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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE HALF MOON HILL QUADRANGLE, BIG HORN COUNTY, MONTANA

[Report includes 36 plates]

By

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[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 Half Moon Hill quadrangle, Big Horn County, Montana, (36 plates; U.S. Geological Survey Open-File Report 79-648). 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 Half Moon Hill 7 1/2-minute quadrangle is in southeastern Big Horn County, Montana, about 45 miles (72 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, and U.S. Highway 212, the Burlington Northern Railroad. The Half Moon Hill quadrangle is about 9 miles (14.5 km) northwest of Decker, Montana, and 22 miles (35 km) north of Sheridan, Wyoming.

Accessibility

The Half Moon Hill quadrangle is accessible from Hardin, Montana, by going first southward on U.S. Interstate Highway 90 and then eastward on U.S. Highway 212 for a total of about 39 miles (63 km) to the Rosebud Creek Road located just west of Busby, Montana, then southward on the Rosebud Creek Road 19 miles (30.6 km) to the north border of the quadrangle. The quadrangle is also accessible from Decker, Montana, by going northward on the partially paved local highway 314 about 9 miles (14.5 km) to the southeastern corner of the quadrangle. Decker is about 18 miles (30 km) by road north of Sheridan, Wyoming, which is also on U.S. Interstate Highway 90. Unimproved roads and trails provide access to the remainder of the quadrangle. The nearest railroad is a spur line of the Burlington Northern Railroad at the Decker Mine, Montana, about 6 miles (9.6 km) southeast of the quadrangle.

Physiography

The Half Moon Hill quadrangle lies within the Missouri Plateau Division of the Great Plains physiographic province. Much of the landscape consists of steep to precipitous slopes which are located between narrow, flat-topped drainage divides and the flat-bottomed valleys of the entrenched streams. Remnants of the plateau are visible at the higher elevations. The northwest portion of the quadrangle is drained by Rosebud Creek which flows northward and empties into the Yellowstone River near the small town of Rosebud. The remainder of the quadrangle is drained by Fourmile Creek, Post Creek, Leaf Rock Creek, Monument Creek, and Spring Creek which flow southeastward into the Tongue River.

The highest elevation, about 4,723 feet (1,440 m), is north of Half Moon Hill in the north-central part of the quadrangle. The lowest elevation, about 3,780 feet (1,152 m), is shared by the North Fork of Monument Creek and Spring Creek in the southeastern part of the quadrangle. Topographic relief in the quadrangle is about 943 feet (287 m).

Climate

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

Land status

The Boundary and Coal Data Map (pl. 2) shows the land ownership status within the Half Moon Hill quadrangle. All of the quadrangle is within the Northern Powder River Basin Known 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 the Half Moon Hill quadrangle as part of the northward extension of the Sheridan coal field. Matson and Blumer (1973, pls. 5A, 5B, and 5C) also mapped the coal beds in the quadrangle. Traces of coal bed outcrops shown by previous workers on planimetric maps that 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 lower part of the Wasatch Formation (Eocene) and to the upper part of the underlying Tongue River Member, the uppermost member of the 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 outcrops, baking the overlying sandstone and shale and forming thick, reddish-colored clinker beds. The Tongue River Member reaches a thickness of about 2,000 feet (610 m) in the Half Moon Hill quadrangle (Lewis and Roberts, 1978). The underlying lower two members of the Fort Union Formation, the Lebo Shale Member and the Tullock Member, are continental in origin but do not contain any coal beds of economic value in this area.

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 Half Moon Hill quadrangle is in the western part of the Powder River structural basin. The coal beds and other strata in general dip southeastward or southward at an angle of less than 2 degrees. In places, this dip is modified by minor, low relief folds and by faults as shown by the structure contour maps (pls. 4, 7, 11, 15, 18, 21, 24, 27, 30, and 33). 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 Half Moon Hill quadrangle are shown in outcrop on the Coal Data Map (pl. 1) and in section on the Coal Data Sheet (pl. 3). The uppermost strata belong to the Wasatch Formation (Eocene), which consists of gray, lenticular beds of sandstone and shale. All of the known coal beds of economic importance belong to the upper part of the Tongue River Member of the Fort Union Formation of Paleocene age.

