UNITED STATES OF THE INTERIOR

GEOLOGICAL SURVEY

Text to Accompany:

COAL RESOURCE OCCURRENCE MAP OF THE MARSHALL SE QUADRANGLE, DUNN AND STARK COUNTIES, NORTH DAKOTA

[Report includes 2 plates]

By

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This report has not been edited for conformity with U.S. Geological Survey editorial standards or stratigraphic nomenclature.

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INTRODUCTION

The occurrence, extent, and preliminary geologic evaluation of coal beds in the Marshall SE quadrangle in west-central North Dakota are described in this report. Since no detailed data are available for this quadrangle, the geological mapping has been entirely dependent on knowledge of the regional geology as well as the geology of adjacent and surrounding quadrangles. In surrounding quadrangles, subsurface data consisting of oil and gas well and exploration drill hole logs and surface data comprised of measured sections were compiled for study and presentation. Federal coal ownership is presented on the Boundary and Coal Data Map, Plate 2. A composite section of the projected geology of this quadrangle is shown on Figure 1. Derivative maps which consist of coal isopachs, structure contours, overburden, mining ratios, reserve categories, and Reserves and Reserve Base, have not been prepared for this quadrangle because of insufficient data.

This work has been performed under contract with the Conservation Division of the U.S. Geological Survey (Contract No. 14-08-0001-17118).

The resource information gathered in this program is in response to the Federal Coal Leasing Amendments Act of 1975 and

