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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE HOME CREEK BUTTE QUADRANGLE, POWDER RIVER COUNTY, MONTANA

[Report includes 41 plates]

By

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ILLUSTRATIONS

[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)	0.9072	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 Home Creek Butte quadrangle, Powder River County, Montana, (41 plates; U.S. Geological Survey Open-File Report 79-091). This set of maps was compiled to support the land-use planning work of the Bureau of Land Management in response to the Federal Coal Leasing Amendments Act of 1976 and to provide a systematic inventory of coal resources on Federal coal lands in Known Recoverable Coal Resource Areas (KRCRAs) in the western United States. The inventory includes only those beds of subbituminous coal that are 5 feet (1.5 m) or more thick and under less than 3,000 feet (914 m) of overburden and those beds of lignite that are 5 feet (1.5 m) or more thick and under less than 1,000 feet (305 m) of overburden.

Location

The Home Creek Butte 7 1/2-minute quadrangle is in northwestern Powder River County, Montana, about 55 miles (88 km) south of Miles City, a town in the Yellowstone River valley of eastern Montana. 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 Miles City. The Home Creek Butte quadrangle is 14 miles (22.5 km) east of Ashland, Montana, and 23 miles (37 km) west-northwest of Broadus, both of which are small towns on east-west U.S. Highway 212.

Accessibility

The quadrangle is accessible from Ashland, Montana, by traveling east on U.S. Highway 212 about 14 miles (22.5 km) to the west border of the quadrangle. The quadrangle is also accessible from Broadus, Montana, by traveling west on U.S. Highway 212 about 23 miles (37 km) to the east border of the quadrangle.

U.S. Highway 212 passes through the center of the quadrangle in an east-west direction. The nearest railroad is at the Big Sky coal mine in the Colstrip SE quadrangle, about 30 miles (48 km) to the northwest. A spur of the Burlington Northern Railroad connects this mine with the main east-west route of the railroad about 35 miles (56 km) farther north-northwest in the Yellowstone River valley.

Physiography

The Home Creek Butte quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The plateau, formed by nearby horizontal strata, has been deeply and intricately dissected producing very rough and rugged topography. Remnants of the plateau surface remain only at higher elevations. The broad, irregular, forested divide between the Pumpkin Creek drainage to the east and the Otter Creek drainage to the west passes north-south through the eastern part of the quadrangle. Pumpkin Creek is 2 to 5 miles (3.2 to 8 km) east of the quadrangle and Otter Creek is 8.5 to 13 miles (13.7 to 20.9 km) west of the quadrangle. Otter Creek and Pumpkin Creek are northward-flowing tributaries of the Tongue River which empties into the Yellowstone River at Miles City. The principal stream in the quadrangle, Home Creek, a westward-flowing tributary of Otter Creek, has cut a deep, narrow valley through the central part of the quadrangle.

The highest elevation, 4,407 feet (1,343 m), is on Home Creek Butte, in the north-central part of the quadrangle. The lowest elevation, about 3,350 feet (1,021 m), is on Home Creek at the western border of the quadrangle. Topographic relief in the quadrangle is 1,057 feet (322 m).

Climate

The climate of Powder River 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 about 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 Boundary and Coal Data Map (pl. 2) shows the land ownership status within the Home Creek Butte quadrangle. All of the quadrangle is within the Northern Powder River Basin Area (KRCRA). There were no outstanding Federal coal leases or prospecting permits as of 1977.

GENERAL GEOLOGY

Previous work

Bass (1932) mapped all of the quadrangle except the southern one and one-half tiers of sections as part of the Ashland coal field. Warren (1959) mapped the southern part of the quadrangle not mapped by Bass. Matson and Blumer (1959, pls. 23A, 24, 25A, and 26) remapped most of the quadrangle.

Traces of coal bed outcrops shown by previous workers on planimetric maps which lack topographic control have been modified to fit the modern topographic map of the quadrangle.

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 Tongue River Member, the uppermost member, of the Fort Union Formation (Paleocene). This member consists of light-colored sandstone, sandy shale, carbonaceous shale, and coal beds. The thicker coal beds have burned along the outcrop and have baked and fused the overlying rock into reddish-colored clinker or slag.

The upper part of the Tongue River Member has been removed by erosion, but about 1,700 feet (518 m) of the middle and lower parts of the member remains in the Home Creek Butte quadrangle.

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 rivers, flood plains, sloughs, swamps, and lakes that occupied the area of 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 content of trace elements by the U.S. Geological Survey, and the results have been 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 rocks found throughout other parts of the western United States.

Structure

The Home Creek Butte quadrangle is in the northeastern part of the Powder River structural basin. The strata, in general, dip southwestward at an angle of less than 1 degree. In places the regional structure is modified by low-relief folds, as shown by the structure contour maps on top of the coal beds (pls. 4, 8, 11, 14, 17, 20, 23, 26, 30, 35, and 38). Some of the nonuniformity in structure may be due to differential compaction and to irregularities in depositon of the coals and other beds as a result of their continental origin.

COAL GEOLOGY

The coal beds in the Home Creek Butte quadrangle are shown in outcrop on the Coal Data Map (pl. 1) and in section on the Coal Data Sheet (pl. 3). All of the mapped coal beds occur in the middle and lower parts of the Tongue River Member of the Fort Union Formation (Paleocene). No commercial coals are known to exist below the Tongue River Member.

