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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE CRAIN PLACE QUADRANGLE, ROSEBUD COUNTY, MONTANA

[Report includes 11 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 Crain Place quadrangle, Rosebud County, Montana (11 plates; U.S. Geological Survey Open-File Report 78-644). This set of maps was compiled to support the land planning work of the Bureau of Land Management's Energy Minerals Activities Recommendation System (EMARS) program, 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 Crain Place 7 1/2-minute quadrangle is in eastern Rosebud County, Montana, about 28 miles (45 km) southwest of Miles City and 11 miles (17.6 km) southeast of Rosebud, Montana. The main east-west route of the Burlington Northern Railroad and U.S. Interstate Highway 94 pass through both Miles City and Rosebud.

Accessibility

The southwest corner of the quadrangle is accessible from Rosebud, Montana, by going south on local Route 447 a distance of 21 miles (33.6 km), thence east 1 mile (1.6 km) to the quadrangle boundary. The northeast corner of the quadrangle is accessible from U.S. Interstate Highway 94, from a point 6 miles (9.6 km) east of Rosebud by going south on Sweeney

Creek Road a distance of 14 miles (22.4 km). Unimproved roads provide access to the rest of the quadrangle.

Physiography

The Crain Place quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The upland plateau surface has been eroded extensively by the Yellowstone River and its tributaries. Only a few flat-topped ridges and knobs remain of the old surface; these are mostly in the southeast quarter of the quadrangle.

The southwest part of the Crain Place quadrangle is drained by tributaries of Rosebud Creek, principally Eagle and Goodman Creeks. The northeast part of the quadrangle is drained by tributaries of Sweeney Creek, mainly Twelvemile, Bell, and Beaver Creeks. A broad divide between the two drainage areas extends diagonally across the quadrangle in an approximate northwest direction.

The highest elevation, about 3,315 feet (1,010 m) is on the divide in the southeast corner of the quadrangle. The lowest elevation, about 2,750 feet (838 m) is on the west border where Eagle Creek leaves the quadrangle. Topographic relief is about 565 feet (172 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) a year. 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 Resource Area (KRCRA) extends from the south and east less than 1 mile (1.6 km) into the southeast quarter of the quadrangle. The Boundary and Coal Data Map (pl. 2) shows the locations of the KRCRA tracts and the land ownership status. There were no outstanding Federal coal leases or prospecting permits as of 1977.

GENERAL GEOLOGY

Previous work

Pierce (1936) mapped the Crain Place quadrangle as part of the Rosebud coal field, Rosebud 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 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. Pierce (1936) considered the Tullock to be a member of the Lance Formation, but since 1949 the U.S. Geological Survey has considered the Tullock to be the lower member of the Fort Union Formation in Montana.

The Tullock Member forms the lowest outcrops in the quadrangle, occurring as the lowermost beds exposed in Eagle and Goodman Creeks in the southwest quarter of the quadrangle. The Tullock Member is approximately 300 feet (91 m) thick and is made up of alternating beds of sandstone and shale, and contains several unimportant local coal beds (Pierce, 1936).

The overlying Lebo Shale Member is 163 to 200 feet (49 to 61 m) thick and consists of shale and a few thin, lenticular sandstones, but no coal beds thick enough to contain Reserve Base coal. This unit crops out in wide, irregular areas conforming to the drainage patterns in most of the western third, the center, and the northeast corner of the quadrangle.

The Tongue River Member of the Fort Union Formation is exposed in a broad belt that trends diagonally southeastward across the quadrangle, creating a major drainage divide. It contains the coal beds of greatest economic interest. The unit is made up mainly of yellow sandstone, sandy shale, carbonaceous shale, and coal. Much of the coal has burned along the outcrops, causing fracturing and baking of the overlying sandstone and shale, forming thick clinker beds. Originally more than 1,000 feet (305 m) thick in this vicinity, most of the Tongue River Member has been removed by erosion so that only about the lower 400 feet (122 m) remains (Pierce, 1936, p. 61).

