UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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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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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INTRODUCTION

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 in about 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.

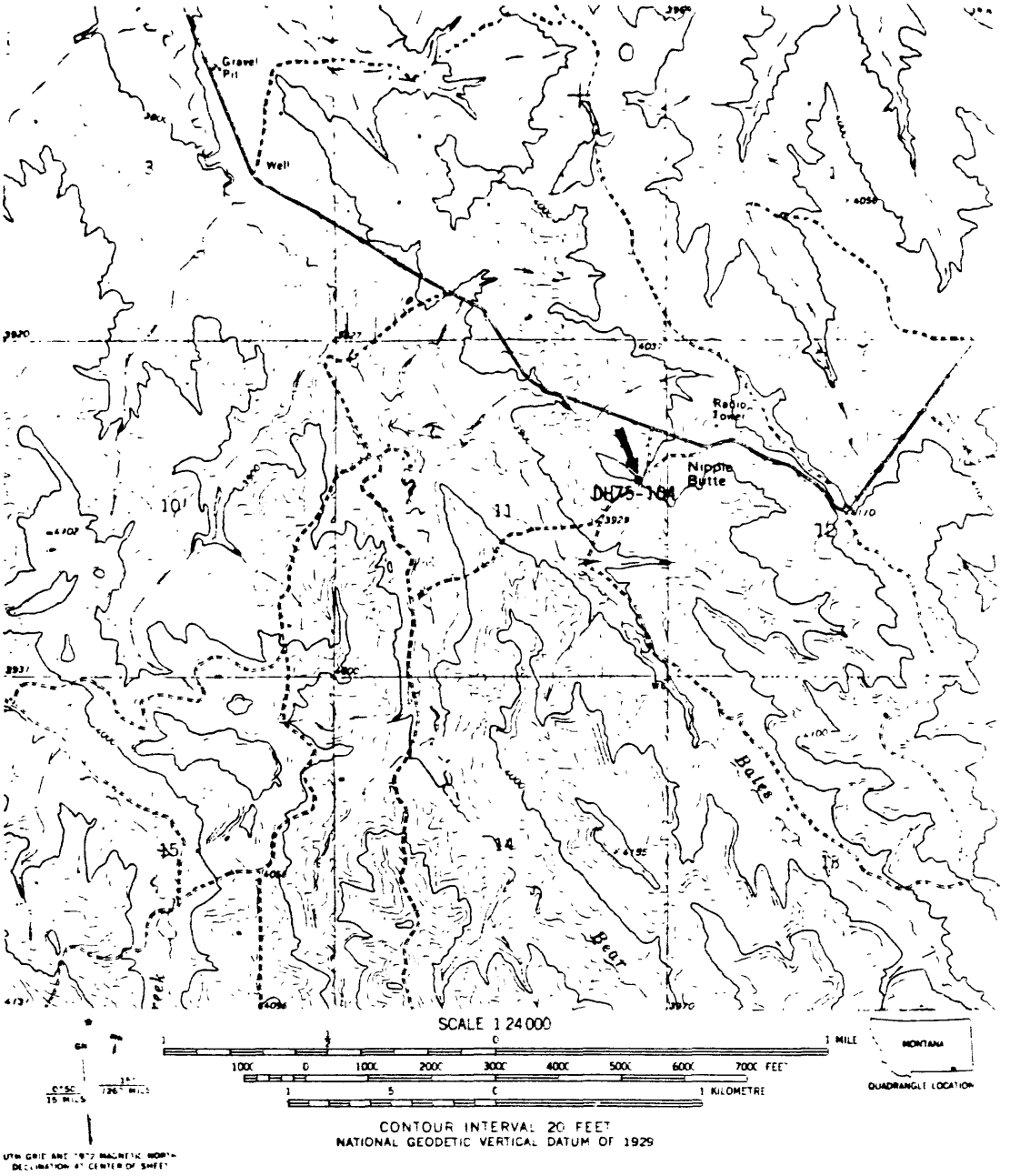

Figure 1.--Map showing location (arrow) of DH75-104, NE 1/2 sec. 11, T. 9 S., R. 45 E., portion of the Bear Creek School, 1:24,000 quadrangle, Montana.

