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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE THREEMILE BUTTES QUADRANGLE, POWDER RIVER COUNTY, MONTANA

[Report includes 53 plates]

By

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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 Threemile Buttes quadrangle, Powder River County, Montana, (53 plates; U.S. Geological Survey Open-File Report 79-100). 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 Threemile Buttes 7 1/2-minute quadrangle is in west-central Powder River County, Montana, about 60 miles (96 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 Threemile Buttes quadrangle is 15 miles (24 km) southeast of Ashland, Montana, and 23 miles (37 km) west of Broadus, both of which are small towns on east-west U.S. Highway 212.

Accessiblity

The quadrangle is accessible from Ashland, Montana, by traveling east on U.S. Highway 212 about 2.5 miles (4 km) to the junction of the Otter Creek Road, then south 10 miles (16 km) to the Tenmile Creek Road, then east 8 miles (12.9 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 22 miles (35 km) to the Pumpkin Creek Road, then south about 9 miles (14.5 km) to Sonnette, then west about 2.3 miles (3.7 km) on the Tenmile Creek Road to the east border of the quadrangle. The nearest railroad is at the Decker coal mine about 45 miles (72 km) to the southwest. A spur of the Burlington Northern Railroad connects this mine with the main east-west route of the railroad about 25 miles (40 km) further south, at Sheridan, Wyoming.

Physiography

The Threemile Buttes 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 by its streams 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 7 to 9 miles (11.3 to 14.5 km) west of the quadrangle. Otter Creek and Pumpkin Creek are both northward-flowing tributaries of the northward-flowing Tongue River, which empties into the Yellowstone River at Miles City. The principal westward-flowing streams in the quadrangle are the North Fork and South Fork of Threemile, Tenmile, and Fifteenmile Creeks, all of which are tributaries of Otter Creek. Skinner Gulch and Doonan Gulch drain eastward to Pumpkin Creek.

The highest elevation, 4,267 feet (1,301 m), is at the top of Threemile Buttes in the north-central part of the quadrangle. The lowest elevation, about 3,415 feet (1,041 m), is where the South Fork of Threemile Creek flows out of the northwestern part of the quadrangle. Topographic relief in the quadrangle is 852 feet (260 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 Threemile Buttes quadrangle. All of the quadrangle is within the Northern Powder River Basin Known Recoverable Coal Resource Area (KRCRA). All of the quadrangle except for a strip along the eastern border is within the Custer National Forest. There were no outstanding Federal coal leases or prospecting permits as of 1977.

GENERAL GEOLOGY

Previous work

Warren (1959, pl. 19) mapped the entire quadrangle as part of the Birney-Broadus coal field. Matson and Blumer (1973, pls. 23A, 23B, 24, 25A, and 25B) remapped most of the quadrangle as part of the Sonnette and Threemile Buttes coal fields.

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 uppermost part of the Tongue River Member has been removed by erosion, but about 1,700 feet (518 m) remains in the Threemile Buttes 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 Threemile Buttes 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, 7, 10, 13, 16, 19, 22, 25, 28, 32, 37, 40, 43, 46, and 49). Some of the nonuniformity in structure may be due to differential compaction and to irregularities in deposition of the coals and other beds as a result of their continental origin.

