UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Text to accompany:

Open-File Report 79-647

1979

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

[Report includes 45 plates]

By

Colorado School of Mines Research Institute

CONTENTS

ILLUSTRATIONS

[Plates are in pocket]

TABLES

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 Decker quadrangle, Big Horn County, Montana, (45 plates; U.S. Geological Survey Open-File Report 79-647). 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 Decker 7 1/2-minute quadrangle is in southeastern Big Horn County, Montana, about 15 miles (24 km) north-northeast of Sheridan, Wyoming. Sheridan is on U.S. Interstate Highway 90 and on the Burlington Northern Railroad. The small town of Decker and the Decker coal mine are within the Decker quadrangle.

Accessibility

The Decker quadrangle is accessible from Sheridan, Wyoming by traveling northward on U.S. Interstate Highway 90 about 6 miles (9.7 km), then northeastward on Wyoming Highway 338 about 10 miles (16.1 km) to the Wyoming-Montana State line and then on Montana Highway 314 (continuous with Wyoming Highway 338) about 2 miles (3.2 km) to the southwestern corner of the Decker quadrangle. Montana Highway 314 continues northeastward through the town of Decker, past the Decker coal mine, and northward across the Decker quadrangle.

Physiography

The Decker quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The plateau, which is formed by nearly horizontal strata, is dissected by the Tongue River and its tributaries. The river flows north-northeastward across the quadrangle and joins the Yellowstone River at Miles City about 100 miles (161 km) north-northeast of the quadrangle. The wide, open valley of the river is occupied by the Tongue River Reservoir in the northern part of the quadrangle. The larger tributary valleys have narrow flood plains. The sides of the valleys rise gently in places and steeply in other places about 100 to 200 feet (30 to 61 m) to the flat-topped interstream divides. The landscape is treeless except for small patches of trees on northward-facing slopes in the northeastern and southeastern parts of the quadrangle.

The highest elevation in the quadrangle, 4,022 feet (1,226 m), is on a butte near the northwest corner of the quadrangle. The lowest elevation, 3,424 feet (1,043.6 m), is the spillway elevation of the Tongue River Reservoir in the northeastern part of the quadrangle. Topographic relief in the quadrangle is about 598 feet (182.3 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 Decker quadrangle. Most of the land, except along the Tongue River valley, are Federal coal lands. All of the quadrangle is within the Northern Powder River Basin Known Recoverable Coal Resource Area (KRCRA). There are no National Forest lands within the quadrangle. The map shows the Federal coal leases which were outstanding as of 1977.

GENERAL GEOLOGY

Previous work

Baker (1929, pls. 28 and 29) mapped the Decker quadrangle as part of the northward extension of the Sheridan coal field. Ayler, Smith, and Deutman (1969, figs. 3, 4, 5, and 6) mapped the strippable coal deposits in the Decker quadrangle, based on Baker's work and available industry data, as part of the strippable coal reserves of Montana. Law and Grazis (1972) made a preliminary map of the geology and coal reserves of the Decker quadrangle. Matson and Blumer (1973, pls. 1, 2, 3, and 4) mapped the principal coal beds in the Decker quadrangle as parts of the Decker, Deer Creek, Roland, and Squirrel Creek coal deposits. Law, Barnum, and Wollenzien (1979) made a fence diagram showing coal bed correlations in the Tongue River Member of the Fort Union Formation, Monarch, Wyoming, and Decker, Montana. 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 Decker quadrangle.

Traces of coal bed outcrops shown by previous workers 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 in the Decker quadrangle is shown on the Coal Data Sheet (pl. 3) of the CRO maps.

The uppermost strata in the quadrangle belong to the Wasatch Formation (Eocene). The Wasatch Formation consists of interbedded soft clay, shale, siltstone, and sandstone containing calcareous concretionary zones, several thin coal beds, and numerous thin fossil zones. As much as 300 feet (91 m) of the basal Wasatch Formation is present in the southeastern part of the quadrangle. A relatively thick, reddish-colored clinker bed, composed of baked and fused sandstone, generally forms an erosion-resistant unit at the base of the formation. The clinker has been formed by the burning of the underlying Roland coal bed of Baker (1929) which marks the top of the Fort Union Formation (Paleocene).

