UNITED STATES DEPARTMENT OF THE INTERIOR

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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE HOLMES RANCH QUADRANGLE, BIG HORN COUNTY, MONTANA

[Report includes 37 plates]

By

Colorado School of Mines Research Institute

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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 Holmes Ranch quadrangle, Big Horn County, Montana, (37 plates; U.S. Geological Survey Open-File Report 79-649). 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 Holmes Ranch quadrangle is in southeastern Big Horn County, Montana. It is about 58 miles (93 km) southeast of Hardin, Montana, a town in the valley of the Bighorn River valley. Hardin is on U.S. Interstate Highway 90 and the Burlington Northern Railroad. The quadrangle is about 18 miles (29 km) northeast of Sheridan, Wyoming. Sheridan is also on U.S. Interstate Highway 90 and the Burlington Northern Railroad. A branch of this railroad runs from Sheridan about 19 miles (30.6 km) north-northeastward and terminates at the Decker coal mine, about 3 miles (4.8 km) west of the Holmes Ranch quadrangle.

Accessibility

The Holmes Ranch quadrangle is accessible from Sheridan, Wyoming, by traveling northward on U.S. Interstate Highway 90 a distance of 6 miles (9.6 km), then continuing northeastward for about 18 miles (29 km) on a paved road to Decker, Montana, then about 5.5 miles (8.8 km) northeastward on an improved graveled road to the western boundary of the quadrangle. The quadrangle is accessible from Ashland, Montana, by taking an improved graveled road that leads southwestward about 50 miles (80 km) to Decker, then going northeastward about 5.5 miles (8.8 km) to the western boundary of the quadrangle.

Physiography

The Holmes Ranch quadrangle lies within the Missouri Plateau Division of the Great Plains Physiographic province. Most of the quadrangle is covered by a broadly rolling upland surface that is highly dissected by tributaries of Deer Creek, Coal Creek, and Corral Creek, which flow westward into the northeastward-flowing Tongue River 1.5 to 4 miles (2.4 to 6.4 km) west of the quadrangle. The highest elevation in the quadrangle, about 4,360 feet (1,329 m), is at the southern border of the quadrangle in the Badger Hills. The lowest elevation, about 3,460 feet (1,055 m), is along the flood plain of Deer Creek at the western border of the quadrangle. Topographic relief in the quadrangle is about 900 feet (274 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 Holmes Ranch quadrangle. All of the quadrangle is within the Northern

Powder River Basin Known Recoverable Coal Resource Area. Most of the coal land in this quadrangle is federally owned. The map shows the land covered by a Federal coal lease as of 1977.

GENERAL GEOLOGY

Previous work

Baker (1929, pl. 29) mapped the Holmes Ranch quadrangle as part of the northward extension of the Sheridan coal field. Ayler, Smith, and Deutman (1969, figs. 2, 3, 4, and 6) mapped the strippable coal deposits in the Holmes Ranch quadrangle, based on Baker's work and coal company data, as part of the strippable coal reserves of Montana. Matson and Blumer (1973, pls. 2 and 3) remapped the principal coal beds as parts of the Deer Creek and Roland coal deposits. The U.S. Geological Survey and the Montana Bureau of Mines and Geology (1976) made a preliminary report of coal drill-hole data and chemical analyses of coal beds in the Holmes Ranch quadrangle and the surrounding area. Culbertson, Kent, and Mapel (1979) made preliminary diagrams showing correlations of coal beds in the Fort Union and Wasatch Formations across the Northern Powder River Basin, northeastern Wyoming and southeastern Montana, including the Holmes Ranch quadrangle. Doelger and Fahy (U.S. Geological Survey unpublished report) prepared a preliminary version of a geologic map of the Holmes Ranch quadrangle, but it is still in preliminary form and has not been prepared for publication.

