UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Text to accompany:

Open-File Report 79-781

1979

COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE BALDY PEAK QUADRANGLE, POWDER RIVER COUNTY, MONTANA

[Report includes 30 plates]

By

Colorado School of Mines Research Institute

CONTENTS

ILLUSTRATIONS

[Plates are in pocket]

Plates 1-29. Coal resource occurrence maps:

1. Coal data map.
2. Boundary and coal data map.
3. Coal data sheet.
4. Isopach and structure contour map of the upper split of the Cook coal bed.
5. Overburden isopach and mining-ratio map of the upper split of the Cook coal bed.
6. Areal distribution and tonnage map of identified resources of the upper split of the Cook coal bed.
7. Isopach map of the Number 5 coal bed.
8. Structure contour map of the Number 5 coal bed.
9. Overburden isopach and mining-ratio map of the Number 5 coal bed.
10. Areal distribution and tonnage map of identified resources of the Number 5 coal bed.
11. Isopach and structure contour map of the Number 5a coal bed.
12. Overburden isopach and mining-ratio map of the Number 5a coal bed.
13. Areal distribution and tonnage map of identified resources of the Number 5a coal bed.
14. Isopach and structure contour map of the Pawnee coal bed.
15. Overburden isopach and mining-ratio map of the Pawnee coal bed.
16. Areal distribution and tonnage map of identified and hypothetical resources of the Pawnee coal bed.

TABLES

Conversion table

To convert	Multiply by	To obtain
feet	0.3048	meters (m)
miles	1.609	kilometers (km)
acres	0.40469	hectares (ha)
tons (short)	0.9072	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 Baldy Peak quadrangle, Powder River County, Montana, (30 plates; U.S. Geological Survey Open-File Report 79-781). 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 Baldy Peak 7 1/2-minute quadrangle is in south-central Powder River County, Montana, about 14 miles (22.5 km) south-southwest of Broadus, a small town in the Powder River valley; about 81 miles (130 km) south-southeast of Miles City, a town in the Yellowstone River valley; about 69 miles (111 km) east-northeast of Sheridan, Wyoming; and about 57 miles (92 km) north of Gillette, Wyoming. Miles City is on U.S. Interstate Highway 94 and the main east-west routes of the Burlington Northern Railroad and the Chicago, Milwaukee, St. Paul and Pacific Railroad. Broadus is on the east-west U.S. Highway 212. Both Sheridan and Gillette are on U.S. Interstate Highway 90 and another branch of the Burlington Northern Railroad.

Accessibility

The quadrangle is accessible from Broadus by going southwest up the Powder River valley on the south side of the river about 17 miles (27 km) on the

graveled Powder River Road to the Butte Creek Road and then south 1 mile (1.6 km) to the northwestern corner of the Baldy Peak quadrangle. A number of unimproved roads provide access to most of the quadrangle. The nearest railroad, the Burlington Northern Railroad, is located about 39 miles (63 km) southwest of the quadrangle up the Powder River valley near Kendrick, Wyoming.

Physiography

The Baldy Peak quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The quadrangle is dissected and drained by Baking Powder Creek, Ernest Creek, Butte Creek, and Buttermilk Creek which flow northwestward into the northeastward-flowing Powder River located about 1 mile (1.6 km) northwest of the quadrangle. The Powder River flows northeastward to Broadus, Montana, and then northward to join the Yellowstone River about 103 miles (166 km) north of the Baldy Peak quadrangle. Butte Creek, the principal stream, flows northwestward across the quadrangle in a wide grass-covered flood plain which is 0.25 to 0.5 mile (0.4 to 0.8 km) wide. The quadrangle is generally rugged hill country formed from an intricately dissected plateau.

The lowest elevation in the quadrangle, about 3,240 feet (988 m), is located on the Butte Creek flood plain in the northwestern corner of the quadrangle. The highest elevation, about 4,245 feet (1,294 m), is Baldy Peak located in the northeastern quarter of the quadrangle. Topographic relief is about 1,005 feet (306 m) in the quadrangle.

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 Northern Powder River Basin Known Recoverable Coal Resource Area (KRCRA) covers most of the Baldy Peak quadrangle. The excluded lands are mainly along Butte and Baking Powder Creeks and their larger tributaries. The Boundary and Coal Data Map (pl. 2) shows the location of the KRCRA tracts and the land ownership status. There are no National Forest lands within the Baldy Peak quadrangle. There were no outstanding Federal coal leases or prospecting permits recorded as of 1977.

