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

[Report includes 24 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 Yarger Butte quadrangle, Powder River County, Montana, (24 plates; U.S. Geological Survey Open-File Report 79-103). 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 Yarger Butte 7 1/2-minute quadrangle is in central Powder River County, Montana, about 12 miles (19.3 km) southwest of Broadus, a small town in the Powder River valley; about 66 miles (106 km) northeast of Sheridan, Wyoming; and about 67 miles (108 km) north of Gillette, Wyoming. Broadus is on east-west U.S. Highway 212. Sheridan and Gillette are on U.S. Interstate 90 and the Burlington Northern Railroad.

Accessibility

The quadrangle is accessible from Broadus by going southwest for a distance of about 16 miles (26 km) on the graveled Powder River Road. All areas of the quadrangle are accessible by unimproved roads and trails. The nearest railroad is the Burlington Northern Railroad at Kendrick, Wyoming, about 43 miles (69 km) airline up the Powder River valley southwest of the Yarger Butte quadrangle.

Physiography

The Yarger Butte quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The Yarger Butte quadrangle area is a remnant of the plateau which has been heavily dissected. In the northern part of the quadrangle, the topography is characterized by broad low-relief valleys drained by eastward-flowing Cache Creek and its tributaries: Buck, Sanders, and Rock Springs Creeks. Cache Creek empties into the northeastward-flowing Powder River about 4 miles (6.4 km) east of the quadrangle. In the central and southwestern parts of the quadrangle, rugged ridge systems with steep-sided narrow valleys channel the drainage in a southeastward direction. Southeastward-flowing Fire Gulch, Yarger Creek, Dry Creek, Flood Creek, and Cedar Creek flow into the Powder River which crosses the southeastern corner of the quadrangle in a broad flood plain which is about 1 mile (1.6 km) wide. The Powder River flows northeastward past Broadus, Montana, and then northward to meet the Yellowstone River about 96 miles (155 km) north of the Yarger Butte quadrangle.

The lowest point in the quadrangle, with an elevation of about 3,160 feet (963 m), is where the Powder River leaves the quadrangle near the southeastern corner. The highest point in the quadrangle is an unnamed hill with an elevation of 4,065 feet (1,239 m) in the northwestern corner of the quadrangle. Topographic relief in the quadrangle is 905 feet (276 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 Basin Known Recoverable Coal Resource Area (KRCRA) covers most of the Yarger Butte quadrangle with the exception of some areas in the southeastern corner of the quadrangle in the flood plain of the Powder River. 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 quadrangle. There were no outstanding Federal coal leases or prospecting permits recorded as of 1977.

COAL GEOLOGY

Previous work

Warren (1959) mapped most of the Yarger Butte quadrangle except the sections in T. 7 S. along the south edge of the quadrangle as part of the Birney-Broadus coal field. Matson, Dahl, and Blumer (1968) mapped the strippable coal deposits on State land in Powder River County. Bryson and Bass (1973) mapped only the sections in T. 7 S. in the southern part of the Yarger Butte 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 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 is burned, baking the overlying sandstone and shale, forming thick, reddish-colored clinker beds. The

upper part of the Tongue River Member has been removed by erosion, leaving about as much as 1,100 feet (335.3 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 Yarger Butte quadrangle is located along the eastern flank of the Powder River structural basin in Montana. Regionally the strata dip west-southwestward at an angle of less than 1 degree. The regional dip is modified in places by minor local folding and faulting (pls. 4, 7, 10, 14, 18, and 21). 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 Yarger Butte quadrangle are shown in outcrop on the Coal Data Map (pl. 1) and in section on the Coal Data Sheet (pl. 3). All of the mapped coal beds occur in the 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 200 feet (61 m) above the base of the Tongue River Member. The Broadus coal bed is successively overlain by an essentially noncoal interval containing a local coal bed of as much as 210 feet (64 m), the Number 9c coal bed, a noncoal interval of about 30 feet (9.1 m), the Number 9b coal bed, a noncoal interval of about 40 to 160 feet (12 to 49 m), the Cache coal bed, a mainly noncoal interval containing two local coal beds about 100 to 150 feet (30.5 to 45.7 m), the Number 8 coal bed, a noncoal interval of about 45 to 80 feet (13.7 to 24.4 m), the Pawnee coal bed, a noncoal interval of about 80 to 110 feet (24.4 to 33.5 m) the Number 5 coal bed, a noncoal interval of about 140 feet (42.7 m), and the upper split of the 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. The rank of coal is controlled by the amount of compaction to which the coal is subjected. The compaction is a result of the original depth of burial of the coal (thickness of overlying overburden) and of the degree of tectonic (mountain-building) activity to which the coal has been subjected. The eastern flank of the Powder River Basin has not been subjected to very much squeezing of sediments produced by tectonic activity so that the rank of coal there is primarily related to the original depth of burial (thickness of overburden) to which the coal has been subjected. Lignite A is a coal that has a heating value of 6,300 to 8,300 Btu per pound (14,654 to 19,306 kJ/kg) on a moist, mineral-matter-free basis. Subbituminous C coal has a heating value of 8,300 to 9,500 Btu per pound (19,306 to 22,097 kJ/kg) on a moist, mineral-matter-free basis.