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

The geological interpretation of the coal beds shown in this quadrangle is based upon all publicly available data from this and adjacent quadrangles, supplemented by the personal geologic knowledge of the area held by the geologist(s) compiling this set of maps. Therefore, the coal-isopach lines, the structure-contour lines, the overburden-isopach lines, and the fault traces may not tie exactly at the quadrangle boundaries with the corresponding lines shown by other mappers on previously published maps or adjacent 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 Wasatch Formation (Eocene) and to the underlying upper part of the Tongue River Member, the uppermost member, of the Fort Union Formation (Paleocene). The Wasatch Formation consists of brownish-gray to light-gray, fine- to coarse-grained lenticular beds of sandstone and interbedded gray shale and some coal. Near its base is a bed of molluscan-bearing coquinoid limestone 1 to 2 feet (0.3 to 0.6 m) thick. In the Holmes Ranch quadrangle, the erosional remnant of the Wasatch Formation is only about 50 to 100 feet (15 to 30 m) in thickness and does not contain mapped coal beds. The base of the Wasatch Formation is at the top of the thick and persistent Roland coal bed as defined by Baker (1929).

The Tongue River Member of the Fort Union Formation is made up mainly of yellow sandstone, sandy shale, carbonaceous shale, and coal. Coal has burned along outcrops, baking the overlying sandstone and shale and forming thick, reddish-colored clinker beds. The Tongue River Member is about 2,400 feet (731 m) thick in the area (Lewis and Roberts, 1978). All of the coal beds described in this report belong to the Tongue River Member. The Lebo Shale Member of the Fort Union Formation, which underlies the Tongue River Member, contains a few thin local coal beds elsewhere in the Northern Powder River Basin, but their existence in this quadrangle is uncertain. Underlying the Lebo Shale Member is the basal Tullock Member which contains thin but persistent coal beds elsewhere, but their existence in this quadrangle is uncertain.

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 Holmes Ranch quadrangle is in the northwestern part of the Powder River structural basin. The coal beds and other strata dip regionally southward at an angle of about 1 degree. However, this dip is modified by minor, low-relief folds. In the southern part of the quadrangle, the continuity of the beds is interrupted by several northeast-trending faults as shown by the structure contour maps (pls. 5, 8, 12, 16, 22, 25, 28, 31, and 34). 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 Holmes Ranch 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 Holmes Ranch quadrangle is the Kendrick coal bed which occurs about 5 to 60 feet (1.5 to 18 m) above the base of the Tongue River Member. The Kendrick coal bed is overlain successively by a noncoal interval of about 500 to 800 feet (152 to 244 m), a local coal bed, a noncoal interval of about 130 to 180 feet (40 to 55 m), the Brewster-Arnold coal bed, a noncoal interval of about 130 to 150 feet (40 to 46 m), a local coal bed, a noncoal interval of about 130 feet (40 m), the Wall coal bed, a noncoal interval of about 80 to 100 feet (24 to 30 m), a local coal bed, a noncoal interval of about 40 feet (12 m), the Cook coal bed, a noncoal interval of about 160 feet (49 m), the Canyon coal bed, a predominantly noncoal interval of about 240 feet (73 m) with a local coal bed near the top of the interval, the Dietz 3 coal bed, a noncoal interval of about 25 to 40 feet (8 to 12 m), the Dietz 2 coal bed, a noncoal interval of about 10 to 120 feet (3 to 37 m), the Anderson (Dietz 1) coal bed, a predominantly noncoal interval of about 60 to 170 feet (37 to 52 m), with a local coal bed near the middle of the interval, the Smith coal bed, a predominantly noncoal interval of about 190 to 300 feet (58 to 91 m), with a thin local coal bed in the upper part of the interval, 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).

