UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

# Results of drilling for coal in 1981, including coal bed correlations, northeastern part of the Crow Indian Reservation, Big Horn County, Montana

by

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## Introduction

In November, 1981, the U. S. Geological Survey drilled coal exploratory holes at 8 locations in the northeastern part of the Crow Indian Reservation, Big Horn County, Montana. Funding was provided by the U. S. Bureau of Indian Affairs as part of their continuing minerals assessment program for Indian reservations. Figure 1 shows the general location of the drilled area. Figures 2 and 4 through 9 show the specific locations of the drill holes. These holes were drilled as part of a program to evaluate the coal resources and to determine the stratigraphic correlations and quality of the coal on the Crow Reservation. It is also a continuation of the study of coal resources by Mapel and Griffith (1981) in the Reserve area of the Crow Reservation which adjoins this area to the south. These holes were drilled to supplement the many holes drilled by Peabody Coal Company during 1969 through 1972.

Drilling was done under contract to the U. S. Geological Survey by Western Drilling Co. of Casper, Wyoming. The geophysical logs were run by Energyline, Inc. of Upton, Wyoming, also under contract to the U. S. Geological Survey.

## Geologic setting

Table 1 shows a generalized stratigraphic section of some Late Cretaceous and younger rocks of the northern Powder River Basin. All the coal beds encountered in the drill holes occur in the Tongue River Member of the Paleocene Fort Union Formation. The Tongue River Member consists of interbedded grayish-yellow to gray sandstone, siltstone, shale, carbonaceous shale, thick, persistent beds of coal and a few very thin beds of silty to sandy limestone. The sediments of the Tongue River Member accumulated some 50

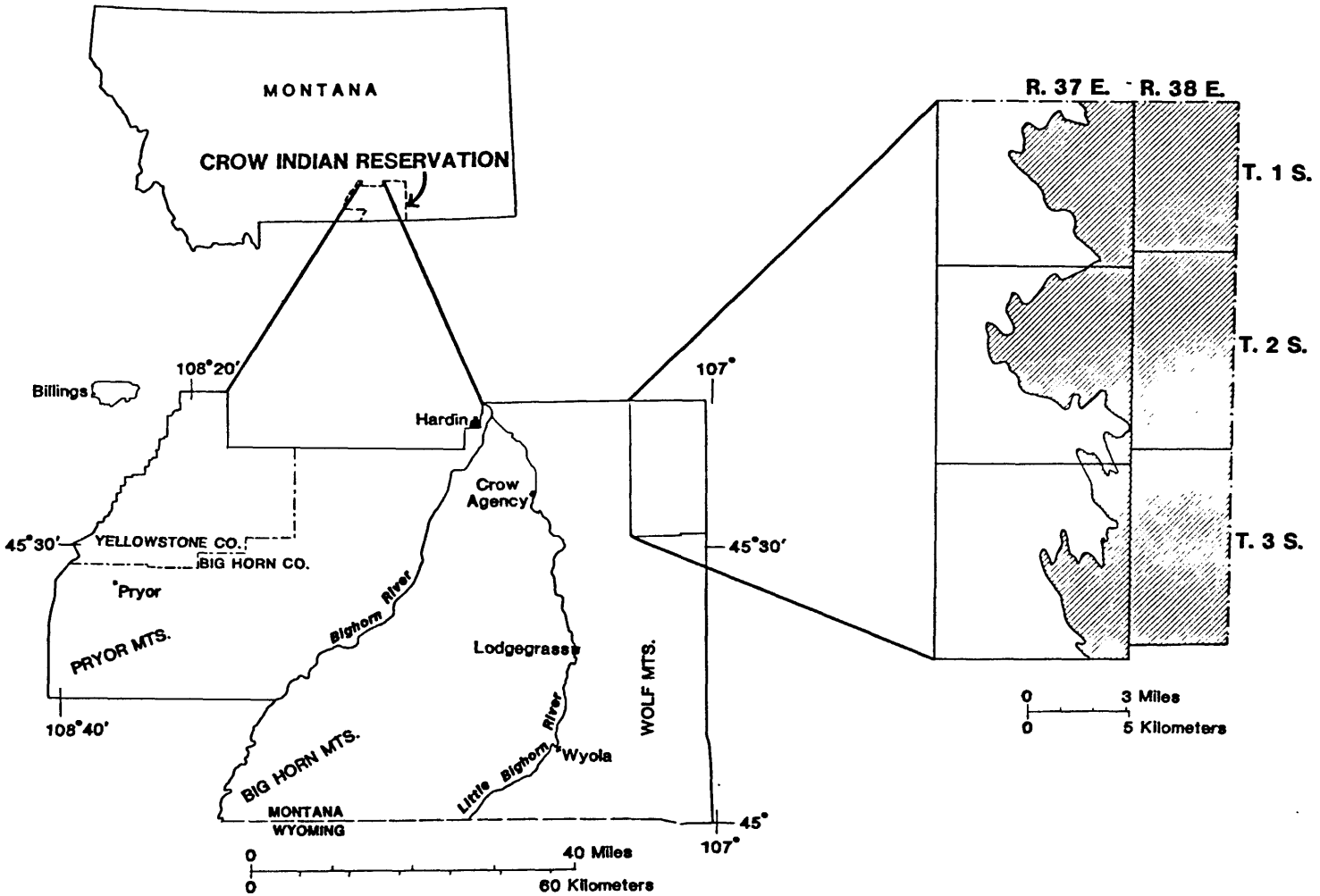



FIGURE 1. -- INDEX MAP SHOWING CROW INDIAN RESERVATION AND GENERAL LOCATION OF EXPLORATORY DRILLING (SHADED)

## TABLE 1.--GENERALIZED STRATIGRAPHIC SECTION OF LATE CRETACEOUS THROUGH EOCENE ROCKS IN THE NORTHERN PART OF THE POWDER RIVER BASIN

| AGE | FORMATION AND MEMBER | | LITHOLOGY |
|---|---|---|---|
| EOCENE | WASATCH | | SHALE, SANDSTONE, COAL |
| PALEOCENE | UNION FORT | TONGUE RIVER MEMBER | SANDSTONE, SHALE, SILTSTONE, COAL |
| | | LEBO SHALE MEMBER | DARK SHALE |
| | | TULLOCK MEMBER | SHALE, SANDSTONE, MINOR COAL |
| LATE CRETACEOUS | HELL CREEK | | SANDSTONE, SHALE |

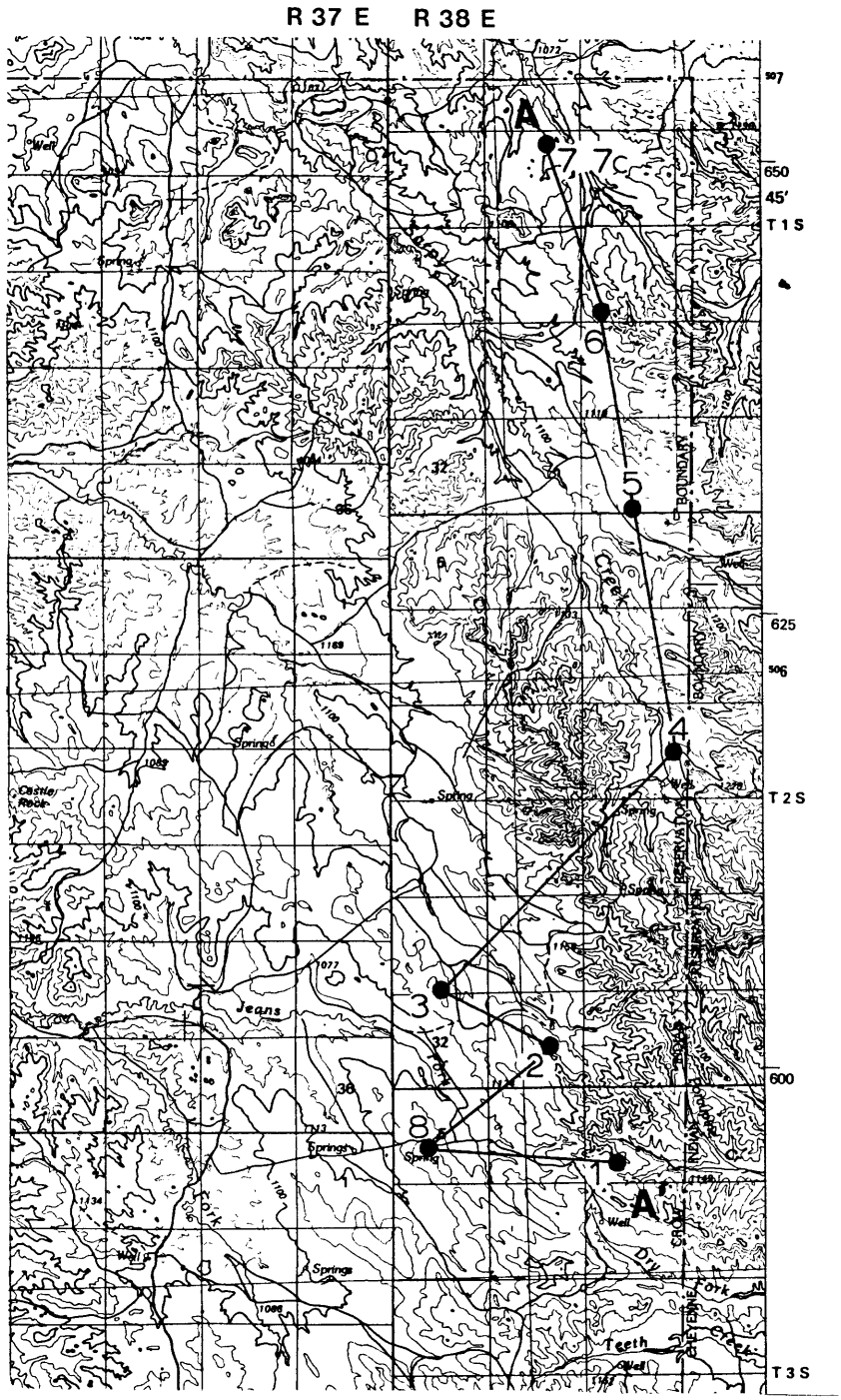



Figure 2. -- Index map showing locations of holes drilled in 1981 and line of section A-A'. Base from Hardin quadrangle (1981).

million years ago in river channels, flood plains, small lakes, and abundant swamps that migrated back and forth over a broad, flat alluvial plain. Locally, the channel-fill sandstones are as much as 100 feet thick, and where the upper part is well cemented they form isolated pinnacles and buttes.

The thicker coal beds have burned back from the outcrop in much of this area. The resulting heat has baked and fused the overlying rocks into a brittle, resistant red rock called clinker. The clinker beds are a prominent feature, especially along the eastern and northern boundaries of the reservation where it caps many of the higher divides.

Underlying the Tongue River Member is the Lebo Shale Member of the Fort Union Formation. It is about 60 feet thick in this area and consists mostly of dark-gray shale, contrasting markedly on the outcrop with the overlying Tongue River Member, which is predominantly light-colored sandstone and siltstone with thick persistent coal beds.

The study area is located on the northwest flank of the Powder River basin. The strata dip generally about 1 degree to the east in the southern part of the area and less than 1 degree to the northeast in the northern part of the area. The regional dip is modified by more than 20 east-northeast trending normal faults that are as much as 3 miles in length and that displace the strata vertically as much as 300 feet.

The coal beds present in the drill holes range in thickness from 1 to 20 feet. Figure 3 shows correlations of the principal coal beds found in drilling from north to south across the area (see figure 2 for location of line of section). The coal bed names, in ascending order, the Robinson, McKay, and Rosebud, are from Dobbin (1929) who reported on the coal in the Forsyth coal field, which lies east of the Reservation. The names of these

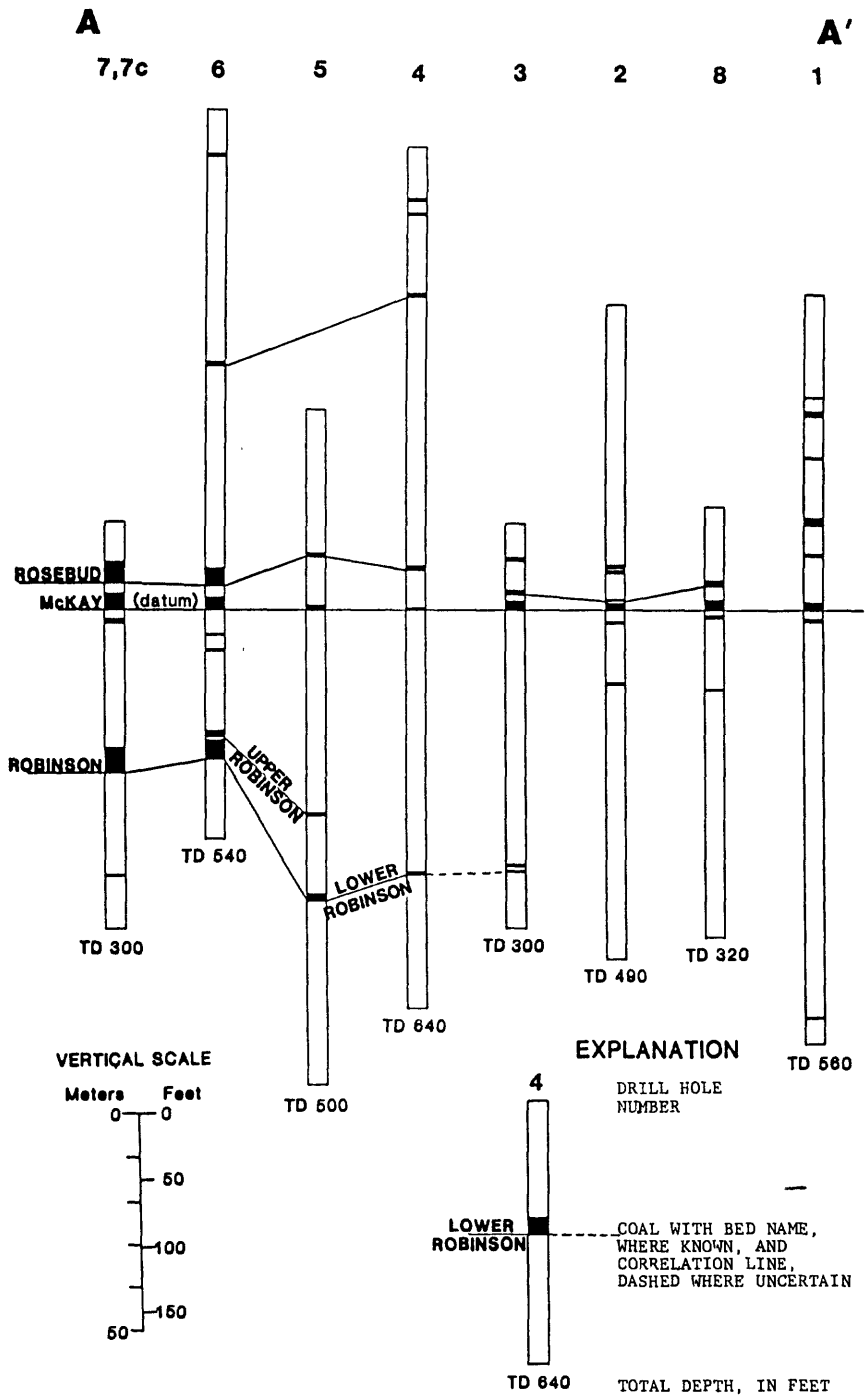



FIGURE 3. --CORRELATION DIAGRAM

beds are also consistent with the names of those beds mined at the Sarpy Creek Mine, three miles north of the Reservation boundary. Figure 3 shows that the rock interval between the Rosebud and McKay beds increases and the thickness of the coal beds decreases to the south. The McKay bed is traceble from the northern to the southern limit of the study area, but the Rosebud pinches out in the middle of T. 2 S., R. 38 E. Similarly, the Robinson bed splits into the Upper and Lower Robinson beds which thin and pinch out to the south in T. 2 S., R. 37 E. These coal bed correlations were determined not only from the U.S. Geological Survey drill hole data, but from Peabody Coal Company data, and from field work done in 1981 and 1982 (Robinson and Van Gosen, 1983).