The top of the Tongue River Member, the uppermost member of the Fort Union Formation (Paleocene), is placed at the top of the Roland coal bed of Baker (1929). All of the coal beds described in this report belong to the Tongue River Member. This member is about 2,000 feet (610 m) thick in the eastern part of the quadrangle (Lewis and Roberts, 1978) and consists of light-colored sandstone, sandy shale, carbonaceous shale, and coal beds. The thicker coal beds have burned along the outcrops and have baked and fused the overlying rocks into reddish-colored clinker or slag.

Coal and other rocks comprising the Wasatch Formation and 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 Eocene and 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 Decker quadrangle is in the central part of the Powder River structural basin. Regionally the strata dip southward or southeastward, but this dip is considerably modified by low-relief folding. In the southern part of the quadrangle, the dip is interrupted by faults of rather small displacement. The structural attitude of the coal beds is shown on the structure-contour maps (pls. 5, 9, 13, 17, 21, 24, 28, 31, 34, 37, and 40). Nonconformity in structural attitude may be due to differential compaction and to irregular depositon of coal beds and the associated continental deposits.

COAL GEOLOGY

The coal beds in the Decker quadrangle are shown in outcrop on the Coal Data Map (pl. 1) and in section on the Coal Data Sheet (pl. 3A, B). All of the mapped coal beds occur in the Tongue River Member of the Fort Union Formation (Paleocene), as shown in the composite columnar section on plate 3A. No commercial coals are known to exist below the Tongue River Member.

The lowermost recognized coal bed in the Decker quadrangle is the Kendrick coal bed which is about 5 to 60 feet (1.5 to 18.3 m) above the base of the Tongue River Member. The Kendrick coal bed is overlain by a noncoal interval of about 280 to 420 feet (85.3 to 128 m), the King coal bed, a noncoal interval of 300 to 375 feet (91 to 114 m), the Brewster-Arnold coal bed, a mainly noncoal interval of about 200 to 275 feet (61 to 84 m) containing local coal beds, the Wall coal bed, a mainly noncoal interval of about 50 to 120 feet (15.2 to 36.6

m) containing a local coal bed, the Cook coal bed, a mainly noncoal interval of about 100 to 180 feet (30.5 to 54.9 m) containing local coal beds, the Canyon coal bed, a mainly noncoal interval of 65 to 150 feet (19.8 to 45.7 m) containing local coal beds, the Dietz 3 coal bed, a noncoal interval of 0 to 120 feet (0-36.6 m), the Dietz 2 coal bed, a noncoal interval of 0 to 160 feet (0-49 m), the Anderson (Dietz 1) coal bed, a mainly noncoal interval of 80 to 400 feet (24 to 122 m), containing the Roland coal bed of Taff (1908), Squirrel Creek, and local coal beds, the Smith coal bed, a noncoal interval of about 40 to 200 feet (12 to 61 m), and the Roland coal bed of Baker (1929).

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 17 miles (27 km) east-southeast of the Decker quadrangle. The Kendrick coal bed occurs in three oil-and-gas test holes (pls. 1 and 3) about 5 to 60 feet (15 to 18.3 m) above the base of the Tongue River Member. 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 strata deposited in a continental environment.

The isopach and structure contour map of the Kendrick coal bed (pl. 40) shows that this coal ranges from 5 to 12 feet (1.5 to 3.7 m) in thickness and dips southeastward at an angle of less than 1 degree, although this dip is modified locally by folding. Overburden on the Kendrick coal bed (pl. 41) ranges from about 1,500 to 2,000 feet (457 to 610 m) in thickness. There is no known, publicly available chemical analysis of the Kendrick coal in or close to the Decker 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 35 miles (56 km) northeast of the Decker quadrangle in the Ashland and Green Creek quadrangles. The correlation of the coal bed in the Decker quadrangle with the King coal bed at that type locality is necessarily uncertain because of the distance involved, the scant subsurface information, and the discontinuous nature of strata deposited in a continental environment.

