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

[Report includes 16 plates]

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ILLUSTRATIONS

[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
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 Hayes Point quadrangle, Custer and Powder River Counties, Montana, (16 plates; U.S. Geological Survey Open-File Report 79-013). 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 Hayes Point 7 1/2-minute quadrangle is in southwestern Custer and northwestern Powder River Counties, Montana, about 38 miles (60.8 km) south of Miles City, Montana. Miles City is on U.S. Interstate Highway 94 and the main lines of the Burlington Northern, and the Chicago, Milwaukee, St. Paul, and Pacific railroads.

Accessibility

The quadrangle is accessible from Miles City, Montana, by going south on U.S. Highway 312 a distance of 13 miles (20.8 km) to the intersection of local Highway 332 (the Tongue River Road), then southwest 36 miles (57.6 km) to the intersection with Liscom Creek Road, then southeast 4 miles (6.4 km) to the west border of the quadrangle. Liscom Creek Road crosses

the quadrangle in a southeasterly direction. A number of unimproved roads give access to the rest of the quadrangle.

Physiography

The Hayes Point quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The upland plateau surface, however, has been almost totally dissected by tributaries of the Tongue River. The Tongue River is west of the quadrangle and flows northeastward to the Yellowstone River. Liscom Creek flows northwestward across the quadrangle to the Tongue River and drains most of the quadrangle. The topography is rugged. Many of the divides are capped with reddish-colored clinker formed by the burning of coal beds. The highest elevation in the quadrangle, a little above 3,700 feet (1,128 m), is 1.5 miles (2.4 km) west of the southeast corner. The lowest elevation, a little below 2,840 feet (866 m), is near the northwest corner. The topographic relief is about 860 feet (262 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) includes the entire Hayes Point quadrangle except small areas in the bottoms of stream valleys in the southwest and northwest corners, and along the north border 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. Part of the northwest quarter of the quadrangle lies in the Liscom Creek Gas Field.

GENERAL GEOLOGY

Previous work

Bass (1932) mapped the Hayes Point quadrangle as part of the Ashland coal field, Rosebud, Powder River, and Custer Counties, Montana. Matson and Blumer (1973) mapped 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 outcropping unit in the quadrangle, occurring as the lowermost beds exposed in the bottom of Liscom Creek near the northwest corner. 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 no economic coal beds.

The Tongue River Member makes up the exposed bedrock in the remainder 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. Much coal has burned along outcrops, baking the overlying sandstone and shale, and forming thick 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 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 Hayes Point 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 the coal beds (pls. 4, 7, 10, and 13) show minor structural trends with less than 40 feet (12.2 m) of relief.

COAL GEOLOGY

Four coal beds, all in the Tongue River Member of the Fort Union Formation, have economic coal resources and are mapped on the surface in this quadrangle (pl. 1): the Terret, the Flowers-Goodale, the Lay Creek, and the Knobloch. Several additional thin, local coal beds, among them the Contact coal bed marking the base of the Tongue River Member, sometimes lie within or beneath these four coal beds (pl. 3).

The Terret coal bed is about 120 feet (37 m) above the base of the Tongue River Member. It is overlain successively by a noncoal interval of about 60 feet (18 m), the Flowers-Goodale coal bed, a noncoal interval of about 30 feet (9 m), the Lay Creek coal bed, a noncoal interval of about 100 feet (30 m), and the Knobloch coal bed. In the south half of the quadrangle, widespread reddish-colored clinker beds have resulted from the burning of

two additional coal beds. Above the Knobloch is a noncoal interval of about 250 feet (76 m), the Sawyer clinker bed, another noncoal interval of about 70 feet (20 m), and the C and D clinker beds. The Sawyer and the C and D coal beds have burned entirely, or the remaining unburned coal is too thin or impure to be of economic interest.

The trace element content of coals in the Hayes Point 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, pl. 147).

Terret coal bed

The Terret coal bed was described by Bass (1932, p. 51) from a small mine on the Terret Ranch (Cook Creek Reservoir quadrangle) in the Ashland coal field, a few miles (a few kilometers) southwest of this quadrangle. The Terret coal bed crops out at the lower elevations along Liscom Creek, the major stream flowing northwestward across the quadrangle. It also crops out along minor stream valleys near the north border and southwest corner of the quadrangle. Along most of the outcrops considerable coal has burned, leaving areas of clinker. The Terret coal bed is relatively flat, but is folded into a broad anticlinal arch near the center of the south boundary of the quadrangle (pl. 13). The Terret coal bed ranges from about 8.4 to 13 feet (2.6 to 4 m) in thickness (pl. 13). The overburden on the

Terret thickens southward from zero at the outcrops and exceeds 700 feet (213 m) in several places in the south half of the quadrangle (pl. 14).