Kendrick coal bed

The Kendrick coal bed was named by Culbertson and Klett (1979) for a coal bed encountered at the 2,240-foot depth in the Amoco Production Co., 1 Kendrick Ranch "B" well, sec. 29, T. 58 N., R. 79 W., Sheridan County, Wyoming. The well is located in the Roundup Draw quadrangle of northern Wyoming, about 11 miles (17.7 km) east-southeast of the Holmes Ranch quadrangle. In the Holmes Ranch quadrangle, the Kendrick coal occurs about 5 to 60 feet (1.5 to 18 m) above the base of the Tongue River Member. Correlation of the Kendrick coal bed in the Holmes Ranch quadrangle with the type locality is uncertain because of the distance involved and the lack of information. An oil-and-gas test hole in the northwestern part of the quadrangle penetrated well below the stratigraphic interval containing the Kendrick coal elsewhere, but the Kendrick coal bed could not be recognized on the log. Information necessary to construct the isopach and structure contour map (pl. 34) was projected in from the Decker quadrangle immediately to the west. This map does not show the Kendrick in the vicinity of the oil-and-gas test hole. The map indicates that the Kendrick coal bed ranges in thickness from about 5 to 7 feet (1.5 to 2.1 m) and has a general eastward dip of about 4 degrees. The general dip is modified by a gentle, southeast-plunging syncline and several northeast-trending faults. Overburden on the Kendrick coal bed ranges in thickness from 1,700 to 2,100 feet (518 to 640 m).

Local coal bed above the Kendrick coal bed

A local coal bed about 5 feet (1.5 m) thick occurs about 500 to 800 feet (152-244 m) above the Kendrick coal bed. Because this coal bed is thin, probably of limited areal extent, and deeply buried, economic coal resources have not been assigned to this bed.

Brewster-Arnold coal bed

The Brewster-Arnold coal bed was named by Baker (1929, p. 37-38, pl. 29) from a small mine on the Brewster-Arnold ranch in sec. 23, T. 6 S., R. 42 E., about 13 miles (21 km) north-northeast of the Holmes Ranch quadrangle in the Birney quadrangle. In the Holmes Ranch quadrangle, the Brewster-Arnold coal bed occurs about 260 to 680 feet (79 to 207 m) above the Kendrick coal bed. This coal is not exposed at the surface in the Holmes Ranch quadrangle, but has been penetrated by an oil-and-gas test hole in the northwestern part of the quadrangle (pls. 1 and 3). Based on this measurement and measurements in adjacent quadrangles, the isopach and structure-contour map (pl. 31) shows that the Brewster-Arnold coal ranges from 5 to 10 feet (1.5 to 3 m) in thickness and dips south-southwestward at an angle of less than 1 degree. Two small, northeast-trending faults interrupt the continuity of the coal bed near the center of the quadrangle. Overburden on the Brewster-Arnold coal bed (pl. 32) ranges from about 1,000 to 1,400 feet (305 to 427 m) in thickness. There is no known chemical analysis of the Brewster-Arnold coal in the Holmes Ranch 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 m) in coal test hole SH-7057, sec. 28, T. 5 S., R. 42 E., in the Birney 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 (21,215 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Brewster-Arnold coal at that location is subbituminous C in rank. Because of the proximity of that location to the Holmes Ranch quadrangle, it is assumed that the Brewster-Arnold coal in this quadrangle is similar and is also subbituminous C in rank.

Local coal bed above the Brewster-Arnold coal bed

A thin, local coal bed that does not crop out occurs about midway between the Brewster-Arnold coal bed and the overlying Wall coal bed. Because this coal bed is only 6 feet (1.8 m) thick and has a limited areal extent, economic coal resources have not been assigned to this 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 10 miles (16 km) north-northeast of the Holmes Ranch quadrangle. The Wall coal occurs about 270 to 290 feet (82 to 88 m) above the Brewster-Arnold coal bed and occurs throughout most of the quadrangle. The Wall coal bed does not crop out but was penetrated by an oil-and-gas test hole in the northwestern part of the quadrangle. Based on this measurement and measurements in adjacent quadrangles, the isopach and structure contour map (pl. 28) shows that the Wall coal bed ranges from about 5 to 30 feet (1.5 to 9.1 m) in thickness and has a general dip of less than 1 degree to the southeast. Several northeast-trending faults interrupt the continuity of the coal bed.

Local coal bed above the Wall coal bed

A local coal bed about 10 feet (3.1 m) thick was penetrated by a drill hole in the northwestern part of the quadrangle. This local coal occurs about 80 to 100 feet (24 to 30 m) above the Wall coal. This coal is assumed to be of limited areal extent because it is not known to occur elsewhere in the quadrangle; therefore, economic coal resources have not been assigned to this bed.

