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

[Report includes 26 plates]

By

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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 Bar V Ranch NE quadrangle, Big Horn County, Montana, (26 plates; U.S. Geological Survey Open-File Report 79-644). 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 Bar V Ranch NE 7 1/2-minute quadrangle is in eastern Big Horn County, Montana, about 42 miles (68 km) southeast of Hardin, Montana, a town in the valley of the Bighorn River near the confluence of the Bighorn River and the Little Bighorn River. Hardin is on U.S. Interstate Highway 90, U.S. Highway 212, and on the Burlington Northern Railroad.

The Bar V Ranch NE quadrangle is 10 miles (16 km) northwest of Decker, Montana, and 23 miles (37 km) north-northwest of Sheridan, Wyoming.

Accessibility

The Bar V Ranch NE 7 1/2-minute quadrangle is accessible from Hardin, Montana, by going southward on U.S. Interstate Highway 90 and then eastward on U.S. Highway 212 for a total of about 39 miles (63 km) to the Rosebud Creek Road located just west of Busby; then southward about 22 miles (35 km) to the Big Bend School near the Penson Ranch; and then west on a light-duty road 2.5 miles (4 km) to the eastern border of the quadrangle. The quadrangle is also accessible from Decker, Montana, by going northward on the partially paved local Highway 314 about 18 miles (29 km) to the Big Bend School on Rosebud Creek, and then westward on a local road about 2.5 miles (4 km) to the eastern border of the quadrangle. Decker is about 18 miles (29 km) by road north of Sheridan, Wyoming. The nearest railroad is a spur line of the Burlington Northern Railroad at the Decker mine, Montana, about 11 miles (17.7 km) southeast of the quadrangle.

Physiography

The Bar V Ranch NE quadrangle lies within the Missouri Plateau Division of the Great Plains physiographic province. The topographic relief of this part of the Missouri Plateau is greater than is typical of the Great Plains because the plateau here is near the Big Horn Mountains and has been deeply dissected. Commonly in this region, remnants of the gently undulating plateau are preserved only along drainage divides between entrenched streams. Much of the landscape is composed of steep to precipitous slopes located between narrow, locally flat-topped, drainage divides and the narrow, locally flat-bottomed, valleys of entrenched streams.

The Bar V Ranch NE quadrangle is located along the eastern flank of the central Wolf Mountains. The Wolf Mountains form a north-south-trending ridge mainly just to the west of the Bar V Ranch NE quadrangle. The ridge separates the drainages of the Little Bighorn River to the west from the drainages of Rosebud Creek and Tongue River to the east. The landscape of the Bar V Ranch NE quadrangle is typical of the Northern Powder River Basin KRCRA.

The Wolf Mountains are the most prominent landform in the quadrangle. From the west, they extend 1 to 2 miles (1.6 to 3.2 km) into the west-central part of the quadrangle. Their upper surface is relatively flat, varying in elevation from about 4,900 feet (1,492 m) along its irregular, dissected edge, to 5,073 feet (1,546 m) at the top of one small, rounded peak. Several, generally flat, mesas or ridges extend eastward from the Wolf Mountains. These ridges have irregular surface outlines, but are typically 0.25 to 1 mile (0.4 to 1.6 km) wide and several miles (several kilometers) long. Typical elevations of the ridges range from 4,500 to 5,000 feet (1,372 to 1,524 m).

The Bar V Ranch NE quadrangle includes parts of three major drainage basins. The northern two-thirds of the quadrangle, east of the Wolf Mountains, drains into Rosebud Creek. The southern one-third of the quadrangle drains into the Tongue River. West of the crest of the Wolf Mountains several small areas, that together cover less than 1 square mile (2.6 sq km), drain into the Little Bighorn River. The Little Bighorn River flows northward about 13 miles (21 km) west of the quadrangle. The north and south forks of Rosebud Creek unite at the eastern edge of the quadrangle to form Rosebud Creek; the Tongue River passes about 10 miles (16 km) southeast of the southeast corner of the quadrangle. Both Rosebud Creek and the Tongue River flow alternately northward and northeastward to the Yellowstone River, which flows eastward about 72 miles (116 km) north of the Bar V Ranch NE quadrangle.

The major streams in the quadrangle are the North Fork Rosebud Creek and the South Fork Rosebud Creek, which flow eastward across the northern part of the quadrangle. Several smaller streams, tributaries of the Tongue River, flow southeastward in the southern part of the quadrangle. The South Fork Rosebud Creek is the only perennial stream in the quadrangle and the only stream with a well-developed, but narrow flood plain.

Most of the area of the quadrangle is occupied by the steep slopes of the narrow valleys. The slopes of the valleys typically rise 200 to 400 feet (61 to 122 m) over distances of 0.2 to 0.7 miles (0.32 to 1.1 km). The longer and higher slopes are locally broken by a relatively flat bench, giving the landscape a stepped appearance.