The King coal bed does not crop out in the Decker quadrangle but has been penetrated by several oil-and-gas test holes (pls. 1 and 3). In these wells it occurs 280 to 420 feet (85.3 to 128 m) above the Kendrick coal bed. The isopach and structure contour map (pl. 37) shows that the King coal bed ranges from about 5 to 22 feet (1.5 to 6.7 m) in thickness and dips generally southward at an angle of less than 1 degree. Overburden on the King coal bed (pl. 38) ranges from about 800 to 1,300 feet (244 to 396 m) in thickness. There is no known, publicly available chemical analysis of the King coal in or close to the Decker 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 in the Tongue River valley at the Brewster-Arnold mine in sec. 23, T. 6 S., R. 42 E. about 16 miles (26 km) northeast of the Decker quadrangle in the Birney quadrangle. The Brewster-Arnold coal bed does not crop out in the Decker quadrangle but has been penetrated by two oil-and-gas test holes (pls. 1 and 3) where it occurs from 300 to 375 feet (91 to 114 m) above the King coal bed. The isopach and structure contour map (pl. 34) shows that the Brewster-Arnold coal bed ranges from about 5 to at least 6 feet (1.5 to 1.8 m) in thickness and dips southeastward at an angle of about 1 degree. Overburden on the Brewster-Arnold coal bed (pl. 35) ranges from about 800 to 1,000 feet (244 to 305 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 12 miles (19 km) north-northeast of the Decker quadrangle in the Birney SW 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 Decker quadrangle is similar and is also subbituminous B in rank.

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 12 miles (19 km) northeast of the Decker quadrangle in the Birney quadrangle. The Wall coal bed occurs about 200 to 275 feet (61 to 84 m) above the Brewster-Arnold coal bed. It does not crop out in the Decker quadrangle but has been penetrated by a number of test holes (pls. 1 and 3). The isopach and structure contour map (pl. 31) shows that the Wall coal bed ranges from less than 5 to 35 feet (1.5 to 11 m) in thickness and, in general, dips southward or southeastward 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. 32) ranges from about 400 to 1,200 feet (122 to 366 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 4 miles (12.2 km) northeast of the Decker 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 Decker quadrangle, it is assumed that the Wall coal in this quadrangle is similar and is also subbituminous B in rank.

Cook coal bed

The Cook coal bed was first described by Bass (1932, p. 79) from exposures on Cook Mountain in the Cook Creek Reservoir quadrangle about 46 miles (74 km) northeast of the Decker quadrangle. In the Decker quadrangle, the Cook coal bed occurs about 50 to 120 feet (15.2 to 36.6 m) above the Wall coal bed. The Cook coal bed does not crop out in the Decker quadrangle, but has been penetrated by a number of test holes (pls. 1 and 3). The isopach and structure contour map (pl. 28) shows that the Cook coal bed ranges from about 5 to 25 feet (1.5 to 7.6 m) in thickness and dips southward or 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. 28) ranges from about 300 to 900 feet (91 to 174 m) in thickness.

There are no known, publicly available chemical analyses of the Cook coal in or close to the Decker quadrangle. It is assumed that the Cook coal is similar to the other closely associated coals in this quadrangle and is probably subbituminous B in rank.

Canyon coal bed

The Canyon coal bed was first described by Baker (1929, p. 36) from exposures in the northward extension of the Sheridan coal field, probably along Canyon Creek in the northern part of the Spring Gulch quadrangle about 10 miles (16 km) north-northeast of the Decker quadrangle. In the Decker quadrangle, the Canyon coal bed occurs about 100 to 180 feet (305 to 54.9 m) above the Cook coal bed. The Canyon coal bed does not crop out in the Decker quadrangle, but is has been penetrated by a number of test holes (pls. 1 and 3). The isopach map (pl. 24) shows that the Canyon coal bed ranges from about 5 to 25 feet (1.5 to 7.6 m) in thickness. The structure contour map (pl. 25) shows that the coal bed, 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. 26) ranges from less than 100 to 800 feet (30.5 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) 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 this location in the Decker quadrangle is subbituminous B in rank.

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 western part of the Decker quadrangle, the Anderson (Dietz 1), Dietz 2, and Dietz 3 coal beds are combined into a single thick coal bed (pls. 1 and 3). The Dietz 3 coal bed is recognized as a separate coal bed over most of the Decker quadrangle. The Dietz 3 coal bed occurs about 65 to 150 feet (19.8 to 45.7 m) above the Canyon coal bed. The isopach map (pl. 20) shows that the Dietz 3 coal bed, where it is separated from the overlying coal beds, is about 5 to 33 (1.5 to 10 m) thick. The structure contour map (pl. 21) shows the coal bed dips eastward or southward at an angle of less than 1 degree. Overburden on the Dietz 3 coal bed (pl. 22) ranges from 0 feet at the outcrops to 300 feet (0-244 m) in thickness.

