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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE TAINTOR DESERT QUADRANGLE, BIG HORN AND ROSEBUD COUNTIES, MONTANA

[Report includes 27 plates]

By

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ILLUSTRATIONS

[Plates are in pocket]

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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 Taintor Desert quadrangle, Big Horn and Rosebud Counties, Montana, (27 plates; U.S. Geological Survey Open-File Report 79-779). 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 Taintor Desert 7 1/2-minute quadrangle is in eastern Big Horn County and southwestern Rosebud County, Montana. It is about 44 miles (70.8 km) southeast of Hardin, Montana, a town in the valley of the Bighorn River near the confluence of the Bighorn River and Little Bighorn River. Hardin is on U.S. Highway 212, U.S. Interstate 90, and on the Burlington Northern Railroad.

Accessibility

The Taintor Desert quadrangle is accessible by going first southward and then eastward on U.S. Highway 212 about 53 miles (84.8 km) to the Muddy Creek Road, thence southward on the Muddy Creek Road about 19 miles (30.6 km) to the Bull Creek Lookout, thence southward in an unimproved local road about 3 miles (4.8 km) to the northern border of the quadrangle. The nearest railroad is the Burlington Northern Railroad, which is about 24 miles (38.4 km) west of the of the quadrangle. A branch of the railroad serves the Decker coal mine which is about 14 miles (22.5 km) south of the quadrangle.

Physiography

The Taintor Desert quadrangle lies within the Missouri Plateau Division of the Great Plains physiographic province. The topographic relief of this part of the Missouri Plateau is greater than is typical of the Great Plains because the plateau has been deeply dissected. Commonly in this region remnants of the gently undulating plateau are preserved only along drainage divides between entrenched streams. Much of the landscape consists of steep to precipitous slopes between the narrow, locally flat-topped drainage divides and the narrow, locally flat-bottomed valleys of the entrenched streams.

Nearly all of the Taintor Desert quadrangle lies on the northwest side of the Tongue River drainage basin. An area of about 2 square miles (5.2 km^2) at the northwest corner of the quadrangle extends into the basin of Rosebud Creek. The divide between the Tongue River and Rosebud Creek trends northeastward across the northwest corner of the quadrangle. The closest approach of the Tongue River to the Taintor Desert quadrangle is about 4 miles (6.4 km) from its southeast corner. Rosebud Creek is about 6 miles (9.7 km) west of the west border of the quadrangle. Both Rosebud Creek and the Tongue River flow variably northward and northeastward toward the Yellowstone River, which flows eastward about 63 miles (101.4 km) north of the quadrangle.

The Taintor Desert quadrangle is drained almost entirely by southeastward-flowing tributaries of the Tongue River. The major tributaries include Prairie Dog Creek and several branches of Canyon Creek. These streams are mostly intermittent. They are deeply entrenched and have well-developed flood plains only toward the east edge of the quadrangle.

The sides of the narrow, major valleys are typically quite steep. Commonly these slopes rise 300 to 500 feet (91.4 to 152.4 m) over distances of 0.5 mile (0.8 km) or less. In places, particularly toward the western part of the quadrangle, the steeper slopes are topped by less steep slopes that grade into remnants of the surfaces of the original plateau.

The divides of the major streams are narrow ridges that locally widen and flatten. These upland mesa areas are almost all smaller than about 0.5 square mile (1.3 km^2). Taintor Desert, located in the western central part of the quadrangle, is one of the largest of these mesa areas. Relatively flat upland surfaces occur at several distinct morphologic levels, in places separated by steep slopes that rise 100 feet (30.5 m) or more, indicating that these areas were not originally part of a single, smooth surface.

