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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE PEARL SCHOOL QUADRANGLE, BIG HORN COUNTY, MONTANA

[Report includes 43 plates]

By

Colorado School of Mines Research Institute

This report has not been edited for conformity with U.S. Geological Survey editorial standards or stratigraphic nomenclature.

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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 Pearl School quadrangle, Big Horn County, Montana, (43 plates; U.S. Geological Survey Open-File Report 79-776). 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 Pearl School 7 1/2-minute quadrangle is in southeastern Big Horn County, Montana. The quadrangle is about 13.5 miles (21.7 km) north of Sheridan, Wyoming, and 0.5 mile (0.8 km) west of Decker, Montana. Sheridan is on U.S. Interstate Highway 90 and the Burlington Northern Railroad. A branch of this railroad runs from Sheridan northeastward about 20 miles (32 km) and terminates at the Decker coal mine which is about 2 miles (3.2 km) east of the Pearl School quadrangle.

Accessibility

The Pearl School quadrangle is accessible from Sheridan, Wyoming, by following U.S. Interstate Highway 90 northward 6 miles (9.7 km) to the paved State Highway 338, thence northeastward on this highway 10 miles (16.1 km) to the southern boundary of the quadrangle. This highway continues northeastward through the southeastern part of the quadrangle to Decker, Montana, and to the

Decker coal mine. Most of the remainder of the quadrangle is accessible by local roads and trails which intersect this highway.

Physiography

The Pearl School quadrangle is within the Missouri Plateau Division of the Great Plains physiographic province. The plateau, which is formed by nearly flat-lying sedimentary strata has been deeply dissected by southeasterly flowing tributaries of the Tongue River. A single meander of the river and a part of its flood plain are in the southeastern part of the quadrangle. The largest tributaries, Squirrel Creek and Youngs Creek, have narrow flood plains. The sides of the narrow tributary valleys rise steeply 200 to 300 feet (61 to 91 m) to broad, grassy interstream divides of little relief. The only timber is found in narrow ribbons along Squirrel and Youngs Creeks or in a few very small patches on northward or westward facing slopes.

The highest elevation, about 4,380 feet (1,335 m), is on an interstream divide near the northwest corner of the quadrangle. The lowest elevation, about 3,470 feet (1,058 m), is along the Tongue River near the southeast corner of the quadrangle. Topographic relief within 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 Pearl School quadrangle. All of the quadrangle is within the Northern Powder River Basin Known Recoverable Coal Resource Area (KRCRA). Federal coal leases which were outstanding as of 1977 are shown in the northeastern, southeastern, and southwestern parts of the quadrangle.

GENERAL GEOLOGY

Previous work

Baker (1929, pl. 28) mapped all of the Pearl School quadrangle as part of the northward extension of the Sheridan coal field. Matson and Blumer (pls. 1 and 4) mapped the principal coal beds as parts of the Decker and Squirrel Creek deposits. Galyard and Murray (U.S. Geol. Survey, unpublished report) later also mapped the quadrangle.

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 (pls. 3A and 3B) of the CRO maps. The uppermost strata in the Pearl School quadrangle belong to the Wasatch Formation of Eocene age, which underlies the highest interstream divides in the quadrangle. It has a maximum thickness of about 200 feet (61 m). The Wasatch Formation consists of lenticular beds of gray to dark-gray shale, gray siltstone, gray to yellowish-gray fine-grained sandstone, and carbonaceous shale. Near its base is a bed of molluscan-bearing coquinoid limestone 1 to 2 feet (0.3 to 0.6 m) thick. The base of the Wasatch Formation is placed at the top of the Roland of Baker (1929) coal bed. The underlying Tongue River Member of the Fort Union Formation of (Paleocene) age, which is about 2,400 feet (732 m) thick, is lithologically similar to the Wasatch Formation. However, the Tongue River Member contains more beds of yellowish-gray sandstone and siltstone, and numerous coal beds.