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.)

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GEOLOGIC LOG OF DRILL HOLE

SHEET 1 OF 4

FEATURE Bear Creek Study Site West Moorhead Coal Field — PROJECT EMRIA No. 8 — STATE Montana

HOLE NO. DH 75-104 — LOCATION Altimeter — GROUND ELEV 4004± — DIP (ANGLE FROM HORIZ) Vertical

COORDS N ... E ... — TOTAL DEPTH 321.0' — BEARING -

BEGUN 7/10/75 — FINISHED 8/10/75 — DEPTH OF OVERBURDEN -

DEPTH AND ELEV OF WATER LEVEL AND DATE MEASURED 224.1' 9/2/75 (3779.9') — LOGGED BY Taucher — LOG REVIEWED BY

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	SOILS ANALYSIS SAMPLE DEPTH (FEET) FROM	TO	SUITABILITY FOR RECONSTRUCTED PROFILE: SUITABLE / LIMITED SUITABILITY / UNSUITABLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
7/10/75. Moved equipment to DH 75-104. BX drive samples 0 to 6.4'.		70				4001.5	2.5			FT. UNION FORMATION - PALEOCENE
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 29.5 to 39.5' in hole. Recovered 5.8' of sample on next run. Losing about 10% water. Reamed hole & set 5" casing to 10.6'.		100	#1 2.5	8.3						0-2.5 SHALE: Gray-brown; moist; oxidized soft; cuts easily with knife; plastic; bedding not readily discernible; core lengths 2 to 12".
		0				3995.7	8.3			2.5-8.3 SANDSTONE: Tan; oxidized; dry; uncemented; crumbles easily between fingers; very fine grain; silty; pulverized.
	10	100					10			
		100	#2 8.3	24.0						8.3-24.0 SHALE & SILTY SHALE: Brown & oxidized 8.3 to 14.8'; dark gray to black & carbonaceous 14.8 to 19.2'; brown & oxidized 19.2 to 22.5'; medium gray 22.5 to 24.0' with dark grey carbonaceous streaks 23.2 to 24.0'; shale is moderately plastic to plastic; sandy siltstone 10.0 to 10.5'; thin (-1") silt & sand streaks in brown, oxidized zones; calcareous 22.0 to 24.0'; begins to air slack, especially in carbonaceous zones; trims easily with knife in brown, oxidized zones; firm & more plastic (trims by knife with difficulty) in carbonaceous zones; core lengths 1 to 6".
Hole at 40.5' 7/12/75. W.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 & reamed hole. Drove 5" CS to 45.6'.	20	83				3980.0	24.0			
						3978.5	25.9			24.0-25.9 COAL: Black; broken; some clay contamination in lower half; cut by vertical fractures.
	30	58					30			
	40	100	#3 25.9	62.5			40			25.9-62.5 SHALE WITH SANDY SHALE & SANDSTONE: Light to medium gray; moist; mostly shale with zones of sandy shale & sandstone; firm, plastic shale (trims by knife with difficulty) 25.9 to 29.0, 31.0 to 40.5, 41.5 to 45.0, & 45.8 to 46.3'; light gray, thin-bedded to laminated silty sandstone which crumbles easily between fingers 29.0 to 31.0 & 56.0 to 57.0'; light gray, uncemented (crumbles easily between fingers) fine grain sandstone 45.0 to 45.8 & 46.3 to 46.7'; slightly plastic, thin-bedded, firm (trims by knife with difficulty) sandy shale or shaley sandstone 40.5 to 41.5, 46.7 to 56.0, 57.0 to 59.4 & 61.3 to 62.5'; laminated, firm dark gray shale & light gray sandstone 59.4 to 61.3'; moderate to active HCl reaction; slickenside at 28.5'; 70° fracture at 53.8'; hard, cemented calcareous concretions at 42.0 to 42.2 & 43.0 to 43.3'; core lengths 1 to 18".
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 90.8'. Losing some water. Dropped samples 60.3 to 70.3 & 70.3 to 73.2' in hole. Recovered parts of both samples. Modified core lifter.		100								
	50	100					50			
	60	100					60			
		58				3941.9	62.5			
	70	100	#4 62.5	80.8			70			
Hole at 90.8' 7/14/75. W.L. at 58.5'. 5" CS at 45.6'. 2-3/4" wire line core 90.8 to 136.3'. Losing some water.		100								
	80	99	#5 80.8	93.2		3923.6	80.8			62.5-80.8 SANDSTONE WITH SILTY SANDSTONE & SHALE: Light gray; moist; fine grain; uncemented (crumbles between fingers), silty sandstone 62.5 to 68.5'? (core loss); medium gray, sandy shale (trims by knife with difficulty) 68.5? to 70.3' uncemented (crumbles between fingers),
	90						90			
		96	#6 93.2	98.6		3911.2	93.2			
*2230' S. & 420' W. of NE Corner, Section 11, T. 9 S., R. 45 E.						3905.8	98.6			

