UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Text to accompany:

Open-File Report 78-647

1978

COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE GRIFFIN COULEE SW QUADRANGLE, ROSEBUD AND TREASURE COUNTIES, MONTANA

[Report includes 7 plates]

By

Colorado School of Mines Research Institute

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 text is for use in conjunction with the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) maps of the Griffin Coulee SW quadrangle, Rosebud and Treasure Counties, Montana (7 plates; U.S. Geological Survey Open-File Report 78-647). 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 Griffin Coulee SW 7 1/2-minute quadrangle is in western Rosebud and eastern Treasure Counties, Montana, about 14 miles (22 km) 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 route of the Burlington Northern Railroad follow the Yellowstone River and pass through Forsyth.

Accessibility

The Griffin Coulee SW quadrangle is accessible from the north by an improved graveled road that follows northward-flowing Reservation Creek

and intersects U. S. Interstate Highway 94 14 miles (22 km) north of the quadrangle and 12 miles (19 km) west of Forsyth. The quadrangle is also accessible from the east by an improved graveled road that intersects paved State Highway 39 about 10 miles (16 km) by road east of the quadrangle. U. S. Interstate Highway 94 is 12 miles (19 km) north of this intersection.

The nearest railroad is a branch line of the Burlington Northern Railroad which runs parallel to State Highway 39 from the Colstrip and Big Sky coal mines northward to the main route of the Burlington Northern in the Yellowstone River valley. At its nearest point the railroad passes 10 miles (16 km) east of the quadrangle.

Physiography

The Griffin Coulee SW quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The quadrangle is on the divide between two northward-flowing tributaries of the Yellowstone River, Armells Creek east of the quadrangle and Sarpy Creek west of the quadrangle. The northern part of the quadrangle is drained by Reservation Creek, a third tributary of the Yellowstone. The divide is a plateau remnant at elevations of about 3,400 to 3,880 feet (1,036 to 1,183 m), sloping northeastward, 0.5 to 1 mile (0.8 to 1.6 km) wide and about 7 miles (11.2 km) long, extending from the south-central border of the quadrangle to the northeast border. The flat top of the plateau remnant is capped by Tertiary gravels (Dobbin, 1930). The sides of the remnant are steep, crenulated, and in places eroded into badlands. A few much smaller remnants of this same

erosion surface are present in other parts of the quadrangle. The remainder of the quadrangle is intricately dissected.

The lowest elevation in the quadrangle, a little below 3,080 feet (939 m), is along Reservation Creek at the north border of the quadrangle. The highest elevation, 3,880 feet (1,183 m), is on the large plateau remnant near the south boundary of the quadrangle. Topographic relief in the quadrangle is 800 feet (244 m).

Climate

The climate of Rosebud and Treasure Counties 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 Griffin Coulee SW quadrangle as shown by the Coal Data Map (pl. 2). However, less than 12 acres (4.8 hectares) of Federal land contain coal of Reserve Base thickness. There were no outstanding Federal coal leases or prospecting permits of record as of 1977.

GENERAL GEOLOGY

Previous work

Dobbin (1930) mapped the Griffin Coulee SW quadrangle as part of the Forsyth coal field, Rosebud, Treasure, and Big Horn 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 Hell Creek Formation (Upper Cretaceous) and the overlying Fort Union Formation (Paleocene). Dobbin (1930) described the Hell Creek as a lower member of the Lance Formation and assigned a Tertiary (?) Eocene (?) age. However, the Hell Creek is now considered to be a separate formation of Upper Cretaceous age. The Fort Union Formation is composed of three members: the upper Tongue River Member, the middle Lebo Shale Member, and the lower Tullock Member. Dobbin (1930) and Pierce (1936) also 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 lowest member of the Fort Union Formation in Montana.

Gray and greenish-gray, sandy shale and clay of the upper part of the Hell Creek Formation crop out in a small area along Reservation Creek near the north border of the quadrangle. The exposed bedrock units in the remainder of the quadrangle belong to the three members of the Fort Union Formation.

The Tullock Member of the Fort Union Formation overlies the Hell Creek Formation and occurs as an irregular belt 1 to 3 miles (1.6 to 4.8 km)

wide extending across the northern part of the Griffin Coulee SW quadrangle. 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 coal beds have not been mapped in the Griffin Coulee SW 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 gentle treeless slopes and diminutive badlands. The Lebo Shale Member may contain thin coal beds, but none have been mapped in this member in the Griffin Coulee SW quadrangle. The outcrops of the Lebo Shale Member occur in an irregular belt 0.5 to 3 miles (0.8 to 4.8 km) wide, extending across the central part of the quadrangle.

