UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Geologic and Selected Geotechnical Properties of Core from Drill Hole DH75-105, West Moorhead Coal Field, Powder River County, Montana

by

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CONTENTS

ILLUSTRATIONS

GEOLOGIC AND SELECTED GEOTECHNICAL PROPERTIES OF CORE FROM DRILL HOLE DH75-105, WEST MOORHEAD COAL FIELD, POWDER RIVER COUNTY, MONTANA

By

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INTRODUCTION

This report presents a geologic log and selected geotechnical data gathered from one core acquired during September and October 1975. The drill site is located 2,110 ft north and 1,200 ft east of the SW cor. sec. 2, T. 9 S., R. 45 E. of the 1:24,000, Bear Creek School quadrangle, West Moorhead Coal Field, Mont. (fig. 1). Drilling began in surficial material and ended 321.0 ft (total depth of hole) into the upper portion of 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 secondary study in conjunction with the Environmental Studies of Energy Lands program was conducted by E. E. McGregor and John Sebesta of the U.S. Geological Survey (USGS) in order to obtain strength data for material overlying potentially economic coal beds. Data acquired from the core to a depth of 152.6 ft were used to determine the principal rock types and their 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 with an "H"-series barrel. For variations in drilling and core recovery see figure 2.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the services of John Sebesta and Jack Odum of the USGS in Denver, Colo., who performed additional geotechnical testing for selected core samples.

EXPERIMENTAL PROCEDURES

After each drilled section, 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 to prevent moisture loss. The core was later logged by C. J. Taucher of the U.S. Bureau of Reclamation (in U.S. Department of the Interior and others, 1977) and selected geotechnical tests on core down to a depth of 152.3 ft were performed by E. E. McGregor and John Sebesta of the USGS. Three of the geotechnical tests were in accordance with ASTM standards and included: grain-size distribution, ASTM designation D422-63; Atterberg limits, ASTM designation D423-66; and unconfined compressive-strength tests, ASTM designation D2166-66 (American Society for Testing and Materials, 1978). Additional tests performed which lack ASTM standards included: one-cycle slake durability, Schmidt hammer, and point load. The slake-durability test followed the procedures of Franklin and Chandra (1972). Schmidt hammer tests