COAL GEOLOGY

The coal beds in the Threemile Buttes 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 in the Threemile Buttes quadrangle is the Broadus coal bed which occurs about 120 to 180 feet (37 to 55 m) above the base of the Tongue River Member. The Broadus coal bed is overlain by a noncoal interval of 190 to 200 feet (58 to 61 m), the Flowers-Goodale coal bed, a noncoal interval of 20 to 80 feet (6 to 24 m), the Nance coal bed, a noncoal interval of 40 to 100 feet (12 to 30 m), the lower split of the Knobloch coal bed, a noncoal interval of 40 to 60 feet (12 to 18 m), the upper split of the Knobloch coal bed, a noncoal interval of 40 to 200 feet (12 to 61 m), the lower split of the Sawyer coal bed, a noncoal interval of 40 to 70 feet (12 to 21 m), the upper split of the Sawyer coal bed, a noncoal interval of 140 to 260 feet (43 to 79 m), the Odell coal bed, a rock interval of about 80 to 140 feet (24 to 43 m) containing only local coal beds, the Dunning (Pawnee) coal bed, a mostly noncoal interval of about 40 to 120 feet (12 to 36 m), the Elk coal bed, a noncoal interval of 30 to 60 feet (9 to 18 m), the Wall coal bed, a noncoal interval of about 20 to 100 feet (6 to 30 m) containing a local coal bed, the lower Cook coal bed, a noncoal interval of 20 to 100 feet (6 to 30 m), the upper Cook coal bed, a noncoal interval of about 100 feet (30 m), the Ferry coal bed, a noncoal interval of about 20 to 50 feet (6 to 15 m), the lower split of the Canyon coal bed, a noncoal interval of 20 to 80 feet (6 to 24 m), the upper split of 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 the quadrangle, but not enough data are presently known to allow our drawing that boundary line with certainty. Therefore, for mapping purposes 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).

Broadus coal bed

The Broadus coal bed was first described by Warren (1959, p. 570) and derives its name from exposures near the town of Broadus in the Broadus quadrangle about 22 miles (35 km) east of the Threemile Buttes quadrangle. The Broadus coal bed occurs about 120 to 180 feet (37 to 55 m) above the base of the Tongue River Member. The Broadus coal bed does not crop out in the Threemile Buttes quadrangle, nor was it cut by deep drill holes. However, the documented occurrences to the east and west allow the projection of the coal bed into the northern part of the quadrangle. The isopach and structure contour map of the Broadus coal bed (pl. 49) shows that the coal ranges from 5 to 20 feet (1.5 to 6 m) in thickness and dips to the northwest at an angle of less than 1 degree, although this dip is locally modified by low-relief folding. Overburden on the Broadus coal bed ranges from 800 to 1,200 feet (244 to 366 m) in thickness (pl. 50).

There is no known, publicly available chemical analysis of the Broadus coal in the Threemile Buttes quadrangle. However, a chemical analysis of the Broadus coal from the Peerless mine, sec. 23, T. 4 S., R. 50 E., about 16.5 miles (26.6 km) east of the Threemile Buttes quadrangle in the Epsie NE quadrangle, shows ash 6.4 percent, sulfur 0.2 percent, and heating value 7,240 Btu per pound (16,840 kJ/kg) on an as-received basis (Gilmour and Dahl, 1967, p. 16). This heating value converts to about 7,735 Btu per pound (17,992 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Broadus coal at that locality is lignite A in rank. However, because the Threemile Buttes quadrangle lies deeper in the Powder River structural basin, it is assumed that the coals are more compacted and that the Broadus coal in this quadrangle is subbituminous C in rank.

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 24 miles (39 km) north-northwest of the Threemile Buttes quadrangle. In the Threemile Buttes quadrangle, the Flowers-Goodale coal bed occurs about 190 to 200 feet (58 to 60 m) above the Broadus coal bed. This coal bed does not crop out in the Threemile Buttes quadrangle and has not been penetrated by coal test holes, but it is projected into the quadrangle from the Yager Butte quadrangle to the west where it has been penetrated by a test hole. The isopach and structure contour map of the Flowers-Goodale coal bed (pl. 46) shows the coal bed projection in the northwestern part of the quadrangle. It is believed to range in thickness from about 5 feet (1.5

m) to 8 feet (2.1 m) and to dip to the north and northeast at an angle of less than 1 degree. Overburden on the Flowers-Goodale coal bed (pl. 47) ranges from about 500 to 1,000 feet (152 to 305 m) in thickness.

There is no known, publicly available chemical analysis of the Flowers-Goodale coal in the Threemile Buttes 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 15 miles (24 km) northwest of the Threemile Buttes quadrangle, in the Cook Creek Reservoir quadrangle, shows ash 8.14 percent, sulfur 0.961 percent, and heating value 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 Threemile Buttes quadrangles have similar positions in the basin, it is assumed that the Flowers-Goodale coal bed in the Threemile Buttes quadrangle is similar and is subbituminous C in rank.