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Hayesellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

GEOLOGIC LOG OF DRILL HOLE

FEATURE Bear Creek Study Site West Moorhead Coal Field PROJECT EMRIA No. 8 STATE Montana

HOLE NO DH 75-104 LOCATION* COORDS. N E Altimeter GROUND ELEV 4004? DIP (ANGLE FROM HORIZ) Vertical

BEGUN 7/10/75 FINISHED 8/10/75 DEPTH OF OVERBURDEN - TOTAL DEPTH 321.0' BEARING -

DEPTH AND ELEV OF WATER LEVEL AND DATE MEASURED 224.1' 9/2/75 (3779.9') LOGGED BY Taucher LOG REVIEWED BY

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	SOILS ANALYSIS SAMPLE DEPTH (FEET) FROM	TO	SUITABILITY FOR RECONSTRUCTED PROFILE: SUITABLE	LIMITED SUITABILITY	UNSUITABLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Hole at 136.3' 7/15/75. W.L. at 84.4'. 5" CS at 45.6'. 2-3/4" wire line core 136.3 to 163.2'. Losing about 15% drill fluid using revert. Hole at 163.2' 7/16/75. W.L. at 98.1'. 5" CS at 45.6'. 2-3/4" wire line core 163.2 to 200.1'. Losing drill fluid. Revert would not seal hole. Inner tube hung up on last run. Broke wire line cable. Hole at 200.1' 7/17/75. 5" CS at 45.6'. Repaired wire line cable. Put 1500 pounds of pea gravel around pipe in DH 75-101. *2230' S. & 420' W. of NE Corner, Section 11, T. 9 S., R. 45 E.		98 96 95 100 90 100 72 85 100 79 100 100 100	#7 98.6	138.5				3865.9	138.5 153.1 162.1 183.1			silty sandstone 70.3 to 72.0'; weakly cemented (crumbles between fingers with difficulty) sandstone 72.0 to 74.0'; moderately cemented, calcareous (can't break between fingers), sandstone 74.0 to 79.6'; silty, uncemented (crumbles easily between fingers), sandstone 79.6 to 80.8'; core lengths 2 to 12". 80.8-93.2 SHALE: Medium gray; moist; plastic with moderately plastic silty shale zones; coal & carbonaceous shale 81.0 to 81.1 & 84.0 to 84.4'; air slacks; trims by knife with difficulty; slight to moderate HCl reaction; slickenside at 84.4'; core lengths 2 to 6". 93.2-98.6 SILTY SANDSTONE: Light gray; brown & oxidized 97.5 to 98.0'; trims easily with knife; moist to wet; very fine grain; silty; carbonaceous streaks 93.6 to 93.7 & 94.5 to 94.6'; core lengths 6 to 18". 98.6-138.5 SHALE: Medium gray; moist; plastic; firm; approaching claystone; difficult trimming with knife; air slacks; dark gray to black carbonaceous shale 112.0 to 112.8, 113.4 to 121.2, 124.0 to 130.0 & 136.5 to 138.5'; uncemented, silty sandstone that crumbles between fingers 121.2 to 123.0'; hard, calcareous concretions 123.0 to 123.2 & 126.8 to 127.2'; becoming harder with tendency to air slack below 131.0'; 70° fracture at 101.5'; 60° fracture at 119.5'; 45° mud-lined joint at 132.3'; several slickensides 136.5 to 138.5'; 1 to 12" core lengths. 138.5-153.1 COAL: Black; moist to wet; few vertical fractures; 2 to 6" core lengths 141.1 to 149.6'; remaining core is badly broken. 153.1-162.1 SHALE, SILTY SHALE AND COAL: Dark gray; moist; plastic; soft & carbonaceous (trims easily with knife) 153.1 to 157.3'; broken coal 157.3 to 158.0'; firm (trims by knife with difficulty), silty shale 158.0 to 162.1'; 2 to 14" core lengths. 162.1-183.1 SANDY SILTSTONE TO SILTY SANDSTONE: Light to medium gray; moist; trace of clay; cuts easily with knife; varies from sandy siltstone to silty sandstone; sand is very fine grain; firm, laminated shale & siltstone 167.0 to 168.2'; firm, laminated shale & sandstone 169.7 to 170.5 & 173.0 to 174.5'; calcareous, cemented concretion 163.2 to 163.8' core lengths 2 to 12".
			#8 162.1	183.1				3842.3 3821.3				