The lowermost recognized coal bed is a local coal bed, which is probably about 400 feet (122 m) above the base of the Tongue River Member. This local bed is overlain successively by a noncoal interval of about 300 feet (91 m), the King coal bed, a noncoal interval of about 75 feet (23 m), a local coal, a noncoal interval of about 75 feet (23 m), a local coal, a noncoal interval of about 40 to 50 feet (12 to 15 m), the Brewster-Arnold coal bed, a noncoal interval of about 90 to 120 feet (27 to 37 m), a local coal bed, a noncoal interval of about 20 to 40 feet (6 to 12 m), the Wall coal bed, a noncoal interval of about 70 to 160 feet (21 to 49 m), the Cook coal bed, a noncoal interval of about 50 to 90 feet (15 to 27 m), the Canyon coal bed, a noncoal interval of about 110 to 120 feet (33 to 37 m), the Dietz 2 and 3 coal beds, a noncoal interval of about 10 feet (3 m), a local coal bed, a noncoal interval of about 2 feet (0.6 m), the Anderson (Dietz 1) coal bed, a noncoal interval of 40 to 220 feet (12 to 67 m), the Smith coal bed, a noncoal interval of 40 to 90 feet (12 to 27 m), a local coal bed, a noncoal interval of about 80 feet (24 m), and the Roland of Baker (1929) 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).

King coal bed

The King coal bed was named by Warren (1959, p. 571), probably from exposures of the coal along King Creek in the Green Creek quadrangle, about 32 miles (51.5

km) northeast of the Half Moon Hill quadrangle. The King coal bed does not crop out within the quadrangle, but an oil test hole in sec. 9, T. 7 S., R. 39 E. penetrated 13 feet (4 m) of the King coal. The King coal bed is probably about 800 feet (244 m) above the base of the Tongue River Member. The isopach and structure contour map of the King coal bed (pl. 33) was constructed primarily by using the data in adjacent quadrangles. This map 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 a low angle where it is not affected by minor, low-relief folding and faulting. Overburden on the King coal bed (pl. 34) ranges from 650 to 1,360 feet (198 to 415 m) in thickness. There are no known publicly available chemical analyses of the King coal in or close to the Half Moon Hill quadrangle. However, it is assumed that the King coal is similar to other closely associated coals in the quadrangle and is subbituminous C in rank.

Local coal beds

Two local coal beds less than 5 feet (1.5 m) thick occur about 75 feet (23 m) and about 150 feet (46 m), respectively, above the King coal bed in an oil well in sec. 9, T. 7 S., R. 39 E. Economic resources have not been assigned to these thin local coal beds.

Brewster-Arnold coal bed

The Brewster-Arnold coal bed was first described by Baker (1929, p. 37 and 38, pl. 29) from exposures in a mine on the Brewster-Arnold Ranch (sec. 23, T. 6 S., R. 42 E.) in the Birney quadrangle about 17 miles (27 km) east-northeast of the Half Moon Hill quadrangle. In the Half Moon quadrangle the Brewster-Arnold coal bed occurs about 200 feet (61 m) above the King coal bed. The Brewster-Arnold coal bed does not crop out within the quadrangle; therefore, the isopach and structure-contour map of the Brewster-Arnold coal bed is based on information from two oil wells in the quadrangle and measurements from adjacent quadrangles.

The isopach and structure contour map of the Brewster-Arnold coal bed (pl. 30) shows that the coal bed is about 5 feet (1.5 m) thick and dips southeastward at a gentle angle. The continuity of the beds is interrupted by several small faults. Overburden on the Brewster-Arnold coal bed (pl. 31) ranges from 380 to 1,200 feet (116 to 366 m) in thickness. A chemical analysis of this coal from the Brewster-Arnold mine, in the Birney quadrangle, sec. 23, T. 6 S., R. 42 E. (Warren, 1959, p. 568) about 17 miles (27 km) east-northeast of the Half Moon Hill quadrangle shows ash 4.6 percent, sulfur 0.6 percent, and a heating value of 8,850 Btu per pound (20,585 kJ/kg) on an as-received basis. This heating value converts to about 9,277 Btu per pound (21,578 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Brewster-Arnold coal at this location is subbituminous C in rank.