Nance coal bed

The Nance coal bed is named for its occurrence at a depth of 242 feet (738 m) in the Nance and Hayes drill hole M11-2, SE¼ SE¼ sec. 25, T. 5 S., R. 42 E., about 26 miles (42 km) west-southwest of the Threemile Buttes quadrangle, in the Browns Mountain quadrangle (Mapel and Martin, 1978, p. 21).

The Nance coal bed does not crop out in the Threemile Buttes quadrangle, nor is it penetrated by any drill holes. However, its presence in the quadrangles to the west and south allow its projection into the western and southern parts of the Threemile Buttes quadrangle. The Nance coal bed occurs about 20 to 80 feet (6 to 24 m) above the Flowers-Goodale coal bed. The bed appears to split off the overlying Knobloch coal bed (pl. 37) near the north boundary of the quadrangle.

The isopach and structure contour map of the Nance coal bed (pl. 43) shows that the coal varies from about 8 to 10 feet (2.4 to 3.0 m) in thickness and dips to the north and east at an angle of less than 1 degree. The dip is locally modified by low-relief folding. Overburden on the Nance coal bed (pl. 44) ranges from about 500 to 1,000 feet (152 to 305 m) in thickness.

There is no known, publicly available analysis of the Nance coal in the Threemile Buttes quadrangle. Because of its close stratigraphic proximity to the Knobloch coal bed, which is known to be subbituminous C in rank, the Nance is also assumed to be subbituminous C in rank in this quadrangle.

Knobloch coal bed

The Knobloch coal bed was named by Bass (1924) from its occurrence at the Knobloch Ranch and coal mine about 22 miles (35.4 km) west of the Threemile Buttes quadrangle, in the Birney Day School quadrangle. In the Threemile Buttes quadrangle, the Knobloch coal bed splits into three distinct coal beds. At the north edge of the quadrangle, the Nance coal bed (pls. 37 and 43) splits off the bottom of the Knobloch coal bed. About 1.5 miles (2.4 km) further south (pls. 37 and 40) the Knobloch coal bed splits again forming the upper and lower splits of the Knobloch coal bed. The lower split of the Knobloch coal bed occurs about 40 to 100 feet (12 to 30 m) above the Nance coal bed. The lower split of the Knobloch coal bed does not crop out in this quadrangle, but it has been penetrated by a coal test hole. The coal bed has also been projected into the quadrangle from test holes to the west. The isopach and structure contour map of the lower split of the Knobloch coal bed (pl. 40) shows that this coal bed ranges from about 5 to 18 feet (1.5 to 5.5 m) in thickness and dips to the east at an angle of less than 1 degree, although local changes in dip caused by low-relief, broad folding do occur. Overburden on the lower split of the Knobloch coal bed (pl. 44) ranges from about 400 to 1,000 feet (122 to 305 m) in thickness.

The upper split of the Knobloch coal bed occurs 40 to 60 feet (12 to 18 m) above the lower split. The isopach and structure contour map of the upper split of the Knobloch coal bed (pl. 37) shows that the coal ranges from 10 to 40 feet (3 to 12 m) in thickness and dips to the east at an angle of less than 1 degree. The dip is modified by local low-relief folding. Overburden on the upper split of the Knobloch coal bed (pl. 38) ranges from 300 to 1,000 feet (91 to 305 m) in thickness.

There is no known, publicly available chemical analysis of the Knobloch coal in the Threemile Buttes 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., 3 miles (4.8 km) west of the Threemile Buttes 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 sample location to the Threemile Buttes quadrangle, and because the sample appears to represent the entire Knobloch coal bed, it appears reasonable to assign a rank of subbituminous C to the upper and lower splits of the Knobloch coal bed in the Threemile Buttes quadrangle.

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 Threemile Buttes quadrangle. In this quadrangle, the Sawyer coal bed occurs as two splits 204 feet (62.2 m) and 283 feet (86.3 m) above the Knobloch coal bed. The Sawyer coal bed does not crop out in the Threemile Buttes quadrangle, but it is penetrated by a coal test hole. It is also projected into the quadrangle from adjacent quadrangles to the north, east, and west.

