsely scattered very light gray silty sandstone
582-585.5	Lignite, grayish-black
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

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
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, very 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, light-brownish-gray to 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 51.--Geophysical logs of hole GS-48

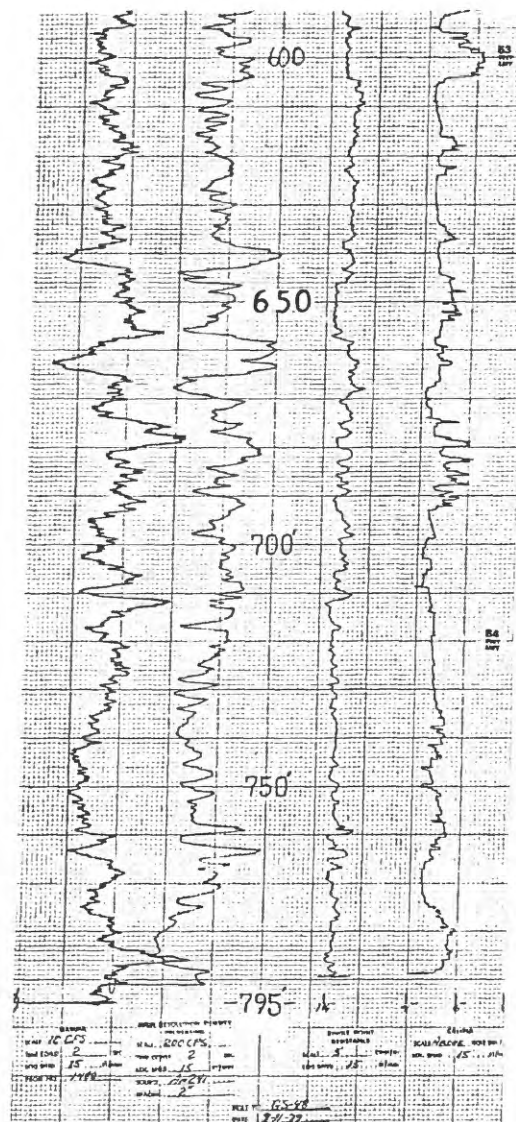


Figure 51.--Geophysical logs of hole GS-48--Continued

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, 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
47-55	Lignite, grayish-black
55-84	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
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
280-290	Siltstone and claystone, light-greenish-gray to olive-gray

Sample log--Continued

Depth (feet)	Lithic description
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; thin coal at 385 ft
398-399.5	Lignite, brownish-black
399.5-412	Siltstone and claystone, medium-light-gray siltstone in upper
	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