The lowest elevations in this quadrangle are between 3,480 and 3,500 feet (1,060.7 and 1,066.8 m), which occur along both the North Fork and South Fork of Canyon Creek where they cross the east edge of the quadrangle near its southeast corner. The highest elevation in the quadrangle is between 4,740 and 4,760 feet (1,444.8 and 1,450.8 m), which is found at the summit of an unnamed peak near the northwest corner of the quadrangle on the divide between Rosebud Creek and the Tongue River. Topographic relief in the Taintor Desert quadrangle is about 1,260 feet (384.0 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 Taintor Desert quadrangle. The northern 1.4 tiers of sections are within the Northern Cheyenne Indian Reservation and contain no Federal coal lands. The remainder of the quadrangle is entirely within the Northern Powder River Basin Known Recoverable Coal Resource Area (KRCRA). There were no outstanding Federal coal leases or prospecting permits recorded as of 1977.

GENERAL GEOLOGY

Previous work

Baker (1929, pl. 28) mapped that part of the Taintor Desert quadrangle south of the Northern Cheyenne Indian Reservation as part of the northward extension of the Sheridan coal field. Matson and Blumer (1973, pls. 5A, 5B, and 6) remapped the principal coal beds in the same area.

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 of Paleocene age.

The Tongue River Member is made up mainly of yellow sandstone, sandy shale, carbonaceous shale, and coal. Much coal has burned along outcrops, baking the overlying sandstone and shale and forming thick, reddish-colored clinker beds. The uppermost part of the Tongue River Member has been removed by erosion. The remaining part of the member is estimated to be as much as 1,900 feet (580 m) thick, but its exact thickness has not been determined.

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 Taintor Desert quadrangle is in the northwestern part of the Powder River structural basin. The coal beds and other strata dip regionally southeastward at an angle of about 1 degree. However, this dip is modified by faults and minor, low relief folds, as shown by the structure contour maps (pls. 4, 7, 10, 11, 14, 17, 18, 21, and 24). Some of the nonconformity in structure may be due to differential compaction and to irregularities in deposition of the coals and other beds as a result of their continental origin.

COAL GEOLOGY

The coal beds in the Taintor Desert 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 coal beds belong to the upper part of the Tongue River Member of the Fort Union Formation.

The lowermost recognized coal bed in the Taintor Desert quadrangle is a local coal bed which occurs 118 feet (40.0 m) below the Brewster-Arnold coal bed.

The Brewster-Arnold coal bed is overlain by a noncoal interval of about 200 feet (61 m), the Wall coal bed, an essentially noncoal interval of 160 to 215 feet (48.8 to 65.5 m) containing two local coal beds, the Canyon coal bed, an essentially noncoal interval of about 210 to 270 feet (64.0 to 82.3 m) containing a local coal bed, the Dietz 3 coal bed, a noncoal interval of about zero to 100 feet (0 to 30.5 m), the Dietz 2 coal bed, a noncoal interval of about 50 to 90 feet (15.2 to 27.4 m), the Anderson (Dietz 1) coal bed, a mainly noncoal interval of about 100 to 145 feet (30.5 to 44 m) containing a local coal bed, and the Smith coal bed.

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).

Local coal beds below the Brewster-Arnold coal bed

The four local coal beds which occur about 85 to 220 feet (25.9 to 67.1 m) below the Brewster-Arnold coal bed were penetrated in an oil and gas test hole near the center of the quadrangle (pls. 1 and 3). Because these local beds are not known to occur elsewhere in or near this quadrangle and because of the resulting lack of data, economic coal resources have not been assigned to them.

Brewster-Arnold coal bed

The Brewster-Arnold coal bed was named by Baker (1929, p. 37-38) from a small mine in the Birney quadrangle on the Brewster-Arnold ranch about 10 miles (16 km) east of the Taintor Desert quadrangle. It was penetrated by the oil and gas test hole near the center of the quadrangle (pls. 1 and 3). Based on this measurement and ones in adjacent quadrangles, the isopach and structure contour map (pl. 24) shows that the Brewster-Arnold coal ranges from about 5 to 10 feet (1.5 to 3.0 m) in thickness and dips southeastward at an angle of about 1 degree. Overburden on the Brewster-Arnold coal bed (pl. 25) ranges from about 240 to 1,040 feet (73 to 317 m) in thickness.

