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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE HODSDON FLATS QUADRANGLE, POWDER RIVER COUNTY, MONTANA

[Report includes 40 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 Hodsdon Flats quadrangle, Powder River County, Montana, (40 plates; U.S. Geological Survey Open-File Report 79-090). 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 Hodsdon Flats 7 1/2-minute quadrangle is in southwest-central Powder River County, Montana, about 17 miles (27 km) west-southwest of Broadus, Montana, a small town in the Powder River valley, and about 62 miles (100 km) northeast of Sheridan, Wyoming. Broadus is on east-west U.S. Highway 212 near its interchanges with U.S. Interstate 312 and State Highway 59. Sheridan is on U.S. Interstate Highway 90, U.S. Highways 87 and 14, and a main east-west line of the Burlington Northern Railroad (formerly the Chicago, Burlington and Quincy Railroad).

Accessibility

The Hodsdon Flats quadrangle is accessible from Broadus by first traveling westward on U.S. Highway 212 about 23 miles (37 km) to Pumpkin Creek, then traveling southward about 15 miles (24 km) on the improved Pumpkin Creek Road through Sonnette to the north edge of the quadrangle. The quadrangle is accessible from

Sheridan by first traveling northward on State Highways 338 and 314 about 19 miles (37 km) to Decker, Montana, then traveling about 66 miles (106 km) northeastward over improved roads to the west edge of the quadrangle. Access to areas within the quadrangle is provided by several improved and unimproved roads. The nearest railroad is the Burlington Northern Railroad at Kendrick, Wyoming, about 40 miles (64 km) south-southwest of the Hodsdon Flats quadrangle.

Physiography

The Hodsdon Flats quadrangle lies within the Missouri Plateau division of the Great Plains physiographic province. More than 80 percent of the quadrangle, including all but its northwest corner, drains into the Powder River, which flows northeastward about 3 miles (5 km) southeast of the quadrangle. The major tributaries of the Powder River in this quadrangle are Bloom Creek, Pinto Creek, Fire Gulch, Cache Creek and its north and south forks, and Salt Creek, all of which are intermittent streams. The northwest corner of the quadrangle is drained mostly by the headwaters of Fifteenmile Creek, a tributary of Otter Creek. Otter Creek flows northward across the Fort Howes quadrangle, toward the Tongue River, about 13 miles (21 km) west of the quadrangle.

The landscape in the Hodsdon Flats quadrangle, particularly that part in the Powder River drainage basin, consists mostly of steep slopes formed by the incising of the intricate drainage networks of the major streams. These slopes typically rise 250 to 350 feet (76 to 107 m) over distances of 0.25 to 0.5 mile (0.4 to 0.8 km). The valley bottoms are narrow with relatively gradual slopes and only locally well-developed flood plains. The crests of the dividing ridges between the streams are typically long and narrow, although locally the ridge tops are gently rounded or flat. In the northwest corner of the quadrangle the streams have not incised greatly and most of the landscape consists of moderate slopes. The highest points in the quadrangle, with elevations of about 4,300 feet (1,311 m), are the double peaks of Gardner Butte near the west edge of the quadrangle. The lowest point in the quadrangle, with an elevation of about 3,400 feet (1,036 m), occurs along Pinto Creek at the southeast corner of the quadrangle. Topographic relief in the quadrangle is about 900 feet (274 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 Hodsdon Flats quadrangle. All of the quadrangle is within the Northern Powder River Basin Known Recoverable Coal Resource Area (KRCRA). The southwestern quarter of the quadrangle is within the Custer National Forest.

In 1977, the quadrangle did not contain outstanding Federal coal leases or prospecting permits.

GENERAL GEOLOGY

Previous work

Warren (1959) mapped all of the Hodsdon Flats quadrangle as part of the Birney-Broadus coal field. Matson, Dahl, and Blumer (1968) mapped the strippable coal deposits on State land in Powder River County. V. W. Carmichael in Matson and Blumer (1973) mapped the northern part of the quadrangle as part of the

Pumpkin Creek coal deposit. Matson and Blumer (1973) mapped the strippable coal beds in the quadrangle as part of the Sonnette and Fire Gulch coal deposits.