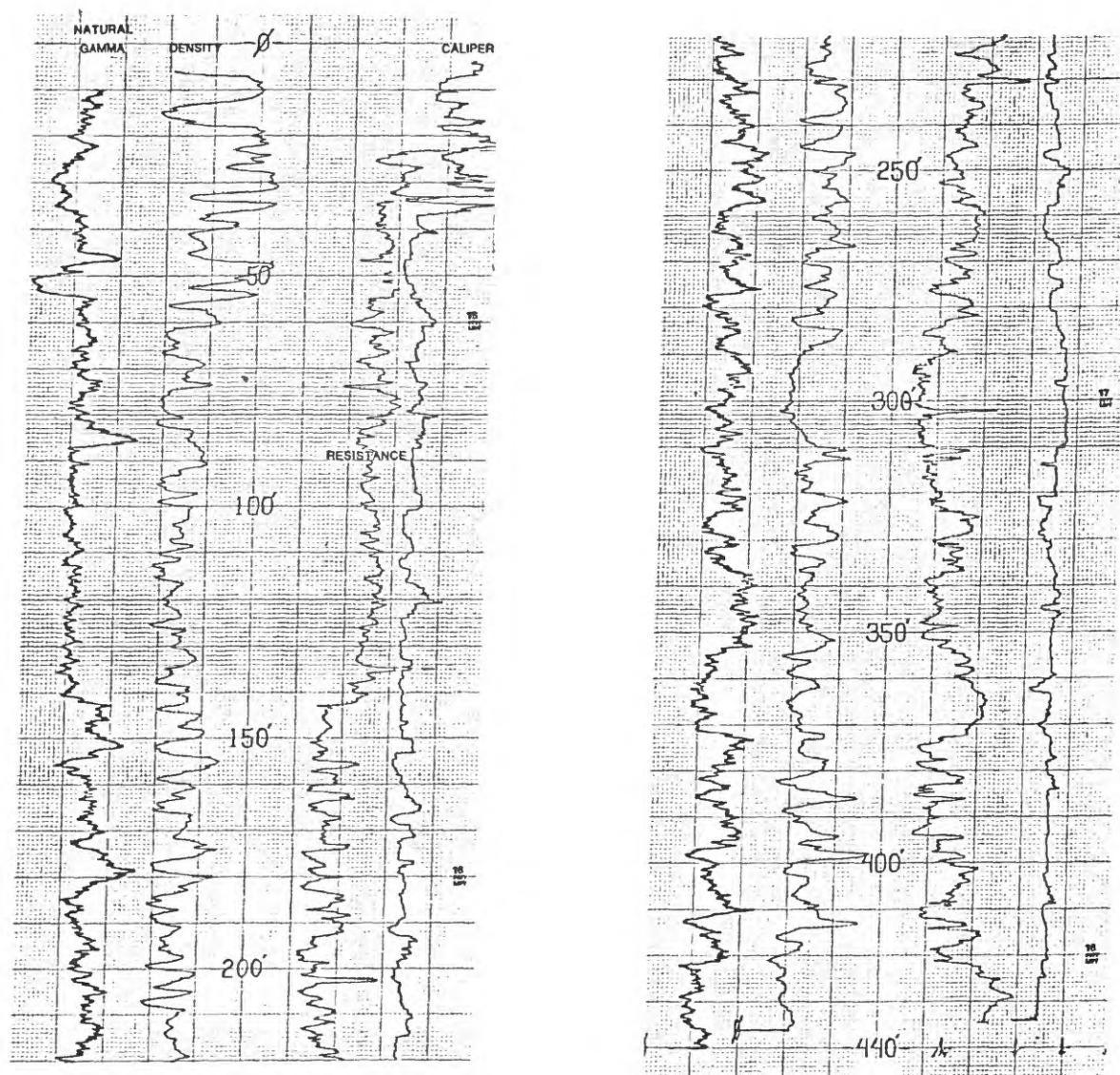


Figure 52.--Geophysical logs of hole GS-49

Coal samples and analyses

Nine core holes were drilled in the east-central and southeastern parts of the Fort Peck Indian Reservation in 1979 to obtain fresh samples of coal for chemical analysis. The locations of the core holes are shown in figure 3. Twenty-one samples of coal collected from cores from the Fort Union Formation are listed in table 1. Proximate and ultimate analyses, and heat-of-combustion, air-dried-loss, forms-of-sulfur, and ash-fusion-temperature determinations on the 21 samples of coal were made by the U.S. Department of Energy, Pittsburgh, Pa. The analyses of 16 of the samples are shown in table 2. The proximate and ultimate analyses of 5 of the 21 samples analyzed were discarded because of questionable low moisture content resulting from inadvertent drying of some samples prior to analysis.

Analyses of the 21 coal samples for ash content and 29 major and minor oxides in the laboratory ash listed in table 2, and analyses of nine trace elements in whole coal listed in table 4 were provided by U.S. Geological Survey laboratories, Lakewood, Colo. Analytical procedures used by the U.S. Geological Survey are described in Swanson and Huffman (1976).

Table 5 contains the data listed in table 3 converted to a whole-coal basis, plus the whole-coal analyses listed in table 4. Table 6 lists 23 additional elements not included in tables 3, 4, and 5, which were looked for but not found. These elements, if present, are in concentration less than their lower limits of detection.

The apparent rank of all coals without questionable low moisture content that were analyzed is lignite A, according to specifications of the American Society for Testing and Materials (1978).

Table 1.--U.S. Geological Survey sample numbers, core-hole numbers, core-hole locations, and depth of sampled interval for 21 samples of coal from the Fort Union Formation, Fort Peck Indian Reservation, Roosevelt and Sheridan Counties, Montana

[All samples were collected from cores. One foot = 0.3048 meter.]