GENERAL GEOLOGY

Previous work

Bryson and Bass (1973) mapped the entire Baldy Peak quadrangle as part of the East Moorhead coal field. Matson and Blumer (1973) mapped only State-owned sections of the quadrangles as part of the East Moorhead coal field in the quadrangle.

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 in this quadrangle 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 as much as 900 feet (274 m) of the member remaining 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 Baldy Peak quadrangle is located along the eastern flank of the Powder River structural basin in Montana. Regionally the strata dip westward or southwestward at an angle of less than 1 degree. The regional dip is modified in places by minor local folding and faulting (pls. 4, 8, 11, 14, 18, 21, 24, and 27). Some irregularities in dip may also be caused by depositional variations as well as differential compaction, common in continental strata.

COAL GEOLOGY

The coal beds in the Baldy Creek 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 Tongue River Member of the Fort Union Formation (Paleocene). No commercial coals are known to exist below the Tongue River Member.

The lowermost coal bed identified in the quadrangle is the Broadus coal bed which occurs about 100 feet (30.5 m) above the base of the Tongue River Member. The Broadus coal bed is successively overlain by a noncoal interval of about 300 feet (91 m), the Number 9c coal bed, a noncoal interval about 40 feet (12 m), the Number 9b coal bed, a noncoal interval of about 40 to 140 feet (12.2 to 42.7 m), the Number 9a coal bed, a noncoal interval about 15 to 120 feet (4.6 to 36.6 m), the Cache coal bed, a noncoal interval of about 80 to 180 feet (24.4 to 54.9 m), containing a local coal bed, the Pawnee coal bed, a noncoal interval of about 40 to 60 feet (12.2 to 18.3 m), the Number 5a coal bed, a noncoal interval of about 10 to 20 feet (3.0 to 6.1 m), the Number 5 coal bed, a noncoal interval of about 50 to 100 feet (15.2 to 30.5 m), the upper split of the Cook coal bed, a noncoal interval of about 70 feet (21 m), the Canyon clinker bed, a noncoal interval about 70 feet (21 m), the Dietz clinker bed, a noncoal interval about 60 feet (18 m), and the Anderson clinker 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 available chemical analyses of coal from this and adjacent quadrangles were considered in our decision to assign a rank of lignite A to the coal in this quadrangle. Analyses of coal are given in the description of the various coal beds.

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 outcrops of the coal bed in the Epsie NE quadrangle near the town of Broadus about 13 miles (20.9 km) north of the Baldy Peak quadrangle. This coal bed is about 100 feet (30 m) above the base of the Tongue River Formation (Bryson and Bass, 1973, pl. 2)). The Broadus coal bed does not crop out in the Baldy Peak quadrangle but has been projected into the southern part of the quadrangle from the quadrangles to the east and south. The isopach map (pl. 27) shows the thickness to range from about 5 to 10 feet (1.5 to 3.0 m) based on measurements in the adjacent quadrangles. The structure contour map (pl. 27) shows the Broadus coal bed to dip westward at an angle of less than 1 degree. The overburden isopach and mining-ratio map (pl. 28) shows that the overburden ranges from about 200 to 900 feet (61 to 274 m) in thickness.

A chemical analysis of the Broadus coal from the Peerless mine, sec. 23, T. 4 S., R. 50 E., in the Epsie NE quadrangle, located 15.4 miles (24.8 km) north of the Baldy Peak quadrangle, shows ash 6.4 percent, sulfur 0.2 percent, and a heating value of 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 location is lignite A in rank. Because of the proximity of that location to the Baldy Peak quadrangle, it is assumed that the Broadus coal in this quadrangle is similar and is also lignite A in rank.

Number 9c coal bed

The Number 9c coal bed, first described by Bryson and Bass (1973, p. 91) outcrops in the northwestern part of the Baldy Peak quadrangle and occurs about 300 feet (91 m) above the Broadus coal bed. The isopach and structure contour map (pl. 24) shows the coal bed to range from about 3 to 5 feet (0.9-1.5 m) in

thickness. The dip is less than 0.5 degree to the west in the Baldy Peak quadrangle. The overburden isopach and mining-ratio map (pl. 22) shows that overburden on the Broadus coal bed ranges from 0 feet at the outcrops to about 400 feet (0-122 m) in thickness.

There is no known, publicly available chemical analysis of the Number 9c coal in the Baldy Peak quadrangle. Because other coals in this area are lignite A in rank, the Number 9c coal has also been assigned a rank of lignite A.

