Geologic and Selected Geotechnical Properties of Core from Drill Hole DH75-104, West Moorhead Coal Field, Powder River County, Montana

by

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

1U.S. Geological Survey, Denver, Colorado
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This report presents a geologic log and selected geotechnical data from a single core acquired by drilling during June through August 1975. The drill site location is 2,230 ft south and 420 ft west of the NE cor. sec. 11, T. 9 S., R. 45 E. in the West Moorhead Coal Field, Powder River County, Mont. (fig. 1). Drilling began in 3 ft of surficial material and continued about 320 ft into the Tongue River Member of the Fort Union Formation (Paleocene age) (U.S. Department of the Interior and others, 1977). The drilling was done by the U.S. Bureau of Reclamation for the U.S. Bureau of Land Management as part of project EMRIA (Energy Mineral Rehabilitation Inventory and Analysis) to "assure adequate data for choosing optimum reclamation objectives and for establishing appropriate data and interpretation for preparation of lease stipulation for the Bear Creek study area." (U.S. Department of the Interior and others, 1977). A related study to the Environmental Studies of Energy Lands program of the U.S. Geological Survey (USGS) was conducted by E. E. McGregor and John Sebesta in order to obtain strength data for materials overlying potentially economic coal beds. They studied the core from drill hole DH75-104 and determined the principal rock types and associated geotechnical characteristics (pl. 1).

The hole was drilled with a Failing Model 314 rotary drill rig and core samples were recovered by wireline drill tools using an "H"-series barrel. For variations in drill and core recovery, see the drill log (fig. 2). After each drill run, the core was removed from the core barrel, placed in 5-ft-long core boxes, and covered by a sheet of 4-mil polyethylene plastic. The core was later logged by G. T. Taucher of the U.S. Bureau of Reclamation (fig. 2) and selected geotechnical tests were performed by E. E. McGregor and John Sebesta of the USGS. Three of the tests followed ASTM standards: grain-size distribution, ASTM designation D422-63; Atterberg limits, ASTM designation D423-66; and unconfined compressive-strength test, ASTM designation D2166-66 (American Society for Testing and Materials, 1978). Other tests performed which lack ASTM standards include 1-cycle slake durability, Schmidt hammer, and point load. The slake-durability test followed the procedures of Franklin and Chandra (1972). Schmidt hammer tests followed Aufmuth (1974); the point-load strength test procedures followed Broch and Franklin (1972). Taucher performed firmness, ease-of-crushability-between-fingers, and knife-trimming tests (fig. 2) during the logging of the core (Taucher, in U.S. Department of the Interior and others, 1977).

ACKNOWLEDGMENTS

The authors gratefully acknowledge the services of John Sebesta and Jack Odum of the USGS who performed additional geotechnical testing for selected core samples.
Figure 1.—Map showing location (arrow) of DH75-104, NE 1/2 sec. 11, T. 9 S., R. 45 E., portion of the Bear Creek School, 1:24,000 quadrangle, Montana.
Figure 2.—Geologic log with descriptions of drill-hole DH75-104 core. (Modified from U.S. Department of the Interior and others, 1977, Appendix B, p. B-4.)
**GEOLOGIC LOG OF DRILL HOLE**

**LOCATION**

*Mar Crack Study Site*  
*EATURI Jwcftt MoorhAad Coal Field*

**PROJECT**

*DORLA No. 8*  
*STATE Montana*

**HOLE NO.** 75-104

**BEGUN** 7/10/75  
**FINISHED** 9/27/75 (3779.9')

**DEPTH OF WATER LEVEL AND DATE MEASURED** 224' 9/27/75

**LOG REVIEWED BY** Tauchert

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**NOTES ON WATER LOSSES AND LEVELS**

**CASING CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS**

7/10/75. Moved equipment to DH 75-104.  
K drive samples 0 to 6.4'.

Hole at 6.4'.

7/11/75. 2-3/4' wire line core (using air) 6.4 to 8.3'. 2-3/4' wire line core (using water) 8.3 to 40.5'.

Dropped sample 25.5' to 39.5' in hole. Recovered 5.8' of sample on next run. Losing about 101 water. Reamed hole for cement to 5'.

Hole at 40.5'.

7/12/75. V.L. at 13.6'. 5' CS at 10.6'. 2-3/4' wire line core 40.5 to 55.3'. Lost water at 45'. Mixed 4 pits of revert but could not get circulation back. Pulled 5' CS and reamed hole. Drove 5' CS to 45.6'.

Hole at 55.3'.

7/13/75. W.L. at ground surface. 5' CS at 45.6'. Washed out casing. 2-3/4' wire line core 55.3' to 59.8'. Losing some water. Dropped samples 60.3 to 70.6 & 70.3 to 73.2' in hole. Recovered parts of both samples. Modified core lifter.

Hole at 90.8'.

7/14/75. W.L. at ground surface. 5' CS at 45.6'. 2-3/4' wire line core 40.5 to 136.3'. Losing some water.

#2230' S. & 420' W. of NE Corner, Section 11 T 9 S. R 45 E.

