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COAL RESOURCE OCCURRENCE AND
COAL DEVELOPMENT POTENTIAL MAPS OF THE
COLSTRIP EAST QUADRANGLE,
ROSEBUD COUNTY, MONTANA

[Report includes 13 plates]

By

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This report has not been edited for
conformity with U.S. Geological Survey
editorial standards or stratigraphic
nomenclature.

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Conversion table

<u>To convert</u>	<u>Multiply by</u>	<u>To obtain</u>
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 Colstrip East quadrangle, Rosebud County, Montana, (13 plates; U.S. Geological Survey Open-File Report 78-836). 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 Colstrip East 7 1/2-minute quadrangle is in south-central Rosebud County, Montana, about 20 miles (32 km) south-southeast of Forsyth, Montana, a town on the Yellowstone River about 100 miles northeast of Billings and 45 miles southwest of Miles City. The Burlington Northern Railroad and U.S. Interstate Highway 94 follow the valley of the Yellowstone River and pass through Forsyth. Part of the town of Colstrip, Montana, is within the southwest corner of the quadrangle.

Accessibility

The Colstrip East quadrangle is accessible by unimproved roads and trails which intersect the paved State Highway 39 which follows Armells Creek and the East Fork of Armells Creek and connects Colstrip with

Interstate Highway 94 at an intersection 6 miles (9.6 km) west of Forsyth. A branch line of the Burlington Northern Railroad parallels State Highway 39 and connects the town of Colstrip and the Colstrip and Big Sky coal mines with the main route of the railroad. A number of unimproved roads and trails provide access to the interior of the quadrangle.

Physiography

The Colstrip East quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The quadrangle is on the divide between the East Fork of Armells Creek on the west and Rosebud Creek on the east and south. Rosebud and Armells Creeks flow northward to the Yellowstone River. Ephemeral tributaries of these two creeks have totally and intricately dissected the plateau. The valleys are steep sided, and in places the narrow-topped interstream ridges are carved into badlands.

The lowest elevations in the quadrangle, just under 2,900 feet (884 m), are along Sprague Creek in the northeast corner of the quadrangle. The highest elevation, 3,580 feet (1,091 m), is at the Mac triangulation station on the drainage divide in the southwest quarter of the quadrangle. Topographic relief is about 680 feet (207 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 quadrangle from the south and east and covers about one-half 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 reserve base (RB) of coal per section for each section of Federal land. A Federal coal lease shown on plate 2 covers a very small part of the area.

GENERAL GEOLOGY

Previous work

Dobbin (1930) mapped the western part of the Colstrip East quadrangle as part of the Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Montana. Pierce (1936) mapped the eastern part of the quadrangle as part of the Rosebud coal field, Rosebud and Custer Counties, Montana. V. W. Carmichael in 1964 mapped the southern part of the quadrangle as part of the Colstrip coal deposit (in Matson and Blumer, 1973, pl. 14). Ayler, Smith, and Deutman (1969, p. 43) discussed the Burley deposit along Spring Creek in the east-central part of the quadrangle as part of the strippable coal deposits in Montana.

Stratigraphy

A generalized columnar section of the coal-bearing rocks is shown on the Coal Data Sheet (pl. 3) of the CRO maps. All of the surficial bedrock strata belong to the upper member of the Fort Union Formation (Paleocene), the Tongue River Member. This unit is made up mainly of yellow sandstone, sandy shale, carbonaceous shale, and three significant coal beds, the Burley, McKay, and Rosebud beds. The Tongue River Member was originally more than 1,000 feet (305 m) thick in this vicinity (Pierce, 1936, p. 61), but much of it has been removed by erosion so that only about the lower 600 feet (183 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 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 Colstrip East 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 Rosebud, McKay, and Burley coal beds (pls. 4, 7, and 10) show a local dip of less than 1 degree to the south or southeast.

