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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE BRANDENBERG QUADRANGLE, CUSTER, ROSEBUD, AND POWDER RIVER COUNTIES, MONTANA

[Report includes 13 plates]

By

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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 Brandenberg quadrangle, Custer, Rosebud, and Powder River Counties, Montana, (13 plates; U.S. Geological Survey Open-File Report 79-004). 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 Brandenberg 7 1/2-minute quadrangle is in southwestern Custer, eastern Rosebud, and northwestern Powder River Counties, Montana, about 43 miles (69.2 km) south-southwest of Miles City, Montana. Miles City is on U.S. Interstate Highway 94 and the main east-west routes of the Burlington Northern and the Chicago, Milwaukee, St. Paul, and Pacific railroads.

Accessibility

The Brandenberg quadrangle is accessible from Miles City, Montana, by going south on U.S. Highway 312 a distance of 13 miles (20.9 km) to the intersection with local Route 332 (the Tongue River Road), and then southwest a distance of 36 miles (57.9 km) to the north border of the quadrangle. Local

Route 332 proceeds southwesterly across the west half of the quadrangle. It connects with U. S. Highway 212 at Ashland, about 18 miles (29 km) to the south-southwest. Unimproved roads provide access to the rest of the quadrangle.

Physiography

The Brandenberg quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The upland pleateau surface, however, has been almost totally dissected by tributaries of the Tongue River. The Tongue River flows northeasterly across the west half of the quadrangle, and Liscom, Goodale, Diamond R, and Beaver Creeks flow northwesterly across the east half of the quadrangle to the river. Drainage divides between the streams are mostly flat-topped and capped with clinker formed by the burning of coal beds. The highest elevation in the quadrangle, 3,692 feet (1,125 m), is near the center of the east border. The lowest elevation, 2,720 feet (829 m), is in the Tongue River bottom near the center of the north border of the quadrangle. The topographic relief is about 972 feet (296 m).

Climate

The climate of Custer, Rosebud, and Powder River 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 Coal Resource Area (KRCRA) covers most of the quadrangle except the northwest quarter. The Boundary and Coal Data Map (pl. 2) shows the locations of the KRCRA tracts and the land ownership status. There were no outstanding Federal coal leases or prospecting permits recorded as of 1977. The Liscom Creek gas field underlies part of the northeast quarter of the quadrangle.

GENERAL GEOLOGY

Previous work

Bass (1932) mapped the Brandenberg quadrangle as part of the Ashland coal field, Rosebud, Powder River, and Custer Counties, Montana. Matson and Blumer (1973) mapped most of the quadrangle as part of the Beaver Creek-Liscom Creek coal deposit in their summary of quality and reserves of strippable coal, selected deposits, southeastern 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). The Fort Union Formation is composed of three members: the upper Tongue River Member, the middle Lebo Shale Member, and the lower Tullock Member. Bass (1932) considered the Tullock to be a member of the Tertiary(?) 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.

The Lebo Shale Member is the lowest exposed unit in the quadrangle. It crops out along the Tongue River and its tributaries in the west half of the quadrangle. The Lebo Shale Member is 160 to 200 feet (49 to 61 m) thick and consists of shale and a few thin, lenticular sandstones, but contains no economically exploitable coal beds.

The Tongue River Member caps the divides and ridges in the east half of the quadrangle and contains the coal beds of economic interest. The unit is made up mainly of yellow sandstone, sandy shale, carbonaceous shale, and coal. Considerable coal has been burned along outcrops, fracturing and baking the overlying sandstone and shale, forming thick reddish-colored clinker beds. Originally as much as 1,600 feet (488 m) thick in this vicinity, most of the Tongue River Member has been removed by erosion so that only about the lower 800 feet (244 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 Brandenberg quadrangle is in the north-central part of the Powder River structural basin. The strata are nearly flat or in places dip southward or westward at an angle of less than 1 degree. Structure contours on top of the coal beds (pls. 4, 7, and 10) show minor structural features.

COAL GEOLOGY

Four primary coal beds, all in the Tongue River Member of the Fort Union Formation, were mapped on the surface in the Brandenberg quadrangle (pl. 1) and are illustrated in section on plate 3. In places, thin, local coal beds lie above or below these four, but are not economically important (pl. 3). A fifth thick coal bed which has entirely burned is evidenced by thick clinker beds capping the tops of ridges in the southeast quarter of the quadrangle.

The Terret coal bed is stratigraphically the lowest bed mapped, lying about 190 feet (58 m) above the base of the Tongue River Member. The Terret is overlain successively by a noncoal interval of 70 feet (21 m), the Flowers-Goodale coal bed, a noncoal interval of 70 feet (21 m), the Knobloch coal bed, a noncoal interval of 245-285 feet (75-87 m), and the Sawyer coal bed. The Sawyer coal bed is too thin, about 3.3 feet (1 m), to have economic coal resources in this quadrangle.

