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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE BEAR SKULL MOUNTAIN QUADRANGLE, POWDER RIVER COUNTY, MONTANA

[Report includes 23 plates]

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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 Bear Skull Mountain quadrangle, Powder River County, Montana, (23 plates; U.S. Geological Survey Open-File Report 79-783). 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 Bear Skull Mountain quadrangle is in southeastern Powder River County, Montana, about 80 miles (129 km) south-southeast of Miles City, a town in the Yellowstone River valley, and about 13 miles (21 km) south of Broadus, Montana, a small town in the Powder River valley. 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 east-west U.S. Highway 212.

Accessibility

The Bear Skull Mountain quadrangle is accessible from Miles City, Montana, by going south on U.S. Highway 312 to Broadus and then on U.S. Highway 212 for a total of about 82 miles (132 km) to the junction of U.S. Highway 212 with State Highway 59, about 4 miles (6.4 km) southeast of Broadus; then continuing south for about 16 miles (26 km) on State Highway 59; and then going westward about 2.4

miles (3.9 km) on an improved road to the east border of the quadrangle. The quadrangle is also accessible from Broadus by going about 14 miles (23 km) southwestward on an improved road on the south side of the Powder River, then going about 5 miles (8 km) southeastward on an improved road along Baking Powder Creek. A number of local trails and roads provide access to all of the quadrangle except the very rugged southern part.

Physiography

The Bear Skull Mountain quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. A north-south sinuous divide separates the northwestward-flowing streams that drain into the northeastward-flowing Powder River, which is 5 to 15 miles (8 to 24 km) northwest of the quadrangle, from the eastward-flowing streams that drain into the northward-flowing Little Powder River, which is 2 to 3 miles (3.2 to 4.8 km) east of the quadrangle. Relief in the eastern part of the quadrangle is moderate, but the western part of the quadrangle is quite rugged. In the southern part of the quadrangle, the hill slopes adjacent to Bear Skull Creek rise abruptly 100 feet (30 m) or more above the deeply incised stream. The highest point in the quadrangle, 4,300 feet (1,311 m), is on Bear Skull Mountain in the southern part of the quadrangle. The lowest point, about 3,300 feet (1,006 m) is adjacent to Allison Creek in the northeast corner of the quadrangle. The topographic relief in the quadrangle is about 1,000 feet (305 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 Northern Powder River Known Recoverable Resource Area (KRCRA) covers only part of the western half of the Bear Skull Mountain quadrangle. The Boundary and Coal Data Map (pl. 2) shows the location of the KRCRA tracts and the land ownership status. There are no National Forests within the quadrangle. There were no outstanding coal leases or prospecting permits recorded in this quadrangle as of 1977.

GENERAL GEOLOGY

Previous work

Matson and Blumer (1973, pl. 18) mapped the strippable coal beds in the quadrangle as part of the East Moorhead coal deposit. Bryson and Bass (1973, pl. 1) also mapped the quadrangle as part of the Moorhead coal field.

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 are the Tongue River, Lebo Shale, and Tullock Members of the Fort Union Formation (Paleocene). The uppermost unit, 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 only about the lower 700 feet (213 m) of this member in the quadrangle. All of the economically minable coal beds are in the Tongue River Member.

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.

The underlying Lebo Shale Member is predominantly dark-gray and light-gray claystone and brown to black, carbonaceous shale containing some beds of siltstone, but no coal of economic value. The Lebo Shale crops out in the eastern half of the quadrangle. The Lebo Shale Member is about 250 feet (76 m) thick in the Bear Skull Mountain quadrangle (Lewis and Roberts, 1978, section B-B').

The basal member of the Tongue River Formation is the Tullock Member which is about 550 feet (168 m) thick in this quadrangle (Lewis and Roberts, 1978). The Tullock Member consists of yellow sandstone, sandy shale, carbonaceous shale, and numerous thin and impure coal beds (Matson and Blumer, 1973, p. 8). The upper part of this member crops out along the eastern border of the quadrangle.