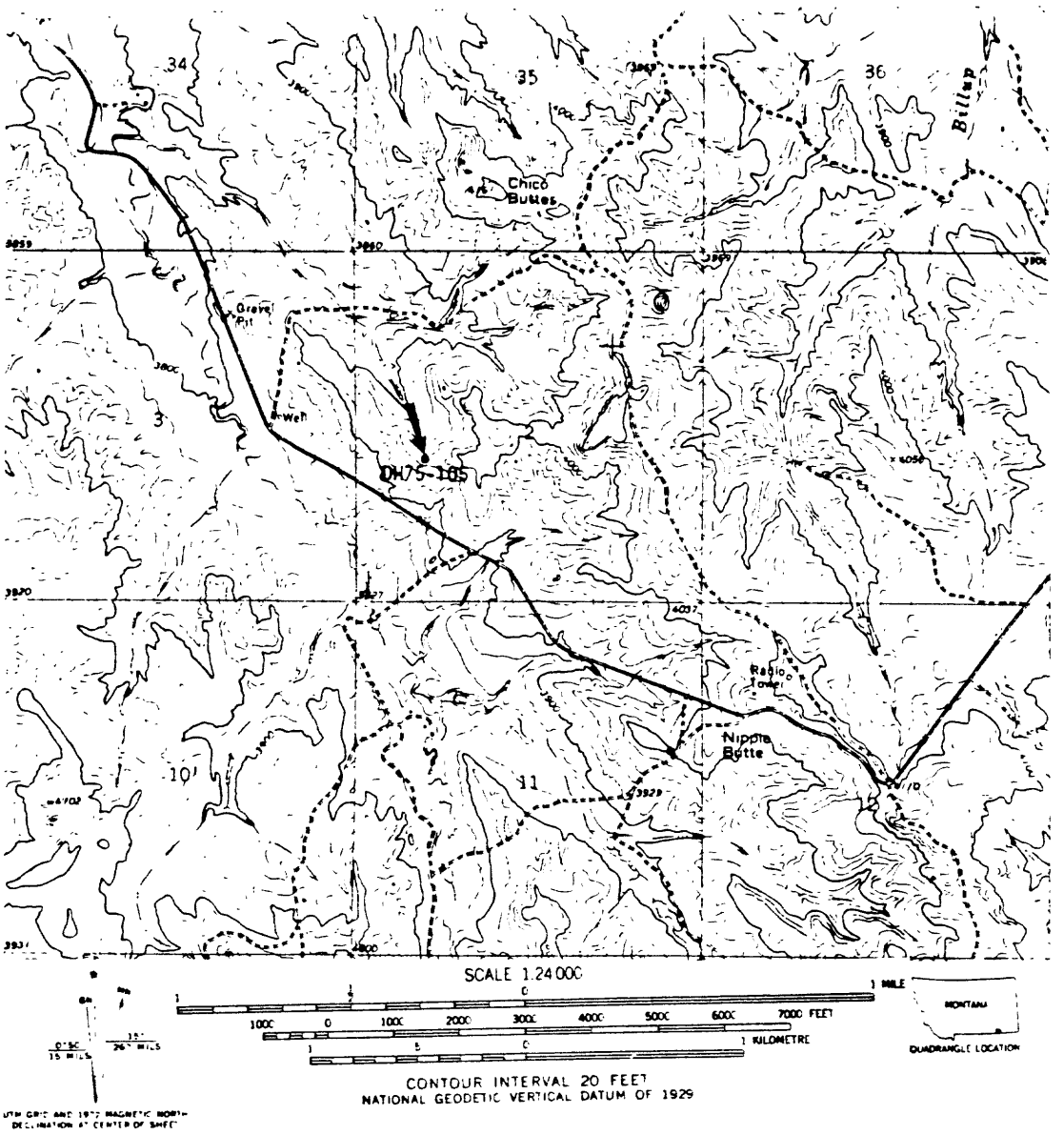

Figure 1.--Map showing location of DH75-105, SW 1/4 sec.2, T. 9 S., R. 45 E., portion of the Bear Creek School, 1:24,000 , quadrangle, Montana.

Figure 2.--Geologic log with descriptions of drill-hole core DH75-105. (Modified from U.S. Department of the Interior and others, 1977, Appendix B, p. B-5.)

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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 75-105 — LOCATION — COORDS N ... E ... — Altimeter GROUND ELEV 3969± — DIP (ANGLE FROM HORIZ) Vertical

