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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE TONGUE RIVER DAM QUADRANGLE, BIG HORN AND ROSEBUD COUNTIES, MONTANA

[Report includes 30 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 Tongue River Dam quadrangle, Big Horn and Rosebud Counties, Montana, (29 plates; U.S. Geological Survey Open-File Report 79-780). 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 Tongue River Dam 7 1/2-minute quadrangle is in southeastern Big Horn County and southwestern Rosebud County, Montana. The quadrangle is about 8 miles (12.9 km) north of Decker, Montana, and 23 miles (37.0 km) north-northeast of Sheridan, Wyoming. Sheridan is on U.S. Interstate Highway 90 and the Burlington Northern Railroad. A branch of this railroad runs from Sheridan northeastward about 20 miles (32 km) and terminates at the Decker coal mine which is about 5 miles (8 km) south of the Tongue River Dam quadrangle.

Accessibility

The Tongue River Dam quadrangle is accessible from Sheridan, Wyoming, by following U.S. Interstate Highway 90 northward 6 miles (9.7 km) to the paved Wyoming State Highway 338, then traveling northward on this highway 9.5 miles (15.3 km) to the Wyoming-Montana border, then proceeding northward on connecting Montana State Highway 314 through Decker, past the Decker coal mine, about 13

miles (21 km) to the southern border of the Tongue River Dam quadrangle. An improved, graveled road to Birney, Montana, passes through the northern part of the quadrangle. Local roads and trails provide access to most of the quadrangle.

Physiography

The Tongue River Dam quadrangle is within the Missouri Plateau Division of the Great Plains physiographic province. The plateau which is formed by nearly flat-lying sedimentary strata, has been deeply dissected by southeastward-flowing tributaries of the Tongue River. The northeastward-flowing Tongue River flows across the southeastern part of the quadrangle in a narrow, deep, steep-sided valley. The Tongue River Dam and the northern part of the Tongue River Reservoir are located there. The sides of the Tongue River and tributary valleys rise steeply 200 to 300 feet (61 to 91 m) to broad, grassy interstream divides of little relief. The only timber is in narrow ribbons along some of the tributaries or in a few very small patches on steep shady slopes.

The highest elevation, about 4,300 feet (1,311 m), is on an interstream divide near the northwest corner of the quadrangle. The lowest elevation, about 3,335 feet (1,017 m) is on the Tongue River near the southeastern corner of the quadrangle. Topographic relief within the quadrangle is about 965 feet (294 m).

Climate

The climate of Big Horn and Rosebud Counties is characterized by pronounced variations in seasonal precipitation and temperature. Annual precipitation in the region varies from less than 12 inches (30 cm) to about 16 inches (41 cm). The heaviest precipitation is from April to August. The largest average monthly precipitation is during June. Temperatures in eastern Montana range from as low as -50°F (-46°C) to as high as 110°F (43°C). The highest temperatures occur in July and the lowest in January; the mean annual temperature is about 45°F (7°C) (Matson and Blumer, 1973, p. 6)

Land status

The Boundary and Coal Data Map (pl. 2) shows the land ownership status within the Tongue River Dam quadrangle. All of the quadrangle is within the Northern Powder River Basin Known Recoverable Coal Resource Area (KRCRA). The Federal government owns most of the coal. There are no National Forest lands within the quadrangle. There were no outstanding Federal coal leases, prospecting permits, or licenses as of 1977.

GENERAL GEOLOGY

Previous work

Baker (1929, pls. 28 and 29) mapped all of the Tongue River Dam quadrangle as part of the northward extension of the Sheridan coal field. Matson and Blumer (1973, pls. 1, 5A, and 5B) mapped some of the principal coal beds as parts of the Decker and Kirby coal deposits. The U.S. Geological Survey and Montana Bureau of Mines (1976, Open-File Report 76-450) made a preliminary report of drill hole data and chemical analyses of coal beds in Campbell, Converse, and Sheridan Counties, Wyoming, and Big Horn, Richland, and Dawson Counties, Montana.

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

Stratigraphy

A generalized columnar section of the coal-bearing rocks is shown on the Coal Data Sheet (pl. 3) of the CRO maps. The exposed bedrock units belong to the upper part of the Tongue River Member, the uppermost member of the Fort Union Formation (Paleocene).

