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

[Report includes 13 plates]

By

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CONTENTS

ILLUSTRATIONS

[Plates are in pocket]

Illustrations--Continued

TABLES

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 test is for use in conjunction with the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) maps of the Colstrip West quadrangle, Rosebud County, Montana, (13 plates; U.S. Geological Survey Open-File Report 78-648). 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 Colstrip West 7 1/2-minute quadrangle is in central Rosebud County, Montana, about 18 miles (29 km) south of Forsyth, Montana, a town in the Yellowstone River valley about 44 miles (70 km) west-southwest of Miles City and 105 miles (168 km) east of Billings. U.S. Interstate Highway 94 and the main east-west route of the Burlington Northern Railroad follow the Yellowstone River and pass through Forsyth.

Accessibility

The Colstrip West quadrangle is accessible from the north by paved State Highway 39 which follows northward-flowing Armells Creek and the East Fork of Armells Creek and intersects Interstate Highway 94 about 16 miles (25.6 km) north of the quadrangle and 7 miles (11 km) west of Forsyth. A

branch of the Burlington Northern Railroad parallels State Highway 39, traverses the eastern part of the quadrangle, and connects the town of Colstrip and the Colstrip Mine with the main route of the railroad in the Yellowstone valley. The town of Colstrip is in the southeast corner of the quadrangle. A number of unimproved roads and trails intersect State Highway 39 and provide access to the remainder of the quadrangle.

Physiography

The Colstrip West quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The quadrangle is dissected and drained by the East Fork of Armells Creek and its tributaries. The East Fork of Armells Creek has a narrow flood plain, 0.5 mile (0.8 km) in width, which rises in elevation from about 3,000 feet (914 m) in the north to about 3,200 feet (975 m) near Colstrip in the south. A few plateau remnants in the south half of the quadrangle rise above 3,500 feet (1,067 m). The lowest elevation in the quadrangle, slightly below 3,000 feet (914 m), is on the East Fork of Armells Creek at the north border of the quadrangle. The highest elevation is 3,630 feet (1,106 m) on a butte in the southern part of the quadrangle. Topographic relief is 630 feet (192 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 a short distance into the southern part of the Colstrip West quadrangle, as shown by the Boundary and Coal Data Map (pl. 2). This map also shows the land ownership status and the two small strips of Federal coal land along the south boundary of the quadrangle which are covered by outstanding Federal coal leases.

GENERAL GEOLOGY

Previous work

Dobbin (1930) mapped the Colstrip West quadrangle as part of the Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Montana. Kepferle (1954) mapped the Castle Rock strippable deposit, and that map provides some information on the southeast and southwest corners of the quadrangle. 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).

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, which 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 a member of

the Lance Formation, but since 1949 the U.S. Geological Survey has considered the Tullock to be the lowest member of the Paleocene Fort Union Formation in Montana.

The Tullock Member crops out along McGilvrey Creek and Corral Creek in two small areas in the north-central part of the quadrangle where the member has been brought to the surface along the crest of a low-relief, northward-trending anticline. Dobbin (1930, p. 12) reports that the Tullock Member is 240 to 270 feet (73 to 82 m) thick and is composed of light-colored sandstone, sandy shale, and several thin coal beds.

The Lebo Shale Member is 105 to 170 feet (32 to 52 m) thick and consists of soft, dark-gray to black shale, clay, and sandy shale with abundant ferruginous concretions (Dobbin, 1930, p. 8). The strata weather into gentle treeless slopes and badlands. The Big Dirty coal bed occurs near the base of the Lebo Shale in the north-central part of the quadrangle.

The Tongue River Member of the Fort Union Formation consists of light-colored sandstone, sandy shale, and important coal beds. The thicker coal beds have burned along the outcrop and have fused the overlying rock into slag or clinker. Dobbin (1930) reports that the Tongue River Member is about 1,700 feet (518 m) thick in the Forsyth coal field, but in the Colstrip West quadrangle most of the member has been removed by erosion so that only about the lower 500 feet (152 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 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 the 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 West quadrangle is in the north-central part of the Powder River structural basin. The strata dip southward or southeastward at an angle of less than 1 degree. Structure contours on top of the Rosebud, McKay, and Stocker Creek coal beds (pls. 4, 7, and 10) show that the regional dip is in places modified by gentle folding or interrupted by faulting. Matson and Blumer (1973, pl. 14) show a fault which cuts the Rosebud coal bed and appears to have about 10 feet (3 m) of displacement (pl. 4).