Coal and other rocks composing 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 Pearl School quadrangle is in the northwestern part of the Powder River structural basin. The regional dip is southeastward at an angle of about 1 degree, although this dip is considerably modified by low-relief folding and is interrupted in places by northeastward-trending faults of low displacement.

COAL GEOLOGY

The coal beds in the Pearl School quadrangle are shown in outcrop on the Coal Data Map (pl. 1A) and in section on the Coal Data Sheet (pls. 3A and 3B). All of the coal beds belong to the Tongue River Member of the Fort Union Formation (Paleocene).

The lowermost recognized coal bed in the Pearl School quadrangle is the Kendrick coal bed which is about 130 to 170 feet (39.6 to 51.8 m) above the base of the Tongue River Member. This coal bed is successively overlain by a noncoal interval about 335 to 375 feet (102 to 114 m), the King coal bed, a noncoal interval of about 300 feet (91 m), the Brewster-Arnold coal bed, a mainly noncoal interval of 180 to 190 feet (54.9 to 57.9 m) containing a local coal bed, the Wall coal bed, a mainly noncoal interval of 15 to 115 feet (4.6 to 35.1 m) containing a local coal bed, the Cook coal bed, a mainly noncoal interval of 45 to 145 feet (13.7 to 44.2 m) containing two local coal beds, the Canyon coal bed, a mainly noncoal interval of 75 to 150 feet (22.9 to 45.7 m) containing a local coal bed, the combined Dietz 2 and Dietz 3 coal beds, a noncoal interval of 0 feet to about 150 feet (0-45.7 m), the Anderson (Dietz 1) coal bed, a noncoal interval of 25 to 265 feet (7.6 to 80.8 m), the Smith coal bed, a mainly noncoal interval of 145 to 250 feet (44.2 to 76.2 m) containing a local coal bed, 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 first described by Culbertson, Kent, and Mapel (1979) from its occurrence in the Amoco Production Co., No. 1 Kendrick Ranch "B" oil-and-gas test well, sec. 29, T. 58 N., R. 79 W., about 25 miles (40 km) east-southeast of the Pearl School quadrangle in the Roundup Draw quadrangle, Wyoming. In the Pearl School quadrangle, the Kendrick coal bed occurs in three oil-and-gas test holes in the northern part of the quadrangle (pls. 1A, 1B, and 3A) about 140 to 170 feet (42.7 to 51.8 m) above the top of the lower tongue of the Lebo Shale Member, which is the most continuous tongue. The correlation of this coal bed with the Kendrick coal bed at its type locality is necessarily uncertain because of the distance involved, the meager subsurface information, and the discontinuous nature of the continental strata.

The isopach and structure contour map of the Kendrick coal bed (pl. 38) shows that this coal bed ranges from about 5 to 11 feet (1.5 to 2.4 m) in thickness and dips southeastward at an angle of about 1 degree. Overburden on the Kendrick coal bed ranges from about 1,400 to 1,900 feet (427 to 579 m) in thickness. There is no known, publicly available chemical analysis of the Kendrick coal in, or close to, the Pearl School quadrangle. It is assumed that this coal is similar to other closely associated coals in the quadrangle and is subbituminous C in rank.

King coal bed

The King coal bed was named by Warren (1959, p. 571) for outcrops of the bed along King Creek, a tributary of the Tongue River about 38 miles (61 km) northeast of the Pearl School quadrangle in the Ashland and Green Creek quadrangles. The correlation of this coal in the Pearl School quadrangle with the King coal bed at this type locality is necessarily uncertain because of the distance involved, the scant subsurface information, and the discontinuous nature of the continental strata.

