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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE TRAIL CREEK SCHOOL QUADRANGLE, ROSEBUD COUNTY, MONTANA

[Report includes 13 plates]

By

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[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 (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 Trail Creek School quadrangle, Rosebud County, Montana, (13 plates; U.S. Geological Survey Open-File Report 78-835). 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 Trail Creek School 7 1/2-minute quadrangle is in west-central Rosebud County, Montana, about 20 miles (32 km) south-southwest of Forsyth, Montana, a town in the Yellowstone River valley about 44 miles (70 km) south-southwest of Miles City and 105 miles (168 km) east of Billings. U.S. Interstate Highway 94 and the main east-west routes of the Chicago, Milwaukee, St. Paul, and Pacific Railroad, and the Burlington Northern Railroad follow the Yellowstone River and pass through Forsyth, the county seat.

Accessibility

The Trail Creek School quadrangle is accessible from the north by the West Fork of Armells Creek Road, an improved, graveled road which passes through the quadrangle and connects with paved State Highway 39

about 8 miles (12.8 m) northeast of the quadrangle. This intersection is 12 miles (19.2 km) south of Interstate Highway 94. A branch of the Burlington Northern Railroad parallels State Highway 39 about 4 to 6 miles (6.4 to 9.6 km) east of the quadrangle and connects the town of Colstrip and the Rosebud (Colstrip) and Big Sky coal mines with the main route of the railroad in the Yellowstone River valley. A number of unimproved roads and trails intersect the West Fork of Armells Creek Road and provide access to most areas within the quadrangle.

Physiography

The Trail Creek School quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. Most of the quadrangle is dissected and drained by the West Fork of Armells Creek which flows northward through the west-central part of the quadrangle. The easternmost part of the quadrangle is drained by tributaries of the East Fork of Armells Creek. The drainage divide between the two forks of Armells Creek is in the east-central part of the quadrangle. The topography is rough in the south half of the quadrangle, which is underlain by the upper part of the Tongue River Member of the Fort Union Formation, containing clinker zones formed by the burning of coal beds. The ridges are generally long and narrow with steep sides and sharp tops. The topography is more subdued in the north half of the quadrangle where the clinker beds are missing. There the hills have gentle slopes, are rounded, and are of moderate relief.

The highest elevation in the quadrangle, 3,735 feet (1,138 m), is at Castle Rock, a butte on the drainage divide near the south-central border of the quadrangle. The lowest elevation, slightly below 2,980 feet (908 m), is on the West Fork of Armells Creek at the north border of the quadrangle. Topographic relief is 755 feet (230 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 a short distance into the southern part of the Trail Creek School quadrangle, as shown by the Coal Data Map (pl. 2). This map also shows the land ownership status and outlines the lands on which there was an outstanding Federal coal lease recorded as of 1977.

GENERAL GEOLOGY

Previous work

Dobbin (1930) mapped the Trail Creek School quadrangle as part of the Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Montana.

Kepferle's (1954) mapping of the Castle Rock strippable deposit gives 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). Ayler, Smith, and Deutman (1969, p. 37-38) discussed the southern part of the quadrangle as part of the Castle Rock-Armells Creek deposit in their summary of the strippable coal reserves of 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), which is composed of three members: the upper Tongue River Member, the middle Lebo Shale Member, and the lower Tullock Member. Dobbin (1930) 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 lowermost member of the Fort Union Formation in Montana.

The upper part of the Tullock Member crops out along the West Fork of Armells Creek and its tributaries in the north-central part of the quadrangle. 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 (Dobbin, 1930, p. 12).

The Lebo Shale Member crops out higher up the slopes as a narrow band surrounding the Tullock outcrop in the north-central part of the quadrangle. 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 treeless slopes and badlands. Where present, the Big Dirty coal bed occurs at the base of the Lebo Shale Member.

The Tongue River Member forms the exposed bedrock unit in all except the north-central part of the quadrangle. The Tongue River Member 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 reddish-colored clinker. Dobbin (1930, p. 16) reports that the entire Tongue River Member is 1,686 feet (514 m) thick in the Forsyth coal field, but in the Trail Creek School quadrangle most of the member has been removed by erosion so that less than 900 feet (274 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 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 Trail Creek School quadrangle is in the northwestern part of the Powder River structural basin. The strata in general dip southeastward at an angle of less than 1 degree. In places, regional structure is modified by minor faults and low relief folds as shown by the structure contour maps on tops of the Rosebud, Stocker Creek, and Robinson coal beds (pls. 4, 7, and 10). Some of the inconsistencies in structure may be due to irregularities in deposition of the coals and other beds as a result of their continental nature.