Cook coal bed

The Cook coal bed was first described by Bass (1932, p. 59 and 60) from exposures in the Cook Creek Reservoir quadrangle about 40 miles (64 km) to the northeast. In the Holmes Ranch quadrangle, the Cook coal bed occurs about 130 to 210 feet (40-64 m) above the Wall coal bed. The Cook coal bed does not crop out in the quadrangle and was not logged in test holes; therefore, the isopach and structure contour map (pl. 25) of the Cook coal bed is based on measurements in adjacent quadrangles. The map shows that the Cook coal bed ranges in thickness from about 5 to 10 feet (1.5 to 3 m) and dips southward at less than 1 degree.

Overburden on the Cook coal bed (pl. 23) ranges from about 300 to 1,250 feet (91.4 to 381 m) in thickness.

There is no known, publicly available chemical analysis of the Cook coal in the Holmes Ranch quadrangle. However, a chemical analysis of this coal from a depth of 48 to 50 feet (14.6 to 15.2 m) in coal test hole SH-64, sec. 10, T. 7 S., R. 46 E., in the Reanus Cone quadrangle about 28 miles (45 km) north-northeast of the Holmes Ranch quadrangle (Matson and Blumer, 1973, p. 59) shows ash 3.130 percent, sulfur 0.151 percent, and heating value 7,948 Btu per pound (18,487 kJ/kg) on an as-received basis. This heating value converts to about 8,204 Btu per pound (19,084 kJ/kg) on a moist, mineral-matter-free basis, indicating that the coal at that location is lignite A in rank. However, this sample was taken at a relatively shallow depth, and the coal may have been oxidized, resulting in a lower caloric value. We feel that a sample of fresh Cook coal in the Holmes Ranch quadrangle would likely be subbituminous C in rank, in accordance with the rank of the other closely associated coals in this quadrangle.

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. These exposures were probably along Canyon Creek, about 9 miles (14.5 km) north of the Holmes Ranch quadrangle, in northern Spring Gulch quadrangle or southern Birney SW quadrangle. In the Holmes Ranch quadrangle, the Canyon coal bed occurs about 120 to 160 feet (37 to 49 m) above the Cook coal bed. Subsurface data are lacking and the coal does not crop out; therefore, the thickness and attitude of the coal bed has been projected in from adjacent quadrangles. The isopach and structure contour map (pl. 22) shows that the Canyon coal bed ranges from about 5 to 20 feet (1.5 to 6.1 m) in thickness and, in general, dips southward at an angle of less than 1 degree. This dip is modified by low-relief folding and faulting.

Overburden on the Canyon coal bed (pl. 23) ranges from 300 to 1,250 feet (91 to 381 m) in thickness.

A chemical analysis of the Canyon coal (Matson and Blumer, 1973, p. 40) in coal test hole SH-48, sec. 16, T. 6 S., R. 40 E., about 15 miles (24 km) north-northwest of the Holmes Ranch quadrangle in the Taintor Desert quadrangle, shows ash 6.090 percent, sulfur 0.188 percent, and heating value 8,914 Btu per pound (20,734 kJ/kg) on an as-received basis. This heating value converts to about 9,492 Btu per pound (22,078 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Canyon coal of that locality is subbituminous C in rank. Because of the proximity of that location to the Holmes Ranch quadrangle, it is assumed that the Canyon coal in this quadrangle is similar and is also subbituminous C.

Local coal bed above the Canyon coal bed

A local coal bed about 7 feet (2.1 m) in thickness occurs above the Canyon coal bed and about 30 feet (9.1 m) below the base of the Dietz 3 coal bed in one coal test hole in the northwest part of the quadrangle. This coal is not known to occur elsewhere in the quadrangle; therefore, economic coal resources have not been assigned to this bed.

Dietz 3 coal bed

The Dietz 1, 2, and 3 coal beds were first described by Taff (1909, p. 139-140) from exposures in the Sheridan coal field, Wyoming. The Dietz 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 1 and Dietz 2 coal beds, which are equivalent to our Dietz 2 and Dietz 3 coal beds.