No coal analyses are available for the Terret coal bed in the quadrangle; however, the Montana Bureau of Mines and Geology cored the Terret coal bed in drill hole SH-7094 in the Brandenberg quadrangle, about 1 mile (1.6 km) west of the Hayes Point quadrangle. An 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 coal is subbituminous C 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 3 miles (4.8 km) west of the Hayes Point quadrangle. The Flowers-Goodale coal bed crops out at the lower elevations along Beaver Creek near the southwest corner of the quadrangle, and in the valleys of Liscom Creek and other streams flowing across the middle and the north border of the quadrangle (pl. 1). The Flowers-Goodale coal bed is relatively flat, and structure contours show a low anticline cresting near the southeast corner of the quadrangle (pl. 10). The coal bed increases in thickness northward across the quadrangle from about 4 to 11 feet (1.2 to 3.4 m). The overburden on the Flowers-Goodale coal bed thickens southward and eastward from zero at the outcrop to over 500 feet (152 m), as shown on plate 11.

The Montana Bureau of Mines and Geology cored the Flowers-Goodale coal in drill hole SH-7084 (sec. 36, T. 1 N., R. 45 E.), located near the center of the Hayes Point quadrangle. An analysis of coal from depths of 54 to 61 feet (16.5 to 18.6 m) shows a heating value of 8,271 Btu per pound (19,240 kJ/kg), ash 5.56 percent, and sulfur 0.38 percent, on an as-received basis. This heating value converts to about 8.750 Btu per pound (20,250 kJ/kg), indicating that the coal is subbituminous C in rank.

Lay Creek coal bed

The Lay Creek coal bed was described by Bass (1932, p. 54) from outcrops near the headwaters of Lay Creek in the northwest quarter of the North Stacey School quadrangle just east of Hayes Point quadrangle. The Lay Creek coal bed lies about halfway between the Flowers-Goodale and Knobloch coal beds and crops out in the northeast quarter of the Hayes Point quadrangle around the headwaters and on the slopes of small tributary streams, and in the valley of Liscom Creek. As far as is known, the bed is confined to areas near the outcrops, where the thickness ranges from about 3 to 9.7 feet (0.9 to 3 m), as shown on plate 7). The bed is nearly flat. The thickness of overburden on the Lay Creek coal bed ranges from zero at the outcrop to over 400 feet (122 m) near the center of the quadrangle (pl. 8). There are no publicly-available chemical analyses for the Lay Creek coal in the quadrangle. It is assumed that the Lay Creek coal is similar in quality and rank to that of associated coal beds in the quadrangle, and is subbituminous C.

Knobloch coal bed

The Knobloch coal bed was described by Bass (1932). The coal-bed name was taken from the Knobloch Ranch and coal mine in the Birney Day School quadrangle located about 24 miles (38 km) southwest of the Hayes Point quadrangle.

The Knobloch coal bed lies about 300 feet (91 m) above the base of the Tongue River Member and crops out around the headwaters of the tributaries of Lay, Liscom, and Beaver Creeks, underlying all but the northwest quarter of the Hayes Point quadrangle. The coal bed is almost flat, showing less than 10 feet of dip per mile (2 m/km) across the quadrangle (pl. 4). The coal bed is lenticular, varying from 8 to about 24 feet (2.4 to about 7.3 m) in thickness in as little as 3 miles (4.8 km). The bed ranges from 2 to 24.5 feet (0.6 to 7.5 m) in thickness (pl. 4). Overburden on the Knobloch coal bed ranges from zero at the outcrop to over 500 feet (152 m) in several small areas on the higher ridges in the southeast quarter of the quadrangle (pl. 5).

At least three chemical analyses are available for the Knobloch coal in the quadrangle. The Montana Bureau of Mines and Geology cored drill hole SH-7094 (sec. 18, T. 1 N., R. 46 E.), and the results of analysis appear to be representative of the Knobloch coal in the quadrangle. An analysis of coal from depths of 67 to 77 feet (20.4 to 23.5 m) shows a heating value of 7,362 Btu per pound (17,120 kJ/kg), ash 13.8 percent, and sulfur 0.8 percent, on an as-received basis (Matson and Blumer, 1973, p. 121). This heating value converts to about 8,540 Btu per pound (19,860 kJ/kg) on a

moist, mineral-matter-free basis, determining the coal to be 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 shown 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 miles (1.2 km) from the measurement point, and Inferred coal extends 2.25 miles (3.6 km) beyond Indicated coal to a distance of 3 miles (4.8 km) from the measurement point.

