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

[Report includes 16 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 Hammond Draw SW quadrangle, Rosebud County, Montana, (16 plates; U. S. Geological Survey Open-File Report 79-012). 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 SW 7 1/2-minute quadrangle is in south-central Rosebud County, Montana, about 28 miles (45 km) south-southeast of Forsyth, Montana, a town on the Yellowstone River about 100 miles (160.9 km) northeast of Billings and 45 miles (72.4 km) southwest of Miles City. The Burlington Northern Railroad, the Chicago, Milwaukee, St. Paul, and Pacific Railroad, and U.S. Interstate Highway 94 follow the valley of the Yellowstone River and pass through Forsyth, the county seat. The town of Colstrip, Montana, is about 6 miles (10 km) west of the northwest corner of the quadrangle.

Accessibility

The Hammond Draw SW quadrangle is accessible from the north by partially paved local Highway 447, which follows the Rosebud Creek valley through the central part of the quadrangle and intersects U.S. Interstate Highway 94 near Forsyth about 30 miles (48 km) north of the quadrangle. The Hammond Draw SW quadrangle is also accessible from the north by paved State Highway 39 which intersects local Highway 447 about 9 miles (14 km) south of Colstrip and intersects U.S. Interstate Highway 94 near Forsyth about 30 miles (48 km) north-northwest of Colstrip.

The Hammond Draw SW quadrangle is also accessible from either Lame Deer or Ashland on U.S. Highway 212 which runs east-west about 8 miles (12.8 km) south of the quadrangle. State Highway 39 intersects U.S. Highway 212 at Lame Deer about 16 miles (26 km) southwest of the quadrangle. An improved, graveled route enters the quadrangle about 14 miles (22 km) northwest of Ashland, follows Greenleaf Creek, and intersects local Highway 447 near the center of the quadrangle. A number of unimproved roads extend accessibility throughout the quadrangle.

Physiography

The Hammond Draw SW quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. Rosebud Creek flows northeastward through the quadrangle and continues northward about 30 miles (48 km) to the Yellowstone River. Rosebud Creek has a flood plain 0.5 to 0.75 mile (0.8 to 1.2 km) wide. The chief tributaries are Miller Creek and Greenleaf Creek from the south and Cow Creek from the west. The valley of

Rosebud Creek has a gentle slope on its southeast side and a considerably steeper slope on its northwest side. The valley is bordered on its northwest side by irregular, flat-topped buttes and ridges that rise 200 to 300 feet (61 to 91 m) above the valley bottom and are capped by reddish-colored clinker beds formed by the burning of coal beds.

The highest elevations, about 3,300 feet (1,006 m), are on buttes in the northwest quarter of the quadrangle. The lowest elevation, about 2,850 feet (869 m), is along Rosebud Creek near the northeast corner of the quadrangle. Topographic relief is about 450 feet (137 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) extends into the southern and northern parts of the quadrangle and covers about one-third of the quadrangle area. The Boundary and Coal Data Map (pl. 2) shows the location of the KRCRA tracts, the land ownership status, and the total tonnage of Reserve Base (RB) and Hypothetical (HYP)

coal per section for each section of Federal land. There were no outstanding Federal coal leases or prospecting permits of record as of 1977.

GENERAL GEOLOGY

Previous work

Bass (1932) mapped most of the Hammond Draw SW quadrangle as part of the Ashland coal field, Rosebud, Powder River, and Custer Counties, Montana. Kepferle (1954) mapped the southern half of the quadrangle as part of the selected deposits of strippable coal in central Rosebud County, Montana. Matson and Blumer (1973) mapped the south edge of the quadrangle as part of the Greenleaf Creek-Miller Creek coal deposit.

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 strata belong to the upper two members of the Fort Union Formation (Paleocene), the Lebo Shale Member, and the overlying Tongue River Member. The upper part of the Lebo Shale Member is exposed along Rosebud Creek near the north border of the quadrangle. It consists of soft clay shale which weathers somber colored to dark gray. No coal beds are exposed in the Lebo Shale.