USGS sample number	USGS core-hole number	Core hole location	Depth interval (feet)
Roosevelt County			
D221125	GS-22C	SW1/4 SE1/4 sec. 26, T. 32 N., R. 51 E.	112.2-117.1
D221126	--do--	-----do-----	150.0-154.4
D221127	--do--	-----do-----	360.5-362.4
D221128	--do--	-----do-----	362.9-367.1
D221129	--do--	-----do-----	371.1-374.0
D221130	GS-13C	SE1/4 SE1/4 sec. 10, T. 31 N., R. 54 E.	131.5-135.9
D221131	GS-20C	NE1/4 SE1/4 sec. 21, T. 31 N., R. 51 E.	217.1-222.1
D221132	GS-28C	SE1/4 SE1/4 sec. 1, T. 32 N., R. 49 E.	165.6-167.5
D221133	--do--	-----do-----	206.0-211.7
D221134	--do--	-----do-----	325.7-330.2
D221135	--do--	-----do-----	331.1-332.1
D221136	GS-34C	NW1/4 NW1/4 sec. 17, T. 32 N., R. 53 E.	228.1-233.2
D221137	--do--	-----do-----	244.0-247.5
D221138	GS-44C	NE1/4 NE1/4 sec. 5, T. 30 N., R. 53 E.	124.0-130.0
Sheridan County			
D221139	GS-40C	NW1/4 NW1/4 sec. 36, T. 33 N., R. 54 E.	113.6-116.0
D221140	--do--	-----do-----	119.6-132.0
D221141	--do--	-----do-----	144.2-147.9
D221142	GS-41C	SW1/4 SW1/4 sec. 31, T. 33 N., R. 53 E.	48.0- 51.3
D221143	--do--	-----do-----	161.3-169.7
D221144	--do--	-----do-----	170.5-175.3
D221145	GS-42C	SE1/4 NE1/4 sec. 22, T. 32 N., R. 54 E.	28.7- 39.5

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, and ash-fusion-temperature determinations for 13 coal samples from the Fort Union Formation, Fort Peck Indian Reservation, Roosevelt and Sheridan Counties, Montana

[All analyses in percent except heat of combustion and ash-fusion temperatures. For each sample number, the analyses reported three ways: first, as received; second, moisture free; and third, moisture and ash free. N/A, not applicable; L, less than value shown; * indicates moisture values less than 30 percent which are questionable and are probably the result of moisture loss during grinding of samples. All analyses by U.S. Department of Energy, 1979.]

Sample number	Proximate analysis				Ultimate analysis					Heat of combustion
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	Sulfur	
D221125	29.4*	29.0	30.3	11.3	6.2	42.0	.6	38.7	1.1	7069
	N/A	41.2	42.8	16.0	4.1	59.5	.9	17.8	1.6	10018
	N/A	49.0	51.0	N/A	4.9	70.9	1.0	21.2	1.9	11931
D221126	26.1*	29.7	33.0	11.2	5.9	44.7	.7	36.6	.9	7414
	N/A	40.2	44.7	15.1	4.1	60.5	.9	18.2	1.2	10027
	N/A	47.3	52.7	N/A	4.8	71.2	1.1	21.4	1.5	11809
D221130	33.7	27.1	30.8	8.4	6.6	41.0	0.8	42.6	0.6	6848
	N/A	40.9	46.4	12.7	4.2	61.9	1.1	19.0	.9	10335
	N/A	46.9	53.1	N/A	4.9	70.9	1.3	21.8	1.1	11837
D221131	24.8*	25.0	32.8	17.4	5.3	41.5	.5	34.8	.6	6664
	N/A	33.3	43.6	23.1	3.4	55.2	.6	16.9	.7	8862
	N/A	43.2	56.8	N/A	4.4	71.8	.8	22.0	1.0	11520
D221133	24.3*	30.0	34.9	10.8	5.5	46.6	.8	35.4	.8	7653
	N/A	39.6	46.1	14.3	3.7	61.6	1.1	18.3	1.0	10111
	N/A	46.2	53.8	N/A	4.4	71.8	1.3	21.3	1.2	11794
D221134	25.8*	26.6	35.5	12.1	5.5	44.3	.6	37.0	.5	7216
	N/A	35.8	47.9	16.3	3.6	59.6	.8	18.9	.7	9720
	N/A	42.8	57.2	N/A	4.3	71.3	.9	22.6	.8	11619

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, and ash- fusion-temperature determinations for 13 coal samples from the Fort Union Formation, Fort Peck Indian Reservation, Roosevelt and Sheridan Counties, Montana--Continued