COMPOSITE COLUMNAR SECTION, MARSHALL SE

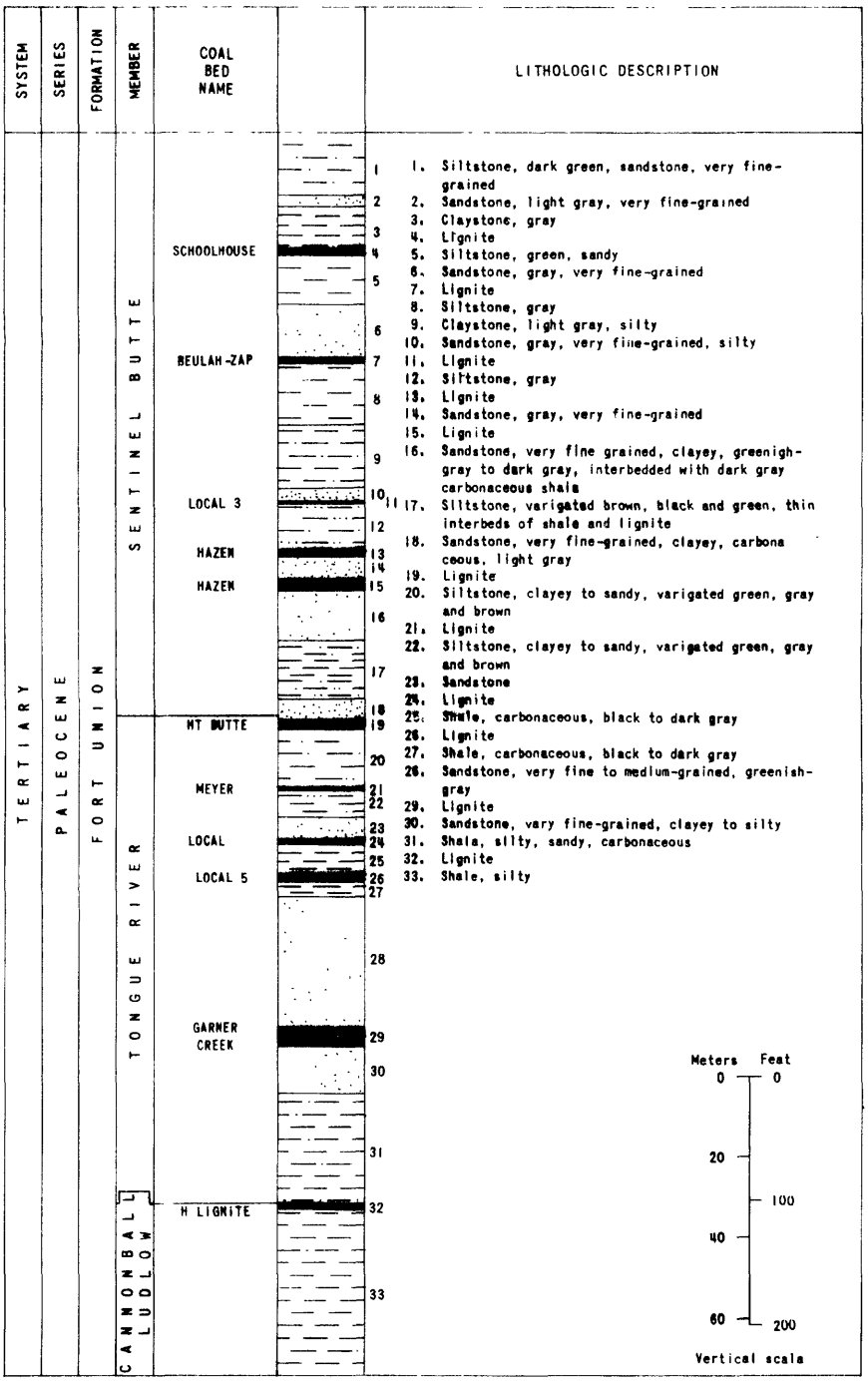

FIG. 1

is part of the U.S. Geological Survey's (USGS) coal program. This information is intended to provide basic data on coal resources for land-use planning purposes by the Bureau of Land Management, state and local governments, and the public.

LOCATION

The Marshall SE 7 1/2 minute quadrangle is located in southwestern Dunn County and northeastern Stark County, North Dakota about 22 miles (35.4 km) northeast of Dickinson and 16 miles (25.7 km) south of Halliday.

ACCESSIBILITY

The area is accessible by State Highway 8 which passes north-south through the quadrangle. State Highway 8 connects with Interstate 94 at Richardton, 8 miles (12.9 km) to the south.

The Burlington Northern Railroad operates and maintains an east-west route which extends through Halliday, Dunn Center and Killdeer about 14 miles (22.5 km) north of the quadrangle. No railroad routes currently pass through or closer to the quadrangle than the existing Burlington Northern route to the north.

PHYSIOGRAPHY

The quadrangle lies in the central portion of a large topographic high known as the Missouri Plateau, which is being dissected by the Knife, Heart, Cannonball and Cedar Creek

Rivers. In the eastern portion of the plateau the topography is generally hilly and along the Missouri River there are bluffs 500-600 feet (152-183 m) high. The western part of the Missouri Plateau is characterized by more irregular topography than that which is prevalent throughout the remainder of the quadrangle. This area, known collectively as "the Badlands", comprises an intricate maze of narrow ravines, sharp crested ridges and pinnacles.

The Marshall SE quadrangle may be characterized as gently rolling to hilly with a maximum relief across the quadrangle of 500 feet (152.4 m). Numerous shallow drainages feed into the Knife River 1 mile (1.6 km) north of the quadrangle. The vegetation is mixed prairie grasses and some of the land is cultivated.

CLIMATE

North Dakota's climate may be characterized as semi-arid; the average annual precipitation is 17 inches (43.2 cm) at Dunn Center which is located 20 miles (32.2 km) northwest of the quadrangle.

Maximum precipitation occurs during the late spring and early summer with slightly over half the total annual precipitation occurring during May, June and July. Although the mean annual temperature is about 40°F (414°C) temperatures as recorded at the Dunn Center weather station by the U.S. Department of Commerce,can range from 120°F (38.9°C) in summer

months to -25°F (-31.7°C) in winter months. The prevailing northerly winds increase in velocity during the colder months of November through March.