The rank of coal in the Robinson, McKay, and Rosebud beds is subbituminous C. Analyses of 96 samples obtained by the Peabody Coal Company show that, on an as-received basis, these coal beds have, on the average, a heating value of 8,350 BTU per pound, a sulfur content of 1 percent, an ash content of 11 percent, and a moisture content of 25 percent.

## Conversion to metric units

This report uses the U.S. Customary System for units of measurement. The factors used for converting to the metric sytem are tabulated below:

| To convert | To | Multiply by |
|---|---|---|
| feet | meters | 0.305 |
| miles | kilometers | 1.609 |
| inches | centimeters | 2.540 |
| Btu/lb | kcal/kg | 0.556 |

## Logs of the drill holes

A total of nine holes were drilled to depths ranging from 220 to 640 feet and samples of the rock penetrated during drilling were collected and described at 5-foot intervals. A suite of geophysical logs was run in each hole to determine the thickness and depth of the coal beds.

Two separate logging runs were made in each hole. The first, using a conventional probe, recorded gamma-ray, density, and electrical resistivity logs. The second, using a high-resolution probe, recorded the same logs with the addition of a caliper log. The density log recorded with the second probe defines the top and base of a coal bed and any partings or impurities in the bed more accurately than did the conventional probe. The resistivity log from each probe was recorded only in the water-filled part of the holes.

Table 2 shows the depth logged by each probe for each hole. At locality 2, the hole partially caved after drilling. Only the upper 290 feet of the hole was logged with the high-resolution probe; the conventional probe could not be lowered into the hole. Caving occured in hole 4 after the high-resolution logging so that only part of the hole could be logged with the conventional probe. At locality 1, the conventional probe malfunctioned so no logs were run with that probe. Two holes were drilled at locality 7. Hole 7 was drilled and logged in order to determine where coring of the major coal beds should start and end in hole 7c. In all, 81 feet of core was recovered (Table 2).

A lithologic log was prepared for each hole and accompanies the geophysical logs. However, the depth and thickness of the coal beds were interpreted from the geophysical logs.

Table 2.--Data on test holes drilled in 1981 in the northeastern part of the Crow Indian Reservation

[Leaders (---) indicate no data]

| Drill Hole number | Location ¼ sec | sec | T.S. | R.E. | Date Drilled | Total depth (feet) Drilled | Logged Conventional | Logged High res. | Cored interval (feet) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | SW | 3 | 3 | 38 | 11/6/81 | 560 | --- | 560 | --- |
| 2 | SE | 33 | 2 | 38 | 11/5/81 | 490 | --- | 290 | --- |
| 3 | SE | 29 | 2 | 38 | 11/5/81 | 300 | 300 | 300 | --- |
| 4 | SE | 15 | 2 | 38 | 11/4/81 | 640 | 495 | 640 | --- |
| 5 | SE | 34 | 1 | 38 | 11/4/81 | 500 | 500 | 500 | --- |
| 6 | SW | 22 | 1 | 38 | 11/3/81 | 540 | 540 | 540 | --- |
| 7 | NE | 16 | 1 | 38 | 11/2/81 | 300 | 300 | 300 | --- |
| 7c | NE | 16 | 1 | 38 | 11/2-11/3/81 | 220 | 219 | 219 | 24-80<br>165-190 |
| 8 | SW | 5 | 3 | 38 | 11/5/81 | 320 | 320 | 320 | --- |

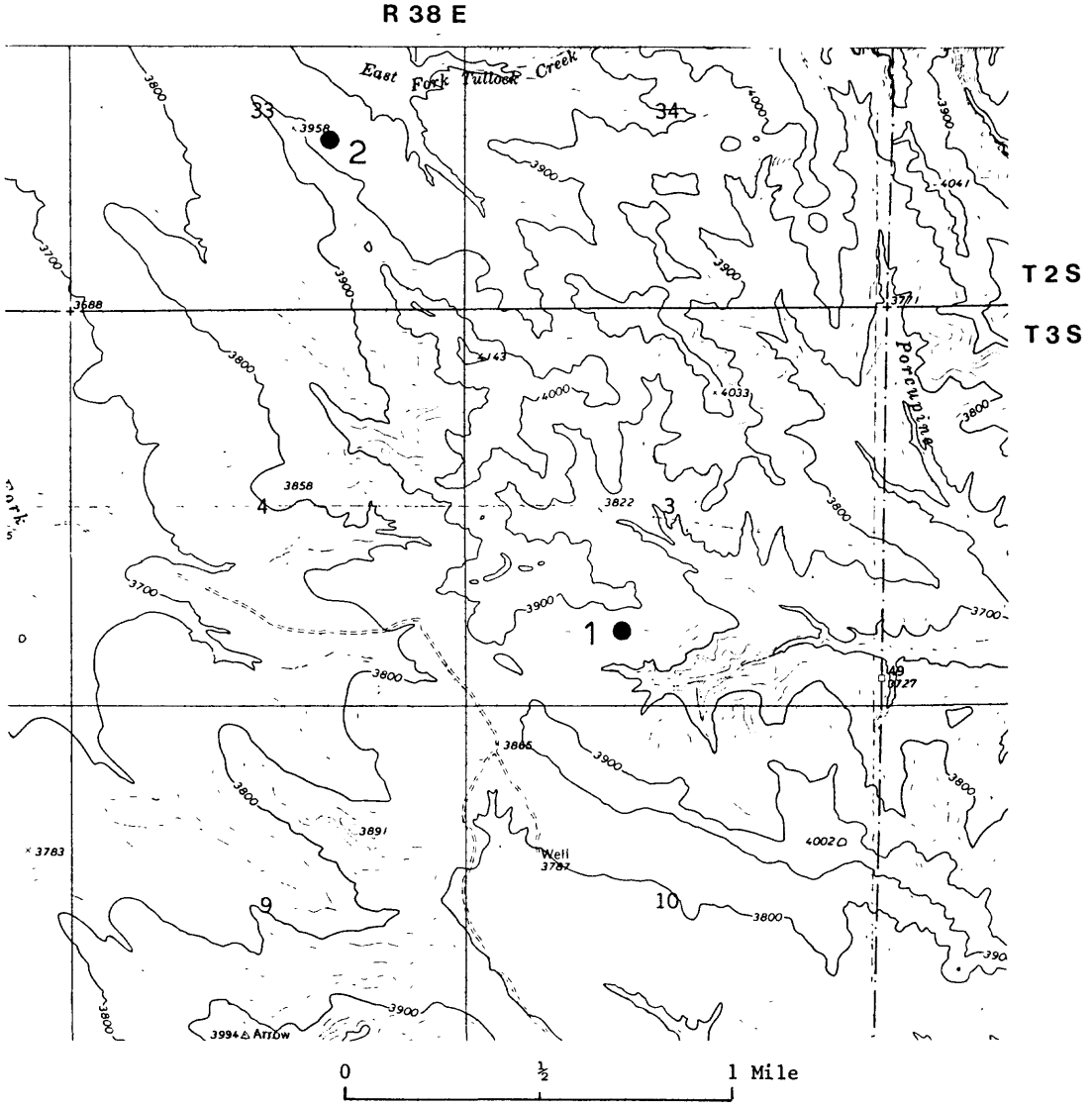



Figure 4. -- Map showing locations of holes 1 and 2. Base from Jeans Fork SE quadrangle (1967).

Hole 1 Elev. 3860 feet Total Depth 560 feet
Location 1000 FSL, 2050 FWL (SE 1/4, SW 1/4) Sec. 3, T. 3 S., R. 38 E.
County Big Horn State Mont. Quadrangle Jeans Fork S.E. 7 1/2'
Drilled by Western Drilling Driller G. Abbott Hole size 5 1/8 inches
Date Started 11/6/81 Date Completed 11/6/81 Geologist L. Robinson
Remarks: Lithology from 5 ft samples. Depth and thickness of coal modified to conform with geophysical logs.

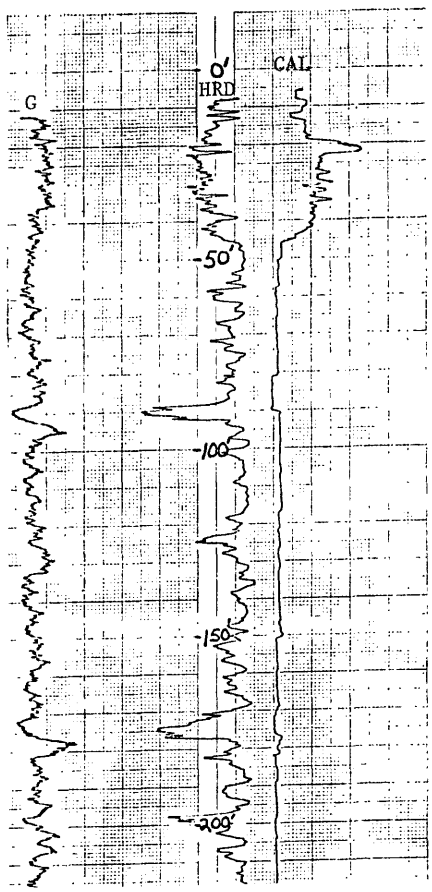
| Depth interval (feet) From | To | Thickness | Lithologic Description |
|---|---|---|---|
| 0 | 15 | 15 | Clay, brown, sandy and silty |
| 15 | 75 | 60 | Sandstone, brownish-gray, very fine grained, slightly silty, grayish-yellow at 40, yellowish-gray at 45, fine-grained at 75 |
| 75 | 77 | 2 | Shale, medium- to dark-gray, carbonaceous in part |
| 77 | 78 | 1 | Coal |
| 78 | 88 | 10 | Siltstone, medium-gray, sandy, carbonaceous in part |
| 88 | 92 | 4 | Coal |
| 92 | 100 | 8 | Siltstone and very fine grained sandstone, gray |
| 100 | 105 | 5 | Sandstone, gray, very fine grained, silty |
| 105 | 118 | 13 | Siltstone, medium-gray |
| 118 | 123 | 5 | Shale, dark-gray, carbonaceous |
| 123 | 125 | 2 | Coal |
| 125 | 135 | 10 | Siltstone, shaley, carbonaceous |
| 135 | 143 | 8 | Sandstone, gray, very fine grained, mostly quartz |
| 143 | 150 | 7 | Siltstone and shale, gray |

| Depth interval (feet) | | | |
|---|---|---|---|
| From | To | Thick-ness | Lithologic Description |
| 150 | 170 | 20 | Sandstone, gray, very fine grained, mostly quartz |
| 170 | 176 | 6 | Coal |
| 176 | 180 | 4 | Shale, dark-gray, carbonaceous, and siltstone |
| 180 | 185 | 5 | Siltstone, gray, some shale |
| 185 | 197 | 12 | Sandstone |
| 197 | 199 | 2 | Coal |
| 199 | 203 | 4 | Siltstone and shale, carbonaceous |
| 203 | 215 | 12 | Sandstone, light-gray, very fine grained |
| 215 | 232 | 17 | Siltstone, gray, sandy |
| 232 | 238 | 6 | Coal, McKay bed |
| 238 | 245 | 7 | Sandstone, very fine grained, clean, well-sorted, some siltstone |
| 245 | 247 | 2 | Coal |
| 247 | 320 | 73 | Siltstone, gray, very fine grained, sandy with some sandstone |
| 320 | 340 | 20 | Sandstone, gray, medium fine- to medium-grained, slightly silty |
| 340 | 365 | 25 | Siltstone, dark-gray, interbedded with very fine grained sandstone, some shale, carbonaceous shale at 355 |
| 365 | 541 | 176 | Sandstone, gray, fine-grained, interbedded with siltstone and shale, carbonaceous zones at 400 and 480 |
| 541 | 542 | 1 | Coal |
| 542 | 560 | 18 | Siltstone, dark-gray |

U.S.Geological Survey
Northeastern Crow Indian Reservation

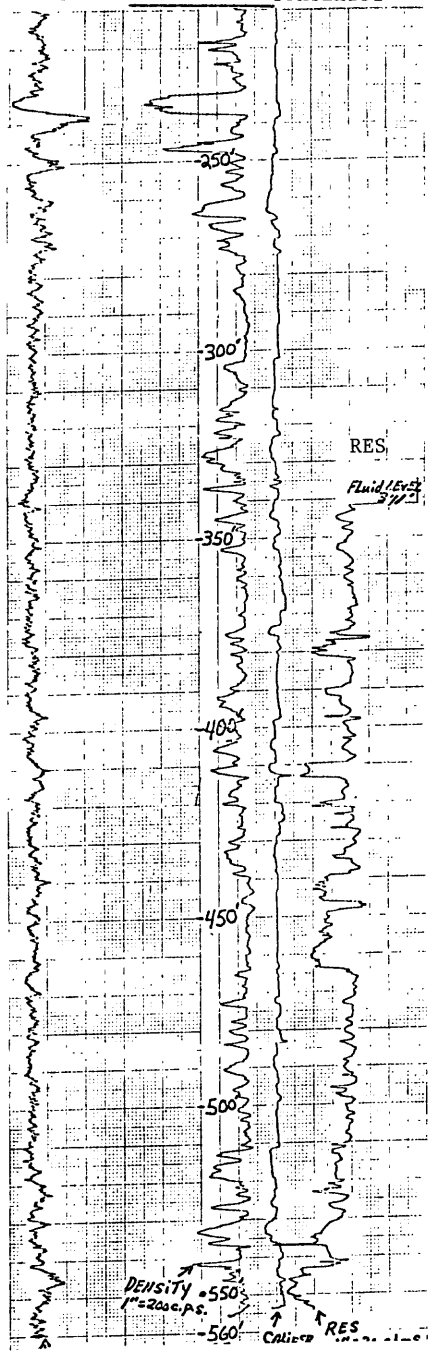
Hole name 1 County Big Horn State Montana
Location 1000' FSL, 2050' FWL Sec. 3 T. 3 S., R. 38E
Elevation 3860 Drilled depth 560 ft Logged depth 560 ft
Drilling medium air and foam Date Logged 11/6/81
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 10 cps/in Logging speed 15 fpm
Density (Den): T.C. Scale Logging speed fpm
High resolution density (HRD) T.C. 2 Scale 200 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 2 in/in Logging speed fpm
Resistance (RES): Scale 20 ohms/in Logging speed fpm
Remarks: Only one log due to breakdown of other probe. Vertical scale 1 in = 40 ft.