There is no known chemical analysis of the Brewster-Arnold coal bed in the Taintor Desert quadrangle, but Matson and Blumer (1973, p. 40) report that a chemical analysis of the Brewster-Arnold coal from a depth of 102 to 110 feet (31 to 35 m) in coal test hole SH-7057, sec. 28, T. 5 S., R. 42 E., in the Birney quadrangle about 9.5 miles (15.3 km) east of the Taintor Desert quadrangle shows ash 12.525 percent, sulfur 0.533 percent, and heating value 7,979 Btu per pound (18,559 kJ/kg) on an as-received basis. This heating value converts to about 9,121 Btu per pound (21,526 kJ/kg) on a moist mineral-matter-free basis, indicating that the Brewster-Arnold coal in this quadrangle is subbituminous C in rank.

Wall coal bed

The Wall coal bed was named by Baker (1929, p. 37), probably from exposures along Wall Creek, a tributary of the Tongue River, about 7 miles (11.3 km) east of the Taintor Desert quadrangle in the Birney quadrangle. The Wall coal bed occurs about 200 feet (61 m) above the Brewster-Arnold coal bed and crops out at a few places in valleys in the southeastern part of the quadrangle. Its position here is generally marked by a thick clinker bed. The isopach and structure contour map (pl. 21) shows that the Wall coal ranges from about 40 to 65 feet (12 to 19.8 m) in thickness and dips southeastward at an angle of less than 1 degree except in the southern part of the quadrangle where this dip is modified by faulting and low-relief folding. Overburden on the Wall coal bed (pl. 22) ranges from zero at the outcrops to about 760 feet (232 m) in thickness.

Several chemical analyses of the Wall coal in the Taintor Desert quadrangle are given by Matson and Blumer (1973, p. 38 and 39). A typical analysis from a depth of 59 to 65 feet (18 to 19.8 m) in coal test hole SH-49, sec. 24, T. 6 S., R. 40 E. shows ash 4.516 percent, sulfur 0.173 percent, and heating value 9,030 Btu per pound (21,004 kJ/kg) on an as-received basis. This heating value converts to about 9,457 Btu per pound (21,997 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Wall coal in the Taintor Desert quadrangle is subbituminous C in rank.

Canyon coal bed

The Canyon coal bed was first described by Baker (1929, pl. 36) from exposures in the northern extension of the Sheridan coal field, although a type locality was not given, it may be along Canyon Creek in northern Spring Gulch quadrangle. This coal occurs about 160 to 215 feet (48.8 to 65.5 m) above the Wall coal bed. The coal bed crops out in the central and eastern parts of the quadrangle. The coal has been burned in most places near the land surface. The isopach map (pl. 17) shows that the Canyon coal bed ranges from about 5 to 30 feet (1.5 to 9.1 m) in thickness. The structure contour map (pl. 18) indicates that the coal bed in general dips southeastward at an angle of about 1 degree although this dip is considerably modified by faulting and low-relief folding, particularly in the southern part of the quadrangle. Overburden on the Canyon coal bed (pl. 19) ranges from zero at the outcrops to about 600 feet (183 m) in thickness.

A chemical analysis of the Canyon coal bed (Matson and Blumer, 1973, p. 40) from a depth of 58 to 68 feet (17.7 to 20.7 m) in coal test hole SH-48, sec. 16, T. 6 S., R. 40 E., in the Taintor Desert quadrangle shows ash 3.086 percent, sulfur 0.213 percent, and heating value 8,776 Btu per pound (20,413 kJ/kg) on an as-received basis. This heating value converts to about 9,055 Btu per pound

(21,062 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Canyon coal in this quadrangle is subbituminous C in rank.

