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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE MINNEHAHA CREEK SOUTH QUADRANGLE, TREASURE AND BIG HORN COUNTIES, MONTANA

[Report includes 16 plates]

By

Colorado School of Mines Research Institute

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[Plates are in pocket]

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Conversion table

To convert	Multiply by	To obtain
feet	0.3048	meters (m)
miles	1.609	kilometers (km)
acres	0.40469	hectares (ha)
tons (short	0.907	metric tons (t)
short tons/acre-ft	7.36	metric tons/hectare-meter (t/ha-m)
Btu/lb	2.326	kilojoules/kilogram (kJ/kg)

INTRODUCTION

Purpose

This text is for use in conjunction with the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) maps of the Minnehaha Creek South quadrangle, Treasure and Big Horn Counties, Montana, (16 plates; U.S. Geological Survey Open-File Report 78-833). This set of maps was compiled to support the land planning work of the Bureau of Land Management in response to the Federal Coal Leasing Amendments Act of 1975, and to provide a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRAs) in the western United States. Coal beds considered in the resource inventory are only those beds 5 feet (1.5 m) or more thick and under less than 3,000 feet (914 m) of overburden.

Location

The Minnehaha Creek South 7 1/2-minute quadrangle is in southern Treasure and northeastern Big Horn Counties, Montana, about 23 miles (37 km) south of Hysham, Montana, a town in the Yellowstone River valley about 71 miles (114 km) west-southwest of Miles City and 78 miles (125 km) east of Billings. U.S. Interstate Highway 94 and the main east-west route of the Burlington Northern Railroad follow the Yellowstone River and pass through Hysham.

Accessibility

The Minnehaha Creek South quadrangle is accessible from the north by the Sarpy Road, an improved, graveled road which passes through the

southwest corner of the quadrangle and connects with U.S. Interstate Highway 94 about 29 miles (46 km) to the north. Additional roads, most of them unimproved, connect other parts of the quadrangle with the Sarpy Road. The quadrangle is also accessible from Hardin, Montana, a small town about 50 miles (80 km) east of Billings, Montana, on U.S. Interstate Highway 90. This access route exits U.S. Interstate Highway 90 at the Sarpy Road intersection 2 miles (3.2 km) east of Hardin; thence it goes east-northeast on an improved, graveled road about 25 miles (40 km) to the Spring Creek School intersection, and from there 3.5 miles (5.6 km) north to the southwest corner of the Minnehaha Creek South quadrangle.

A railroad spur runs south from the main east-west line of the Burlington Northern Railroad near Hysham, parallel with the Sarpy Road, about 35 miles (56 km) to the Absaloka coal mine located in the Wolf School quadrangle about 4 miles (6 km) south of the Minnehaha Creek South quadrangle. The railroad spur passes through the southwest corner of the Minnehaha Creek South quadrangle.

Physiography

The Minnehaha Creek South quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. Most of the quadrangle has been dissected by tributaries of Sarpy Creek, which flows northward near the west boundary of the quadrangle. The primary drainages in the quadrangle are Minnehaha and Horse Creeks, which flow westward to Sarpy Creek.

The highest elevations in the quadrangle are near the southeast corner, at the northwest extremity of the Little Wolf Mountains. Elevations of

the high ridges reach 3,860 feet (1,177 m). The lowest elevations, about 3,040 feet (927 m) are in the stream valleys just south of the northwest corner of the quadrangle. The topographic relief is 820 feet (250 m).

Climate

The climate of Treasure and Big Horn Counties is characterized by pronounced variations in seasonal precipitation and temperature. Annual precipitation in the region varies from less than 12 inches (30 cm) to 16 inches (41 cm). The heaviest precipitation is from April to August. The largest average monthly precipitation is during June. Temperatures in eastern Montana range from as low as -50 °F (-46 °C) to as high as 110 °F (43 °C). The highest temperatures occur in July and the lowest in January; the mean annual temperature is about 45 °F (7 °C) (Matson and Blumer, 1973, p. 6).

