UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

COAL GEOLOGY OF THE GARRISON AREA, McLEAN COUNTY, NORTH DAKOTA

By

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Open-File Report 81-22

1981

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To convert English units	Multiply by	To obtain metric units
Feet	0.3048	Meters
$Miles^2$	2.589	$Kilometers^2$

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ABSTRACT

The Garrison area is located on the eastern flank of the Williston Basin. The area encompasses about 930 mi^2 (fig. 1) and has a maximum topographic relief of approximately 350 ft. The Fort Union Formation of Paleocene age underlies the area and consists of interbedded siltstone, claystone, sandstone, and lignite-rank coal. The principal coal beds in the area are the Garrison Creek and Minter. The Fort Union is unconformably covered by glacial till in most of the area.

INTRODUCTION

Location

The Garrison area is located in northern McLean County, North Dakota, and covers approximately 930 mi^2. The area is bounded by Ward County on the north, Lake Sakakawea on the southwest, Turtle Lake on the southeast, and the towns of Ruso on the east, and Roseglen on the northwest.

Purpose

This report provides information concerning outcrop location, thickness, areal extent, and physical and chemical characteristics of the coal beds in the Williston Basin, McLean County, North Dakota. The relationship between the coal beds and local glacial geology is also discussed.

Previous Investigations

Wilder and Wood (1902) were the first to survey the coal of McLean County and to report on the local mining activity. Andrews (1939) mapped in detail the geology of the Garrison area and named four principal beds--the Wolf Creek, Coteau, Garrison Creek, and Minter, in ascending stratigraphic order. Brant (1953, p. 23-25) estimated the coal resources of McLean County and reported on

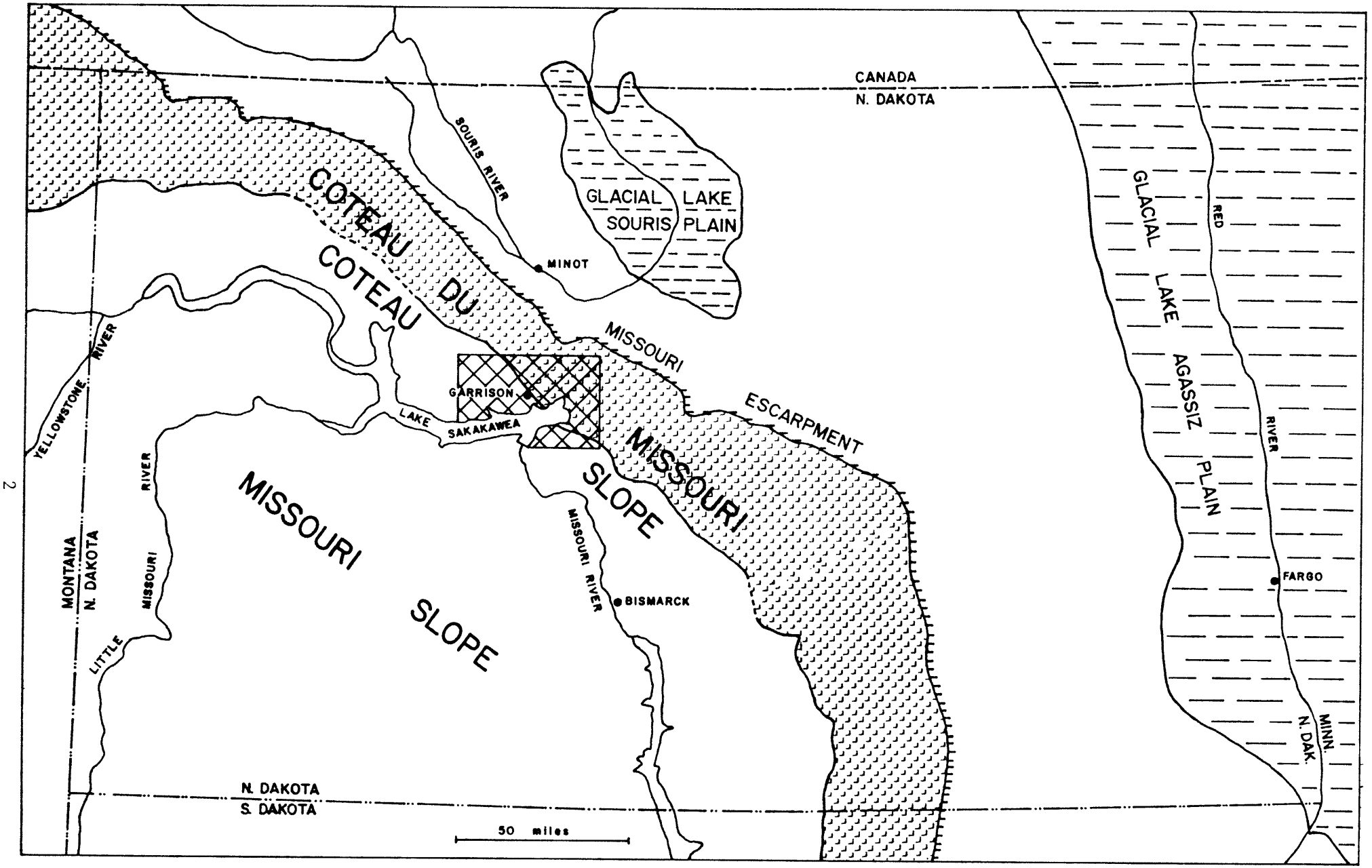

Figure 1.--Physiographic divisions of Garrison area. Area of report is cross-hatched. (From Clayton and Freers, 1967, figure R-1)

coal production through 1950. The Fort Berthold Reservation, bordering on the southwest part of the area, was studied by the U.S. Bureau of Mines (Harrer, 1961). Bluemle (1971) described the general geology of McLean County; Lemke (1960) and Bluemle (1975) described the glacial geomorphology of the area. All known coal analyses from mines in the area were compiled by Magnusson (1960). Klausing (1971) compiled the water-well data for McLean County. During 1977 and 1978, the U.S. Geological Survey conducted drilling programs for coal evaluation in the area (Menge, 1978; U.S. Geological Survey and North Dakota Geological Survey, 1979).