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole . . . . . D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed . . . . . P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx. size of hole (X-series) . Ex = 1-1/2", Ax = 1-7/8", Bx = 2-3/8", Nx = 3"
Approx. size of core (X-series) . Ex = 7/8", Ax = 1-1/8", Bx = 1-5/8", Nx = 2-1/8"
Outside dia. of casing (X-series) . Ex = 1-13/16", Ax = 2-1/4", Bx = 2-7/8", Nx = 3-1/2"
Inside dia. of casing (X-series) . Ex = 1-1/2", Ax = 1-29/32", Bx = 2-3/8", Nx = 3"

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GEOLOGIC LOG OF DRILL HOLE

SHEET 3 OF 4

FEATURE Bear Creek Study Site West Moorhead Coal Field — PROJECT EMRIA No. 8 — STATE Montana

HOLE NO DH 75-104 — LOCATION * — COORDS N ... E ... — Altimeter GROUND ELEV 4004± — DIP (ANGLE FROM HORIZ) Vertical

BEGUN 7/10/75 — FINISHED 8/10/75 — DEPTH OF OVERBURDEN — — TOTAL DEPTH 321.0' — BEARING —

DEPTH AND ELEV OF WATER LEVEL AND DATE MEASURED 226.1' 9/2/75 (3779.9') — LOGGED BY Taucher — LOG REVIEWED BY

NOTES ON WATER LOSSES AND LEVELS CASING CEMENTING CAVING, AND OTHER DRILLING CONDITIONS

Hole at 200.1' 7/23/75. 5" CS at 45.6'. W.L. at 145.0'. 2-3/4" wire line core 200.1 to 219.7'. Losing about 40% drill water. Samples 207.9 to 210.8 & 210.8 to 219.7' fell out of barrel. Redrilled these zones to recover samples.

Hole at 219.7' 7/24/75. 5" CS at 45.6'. W.L. at 149.5'. 2-3/4" wire line core 219.7 to 273.2'. Soft zones 266.0 to 273.2' washed away. Losing 15 to 20% drill water.

Hole at 273.2' 7/25/75. 5" CS at 45.6'. Washed out cave and cuttings 190.0 to 273.3'. 2-3/4" wire line core 273.2 to 303.2'.

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

TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	BOULD ANALYSIS SAMPLE DEPTH (FEET) FROM	TO	SUITABILITY FOR RECONSTRUCTED PROFILE: SUITABLE	LIMITED SUITABILITY	UNSUITABLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING
210	63	#9 183.1	219.5							
	86							20		
	73									
220							3784.9	219.5		
		#10 219.5	227.8					2 20		
	100						3776.6	227.8		
230	87							2 30		
	75									
240								2 40		
	65									
250		#11 227.8	285.0					250		
	86									
260								260		
	25									
270								270		
	38									
280								280		
	96						3718.5	285.9		
290								290		
	100	#12 297.0	304.5				3707.6	296.8		

CLASSIFICATION AND PHYSICAL CONDITION

183.1-219.5 SHALE & SILTY SHALE: Medium to dark gray & slightly carbonaceous 183.1 to 198.6'; dark gray and carbonaceous 198.6 to 199.1'; coal alternating with black carbonaceous shale 199.1 to 200.5'; black, carbonaceous shale with thin coal stringers 200.5 to 204.5'; medium gray shale 204.5 to 208.3'; light gray, 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; silty shale below 208.3' is more firm & approaches claystone; moist; bedding not readily discernible except below 208.3' where laminations are present; plastic when reworked; core lengths 1 to 12".