Land status

The Northern Powder River Basin Known Recoverable Resource Area (KRCRA) boundary is drawn around the areas of higher elevation in the east half of the Minnehaha Creek South quadrangle, as shown by the Coal Data Map (pl. 2). This map also shows the land ownership status. There were no outstanding Federal coal leases or prospecting permits of record as of 1977.

The map shows the position of the east boundary of the Crow Indian Reservation established in 1868, located about 0.5 mile (0.8 km) west of the east boundary of the quadrangle. The U.S. Government obtained these tribal lands from the Crow Indians by cession in 1899, examined the lands

for coal, and disposed of the noncoal lands. In 1958 the U.S. Government returned what remained of the Federal coal lands west of the old boundary line to the Crow Indian Tribe. The only remaining Federal coal lands at present are east of the boundary line. Specific coal bed maps and coal reserve determinations in this report are limited to the Federal lands east of the old boundary.

GENERAL GEOLOGY

Previous work

Rogers and Lee (1923) mapped the Minnehaha Creek South quadrangle as part of the Tullock Creek coal field, Rosebud and Big Horn Counties, Montana.

Stratigraphy

A generalized columnar section of the coal-bearing rocks is shown on the Coal Data Sheet (pl. 3) of the CRO maps. The exposed bedrock units belong to the Fort Union Formation (Paleocene), which is composed of three members: the upper Tongue River Member, the middle Lebo Shale Member, and the lower Tullock Member. Rogers and Lee (1923, p. 29) represented the Tullock to be a member of the Lance Formation, but since 1949 the U.S. Geological Survey has considered the Tullock to be the lowermost member of the Fort Union Formation in Montana.

The upper part of the Tullock Member crops out in the bottoms of Minnehaha Creek and other tributaries of Sarpy Creek in the northwest quarter of the quadrangle. The Tullock Member is 289 to 313 feet (88 to 95 m)

thick and is composed of light-colored sandstone, sandy shale, carbonaceous shale, and several thin coal beds (Rogers and Lee, 1923, p. 29, 30).

The Lebo Shale Member crops out in the lower elevations across the northern and western parts of the quadrangle. The Lebo Shale Member is 135 to 155 feet (41 to 47 m) thick and consists of soft, dark-gray to olive-gray and drab shale with a few beds of gray or yellow sandstone (Rogers and Lee, 1923, p. 35). The strata weather into treeless slopes and badlands. The Lebo Shale Member may carry two thin coal beds, lying about 20 to 70 feet (6 and 21 m) below the top of the member. However, only rarely are these found to contain as much as 1.5 feet (0.46 m) of even moderately clean coal (Rogers and Lee, 1923, p. 39).

The Tongue River Member forms the exposed bedrock unit throughout the higher elevations of the eastern and southern areas of the quadrangle. The Tongue River Member consists of light-colored sandstone, sandy shale, and several important coal beds. The thicker coal beds have burned along the outcrop and have fused the overlying rock into slag or reddish-colored clinker. The Tongue River Member is at least 1,275 feet (389 m) thick in the [Little] Wolf Mountains, about 7 miles (11 km) to the southeast (Rogers and Lee, 1923, p. 41); however, in the Minnehaha Creek South quadrangle most of the member has been removed by erosion so that only about 675 feet (206 m) remain.

Coal and other rocks comprising the Tongue River Member were deposited in a continental environment at elevations of perhaps a few tens of feet (a few meters) above sea level in a vast area of shifting flood plains,

sloughs, swamps, and lakes that occupied the Northern Great Plains in Paleocene (early Tertiary) time.

Representative samples of the sedimentary rocks overlying and interbedded with minable coal beds in the eastern and northern Powder River Basin have been analyzed for the trace element content by the U.S. Geological Survey and the results summarized by the U.S. Department of Agriculture and others (1974) and by Swanson (in Mapel and others, 1977, pt. A, p. 42-44). The rocks contain no greater amounts of trace elements of environmental concern than do similar rock types found throughout other parts of the western United States.