LAND STATUS

The quadrangle lies in the western one-half of the Knife River Known Recoverable Coal Resources Area (KRCRA). The Federal Government owns the coal rights to approximately 35 percent of the quadrangle as shown on Plate 2 of the coal resource occurrence map. In addition, the Federal Government has restricted coal rights on less than one percent of the area incorporated in the quadrangle.

PREVIOUS WORK

This report has drawn on a number of basic data reports on the coal occurrences in the Knife River KRCRA, including: Law (1977), Benson (1953), and the United States Geological Survey (USGS) and North Dakota Geological Survey (NDGS) (1976, 1977). Ground water data reports in the Knife River area were also used, including: Croft (1970) and Klausing (1971, 1974, 1976).

METHOD OF STUDY

No records of drill holes in this quadrangle were found. Lithologic and geophysical logs from drill holes and measured sections in adjacent quadrangles provided the basic data for this study. On the surrounding quadrangles, the quality of the available coal information is variable. Lithologic and

geophysical logs from exploration holes drilled by the North Dakota Geological Survey, North Dakota State Water Commission and private coal companies generally provide the most detailed and reliable subsurface data. Lithologic logs of private water wells are less detailed and less reliable, but they provide usable information in some cases. Where the data for a specific coal bed appeared to be inaccurate or inconsistent with surrounding drill hole data, it was not included in the data base that was used for construction of derivative maps for that coal bed.

Projected coal outcrop traces from previous investigations (Law, 1977) were plotted on the coal data map, Plate 1.

GEOLOGY

STRATIGRAPHY

The stratigraphy in the Marshall SE quadrangle is based on geologic data from the Willow Creek West and Marshall quadrangles. The oldest rocks present in the uppermost 1000 feet (305 m) of stratigraphic section in the Marshall SE quadrangle are the Paleocene age Ludlow-Cannonball, and the coal-bearing Tongue River and Sentinel Butte members of the Fort Union Formation (Rehbein, 1977). Sandstones, siltstones and shales of this formation are locally mantled by erosional remnants of the Upper Paleocene-Lower Eocene Golden Valley Formation and by Quaternary glacial, eolian, and alluvial deposits.

Fort Union Formation - Paleocene.

Ludlow-Cannonball member - these sediments underlie but do not crop out in the study area. The Cannonball is the youngest known marine strata in the northern Great Plains region. It is about 350 feet (107 m) thick and consists of shale and thin-bedded sandstone which thins and interfingers to the west with the time-equivalent continentally deposited Ludlow member.

Tongue River member - this member ranges from 350 to 900 feet (107 to 274 m) thick and consists of an alternating sequence of fluvially deposited sandstone, siltstone, shale, and lignite. It conformably overlies the marine Cannonball and the time equivalent, nonmarine Ludlow members. The Tongue River member is lithologically similar to the overlying Sentinel Butte member, and in places cannot be distinguished from it. The contact between the Tongue River and Sentinel Butte members, which has been arbitrarily set at the top of the HT Butte lignite, is conformable.

Sentinel Butte member - this member averages 500 feet (152 m) in thickness and consists of an alternating sequence of fluvially deposited sandstone, siltstone, shale, carbonaceous shale and lignite. In general, the sandstones are fine grained and poorly cemented. Shales range from soft plastic near-clay to moderately indurated claystone. Locally, there are thin, calcareous or silicious concretions. Shales and siltstones

readily break down and form gentle slopes beneath the sandstone ledges.

Golden Valley Formation - Eocene.

This formation consists of about 200 feet (61 m) of alternating shales, siltstones, and crossbedded sandstones. These sediments, which comformably overlie the Sentinel Butte member, have been eroded away in much of the study area.

Channel Deposits - Pleistocene.

Sand and gravel channel deposits of an indeterminate thickness lie beneath early Wisconsinan glacial till and Quaternary alluvium in the area.

Glacial Till - Pleistocene.

The glacial till is a heterogeneous mixture of clay, silt, sand, gravel, cobbles, and boulders which was deposited during Wisconsinan episodes of continental glaciation.

Eolian Deposits - Pleistocene and Recent.