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.

Estimated coal resources in this quadrangle were calculated 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 per hectare-meter) for subbituminous coal yields the coal resources in short tons of coal for each isopached coal bed. Reserve Base and Reserve tonnage values for the four coal beds, Terret, Flowers-Goodale, Lay Creek, and Knobloch, 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 coal in this quadrangle is estimated to be 535.68 million short tons (485.86 million t), of which 515.83 million short tons (467.86 million t) is surface minable and 19.85 million short tons (18.00 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 9.8 percent of the Reserve Base tonnage is classed as Measured, 47.1 percent as Indicated, and 43.1 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 in this quadrangle 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, 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, plate 16, 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.

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). The Hayes Point quadrangle has a high development potential for surface mining due to the superimposition of the Terret, Flowers-Goodale, Lay Creek, and Knobloch coal beds.

The lowermost coal bed, the Terret (pl. 14), has moderately wide bands having high development potential (mining-ratio values 0 to 10) along the bottoms and lower sides of valleys throughout most of the quadrangle. Above these bands on the valley sides are narrow bands of moderate development potential (10 to 15 mining-ratio values) also extending across the north two-thirds of the quadrangle. Above the bands of moderate development potential are wide areas of low development potential (mining-ratio values greater than 15) covering the interstream areas up to the arbitrary stripping limit of 500 feet (152 m) of overburden. Much of this overburden includes the Flowers-Goodale, Lay Creek, and Knobloch coal beds.

The Flowers-Goodale coal bed (pl. 11) has high development potential in a moderately wide band on the valley sides throughout most of the quadrangle. Above this is a narrow band of moderate development potential. Wide areas of low development potential occupy the interstream areas up to the arbitrary stripping limit at the 500 foot (152 m) overburden isopach. Much of the overburden includes the Lay Creek and Knobloch coal beds.

The Lay Creek coal bed (pl. 8) is of Reserve Base thickness in an arcuate area in the central part of the quadrangle. Within this arcuate area are separated areas of high development potential between the outcrops and the 10 mining-ratio contour. Above these areas are narrow areas of moderate development potential. Still higher are considerable areas of low development potential which cover the interstream divides. In places the overburden on the Lay Creek coal bed includes the Knobloch coal bed which is about 100 feet (30 m) above the Lay Creek coal bed.

The Knobloch coal bed (pl. 5) has a wide band of high development potential along the sides of valleys in the south-central and eastern parts of the quadrangle extending from the outcrops to the 10 mining-ratio contour. Above this is a narrow band of moderate development potential, and still higher are wide areas of low development potential extending from the 15 mining-ratio contour to the arbitrary stripping limit at the 500 foot (152 m) overburden isopach.

About 78 percent of the Federal land in the quadrangle has a high development potential for surface mining, 7 percent has a moderate

development potential, 7 percent has a low development potential, and 8 percent has no development potential for surface mining.

Development potential for underground mining and in-situ gasification

Coal beds 5 feet (1.5 m) or more in thickness lying more than 500 feet (152 m) but less than 3,000 feet (914 m) below the surface of this quadrangle are considered to have development potential for underground mining. Estimates of the tonnage of underground-minable coal are listed in table 2 by development-potential category for each coal bed. Coal is not currently being mined by underground methods in the Northern Powder River Basin because of poor economics. Therefore, the coal development potential for underground mining of these resources is rated as low, and a Coal Development Potential map for underground mining was not made.

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 Hayes Point 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
Reserve Base tonnage				
Knobloch	66,570,000	20,250,000	55,660,000	142,480,000
Lay Creek	6,350,000	7,660,000	10,770,000	24,780,000
Flowers-Goodale	33,560,000	26,500,000	62,980,000	123,040,000
Terret	42,030,000	27,070,000	156,430,000	225,530,000
Total	148,510,000	81,480,000	285,840,000	515,830,000

Table 2.--Underground-minable coal resource tonnage by development-potential category for Federal coal lands (in short tons) in the Hayes Point 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
Reserve Base tonnage				
Knobloch	0	0	16,540,000	16,540,000
Flowers-Goodale	0	0	2,860,000	2,860,000
Terret	0	0	450,000	450,000
Total	0	0	19,850,000	19,850,000

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