Local coal bed

A local coal bed, 6 feet (1.8 m) thick, occurs 90 to 120 feet (27 to 37 m) above the Brewster-Arnold coal bed. Economic coal resources have not been assigned to this local coal bed because of limited data about its areal extent.

Wall coal bed

The Wall coal bed was named by Baker (1929, p. 37) probably from exposures of the coal along Wall Creek, a tributary of the Tongue River, about 13 miles (21 km) east of the Half Moon Hill in the Birney quadrangle. The Wall coal bed does not crop out within the quadrangle, but drill holes indicate that it occurs about 120 to 170 feet (37 to 52 m) above the Brewster-Arnold coal bed. The isopach and structure contour map of the Brewster-Arnold coal bed (pl. 27) indicates that the coal bed ranges from 15 to 60 feet (4.6 to 18 m) in thickness and dips southeastward at a low angle where it is not affected by minor faults and folds. Overburden on the Wall coal bed (pl. 28) ranges from 200 feet (61 m) to about 880 feet (268 m). There are no known publicly available chemical analyses of the Wall coal in or close to the Half Moon Hill quadrangle. However, it is assumed that the Wall coal is similar to other closely associated coals in the quadrangle and is subbituminous C in rank.

Cook coal bed

The Cook coal bed was first described by Bass (1932, p. 79) from exposures in the Cook Creek Reservoir quadrangle about 45 miles (72 km) northeast of the Half Moon Hill quadrangle. In the Half Moon Hill quadrangle the Cook coal bed occurs about 70 to 160 feet (21 to 49 m) above the Wall coal bed. The Cook coal bed does not crop out within the Half Moon Hill quadrangle; therefore, the isopach and structure contour map of the Cook coal bed (pl. 24) was based on drill hole data and measurements from adjacent quadrangles. This map indicates that the Cook coal bed ranges from about 5 to about 20 feet (1.5 to 6.1 m) in thickness and, in general, dips southeastward at a gentle angle except where it is affected by a broad, southeastward-plunging syncline. The overburden on the Cook coal bed (pl. 25) ranges from about 300 to 840 feet (91 to 256 m) in thickness.

There are no known, publicly available chemical analyses of the Cook coal bed in or close to the Half Moon Hill quadrangle. However, it is assumed that the Cook coal is similar to other closely associated coals in the quadrangle and is subbituminous C 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. Although a type locality was not given, it probably is along Canyon Creek in northern Spring Gulch quadrangle, about 9 miles (14.5 km) to the east of this quadrangle. In the Half Moon Hill quadrangle, the Canyon coal bed occurs 50 to 90 feet (15 to 27 m) above the Cook coal bed. Several small outcrops of Canyon coal are located in the northwestern and northeastern portions of the quadrangle. The isopach and structure contour map (pl. 21) shows that the Canyon coal bed ranges from about 5 to 25 feet (1.5 to 7.6 m) in thickness and dips southeastward at a gentle angle where it is not affected by minor, low-relief folds and small faults. Overburden on the Canyon coal bed (pl. 22) ranges from zero along the outcrops in the northern part of the quadrangle to about 720 feet (219 m).

There is no known, publicly available chemical analyses of the Canyon coal in the Half Moon Hill quadrangle. However, a chemical analysis of this coal from a depth of 104 to 113 feet (32 to 34 m) in coal test hole SH-36, sec. 19, T. 6 S., R. 39 E., about 4.5 miles (7.2 km) north of the Half Moon Hill quadrangle in the Kirby quadrangle (Matson and Blumer, 1973, p. 34) shows ash 3.243 percent, sulfur 0.224 percent, and heating value 9,113 Btu per pound (21,197 kJ/kg) on an as-received basis. This heating value converts to about 9,418 Btu per pound (21,906 kJ/kg) on a moist, mineral-matter-free basis, indicating that the coal at this location is subbituminous C in rank. Because of the proximity of this location to the Half Moon Hill quadrangle, it is assumed that the Canyon coal is similar and is also subbituminous C in rank.