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 Crain Place quadrangle is in the north-central portion of the Powder River structural basin. The strata are nearly flat or in places dip southward at an angle less than 1 degree. Structure contours on top of the Burley coal bed (pl. 8) show a dip of less than 10 feet per mile (2 m per km) to the south and west in the south half of the quadrangle.

COAL GEOLOGY

Four coal beds, three in the Tongue River Member and one near the base of the Lebo Shale Member of the Fort Union Formation, were mapped on the surface (pl. 1) and are shown in section (pl. 3) in this quadrangle. The highest bed stratigraphically is the Terret coal bed. This is underlain successively by a noncoal interval of 70 feet (21 m), the Burley coal bed, another noncoal interval of 50 feet (15 m), the Trail Creek coal bed, and a noncoal interval of 90 feet (27 m), down to the base of the Tongue River Member. A fourth coal bed is in and near the bottom of the Lebo Shale Member, about 200 feet below the base of the Tongue River Member. Only

the Terret and Burley coal beds are sufficiently thick and continuous to contain economic coal resources.

The trace element content of coals in the Crain Place quadrangle has not been determined; however, coals in the Northern Great Plains, including those in the Fort Union Formation in Montana, have been found to contain, in general, appreciably lesser amounts of most elements of environmental concern than coals in other areas of the United States (Hatch and Swanson, 1977, p. 147).

Terret coal bed

The Terret coal bed was named by Bass (1932, p. 5) after a small coal mine on the Terret Ranch in the Ashland coal field (Cook Creek Reservoir quadrangle) about 20 miles (32 km) southeast of the Crain Place quadrangle.

The Terret coal bed crops out along a narrow belt along the south and east borders in the southeast quarter of the Crain Place quadrangle (pl. 1). Structure on the bed is almost flat (pl. 5); a slight northwest dip may be interpreted from the few data points. Along most of the outcrops much coal has burned, leaving broad areas of clinker. In a number of places, the clinker has been removed by erosion exposing the coal bed. Based on these outcrops plus two drill holes, the thickness of the coal bed is seen to increase southward across its area of occurrence from about 8 feet (2.4 m) to more than 18 feet (5.5 m), as shown on plate 4. The overburden covering the Terret coal bed ranges from zero to over 100 feet (30 m) in thickness (pl. 6).

No coal analyses are available for the Terret coal bed in the Crain Place quadrangle; however, the Montana Bureau of Mines and Geology drilled and cored the Terret coal in State Hole SS-5C just across the quadrangle line to the east in the Miller Creek SW quadrangle. At a depth of 109 to 127 feet (33.2 to 38.7 m) an analysis indicated a heating value of 8,020 Btu per pound, ash 9.43 percent, and sulfur 1.18 percent on an as-received basis (Matson and Blumer, 1973, p. 102). These figures indicate that the coal is subbituminous C in rank.

Burley coal bed

The Burley coal bed was named by Dobbin (1930, p. 27) for outcrops at the Burley Ranch in the Forsyth coal field (Colstrip East quadrangle) about 10 miles (16 km) west of the Crain Place quadrangle.

The Burley coal bed crops out around some of the higher elevations on the major drainage divide in the north half of the quadrangle and rims the high plateau which makes up the southeast quarter.

Structure on the Burley coal bed is relatively flat, dipping less than 20 feet per mile (9.8 m per km) to the south (pl. 8). The thickness ranges from about 3 to 10 feet (0.9 to 3 m) northward across the quadrangle (pl. 8). Overburden on the Burley bed ranges from zero to more than 200 feet (61 m) in thickness, with the thickest overburden nearest the southeast corner of the quadrangle (pl. 9); this overburden contains the Terret coal bed. There are no known published chemical analyses of coal from the Burley bed; however, it is assumed that the quality of the coal is similar to that of other coal beds of the Fort Union Formation, and is subbituminous C in rank.