GEOPHYSICAL LOGS



U.S. Geological Survey

Hole name 1 continued



Sample Log U.S. GEOLOGICAL SURVEY Page 1 of 2

Hole 2 Elev. 3845 feet Total Depth 490 feet
Location 1800 FEL, 2300 FSL (NW 1/4, SE 1/4) Sec. 33, T. 2 S., R. 38 E.
County Big Horn State Mont. Quadrangle Jeans Fork SE 7 1/2'
Drilled by Western Drilling Driller G. Abbott Hole size 5 1/8 inches
Date Started 11/5/81 Date Completed 11/5/81 Geologist L. Robinson
Remarks: Lithology from 5 ft samples. Depth and thickness of coal modified to conform with geophysical logs.

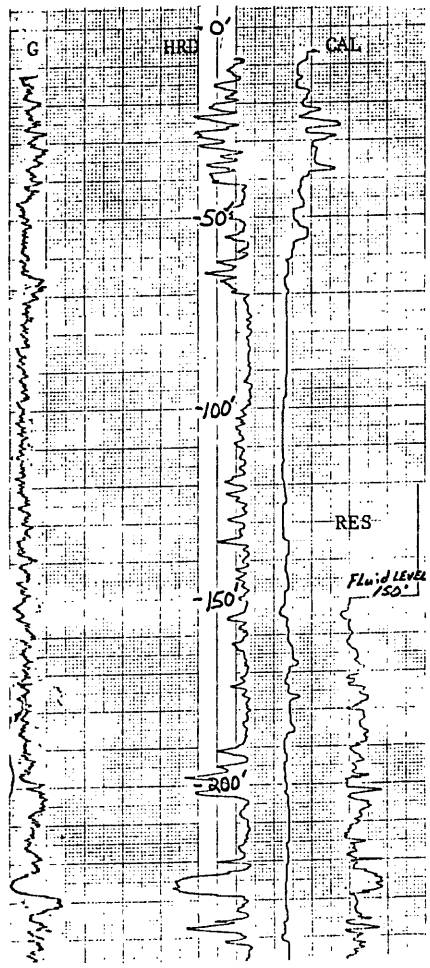
| Depth interval (feet) From | To | Thickness | Lithologic Description |
|---|---|---|---|
| 0 | 5 | 5 | Sand |
| 5 | 10 | 5 | Sandstone, grayish-brown, very fine grained, oxidized, silty |
| 10 | 40 | 30 | Sandstone, grayish-yellow, very fine grained, well-sorted |
| 40 | 45 | 5 | Claystone, brown, some sandstone and carbonaceous material |
| 45 | 51 | 6 | Sandstone, yellowish-brown, fine-grained, silty |
| 51 | 54 | 3 | Shale, coaly, carbonaceous |
| 54 | 65 | 11 | Siltstone, medium-gray, sandy |
| 65 | 85 | 20 | Sandstone, gray, very fine grained, silty |
| 85 | 95 | 10 | Siltstone, medium-gray, sandy |
| 95 | 135 | 40 | Sandstone, grayish-yellow, medium-grained, medium fine-grained at 110, and fine-grained at 130 |
| 135 | 140 | 5 | Sandstone, gray, very fine grained, some siltstone |
| 140 | 150 | 10 | Sandstone, light-gray interbedded with siltstone, brown |

| Depth interval (feet) | | | |
|---|---|---|---|
| From | To | Thick-ness | Lithologic Description |
| 150 | 170 | 20 | Sandstone, gray, fine-grained, clean, medium-grained at 160, water at 165 |
| 170 | 196 | 26 | Siltstone, gray interbedded with shale, gray, clayey at 180 |
| 196 | 198 | 2 | Coal |
| 198 | 200 | 2 | Shale and siltstone, gray |
| 200 | 201 | 1 | Coal |
| 201 | 220 | 19 | Siltstone and shale interbedded, gray |
| 220 | 221 | 1 | Coal |
| 221 | 223 | 2 | Shale and siltstone, gray |
| 223 | 228 | 5 | Coal, McKay bed |
| 228 | 237 | 9 | Siltstone and shale, gray |
| 237 | 238 | 1 | Coal |
| 238 | 282 | 44 | Siltstone and shale interbedded, gray |
| 282 | 284 | 2 | Coal |
| 284 | 300 | 16 | Siltstone and shale, sandy |
| 300 | 315 | 15 | Claystone, gray, silty, sandy |
| 315 | 320 | 5 | Shale, dark-gray, carbonaceous, clayey |
| 320 | 420 | 100 | Sandstone, gray, very fine grained, silty, some shale and siltstone lenses |
| 420 | 425 | 5 | Shale, dark-gray |
| 425 | 490 | 65 | Shale and siltstone, medium-gray |

U.S.Geological Survey
Northeastern Crow Indian Reservation

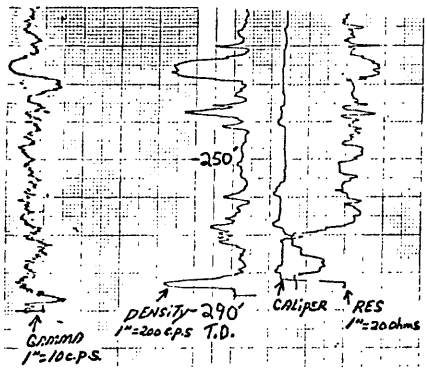
Hole name 2 County Big Horn State Montana
Location 1800' FEL, 2300' FSL Sec. 33 T. 2 S., R. 38E
Elevation 3845 Drilled depth 490 ft Logged depth 290 ft
Drilling medium air and foam Date Logged 11/5/81
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 10 cps/in Logging speed 15 fpm
Density (Den): T.C. Scale Logging speed fpm
High resolution density (HRD) T.C. 2 Scale 200 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 2 in/in Logging speed fpm
Resistance (RES): Scale 20 ohms/in Logging speed fpm
Remarks: Hole caved before second log could be run. Sample log indicates no coal below 290 ft. Vertical scale 1 in = 40 ft.

GEOPHYSICAL LOGS



U.S. Geological Survey

Hole name 2 continued



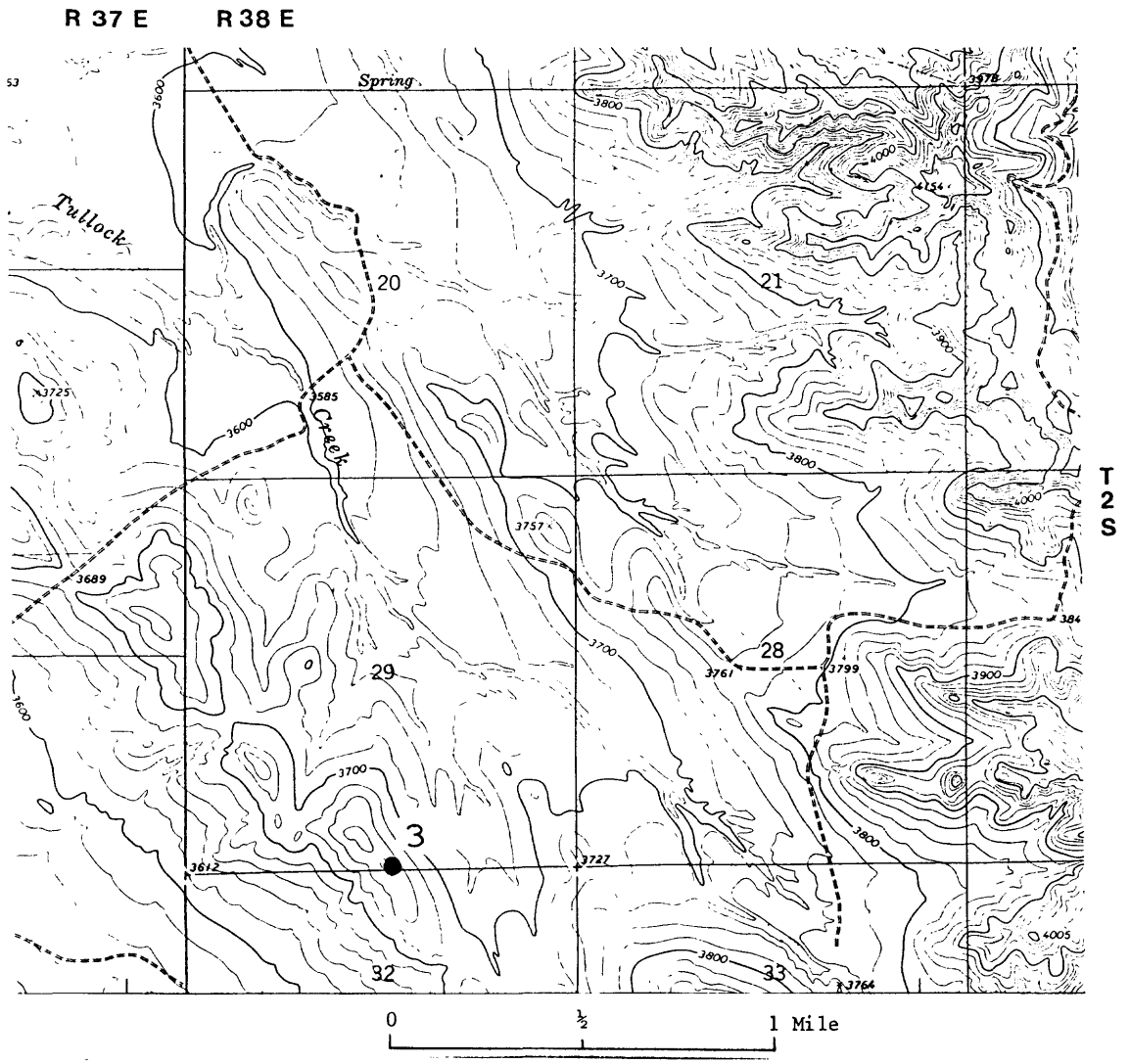



Figure 5. -- Map showing location of hole 3. Base from Jeans Fork NE quadrangle (1967).

Hole 3 Elev. 3760 feet Total Depth 300 feet
Location 2700 FWL, 100 FSL (SW 1/4 , SE 1/4 ) Sec. 29 , T. 2 S., R. 38 E.
County Big Horn State Mont. Quadrangle Jeans Fork NE 7 1/2'
Drilled by Western Drilling Driller G. Abbott Hole size 5 1/8 inches
Date Started 11/5/81 Date Completed 11/5/81 Geologist L.Robinson
Remarks: Lithology from 5 ft samples. Depth and thickness of coal modified to conform with geophysical logs.

| Depth interval (feet) From | To | Thickness | Lithologic Description |
|---|---|---|---|
| 0 | 25 | 25 | Sandstone, grayish-yellow, medium fine- to fine-grained at base to very fine grained at 20, clean, well-sorted, mostly quartz, medium-grained at 25 |
| 25 | 27 | 2 | Coal |
| 27 | 48 | 21 | Sandstone, grayish-yellow, fine-grained to medium-grained at 25 |
| 48 | 51 | 3 | Coal |
| 51 | 55 | 4 | Shale, dark-gray, silty |
| 55 | 62 | 7 | Coal, McKay bed |
| 62 | 70 | 8 | Sandstone, medium-gray and siltstone, sandy |
| 70 | 80 | 10 | Siltstone, medium-gray, sandy |
| 80 | 115 | 35 | Shale, medium-gray, silty, carbonaceous and dark-gray at 115 |
| 115 | 120 | 5 | Sandstone, light-gray, very fine grained, clean |
| 120 | 130 | 10 | Shale, medium dark-gray, silty, water |
| 130 | 155 | 25 | Shale, medium-gray, some siltstone |
| 155 | 160 | 5 | Sandstone, light-gray, very fine grained, silty |