Structure

The Minnehaha Creek South quadrangle is in the northwestern part of the Powder River structural basin. The strata in general dip southeastward at about 60 feet per mile (11.4 m per km) or less. In places the regional structure is modified by low relief folds (Rogers and Lee, 1923, pl. 10).

COAL GEOLOGY

Six coal beds, all in the Tongue River Member, are mapped on the surface in this quadrangle (pl. 1) or are shown in section on plate 3. Only four of these are of sufficient thickness to contain economic reserves. The stratigraphically lowest of these four is the Robinson coal bed, which is about 100 feet (30.5 m) above the base of the Tongue River Member. The coal is overlain successively by a noncoal interval of about 60 feet (18 m), the Stocker Creek coal bed, a noncoal interval of 60 feet (18 m), the Rosebud-McKay coal bed, a noncoal interval of 30 feet (9 m), and the Q coal bed.

The trace element content of coals in the quadrangle has not been determined; however, coals in the Northern Great Plains, including those in the Fort Union Formation in Montana, have been found to contain, in general, appreciably lesser amounts of most elements of environmental concern than coals in other areas of the United States (Hatch and Swanson, 1977, p. 147).

Robinson coal bed

The Robinson coal bed was first described by Dobbin (1930, p. 27) from outcrops on the Robinson Ranch in the McClure Creek quadrangle adjacent to the Minnehaha Creek South quadrangle on the east. The Robinson coal bed crops out on the valley slope south of Minnehaha Creek in the north half of the quadrangle, and on the valley slopes of Horse Creek in the south half of the quadrangle.

The detail maps (structure, isopach, etc.) of the coal beds with economic reserves are limited to the area containing Federal coal, the narrow strip along the east boundary of the quadrangle. Within this area the Robinson coal bed dips gently southward, about 10 feet per mile (1.9 m per km), and increases from 5 to 17 feet (1.5 to 5.2 m) in thickness (pl. 10). The overburden on the Robinson coal bed ranges from zero to over 400 feet (122 m) in thickness (pl. 11). This overburden includes the Stocker Creek, Rosebud-McKay, and Q coal beds where unburned.

There are no known published chemical analyses of the Robinson coal. However, there is an available analysis of the Rosebud coal bed which overlies the Robinson coal bed, located 3 miles (4.8 km) east of the Minnehaha Creek South quadrangle. It is assumed that the Robinson coal is similar in rank to the Rosebud coal in this area and is subbituminous B.

Stocker Creek coal bed

The Stocker Creek coal bed was first described by Dobbin (1930, p. 27) from outcrops near the head of Stocker Creek (Colstrip West and Trail Creek School quadrangles) in the Forsyth coal field, about 10 miles (16 km) east of the Minnehaha Creek South quadrangle. The Stocker Creek coal bed crops out on the valley slopes 60 feet (18 m) above the Robinson coal bed, but is confined to the north half of the quadrangle (pl. 1). Structure contours on top of the Stocker Creek coal bed conform to structure on the other coal beds in the quadrangle, dipping gently southward. The thickness increases southward from 2.6 feet to over 7 feet (0.8 to over 2.2 m), as shown on plate 13. Overburden on the Stocker Creek coal bed ranges up to 400 feet (122 m) in thickness (pl. 14). This overburden includes the Rosebud-McKay and Q coal beds where uneroded and unburned.

There are no known published chemical analyses of the Stocker Creek coal. However, there is an analysis of the Rosebud-McKay coal bed which overlies the Stocker Creek coal bed, located 3 miles (4.8 km) east of the Minnehaha Creek South quadrangle. It is assumed that the Stocker Creek coal is similar in rank to the Rosebud-McKay coal in this area and is subbituminous B.

Rosebud-McKay coal bed

The Rosebud coal bed was first described by Dobbin (1930, p. 27) for outcrops along Rosebud Creek in the Forsyth coal field. A specific type locality was not given. The McKay coal bed was also described by Dobbin (1930, p. 27) without designating a specific type locality. Throughout much

of the area the McKay bed is considered a split of the Rosebud bed, and the two are called the Rosebud-McKay bed.