The King coal bed does not crop out in the Pearl School quadrangle but has been penetrated by the three oil-and-gas test holes in the north-central part of the quadrangle (pls. 1A, 1B, and 3A). In these wells it occurs 338 to 376 feet (103 to 114.6 m) above the Kendrick coal bed and 5 feet (1.5 m) or less above the top of the upper tongue of the Lebo Shale. The isopach and structure contour map (pl. 35) shows that the King coal bed ranges from about 5 to 15 feet (1.5 to 4.6 m) in thickness and dips southeastward at an angle of 1.5 degrees or less. Overburden on the King coal bed (pl. 36) ranges from about 1,100 to 1,500 feet

(335 to 457 m) in thickness. There is no known, publicly available chemical analysis of the King coal in, or close to, the Pearl School quadrangle. It is assumed that the King coal is similar to closely associated coals in the quadrangle and is subbituminous C in rank.

Brewster-Arnold coal bed

The Brewster-Arnold coal bed was first described by Bass (1924) for coal at the Brewster-Arnold mine about 20 miles (32 km) northeast of the Pearl School quadrangle in the Birney quadrangle. The correlation of this coal bed in the Pearl School quadrangle with the Brewster-Arnold coal bed at its type locality is necessarily uncertain because of the distance involved, the meager subsurface information, and the discontinuous nature of the continental strata.

The Brewster-Arnold coal bed does not crop out in the Pearl School quadrangle but has been penetrated by three oil-and-gas test holes in the north-central part of the quadrangle (pls. 1A, 1B, and 3A) where it occurs from 303 to 312 feet (92.4 to 95.4 m) above the King coal bed. The isopach and structure contour map (pl. 32) shows that the Brewster-Arnold coal bed ranges from about 5 to 10 feet (1.5 to 3.0 m) in thickness and dips southeastward at an angle of about 0.5 degree. Overburden on the Brewster-Arnold coal bed (pl. 33) ranges from about 700 to 1,200 feet (213 to 366 m) in thickness.

A chemical analysis of the Brewster-Arnold coal from a depth of 70 to 75 feet (21.3 to 22.9 m) in coal test hole SH-44, sec. 31, T. 6 S., R. 42 E. (Matson and Blumer, 1973, p. 43), about 16 miles (25.8 km) northeast of the Pearl School quadrangle in the Birney quadrangle, shows ash 4.534 percent, sulfur 0.347 percent, and heating value 9,191 Btu per pound (21,378 kJ/kg) on an as-received basis. This heating value converts to about 9,628 Btu per pound (22,395 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Brewster-Arnold coal at that location is subbituminous B in rank. It is assumed that the Brewster-Arnold coal in the Pearl School quadrangle is similar and is also subbituminous B in rank.

Local coal bed below the Wall coal bed

A local coal bed 46 feet (14 m) below the Wall coal bed was penetrated in coal test hole U.S. 7733, sec. 21, T. 8 S., R. 39 E. (pls. 1B, and 3A). This local bed is only 4 feet (1.2 m) thick, and economic coal resources have not been assigned to it.

Wall coal bed

The Wall coal bed was named by Baker (1929, p. 37) for exposures of the coal along Wall Creek, a tributary of the Tongue River, about 16 miles (25.8 km) northeast of the Pearl School quadrangle in the Birney quadrangle. The Wall coal bed occurs about 180 to 190 feet (54.9 to 57.9 m) above the Brewster-Arnold coal bed. It does not crop out in the Pearl School quadrangle but has been penetrated by a number of test holes (pls. 1 and 3). The isopach and structure contour map (pl. 29) shows that the Wall coal bed ranges from 3 to 30 feet (0.9 to 9.1 m) in thickness and, in general, dips southeastward or eastward at an angle of 1 degree or less, although this dip is modified by low-relief folding and faulting. Overburden on the Wall coal bed (pl. 30) ranges from about 450 to 1,050 feet (137 to 320 m) in thickness.

A chemical analysis of the Wall coal from a depth of 73 to 83 feet in coal test hole SH-707, sec. 33, T. 7 S., R. 41 E. (Matson and Blumer, 1973, p. 39), about 8.3 miles (13.4 km) northeast of the Pearl School quadrangle in the Spring Gulch quadrangle, shows ash 3.953 percent, sulfur 0.443 percent, and heating value 9,556 Btu per pound (22,227 kJ/kg) on an as-received basis. This heating value converts to about 9,949 Btu per pound (22,132 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Wall coal at that location is subbituminous B in rank. Because of the proximity of that location to the Pearl School quadrangle, it is assumed that the Wall coal in this quadrangle is similar and is also subbituminous B in rank.