The trace element content of coals in the Brandenberg 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).

Terret coal bed

The Terret coal bed was described by Bass (1932, p. 51) after a small mine on Dugout Creek on the Terret Ranch 0.25 mile (0.4 km) south of the Brandenberg quadrangle (in the Cook Creek Reservoir quadrangle) in the Ashland coal field. The Terret coal bed lies about 190 feet (58 m) above the base of the Tongue River Member and crops out along the base of the hills and divides bordering the Tongue River and its tributaries (pl. 1). Structure on the Terret coal bed is relatively flat. A regional southward dip of about 20 feet per mile (3.8 m/km) is modified by minor folds (pl. 10). The thickness of the Terret bed increases northeasterly from about 3 feet (0.9 m) to over 12.5 feet (3.8 m), as is also shown on plate 10. Overburden on the Terret ranges in thickness from zero at the outcrop to over 500 feet (152 m) locally near the east border of the quadrangle.

The Montana Bureau of Mines and Geology cored the Terret coal in drill hole SH-7094 in the northeast quarter of the Brandenberg quadrangle (sec. 16, T. 1 N., R. 45 E.). A chemical analysis of coal from depths of 38 to 44 feet (11.6 to 13.4 m), shows a heating value of 8,170 Btu per pound (19,000 kJ/kg), ash 5.77 percent, and sulfur 0.69 percent, on an as-received

basis (Matson and Blumer, 1973, p. 121). This heating value converts to about 8,670 Btu per pound (20,170 kJ/kg) on a moist, mineral-matter-free basis, and indicates that the Terret coal is subbituminous C in rank.

Flowers-Goodale coal bed

The Flowers-Goodale coal bed was described by Bass (1932, p. 53) after two small coal mines located in the east-central part of the Brandenberg quadrangle (pl. 1). The coal bed crops out about 70 feet (21 m) above the Terret coal bed on the slopes of the Tongue River valley and its tributaries. Regionally, the Flowers-Goodale coal bed is relatively flat, dipping southward about 20 feet per mile (3.8 m/km), but this is modified locally by minor folding (pl. 7). The coal bed is lenticular, with rapid changes in thickness from about 4 feet to over 12 feet (1.2 to over 3.7 m) in short distances (pl. 7). Overburden on the Flowers-Goodale coal bed ranges from zero at the outcrop to over 500 feet (152 m) in thickness on the high ridges near the east border of the quadrangle (pl. 8). There are no publicly available chemical analyses for the Flowers-Goodale coal in the quadrangle. The Montana Bureau of Mines and Geology cored the Flowers-Goodale coal in drill hole SH-7076 located in the Cook Creek Reservoir quadrangle a few hundred feet (a few hundred meters) southwest of the southeast corner of the Brandenberg quadrangle. A chemical analysis of coal from depths of 53 to 62 feet (16 to 18.9 m) shows a heating value of 8,102 Btu per pound (18,845 kJ/kg), ash 8.144 percent, and sulfur 0.961 percent, on an as-received basis (Matson and Blumer, 1973, p. 121). This heating value converts to

about 8,820 Btu per pound (20,515 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Flowers-Goodale coal is subbituminous C in rank.

Knobloch coal bed

The Knobloch coal bed was described by Bass (1932, p. 52); the name of the coal bed was taken from the Knobloch Ranch and coal mine located in the Birney Day School quadrangle about 26 miles (42 km) south-southwest of the Brandenberg quadrangle. The Knobloch coal bed lies about 70 feet (21 m) above the Flowers-Goodale coal bed and about 330 feet (100 m) above the base of the Tongue River Member.

The Knobloch coal bed crops out on the crests of the higher divides in the eastern and southern parts of the quadrangle. Considerable coal has burned near the outcrop, and the resultant clinker, being resistant to erosion, caps many of the interstream divides (pl. 1). The area remaining with unburned coal is reduced to about 3 square miles (780 ha) located near the center of the east border of the quadrangle. The Knobloch coal bed dips slightly westward and ranges in thickness from about 12 to 27 feet (3.7 to 8.2 m), as shown on plate 4. Overburden on the Knobloch coal bed ranges from close to zero near the outcrops to more than 300 feet (91 m) in local areas (pl. 5). There are no publicly available chemical analyses for the Knobloch coal in the Brandenberg quadrangle. The Montana Bureau of Mines and Geology cored the Knobloch coal in drill hole SH-7074 (sec. 20, T. 1 S., R. 45 E.) located about 0.5 mile (0.8 km) south of the Brandenberg quadrangle, in the Cook Creek Reservoir quadrangle. A chemical analysis of coal from depths of 100 to 106 feet (30.4 to 32.3 m) shows a heating value of

8,417 Btu per pound (19,578 kJ/kg), ash 7.154 percent, and sulfur 0.496 percent, on an as-received basis (Matson and Blumer, 1973, p. 121). This heating value converts to about 9,070 Btu per pound (21,080 kJ/kg) on a moist, mineral-matter-free basis, indicating the the coal is subbituminous C in rank.

