UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Text to Accompany:

COAL RESOURCE OCCURRENCE MAP OF THE GARRISON DAM NORTH QUADRANGLE, MERCER AND MCLEAN 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 Garrison Dam North 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 of coal per section is presented on the Boundary and Coal Data Map, Plate 2. A composite section of the projected geology of this quadrangle is shown in 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 prograsm is in responset to the Federal Coal Leasing Amendments Act of 1975 and is part of the United States Geological Survey's (USGS)

COMPOSITE COLUMNAR SECTION, GARRISON DAM NORTH

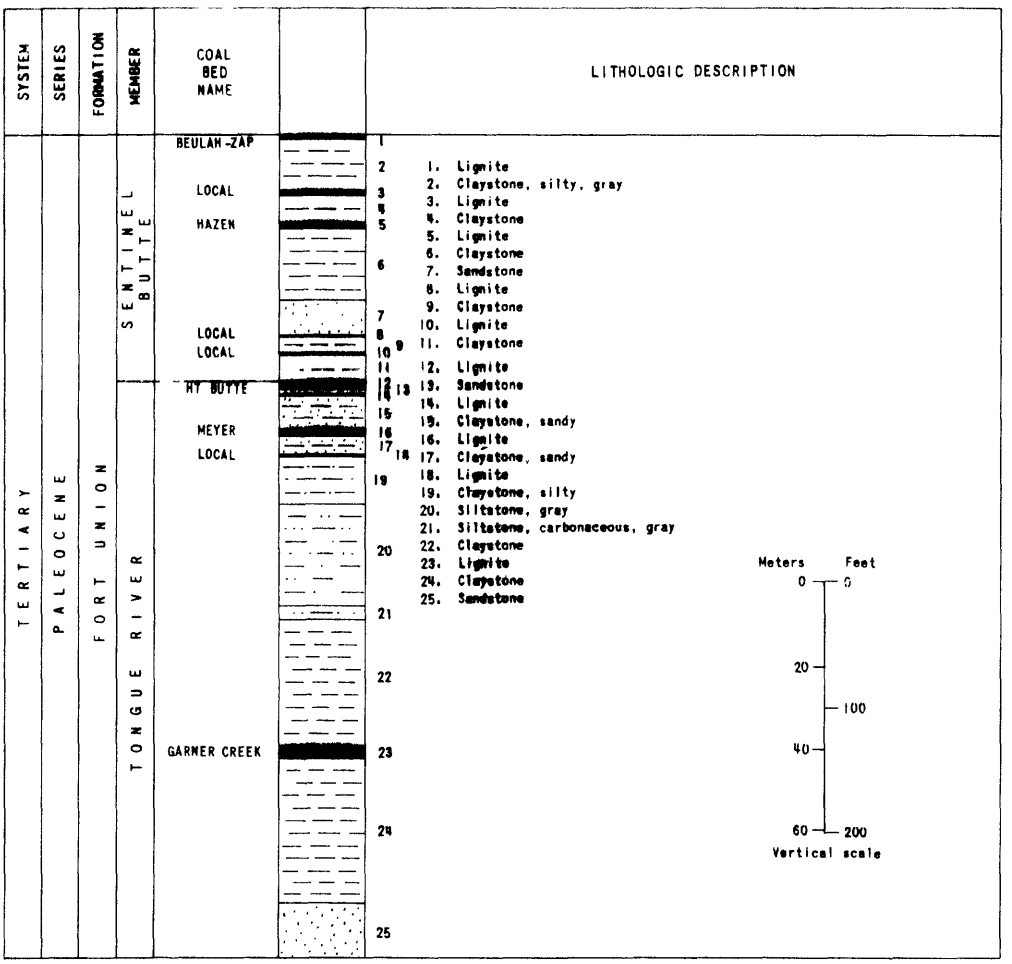

FIG. 1

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 Garrison Dam North 7 1/2 minute quadrangle is located in northern Mercer County and southern McLean County, North Dakota about 2 miles (3.2 km) south of Garrison and 1/2 miles (0.8 km) north of Riverdale.

ACCESSIBILITY

The area is accessible by State Highway 200 which passes through the southern section of the quadrangle and connects with State Highway 83 twelve miles (19.3 km) to the east. State Highway 83 connects with Interstate 94 at Bismarck, 66 (106.2 km) to the south.

The Soo Line Railroad operates and maintains a north-south route which extends through Garrison and Underwood and passes through the northeast corner of the quadrangle.

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 plateau. This area known collectively as "the Badlands" comprises an intricate maze of narrow ravines, sharp crested ridges and pinnacles.

The Garrison Dam North quadrangle may be characterized as gently rolling to hilly and is heavily dissected by stream drainage near the shore of Lake Sakakawea. The maximum relief across the quadrangle is 300 feet (91.4 m). Numerous shallow drainages feed into Lake Sakakawea throughout 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 17.2 inches (43.7 cm) at Beulah which is located 22 miles (35.4 km) southwest 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 43°F (6.1°C) temperatures as recorded at the Beulah weather station by the U.S. Department of Commerce, can range from 105°F (40.6°C) in summer months to -27°F (-32.8°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 northern one-half of the Knife River Known Recoverable Coal Resources Area (KRCRA). The Federal Government owns the coal rights to approximately 5 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 and surrounding 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 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 Garrison Dam North quadrangle is based on geologic data from Emmet SE and Garrison Dam South quadrangles. The oldest rocks present in the uppermost 600 feet (182.9 m) of stratigraphic section in the Garrison Dam North quadrangle are the Paleocene age 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.