The lowermost recognized coal bed is the Flowers-Goodale coal bed which occurs about 350 feet (107 m) above the base of the Tongue River Member. The Flowers-Goodale coal bed is overlain by a noncoal interval of about 120 feet (36.6 m), the Knobloch coal bed, a noncoal interval of about 120 feet (36.6 m), the Sawyer coal bed, a noncoal interval of about 220 feet (67 m), the Odell coal bed, a noncoal interval of about 110 feet (33.5 m) containing only local coal beds, the Pawnee coal bed, a noncoal interval of about 10 feet (3.3 m), the Elk coal bed, a noncoal interval of about 70 feet (21.3 m), the Wall coal bed, a noncoal interval of about 90 feet (27 m) containing a local coal bed, the lower Cook coal bed, a noncoal interval of 1 to 10 feet (0.3 to 3 m), the upper Cook coal bed, a noncoal interval of about 100 feet (30 m) containing a local coal bed, the Ferry coal bed, a noncoal interval of about 75 to 95 feet (23 to 29 m) containing a local coal bed, the Canyon coal bed, a noncoal interval of about 160 feet (49 m), and the Garfield clinker bed which was formed by the burning of the Garfield coal bed.

The coal found along the eastern flank of the Powder River Basin in Montana increases in rank from lignite in the east to subbituminous in the deeper parts of the basin to the west. All coal analyses available at the present time from this and adjacent quadrangles were considered in our decision to assign a rank of subbituminous C to the coal in this quadrangle. The lignite-subbituminous boundary may fall somewhere within the eastern part of this quadrangle, but not enough data are presently known to allow our drawing that boundary line with certainty. Therefore, a rank of subbituminous C has been arbitrarily assigned by us to all of the coal in the entire quadrangle. Additional data to be obtained in the future may make a more precise determination of the location of this boundary line possible.

The trace-element content of coals in this 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).

Flowers-Goodale coal bed

The Flowers-Goodale coal bed was first described by Bass (1932, p. 53) from two small mines in the Brandenberg quadrangle, about 18 miles (29 km) north-northwest of the Home Creek Butte quadrangle. The Flowers-Goodale coal bed occurs about 350 feet (107 m) above the base of the Tongue River Member. This coal bed does not crop out in the Home Creek Butte quadrangle and has not been penetrated by coal test holes, but it is projected into the quadrangle from the Coleman Draw quadrangle to the west where it has been penetrated by a few test holes. The isopach and structure contour map of the Flowers-Goodale coal bed (pl. 38) shows the coal bed projection along the western edge of the quadrangle. It is believed to range in thickness from less than 5 feet (1.5 m) to 7 feet (2.1 m) and to dip to the south at less than 1 degree. Overburden on the Flowers-Goodale coal (pl. 39), where it is 5 feet (1.5 m) or more thick, ranges from about 420 to 1,100 feet (128 to 335 m) in thickness. There is no known, publicly available chemical analysis of the Flowers-Goodale coal bed in the Home Butte Creek quadrangle. However, an analysis of this coal from a depth of 53 to 62 feet (16 to 19 m) in drill hole SH-7076 (sec. 14, T. 1 S., R. 45 E.), about 10 miles (16 km) northwest of the Home Creek Butte quadrangle in the Cook Creek Reservoir quadrangle, shows ash 8.14 percent, sulfur 0.961 percent, and a heating value of 8,102 Btu per pound (18,845 kJ/kg) on an as-received basis (Matson and

Blumer, 1973, p. 121). This heating value converts to about 8,820 Btu per pound (20,515 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Flowers-Goodale coal in the Cook Creek Reservoir quadrangle is subbituminous C in rank. Because the Cook Creek Reservoir and the Home Creek Butte quadrangles have similar positions in the basin, it is assumed that the Flowers-Goodale coal in the Home Creek Butte quadrangle is similar and is subbituminous C in rank.

Knobloch coal bed

The Knobloch coal bed was named by Bass (1924) from the Knobloch Ranch and coal mine in the Birney Day School quadrangle, about 23 miles (37 km) southwest of the Home Creek Butte quadrangle. In the Home Creek Butte quadrangle, the Knobloch coal bed is about 120 feet (36.6 m) above the Flowers-Goodale coal bed. The Knobloch coal bed does not crop out, nor has it been penetrated by coal test holes, in this quadrangle. However, the coal bed has been projected into the quadrangle from all of the surrounding quadrangles. The isopach and structure contour map of the Knobloch coal bed (pl. 35) shows that this coal bed ranges from about 16 to 50 feet (4.9 to 15 m) in thickness, and, in general, is nearly flat-lying, although gentle local dips occur in the northern and southern parts of the quadrangle. These are caused by low-relief, broad folding. Overburden on the Knobloch coal bed (pl. 36) ranges from about 240 to 1,240 feet (73 to 378 m) in thickness.