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 Bear Skull Mountain quadrangle is on the eastern flank of the Powder River structural basin. Regionally, the strata dips westward at an angle of about 1 degree, although the regional dip is modified in places by minor local folding (pls. 4, 7, 11, 17, and 20).

COAL GEOLOGY

The coal beds in the Bear Skull Mountain quadrangle are shown in outcrop on the Coal Data Map (pl. 1) and in section on the Coal Data Sheet (pl. 3). Except for a thin local bed, all of the coal beds are in the Tongue River Member of the Fort Union Formation. The lowermost important coal is the Contact coal bed, which occurs at the base of the Tongue River Member. The Contact coal bed is overlain successively by a noncoal interval of about 35 to 90 feet (11 to 27 m), the Broadus coal bed, a noncoal interval of about 35 to 40 feet (11 to 12 m), a local coal bed, a noncoal interval of about 10 to 20 feet (3 to 6 m), the Number 11 coal bed, a noncoal interval of about 50 feet (15 m), two local coal beds a few feet apart (about 1 meter), a noncoal interval of about 10 feet (3 m), the Number 9a coal bed, a noncoal interval of about 30 feet (9 m), a local coal bed, a noncoal interval of about 10 to 40 feet (3 to 12 m), the Cache coal bed, a noncoal interval of about 150 feet (46 m), the Number 5a coal bed, a noncoal interval of about 30 feet (9 m), the Number 5 coal bed, a noncoal interval of about 75 to 100 feet (23 to 30 m), and the Upper Cook 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 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.

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).

Contact coal bed

The Contact coal bed, the basal bed of the Tongue River Member, was first described by Bass (1932, p. 53) from exposures in T. 2 N., R. 48 E., in the Kirkpatrick Hill quadrangle about 45 miles (72 km) north-northwest of the Bear Skull Mountain quadrangle. As shown by the isopach and structure contour map (pl. 20), the Contact coal bed ranges from less than 4 to about 6 feet (1.2 to 1.8 m) in thickness and in general dips westward at less than 1 degree. The general dip is modified by several small folds of low relief. Overburden on the Contact coal bed where it is more than 5 feet (1.5 m) thick (pl. 21) ranges from 0 feet at the outcrops to about 400 feet (0-122 m) in thickness.

There is no publicly available chemical analysis of the Contact coal in the Bear Skull Mountain quadrangle. Because other coals in the area are lignite A in rank, the Contact coal has also been assigned a rank of lignite A.

Broadus coal bed

The Broadus coal bed, first described by Warren (1959, p. 570), derives its name from exposures near the town of Broadus in the Epsie NE quadrangle about 13 miles (21 km) north of the Bear Skull Mountain quadrangle. The Broadus coal bed crops out in the central and southern parts of the quadrangle and at the north-central edge of the quadrangle. The Broadus coal bed occurs about 35 to 90 feet (11 to 27 m) above the Contact coal bed which is at the base of the Tongue River Member. The isopach and structure contour map of the Broadus coal bed (pl. 17) shows that the Broadus coal bed ranges from about 2.5 to 10 feet (0.8 to 3 m) in thickness and dips northwestward at an angle of slightly more than 1 degree. The general dip is modified locally by minor folding. Overburden on the Broadus coal bed (pl. 18) ranges from 0 feet at the outcrops to 600 feet (0-183 m) in thickness.

There is no known, publicly available chemical analysis of the Broadus coal in this quadrangle, but a chemical analysis of the Broadus coal from the Peerless mine, sec. 23. T. 4 S., R. 50 E., about 15 miles (24 km) north-northwest of the Bear Skull Mountain 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. Because of the proximity of that location to the Bear Skull Mountain quadrangle it is assumed that the coals are similar and the Broadus coal in this quadrangle is also lignite A in rank.

Number 11 coal bed

The Number 11 coal bed was first described by Bryson and Bass (1973, p. 100) from exposures in the Moorhead coal field which includes the Bear Skull Mountain quadrangle. The Number 11 coal bed occurs about 40 to 55 feet (12 to 17 m) above the Broadus coal bed. The Number 11 coal bed crops out only in small scattered areas near the northern and southern boundaries of the quadrangle. The isopach and structure contour map (pl. 14) shows that the Number 11 coal bed ranges from 2.8 to 5.9 feet (0.8 to 1.8 m) in thickness. Data are insufficient to show the dip of the Number 11 coal bed, but it probably dips westward at an angle of about 1 degree like the other coal beds in the quadrangle. Overburden on the Number 11 coal bed (pl. 15) is about 100 feet (30 m) thick on a small area in the northern part of the quadrangle where the coal attains reserve-base thickness (5 feet or 3 m).