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

Stratigraphy

The exposed bedrock units belong to the Tongue River Member, the uppermost member of the Fort Union Formation (Paleocene). The Tongue River Member is made up mainly of yellow to gray sandstone, sandy shale, carbonaceous shale, and coal. Much of the coal has burned, baking the overlying sandstone and shale and forming thick, reddish-colored clinker beds. The upper part of the Tongue River Member has been removed by erosion, leaving about 900 feet (274 m) of the member in the 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 Hodsdon Flats quadrangle is in the northeastern part of the Powder River structural basin. Regionally the strata dip southwestward at an angle of less than 1 degree. The regional dip is modified in places by minor local folding (pls. 4, 7, 10, 13, 16, 19, 22, 25, 28, 31, 34, and 37).

COAL GEOLOGY

The coal beds in the Hodsdon Flats 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 coal beds are in the Tongue River Member of the Fort Union Formation (Paleocene). No commercial coal deposits are known to exist below the Tongue River Member.

The lowermost coal bed that has been identified in this quadrangle is the Nance coal bed which occurs at least 600 feet (183 m) above the base of the Tongue River Member. The Nance coal bed is overlain successively by a noncoal interval of about 60 feet (18 m), the Upper Knobloch coal bed, a noncoal interval of about 220 feet (67 m), the Cache coal bed, a noncoal interval of about 80 to 100 feet (24 to 30 m), the Number 8 coal bed, a predominantly noncoal interval of about 60 feet (18 m) with a local coal bed near the base of the interval, the Pawnee (Dunning) coal bed, a predominantly noncoal interval of about 150 feet (46 m) containing two local coal beds, the Elk coal bed, a noncoal interval of about 25 feet (7.6 m), the Number 5 coal bed, a noncoal interval of about 20 feet (6.1 m), the Lower Cook coal bed, a noncoal interval of about 1 to 30 feet (0.3 to 9.1 m), the Upper Cook coal bed, a noncoal interval of about 20 to 70 feet (6 to 21 m), the Ferry coal bed, a noncoal interval of about 20 to 60 feet (6 to 18 m), the Lower Canyon coal bed, a noncoal interval of about 40 to 60 feet (12 to 18 m), the Upper Canyon coal bed, a predominantly noncoal interval of about 100 to 150 feet (30 to 46 m), the Lower Garfield coal bed, a noncoal interval from 0 to 40 feet (0-12 m), and the Upper 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. The rank of coal is controlled by the amount of compaction to which the coal is subjected. The compaction is a result of the original depth of burial of the coal (thickness of overlying overburden) and of the degree of tectonic (mountain-building) activity to which the coal has been subjected. The eastern flank of the Powder River Basin has not been subjected to very much squeezing of sediments produced by tectonic activity so that the rank of coal there is primarily related to the original depth of burial (thickness of overburden) to which the coal has been subjected. Lignite A is a coal that has a heating value of 6,300 to 8,300 Btu per pound (14,654 to 19,306 kJ/kg) on a moist, mineral-matter-free basis. Subbituminous C coal has a heating value of 8,300 to 9,500 Btu per pound (19,306 to 22,097 kJ/kg) on a moist, mineral-matter-free basis. Subbituminous B coal has a heating value of 9,500 to 10,500 Btu per pound (22,097 to 24,423 kJ/kg) on a moist, mineral-matter-free basis.

All available analyses of the Broadus coal bed, the stratigraphically lowermost coal bed of importance near this quadrangle, were considered in making our decision to assign a rank of subbituminous C to the Broadus coal near this quadrangle. Overlying coal beds in this quadrangle grade upward into increasingly lower ranks of coal (coal having lower Btu values per pound of coal on a moist, mineral-matter-free basis), as the coal is less and less compacted because of decreasing amounts of overburden. Several of the overlying coal beds in this quadrangle, which are stratigraphically higher than the Broadus coal bed, have been determined to be lignite in rank. However, early in this mapping project to expedite the calculation of resource tonnage and the evaluation of development potential for surfacing mining of the near-surface coal beds, it was arbitrarily decided by us to assign a rank of subbituminous C to all of the coal beds above the Broadus in this quadrangle. Consequently, we have used the 500-foot (152-m) stripping limit (which the USGS has arbitrarily assigned for multiple beds of subbituminous coal in this area of Montana) in this quadrangle for all of the coal beds above the Broadus even though our subsequent detailed work has indicated that the 200-foot (61-m) stripping limit assigned for lignite beds in this area should have been used for the upper beds of lignite rank.