There is no known, publicly available chemical analysis of the Knobloch coal in the Home Creek Butte quadrangle. However, a chemical analysis of the Knobloch coal from a depth of 116 to 135 feet (35.3 to 41.1 m) in coal test hole SH-7051, sec. 33, T. 4 S., R. 46 E., 5 miles (8 km) south-southwest of the Home Creek Butte quadrangle, in the Yager Butte quadrangle (Matson and Blumer, 1973, p. 68) shows ash 4.648 percent, sulfur 0.229 percent, and heating value 8,282 Btu per pound (19,263 kJ/kg) on an as-received basis. This heating value converts to about 8,686 Btu per pound (20,203 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Knobloch coal at that location is subbituminous C in rank. Because of the proximity of that location to the Home Creek Butte quadrangle, it is assumed that the Knobloch coal in this quadrangle is similar and is also subbituminous C in rank.

Sawyer coal bed

The Sawyer coal bed was first described by Dobbin (1930, p. 28) from exposures in the foothills of the Little Wolf Mountains in the Forsyth coal field (Rough Draw and Black Spring quadrangles) about 40 miles (64 km) west-northwest of the Home Creek Butte quadrangle. In this quadrangle, the Sawyer coal bed is about 120 feet (36.6 m) above the Knobloch coal bed. The Sawyer coal bed does not crop out in the Home Creek Butte quadrangle, nor is it penetrated by coal test holes. However, it is projected into the quadrangle from all of the surrounding quadrangles. Data from these quadrangles indicate that in the southern and northern parts of the quadrangle the Sawyer coal bed is split into two coal beds. As shown by the isopach map (pl. 29), the unsplit Sawyer coal in the central part of the quadrangle is believed to consist of a single bed ranging from about 2 to 22 feet (0.6 to 6.7 m) in thickness. Where the Sawyer coal bed is split into two beds, each bed may range from 2 to 16 feet (0.6 to 4.9 m) in thickness. As shown by the structure contour map (pl. 30) the Sawyer coal, in general, dips southward at an angle of less than 1 degree, but this dip is modified in places by broad, low-relief folding. Overburden on the Sawyer coal bed (pl. 31) ranges from about 200 to more than 1,000 feet (61 to 305 m) in thickness.

There is no known, publicly available chemical analysis of the Sawyer coal in the Home Creek Butte quadrangle. However, a chemical analysis of the Sawyer coal from a depth of 90 to 97 feet (27.4 to 29.6 m) in coal test hole SH-7064, sec. 8, T. 3 S., R. 46 E., about 3.5 miles (5.6 km) west of the Home Creek Butte quadrangle in the Coleman Draw quadrangle (Matson and Blumer, 1973, p. 73), shows ash 4.026 percent, sulfur 0.352 percent, and a heating value of 7,965 Btu per pound (18,527 kJ/kg) on an as-received basis. This heating value converts to about 8,300 Btu per pound (19,306 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Sawyer coal at that location is on the border between lignite A and subbituminous C in rank. Because of the proximity of that location to the Home Creek Butte quadrangle, it is assumed that the Sawyer coal in this quadrangle is similar and is also close to the border between lignite A and subbituminous C in rank. For purposes of calculating the tonnage of coal resources all of the coal in this quadrangle has been assigned a rank of subbituminous C.

Odell coal bed

The Odell coal bed was first described by Warren (1959, p. 572) probably from exposures near O'Dell Creek in the Green Creek quadrangle, about 16 miles (25.7 km) southwest of the Home Creek Butte quadrangle. The Odell coal bed occurs about 220 feet (67 m) above the Sawyer coal bed. It crops out in the southwest corner of this quadrangle and in the Threemile Buttes quadrangle to the south and the Coleman Draw quadrangle to the west. The isopach and structure contour map of the Odell coal bed (pl. 26) shows that the coal ranges from 3.5 to about 8 feet (1.1 to 2.4 m) in thickness and dips southwestward at an angle of less than 1 degree. Overburden on the Odell coal bed (pl. 27) ranges from 0 feet at the outcrop to about 400 feet (0-121.9 m) in thickness.

There is no known, publicly available chemical analysis of the Odell coal in, or near, this quadrangle. However, it is reasonable to assume that the Odell is similar to other closely associated coals in this quadrangle and is subbituminous C in rank.

Pawnee (Dunning) coal bed

The Pawnee coal bed was first described by Warren (1959, p. 572) when he mapped it (1959, pl. 19) in the southeastern part of the Home Creek Butte quadrangle. In the southwestern part of the quadrangle, Warren mapped the Dunning coal bed at about the same stratigraphic horizon. Warren states (1959, p. 572) that he "believes that the upper bench of the Pawnee is the same as the Dunning bed, but since the two benches coalesce eastward, the name Dunning is not used east of the Otter Creek-Pumpkin Creek divide." North of the area mapped by Warren, in the Home Creek Butte quadrangle, Bass (1932, pl. 3) mapped the Dunning and Pawnee coal beds as the E coal bed. Matson and Blumer (1973, pls. 23A and 25A) remapped the Dunning bed in the southwestern part of the Home Creek Butte quadrangle and the Pawnee coal bed in the southeastern part of the quadrangle. On plates 1, 3, 23, 24, and 25 of this report, the E coal bed of Bass and the Dunning coal bed of Warren (and Matson and Blumer) are shown as the Pawnee coal bed.