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**EXPLANATION**

- **ORE LOSS**
  - Type of hole: D = Diamond, H = Hopenstell, S = Shot, C = Churn, M = Mud
  - Comments about hole:  
    - Approx. size of core (inches): 2-1/2
    - Threshold size of core (inches): 2-1/2
  - Type of hole (core):  
    - Core size (inches): 2-1/2
  - Core size (inches): 2-1/2
  - Cross cut:  
    - Cross cut size (inches): 2-1/2
  - Core size (inches): 2-1/2
  - Core size (inches): 2-1/2

- **CORE RECOVERY**
  - Type of hole: D = Diamond, H = Hopenstell, S = Shot, C = Churn
  - comments about hole:  
    - Approx. size of core (inches): 2-1/2
    - Threshold size of core (inches): 2-1/2
  - Type of hole (core):  
    - Core size (inches): 2-1/2
  - Core size (inches): 2-1/2
  - Cross cut:  
    - Cross cut size (inches): 2-1/2
  - Core size (inches): 2-1/2
  - Core size (inches): 2-1/2

- **FEATURE**
  - Measurement: DORLA No. 8  
  - State: Montana  
  - Sheet: 1  
  - Hole No. DH 75-104
GEOLOGIC LOG OF DRILL HOLE

**HOLE NO.** 75-4-04

**LOCATION:** NE Corner, Section 11, T. 9 S., R. 45 E

**DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:** 7/25/75

**DEPTH OF OVERBURDEN:** 7/24/75

**LOSS AND LEVELS:**

<table>
<thead>
<tr>
<th>HOE</th>
<th>DEPT FROM</th>
<th>DEPT TO</th>
<th>CORE LOSS</th>
<th>TYPE OF HOLE</th>
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<tr>
<td>273.2</td>
<td>200.1</td>
<td>145.0</td>
<td>2-3/4'' wire core 200.1 to 219.7</td>
<td>Slick shale</td>
</tr>
<tr>
<td>210.8</td>
<td>219.7</td>
<td>145.0</td>
<td>2-3/4'' wire core 210.8 to 219.7</td>
<td>Slick shale</td>
</tr>
<tr>
<td>266.0</td>
<td>273.2</td>
<td>210.8</td>
<td>Washed out of barrel. Sampled to recover cones to recover samples.</td>
<td>Soft shale</td>
</tr>
<tr>
<td>236.7</td>
<td>239.0</td>
<td>230.2</td>
<td>Washed out of barrel. Sampled to recover cones to recover samples.</td>
<td>Soft shale</td>
</tr>
<tr>
<td>227.8</td>
<td>236.7</td>
<td>227.8</td>
<td>Washed out of barrel. Sampled to recover cones to recover samples.</td>
<td>Soft shale</td>
</tr>
</tbody>
</table>

**CLASSIFICATION AND PHYSICAL CONDITION:**

- **220.0-223.0**: Medium to dark grey, slightly carbonaceous medium grey, slightly calcareous, silty shale 199.1 to 208.3'; black, carbonaceous shale with thin coal stringers 200.5 to 204.5'; medium grey shale 204.5 to 208.3'; light grey, slightly calcareous, silty shale 208.3 to 219.5'; shale is firm & difficult to trim with knife; soft zone 199.1 to 200.5'; cuts easily with knife; slightly shaley below 208.3'; in more firm & approaches claystone; moist; bedding not readily discernible except below 208.3' where laminations are present; plastic when reworked; core lengths 1 to 10'.
- **219.5-227.8**: Sandy sandstone: Alternating bands of light grey, un cemented, fine grain sandstone and firm, dark grey, plastic shale; moist; trims easily with knife; slight HCl reaction; hard, calcareous cemented claystone 227.0 to 227.4'; core lengths 2 to 18'.
- **227.8-285.9**: Shale sandstone: Medium grey, firm (difficult trimming with knife) shale 227.8 to 228.2'; hard, calcareous cemented claystone (cratches with knife) 229.2 to 230.0'; medium grey, firm (difficult trimming with knife) shale 230.0 to 231.5'; light grey, un cemented, fine grain sandstone with several shale stringers (trims easily with knife) 231.5 to 235.0'; firm (difficult trimming with knife) carbonaceous shale 235.0 to 235.5'; firm (difficult trimming with knife) claystone 235.5 to 235.9'; light grey, un cemented, fine grain sandstone with several shale stringers (trims easily with knife) 235.9 to 236.7'; firm, medium grey shale with several sandstone stringers 236.7 to 239.0' (trims by knife with difficulty); weakly cemented (crumbles between fingers), fine grain sandstone with clay contamination & several shale stringers 239.0 to 243.5'; medium grey, firm (difficult trimming with knife) shale 243.5 to 252.5'; with carbonaceous streaks 246.4 to 248.6'; firm (trims easily with knife), sandy shale or shaley sandstone 252.2 to 256.9'; medium grey, firm (difficult trimming with knife) shale 256.9 to 257.5'; light grey, un cemented shaley sandstone that trims easily with knife 257.5 to 262.5'; medium grey; firm (trims by knife with difficulty) shale 262.5 to 285.9' with several thin
**GEOLOGIC LOG OF DRILL HOLE**