At the start of this mapping contract, what appeared to us to be all of the available analyses of the Broadus coal bed, the stratigraphically lower-most coal

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

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

Broadus coal bed

The Broadus coal bed was first described by Warren (1959, p. 570) and derives its name from exposures in the Epsie NE quadrangle near the town of Broadus, about 6 miles (9.7 km) northeast of the Yarger Butte quadrangle. This

coal bed is about 200 feet (61 m) above the base of the Tongue River Formation. The Broadus coal bed does not crop out in the Yarger Butte quadrangle. However, it has been penetrated by an oil-and-gas test hole near the northeastern corner of the quadrangle (pls. 1 and 3). The isopach and structure contour map (pl. 21) shows that the coal bed ranges from less than 5 feet (1.5 m) to at least 15 feet (4.5 m) in thickness, and that the bed dips to the west at an angle of less than 1 degree. The overburden (pl. 22) ranges from 0 feet at the outcrops to more than 600 feet (0-183 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 about 8 miles (12.9 km) northeast of the Yarger Butte 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 Yarger Butte quadrangle, it is assumed that the Broadus coal in this quadrangle is similar and is also lignite A in rank.

Number 9b coal bed

The Number 9b coal bed was first mapped by Warren (1959, pl. 24) as a local coal bed, and later named the Number 9b coal bed by Bryson and Bass (1973, p. 91). The Number 9b coal bed is about 110 to 275 feet (33.5 to 84 m) above the Broadus coal bed. The isopach map (pl. 17) shows that the Number 9b coal bed ranges in thickness from less than 4 feet (1.2 m) to at least 11 feet (3.4 m). The structure contour map (pl. 18) shows that the bed dips to the west at an angle of less than 1 degree, although this dip is modified in places by local

folding. The overburden (pl. 19) ranges from 0 feet at the outcrops to more than 500 feet (0-152.4 m) in thickness.

There is no known, publicly available chemical analysis of the Number 9b coal in the Yarger Butte quadrangle. Because of the stratigraphic relationship of the Number 9b coal to the Broadus coal bed, it is assumed the coals are similar and we have assigned a rank of lignite A to the Number 9b coal in this quadrangle.

Cache coal bed

The Cache coal bed, first named by Warren (1959, p. 572), derives its name from exposures along Cache Creek in the Yarger Butte and Lonesome Peak quadrangles. The Cache coal bed is about 40 to 160 feet (12 to 49 m) above the Number 9b coal bed. The bed is marked in places by a clinker bed formed by the burning of the coal. The isopach map (pl. 13) shows that the coal bed ranges from about 4 feet to at least 14 feet (1.2 to 2.7 m) in thickness. The bed dips to the west at an angle of less than 1 degree (pl. 14). The overburden (pl. 15) ranges from 0 feet at the outcrops to more than 500 feet (0-152.4 m) in thickness.

A chemical analysis of the Cache (T) coal from drill hole SH-719, sec. 19, T. 9 S., R. 50 E., located about 14 miles (22.5 km) south of the Yarger Butte quadrangle in the Three Bar Ranch quadrangle from a depth of 160 to 170 feet (49 to 52 m), shows ash 5.671 percent, sulfur 0.546 percent, and a heating value of 7,494 Btu per pound (17,431 kJ/kg) on an as-received basis (Matson and Blumer, 1973, p. 93). This heating value converts to about 7,945 Btu per pound (18,480 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Cache coal at that location is lignite A in rank. Because of the proximity of that location to the Yarger Butte quadrangle, it is assumed that the Cache coal in this quadrangle is similar and is also lignite A in rank.

Number 8 coal bed

The Number 8 coal bed was first described by Warren (1959, pl. 20) as a local bed and later named the Number 8 coal by Bryson and Bass (1973, p. 82). The Number 8 coal bed is about 100 to 150 feet (30.5 to 45.7 m) above the Cache coal bed. The bed is marked in places by a clinker bed formed by the burning of the coal. The isopach and structure contour map (pl. 10) shows that the coal bed ranges in thickness from about 3 to 11 feet (0.9 go 3.4 m) and dips to the west at an angle of less than 1 degree. The overburden (pl. 11) ranges from 0 feet at the outcrops to about 400 feet (0 to 122 m) in thickness.