Coal has been mined from the Burley coal bed from an open pit called the Colson Mine located near the center of the quadrangle (pl. 1). No information is available as to quantity or quality (Pierce, 1936, p. 100), but it may be assumed that only a small amount of coal was mined a long time ago for local ranch use.

Other coal beds

The next lower coal bed is the Trail Creek, which lies about 50 feet (15 m) below the Burley coal bed and 40 feet (12 m) above the base of the Tongue River Member. The Trail Creek coal bed crops out discontinuously on both sides of the major drainage divide in the north half of the quadrangle. It has not been recognized in the south third of the quadrangle. Measured thicknesses range from about 1.5 to 2.5 feet (0.4 to 1.6 m). Because of its thinness and lack of continuity, no economic coal resources have been attributed to the Trail Creek bed.

The lowest coal stratigraphically is unnamed. It occurs about 290 feet (88 m) below the Trail Creek coal bed, near the base of the Lebo Shale Member, and may be the equivalent of the Big Dirty coal bed of Dobbin (1930, p. 26) in the Forsyth coal field located about 12 miles (19 km) to the west. Section measurements show that it is actually two or more discontinuous beds, 5 to 15 feet (1.55 to 4.6 m) apart which were undifferentiated in the field (Pierce, 1936, p. 98). Each measures less than 1 to 2.3 feet (0.3 to 0.7 m) in thickness. The coal beds crop out on the valley slopes of westward-flowing tributaries of Rosebud Creek in the southwest quarter of the quadrangle. The coal quality is extremely variable, grading from good coal to bony coal, to

bone or carbonaceous shale in the short distance between measurements along the outcrop (Pierce, 1936, p. 98, 99). Because of the thinness and poor quality, no economic resources have been attributed to the unnamed coal beds.

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 the Crain Place quadrangle.

Coal resource tonnages derived in this report are the Reserve Base part of the Identified Resources found within 3 miles (4.8 km) of a point of coal-bed measurement, as discussed in U.S. Geological Survey Bulletin 1450-B.

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

Reserves are the recoverable part of the Reserve Base coal. For surface-minable coal in this quadrangle, the coal reserves are considered

to be 85 percent (the recovery factor for this area) of that part of the Reserve Base that is beneath 500 feet (152 m) or less of overburden. This depth of overburden is the stripping limit for multiple, relatively thin (5 to 40 feet or 1.5 to 12 m 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 and 8). 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 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 Terret and Burley coal beds are shown on plates 7 and 10, 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 calculated to be 23.94 million short tons (21.72 million metric 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 table 1. All numbers are rounded to the nearest one-hundredth of a million short tons. About 11 percent of the Reserve Base tonnage is classed as Measured, 72 percent as Indicated, and 17 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 ratios 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 plates 6 and 9. These mining-ratio values for each development-potential category are based on current economic and technological criteria and were provided by the U.S. Geological Survey. Calculated 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. 11) depicts the highest coal development potential category which occurs within each smallest legal subdivision of Federal coal land, normally about 40 acres. If such a 40-acre tract of land contains areas of high, moderate, and low development potential, the entire tract is assigned to the high category for CDP mapping purposes.

The coal development potential for surface mining methods (where there is less than 500 feet or 152 m of overburden) is shown on the Coal Development Potential map (pl. 11). Both the Terret and Burley coal beds

have a high development potential over their entire area of occurrence in the quadrangle. The rest of the quadrangle has no coal development potential for surface mining.

Development potential for underground mining and in situ gasification

All known economically minable coal in the Crain Place quadrangle is contained in the Terret and Burley coal beds within surface minable depths. Since there is no known Reserve Base coal at depths beneath these coal beds, the development potential for underground mining in the Crain Place quadrangle is rated as unknown or none. No table of coal resource tonnage by development potential category for underground mining methods was made, nor was a Coal Development Potential map for underground mining methods 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 Crain Place 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
Terret	21,450,000	0	0	21,450,000
Burley	2,480,000	10,000	0	2,490,000
Total	23,930,000	10,000	0	23,940,000

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