The Pawnee coal bed occurs about 110 feet (33.5 m) above the Odell coal bed. The isopach and structure contour map of the Pawnee bed (pl. 23) shows that the coal ranges from about 3 to 6 feet (0.9 to 1.8 m) in thickness and dips slightly to the southwest. The dip is modified locally by broad, low-relief folding. Overburden on the Pawnee coal bed (pl. 24) ranges from 0 feet at the outcrops to more than 600 feet (0-183 m) in thickness.

There is no known, publicly avilable chemical analysis of the Pawnee coal in the Home Creek Butte quadrangle. However, an analysis of the Pawnee (Dunning) coal from a depth of 43 to 52 feet (13 to 16 m) in drill hole SH-7149, sec. 14, T. 4 S., R. 46 E. (Matson and Blumer, 1973, p. 105), about 1.5 miles (3.6 km) southwest of the Home Creek Butte quadrangle in the Yager Butte quadrangle shows ash 4.872 percent, sulfur 0.229 percent, and heating value 8,005 Btu per pound

(18,619 kJ/kg) on an as-received basis. This heating value converts to about 8,415 Btu per pound (19,573 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Pawnee coal at that location is subbituminous C in rank. Because of the proximity of that location to the Home Creek Butte quadrangle, it is assumed that the Pawnee (Dunning) coal in this quadrangle is similar and is also subbituminous C in rank.

Elk coal bed

The Elk coal bed was first described by Warren (1959, p. 573) from exposures in the Birney-Broadus coal field, probably along Elk Creek in northern Goodspeed Butte quadrangle, about 9 miles (14.4 km) south of the Home Creek Butte quadrangle. In the southeastern part of the Coleman Draw quadrangle and the southwestern part of the Home Creek Butte quadrangle, Bass (1932, pl. 3) mapped an uncorrelated bed which we have correlated with the Elk bed of Warren because it occurs at about the same stratigraphic horizon. In the Home Creek Butte quadrangle, the Elk coal bed lies about 10 feet (3.3 m) above the Pawnee bed. The isopach and structure contour map (pl. 20) shows that the Elk coal bed ranges from about 5 to 16 feet (1.5 to 4.9 m) in thickness and is practically flat-lying. The overburden isopach and mining-ratio map of the Elk bed (pl. 21) shows that the overburden, where the Elk bed is 5 feet (1.5 m) or more thick, ranges from 0 feet at the outcrops to more than 300 feet (0 to 91.4 m) in thickness.

An analysis of the Elk coal bed was obtained from a depth of 86 to 94 feet (26.2 to 28.6 m) in coal test hole SH-7050, sec. 4, T. 5 S., R. 47 E., in the Threemile Buttes quadrangle, about 4.5 miles (7.2 km) south of the Home Creek Butte quadrangle. It showed ash 4.666 percent, sulfur 0.3 percent, and a heating value of 7,125 Btu per pound (16,573 kJ/kg) on an as-received basis. This converts to a heating value of 7,474 Btu per pound (17,384 kJ/kg) on a moist, mineral-matter-free basis. This indicates that the Elk coal bed is lignite A in rank at that location. Because of its proximity to the Home Creek Butte quadrangle, it is reasonable to assume a rank of lignite A for the Elk coal bed in that quadrangle also.

Wall coal bed

The Wall coal bed was first described by Baker (1929, p. 37) in the northward extension of the Sheridan coal field. It probably derives its name from exposures along Wall Creek in the Birney quadrangle, about 35 miles (56 km) southwest of the Home Creek Butte quadrangle.

In the Home Creek Butte quadrangle, the Wall coal bed occurs about 70 feet (21 m) above the Elk coal bed. It crops out only in the southern part of the quadrangle (pl. 1) where it was mapped by Warren (1959, pl. 19). The coal thins northward and was not mapped by Bass (1932, pl. 3) in the northern part of the quadrangle. The isopach and structure contour map of the Wall coal bed (pl. 17) shows that the coal ranges from about 4 to 8.8 feet (1.2 to 2.7 m) in thickness and is almost flat-lying. The overburden isopach and mining-ratio map (pl. 18) shows that the overburden ranges from 0 feet at the outcrops to about 200 feet (0-61 m) in thickness where the coal is more than 5 feet (1.5 m) thick.

There are no known, publicly available chemical analyses of the Wall coal in, or near, the Home Creek Butte quadrangle. For purposes of calculation of resources it is assumed that the Wall coal is similar to other closely associated coals in this quadrangle and is subbituminous C in rank.

Cook coal bed

The name Cook coal bed was first used by Bass (1932, p. 59-60) for exposures of coal on the slopes of Cook Mountain in the Cook Creek Reservoir quadrangle, about 7 miles (11.3 km) west-northwest of the Home Creek Butte quadrangle. Bass (1932, pl. 3) did not map the Cook coal bed in the Home Creek Butte quadrangle. Warren (1959, pl. 19) mapped the Cook coal bed in the southern part of the quadrangle, and a coal test hole in the south-central part of the quadrangle penetrated an Upper and a Lower Cook coal bed which have 10 feet (3 m) of separation (pls. 1 and 3).