The lower split of the Sawyer coal bed ranges in thickness (pl. 31) from about 5 to 17 feet (1.5 to 5.2 m) and dips (pl. 32) to the east at an angle of less than 1 degree. The dip is modified locally by low-relief folding. Overburden on the lower split of the Sawyer coal bed (pl. 35) ranges in thickness from about 400 to 1,000 feet (122 to 305 m).

The upper split of the Sawyer coal bed occurs about 79 feet (24.1 m) above the lower split of the Sawyer coal bed. The coal ranges in thickness (pl. 31) from about 5 to 20 feet (1.5 to 6.1 m) and dips (pl. 32) to the east at an angle of less than 1 degree. The dip is modified locally by low-relief folding. Overburden on the upper split of the Sawyer coal bed (pl. 33) ranges from about 200 to 800 feet (61 to 244 m) in thickness.

There is no known, publicly available chemical analysis of the Sawyer coal in the Threemile Buttes 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 7 miles (11.3 km) northwest of the Threemile Buttes 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 Threemile Buttes 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 about 16 miles (25.7 km) west of the Threemile Buttes quadrangle in the Green Creek quadrangle. The Odell coal bed occurs about 140 to 260 feet (43 to 79 m) above the Sawyer coal bed. It crops out in two gullies along the west side of the Threemile Buttes quadrangle. The isopach and structure contour map of the Odell coal bed (pl. 28) shows that the coal ranges from about 5 to 8 feet (1.5 to 2.4 m) in thickness and dips southwestward at an angle of less than 1 degree. Overburden on the Odell coal bed (pl. 29) ranges from 0 feet at the outcrops to about 600 feet (0-183 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 coal is similar to other closely associated coals in this quadrangle and is subbituminous C in rank.

Dunning (Pawnee) coal bed

The Dunning (Pawnee) coal bed was first described by Warren (1959, p. 572) when he mapped it (1959, pl. 19) in the Threemile Buttes quadrangle. Matson and Blumer (1973, pl. 23A) also mapped the Dunning (Pawnee) coal bed in the quadrangle.

We have used the name Dunning for this coal bed in the Threemile Buttes, Yager Butte, Goodspeed Butte, and Reanus Cone quadrangles based upon usage in early day geological reports on those areas by previous authors (Warren 1959; and others). However, in twenty-one adjacent quadrangles surrounding these four quadrangles we have mapped a coal bed at this same stratigraphic horizon which we, and others, have called the Pawnee 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 Threemile Buttes quadrangle. Based upon our present-day coal isopachs and structure contours, the Dunning and Pawnee appear to be the same coal bed.

The Dunning (Pawnee) coal bed occurs about 80 to 140 feet (24 to 43 m) above the Odell coal bed. The isopach and structure contour map of the Dunning (Pawnee) coal bed (pl. 25) shows that the coal ranges from 2 to 24 feet (0.6 to 73 m) in thickness and dips to the south and west. The dip is modified locally by broad, low-relief folding. Overburden on the Dunning (Pawnee) coal bed (pl. 26) ranges from 0 feet at the outcrops to more than 500 feet (0-152 m) in thickness.

There is no known, publicly available chemical analysis of the Dunning (Pawnee) coal in the Threemile Buttes quadrangle. However, an analysis of the Dunning (Pawnee) 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 mile (1.6 km) west of the Threemile Buttes 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 Dunning (Pawnee) coal at that location is subbituminous C in rank. Because of the proximity of that location to the Threemile Buttes quadrangle, it is assumed that the Dunning (Pawnee) 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 in the Birney-Broadus coal field, probably along Elk Creek just south of the Threemile Buttes quadrangle in the Goodspeed Butte quadrangle.

In the Threemile Buttes quadrangle, the Elk coal bed lies about 40 to 120 feet (12 to 36 m) above the Dunning (Pawnee) bed and it crops out in several draws along the west side of the quadrangle. The isopach and structure contour map (pl. 22) shows that the Elk coal bed ranges from about 4 to 19 feet (1.2 to 5.8 m) in thickness and dips slightly to the southwest. The overburden isopach and mining-ratio map of the Elk bed (pl. 23) 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 400 feet (0 to 122 m) in thickness.