Dietz 2 coal bed

In the western part of the Decker quadrangle, the Dietz 2 coal bed is combined with the Anderson (Dietz 1) coal bed, and, in places, with the Dietz 3 coal bed. The isopach map (pl. 16) shows that the coal bed ranges from about 5 to 30 feet (1.5 to 9.1 m) in thickness. The structure contour map (pl. 17) shows that the coal bed, in general, dips southward at an angle of 1 degree or less, although this dip is modified in places by low-relief folding and faulting. Overburden on the Dietz 2 bed (pl. 18) ranges from about 0 to 700 feet (0-213 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. 36, T. 8 S., R. 38 E., about 6 miles (10 km) west of the Decker quadrangle in the Bar V Ranch quadrangle (Matson and

Blumer, 1973, p. 20), shows ash 2.863 percent, sulfur 0.304 percent, and heating value 9,305 Btu per pound (21,643 kJ/kg) on an as-received basis. This heating value converts to about 9,579 Btu per pound (22,281 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 Decker quadrangle, it is assumed that the Dietz coal in the Decker 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; probably exposures along Anderson Creek in the southern part of the Spring Gulch quadrangle, about 2 miles (3.2 km) northeast of the Decker 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 10 miles (16 km) southwest of the Decker quadrangle in the northern part of the Sheridan 7.5-minute quadrangle, Wyoming. The Dietz 1 coal bed is equivalent to the Anderson coal bed as mapped by Baker (1929, p. 28).

The Anderson (Dietz 1) coal bed is combined with the Dietz 2 and 3 coal beds in the western part of the Decker quadrangle (pls. 12, 13, 14, and 15). The isopach map (pl. 12) shows that the Anderson (Dietz 1) coal bed, where it is not combined with the Dietz beds, ranges from about 5 to 35 feet (1.5 to 10.7 m) in thickness. Where the Anderson (Dietz 1) coal bed is combined with the Dietz 2 coal bed in the western part of the quadrangle, the thickness of the combined beds ranges from 45 to 60 feet (12.7 to 18.3 m). Where the Anderson (Dietz 1) is combined with the Dietz 2 and 3 coal beds in the extreme western part of the quadrangle, the thickness of the combined beds ranges from 70 to 75 feet (21.3 to 22.9 m). The structure contour map (pl. 13) shows that the coal beds, in general, dip southwestward 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 500 feet (0-152 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), in coal test hole SH-7018, sec. 19, T. 9 S., R. 40 E., about 0.5 mile (0.8 km) west of the Decker quadrangle 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 (24,288 kJ/kg) on a mineral-matter-free basis, indicating that the Anderson (Dietz 1) coal at that location is subbituminous B in rank. Because of the proximity of that location to the Decker quadrangle, it is assumed that the coal in this quadrangle is similar and 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 11 miles (17.7 km) south-southwest of the Decker quadrangle. In the Decker quadrangle, the Smith coal bed occurs about 80 to 400 feet (24 to 122 m) above the Anderson (Dietz 1) coal bed and crops out along the sides of the valleys throughout much of the quadrangle. The isopach map (pl. 8) shows that the Smith coal bed ranges from about 5 to 25 feet (1.5 to 7.6 m) in thickness. The structure contour map (pl. 9) shows that the Smith coal bed, in general, dips to the southwest 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 outcrops 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 3 miles (4.8 km) east of the Decker 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 Decker quadrangle is similar and is subbituminous C in rank.

Roland coal bed of Baker (1929)

The Roland coal bed of Baker (1929) 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) in the John Bell coal mine in sec. 8, T. 9 S., R. 39 E., in the Pearl School quadrangle about 5 miles (8 km) west of the Decker quadrangle. Outcrops of the Roland coal bed of Baker (1929) are shown on the Coal Data Map (pl. 1). In the Decker quadrangle, the Roland coal bed of Baker (1929) occurs about 40 to 200 feet (12 to 61 m) above the Smith coal bed. The isopach and structure contour maps (pls. 4 and 5) show that the Roland coal bed of Baker (1929) ranges in thickness from 5 to 13 feet (1.5 to 4 m) and dips generally 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 coal bed (pl. 6) ranges from 0 at the outcrops to about 400 feet (0-122 m) in the southeastern part of the quadrangle.

A chemical analysis of the Roland coal of Baker (1929) (Matson and Blumer, 1973, p. 27) from a depth of 53 to 63 feet (16 to 19 m) in coal test hole SH-702, sec. 26, T. 9 S., R. 40 E., in the Decker quadrangle, shows ash 3.924 percent, sulfur 0.238 percent, and heating value 8,876 Btu per pound (20,646 kJ/kg) on an as-received basis. This heating value converts to about 9,239 Btu per pound (21,490 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Roland of Baker (1929) coal in this quadrangle is subbituminous C in rank.