Dietz 2 and 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, Wyoming. The coal bed which Baker (1929, pl. 28) mapped as the Anderson coal bed in the Half Moon Hill quadrangle was remapped by Matson and Blumer (1973, pl. 5B) as the Dietz coal beds (upper or combined benches). Matson and Blumer (1973, pl. 5A) mapped a higher bed in the northern part of the quadrangle as the Anderson coal bed. Faults, unsuspected by Baker, were revealed by coal test holes drilled to support the field mapping of Matson and Blumer. The compiled maps accompanying this report follow the interpretation of Matson and Blumer (1973, pls. 5A and 5B). We believe that the two combined Dietz benches mapped by Matson and Blumer are equivalent to the Dietz 2 and 3 of Taff, and that the Anderson coal bed is equivalent to the Dietz 1 of Taff.

In the Half Moon Hill quadrangle the Dietz 3 coal bed occurs about 100 to 200 feet (30 to 61 m) above the Canyon coal bed. The isopach and structure contour map of the Dietz 3 coal bed (pl. 18), based principally on measurements in adjacent quadrangles, shows that this coal ranges from about 10 to 15 feet (3.0 to 4.6 m) in thickness and, where it is not affected by small faults and minor, low-relief folding, dips southeastward at a gentle angle. Overburden on the Dietz 3 coal bed (pl. 19) ranges from zero at the outcrops to about 500 feet (152 m) in thickness.

There is no known, publicly available chemical analysis of the Dietz 3 coal bed in the Half Moon Hill quadrangle. However, a chemical analysis of this coal from a depth of 152 to 162 feet (46.3 to 49.4 m) in coal test hole SH-107, sec. 30, T. 7 S., R. 40 E., about 0.4 miles (0.6 km) east of this quadrangle in the Tongue River Dam quadrangle (Matson and Blumer, 1973, p. 35) shows ash 3.608 percent, sulfur 0.201 percent, and heating value of 8,950 Btu per pound (20,818 kJ/kg) on an as-received basis. This heating value converts to about 9,285 Btu per pound (21,597 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Dietz 3 coal at this location is subbituminous C in rank. Because of the proximity of this location to the Half Moon Hill quadrangle, it is assumed that the Dietz 3 coal in this quadrangle is similar and is also subbituminous C in rank.

In the western part of the Half Moon Hill quadrangle, the Dietz 2 and Dietz 3 coal beds are combined into a single thick coal bed, but in the eastern part of the quadrangles the beds are separated by a rock interval of up to 80 feet (24.4 m). In this eastern area the Dietz 2 coal bed (pl. 14) ranges from about 15 to 30 feet (4.6 to 9.2 m) in thickness. The thickness of the combined Dietz 2 and 3 coal beds ranges from about 25 to 45 feet (7.6 to 13.7 m). The structure contour map of the Dietz 2 coal bed (pl. 15) shows that the coal bed dips southeastward at an angle of about 1 degree except where this dip is interrupted by low-relief folding or faulting. Overburden on the Dietz 2 coal bed (pl. 16) ranges from zero at the outcrops to about 560 feet (171 m) in thickness.

A chemical analysis of the Dietz 2 coal from a depth of 240 to 247 feet (73 to 75 m) in coal test hole BMC-727, sec. 36, T. 8 S., R. 38 E., about 800 feet (244 m) west of the Half Moon Hill quadrangle in the Bar V Ranch quadrangle (Matson and Blumer, 1973, p. 20) shows ash 2.863 percent, sulfur 0.008 percent, and heating value 9,305 Btu per pound (21,643 kJ/kg) on an as-received basis. This heating value converts to 9,579 Btu per pound (22,281 kJ/kg), indicating that the Dietz 2 coal at this location is subbituminous B in rank, although close to subbituminous C. Because of the proximity of this location to the Half Moon Hill quadrangle, it is assumed that the Dietz 2 coal in this quadrangle is similar and is either subbituminous B or C in rank.

Anderson (Dietz 1) coal bed and the combined Anderson (Dietz 1), Dietz 2, and Dietz 3 coal beds

The Anderson coal bed was first described by Baker (1929, p. 35) from exposures in the northward extension of the Sheridan coal which includes the Half Moon Hill quadrangle. The Dietz 1 coal bed was named by Taff (1909, p. 129) for coal exposures at the No. 1 mine at the old mining town of Dietz in the Sheridan coal field, Wyoming, about 17 miles (27.4 km) south of the Half Moon Hill quadrangle in the Acme quadrangle. The Dietz 1 coal bed is equivalent to the Anderson coal bed as mapped by Baker (1929, p. 28) and Matson and Blumer (1973, pl. 1).

