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

[Report includes 13 plates]

By

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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 Volborg quadrangle, Custer and Powder River Counties, Montana, (13 plates; U.S. Geological Survey Open-File Report 79-019). 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 Volborg 7 1/2-minute quadrangle is in southern Custer and northern Powder River Counties, Montana, about 38 miles (60.8 km) south-southeast of Miles City, Montana. Miles City is located on U.S. Interstate Highway 94, and the main east-west lines of the Burlington Northern and the Chicago, Milwaukee, St. Paul, and Pacific railroads.

Accessibility

The Volborg quadrangle is accessible from Miles City, Montana, by traveling south on U.S. Highway 312, a distance of 44 miles (70.4 km), to the north border of the quadrangle. U.S. Highway 312 continues southward and eastward to Broadus, Montana, a small town located 27 miles (43.2 km)

southeast of the quadrangle border. A number of roads, graveled and unimproved, provide access to the quadrangle from U. S. Highway 312.

Physiography

The Volborg quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The upland plateau surface, however, has been almost completely dissected by tributaries of Pumpkin Creek. Pumpkin Creek and its principal tributary SL Creek, flow northward through the center of the quadrangle and are intersected by laterally flowing minor tributaries. The divides between these creeks are resistant ridges and knobs, capped with reddish-colored clinker which has been formed as a result of the burning of coal beds. The ridges near the center of the east border of the quadrangle reach 3,467 feet (1,057 m) in elevation and are the highest points in the quadrangle. The lowest elevation, about 2,900 feet (884 m), is where Pumpkin Creek leaves the quadrangle near the center of the north border. Topographic relief is about 567 feet (173 m).

Climate

The climate of Custer 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) encompasses parts of the east half of the southeast quarter and the west half of the northwest quarter of the quadrangle. The Boundary and Coal Data Map (pl. 2) shows the location of the KRCRA tracts and the land ownership status. There were no outstanding Federal coal leases or prospecting permits as of 1977.

GENERAL GEOLOGY

Previous work

Bass (1932) mapped the northwestern part of the Volborg quadrangle as part of the Ashland coal field, Rosebud, Powder River, and Custer Counties, Montana. Parker and Andrews (1939) mapped the northeastern part of the quadrangle as part of the Mizpah coal field, Custer County, Montana. Bryson, 1952, mapped most of the south one-third of the quadrangle as part of the Coalwood coal field, Powder River County, 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 lowermost Tullock Member. Only the Tongue River and Lebo Shale Members are exposed within the quadrangle. The Lebo Shale Member is equivalent to the upper part of the somber-colored beds (Tertiary?) of Parker and Andrews (1939, p. 95).

The Lebo Shale Member occupies the broad valley of Pumpkin and Little Pumpkin Creeks. It is 160 to 200 feet (49 to 61 m) thick and consists of shale and a few thin, lenticular sandstones. A local coal bed occuring about 170 feet below the top of the member crops out for a few hundred feet (tens of meters) near the northeast corner of the quadrangle, but attains a thickness of only about 2 feet (0.6 m).

The Tongue River Member occupies the higher elevations above the bottoms of Pumpkin Creek and its larger tributaries. This unit is made up mainly of yellow sandstone, sandy shale, carbonaceous shale, and coal. Much coal has burned along outcrops, baking the overlying sandstone and shale, and forming thick reddish-colored clinker beds. Originally more than 1,000 feet (305 m) thick in this vicinity, most of the member has been removed by erosion so that only about the lower 400 feet (122 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 Volborg quadrangle is in the northeastern part of the Powder River structural basin. Except where interrupted by slight folding, the strata dip north-northwestward about 30 to 50 feet per mile (5.7 to 9.5 m per km), as shown by the structure contour map on the Knobloch coal bed (plate 4).

