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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE HAMMOND DRAW QUADRANGLE, ROSEBUD COUNTY, MONTANA

[Report includes 16 plates]

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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 Hammond Draw quadrangle, Rosebud County, Montana, (16 plates; U.S. Geological Survey Open-File Report 79-011). 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 Hammond Draw 7 1/2-minute quadrangle is in east-central Rosebud County, Montana, about 30 miles (48 km) southeast of Forsyth, Montana, and 42 miles (67 km) southwest of Miles City, Montana, towns in the Yellowstone River valley in eastern Montana. U.S. Interstate Highway 94 and the main east-west routes of the Chicago, Milwaukee, St. Paul, and Pacific Railroad, and the Burlington Northern Railroad follow the Yellowstone River and pass through Forsyth and Miles City.

Accessibility

The Hammond Draw quadrangle is accessible from Miles City, Montana, by following U.S. Highway 312 southeastward 14 miles (22 km) and then partially paved local Highway 332 southwestward along the Tongue River 42

miles (68 km) to the eastern edge of the quadrangle. Local Highway 332, the Tongue River Road, passes through the southeastern part of the quadrangle. The quadrangle is also accessible from Forsyth by going east about 11 miles (17.5 km) on U.S. Interstate Highway 94 and then south-southeastward about 30 miles (48 km) on the partially paved local Highway 447 to the vicinity of the quadrangle. Local Highway 447 follows Rosebud Creek and passes 1 to 2.5 miles (1.6 to 4 km) west of the quadrangle, from where the quadrangle can be reached by several unimproved roads and trails.

The Hammond Draw quadrangle is accessible from Ashland, Montana, a small town on the Tongue River about 11 miles (17.6 km) south of the quadrangle on the graveled local Highway 332, the Tongue River Road. Ashland is on U.S. Highway 212, 21 miles (34 km) east of Lame Deer and 63 miles (101 km) east of U.S. Interstate Highway 90 near Hardin, Montana.

The nearest railroad is a spur of the Burlington Northern Railroad which connects the main east-west route of the railroad in the Yellowstone Valley near Forsyth with the Rosebud (Colstrip) and Big Sky coal mines near Colstrip, Montana. The Rosebud (Colstrip) mine is 7 miles (11 km) west of the Hammond Draw quadrangle and 35 miles (56 km) from the Yellowstone River valley.

Physiography

The Hammond Draw quadrangle is within the Missouri Plaeau division of the Great Plains physiographic province. The plateau surface, resulting from nearly flat-lying rock strata, has been maturely dissected by tributaries of the Tongue River, which passes through the southeast quarter

of the Hammond Draw quadrangle, and Rosebud Creek a few miles (a few kilometers) to the west of the quadrangle. Both these streams are northward flowing tributaries of the Yellowstone River. The divide between the two is an irregular, forest-covered ridge in the western part of the quadrangle. The divide rises 400 to 500 feet (122 to 152 m) above the Tongue River and Rosebud Creek valleys. The Tongue River has a flood plain 0.5 to 1 mile (0.8 to 1.6 km) wide from which the sides of the valley rise steeply to flat-topped intertributary ridges.

The highest elevation in the quadrangle, 3,342 feet (1,019 m), is on the divide in the northwest quarter of the quadrangle. The lowest elevation, about 2,775 feet (846 m), is along the Tongue River on the eastern border of the quadrangle. Topographic relief is 567 feet (173 m).

Climate

The climate of Rosebud County 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 about one-half of the quadrangle. The Coal Data Map

(pl. 2) shows the KRCRA boundary and land ownership status. There were no outstanding Federal coal leases or prospecting permits as of 1977.

GENERAL GEOLOGY

Previous work

Bass (1932) mapped the quadrangle as part of the Ashland coal field, Rosebud, Powder River, and Custer Counties, Montana.

Stratigraphy

A generalized columnar section of the coal-bearing rocks is shown on the Coal Data Sheet (pl. 3) of the CRO maps. The exposed bedrock units belong to the upper member of the Paleocene Fort Union Formation, the Tongue River Member. The Tongue River Member, the principal coal-bearing unit, consists of arkosic sandstone, sandy shale, carbonaceous shale, and coal. Its color is generally yellowish-gray, but in many outcrops the coal has burned and the overlying strata have been baked and altered to a brick-red or reddish-brown clinker. The upper part of the Tongue River Member has been removed by erosion in the Hammond Draw quadrangle so that only about 700 feet (213 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 Hammond Draw quadrangle is in the north-central part of the Powder River structural basin. The strata are nearly flat or in places dip southward at an angle of less than 1 degree. Structure contours on top of the coal beds (pls. 4, 7, 10, and 13) show minor structural features.