The Anderson (Dietz 1) coal bed has been extensively burned near the surface in the Half Moon Hill quadrangle. The isopach map (pl. 10) shows that the Anderson (Dietz 1) coal bed ranges from about 5 to 45 feet (1.5 to 13.7 m) in thickness. The combined Anderson (Dietz 1), Dietz 2, and Dietz 3 coal beds range from about 60 to 82 feet (18.3 to 25 m) in thickness. The structure contour map of the Anderson (Dietz 1) coal bed (pl. 11) shows that the coal bed dips southeastward at an angle of 1 or 2 degrees except where this dip is modified by low-relief folding or faulting. Overburden on the Anderson (Dietz 1) coal bed (pl. 12) ranges from zero at the outcrops to about 440 feet (134 m) in thickness.

A chemical analysis of the Anderson coal bed at a depth of 142 to 148 feet (12.8 to 45.1 m) in coal test hole SH-7017, sec. 12, T. 8 S., R. 38 E., about 0.25 mile (0.4 km) west of the Half Moon Hill quadrangle in the Bar V Ranch NE quadrangle (Matson and Blumer, 1973, p. 20) shows ash 4.255 percent, sulfur 0.250 percent, and heating value 9,003 Btu per pound (20,941 kJ/kg) on an as-received basis. This heating value converts to about 9,403 Btu per pound (21,871 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Anderson (Dietz 1) coal at this location is subbituminous C in rank. Because of the proximity of this location to the Half Moon Hill quadrangle, it is assumed that the Anderson (Dietz 1) coal in this quadrangle is similar and is also subbituminous C in rank.

Smith coal bed

The Smith coal bed was named by Taff (1909, p. 130,141) for exposures in the Smith mine in sec. 10, T. 56 N., R. 84 W. about 19 miles (30.6 km) south of the Half Moon Hill quadrangle and about 1 mile (1.6 km) north of Sheridan, Wyoming. In the Half Moon Hill quadrangle the Smith coal occurs about 40 to 220 feet (12 to 67 m) above the Anderson (Dietz 1) coal bed. The isopach and structure contour map of the Smith coal bed (pl. 7) shows that this coal ranges from about 5 to 25 feet (1.5 to 7.6 m) in thickness and dips southward and southeastward at a gentle angle where it is not affected by faults and minor, low-relief folds. Overburden on the Smith coal bed (pl. 8) ranges from zero at the outcrops to about 340 feet (104 m).

There is no known, publicly available chemical analysis of the Smith coal in the Half Moon Hill quadrangle. However, a chemical analysis of this coal in coal test hole SH-7022, sec. 10, T. 9 S., R. 41 E., about 11 miles (17.7 km) southeast of this quadrangle in the Holmes Ranch quadrangle (Matson and Blumer, 1973, p. 25) shows ash 6.849 percent, sulfur 0.591 percent, and heating value 8,272 Btu per pound (19,241 kJ/kg) on an as-received basis. This heating value converts to about 8,880 Btu per pound (20,655 kJ/kg) on a moist, mineral-matter-free basis, indicating that the coal at this location is subbituminous C in rank. Because of the proximity of this location to the Half Moon Hill quadrangle, it is assumed that the Smith coal in this quadrangle is similar and is also subbituminous C in rank.

Local coal bed

A local coal bed, 2.4 feet (0.7 m) thick occurs about 90 feet (27 m) above the Smith coal bed in the Half Moon Hill quadrangle. Economic coal resources have not been assigned to this thin local coal bed.

Roland of Baker (1929) coal bed

The Roland of Baker (1929) coal bed was first described by Baker (1929, p. 34) in the northward extension (Montana part) of the Sheridan coal field in a mistaken correlation with the Roland coal bed of Taff (1909) in the Sheridan, Wyoming, coal field. Baker's Roland coal bed reaches a maximum thickness of about 17 feet (5.2 m) at the John Bell coal mine in sec. 8, T. 9 S., R. 39 E. in the Pearl School quadrangle, about 5 miles (8 km) south of the Half Moon Hill quadrangle. In the Half Moon Hill quadrangle, the Roland of Baker (1929) coal bed occurs about 170 feet (52 m) above the Smith coal bed. In the southwestern part of the quadrangle, a clinker bed formed by the burning of this coal crops out on the lower slopes of the mesa (pl. 1A). The isopach and structure contour map of the Roland of Baker (1929) coal bed (pl. 4) shows that this bed ranges from 3.7

to about 14 feet (1.1 to 4.3 m) in thickness and dips southward and eastward at a gentle angle where it is not affected by faults and minor, low-relief folds. Overburden on the Roland of Baker (1929) coal bed (pl. 5) ranges from zero at the outcrops to about 120 feet (37 m) in thickness.