Sample number	Forms of sulfur				Ash fusion temperature, °F	
	Air dried loss	Sulfate	Pyritic	Organic	Initial deformation	Softening Fluid
D221125	21.4 N/A N/A	.02 .04 .04	.69 .98 1.17	.41 .59 .70	2,060	2,090 2,120
D221126	18.3 N/A N/A	.03 .04 .04	.53 .71 .84	.37 .50 .59	2,070	2,100 2,130
D221130	25.9 N/A N/A	0.02 .03 .04	0.11 .17 .20	0.48 .73 .84	2,080	2,110 2,140
D221131	17.9 N/A N/A	.02 .03 .03	.26 .34 .44	.29 .38 .50	2,110	2,210 2,400
D221133	14.9 N/A N/A	.01 .01 .01	.15 .20 .23	.64 .84 .98	2,070	2,190 2,300
D221134	17.8 N/A N/A	.01 .02 .02	.06 .09 .10	.44 .59 .71	2,000	2,050 2,100

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, and ash-fusion-temperature determinations for 13 coal samples from the Fort Union Formation, Fort Peck Indian Reservation, Roosevelt and Sheridan Counties, Montana--Continued

Sample number	Proximate analysis				Ultimate analysis				Heat of combustion
	Moisture	Volatile matter	Fixed carbon	Ash	Hydrogen	Carbon	Nitrogen	Oxygen	
D221138	37.9	24.4	30.1	7.6	6.8	39.0	.7	45.3	Btu/lb
	N/A	39.3	48.5	12.2	4.2	62.7	1.1	18.8	.6
	N/A	44.7	55.3	N/A	4.8	71.5	1.2	21.4	.9
D221139	35.3	25.8	27.5	11.4	6.7	37.7	.6	42.5	1.0
	N/A	39.9	42.5	17.6	4.3	58.2	1.0	17.2	1.2
	N/A	48.3	51.7	N/A	5.2	70.6	1.2	20.9	1.8
D221140	30.9	27.1	32.6	9.4	6.4	42.5	.7	40.5	2.2
	N/A	39.2	47.2	13.6	4.2	61.4	1.0	18.8	.6
	N/A	45.4	54.6	N/A	4.9	71.1	1.2	21.8	.9
D221141	34.0	21.1	24.6	20.3	6.1	30.6	.6	38.3	1.0
	N/A	32.0	37.2	30.8	3.5	46.4	.9	12.3	4.1
	N/A	46.2	53.8	N/A	5.0	67.0	1.3	17.7	6.2
D221142	21.5*	34.2	35.1	9.2	5.7	49.9	1.0	33.3	8.9
	N/A	43.6	44.7	11.7	4.2	63.5	1.3	18.1	.9
	N/A	49.4	50.6	N/A	4.8	71.9	1.4	20.5	1.2
D221143	20.4*	29.9	31.4	18.3	5.2	42.8	.9	29.5	1.3
	N/A	37.5	39.5	23.0	3.6	53.7	1.1	14.3	3.4
	N/A	48.7	51.3	N/A	4.7	69.8	1.4	18.6	4.2
D221145	36.6	23.4	28.0	12.0	6.6	37.0	.7	42.6	5.5
	N/A	36.9	44.2	18.9	4.0	58.4	1.0	15.9	1.1
	N/A	45.5	54.5	N/A	5.0	72.0	1.3	19.6	1.8
									2.2
									6247
									9849
									12147

Table 2.--Proximate and ultimate analyses, and heat-of-combustion, forms-of-sulfur, and ash-fusion-temperature determinations for 13 coal samples from the Fort Union Formation, Fort Peck Indian Reservation, Roosevelt and Sheridan Counties, Montana--Continued

Sample number	Forms of sulfur				Ash fusion temperature, °F		
	Air dried loss	Sulfate			Initial deformation	Softening Fluid	
		Sulfate	Pyritic	Organic			
D221138	32.9 N/A N/A	.01 .01 .01	.23 .37 .42	.33 .53 .60	2,160	2,250	2,340
D221139	30.8 N/A N/A	.03 .05 .06	.59 .92 1.11	.55 .85 1.03	2,050	2,110	2,250
D221140	23.2 N/A N/A	.04 .05 .06	.14 .21 .24	.41 .59 .68	2,050	2,100	2,150
D221141	29.9 N/A N/A	.02 .04 .05	3.50 5.30 7.67	.56 .85 1.22	1,940	2,030	2,140
D221142	13.3 N/A N/A	.01 .01 .01	.42 .53 .60	.50 .64 .72	2,170	2,260	2,340
D221143	13.5 N/A N/A	.01 .01 .02	2.60 3.27 4.25	.76 .95 1.24	1,960	2,060	2,140
D221145	31.2 N/A N/A	.01 .01 .01	.79 1.25 1.54	.32 .50 .61	2,060	2,150	2,270