COAL GEOLOGY

Five primary coal beds, all in the Tongue River Member, are mapped on the surface in this quadrangle (pl. 1) and are shown in section on plate 3. Two thin, local coal beds crop out in places, but are not of economic importance.

The Burley coal bed is stratigraphically the lowermost, named coal bed mapped, lying about 130 feet (40 m) above the base of the Tongue River Member. A thin, local coal bed occurs at about this stratigraphic position along Joe Leg Creek in the east-central part of the quadrangle. The Burley coal bed is overlain successively by a noncoal interval of about 50 to 80 feet (15.2 to 24.4 m), the Terret coal bed, a noncoal interval of about 35 feet (11 m), the McKay coal bed, a noncoal interval of 5 to 10 feet (1.5 to 3 m), the Rosebud coal bed, a noncoal interval of 60 to 120 feet (18 to 37 m), and the Knobloch coal bed.

The trace element content of coals in the Hammond Draw 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).

Burley coal bed

The Burley coal bed was described by Dobbin (1930, p. 27) from outcrops at the Burley Ranch in the Forsyth coal field (Colstrip East quadrangle) about 12 miles (19 km) northwest of the Hammond Draw quadrangle.

The Burley coal bed crops out in the Hart Creek and Alfalfa Creek valleys in the northeast quarter of the quadrangle, and in valleys near the northwest corner of the quadrangle (pl. 1). The thickness of the Burley coal bed ranges from 3.3 to about 6 feet (1 to about 1.8 m), as shown by plate 13. The coal bed dips southward less than 1 degree (pl. 13). The overburden on the Burley bed ranges in thickness from zero to about 295 feet (90 m). This overburden includes the Terret and in places the Knobloch coal beds. There are no known published chemical analyses of coal from the Burley bed; however, it is assumed that the Burley coal is similar in rank to other closely associated coal beds nearby, and is subbituminous C in rank.

Terret coal bed

The Terret coal bed was named by Bass (1932, p. 51) from a small mine on the Terret Ranch in the Cook Creek Reservoir quadrangle just southeast of the Hammond Draw quadrangle. The coal crops out in the north-central

part of the quadrangle and near the southeast corner. The isopach map (pl. 10) shows that the thickness of the Terret coal bed ranges from about 3 to about 12 feet (0.9 to 3.7 m). The bed is nearly flat or dips southward less than 1 degree (pl. 10). Overburden on the Terret coal bed (pl. 11) ranges in thickness from near zero at the outcrops to over 200 feet (61 m).

There are no known chemical analyses of the Terret coal in the Hammond Draw quadrangle, but one is available from drill hole SH-7094, sec. 16, T. 1 N., R. 45 E., in the Brandenberg quadrangle, about 3 miles (4.8 km) east of the Hammond Draw quadrangle. 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. Because of the proximity of this drill hole to the Hammond Draw quadrangle it is assumed that the Terret coal in the Hammond Draw quadrangle is similar and is subbituminous C in rank.

McKay coal bed

The McKay coal bed was named by Dobbin (1930, p. 27) from exposures on the McKay ranch in the eastern part of the Colstrip East quadrangle in the Forsyth coal field about 12 miles (19 km) northwest of the Hammond Draw quadrangle. Dobbin states that the McKay bed may be considered a split of the Rosebud coal bed because the interval between them in several places is less than 7 feet (2.1 m). The outcrop of the McKay coal follows

closely that of the Rosebud coal, and where the Rosebud coal has burned the McKay coal is generally concealed by clinker. For this reason the McKay coal bed is difficult to map, and in this quadrangle it has been mapped for only a short distance at the head of Hammond Draw in the southwest quarter of the quadrangle (pl. 1). Here the McKay coal is 2.5 to 4.7 feet (0.8 to 1.4 m) thick. Economic coal resources have not been assigned to the McKay coal bed in this quadrangle.