COAL GEOLOGY

Dobbin (1930, pl. 7) mapped seven coal beds in the Colstrip West quadrangle area of the Forsyth coal field. The upper three coal beds, the Rosebud, McKay, and Stocker Creek, contain Reserve Base coal and are described in detail later. The lower four coal beds, the Robinson, Burley, Big Dirty, and Hambre, are too thin to be assigned reserves.

The Hambre coal bed, the stratigraphically lowest coal bed in the Colstrip West quadrangle, is in the Tullock Member, about 35 feet (11 m) below its top. The Hambre coal bed is described by Dobbin (1930, p. 26) as averaging 3 feet (0.9 m) in thickness and being composed of carbonaceous shale and coal, interbedded with innumerable thin stringers of carbonaceous sandstone. The Hambre coal bed crops out in a very small area near the lower end of Corral Creek in the north-central part of the quadrangle.

The Big Dirty coal bed is in the Lebo Shale Member near its base, about 35 feet (11 m) above the Hambre coal. The Big Dirty coal bed in most places consists of carbonaceous shale, carbonaceous sandstone, and thin, lenticular beds of coal (Dobbin, 1930, p. 26). The Big Dirty coal bed crops out only in two small areas in the north-central part of the quadrangle along Corral and McGilvrey Creeks.

The Burley coal bed is in the Tongue River Member, about 130 feet (40 m) above its base, and about 235 to 300 feet (72 to 91 m) above the Big Dirty coal bed. The Burley coal bed crops out in the eastern part of the quadrangle, both east and west of the East Fork of Armells Creek. Its thickness ranges from 3.5 to 4.0 feet (1.1 to 1.2 m).

The Robinson coal bed is about 45 feet (14 m) above the Burley coal bed and crops out for short distances in the central and eastern parts of the quadrangle where it has a thickness of 2.5 to 4.5 feet (0.8 to 1.4 m). Coal resources have not been assigned to the Robinson coal bed because of the thinness of the bed.

The Stocker Creek coal bed is about 115 to 130 feet (35 to 40 m) above the Robinson coal bed. The McKay coal bed is about 40 feet (12 m) above the Stocker Creek coal bed. The Rosebud coal bed, which is a few feet to 30 feet (9 m) above the McKay coal bed, is the most valuable coal bed in the Colstrip West quadrangle.

The trace element content of coals in the Colstrip West 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).

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 locality was not given, but probably would be east or southeast of the Colstrip West quadrangle.

The Rosebud coal bed crops out in a belt about 2 miles (3.2 km) wide along the south edge of the Colstrip West quadrangle (pl. 1). The coal has been burned along the outcrop forming extensive areas of clinker. The bed has a dip of less than 1 degree to the south and southeast which is interrupted by a minor fault and a local, low-relief anticline (pl. 4). The unburned coal is generally 15 to 27 feet (4.5 to 8.2 m) thick (pl. 4). Overburden on the Rosebud coal bed ranges from zero to 200 feet (61 m) in thickness, as shown on plate 5.

A chemical analysis of the Rosebud coal from drill hole RB-59, sec. 31, T. 2 N., R. 41 E., in the Colstrip West quadrangle reported by Matson and Blumer (1973, p. 79) shows ash 8.89 percent, sulfur 1.00 percent, and a heating value of 8,990 Btu per pound as received. This heating value converts to 9,868 Btu on a moist, mineral-matter-free basis, which is within the range of 9,500 to 10,500 Btu, indicating that the coal is subbituminous B in rank.

McKay coal bed

The McKay coal bed was described by Dobbin (1930, p. 27) from exposures on the old McKay Ranch (T. 2 N., R. 42 E., Colstrip East quadrangle) in the Forsyth coal field. Dobbin states that the McKay coal 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 more than 30 feet (9 m). The outcrop of the McKay coal bed follows very closely that of the Rosebud coal bed, and where the Rosebud coal bed is burned, the McKay coal bed is concealed by the Rosebud clinker. For this reason the outcrop of the McKay coal bed was not mapped separately by Dobbin (1930, pl. 7), nor is it shown on the CRO Coal Data Map (pl. 1). Because the McKay coal bed was not measured in the Colstrip West quadrangle, the 4 to 6 foot (1.2 to 1.8 m) thickness shown on the isopach map (pl. 7) is based on measurements projected from the adjacent Colstrip SW quadrangle. Overburden on the McKay coal bed in the Colstrip West quadrangle ranges from zero to slightly over 200 feet (0 to 61 m) in thickness.