The very upper part of the Tongue River Member has been removed by erosion. The part of the member remaining in the quadrangle is estimated to be as much as 2,000 feet (610 m) thick, and consists of interbedded, yellowish-gray to light-

gray, fine-grained sandstone, light- to dark-gray siltstone, gray shale and claystone, brown carbonaceous shale, and coal. Much of the near-surface coal has been burned, baking the overlying sandstone and shale and forming thick, reddish-colored clinker beds.

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 Tongue River Dam quadrangle is on the northwestern flank of the Powder River structural basin. The strata dip regionally southeastward, although this dip is modified considerably by low-relief folding and faulting, as shown by the structure contour maps of the coal beds (pls. 4, 7, 10, 14, 17, 20, 23, and 26).

COAL GEOLOGY

The coal beds in the Tongue River Dam 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 upper half of the Tongue River Member of the Fort

Union Formation (Paleocene). No commercial coals are known to exist below the Tongue River Member.

The lowermost recognized coal bed is the King coal bed which occurs about 900 to 1,040 feet (284-317 m) above the base of the Tongue River Member. The King coal bed is overlain by a mainly noncoal interval of about 200 to 240 feet (61 to 73 m) containing two local coal beds, the Brewster-Arnold coal bed, a mainly noncoal interval of 160 to 340 feet (49 to 104 m) containing a local coal bed, the Wall coal bed, a mainly noncoal interval of 60 to 230 feet (18.3 to 70 m) containing two local coal beds, the Cook coal bed, a mainly noncoal interval of about 40 to 280 feet (12 to 85 m) containing a local coal bed, the Canyon coal bed, a mainly noncoal interval of 120 to 280 feet (36.6 to 85 m) containing two local coal beds, the Dietz 3 coal bed, a noncoal interval of about 4 to 80 feet (1.2 to 24.3 m), the Dietz 2 coal bed, a mainly noncoal interval of 40 to 120 feet (12 to 37 m) containing a local coal bed, the Anderson (Dietz 1) coal bed, and a noncoal interval of up to 60 feet (18 m).

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).

King coal bed

The King coal bed was named by Warren (1959, p. 571) for outcrops of the bed along King Creek, a tributary of the Tongue River about 28 miles (45 km) northeast of the Tongue River Dam quadrangle in the Ashland and Green Creek quadrangles. The correlation of this coal bed in the Tongue River Dam quadrangle with the King coal bed at its type locality is necessarily uncertain because of the

distance involved, the scant information, and the discontinuous nature of the strata deposited in a continental environment.

The King bed does not crop out in the Tongue River Dam quadrangle but has been penetrated by the oil-and-gas test hole in the northeastern part of the quadrangle (pls. 1A, 1B, and 3). In this hole the King coal bed occurs about 1,040 feet (317 m) above the base of the Tongue River Member. The isopach and structure contour map (pl. 26), based largely on data in the quadrangles to the west and south, shows that the King coal bed ranges from about 5 to 15 feet (1.5 to 4.6 m) in thickness and dips southeastward at an angle of about 1 degree. Overburden on the King coal bed (pl. 27) ranges from about 650 to 1,100 feet (198 -335 m) in thickness.

There is no known, publicly available chemical analysis of the King coal in or close to the Tongue River Dam quadrangle. It is assumed that the King coal is similar to closely associated coals in the quadrangle and is subbituminous B in rank.

Brewster-Arnold coal bed

The Brewster-Arnold coal bed was first described by Bass (1924) for coal at the Brewster-Arnold mine, sec. 23, T. 6 S., R. 42 E., about 10 miles (16.1 km) northeast of the Tongue River Dam quadrangle near the center of the Birney quadrangle.

The Brewster-Arnold coal bed does not crop out in the Tongue River Dam quadrangle but has been penetrated by two oil-and-gas test holes in the northern part of the quadrangle (pls. 1A, 1B, and 3). This coal bed occurs about 200 to 240 feet above the King coal bed. The isopach and structure contour map (pl. 23) shows that the Brewster-Arnold coal bed ranges from about 5 to 10 feet (1.5 to 3 m) in thickness and dips southeastward at an angle of about 1 degree.

