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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE FOURMILE CREEK QUADRANGLE, CUSTER COUNTY, MONTANA

[Report includes 8 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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[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 Fourmile Creek quadrangle, Custer County, Montana, (8 plates; U.S. Geological Survey Open-File Report 78-640). 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 Fourmile Creek 7 1/2-minute quadrangle is in southwestern Custer County, Montana, about 32 miles (51.2 km) south of Miles City, Montana.

Accessibility

The quadrangle is accessible from Miles City, Montana, by going southward on U.S. Highway 312 and Montana State Highway 332 (Tongue River Road) a distance of 32 miles (51.2 km) to Garland School, and thence south on Foster Creek Road 2 miles (3.2 km) to the north border of the quadrangle. Foster Creek Road is an improved county road which passes north-south through the center of the quadrangle. A number of unimproved roads provide access to the rest of the quadrangle.

Physiography

The Fourmile Creek quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The upland plateau surface, however, has been almost completely dissected by tributaries of the Tongue River (Foster Creek and Lay Creek in this quadrangle). Ridges remain as remnants of the old plateau surface in the southwest quarter of the quadrangle, along the divide between Foster Creek and Lay Creek. These have elevations up to 3,200 feet (975 m) and are the highest points in the quadrangle. The lowest elevation, about 2,650 feet (807 m), occurs where Foster Creek leaves the quadrangle near the center of the north border. Topographic relief is about 550 feet (168 m).

Climate

The climate of Custer 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 Coal Resource Area (KRCRA) extends into the south half of the quadrangle. The Boundary and Coal Data Map (pl. 2) shows the location of the KRCRA tracts and the coal

land ownership status. Approximately 30 percent of the land underlain by coal of Reserve Base thickness is federally owned. There were no outstanding Federal coal leases or prospecting permits as of 1977.

GENERAL GEOLOGY

Previous work

N. W. Bass (1932) mapped the south two-thirds of the Fourmile Creek quadrangle as part of the Ashland coal field, Rosebud, Powder River, and Custer Counties, Montana. W. G. Pierce (1936) mapped the north third of the 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 lowermost 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 Foster Creek valley in the north third 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 unimportant local coal beds (Pierce, 1936).

The overlying 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 mappable coal beds. The Lebo Shale occupies most of the broad valley of Foster Creek in a belt extending southeastward across the quadrangle.

The Tongue River Member caps the upland plateaus and ridges in the south two-thirds of the quadrangle and contains the only coal beds of economic interest. This unit is made up mainly of yellow sandstone, sandy shale, carbonaceous shale, and coal. Much coal has been burned along outcrops, fracturing and baking the overlying sandstone and shale to form thick reddish-colored 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 Fourmile Creek quadrangle is in the north-central part of the Powder River structural basin. The strata dip southward about 40 feet per mile (7.6 m per km). A broad, shallow syncline with up to 80 feet (24.4 m) of structural relief is mapped on the Terret coal bed following the valley of Foster Creek in a southeast direction across the quadrangle (pl. 5).

COAL GEOLOGY

Three coal beds, all in the Tongue River Member of the Fort Union Formation, were mapped on the surface in this quadrangle (pl. 1) and are shown in section on plate 3. The lowest of these is an unnamed local bed, an estimated 250 to 300 feet above the base of the Tongue River Member. As it is thin (less than 5 feet or 1.5 m) and discontinuous throughout most of its occurrences, no economic resources have been attributed to it. It is overlain successively by a 15 to 30 foot (4.6 to 9.1 m) thick noncoal interval, the Terret coal bed, another 70 foot (21.3 m) thick noncoal interval, and the Flowers-Goodale coal bed.

The trace element content of coals in the Fourmile Creek 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 described by Bass (1932, p. 51) from a small mine on the Terret Ranch (Cook Creek Reservoir quadrangle) in the Ashland coal field about 15 miles (24 km) to the southwest of this quadrangle. The Terret bed crops out around the crest of the divide between Foster Creek and Lay Creek in the southwest quarter of the Fourmile Creek quadrangle. Along most of the outcrops much coal has been burned, leaving broad areas of clinker. In a number of places, the clinker has been removed by surface erosion exposing the coal bed. Based on these coal outcrops the Terret coal bed is seen to range from 2.3 to over 9.6 feet (0.7 to over 2.9 m) in thickness (pl. 4).

Overburden on the Terret coal bed ranges from zero to more than 160 feet (48.8 m), as shown on plate 6. The Flowers-Goodale coal bed is interpreted to lie within this interval, about 70 feet (21.3 m) above the Terret. The few occurrences are small, and the coal bed is thin, ranging from 2 to 3.8 feet (0.61 to 1.16 m) in thickness. No economic coal resources have been attributed to the Flowers-Goodale bed in this quadrangle.

No coal analyses are available for the Terret coal bed in the Fourmile Creek quadrangle; however, the Montana Bureau of Mines and Geology drilled, cored, and analyzed the Terret coal in State Hole SS-5C (sec. 3, T. 3 N., R. 44 E.) in the Miller Creek SW quadrangle, about 14 miles (22.4 km) northwest of the northwest corner of the Fourmile Creek quadrangle. The coal is subbituminous C in rank. At depths of 109 to 127 feet (33.2 to 38.7 m), the analyses

show a heating value of 8,020 Btu per pound, ash 9.43 percent, and sulfur 1.8 percent, as received (Matson and Blumer, 1973, p. 102).

COAL RESOURCES

Data from oil-and-gas and coal test holes, as well as 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 200 feet (61 m) or less of overburden. This depth of overburden is the stripping limit for single, relatively thin (5 to 40 feet or 1.5 to 12 m thick) beds of subbituminous coal in this area.

The acreage underlain by a coal bed was measured by planimeter. The coal resources in the quadrangle were computed using the acreage numbers 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 to yield the coal resources in short tons of coal for each isopached coal bed.

Reserve Base and Reserve tonnage numbers for the Terret coal bed are shown on plate 7, 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 9.01 million short tons (8.17 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 9 percent of the Reserve Base tonnage is classed as Measured, 48 percent as Indicated, and 43 percent as Inferred.

COAL DEVELOPMENT POTENTIAL

Areas where coal beds are 5 feet (1.5 m) or more thick and are overlain by 200 feet (61 m) or less of overburden are considered to have potential for surface mining in this quadrangle 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 plate 6. 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 8, 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.

The coal development potential for surface-mining methods (less than 200 feet or 61 m of overburden) is shown on the Coal Development Potential map (pl. 8). The Terret coal has a high development potential over its entire area of occurrence in the south two-thirds of this 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 Fourmile Creek quadrangle is contained in the Terret coal bed within surface-minable depths. Since there is no known Reserve Base coal at depths beneath the Terret coal bed, the development potential for underground mining in the Fourmile Creek 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 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 Fourmile Creek quadrangle, Custer 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	6,120,000	2,600,000	290,000	9,010,000
Total	6,120,000	2,600,000	290,000	9,010,000

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