Rosebud coal bed

The Rosebud coal bed was named by Dobbin (1930, p. 27) from outcrops along Rosebud Creek in the Forsyth coal field. A specific type location was not given. In the Hammond Draw quadrangle, the Rosebud coal bed has been mapped only in the southern part of the quadrangle west of the Tongue River. East of the Tongue River the Flowers-Goodale coal bed occupies the same stratigraphic interval (Bass, 1932, p. 54). The Rosebud coal decreases in thickness northward and eastward from 25.4 feet to about 5 feet (7.7 m to about 1.5 m) and dips southward less than 1 degree, as shown by the isopach and structure map (pl. 7). Overburden on the Rosebud coal bed ranges in thickness from zero at the outcrop to about 140 feet (43 m).

There are no known published chemical analyses of the Rosebud coal bed in the Hammond Draw quadrangle. A chemical analysis of the Rosebud coal from drill hole SH-70102, sec. 16, T. 1 S., R. 43 E. in the Hammond Draw SW quadrangle, about 2.5 miles (4 km) west of the Hammond Draw quadrangle, shows ash 6.76 percent, sulfur 0.70 percent, and heating value 8,454 Btu per pound (21,085 kJ/kg) on a moist, mineral-matter-free basis

(Matson and Blumer, 1973, p. 124), indicating that the Rosebud coal at this location is subbituminous C in rank. Because this location is so close to the Hammond Draw quadrangle it is assumed that the Rosebud coal in the Hammond Draw quadrangle is similar and is also subbituminous C in rank.

Flowers-Goodale coal bed

The Flowers-Goodale coal bed was first described by Bass (1932, p. 53) from the small Flowers mine and the Goodale mine in the east-central part of the Brandenberg quadrangle directly east of the Hammond Draw quadrangle. In the Hammond Draw quadrangle, the Flowers-Goodale coal bed has been mapped only east of the Tongue River in the southeastern part of the quadrangle (pls. 1 and 3). Bass (1932, p. 54) states that the Flowers-Goodale coal bed occurs at the approximate position of the Rosebud coal bed west of the Tongue River and may represent that bed east of the river. The Flowers-Goodale coal bed in the Hammond Draw quadrangle is estimated to be only about 3.6 feet (1.1 m) thick and, therefore, has not been assigned economic coal resources.

Knobloch coal bed

The Knobloch coal bed was named by Bass (1924) from a small mine on the Knobloch Ranch on the Tongue River in the Birney Day School quadrangle, 18 miles (29 km) south-southwest of the Hammond Draw quadrangle.

In the Hammond Draw quadrangle, the Knobloch coal bed occurs about 300 to 360 feet (91 to 110 m) above the base of the Tongue River Member. In the southern part of the quadrangle west of the Tongue River, the Knobloch coal at one time covered a considerable part of the wide interstream areas,

but most of the coal has been burned. Now there are only limited areas of coal remaining. Here the Knobloch coal occurs about 60 to 120 feet (18 to 37 m) above the Rosebud coal bed. Near the southeast corner of the quadrangle, east of the Tongue River, the Knobloch coal bed occurs on a few hill tops at about the same distance above the Flowers-Goodale coal bed. In the northern part of the quadrangle, the Knobloch coal bed occurs near the crest of the major drainage divide. Here the Rosebud coal bed has not been mapped because it is thin or absent and the Knobloch coal bed is about 130 to 150 feet (40 to 46 m) above the Terret coal bed (pls. 1 and 3).

The Knobloch coal bed ranges from 4.3 to about 19 feet (1.3 to about 5.8 m) in thickness (pl. 4). Overburden on the Knobloch coal bed ranges from zero near the outcrops to about 120 feet (37 m) in thickness (pl. 5).

There are no known chemical analyses of the Knobloch coal in the Hammond Draw quadrangle. An analysis of this coal in drill hole SH-70102, sec. 16, T. 1 S., R. 43 E. in the Hammond Draw SW quadrangle, about 3 miles (4.8 km) west of the Hammond Draw quadrangle shows ash 6.57 percent, sulfur 0.44 percent, and heating value 8,209 Btu per pound (19,094 kJ/kg) on an as-received basis (Matson and Blumer, 1973, p. 124). This heating value converts to about 8,790 Btu per pound (20,446 kJ/kg) on a moist, mineral-matter-free basis, which indicates that the Knobloch coal is subbituminous C in rank. Because this drill hole is so close to the Hammond Draw quadrangle it is assumed that the Knobloch coal in the Hammond Draw quadrangle is similar and is also 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 (RB) 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 thick) 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 isopached coal bed.