Overburden on the Brewster-Arnold coal bed (pl. 24) ranges from about 400 to 900 feet (122 to 274 m) in thickness.

A chemical analysis of the Brewster-Arnold coal bed from a depth of 70 to 75 feet (21.3 to 22.9 m) in coal test hole SH-44, sec. 31, T. 6 S., R. 42 E. (Matson and Blumer, 1973, p. 43), about 6 miles (9.6 km) east-northeast of the Tongue River Dam quadrangle in the Birney SW quadrangle, shows ash 4.534 percent, sulfur 0.347 percent, and heating value 9,197 Btu per pound (21,378 kJ/kg) on an as-received basis. This heating value converts to about 9,628 Btu per pound (22,395 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Brewster-Arnold coal at that location is subbituminous B in rank. It is assumed that the Brewster-Arnold coal in the Tongue River Dam quadrangle is similar and is subbituminous B in rank.

Wall coal bed

The Wall coal bed was named by Baker (1929, p. 37) from exposures of coal along Wall Creek, a tributary of the Tongue River, about 7 miles (11.3 km) east-northeast of the Tongue River Dam quadrangle in the Birney quadrangle. The Wall coal bed occurs about 160 to 340 feet (49 to 104 m) above the Brewster-Arnold coal bed. It does not crop out in the Tongue River Dam quadrangle, but it has been penetrated by a number of test holes (pls. 1A, 1B, and 3). The isopach and structure contour map (pl. 20) shows that the Wall coal bed ranges in thicknesses from about 30 to 60 feet (9.1 to 18.3 m) and, in general, dips southeastward at an angle of less than 1 degree, although this dip is considerably modified by low-relief folding and faulting. Overburden on the Wall coal bed (pl. 21) ranges from about 200 to 600 feet (6.1 to 183 m) in thickness.

A chemical analysis of the Wall coal bed from a depth of 73 to 83 feet (22.3 -25.3m) in coal test hole SH-707, sec. 33, T. 7 S., R. 41 E. (Matson and Blumer, 1973, p. 39) about 1 mile (1.6 km) east of the Tongue River Dam quadrangle in

the Spring Gulch quadrangle, shows ash 3.953 percent, sulfur 0.443 percent, and heating value 9,556 Btu per pound (22,227 kJ/kg) on an as-received basis. This heating value converts to about 9,949 Btu per pound (22,132 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Wall coal at that location is subbituminous B in rank. Because of the proximity of that location to the Tongue River Dam quadrangle, it is assumed that the Wall coal in this quadrangle is similar and is also subbituminous B in rank.

Cook coal bed

The Cook coal bed was first described by Bass (1932, p. 79) from exposures on Cook Mountain in the Cook Creek Reservoir quadrangle about 40 miles (64 km) northeast of the Tongue River Dam quadrangle. In the Tongue River Dam quadrangle, the Cook coal bed occurs about 60 to 230 feet (18 to 70 m) above the Wall coal bed. The Cook coal bed was not mapped at the surface in this quadrangle by any previous workers, but the structure contours of the bed indicate that it should crop out at the very eastern edge of the quadrangle in the valley of Post Creek. The bed has also been penetrated by a number of test holes (pls. 1A, 1B, and 3). The isopach and structure contour map (pl. 17) shows that the Cook coal bed ranges from about 1 to 15 feet (0.3 to 4.8 m) in thickness and, in general, dips southeastward at an angle of about 1 degree, although this dip is modified by low-relief folding. Overburden on the Cook coal bed (pl. 18) ranges from 0 at the outcrop to about 500 feet (0-152 m) in thickness.

There is no known, publicly available chemical analyses of the Cook coal in or close to the Tongue River Dam quadrangle. It is assumed that the Cook coal is similar to the other closely associated coals in the Tongue River Dam quadrangle and is probably subbituminous B in rank.