Development and Access

Mining in the area started prior to 1880 at Fort Stevenson, 5 mi south of Garrison. Since that time more than 70 small mines have operated throughout McLean County, with a majority of them centered around the Garrison area (Brant, 1953, p. 25)(pl. 1). In 1950, only two mines were in operation commercially near Garrison. Both operations strip-mined the Garrison Creek bed (Brant, 1953, p. 25). The Custer Creek mine, located in sections 18 and 19, T. 148 N., R. 83 W., was abandoned in 1964. Burns and Wretling Coal, Inc., mined coal near Garrison in 1966 for $3.50 to $3.80 a ton (Bluemle, 1971, p. 63) but has since abandoned operations.

Coal could be transported from the area by a branch of the Minneapolis, St. Paul, and Sault Ste. Marie (Soo Line) Railroad, which passes through Coleharbor, Garrison, Max, Benedict, and Ruso (pl. 1). U.S. Highway 83, North Dakota State Highways 37, 28, 53, 41, and 200, and a network of graded section-line roads provide access to the area (pl. 1).

Geomorphology

The Garrison area can be separated into two distinct geomorphic divisions: (1) the high knob-and-kettle terrain of the Coteau du Missouri, and (2) the gently rolling sheet-moraine plain of the Coteau Slope (fig. 1). Most of the

landforms in these two divisions were formed by glacial deposition. Plate 2 is a bedrock topography map that shows low areas which indicate the location of several old river channels.

The Coteau du Missouri is a dead-ice moraine created by the Late Wisconsin glaciers (Bluemle, 1971, p. 44). The characteristics of dead-ice moraine are knob-and-kettle topography, nonintegrated drainage, numerous ponds and sloughs, and bouldery till (Bluemle, 1971, p. 27). Thickness of the till along the Coteau ranges from 100 ft to more than 360 ft.

Eskers of varying size occur on the Coteau. The largest esker in the area extends southeast from section 7 to 35, T. 150 N., R. 82 W. (Bluemle, 1971, p. 28). An esker in T. 150 N., R. 80 W., section 29, was drilled in 1977 for the U.S. Geological Survey. It is composed of 70 ft of sand and pea-sized gravel deposited on top of till.

The sheet moraine of the Coteau Slope is a relatively thin layer of glacial till which is draped over the pre-existing landscape (Bluemle, 1971, p. 27). It is discontinuous along the major drainages north of Lake Sakakawea. Thickness of the sheet moraine ranges from 0 to approximately 150 ft.

The modern-day Douglas Creek drainage system west of Garrison occupies well-defined, melt-water trenches (Bluemle, 1971, p. 32). Part of the Garrison Creek drainage system flows down a possible melt-water trench. Melt-water trenches on the Coteau Slope area cut into bedrock, whereas those on the Coteau du Missouri are commonly cut into till. Melt-water trenches on the Coteau du Missouri are poorly defined owing to collapse of the dead-ice moraine as the stagnant ice underneath melted (Bluemle, 1971, p. 32).

STRATIGRAPHY

The Tongue River and Sentinel Butte Members of the Fort Union Formation (Paleocene) crop out or are unconformably covered by glacial drift. Maximum thickness of the two members is about 800 ft in western McLean County (Bluemle,

(1971). The Tongue River Member consists of nonmarine, light-buff-yellow sandstone, siltstone, claystone, small lenses of limestone, and lignitic coal. The four coal beds discussed in this report occur in the Tongue River. They are (in ascending stratigraphic order) the Wolf Creek, Coteau, Garrison Creek, and Minter.

The nonmarine Sentinel Butte Member conformably overlies the Tongue River. This unit consists of light-gray to brownish-gray siltstone, sandstone, claystone, and lignite.

The contact between the Tongue River and Sentinel Butte is difficult to define in this area for two reasons: (1) poor bedrock exposures, and (2) difficulty of correlating this area to an area with an accepted contact. A lack of data precludes correlation to western North Dakota where Royse (1967) defined the contact. Bluemle (1971) tentatively identified the contact in the vicinity of Garrison Dam at an elevation of approximately 1,900 ft. Using Royse's (1967, p. 3-7) definition of the Tongue River-Sentinel Butte contact, the contact is tentatively placed at the top of the Minter coal zone.

STRUCTURE

The Garrison area is on the eastern flank of the Williston Basin where the regional dip is less than 0.5° W. The structural interpretation of the Garrison area is based on the structure map of the top of the Minter coal zone (pl. 1). In Rs. 85 and 87 W., the dip increases to about 0.7° W., possibly indicating the flank of a syncline which Rehbein (1977) described near the town of Golden Valley, North Dakota, south of McLean County. Superimposed on both the regional dip and the possible syncline are minor folds and irregularities.

COAL

The Garrison Creek and Minter coal beds are the principal, correlative beds in the Garrison area (pls. 3, 4). Other beds are known to be present

(pls. 3, 4), but because of an absence of data or restricted areal extent, the development potential is not known. Table 1 contains analyses of the main coals in this report. Drill-hole data used on all plates are listed in table 2. Drill-hole data used only on plate 2 are listed in table 3.