The Tongue River Member, which overlies the Lebo Shale Member, consists of yellow sandstone, sandy shale, carbonaceous shale, and significant coal beds. The Tongue River Member is about 1,600 feet (488 m) thick in the Ashland coal field (Bass, 1932); however, in the Hammond Draw SW quadrangle, the upper part of the member has been removed by erosion so that only about the lower 600 feet (183 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 SW quadrangle is in the north-central part of the Powder River structural basin. The strata are nearly flat or in places dip southward or southeastward at an angle of less than 1 degree. Structure contours on top of the Knobloch, Rosebud, McKay, and Burley coal beds (pls. 4, 7, 10, and 13) show a local dip of less than 1 degree to the south or southeast, although in places the structure is modified by minor, local warping and folding.

COAL GEOLOGY

Six coal beds have been mapped on the surface of the Hammond Draw SW quadrangle (pl. 1) and are shown in section on plate 3. The coal beds,

all in the Tongue River Member of the Fort Union Formation, in ascending order are the Burley, the McKay, the Rosebud, a local bed, the Knobloch, and the Sawyer. The Burley coal bed is about 120 feet (37 m) above the base of the Tongue River Member. The Burley coal bed is overlain successively by a noncoal interval of 175 to 200 feet (53 to 61 m), the McKay coal bed, a noncoal interval of about 15 to 25 feet (4.6 to 7.6 m), the Rosebud coal bed, a noncoal interval of 15 to 50 feet (4.6 to 15 m), a local coal bed, a noncoal interval of 20 to 30 feet (6 to 9 m), the Knobloch coal bed, a noncoal interval of about 160 feet (49 m), and the Sawyer clinker bed.

The trace element content of coals in the Hammond Draw SW 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 in the Forsyth coal field at the Burley Ranch in the northeast corner of the Colstrip East quadrangle about 7 miles (11 km) north-northwest of the Hammond Draw SW quadrangle.

The Burley bed crops out along Rosebud Creek in the north half of the Hammond Draw SW quadrangle where it occurs about 120 feet (37 m) above the base of the Tongue River Member. The bed ranges from 3.5 to slightly over 7 feet (1.1 to 2.1 m) in thickness and dips less than 0.5 degree

southeastward (pl. 13), except where this dip is interrupted by minor folding. The overburden on the Burley coal bed ranges from zero at the outcrop to 300 feet (91 m) in thickness, as shown by plate 14.

There are no known publicly available chemical analyses of the Burley coal bed; it is assumed, however, that the coal is similar in rank to other coal beds in the Hammond Draw SW quadrangle and is subbituminous C.

McKay coal bed

The McKay coal bed was described 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 a few miles (a few km) north-northwest of the Hammond Draw SW quadrangle. Dobbin states that the McKay bed may be considered a lower 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 is burned the McKay coal is generally concealed by the overlying clinker. The isopach map of the McKay coal bed (pl. 10) indicates that the coal ranges from about 1.8 to over 8 feet (0.6 to over 2.4 m) in thickness. The structure map (pl. 10) shows a dip of less than 1 degree to the east or southeast, which is interrupted in places by minor folding. The overburden on the McKay coal (pl. 11) ranges from zero to 300 feet (91 m) in thickness.

There are no known publicly available chemical analyses of the McKay coal in the Hammond Draw SW quadrangle. It is assumed that the McKay coal

is similar in rank to other coals in the Hammond Draw SW quadrangle and is subbituminous C.

Rosebud 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 location was not given. The Rosebud coal bed has been eroded or burned in the northern and central parts but underlies the southeastern part of the Hammond Draw SW quadrangle. The thickness of the Rosebud coal bed as shown by the isopach and structure map (pl. 7) ranges from about 4 to 24 feet (1.2 to 7.3 m). The coal bed dips at an angle of less than 1 degree (pl. 7) in diverse directions because of minor local warping or folding. Overburden on the Rosebud coal bed (pl. 8) ranges in thickness from zero to about 300 feet (91 m).