The isopach and structure contour map of the Lower Cook coal bed (pl. 14) shows that this coal bed ranges from about 4 to 13.1 feet (1.2 to 4 m) in thickness and dips west-southwestward at an angle of less than 1 degree, although this dip is modified by minor, low-relief folding. The overburden isopach and mining-ratio map (pl. 15) shows that the overburden thickness on the Lower Cook coal bed ranges from 0 feet at the outcrops to about 300 feet (0-91 m) in thickness where the coal bed is more than 5 feet (1.5 m) thick. The isopach and structure contour map of the Upper Cook coal bed (pl. 11) shows that this coal bed ranges from 4 to 5.6 feet (1.2 to 1.7 m) in thickness and dips westward at an angle of less than 1 degree. The overburden isopach and mining-ratio map (pl. 12) shows that the overburden thickness on the Upper Cook coal bed ranges from 0 feet at the outcrops to about 300 feet (0-91 m) where the coal is more than 5 feet (1.5 m) thick.

There is no known, publicly available chemical analysis of the Cook coal in the Home Creek Butte quadrangle. A chemical analysis of this coal from a depth of 72 to 82 feet (22 to 25 m) in coal test hole SH-7177, sec. 7, T. 5 S., R. 48 E., about 6 miles (9.7 km) south-southeast of the Home Creek Butte quadrangle in the Sonnette quadrangle (Matson and Blumer, 1973, p. 110) shows ash 6.500 percent, sulfur 0.736 percent, and heating value 7,186 Btu per pound (16,715 kJ/kg) on an as-received basis. This heating value converts to about 7,686 Btu per pound (17,888 kJ/kg) on a moist, mineral-matter-free basis, indicating that the coal at that location is lignite A in rank. Because that location is at about the same position in the basin as the Cook coal in the Home Creek Butte quadrangle, it is assumed that the Cook coal in this quadrangle is similar and may also be lignite A in rank.

Ferry coal bed

The Ferry coal bed was first described by Warren (1959, p. 573) from exposures in the central and southwestern parts of the Birney-Broadus coal field, probably in the Threemile Buttes and Sonnette quadrangles which are just south and southeast of the Home Creek Butte quadrangle and where its thickest sections of 11 to 12.5 feet (3.4 to 3.8 m) were measured.

In the Home Creek Butte quadrangle, the Ferry coal bed occurs about 100 feet (30.5 m) above the Cook coal bed. Warren (1959, pl. 19) mapped the Ferry coal bed in the southern part of the Home Creek Butte quadrangle. Matson and Blumer (1973, pls. 24 and 26) mapped this bed throughout the quadrangle.

The isopach and structure contour map (pl. 7) shows that the Ferry coal bed is thickest in the northern part of the quadrangle where the coal ranges from 4.8 to 24 feet (2.5 to 7.3 m) in thickness. In the southern part of the quadrangle, the coal ranges from about 3 to 17 feet (0.9 to 5.2 m) in thickness. The structure contour map (pl. 8) shows that the Ferry coal bed, in general, dips southward or southwestward at an angle of less than 1 degree, although there is a minor, low-relief anticline in the southern part of the quadrangle. Overburden on the Ferry coal bed (pl. 9), where it is at least 5 feet (1.5 m) thick, ranges from 0 feet at the outcrops to about 360 feet (0-110 m) in thickness.

There is no known, publicly available chemical analysis of the Ferry coal in, or close to, the Home Creek Butte quadrangle. However, Matson and Blumer (1973, p. 112) show chemical analyses for the Canyon coal bed in holes SH-7151 and SH-7152 in the southern part of the Home Creek Butte quadrangle. Their drill hole location map (Matson and Blumer, 1973, pl. 24) shows that the coal sampled is probably the Ferry coal bed of this report. Analyses of coal samples from 90 to 100 feet (27.4 to 30.5 m) in coal test hole SH-7151, sec. 4, T. 4 S., R. 47 E., in the Home Creek Butte quadrangle show ash 5.971 percent, sulfur 0.912 percent, and heating value 6,661 Btu per pound (15,494 kJ/kg) on an as-received basis. This heating value converts to 7,084 Btu per pound (16,477 kJ/kg) on a moist, mineral-matter-free basis, indicating that the coal is lignite A in rank.

Canyon coal bed

The Canyon coal bed was first described by Baker (1929, p. 36-37) from exposures in the northward extension of the Sheridan coal field. These exposures were probably along Canyon Creek in northern Spring Gulch quadrangle, about 38 miles (61 km) southwest of the Home Creek Butte quadrangle. In the Home Creek Butte quadrangle, the Canyon coal bed occurs about 75 to 95 feet (23 to 29 m) above the Ferry coal bed. The Canyon coal bed or its clinker crops out on the high hill slopes in the northern and southern parts of the quadrangle (pl. 1). Bass (1932) did not map it in the northern part of the quadrangle. Warren (1959, pl. 19) mapped it in the southern part of the quadrangle and Matson and Blumer (1973, pls. 24 and 26) remapped the Canyon coal bed over the entire quadrangle. The isopach and structure contour map (pl. 4) shows that the Canyon coal bed ranges from about 5 to 15 feet (1.5 to 4.6 m) in thickness. It dips slightly to the southwest at an angle of less than 1 degree. This dip is modified locally by a broad low-relief anticline which extends southward from the central part of the quadrangle. Where the coal bed is 5 feet (1.5 m) or more thick, the overburden thickness (pl. 5) ranges from 0 feet at the outcrop to more than 200 feet (0-61 m). As indicated earlier, chemical analyses attributed to the Canyon coal bed in this quadrangle are believed by the present authors to apply to the Ferry coal bed. A chemical analysis of Canyon coal was reported (Matson and Blumer, 1973, p. 112) from a depth of 42 to 50 feet (12.8 to 15.2 m) in coal test hole SH-7142, sec. 23, T. 4 S., R. 47 E., in Threemile Buttes quadrangle, about 2 miles (3.2