The Tongue River Member of the Fort Union Formation consists of light-colored sandstone and sandy shale and contains important coal beds. Dobbin (1930, p. 12-20) reports that the Tongue River Member is about 1,700 feet (518 m) thick in the Forsyth coal field, but in the Griffin Coulee SW quadrangle most of the member has been removed by erosion so that only about the lower 400 feet (122 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 Griffin Coulee SW 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 coal bed (pl. 4) show a local dip of less than 1 degree to the south and southeast along the south border of the quadrangle.

COAL GEOLOGY

Three important coal beds, the Burley, Robinson, and Rosebud, and one minor local bed, 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 coal bed, the Burley, is about 130 feet (40 m) above the base of the Tongue River Member; the Robinson coal bed is 45 to 65 feet (14 to 20 m) above the Burley. The local coal bed, which is only 2 feet (0.6 m) thick and crops out for a distance of about 0.5 mile (0.8 km) in the southwestern part of the quadrangle, is 60 to 70 feet (18 to 21 m) above the

Robinson. The Rosebud coal bed is about 160 feet (49 m) above the local bed, and is the only coal bed of sufficient thickness to be assigned Reserve Base coal in the Griffin Coulee SW quadrangle.

The trace element content of coals in the Griffin Coulee SW 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 in the Forsyth coal field, but a specific type locality was not named.

The Rosebud coal bed crops out on the steep sides of the plateau remnant in the south-central part of the Griffin Coulee SW quadrangle (pl. 1). It dips very gently, less than 1 degree to the south and southeast (pl. 4). There is only one published measurement of the thickness of the Rosebud coal in the Griffin Coulee SW quadrangle, 7.2 feet (2.2 m), shown on the isopach map, plate 4. Overburden on the Rosebud coal bed ranges from zero to slightly over 200 feet (61 m) in thickness, as shown on plate 5. Much of the coal has been burned along outcrops, and the overlying rock has been fused to slag or clinker.

There are no published analyses of the Rosebud coal bed in the Griffin Coulee SW quadrangle. The nearest known analyses are from the Colstrip mine, 15 miles (24 km) southeast of the Griffin Coulee SW quadrangle.

Twenty-four samples 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, heat value 8,780 to 9,330 Btu per pound (Gilmour and Dahl, 1967). These analyses indicate that this coal is subbituminous B in rank. Because of the proximity of the Colstrip East and the Griffin Coulee SW quadrangles, it is assumed that the Rosebud coal in the Griffin Coulee SW quadrangle is also subbituminous B in rank.

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 200 feet (61 m) or less of overburden, the stripping limit for single, thin (5 to 40 feet or 1.5 to 12 m thick) beds of subbituminous coal in this area.

Coal resources in the Griffin Coulee SW quadrangle were calculated using data obtained from the coal isopach map (pl. 4). 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 coal bed are shown on plate 6 and are rounded to the nearest one-hundredth of a million short tons.

The total Reserve Base tonnage of federally owned coal in the Griffin Coulee SW quadrangle is calculated to be 0.93 million short tons (0.84 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, 77 percent as Indicated, and 19 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 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 map, plate 5. 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 for surface mining-methods (less than 200 feet or 61 m of overburden) is shown on the Coal Development Potential map (pl. 7). This map 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.

In the Griffin Coulee SW quadrangle, only eight tracts (about 250 acres or 101 hectares) of Federal land are assigned a potential for surface mining. Of this land, 66 percent has a high development potential, 2 percent has a moderate development potential, and 32 percent has a low development potential for surface mining.

Table 1 shows the total short tons of surface minable coal on Federal land in the Griffin Coulee SW quadrangle classified as to development potential based on the mining ratio. Of the 930,000 tons of coal shown in table 1, 22 percent has a high development potential, 5 percent has a moderate development potential, and 73 percent has a low development potential.

Development potential for underground mining and in situ gasification

All known minable coal in the Griffin Coulee SW quadrangle is within surface minable depths. Because there are no known underground coal resources below the stripping limit of the Rosebud coal bed, 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 Griffin Coulee SW quadrangle, Rosebud and Treasure Counties, 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	200,000	50,000	680,000	930,000
Total	200,000	50,000	680,000	930,000

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.

Gilmour, E. H., and Dahl, G. G., Jr., 1967, Montana coal analyses, Montana Bureau of Mines and Geology, Special Publication 43, 21 p.

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.

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.