The highest elevation in the quadrangle is 5,073 feet (1,546 m) in the Wolf Mountains. The lowest elevation in the quadrangle is about 4,130 feet (1,259 m) along Spring Creek at the eastern edge of the quadrangle. Thus, relief in the quadrangle is about 943 feet (287 m).

Climate

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

Land status

The Boundary and Coal Data Map (pl. 2) shows the land ownership status within the Bar V Ranch NE quadrangle. All of the quadrangle except the eastern one and one-half rows of sections is within the Crow Indian Reservation which contains no Federal coal land. All of the land outside of the Indian Reservation is within the Northern Powder River Basin Known Recoverable Coal Resource Area (KRCRA). There were no outstanding Federal coal leases or prospecting permits recorded as of 1977.

GENERAL GEOLOGY

Previous work

Baker (1929, pl. 8) mapped that part of the Bar V Ranch NE quadrangle east of the Crow Indian Reservation as part of the northward extension of the Sheridan coal field. Matson and Blumer (1973, pls. 5A, 5B, and 5C) remapped the coal beds in the same area. Traces of coal-bed outcrops shown by previous workers primarily on planimetric maps that lack topographic control have been modified to fit the modern topographic map of the quadrangle.

Stratigraphy

A generalized columnar section of the coal-bearing rocks is shown on the Coal Data Sheet (pl. 3) of the CRO maps. The exposed bedrock units belong to the Wasatch Formation (Eocene) and to the underlying upper part of the Tongue River Member, the uppermost member of the Fort Union Formation (Paleocene).

The uppermost strata in the quadrangle belong to the Wasatch Formation. The Wasatch Formation consists of fine- to coarse-grained lenticular sandstone beds with interbedded gray shale and coal. The Wasatch also contains a fossiliferous zone of clams and snails as much as 30 feet (9.1 m) thick. An erosion-resistant clinker zone crops out along the coal horizons. The basal 100 feet (30 m) of this unit are preserved in the mapped part of the Bar V Ranch NE quadrangle. The base of the Wasatch is placed at the top of the Roland of Baker (1929) coal bed (Lewis and Roberts, 1978). There are no mapped coal beds in this quadrangle which belong to the Wasatch Formation.

The Tongue River Member of the Fort Union Formation consists mainly of yellow sandstone, sandy shale, carbonaceous shale, and coal. Coal has burned along outcrops, baking the overlying sandstone and shale and forming thick, reddish-colored clinker beds. The Tongue River Member is about 1,800 feet (549 m) thick in the area (Lewis and Roberts, 1978).

Coal and other rocks comprising the Tongue River Member were deposited in a continental environment at elevations of perhaps a few tens of feet (a few meters) above sea level in a vast area of shifting rivers, flood plains, sloughs, swamps, and lakes that occupied the area of the Northern Great Plains in Paleocene (early Tertiary) time.

Directly below the Tongue River Member is the Lebo Shale Member of the Fort Union Formation, which partly intertongues with the Tongue River Member, and consists of mudstone, shale, sandstone, and thin local coal beds. The Tullock Member of the Fort Union Formation underlies the Lebo Shale Member and contains siltstones, sandstones, and local coal beds (Culbertson, Kent, and Mapel, 1979). In the Bar V Ranch NE quadrangle, no important coal beds exist in the lower two members of the Fort Union Formation.

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 Bar V Ranch NE quadrangle is in the western part of the Powder River structural basin. The strata, in general, dip eastward or southeastward at an angle of less than 2 degrees. In places this dip is modified by minor, low-relief folds and by faults as shown by the structure contour maps (pls. 4, 8, 11, 14, 17, 20, and 23). Some of the nonconformity in structure may be due to differential compaction and to irregularities in deposition of the coals and other rock layers as a result of their continental origin.

COAL GEOLOGY

The recognized coal beds in the Bar V Ranch NE quadrangle are shown in outcrop on the Coal Data Map (pl. 1) and in section on the Coal Data Sheet (pl. 3).

All of the known coal beds belong to the upper part of the Tongue River Member of the Fort Union Formation. No commercial coals are found below the Tongue River Member.

The lowermost recognized coal bed is the Wall coal bed. The Wall coal bed is overlain successively by a noncoal interval of about 80 feet (24.4 m), the Cook coal bed, a noncoal interval of about 120 feet (36.6 m), the Canyon coal bed, a noncoal interval of about 175 feet (53.3 m), the Dietz 2 and 3 coal beds, a noncoal interval of about 130 feet (40 m), a local coal bed, a noncoal interval of about 8 feet (2.4 m), the Anderson (Dietz 1) coal bed, a noncoal interval of about 40 to 160 feet (12 to 49 m), the Smith coal bed, a noncoal interval of about 135 feet (41 m), a local coal bed, a noncoal interval of about 100 feet (30.5 m), and the Roland of Baker (1929) coal bed.

The trace-element content of coals in this quadrangle has not been determined; however, coals in the Northern Great Plains, including those in the Fort Union Formation in Montana, have been found to contain, in general, appreciably lesser amounts of most elements of environmental concern than coals in other areas of the United States (Hatch and Swanson, 1977, p. 147).