The Dietz 3 coal bed occurs in the western part of the Holmes Ranch quadrangle about 60 to 240 feet (18.3 to 73 m) above the Canyon coal bed. The isopach and structure contour map (pl. 19) shows that this coal bed ranges from 5 to 15 feet (1.5 to 4.6 m) in thickness and has a general southwestward dip of less than 1 degree. Overburden on the Dietz 3 coal bed (pl. 20) ranges from 100 to 800 feet (30 to 244 m) in thickness.

There is no known, publicly available chemical analysis of the Dietz 3 coal in the Holmes Ranch quadrangle. However, a chemical analysis of this coal in test hole SH-107, sec. 30, T. 7 S., R. 40 E., in the Tongue River Dam quadrangle about 10 miles (16 km) northwest of the Holmes Ranch quadrangle (Matson and Blumer, 1973, p. 35) shows ash 3.729 percent, sulfur 0.234 percent, and heating value 9,301 Btu per pound (21,634 kJ/kg) on an as-received basis. This heating value converts to about 9,661 Btu per pound (22,476 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Dietz 3 coal at that location is subbituminous B in rank. Because of the proximity of that location to the Holmes Ranch quadrangle, it is assumed that the Dietz 3 coal in this quadrangle is similar and is subbituminous B in rank.

Dietz 2 coal bed

Matson and Blumer (1973, pl. 5B) mapped the Dietz 2 coal bed in the Holmes Ranch quadrangle. Baker (1929, pls. 28 and 29) mapped a local bed in places at about the same stratigraphic position.

The Dietz 2 coal bed occurs 40 feet (12 m) above the Dietz 3 coal bed. The isopach and structure contour maps of the Dietz 2 coal bed (pls. 15 and 16) shows that this coal bed ranges from about 5 to 20 feet (1.5 to 6 m) in thickness and, in general, dips southward at an angle of less than 1 degree. This dip is modified by low-relief folding and faulting. Overburden on the Dietz 2 coal bed (pl. 17) ranges from zero at the outcrops to about 900 feet (274 m) in thickness.

A chemical analysis of the Dietz 2 coal at a depth of 90 to 94 feet (27 to 29 m) in drill hole SH-107, sec. 30, T. 7 S., R. 40 E., (Matson and Blumer, 1973, p. 35) about 10 miles (16 km) northwest of the Holmes Ranch quadrangle in the Tongue River Dam quadrangle, shows ash 3.882 percent, sulfur 0.222 percent, and heating value 9,073 Btu per pound (21,103 kJ/kg) on an as-received basis. This heating value converts to about 9,439 Btu per pound (21,956 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 Holmes Ranch 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 (Dietz 1) coal bed was first described by Baker (1929, p. 35) from exposures in the northward extension of the Sheridan coal field which includes the Holmes Ranch quadrangle. These exposures were probably along Anderson Creek in the southern part of the adjacent Spring Gulch quadrangle to the north. The Dietz 1 coal bed was named by Taff (1909, p. 139-140) for exposures at the abandoned No. 1 mine at the old mining town of Dietz in the Sheridan coal field, Wyoming, about 15 miles (24 km) southwest of the Holmes Ranch quadrangle in the Acme quadrangle. The Dietz 1 coal bed is equivalent to the Anderson coal bed as mapped by Baker (1929, pl. 28).

In the Holmes Ranch quadrangle, the Anderson (Dietz 1) coal bed occurs about 20 to 170 feet (6.1 to 52 m) above the Dietz 2 coal bed. A thick clinker bed formed by the burning of the Anderson coal bed covers rather large areas in the northern part of the quadrangle. As shown by the isopach and structure contour maps (pls. 11 and 12), the Anderson (Dietz 1) coal bed ranges from 5 to 25 feet

(1.5 to 7.6 m) in thickness and has a general southward dip of about 1 degree. This dip is modified by low-relief folding and faulting. Overburden on the Anderson (Dietz 1) coal bed (pl. 13) ranges from 0 feet at the outcrops to about 600 feet (0-183 m) in thickness.