Local coal beds

Local coal beds occur at several places stratigraphically in this quadrangle. Because these beds are generally thin and of limited areal extent, economic resources have not been assigned to them.

COAL RESOURCES

Data from all publicly available drill holes and from surface mapping by others (see list of references) were used to construct outcrop, isopach, and structure contour maps of the coal beds in this quadrangle. Because of the press time, our contract with the U.S. Geological Survey for these maps did not permit us to go to the field to do any checking on the data.

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

<u>Identified Resources</u> 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. <u>Measured</u> coal is coal located within 0.25 mile (0.4 km) of a measurement point, <u>Indicated</u> coal extends

0.5 mile (0.8 km) beyond Measured coal to a distance of 0.75 mile (1.2 km) from the measurement point, and Inferred coal extends 2.25 miles (3.6 km) beyond Indicated coal to a distance of 3 miles (4.8 km) from the measurement point.

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

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

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

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

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

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

As shown by table 1, the total tonnage of federally owned, surface-minable Reserve Base coal in this quadrangle is estimated to be 2,178.73 million short tons (1,976.54 million t). The total tonnage of federally owned, surface-minable Hypothetical coal is estimated to be 0.51 million short tons (0.46 million t). As shown by table 2, the total federally owned, underground-minable Reserve Base coal is estimated to be 1,240.41 million short tons (1,125.30 million t). The total federally owned, underground-minable Hypothetical coal is estimated to be 47.93 million short tons (43.48 million t). The total tonnage of surface- and underground-minable Reserve Base coal is 3,419.14 million short tons (3,101,84 million t), and the total of surface- and underground-minable Hypothetical coal is 48.44 million short tons (43.94 million t).

About 5 percent of the surface-minable Reserve Base tonnage is classed as Measured, 38 percent as Indicated, and 57 percent as Inferred. About 3 percent of the underground-minable Reserve Base tonnage is Measured, 14 percent is Indicated, and 83 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). The first thickness of overburden is the assigned stripping limit for surface mining of multiple beds of subbituminous coal in this area. Areas having a potential for surface mining were assigned a high, moderate, or low development potential based on their mining 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 that the Federal coal lands have for surface-mining methods is shown on the Coal Development Potential map (pl. 43). Most of the Federal coal lands have a high development for surface mining. Coal lands having moderate development potential are mostly concentrated near the northern border of the quadrangle, and a fairly large tract of low development potential is near the southeastern corner of the quadrangle.

The Kendrick (pl. 41), King (pl. 38), and Brewster-Arnold (pl. 35) coal beds have no development potential for surface mining because all of the coal 5 feet (1.5 m) or more thick is found under more than 500 feet (152.4 m) of overburden (the stripping limit).

The Wall coal bed (pl. 32) has a small area of high development potential along the Tongue River near the northern edge of the quadrangle. Fairly large tracts of moderate and low development potential occur along the Tongue River in the northern third of the quadrangle. The remainder of the coal extending southward has no mining potential for surface mining because the coal is under more than 500 feet (152 m) of overburden.

The Cook coal bed (pl. 29) has low development potential for surface mining over about two-thirds of the quadrangle, where the coal is within the stripping limit, because the mining-ratio values are greater than 15. The rest of the coal has no development potential, as it is beyond the stripping limit.

The Canyon coal bed (pl. 26) has large areas of high development potential for surface mining in the northern part of the quadrangle extending from the Tongue River Reservoir to the 10 mining-ratio contour. Large areas of moderate development potential extend from the 10 mining-ratio contour on the Tongue River Reservoir to the 15 mining-ratio contour. Most of the Canyon coal in this quadrangle has a low development potential extending from the 15 mining-ratio contour or the Tongue River Reservoir to the stripping limit. Areas of no development potential are found near the northwestern, southwestern, and southeastern corners of the quadrangle.

The Dietz 3 coal bed (pl. 22) has large areas of high development potential for surface mining extending from the outcrops or the Tongue River Reservoir to the 10 mining-ratio contour. Fairly wide areas of moderate development potential occur between the 10 and 15 mining-ratio contours. Narrow to very wide areas of low development potential occur between the 15 mining-ratio contour to the stripping limit. A large area of no development potential is found near the southeastern corner of the quadrangle, and isolated areas of no development potential occur near the southwestern corner of the quadrangle.

