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

[Report includes 22 plates]

By

Colorado School of Mines Research Institute

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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 Birney SW quadrangle, Rosebud and Big Horn Counties, Montana, (22 plates; U.S. Geological Survey Open-File Report 79-645). 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

Most of the Birney SW 7 1/2-minute quadrangle is in southwestern Rosebud County, Montana, but a small portion of the northwestern part of the quadrangle is in eastern Big Horn County, Montana. It is about 48 miles (77 km) southeast of Hardin, Montana, a town in the valley of the Bighorn River near the confluence of the Bighorn River and the Little Bighorn River. Hardin is on U.S. Interstate Highway 90, U.S. Highway 212, and the Burlington Northern Railroad. The quadrangle is about 32 miles (51.5 km) northeast of Sheridan, Wyoming. Sheridan is also on U.S. Interstate Highway 90 and the Burlington Northern Railroad. A branch of the Burlington Northern Railroad runs from Sheridan about 19 miles (30.6 km) north-northeastward and terminates at the Decker coal mine in the Decker quadrangle which is about 14 miles (22.5 km) southwest of the Birney SW quadrangle.

Accessibility

The Birney SW quadrangle is accessible from U.S. Highway 212 at Ashland, Montana, by taking the Tongue River Road, an improved, graveled road, that proceeds southwestward about 32 miles (51.5 km) up the Tongue River valley to the southeastern corner of the quadrangle. This road continues westward and southward about 37 miles (59.5 km) to the Decker coal mine.

Physiography

The Birney SW 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 by youthful streams. Remnants of the plateau are preserved along drainage divides between entrenched streams. The Birney SW quadrangle is drained by the southeastward-flowing tributaries of the Tongue River which flows through the southeastern part of the quadrangle. The Tongue River flows northeastward and empties into the Yellowstone River at Miles City about 85 miles (136.8 km) northeast of the Birney SW quadrangle.

The highest elevation, about 4,180 feet (1,274 m), is on a flat-topped hill in the northeastern corner of the quadrangle. The lowest elevation, about 3,125 feet (952 m), is on the flood plain of the Tongue River in the southeastern corner of the quadrangle. Topographic relief is about 1,055 feet (322 m).

Climate

The climate of Rosebud and Big Horn 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 Birney SW quadrangle. About 1.5 square miles (5.76 square km) in the northwestern corner of the quadrangle are within the Northern Cheyenne Indian Reservation, which contains no Federal coal land. 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 as of 1977.

GENERAL GEOLOGY

Previous work

Baker (1929, pl. 28) mapped all of the Birney SW quadrangle, except the small tract contained in the Northern Cheyenne Indian Reservation, as part of the northward extension of the Sheridan coal field. Matson and Blumer (1973, pls. 6 and 7) remapped the principal coal beds in the same area.

The traces of coal outcrops shown by previous workers primarily 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 continental Fort Union Formation (Paleocene).

The Tongue River Member is made up mainly of yellow sandstone, sandy shale, carbonaceous shale, and coal. Much coal has burned along the outcrops, baking the overlying sandstone and shale and forming thick, reddish-colored clinker beds. The uppermost part of the Tongue River has been removed by erosion. The lower part of the member is beneath the surface of 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 Birney SW 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, 13, 16, and 29). 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 Birney SW 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. No economic coal beds are known to exist in the underlying Lebo Shale Member and Tullock Member of the Fort Union Formation.

The lowermost recognized coal bed in the Birney SW quadrangle is a local bed which occurs 39 feet (11.9 m) below the Flowers-Goodale coal bed. The Flowers-Goodale coal bed is overlain by a noncoal interval of about 500 to 600 feet (152 to 183 m), the Brewster-Arnold coal bed, an interval of about 100 to 130 feet (30.5 to 39.6 m) containing two thin coal beds, the Carlson coal bed, a noncoal interval of about 40 feet (12.2 m), a local coal bed, a noncoal interval of a few feet (about 1 to 2 m), the Wall coal-and-clinker bed, a noncoal interval of about 100 feet (30.5 m), a local coal bed, a noncoal interval of 80 feet (24.4 m), another local coal, a noncoal interval of about 40 feet (16 m), the Canyon coal bed, a noncoal interval of about 140 feet (42.7 m), a local coal bed, a noncoal interval of a few feet (1 to 2 m), the Dietz 2 coal bed, a noncoal interval of about 40 feet (12.2 m), and the Anderson (Dietz 1) coal-and-clinker 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 bed below the Flowers-Goodale coal bed

A local coal bed about 4 feet (1.2 m) in thickness which occurs 39 feet (11.9 m) below the Flowers-Goodale coal bed was penetrated by an oil well in the southeastern part of the quadrangle (pls. 1 and 3). Because this local coal bed is thin and is not known to occur at other places within the quadrangle, economic coal resources have not been assigned to this bed.