Table 3.--Major- and minor-oxide and trace element composition of the laboratory ash of 21 coal samples from the Fort Union Formation, Fort Peck Indian Reservation, Roosevelt and Sheridan Counties, Montana

(Lignite ashed at 525°C. L, less than value shown. S after element title indicates determinations by semiquantitative emission spectrography. The spectrographic results are to be identified with geometric brackets whose boundaries are part of the ascending series 0.12, 0.18, 0.26, 0.38, 0.56, 0.83, 1.2, etc. but reported as midpoints of the brackets, 0.1, 0.15, 0.2, 0.3, 0.5, 0.7, 1.0, etc. Precision of the spectrographic data is plus-or-minus one bracket at 68 percent or plus-or-minus two brackets at 95 percent confidence level. All analyses by U.S. Geological Survey laboratories, Lakewood, Colorado)

Sample number	Ash (percent)	SiO ₂ (percent)	Al ₂ O ₃ (percent)	CaO (percent)	MgO (percent)	Na ₂ O (percent)	K ₂ O (percent)	Fe ₂ O ₃ (percent)	TiO ₂ (percent)	P ₂ O ₅ (percent)	Sample number
D221125	12.8	30	12	14	5.67	0.34	0.80	11	0.99	0.080L	D221125
D221126	13.0	30	18	15	5.39	.37	.78	9.0	.32	.080	D221126
D221127	20.0	34	18	8.5	2.52	4.18	1.2	10	.57	.050L	D221127
D221128	23.1	47	23	9.5	2.21	3.95	1.7	2.3	.63	.040	D221128
D221129	13.3	34	13	15	1.42	.51	1.2	4.0	.45	.080	D221129
D221130	9.7	32	16	18	4.82	.77	.98	6.0	.48	.21	D221130
D221131	18.5	41	25	8.7	1.49	4.62	1.6	3.9	.58	.050	D221131
D221132	29.3	41	16	7.3	3.42	.61	1.9	12	.47	.070	D221132
D221133	12.4	28	16	20	5.26	1.16	1.43	4.4	.50	.080L	D221133
D221134	14.6	41	17	12	2.24	4.96	1.9	3.9	.58	.41	D221134
D221135	27.8	45	23	6.6	1.40	3.50	2.4	2.2	.80	.070	D221135
D221136	21.0	26	9.1	11	4.23	1.00	1.0	21	.25	.29	D221136
D221137	24.7	41	16	6.7	3.37	1.13	2.0	11	.53	.12	D221137
D221138	9.3	28	19	21	5.85	.44	.43	3.4	.45	.11	D221138
D221139	15.0	28	21	9.9	2.95	5.41	.44	9.3	.38	.070L	D221139
D221140	10.9	34	16	12	3.96	6.94	1.3	5.4	.43	.46	D221140
D221141	21.5	43	18	5.3	2.11	3.67	1.1	11	.58	.090	D221141
D221142	18.6	28	18	12	4.36	.25	.29	11	.55	.050	D221142
D221143	9.8	18	12	20	6.80	4.00	.48	9.7	.28	.61	D221143
D221144	14.4	28	14	13	4.94	3.37	1.2	9.2	.43	.14	D221144
D221145	13.9	21	11	13	4.63	1.15	.53	17	.30	.36	D221145