Wolf Creek bed.--The Wolf Creek (WC) bed is stratigraphically the lowest identified bed in the area (pls. 3, 4)(Andrews, 1939). No isopach map was drawn because of a lack of subsurface data. Where the bed can be correlated, it is usually less than 4 ft thick.

Coteau bed.--The Coteau bed (pls. 3, 4) is present in the northeast part of the area. No isopach map was drawn because the bed lacks areal extent. To the north of the Garrison area in T. 152 N., R. 81 W., the Coteau bed is 17-19 ft thick. Andrews (1939) tentatively correlated the Coteau bed to the Garrison Creek bed. However, interpretation of geophysical logs obtained in 1977 and 1978 seems to disprove that correlation (pls. 3, 4).

Garrison Creek zone.--The Garrison Creek (GC) zone is divided into upper and lower beds--the GC_1 and GC_2 beds, respectively. The GC_1 bed ranges in thickness from 1.5 to 16 ft (pl. 5). Thickness of the GC_2 bed ranges from 0 to 8 ft (pl. 6). Interburden between the GC_1 and GC_2 beds is from 16 to 73 ft thick. The Garrison Creek zone was mined in the larger mines in the area, such as the Custer Creek and B&W mines.

Minter zone.--The Minter (M) zone consists of one to five coal beds with a total coal thickness of 1-15 ft (pl. 7). Interburden between the Garrison Creek and Minter zones ranges in thickness from 53 to 104 ft. In Tps. 149 and 150 N., R. 84 W., one bed of the Minter zone is consistently greater than 5 ft thick and less than 100 ft deep (pl. 7). Correlation diagram B-B' (pl. 3) includes the western part of this area.

Table 1.--Proximate and ultimate analyses of mine-face coal samples, Garrison area, McLean County, North Dakota

[From Magnusson, 1960. Form of analysis: A, as received; B, moisture free; --, no data]

Coal bed name	Location T.N.	R.W.	Sec.	Type of analysis	Proximate (percent) Moisture	Volatile matter	Fixed carbon	Ash	Ultimate (percent) Sulfur	Heating value Btu/lb
Minter----------	149	85	12	A	37	29.2	28.6	5.2	0.54	6,596
Garrison Creek----	148	83	18	A	40.2	----	----	---	----	6,630
				B	----	44.6	48.6	6.8	.6	11,080
Garrison Creek----	148	84	19	A	38.1	28.3	29.4	4.2	.26	6,731
Coteau----------	152	81	26	A	40.7	----	----	---	----	6,550
				B	----	44.0	48.1	7.9	.7	11,050

CONCLUSIONS

Numerous discontinuous coal beds of restricted areal extent are present in the Garrison area. The most continuous beds are in the Garrison Creek and Minter zones. Both zones are potentially valuable for future coal development because of the thickness of the beds under shallow overburden, the nearby transportation routes, and the availability of water.

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EXPLANATION OF DRILL-HOLE DATA ON TABLES 2 AND 3

All drill holes are listed in order of Township, Range, and Section.

McL 39	Original drill-hole identification numbers-- letters indicate source of data: USAF, USCE, USBR, and WW - Klausing, 1971 G - Menge, 1978 McL - U.S. Geological Survey and North Dakota Geological Survey, 1979
1925	Elevation above mean sea level of top of hole
T 48 R 15 C 1 Ct R 34 C 3 WC R 28 C 1 L	Lithologic section - thicknesses in feet T - till R - rock; includes sandstone, siltstone, and claystone C - coal seams; M, Minter zone; GC, Garrison Creek zone; Ct, Coteau zone; WC, Wolf Creek zone; and L, Local beds
TD 200	Total depth drilled, in feet

Hole locations for data in table 2 are on all plates.

Hole locations for data in table 3 are on plate 2 only.

Table 2.--Drill-hole data

[Used on all plates]

T. 146 N., R. 81 W.

WW 3934	
1952	
T	18
R	61
C	5 Ct?
R	456
TD	540

T. 146 N., R. 82 W.

WW 3922	
2027	
T	66
R	10
C	6 M?
R	54
C	4 GC_1
R	119
C	6 WC?
R	135
TD	400

T. 147 N., R. 81 W.

WW 2724	
1829	
T	50
C	9 WC?
R	11
TD	70

T. 147 N., R. 82 W.

WW 3927		G 54	
1841		1877	
T	110	T	48
R	20	R	1.5
C	8 L	C	6.5 WC?
R	22	R	22
TD	160	C	2.5 L
		R	3
		C	2 L
		R	90.5
		C	1 L
		R	3
		TD	180

T. 147 N., R. 82 W.

McL 39		McL 4		G 55		WW 4096	
1925		1952		2012		2000	
T	58	T	53	CH		T	27
R	15	R	17	TD	316	C	2 M?
C	1 Ct?	C	2 GC_1			R	37
R	34	R	22			C	4 GC_1
C	3 WC?	C	3 Ct?			R	30
R	28	R	11			TD	100
C	1 L	C	1 L				
R	60	R	21				
TD	200	C	2 WC?				
		R	2				
		C	3 WC?				
		R	163				
		TD	300				

T. 147 N., R. 83 W.

WW 4040	
1901	
T	9
R	18
C	4 GC_1
R	29
TD	60

T. 148 N., R. 81 W.

G 57		WW 3952		G 52		G 53		G 56	
1951		1875		1875		1918		1850	
T	60	T	106	T	179	T	107	T	143
R	2	R	5	TD	179	R	1	TD	143
C	2 GC_2	C	8 WC?			C	4.5 WC?		
R	1	R	21			R	61.5		
C	2.5 GC_2	TD	140			TD	174		
R	26								
C	1.5 L								
R	39								
C	1.5 WC								
R	4								
C	1.5 WC								
R	19								
TD	160								