It is recommended that the 200-foot (61-m) stripping limit and the lignite weight conversion factor should be used in any future revisions of the maps and coal tonnage calculations of the lignite beds in this quadrangle. The use of the 200-foot (61-m) stripping limit will produce a more conservative and realistic picture of the surface-mining potential of the various coal beds in this quadrangle.

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).

Nance coal bed

The Nance coal bed is the lowest coal bed that has been identified in this quadrangle and is named for its occurrence at a depth of 242 feet (74 m) in the Nance and Hayes M11-2 drill hole, sec. 25, T. 5 S., R. 42 E., in the Browns Mountain quadrangle, about 30 miles (48 km) west of the Hodsdon Flats quadrangle (Mapel and Martin (1978, p. 21).

The Nance coal bed does not crop out in the Hodsdon Flats quadrangle but is penetrated by a drill hole in the northwestern part of the quadrangle. In the Hodsdon Flats quadrangle, the Nance coal bed occurs at least 600 feet (183 m) above the base of the Tongue River Member. The isopach and structure contour map (pl. 37) shows that the Nance coal ranges from about 10 to 12 feet (3.0 to 3.7 m) in thickness and has a general southwestward dip of less than a half degree. A minor northwest-trending fault interrupts the continuity of the coal bed. Overburden on the Nance coal bed (pl. 38) ranges from about 800 to 1,000 feet (244 to 305 m) in thickness.

There is no known, publicly available chemical analysis of the Nance coal in the Hodsdon Flats quadrangle. Because other coals in this area are subbituminous C in rank, the Nance coal has also been assigned a rank of subbituminous C by us.

Upper Knobloch coal bed

The Knobloch coal bed was named by Bass (1924) from exposures at the small mine on the Knobloch Ranch in the Tongue River valley in the Birney Day School quadrangle about 28 miles (45 km) west-northwest of the Hodsdon Flats quadrangle. The coal bed identified as the Knobloch in this report was called the middle bench of the Knobloch by Matson and Blumer (1973, pls. 11A and 33) and the Middle Knobloch by Culbertson and Klett (1976) in the Browns Mountain quadrangle about 25 miles (40 km) west of the Hodsdon Flats quadrangle.

The Upper Knobloch coal bed does not crop out in the Hodsdon Flats quadrangle but was penetrated by a drill hole in the northwestern part of the quadrangle. In this drill hole the Upper Knobloch coal bed occurs about 60 feet (18 m) above the Nance coal bed. The isopach and structure contour map (pl. 34) shows that the Upper Knobloch coal bed ranges from about 8 to 10 feet (2.4 to 3 m) in thickness and has a general eastward dip of less than half a degree. The general dip is modified by a minor fault and low-relief folding. Overburden on the Upper Knobloch coal bed (pl. 35) ranges from about 800 to 1,000 feet (244 to 305 m) in thickness.

There is no known, publicly available chemical analysis of the Upper Knobloch coal in the Hodsdon Flats quadrangle. A chemical analysis of the Upper Knobloch coal from drill hole SH-7044, sec. 30, T. 5 S., R. 46 E., about 11 miles (18 km) west of the Hodsdon Flats quadrangle in the Goodspeed Butte quadrangle, shows ash 5.423 percent, sulfur 0.157 percent, and heating value 8,515 Btu per pound (19,806 kJ/kg) on an as-received basis (Matson and Blumer, 1973, p. 68). This heating value converts to about 9,003 Btu per pound (20,942 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Upper Knobloch coal at that location is subbituminous C in rank. Because of the proximity of that location to the Hodsdon Flats quadrangle, it is assumed that the Upper Knobloch coal in the Hodsdon Flats quadrangle is similar and is subbituminous C in rank.

Cache coal bed

The Cache coal bed was named by Warren (1959, p. 572) for exposures along Cache Creek in the Yarger Butte and Lonesome Peak quadrangles about 6 miles (9.7 km) east of the Hodsdon Flats quadrangle.

In the Hodsdon Flats quadrangle, the Cache coal bed occurs about 220 feet (67 m) above the Upper Knobloch coal bed. The isopach and structure contour map of the Cache coal bed (pl. 31), which is based on projections of data found in the adjacent Yarger Butte and Bloom Creek quadrangles, shows that the Cache coal bed ranges from about 3 to 5 feet (0.9 to 1.5 m) in thickness and has a general southwestward dip of less than a half degree. Overburden on the Cache coal bed (pl. 32) ranges from about 20 to 200 feet (6.1 to 61 m) in thickness.

