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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE SARPY SCHOOL QUADRANGLE, BIG HORN, ROSEBUD, AND TREASURE COUNTIES, MONTANA

[Report includes 13 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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ILLUSTRATIONS

[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)	0.9072	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 Sarpy School quadrangle, Big Horn, Rosebud, and Treasure Counties, Montana, (13 plates; U.S. Geological Survey Open-File Report 79-018). 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 1976, 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 Sarpy School 7 1/2-minute quadrangle is in northeastern Big Horn, western Rosebud, and southeastern Treasure Counties, Montana, about 34 miles (54 km) south-southeast 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 Sarpy School quadrangle is accessible from the northwest by way of the Sarpy Road, an improved, graveled road that connects the town of

Hysham, Montana, (34 miles or 54 km to the north-northwest) with the town of Hardin (32 miles or 51 km to the west). The quadrangle is accessible from an intersection 4 miles (6 km) east of Hysham on U.S. Interstate Highway 94, then south on the Sarpy Road about 33 miles (52.8 km) to the Absaloka Coal Mine Road intersection, and then east about 6 miles (9.6 km) to the west border of the quadrangle. The quadrangle is accessible from an intersection 2 miles (3.2 km) east of Hardin on U.S. Highway 90, then east on the Sarpy Road about 27 miles (43.2 km) to the Absaloka Coal Mine Road intersection, and then east about 6 miles (9.6 km) to the west border of the quadrangle. Additional roads, most of them unimproved, lead to other parts of the quadrangle.

The nearest railroad is a spur which runs southward from the main line of the Burlington Northern Railroad near Hysham, parallel with the Sarpy Road, about 35 miles (56 km) to the Absaloka coal mine located near the center of the Wolf School quadrangle, about 4 miles (6.4 km) west of the Sarpy School quadrangle.

Physiography

The Sarpy School quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. Most of the quadrangle has been dissected by East Fork Sarpy Creek and its tributaries which flow northwestward across the quadrangle. The Little Wolf Mountains form a major drainage divide running northward near the east border of the quadrangle, and then curving northwestward across the north half. The highest elevation

is in the Little Wolf Mountains near the center of the northeast quarter of the quadrangle. The highest ridge reaches 4,807 feet (1,465 m). The lowest elevation, just below 3,380 feet (1,030 m) is near the center of the west border where East Fork Sarpy Creek flows out of the quadrangle. The topographic relief is 1,427 feet (435 m).

Climate

The climate of Big Horn, Rosebud, and Treasure 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 entire quadrangle lies within the Northern Powder River Basin Known Recoverable Coal Resource Area (KRCRA) boundary. The Coal Data Map (pl. 2) shows the land ownership status. There were no outstanding Federal coal leases or prospecting permits as of 1977.

GENERAL GEOLOGY

Previous work

Dobbin (1930) mapped the quadrangle as part of the Forsyth coal field, Rosebud, Treasure, 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 bedrock units belong to the Fort Union Formation (Paleocene) which in the general area is composed of three members: the upper Tongue River Member, the middle Lebo Shale Member, and the lower Tullock Member. Dobbin (1930, p. 12) considered the Tullock to be a member of the Tertiary (Eocene?) Lance Formation, but since 1949 the U.S. Geological Survey has considered the Tullock in Montana to be the lowermost member of the Fort Union Formation.

Neither the Tullock Member nor the Lebo Shale Member crop out in the Sarpy School quadrangle; the only outcropping beds are of the Tongue River Member. The Tongue River Member consists of light-colored sandstone, sandy shale, and several important coal beds. The thicker coal beds have burned along their outcrops, and this has fused the overlying rock into reddish-colored clinker. The Tongue River Member is at least 1,686 feet (514 m) thick in the Little Wolf Mountains (Dobbin, 1930, p. 16); however, in the valley of East Fork Sarpy Creek, on the west border of the quadrangle, most of the member has been removed by erosion so that only about 300 feet (91 m) remains.

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 their 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 Sarpy School quadrangle is in the northwestern part of the Powder River structural basin. The quadrangle lies west of the major basin axis. The rocks rise uniformly westward at an angle of less than 1 degree (Dobbin, 1930, p. 23). No large faults have been reported in the quadrangle.