Sample number	Ag-S (ppm)	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Ce-S (ppm)	Cu (ppm)	Ga-S (ppm)	Ge-S (ppm)	La-S (ppm)	Sample number
D221125	1L	1,000	1,500	15	1.0L	150	49	50	10	50	D221125
D221126	1L	1,000	3,000	7	1.0L	150	49	30	5	50	D221126
D221127	1L	1,000	1,000	10	1.0L	100L	88	50	5	50	D221127
D221128	1L	700	3,000	7	1.0	100L	24	30	3	50	D221128
D221129	1L	1,500	7,000	15	1.0	200	90	50	10	70	D221129
D221130	1L	1,000	3,000	15	4.0	150	114	30	5	70	D221130
D221131	1L	1,500	5,000	10	1.0L	150	30	70	7	100	D221131
D221132	1L	700	700	15	1.0L	100L	69	30	10	50	D221132
D221133	1L	2,000	1,500	10	1.0	150	53	30	5	70	D221133
D221134	1L	2,000	3,000	7	1.0	100	133	50	7	70	D221134
D221135	1L	1,500	5,000	15	1.0	150	77	70	7	100	D221135
D221136	1L	1,000	7,000	10	1.0L	100L	29	30	7	70	D221136
D221137	1L	1,000	7,000	10	1.0L	100L	38	20	7	70	D221137
D221138	2	1,000	1,500	5	2.0	100	43	30	5	70	D221138
D221139	1L	700	5,000	20	2.0	100L	63	50	10	100	D221139
D221140	1L	700	7,000	7	1.0L	150	44	20	5	50	D221140
D221141	1L	700	2,000	15	2.0	200	48	50	20	70	D221141
D221142	1L	1,500	2,000	15	1.0	200	109	50	15	100	D221142
D221143	1L	1,500	2,000	5	1.0	150	35	20	7	70	D221143
D221144	1L	1,000	15,000	10	1.0	150	66	30	5	70	D221144
D221145	1L	1,000	5,000	7	1.0L	100L	36	20	5	50	D221145

Table 3.--Major- and minor-oxide and trace element composition of the laboratory ash of 21 coal samples from the Fort Union Formation, Fort Peck Indian Reservation, Roosevelt and Sheridan Counties, Montana--Continued

Sample number	Li (ppm)	Mn (ppm)	Mo-S (ppm)	Nb-S (ppm)	Ni-S (ppm)	Pb (ppm)	Sc-S (ppm)	Sr-S (ppm)	V-S (ppm)	Y-S (ppm)	Sample number
D221125	49	650	30	70	20	28	20	1,000	100	70	D221125
D221126	61	272	30	50	15	36	10	700	50	70	D221126
D221127	67	249	20	30	70	45	20	1,500	200	70	D221127
D221128	102	280	7	50	7	58	10L	2,000	70	50	D221128
D221129	27	565	20	30	30	34	20	3,000	150	100	D221129
D221130	41	549	30	30	50	43	20	1,000	150	100	D221130
D221131	122	201	7	70	20	56	20	3,000	150	70	D221131
D221132	56	209	20	30	70	44	20	1,000	150	100	D221132
D221133	55	363	20	50	20	68	15	2,000	150	70	D221133
D221134	60	558	15	30	30	45	20	2,000	150	70	D221134
D221135	100	356	7	100	30	80	20	2,000	200	100	D221135
D221136	29	328	30	30	30	30L	15	1,500	100	50	D221136
D221137	41	169	15	50	30	28	15	1,500	150	70	D221137
D221138	69	486	15	50	20	83	15	1,000	50	50	D221138
D221139	67	455	50	70	100	49	30	3,000	150	150	D221139
D221140	51	373	20	30	50	35	15	2,000	100	50	D221140
D221141	44	180	15	50	50	33	20	1,500	150	70	D221141
D221142	55	270	50	50	20	40	20	700	100	100	D221142
D221143	38	534	15	30	20	33	10	3,000	50	50	D221143
D221144	31	389	20	30	50	30L	20	2,000	100	70	D221144
D221145	38	354	15	20	15	31	10	2,000	70	50	D221145

Sample number	Yb-S (ppm)	Zn (ppm)	Zr-S (ppm)
D221125	5	35	500
D221126	5	32	300
D221127	5	66	300
D221128	5	34	500
D221129	10	272	500
D221130	10	94	500
D221131	7	20L	700
D221132	7	78	500
D221133	5	25	700
D221134	5	42	500
D221135	10	76	1,000
D221136	5	33	300
D221137	5	63	700
D221138	5	68	300
D221139	15	165	1,000
D221140	5	55	500
D221141	7	39	700
D221142	7	129	700
D221143	3	29	200
D221144	7	67	500
D221145	3	44	300