Local coal bed below the Cook coal bed

A local coal bed 6 feet (1.8 m) below the Cook coal bed is penetrated by an oil-and-gas test hole in sec. 16, T. 9 S., R. 39 E. (pls. 1B, and 3B). This local bed is only 4 feet (1.2 m) thick, and economic coal resources have not been assigned to it.

Cook coal bed

The Cook coal bed was first described by Bass (1932, p. 79) from exposures in the Cook Creek Reservoir quadrangle about 50 miles (80.5 km) northeast of the Pearl School quadrangle. In the Pearl School quadrangle, the Cook coal bed occurs about 15 to 115 feet (4.6 to 35 m) above the Wall coal bed. The Cook coal bed does not crop out in the Pearl School quadrangle, but has been penetrated by a number of test holes (pls. 1 and 3). The isopach and structure contour map (pl. 26) shows that the Cook coal bed ranges from about 5 to 25 feet (1.5 to 7.6 m) in thickness and dips southeastward at an angle of 1 degree or less. This dip is interrupted in places by faults of low displacement. Overburden on the Cook coal bed (pl. 27) ranges from about 350 to 1,000 feet (107 to 305 m) in thickness. There are no known, publicly available chemical analyses of the Cook coal in, or close to, the Pearl School quarangle. It is assumed that the Cook coal is similar to the other closely associated coals in this quadrangle and is either subbituminous B or C in rank.

Local coal beds above the Cook coal bed

Local coal beds occur at intervals of 24 to 60 feet (7.3 to 18.3 m) above the Cook coal bed in the oil-and-gas test hole in sec. 16, T. 9 S, R. 39 E. (pls. 1B and 3B). These two beds are 8 and 10 feet (2.4 and 3.0 m) thick, respectively.

Because they do not occur in other test holes in the quadrangle, it is assumed that they are limited in areal extent and, therefore, have not been assigned economic coal 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. Although a type locality was not given, it probably is along Canyon Creek either in northern Spring Gulch quadrangle or southwestern Birney SW quadrangle, about 12 miles (19.3 km) northeast of the Pearl School quadrangle. In the Pearl School quadrangle, the Canyon coal bed occurs about 45 to 145 feet (13.7 to 44.2 m) above the Cook coal bed. The Canyon coal bed does not crop out in the Pearl School quadrangle, but it has been penetrated by a number of test holes (pls. 1 and 3). The isopach and structure map (pl. 23) shows that the Canyon coal bed ranges from about 8 to 20 feet (2.4 to 6.1 m) in thickness and in general dips southeastward at an angle of about 1 degree, although this dip is modified or interrupted in places by low-relief folding and faulting. Overburden on the Canyon coal bed (pl. 24) ranges from about 250 to 800 feet (76.2 to 244 m) in thickness.

A chemical analysis of the Canyon coal from a depth of 126 to 130 feet (38.4 to 39.6 m) in coal test hole SH-703, sec. 26, T. 8 S., R. 40 E. (Matson and Blumer, 1973, p. 20), about 3.5 miles (5.6 km) east of the Pearl School quadrangle in the Decker quadrangle, shows ash 2.485 percent, sulfur 0.377 percent, and heating value 9,541 Btu per pound (22,192 kJ/kg) on an as-received basis. This heating value converts to about 9,784 Btu per pound (22,758 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Canyon coal at that location is subbituminous B in rank. Because of the proximity of that location to the Pearl School quadrangle, it is assumed that the Canyon coal in this quadrangle is similar and is also subbituminous B in rank.