A chemical analysis of the Anderson (Dietz 1) coal (Matson and Blumer, 1973, p. 25) from a depth of 193 to 201 feet (59 to 61 m) in coal test hole SH-7020, sec. 35, T. 9 S., R. 40 E., in the Decker quadrangle about 1 mile (1.6 m) west of the Holmes Ranch quadrangle, shows ash 3.843 percent, sulfur 0.777 percent, and heating value 9,247 Btu per pound (21,509 kJ/kg) on an as-received basis. This heating value converts to about 9,617 Btu per pound (22,368 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Anderson (Dietz 1) coal at that locality is subbituminous B in rank. Because of the proximity of that location to the Holmes Ranch quadrangle, it is assumed that the Anderson (Dietz 1) coal bed in this quadrangle is similar and is also subbituminous B in rank.

Local coal bed above the Anderson coal bed

A local coal bed, 6 feet (1.8 m) in thickness, occurs about 90 feet (27 m) above the Anderson coal bed in a coal test hole in sec. 10, T. 9 S., R. 41 E., (Matson and Blumer, 1973, Appendix, SH-7022). Economic coal resources have not been assigned to this local coal bed of limited areal extent.

Smith coal bed

The Smith coal bed was first described by Taff (1909, p. 130 and 141) from exposures in the Smith mine in the Sheridan coal field, Wyoming, about 14 miles (22.5 km) southwest of the Holmes Ranch quadrangle in the Sheridan quadrangle, Wyoming. In the Holmes Ranch quadrangle, the Smith coal bed occurs about 60 to 170 feet (18 to 52 m) above the Anderson (Dietz 1) coal bed. The isopach and structure contour map of the Smith coal bed (pl. 8) shows that the coal ranges in thickness from 5 to 20 feet (1.5 to 6.1 m) and in general dips southward at an angle of slightly more than 1 degree. This dip is modified by low-relief folding and faulting. Overburden on the Smith coal bed (pl. 9) ranges in thickness from 0 feet at the outcrops to about 500 feet (0-152 m).

A chemical analysis of the Smith coal (Matson and Blumer, 1973, p. 25) from a depth of 41 to 50 feet (12.5 to 15.2 m) in coal test hole SH-7022, sec. 10, T. 9 S., R. 41 E., in the Holmes Ranch quadrangle 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 value converts to about 8,880 Btu per pound (20,655 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Smith coal is subbituminous C in rank.

Local coal bed above the Smith coal bed

A local coal bed 2 feet (0.6 m) in thickness occurs about 250 feet (76 m) above the Smith coal bed in sec. 6, T. 10 S., R. 42 E., (Montana Bureau of Mines and Geology, US-76146). 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 of the Sheridan coal field, Montana, in a mistaken correlation with the Roland coal bed of Taff (1909) in the Sheridan coal field, Wyoming. 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 10 miles (16 km) west of the Holmes Ranch quadrangle. Outcrops of the Roland of Baker (1929) coal bed are shown on the Coal Data Map (pl. 1). In the Holmes Ranch quadrangle, the Roland of Baker (1929) coal bed occurs about 190 to 300 feet (60 to 91 m) above the Smith coal bed. The isopach and structure contour maps (pls. 4 and 5) show that the Roland of Baker (1929) coal bed ranges in thickness from 2 to 11 feet (0.6 to 3.3 m) and dips southward at an angle of 1 to 2 degrees except where the coal bed is affected by faulting and low-relief folding. Overburden on the Roland of Baker (1929) coal bed (pl. 6) ranges from 0 feet at the outcrops to about 400 feet (0-122 m) in the southwestern part of the quadrangle.

A chemical analysis of the Roland of Baker (1929) coal (Matson and Blumer, 1973, p. 27) from a depth of 53 to 63 feet (16 to 19 m) in coal test hole SH-7024, sec. 25, T. 8 S., R. 41 E., in the Holmes Ranch quadrangle shows ash 5.875 percent, sulfur 0.674 percent, and heating value 7,021 Btu per pound (16,331 kJ/kg) on an as-received basis. This value converts to about 7,459 Btu per pound (17,350 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Roland of Baker (1929) coal in this quadrangle is lignite A in rank.