T. 148 N., R. 82 W.

McL 3		USAF 1	
1945		1890.5	
T	100	T	72
TD	100	C	8.5 WC?
		R	8
		C	4 WC?
		R	7.5
		TD	100

T. 148 N., R. 83 W.

USCE	
1864	
T	72
R	5
C	1 L
R	9
TD	87

T. 148 N., R. 84 W.

WW 5582	
1960	
T	50
C	3 GC_1
R	7
TD	60

Table 2.--Drill-hole data - continued

T. 148 N., R. 84 W.

G 47		WW 4055		WW 4053		WW 5804		McL 5		WW 5787	
1941		1932		1905		1965		1952		1940	
T 23		T 142		T 14		T 58		T 35		T 80	
R 5		C 5	WC	R 10		C 6	GC_1	R 12		C 6	GC_1
C 1	GC_1?	R 13		C 6	GC_1?	R 16		C 1	GC_1	R 14	
R 8		TD 160		R 112		TD 80		R 2		TD 100	
C 1	L?			C 3	L			C 6	GC_1		
R 8.5				R 42				R 99			
C 2.5	L?			C 5	WC			C 1	L		
R 4				R 108				R 1			
C 2	L?			TD 300				C 2	L		
R 8								R 26			
C 2	L?							C 2	WC?		
R 14.5								R 39			
C 6	GC_2							C 2	L		
R 58.5								R 72			
C 1.5	L							TD 300			
R 18.5											
C 1	WC										
R 4											
C 1.5	WC										
R 7.5											
C 2	WC										
R 20											
TD 200											

T. 148 N., R. 84 W.

WW 5791	
1952	
T 33	
R 5	
C 4	GC_1
R 18	
TD 60	

T. 148 N., R. 85 W.

McL 16		McL 38		USAF 2	
2016		1961		1957	
T 8		T 24		T 9	
R 8		R 28		R 50.5	
C 2	M	C 3	L	C 2.5	L
R 14		R 69		R 39	
C 1	M	C 2	GC_1	TD 101	
R 54		R 64			
C 2	L	C 6	GC_2		
R 47		R 6			
C 2	GC_1	C 1	L		
R 53		R 17			
C 5	GC_2	C 2	L		
R 79		R 20			
C 2	WC?	C 2	L		
R 21		R 44			
C 3	WC?	C 3	WC?		
R 77		R 9			
C 2	L	TD 300			
TD 380					

T. 148 N., R. 85 W.

G 169	
1920	
R 20	
C 2	L
R 38	
C 0.5	GC_1
R 3	
C 1.5	GC_1
R 63	
C 2	L
R 8	
C 8	GC_2
R 66	
C 8	WC?
R 39	
C 5	L
R 9	
C 4.5	L
R 22.5	
TD 300	

T. 148 N., R. 86 W.

McL 13		McL 14		McL 15		McL 6	
1992		2040		1970		1900	
T 278		T 15		T 37		T 14	
TD 278		R 13		R 18		R 14	
		C 2	L	C 2	M	C 2	M
		R 86		R 17		R 21	
		C 7	M	C 2	L	C 2	L
		R 104		R 75		R 43	
		C 5	GC_1	C 5	GC_1	C 2	GC_1
		R 30		R 39		R 10	
		C 2	GC_2	C 4	GC_2	C 4	GC_1
		R 1		R 111		R 41	
		C 2	GC_2	C 2	WC	C 5	GC_2
		R 97		R 8		R 97	
		C 2	WC?	TD 320		C 2	WC
		R 14				R 23	
		TD 380				TD 280	

T. 148 N., R. 87 W.

McL 12	
2061	
T 18	
R 66	
C 1	L
R 96	
C 2	M
R 1	
C 5	M
R 101	
C 5	GC_1
R 21	
C 1	L
R 4	
C 2	GC_2
R 2	
C 2	GC_2
R 73	
TD 400	

Table 2.--Drill-hole data - continued

T. 148 N., R. 87 W.

McL 9		USAF 3		McL 8		McL 7	
1976		1954		1995		1984	
T 204	T 14		R 122		T 13		
TD 204	R 18		C 5	L	R 18		
	C 1.5	L	R 3		C 3	L	
	R 18		C 2	L	R 1		
	C 2	L	R 29		C 2	L	
	R 49.5		C 2	L	R 18		
	TD 103		R 16		C 2	L	
			C 2	L	R 67		
			R 63		C 1	M	
			C 2	M	R 2		
			R 15		C 4	M	
			C 2	M	R 20		
			R 13		C 2	L	
			C 4	M	R 31		
			R 23		C 2	L	
			C 2	L	R 21		
			R 33		C 2	L	
			C 4	GC_1	R 20		
			R 2		C 4	GC_1	
			C 4	GC_1	R 4		
			R 5		C 3	GC_1	
			C 2	GC_1	R 6		
			R 5		C 3	GC_1	
			TD 360		R 36		
					C 2	GC_2?	
					R 2		
					C 2	GC_2?	
					R 29		
					TD 320		

T. 149 N., R. 80 W.

WW 4082	
1920	
T 40	
R 101	
C 7	WC?
R 12	
TD 160	

T. 149 N., R. 81 W.

McL 2		G 45	
1960		2005	
T 60		T 26	
R 58		R 2	
C 2	GC_2?	C 1	M
R 180		R 3	
TD 300		C 1	M
		R 2	
		C 2	M
		R 15	
		C 4	M
		R 22	
		C 2	L
		R 61.5	
		C 4.5	GC_2?
		R 1.5	
		C 3.5	GC_2?
		R 33	
		C 2	Ct?
		R 1	
		C 1	Ct?
		R 7	
		C 1	Ct?
		R 5.5	
		C 3	Ct?
		R 56.5	
		TD 261	