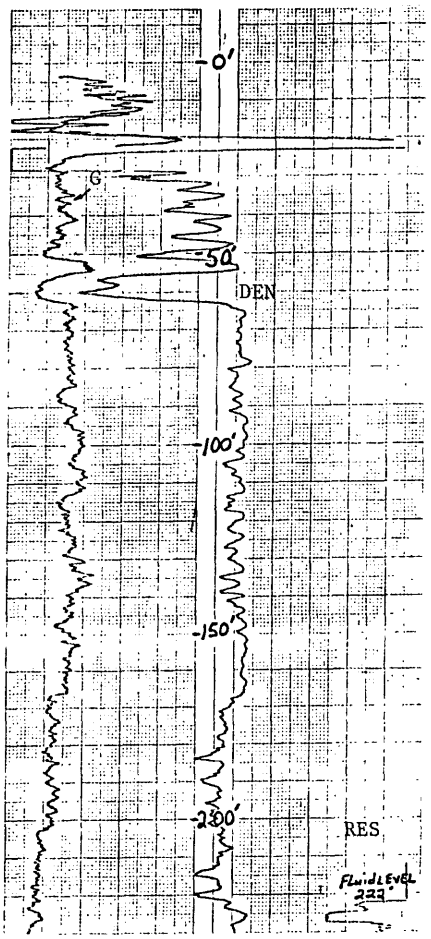
Hole No. 3 Page 2 of 2

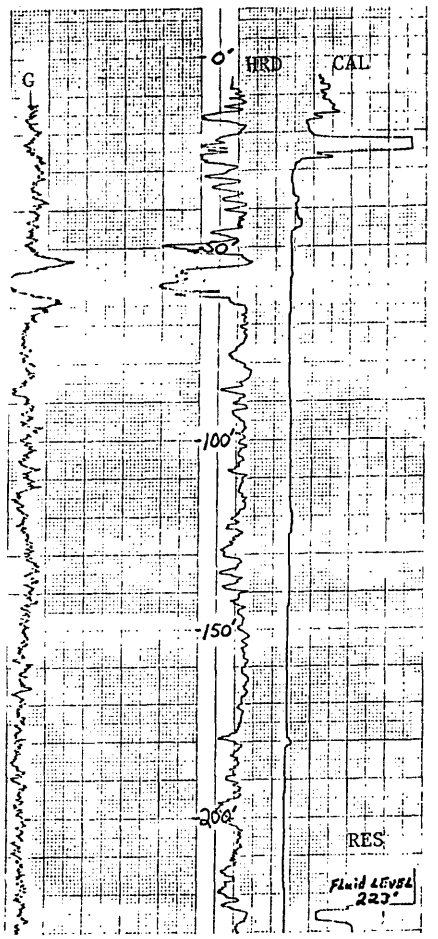
| Depth interval (feet) From | To | Thickness | Lithologic Description |
|---|---|---|---|
| 160 | 251 | 91 | Shale, gray, silty to siltstone, some thin sandstone, yellowish-orange, very fine grained |
| 251 | 253 | 2 | Coal, Lower Robinson bed (?) |
| 253 | 256 | 3 | Siltstone |
| 256 | 257 | 1 | Coal |
| 257 | 300 | 43 | Sandstone, gray, very fine grained |

U.S.Geological Survey
Northeastern Crow Indian Reservation

Hole name 3 County Big Horn State Montana
Location 2700′ FWL, 100′ FWL Sec. 29 T. 2 S., R. 38E
Elevation 3760 Drilled depth 300 ft Logged depth 300 ft
Drilling medium air and foam Date Logged 11/5/81
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 10 cps/in Logging speed 15 fpm
Density (Den): T.C. 2 Scale 100 cps/in Logging speed 15 fpm
High resolution density (HRD) T.C. 2 Scale 200 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 2 in/in Logging speed fpm
Resistance (RES): Scale 20 ohms/in Logging speed fpm
Remarks: Vertical scale 1 in. = 40 ft.

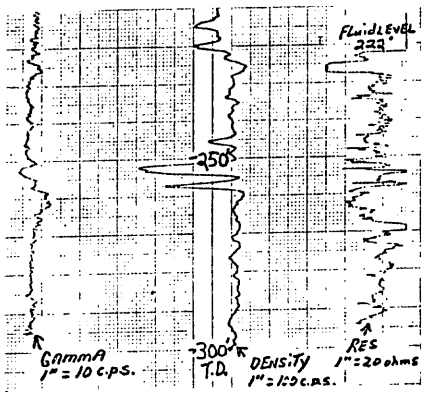
GEOPHYSICAL LOGS

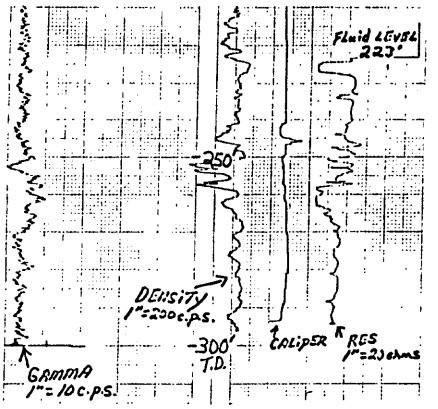


U.S. Geological Survey

Hole name 3 continued



R 38 E

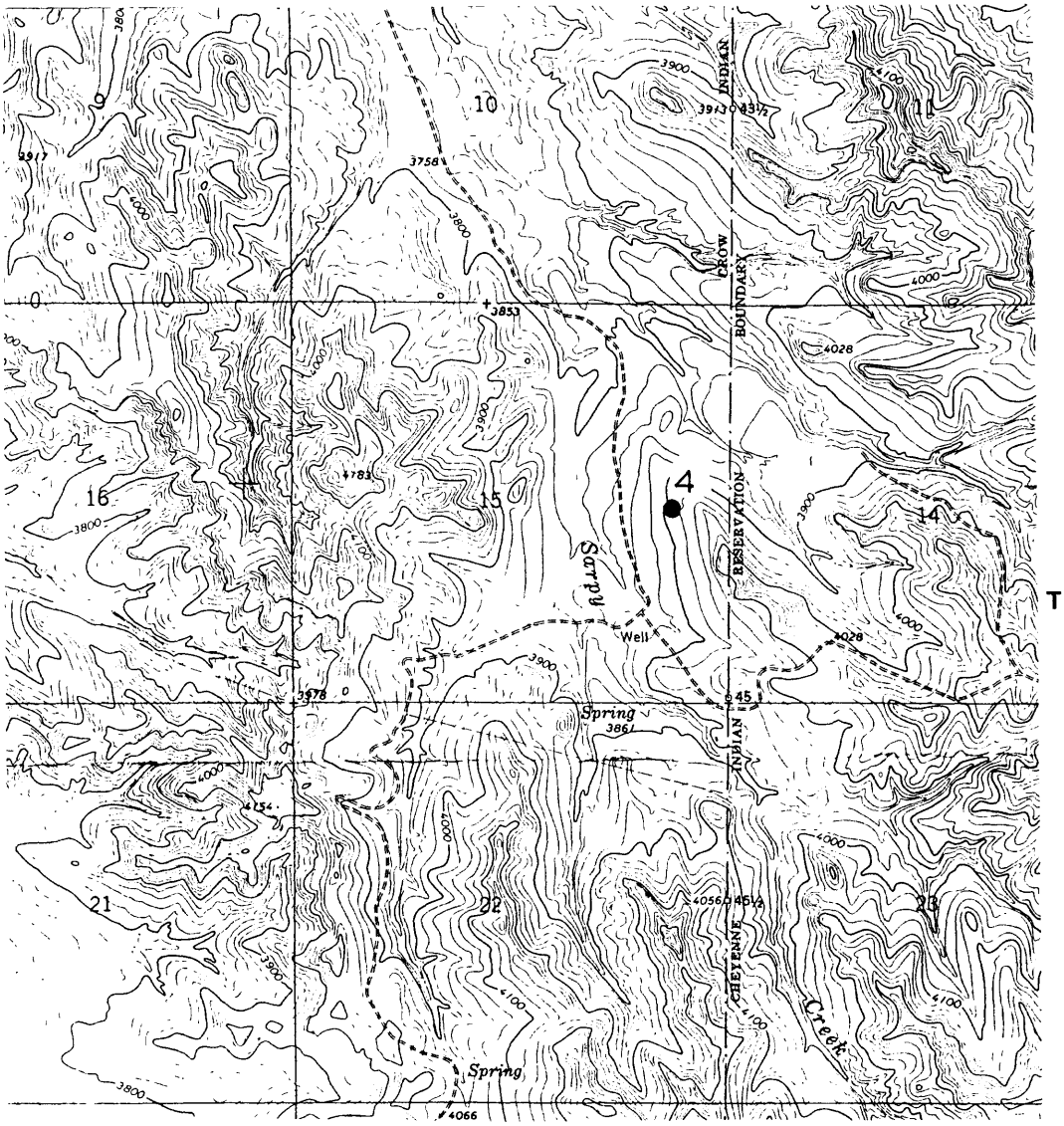



Figure 6. -- Map showing location of hole 4. Base from Jeans Fork NE quadrangle (1967).

Hole 4 Elev. 3910 feet Total Depth 640 feet

Location 750 W of Reserv. Bndry., 2550 FSL (NE 1/4, SE 1/4) Sec. 15, T. 2 S., R. 38 E.

County Big Horn State Mont. Quadrangle Jeans Fork NE 7 1/2'

Drilled by Western Drilling Driller G. Abbott Hole size 5 1/8 inches

Date Started 11/4/81 Date Completed 11/4/81 Geologist L. Robinson

Remarks: Lithology from 5 ft samples. Depth and thickness of coal modified to conform with geophysical logs.

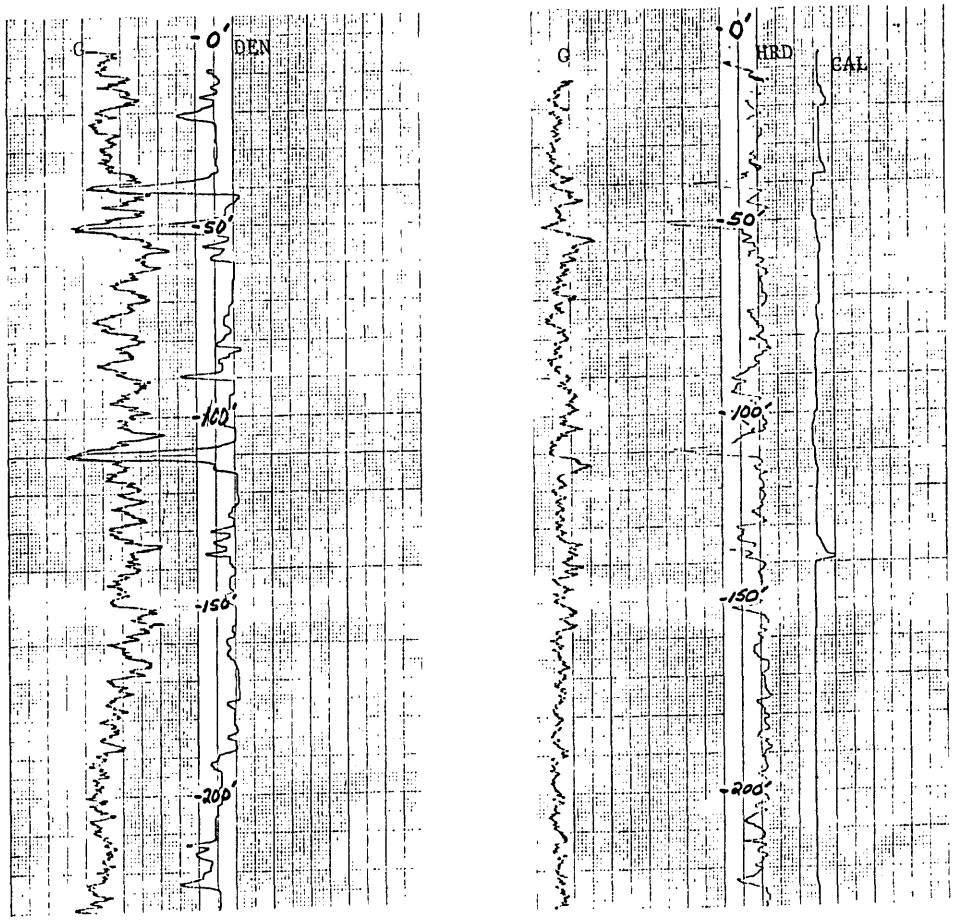
| Depth interval (feet) From | To | Thickness | Lithologic Description |
|---|---|---|---|
| 0 | 38 | 38 | Sandstone, grayish-yellow, very fine grained |
| 38 | 40 | 2 | Coal |
| 40 | 49 | 9 | Siltstone, gray, shaley |
| 49 | 51 | 2 | Coal |
| 51 | 55 | 4 | Shale, dark-gray, carbonaceous |
| 55 | 60 | 5 | Shale, light-gray |
| 60 | 70 | 10 | Siltstone, light-gray |
| 70 | 95 | 25 | Sandstone, gray, very fine grained, silty |
| 95 | 108 | 13 | Siltstone, gray, sandy |
| 108 | 111 | 3 | Coal |
| 111 | 115 | 4 | Siltstone, carbonaceous, thinly-laminated |
| 115 | 120 | 5 | Sandstone, gray, very fine grained, silty |
| 120 | 140 | 20 | Siltstone, gray, slightly sandy |
| 140 | 165 | 25 | Sandstone, gray, very fine grained |
| 165 | 185 | 20 | Siltstone, gray, sandy, very thinly laminated |

| Depth interval (feet) | | | |
|---|---|---|---|
| From | To | Thick-ness | Lithologic Description |
| 185 | 313 | 128 | Sandstone, gray, very fine grained, silty, coarsening to medium fine-grained at 230 to 265, fine-grained below 265 |
| 313 | 316 | 3 | Coal, Rosebud bed |
| 316 | 337 | 21 | Sandstone, gray, very fine grained with siltstone |
| 337 | 343 | 6 | Shale, light-gray, silty |
| 343 | 344 | 1 | Coal, McKay bed |
| 344 | 385 | 41 | Siltstone, shale and very fine grained sandstone, interbedded |
| 385 | 395 | 10 | Sandstone, gray, medium-grained, slightly clayey |
| 395 | 415 | 20 | Siltstone, sandy |
| 415 | 470 | 55 | Sandstone, gray, very fine grained |
| 470 | 495 | 25 | Shale, gray and siltstone, some sandstone interbedded |
| 495 | 515 | 20 | Sandstone, gray, medium-grained, fine-grained at 510, medium fine-grained at 515 |
| 515 | 520 | 5 | Shale, medium-gray |
| 520 | 538 | 18 | Sandstone, gray, fine-grained |
| 538 | 541 | 3 | Coal, Lower Robinson |
| 541 | 580 | 39 | Shale, dark-gray to gray, silty |
| 580 | 585 | 5 | Shale, dark-gray carbonaceous |
| 585 | 590 | 5 | Shale, greenish-gray |
| 590 | 620 | 30 | Shale, medium-gray, some siltstone |
| 620 | 635 | 15 | Sandstone and siltstone, sandy, gray |
| 635 | 640 | 5 | Shale, medium-gray |

U.S.Geological Survey
Northeastern Crow Indian Reservation

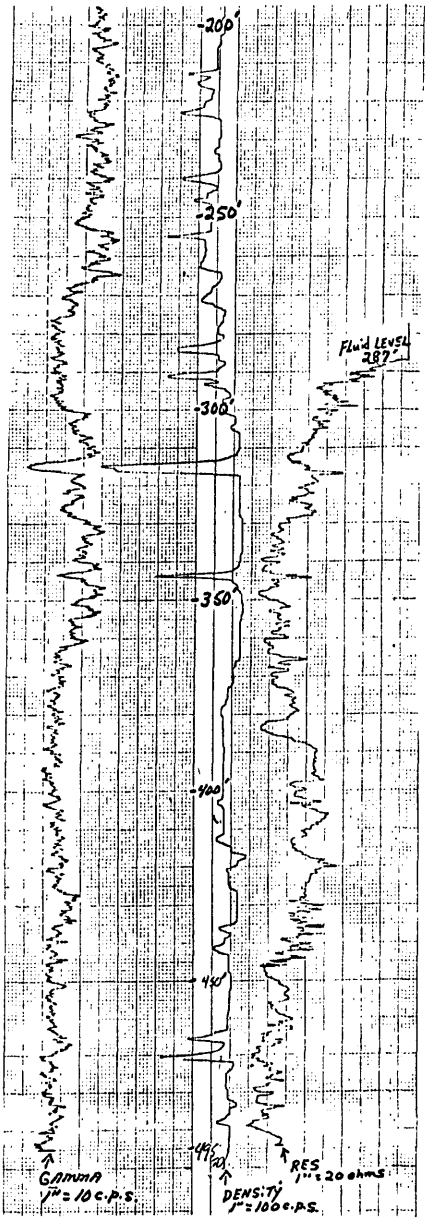
Hole name 4 County Big Horn State Montana
Location 750' FEL, 2550' FSL Sec. 15 T. 2 S., R. 38E
Elevation 3910 Drilled depth 640 ft Logged depth 640 ft, 495 ft
Drilling medium air and foam Date Logged 11/4/81
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 10 cps/in Logging speed 15 fpm
Density (Den): T.C. 2 Scale 100cps/in Logging speed 15 fpm
High resolution density (HRD) T.C. 2 Scale 200 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 2 in/in Logging speed fpm
Resistance (RES): Scale 20 ohms/in Logging speed fpm
Remarks: Vertical scale 1 in. = 40 ft. Conventional log run only to 495 ft. due to caving.