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 and shale, and lignite. It conformably overlies the Cannonball member and the time-equivalent, nonmarine Ludlow member. 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 approximately 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 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 conformably overlie the Sentinel Butte member, have been eroded away in much of the study area.

Channel Deposits - Pleistocene.

Sand and gravel channel deposits of 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 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 (3.0 m) 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

The Tongue River lignites are thick and laterally 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 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

Four 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 Garrison Dam North quadrangle. Because of the laterally continuous nature of the

Knife River coal beds, it is reasonable to expect their extension into this quadrangle. The Garner Creek coal bed is stratigraphically the lowest recognized coal bed. It is successively overlain by a rock interval approximately 245 feet (74.7 m) thick containing one local coal bed; the Meyer coal bed; non-coal bearing rocks approximately 30 feet (9.1 m) thick; the HT Butte coal bed; a rock interval approximately 125 feet (38.1 m) thick containing one local bed; the Hazen coal bed; a rock interval approximately 65 feet (19.8 m) thick containing one local bed; and the Beulah-Zap coal bed. Figure 1 and Table 1 show the coal bed names and their stratigraphic position.

Drill hole data from the Hazen NE, Garrison Dam South, and Riverdale South quadrangles to the south, indicate that the Meyer coal bed varies in thickness from 7 to 9 feet (2.1 to 2.7 m); the HT Butte coal bed varies in thickness from 7 to 17 feet (2.1 to 5.2 m); the Hazen coal bed varies from 2.5 to 14 feet (0.8 to 4.3 m); and the Beulah Zap coal bed varies from 1 to 7 feet (0.3 to 21 m). The H Lignite, Garner Creek and Schoolhouse coal beds were not penetrated by drilling.

The closest drill hole located approximately 1 mile (1.6 km) to the south, the Meyer is the lowerst coal bed. It measures 7 feet (2.1 m) and is successively overlain by 17 feet (5.2 m) of rock; the HT Butte coal bed which is 7 feet (2.1 m) thick and overlain by approximately 109 feet (33.2 m) of rock;

Table 1 -- Coal Bed Names and Stratigraphic Position

Bed Name	Other Names
Beulah-Zap	Dunn Center, Herman
↑	
65 ft	
↓	
Hazen	Spur, Hazen "B" Kruckenberg, Red Butte
↑	
125 ft	
↓	
HT Butte	Hazen "A", Garrison Creek, Yeager, Hagel, Berg
↑	
30 ft	Keuther, Stanton
↓	
Meyer	-----
↑	
245 ft	
↓	
Garner Creek	

the Hazen coal bed which is 2.5 feet (0. m) thick and overlain by 170 feet (51.8 m) of rock; and the Beulah-Zap coal bed which is 1 foot (0.3 m) thick and overlain by 51 feet (15.5 m) thick.

The coal beds of the Fort Union Formation in the Knife River KRCRA area are lignite in rank and contain 0.4 to 1.2 percent sulfur, less than 10 percent ash and between 5900 and 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-4).

COAL DEVELOPMENT POTENTIAL

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

REFERENCES

Bauer, C.M., and Herald, F.A., 1921, Lignite in the western part of the Fort Berthold Indian Reservation south of Missouri River, North Dakota: U.S. Geological Survey Bulletin 726-D, 77 p.

Bensen, W.E., 1951, Geologic map of North Dakota southwest of the Missouri River: U.S. Geological Survey Preliminary Map, Scale 1:500,000.

_____, 1953, Geology of the Knife River area, North Dakota: U.S. Geological Survey Open-File Report 1953, 323 p.

Bluemle, J.P., 1971, Geology of McLean County, North Dakota: North Dakota Geological Survey, Bulletin 60, Part I, 65 p.

Brant, R.A., 1953, Lignite resources of North Dakota: U.S. Geological Survey Circular 226, 78 p.

Carlson, C.G., 1972, Stratigraphic position of lignite beds in Tertiary rocks of Mercer and Oliver Counties, North Dakota, in Ting, T.T.C. (Ed), Depositional environments of the lignite-bearing strata in western North Dakota: North Dakota Geological Survey Guidebook No. 3, Miscellaneous Series No. 50, p 95-104.

_____, 1973, Geology of Mercer and Oliver Counties, North Dakota: North Dakota Geological Survey Bulletin 56, Part I, 72 p.

Clayton, Lee, 1969, Geologic map of Dunn County, North Dakota: North Dakota Geological Survey Miscellaneous Map 11, Scale 1:2 miles.

Colton, R.B., Lemke, R.W., and Lindvall, R.M., 1963, Preliminary glacial map of North Dakota: U.S. Geological Survey Miscellaneous Geological Investigations Map I-331, Scale 1:500,000.