km) south of the Home Creek Butte The analysis shows ash 3.856 percent, sulfur 0.389 percent, and heating value 6,904 Btu per pound (16,059 kJ/kg) on an as-received basis. This heating value converts to about 7,180 Btu per pound (16,701 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Canyon coal in that area is lignite A in rank. Because of the proximity of that sample to the Home Creek Butte quadrangle, it is assumed that the Canyon coal in this quadrangle is similar and is lignite A in rank.

Garfield clinker bed

The highest hills in the north-central part of the quadrangle are capped by a reddish-colored clinker bed formed by the burning of the Garfield coal bed. No Garfield coal has been reported in the quadrangle.

Local coal beds

Numerous local coal beds occur at various places in the Home Creek Butte quadrangle. These are all less than 5 feet (1.5 m) thick and, therefore, economic coal resources have not been assigned to them.

COAL RESOURCES

Data from all publicly available drill holes and from 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.

A coal resource classification system has been established by the U.S. Bureau of Mines and the U.S. Geological Survey and published in U.S. Geological Survey Bulletin 1450-B (1976). Coal resource is the estimated gross quantity of coal in the ground that is now economically extractable or that may become so. Resources are classified as either Identified or Undiscovered. <u>Identified Resources</u> are specific bodies of coal whose location, rank, quality, and quantity are known from geologic evidence supported by specific measurements.

Undiscovered Resources are bodies of coal which are surmised to exist on the basis of broad geologic knowledge and theory.

Identified Resources are further subdivided into three categories of reliability of occurrence: namely Measured, Indicated, and Inferred, according to their distance from a known point of coal-bed measurement. Measured coal is coal located within 0.25 mile (0.4 km) of a measurement point, 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.

Undiscovered Resources are classified as either Hypothetical or Speculative. Hypothetical Resources are those undiscovered coal resources in beds that may reasonably be expected to exist in known coal fields under known geologic conditions. In general, Hypothetical Resources are located in broad areas of coal fields where the coal bed has not been observed and the evidence of coal's existence is from distant outcrops, drill holes, or wells that are more than 3 miles (4.8 km) away. Hypothetical Resources are located beyond the outer boundary of the Inferred part of Identified Resources in areas where the assumption of continuity of the coal bed is supported only by extrapolation of geologic evidence. Speculative Resources are undiscovered resources that may occur in favorable areas where no discoveries have been made. Speculative Resources have not been estimated in this report.

For purposes of this report, Hypothetical Resources of subbituminous coal are in coal beds which are 5 feet (1.5 m) or more thick, under less than 3,000 feet (914 m) of overburden, but occur 3 miles (4.8 km) or more from a coal-bed measurement. Hypothetical Resources of lignite are in lignite beds which are 5 feet (1.5 m) or more thick, under less than 1,000 feet (305 m) of overburden, but occur 3 miles (4.8 km) or more from a coal-bed measurement.

Reserve Base coal is that economically minable part of Identified Resources from which Reserves are calculated. In this report, Reserve Base coal is the gross amount of Identified Resources that occurs in beds 5 feet (1.5 m) or more thick and under less than 3,000 feet (914 m) of overburden for subbituminous coal or under less than 1,000 feet (305 m) of overburden for lignite.

Reserve Base coal may be either surface-minable coal or underground-minable coal. In this report, surface-minable Reserve Base coal is subbituminous coal that is under less than 500 feet (152 m) of overburden or lignite that is under less than 200 feet (61 m) of overburden. In this report, underground-minable Reserve Base coal is subbituminous coal that is under more than 500 feet (152 m), but less than 3,000 feet (914 m) of overburden, or lignite that is under more than 200 feet (61 m), but less than 1,000 feet (305 m) of overburden.

Reserves are the recoverable part of Reserve Base coal. In this area, 85 percent of the surface-minable Reserve Base coal is considered to be recoverable (a recovery factor of 85 percent). Thus, these Reserves amount to 85 percent of the surface-minable Reserve Base coal. For economic reasons coal is not presently being mined by underground methods in the Northern Powder River Basin. Therefore, the underground-mining recovery factor is unknown and Reserves have not been calculated for the underground-minable Reserve Base coal.

Tonnages of coal resources were estimated using coal-bed thicknesses obtained from the coal isopach map for each coal bed (see list of illustrations). The coal resources, in short tons, for each isopached coal bed are the product of the acreage of coal (measured by planimeter), the average thickness in feet of the coal bed, and a conversion factor of 1,770 short tons of subbituminous coal per acre-foot (13,018 metric tons per hectare-meter) or a conversion factor of 1,750 short tons of lignite per acre-foot (12,870 metric tons per hectare-meter). Tonnages of coal in Reserve Base, Reserves, and Hypothetical categories, rounded to the nearest one-hundredth of a million short tons, for each coal bed are shown on the Areal Distribution and Tonnage maps (see list of illustrations).