COAL GEOLOGY

Seven 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. An eighth coal bed was present in the past, but it has been exposed and burned. Its residual clinker caps the Little Wolf Mountains (pl. 1). Only three of the coal beds are of sufficient thickness to contain economic resources. The stratigraphically lowest of the three is the Robinson coal bed, which is about 100 feet (30.5 m) above the base of the Tongue River Member. The Robinson is overlain by a noncoal interval of about 30 feet (9 m), the Stocker Creek coal bed, a noncoal interval of 60 feet (18 m), and the Rosebud-McKay coal bed. Two additional coal beds, the Popham and the Proctor, lie 280 feet (85 m)

and 400 feet (122 m), respectively, above the Rosebud-McKay coal bed, but they are too thin to contain economic resources. Two more thin coal beds, local and unnamed, lie 360 feet (110 m) and 585 feet (178 m) above the Proctor coal bed (pl. 3).

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 situated immediately north of the Sarpy School quadrangle. Its dimensions and position within the quadrangle are projected from data in adjacent quadrangles. The Robinson coal bed lies about 100 feet (30.5 m) above the base of the Tongue River Member and dips east-southeast 40 feet per mile (7.6 m per km). It decreases in thickness eastward across the quadrangle from 17 feet (5.2 m) to 6 feet (1.8 m), as shown on plate 10.

The overburden on the Robinson coal bed ranges from about 20 feet (6 m) to over 1,400 feet (427 m) in thickness (pl. 11). This overburden includes the Stocker Creek and Rosebud-McKay coal beds.

There are no known published chemical analyses of the Robinson coal. However, the overlying Rosebud coal bed has been analyzed from a core sample in the McClure Creek quadrangle just north of the Sarpy School

quadrangle. It is assumed that the Robinson coal is similar in rank to the Rosebud coal in that quadrangle 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 (in the Colstrip West and Trail Creek School quadrangles) in the Forsyth coal field, about 6 miles (9.6 km) east-northeast of the Sarpy School quadrangle. The Stocker Creek coal bed lies about 30 feet (9 m) above the Robinson coal bed and crops out in the bottom of East Fork Sarpy Creek near the center of the west border of the Sarpy School quadrangle (pl. 1). There are no other Stocker Creek coal-bed data in the quadrangle; the dimensions and position of the bed are projected into the Sarpy School quadrangle from adjacent quadrangles (pl. 7). The structure contours on top of the Stocker Creek coal bed are drawn to conform to the structure on other coal beds and show a dip of less than 1 degree east-southeastward. The thickness of the bed decreases from more than 6 feet (1.8 m) to less than 3 feet (0.9 m) southward across the quadrangle. Where the bed is more than 5 feet (1.5 m) thick, the overburden ranges in thickness from less than 200 feet (61 m) near the outcrops around the center of the west border of the quadrangle to more than 1,400 feet (427 m) in the Little Wolf Mountains (pl. 8).

There are no known published chemical analyses of the Stocker Creek coal. However, the overlying Rosebud coal bed has been analyzed from a core sample in the McClure Creek quadrangle just north of the Sarpy School

quadrangle. It is assumed that the Stocker Creek coal is similar in rank to the Rosebud coal in that quadrangle and is subbituminous B.

Rosebud-McKay coal bed

The Rosebud coal bed was first described by Dobbin (1930, p. 27) from outcrops along Rosebud Creek in the Forsyth coal field 12 or more miles (19 or more km) east of the Sarpy School quadrangle. A specific type locality was not given. The McKay coal bed was also described by Dobbin (1930, p. 27) without designating a type locality. The McKay bed may be considered a split of the Rosebud bed (Dobbin, 1930, p. 27).

The Rosebud-McKay coal bed lies about 60 feet (16 m) above the Stocker Creek coal bed and crops out in the valley of East Fork Sarpy Creek near the center of the west border of the Sarpy School quadrangle (pl. 1). There are no other Rosebud-McKay coal bed data in the quadrangle; the dimensions and position of the bed are projected into the Sarpy School quadrangle from the adjacent quadrangles.