There is no known, publicly available chemical analysis of the Cache coal in the Hodsdon Flats quadrangle. Because other coals in this area are subbituminous C in rank, the Cache coal has also been assigned a rank of subbituminous C by us.

Number 8 coal bed

The Number 8 coal bed was first described by Bryson and Bass (1973, p. 82) from exposures along the valley of Pinto Creek in the Huckins School quadrangle about 2 miles (3.2 km) southeast of the Hodsdon Flats quadrangle.

In the Hodsdon Flats quadrangle, the Number 8 coal bed occurs about 80 feet (24 m) above the Cache coal bed. The Number 8 coal bed crops out in a small area in the southeastern part of the quadrangle. The isopach and structure contour map (pl. 28) shows that the Number 8 coal bed ranges from about 3 to 10 feet (0.9 to 3.0 m) in thickness and has a general southwestward dip of less than a half degree. Overburden on the Number 8 coal bed (pl. 29) ranges from 0 feet to about 400 feet (0-122 m) in thickness.

There is no known, publicly available chemical analysis of the Number 8 coal in the Hodsdon Flats quadrangle. Because other coals in the area are subbituminous C in rank, the Number 8 coal has also been assigned a rank of subbituminous C.

Pawnee (Dunning) coal bed

The Pawnee coal bed was first described by Warren (1959, p. 572) from exposures in the Birney-Broadus coal field, Montana, which includes the Hodsdon Flats quadrangle. In the nearby Threemile Buttes, Yager Butte, Goodspeed Butte, and Reanus Cone quadrangles to the northwest, west, and southwest we have mapped this same coal bed. However, in those quadrangles the coal is called the Dunning coal bed after usage in early day geological reports on those areas by previous authors. Based upon our present-day coal isopachs and structure contours, the Pawnee and Dunning appear to be the same coal bed.

The Pawnee (Dunning) coal bed crops out in the southeastern part of the quadrangle, where it is marked in places by an extensive clinker bed formed by the burning of the coal. The Pawnee (Dunning) coal bed occurs about 60 feet

(18 m) above the Number 8 coal bed. The isopach and structure contour map (pl. 25) shows that the Pawnee (Dunning) coal bed ranges from about 14 to 22 feet (4.3 to 6.7 m) in thickness and has a general southwestward dip of less than a half degree. A minor fault in the western part of the quadrangle interrupts the continuity of the coal bed. Overburden on the Pawnee (Dunning) coal bed (pl. 26) ranges from 0 feet to about 600 feet (0-183 m) in thickness.

There is no known, publicly available chemical analysis of the Pawnee (Dunning) coal in the Hodsdon Flats quadrangle. However, a chemical analysis of the Pawnee (Dunning) coal (Matson and Blumer, 1973, p. 110) from a depth of 30 to 37 feet (9.1 to 11.3 m) in drill hole SH-7116, sec. 29, T. 4 S., R. 48 E., in the Sonnette quadrangle about 5.2 miles (8.4 km) north of the Hodsdon Flats quadrangle, shows ash 6.925 percent, sulfur 1.400 percent, and heating value 7,902 Btu per pound (18,380 kJ/kg) on an as-received basis. This heating value converts to about 8,490 Btu per pound (19,748 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Pawnee (Dunning) coal at that location is subbituminous C in rank. Because of the proximity of that location to the Hodsdon Flats quadrangle, it is assumed that the coals are similar and that the Pawnee (Dunning) coal in this quadrangle is also subbituminous C in rank.

Elk coal bed

The Elk coal bed was first described by Warren (1959, p. 573) from exposures along Elk Creek in the northern part of the Goodspeed Butte quadrangle about 9 miles (14.5 km) west of the Hodsdon Flats quadrangle. The Elk coal bed occurs about 150 feet (46 m) above the Pawnee (Dunning) coal bed in the Hodsdon Flats quadrangle. The Elk coal bed does not crop out in the Hodsdon Flats quadrangle but was penetrated by a drill hole in the western part of the quadrangle. The isopach and structure contour map (pl. 22) shows that the Elk coal bed ranges from about 4 to 6 feet (1.2 to 1.8 m) in thickness and has a general westward dip of less than 1 degree. Overburden on the Elk coal bed (pl. 23) ranges from about 200 to 400 feet (61 to 122 m) in thickness.