An analysis of the Elk coal 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 (Matson and Blumer, 1973, p. 104). It shows ash 4.66 percent, sulfur 0.340 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 a rank of lignite A for the Elk coal bed at this location.

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 about 31 miles (50 km) southwest of the Threemile Buttes quadrangle in the southern part of the Birney quadrangle.

In the Threemile Buttes quadrangle, the Wall coal bed occurs about 30 to 60 feet (9 to 18 m) above the Elk coal bed. It crops out only in the northern part of the quadrangle (pl. 1) where it was mapped by Warren (1959, pl. 19). The isopach and structure contour map of the Wall coal bed (pl. 19) shows that the coal ranges from about 3 to 12 feet (0.9 to 3.7 m) in thickness and is almost flat lying. The overburden isopach and mining-ratio map (pl. 20) shows that the overburden ranges from 0 feet at the outcrops to about 400 feet (0-122 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 Threemile Buttes 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 about 16 miles (26 km) northwest of the Threemile Buttes quadrangle in the Cook Creek Reservoir quadrangle. Warren (1959, pl. 19) mapped the Cook coal bed in the Threemile Buttes quadrangle and Matson and Blumer (1973, pl. 23A) remapped it. A number of coal test holes penetrate an Upper Cook and a Lower Cook coal bed and show about 20 to 100 feet (6 to 30 m) of vertical separation (pls. 1 and 3).

The isopach and structure contour map of the lower split of the Cook coal bed (pl. 16) shows that this coal bed ranges from about 4 to 14 feet (1.2 to 4.3 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. 17) shows that the overburden thickness on the lower split of the 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 split of the Cook coal bed (pl. 13) shows that this coal bed ranges from about 4 to 16 feet (1.2 to 4.9 m) in thickness and is nearly flat lying, although the dip is modified locally by low-relief folding. The overburden isopach and mining-ratio map (pl. 14) shows that the overburden thickness on the upper split of the Cook coal bed ranges from 0 feet at the outcrops to more than 200 feet (0-61 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 Threemile Buttes 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 1.5 miles (2.4 km) east of the Threemile Buttes 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 Threemile Buttes quadrangle, it is assumed that the Cook coal in this quadrangle is similar and is also 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 adjacent Sonnette quadrangles, where its thickest sections of 11 and 12.5 feet (3.4 and 3.8 m) were measured. Matson and Blumer (1973, pls. 24 and 26) also mapped this bed throughout the quadrangle as part of the Sonnette coal field.

In the Threemile Buttes quadrangle, the Ferry coal bed occurs about 100 feet (30.5 m) above the Cook coal bed, but it has been removed by erosion over much of the quadrangle.

The isopach and structure contour map (pl. 10) shows that the Ferry coal bed is thickest in the northern part of the quadrangle where the coal reaches 8 feet (2.4 m) in thickness. In the southern part of the quadrangle, the coal ranges from about 2 to 6 feet (0.9 to 1.8 m) in thickness. The structure contours show that the Ferry coal bed, in general, dips southward or southwestward at an angle of less than 1 degree, although the dips are modified by a minor, low-relief anticline in the central part of the quadrangle. Overburden on the Ferry coal bed, where it is at least 5 feet (1.5 m) thick, ranges from 0 feet at the outcrops to about 200 feet (0-61 m) in thickness.

There is no known, publicly available chemical analysis of the Ferry coal in or close to the Threemile 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 about 1 mile (1.6 km) north of the Threemile Buttes quadrangle. The 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 7,804 Btu per pound (16,477 kJ/kg) on a moist, mineral-matter-free basis, indicating that the coal is lignite A in rank. Because of the proximity of that sample location to the Threemile Buttes quadrangle, it has been assumed that the Ferry coal bed in the Threemile Buttes quadrangle is also 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. Although a type locality was not given, it may be along Canyon Creek in the northern part of the Spring Gulch quadrangle, about 35 miles (56 km) west-southwest of the Threemile Buttes quadrangle. In the Threemile Buttes quadrangle, the lower split of the Canyon coal bed occurs about 20 to 50 feet (6 to 15 m) above the Ferry coal bed. The upper split of the Canyon coal bed, or its clinker, occurs 20 to 80 feet above the lower split and it crops out on the high hill slopes in the northern and southern parts of the quadrangle (pl. 1). 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 and its upper split range from about 2 to 14 feet (0.6 to 4.3 m) in thickness. They dip slightly to the southwest at an angle of less than 1 degree. The lower split of the Canyon coal bed begins at the split line in the southeast quadrant of the quadrangle and dips to the south at a somewhat steeper angle than the upper split. The coal ranges in thickness from about 2 to 8 feet (0.6 to 2.4 m) (pl. 7).