Local coal bed above the Canyon coal bed

A local coal bed occurs 24 to 30 feet (7.3 to 9.1 m) above the Canyon coal bed in the oil-and-gas test holes in sec. 16 and 27, T. 9 S., R. 39 E., but it is not present in other test holes. This local bed is 4 and 7 feet (1.2 and 2.1 m) thick in the two holes. Because of the thinness and limited areal extent of this local coal bed, economic coal resources have not been assigned to it.

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, Montana. Baker did not map the Dietz 2 and 3 coal beds but, in places, shows a local coal bed at about their stratigraphic position. The Dietz 2 and 3 coal beds of this report are equivalent to the Dietz 1 and 2, respectively, as mapped by Matson and Blumer (1973, pl. 4).

In the central part of the Pearl School quadrangle, the Anderson, Dietz 2, and Dietz 3 coal beds are combined into a single thick coal bed (pls. 1 and 3). In the Decker quadrangle just to the east, the Dietz 3 coal bed is recognized as a separate coal bed, and this separation is projected a short distance into the Pearl School quadrangle (pls. 20, 21, and 22). The base of the Dietz 3 coal bed occurs about 75 to 150 feet (22.9 to 45.7 m) above the Canyon coal bed (pl. 3). The isopach and structure map (pl. 20) shows that the Dietz 3 coal bed, where it is separated from the higher coal beds, is about 30 feet (9.1 m) thick, and dips eastward or southward at an angle of less than 1 degree. Overburden on the Dietz 3 coal bed (pl. 21) ranges from about 100 to 600 feet (30.5 to 182.9 m) in thickness.

Combined Dietz 2 and Dietz 3 coal beds

In the western part of the Pearl School quadrangle, the Dietz 2 and Dietz 3 coal beds are combined into a single, thick coal bed (pls. 16, 17, 18, and 19). The isopach map (pl. 16) shows that this combined bed ranges from about 30 to 60 feet (9.1 to 18.3 m) in thickness. The structure contour map (pl. 17) shows that the coal bed in general dips southeastward at an angle of 1 degree or less, although this dip is modified in places by low-relief folding and faulting. Overburden on the combined Dietz 2 and 3 coal beds (pl. 18) ranges from about 100 to 680 feet (30.5 to 207.3 m) in thickness.

A chemical analysis of the Dietz coal from a depth of 240 to 247 feet (73.2 to 75.3 m) in coal test hole BMC-727, sec. 25, T. 9 S., R. 39 E., about 700 feet (213 m) west of the Pearl School quadrangle in the Bar V Ranch quadrangle (Matson and Blumer, 1973, p. 20), shows ash 2.485 percent, sulfur 0.377 percent, and heating value 9,541 Btu per pound (22,192 kJ/kg) on an as-received basis. This heating value converts to about 9,784 Btu per pound (22,785 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Dietz coal at that location is subbituminous B in rank. Because of the proximity of that location to the Pearl School quadrangle, it is assumed that the Dietz coal in the Pearl School quadrangle is similar and is also subbituminous B in rank.

Anderson (Dietz 1) coal bed

The Anderson coal bed was first described by Baker (1929, p. 35) from exposures in the northward extension of the Sheridan coal field, Montana, which includes the Pearl School quadrangle. The Dietz 1 coal bed was named by Taff (1909, p. 129-140) for exposures at the abandoned No. 1 mine at the old mining town of Dietz in the Sheridan coal field, Wyoming, about 9 miles (14.5 km) south of the Pearl School quadrangle in the Acme quadrangle, Wyoming. The Dietz 1 coal bed is equivalent to the Anderson coal bed as mapped by Baker (1929, p. 28).