There is no known, publicly available chemical analysis of the Elk coal in the Hodsdon Flats quadrangle. A chemical analysis of the Elk coal from drill hole SH-7050, sec. 4, T. 5 S., R. 47 E., in the Threemile Buttes quadrangle (Matson and Blumer, 1973, p. 104) about 4.5 miles (7.2 km) north-northwest of the Hodsdon Flats quadrangle, shows ash 4.666 percent, sulfur 0.340 percent, and heating value 7,125 Btu per pound (16,573 kJ/kg) on an as-received basis. This heating value converts to about 7,474 Btu per pound (17,384 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Elk coal at that locality is lignite A in rank. Because of the proximity of that location to the Hodsdon Flats quadrangle, it is assumed that the Elk coal in the Hodsdon Flats quadrangle is similar and is also lignite A in rank.

Number 5 coal bed

The Number 5 coal bed was first described by Bryson and Bass (1973, p. 71) from exposures along Bradshaw, Rough, and Trail Creeks in the Bradshaw Creek quadrangle about 12 to 14 miles (19 to 22.5 km) south-southwest of the Hodsdon Flats quadrangle. The Number 5 coal bed occurs about 25 feet (7.6 m) above the Elk coal bed in the Hodsdon Flats quadrangle. The Number 5 coal bed crops out in a small area near the southern border of the quadrangle. The Number 5 coal bed is less than 5 feet (1.5 m) thick in the Hodsdon Flats quadrangle and, consequently, economic coal resources have not been assigned to it.

Upper and lower splits of the Cook coal bed

The Cook coal bed was named by Bass (1932, p. 59) from outcrops on Cook Mountain in the Cook Creek Reservoir quadrangle in the Ashland coal field, about 25 miles (40 km) northwest of the Hodsdon Flats quadrangle. Warren (1959, p. 573) recognized an upper bench of the Cook coal bed in the Birney-Broadus coal field which includes the Hodsdon Flats quadrangle. Matson and Blumer (1973, p. 107 and pl. 25B) recognized two benches of the Cook coal bed in the Sonnette coal deposit which includes the Hodsdon Flats quadrangle.

In the Hodsdon Flats quadrangle, the lower split of the Cook coal bed occurs about 220 to 240 feet (67 to 73 m) above the Pawnee coal bed. The lower split of the Cook coal bed does not crop out in the Hodsdon Flats quadrangle but was penetrated by three drill holes in the western part of the quadrangle. The isopach and structure contour map (pl. 19) shows that the lower split of the Cook coal bed ranges from about 6 to 12 feet (1.8 to 3.7 m) in thickness and has a general westward dip of less than a half degree. In places, the general dip is modified by low-relief folding and faulting. Overburden on the lower split of the Cook coal bed (pl. 20) ranges from about 200 to 500 feet (61 to 152 m) in thickness.

The rock separation between the lower and upper splits of the Cook coal bed ranges from a few feet (roughly 1 to 2 m) to about 25 feet (7.6 m) in thickness. The upper split of the Cook coal bed crops out over most of the quadrangle and is marked by an extensive clinker bed formed by the burning of the coal. The isopach and structure contour map (pl. 16) shows that the upper split of the Cook coal bed ranges from about 6 to 24 feet (1.8 to 7.3 m) in thickness and has a general southwestward dip less than half a degree. In places the general dip is modified by low-relief folding and faulting. Overburden on the upper split of the Cook coal bed (pl. 17) ranges from 0 feet to about 500 feet (0-152 m) in thickness.

A chemical analysis of the Cook coal (Matson and Blumer, 1973, p. 99) from a depth of 125 to 133 feet (38 to 41 m) in drill hole SH-7135, sec. 29, T. 6 S., R. 48 E., in the southern part of the Hodsdon Flats quadrangle shows ash 3.458 percent, sulfur 0.348 percent, and heating value 8,198 Btu per pound (19,069 kJ/kg) on an as-received basis. This heating value converts to about 8,492 Btu per pound (19,751 kJ/kg), indicating that the Cook coal at this location in the Hodsdon Flats quadrangle is subbituminous C 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 which includes the Hodsdon Flats quadrangle. The second-thickest section of the Ferry coal bed (11 feet or 3.3 m) in the coal field was measured in sec. 18, T. 5 S., R. 48 E. in the Sonnette quadrangle about 2 miles (3.2 km) north of the Hodsdon Flats quadrangle.