Dietz 2 and Dietz 3 coal beds

The Dietz 1, 2, and 3 coal beds were first described by Taff (1909, p. 139-140) from exposures in the Sheridan coal field in northern Wyoming. Baker (1929, pl. 28) did not map the Dietz coal beds in the Taintor Desert quadrangle, but in places shows a local coal bed at about their stratigraphic position. Matson and Blumer (1973, pl. 5B) mapped the Dietz coal beds (upper or combined benches) in the southwestern part of the quadrangle. Faults, unsuspected by Baker, were revealed by coal test holes drilled to support the field mapping of Matson and Blumer. These authors (1973, p. 31) state, "Extensive field work and interpretations were required on the Kirby area because of the structural complexity. Drilling was begun during the 1969 field season, and additional holes were drilled during the 1970 field season. In mid-winter 1972-73, more holes were drilled to verify some of the interpretations and to assist in final preparation of the maps." The compiled maps accompanying this report rely mainly on the interpretations of Matson and Blumer and on the previous field experience of our geologist who compiled the maps in this area. We believe that the two combined Dietz benches mapped by Matson and Blumer are equivalent to the Dietz 2 and Dietz 3 coal beds of Taff, and that the Anderson coal bed is equivalent to the Dietz 1 of Taff.

In the Taintor Desert quadrangle, the Dietz 3 coal bed occurs about 240 to 270 feet (73.2 to 82.3 m) above the Canyon coal bed. In the western part of the quadrangle, the Dietz 2 and 3 coal beds are combined into a single bed, but eastward this bed splits into two beds having as much as 100 feet (30.5 m) of separation. The isopach and structure contour map (pl. 14) shows that the Dietz 3 coal bed ranges from 5 to 10 feet (1.5 to 3.0 m) in thickness and dips southeastward or eastward at an angle of about 1 degree. The Dietz 2 coal bed (pl. 10), which is 7 to 80 feet (2.1 to 24.4 m) above the Dietz 3 coal bed, ranges from about 5 to 15 feet (1.5 to 4.6 m) in thickness and dips southeastward at about 1 degree (pl. 11). The combined Dietz 2 and Dietz 3 coal beds (pl. 10), which occurs in the western part of the quadrangle, ranges from about 15 to 30 feet (4.6 to 9.1 m) in thickness and dips southeastward at an angle of 1 degree or less, although this dip is considerably modified by faulting and low-relief folding (pl. 11). Overburden on the Dietz 2 and on the Dietz 2 and 3 coal beds combined (pl. 12) ranges from zero at the outcrops to about 320 feet (97.5 m) in thickness. Overburden on the Dietz 3 coal bed ranges from zero at the outcrops to about 285 (86.9 m) in thickness.

A chemical analysis of the Dietz 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., about 1,000 feet (305 m) south of the Taintor Desert quadrangle in the Tongue River Dam quadrangle (Matson and Blumer, 1973, p. 34) shows ash 4.914 percent, sulfur 0.033 percent, heating value 8,275 Btu per pound (19,248 kJ/kg) on an as-received basis. This heating value converts to about 8,700 Btu per pound (20,236 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Dietz coal at this location is subbituminous C in rank. Because of the proximity of this location to the Taintor Desert quadrangle, it is assumed that the Dietz coal in this quadrangle is similar and is also 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 northern extension of the Sheridan coal field which includes the Taintor Desert quadrangle, probably from exposures along Anderson Creek in the Spring Gulch 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 25 miles (7.6 km) south-southwest of the Taintor Desert quadrangle in the Acme quadrangle. The Dietz 1 coal bed is equivalent to the Anderson coal bed as mapped by Baker (1929, pl. 28) and Matson and Blumer (1973, pl. 5A).

In the Taintor Desert quadrangle, the Anderson (Dietz 1) coal bed occurs about 50 feet (15 m) above the Dietz 2 coal bed. The coal has been burned in many places near the surface of the land. The isopach and structure contour map (pl. 7) shows that the Anderson (Dietz 1) 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 except where this dip is modified by low-relief folding. Overburden on the Anderson (Dietz 1) coal bed (pl. 8) where the coal is more than 5 feet (1.5 m) thick ranges from zero at the outcrops to about 250 feet (76 m) in thickness.