Canyon coal bed

The Canyon coal bed was first described by Baker (1929, p. 36) from exposures in the northward extension of the Sheridan coal field, probably along Canyon Creek in the northern part of the Spring Gulch quadrangle about 3 miles (4.8 km) east of the Tongue River Dam quadrangle. In the Tongue River Dam, the Canyon coal bed occurs about 40 to 280 feet (12 to 85 m) above the Cook coal bed and crops out in the eastern part of the quadrangle. The isopach map (pl. 13) shows that the Canyon coal bed ranges from about 2 to 20 feet (0.6 to 6.1 m) in thickness. The structure contour map (pl. 14) indicates that the coal bed, in general, dips souteastward at an angle of about 1 degree, although this dip is modified by low-relief folding and faulting. Overburden on the Canyon coal bed (pl. 15) ranges from 0 at the outcrops to about 400 feet (0-122 m).

A chemical analysis of the Canyon coal bed from a depth of 126 to 130 feet (38.4 to 39.6 m) in coal test hole SH-703, sec. 26, T. 8 S., R. 40 E. (Matson and Blumer, 1973, p. 20) about 1.75 miles (2.8 km) south of the Tongue River Dam quadrangle in the Decker quadrangle, shows ash 2.485 percent, sulfur 0.377 percent, and heating value 9,541 Btu per pound (22,192 kJ/kg) on an as-received basis. This heating value converts to about 9,784 Btu per pound (22,758 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Canyon coal at that location is subbituminous B in rank. Because of the proximity of that location to the Tongue River Dam quadrangle, it is assumed that the Canyon coal in this quadrangle is similar and is also subbituminous B in rank.

Dietz 3 coal bed

The Dietz 1, 2, and 3 coal beds were first described by Taff (1909, p. 139-140) from exposures in the Sheridan coal field, Wyoming. The Dietz 2 coal bed is equivalent to the Anderson coal bed as mapped by Baker (1929, pl. 28) in the northward extension of the Sheridan coal field, Montana. Baker did not map the

Dietz 2 and 3 coal beds but in places shows a local coal bed at about their stratigraphic position. The Dietz 2 and 3 coal beds of this report are equivalent to the Dietz 1 and 2, respectively, as mapped by Matson and Blumer (1973, pl. 4).

In the Tongue River Dam quadrangle, the Dietz 3 coal bed occurs about 120 to 280 feet (61 to 85 m) above the Canyon coal bed. The Dietz 3 coal bed is generally burned where near the land surface (pl. 1A). The isopach and structure contour map (pl. 10) shows that the Dietz 3 coal bed ranges from about 3 to 15 feet. Overburden on the Dietz 3 coal bed (pl. 11) ranges from 0 at the outcrops to about 200 feet (0-61 m) in thickness.

There is no known, publicly available chemical analysis of the Dietz 3 coal in or near the Tongue River Dam quadrangle. It is assumed that the Dietz 3 coal is similar to other closely associated coals in the Tongue River Dam quarangle and is either subbituminous B or C in rank.

Dietz 2 coal bed

The Dietz 2 coal bed occurs about 4 to 80 feet (1.2 to 24 m) above the Dietz 3 coal bed. A clinker bed formed by the burning of the Dietz 2 coal bed crops out extensively in the quadrangle, and the coal has been penetrated by three coal test holes. The isopach and structure contour map (pl. 7) shows that the Dietz 2 coal ranges from about 15 to 30 feet (4.6 to 9.1 m) in thickness and, in general, dips southeastward at an angle of about 1 degree, although this dip is modified by low-relief folding and faulting. Overburden on the Dietz 2 coal bed (pl. 8) ranges from near 0 to about 100 feet (0-30.5 m) in thickness.

A chemical analysis of the Dietz 2 coal from a depth of 96 to 106 feet (29.3 to 32.3 m) in coal test hole SH-31, sec. 8, T. 7 S., R. 40 E. (Matson and Blumer (1973, p. 34) in the Tongue River Dam quadrangle, shows ash 4.914 percent, sulfur 0.288 percent, and heating value 8,275 Btu per pound (19,248 kJ/kg) on an

as-received basis. This heating value converts to about 8,703 Btu per pound (20,243 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Dietz 2 coal in this quadrangle is subbituminous C in rank.