Flowers-Goodale coal bed

The Flowers-Goodale coal bed was named by Bass (1932, p. 53-54) for exposures at mines in the Ashland coal field about 40 miles (64 km) northeast of the Birney SW quadrangle in the Brandenberg quadrangle. In the Birney SW quadrangle, the Flowers-Goodale coal bed occurs about 180 feet (55 m) above the base of the Tongue River Member. This coal bed does not crop out in the Birney SW quadrangle, but it was penetrated by an oil-and-gas test hole in the southeastern part of the quadrangle (pls. 1 and 3). Based on this measurement and measurements in adjacent quadrangles, the isopach and structure map (pl. 19) shows that the Flowers-Goodale coal ranges from about 4 to 12 feet (1.2 to 3.7 m) in thickness and, in general, dips south to southwestward at an angle of less than 1 degree. The regional dip is modified near the center of the quadrangle by a gentle, southeastward-plunging anticline. There is no known chemical analysis of the Flowers-Goodale coal bed in the Birney SW quadrangle, but Matson and Blumer (]973, p. 121) report that a chemical analysis of the Flowers-Goodale coal from a depth of 53 to 62 feet (16 to 19 m) in coal test hole SH-7076, sec. 14, T. 1 S., R. 45 E., in the Cook Creek Reservoir quadrangle about 34 miles (55 km) northeast of the Birney SW quadrangle, shows ash 8.14 percent, sulfur 0.961 percent, and heating value 8,102 Btu per pound (18,845 kJ/kg) on an as-received basis. This heating value converts to about 8,820 Btu per pound (20,515 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Flowers-Goodale coal at that location is subbituminous C in rank. It is assumed that the Flowers-Goodale coal in the Birney SW quadrangle is similar and is also subbituminous C in rank.

Nance, Knobloch, and King coal beds

The Nance, Knobloch, and King coal beds, which have been recognized in the Birney quadrangle just east of the Birney SW quadrangle, have not been recognized in this quadrangle because they are either thin or absent. Therefore, economic coal resources have not been assigned to them in this quadrangle.

Brewster-Arnold coal bed

The Brewster-Arnold coal bed was named by Baker (1929, p. 37-38) from a small mine on the Brewster-Arnold ranch in sec. 23, T. 6 S., R. 42 E. in the Birney quadrangle, about 4 miles (6.4 km) east of the Birney SW quadrangle. In the Birney SW quadrangle, the Brewster-Arnold coal bed occurs about 500 to 600 feet (152 to 183 m) above the Flowers-Goodale coal bed. This coal bed is not exposed at the surface in the Birney SW quadrangle, but it has been penetrated by three test holes in the eastern part of the quadrangle (pls. 1 and 3). Based on these measurements and measurements in adjacent quadrangles, the isopach and structure map (pl. 16) shows that the Brewster-Arnold coal ranges from about 10 to 16 feet (3.0 to 4.9 m) in thickness and dips southeastward at an angle of less than 1 degree. Several small faults occur in the southwestern part of the quadrangle. Overburden on the Brewster-Arnold coal bed (pl. 17) ranges from about 0 feet at the outcrops to 800 feet (0-244 m) in thickness. There is no known chemical analysis of the Brewster-Arnold coal in the Birney SW 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 33.5 m) in coal test hole SH-7057, sec. 28, T. 5 S., R. 42 E., in the Birney quadrangle, about 3.5 miles (5.6 km) east of the Birney SW quadrangle, shows ash 12.525 percent, sulfur 0.533 percent, and heating value 7,979 Btu per pound (21,215 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Brewster-Arnold coal at that location is high lignite A in rank. Because of the proximity of that location to the Birney SW quadrangle, it is assumed that the Brewster-Arnold coal in this quadrangle is very near subbituminous C in rank because it occurs below the Wall coal bed of subbituminous C rank. Therefore, for purposes of tonnage calculations and the stripping limit delineation, we have considered that the Brewster-Arnold coal in this quadrangle is subbituminous C in rank.