There is no known, publicly available chemical analysis of the Roland of Baker (1929) coal bed in the Half Moon Hill quadrangle. However, a chemical analysis of this coal in coal test hole SH-7033, sec. 34, T. 8 S., R. 39 E., about 1.5 miles (2.4 km) south of this quadrangle in the Pearl School quadrangle (Matson and Blumer, 1973, p. 29) shows ash 4.601 percent, sulfur 0.259 percent, and heating value 8,082 Btu per pound (18,799 kJ/kg) on an as-received basis. This heating value converts to about 8,472 Btu per pound (19,705 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Roland coal at this location is subbituminous C in rank. Because of the proximity of this location to the Half Moon Hill quadrangle, it is assumed that the Roland of Baker (1929) coal in this quadrangle is similar and is subbituminous C in rank.

COAL RESOURCES

Data from all publicly available drill holes and from surface mapping by others (see list of references) were used to construct outcrop, isopach, and structure contour maps of the coal beds in this quadrangle.

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

Undiscovered Resources are bodies of coal which are surmised to exist on the basis of broad geologic knowledge and theory.

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

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

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

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.

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. 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.

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). 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 3,340.49 million short tons (3,030.49 million t). The total tonnage of federally owned, surface-minable

Hypothetical coal is estimated to be 9.16 million short tons (8.31 million t). As shown by table 2, the total, federally owned, underground-minable Reserve Base coal is estimated to be 1,820.85 million short tons (1,651.88 million t). The total, federally owned, underground-minable Hypothetical coal is estimated to be 454.27 million short tons (412.11 million t). The total tonnage of surface- and underground-minable Reserve Base coal is 5,161.34 million short tons (4,682.37 million t), and the total of surface- and underground-minable Hypothetical coal is 463.43 million short tons (420.42 million t).

About 5 percent of the surface-minable Reserve Base tonnage is classed as Measured, 24 percent as Indicated, and 71 percent as Inferred. About 1 percent of the underground-minable Reserve Base tonnage is Measured, 8 percent is Indicated, and 91 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. This thickness of overburden is the assigned stripping limit for surface mining of multiple beds of subbituminous coal in this area. Areas having a potential for surface mining were assigned a high, moderate, or low development potential based on their mining-ratio values (cubic yards of overburden per short ton of recoverable coal).

The formula used to calculate mining-ratio values for 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 that the Federal coal lands have for surface-mining methods is shown on the Coal Development Potential Map (pl. 36). Most of the Federal coal lands have a high development potential for surface mining.

The King coal bed (pl. 34) has no development potential for surface-mining methods because all of the coal 5 feet (1.5 m) or more thick is found below the stripping limit.

The Brewster-Arnold coal bed (pl. 31) has a low development potential for surface mining because all of the mining-ratio values are greater than 15.

The Wall coal bed (pl. 28) has no development potential for surface mining over most of the quadrangle. There are a few scattered areas of low and moderate development potential in the northwestern, northeastern, and south-central parts of the quadrangle, and one area of high development potential in the northwestern part of the quadrangle.

The Cook coal bed (pl. 25) has a low development potential for surface mining because all of the mining-ratio contour values are greater than 15.

Most of the Canyon coal bed has a low development potential for surface mining except in the central part of the quadrangle where there is some moderate development potential and in the northern part of the quadrangle where there are bands of moderate and high development potential.

The Dietz 3 coal bed (pl. 19) has fairly extensive areas of high development potential for surface mining on a considerable part of the Federal lands in the eastern part of the quadrangle adjacent to the streams and extending from the boundary of the coal to the 10 mining-ratio contour. There are also fairly extensive areas of moderate development on the hill slopes between the 10 and 15 mining-ratio contours. Areas of low development potential occur under prominent hills and isolated buttes.