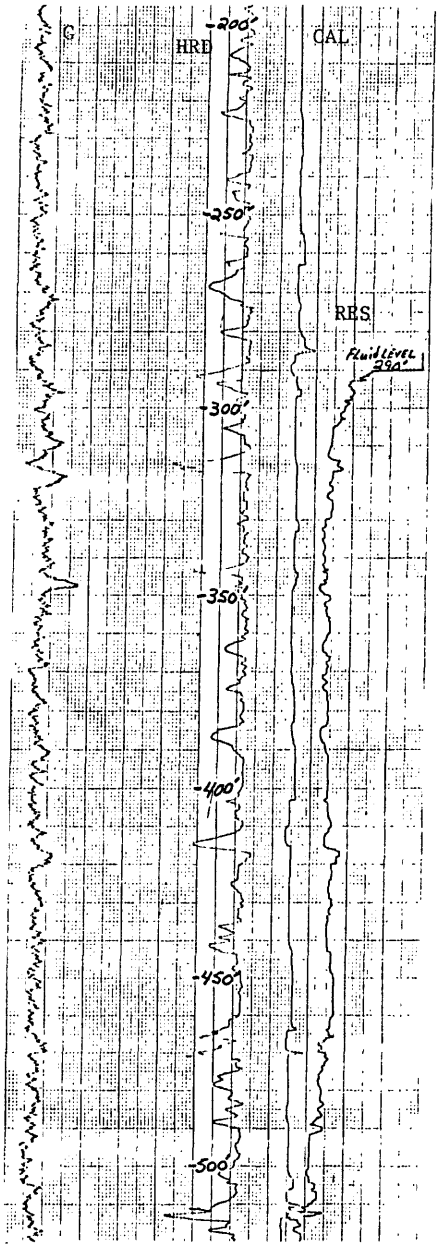
GEOPHYSICAL LOGS



U.S. Geological Survey

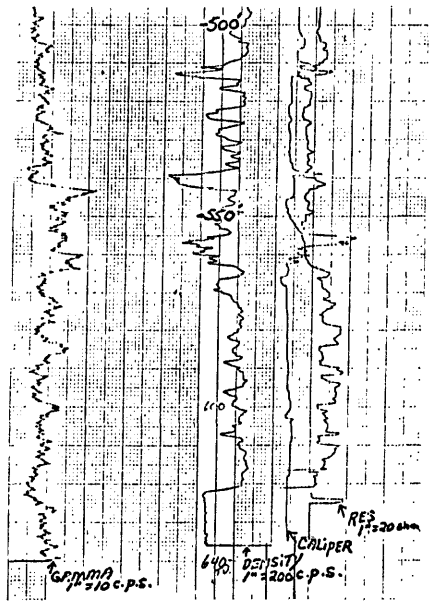
Hole name 4 continued



U.S. Geological Survey

Hole name 4 continued



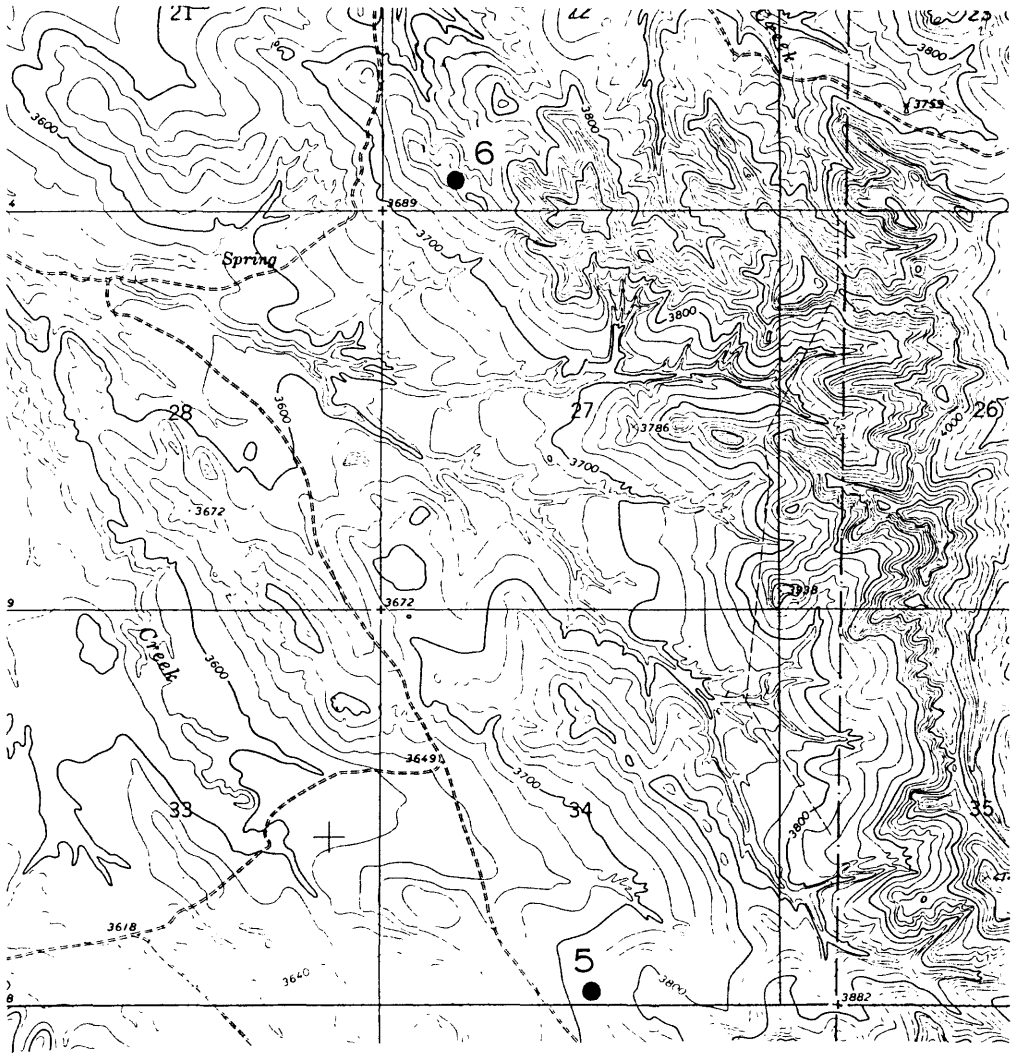



Figure 7. -- Map showing locations of holes 5 and 6. Base from Jeans Fork NE quadrangle (1967).

Sample Log U.S. GEOLOGICAL SURVEY Page 1 of 2

Hole 5 Elev. 3740 feet Total Depth 500 feet

Location 250 FSL, 2850 FWL (SW 1/4 , SE 1/4 ) Sec. 34 , T. 1 S., R. 38 E.

County Big Horn State Mont. Quadrangle Jeans Fork NE 7 1/2'

Drilled by Western Drilling Driller G.Abbott Hole size 5 1/2' inches

Date Started 11/4/81 Date Completed 11/4/81 Geologist L. Robinson

Remarks: Lithology from 5 ft. samples. Depth and thickness of coal modified to conform with geophysical logs

| Depth interval (feet) From | To | Thickness | Lithologic Description |
|---|---|---|---|
| 0 | 108 | 108 | Sandstone, grayish-yellow to yellowish-gray, very fine grained, medium fine-grained at 40, medium-grained at 60, fine-grained below 60 to medium-grained from below 90 to 108 |
| 108 | 111 | 3 | Coal, Rosebud bed |
| 111 | 120 | 9 | Sandstone, gray, fine-grained, clean, well-sorted |
| 120 | 130 | 10 | Siltstone and shale, sandy, gray |
| 130 | 140 | 10 | Sandstone, gray, some shale |
| 140 | 146 | 6 | Shale, gray, silty |
| 146 | 150 | 4 | Coal, McKay bed |
| 150 | 155 | 5 | Sandstone and shale, gray, silty |
| 155 | 170 | 15 | Sandstone, gray, medium fine-grained, fine-grained at 170 |
| 170 | 235 | 65 | Sandstone, gray, very fine grained |
| 235 | 245 | 10 | Siltstone, gray, sandy |
| 245 | 265 | 20 | Sandstone, very fine grained |
| 265 | 301 | 36 | Siltstone, gray, sandy and sandstone, some interbedded shale |

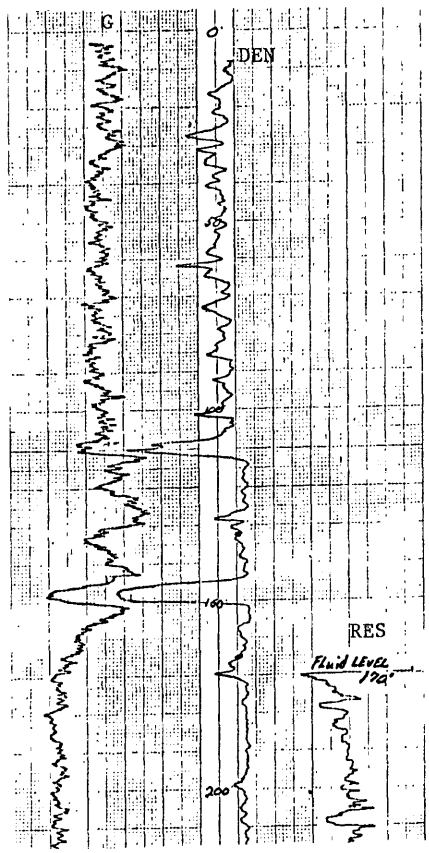
| Depth interval (feet) | | | |
|---|---|---|---|
| From | To | Thick-ness | Lithologic Description |
| 301 | 303 | 2 | Coal, Upper Robinson bed |
| 303 | 315 | 12 | Shale and carbonaceous shale, dark-brown and gray |
| 315 | 320 | 5 | Siltstone, gray, sandy |
| 320 | 340 | 20 | Sandstone, gray, very fine grained, silty to siltstone |
| 340 | 355 | 15 | Siltstone, gray, sandy |
| 355 | 360 | 5 | Shale, dark-gray, carbonaceous |
| 360 | 366 | 6 | Coal, Lower Robinson bed |
| 366 | 395 | 29 | Shale, gray and brown, some carbonaceous layers |
| 395 | 420 | 25 | Siltstone, gray, sandy |
| 420 | 440 | 20 | Sandstone, gray, fine-grained |
| 440 | 500 | 60 | Sandstone, gray, fine-grained interbedded with siltstone |

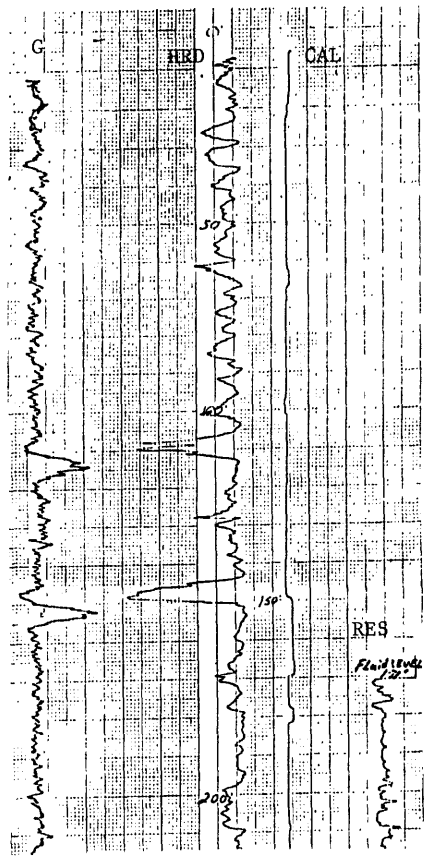
U.S.Geological Survey

Northeastern Crow Indian Reservation

Hole name 5 County Big Horn State Montana
Location 250' FSL, 2850' FWL Sec. 34 T. 1 S., R. 38E
Elevation 3740 Drilled depth 500 ft Logged depth 500 ft
Drilling medium air and foam Date Logged 11/4/81
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 10 cps/in Logging speed 15 fpm
Density (Den): T.C. 2 Scale 100 cps/in Logging speed 15 fpm
High resolution density (HRD) T.C. 2 Scale 200 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 2 in/in Logging speed fpm
Resistance (RES): Scale 20 ohms/in Logging speed fpm
Remarks: Vertical scale 1 in. = 40 ft.