Local coal beds above the Brewster-Arnold coal bed

Two local coal beds that do not crop out occur between the Brewster-Arnold and Carlson coal beds in a coal drill hole. Because the local coal beds are less than 5 feet (1.5 m) in thickness and have a limited areal extent, economic coal resources have not been assigned to them.

Carlson coal bed

The localized Carlson coal bed was first described by Baker (1929, p. 49) from outcrops on the Carlson Ranch located along Bull Creek in the northeastern part of the Birney SW quadrangle. The Carlson coal bed occurs about 100 to 130 feet (30.5 to 39.6 m) above the Brewster-Arnold coal bed and ranges from 3.3 to 5± feet (1.0 to 1.5 m) in thickness (pls. 1 and 3). Due to the limited areal extent, the thinness, and poor quality of the localized Carlson coal bed, maps have not been constructed for it, and economic coal resources have not been assigned to this coal bed.

Local coal bed

A local coal bed about 3 feet (0.9 m) thick occurs a few feet (a few meters) below the base of the Wall coal bed (pl. 3). Because of the limited areal extent and the thinness of the coal, economic coal resources have not been assigned to this local coal bed.

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 in the Birney quadrangle about 1 mile (1.6 km) east of the Birney SW quadrangle. The Wall coal occurs about 160 to 200 feet (49 to 61 km) above the Carlson coal bed and is present over more than half of the quadrangle (pls. 1 and 3). An extensive clinker bed marks the position of the Wall coal bed in most places near the surface. The isopach and structure map (pl. 13) shows that the Wall coal bed ranges from about 10 to 55 feet (3.0 to 16.8 m) in thickness and dips regionally southeastward at an angle of 1 degree or less. However, this dip is modified by low-relief folding. In the southwestern part of the quadrangle, faulting interrupts the continuity of the beds. Overburden on the Wall coal bed (pl. 14) ranges from 0 feet at the outcrops to about 560 feet (0-171 m) in thickness.

A chemical analysis of the Wall coal (Matson and Blumer, 1973, p. 39) from a depth of 150 to 159 feet (45.7 to 48.5 m) in coal test hole SH-110, sec. 33, T. 5 S., R. 41 E. in the northern part of the Birney SW quadrangle, shows ash 5.790 percent, sulfur 0.380 percent, and heating value 8,972 Btu per pound (20,869 kJ/kg) on an as-received basis. This heating value converts to about 9,523 Btu per pound (22,150 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Wall coal in this quadrangle is subbituminous C in rank.

Local coal beds above the Wall coal bed

Two local coal beds occur about 100 to 175 feet (30.5 to 53.3 m) above the Wall coal bed. The lower one is 3 feet (0.9 m) thick, and the higher one is unmeasured. Both local beds are of limited areal extent and have not been assigned economic resources.

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, possibly along the North Fork of Canyon Creek in this quadrangle. In the Birney SW quadrangle, the Canyon coal bed occurs about 160 to 240 feet (48.8 to 73.2 m) above the Wall coal bed. Its position near the surface is generally marked by a clinker bed formed by burning of the coal. The isopach and structure contour map (pl. 10) shows that the Canyon coal bed ranges from 3.8 to 20 feet (1.2 to 61 m) in thickness and, in general, dips southeastward at an angle of 1 degree or less. This dip is modified by low-relief folding and faulting. Overburden on the Canyon coal bed (pl. 11), where the coal is more than 5 feet (1.5 m) thick, ranges from 0 feet at the outcrops to about 450 feet (0-139 m) in thickness.

A chemical analysis of the Canyon coal (Matson and Blumer, 1973, p. 40) from a depth of 55 to 60 feet (16.8 to 18.3 m) in coal test hole SH-47, sec. 3, T. 6 S., R. 40 E., about 3.25 miles (5.2 km) west of the Birney SW quadrangle in the Taintor Desert quadrangle, shows ash 6.747 percent, sulfur 0.651 percent, and heating value 8,006 Btu per pound (18,622 kJ/kg) on an as-received basis. This heating value converts to about 8,585 Btu per pound (19,969 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Canyon coal at that location is subbituminous C in rank. Because of the proximity of that location to the Birney SW quadrangle, it is assumed that the Canyon coal in this quadrangle is similar and is also subbituminous C in rank.