The Dietz 2 coal bed (pl. 18) has large areas of high development potential for surface mining which extend from the valleys up the slopes to the 10 mining-ratio contour. Narrow to wide 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 higher hills. Much of the coal in the southeastern corner has no development potential because the coal is under more than 500 feet (152 m) of overburden.

The Anderson (Dietz 1) coal (pl. 14) has extensive areas of high development potential for surface mining extending from the coal boundary up the slopes of the hills to the 10 mining ratio. All of the Anderson (Dietz 1) coal west of the Tongue River has a high development potential. Thin bands of moderate development potential parallel the high development potential and lie between the 10 and 15 mining-ratio contours on the east side of the river. On this side of the river large areas of low development potential extend from the 15 mining-ratio under the higher hills. A small area in the southeastern part of the quadrangle has no development potential because the coal is under more than 500 feet (152 m) of overburden.

The Smith coal bed (pl. 10) contains fairly large areas of high development potential for surface mining 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 and the crests of the higher hills.

The Roland coal bed of Baker (1929) (pl. 6) has large areas of high development potential for surface mining 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 83 percent of the Federal coal lands in the quadrangle has a high development potential for surface mining, 13 percent has a moderate development potential, and 4 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 Decker 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)	14,610,000	2,970,000	7,250,000	24,830,000
Smith	72,390,000	9,520,000	25,410,000	107,320,000
Anderson (Dietz 1)	465,210,000	32,690,000	51,320,000	549,220,000
Dietz 2	60,210,000	77,780,000	52,740,000	190,730,000
Dietz 3	115,990,000	110,660,000	152,990,000	379,640,000
Canyon	90,320,000	123,300,000	211,810,000	425,430,000
Cook	0	0	207,980,000	207,980,000
Wall	1,410,000	164,040,000	128,130,000	293,580,000
Total	820,140,000	520,960,000	837,630,000	2,178,730,000
Hypothetical Resource tonnage				
Canyon	0	0	510,000	510,000
Total	0	0	510,000	510,000
Grand Total	820,140,000	520,960,000	838,140,000	2,179,240,000

Table 2.--Underground-minable coal resource tonnage (in short tons) by development-potential category for Federal lands in the Decker 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)	0	0	3,100,000	3,100,000
Dietz 2	0	0	29,760,00	29,760,000
Dietz 3	0	0	77,910,000	77,910,000
Canyon	0	0	142,100,000	142,100,000
Cook	0	0	201,900,000	201,900,000
Wall	0	0	321,900,000	321,900,000
King	0	0	300,040,000	300,040,000
Kendrick	0	0	127,040,000	127,040,000
Brewster-Arnold	0	0	36,660,000	36,660,000
Total	0	0	1,240,410,000	1,240,410,000
Hypothetical Resource tonnage				
Canyon	0	0	1,630,000	1,630,000
King	0	0	43,910,000	43,910,000
Kendrick	0	0	1,520,000	1,520,000
Brewster-Arnold	0	0	870,000	870,000
Total	0	0	47,930,000	47,930,000
Grand Total	0	0	1,288,340,000	1,288,340,000

REFERENCES

Ayler, M. F., Smith, J. B., and Deutman, G. M., 1969, Strippable coal resources of Montana: U.S. Bureau of Mines Preliminary Report 172, 68 p.

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

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

_______1932, The Ashland coal field, Rosebud, Powder River, and Custer Counties, Montana: U.S. Geological Survey Bulletin 831-B, p. 19-105.

Culbertson, W. C., Kent, B. H., and Mapel, W. J., 1979, 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: U.S. Geological Survey Open-File Report 79-1201, 2 sheets.

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

Law, B. E., Barnum, B. E., and Wollenzien, T. P., 1979, Coal bed correlations in the Tongue River Member of the Fort Union Formation, Monarch, Wyoming, and Decker, Montana: U.S. Geological Survey Miscellaneous Geological Investigations Map I-1128.

Law, B. E., and Grazis, S. L., 1972, Preliminary geologic map and coal resources of the Decker quadrangle, Big Horn County, Montana: U.S. Geological Survey Open-File report.

Lewis, B. D., and Roberts, R. S., 1978, Geology and water-yielding characteristics of rocks of the Northern Powder River Basin; southeastern Montana: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-847-D.

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

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

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

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

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

Warren, W. C., 1959, Reconnaissance geology of the Birney-Broadus coal field, Rosebud and Powder River Counties, Montana: U.S. Geological Survey Bulletin 1072-J, p. 561-585.