In the Pearl School quadrangle, the Anderson (Dietz 1) coal bed is above the Dietz 2 coal bed an interval of 0 to 150 feet (0-45.7 m). The Anderson (Dietz 1) coal bed is separated from the combined Dietz 2 and 3 coal beds in the western part of the Pearl School quadrangle (pls. 12, 13, 14, and 15). The isopach map (pl. 12) shows that the Anderson (Dietz 1) coal bed in this area ranges from about 10 to 40 feet (3.0 to 12.2 m) in thickness. Where the Anderson (Dietz 1) coal bed is combined with the Dietz 2 in the southeastern part of the quadrangle, the thickness of the combined beds ranges from 55 to 65 feet (16.8 to 19.8 m). Where the Anderson (Dietz 1) is combined with the Dietz 2 and 3 coal beds in the central part of the quadrangle, the thickness of the combined beds ranges from 70 to 85 feet (21.3 to 25.9 m). The structure contour map (pl. 18) shows that the coal beds, in general, dip southeastward at an angle of about 1 degree or less, although this dip is modified by low-relief folding and faulting. Overburden on the Anderson (Dietz 1) or on the combined beds (pl. 14) ranges from 0 feet at the outcrops to about 700 feet (0-213 m) in thickness.

A chemical analysis of the Anderson (Dietz 1) coal at a depth of 215 to 218 feet (65.5 to 66.4 m), sec. 19, T. 9 S., R. 40 E., in the Pearl School quadrangle (Matson and Blumer, 1973, p. 20) shows ash 5.660 percent, sulfur 0.283 percent, and heating value 9,850 Btu per pound (22,911 kJ/kg) on an as-received basis. This heating value converts to about 10,442 Btu per pound on a mineral-matter-free basis, indicating that the Anderson (Dietz 1) coal bed in the Pearl School quadrangle is subbituminous B in rank.

Smith coal bed

The Smith coal bed was first described by Taff (1909, p. 130) from exposures in the Sheridan coal field in the northern part of the Sheridan quadrangle, Wyoming, about 10 miles (16.1 km) south of the Pearl School quarangle. In the Pearl School quadrangle, the Smith coal bed occurs about 25 to 265 feet (7.6 to 80.8

m) above the Anderson (Dietz 1) coal bed and crops out along the sides of the valleys throughout most of the quadrangle. The isopach and structure map (pl. 8) shows that the Smith coal bed ranges from about 5 to 20 feet (1.5 to 6.1 m) in thickness. The structure contour map (pl. 9) shows that the Smith coal bed in general dips at an angle of about 1 degree, although this dip is considerably modified by low-relief folding and faulting. Overburden on the Smith coal bed (pl. 9) ranges from 0 feet at the outcrop to about 400 feet (0-122 m) in thickness.

A chemical analysis of the Smith coal 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., about 9 miles (14.5 km) east of the Pearl School 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 Smith coal at that location is subbituminous C in rank. It is assumed that the Smith coal in the Pearl School quadrangle is similar and is subbituminous C in rank.

Local coal bed above the Smith coal bed

A local coal bed of limited areal extend occurs 40 feet (12.2 m) above the Smith coal bed in the oil-and-gas test hole in sec. 27, T. 9 S., R. 39 E. (pls. 1 and 3B) and outcrops nearby in the south-central part of the quadrangle (pl. 1A). This local coal bed ranges from 2.6 to 10 feet (0.8 to 3.5 m) in thickness. Because of its thinness and limited areal extent, it has not been assigned economic coal resources.

Roland of Baker (1929) coal bed

The Roland coal bed was named by Taff (1909, p. 130 and 142) from exposures in the Sheridan coal field, Wyoming. A coal assumed to be the same bed was called the Roland coal bed in the northward extension of the Sheridan coal field, Montana, by Baker (1929). Subsequent work in the Sheridan coal field has shown that the Roland coal bed of Baker (1929) lies about 125 feet (38 m) above the original Roland coal bed of Taff (1909).

The top of the Roland coal bed of Baker (1929) is generally used in southern Montana as the contact between the Fort Union Formation (Paleocene) and the overlying Wasatch Formation (Eocene).