Anderson (Dietz 1) coal bed

The Anderson coal bed was first described by Baker (1929, p. 35) from exposures in the northward extension of the Sheridan coal field, Montana, which includes the Tongue River Dam quadrangle. The Dietz 1 coal bed was named by Taff (1909, p. 129-140) for exposures at the abandoned No. 1 mine at the old mining town of Dietz in the Sheridan coal field, Wyoming, about 19 miles (30.6 km) south of the Tongue River Dam quadrangle in the Sheridan quadrangle, Wyoming. The Dietz 1 coal bed is equivalent to the Anderson coal bed as mapped by Baker (1929, pls. 28 and 29).

The Anderson (Dietz 1) coal bed occurs about 40 to 120 feet (12-37 m) above the Dietz 2 coal bed. A clinker bed formed by the burning of the Anderson coal bed crops out in the northwestern part of the quadrangle. The Anderson (Dietz 1) coal has been almost entirely burned. The isopach and structure contour map (pl. 4) shows that the unburned coal ranges from about 12 to 20 feet (3.7 to 6.1 m) in thickness and dips southward at an angle of about half a degree. Overburden on the Anderson (Dietz 1) coal bed (pl. 5) ranges from about 30 to 100 feet (9.1 to 30.5 m) in thickness.

A chemical analysis of the Anderson (Dietz 1) coal in drill hole SH-31, sec. 8, T. 7 S., R. 40 E. in the Tongue River Dam quadrangle (Matson and Blumer, 1973, p. 34) shows ash 8.116 percent, sulfur 0.650 percent, and heating value 7,277 Btu per pound (16,926 kJ/kg) on an as-received basis. This heating value converts to about 7,920 Btu per pound on a moist, mineral-matter-free basis, indicating that the coal at the extreme north end of this quadrangle is lignite

A in rank. It probably would grade upward to subbituminous C in rank at the southern end of the quadrangle.

Local coal beds

The local coal beds which occur in this quadrangle are thin and of limited areal extent and consequently have not been assigned economic coal resources.

COAL RESOURCES

Data from all publicly available drill holes and from surface mapping by others (see list of references) were used to construct outcrop, isopach, and structure contour maps of the coal beds in this quadrangle. Because of the press of time, our contract with the U.S. Geological Survey for these maps did not permit us to go to the field to do any checking on the data.

A coal resource classification system has been established by the U.S. Bureau of Mines and the U.S. Geological Survey and published in U.S. Geological Survey Bulletin 1450-B (1976). Coal resource is the estimated gross quantity of coal in the ground that is now economically extractable or that may become so. Resources are classified as either Identified or Undiscovered. Identified Resources are specific bodies of coal whose location, rank, quality, and quantity are known from geologic evidence supported by specific measurements. Undiscovered Resources are bodies of coal which are surmised to exist on the basis of broad geologic knowledge and theory.

Identified Resources are further subdivided into three categories of reliability of occurrence; namely Measured, Indicated, and Inferred, according to their distance from a known point of coal-bed measurement. Measured coal is coal located within 0.25 mile (0.4 km) of a measurement point, Indicated coal extends 0.5 mile (0.8 km) beyond Measured coal to a distance of 0.75 mile (1.2 km) from the measurement point, and Inferred coal extends 2.25 miles (3.6 km) beyond Indicated coal to a distance of 3 miles (4.8 km) from the measurement point.

Undiscovered Resources are classified as either Hypothetical or Speculative. Hypothetical Resources are those undiscovered coal resources in beds that may reasonably be expected to exist in known coal fields under known geologic conditions. In general, Hypothetical Resources are located in broad areas of coal fields where the coal bed has not been observed and the evidence of coal's existence is from distant outcrops, drill holes, or wells that are more than 3 miles (4.8 km) away. Hypothetical Resources are located beyond the outer boundary of the Inferred part of Identified Resources in areas where the assumption of continuity of the coal bed is supported only by extrapolation of geologic evidence. Speculative Resources are undiscovered resources that may occur in favorable areas where no discoveries have been made. Speculative Resources have not been estimated in this report.