The Rosebud-McKay coal bed crops out on the ridges along the east boundary of the north half of the quadrangle. In the south half of the quadrangle, the Rosebud-McKay coal bed crops out on the south valley slope of Horse Creek (pl. 1). The coal has burned in many places along the outcrop forming extensive clinker areas. The coal bed increases in thickness southward from less than 2 feet (0.6 m) to more than 24 feet (7.3 m), as shown on plates 1 and 7. Overburden on the Rosebud-McKay coal bed ranges from zero to more than 300 feet (91 m) in thickness (pl. 8). This overburden includes the Q coal bed where uneroded and unburned.

There are no known published chemical analyses of the Rosebud or McKay coals from the Minnehaha Creek South quadrangle. However, a chemical analysis of the Rosebud coal from drill hole RB-66 in sec. 13, T. 2 N., R. 38 E. in the Trail Creek School quadrangle about 3 miles (4.8 km) east of the Minnehaha Creek South quadrangle shows ash 11.17 percent, sulfur 0.68 percent, and heating value 8,820 Btu per pound on an as-received basis. This heating value converts to about 9,900 Btu per pound on a moist, mineral-matter-free basis, indicating that the coal is subbituminous B in rank.

Q coal bed

The Q coal bed was named by Rogers and Lee (1923, p. 75) from outcrops in the southeast part of the Tullock coal field, Rosebud and Big Horn Counties, Montana.

The Q coal bed is separated from the Rosebud coal bed below it by a noncoal interval of about 30 feet (9.1 m), and it may actually be a split of the Rosebud. If so, it appears to be a stratigraphic equivalent of the Lee coal bed as mapped in quadrangles to the east of the Minnehaha Creek South quadrangle.

The Q coal bed crops out around the higher elevations in the southeast quarter of the Minnehaha Creek South quadrangle. The gentle dip southward conforms to the structure of the coal beds below. The thickness of the Q coal bed increases from less than 4 feet (1.2 m) to more than 7 feet (2.1 m) within the narrow strip east of the old 1868 Crow Reservation boundary (pl. 4). Rogers and Lee (1923, pl. 16) show that the coal bed thickness continues to increase to more than 11 feet (3.35 m) in the next 2 miles (3.2 km) west of the old 1868 boundary. The overburden on the Q bed ranges from zero to over 300 feet (91 m) in thickness (pl. 5).

There are no known published chemical analyses of the Q coal. It is assumed that the Q coal is similar in rank to the Rosebud coal in this area and is subbituminous B.

COAL RESOURCES

Data from all publicly available surface mapping by others (see list of references) were used to construct outcrop, isopach, and structure contour maps of the coal beds in this quadrangle; there are no publicly available drill hole data.

Coal resource tonnages shown in this report are the Reserve Base part of the Identified Resources as discussed in U.S. Geological Survey Bulletin 1450-B.

The Reserve Base for subbituminous coal is coal that is 5 feet (1.5 m) or more thick, under 3,000 feet (914 m) or less of overburden, and located within 3 miles (4.8 km) of a point of coal-bed measurement. Reserve Base is further subdivided into reliability categories according to their nearness to a measurement of the coal bed. Measured coal is coal within 0.25 mile (0.4 km) of a measurement, Indicated coal extends 0.5 mile (0.8 km) beyond Measured coal to a distance of 0.75 mile (1.2 km) from the measurement point, and Inferred coal extends 2.25 miles (3.6 km) beyond Indicated coal to a distance of 3 miles (4.8 km) from the measurement point.

Reserves are the recoverable part of the Reserve Base coal. For surface-minable coal in this quadrangle, the coal reserves are considered to be 85 percent (the recovery factor for this area) of that part of the Reserve Base that is beneath 500 feet (152 m) or less of overburden, the stripping limit for multiple, thin (5 to 40 feet or 1.5 to 12 m thick) beds of subbituminous coal in this area.