Baker (1929, pl. 28) mapped the Roland of Baker (1929) coal bed in the Pearl School quadrangle and measured several surface sections (pls. 1A, 3A, and 3B), although the coal has been burned in most places near the surface. The isopach map (pl. 4) shows that the Roland of Baker (1929) coal ranges from about 7 to 14 feet (2.1 to 4.3 m) in thickness. The structure contour map (pl. 5) shows that the Roland of Baker (1929) coal bed in general dips southeastward at an angle of about 1 degree, although this dip is considerably modified by low-relief folding and faulting. Overburden on the Roland of Baker (1929) coal bed (pl. 6) ranges from 0 feet at the outcrop to about 300 feet (0-91.4 m).

A chemical analysis of the Roland of Baker (1929) coal from a depth of 38 to 46 feet (11.6 to 14.0 m) in coal test hole SH-7033, sec. 34, T. 8 S., R. 39 E. 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 (19,706 kJ/kg) on a moist, mineral-matter-free basis, indicating that the coal in this quadrangle is 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.

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 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.

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 4,310.72 million short tons (3,910.69 million t). There is no federally owned, surface-minable Hypothetical coal in the Pearl School quadrangle. As shown by table 2, the total federally owned, underground-minable Reserve Base coal is estimated to be 2,477.21 million short tons (2,247.32 million t). The total federally owned, underground-minable Hypothetical coal is estimated to be 6.79 million short tons (6.16 million t). The total tonnage of surface- and underground-minable Reserve Base coal is 6,787.93 million short tons (6,158.01 million t), and the total of surface- and underground-minable Hypothetical coal is 6.79 million short tons (6.16 million t).

About 12 percent of the surface-minable Reserve Base tonnage is classed as Measured, 44 percent as Indicated, and 44 percent as Inferred. About 4 percent of the underground-minable Reserve Base tonnage is Measured, 26 percent is Indicated, and 70 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 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 or high topographic relief, the area of moderate development potential for surface mining of a coal bed (area having mining-ratio values of 10 to 15) is often restricted to a narrow band between the high and low development-potential areas. In fact, because of the 40-acre (16.2-ha) minimum size of coal development-potential tracts, the narrow band of moderate development-potential area often does not appear on the CDP map because it falls within the 40-acre (16.2-ha) tracts that also include areas of high development potential. The Coal Development Potential (CDP) map then shows areas of high development potential abutting against areas of low development potential.

The coal development potential of the unleased Federal coal lands for surface mining is shown on the Coal Development Potential map (pl. 41). Most of the unleased Federal coal lands in the Pearl School quadrangle have a high development potential for surface mining. A few scattered, small tracts (about 560 acres total) have a moderate development potential, and one tract of about 280 acres near the northeastern corner of the quadrangle has a low development potential.

The lowermost coal beds, the Kendrick, the King, and the Brewster-Arnold coal beds, have no potential for surface mining as they are below the arbitrarily assigned stripping limit of 500 feet (152.4 m), as shown by the overburden isopachs on plates 39, 36, and 33, respectively.

Practically all of the Wall coal is also below the stripping limit (pl. 30) and thus has no development potential for surface mining. Limited areas in the bottoms of valleys in the northeastern and southeastern parts of the quadrangle have a little less than 500 feet (152.4 m) of overburden and have a low development potential for surface mining (mining-ratio values greater than 15). A minute area along the north border of the quadrangle has mining-ratio values between 10 and 15, and thus a moderate development potential.

Most of the Cook coal (pl. 27) has an overburden thickness greater than 500 feet (152.4 m) and thus has no development potential for surface mining. Some areas in the valleys have slightly less than 500 feet (152.4 m) of overburden and a low development potential (mining-ratio values greater than 15). A limited area along Spring Creek in the northeastern part of the quadrangle has a moderate development potential (mining-ratio values 10-15).

The Canyon coal bed (pl. 24) has a high development potential (mining-ratio values less than 10) only in a very small area along Youngs Creek in the southwestern part of the quadrangle. There are rather limited areas of moderate development potential (mining-ratio values 10-15) in the southwestern and in the northeastern parts of the quadrangle. There are quite extensive areas of low development potential between the 15 mining-ratio contour and the 500-foot (152-m) overburden isopach. There are wide areas of no development potential on the interstream divides above the 500-foot (152.4-m) overburden isopach.