For purposes of this report, Hypothetical Resources of subbituminous coal are in coal beds which are 5 feet (1.5 m) or more thick, under less than 3,000 feet (914 m) of overburden, but occur 3 miles (4.8 km) or more from a coal-bed measurement. Hypothetical Resources of lignite are in lignite beds which are 5 feet (1.5 m) or more thick, under less than 1,000 feet (305 m) of overburden, but occur 3 miles (4.8 km) or more from a coal-bed measurement.

Reserve Base coal is that economically minable part of Identified Resources from which Reserves are calculated. In this report, Reserve Base coal is the gross amount of Identified Resources that occurs in beds 5 feet (1.5 m) or more thick and under less than 3,000 feet (914 m) of overburden for subbituminous coal or under less than 1,000 feet (305 m) of overburden for lignite.

Reserve Base coal may be either surface-minable coal or underground-minable coal. In this report, surface-minable Reserve Base coal is subbituminous coal that is under less than 500 feet (152 m) of overburden or lignite that is under less than 200 feet (61 m) of overburden. In this report, underground-minable

Reserve Base coal is subbituminous coal that is under more than 500 feet (152 m), but less than 3,000 feet (914 m) of overburden, or lignite that is under more than 200 feet (61 m), but less than 1,000 feet (305 m) of overburden.

Reserves are the recoverable part of Reserve Base coal. In this area, 85 percent of the surface-minable Reserve Base coal is considered to be recoverable (a recovery factor of 85 percent). Thus, these Reserves amount to 85 percent of the surface-minable Reserve Base coal. For economic reasons coal is not presently being mined by underground methods in the Northern Powder River Basin. Therefore, the underground-mining recovery factor is unknown and Reserves have not been calculated for the underground-minable Reserve Base coal.

Tonnages of coal resources were estimated using coal-bed thicknesses obtained from the coal isopach map for each coal bed (see list of illustrations). The coal resources, in short tons, for each isopached coal bed are the product of the acreage of coal (measured by planimeter), the average thickness in feet of the coal bed, and a conversion factor of 1,770 short tons of subbituminous coal per acre-foot (13,018 metric tons per hectare-meter) or a conversion factor of 1,750 short tons of lignite per acre-foot (12,870 metric tons per hectare-meter). Tonnages of coal in Reserve Base, Reserves, and Hypothetical categories, rounded to the nearest one-hundredth of a million short tons, for each coal bed are shown on the Areal Distribution and Tonnage maps (see list of illustrations).

As shown by table 1, the total tonnage of federally owned, surface-minable Reserve Base coal in this quadrangle is estimated to be 2,287.20 million short tons (2,074.95 million t). The total tonnage of federally owned, surface-minable Hypothetical coal is estimated to be 1.06 million short tons (90.96 million t). As shown by table 2, the total federally owned, underground-minable Reserve Base coal is estimated to be 1,788.57 million short tons (1,622.59 million t). The total federally owned, underground-minable Hypothetical coal is estimated to be

402.90 million short tons (365.51 million t). The total tonnage of surface- and underground-minable Reserve Base coal is 4,075.77 million short tons (3,697.54 million t), and the total of surface- and underground-minable Hypothetical coal is 403.96 million short tons (366.47 million t).

About 5 percent of the surface-minable Reserve Base tonnage is classed as Measured, 26 percent as Indicated, and 69 percent as Inferred. About 1 percent of the underground-minable Reserve Base tonnage is Measured, 12 percent is Indicated, and 87 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 ratios (cubic yards of overburden per short ton of recoverable coal).

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

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

where MR = mining ratio

t_o = thickness of overburden, in feet

t_c = thickness of coal, in feet

rf = recovery factor = 0.85 in this area

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

The mining-ratio values are used to rate the degree of potential that areas within the stripping limit have for surface-mining development. Areas having mining-ratio values of 0 to 10, 10 to 15, and greater than 15 are considered to have high, moderate, and low development potential, respectively. This grouping of mining-ratio values was provided by the U.S. Geological Survey and is based on economic and technological criteria. Mining-ratio contours and the stripping-limit overburden isopach, which serve as boundaries for the development-potential areas, are shown on the overburden isopach and mining-ratio contour plates. Estimated tonnages of surface-minable Reserve Base and Hypothetical coal resources in each development-potential category (high, moderate, and low) are shown in table 1.