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 shows ash 6.76 percent, sulfur 0.70 percent, and heating value 8,454 Btu per pound (19,664 kJ/kg) on an as-received basis (Matson and Blumer, 1973, p. 124). This heating value converts to about 9,065 Btu per pound (21,085 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Rosebud coal is subbituminous C in rank.

Local coal bed

A local coal bed occurs in places from 15 to 50 feet (4.6 to 15.2 m) above the Rosebud coal bed. This bed is generally less than 5 feet (1.5 m) thick. Because of its thinness and local occurrence it has not been assigned 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, 24 miles (39 km) south of the Hammond Draw SW quadrangle.

In the Hammond Draw SW quadrangle, the Knobloch coal bed is about 300 to 400 feet (91 to 122 m) above the base of the Tongue River Member and about 40 to 80 feet (12 to 24 m) above the Rosebud coal bed. The Knobloch coal bed occurs in the area east of Rosebud Creek in the southern part of the quadrangle. On the higher elevations in the eastern part of the quadrangle the bed has been almost entirely burned, forming an extensive reddish-colored clinker deposit. As shown by the isopach map (pl. 4), the Knobloch coal bed ranges from 18 to 25 feet (5.5 to 7.6 m) in thickness. Structure contours on top of the Knobloch coal bed (pl. 4) show that the Knobloch coal dips to the south or southeast at an angle of less than 1 degree, and that this dip is modified by minor warping or folding. Overburden on the Knobloch coal bed (pl. 5) ranges from zero to 200 feet (61 m) in thickness.

A chemical analysis of the Knobloch coal bed from drill hole SH-70102, sec. 16, T. 1 S., R. 43 E. in the Hammond Draw SW 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.

Sawyer coal bed

Clinker beds, formed by the burning of the Sawyer coal bed, cap two buttes in the south-central part of the quadrangle. The Sawyer coal appears to have been entirely burned in this quadrangle.

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 part of the Identified Resources and the Hypothetical (HYP) part of the Undiscovered Resources as discussed in U.S. Geological Survey Bulletin 1450-B (1976).

The Reserve Base for subbituminous coal is coal that is 5 feet (1.5 m) or more thick, under 3,000 feet (914 m) or less of overburden, and located within 3 miles (4.8 km) of a point of coal-bed measurement. Reserve Base is further subdivided into reliability categories according to their nearness to a measurement of the coal bed. Measured coal is coal within 0.25 mile (0.4 km) of a measurement, Indicated coal extends 0.5 mile (0.8 km) beyond Measured coal to a distance of 0.75 mile (1.2 km) from the measurement point, and Inferred coal extends 2.25 miles (3.6 km) beyond Indicated coal to a distance of 3 miles (4.8 km) from the measurement point.

Hypothetical Resources are undiscovered coal resources in beds that may reasonably be expected to exist in known mining districts under known

geologic conditions. In general, Hypothetical Resources are located in broad areas of coal fields where no points of observation are present, and the evidence of the coal's existence is from distant outcrops, drill holes, or wells that are more than 3 miles (4.8 km) away. Hypothetical Resources are located beyond the outer boundary of the Inferred part of Identified Resources in areas where the assumption of continuity of the coal bed is supported only by extrapolation of geologic evidence. For purposes of this report, tonnages were calculated for only those Hypothetical coal resources in beds that are estimated to be 5 feet (1.5 m) or more thick and to be under less than 3,000 feet (914 m) of overburden.

Reserves are the recoverable part of the Reserve Base coal. For surface-minable coal in this quadrangle, the coal reserves are considered to be 85 percent (the recovery factor for this area) of that part of the Reserve Base that is beneath 500 feet (152 m) or less of overburden. This depth of overburden is the stripping limit for multiple, thin (5 to 40 feet or 1.5 to 12 m thick) beds of subbituminous coal in this area.

The estimates of coal resources in the Hammond Draw SW quadrangle were made using data obtained from the coal isopach maps (pls. 4, 7, 10, and 13). The coal-bed acreage (measured by planimeter) multiplied by the average isopached thickness of the coal bed times a conversion factor of 1,770 short tons of coal per acre-foot (13,028 metric tons/hectare-meter) for subbituminous coal yields the coal resources in short tons of coal for each isopached coal bed. Reserve Base and Reserve tonnage values for the Knobloch, Rosebud, McKay, and Burley coal beds are shown on plates 6, 9,

12, and 15, respectively, and are rounded to the nearest one-hundredth of a million short tons.