As shown by table 1, the total tonnage of federally owned, surface-minable Reserve Base coal in this quadrangle is estimated to be 406.59 million short tons (368.86 million t). The total tonnage of federally owned, surface-minable Hypothetical coal is estimated to be 329.20 million short tons (289.65 million t). As shown by table 2, the total federally owned, underground-minable Reserve Base coal is estimated to be 504.46 million short tons (457.65 million t). The total federally owned, underground-minable Hypothetical coal is estimated to be 1,209.58 million short tons (1,097.33 million t). The total tonnage of surface- and underground-minable Reserve Base coal is 911.05 million short tons (826.50 million t), and the total of surface- and underground-minable Hypothetical coal is 1,538.78 million short tons (1,395.98 million t).

About 6 percent of the surface-minable Reserve Base tonnage is classed as Measured, 21 percent as Indicated, and 73 percent as Inferred. None of the underground-minable Reserve Base tonnage is Measured, None is Indicated, and all percent is Inferred.

The total tonnages per section for both Reserve Base and Hypothetical coal, including both surface- and underground-minable coal are shown in the northwest corner of the Federal coal lands in each section on plate 2. All numbers on plate 2 are rounded to the nearest one-hundredth of a million short tons.

COAL DEVELOPMENT POTENTIAL

There is a potential for surface-mining in the Northern Powder River Basin in areas where subbituminous coal beds 5 feet (1.5 m) or more thick are overlain by less than 500 feet (152 m) of overburden (the stripping limit), or where lignite beds of the same thickness are overlain by 200 feet (61 m) or less of overburden (the stripping limit). This thickness of overburden is the assigned stripping limit for surface mining of multiple beds of subbituminous coal in this area. Areas having a potential for surface mining were assigned a high, moderate, or low development potential based on their mining ratios (cubic yards of overburden per short ton of recoverable coal).

The formula used to calculate mining-ratio values for coal is:

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

where
MR = mining ratio
t_o = thickness of overburden, in feet
t_c = thickness of coal, in feet
rf = recovery factor = 0.85 in this area
cf = conversion factor = 0.911 cu. yds./short ton for subbituminous coal or 0.922 cu. yds./short ton for lignite

The mining-ratio values are used to rate the degree of potential that areas within the stripping limit have for surface-mining development. Areas having mining-ratio values of 0 to 10, 10 to 15, and greater than 15 are considered to have <u>high</u>, <u>moderate</u>, and <u>low development potential</u>, respectively. This grouping of mining-ratio values was provided by the U.S. Geological Survey and is based on economic and technological criteria. Mining-ratio contours and the stripping-limit overburden isopach, which serve as boundaries for the development-potential areas, are shown on the overburden isopach and mining-ratio contour plates. Estimated tonnages of surface-minable Reserve Base and Hypothetical coal resources in each development-potential category (high, moderate, and low) are shown in table 1.

Estimated tonnages of underground-minable coal resources are shown in table 2. Because coal is not presently being mined by underground mining in the Northern Powder River Basin for economic reasons, for purposes of this report all of the underground-minable coal resources are considered to have low development potential.

Development potential for surface-mining methods

The Coal Development Potential (CDP) map included in this series of maps pertains only to surface mining. It depicts the highest coal development-potential category which occurs within each smallest legal subdivision of land (normally about 40 acres or 16.2 ha). For example, 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. Alternatively, if such a 40-acre (16.2-ha) tract of land contains areas of moderate, low, and no development potential, the entire tract is assigned to the moderate development-potential category for CDP mapping purposes. For practical reasons, the development-potential categories of areas of coal smaller than 1 acre (0.4 ha) have been disregarded in assigning a development potential to the entire 40-acre (16.2-ha) tract.

In areas of moderate to high topographic relief, the area of moderate development potential for surface mining of a coal bed (area having mining-ratio values of 10 to 15) is often restricted to a narrow band between the high and low development-potential areas. In fact, because of the 40-acre (16.2-ha) minimum size of coal development-potential tracts, the narrow band of moderate development-potential area often does not appear on the CDP map because it falls within the 40-acre (16.2-ha) tracts that also include areas of high development potential. The Coal Development Potential (CDP) map then shows areas of high development potential abutting against areas of low development potential.

The coal development potential for surface mining methods in the Home Creek Butte quadrangle is shown on the Coal Development Potential Map (pl. 41). Almost all of the Federal coal lands in the quadrangle have a high or moderate development potential for surface mining, the coal beds having potential for surface mining, in ascending order, are: the Flowers-Goodale, Knobloch, Sawyer, Odell, Pawnee, Elk, Wall, Cook, Ferry, and Canyon.

The Flowers-Goodale coal bed (pl. 39) has a low development potential for surface-mining methods because the mining-ratio values are greater than 15.

The Knobloch coal bed (pl. 36) has a low development potential over most of the Home Creek Butte quadrangle. However, a small area along the west-central portion of the quadrangle has a high development potential; a somewhat larger area of moderate development potential lies between the 10 and 15 mining-ratio contours and separates the high and low development potential areas.