Overburden on the lower split of the Canyon coal bed (pl. 8) ranges from 0 feet at the outcrops to about 100 feet (0-30 m) in thickness. Overburden on the upper split of the Canyon coal bed ranges from 0 feet at the outcrops to 200 feet (0-61 m) (pl. 5).

A chemical analysis of Canyon coal in the Threemile Buttes quadrangle 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. 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 this area is lignite A in rank.

Local coal beds

Numerous local coal beds of limited areal extent occur at various places in the Threemile Buttes 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. 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 2,318.48 million short tons (2,103.33 million t). The total tonnage of federally owned, surface-minable Hypothetical coal is estimated to be 67.01 million short tons (60.79 million t). As shown by table 2, the total federally owned, underground-minable Reserve Base coal is estimated to be 1,702.28 million short tons (1,544.31 million t). The total federally owned, underground-minable Hypothetical coal is estimated to be 443.18 million short tons (402.05 million t). The total tonnage of surface- and underground-minable Reserve Base coal is 4,020.76 million short tons (3,647.63 million t), and the total of surface- and underground-minable Hypothetical coal is 510.19 million short tons (462.84 million t).

About 4 percent of the surface-minable Reserve Base tonnage is classed as Measured, 24 percent as Indicated, and 72 percent as Inferred. About 1 percent of the underground-minable Reserve Base tonnage is Measured, 6 percent is Indicated, and 93 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). The 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 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 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 in the Threemile Buttes quadrangle is shown on the Coal Development Potential Map (pl. 52). 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, Nance, Knobloch, Sawyer, Odell, Dunning (Pawnee), Elk, Wall, Cook, Ferry, and Canyon.

The Flowers-Goodale coal bed (pl. 47) has only a small area of low development potential for surface mining because the mining ratios over most of the coal bed are greater than 15.

The Nance coal bed (pl. 44) has a few small areas of low development potential where overburden depths are 500 feet (152 m) or less.

The lower split of the Knobloch coal bed (pl. 41) has a low development potential along the western edge of the Threemile Buttes quadrangle where overburden depths are less than 500 feet (152 m). However, the main portion of the Knobloch coal bed (pl. 38) has a small area of high development potential in the extreme northwest corner of the quadrangle where overburden depths are shallow.

A somewhat larger area of moderate development potential lies between the 10 and 15 mining-ratio contours and separates the small, high, and the very large low development potential areas.

The upper and lower splits of the Sawyer coal bed (pls. 33 and 35) have only a low development potential in the Threemile Buttes quadrangle. Several areas where overburden thickness is less than 500 feet (152 m) occur in stream valleys in the western part of the quadrangle.

The Odell coal bed (pl. 29) has development potential over much of the western half of the quadrangle. Several small areas of high development potential occur in deep stream valleys along the west edge of the quadrangle. Most of the coal in this bed has a low development potntial because of excessive overburden depths.

The Dunning (Pawnee) coal bed (pl. 26) has numerous large areas of high and moderate development potential in the central part of the quadrangle where the overburden has been deeply dissected. About half of the coal in this bed has a low development potential and the remainder has a high or moderate development potential.

The Elk coal bed (pl. 23) occurs over most of the western half of the quadrangle. About half of the bed has a low development potential, about one-third of the bed has a high development potential, and the remainder has a moderate development potential. The high development potential occurs in the areas of deep erosion in the western part of the quadrangle.

The Wall coal bed (pl. 20) occurs only in a very small area in the northwest corner of the quadrangle; its development potential is high to moderate in the stream valleys and low beneath the higher ridges.

The lower split of the Cook coal bed (pl. 17) has several narrow areas of high development potential along the deeply eroded valleys in the western part of the quadrangle. Much of the bed has only a low development potential because of overburden depths. Areas of moderate development potential separate the high and low development potential areas.