The Ferry coal bed does not crop out in the Hodsdon Flats quadrangle. The Ferry coal bed occurs about 60 feet (18 m) above the upper split of the Cook coal bed. The isopach and structure contour map (pl. 13) of the Ferry coal bed is based on projections of information found in the Sonnette quadrangle just north of the Hodsdon Flats quadrangle. This map shows that the Ferry coal bed ranges from about 4 to 8 feet (1.2 to 2.4 m) in thickness and has a general southward dip of less than a half degree. Overburden on the Ferry coal bed (pl. 14) ranges from about 100 to 200 feet (30 to 61 m) in thickness.

There is no known, publicly available chemical analysis of the Ferry coal in the Hodsdon Flats quadrangle. Because most of the other coals in this area are subbituminous C in rank, the Ferry coal has also been assigned a rank of subbituminous C.

Upper and lower splits of the Canyon coal bed

The Canyon coal bed was first described by Baker (1929, p. 36) from exposures in the northward extension of the Sheridan coal field, probably along Canyon Creek in the northern part of the Spring Gulch quadrangle about 40 miles (64.4 km) west of the Hodsdon Flats quadrangle. Warren (1959, p. 574) mapped the Canyon coal bed in the Hodsdon Flats quadrangle as part of the Birney-Broadus coal field. He observed that in the Sonnette quadrangle, just north of the Hodsdon Flats quadrangle, the Canyon coal bed is a zone split into two benches 45 to 55 feet (13.7 to 16.8 m) apart.

In the Hodsdon Flats quadrangle, the lower split of the Canyon coal bed occurs about 20 to 70 feet (6.1 to 21 m) above the Ferry coal bed. The lower split of the Canyon coal bed crops out in the northern part of the quadrangle. The isopach and structure contour map (pl. 10) shows that the lower split of the Canyon coal bed ranges from about 4 to 12 feet (1.2 to 3.7 m) in thickness and has a general southward dip of less than half a degree. Overburden on the lower split of the Canyon coal bed (pl. 11) ranges from 0 feet to about 100 feet (0-30 m).

The rock separation between the lower and upper splits of the Canyon coal bed ranges from about 40 to 60 feet (12 to 18 m) in thickness. The upper split of the Canyon coal bed crops out in the northern part of the quadrangle. South of the split line (pl. 7) the upper and lower splits of the Canyon coal bed merge into one bed called the Canyon bed. In the Hodsdon Flats quadrangle, the upper split of the Canyon coal bed ranges from about 4 to 10 feet (1.2 to 3.0 m) in thickness and has a general southward dip of less than half a degree. In places the general dip is modified by low-relief folding. Overburden on the upper split of the Canyon coal bed (pl. 8) ranges from about 0 to 100 feet (0-30 m) in thickness.

The isopach and structure contour map (pl. 7) shows that the Canyon coal bed ranges from about 6 to 15 feet (1.8 to 4.6 m) in thickness and has a general southwestward dip of less than half a degree. In places the general dip is modified by low-relief folds and faults. Overburden on the Canyon coal bed (pl. 8) ranges from about 0 to 200 feet (0-61 m) in thickness.

There are no known, publicly available chemical analyses of the upper and lower splits of the Canyon coal bed in the Hodsdon Flats quadrangle. However, a chemical analysis of the unified Canyon coal (Matson and Blumer, 1973, p. 96) from a depth of 54 to 64 feet (16 to 20 m) in drill hole SH-7134, sec. 29, T. 6 S., R. 48 E., in the southwestern part of the Hodsdon Flats quadrangle shows ash 5.157 percent, sulfur 0.523 percent, and heating value 7,296 Btu per pound (16,970 kJ/kg). This heating value converts to about 7,693 Btu per pound (17,893 kJ/kg), indicating that the Canyon coal bed at this location in the Hodsdon Flats quadrangle is lignite A in rank. Because of their close stratigraphic relationship to the Canyon coal bed, it is assumed that the upper and lower splits of the Canyon coal bed are also lignite A in rank.