Local coal bed above the Canyon coal bed

In the western part of the quadrangle, Baker (1929, pl. 28) mapped a discontinuous local coal bed above the Canyon coal bed and below the Anderson (Dietz 1) coal bed. In places this local bed is relatively close to the Anderson (Dietz 1) coal bed, and therefore has been correlated with the Dietz 2 coal bed. In places, particularly in the northwestern part of the quadrangle, the bed is closer to the Canyon coal bed and has been interpreted as a local coal bed. Where interpreted as a local coal bed it is thin or unmeasured and has not been assigned economic coal resources.

Dietz 2 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 1 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. Baker did not map the Dietz 2 and 3 coal beds, but in places shows a local coal bed at about their stratigraphic position. Matson and Blumer (1973, pl. 5B) mapped the Dietz 2 coal bed in the Taintor Desert quadrangle just west of the Birney SW quadrangle. The Dietz 2 coal bed has been extended eastward into the Birney SW quadrangle correlated in places with a local coal bed mapped by Baker (1929, pl. 28).

The Dietz 2 coal bed occurs in the western part of the Birney SW quadrangle about 140 to 240 feet (42.4 to 73.2 m) above the Canyon coal bed. The isopach and structure contour map of the Dietz 2 coal bed (pl. 7) shows that this coal bed ranges from about 5 to 20 feet (1.5 to 6.1 m) in thickness and is nearly horizontal. Overburden on the Dietz 2 coal bed (pl. 8) ranges from 0 feet at the outcrops to about 260 feet (0-79 m) in thickness.

A chemical analysis of the Dietz 2 coal at a depth of 96 to 106 feet (29 to 32 m) in drill hole SH-31, sec. 8, T. 7 S., R. 40 E. (Matson and Blumer, 1973, p. 34) about 5 miles (8.0 km) west-southwest of the Birney SW quadrangle 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 8,612 Btu per pound (20,032 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Dietz 2 coal at that location is subbituminous C in rank. Because of the proximity of that location to the Birney SW quadrangle, it is assumed that the Dietz 2 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 northward extension of the Sheridan coal field which includes the Birney SW 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

The type locality probably was along Anderson Creek in the southern part of the Spring Gulch quadrangle, about 7.5 miles (12 km) south of the Birney SW quadrangle.

Sheridan coal field, Wyoming, about 25 miles (40.3 km) south-southwest of the Birney SW quadrangle in the Sheridan quadrangle. The Dietz 1 coal bed is equivalent to the Anderson coal bed as mapped by Baker (1929, pl. 28).

In the Birney SW quadrangle, the Anderson (Dietz 1) coal bed occurs about 40 to 50 feet (12.2 to 15.2 m) above the Dietz 2 coal bed. A thick clinker bed formed by the burning of the Anderson coal bed caps the higher hills in the northern part of the quadrangle. There are only small patches of unburned coal remaining. As shown by the isopach and structure contour map (pl. 4), these small patches of Anderson coal range from about 5 to 20 feet (1.5 to 6.1 m) in thickness. Overburden on these areas (pl. 5) ranges from 0 feet to about 200 feet (0-61 m) in thickness. A chemical analyses of the Anderson coal (Matson and Blumer, 1973, p. 34) from a depth of 35 to 45 feet in coal test hole SH-31, sec. 8, T. 7 S., R. 8 E., about 5 miles (8 km) west-southwest of the Birney SW quadrangle in the Tongue River Dam quadrangle, indicates that this coal is lignite A in rank, although close to subbituminous C in rank.

COAL RESOURCES

Data from all publicly available drill holes and from surface mapping by others (see list of references) in this and adjacent quadrangles 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 1,592.24 million short tons (1,444.48 million t). The total tonnage of federally owned, surface-minable Hypothetical coal is estimated to be 60.05 million short tons (54.48 million t). As shown by table 2, the total federally owned, underground-minable Reserve Base coal is estimated to be 232.93 million short tons (211.31 million t). The total federally owned, underground-minable Hypothetical coal is estimated to be 34.81 million short tons (31.58 million t). The total tonnage of surface- and underground-minable Reserve Base coal is 1,825.17 million short tons (1,655.79 million t), and the total of surface- and underground-minable Hypothetical coal is 94.86 million short tons (86.06 million t).

About 3 percent of the surface-minable Reserve Base tonnage is classed as Measured, 21 percent as Indicated, and 76 percent as Inferred. None of the underground-minable Reserve Base tonnage is Measured, 4 percent is Indicated, and 96 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). 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 low development potential abutting against areas of high development potential.