Estimated tonnages of underground-minable coal resources are shown in table 2. Because coal is not presently being mined by underground mining in the Northern Powder River Basin for economic reasons, for purposes of this report all of the underground-minable coal resources are considered to have low development potential.

Development potential for surface-mining methods

The Coal Development Potential (CDP) map included in this series of maps pertains only to surface mining. It depicts the highest coal development-

potential category which occurs within each smallest legal subdivision of land (normally about 40 acres or 16.2 ha). For example, if such a 40-acre (16.2-ha) tract of land contains areas of high, moderate, and low development potential, the entire tract is assigned to the high development-potential category for CDP mapping purposes. Alternatively, if such a 40-acre (16.2-ha) tract of land contains areas of moderate, low, and no development potential, the entire tract is assigned to the moderate development-potential category for CDP mapping purposes. For practical reasons, the development-potential categories of areas of coal smaller than 1 acre (0.4 ha) have been disregarded in assigning a development potential to the entire 40-acre (16.2-ha) tract.

In areas of moderate or high topographic relief, the area of moderate development potential for surface mining of a coal bed (area having mining-ratio values of 10 to 15) is often restricted to a narrow band between the high and low development-potential areas. In fact, because of the 40-acre (16.2-ha) minimum size of coal development-potential tracts, the narrow band of moderate development-potential area often does not appear on the CDP map because it falls within the 40-acre (16.2-ha) tracts that also include areas of high development potential. The Coal Development Potential (CDP) map then shows areas of high development potential abutting against areas of low development potential.

The coal development potential for surface-mining methods on Federal coal lands is shown on the Coal Development Potential map (pl. 29). All of the Federal coal lands have development potential for surface mining except for an area of about 1 square mile (2.6 km^2) in the northeastern corner of the quadrangle.

The King coal bed (pl. 27) has no development potntial for surface mining in this quadrangle because the overburden on the coal bed is everywhere thicker than 500 feet (152 m), the stripping limit for quadrangles in the Northern Powder River Basin with multiple thin beds of subbituminous coal.

The Brewster-Arnold coal bed (pl. 24) has a few small areas with low development potential (mining-ratio values greater than 15) for surface mining in valley bottoms along the eastern edge of the quadrangle. Otherwise the Brewster-Arnold coal bed has no development potential for surface mining methods.

The Wall coal bed (pl. 21) has moderately large areas with development potential for surface mining, excluding broad upland areas in the northern part of the quadrangle and narrower upland areas in the southern part of the quadrangle. The Wall coal bed has high development potential (mining-ratio values less than 10) on the bottoms and lower slopes of valleys throughout the quadrangle. In the northwestern part of the quadrngle, the area of high development potential extends to the stripping limit of 500 feet (152 m) of overburden. Except in the southern part of the quadrangle, the Wall coal bed has moderate development potential (mining-ratio values of 10 to 15) in generally narrow areas on the upper slopes of valleys between the 10 mining-ratio contour and the stripping limit. In the southern part of the quadrangle, there are broader areas of moderate development potential extending across some of the rounded uplands to the stripping limit or to the 15 mining-ratio contour. There are a few small areas of low development potential (mining-ratio values of more than 15), around the crests of broad ridges in the southern part of the quadrangle, extending up to the stripping limit. There are broad areas, particularly in the northern and western parts of the quadrangle, with no development potential for surface mining methods because the thickness of overburden exceeds the 500-foot (152-m) stripping limit.

The Cook coal bed (pl. 18) has broad areas of development potential for surface-mining methods in the central and southern parts of the quadrangle, where the bed is Reserve Base thickness. The Cook coal bed has only narrow areas of high development potential (mining-ratio values of less than 10) along the valley

bottoms of the Tongue River and Post Creek. Narrow areas of moderate development potential (mining-ratio values between 10 and 15) extend up the valley bottoms and sides from the 10 mining-ratio contour and occur isolated from the areas of high development potential in separate areas in the valley of Leaf Rock Creek. Most of the area of the Cook coal bed has low development potential (mining-ratio values of more than 15). There are also a few small areas, beneath the higher hills, where the Cook coal bed has no development potential for surface mining because the thickness of overburden exceeds the 500-foot (152-m) stripping limit.