BEGUN 9/20/75 — FINISHED 10/7/75 — DEPTH OF OVERBURDEN 3.3' — TOTAL DEPTH 312.5' — BEARING -

DEPTH AND ELEV OF WATER LEVEL AND DATE MEASURED 138.2' 11/17/75 (3810.8) — 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 (%)	BOULD 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 started 9/20/75. NX drive sample 0 to 3.3'. 2-3/4" wire line core 3.3 to 19.3'. Reamed hole & set 5" CS to 18.6'. Hole at 19.3' 9/20/75. 5" CS at 18.6'. W.L. at 12.5'. 2-3/4" wire line core 19.3 to 94.3'. Dropped sample 46.6 to 54.9'. (Recovered on next run). Pulled tools & changed bit. Hole at 94.3' 9/22/75. 5" CS at 18.6'. W.L. at 24.6'. 2-3/4" wire line core 94.3 to 151.4'. Samples 134.9 to 144.9 & 144.9 to 151.4' dropped in hole. Redrilled & recovered most of samples. *2110' N. & 1200' E of SW Corner, Section 2, T. 9 S., R. 45 E.		91 22 100 100 100 89 100 100 70 99 99 100 56 100 99	#1 10.6 #2 38.6 #3 45.6 #4 92.8	34.6 45.6 92.8 108.9				3965.7 3961.2 3960.0 3958.4 3934.4 3932.4 3930.4 3923.4 3876.2	3.3 7.8 9.0 10.6 34.6 36.6 38.6 45.6 92.8			0-3.3 SANDY CLAY: Tan; dry; few roots; approximately 45% fine sand & 55% low to medium plasticity fines (CL). FT. UNION FORMATION - PALEOCENE 3.3-7.8 SANDSTONE: Tan; dry; oxidized; fine grain; crumbles between fingers; silty; lost most of sample; pulverized. 7.8-9.0 SHALE: Brown; oxidized; damp; plastic; cuts easily with knife; calcareous; badly broken. 9.0-10.6 SANDSTONE: Tan; dry; oxidized; fine grain; silty; crumbles between fingers. 10.6-34.6 SHALE: Brown & oxidized 10.6 to 13.1'; dark gray & carbonaceous 13.1 to 16.5'; dark gray to black & carbonaceous 16.5 to 19.3'; medium to dark gray 19.3 to 24.6'; light to medium gray 24.6 to 33.3'; medium to dark gray 33.3 to 34.6'; coal 22.2 to 22.4 & 23.7 to 23.8'; moist; moderately firm to firm 10.6 to 19.3' (trims easily with knife); very firm claystone 19.3 to 24.3' (difficult trimming with knife); moderately firm 24.3 to 34.6' (trims by knife with difficulty); very plastic when reworked except low plasticity silty shale to clayey siltstone 24.3 to 34.6'; calcareous 24.3 to 34.6'; badly broken 10.6 to 15.0'; core lengths 1 to 24" 15.0 to 34.6'; 70° joint at 27.9'. 34.6-36.6 COAL: 2 to 8" core lengths. 36.6-38.6 SHALE: Medium to dark grey; firm; difficult trimming with knife; plastic; scattered carbonaceous fragments; coal 37.4 to 37.6'; 2 to 12" core lengths. 38.6-45.6 SANDSTONE: Light gray; moist; compact; clayey near top becoming silty with depth; thin-bedded; crumbles between fingers with difficulty; very fine grain (approaching siltstone); core lengths 6 to 12". 45.6-92.8 SHALE: Medium gray; moist; plastic shale 45.6 to 46.4' (difficult trimming with knife); coal 46.4 to 46.6'; plastic shale 46.6 to 62.4' (difficult trimming with knife); shaley; fine grain sandstone 62.4 to 64.3' (crumbles between fingers with difficulty); plastic shale 64.3 to 74.7' (difficult trimming by knife); laminated plastic shale & sandy shale 74.7 to 76.9' (trims by knife with difficulty); broken coal & carbonaceous shale 76.9 to 77.5'; plastic shale 77.5 to 78.1' (trims by knife with difficulty); coal 78.1 to 78.5', firm,

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"

GEOLOGIC LOG OF DRILL HOLE

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

HOLE NO DH 75-105 LOCATION * COORDS N E GROUND ELEV 3969± Altimeter DIP (ANGLE FROM HORIZ.) Vertical