Croft, M.G., 1970, Ground water basic data, Mercer and Oliver Counties, North Dakota: North Dakota State Water Commission County Ground Water Studies 15, Part II, 268 p.

Electric Log Services, Inc., 1977, Electrical, radioactivity and hydrocarbon survey: Rocky Mountain Well Log Service Index to Northern Rockies, 1702 p.

REFERENCES (Continued)

Hainer, J.L., 1956, The geology of North Dakota: North Dakota Geological Survey Bulletin 31, 52 p.

Hancock, E.T., 1921, The New Salem lignite field, Morton County, North Dakota: U.S. Geological Survey Bulletin 726-A, 39 p.

Johnson, W.D., and Kunkel, R.P., 1959, The Square Buttes coal field, Oliver and Mercer Counties, North Dakota: U.S. Geological Survey Bulletin 1076, 91 p.

Klausing, R.L., 1971, Ground water basic data, McLean County North Dakota: North Dakota State Water Commission County Ground Water Studies 19, Part II, 468 p.

_____, 1974, Ground water resources of McLean County North Dakota: North Dakota State Water Commission County Ground Water Studies 19, Part III, 73 p.

_____, 1976, Ground water basic data for Dunn County, North Dakota: North Dakota State Water Commission County Ground Water Studies 25, Part II, 501 p.

Law, R., 1977, Preliminary report on the geology of the near-surface coal beds in the Knife River area, North Dakota: U.S. Geological Survey Open File Report 77-481, 12 p.

Leonard, A.G. Babcock, E.J., and Dove, L.P., 1925, The lignite deposits of North Dakota: North Dakota Geological Survey Bulletin No. 4, 240 p.

Menge, M., 1977, A preliminary report on the near-surface Federal Coal Reserve Base underlying the south half of the Dunn Center Lignite Field, Dunn County, North Dakota: U.S. Geological Survey Open-File Report, in preparation, 127 p.

North Dakota Geological Survey, 1973, Mineral and water resources of North Dakota: North Dakota Geological Survey Bulletin 63, 252 p.

_____, 1977, Unpublished Summary of 1977 Drilling, 19 p.

Pollard, B.C., Smith, J.E., and Knox, C.C., 1972, Strippable lignite reserves of North Dakota, location, tonnage, and characteristics of lignite and overburden: U.S. Bureau of Mines Information Circular 8537, 37 p.

REFERENCES (Continued)

Rehbein, E.A., 1977, Preliminary report on stratigraphy and depositional environments of the lignites in the Fort Union Formation, west-central North Dakota: U.S. Geological Survey Open-File Report 77-69, 23 p.

Royse, C.F. & Jr., 1967, Tongue River-Sentinel Butte contact in western North Dakota: North Dakota Geological Survey Report of Investigation No. 45, 53 p.

_____, 1971, A sedimentologic analysis of the Tongue River-Sentinel Butte interval (Paleocene) of the Williston Basin, western North Dakota: North Dakota Geological Survey Miscellaneous Series No. 43, 80 p.

_____, 1972, the Tongue River and Sentinel Butte Formations (Paleocene) of western North Dakota, In Ting, T.T.C. (Ed), Depositional environments of the lignite-bearing strata in western North Dakota: North Dakota Geological Survey Guidebook No. 3, Miscellaneous Series No. 50. p 31-42.

Sondreal, E.A., Kube, W.R., and Elder, J.L., 1968, Analysis of the Northern Great Plains province lignite and their ash -- A study of variability: U.S. Bureau of Mines Report Inv. 7158, 94 p.

Swanson, Vernon E. et.al., 1976, Collection, chemical analysis and evaluation of coal samples in 1975, U.S. Geological Survey Open-File Report 76-468, 503 p.

United States Department of Interior, 1977, Resource and potential reclamation evaluation of Horse Nose Butte study area. Dunn Center lignite field: U.S. Department of Interior EMRIA Report No. 9, 83 p.

United States Geological Survey and Montana Bureau of Mines and Geology, 1976, Preliminary report of coal beds in Campbell and Sheridan Counties, Wyoming: Custer, Praire, Garfield Counties, Montana; and Mercer County, North Dakota: U.S. Geological Survey Open-file Report 76-319, 377 p.

United States Geological Survey and North Dakota Geological Survey, 1976, Preliminary report on 1975 drilling of lignites in western North Dakota: Adams, Bowman, Dunn, Hettinger, McLean, Mercer, Oliver, Slope, and Williams Counties: U.S. Geological Survey Open-File Report 76-869, 144 p.

REFERENCES (Continued)

_____, 1977, Preliminary report of 1976 drilling of lignites in western North Dakota: Adams, Billings, Dunn, Hettinger, McKenzie, Mercer, Morton, Oliver, Slope, and Stark Counties: U.S. Geological Survey Open-File Report 77-857, 336 p.

Zubovic, Peter, Stadnichanko, Taisia, and Shaffey, N.B., 1961, Geochemistry of minor elements in coals of the Northern Great Plains coal province: U.S. Geological Survey Bulletin 117-A, 58 p.

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

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

Element	Concentrations in % 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