Garfield coal bed

The Garfield coal bed was first described by Warren (1959, p. 575) from exposures in the Birney-Broadus coal field, which includes the Hodsdon Flats quadrangle. Warren observed an upper and a lower Garfield coal bed in the Poker Jim Butte and Fort Howes quadrangles about 19 miles (30.6 km) west of the Hodsdon Flats quadrangle. The lower Garfield occurs about 100 to 150 feet (30 to 46 m) above the Canyon coal bed in the Hodsdon Flats quadrangle.

In the northwestern part of the Hodsdon Flats quadrangle, the upper and lower splits of the Garfield coal bed are separated by a rock interval of 0 feet to about 20 feet (0-6.1 m) in thickness. As these splits are traced southward, the interval between them decreases until the two splits combine into a single bed. Because the splits are close together, the Garfield coal bed and its splits will be considered as a single coal bed. The isopach and structure map of the Garfield coal bed and its splits (pl. 4) shows that coal beds range from about 2 to 8 feet (0.6 to 2.4 m) in thickness and have a general southward dip of slightly more than 1 degree to less than half a degree. Overburden on the coal bed (pl. 5) ranges from about 0 to 100 feet (0-30 m) in thickness.

There is no known, publicly available chemical analysis of the Garfield coal in the Hodsdon Flats quadrangle. Because other near-surface coals in the area are lignite A in rank, the Garfield coal has also been assigned a rank of lignite A by us.

Local coal beds

Local coal beds in the Hodsdon Flats quadrangle (pl. 3, composite section) occur between the Number 8 and Pawnee (Dunning) coal beds, between the Pawnee (Dunning) and Elk coal beds, and between the Upper Canyon and Lower Garfield coal beds. These local coal beds are thin and of small areal extent and, therefore, have not been assigned economic coal resources.

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. Identified Resources 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 1,616.48 million short tons (1,466.47 million t). The total tonnage of federally owned, surface-minable Hypothetical coal is estimated to be 8.70 million short tons (7.89 million t). As shown by table 2, the total federally owned, underground-minable Reserve Base coal is estimated to be 708.96 million short tons (643.17 million t). The total federally owned, underground-minable Hypothetical coal is estimated to be 92.27 million short tons (83.71 million t). The total tonnage of surface- and underground-minable Reserve Base coal is 2,325.44 million short tons (2,109.64 million t), and the total of surface- and underground-minable Hypothetical coal is 100.97 million short tons (91.60 million t).

About 4 percent of the surface-minable Reserve Base tonnage is classed as Measured, 22 percent as Indicated, and 74 percent as Inferred. About 1 percent of the underground-minable Reserve Base tonnage is Measured, 9 percent is Indicated, and 90 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 first 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-ratio values (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 high, moderate, and low development potential, 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 or 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 on Federal coal lands is shown on the Coal Development Potential map (pl. 40).

The Nance and Upper Knobloch coal beds (pls. 38 and 35) have no development potential for surface mining because their overburden is greater than 500 feet (152 m) in thickness.

The surface-mining potential of the Cache coal bed (pl. 32) is limited to a small area in the southeastern part of the quadrangle. This area contains small areas of high, moderate, and low development potential.

The Number 8 coal bed (pl. 29) has large areas of high development potential extending from the outcrop up the valleys to the 10 mining-ratio contour. Narrow bands of moderate development potential occur between the 10 and 15 mining-ratio contours. Relatively large areas of low development potential extend from the 15 mining-ratio contours to the stripping limit.

The Pawnee (Dunning) coal bed (pl. 26) has development potential for surface mining over much of the quadrangle. Very large areas of high development potential extend from the outcrops to the 10 mining-ratio contour. Very large areas of moderate development potential occur as bands between the 10 and 15 mining-ratio contours. Extremely large areas of low development potential extend from the 15 mining-ratio contour to the 500-foot (152-m) stripping limit. Relatively large areas of no development occur between 500-foot overburden isopach and the crests of the highest hills.

The Elk coal bed (pl. 23) has development potential for surface mining in a very small area along the western border of the quadrangle. There are no areas of high or moderate development potential because all mining-ratio contours falling within the stripping limit for the Elk coal bed in this quadrangle have values greater than 15. All of the Elk coal in this quadrangle has a low development potential for surface mining.