T. 149 N., R. 81 W.

G 46		USAF 4		G 51	
1948		1958		1895	
T 190	T 82.5		T 152		
R 10	C 1.5	GC_2	TD 152		
TD 200	R 1.5				
	C 2.5	GC_2			
	R 10.5				
	TD 98.5				

T. 149 N., R. 82 W.

G 28		WW 4075		G 50		WW 4073	
2008		1962		1952		1890	
T 35		T 55		T 70		T 70	
R 9		R 11		R 102		R 36	
C 5	M	C 5	GC_2	C 1.5	WC?	C 5	WC
R 68		R 9		R 26.5		R 9	
C 1	GC_2	TD 80		TD 200		TD 120	
R 1							
C 3	GC_2						
R 9							
C 2	L						
R 123							
C 2	WC						
R 5.5							
C 5.5	WC						
R 94							
TD 363							

T. 149 N., R. 83 W.

G 49		G 48	
1987		1938	
T 57		T 150	
R 47		R 3	
C 1.5	GC_2?	C 3	Ct?
R 117.5		R 68	
C 1	WC?	TD 224	
R 4.5			
C 1.5	WC?		
R 7.5			
C 2.5	WC?		
R 26			
TD 266			

T. 149 N., R. 84 W.

G 17		G 18		G 14	
2010		2023		2024	
T 56		T 34		T 35	
R 1		C 9.5	M	R 27	
C 6.5	M	R 84.5		C 9	M
R 47		C 3	GC^1	R 42.5	
C 2.5	L	R 27		C 3	L
R 29.5		C 1	L	R 24.5	
C 2.5	GC_1	R 103.5		C 1	GC_1
R 36.5		C 2	WC	R 1.5	
C 1.5	L?	R 66.5		C 0.5	GC_1
R 44.5		C 2	L	R 38	
C 2	L	R 69		C 1	L
R 46		TD 402		R 93	
C 2	WC			C 2	WC?
R 85.5				R 82	
TD 363				TD 360	

Table 2.--Drill-hole data - continued

T. 149 N., R. 84 W.

G 19			G 20			G 21			USAF 6			G 7		
1998			2008			1964			2008			2024		
T	25		T	20		T	160		T	52.7		T	45	
R	2		R	14		R	27		C	7.3	M	R	2	
C	3	M	C	2	M	C	1.5	L?	R	41.5		C	9.5	M
R	1		R	2		R	42.5		TD	100.5		R	42	
C	1.5	M	C	1.5	M	C	1	L?				C	2	L
R	1		R	1		R	11.5					R	27.5	
C	2.5	M	C	2.5	M	C	3.5	L				C	2.5	GC_1
R	1.5		R	1.5		R	5					R	46	
C	5.5	M	C	5.5	M	C	2	L				C	1.5	L
R	45.5		R	72		R	46					R	115.5	
C	1.5	L	C	4.5	GC_1	TD	300					C	2	WC
R	33		R	38								R	24.5	
C	1.5	GC_1	C	1	L							TD	320	
R	1		R	100										
C	2.5	GC_1	C	2.5	WC?									
R	28		R	52										
C	1	L	TD	320										
R	14.5													
C	1.5	L												
R	81													
C	2	WC												
R	44													
TD	300													

G 8			G 9			G 6		
1994			2018			2026		
T	181		T	23		T	75	
R	44.5		R	3		R	207	
C	1.5	L	C	3	M	C	1	WC?
R	96		R	1		R	30	
TD	323		C	5	M	C	1	WC?
			R	47.5		R	7	
			C	1.5	L	TD	321	
			R	36				
			C	5	GC_1			
			R	32				
			C	1.5	L			
			R	100.5				
			C	2.5	WC?			
			R	15				
			C	1	WC?			
			R	42.5				
			TD	320				

T. 149 N., R. 84 W.

G 5			G 4			G 3		
2008			1962			1968		
T	53		T	15		T	26	
R	27		R	1		R	54	
C	1.5	L	C	4	M	C	2	L
R	36.5		R	50		R	42	
C	4	GC_1	C	1.5	L	C	2	GC_1
R	36.5		R	40		R	1	
C	1	GC_2?	C	4.5	GC_1	C	2	GC_1
R	141.5		R	18		R	3	
TD	301		C	1	L	C	2	L
			R	18		R	42	
			C	2	L?	C	2	L?
			R	27.5		R	25.5	
			C	2	L	C	2	L
			R	32		R	28.5	
			C	1.5	WC?	C	4	L
			R	42		R	18.5	
			TD	260		C	1.5	WC?
						R	23	
						TD	281	

T. 149 N., R. 85 W.

G 13			G 12		
1994			2042		
T	25		T	100	
R	29.5		R	1	
C	7	M	C	2	M
R	10.5		R	21	
C	3	M	C	1.5	M
R	1.5		R	1.5	
C	5	M	R	6.5	M
R	82		R	42	
C	2	GC_1	C	1	L
R	1.5		R	38	
C	1	GC_1	C	1.5	GC_1
R	132		R	1.5	
TD	300		C	1.5	GC_1
			R	120	
			C	1.5	WC?
			R	20.5	
			TD	360	