A chemical analysis of the Anderson (Dietz 1) coal from a depth of 35 to 45 feet (10.7 to 13.7 m) in coal test hole SH-31, sec. 8, T. 7 S., R. 40 E., about 1,000 feet (305 m) south of the Taintor Desert quadrangle in the Tongue River Dam quadrangle (Matson and Blumer, 1973, p. 34) shows ash 8.116 percent, sulfur 0.064 percent, and heating value 7,277 Btu per pound on an as-received basis. This heating value converts to about 7,914 Btu per pound (18,408 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Anderson (Dietz 1) coal at this location is lignite A in rank, although close to subbituminous C in rank. Because of the proximity of this location to the Taintor Desert quadrangle, it is assumed that the Anderson (Dietz 1) coal in this quadrangle is similar and is also high lignite A in rank, close to subbituminous C in rank.

Smith coal bed

The Smith coal bed was first described by Taff (1909, p. 130) for exposures in the Sheridan coal field in the northern part of the Sheridan quadrangle, Wyoming, about 26 miles (41.8 km) south-southwest of the Taintor Desert quadrangle. In the Taintor Desert quadrangle, the Smith coal bed occurs about 100 to 145 feet (30.5 to 44 m) above the Anderson (Dietz 1) coal bed in the northwestern part of the quadrangle. The isopach and structure contour map (pl. 4) shows that the Smith coal bed ranges from about 3 to 6.4 feet (0.9 to 2.0 m) in thickness and dips southeastward at an angle of about 1 degree. Overburden on the Smith coal bed (pl. 5) ranges from zero at the outcrops to about 160 feet (48.8 m) in thickness.

There is no known, publicly available chemical analysis of the Smith coal bed in or close to the Taintor Desert quadrangle. It is assumed that the Smith coal bed is similar to the closely associated Anderson (Dietz 1) coal bed in this quadrangle and is high lignite A in rank, close to subbituminous C in rank.

Local coal beds

The local coal beds which occur above the Wall, Canyon, and Anderson (Dietz 1) coal beds in the Taintor Desert quadrangle are of limited areal extent and are generally less than 5 feet (1.5 m) thick. Consequently, they 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.

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. <u>Identified Resources</u> are specific bodies of coal whose location, rank, quality, and quantity are known from geologic evidence supported by specific measurements. <u>Undiscovered</u>

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 2,737.58 million short tons (2,483.53 million t). The total tonnage of federally owned, surface-minable Hypothetical coal is estimated to be 37.92 million short tons (34.40 million t). As shown by table 2, the total federally owned, underground-minable Reserve Base coal is estimated to be 1,141.79 million short tons (1,035.83 million t). The total federally owned, underground-minable Hypothetical coal is estimated to be 8.77 million short tons (7.96 million t). The total tonnage of surface- and underground-minable Reserve Base coal is 3,879.37 million short tons (3,519.36 million t), and the total of surface- and underground-minable Hypothetical coal is 46.69 million short tons (42.36 million t).

About 5 percent of the surface-minable Reserve Base tonnage is classed as Measured, 28 percent as Indicated, and 67 percent as Inferred. About 3 percent of the underground-minable Reserve Base tonnage is Measured, 20 percent is Indicated, and 77 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, or where lignite beds of the same thickness are overlain by 200 feet (61 m) or less of overburden. Because the coal in this quadrangle is subbituminous C in rank, or nearly so, a stripping limit of 500 feet (152 m) has been used for all coal beds. Likewise, the coal tonnages shown in tables 1 and 2 have been calculated as if the coal were all subbituminous. 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 subbituminous 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

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 low development potential abutting against areas of high development potential.

The coal development potential of the Federal coal lands for surface mining is shown on the Coal Development Potential map (pl. 27). Almost all of the

Federal coal lands in this quadrangle have a high development potential for surface mining. A few scattered tracts have a moderate or low development potential.