**LOCATION:** Bear Creek Study Site

**PROJECT:** Rockhead Coal Field

**STATE:** Montana

**HOLE NO:** DB 75-104

**ORIGIN:** Bureau of Reclamation

**DATE:** 7/10/75

**FINISHED:** 8/10/75

**DEPTH OF OVERBURDEN:** 321.0' BEARING

**DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED:** 224.4', 8/3/75 (3779.9'), LOGGED BY Taucher

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**NOTES ON WATER LOSSES AND LEVELS:**

- **Casing Cementing:**
  - 285.9-296.8 COAL:
    - Black; wet; badly broken in upper half; good core in lower half; 6" black, carbonaceous shale near middle (unable to determine depth as coal was sampled at the drill site).
  - 296.8-301.7 SHALE:
    - Light gray; moist; firm; difficult trimming with knife; bedding not readily discernible; plastic; 1 to 12" core lengths.
  - 301.7-313.2 SILTSTONE:
    - Light gray; firm trims by knife with difficulty; trace of clay; some very fine sand; 1 to 6" core lengths.

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**NOTES CONTINUED**

- **with 7-7/8" rock bit 311.0 to 321.0'. Washed hole with 1600 gallons of water. Pulled tools. Set 4" plastic pipe to 307'. Pipe slotted 286.0 to 297.0 & 139.0 to 154.0'. Gravel (Pea) packed hole 280 to 311'. Granular bentonite & pea gravel to 280'. Gravel (Pea) packed hole 130 to 155'. Granular bentonite & pea gravel 0 to 130'. Pulled 8" CS.

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**EXPLANATION**

- **Type of hole:** D = Diamond, H = Rotary, S = Shaft, C = Churn
- **Appro. size of hole (X-series):** Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8" Mx = 3"'
- **Appro. size of core (X-series):** Ex = 1-13/16", Ax = 1-1/4", Bx = 2-7/8" Mx = 3-1/2"
SUMMARY OF THE PRINCIPAL ROCK TYPES AND THEIR GEOTECHNICAL CHARACTERISTICS

Plate 1 summarizes the lithologic description in relation to selected geotechnical properties that were measured on selected core samples. A detailed lithology is presented in figure 2.

The lithologies consist basically of shales, carbonaceous shales, claystones, siltstones, coal, and a limestone. The shales have high plasticity, low Schmidt hammer values (<20), and point-load strengths ranging from low to medium (0.5 MPa (megapascals) and lower). However, the sandy shale between 236.7 and 239.0 has a point-load value of approximately 0.5 MPa that is a result of carbonate cement. Firmness has increased point-load values (about 1.0 MPa) for shale between 282.1 and 282.8 ft. Those shales with unconfined compressive values at or above 0.50 MPa tend to be firmer or are weakly cemented as compared with shales with unconfined compressive values below 0.50 MPa.

Most carbonaceous shales have medium to high plasticity, very low Schmidt hammer strength (<10) and unconfined compressive strength (<0.25 MPa), and low point-load values (0.5 MPa and less). The carbonaceous shale sampled at 155.5 and at 129.6 ft are the exception. The carbonaceous shale at 155.5 ft possesses a higher Schmidt hammer value (>10), unconfined compressive strength (>0.60 MPa), point-load strength (>0.55 MPa), and a high resistance to slacking value (>50 percent). These strength characteristics could be a result of a high percentage of "bone" (coal with a high shale content) at this footage, which, being quite strong, would give rise to high strength properties. At 128.4 ft, this material has a Schmidt hammer value above 30, and point-load values above 3.0 MPa. These values are probably due to carbonate cement.

The sandstones range from fine to very fine in grain size, are non-cemented, and most have low Schmidt hammer values (less than 10), point-load strengths (0.5 MPa or less), and can be easily crumbled between fingers. A few sandstone beds are reported to be weakly to moderately cemented (fig. 2), but the cement does not appear to contribute to strength. It is possible that localized carbonate patches or detrital grains within this sandstone are being interpreted as cement. However, the carbonate cement, not described in figure 2, present in the sandstone interval between 77.5 and 78.0 ft gives a Schmidt hammer value of 29 and point-load indices above 6.9 MPa.

Siltstone, claystone, and limestone units are minor parts of this core. Siltstones are calcareous, firm, and are easily cut with a knife. Unfortunately, very few Schmidt hammer point-load strength and resistance to slake values were acquired for this material to draw generalities about their strength properties. The claystones are cemented by carbonate and can be only scratched with a knife. Because the claystone is a very minor constituent of the lithology, no further strength tests were performed on it. The single limestone bed had an extremely high Schmidt hammer value (40), and point-load strength (above 3.5 MPa) as compared to the other material comprising this core. The interlocking crystalline nature of the limestone bed gives rise to its greater strength.

The coal beds were not tested for strength properties in this study.
REFERENCES CITED