Unconsolidated dune and loess-like deposits from several inches to more than five feet thick, mantle most of the study area. The loess-like deposits consist of silty clays, clayey silt, and silty to clayey sands and are probably of late Pleistocene to Recent age. Recent dunes, consisting of silts and very fine grained uniform sand, have been deposited on the lee side of knobs and ridges.

Alluvium - Recent.

Alluvium consisting of clay, silt, sand, and gravel mantles valley floors in the study area.

STRUCTURE

Regionally, the Knife River KRCRA is located on the southeastern flank of the Williston Basin, approximately 60 miles (97 km) from the basin center. Generally, the sedimentary units are flat lying or gently undulating, with a northward to northeastward regional dip ranging from less than 10 feet per mile (1.9 m per km) to 180 feet per mile (34 m per km). Upper strata have been warped into a gentle syncline with a northeast to southwest trending axis located approximately 10 miles (16 km) east of the town of Dodge. The dips on the flanks of the syncline are approximately 18 feet per mile (3.4 m per km). Major faulting has not been observed in the area (Menge, 1977). Surficial materials generally mask most of the older stratigraphic units, making it difficult to assess the importance of minor faulting.

DEPOSITIONAL ENVIRONMENTS OF THE LIGNITES

Many of the Ludlow member lignites are of small areal extent, display lenticularity and are interbedded with distributary channels indicative of deposition in a delta plain.

The thinner Ludlow lignites are laterally more extensive than the lenticular beds; there is evidence of them having been deposited on the plains of abandoned delta lobes (Rehbein, 1977).

The Tongue River lignites differ from the Ludlow lignites of deltaic origin in that they are thicker and laterally more extensive. The HT Butte bed at the top of the Tongue River Formation can be traced over thousands of square miles. The lignite beds of the Tongue River member in contrast to the Ludlow lignites were formed in large swamps adjacent to fluvial channels (Rehbein, 1977).

The Sentinel Butte lignites, though fewer in number, are almost as continuous as the Tongue River lignites and had a similar depositional environment.

COAL GEOLOGY

Seven major coal beds and several local coal beds are either mapped at the surface or identified in the subsurface in quadrangles surrounding and adjacent to the Marshall SE quadrangle. Because of the laterally continuous nature of the Knife River coal beds, it is reasonable to expect the extension of them into this quadrangle. The H Lignite coal bed is stratigraphically the lowest recognized coal bed. It is successively overlain by non-coal bearing rocks approximately 125 feet (38.1 m) thick; the Garner Creek coal bed; a sequence rock approximately 190 feet (57.9 m) thick containing a local coal bed and Local 5 (a local coal bed correlatable between

several quadrangles); the Meyer coal bed, a sequence of non-coal bearing rocks approximately 45 feet (13.7 m) thick; the HT Butte coal bed; a sequence of non-coal bearing rocks approximately 105 feet (32.0 m) thick; the Hazen coal bed; a sequence of rock which averages 175 feet (53.3 m) thick, and includes one local coal bed (Local 3, a local coal bed correlatable between several quadrangles); the Beulah-Zap coal bed; a sequence of non-coal bearing rocks which averages 80 feet (24.4 m) thick; and the Schoolhouse coal bed. Table 1 and Figure 1 show the coal bed names and their stratigraphic position.

On the Marshall, Marshall NW and Schaffner Creek quadrangles to the north, drill hole data indicate that the H Lignite coal bed varies in thickness from 3 to 7 feet (0.9 to 2.1 m); the Garner Creek coal bed varies in thickness from 8 to 13 feet (2.4 to 4.0 m); the Meyer coal bed varies in thickness from 4 to 17 feet (1.2 to 5.2 m); the HT Butte coal bed varies in thickness from 4 to 8 feet (1.2 to 2.4 m); the Hazen coal bed varies from 1 to 8 feet (0.3 to 2.4 m); the Beulah Zap coal bed varies from 0 to 19 feet (0 to 5.8 m); and the Schoolhouse coal bed varies from 2 to 8 feet (0.6 to 2.4 m).