The lowermost major coal bed, the Brewster-Arnold, has no areas of high or moderate development potential. This coal bed has only wide areas of low development potential for surface mining extending from the bottom of the major stream valleys to the 500-foot overburden isopach, the arbitrarily assigned stripping limit.

The Wall coal bed (pl. 22) has wide areas of high development potential extending from the boundary of the unburned coal to the 10 mining-ratio contour or to the 500-foot isopach, the arbitrarily assigned stripping limit. There are small areas of moderate development potential between the 10 mining-ratio contour and the 500-foot overburden isopach in the western and northern parts of the quadrangle. There are no areas of low development potential for the Wall coal bed.

The Canyon coal bed (pl. 19) has rather limited areas of high development potential in the valleys or lower hill slopes extending from the boundary of the unburned coal to the 10 mining-ratio contour. There are narrow bands and some wider areas of moderate development potential on the lower hill slopes between the 10 and 15 mining-ratio contours. The Canyon coal bed has wide areas of low development potential extending from the 15 mining-ratio contour to the crests of the hills or, in the northwestern part of the quadrangle to the 500-foot overburden isopach.

The Dietz 3 coal bed (pl. 15) has quite narrow bands of high development potential on the hill slopes between the boundary of the unburned coal and the 10 mining-ratio contour. There is a narrow band of moderate development potential between the 10 and 15 mining-ratio contours and larger areas of low development potential extending from the 15 mining-ratio contour to the crests of the hills.

The Dietz 2 and the Dietz 2 and 3 coal beds combined (pl. 12) have quite wide areas of high development potential extending from the boundary of the coal to the 10 mining-ratio contour. There are narrow bands of moderate development potential between the 10 and 15 mining-ratio contours, and wider areas of low development potential extending from the 15 mining-ratio contour to the hill crests.

The Anderson (Dietz 1) coal bed (pl. 8) has relatively narrow bands of high development potential on the hill slopes extending from the boundary of the unburned coal to the 10 mining-ratio contour. There are narrow bands of moderate development potential between the 10 and 15 mining-ratio contours, and wider areas of low development potential extending from the 15 mining-ratio contour to the crests of the hills.

The Smith coal bed (pl. 5) has small areas of high, moderate, and low development potential in the northwestern part of the quadrangle.

As shown by the CDP map (pl. 27), about 95 percent of the Federal coal lands have a high development potential for surface mining, 2 percent have a moderate development potential, and 3 percent have a low 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 Taintor Desert 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				
Smith	1,170,000	900,000	1,360,000	3,430,000
Anderson	32,080,000	9,080,000	21,450,000	62,610,000
Dietz 2 and Dietz 2 and 3 combined	136,970,000	14,400,000	19,840,000	171,210,000
Dietz 3	17,770,000	9,230,000	9,880,000	36,880,000
Canyon	169,410,000	217,030,000	294,670,000	681,110,000
Wall	1,674,790,000	29,780,000	0	1,704,570,000
Brewster-Arnold	0	0	77,770,000	77,770,000
Total	2,032,190,000	280,420,000	424,970,000	2,737,580,000
Hypothetical Resource tonnage				
Dietz 2 and Dietz 2 and 3 combined	10,730,000	5,170,000	2,550,000	18,450,000
Brewster-Arnold	0	0	19,470,000	19,470,000
Total	10,730,000	5,170,000	22,020,000	37,920,000
Grand Total	2,042,920,000	285,590,000	446,990,000	2,775,500,000

Table 2.--Underground-minable coal resource tonnage (in short tons) by development-potential category for Federal lands in the Taintor Desert 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	14,990,000	14,990,000
Wall	0	0	908,200,000	908,200,000
Brewster-Arnold	0	0	218,600,000	218,600,000
Total	0	0	1,141,790,000	1,141,790,000
Hypothetical Resource tonnage				
Brewster-Arnold	0	0	8,770,000	8,770,000
Total	0	0	8,770,000	8,770,000
Grand Total	0	0	1,150,560,000	1,150,560,000

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