BEGUN 9/20/75 FINISHED 10/7/75 DEPTH OF OVERBURDEN 3.3' TOTAL DEPTH 312.5' BEARING

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED 150.2' 11/17/75 (3810.8) 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 (%)	BOILS 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
*2110' N. & 1200' E. of SW Corner, Section 2, T. 9 S., R. 45 E.												plastic shale 78.3 to 91.0' with carbonaceous zones 85.5 to 85.7 & 90.7 to 91.0' (trims by knife with difficulty); sandy shale 91.0 to 92.8' (trims by knife with difficulty); 60 to 70° joints at 47.3, 48.1 & 48.3'; badly broken 52.9 to 54.9'; 70° joint at 67.0 & 86.8'; air slacks; moderately calcareous 54.0 to 92.8'.
	110	100						3860.1	108.9			92.8-108.9 SANDSTONE: Light gray; moist; fine grain; silty; cemented & calcareous 92.8 to 95.4' (scratches with knife); compact but not cemented 95.4 to 108.9' (crumbles between fingers with difficulty); thin-bedded; core lengths 1 to 24".
	120	88	#5 108.9	126.0					120			
		100	(Minus coal)					3843.0	126.0			
Hole at 151.4' 9/23/75. 5" CS at 18.6'. W.L. at 35.1'. 2-3/4" wire line core 151.4 to 174.9'. Losing water 152.6 to 160.5'. 100% water loss at 160.5'. Mixed 500 gallons of revert with no drill water return. Sample 164.9 to 174.9' dropped in hole. Recovered 6.6' water level at 141.5' at end of shift.	130	82						3840.0	129.0			108.9-126.0 SHALE WITH SANDSTONE & COAL: Moist; medium gray, slightly calcareous, firm plastic shale 108.9 to 117.9' (trims by knife with difficulty); dark gray to black carbonaceous shale with thin coal streaks 117.9 to 119.8'; medium gray, plastic, firm shale 119.8 to 120.8' (trims by knife with difficulty); uncemented, fine grain sandstone 120.8 to 121.3' (crumbles between fingers); soft, plastic shale 121.3 to 121.5' (cuts easily with knife); badly broken coal with numerous shale partings 121.5 to 123.3'; firm, black, carbonaceous shale 123.3 to 124.8' (trims by knife with difficulty); medium gray, firm shale 124.8 to 126.0' with uncemented fine grain sandstone 125.6 to 125.9' (trims by knife with difficulty); laminated 124.0 to 126.0'; air slacks in places; slickensides 117.9 to 119.8'; core lengths 1 to 18".
	140	76	#6 129.0	152.6					140			
	150	100							150			
		83						3816.4	152.6			
Hole at 174.9' 9/24/75. 5" CS at 18.6'. W.L. at 41.1' at end of shift. 2-3/4" wire line core 174.9 to 244.9'. No water return except 5-10% on last run. Samples 174.9 to 184.9, 192.3 to 202.3, 214.9 to 224.9 & 224.9 to 234.9' dropped in hole. Redrilled & recovered parts of all samples. Parts of samples 192.3 to 202.3, 204.9 to 214.9, 214.9 to 224.9 & 224.9 to 234.9' washed away during drilling. Used revert.	160	69							160			
		66							170			126.0-129.0 SILTSTONE: Light gray; moist; trace of clay & fine sand; low plasticity; crumbles between fingers; shaley 126.0 to 127.0'; badly broken.
	170	64						3790.0	179.0			129.0-152.6 SHALE: Medium gray; hard; trims by knife with difficulty; almost fissile; claystone; laminated with carbonaceous streaks 130.0 to 131.0'; slightly calcareous 131.0 to 133.5'; dark gray & carbonaceous 150.0 to 152.6' air slacks; core lengths 1 to 6"; badly broken 143.5 to 144.0'.
	180								180			
								3783.2	185.8			
	190	100							190			152.6-179.0(7) COAL: Dropped core samples 164.9 to 174.9 & 174.9 to 184.9' in hole. Redrilled & recovered 69 & 66% of core respectively; bottom contact of coal picked from resistivity log; driller reported shale partings at 169.5 to 169.7 & 176.3 to 176.7'.
		55	#7 191.4	210.6				3777.6	191.4			

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 = .78",	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 75-105 — LOCATION COORDS. N * E — Altimeter GROUND ELEV 3969± — DIP (ANGLE FROM HORIZ.) Vertical