Table 4.--Content of nine trace elements in 21 coal samples from the Fort Union Formation, Fort Peck Indian Reservation, Roosevelt and Sheridan Counties, Montana

(Analyses in air-dried (32°C) coal. N, not detected. All analyses by U.S. Geological Survey laboratories, Lakewood, Colorado)

Sample number	As (ppm)	Co (ppm)	Cr (ppm)	F (ppm)	Hg (ppm)	Sb (ppm)	Se (ppm)	Th (ppm)	U (ppm)	Sample number
D221125	10	1.2	7.0	65	0.12	1.0	N	3.3	5.9	D221125
D221126	6.2	1.1	3.3	55	.10	.8	N	4.4	2.7	D221126
D221127	37	5.1	15	60	.26	2.4	2.2	4.6	4.1	D221127
D221128	8.4	1.7	8.4	40	.11	.8	N	9.0	3.9	D221128
D221129	3.3	1.6	7.0	55	.04	1.3	.8	2.4	2.4	D221129
D221130	5.7	1.9	7.0	60	.06	1.1	.7	2.2	2.7	D221130
D221131	9.8	1.1	4.6	40	.06	.9	1.7	5.8	2.1	D221131
D221132	39	13	15	140	.17	2.0	1.0	5.4	5.3	D221132
D221133	15	1.0	3.8	30	.07	.9	.9	N	3.4	D221133
D221134	3.6	1.8	7.3	75	.05	.7	1.0	3.3	1.6	D221134
D221135	3.0	2.0	14	120	.09	1.2	2.4	12	4.7	D221135
D221136	11	1.9	17.0	65	.11	1.2	N	N	2.1	D221136
D221137	8.8	4.3	17	110	.05	1.8	N	3.8	3.3	D221137
D221138	2.3	.6	4.0	40	.02	.3	.5	2.6	1.0	D221138
D221139	11	6.2	5.0	55	.20	2.6	N	4.0	3.2	D221139
D221140	5.7	1.7	6.4	60	.09	1.0	.6	2.4	1.4	D221140
D221141	210	2.6	13	95	.42	2.4	N	3.7	2.9	D221141
D221142	14	1.4	5.7	40	.16	1.0	1.2	5.5	4.3	D221142
D221143	2.5	1.2	2.5	30	.04	.7	N	1.7	1.0	D221143
D221144	8.4	3.7	8.8	60	.12	1.0	.4	2.3	3.2	D221144
D221145	10	1.1	4.4	40	.12	.7	.5	2.1	1.6	D221145

Table 5.--Major-, minor-, and trace-element composition of 21 coal samples from the Fort Union Formation, Fort Peck Indian Reservation, Roosevelt and Sheridan Counties, Montana

(Values in percent or parts per million. As, Co, Cr, F, Hg, Sb, Se, Th, and U values are from direct determinations on air-dried (32°C) coal; all other values are calculated from analyses of coal ash. S after element title indicates analysis by emission spectrography; L, less than value shown; N, not detected. All analyses by U.S. Geological Survey laboratories, Lakewood, Colorado)

Sample number	Si (percent)	Al (percent)	Ca (percent)	Mg (percent)	Na (percent)	K (percent)	Fe (percent)	Ti (percent)	Ag-S (ppm)	As (ppm)	Sample number
D221125	1.8	0.84	1.3	0.44	0.032	0.085	1.0	0.076	0.15L	10	D221125
D221126	1.9	1.2	1.4	.42	.036	.084	1.82	.023	.35L	39.2	D221126
D221127	3.2	1.6	1.2	.30	.02	.082	1.5	.088	.2L	3.4	D221127
D221128	5.1	2.8	1.6	.11	.086	.32	.37	.087	.21L	8.4	D221128
D221129	2.1	.94	1.5	.11	.050	.13	.37	.036	.15L	3.3	D221129
D221130	1.5	.81	1.3	.28	.055	.079	.41	.028	.1L	5.7	D221130
D221131	3.5	2.5	1.1	.47	.03	.24	2.50	.064	.2L	9.8	D221131
D221132	5.6	2.5	1.5	.60	.13	.47	2.5	.082	.3L	39	D221132
D221133	2.8	1.9	1.7	.59	.11	.044	.38	.037	.15L	15	D221133
D221134	2.8	1.3	1.3	.20	.54	.23	.39	.051	.15L	3.6	D221134
D221135	5.8	3.3	1.3	.23	.72	.56	.42	.13	.3L	3.0	D221135
D221136	2.5	2.0	1.2	.33	.16	.17	3.1	.031	.2L	11	D221136
D221137	4.7	2.0	1.2	.50	.21	.42	1.5	.078	.2L	8.8	D221137
D221138	1.2	.93	1.4	.33	.030	.033	.22	.025	.2L	2.3	D221138
D221139	1.9	1.6	1.1	.27	.60	.055	.97	.034	.15L	11	D221139
D221140	1.7	.89	.94	.26	.56	.12	.41	.028	.1L	5.7	D221140
D221141	4.3	2.0	1.6	.27	.58	.20	1.6	.075	.2L	210	D221141
D221142	2.4	1.7	1.6	.49	.034	.045	1.5	.061	.2L	14	D221142
D221143	.84	.61	1.4	.40	.29	.039	.67	.016	.1L	2.5	D221143
D221144	1.9	1.0	1.3	.43	.36	.14	.92	.037	.15L	8.4	D221144
D221145	1.4	.82	1.3	.39	.12	.061	1.7	.025	.15L	10	D221145

