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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE McCLURE CREEK QUADRANGLE, ROSEBUD AND TREASURE COUNTIES, MONTANA

[Report includes 15 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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[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 McClure Creek quadrangle, Rosebud and Treasure Counties, Montana, (15 plates; U.S. Geological Survey Open-File Report 78-834). 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 McClure Creek 7 1/2-minute quadrangle is in west-central Rosebud County and southeastern Treasure County, Montana, about 20 miles (32 km) south of Forsyth, Montana, a town in the Yellowstone River valley about 44 miles (70 km) south-southwest of Miles City and 105 miles (168 km) east of Billings. U.S. Interstate Highway 94 and the main east-west routes of the Burlington Northern Railroad and the Chicago, Milwaukee, St. Paul, and Pacific Railroad follow the Yellowstone River and pass through Forsyth.

Accessibility

The McClure Creek quadrangle is accessible from the northeast by U.S. Interstate Highway 94 from an intersection 6 miles (9.6 km) west of

Forsyth, then southward 12 miles (19.2 km) on State Highway 39 to the graveled West Fork of Armells Creek Road, then 16 miles (26 km) southwestward to the graveled Horse Creek Road, and then about 3 miles (4.8 km) westward to the east border of the quadrangle. The McClure Creek quadrangle is also accessible from the northwest by U.S. Interstate Highway 94 from an intersection 22 miles (35 km) west of Forsyth, then southward about 22 miles (35 km) on the graveled Sarpy Creek Road, and then eastward about 6.5 miles on the graveled Horse Creek Road to the west border of the quadrangle. The Horse Creek road continues across the southern part of the quadrangle to connect with the West Fork of Armells Creek Road. Unimproved roads and trails provide access to all but the roughest parts of the quadrangle in the Little Wolf Mountains.

The railroad closest to the McClure Creek quadrangle is the branch of the Burlington Northern Railroad which services the Colstrip coal mine and which passes 11 to 12 miles (17.6 to 19.2 km) east of the quadrangle.

Physiography

The McClure Creek quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The quadrangle is dissected and drained by two northward-flowing tributaries of the Yellowstone River: Sarpy Creek, which is 6 to 7 miles (9.6 to 11.2 km) west of the quadrangle, and Armells Creek, the West Fork of which is 2 to 3 miles (3.2 to 4.8 km) east of the quadrangle.

The divide between the two streams is called the Little Wolf Mountains. Trending northward across the west-central part of the quadrangle,

the mountains rise several hundred feet (a few hundred meters) above the surrounding areas. They are composed of long, narrow, steep-sided ridges which are rugged and timbered. In the northeast quarter of the quadrangle, the topography is low and subdued. In the northwest quarter of the quadrangle, there is a relatively flat-topped, steep-sided terrace at an elevation of 3,700 to 3,800 feet (1,128 to 1,158 m), covered by Tertiary gravel.

The highest elevation, about 4,260 feet (1,298 m), is near the southwest corner of the quadrangle in the Little Wolf Mountains. The lowest elevation, 3,080 feet (939 m), is on a stream near the northeast corner of the quadrangle. Topographic relief is 1,180 feet (360 m).

Climate

The climate of 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 Northern Powder River Basin Known Recoverable Resource Area (KRCRA) covers about half of the McClure Creek quadrangle, as shown by the Boundary and Coal Data Map (pl. 2). This map also shows the coal land

ownership status, and the location of approximately 1,940 acres (786 ha) of Federal coal land which was covered by an outstanding Federal coal lease of record in 1977.

GENERAL GEOLOGY

Previous work

Dobbin (1930) mapped the McClure Creek quadrangle as part of the Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Montana. Kepferle (1954) mapped some of the quadrangle as part of the West Fork Armells Creek deposit, Rosebud County, Montana. V. W. Carmichael (1964) mapped some of the quadrangle as part of the Colstrip coal deposit (in Matson and Blumer, 1973, pl. 14).

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 upper two members of the Paleocene Fort Union Formation: the upper Tongue River Member and the middle Lebo Shale Member.

The Lebo Shale Member is the lowest unit exposed in the quadrangle. It crops out in very limited areas in the northwest and northeast corners of the quadrangle. The Lebo Shale Member is 105 to 170 feet (32 to 52 m) thick and consists of soft, dark-gray to black shale, clay, and sandy shale with abundant ferruginous concretions (Dobbin, 1930, p. 8).

The Tongue River Member is exposed throughout most of the quadrangle and contains the coal beds of greatest economic interest. The unit is

made up mostly of yellow sandstone, sandy shale, carbonaceous shale, and coal. Much of the coal has burned along the outcrop, baking the overlying sandstone and shale and forming thick clinker beds. Originally about 1,700 feet (518 m) thick (Dobbin, 1930, p. 16), much of the Tongue River Member has been removed by erosion, and only about 1,200 feet (366 m) remains. The lowest 130 feet (40 m) of the unit, which contains no coal beds, are responsible for the subdued topography in the northeast quarter of the quadrangle.