BEGUN 9/20/75 — FINISHED 10/7/75 — DEPTH OF OVERBURDEN 3.3' — TOTAL DEPTH 312.5' — BEARING -

DEPTH AND ELEV. OF WATER LEVEL AND DATE MEASURED 158.2' 11/17/75 (3810.8) — 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 SAMPLES 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
9/31/75 Repaired equipment. W.L. at 150.0'.		100										
	210	57						3758.4	210.6			179.0(?)-185.8 SHALE: Dark gray; carbonaceous; moist; moderately firm to firm; trims with knife; air slacks; plastic; core lengths 6 to 12"; upper contact picked from resistivity log; shaley coal 185.2 to 185.8'.
												185.8-191.4 COAL: Core lengths 6". Contains some clay contamination.
	220	12	#8									191.4-210.6 SHALE: Medium to dark gray; moist; firm; cuts by knife with difficulty; begins to air slack; carbonaceous 201.0 to 203.0'; broken 193.0 to 195.0' contains fine grain sand laminations 209.0 to 210.6'; core lengths 1 to 8". Driller reported washing away approximately 40% of core; core not recovered, could possibly contain uncemented sandstone streaks.
			210.6	231.7								
Hole at 244.9' 10/1/75. 5" CS at 18.6'. W.L. at 150.0'. Washed 82' of cave & cuttings out of hole. 2-3/4" wire line core 244.9 to 311.9'. 25% water return 244.9 to 275.0'. 100% water loss below 275.0'. Used about 6,000 gallons of water. W.L. holding at 12.0'.	230	45						3737.3	231.7			210.6-231.7 SANDSTONE WITH SILTSTONE & SHALE: Only 3' core recovery as material washed away during drilling; core recovered was very soft, laminated light gray siltstone, very fine grain sandstone & medium gray silty shale; crumbles easily between fingers; shales are slightly plastic.
	240	100	#9									
			231.7	244.9				3721.1	247.9			
								3720.4	248.6			231.7-247.9 SHALE: Medium to dark gray; plastic; moist; slightly carbonaceous; firm; difficult trimming by knife; air slacks; several slickensides 243.8 to 243.9'; 2 to 12" core lengths.
	250	100						3718.8	250.2			
								3714.7	254.3			247.9-248.6 CARBONACEOUS SHALE & COAL: Badly broken; black; moist; shale is moderately firm; alternating coal & shale streaks; several slickensides 248.4 to 248.6'.
	260	62	#10									
			254.3	268.4								
								3700.6	268.4			248.6-250.2 CLAYEY SANDSTONE: Light gray; moist; moderately firm; crushes between fingers; sand is fine grain; moderately plastic when reworked; occasional small coal fragments; core lengths 6".
	270	80						3697.5	271.5			
								3690.3	278.7			250.2-254.3 SHALE: Medium to dark gray; moist; firm; difficult trimming with knife; air slacks; several 15 to 70° slickensides 252.0 to 254.3'; plastic; core lengths 2 to 12".
	280	100	#11									
			278.7	285.4				3683.6	285.4			
								3680.9	288.1			254.3-268.4 SANDSTONE & SHALE: Alternating laminations of light gray silty sandstone & dark gray plastic shale; moist; mostly silty sandstone in upper half grading to mostly shale in lower half; silty sandstones are uncemented, crumble between fingers & begin to wash away during drilling; shale is moderate
	290	83										
*2110' N. & 1200' E. of SW Corner, Section 2, T. 9 S., R. 45 E.			#12									
		100	285.4	306.6								

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 75-105 LOCATION * Altimeter GROUND ELEV 3969± DIP (ANGLE FROM HORIZ.) Vertical

COORDS N E

BEGUN 9/20/75 FINISHED 10/7/75 DEPTH OF OVERBURDEN 3.3' TOTAL DEPTH 312.5' BEARING

DEPTH AND ELEV OF WATER LEVEL AND DATE MEASURED 158.2' 11/17/75 (3810.8) 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 (%)	BOILS 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 311.9' 10/2/75. 5" CS at 18.6'. Pulled 5" CS. Set 8" CS to 2.0'. Reamed hole to 102.5' with 7-7/8" rock bit. Repaired equipment. Hole at 311.9' 10/3/75. 8" CS at 2.0'. W.L. at 8.0' Reamed hole 102.5 to 192.5' with 7-7/8" rock bit. Lost some water in coal. 100% water return after using revert. Hole at 311.9' 10/4/75. 8" CS at 2.0'. W.L. at 155.0'. Reamed hole 192.5 to 272.5' with 7-7/8" rock bit. Cuttings sticking & bridging over hole. Hole at 311.9' 10/5/75. 8" CS at 2.0'. Washed 70' of cuttings from hole. Reamed hole 272.5 to 312.5' with 7-7/8" rock bit. Flushed hole with 1600 gallons of water. Hole at 312.5' 10/6/75. 8" CS at 2.0'. Reamed bridged areas in hole. Flushed hole with 800 gallons of water. Set 4" plastic pipe in hole to 298.7'. Pipe slotted 152.6 to 191.4 & 271.5 to 278.7'. Gravel (pea) packed hole 312.5 to 265.0 Gravel & bentonite pack 265.0 to 198.6 *2110' N. & 1200' E. of SW Corner, Section 2, T. 9 S., R. 45 E.		100 88 0						3662.4 3659.1 3658.1 3657.1 3656.5	306.6 309.9 310.9 311.9 312.5			core lengths 1 to 3" in upper half & 3 to 12" in lower half. 268.4-271.5 SHALE: Medium to dark gray; moist; firm; difficult trimming by knife almost claystone; plastic when reworked; air slacks; 60° slickenside at 269.5'; core lengths 1 to 6". 271.5-278.7 COAL: Broken in 1 to 2" fragments. 278.7-285.4 CLAYEY SILTSTONE: Light gray; moist; firm; trims by knife with difficulty; bedding not readily discernible; vertical coal streaks 283.9 to 284.9'; coal fragments 284.9 to 285.5'; low plasticity when reworked; some very fine sand; core lengths 3 to 4". 285.4-288.1 SHALE: Alternating laminations of light gray shale & dark gray, carbonaceous shale; moist; plastic; breaks along laminations; trims by knife with difficulty; core lengths 2 to 6". 288.1-306.6 SILTY SHALE: Light gray; moist; firm; difficult trimming with knife; approaching claystone; bedding not readily discernible; silty; moderately plastic to plastic; slightly calcareous; 90° joints 294.7 to 296.0 & 302.6 to 303.8'; air slacks 305.6 to 306.6'; core lengths 3 to 24". 306.6-309.1 SHALEY COAL: Black; appears to contain clay contamination; breaks along bedding planes; similar in appearance to lignite; varies from highly carbonaceous shale to shaley coal; core lengths 3 to 6". 309.1-310.9 CLAYEY SILTSTONE: Light gray; moist; firm; trims by knife with difficulty; some very fine sand; low plasticity; bedding not discernible; slightly carbonaceous; core lengths 6". 310.9-311.9 SANDSTONE: Light gray; moist; very fine grain; some silt; crumbles easily between fingers; core lengths 6"; moderately calcareous.
									320 330 340 350 360 370 380 390			