219.5-227.8 SHALEY SANDSTONE: Alternating bands of light gray, uncemented, fine grain sandstone and firm, dark gray, 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 WITH SANDSTONE: Medium gray, firm (difficult trimming with knife) shale 227.8 to 229.2'; hard, calcareous cemented claystone (scratches with knife) 229.2 to 230.0'; medium gray, firm (difficult trimming with knife) shale 230.0 to 231.5'; light gray, uncemented, fine grain sandstone with several shale stringers (trims easily with knife) 231.5 to 235.0'; firm (difficult trimming with knife) calcareous shale & claystone 235.0 to 235.9'; light gray, uncemented, fine grain sandstone with several shale streaks (trims easily with knife) 235.9 to 236.7'; firm, medium gray 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 gray, firm (difficult trimming with knife), shale 243.5 to 252.2' with carbonaceous streak 248.4 to 248.5'; firm (trims easily with knife), sandy shale or shaley sandstone 252.2 to 254.9'; medium gray, firm (difficult trimming with knife) shale 254.9 to 257.5'; light gray, uncemented shaley sandstone that trims easily with knife 257.5 to 262.5'; medium gray; firm (trims by knife with difficulty) shale 262.5 to 285.9' with several thin

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole ... D = Diamond, H = Hoystellite, S = Shot, C = Churn
Hole sealed ... P = Packer, Cm = Cemented, Cs = Bottom of casing
Approx size of hole (X-series) ... Ex = 1-1 2" Ax = 1-7/8" Bx = 2-3/8" Nx = 3"
Approx size of core (X-series) ... Ex = 7/8" Ax = 1-1/8" Bx = 1-5/8" Nx = 2-1/8"
Outside dia of casing (X-series) ... Ex = 1-13 16" Ax = 2-1.4" Bx = 2-7/8" Nx = 3-1/2"
Inside dia of casing (X-series) ... Ex = 1-1 2" Ax = 1-29 32" Bx = 2-3/8" Nx = 3"

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GEOLOGIC LOG OF DRILL HOLE

SHEET 4 OF 4

FEATURE Bear Creek Study Site, West Moorhead Coal Field — PROJECT EMRIA No. 8 — STATE Montana

HOLE NO DH 75-104 — LOCATION * — COORDS. N ... E ... — Altimeter GROUND ELEV 4004± — DIP (ANGLE FROM HORIZ) Vertical