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. 2, 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 McClure Creek quadrangle is in the northwestern part of the Powder River structural basin. The strata dip southeast or east-southeastward

at an angle of less than 1 degree. Structure contours on top of the Rosebud-McKay, Stocker Creek, and Robinson coal beds (pls. 5, 8, and 12) show that the regional dip is in places modified by gentle folding or warping. The local irregularities of structure may be due to discontinuities in deposition, a characteristic of these continental sedimentary deposits.

COAL GEOLOGY

Dobbin (1930) mapped five coal beds in the McClure Creek quadrangle area of the Forsyth coal field in the Tongue River Member of the Fort Union Formation. The upper four coal beds, the Rosebud, McKay, Stocker Creek, and Robinson, contain Reserve Base coal; the lowest coal bed, the Burley, is too thin to be assigned reserves.

The base of the Tongue River Member is overlain successively by a noncoal interval of 130 feet (40 m), the Burley coal bed, a noncoal interval of 40 to 80 feet (12 to 24 m), the Robinson coal bed, a noncoal interval of 125 to 130 feet (38 to 40 m), the Stocker Creek coal bed, a noncoal interval of 30 to 40 feet (9 to 12 m), a noncoal interval of zero to 30 feet (9 m), and the Rosebud coal bed.

The trace element content of coals in the McClure Creek 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, p. 147).

Burley coal bed

The Burley coal bed, the stratigraphically lowest coal bed in the McClure Creek quadrangle, crops out only in the northwest quarter of the quadrangle (pl. 1). The Burley coal ranges from 2.7 to 4.0 feet (0.8 to 1.2 m) in thickness (pls. 1 and 3). Because it is less than 5 feet (1.5 m) thick, the Burley coal bed does not contain any Reserve Base coal.

Robinson coal bed

The Robinson coal bed was described by Dobbin (1930, p. 27) from outcrops on the Robinson Ranch in the McClure Creek quadrangle. The Robinson coal bed crops out in the northern part of the quadrangle. The thickness of the Robinson coal bed as measured at outcrops in the McClure Creek quadrangle ranges from 2.4 to 7.1 feet (0.7 to 2.2 m). However, projections of data from adjacent quadrangles indicate that the coal may be as much as 16 feet (4.9 m) thick in the southwestern part of the quadrangle (pl. 11). Structure contours on top of the Robinson coal bed (pl. 12) show a dip of less than 1 degree southeastward or east-southeastward except where the structure is modified by minor folding or warping. Overburden on the Robinson coal bed (pl. 13) ranges in thickness from zero in the northern part of the quadrangle to over 800 feet (244 m) in the southwestern part. The mining ratios range from zero to over 15 (pl. 13). There is no known published chemical analysis of the Robinson coal. It is assumed that the Robinson coal is similar in rank to associated coal beds in this area and is subbituminous B.

Local coal bed

A local coal bed, 1.7 feet (0.5 m) thick, crops out for a short distance on a ridge in the north-central part of the quadrangle. This local coal bed is too thin to contain Reserve Base coal.

Stocker Creek coal bed

The Stocker Creek coal bed was 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. This coal bed crops out in the northern part of the McClure Creek quadrangle. The thickness of the Stocker Creek coal bed ranges from 2.5 to 9.0 feet (0.8 to 2.7 m), as shown on plate 8. Structure contours on top of the Stocker Creek coal bed (pl. 8) show a dip of less than 1 degree south-southeastward except where the structure is modified by minor folding or warping. Overburden on the Stocker Creek coal bed (pl. 9) ranges in thickness from zero in the northern part of the quadrangle to over 800 feet (244 m) in the southwestern part. This overburden includes the Rosebud and McKay coal beds where they are uneroded and unburned.

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

McKay coal bed

The McKay coal bed was described by Dobbin (1930, p. 26) from exposures on the McKay Ranch (Colstrip East quadrangle) in the Forsyth coal field, but a type locality was not designated. The McKay coal bed may

be a split of the Rosebud coal bed because the interval between them in several places is less than 7 feet (2.1 m) and at no place is it more than 30 feet (9 m) (Dobbin, 1930, p. 27). The outcrop of the McKay coal bed follows very closely that of the Rosebud coal bed, and is often concealed by the Rosebud clinker. For this reason the outcrop of the McKay coal bed is not mapped separately, nor is it shown at the surface in the south half of the McClure Creek quadrangle (pl. 1). In the northwest quarter of the quadrangle, the McKay coal bed is recognized as being separate from the Rosebud bed, and a split line separating the area of the McKay coal bed from that of the Rosebud-McKay coal bed has been drawn (pl. 3). North of this line the McKay coal ranges from 2.0 to 3.4 feet (0.6 to 1.0 m) in thickness. South of this line the McKay coal bed is mapped together with the Rosebud coal bed as the Rosebud-McKay coal bed.