Number 9b coal bed

The Number 9b coal bed was first mapped by Warren (1959, pl. 24) as a local bed, and later named the Number 9b coal bed by Bryson and Bass (1973, p. 91). The Number 9b coal bed occurs about 40 feet (12.2 m) above the 9c coal bed. This coal bed outcrops only locally in the northwestern part of this quadrangle, and is shown in composite section on plate 3 with a thickness of 2 feet (0.6 m) (Bryson and Bass, 1973, pl. 6, sec. 833). Because the Number 9b coal bed is less than 5 feet (1.5 m) thick in the Baldy Peak quadrangle, it has not been assigned economic coal resources.

Number 9a coal bed

The Number 9a coal bed was first described by Bryson and Bass (1973, p. 91) from outcrops in the Moorhead coal field which includes the Baldy Peak quadrangle. This coal bed is about 40 to 140 feet (12.1 to 42.7 m) above the Number 9b coal bed. The Number 9a coal bed outcrops in the northwestern and central parts of the Baldy Peak quadrangle as shown on plate 1. The isopach and structure contour map (pl. 21) shows the Number 9a coal bed to range in thickness from about 3 to 8 feet (0.9 to 2.4 m) and, in general, to dip westward at an angle of less than 1 degree. The overburden isopach and mining-ratio map (pl. 22) shows that the overburden ranges from 0 feet at the outcrops to about 400 feet (0-122 m).

There is no known, publicly available chemical analysis of the Number 9a coal in the Baldy Peak quadrangle. Because other coals in this quadrangle are lignite A in rank, the Number 9a coal has also been assigned a rank of lignite A.

Cache coal bed

The Cache coal bed, first named by Warren (1959, p. 572), derives its name from outcrops along the Cache Creek about 7 miles (11 km) north of the Baldy Peak quadrangle in the Lonesome Peak quadrangle. This coal bed is 15 to 120 feet (4.6 to 36.6 m) above the Number 9a coal bed in the Baldy Peak quadrangle. The Cache coal bed is present throughout most of the Baldy Peak quadrangle, except where it has been removed by erosion in the principal valleys. As shown on plates 1 and 3, the Cache coal bed has been burned near the land surface forming a resistant, bright reddish-orange clinker bed (Bryson and Bass, 1973, p. 91 and 101). Bryson and Bass refer to the Cache coal bed as the Number 8-9 coal bed in their report. The isopach map (pl. 17) shows that the Cache coal bed ranges from about 12 to 27 feet (3.7 to 8.2 m) in thickness. The structure contour map (pl. 18) shows a westward dip of less than 1 degree. Overburden on the Cache coal bed (pl. 19) ranges from 0 feet at the outcrops to about 600 feet (0-183 m) in thickness.

A chemical analysis of the Cache (T) coal bed from a depth of 103 to 112 (31.4 to 34.1 m) in drill hole SH-713, sec. 6, T. 8 S., R. 51 E., in the Baldy Peak quadrangle, shows ash 4.601 percent, sulfur 0.741 percent, and heating value of 7,208 Btu per pound (16,765 kJ/kg) on an as-received basis (Matson and Blumer, 1973, p. 93). This heating value converts to about 7,556 Btu per pound (17,575 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Cache coal bed in the Baldy Peak quadrangle is lignite A in rank.

Pawnee coal bed

The Pawnee coal bed was first named by Warren (1959, p. 572) from exposures in the Birney-Broadus coal field, which is a few miles (a few km) northwest of the Baldy Peak quadrangle. This coal bed occurs about 80 to 180 feet (24 to 55 m) above the Cache coal bed in the Baldy Peak quadrangle. The Pawnee coal bed crops out in the western and southern parts of the quadrangle. The isopach and structure map (pl. 14) shows that the Pawnee coal bed ranges from about 3 to 18 feet (0.9 to 5.5 m) in thickness and dips westward at an angle of less than 1 degree. Overburden on the Pawnee coal bed (pl. 15) ranges from 0 feet at the outcrops to about 300 feet (0-91 m) in thickness.

There is no known, publicly available chemical analysis of the Pawnee coal in the Baldy Peak quadrangle. Because other coals in this area are lignite A in rank, the Pawnee coal bed also has been assigned a rank of lignite A.