Table 2.--Drill-hole data - continued

T. 149 N., R. 85 W.

G 10			G 11			McL 19			G 1			G 2			McL 17		
1985			2002			2037			1986			1978			2055		
T	35		T	20		T	17		T	22		T	25		T	22	
C	4	M	R	30		R	80		R	28		C	1	M	R	108	
R	1		C	5.5	M	C	7	M	C	5.5	M	R	48		C	2	M
C	2	M	R	1		R	49		R	5		C	6.5	L	R	1	
R	18.5		C	1.5	M	C	4	L	C	1	L	R	45.5		C	3	M
C	9	M	R	22		R	50		R	45		C	3	GC_1	R	46	
R	52		C	1	M	C	2	GC_1	C	5.5	L	R	129		C	3	L
C	2	L	R	1		R	26		R	5		C	3.5	WC?	R	48	
R	39.5		C	5	M	C	2	GC_2	C	1	L	R	19.5		C	2	GC_1
C	4.5	GC_1	R	27.5		R	2		R	46		TD	281		R	33	
R	12.5		C	1	L	C	2	GC_2	C	3	GC_1				C	2	GC_2
C	2	L	R	16		R	139		R	53					R	2	
R	101		C	2	L	TD	380		C	2	L				C	2	GC_2
C	2	WC?	R	37					R	1.5					R	102	
R	25.5		C	5	GC_1				C	5.5	GC_2				C	3	WC?
C	1	L	R	1.5					R	2					R	20	
R	28		C	2.5	L				C	1	L				C	3	L
TD	340		R	129.5					R	51					R	12	
			C	2.5	WC?				C	1	WC				C	1	L
			R	85.5					R	1					R	5	
			C	4.5	L				C	1	WC				TD	420	
			R	9					R	14							
			C	1	L				TD	302							
			R	99.5													
			TD	511													

T. 149 N., R. 86 W.

McL 26			McL 20			McL 21			McL 18			McL 11			G 59		
2145			2120			2195			2075			2165			2153		
T	44		T	106		T	197		T	28		T	134		T	90	
R	254		R	27		R	4		R	166		R	217		R	239	
C	6	M	C	1	L	C	2	L	C	2	M	C	2	M	C	7	M
R	31		R	2		R	3		R	11		R	20		R	49	
C	5	L	C	2	L	C	2	L	C	6	M	C	7	M	C	1	L
R	50		R	170		R	175		R	44		R	81		R	14	
C	1	GC_1	C	1	M	C	2	M	C	4	L	C	2	GC_1	TD	400	
R	8		R	2		R	2		R	55		R	7				
C	1	GC_1	C	3	M	C	4	M	C	2	GC_1	C	3	GC_1			
TD	400		R	39		R	41		R	35		R	7				
			C	4	L	C	2	L	C	3	GC_2	C	1	L			
			R	58		R	52		R	1		R	18				
			C	2	GC_1	C	5	GC_1	C	3	GC_2	C	1	GC_2			
			R	5		R	1		R	20		TD	500				
			C	2	GC_1	C	1	GC_1	TD	380							
			R	17		R	16										
			C	2	GC_2	C	2	GC_2									
			R	1		R	2										
			C	2	GC_2	C	1	GC_2									
			R	34		R	26										
			TD	480		TD	540										

Table 2.--Drill-hole data - continued

T. 149 N., R. 87 W.

McL 22		McL 10		WW 3622	
2093		2058		2002	
T 186		T 70		T 412	
R 144		R 73		R 19	
C 6	M	C 4	L	C 5	GC_2
R 18		R 22		R 4	
C 2	L	C 1	L	TD 440	
R 14		R 56			
C 4	L	C 1	L		
R 28		R 54			
C 2	GC_1	C 1	L		
R 2		R 10			
C 4	GC_1	C 2	M		
R 24		R 19			
C 4	GC_2	C 1	M		
R 2		R 1			
TD 440		C 5	M		
		R 31			
		C 2	L		
		R 36			
		C 1	GC_1		
		R 4			
		C 2	GC_1		
		R 5			
		TD 401			

T. 150 N., R. 80 W.

USAF 5		G 60	
2063		2064	
T 54		T 361	
R 33		TD 361	
C 3.5	GC_2		
R 9.5			
TD 100			

T. 150 N., R. 81 W.

G 43		G 39		G 44		G 38	
2154		2058		2048		1978	
T 100		T 143		T 142		T 100	
R 2		R 2		R 3		R 120	
C 2	M	C 3	GC_2	C 1	GC_2?	TD 220	
R 16.5		R 213		R 125			
C 1	M	TD 361		TD 271			
R 90							
C 1.5	GC_2						
R 15.5							
C 2.5	L						
R 6							
C 3	L						
R 16							
C 5	Ct?						
R 57							
C 1	WC?						
R 130							
C 1	L						
R 10							
TD 460							

T. 150 N., R. 82 W.

G 30		WW 4077		G 29		WW 4076	
2112		2011		1968		2081	
T 234		T 347		T 260		T 172	
R 15.5		R 8		R 18		R 28	
C 1.5	GC_2	C 5	L	C 3	WC?	C 2	GC_2
R 6.5		R 20		R 19		R 10	
C 1.5	GC_2	TD 380		TD 300		C 4	GC_2
R 26						R 84	
C 3	L?					TD 300	
R 5.5							
C 1.5	L?						
R 9							
C 6	Ct?						
R 9							
C 1	L?						
R 45							
C 1.5	WC?						
R 3							
C 1.5	WC?						
R 6.5							
C 3.5	WC?						
R 41							
TD 422							

T. 150 N., R. 83 W.

G 25		WW 1370	
2080		2101	
T 102		T 128	
R 14		R 8	
C 2	M	C 10+	M
R 86		TD 146	
C 2.5	GC_1		
R 52			
C 1	GC_2		
R 4			
C 2.5	GC_2		
R 4.5			
C 1.5	L?		
R 1.5			
C 0.5	L?		
R 1			
C 2.5	L?		
R 16.5			
C 3.5	L?		
R 44.5			
C 3	L?		
R 27.5			
C 1	L?		
R 4			
C 1.5	L?		
R 21			
C 2	WC?		
R 1			
C 1	WC?		
R 1			
C 3	WC?		
R 32			
TD 440			