Rosebud-McKay coal bed

The Rosebud coal bed was described by Dobbin (1930, p. 27) from outcrops along Rosebud Creek in the Forsyth coal field. A specific type locality was not given.

In the south half of the McClure Creek quadrangle, the Rosebud and McKay coal beds are combined and mapped as a single bed. The combined bed ranges in thickness from 8 to 27 feet (2.4 to 8.2 m), as shown on plate 4. The greatest thickness is in the southern part of the quadrangle. The overburden on the Rosebud-McKay coal ranges in thickness from zero to over 500 feet (152 m). The thickest overburden is in the southwest quarter of the quadrangle. The mining-ratio values range from zero to over 15 (pl. 6).

Matson and Blumer (1973, p. 79) report two analyses of cores of the Rosebud coal bed in the McClure Creek quadrangle. One, in sec. 29, T. 2 N., R. 39 E., shows 8.30 percent ash, 0.81 percent sulfur, and a heating value of 9,010 Btu per pound as received. The second, in sec. 13, T. 2 N., R. 38 E., shows ash 11.17 percent, sulfur 0.68 percent, and a heating value of 8,820 Btu per pound as received. These heating values convert to about 9,825 Btu and 9,930 Btu, respectively, on a moist, mineral-matter-free basis, indicating that the coal is subbituminous B in rank.

The trace element content of coals in the McClure Creek 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).

COAL RESOURCES

Data from drill holes and 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.

Coal resource tonnages shown in this report are the Reserve Base (RB) part of the Identified Resources and, if present, 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 miles (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 coal resources are undiscovered resources in known mining districts (at least 3 miles or 4.8 km from a measurement point) that may reasonably be expected to exist based on known geologic conditions.

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 McClure Creek quadrangle were calculated using data obtained from the coal isopach maps (pls. 4, 8, and 11). 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 per hectare-meter) 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

Rosebud-McKay, Stocker Creek, and Robinson coal beds are shown on plates 7, 10, and 14, 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 McClure Creek quadrangle is calculated to be 296.67 million short tons (269.14 million t). In addition, the Hypothetical coal tonnage is calculated to be 20.58 million short tons (18.67 million t). The Reserve Base (RB) and Hypothetical (HYP) 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 3 percent of the Reserve Base tonnage is classed as Measured, 31 percent as Indicated, and 66 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 6, 9, and 13, 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. Calculated tonnages in each development potential category (high, moderate, and low) for surface mining are shown in table 1.

Development potential for surface-mining methods

The Coal Development Potential (CDP) map, plate 15 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 with more than one category of high, moderate, and low development potential, the entire tract is assigned to the highest category for CDP mapping purposes.

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. 15). About 84 percent of the 40-acre (16.2 ha) tracts of Federal coal lands in the McClure Creek quadrangle that have a potential for surface mining have a high development potential, about 13 percent have a moderate development potential, and 3 percent have a low development potential.

Development potential for underground mining and in situ gasification

The Stocker Creek and Robinson coal beds underlie areas that in places are deeper than the stripping limit which is 500 feet (152 m) in this quadrangle (pls. 9 and 13). Where the coal beds are more than 5 feet (1.5 m) thick these areas have a potential for underground mining. Coal is not currently being mined by underground methods in the Northern Powder River Basin because of poor economics. Therefore, the coal-development potential for underground mining of these resources is rated as low, and a Coal Development Potential map for underground mining was not made. Underground-minable coal resource tonnages within the McClure Creek quadrangle are shown by development potential category in table 2. The total underground-minable resource for Federal lands in the McClure Creek quadrangle is estimated to be 15.19 million short tons (13.78 million t).

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 McClure Creek quadrangle, 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
Rosebud-McKay	49,160,000	36,470,000	33,370,000	119,000,000
Robinson	21,000,000	20,000,000	74,440,000	115,440,000
Stocker Creek	12,800,000	7,820,000	47,000,000	67,620,000
Total	82,960,000	64,290,000	154,810,000	302,060,000

Table 2.--Underground-minable coal resource tonnage by development potential category for Federal coal lands (in short tons) in the McClure Creek quadrangle, 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
Rosebud-McKay	0	0	4,280,000	4,280,000
Robinson	0	0	8,230,000	8,230,000
Stocker Creek	0	0	2,680,000	2,680,000
Total	0	0	15,190,000	15,190,000

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