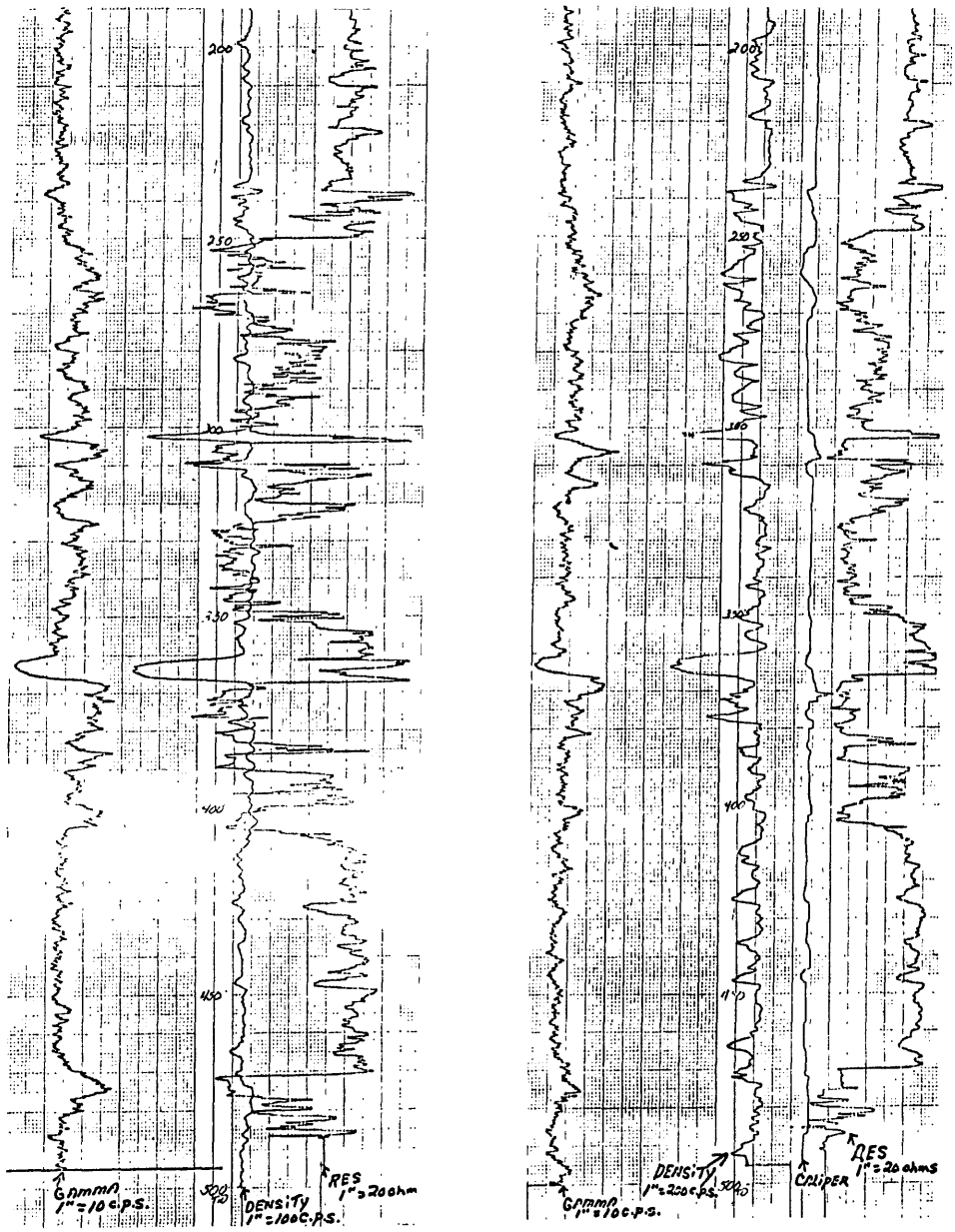
GEOPHYSICAL LOGS



U.S. Geological Survey

Hole name 5 continued



Hole 6 Elev. 3790 feet Total Depth 540 feet
Location 500 FWL, 800 FSL ( SW 1/4 , SW 1/4 ) Sec. 22 , T. 1 S., R. 38 E.
County Big Horn State Mont. Quadrangle Jeans Fork NE 7 1/2 '
Drilled by Western Drilling Driller G. Abbott Hole size 5 1/8 inches
Date Started 11/3/81 Date Completed 11/3/81 Geologist L. Robinson
Remarks: Lithology from 5 ft. samples. Depth and thickness of coal modified to conform with geophysical logs.

| Depth interval (feet) From | To | Thickness | Lithologic Description |
|---|---|---|---|
| 0 | 5 | 5 | Siltstone, yellowish-gray |
| 5 | 13 | 8 | Sandstone, grayish-yellow, very fine grained, silty |
| 13 | 23 | 10 | Siltstone, yellowish-brown, shaley, sandy, iron-stained |
| 23 | 33 | 10 | Shale, light-gray |
| 33 | 35 | 2 | Coal |
| 35 | 40 | 5 | Shale, very dark gray, silty |
| 40 | 45 | 5 | Shale, light-gray, silty |
| 45 | 50 | 5 | Siltstone, blueish-gray |
| 50 | 55 | 5 | Shale, blueish-gray, silty |
| 55 | 60 | 5 | Shale, brown, sandy |
| 60 | 65 | 5 | Sandstone, grayish-yellow, very fine grained, poorly cemented |
| 65 | 122 | 57 | Sandstone, yellowish-gray, well-sorted, clean, subangular to rounded grains, calcareous at top coarsens downward from very fine grained to medium fine-grained at 120 |
| 122 | 126 | 4 | Siltstone, gray, thin hard layer at 126 |

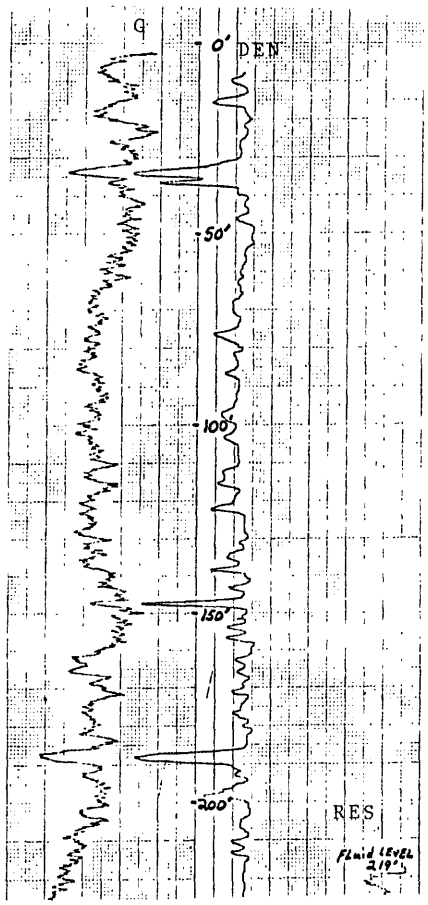
| Depth interval (feet) | | | |
|---|---|---|---|
| From | To | Thick-ness | Lithologic Description |
| 126 | 130 | 4 | Sandstone, grayish-yellow, medium-grained |
| 130 | 135 | 5 | Sandstone, gray, medium-grained, silty, water |
| 135 | 147 | 12 | Shale, gray, silty |
| 147 | 148 | 1 | Coal |
| 148 | 187 | 39 | Shale, gray, silty; thin sandy calcareous layer at 175 |
| 187 | 190 | 3 | Coal |
| 190 | 205 | 15 | Shale, gray to medium-dark-gray, some brown shale |
| 205 | 240 | 35 | Siltstone, gray and brown, sandy grading to sandstone at 220, interbedded with shale and siltstone |
| 240 | 335 | 95 | Sandstone, gray, very fine grained, poorly cemented, shale layer at 255, sandstone coarsens to fine-grained at 280, some interbedded shale and siltstone |
| 335 | 341 | 6 | Sandstone, gray, very fine grained |
| 341 | 354 | 13 | Coal, Rosebud bed |
| 354 | 362 | 8 | Shale, grayish-brown, carbonaceous |
| 362 | 372 | 10 | Coal, McKay bed |
| 372 | 389 | 17 | Shale, gray and siltstone |
| 389 | 390 | 1 | Coal |
| 390 | 400 | 10 | Sandstone, gray, very fine grained, silty |
| 400 | 401 | 1 | Coal |
| 401 | 405 | 4 | Shale, gray |
| 405 | 423 | 18 | Sandstone, gray, very fine grained, some gray shale |

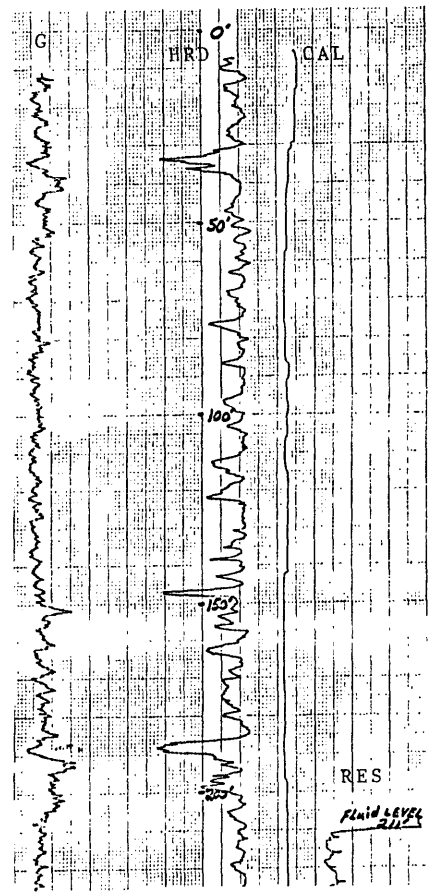
| Depth interval (feet) | | | |
|---|---|---|---|
| From | To | Thick-ness | Lithologic Description |
| 423 | 424 | 1 | Siltstone, yellowish-brown, hard |
| 424 | 460 | 36 | Shale, gray interbedded with siltstone and very fine grained sandstone |
| 460 | 464 | 4 | Coal, Robinson bed |
| 464 | 466 | 2 | Shale |
| 466 | 480 | 14 | Coal, Robinson bed |
| 480 | 500 | 20 | Shale and siltstone, blueish-gray |
| 500 | 520 | 20 | Sandstone, light-gray, very fine grained, interbedded with gray shale |
| 520 | 540 | 20 | Sandstone, gray, very fine grained, silty |

U.S.Geological Survey
Northeastern Crow Indian Reservation

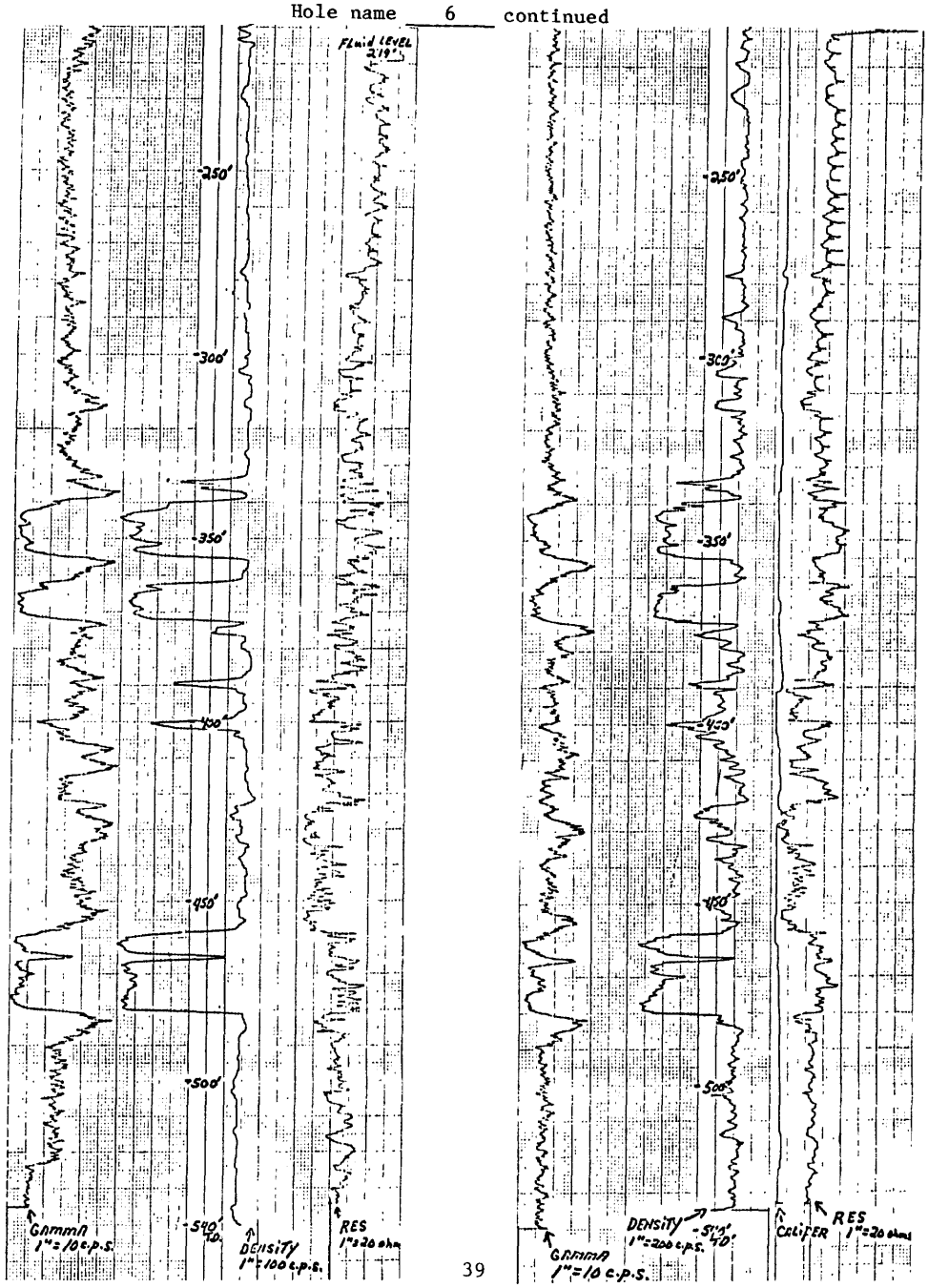
Hole name 6 County Big Horn State Montana
Location 500′ FWL, 800′ FSL Sec. 22 T. 1 S., R. 38E
Elevation 3792 Drilled depth 540 ft Logged depth 540 ft
Drilling medium air and foam Date Logged 11/3/81
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 10 cps/in Logging speed 15 fpm
Density (Den): T.C. 2 Scale 100 cps/in Logging speed 15 fpm
High resolution density (HRD) T.C. 2 Scale 200 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 2 in/in Logging speed fpm
Resistance (RES): Scale 20 ohms/in Logging speed fpm
Remarks: Vertical scale 1 in. = 40 ft.