Early in this mapping project, to expedite the calculation of resource tonnage and the evaluation of development potential for surface mining of the near-surface coal beds, it was arbitrarily decided by us to assign a rank of subbituminous to all of the coal beds located in this quadrangle, where the vast majority of the coal beds are subbituminous in rank. Consequently, we have used the 500-foot stripping limit (which the USGS has arbitrarily assigned for multiple beds of subbituminous coal in the Northern Powder River Basin, Montana) for all of the coal beds in this quadrangle, even though our subsequent detailed work has indicated that the 200-foot stripping limit assigned for lignite beds in the Northern Powder River Basin should have been used for the upper coal bed, the Roland of Baker (1929) coal bed.

It is recommended that the 200-foot stripping limit and the lignite conversion factor should be used for the Roland of Baker (1929) coal bed in this quadrangle in any future revisions of its maps and coal tonnage calculations. The use of the 200-foot stripping limit for the Roland coal in this quadrangle will produce a more conservative and realistic picture of the surface-mining potential of this coal bed.

COAL RESOURCES

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

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

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

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

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

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

Reserve Base coal may be either surface-minable coal or underground-minable coal. In this report, surface-minable Reserve Base coal is subbituminous coal that is under less than 500 feet (152 m) of overburden or lignite that is under less than 200 feet (61 m) of overburden. In this report, underground-minable Reserve Base coal is subbituminous coal that is under more than 500 feet (152 m), but less than 3,000 feet (914 m) of overburden, or lignite that is under more than 200 feet (61 m), but less than 1,000 feet (305 m) of overburden.

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

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

As shown by table 1, the total tonnage of federally owned, surface-minable Reserve Base coal in this quadrangle is estimated to be 1,455.90 million short tons (1,320.79 million t). The total tonnage of federally owned, surface-minable Hypothetical coal is estimated to be 4.60 million short tons (4.17 million t). As shown by table 2, the total federally owned, underground-minable Reserve Base coal is estimated to be 959.13 million short tons (870.12 million t). The total federally owned, underground-minable Hypothetical coal is estimated to be 295.70 million short tons (268.26 million t). The total tonnage of surface- and underground-minable Reserve Base coal is 2,415.03 million short tons (2,190.92 million t), and the total of surface- and underground-minable Hypothetical coal is 300.30 million short tons (272.43 million t).

About 6 percent of the surface-minable Reserve Base tonnage is classed as Measured, 28 percent as Indicated, and 66 percent as Inferred. About 1 percent of the underground-minable Reserve Base tonnage is Measured, 12 percent is Indicated, and 87 percent is Inferred.

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

COAL DEVELOPMENT POTENTIAL

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

The formula used to calculate mining-ratio values for subbituminous coal and lignite 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

cf = conversion factor = 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 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. 37). Most of the Federal coal lands have a high development for surface mining. Coal lands having low development potential are mostly concentrated near the southern border of the quadrangle, and small tracts of moderate development potential are scattered throughout the quadrangle.

The Kendrick (pl. 35), Brewster-Arnold (pl. 32), Wall (pl. 29), and Cook (pl. 26) coal beds have low surface-mining development potentials because all of the mining-ratio values are greater than 15 or have no development potential because all of the coal 5 feet (1.5 m) or more thick is found below the stripping limit of 500 feet (152.4 m) or more of overburden.

The Wall coal bed (pl. 23) lacks high development potential and has only two very small tracts of moderate development potential along the northern border of the quadrangle. The remainder of the coal extending southward from the coal boundary has low development potential. A large area near the center of the quadrangle has no mining potential because the coal is less than 5 feet (1.5 m) in thickness.

Information on the Dietz 3 coal bed is limited to a triangular-shaped area in the western one-half of the quadrangle. One very small area in the northwestern part of the quadrangle has high development potential. Moderate development potential is limited to several small tracts along the west side of the quadrangle. Most of the area within the coal boundary has low mining potential.