COAL RESOURCES

Data from drill holes as well as 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 derived in this report are the Reserve Base part of the Identified Resources found within 3 miles (4.8 km) of a point of coal-bed measurement, 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. This depth of overburden is the stripping limit for multiple, relatively thin (5 to 40 feet or 1.5 to 12 m) beds of subbituminous coal in this area.

The acreage underlain by a coal bed was measured by planimeter. The coal resources in the quadrangle were computed using these acreage numbers 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 to yield the coal resources in short tons of coal for each ispached coal bed.

Reserve Base and Reserve tonnage numbers for the Terret, Flowers-Goodale, and Knobloch coal beds are shown on plates 6, 9, and 12, respectively, rounded to the nearest one-hundredth of a million short tons.

The total Reserve Base tonnage of federally owned coal in this quadrangle is calculated to be 170.63 million short tons (154.79 million t) of which 168.83 million short tons (153.16 million t) is surface minable, and 1.80 million short tons (1.63 million t) is underground minable. 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 tables 1 and 2. All numbers are rounded to the nearest one-hundredth of a million short tons. About 9.7 percent of the Reserve Base tonnage is classed as Measured, 44.3 percent as Indicated, and 46 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-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 plates 5, 8, and 11. 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 surface mining are shown in table 1.

Development potential for surface-mining methods

The Coal Development Potential (CDP) map (pl. 13) 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. 13). Most of the Federal coal lands in the east half and the south half of the southwest quarter of the quadrangle have a high development potential for surface mining because of the superimposed Terret, Flowers-Goodale, and Knobloch coal beds. The Federal coal lands in the remainder of the quadrangle have no development potential because these coal beds have been removed by erosion or are less than 5 feet (1.5 m) thick.

The Terret coal bed (pl. 11) has moderate-sized areas of high development potential above the outcrops and below the 10 mining-ratio contour in the valley bottoms or on their lower sides. Above these areas is a narrow band of moderate development potential (10 to 15 mining-ratio values); and above the narrow band are wide areas of low development potential (mining-ratio values greater than 15) on the crests of hills.

The Flowers-Goodale coal bed (pl. 8) has areas of high, moderate, and low development potential which are very similar to those of the Terret coal bed, but which are at higher elevations in the valleys or on the ridges.

The Knobloch coal bed (pl. 5) is present only in the east-central part of the quadrangle. This coal has wide areas of high development potential (0 to 10 mining-ratio values), narrow bands of moderate development

potential (10 to 15 mining-ratio values), and only small areas of low development potential under the crests of hills.

Federal coal lands cover about 48 percent of the quadrangle. About 68.5 percent of the Federal coal lands have a high development potential for surface mining, about 0.5 percent have a moderate development potential, none have a low development potential, and 31 percent have no coal development potential for surface mining because of the absence of coal beds of minable thickness.

Development potential for underground mining and in-situ gasification

Coal beds of economic thickness (5 feet or 1.5 m or more) lying more than 500 feet (152 m) but less than 3,000 feet (914 m) below the surface in this quadrangle are considered to have development potential for underground mining. Tonnage estimates of such underground-minable coal are listed in table 2 by coal bed and by coal development-potential category.

Coal is not being mined currently by underground methods in the Northern Powder River Basin, Montana, because of poor economics. For this reason the coal development potential for all the underground-minable coal resource tonnage listed in table 2 is classified 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 stripping 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 Brandenberg quadrangle, Custer, Rosebud, and Powder River 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
Knobloch	27,130,000	10,480,000	42,880,000	80,490,000
Flowers-Goodale	18,300,000	10,590,000	21,140,000	50,030,000
Terret	34,290,000	2,240,000	1,780,000	38,310,000
Total	79,720,000	23,310,000	65,800,000	168,830,000

Table 2.--Underground-minable coal resource tonnage by development-potential category for Federal coal lands (in short tons) in the Brandenberg quadrangle, Custer, Rosebud, and Powder River 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
Flowers-Goodale	0	0	250,000	250,000
Terret	0	0	1,550,000	1,550,000
Total	0	0	1,800,000	1,800,000

REFERENCES

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