Except where interrupted by gentle folding, the Rosebud-McKay coal bed dips eastward, less than 1 degree, and ranges from about 5 to 26 feet (1.5 to 7.9 m) in thickness, as shown on plate 4. Where the coal bed exceeds 5 feet (1.5 m) in thickness, the overburden above the Rosebud-McKay coal bed ranges from zero near the center of the west border of the quadrangle to more than 1,300 feet (306 m) in thickness (pl. 5) in the Little Wolf Mountains.

There are no known published chemical analyses of the Rosebud-McKay coal in the Sarpy School 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 McClure Creek quadrangle about 3 miles (4.8 km) north of the Sarpy School quadrangle shows ash 11.17 percent, sulfur 0.68 percent, and heating value 8,820 Btu per pound, on an as-received basis (Matson and Blumer, 1973, p. 79). 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.

A chemical analysis of coal mined from both the Rosebud and Robinson coal beds at the Absaloka coal mine in the Wolf School quadrangle (60 percent Rosebud-McKay and 40 percent Robinson), about 3 miles (4.8 km) west of the Sarpy School quadrangle, was reported to analyze ash 10 percent, sulfur 0.75 percent, and Btu 8,450 per pound, on an as-received basis (McGraw-Hill, 1978, p. 967). This heating value converts to about 9,400 Btu per pound on a moist, mineral-matter-free basis, indicating that the coal, mixed from both beds in the proportions given above, is subbituminous C in rank.

Proctor coal bed

The Proctor coal bed was first described by Dobbin (1930, p. 28) from outcrops near the east base of Wolf Mountain (Little Wolf Mountains of later authors). The Proctor coal bed lies about 400 feet (122 m) above the Rosebud-McKay coal bed. One measurement of the Proctor coal bed located near the center of the east border of the Sarpy School quadrangle (pl. 1), is 5 feet (1.5 m) in thickness, the minimum for Reserve Base coal. However, Dobbin (1930, p. 28) describes the Proctor coal bed as having an average thickness

of only slightly over 3 feet (0.9 m), which is below Reserve Base thickness. No maps or calculations of coal resources have been made for the Proctor coal bed.

COAL RESOURCES

Data from all publicly available drill holes and from 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.

Coal resource tonnages shown in this report are the Reserve Base (RB) part of the Identified Resources and the Hypothetical (HYP) part of the Undiscovered 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.

Hypothetical Resources are undiscovered coal resources in beds that may reasonably be expected to exist in known mining districts under known geologic conditions. In general, Hypothetical Resources are located in broad areas of coal fields where no points of observation are present and the evidence for the coal's existence is from distant outcrops, drill holes, or wells

that are more than 3 miles (4.8 km) away. Hypothetical Resources are located beyond the outer boundary of the Inferred part of Identified Resources in areas where the assumption of continuity of the coal bed is supported only by extrapolation of geologic evidence. For purposes of this report, tonnages were calculated for only those Hypothetical coal resources in beds that are estimated to be 5 feet (1.5 m) or more thick and to be under less than 3,000 feet (914 m) of overburden.

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 resources in the Sarpy School quadrangle were calculated using data obtained from the coal isopach maps (pls. 4, 7, and 10). 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 metric tons/hectare-meter) for subbituminous coal yields the coal resources in short tons of coal for each isopached coal bed. Reserve Base, Reserve, and Hypothetical tonnage values for the Rosebud-McKay, Stocker Creek, and Robinson coal beds are shown on plates 6, 9, and 12, 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 Sarpy School quadrangle is calculated to be 481.53 million short tons (436.84 million t). The total Hypothetical tonnage is calculated to be 404.32 million short tons (366.80 million t). The Reserve Base and Hypothetical tonnage totals per section are shown in the northwest corner of each section on CRO plate 2 and by development-potential category in tables 1 and 2. All numbers are rounded to the nearest one-hundredth of a million short tons. None of the Reserve Base tonnage is classed as Measured, 4 percent is Indicated, and 96 percent is 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 mapping 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-ratio values 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, and 11 for the Rosebud-McKay, Stocker Creek, and Robinson 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 (high, moderate, and low), for both Reserve Base and Hypothetical coal, for surface mining are shown in table 1. Estimated tonnages for underground mining are shown in a like manner in table 2.