COAL GEOLOGY

Five coal beds have been mapped on the surface of the Colstrip East 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 Terret-Robinson, the Terret upper split, the McKay, and the Rosebud. The Burley coal bed is about 130 feet (39.6 m) above the base of the Tongue River Member. The Terret-Robinson coal bed is 60 to 100 feet (18 to 30 m) above the Burley bed, the upper split of the Terret coal bed is about 15 feet (5 m) above the Terret-Robinson coal, the McKay coal bed is 110 to 130 feet (34 to 40 m) above the upper split of the Terret, and the Rosebud coal bed is less than 20 feet (6 m) above the McKay. The Terret-Robinson and the upper split of the Terret have a limited extent and are less than 5 feet (1.5 m) thick, and therefore have not been assigned reserves.

The trace element content of coals in the Colstrip East 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 named by Dobbin (1930, p. 27) from outcrops in the Forsyth coal field at the Burley Ranch in the northeastern corner of the Colstrip East quadrangle.

The Burley bed crops out in the north half of the Colstrip East quadrangle where it occurs about 130 feet (39 m) above the base of the Tongue River Member. The bed varies from 4 to slightly over 8 feet (1.2 to 2.4 m) in thickness and dips less than 0.5 degree southeastward (pl. 4). The overburden on the Burley coal bed ranges from 0 to 400 feet (122 m).

There are no known published chemical analyses of the Burley coal bed; it is assumed, however, that the coal is similar in rank to other coal beds in the Colstrip East quadrangle and is subbituminous B.

McKay coal bed

The McKay coal bed was named by Dobbin (1930, p. 27) for exposures on the McKay ranch in the eastern part of the Colstrip East quadrangle in the Forsyth coal field. 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) and at no place is the interval over 30 feet (9 m). The outcrop of the McKay coal follows very closely that of the Rosebud coal, and where the Rosebud is burned the McKay coal is concealed by clinker. In this quadrangle, the McKay coal bed is almost totally concealed and has been mapped for only a short distance in the west-central part of the

quadrangle. The isopachs of the McKay coal (pl. 5) are based on the one thickness measurement in the Colstrip East quadrangle and measurements in the adjacent quadrangles. The isopachs indicate that the coal ranges from about 4 to 9 feet (1.2 to 2.7 m) in thickness. The structure map (pl. 4) shows a southward dip of less than 1 degree which is interrupted in the southern part of the quadrangle by local gentle folding. The overburden on the McKay coal (pl. 8) ranges from zero to about 250 feet (76 m) in thickness, but is generally less than 200 feet (61 m). The mining ratios range from zero to over 15, as shown on plate 8.

There are no known published chemical analyses of the McKay coal in the Colstrip East quadrangle. The nearest analysis is from coal test drill hole RB-58, located in sec. 5, T. 1 N., R. 41 E., in the Colstrip SE quadrangle about 0.5 mile (0.8 km) south of the Colstrip East quadrangle. Matson and Blumer (1973, p. 78) report a coal analysis of 6.50 percent ash, 1.41 percent sulfur, and a heating value of 8,930 Btu per pound as received. The above analysis indicates that the coal is subbituminous B in rank (heat value of 8,500 to 10,500 Btu on a moist, mineral-matter-free basis). Because of the proximity of the analyzed coal to the McKay coal in the Colstrip East quadrangle, it is assumed that the latter coal is also subbituminous B.

Rosebud coal bed

The Rosebud coal bed was named by Dobbin (1930, p. 27) for outcrops along Rosebud Creek in the Forsyth coal field. A specific type location was not given. The Rosebud coal in most places has burned at its

outcrop. The resulting clinker is exposed extensively in the south half of the Colstrip East quadrangle. The thickness of the Rosebud coal as shown by the isopach and structure map (pl. 4) ranges from about 7 to 24 feet (2.1 to 7.3 m). The coal dips southward or southeastward at an angle of less than 1 degree (pl. 4). Overburden on the Rosebud coal bed (pl. 5) ranges in thickness from zero to almost 200 feet (61 m), but generally is less than 100 feet (30.5 m), and the mining ratios range from zero to slightly over 10 (pl. 6).