The total Reserve Base tonnage of federally owned surface-minable coal in the Hammond Draw SW quadrangle is calculated to be 107.57 million short tons (97.57 million t). The Hypothetical Resource tonnage is calculated to be 3.71 million short tons (3.36 million t). The grand total of Reserve Base and Hypothetical Resource tonnage is 111.28 million short tons (100.93 million t). There is no known underground-minable coal. 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, 38 percent as Indicated, and 52 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 maps, plate 5, for the Knobloch coal bed, plate 8 for the Rosebud coal bed, plate 11 for the McKay coal bed, and plate 14 for the Burley coal bed. 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, plate 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.

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). This map shows two areas of high development potential, one in the north fourth of the quadrangle and the other in the south half of the quadrangle. The two areas of high development potential are separated by a large area along Rosebud Creek in the central part of the quadrangles and along Miller Creek near the west edge of the quadrangle

where the coal beds have been removed by erosion and the Federal lands therefore have no development potential. The Rosebud Creek valley also separates the northern area of high development potential into two segments, a large segment west of the valley and a small segment to the east.

The area of high development potential in the north fourth of the quadrangle is formed principally by the Burley coal bed. Although the Burley coal bed is quite thin in this area (5 to 7 feet or 1.5 to 2.1 m), its overburden is also thin enough in most places to yield mining ratios less than 10 (pl. 14). Along the southwest margin of this area, where the overburden on the Burley coal bed increases in thickness, there are a few small tracts of low and moderate development potential. Northwest of these small tracts the Burley coal bed is overlain by the moderately thick (5 to 8 feet or 1.5 to 2.4 m) McKay coal bed (pl. 11). This extends the area of high development potential. South of the northern area of high development potential the Burley bed decreases to less than 5 feet (1.5 m) in thickness, and in the remainder of the quadrangle the Burley coal has no development potential.

The area of high development potential in the south half of the Hammond Draw SW quadrangle is formed by superimposition of the McKay, Rosebud, and Knobloch coal beds separated by noncoal intervals of 15 to 80 feet (4.6 to 24.4 m). The lowest bed, the McKay coal bed, is quite thin (5 to 8 feet or 1.5 to 2.4 m), but the overburden is sufficiently thin in bands along tributary streams to yield mining ratios of less than 10 (pl. 10), and to place much of the McKay coal in the high development-potential category. The Rosebud coal bed is thicker (4 to 24 feet or 1.2 to 7.3 m), so it too has

wide bands along tributary valleys where the mining ratio is less than 10 (pl. 8) and the development potential is high. The Knobloch coal bed, being 18 to 25 feet (5.5 to 7.6 m) thick, and under relatively thin overburden (less than 200 feet) has mining ratios every place less than 10, and so is entirely in the high development-potential category.

About 55 percent of the Federal coal lands in the quadrangle are in the two areas of high development potential, 42 percent are in the large area of no development potential; 2 percent and 1 percent, respectively, are in the small areas of moderate and low development potential.

Development potential for underground mining and in-situ gasification

All known minable coal in the Hammond Draw SW quadrangle is within surface-minable depths. Because there are no known underground coal resources below the stripping limit of 500 feet (152 m), there are no underground-minable coal resources and, therefore, no Coal Development Potential for underground mining.

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 SW 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	9,110,000	0	0	9,110,000
Rosebud	36,300,000	6,990,000	3,470,000	46,760,000
McKay	21,370,000	6,580,000	7,750,000	35,700,000
Burley	7,500,000	3,600,000	4,900,000	16,000,000
Total	74,280,000	17,170,000	16,120,000	107,570,000
Hypothetical Resource tonnage				
Burley	0	0	3,710,000	3,710,000
Total	0	0	3,710,000	3,710,000
Grand Total	74,280,000	17,170,000	19,830,000	111,280,000

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