GEOPHYSICAL LOGS



Hole name 6 continued



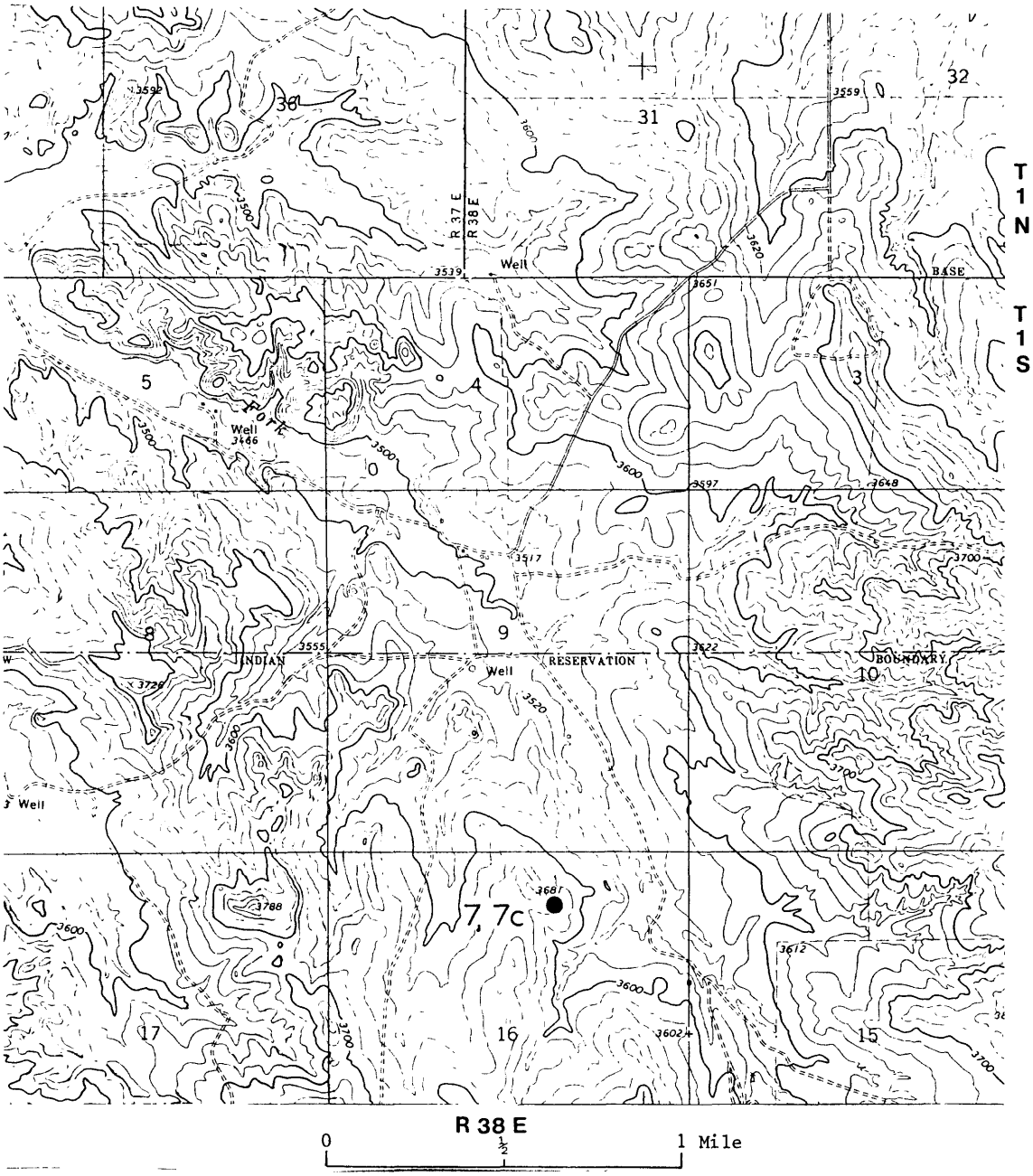



Figure 8. -- Map showing locations of holes 7 and 7c. Base from Wolf School quadrangle (1972).

Hole 7 and 7c (composite) Elev. 3635 feet Total Depth 300 feet
Location 700 FNL, 1950 FEL (NW 1/4, NE 1/4) Sec. 16, T. 1 S., R. 38 E.
County Big Horn State Mont. Quadrangle Wolf School 7 1/2'
Drilled by Western Drilling Driller G. Abbott Hole size 5 1/8 inches
Date Started 11/2/81 Date Completed 11/3/81 Geologist L. Robinson
Remarks: Composite of core from 7 c and sample log from 7. Lithology from 5 ft. samples where not cored. Depth and thickness of coal modified to conform with geophysical logs.

| Depth interval (feet) From | To | Thickness | Lithologic Description |
|---|---|---|---|
| 0 | 5 | 5 | Sandstone, grayish-yellow, very fine grained, slightly silty, some thin shale |
| 5 | 15 | 10 | Sandstone, yellowish-gray, very fine grained, well-sorted, subangular grains |
| 15 | 24 | 9 | Sandstone, grayish-yellow, very fine grained |
| | | | Begin Core Description |
| 24.0 | 27.0 | 3.0 | Sandstone, grayish-yellow, fine-grained, slightly calcareous, thinly laminated, flat-bedded, clean, well-sorted, fairly well-cemented, subrounded to subangular grains, 1/2-inch iron nodules |
| 27.0 | 27.6 | 0.6 | Sandstone, yellowish-gray, medium-grained, well-sorted, fairly well-cemented, subrounded grains |
| 27.6 | 29.0 | 1.4 | Sandstone, light-gray, medium-grained, poorly cemented, coal fragments |
| 29.0 | 44.8 | 15.8 | Coal, Rosebud bed, scattered pyrite at 33.0, 36.5, 38.0 and 41.0, dull with shiny streaks 40.0-41.0, charcoal at 43.5 |
| 44.8 | 46.1 | 1.3 | Shale, medium-gray, 0.2 carbonaceous layer at 45.7 |

| Depth interval (feet) | | | |
|---|---|---|---|
| From | To | Thickness | Lithologic Description |
| 46.1 | 47.6 | 1.5 | Siltstone, gray, shaley, carbonaceous fragments |
| 47.6 | 51.0 | 3.4 | Sandstone, gray, very fine grained, silty, well-cemented, black carbonaceous matter along rippled bedding planes |
| 51.0 | 52.1 | 1.1 | Siltstone, light-gray, sandy, thinly laminated, 1/4-inch coal at 51.8 |
| 52.1 | 53.8 | 1.7 | Coal, McKay bed, black, crumbly, pyrite streaks throughout |
| 53.8 | 63.1 | 9.3 | Coal, McKay bed (cont.), black, shiny, bright |
| 63.1 | 63.2 | 0.1 | Shale, brown, carbonaceous |
| 63.2 | 63.4 | 0.2 | Coal, McKay bed (cont.), pyritic |
| 63.4 | 63.8 | 0.4 | Shale, medium-gray, carbonaceous and dark-gray at base |
| 63.8 | 64.3 | 0.5 | Coal, McKay bed (cont.) |
| 64.3 | 64.7 | 0.4 | Shale, gray, rooted at top, carbonaceous streaks |
| 64.7 | 71.0 | 6.3 | Siltstone, gray, sandy, carbonaceous along rippled bedding planes |
| 71.0 | 71.5 | 0.5 | Coal |
| 71.5 | 71.8 | 0.3 | Shale, dark-gray, carbonaceous, clayey |
| 71.8 | 72.5 | 0.7 | Coal |
| 72.5 | 72.7 | 0.2 | Shale, black, carbonaceous |
| 72.7 | 74.7 | 2.0 | Coal, shaley, pyrite at 74.0 |
| 74.7 | 78.0 | 3.3 | Siltstone, medium-gray, sandy, carbonaceous, coal fragments |
| 78.0 | 78.7 | 0.7 | Sandstone, light-gray, very fine grained, silty, scattered coal fragments, well-sorted |
| 78.7 | 80.0 | 1.3 | Siltstone, light-gray, sandy, some shaley streaks |
| | | | End of core description |

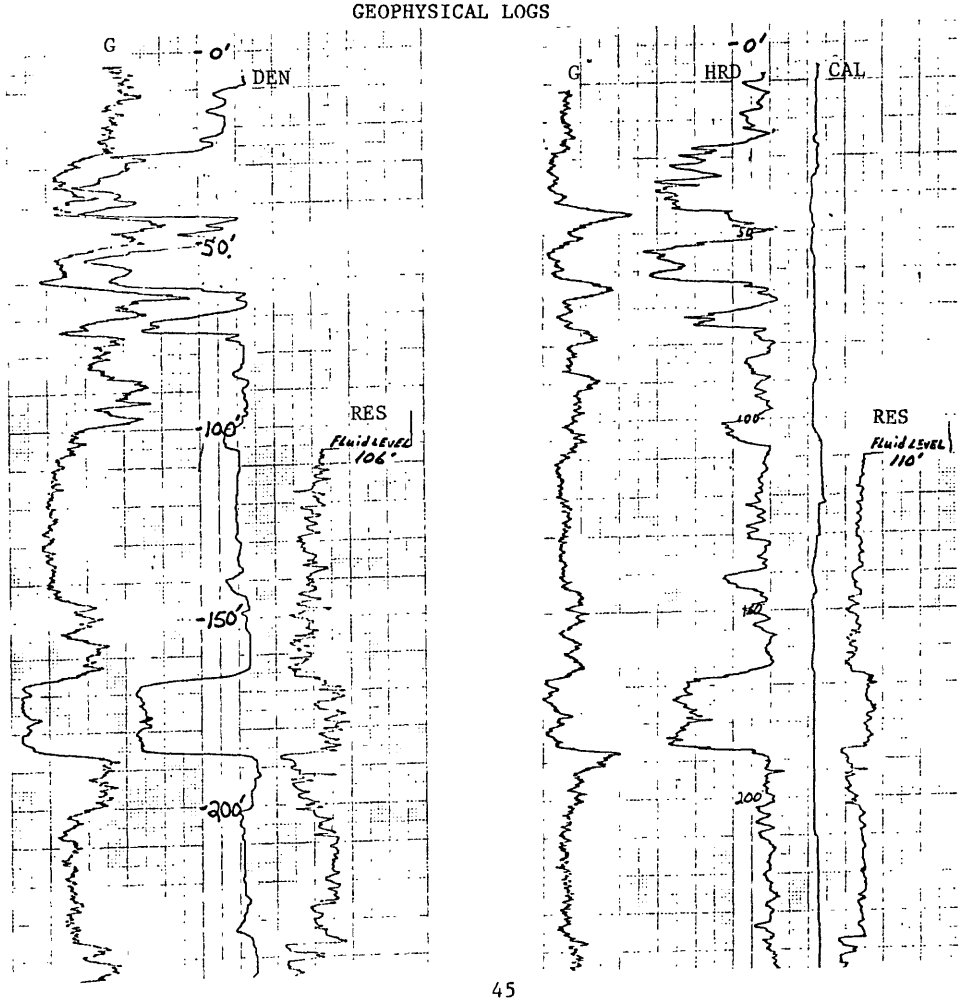
| Depth interval (feet) | | | |
|---|---|---|---|
| From | To | Thick-ness | Lithologic Description |
| 80 | 97 | 17 | Siltstone, medium-gray |
| 97 | 100 | 3 | Shale, medium-gray |
| 100 | 120 | 20 | Sandstone, gray, very fine grained, medium-grained at 115, silty, slightly clayey, water at 120 |
| 120 | 146 | 26 | Sandstone, gray, fine- to medium-grained, silty |
| 146 | 148 | 2 | Sandstone, very fine grained, limy, hard |
| 148 | 165 | 17 | Shale, gray, silty |
| | | | Begin core description |
| 165.0 | 166.7 | 1.7 | Sandstone, light-gray, rippled, silty and shaley along bedding planes |
| 166.7 | 167.0 | 0.3 | Shale, dark-gray, carbonaceous |
| 167.0 | 174.1 | 7.1 | Coal, Robinson bed, 1/4-inch layer of pyrite at 170, top 1.5 ft is broken and crumbly, scattered pyrite |
| 174.1 | 174.4 | 0.3 | Coal, Robinson bed (cont.), with pyrite nodules, 1/8 to 1 inch in diameter, subrounded |
| 174.4 | 174.5 | 0.1 | Pyrite nodules |
| 174.5 | 186.5 | 12.0 | Coal, Robinson bed (cont.), pyrite and gypsum scattered throughout, bottom 1 ft is crumbly, fissile and pyritic |
| 186.5 | 188.5 | 2.0 | Shale, medium-gray, some carbonaceous material |
| 188.5 | 189.8 | 1.3 | Siltstone, medium-gray, some large coal fragments, sandy, carbonaceous |
| | | | End of core description |
| 189.8 | 195 | 5.2 | Shale, gray; thin, hard siltstone at 193 |

| Depth interval (feet) | | | |
|---|---|---|---|
| From | To | Thick-ness | Lithologic Description |
| 195 | 200 | 5 | Siltstone, gray, sandy |
| 200 | 240 | 40 | Sandstone, light-gray, very fine grained, silty |
| 240 | 250 | 10 | Shale, medium-gray |
| 250 | 260 | 10 | Siltstone, gray, sandy |
| 260 | 261 | 1 | Coal |
| 261 | 295 | 34 | Shale, medium-gray |
| 295 | 300 | 5 | Shale, dark-brown, carbonaceous |

U.S.Geological Survey
Northeastern Crow Indian Reservation

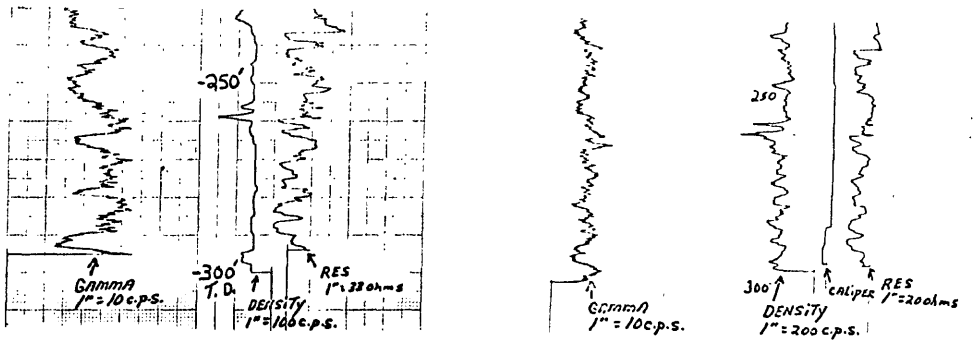
Hole name 7 County Big Horn State Montana
Location 700' FNL, 1950' FWL Sec. 16 T. 1 S., R. 38E
Elevation 3635 Drilled depth 300 ft Logged depth 300 ft
Drilling medium air and foam Date Logged 11/2/81
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 10 cps/in Logging speed 15 fpm
Density (Den): T.C. 2 Scale 100 cps/in Logging speed 15 fpm
High resolution density (HRD) T.C. 2 Scale 200 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 2 in/in Logging speed fpm
Resistance (RES): Scale 20 ohms/in Logging speed fpm
Remarks: Vertical scale 1 in. = 40 ft.