There is no known, publicly available chemical analysis of the Number 11 coal in the Bear Skull Mountain quadrangle. Because other coals in this area are lignite A in rank, the Number 11 coal has also been assigned a rank of lignite A.

Local coal beds above the Number 11 coal bed

Two local coal beds a few feet apart (about 1 meter), each with a thickness of less than 5 feet (1.5 m), occur about 50 to 60 feet (15 to 18 m) above the Number 11 coal bed. Resources have not been calculated for these beds.

Number 9a coal bed

The Number 9a coal bed was first described by Bryson and Bass (1973, p. 103) from exposures of a lenticular coal bed in T. 8 S., R. 51 E., in the Bear Skull Mountain quadrangle. Here the Number 9a coal bed is about 55 to 75 feet (17 to 23 m) above the Number 11 coal bed. Because the Number 9a coal bed is less than 3 feet (0.9 m) thick, economic coal resources have not been assigned to it.

Local coal bed above the Number 9a coal bed

In the northern half of the quadrangle, a local coal bed occurs about 110 to 130 feet (33 to 40 m) above the No. 11 coal bed (pl. 3). This local coal bed is probably stratigraphically higher than the Number 9a coal bed, but its stratigraphic relationship to the Number 9a coal bed cannot be precisely determined because the 9a coal bed and the local coal bed do not occur in the same area. Economic coal resources have not been calculated for this bed because it is less than 5 feet (1.5 m) thick and has only a limited areal extent.

Cache coal bed

The Cache coal bed was first described by Warren (1959, p. 572). This bed is named for exposures along Cache Creek in the Lonesome Peak and Yarger Butte quadrangles, about 10 miles (16 km) northwest of the Bear Skull Mountain quadrangle. In the Bear Skull Mountain quadrangle, the Cache coal bed occurs about 110 to 180 feet (33 to 55 m) above the Number 11 coal bed. The position of the Cache coal bed near the surface is generally marked by a clinker bed formed by the burning of the coal. The isopach and structure maps (pls. 10 and 11) show that the Cache coal bed ranges from 9 to 26 feet (2.7 to 7.9 m) in thickness

and, in general, dips westward at an angle of about 0.5 degree. Overburden on the Cache coal bed (pl. 12) ranges from 0 feet at the outcrops to about 400 feet (0-122 m). The T coal bed of Matson and Blumer (1974, p. 92) is equivalent to the Cache coal bed.

A chemical analysis of the $T_{(Cache)}$ coal (Matson and Blumer, 1973, p. 93) in drill hole SH-712 from a depth of 150 to 158 feet (46 to 48 m) in sec. 9, T. 8 S., R. 51 E., in the Bear Skull Mountain quadrangle, shows ash 5.304 percent, sulfur 0.674 percent, and heating value 7,014 Btu per pound (16,314 kJ/kg) on an as-received basis. This heating value converts to about 7,407 Btu per pound (17,228 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Cache coal in the Bear Skull Mountain quadrangle is lignite A in rank.

Number 5a coal bed

The Number 5a coal bed was first described by Bryson and Bass (1973, p. 103) from exposures in T. 8 S., R. 51 E. in the Bear Skull Mountain quadrangle. In this quadrangle, the Number 5a coal bed is about 150 feet (46 m) above the Cache coal bed and crops out in a few small isolated areas along the western border of the quadrangle. Its only measured thickness is 2.5 feet (0.8 m). Because of the thinness and the limited areal extent of the Number 5 coal bed, economic coal resources have not been calculated for it.