NOTES CONTINUED
Hole at 312.5' 10/7/75, 8" CS at 2.0'. Gravel (pea) packed hole 198.6 to 145.0' Gravel & bentonite pack 145.0 to 120.0'. Bailed hole until water was reasonably clear. Water entering hole at rate of 4 gallons per minute. Pulled 8" CS. Moved rig to DH 75-109.

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"

were done in accordance with procedures described by Aufmuth (1974) and the point-load strength tests followed procedures described by Broch and Franklin (1972). Taucher (in U.S. Department of the Interior and others, 1977) tested for firmness, ease of crushability between fingers, and ease of knife-trimming (fig. 2) during the logging of the drill core.

SUMMARY OF THE PRINCIPAL ROCK TYPES AND THEIR GEOTECHNICAL CHARACTERISTICS

A detailed lithologic description is presented in figure 2. Plate 1 is a summary of the lithology description in relation to selected geotechnical properties acquired from selected samples of the core.

The lithology of the core consists basically of shales, carbonaceous shales, claystones, siltstones, sandstones, coal, and a limestone bed.

The shales are firm and have a high plasticity, high unconfined compressive strength (about 0.50 MPa), high Schmidt hammer values (above 15), low to high point-load strength (1.0 to above 0.5 MPa), and high resistance to slaking (greater than 60 percent). Their high strength is due to weak-to-moderate carbonate cementing (as indicated by HCl tests). An exception is the shale at interval 7.8-9.0 ft which is calcareous, but not firm, easily trimmed by a knife, and the cores are highly broken, indicating a weaker material due perhaps to release of stored stress or to poor drilling techniques.

Carbonaceous shales are characteristically firm to moderately firm, noncalcareous to moderately calcareous, have low unconfined compressive strengths (less than 0.50 MPa), and very low slake durability values (below 20 percent). These low strength properties are probably a result of the carbonaceous content of the material, and of local slickensides. However, the carbonaceous shale bed at 150.0-152.6 ft, is difficult to trim with a knife, weakly cemented, has a high unconfined compressive strength (above 0.50 MPa), a higher point load strength (0.4 MPa), and a much higher slake-durability value (above 80 percent). The higher strength of this bed is probably due to lithologic compaction and to the carbonate cement.

Claystones, which are minor constituents of the core, have strength properties very similar to those for shales. Siltstones, however, have very low strength properties as indicated by the Schmidt hammer values (less than 10); they are easy to crumble between the fingers. The high resistance to slaking (greater than 60 percent) for the siltstone sample at 31 ft is probably due to its carbonate cement, as indicated by the HCl test.

The sandstones vary from silty to clayey in content, have a wide range of calcareous cements, generally can be crumbled between fingers, have Schmidt hammer strengths less than 10, unconfined compressive strengths greater than 0.60 MPa, and slake durability strengths above 80 percent. The wide range of strength properties is probably due to the amount of included silt and clay, and to the amount of carbonate cement (as indicated by HCl tests).

The limestone bed(?) (pl. 1), which was not described by Taucher, has a very high point-load strength of greater than 6 MPa. The crystalline structure of the limestone is probably a factor in this high strength characteristic.

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

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