The Dietz 2 coal bed and the combined Dietz 2 and 3 coal beds (pl. 16) are extensively burned in the southeastern quarter of the quadrangle, but in the remainder of the quadrangle these coal beds generally have extensive areas of high development potential for surface mining extending from the boundary of the coal to the 10 mining-ratio contour. There are also extensive areas of moderate development potential extending from the 10 mining-ratio contour to the crests of the hills in many places. Some of the higher hills are underlain by areas of low development potential above the 15 mining-ratio contour.

The Anderson (Dietz 1) coal bed and the combined Anderson (Dietz 1), Dietz 2, and Dietz 3 coal beds (pl. 12) are absent over wide areas due to extensive burning of the coal. However, there are still wide areas of high development potential for surface mining between the boundary of the unburned coal and the 10 mining-ratio contour. There are generally narrow bands of moderate development potential on the hill slopes between the 10 and 15 mining-ratio contours. The higher hills are capped by areas of low development potential above the 15 mining-ratio contour.

The Smith coal bed (pl. 8) has rather limited areas of high development potential for surface mining on the hills between the boundary of the coal and the 10 mining-ratio contour. This coal bed also has narrow bands of moderate development potential between the 10 and 15 mining-ratio contours and wider areas of low development potential extending above the 15 mining-ratio contour to the crests of the hills.

The Roland of Baker (1929) coal bed (pl. 5) is confined to a small tract in the southwestern part of the quadrangle. In this area the coal has mostly high and moderate development potential for surface mining with minor amounts of low development potential.

About 83 percent of the Federal coal lands in the quadrangle have a high development potential for surface mining, 9 percent have a moderate development potential, and 8 percent have a low 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 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 Half Moon Hill quadrangle, Big Horn County, Montana

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

Coal bed	High development potential (0-10 mining ratio)	Moderate development potential (10-15 mining ratio)	Low development potential (>15 mining ratio)	Total
Reserve Base tonnage				
Roland of Baker (1929)	3,200,000	1,090,000	1,300,000	5,590,000
Smith	125,540,000	55,980,000	58,800,000	240,320,000
Anderson (Dietz 1)	450,200,000	96,190,000	57,530,000	603,920,000
Dietz 2 and 3	661,190,000	183,350,000	45,400,000	889,940,000
Dietz 3	114,000,000	119,350,000	53,610,000	286,960,000
Canyon	58,110,000	26,910,000	537,430,000	622,450,000
Cook	0	4,410,000	277,530,000	281,940,000
Wall	49,940,000	279,460,000	78,980,000	408,380,000
Brewster-Arnold	0	0	990,000	990,000
Total	1,462,180,000	766,740,000	1,111,570,000	3,340,490,000
Hypothetical Resource tonnage				
Anderson (Dietz 1)	250,000	0	0	250,000
Dietz 2 and 3	440,000	0	0	440,000
Canyon	0	0	4,110,000	4,110,000
Wall	0	0	4,360,000	4,360,000
Total	690,000	0	8,470,000	9,160,000
Grand Total	1,462,870,000	766,740,000	1,120,040,000	3,349,650,000

Table 2.--Underground-minable coal resource tonnage (in short tons) by development-potential category for Federal lands in the Half Moon Hill quadrangle, Big Horn County, Montana

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

Coal bed	High Development potential	Moderate development potential	Low development potential	Total
Reserve Base tonnage				
Dietz 2	0	0	30,530,000	30,530,000
Dietz 3	0	0	280,000	280,000
Canyon	0	0	88,810,000	88,810,000
Cook	0	0	120,890,000	120,890,000
Wall	0	0	1,419,620,000	1,419,620,000
Brewster-Arnold	0	0	76,200,000	76,200,000
King	0	0	84,520,000	84,520,000
Total	0	0	1,820,850,000	1,820,850,000
Hypothetical Resource tonnage				
Canyon	0	0	24,440,000	24,440,000
Cook	0	0	300,000	300,000
Wall	0	0	181,000,000	181,000,000
Brewster-Arnold	0	0	8,900,000	8,900,000
King	0	0	239,630,000	239,630,000
Total	0	0	454,270,000	454,270,000
Grand Total	0	0	2,275,120,000	2,275,120,000

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