Number 5 coal bed

The Number 5 coal bed was first described by Bryson and Bass (1973, p. 86) from exposures in T. 9 S., R. 49 E., in the Three Bar Ranch quadrangle, about 10 miles (16 km) southwest of the Bear Skull Mountain quadrangle. The Number 5 coal bed is about 80 to 135 feet (24 to 41 m) below the Upper Cook coal bed and about 170 to 180 feet (52 to 55 m) above the Cache coal bed. The Number 5 coal bed crops out along the west boundary of the quadrangle and occurs as small isolated tracts in the northern part of the quadrangle. The isopach and structure map

(pl. 7) shows that the Number 5 coal bed ranges from 7 to 9 feet (2.1 to 2.7 m) in thickness and dips westward at an angle of less than 1 degree. Overburden on the Number 5 coal bed (pl. 8) 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 5 coal in the Bear Skull Mountain quadrangle. Because other coals in this area are lignite A in rank, the Number 5 coal has also been assigned the rank of lignite A.

Upper split of the Cook coal bed

The Cook coal bed was named by Bass (1932, p. 79) for outcrops in the Ashland coal field on Cook Mountain in the Cook Creek Reservoir quadrangle, which lies about 45 miles (72 km) northwest of the Bear Skull Mountain quadrangle. Warren (1959, p. 573) recognized an upper bench of the Cook. Matson and Blumer (1973, p. 100) divided the Cook coal bed into two benches, or splits, separated by a parting as thick as 34 feet (10 m). The lower split does not occur in this quadrangle. In the Bear Skull Mountain quadrangle, the Upper Cook coal bed occurs about 80 to 100 feet (24 to 30 m) above the Number 5 coal bed. The Upper Cook coal bed crops out in a small area along the western part of the quadrangle. The isopach and structure map (pl. 4) shows that this bed is about 10 feet (3 m) thick and has a general eastward dip of about 1 degree. Overburden on the Upper Cook coal bed (pl. 5) ranges from 0 feet at the outcrops to less than 100 feet (0-30 m) in thickness.

A chemical analysis of the Cook coal (Matson and Blumer, 1973, p. 99) from a depth of 115 to 125 feet (35 to 38 m) in coal test hole SH-7135, sec. 29, T. 6 S., R. 48 E., in the Hodsdon Flats quadrangle, about 20 miles (32 km) west-northwest of the Bear Skull Mountain quadrangle, shows ash 4.738 percent, sulfur 0.258 percent, and heating value 7,350 Btu per pound (17,096 kJ/kg) on an as-received basis. This heating value converts to about 7,716 Btu per pound (17,946 kJ/kg)

on a moist, mineral-matter-free basis, indicating that the Upper Cook coal at that location is lignite A in rank. Because the Bear Skull Mountain quadrangle is closer to the eastern flank of the basin than that location it is assumed that the Upper Cook coal in this quadrangle is no higher in rank and is also lignite A in rank.

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 (-.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 of lignite 5 feet (1.5 m) or more thick and under less than 1,000 feet (305 m) of overburden.

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 297.68 million short tons (270.06 million t). The total tonnage of federally owned, surface-minable Hypothetical coal is estimated to be 3.28 million short tons (2.98 million t). As shown by table 2, the total federally owned, underground-minable Reserve Base coal is estimated to be 203.69 million short tons (184.79 million t). There is no federally owned, underground-minable Hypothetical coal. The total tonnage of surface- and underground-minable Reserve Base coal is 501.37 million short tons (454.84 million t), and the total of surface- and underground-minable Hypothetical coal is 3.28 million short tons (2.98 million t).

About 8 percent of the surface-minable Reserve Base tonnage is classed as Measured, 40 percent as Indicated, and 52 percent as Inferred. About 1 percent

of the underground-minable Reserve Base tonnage is Measured, 17 percent is Indicated, and 82 percent is Inferred.