Analyses of 24 samples of the Rosebud coal bed from sec. 34, T. 2 N., R. 41 E. in the Colstrip East quadrangle show the following range: ash 6.4 to 9.2 percent, sulfur 0.5 to 1.0 percent, heating value 8,780 to 9,330 Btu per pound (Gilmour and Dahl, 1967). The samples that have the highest ash content have the lowest heating values. These analyses indicate that the Rosebud coal in the Colstrip SE quadrangle is subbituminous B in rank, 9,500 to 10,500 Btu per pound on a moist, mineral-matter-free basis.

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 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, thin (5 to 40 feet or 1.5 to 12 m thick) beds of subbituminous coal in this area.

Estimated coal resources in the Colstrip East quadrangle were calculated using data obtained from the coal isopach maps (pls. 4, 7, and 10). The coal-bed acreage (measured by planimeter) multiplied by the average isopached thickness of the coal bed times a conversion factor of 1,770 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 Rosebud, McKay, and Burley coal beds are shown on plates 6, 9, and 12 and are rounded to the nearest one-hundredth of a million short tons.

The total Reserve Base tonnage of federally owned coal in the Colstrip East quadrangle is calculated to be 128.87 million short tons (113.78

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 4 percent of the Reserve Base tonnage is classed as Measured, 19 percent as Indicated, and 77 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 is as follows:

$$MR = \frac{t_o (0.911)}{t_c (rf)} \quad \text{where } MR = \text{mining ratio}$$

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 Rosebud coal bed, plate 8 for the McKay coal bed, and plate 11 for the Burley coal bed. 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, plate 13, 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). 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, 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. 13). In the Colstrip East quadrangle, 48 percent of the surface-minable coal resource on Federal lands has high development potential, 9 percent has moderate development potential, and 43 percent has low development potential (see table 1).

Development potential for underground mining and in situ gasification

All known minable coal in the Colstrip East quadrangle is within surface minable depths. Because there are no known underground coal resources below the stripping limit, no Coal Development Potential map for underground mining or estimates of underground coal resources were 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.

COAL MINE

The original part of the Rosebud coal mine is in the southwestern corner of the Colstrip East quadrangle.

The Northern Pacific Railway opened the mine in 1924 and stopped production in 1958 as diesel fuel supplemented coal for locomotives. Montana Power Company purchased the property in 1959, and its coal producing subsidiary, Western Energy Company, has operated the mine to the present time. Only the Rosebud coal bed is mined. Its average thickness here is about 24 feet (7.3 m). Average ash content is 8.45 percent, sulfur 0.8 percent, and heating value 8,750 Btu per pound (20,352 kJ/kg) on an as-received basis.

Coal production during 1977 was 9,773,676 short tons (8,864,724 t). All of the coal was produced by surface-mining methods. The principal use of the coal is for generation of electric power. Large power plants are near the mine, and coal is also shipped by unit train to power plants at Billings, Montana, and to states to the east.

Mining of Federal coal land in secs. 26 and 34, T. 2 N., R. 41 E., was carried on between 1941 and 1946 under a valid Federal coal lease number Bil 020989. Then, on April 30, 1948, that lease was modified to exclude section 26 and parts of other sections to the south, such as a part of sec. 2, T. 1 N., R. 41 E. The new, April 1948, modified lease is number Bil 020989-038770 and it covers all current activities. Even though parts of Federal coal land in secs. 26 and 34, T. 2 N., R. 41 E. are shown on plate 1 as part of the Rosebud strip mine, a Federal coal lease is not shown for

these areas on plate 2 because only current lease numbers and boundaries are shown.

Table 1. --Surface-minable coal resource tonnage by development potential category for Federal coal lands (in short tons) in the Colstrip East 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
Rosebud	42,600,000	0	0	42,600,000
McKay	14,030,000	7,490,000	7,700,000	29,220,000
Burley	4,890,000	4,550,000	47,610,000	57,050,000
Total	61,520,000	12,040,000	55,310,000	128,870,000

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