Table 2.--Drill-hole data - continued

T. 150 N., R. 83 W.

McL 1		G 26		McL 27	
2180		2126		2085	
T	141	T	220	T	86
R	18	R	220	R	16
C	3 L	TD	440	C	5 M
R	23			R	55
C	2 L			C	2 GC_2
R	27			R	161
C	3 M			C	1 WC
R	6			R	54
C	5 M			TD	380
R	72				
C	1 GC_1?				
R	16				
C	3 GC_2?				
R	16				
C	2 L?				
R	31				
C	3 L				
R	43				
C	1 L				
R	18				
C	1 L				
R	1				
C	2 L				
R	102				
TD	540				

T. 150 N., R. 84 W.

G 23		G 22		G 16	
2102		2011		2042	
T	175	T	160	T	69
R	16	R	2	C	3 M
C	5 M	C	0.5 L?	R	3.5
R	74	R	2	C	9.5 M
C	1 GC_1	C	1 L?	R	87
R	14	R	14.5	C	2 GC_1
C	1 GC_1	C	2 L	R	50.5
R	41	R	32	C	1 L
C	2 GC_2	C	3 L	R	36.5
R	16	R	123	C	2.5 L
C	4 L	TD	340	R	62.5
R	51			C	2 L
TD	400			R	53
				TD	382

T. 150 N., R. 84 W.

G 15	
2034	
T	50
R	9.5
C	1 M
R	1
C	1 M
R	1
C	2 M
R	5.5
C	9.5 M
R	72.5
C	2.5 GC_1
R	54
C	1.5 L
R	53
C	1 L
R	45.5
C	2 L
R	3.5
TD	316

T. 150 N., R. 85 W.

McL 36		McL 37		McL 28	
2069		2050		2112	
T	26	T	48	T	30
R	126	R	100	R	56
C	4 M	C	5 M	C	1 L
R	3	R	2	R	128
C	5 M	C	5 M	C	2 M
R	77	R	73	R	1
C	1 GC_1?	C	1 GC_1?	C	3 M
R	11	R	6	R	6
C	2 GC_1?	C	2 GC_1?	C	8 M
R	15	R	39	R	78
C	2 GC_1?	C	1 L	C	2 GC_1
R	32	R	23	R	1
C	2 GC_2?	C	2 GC_2	C	1 GC_1
R	94	R	53	R	112
TD	400	TD	360	C	2 WC
				R	29
				TD	460

T. 150 N., R. 86 W.

McL 35		McL 34		McL 31		McL 29		McL 30		McL 25	
2163		2157		2126		2150		2132		2125	
T	86	T	36	T	58	T	48	T	50	T	20
R	48	R	81	R	34	R	214	R	27	R	75
C	1 L	C	3 L	C	2 L	C	1 M	C	2 L	C	2 L
R	158	R	217	R	81	R	80	R	91	R	89
C	1 M	C	1 M	C	1 L	C	16 GC_1	C	2 L	C	1 L
R	56	R	79	R	145	R	52	R	129	R	152
C	14 GC_1	C	11 GC_1	C	1 M	C	1 GC_2	C	4 M	C	4 M
R	50	R	47	R	1	R	9	R	31	R	17
C	3 GC_2	C	3 GC_2	C	3 M	C	1 GC_2	C	7 L	C	7 M
R	25	R	22	R	22	R	15	R	58	R	53
C	2 L	TD	500	C	7 L	C	3 L	C	4 GC_1	C	6 GC_1
R	56			R	59	R	40	R	14	R	31
TD	500			C	6 GC_1	C	1 WC	C	1 GC_2?	C	3 GC_2
				R	19	R	19	R	1	TD	460
				C	1 GC_1?	TD	500	C	1 GC_2?		
				R	1			R	38		
				C	1 GC_1?			TD	460		
				R	18						
				TD	460						

Table 2.--Drill-hole data - continued

T. 150 N., R. 87 W.

McL 33			McL 32			McL 24			McL 23		
2178			2190			2140			2135		
T	26		T	55		T	142		T	106	
R	140		R	135		C	2	L	R	83	
C	2	L	C	3	L	R	2		C	2	L
R	13		R	96		C	2	L	R	2	
C	3	L	C	3	L	R	40		C	1	L
R	77		R	2		C	2	L	R	217	
C	3	L	C	2	L	R	42		C	2	L
R	3		R	136		C	2	L	R	8	
C	1	L	C	1	L	R	238		C	4	GC_1
R	74		R	8		C	4	GC_1	R	7	
C	1	M	C	9	GC_1	R	8		C	8	GC_1
R	61		R	8		C	8	GC_1	R	14	
C	3	GC_1	C	1	L	R	8		C	7	GC_2
R	2		R	45		TD	500		R	19	
C	3	GC_1	C	7	GC_2				TD	480	
R	51		R	29							
C	7	GC_2	TD	540							
R	36										
C	2	L									
R	12										
TD	520										

Table 3.--Drill-hole data

[Used only on bedrock topography map, plate 2]

T. 146 N., R. 83 W.

WW 4083
1958
T 226
R 34
TD 260

T. 147 N., R. 80 W.

WW 2732	WW 2728	WW 2723
1868	1848	1843
T 104	T 68	T 173
R 16	R 32	R 7
TD 120	TD 100	TD 180

T. 147 N., R. 81 W.

WW 4098	WW 2727	USBR	WW 2725	WW 2719	WW 4097	WW 2720
1912	1864	1840	1830	1838	1863	1852
T 154	T 55	T 9.5	T 28	T 85	T 98	T 21
R 66	R 25	R 18.5	R 22	R 35	R 82	R 39
TD 220	TD 80	C 2	TD 50	TD 120	TD 180	TD 60
		TD 30				