Number 5a coal bed

The Number 5a coal bed was first described by Bryson and Bass (1973, p. 91) from exposures in the Moorhead coal field which includes the Baldy Peak quadrangle. This coal bed crops out locally near the eastern border of the Baldy Peak quadrangle. The Number 5a coal bed occurs about 40 to 60 feet (12 to 18 m) above the Pawnee coal bed and about 40 feet (12.2 m) below the next stratigraphically higher coal bed, the Number 5 coal bed. The isopach and structure contour map (pl. 11) shows that the Number 5a coal bed ranges from about 5 to 7.7 feet (1.5 to 2.3 m) in thickness and dips westward at an angle of less than 1 degree. Overburden on the Number 5a coal bed 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 Number 5a coal in or near the Baldy Peak quadrangle. Because other coals in this quadrangle are lignite A in rank, the Number 5a coal has also been assigned a rank of lignite A.

Number 5 coal bed

The Number 5 coal bed was first described by Bryson and Bass (1973, p. 91) from exposures in the Moorhead coal field which includes the Baldy Peak quadrangle. The Number 5 coal bed has been burned in most places near the land surface, forming a red band of clinker on the steep-sided ridges (Bryson and Bass, 1973, p. 91) in the Baldy Peak quadrangle. The isopach map (pl. 7) shows that the Number 5 coal bed ranges from about 4 to 15.5 feet (1.2 to 4.7 m) in thickness in the Baldy Peak quadrangle. The structure contour map (pl. 8) shows that the coal bed generally dips westward at an angle of less than 1 degree. Overburden on the Number 5 coal bed (pl. 9) ranges from 0 feet at the outcrops to about 300 feet (0-91 m) in thickness.

There is no known, publicly available chemical analysis of the Number 5 coal in the Baldy Peak quadrangle. Because other coals in this quadrangle are lignite A in rank, the Number 5 coal has also been assigned a rank of lignite A.

Upper split of the Cook coal bed

The Cook coal bed was first described by Bass (1932, p. 59) from exposures on Cook Mountain in the Cook Creek Reservoir quadrangle about 37 miles (59.5 km) northwest of the Baldy Peak quadrangle. Warren (1959, p. 573) recognized the upper split of the Cook coal bed in the Birney-Broadus coal field a few miles (a few km) northwest of this quadrangle. Bryson and Bass (1973, pl. 1) mapped the Cook (Number 4) coal bed in the Moorhead coal field, which includes the Baldy Peak quadrangle. A preliminary regional isopach map of the Cook coal bed shows that the Cook (Number 4) coal bed of the Bryson and Bass (1973) is the upper split of the Cook coal bed. The upper split of the Cook coal bed or its clinker bed crops out on the interstream divides in the quadrangle. It occurs about 50 to 100 feet (15.2 to 30.5 m) above the Number 5 coal bed. The isopach and structure contour map (pl. 4) shows that the upper split of the Cook coal bed ranges

from about 10 to 16 feet (3 to 4.9 m) in thickness and dips westward at an angle of less than 1 degree. Overburden on the upper split of the Cook coal bed (pl. 5) 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 coal of the upper split of the Cook coal bed in this quadrangle. Because other coals in this quadrangle are lignite A in rank, the coal of the upper split of the Cook coal bed has also been assigned a rank of lignite A.

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 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 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 lignite that is under less than 200 feet (61 m) of overburden. In this report, underground-minable Reserve Base coal is 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 1,750 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 818.98 million short tons (742.98 million t). The total tonnage of federally owned, surface-minable Hypothetical coal is estimated to be 34.62 million short tons (31.41 million t). As shown by table 2, the total federally owned, underground-minable Reserve Base coal is estimated to be 540.24 million short tons (490.11 million t). The total federally owned, underground-minable Hypothetical coal is estimated to be 40.65 million short tons (36.88 million t). The total tonnage of surface- and underground-minable Reserve Base coal is 1,359.22 million short tons (1,233.08 million t), and the total of surface- and underground-minable Hypothetical coal is 75.27 million short tons (68.28 million t).

About 4 percent of the surface-minable Reserve Base tonnage is classed as Measured, 25 percent as Indicated, and 71 percent as Inferred. About 1 percent

of the underground-minable Reserve Base tonnage is Measured, 19 percent is Indicated, and 79 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 lignite beds 5 feet (1.5 m) or more thick are overlain by 200 feet (61 m) or less of overburden (the stripping limit). This thickness of overburden is the assigned stripping limit for lignite 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 lignite is:

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

where MR = mining ratio
t_o = thickness of overburden, in feet
t_c = thickness of lignite, in feet
rf = recovery factor = 0.85 in this area
cf = conversion factor = 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 to high topographic relief, the area of moderate-development potential for surface mining of a coal bed (area having mining-ratio values of 10 to 15) is often restricted to a narrow band between the high and low development-potential areas. In fact, because of the 40-acre (16.2-ha) minimum

size of coal development-potential tracts, the narrow band of moderate development-potential area often does not appear on the CDP map because it falls within the 40-acre (16.2-ha) tracts that also include areas of high development potential. The Coal Development Potential (CDP) map then shows areas of high development potential abutting against areas of low development potential.