BEGUN 7/10/75 — FINISHED 8/10/75 — DEPTH OF OVERBURDEN - — TOTAL DEPTH 321.0' — BEARING -

DEPTH AND ELEV OF WATER LEVEL AND DATE MEASURED 224.1' 9/2/75 (3779.9') — LOGGED BY Taucher — LOG REVIEWED BY

NOTES ON WATER LOSSES AND LEVELS, CASING, CEMENTING, CAVING, AND OTHER DRILLING CONDITIONS	TYPE AND SIZE OF HOLE	CORE RECOVERY (%)	BOREHOLE ANALYSIS SAMPLE DEPTH (FEET) FROM	TO	SUITABILITY FOR RECONSTRUCTED PROFILE: SUITABLE	LIMITED SUITABILITY	UNSUITABLE	ELEVATION (FEET)	DEPTH (FEET)	GRAPHIC LOG	SAMPLES FOR TESTING	CLASSIFICATION AND PHYSICAL CONDITION
Hole at 303.2' 7/26/75. 5" CS at 45.6'. W.L. at 133.0'. 2-3/4" wire line core 303.2 to 313.2'; repaired logging truck & moved water pump to new location. Logged hole with geophysical probes. Hole at 313.2' 7/27/75. 5" CS at 45.6'. W.L. at 135.0'. Pulled 5" CS. Set 8" CS to 3'; repairs on equipment. Hole at 313.2' 7/28/75. Pulled 8" CS as it would not seal flows. Set 8" CS to 4.4'. Reamed hole with 7-7/8" rock bit to 92.5'. Hole at 313.2' 7/29/75. 8" CS at 4.4'. Reamed hole with 7-7/8" rock bit 92.5 to 192.1'. Hole filled with mud at start of shift. Hole at 313.2' 7/30/75. 8" CS at 4.4'. W.L. at 30.0'. Reamed hole with 7-7/8" rock bit 192.1 to 222.5'. Dropped 130' of rods in hole. Hole at 313.2' 8/5/75. 8" CS at 4.4'. Fished for & recovered tools. Washed cave & cuttings to 222.5'. Hole at 313.2' 8/6/75. 8" CS at 4.4'. W.L. at 137.0'. Reamed hole with 7-7/8" rock bit 222.5 to 311.4'. Used revert. Hole at 313.2' 8/7/75. 8" CS at 4.4'. Reamed hole	300 310 320 330 340 350 360 370 380 390	100 No core rock bit						3702.7 3691.2 3683.4	301.7 310 313.2 320 321.0 330 340 350 360 370 380 390	rock bit		uncemented sand streaks 273.2 to 273.9' hard, claystone concretions 263.6 to 264.2 & 274.4 to 274.5'; moist; core lengths 1 to 18". 285.9-296.8 COAL: Black; wet; badly broken in upper half; good core in lower half; 6" black, carbonaceous plastic 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.

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 321'. Granular bentonite & pea gravel 155.0 to 280'. Gravel (Pea) packed hole 130 to 155'. Granular bentonite & pea gravel 0 to 130'. Pulled 8" CS.

Hole at 321' 8/9/75. W.L. at 94.5'. Bailed hole. Unable to get bailer to bottom of pipe. Washed hole to bottom with wash rods.

Hole at 321' 8/10/75. W.L. at 142.0'. Bailed hole for 3½ hours. Water fairly clean. Unable to lower water level below 250' by bailing. Moved equipment to DH 75-102.

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

EXPLANATION

CORE LOSS

CORE RECOVERY

Type of hole	D = Diamond, H = Hoystellite, S = Shot, C = Churn			
Hole sealed	P = Packer, Cm = Cemented, Cs = Bottom of casing			
Appro. size of hole (X-series)	Ex = 1-1/2"	Ax = 1-7/8"	Bx = 2-3/8"	Nx = 3"
Approx. size of core (X-series)	Ex = 7/8"	Ax = 1-1/8"	Bx = 1-5/8"	Nx = 2-1/8"
Outside dia. of casing (X-series)	Ex = 1-13/16"	Ax = 2-1/4"	Bx = 2-7/8"	Nx = 3-1/2"
Inside dia. of casing (X-series)	Ex = 1-1/2"	Ax = 1-29/32"	Bx = 2-3/8"	Nx = 3"

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

American Society for Testing and Materials, 1978, Natural building stones; soils and rock; peats, mosses, and humus, Pt. 19 of 1978 Annual book of ASTM standards: American Society for Testing and Materials, 500 p.

Aufmuth, R. E., 1974, Site engineering indexing of rock, in Field testing instrumentation of rock--a symposium: American Society for Testing and Materials, p. 81-99.

Broch, E., and Franklin, J. A., 1972, The point-load strength test: International Journal of Rock Mechanics and Mining Sciences, v. 9, no. 6, p. 669-697.

Franklin, J. A., and Chandra, R. H., 1972, The slake-durability test: International Journal of Rock Mechanics and Mining Sciences, v. 9, no. 3, p. 325-341.

U.S. Department of the Interior, Bureau of Land Management, Bureau of Reclamation, Geological Survey, 1977, Bear Creek study area-West Moorhead Coal Field, Montana--resource and potential reclamation evaluation: U.S. Bureau of Land Management EMRIA Report 8, 148 p., Appendices A to G.