The upper split of the Cook coal bed (pl. 14) has several large areas of high development potential in the north and south parts of the quadrangle. These are surrounded by small areas of moderate development potential and the remainder of the coal has only a low development potential.

The Ferry coal bed (pl. 11) occurs in small patches in the central part of the quadrangle. It generally has a high development potential around the edges of these patches. Small areas of low development potential occur under the higher buttes and these are separated from the high development potential areas by bands of moderate development potential.

The lower split of the Canyon coal bed (pl. 8) occurs only in the southeast corner of the quadrangle where the bulk of the coal has a high development potential. Small areas of low development potential occur under the higher buttes and these are separated from the areas of high development potential by narrow bands of moderate development potential.

The upper split of the Canyon coal bed (pl. 5) occurs as a narrow band of high development potential coal rimming the east-central part of the quadrangle. Several small patches of low development potential occur under the high buttes and the remainder of the coal is of moderate development potential.

About 95 percent of the Federal coal lands has a high development potential for surface mining, 2 percent has a moderate development potential, and 3 percent has a low 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 Threemile Buttes 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				
Upper Canyon	33,940,000	4,760,000	630,000	39,330,000
Lower Canyon	20,990,000	3,170,000	7,480,000	31,640,000
Ferry	8,980,000	6,050,000	23,740,000	38,770,000
Upper Cook	53,080,000	32,090,000	54,430,000	139,600,000
Lower Cook	51,890,000	47,600,000	167,140,000	266,630,000
Wall	12,200,000	6,230,000	24,150,000	42,580,000
Elk	110,650,000	45,840,000	145,800,000	302,290,000
Dunning (Pawnee)	258,440,000	170,600,000	452,630,000	881,670,000
Odell	4,480,000	7,570,000	143,480,000	155,530,000
Upper Sawyer	0	0	145,490,000	145,490,000
Lower Sawyer	0	0	78,360,000	78,360,000
Upper Knobloch	3,020,000	11,890,000	126,570,000	141,480,000
Lower Knobloch	0	0	34,640,000	34,640,000
Nance	0	0	17,020,000	17,020,000
Flowers-Goodale	0	0	3,450,000	3,450,000
Total	557,670,000	335,800,000	1,425,010,000	2,318,480,000
Hypothetical Resource tonnage				
Odell	0	0	31,960,000	31,960,000
Upper Sawyer	0	0	16,250,000	16,250,000
Lower Sawyer	0	0	9,540,000	9,540,000
Upper Knobloch	0	0	5,100,000	5,100,000
Nance	0	0	3,660,000	3,660,000
Flowers-Goodale	0	0	500,000	500,000
Total	0	0	67,010,000	67,010,000
Grand Total	557,670,000	335,800,000	1,492,020,000	2,385,490,000

Table 2.--Underground-minable coal resource tonnage (in short tons) by development-potential category for Federal lands in the Threemile Buttes 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				
Dunning (Pawnee)	0	0	64,160,000	64,160,000
Odell	0	0	23,810,000	23,810,000
Upper Sawyer	0	0	328,120,000	328,120,000
Lower Sawyer	0	0	355,320,000	355,320,000
Upper Knobloch	0	0	571,290,000	571,290,000
Lower Knobloch	0	0	76,240,000	76,240,000
Nance	0	0	119,050,000	119,050,000
Flowers-Goodale	0	0	53,360,000	53,360,000
Broadus	0	0	110,930,000	110,930,000
Total	0	0	1,702,280,000	1,702,280,000
Hypothetical Resource tonnage				
Odell	0	0	5,750,000	5,750,000
Upper Sawyer	0	0	78,420,000	78,420,000
Lower Sawyer	0	0	45,410,000	45,410,000
Upper Knobloch	0	0	179,800,000	179,800,000
Nance	0	0	91,430,000	91,430,000
Flowers-Goodale	0	0	80,000	80,000
Broadus	0	0	42,290,000	42,290,000
Total	0	0	443,180,000	443,180,000
Grand Total	0	0	2,145,460,000	2,145,460,000

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