The coal development potential for surface-mining methods is shown on the CDP map (pl. 30). Approximately 82 percent of the Federal land in this quadrangle has a high development potential for surface mining of coal because of the Cache coal bed.

The Broadus coal bed (pl. 28) has a very limited area of development potential for surface mining located in the southeastern part of the Baldy Peak quadrangle. There are no areas of high development potential. There are two small areas of moderate development potential within the 15 mining-ratio coutour in the Butte Creek flood plain near the southeast corner of the quadrangle. Low development potential exists between the 15 mining-ratio contour and the 200-foot (61-m) overburden isopach located on the Butte Creek flood plain. The 200-foot (61-m) overburden isopach is the assigned stripping limit for surface mining of lignite in this quadrangle. Areas of no development potential for surface mining extend beyond the 200-foot (61-m) overburden isopach.

The Number 9c coal bed (pl. 25) has a very limited area of development potential for surface mining in the northwestern part of the Baldy Peak quadrangle. Small areas of high development potential occur adjoining the Butte Creek flood plain between the boundary of the coal and the 10 mining-ratio contour. Narrow bands of moderate development potential occur on the hill slopes between the 10 and 15 mining-ratio contours. Areas of low development potential occur between the 15 mining-ratio contour and the 200-foot (61-m) overburden isopach.

Areas of no development potential for surface mining extend from the 200-foot (61-m) overburden isopach to the crests of the hills.

The Number 9a coal bed (pl. 22) has limited areas of development potential for surface mining in the Baldy Peak quadrangle in the northwestern and central parts of the quadrangle. There are rather narrow areas of high development on the lower hill slopes between the boundary of the coal and the 10 mining-ratio contour. Narrow bands of moderate development potential occur between the 10 and 15 mining-ratio contours. Slightly wider bands of low development potential occur between the 15 mining-ratio contour and the 200-foot (61-m) overburden isopach. Wide areas of no development potential for surface mining extend from the 200-foot (61-m) overburden isopach to the crests of the hills.

The Cache coal bed (pl. 19) has greater development potential for surface mining than other coal beds in the Baldy Peak quadrangle. Wide areas of high development potential extend from the coal boundary near the flood plains to the 10 mining-ratio contour on the hill slopes or to the 200-foot (61-m) overburden isopach. There are some narrow areas of moderate development potential between the 10 mining-ratio contour and the 200-foot (61-m) overburden isopach. There are no areas of low development potential. There are wide areas of no development potential for surface mining extending from the 200-foot (61-m) overburden isopach to the crests of the forest-covered ridges.

The Pawnee coal bed (pl. 15) underlies all of the upper valleys and ridges in the western part of the Baldy Peak quadrangle. There are narrow to wide areas of high development potential for surface mining extending from the boundary of the coal to the 10 mining-ratio contour. Narrow bands of moderate development potential extend from the 10 mining-ratio contour to the 15 mining-ratio contour or to the 200-foot (61-m) overburden isopach. There are narrow bands of low development potential in the southern part of the quadrangle between the 15

mining-ratio contour and the 200-foot (61-m) overburden isopach. In the southern part of the quadrangle, there are small areas of no development potential for surface mining on the tops of the ridges above the 200-foot (61-m) overburden isopach.

The Number 5a coal bed (pl. 12) has small areas of development potential for surface mining on some of the high ridges in the southeastern part of the quadrangle. There are narrow bands of high development potential (mining-ratio values less than 10) and even narrower bands of moderate development potential (mining-ratio values 10 to 15). There are small areas of low development potential between the 15 mining-ratio contour and the 200-foot (61-m) overburden isopach.

The Number 5 coal bed (pl. 9) has a development potential for surface mining on most of the interstream divides in the quadrangle. There are narrow to wide bands of high development potential (mining-ratio values 0 to 10) circling the ridges about midway up the slopes. These are succeeded at higher elevations by narrow bands of moderate development potential (mining-ratio values 10 to 15). Areas of low development potential (mining-ratio values greater than 15) extend to the hill crests or to the 200-foot (61-m) overburden isopach.