There is no known, publicly available chemical analysis of the Number 8 coal in or near the Yarger Butte quadrangle. Because of the stratigraphic relationship of the Number 8 coal bed to the Cache coal, it is assumed that the coals are similar and we have assigned a rank of lignite A to the Number 8 coal in this quadrangle.

Pawnee coal bed

The Pawnee coal bed was first described by Warren (1959, p. 572) from exposures in the Birney-Broadus coal field, Montana, possibly from the Epsie quadrangle north of the Yarger Butte quadrangle, where the coal bed is quite thick, or possibly from exposures along Pawnee Creek in the Birney Day School quadrangle about 34 miles (54.7 Km) west-northwest of the Yarger Butte quadrangle. The Pawnee coal bed is about 45 to 80 feet (13.7 to 24.4 m) above the Number 8 coal bed in the Yarger Butte quadrangle. The isopach and structure contour map (pl. 7) shows that the coal bed ranges from about 10 feet to at least 21 feet (3 to 6.4 m) in thickness and that the dip is to the west at an angle of less than 1 degree. The overburden (pl. 8) ranges from 0 feet at the outcrops to more than 300 feet (0-91 m) in thickness.

A chemical analysis of the Pawnee coal from a core sample, lab. number I-73316, taken 69 feet (21 m) below the surface and located in the northwest quarter of the Yarger Butte quadrangle in sec. 36, T. 5 S., R. 48 E., shows ash

6.0 percent, sulfur 0.2 percent, and a heating value of 7,650 Btu per pound (17,793 kJ/kg) on an as-received basis (Matson, Dahl, and Blumer, 1968, p. 19). This heating value converts to about 8,130 Btu per pound (18,989 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Pawnee coal is high lignite A in rank at that location. Because that location is in the northwest quarter of the Yarger Butte quadrangle, it is assumed that the Pawnee coal in the entire Yarger Butte quadrangle is similar and is lignite A in rank.

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 28 miles (45 km) northwest of the Yarger Butte quadrangle. Warren (1959, p. 573) recognized an upper bench of the Cook coal bed in the Birney-Broadus coal field a few miles (a few kilometers) northwest of the quadrangle. Bryson and Bass (1973, pl. 1) mapped the Cook (Number 4) coal bed in the Moorhead coal field, which includes the Yarger Butte quadrangle. A preliminary regional isopach map of the Cook coal bed shows that the Cook (Number 4) coal bed of Bryson and Bass (1973) is the upper split of the Cook coal bed.

The upper split of the Cook coal bed is about 200 to 250 feet (61 to 76 m) above the Pawnee coal bed in this quadrangle. The upper split of the Cook coal bed has been burned in places, forming a reddish-colored clinker bed in several areas.

The isopach and structure contour map (pl. 4) shows that the coal bed ranges from about 7 feet to about 12 feet (2.1 to 3.7 m) in thickness and has a westerly dip of less than 1 degree. The overburden (pl. 5) ranges from 0 feet at the outcrops to about 100 feet (0-30.5 m) in thickness.

A chemical analysis of coal from the upper split of the Cook coal bed from drill hole SH-7117, located in the Sonnette quadrangle about 5.5 miles (8.9 km)

northwest of the Yarger Butte quadrangle in sec. 7, T. 5 S., R. 48 E. from a depth of 72 to 82 feet (22 to 25 m), shows ash 6.500 percent, sulfur 0.736 percent, and a heating value of 7,186 Btu per pound (16,714 kJ/kg) on an as-received basis (Matson and Blumer, 1973, p. 110). This heating value converts to about 7,686 Btu per pound (17,877 kJ/kg) on a moist, mineral-matter-free basis, indicating that coal from the upper split of the Cook coal bed at that location is lignite A in rank. Because of the proximity of that location to the Yarger Butte quadrangle, coal from the upper split of the Cook coal bed has also been assigned a rank of lignite A in this quadrangle.

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 553.44 million short tons (502.08 million t). The total tonnage of federally owned, surface-minable Hypothetical coal is estimated to be 3.49 million short tons (3.17 million t). As shown by table 2, the total federally owned, underground-minable Reserve Base

coal is estimated to be 6.57 million short tons (5.96 million t). There is no federally owned, underground-minable Hypothetical coal in the Yarger Butte quadrangle. The total tonnage of surface- and underground-minable Reserve Base coal is 560.01 million short tons (508.04 million t), and the total of surface- and underground-minable Hypothetical coal is 3.49 million short tons (3.17 million t).