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

COAL DEVELOPMENT POTENTIAL

There is a potential for surface-mining in the Northern Powder River Basin in areas where subbituminous coal beds 5 feet (1.5 m) or more thick are overlain by less than 500 feet (152 m) of overburden (the stripping limit), or where lignite beds of the same thickness are overlain by 200 feet (61 m) or less of overburden (the stripping limit). This last thickness of overburden is the assigned stripping limit for surface mining of 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 coal, in feet
rf = recovery factor = 0.85 in this area
cf = conversion factor = 0.922 cu. yds./ short ton for lignite coal

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 Contact coal bed has a potential for surface mining in two areas, one near the central part of the quadrangle and one near the southern boundary of the quadrangle. The Contact coal bed (pl. 21) has rather limited areas of high development potential extending from the outcrops up the hill slopes to the 10 mining-ratio contour. There are narrow bands of moderate development potential higher in the valleys between the 10 and 15 mining-ratio contours. Wide areas of low development potential extend from the 15 mining-ratio contour under the hills to the arbitrarily assigned stripping limit of 200 feet (61 m) of overburden. There are areas of no development potential for surface mining beneath the crests of the hills.

The Broadus coal bed has a potential for surface mining in the western half of the quadrangle. The Broadus coal bed (pl. 18) has very limited areas of high development potential extending from the outcrops a short distance up the stream valleys. A very narrow band of moderate development potential parallels the high development potential. Wide areas of low development potential extend from the 15 mining-ratio contour to the arbitrarily assigned stripping limit at the 200-foot overburden isopach. Large areas of no development potential exist under the crests of the hills above the 200-foot overburden isopach.

An area of about 160 acres (65 ha) in the northern part of the quadrangle is the only place the Number 11 coal bed is greater than 5 feet (1.5 m) thick. All of this coal has a high or moderate development potential (pl. 15).

The Cache coal bed (pl. 12) has large areas of high development potential extending from the outcrops to the 10 mining-ratio contour or to the arbitrarily assigned stripping limit at the 200-foot overburden isopach. Very limited areas of moderate development potential occur between the 10 and 15 mining-ratio contours. There are small areas of low development potential between the 15 mining-ratio contour and the 200-foot overburden isopach. Moderately large areas of no development potential extend under the crests of the hills above the 200-foot overburden isopach.

The Number 5 coal bed has a potential for surface mining in a small area along the western boundary of the quadrangle. Most of the Number 5 coal bed (pl. 8) has high or moderate development potential. Some low development potential is present between the 15 mining-ratio contour and the arbitrarily assigned 200-foot overburden isopach.

Surface-mining potential for the Upper Cook coal bed is limited to a very small area along the western border of the quadrangle. Most of the Upper Cook coal bed (pl. 5) has high development potential; very limited areas have moderate and low development potential.

About 32 percent of the Federal coal lands in the quadrangle has a high development potential for surface mining, 9 percent has a moderate development potential, 8 percent has a low development potential, and 51 percent has no development potential.

Development potential for underground mining and in-situ gasification

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

In-situ gasification of coal on a commercial scale has not been done in the United States. Therefore, the development potential for in-situ gasification of coal found below the surface-mining limit in this area is rated as low, and a Coal Development Potential map for in-situ gasification of coal was not made.

Table 1.--Surface-minable coal resource tonnage (in short tons) by development-potential category for Federal coal lands in the Bear Skull Mountain 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	1,350,000	210,000	30,000	1,590,000
Number 5	6,740,000	3,310,000	3,250,000	13,300,000
Cache	160,690,000	8,190,000	1,540,000	170,420,000
Number 11	440,000	350,000	0	790,000
Broadus	8,190,000	27,800,000	53,070,000	89,060,000
Contact	5,190,000	3,070,000	14,260,000	22,520,000
Total	182,600,000	42,930,000	72,150,000	297,680,000
Hypothetical Resource tonnage				
Upper Cook	2,490,000	60,000	0	2,550,000
Number 5	730,000	0	0	730,000
Total	3,220,000	60,000	0	3,280,000
Grand Total	185,820,000	42,990,000	72,150,000	300,960,000

Table 2.--Underground-minable coal resource tonnage (in short tons) by development-potential category for Federal lands in the Bear Skull Mountain 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				
Number 5	0	0	120,000	120,000
Cache	0	0	57,490,000	57,490,000
Broadus	0	0	141,540,000	141,540,000
Contact	0	0	4,540,000	4,540,000
Total	0	0	203,690,000	203,690,000

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