The lower split of the Cook coal bed (pl. 20) has development potential for surface mining in the western part of the quadrangle. Small areas of high development potential extend from the coal boundary up the stream valleys to the 10 mining-ratio contour. Small areas of moderate development potential occur as narrow bands between the 10 and 15 mining-ratio contours. Extremely large areas of low development extend from the 15 mining-ratio contour under the crests of the hills.

The upper split of the Cook coal bed (pl. 17) has development potential for surface mining over most of the quadrangle. Extremely large areas of high development potential extend from the coal outcrops up the slopes to the 10 mining-ratio contour. Large areas of moderate development potential occur between the 10 and 15 mining-ratio contours. Equally large areas of low development potential extend from the 15 mining-ratio contour under the crests of the hills.

The Ferry coal bed (pl. 14) has development potential for surface mining in a relatively small area in the northwestern part of the quadrangle. Small areas of high development potential extend up the valleys from the coal boundary to the 10 mining-ratio contour. Small areas of moderate development occur as narrow bands between the 10 and 15 mining-ratio contours. Relatively large areas of low development potential extend from the 15 mining-ratio contour under the crests of the higher hills.

The lower split of the Canyon coal bed (pl. 11) has development potential for surface mining in the northern part of the quadrangle. A relatively large area of high development potential extends from the outcrop to the 10 mining-ratio contour. An equally large area of moderate development potential extends from the 10 mining-ratio to the 15 mining-ratio contours. A similar-sized area of low development potential is found between the 15 mining-ratio contour and the crests of the hills.

The upper split of the Canyon coal bed and the Canyon coal bed (pl. 8) have development potential for surface mining in the western part of the quadrangle. Large areas of high development potential extend from coal outcrop to the 10 mining-ratio contour. Smaller areas of moderate development potential occur between the 10 and 15 mining-ratio contours. Large areas of low development potential extend from the 15 mining-ratio contour under the crests of the hills.

The Garfield coal bed (pl. 6) has development potential for surface mining in scattered areas in the northwestern part of the quadrngle. Small areas of high development potential extend from the outcrops to the 10 mining-ratio contour. Very small areas of moderate development potential occur as narrow bands between the 10 and 15 mining-ratio contours. An insignificant amount of low development potential extends from the 15 mining-ratio contour under the crests of a few hills.

About 93 percent of the Federal coal lands in the quadrangle has a high development potential for surface mining, 4 percent has a moderate development potential, 2 percent has a low development potential, and 1 percent has no development potential.

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 Hodsdon Flats 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				
Garfield	4,880,000	910,000	90,000	5,880,000
Upper Canyon	47,980,000	26,220,000	42,030,000	116,230,000
Lower Canyon	12,070,000	10,940,000	10,890,000	33,900,000
Ferry	1,850,000	2,370,000	22,470,000	26,690,000
Upper Cook	215,770,000	193,870,000	192,180,000	601,820,000
Lower Cook	1,050,000	2,180,000	116,570,000	119,800,000
Elk	0	0	4,140,000	4,140,000
Pawnee (Dunning)	99,420,000	119,790,000	466,570,000	685,780,000
Number 8	7,700,000	2,570,000	9,950,000	20,220,000
Cache	1,110,000	350,000	560,000	2,020,000
Total	391,830,000	359,200,000	865,450,000	1,616,480,000
Hypothetical Resource tonnage				
Ferry	200,000	0	0	200,000
Pawnee (Dunning)	0	0	8,500,000	8,500,000
Total	200,000	0	8,500,000	8,700,000
Grand Total	392,030,000	359,200,000	873,950,000	1,625,180,000

Table 2.--Underground-minable coal resource tonnage (in short tons) by development-potential category for Federal lands in the Hodsdon Flats 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				
Upper Cook	0	0	5,340,000	5,340,000
Lower Cook	0	0	2,830,000	2,830,000
Pawnee (Dunning)	0	0	276,660,000	276,660,000
Knobloch	0	0	193,180,000	193,180,000
Nance	0	0	230,950,000	230,950,000
Total	0	0	708,960,000	708,960,000
Hypothetical Resource tonnage				
Pawnee (Dunning)	0	0	1,050,000	1,050,000
Knobloch	0	0	20,150,000	20,150,000
Nance	0	0	71,070,000	71,070,000
Total	0	0	92,270,000	92,270,000
Grand Total	0	0	801,230,000	801,230,000

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