A chemical analysis of the McKay coal from drill hole RB-59, sec. 31, T. 2 N., R. 41 E. in the Colstrip West quadrangle reported by Matson and Blumer (1973, p. 78) shows ash 7.79 percent, sulfur 1.23 percent, and a heating value of 8,980 Btu per pound as received. This heating value converts to 9,739 Btu on a moist, mineral-matter-free basis, which is within the range of 9,500 to 10,500 Btu, indicating that the coal is subbituminous B in rank.

Stocker Creek coal bed

The Stocker Creek coal bed was described by Dobbin (1930, p. 27) from outcrops near the head of Stocker Creek in the Forsyth coal field (Colstrip West and Trail Creek School quadrangles). This coal bed crops out in the southwestern part of the Colstrip West quadrangle. The isopach map (pl. 10) indicates that the thickness of the Stocker Creek coal bed ranges from about 3 to 8 feet (0.9 to 2.4 m). Structure contours on top of the Stocker Creek coal bed (pl. 10) show a dip of less than 1 degree southward or southeastward which is interrupted by the minor fault and local, low-relief anticline previously mentioned. Overburden on the Stocker Creek coal bed (pl. 11) is generally less than 200 feet (61 m) thick, but there is a small area where the overburden ranges from 200 to 300 feet (61 to 91 m) in thickness.

There are no known published chemical analyses of the Stocker Creek coal. It is assumed that the Stocker Creek coal is similar in rank to the Rosebud and McKay coals in this area and is subbituminous B.

COAL RESOURCES

Data from coal test holes and 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, the stripping limit for multiple, thin (5 to 40 feet or 1.5 to 12 m thick) beds of subbituminous coal in this area.

Coal resources in the Colstrip West 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 (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 Rosebud, McKay, and Stocker Creek coal beds are shown on plates 6, 9, and 12, respectively, 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 West quadrangle is calculated to be 40.86 million short tons (37.06 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:

$$MR = \frac{t_o\ (0.911)}{t_c\ (rf)}$$

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, plates 5, 8, and 11, for the Rosebud, McKay, and Stocker Creek coal beds, respectively. 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. 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. 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 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. 13). In the Colstrip West quadrangle, about 94 percent of the surface minable coal resource on Federal lands has a high development potential,

about 3 percent has a moderate development potential, and about 3 percent has a low development potential.

Development potential for underground mining and in situ gasification

All known minable coal in the Colstrip West 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 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.

Table 1.--Surface-minable coal resource tonnage by development-potential category for Federal coal lands (in short tons) in the Colstrip West 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	28,930,000	1,940,000	0	30,870,000
McKay	10,000	40,000	1,900,000	1,950,000
Stocker Creek	3,220,000	1,850,000	2,970,000	8,040,000
Total	32,160,000	3,830,000	4,870,000	40,860,000

REFERENCES

Dobbin, C. E., 1930, The Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Montana: U.S. Geological Survey Bulletin 812-A, p. 1-55.

Hatch, J. R., and Swanson, V. E., 1977, Trace elements in Rocky Mountain coals, in Proceedings of the 1976 symposium, Geology of Rocky Mountain coal, 1977: Colorado Geological Survey, Resource Series 1, p. 143-163.

Kepferle, R. C., 1954, Selected deposits of strippable coal in central Rosebud County, Montana: U.S. Geological Survey Bulletin 995-I, p. 333-381.

Mapel, W. J., Swanson, V. E., Connor, J. J., Osterwald, F. W., and others, 1977, Summary of the geology, mineral resources, environmental geochemistry, and engineering geologic characteristics of the northern Powder River coal region, Montana: U.S. Geological Survey Open-File Report 77-292.

Matson, R. E., and Blumer, J. W., 1973, Quality and reserves of strippable coal, selected deposits, southeastern Montana: Montana Bureau of Mines and Geology Bulletin 91, 135 p.

Pierce, W. G., 1936, The Rosebud coal field, Rosebud and Custer Counties, Montana: U.S. Geological Survey Bulletin 847-B, p. 43-120.

U.S. Bureau of Mines and U.S. Geological Survey, 1976, Coal resource classification system of the U.S. Bureau of Mines and U.S. Geological Survey: U.S. Geological Survey Bulletin 1450-B, 7 p.

U. S. Department of Agriculture, Interstate Commerce Commission, and U. S. Department of the Interior, 1974, Final environmental impact statement on proposed development of coal resources in the eastern Powder River coal basin of Wyoming: v. 3, p. 39-61.