To the east of the Marshall SE quadrangle, the drill hole data on the Willow Creek West quadrangle indicate that the Hazen coal bed is approximately 11.5 feet (3.5 m) thick; the

Table 1 -- Coal Bed Names and Stratigraphic Position

Bed Name	Stratigraphic Equivalent
Schoolhouse	Otter Creek
↑ 80 ft ↓	
Beulah-Zap	Dunn Center, Herman
↑ 115 ft ↓	
Local 3	
↑ 60 ft ↓	
Hazen	Spear, Hazen "B", Kruckenberg, Red Butte
↑ 105 ft ↓	
HT Butte	Hazen "A", Garrison Creek, Yeager, Hagel, Berg, Keuther, Stanton
↑ 45 ft ↓	
Meyer	
↑ 45 ft ↓	
Local 5	
↑ 145 ft ↓	
Garner Creek	
↑ 125 ft ↓	
H Lignite	

Beulah-Zap coal bed varies in thickness from 3.5 to 4 feet (1.1 to 1.2 m); and the Schoolhouse coal is approximately 5.5 feet (1.7 m) in thickness. The H Lignite, Garner Creek and Meyer coal beds were not intersected by drill holes in the Willow Creek West quadrangle.

On the closest drill hole, which is located approximately 0.5 miles (0.8 km) north of the northern quadrangle boundary, the H Lignite is the lowermost coal bed and is 7 feet (2.1 m) thick. It is successively overlain by 112 feet (34.1 m) of rock; the Garner Creek coal bed which is 13 feet (4.0 m) thick; 98 feet (29.9 m) of rock; the Meyer coal bed which is 4 feet (1.2 m) thick; 68 feet (20.7 m) of rock; the HT Butte coal bed which is 4 feet (1.2 m) thick; and 350 feet (106.7 m) of overburden which includes a local bed (Local 4, a local bed correlatable between adjacent quadrangles) which is 8 feet (2.4 m) thick.

The coal beds of the Fort Union Formation in the Knife River area are lignite in rank and contain 0.4 to 1.2 percent sulfur, less than 10 percent ash, with caloric values ranging from 5910 to 7300 BTU/lb (Table A-1). Coal analyses indicate that these coals have less than or about the same amount of trace elements as coal beds in other areas of the northern Great Plains coal province (Tables A-2 through A-5).

COAL DEVELOPMENT POTENTIAL

Coal development potential for all mining methods (surface, subsurface and in situ gasification) in this quadrangle is rated unknown, because of insufficient data for their evaluation.

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APPENDIX A

PROXIMATE AND ELEMENTAL ANALYSES

Table A-1 Proximate Analyses (as received)

Bed Name	No. of Samples	Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Sulphur (Ultimate) %	Btu/lb*	Data Source
HT Butte	2	36.6	27.9	29.5	5.9	0.7	6970	Pollard et al., 1972
HT Butte	2	32.4	31.6	30.3	5.9	0.7	7024	Brant, 1953
HT Butte	3	35.5	28.6	31.1	4.9	0.5	7150	Johnson & Kunkel, 1959
Hazen	1	41.0	25.9	28.9	4.2	0.5	6290	Johnson & Kunkel 1959
Beulah-Zap	15	36.1	26.9	30.7	6.2	0.73	6890	Sondreal, Kube Elder, 1968
Beulah-Zap	3	34.0	29.0	29.0	8.0	0.8	6800	Pollard, et al., 1972
Beulah-Zap	1	39.5	28.3	25.3	6.9	0.4	5910	Johnson & Kunkel, 1959
Beulah-Zap	2	35.7	28.5	30.8	4.9	0.6	7018	Brant, 1953
Beulah-Zap	2	35.88	27.66	30.18	6.27	1.00	6566	Leonard, et al., 1925
Beulah-Zap	4	36.3	28.1	29.6	6.0	1.16	7028	USGS & Mont.Bur. of Mines & Geol. 1976
Beulah-Zap	10	29.6	29.6	34.2	6.7	0.5	7330	Swanson et al., 1976
Schoolhouse	1	35.8	26.9	31.7	6.6	1.0	6910	Pollard, et al., 1972
Schoolhouse	3	38.1	27.5	28.7	5.7	1.2	6720	Johnson & Kunkel 1959
Ave. Dunn Co.	-	40.6	-	-	7.0	0.6	6310	USDI, 1977
Ave. N.D.	-	36.0	28.0	29.0	6.0	0.7	6600	Leonard, et al., 1925