The upper split of the Cook coal bed (pl. 5) has several rather limited areas of development potential for surface mining in the Baldy Peak quadrangle near the crests of the ridges. The areas of high, moderate, and low development potential are all quite small.

About 79 percent of the Federal lands in the Baldy Peak quadrangle has a high development potential for surface mining, 2 percent has a moderate development potential, 4 percent has a low development potential, and 15 percent has no development potential for surface mining.

Development potential for underground mining and in-situ gasification

Lignite beds 5 feet (1.5 m) or more in 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 in this region. 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 Baldy Peak 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 Cook	21,140,000	2,640,000	730,000	24,510,000
Number 5	92,660,000	45,320,000	15,640,000	153,620,000
Number 5a	3,200,000	1,900,000	3,660,000	8,760,000
Pawnee	115,530,000	21,510,000	4,910,000	141,950,000
Cache	434,420,000	26,960,000	0	461,380,000
Number 9a	6,010,000	2,660,000	6,390,000	25,060,000
Number 9c	210,000	50,000	1,990,000	2,250,000
Broadus	0	720,000	10,730,000	11,450,000
Total	673,170,000	101,760,000	44,050,000	818,980,000
Hypothetical Resource tonnage				
Upper Cook	12,560,000	430,000	0	12,990,000
Pawnee	17,660,000	3,970,000	0	21,630,000
Total	30,220,000	4,400,000	0	34,620,000
Grand Total	703,390,000	106,160,000	44,050,000	853,600,000

Table 2.--Underground-minable coal resource tonnage (in short tons) by development-potential category for Federal lands in the Baldy Peak 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	380,000	380,000
Number 5	0	0	8,440,000	8,440,000
Number 5a	0	0	230,000	230,000
Pawnee	0	0	28,030,000	28,030,000
Cache	0	0	338,300,000	338,300,000
Number 9a	0	0	8,360,000	8,360,000
Number 9c	0	0	2,390,000	2,390,000
Broadus	0	0	154,110,000	154,110,000
Total	0	0	540,240,000	540,240,000
Hypothetical Resource tonnage				
Pawnee	0	0	14,580,000	14,580,000
Broadus	0	0	26,070,000	26,070,000
Total	0	0	40,650,000	40,650,000
Grand Total	0	0	580,890,000	580,890,000

REFERENCES

Bass, N. W., 1932, The Ashland coal field, Rosebud, Powder River, and Custer Counties, Montana: U.S. Geological Survey Bulletin 831-B, p. 19-105.

Bryson, R. P., and Bass, N. W., 1973, Geology of Moorhead coal field, Powder River, Big Horn, and Rosebud Counties, Montana: U.S. Geological Survey Bulletin 1338, 116 p.

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

Hatch, J. R., and Swanson, V. E., 1977, Trace elements in Rocky Mountain coals, in Proceedings of the 1976 symposium, Geology of Rocky Mountain coal, 1977: Colorado Geological Survey, Resource Series 1, p. 143-163.

Mapel, W. J., Swanson, V. E., Connor, J. J., Osterwald, F. W., and others, 1977, Summary of the geology, mineral resources, environmental geochemistry, and engineering geologic characteristics of the northern Powder River coal region, Montana: U.S. Geological Survey Open-File Report 77-292.

Matson, R. E., and Blumer, J. W., 1973, Quality and reserves of strippable coal, selected deposits, southeastern Montana: Montana Bureau of Mines and Geology Bulletin 91, 135 p.

Matson, R. E., Dahl, G. G., Jr., and Blumer, J. W., 1968, Strippable coal deposits on State land, Powder River County, Montana: Montana Bureau of Mines and Geology Bulletin 69, 81 p.

U.S. Bureau of Mines and U.S. Geological Survey, 1976, Coal resource classification system of the U.S. Bureau of Mines and U.S. Geological Survey: U.S. Geological Survey Bulletin 1450-B, 7 p.

U.S. Department of Agriculture, Interstate Commerce Commission, and U.S. Department of the Interior, 1974, Final environmental impact statement on proposed development of coal resources in the eastern Powder River coal basin of Wyoming, v. 3, p. 39-61.

Warren, W. C., 1959, Reconnaissance geology of the Birney Broadus coal field, Rosebud and Powder River Counties, Montana: U.S. Geological Survey Bulletin 1072-J, p. 561-585.