COAL GEOLOGY

Seven coal beds, six of which are in the Tongue River Member of the Fort Union Formation, were mapped on the surface in this quadrangle (pl. 1) and are shown in section on plate 3. The lowest of these is the local coal bed in the Lebo Shale Member. The lowest of the six in the Tongue River Member is the Contact coal bed which lies just above the base of this member. The Contact coal bed is overlain successively by a noncoal interval of 30 feet (9 m), the Volborg coal bed, a noncoal interval of 25 feet (7.6 m), the Terret coal bed, a noncoal interval of about 40 feet (12 m), the Allen coal bed, a noncoal interval of about 35 feet (11 m), the Flowers-Goodale coal bed, a noncoal interval of 65 feet (19.8 m), and the Knobloch coal bed. In the southeast quarter of the quadrangle the Knobloch coal bed splits into two beds with as much as 20 feet (6 m) of separation. The two beds are called the Upper Knobloch (Kn_1) and the Lower Knobloch (Kn_2), as shown on plate 1.

The coal found along the eastern flank of the Powder River Basin in Montana increases in rank from lignite, located along the outcrop areas in the east, to subbituminous A, B, and C in the deeper parts of the basin to the west. There are no known publicly available chemical analyses of coal from the Volborg quadrangle. However, all analyses of coals from adjacent quadrangles, including the Foster Creek School quadrangle to the west, indicate that these coals are all lignite A in rank. Therefore, a rank of lignite A has been assigned by us to all of the coals in the Volborg quadrangle.

The trace element content of coals in the Volborg 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).

Contact coal bed

The Contact coal bed was first described by Bass (1932) from exposures in the Kirkpatrick Hill quadrangle in the northeastern part of the Ashland coal field, a few miles (a few kilometers) north of the Volborg quadrangle.

The Contact coal bed occurs just above the contact between the Lebo Shale Member and the overlying Tongue River Member in the north two-thirds of the Volborg quadrangle (pl. 1). Its thickness is generally less than 2.8 feet (0.8 m). Because of its thinness no economic coal resources have been attributed to it.

Volborg coal bed

The Volborg coal bed was first described by Parker and Andrews (1939) from exposures east of the Volborg Post Office in the Volborg quadrangle. It lies 25 to 40 feet (7.6 to 12 m) above the Contact coal bed and attains a thickness of 2.7 feet (0.8 m). Because of its thinness no economic coal resources have been attributed to it.

Terret coal bed

The Terret coal bed was first described by Bass (1932, p. 51) from a small mine on the Terret Ranch (Cook Creek Reservoir quadrangle) in the Ashland coal field about 22 miles (35 km) west-southwest of the Volborg quadrangle. The Terret coal bed crops out on both sides of Pumpkin and SL Creek valleys, where it occurs about 60 feet (18 m) above the base of the Tongue River Member. In the northwest quarter of the quadrangle, the Terret coal bed is of Reserve Base thickness, reaching a maximum of 7.4 feet (2.3 m), as shown on plate 10. The bed dips gently westward, with minor variations in the amount of dip (pl. 10). The overburden on the Terret bed exceeds 200 feet (61 m) in thickness locally and, in places, contains the Flowers-Goodale or Knobloch coal beds (pl. 11). No coal analyses are available from the Terret coal bed in the Volborg quadrangle; however, the Montana Bureau of Mines and Geology drilled and cored the Terret coal in drill hole FC-16 (sec. 17, T. 1 N., R. 48 E.) in the Foster Creek School quadrangle, about 2 miles (3.2 km) west of the Volborg quadrangle. An analysis of coal from depths of 53 to 62 feet (16 to 18.9 m) shows ash 5.14 percent, sulfur 0.21 percent, and a heating value of 7,820 Btu per pound

(18,189 kJ/kg) on an as-received basis (Matson and Blumer, 1973, p.86). This heating value converts to about 8,244 Btu per pound (19,176 kJ/kg) on a moist, mineral-matter-free basis which determines the coal to be lignite A in rank. It is assumed that the Terret coal in the Volborg quadrangle is similar and is also lignite A in rank.