Dietz 2 coal which is 5 feet (1.5 m) or greater in thickness is limited to the western half of the quadrangle. In the northwestern part of the quadrangle, areas of high development potential extend from the valleys up the slopes to the 10 mining-ratio contour. Narrow beds of moderate development potential occur between the 10 and 15 mining-ratio contours. Low development potential coal extends from the 15 mining-ratio contour under the higher hills. All coal east of the coal boundary line has no development potential because the coal is less than 5 feet (1.5 m) in thickness.

Extensive areas of the Anderson (Dietz 1) coal bed (pl. 1) burned along the outcrop baking the overlying rocks into a reddish-colored clinker. The Anderson (Dietz 1) coal (pl. 13) has extensive areas of high development potential extending from the coal boundary up the slopes of the hills to the 10 mining ratio. Thin bands of moderate development potential parallel the high development potential and lie between the 10 and 15 mining-ratio contours. Relatively large areas of low development potential extend from the 15 mining-ratio under the higher hills. A fairly large area in the southwestern part of the quadrangle has no development potential because the coal is less than 5 feet (1.5 m) in thickness.

The Smith coal bed (pl. 9) contains fairly large areas of high development potential extending from the outcrops up the sides of the hills to the 10 mining ratio contour. Narrow bands of moderate development potential parallel the high development potential areas and extend under the hills to the 15 mining-ratio contour. Fairly large areas of low development potential occur between the 15 mining-ratio contour and the crests of the higher hills. Two moderately sized areas of no development potential occur in the southeastern part of the quadrangle where the coal is less than 5 feet (1.5 m) in thickness.

The Roland of Baker (1929) coal bed has large areas of high development potential extending from the outcrops up the stream valleys to the 10 mining-ratio contours. Narrow bands of moderate development potential occur between the 10 and 15 mining-ratio contours. Low development potential coal extends from the 15 mining-ratio contour under the crests of the hills.

About 72 percent of the Federal coal lands in the quadrangle has a high development potential for surface mining, 11 percent has a moderate development potential, and 17 percent has 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 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 Holmes Ranch 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)	61,790,000	23,320,000	45,510,000	130,620,000
Smith	38,090,000	39,310,000	225,530,000	302,930,000
Anderson (Dietz 1)	105,410,000	217,800,000	279,140,000	602,350,000
Dietz 2	56,120,000	51,190,000	130,420,000	237,730,000
Dietz 3	20,000	850,000	74,840,000	75,710,000
Canyon	0	1,480,000	85,660,000	87,140,000
Cook	0	0	18,780,000	18,780,000
Wall	0	0	640,000	640,000
Total	261,430,000	333,950,000	860,520,000	1,455,900,000
Hypothetical Resource tonnage				
Anderson (Dietz 1)	0	0	3,690,000	3,690,000
Canyon	0	0	910,000	910,000
Total	0	0	4,600,000	4,600,000
Grand Total	261,430,000	333,950,000	865,120,000	1,460,500,000

Table 2.--Underground-minable coal resource tonnage (in short tons) by development-potential category for Federal lands in the Holmes Ranch 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				
Smith	0	0	10,770,000	10,770,000
Anderson (Dietz 1)	0	0	101,910,000	101,910,000
Dietz 2	0	0	56,120,000	56,120,000
Dietz 3	0	0	25,330,000	25,330,000
Canyon	0	0	152,700,000	152,700,000
Cook	0	0	66,180,000	66,180,000
Wall	0	0	385,780,000	385,780,000
Brewster-Arnold	0	0	146,360,000	146,360,000
Kendrick	0	0	13,980,000	13,980,000
Total	0	0	959,130,000	959,130,000
Hypothetical Resource tonnage				
Anderson (Dietz 1)	0	0	5,510,000	5,510,000
Dietz 2	0	0	300,000	300,000
Canyon	0	0	209,100,000	209,100,000
Wall	0	0	56,860,000	56,860,000
Brewster-Arnold	0	0	23,930,000	23,930,000
Total	0	0	295,700,000	295,700,000
Grand Total	0	0	1,254,830,000	1,254,830,000

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