The coal development potential that the Federal coal lands have for surface-mining methods is shown on the Coal Development Potential map (pl. 22). Most of the Federal coal lands in the quadrangle have a high development potential for surface mining.

The Flowers-Goodale coal bed (pl. 20) has no potential for surface mining in this quadrangle, as all of the coal in this bed is below the arbitrarily assigned stripping-limit depth of 500 feet (152.4 m) of overburden.

The Brewster-Arnold coal bed (pl. 17) has rather limited areas of high development potential in the bottoms of the valleys in the eastern part of the quadrangle extending from the outcrops of the coal to the 10 mining-ratio contour. There are narrow bands of moderate development potential higher in the valleys between the 10 and 15 mining-ratio contours. There are wide areas of low development potential under the hills extending from the 15 mining-ratio contour to the arbitarily assigned stripping limit at the 500-foot overburden isopach. There are considerable areas of no development potential for surface mining under the crests of the hills above the 500-foot overburden isopach.

The Wall coal bed (pl. 14) has wide to very wide areas of high development potential extending from the boundary of the coal to the 10 mining-ratio contour, or in the southern part of the quadrangle extending to the crests of the hills. In the central and northern parts of the quadrangle, there are relatively narrow bands of moderate development potential on the hill slopes extending from the 10 mining-ratio contour to the 15 mining-ratio contour or to the 500-foot overburden isopach. In the northeastern part of the quadrangle, there is a wide area of low development between the 15 mining-ratio contour and the 500-foot overburden isopach. In the central and northeastern parts of the quadrangle, there are also small areas of no development potential under the crests of the hills above the 500-foot overburden isopach.

The Canyon coal bed (pl. 11) has only small scattered areas of high development potential (mining-ratio values less than 10). There are similar small areas of moderate development potential (mining-ratio values 10 to 15) and wider areas of low development potential (mining-ratio values greater than 15).

The Dietz 2 coal bed (pl. 8) has small areas of high, moderate, and low development potential on two ridges in the west-central part of the quadrangle.

The Anderson (Dietz 1) coal bed (pl. 5) has practically no potential for surface mining, because this coal has been almost entirely burned. There are only very small isolated areas at the crests of hills where this coal has high and low development potential.

About 72 percent of the Federal coal lands in the quadrangle have a high development potential for surface mining, 12 percent has a moderate development potential, 15 percent has a low development potential, and 1 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 Birney SW quadrangle, Rosebud and Big Horn 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)	80,000	0	30,000	110,000
Dietz 2	14,140,000	4,000,000	3,180,000	21,320,000
Canyon	16,140,000	10,120,000	37,210,000	63,470,000
Wall	939,360,000	59,090,000	89,160,000	1,087,610,000
Brewster-Arnold	36,090,000	43,470,000	340,170,000	419,730,000
Total	1,005,810,000	116,680,000	469,750,000	1,592,240,000
Hypothetical Resource tonnage				
Anderson (Dietz 1)	350,000	0	170,000	520,000
Dietz 2	8,010,000	50,000	0	8,060,000
Brewster-Arnold	0	4,660,000	46,810,000	51,470,000
Total	8,360,000	4,710,000	46,980,000	60,050,000
Grand Total	1,014,170,000	121,390,000	516,730,000	1,652,290,000

Table 2.--Underground-minable coal resource tonnage (in short tons) by development-potential category for Federal lands in the Birney SW quadrangle, Rosebud and Big Horn 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				
Wall	0	0	35,580,000	35,580,000
Brewster-Arnold	0	0	79,820,000	79,820,000
Flowers-Goodale	0	0	117,530,000	117,530,000
Total	0	0	232,930,000	232,930,000
Hypothetical Resource tonnage				
Brewster-Arnold	0	0	17,800,000	17,800,000
Flowers-Goodale	0	0	17,010,000	17,010,000
Total	0	0	34,810,000	34,810,000
Grand Total	0	0	267,740,000	267,740,000

REFERENCES

Baker, A. A., 1929, The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Montana: U.S. Geological Survey Bulletin 806-B, p. 15-67.

Bass, N. W., 1924, Coal in Tongue River valley, Montana: U.S. Geological Survey Press Memoir 16748.

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

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

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

Taff, J. A., 1909, The Sheridan coal field, Wyoming: U.S. Geological Survey Bulletin 341, p. 123-150.

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

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

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