COAL GEOLOGY

Dobbin (1930, p. 7) mapped five coal beds in the Trail Creek School quadrangle. The stratigraphically lowest is the Big Dirty coal bed which is at the base of the Lebo Shale Member. The next higher coal bed is the Burley which is 130 feet (40 m) above the base of the Tongue River Member and 260 feet (79 m) above the Big Dirty coal bed. The Burley coal bed is overlain successively by a noncoal interval of 45 to 70 feet (14 to 21 m), the Robinson coal bed, a noncoal interval of 80 to 120 feet (24 to 37 m), the Stocker Creek coal bed, a noncoal interval of 55 to 85 feet (17 to 26 m), and the Rosebud coal bed.

Based on available information, the lower two coal beds, the Big Dirty and the Burley beds, are not known to contain economic coal resources. Dobbin (1930, p. 26) describes the Big Dirty coal bed as usually consisting

of carbonaceous shale, carbonaceous sandstone, and thin, lenticular beds of coal. The Burley coal bed is about 3 feet (0.9 m) thick in the Trail Creek School quadrangle, too thin for Reserve Base coal. The three highest coal beds, the Robinson, Stocker Creek, and Rosebud, contain important coal resources.

The trace element content of coals in the 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 named by Dobbin (1930, p. 27) for outcrops along Rosebud Creek in the Forsyth coal field about 17 miles (27 km) east of the Trail Creek School quadrangle. A specific type locality was not given.

The Rosebud coal bed crops out in a belt about 2 miles (3.2 km) wide along the south edge of the Trail Creek School quadrangle (pl. 1). The coal has been burned along the outcrop forming extensive areas of reddish-colored clinker. The bed has a dip of less than 1 degree to the southeast except where the structure is modified by minor folding and faulting in the southwest quarter of the quadrangle. The unburned coal is generally 15 to 29 feet (4.6 to 8.8 m) thick (pl. 4). Overburden on the Rosebud coal bed is generally less than 200 feet (61 m) in thickness; only in one small area is

the overburden thickness slightly greater than 200 feet (61 m), as shown on plate 5. The mining-ratio values range from zero to slightly over 10 (pl. 5).

A chemical analysis of the Rosebud coal from drill hole RB-64, sec. 34, T. 2 N., R. 39 E. in the Trail Creek School quadrangle, reported by Matson and Blumer (1973, p. 79) shows ash 8.47 percent, sulfur 0.82 percent, and a heating value of 8,990 Btu per pound as received. This heating value converts to about 9,800 Btu per pound of 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 named by Dobbin (1930, p. 27) from outcrops near the head of Stocker Creek (Colstrip West and Trail Creek School quadrangles) in the Forsyth coal field. This coal bed crops out in the south half of the Trail Creek School quadrangle. The isopach map (pl. 7) indicates that the thickness of the Stocker Creek coal bed ranges from about 2.8 to 7.3 feet (0.9 to 2.2 m). Structure contours on top of the Stocker Creek coal bed (pl. 7) show a dip of less than 1 degree southward or southeastward except where the structure is modified by minor folding and faulting, as in the southwest quarter of the quadrangle. Overburden on the Stocker Creek coal bed (pl. 8) is generally less than 200 feet (61 m) thick, but there is a small area in the southwest corner of the quadrangle where the overburden increases to 400 feet (122 m) in thickness. This overburden includes the Rosebud coal bed where it is uneroded and unburned.

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 overlying Rosebud coal in this area and is subbituminous B.

Robinson coal bed

The Robinson coal bed was named by Dobbin (1930, p. 27) from outcrops on the Robinson Ranch in the McClure Creek quadrangle adjacent to the Trail Creek School quadrangle on the west. The Robinson coal bed crops out in the south-central part of the Trail Creek School quadrangle. The thickness of the Robinson coal bed (pl. 10) ranges from 2.0 to 8.4 feet (0.6 to 2.6 m). Structure contours on top of the Robinson coal bed (pl. 10) show a dip of less than 1 degree westward which is interrupted in the central and southern parts of the quadrangle by minor faulting and warping. Overburden on the Robinson coal bed (pl. 11) ranges from zero to just over 470 feet (143 m) in thickness. This overburden includes the Stocker Creek and Rosebud coal beds where uneroded and unburned.

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

The trace element content of coals in the Trail Creek School 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).

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.

Estimated coal resources in the Trail Creek School 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 t/ha-m) 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, Stocker Creek, and Robinson 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 Trail Creek School quadrangle is calculated to be 51.90 million short tons (47.04 million 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 30 percent of the Reserve Base tonnage is classed as Measured, 46 percent as Indicated, and 24 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, plates 5, 8, and 11, for the Rosebud, Stocker Creek, and Robinson 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. 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 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). Most of the Federal coal lands in the Trail Creek School quadrangle that have a potential for surface mining have a high development potential; a minor amount of these lands have a moderate development potential.

Development potential for underground mining and in situ gasification

All known minable coal in the Trail Creek School 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 land (in short tons) in the Trail Creek School 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	24,350,000	660,000	0	25,010,000
Stocker Creek	11,750,000	4,910,000	7,560,000	24,220,000
Robinson	1,160,000	1,370,000	140,000	2,670,000
Total	37,260,000	6,940,000	7,700,000	51,900,000

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