Development potential for surface-mining methods

The Coal Development Potential (CDP) map included in this series of maps pertains only to surface mining. It 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 CDP map (pl. 13). Most of the Federal coal lands in the west-central part of the quadrangle have a high development potential for surface mining because of the presence of the Robinson coal bed. The Federal coal lands adjacent to the north border of the quadrangle have a high development potential due to the presence of the Rosebud-McKay coal bed.

The Robinson coal bed (pl. 11) has a small area of high development potential extending up the valleys from the west border of the quadrangle to the 10 mining-ratio contour. Above this contour is a relatively narrow band

of moderate development potential between the 10 and 15 mining-ratio contours, and a wide area of low development potential between the 15 mining-ratio contour and the arbitrarily assigned stripping limit of 500 feet (152 m) of overburden in the central part of the quadrangle. In the remainder of the quadrangle, the Robinson coal bed does not have a development potential for surface mining as its overburden is thicker than 500 feet, but it does have a development potential for subsurface-mining methods.

The Rosebud-McKay coal bed (pl. 5) has a wide area of high development potential in the west-central part of the quadrangle above the outcrops and below the 10 mining-ratio contour. Along the north border of the quadrangle there are small areas of high development potential. Above the areas of high development potential are fairly wide bands of moderate development potential along the valley sides between the 10 and 15 mining-ratio contours. Higher on the valley sides are bands of low development potential between the 15 mining ratio contour and the stripping limit at the 500-foot overburden isopach. In the eastern part of the quadrangle, the Rosebud-McKay coal bed has no development potential for surface mining because its overburden has a thickness greater than 500 feet, the arbitrary stripping limit. In the southern part of the quadrangle, the Rosebud-McKay coal bed has a low development potential or no development potential because of the thinness of the coal or the thick overburden.

The Stocker Creek coal bed (pl. 8) has a development potential only in the north third of the quadrangle where the coal is more than 5 feet thick. The development potential for surface mining is low between the north and

and northwest borders of the quadrangle and the 500-foot overburden isopach. Above the 500-foot overburden isopach within the north third of the quadrangle the Stocker Creek coal bed has a development potential for subsurface mining.

Approximately 28 percent of the Federal coal lands in the quadrangle has a high development potential for surface mining, 9 percent has a moderate development potential, 30 percent has a low development potential, and 33 percent has no development potential.

Development potential for underground mining and in-situ gasification

The identified resources (Reserve Base) and Hypothetical tonnage calculated for each of the coal beds lying below the stripping limit of 500 feet are shown in table 2. Currently, there is no underground mining of coal in the Northern Powder River Basin because of poor economics. For this reason, the coal development potential for underground mining these deep resources is rated as low, and a Coal Development Potential Map for underground mining was not 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 lands (in short tons) in the Sarpy School quadrangle, Big Horn, Rosebud, and Treasure 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
Reserve Base tonnage				
Rosebud-McKay	95,400,000	47,670,000	53,030,000	196,100,000
Stocker Creek	0	0	7,200,000	7,200,000
Robinson	13,070,000	16,790,000	78,110,000	107,970,000
Total	108,470,000	64,460,000	138,340,000	311,270,000
Hypothetical Resource tonnage				
Rosebud-McKay	900,000	11,030,000	78,450,000	90,380,000
Stocker Creek	0	0	7,990,000	7,990,000
Robinson	0	0	56,860,000	56,860,000
Total	900,000	11,030,000	143,300,000	155,230,000
Grand Total	109,370,000	75,490,000	281,640,000	466,500,000

Table 2.--Underground-minable coal resource tonnage by development-potential category for Federal coal lands (in short tons) in the Sarpy School quadrangle, Big Horn, Rosebud, and Treasure Counties, Montana

[To convert short tons to metric tons, multiply by 0.9072]

Coal bed	High development potential	Moderate development potential	Low development potential	Total
Reserve Base tonnage				
Rosebud-McKay	0	0	117,940,000	117,940,000
Stocker Creek	0	0	4,290,000	4,290,000
Robinson	0	0	48,030,000	48,030,000
Total	0	0	170,260,000	170,260,000
Hypothetical Resource tonnage				
Rosebud-McKay	0	0	109,870,000	109,870,000
Stocker Creek	0	0	19,670,000	19,670,000
Robinson	0	0	119,550,000	119,550,000
Total	0	0	249,090,000	249,090,000
Grand Total	0	0	419,350,000	419,350,000

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