* To convert Btu/lb to Kilojoules/Kilogram, multiply by 2.326

Table A-2 -- Elemental Analysis of HT Butte Coal Bed

Element	Concentration in % Sample No.* D-80824	Sample No.* D-80825	Sample No.* D-80823
Sulphur	0.6	0.4	0.4
Hydrogen	6.8	6.9	6.9
Carbon	41.5	43.1	42.3
Nitrogen	0.7	0.6	0.7
Oxygen	44.0	45.0	45.5

*Johnson and Kunkel, 1959.

Table A-3 -- Elemental Analysis of Hazen Coal Bed

Element	Concentration-in % Sample No.* D-55178	Sample No.* 49875
Sulphur	0.5	
Hydrogen	7.0	
Carbon	38.0	
Nitrogen	0.6	
Oxygen	49.7	
U		0.0001
Ge**		ND
Ga**		0.002
V**		0.005
Cu**		0.004
Cr**		0.002
Zn**		0.01
Ni**		0.005
Co**		0.002
Be**		0.0003
Y**		0.01
La**		0.02
Mo**		ND

* Johnson and Kunkel, 1959
** Results in percent of ash

Table A-4 -- Elemental Analysis of Beulah-Zap Coal Bed

Element	Concentration in % Sample No.* 49879	Sample No.*** ND-KR-Bu	Sample No.**** ND-TT-DS	Sample No.***** D175930 to D17539
Sulphur				0.5
Hydrogen				6.2
Carbon				44.6
Nitrogen				0.7
Oxygen				41.3
U	0.0003			0.00005
Ge**	ND	0.001	ND	ND
Ga**	0.002	0.002	0.004	0.0015
V**	0.008	0.005	0.007	0.0035
Cu**	0.005	0.007	0.02	0.0055
Cr**	0.006	0.005	0.004	0.0025
Zn**	ND	ND	ND	0.0025
Ni**	0.005	0.003	0.006	0.0020
Co**	0.002	0.001	0.002	0.0010
Be**	0.0002	0.0008	0.0008	0.0003
Y**	0.01	0.004	ND	0.0025
La**	0.01	0.004	ND	0.01
Mo**	ND	0.002	0.004	0.0010
B**		0.24		0.110
Ti**		0.2		0.70******
Sn**		ND		---

* Johnson and Kunkel, 1959
** Results in percent of ash
*** Zubovic et al., 1961, average of 4 samples
**** Zubovic et al., 1961, average of 2 samples
***** Swanson et al., 1976
****** as TiO_2

Table A-5 - Elemental Analaysis of Schoolhouse Coal Bed

	Concentrations in %				
Element	Sample No.* D-55179	Sample No.* D-55176	Sample No.* D-55175	Sample No.* 49874	Sample No.* 49880
Sulphur	0.9	0.5	2.1		
Hydrogen	7.1	6.9	6.7		
Carbon	39.9	40.4	39.2		
Nitrogen	0.6	0.6	0.6		
Oxygen	46.4	47.4	43.6		
U				0.0001	0.0001
Ge**				ND	ND
Ga**				0.002	0.002
V**				0.01	0.006
Cu**				0.02	0.004
Cr**				0.007	0.005
Zn**				0.7	0.06
Ni**				0.002	0.003
Co**				0.001	0.001
Be**				0.001	0.0007
Y**				0.01	ND
La**				0.02	ND
Mo**				ND	ND

* Johnson and Kunkel, 1959
** Results in percent of ash