T. 147 N., R. 82 W.

WW 3926	WW 2716
1927	1885
T 44	T 16
R 56	R 44
TD 100	TD 60

T. 147 N., R. 83 W.

WW 3924	WW 4042	WW 2714	WW 3923
1860	1865	1905	1921
T 209	T 56	T 160	T 343
R 31	R 84	R 40	R 37
TD 240	TD 140	TD 200	TD 380

T. 148 N., R. 80 W.

WW 4085	WW 2745	WW 3948	WW 2747
1910	1862	1901	1860
T 167	T 278	T 161	T 240
R 33	R 22	R 39	R 20
TD 200	TD 300	TD 200	TD 260

T. 148 N., R. 81 W.

WW 3949	WW 2743
1890	1850
T 71	T 150
R 29	R 30
TD 100	TD 180

T. 148 N., R. 81 W.

WW 2740	WW 4101	WW 2742	WW 2744	WW 2735	WW 4100	WW 3930
1856	1840	1844	1864	1860	1856	1860
T 205	T 293	T 175	T 212	T 96	T 236	T 56
R 15	R 27	C 5	R 18	R 24	R 24	R 24
TD 220	TD 320	TD 180	TD 230	TD 120	TD 260	TD 80

T. 148 N., R. 81 W.

WW 2737	WW 2733
1847	1850
T 67	T 95
R 13	R 25
TD 80	TD 120

T. 148 N., R. 82 W.

WW 3953	WW 3932	WW 3933	WW 4102
1882	1845	1860	1870
T 104	T 250	T 237	T 195
R 56	R 30	R 13	R 25
TD 160	TD 280	TD 250	TD 220

Table 3.--Drill-hole data - continued

T. 148 N., R. 82 W.

WW 3931		WW 2739		WW 4103	
1880		1880		1893	
T	266	T	205	T	70
R	34	R	25	R	70
TD	300	TD	230	TD	140

T. 148 N., R. 83 W.

WW 5593		WW 5594	
1845		1894	
T	96	T	131
R	24	R	9
TD	120	TD	140

T. 148 N., R. 84 W.

WW 5789		WW 5777		WW 4064	
1932		1905		1922	
T	207		33	T	159
R	13	R	7	R	1
TD	220	TD	40	C	3 WC
				R	17
				TD	180

T. 148 N., R. 85 W.

WW 2835		WW 2834	
1932		1890	
T	25	T	136
R	55	R	24
TD	80	TD	160

T. 148 N., R. 86 W.

WW 4043		WW 4044		WW 4045	
1967		1917		1902	
T	19	T	218	T	327
R	19	R	22	R	33
TD	38	TD	240	TD	360

T. 148 N., R. 87 W.

WW 3626		WW 3619	
1966		1954	
T	373	T	349
R	47	R	21
TD	420	TD	370

T. 149 N., R. 80 W.

WW 5600		WW 5599		WW 5597	
1990		1958		1935	
T	39	T	95	T	132
R	21	R	5	R	8
TD	60	TD	100	TD	140

T. 149 N., R. 81 W.

WW 3951		WW 5595	
1900		1910	
T	80	T	71
R	20	R	69
TD	100	TD	140

T. 149 N., R. 82 W.

WW 5589		WW 5591		WW 2833	
2020		1940		1895	
T	155	T	98	T	170
R	25	R	42	R	50
TD	180	TD	140	TD	220

WW 5592		WW 2805	
1902		1850	
T	128	T	108
R	32	R	32
TD	160	TD	140

T. 149 N., R. 84 W.

WW 5583	
1935	
T	79
R	21
TD	100

T. 149 N., R. 84 W.

WW 5809		WW 5817		WW 4060	
1960		1940		1920	
T	163	T	168	T	68
R	17	R	32	R	12
TD	180	TD	200	TD	80

T. 149 N., R. 85 W.

WW 2838	
2035	
T	52
R	28
TD	80

T. 149 N., R. 86 W.

WW 3618		WW 5570	
2105		2050	
T	28	T	51
R	32	R	9
TD	60	TD	60

T. 149 N., R. 87 W.

WW 3616		WW 5571		WW 5561	
2085		2070		2000	
T	55	T	26	T	295
R	6	R	9	R	25
C	4	C	7	TD	320
R	15	R	18		
TD	80	TD	60		

T. 150 N., R. 80 W.

WW 4080		WW 5603		WW 4081	
2015		2035		1985	
T	338	T	225	T	169
R	42	R	35	R	21
TD	380	TD	260	TD	190

Table 3.--Drill-hole data - continued

T. 150 N., R. 80 W.

WW 5601	
2045	
T	162
R	98
TD	260

WW 2801	
1985	
T	82
R	18
TD	100

T. 150 N., R. 81 W.

WW 2832	
2068	
T	74
R	26
TD	100

T. 150 N., R. 82 W.

WW 5586	
2023	
T	97
R	23
TD	120

WW 5585	
2049	
T	80
R	20
TD	100

WW 5587	
1948	
T	131
R	9
TD	140

T. 150 N., R. 84 W.

WW 5578	
2125	
T	120
R	20
TD	140

T. 150 N., R. 85 W.

USAF 7	
2070.7	
T	83
R	18.3
TD	101.3

T. 150 N., R. 86 W.

WW 3617	
2120	
T	18
R	42
TD	60

T. 150 N., R. 87 W.

WW 2848	
2168	
T	1
R	39
TD	40

WW 2847	
2135	
T	172
R	28
TD	200

T. 150 N., R. 87 W.

WW 2845	
2105	
T	24
R	16
TD	40

WW 2846	
2125	
T	20
R	40
TD	60