Reserve Base and Reserve tonnage numbers for the Knobloch, Rosebud, Terret, and Burley coal beds are shown on plates 6, 9, 12, and 15, respectively, rounded to the nearest one-hundredth of a million short tons.

The total Reserve Base tonnage of surface-minable federally owned coal in this quadrangle is estimated to be 89.49 million short tons (81.17 million t). There are no known underground-minable coal resources. The Reserve Base tonnage totals per section are shown in the northwest corner of each section on CRO plate 2 and by development-potential category in table 1. All numbers are rounded to the nearest one-hundredth of a million short tons. About 10 percent of the Reserve Base tonnage is classed as Measured, 50 percent as Indicated, and 40 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 plates 5, 8, 11, and 14. 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. 16) included in this series of maps depicts the highest coal development-potential category which occurs within each smallest legal subdivision of land (normally about 40 acres or 16.2 ha). If such a 40-acre (16.2-ha) tract of land contains areas of high, moderate, and low development potential, the entire tract is assigned to the high development-potential category for CDP mapping purposes, etc.

In areas of moderate to high topographic relief, the area of moderate development potential for surface mining of a coal bed (area having 10 to 15 mining-ratio values) is often restricted to a narrow band between the high and low development-potential areas. In fact, due to the 40-acre (16.2-ha)

minimum size of coal development-potential increments, the narrow strip of moderate development-potential area is often absorbed into the 40-acre (16.2-ha) tracts of high development-potential category. The Coal Development Potential (CDP) map then shows areas of low development potential abutting against areas of high development potential.

The coal development potential for surface-mining methods (less than 500 feet or 152 m of overburden) is shown on the Coal Development Potential map (pl. 16). Most of the federally owned coal lands in the quadrangle have either a high development potential or no development potential. Only a few scattered tracts have a moderate or low development potential. About 48 percent of the Federal coal lands have a high development potential, 2 percent have a moderate development potential, 1 percent have a low development potential, and 49 percent have no development potential for surface mining.

The Burley coal bed (pl. 14) has a development potential for surface mining only in the northern part of the quadrangle where the bed is more than 5-feet thick. A band of high development potential is present between the outcrops and the 10 mining-ratio contour in the lower parts of the valleys. Above this in the valleys are narrow bands of moderate development potential between the 10 and 15 mining-ratio contours. Above these bands are wide areas of low development potential which cover the interstream divides above the 15 mining-ratio contour.

The Terret coal bed (pl. 11) has a development potential for surface mining in the north-central part of the quadrangle. Here there is a narrow

band of high development potential (mining-ratio values 0 to 10) at the head of stream valleys. Above this is a very narrow band of moderate development potential (mining-ratio values 10 to 15). Still higher are larger areas of low development potential (mining-ratio values above 15) on the crest of ridges.

The Rosebud coal bed has a development potential for surface mining in the southwest quarter of the quadrangle (pl. 8). Here there are large areas of high development potential above the outcrops or the 5-foot coal bed isopach and below the 10 mining-ratio contour. There are narrow bands of moderate development potential along the valley sides between the 10 and 15 mining-ratio contours. There are a few areas of low development potential on the crest of hills above the 15 mining-ratio contour.

The Knobloch coal bed (pl. 5) has a development potential for surface mining in limited, narrow areas along the crest of the major drainage divide in the north-central part of the quadrangle. Most of the coal here has a high development potential, as it is above the outcrops and below the 10 mining-ratio contour.

In the east third of the quadrangle, much of the Federal coal lands have no development potential because the coal beds have been removed by erosion near the Tongue River. Some of the Federal coal lands in the northwest quarter of the quadrangle have no development potential because the coal beds there are less than 5 feet (1.5 m) thick.

Development potential for underground mining and in-situ gasification

All known minable coal in the Hammond Draw quadrangle is within surface-minable depths. Because there are no known underground coal resources below the stripping limit of 500 feet (152 m), a Coal Development Potential map for underground mining and estimates of underground-minable coal resources were 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 Hammond Draw quadrangle, Rosebud County, 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				
Knobloch	4,700,000	0	0	4,100,000
Rosebud	50,760,000	4,420,000	2,790,000	57,970,000
Terret	8,050,000	2,400,000	4,140,000	14,590,000
Burley	2,760,000	2,520,000	6,950,000	12,230,000
Total	66,270,000	9,340,000	13,880,000	89,490,000

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