The Canyon coal bed (pl. 15) has development potential for surface mining everywhere within the area of Reserve-Base-thick coal, which includes almost all of the quadrangle. There is high development potential (mining-ratio values less than 10) in narrow areas along the bottoms and lower slopes of valleys in the quadrangle. There are generally narrow bands of moderate development potential (mining-ratio values between 10 and 15) upslope of the 10 mining-ratio contour on the valley sides and floor, although there are broader areas of moderate development potential on the more gentle slopes of the undissected valleys in the southwestern part of the quadrangle. There are extensive areas of low development potential (mining-ratio values greater than 15) beneath the broad upland areas between the major streams. There are no areas within the boundary of coal that have no development potential for surface-mining methods.

The Dietz 3 coal bed (pl. 11) has development potential for surface-mining methods everywhere within the boundary of Reserve Base coal, which is mostly along the western edge of the quadrangle. There are narrow areas of high development potential (mining-ratio values less than 10) on the bottoms and sides of the valleys where the Dietz 3 coal bed has not been burned or eroded. There are very narrow areas of moderate development potential (mining-ratio values between 10 and 15) on the steep slopes of the sides of some of the valleys and somewhat

broader areas of moderate development potential around some of the flatter ridgetops in the northern part of the quadrangle and across some of the more gently sloping valleys in the southern part of the quadrangle. Beneath the higher ridges and hill tops there are comparatively broad areas of low development potential (mining-ratio values greater than 15). There are no areas of no development potential for surface-mining methods for the Dietz 3 coal bed within the boundary of Reserve Base coal.

Because most of the Dietz 2 coal bed (pl. 8) in the Tongue River Dam quadrangle has been burned or eroded, there are only a few small areas with development potential for surface mining of this bed in the northwestern part of the quadrangle. Everywhere it is present the Dietz 2 coal bed has high development potential for surface-mining methods (mining-ratio values less than 10).

The Anderson (Dietz 1) coal bed (pl. 5) is present only in two small areas in the northwestern corner of the quadrangle. All of the Anderson coal bed has high development potential for surface-mining methods (mining-ratio values less than 10).

About 5 percent of the Federal col land in the Tongue River Dam quadrangle has high development potential for surface mining, 18 percent has moderate development potential, 15 percent has low development potential, and 2 percent has no development potential for surface mining.

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 Tongue River Dam quadrangle, Big Horn and Rosebud Counties, 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				
Anderson (Dietz 1)	2,410,000	0	0	2,410,000
Dietz 2	59,560,000	140,000	0	59,700,000
Dietz 3	17,210,000	58,020,000	58,430,000	133,660,000
Canyon	103,300,000	175,230,000	358,820,000	637,350,000
Cook	2,450,000	5,920,000	269,980,000	278,350,000
Wall	832,950,000	299,990,000	36,710,000	1,169,650,000
Brewster-Arnold	0	0	6,080,000	6,080,000
Total	1,017,880,000	539,300,000	730,020,000	2,287,200,000
Hypothetical Resource tonnage				
Wall	130,000	0	0	130,000
Brewster-Arnold	0	0	930,000	930,000
Total	130,000	0	930,000	1,060,000
Grand Total	1,018,010,000	539,300,000	730,950,000	2,288,260,000

Table 2.--Underground-minable coal resource tonnage (in short tons) by development-potential category for Federal lands in the Tongue River Dam quadrangle, Big Horn and Rosebud Counties, 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				
Canyon	0	0	370,000	370,000
Cook	0	0	4,750,000	4,750,000
Wall	0	0	1,586,120,000	1,586,120,000
Brewster-Arnold	0	0	76,490,000	76,490,000
King	0	0	120,840,000	120,840,000
Total	0	0	1,788,570,000	1,788,570,000
Hypothetical Resource tonnage				
Wall	0	0	52,760,000	52,760,000
Brewster-Arnold	0	0	13,410,000	13,410,000
King	0	0	336,730,000	336,730,000
Total	0	0	402,900,000	402,900,000
Grand Total	0	0	2,191,470,000	2,191,470,000

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