About 12 percent of the surface-minable Reserve Base tonnage is classed as Measured, 47 percent as Indicated, and 41 percent as Inferred. None of the underground-minable Reserve Base tonnage is Measured, 3 percent is Indicated, and 97 percent is Inferred.

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

COAL DEVELOPMENT POTENTIAL

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

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

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

where MR = mining ratio

t_o = thickness of overburden, in feet

t_c = thickness of coal, in feet

rf = recovery factor = 0.85 in this area

cf = conversion factor = 0.911 cu. yds./short ton for subbituminous coal or 0.922 cu. yds./short ton for lignite

The mining-ratio values are used to rate the 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. Estimated tonnages of surface-minable Re-Serve 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 methods 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.

The coal development potential that the Federal coal lands have for surface-mining methods is shown on the Coal Development Potential map (pl. 24). Most of the Federal coal lands in the quadrangle have a high development potential for surface mining because of the Cache coal bed.

The Broadus coal bed (pl. 22) has a small area of high development potential for surface mining within the 10 mining-ratio contour, located in the Cache Creek flood plain. Moderate development potential areas exist between the 10 and 15 mining-ratio contours. Low development potential areas exist between the 15 mining-ratio contour and the 500-foot (152-m) overburden isopach, the stripping limit in this quadrangle. Very limited areas of no development potential exist between the 500-foot (152-m) overburden isopach and the crests of the hills.

The Number 9b coal bed (pl. 19) has a high development potential for surface mining in most of the valleys (areas of 0 to 10 mining-ratio values). Moderate development potential areas (10 to 15 mining-ratio values) generally occur as bands surrounding the high development potential areas further uphill. Low development potential areas (greater than 15 mining-ratio values within the stripping limit) are extensive with small areas of no development potential beneath the upper hill areas.

The Cache coal bed (pl. 15) has large areas of high development potential for surface mining located in the drainage-basin areas of the quadrangle. Moderate development potential areas extend from the 10 to the 15 mining-ratio

contour. Low development potential areas occupy the upper hill tops from the 15 mining-ratio contour to the 500-foot (152-m) overburden isopach. No development potential areas for surface mining are very limited and are located at the tops of a few hills.

The Number 8 coal bed (pl. 11) has a high development potential for surface mining along the upper valley walls and low-relief hills. At the base of the higher hills moderate development potential areas form thin bands around the high development potential areas. Low development potential areas occupy the high hill areas.

The Pawnee coal bed (pl. 8) has a large area of high development potential for surface mining extending from the boundary of the coal to the base of the hills. At higher elevations the moderate development potential areas (10 to 15 mining-ratio values) form bands around the high development potential areas. Low development potential areas are extensive and occupy all of the upper hill areas in the quadrangle.

The Cook coal bed (pl. 5) has an isolated area of high development potential for surface mining in the west-central part of the quadrangle. This area occupies the upper areas of a ridge system south of Cache Creek and north of the Dry Fork Fire Gulch valley.

About 79 percent of the Federal coal lands in the quadrangle has a high development potential for surface mining, 5 percent has a moderate development potential, 10 percent has a low development potential, and 6 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 Yarger Butte quadrangle, Powder River County, Montana

[Development potentials are based on mining ratios (cubic yards of overburden/short ton of recoverable coal). To convert short tons to metric tons, multiply by 0.9072]

Coal bed	High development potential (0-10 mining ratio)	Moderate development potential (10-15 mining ratio)	Low development potential (>15 mining ratio)	Total
Reserve Base tonnage				
Upper Cook	3,300,000	140,000	0	3,440,000
Pawnee	112,460,000	39,060,000	34,630,000	186,150,000
Number 8	6,710,000	1,980,000	6,510,000	15,200,000
Cache	71,400,000	33,570,000	65,340,000	170,310,000
Number 9b	25,110,000	15,630,000	30,890,000	71,630,000
Broadus	230,000	1,990,000	104,490,000	106,710,000
Total	219,210,000	92,370,000	241,860,000	553,440,000
Hypothetical Resource tonnage				
Upper Cook	3,460,000	30,000	0	3,490,000
Total	3,460,000	30,000	0	3,490,000
Grand Total	222,670,000	92,400,000	241,860,000	556,930,000

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

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

Coal bed	High Development potential	Moderate development potential	Low development potential	Total
Reserve Base tonnage				
Cache	0	0	2,050,000	2,050,000
Number 9b	0	0	210,000	210,000
Broadus	0	0	4,310,000	4,310,000
Total	0	0	6,570,000	6,570,000

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