Flowers-Goodale coal bed

The Flowers-Goodale coal bed was described by Bass (1932, p. 53) from two small coal mines located in the Brandenberg quadrangle, about 20 miles (32 km) west of the Volborg quadrangle. The Flowers-Goodale coal bed crops out around the crests of the high ridges near the northwest corner of the quadrangle (pl. 1). The bed dips to the northwest about 30 feet per mile (5.7 m/km) and ranges in thickness from about 4 feet to 8 feet (1.2 to 2.4 m), as shown on plate 7. The overburden covering the Flowers-Goodale coal bed, where the bed is 5 feet (1.5 m) or more thick, ranges from zero to about 100 feet (30 m) in thickness (pl. 8).

An analysis of the Flowers-Goodale coal from the Volborg quadrangle is not available; however, the Montana Bureau of Mines and Geology drilled and cored the Flowers-Goodale coal in drill hole FC-32 (sec. 25, T. 1 N., R. 47 E.) about 4 miles (6.4 km) west of the Volborg quadrangle in the Foster Creek School quadrangle. An analysis of the coal from 83 to 95.5 feet (25.3 to 29.1 m) shows a heating value of 7,540 Btu per pound (17,538 kJ/kg), ash 7.27 percent, and sulfur 0.36 percent, on an as-received basis (Matson and Blumer, 1973, p. 86). This heating value converts to about 8,130 Btu

per pound (18,910 kJ/kg) on a moist, mineral-matter-free basis and determines the coal to be lignite A in rank. It is assumed that the Flowers-Goodale coal in the Volborg quadrangle is similar and is also lignite A in rank.

Knobloch coal bed

The Knobloch coal bed was first described by Bass (1932). The name was derived from the Knobloch Ranch and coal mine in the Birney Day School quadrangle located about 40 miles (64 km) southwest of the Volborg quadrangle.

The Knobloch coal bed occurs about 65 feet (19.8 m) above the Flowers-Goodale coal bed and crops out around the higher elevations in the southeastern and northwestern parts of the quadrangle. Along the outcrops much coal has burned, baking the overlying shale and sandstone to clinker (pl. 1).

An area of unburned Knobloch coal along the east-central border of the quadrangle is estimated to range from 1 to 18 feet (0.3 to 5.5 m) in thickness and to dip westward at an angle of less than 1 degree (pl. 4) based on measurements in the Divide School quadrangle to the east. Overburden on this unburned coal ranges from about 80 to 160 feet (24 to 49 m) in thickness (pl. 5).

In the southeastern part of the quadrangle, the Knobloch coal bed splits into two beds with as much as 20 feet (6 m) of separation (pls. 1 and 4). The Lower Knobloch (Kn_2) decreases in thickness westward from

12 to 2 feet (3.7 to 0.6 m), as shown on plate 4. The bed dips north or northwest about 30 feet per mile (5.7 m/km) and is covered with overburden up to about 100 feet (30 m) in thickness. The Upper Knobloch (Kn_1) coal split is not shown on plates 5 or 6 because its thickness is less than 5 feet (1.5 m), and/or it is not on Federal lands.

An analysis of the Knobloch coal from the Volborg quadrangle is not available; however, the Montana Bureau of Mines and Geology drilled and cored the Knobloch coal in drill hole FC-11 (sec. 3, T. 1 S., R. 47 E.) in the North Stacey School quadrangle about 8 miles (12.8 km) west of the Volborg quadrangle. An analysis of the coal from depths of 84 to 100 feet (25.6 to 30.5 m) shows a heating value of 7,500 Btu per pound (17,445 kJ/kg), ash 8.36 percent, and sulfur 0.32 percent, on an as-received basis (Matson and Blumer, 1973, p. 86). This heating value converts to about 8,190 Btu per pound (19,050 kJ/kg) on a moist, mineral-matter-free basis, and determines the coal to be lignite A in rank. It is assumed that the Knobloch coal in the Volborg quadrangle is similar and is also lignite A in rank.

COAL RESOURCES

Data from oil-and-gas and coal test 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 shown in this report are the Reserve Base (RB) part of the Identified Resources (as discussed in U.S. Geological Sur-

vey Bulletin 1450-B). The Reserve Base for lignite is lignite that is 5 feet (1.5 m) or more thick, under 1,000 feet (305 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 200 feet (61 m) or less of overburden. This depth of overburden is the stripping limit for beds of lignite in this area.