Estimated coal resources in the Minnehaha Creek South quadrangle were calculated using data obtained from the coal isopach maps (pls. 4, 7, 10, and 13). The coal-bed acreage (measured by planimeter) multiplied by the average isopached thickness of the coal bed times a conversion factor of 1,770 short tons of coal per acre-foot (13,028 t/ha-m) for subbituminous coal yields the coal resources in short tons of coal for each isopached coal bed. Reserve Base and Reserve tonnage values for the Q, Rosebud-McKay, Robinson, and Stocker Creek coal beds are shown on plates 6, 9, 12, and 15, respectively, and are rounded to the nearest one-hundredth of a million short tons.

The total Reserve Base tonnage of federally owned coal in the Minnehaha Creek South quadrangle is calculated to be 39.46 million short tons (35.79 million t). The Reserve Base tonnage totals per section are shown in the northwest corner of each section on CRO plate 2 and by development potential category in table 1. All numbers are rounded to the nearest one-hundredth of a million short tons. About 0.5 percent of the Reserve Base tonnage is classed as Measured, 15 percent as Indicated, and 84.5 percent as Inferred.

COAL DEVELOPMENT POTENTIAL

Areas where coal beds are 5 feet (1.5 m) or more thick and are overlain by 500 feet (152 m) or less of overburden are considered to have potential for surface mining and were assigned a high, moderate, or low development potential based on the mining ratio (cubic yards of overburden per ton of recoverable coal). The formula used to calculate mining ratios for subbituminous coal is as follows:

$$MR = \frac{t_o\ (0.911)}{t_c\ (rf)}$$

where MR = mining ratio
t_o = thickness of overburden
t_c = thickness of coal
rf = recovery factor = 0.85
0.911 = conversion factor (cu. yds./ton)

Areas of high, moderate, and low development potential are here defined as areas underlain by coal beds having respective mining-ratio values of 0 to 10, 10 to 15, and greater than 15, as shown on CRO maps, plates 5, 8, 11, and 14 for the Q, Rosebud-McKay, Robinson, and Stocker Creek coal beds,

respectively. These mining-ratio values for each development-potential category are based on economic and technological criteria and were provided by the U.S. Geological Survey. Estimated tonnages in each development-potential category are shown in table 1.

Development potential for surface-mining methods

The Coal Development Potential (CDP) map, plate 16, included in this series of maps depicts the highest coal development-potential category which occurs within each smallest legal subdivision of land (normally about 40 acres or 16.2 ha). If such a 40-acre (16.2-ha) tract of land contains areas of high, moderate, and low development potential, the entire tract is assigned to the high development-potential category for CDP mapping purposes, etc.

The coal development potential for surface-mining methods (less than 500 feet or 152 m of overburden) is shown on the Coal Development Potential map (pl. 16). All the tracts of Federal coal lands in the Minnehaha Creek South quadrangle that have any potential for surface mining have a high development potential; some of the Federal coal lands do not have any economically recoverable coal and, therefore, have no development potential.

Development potential for underground mining and in situ gasification

All known economically minable coal in the Minnehaha Creek South quadrangle is within surface-minable depths. Because there are no known underground coal resources below the stripping limit, no Coal Development Potential map for underground mining or estimates of underground resources were made.

In situ gasification of coal on a commercial scale has not been done in the United States. Therefore, the development potential for in situ gasification of coal found below the surface-mining limit in this area is rated as low.

Table 1.--Surface-minable coal resource tonnage by development-potential category for Federal coal land (in short tons) in the Minnehaha Creek South quadrangle, Treasure and Big Horn Counties, Montana

[Development potentials are based on mining ratios (cubic yards of overburden/short ton of recoverable coal). To convert short tons to metric tons, multiply by 0.9072]

Coal bed	High development potential (0-10 mining ratio)	Moderate development potential (10-15 mining ratio)	Low development potential (>15 mining ratio)	Total
Q	1,200,000	500,000	480,000	2,180,000
Rosebud-McKay	11,920,000	800,000	50,000	12,770,000
Stocker Creek	1,000,000	1,140,000	2,450,000	4,590,000
Robinson	10,630,000	7,730,000	1,560,000	19,920,000
Total	24,750,000	10,170,000	4,540,000	39,460,000

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