The Dietz 3 coal bed (pl. 21) has no areas of high development potential (mining-ratio values less than 10). There are limited areas of moderate development potential (mining-ratio values 10-15) near the eastern border of the quadrangle. There are small areas of low development potential between the 15 mining-ratio contour and the 500-foot (152.4-m) overburden isopach. Small areas of no development potential extend between the 500-foot (152.4-m) overburden isopach and the crests of the hills.

In the western part of the quadrangle, the combined Dietz 2 and Dietz 3 coal beds (pl. 18) have wide areas of high development potential extending from the boundary of the coal to the 10 mining-ratio contour, or to the stripping limit at the 500-foot (152.4-m) overburden isopach. There are some quite wide areas of moderate development potential extending from the 10 mining-ratio contour to the 15 mining-ratio contour, or to the 500-foot (152.4-m) overburden isopach. There are only a few small areas of low development potential (mining-ratio values greater than 15). Fairly extensive areas of no development potential occur between the 500-foot (152.4-m) overburden isopach and the crests of the hills.

The Anderson (Dietz 1), the combined Anderson (Dietz 1) and Dietz 2, and the combined Anderson (Dietz 1), Dietz 2, and Dietz 3 coal beds (pl. 14) have a high development potential (mining-ratio values less than 10) over most of the quadrangle. There are some fairly wide areas of moderate development potential (mining-ratio values 10-15). There are a few small areas of low development potential (mining-ratio values greater than 15). In the central part of the quadrangle, there is a small area of no development potential above the 500-foot (152.4-m) overburden isopach.

The Smith coal bed (pl. 10) in general has relatively narrow areas of high development potential extending from the boundary of the coal to the 10 mining-ratio contour. There are narrow to wide areas of moderate development potential (mining-ratio values 10-15). Some areas of low development potential (mining-ratio values greater than 15) cap the higher hills.

The Roland of Baker (1929) coal bed (pl. 6) has areas of high, moderate, and low development potential on the principal stream divides. The areas of high development potential are quite extensive.

About 97 percent of the unleased Federal coal lands in the Pearl School quadrangle has a high development potential for surface mining, 2 percent has a moderate development potential, and 1 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 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 Pearl School 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	102,740,000	19,280,000	7,030,000	129,050,000
Smith	191,450,000	205,740,000	79,020,000	476,210,000
Anderson (Dietz 1) and combined Dietz 2 and 3	2,036,800,000	193,580,000	77,660,000	2,308,040,000
Dietz 2 and 3	575,390,000	247,280,000	7,630,000	830,300,000
Dietz 3	4,380,000	11,380,000	16,600,000	32,360,000
Canyon	2,360,000	73,180,000	288,580,000	364,120,000
Cook	0	900,000	146,450,000	147,350,000
Wall	0	500,000	22,790,000	29,290,000
Total	2,913,120,000	751,840,000	645,760,000	4,310,720,000

Table 2.--Underground-minable coal resource tonnage (in short tons) by development-potential category for Federal lands in the Pearl School 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				
Anderson (Dietz 1) and combined Dietz 2 and 3	0	0	194,970,000	194,970,000
Dietz 2 and 3	0	0	248,340,000	248,340,000
Dietz 3	0	0	13,800,000	13,800,000
Canyon	0	0	445,540,000	445,540,000
Cook	0	0	714,940,000	714,940,000
Wall	0	0	545,800,000	545,800,000
King	0	0	94,550,000	94,550,000
Kendrick	0	0	91,820,000	91,820,000
Brewster-Arnold	0	0	127,450,000	127,450,000
Total	0	0	2,477,210,000	2,477,210,000
Hypothetical Resource tonnage				
King	0	0	360,000	360,000
Brewster-Arnold	0	0	6,430,000	6,430,000
Total	0	0	6,790,000	6,790,000
Grand Total	0	0	2,484,000,000	2,484,000,000

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