Sample number	B-S (ppm)	Ba-S (ppm)	Be-S (ppm)	Cd (ppm)	Ce-S (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)	F (ppm)	Ga-S (ppm)	Sample number
D221125	100	150	1.5	0.13L	20	1.2	7.0	6.3	65	5	D221125
D221126	100	500	1.5	.20L	20	1.2	3.3	6.4	55	5	D221126
D221127	200	200	1.5	.20L	20	5.1	15	18	60	7	D221127
D221128	150	1,000	2	.23	201	5.7	8.4	5.5	40	7	D221128
D221129	200	700	2	.13	20	1.6	7.0	12	55	7	D221129
D221130	100	300	1.5	.39	15	1.9	7.0	11	60	3	D221130
D221131	300	1,000	2	.19L	30	1.1	4.6	5.6	40	10	D221131
D221132	200	150	5	.20L	30L	13	15	20	140	10	D221132
D221133	300	200	1.5	.12	15	1.8	3.8	6.6	30	3	D221133
D221134	300	500	1.5	.15	15	1.8	7.3	19	75	7	D221134
D221135	300	1,500	3	.28	50	2.0	14	21	120	20	D221135
D221136	150	1,000	2	.25L	20L	4.3	7.0	9.4	65	7	D221136
D221137	200	2,000	3	.25L	20L	4.3	17	9.4	110	7	D221137
D221138	100	150	3.5	.19	10	6.2	4.0	4.0	40	3	D221138
D221139	100	700	3	.30	15L	6.2	5.0	9.5	55	10	D221139
D221140	100	700	.7	.11L	15	1.7	6.4	4.8	60	3	D221140
D221141	150	500	3	.20L	50	2.6	13.7	10	95	10	D221141
D221142	100	500	3	.37	50	1.4	2.5	20	40	7	D221142
D221143	150	200	1.5	.20	15	1.2	2.5	3.4	30	2	D221143
D221144	150	2,000	1.5	.14	20	3.7	8.8	9.5	60	5	D221144
D221145	100	700	1	.14L	15L	1.1	4.4	5.0	40	3	D221145

Table 6.--Elements looked for but not detected in 21 coal samples from the Fort Union Formation, Fort Peck Indian Reservation, Roosevelt and Sheridan Counties, Montana

(Approximate lower detection limits for these elements in coal ash, determined by the six-step spectrographic method of the U.S. Geological Survey, are included)

Element	Symbol	Lower limit of detection (ppm) in coal ash
Gold	Au	50
Bismuth	Bi	20
Dysprosium	Dy	100
Erbium	Er	100
Europium	Eu	200
Gadolinium	Gd	100
Hafnium	Hf	200
Holmium	Ho	50
Indium	In	20
Lutetium	Lu	70
Neodymium	Nd	150
Palladium	Pd	5
Praseodymium	Pr	200
Platinum	Pt	100
Rhenium	Re	100
Samarium	Sm	200
Tin	Sn	20
Tantalum	Ta	1,000
Terbium	Tb	700
Tellurium	Te	5,000
Thallium	Tl	100
Thulium	Tm	50
Tungsten	W	200

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