Estimated coal resources in this 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 1,750 short tons of coal per acre-foot (12,880 metric tons/hectare-meter) for lignite yields the lignite resources in short tons for each isopached bed. Reserve Base and Reserve tonnage values for the Terret, Flowers-Goodale, and Knobloch 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 surface-minable and underground-minable lignite in this quadrangle is calculated to be 20.35 million short tons (18.46 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 tables 1 and 2. All numbers are rounded to the nearest one-hundredth of a million short tons. About 59 percent of the Reserve Base tonnage is classed as Measured, 16 percent as Indicated, and 25 percent as Inferred.

COAL DEVELOPMENT POTENTIAL

Areas where coal beds are 5 feet (1.5 m) or more thick and are overlain by 200 feet (61 m) or less of overburden are considered to have potential for surface mining in this quadrangle 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 lignite is as follows:

$$MR = \frac{t_o\ (0.922)}{t_c\ (rf)}$$

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

Areas of high, moderate, and low development potential for surface-mining methods are defined as areas underlain by coal beds having less than 200 feet (61 m) of overburden and having respective mining-ratio values of

0 to 10, 10 to 15, and greater than 15. Mining-ratio contours and the stripping-limit overburden isopach which serve as boundaries for these development-potential areas are shown on plates 5, 8, and 11. The 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, plate 13 in this series of maps, depicts the highest coal development-potential category which occurs within each smallest legal subdivision of Federal coal 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 200 feet or 61 m of overburden) is shown on the CDP map (pl. 13). There are two areas of high development potential: a principal area in the northwest quarter of the quadrangle and a very small area at the east border of the quadrangle. These two areas are separated by a large area of no development potential occupying the remainder of the quadrangle where the coal beds are thin or have been removed by erosion in the valleys of Pumpkin Creek and its tributaries.

The principal area of high development potential in the northwest quarter of the quadrangle is formed mainly by the Terret coal bed. The Terret coal bed is relatively thin, 3 to 9 feet (0.9 to 2.7 m), as shown by plate 10. However, in wide bands along the sides of tributary valleys the mining-ratio values are less than 10, and hence the development potential is high (p. 11). Also near the northwest corner of the quadrangle the Flowers-Goodale coal bed is about 80 feet (24 m) above the Terret coal bed, and most of the Flowers-Goodale coal bed has mining-ration values below 10 and hence a high development potential.

The small area of high development potential at the east edge of the quadrangle is formed by the overlying Knobloch coal bed (pl. 5). The Knobloch coal is 1 to 18 feet (0.3 to 5.5 m) thick and has narrow bands along tributary valleys where the mining-ratio values are less than 10, and the development potential is high.

About 22 percent of the Federal coal lands in the quadrangle has a high development potential for surface mining; the remaining 78 percent has no development potential as shown by plate 13. Although most of the 40-acre (16.2 ha) subdivisions are rated high development potential, based upon mining-ratio contours (pl. 13), some of the coal may fall into a lower development-potential category as listed in table 1.

Development potential for underground mining and in-situ gasification

A small part of the Terret coal bed of Reserve-Base thickness occurs below the surface-minable depth of 200 feet (61 m) in the quadrangle. This

coal is considered to be underground minable and is listed by development-potential category in table 2. Coal is not presently being mined by underground methods in the Northern Powder River Basin, Montana, because of poor economics. For this reason the coal development potential for underground mining of this coal 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 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 Volborg quadrangle, Custer 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	100,000	260,000	40,000	400,000
Flowers-Goodale	660,000	460,000	690,000	1,810,000
Terret	11,250,000	2,480,000	4,330,000	18,060,000
Total	12,010,000	3,200,000	5,060,000	20,270,000

Table 2.--Underground-minable coal resource tonnage by development-potential category for Federal coal lands (in short tons) in the Volborg quadrangle, Custer 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
Knobloch	0	0	0	0
Flowers-Goodale	0	0	0	0
Terret	0	0	80,000	80,000
Total	0	0	80,000	80,000

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