GEOPHYSICAL LOGS



U.S. Geological Survey

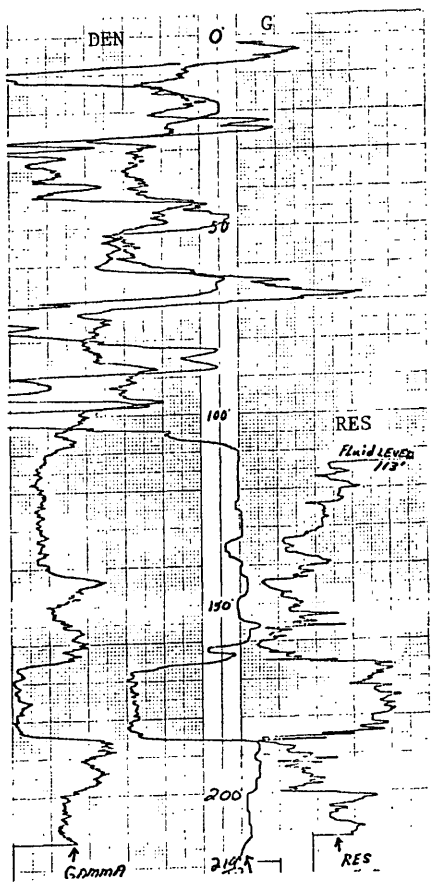
Hole name 7 continued

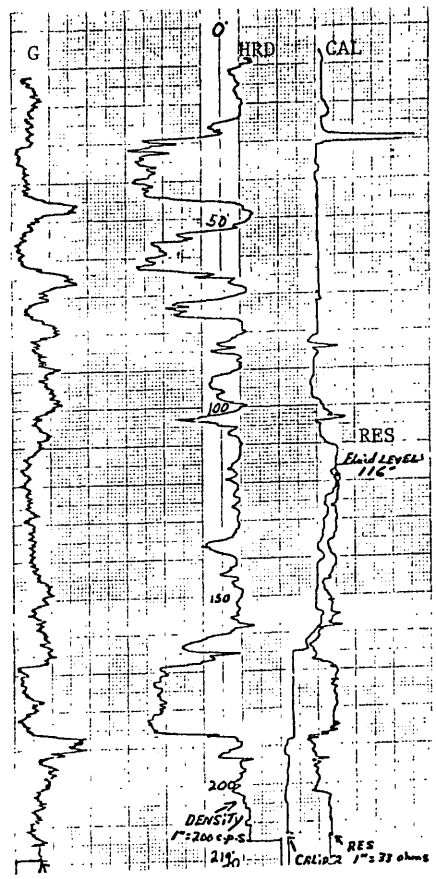


U.S.Geological Survey
Northeastern Crow Indian Reservation

Hole name 7c County Big Horn State Montana
Location 10′ N, of hole 7 Sec. 16 T. 1 S., R. 38E
Elevation 3635 Drilled depth 220 ft Logged depth 219 ft
Drilling medium air and foam Date Logged 11/3/81
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 10 cps/in Logging speed 15 fpm
Density (Den): T.C. 2 Scale 100 cps/in Logging speed 15 fpm
High resolution density (HRD) T.C. 2 Scale 200 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 2 in/in Logging speed fpm
Resistance (RES): Scale 33 ohms/in Logging speed fpm
Remarks: Twin of 7, core hole. Vertical scale 1 in. = 40 ft.

GEOPHYSICAL LOGS



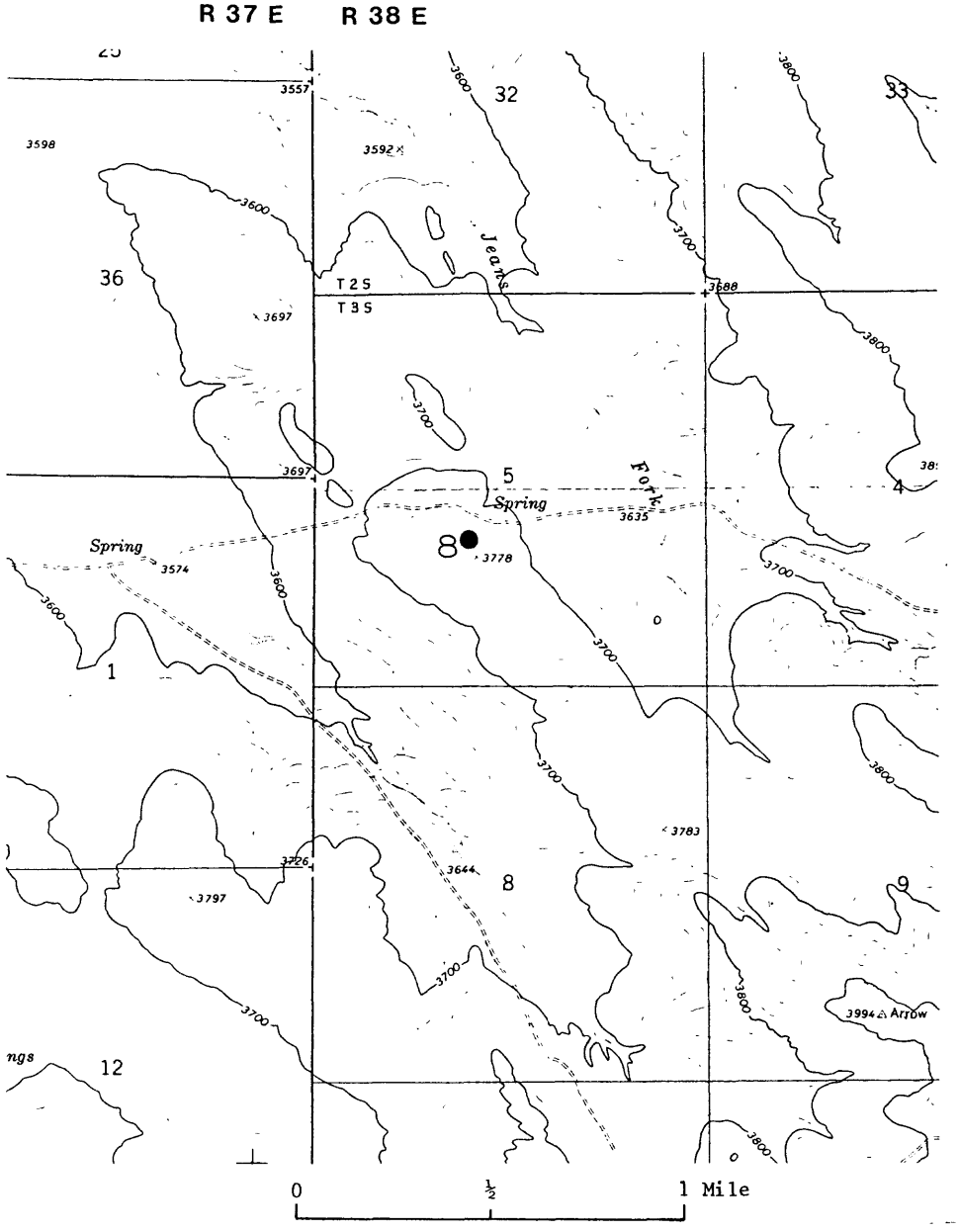



Figure 9. -- Map showing location of hole 8. Base from Jeans Fork SE quadrangle (1967).

Hole 8 Elev. 3775 feet Total Depth 320 feet
Location 2000 FWL, 1850 FSL, (NE 1/4 , SW 1/4 ) Sec. 5 , T. 3 S., R. 38 E.
County Big Horn State Mont. Quadrangle Jeans Fork SE 7 1/2 '
Drilled by Western Drilling Driller G. Abbott Hole size 5 1/8 inches
Date Started 11/5/81 Date Completed 11/5/81 Geologist L. Robinson
Remarks: Lithology from 5 ft. samples. Depth and thickness of coal modified to conform with geophysical logs.

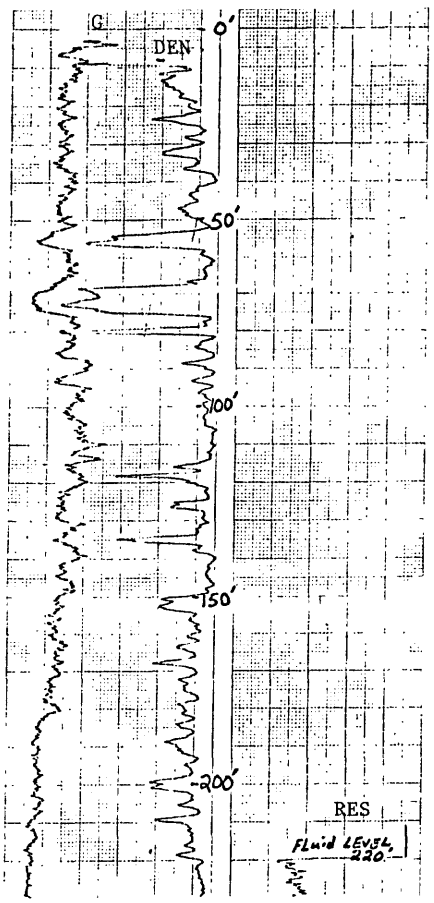
| Depth interval (feet) From | To | Thickness | Lithologic Description |
|---|---|---|---|
| 0 | 35 | 35 | Sandstone, grayish-yellow, fine- to medium fine-grained at 15, clean, well-sorted, fine-grained again at 20, subrounded grains, coarsens to medium fine-grained at 35 |
| 35 | 40 | 5 | Siltstone, medium-gray, shaley |
| 40 | 54 | 14 | Sandstone, yellowish-brown, medium fine-grained, well-sorted |
| 54 | 58 | 4 | Coal |
| 58 | 68 | 10 | Sandstone, light-gray, very fine grained, clean well-sorted |
| 68 | 76 | 8 | Coal, McKay bed |
| 76 | 80 | 4 | Siltstone, shaley |
| 80 | 82 | 2 | Coal |
| 82 | 105 | 23 | Siltstone, shaley, sand at 100 |
| 105 | 120 | 15 | Shale, medium- to dark-gray, silty, carbonaceous at 115. |
| 120 | 130 | 10 | Sandstone, gray, fine-grained, slightly silty |
| 130 | 135 | 5 | Shale, dark-brown, carbonaceous |
| 135 | 136 | 1 | Coal |

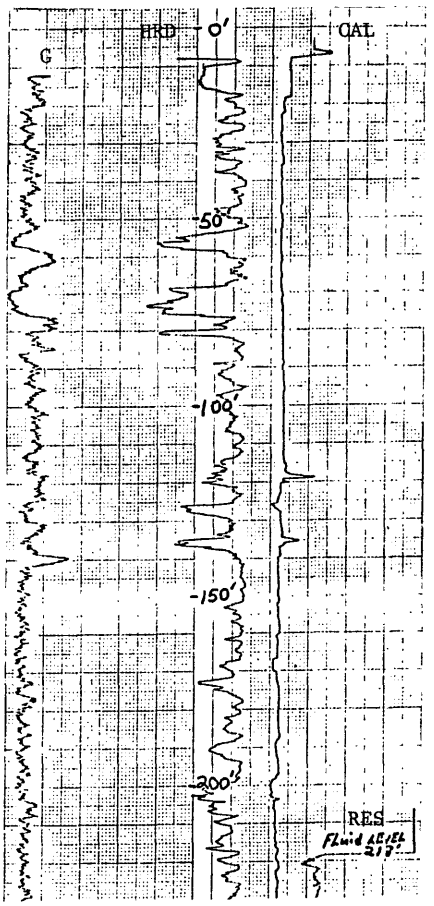
| Depth interval (feet) | | | |
|---|---|---|---|
| From | To | Thick-ness | Lithologic Description |
| 136 | 140 | 4 | Siltstone, light-gray, sandy |
| 140 | 205 | 65 | Sandstone, very fine grained, silty to fine-grained at 160, coarsening to medium fine-grained at 200, fine-grained at 205 |
| 205 | 215 | 10 | Shale, medium-gray to dark-brown, carbonaceous |
| 215 | 255 | 40 | Sandstone, very fine grained |
| 255 | 285 | 30 | Siltstone, medium-gray, sandy |
| 285 | 320 | 35 | Sandstone, gray, fine-grained |

U.S.Geological Survey
Northeastern Crow Indian Reservation

Hole name 8 County Big Horn State Montana
Location 2000′ FWL, 1850′ FSL Sec. 5 T. 3 S., R. 38E
Elevation 3775 Drilled depth 320 ft Logged depth 320 ft
Drilling medium air and foam Date Logged 11/5/81
Geophysical logs:
Gamma ray (G): T.C. 2 Scale 10 cps/in Logging speed 15 fpm
Density (Den): T.C. 2 Scale 100 cps/in Logging speed 15 fpm
High resolution density (HRD) T.C. 2 Scale 200 cps/in Logging speed 15 fpm
Caliper (CAL): Scale 2 in/in Logging speed fpm
Resistance (RES): Scale 20 ohms/in Logging speed fpm
Remarks: Vertical scale 1 in. = 40 ft.

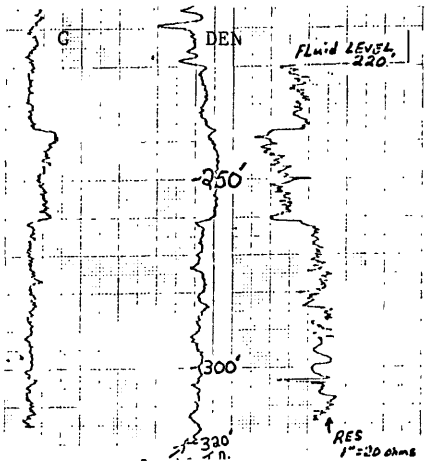
GEOPHYSICAL LOGS

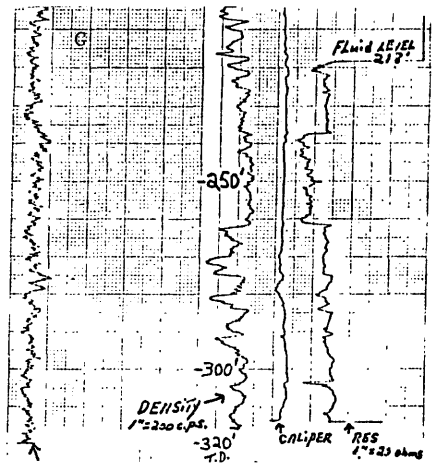


U.S. Geological Survey

Hole name 8 continued



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