The Sawyer coal bed and/or its splits (pls. 31 and 33) has a low development potential over the entire quadrangle. In the west where overburden is shallow, the coal is thinner; while in the east, where the coal is thicker, the overburden is also thicker and the resulting mining-ratio values are all greater than 15.

The Odell coal bed (pl. 27) has potential for development only in the southwest corner of the quadrangle. A small area of high and moderate development potential occurs in a deep gully in the center of the occurrence. Most of the coal in this bed has a low development potential.

The Pawnee coal bed (pl. 24) has numerous small areas of high and moderate development potential where the overburden has been deeply dissected. Most of the coal in this bed has a low development potential.

The Elk coal bed (pl. 21) occurs in a very small area in the southwestern corner of the quadrangle. For the most part it has a low development potential, although small areas of high and moderate development potential occur where the overburden has been removed in gullies.

The Wall coal bed (pl. 18) occurs only in a very small area in the southwest corner of the quadrangle; its development potential is high to moderate in the gullies and low beneath the higher ridges.

The Cook coal bed (pls. 12 and 15) occurs as two splits in the southern part of the Home Creek Butte quadrangle. The bulk of the coal contained in these splits has a low development potential, although numerous small areas of high and moderate development potential occur in the gullies.

The Ferry coal bed (pl. 9) is absent in the central part of the quadrangle, but it has a generally high development potential in the northern and southern parts of the quadrangle. Small areas of low and moderate development potential occur under the higher buttes.

The Canyon coal bed (pl. 5) occupies two relatively small areas in the north and south-central parts of the quadrangle, and its development potential is generally high. Some smaller areas of low to moderate development potential occur beneath the higher buttes.

Development potential for underground mining and in-situ gasification

Subbituminous coal beds 5 feet (1.5 m) or more in thickness lying more than 500 feet (152 m) but less than 3,000 feet (914 m) below the surface and lignite beds of the same thickness lying more than 200 feet (61 m) but less than 1,000 feet (305 m) below the surface are considered to have development potential for underground mining. Estimates of the tonnage of underground-minable coal are listed in table 2 by development-potential category for each coal bed. Coal is not currently being mined by underground methods in the Northern Powder River Basin because of poor economics. Therefore, the coal development potential for underground mining of these resources for purposes of this report is rated as low, and a Coal Development Potential map for underground mining was not 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, and a Coal Development Potential map for in-situ gasification of coal was not made.

Table 1.--Surface-minable coal resource tonnage (in short tons) by development-potential category for Federal coal lands in the Home Creek Butte quadrangle, Powder River 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
Reserve Base tonnage				
Canyon	26,370,000	6,450,000	4,580,000	37,400,000
Ferry	97,250,000	28,060,000	4,540,000	129,850,000
Upper Cook	1,510,000	650,000	4,590,000	6,750,000
Lower Cook	14,240,000	9,550,000	23,010,000	46,800,000
Wall	1,070,000	420,000	990,000	2,480,000
Elk	2,280,000	710,000	1,450,000	4,440,000
Pawnee	5,040,000	4,980,000	55,830,000	65,850,000
Odell	3,010,000	2,630,000	12,720,000	18,360,000
Upper Sawyer	0	0	26,420,000	26,420,000
Lower Sawyer	0	0	3,540,000	3,540,000
Knobloch	15,350,000	44,600,000	4,750,000	64,700,000
Total	166,120,000	98,050,000	142,420,000	406,590,000
Hypothetical Resource tonnage				
Ferry	4,370,000	3,130,000	270,000	7,770,000
Pawnee	940,000	1,120,000	7,080,000	9,140,000
Upper Sawyer	0	0	76,100,000	76,100,000
Lower Sawyer	0	0	4,730,000	4,730,000
Knobloch	105,450,000	96,340,000	24,820,000	226,610,000
Flowers-Goodale	0	0	4,850,000	4,850,000
Total	110,760,000	100,590,000	117,850,000	329,200,000
Grand Total	276,880,000	198,640,000	260,270,000	735,790,000

Table 2.--Underground-minable coal resource tonnage (in short tons) by development-potential category for Federal lands in the Home Creek Butte quadrangle, Powder River County, Montana

[To convert short tons to metric tons, multiply by 0.9072]

Coal bed	High Development potential	Moderate development potential	Low development potential	Total
Reserve Base tonnage				
Pawnee	0	0	3,040,000	3,040,000
Upper Sawyer	0	0	80,750,000	80,750,000
Lower Sawyer	0	0	57,770,000	57,770,000
Knobloch	0	0	345,650,000	345,650,000
Flowers-Goodale	0	0	17,250,000	17,250,000
Total	0	0	504,460,000	504,460,000
Hypothetical Resource tonnage				
Upper Sawyer	0	0	237,090,000	237,090,000
Lower Sawyer	0	0	52,380,000	53,380,000
Knobloch	0	0	880,070,000	880,070,000
Flowers-Goodale	0	0	40,040,000	40,040,000
Total	0	0	1,209,580,000	1,209,580,000
Grand Total	0	0	1,714,040,000	1,714,040,000

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