Wall coal bed

The Wall coal bed was named by Baker (1929, p. 37) probably from exposures of the coal along Wall Creek, a tributary of the Tongue River in the Birney quadrangle, about 20 miles (32 km) east-northeast of the Bar V Ranch NE quadrangle. The Wall coal bed does not crop out in the quadrangle. The isopach and structure contour map of the Wall coal bed (pl. 23) was constructed by using data in adjacent quadrangles. This map shows that the Wall coal bed ranges from 25 to 35 feet (7.6 to 10.7 m) in thickness and dips southeastward at a low angle, except where it is affected by minor faults. Overburden on the Wall coal bed (pl. 24) ranges from about 400 feet (122 m) in the northern part of the quadrangle to about 800 feet (244 m) in the southern part of the quadrangle. There are no known publicly available chemical analyses of the Wall coal in or close to the Bar V Ranch NE quadrangle. However, it is assumed that the Wall Creek coal is similar to other closely associated coals in the quadrangle and is subbituminous C in rank also.

Cook coal bed

The Cook coal bed was first described by Bass (1932, p. 59 and 60) from exposures in the Cook Creek Reservoir quadrangle, about 48 miles (77 km) to the northeast. In the Bar V Ranch NE quadrangle, the Cook coal bed occurs about 80 feet (24.4 m) above the Wall coal bed. The isopach and structure contour map of the Cook coal bed (pl. 20), based on measurements in adjacent quadrangles, shows that the Cook coal bed ranges from less than 5 feet to about 10 feet (1.5 to 3.0 m) in thickness and dips southeastward at an angle of less than 1 degree. Overburden on the Cook coal bed (pl. 21) ranges from about 500 to 800 feet (152 to 244 m) in thickness. There are no publicly available chemical analyses of the Cook coal in or close to the Bar V Ranch NE quadrangle; however, it is assumed that the Cook coal is similar to other closely associated coals in the quadrangle and is subbituminous C in rank also.

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 could have been along Canyon Creek in the Spring Gulch quadrangle, about 14 miles (22.5 km) to the east. In the Bar V Ranch NE quadrangle, the Canyon coal bed occurs about 120 feet (36.6 m) above the Cook coal bed. In the Bar V Ranch NE quadrangle, the Canyon coal bed does not crop out. The isopach and structure contour map of the Canyon coal bed (pl. 17) is based on measurements in adjacent quadrangles. This map shows that the Canyon coal bed ranges from less than 5 feet (1.5 m) to as much as 20 feet (6.1 m) in thickness and dips southeastward at an angle of less than 1 degree. Overburden on the Canyon coal bed (pl. 18) ranges from about 400 to 600 feet (122 to 183 m) in thickness. There is no known, publicly available chemical analysis of the Canyon coal in the Bar V Ranch quadrangle. However, a chemical analysis of this coal in coal test hole SH-36, sec. 16, T. 6 S., R. 39 E., about 5.5 miles (8.8 km) northeast of this quadrangle in the Kirby quadrangle (Matson and Blumer, 1973, p. 34) shows ash 3.243 percent, sulfur 0.026 percent, and heating value 9,113 Btu per pound (21,197 kJ/kg) on an as-received basis. This heating value converts to about 9,418 Btu per pound (21,906 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Canyon coal bed at that location is subbituminous C in rank. Because of the proximity of that location to the Bar V Ranch NE quadrangle, it is assumed that the Canyon coal in this quadrangle is similar and is subbituminous C in rank also.

Dietz 2 and 3 coal beds

The Dietz 1, 2, and 3 coal beds were first described by Taff (1909, p. 139-40) from exposures in the Sheridan coal field, Wyoming. The coal bed which Baker (1929, pl. 8) mapped as the Anderson coal bed in the Spring Creek Ranch quadrangle, just north of the Bar V Ranch NE quadrangle, was remapped by Matson and Blumer (1973, pl. 5B) as the Dietz coal beds (upper or combined benches). Matson and Blumer (1973, pl. 5A) mapped a higher bed in the northeastern part of the Bar V Ranch NE quadrangle as the Anderson coal bed. Faults, unsuspected by Baker, were revealed by coal test holes drilled to support the field mapping of Matson and Blumer. The compiled maps accompanying this report follow the interpretations of Matson and Blumer (1973, pls. 5A and 5B). We believe that the two combined Dietz benches mapped by Matson and Blumer are equivalent to the Dietz 2 and 3 of Taff, and that the Anderson coal bed is equivalent to the Dietz 1 of Taff.

In the mapped part of the Bar V Ranch NE quadrangle, the Dietz 2 and 3 coal beds crop out only in the extreme northeastern part of the quadrangle. Information from adjacent quadrangles indicates that the Dietz coal beds occur about 175 feet (53.3 m) above the Canyon coal bed. The isopach and structure contour map of the combined Dietz 2 and 3 coal beds (pl. 14), based primarily on measurements in adjacent quadrangles, shows that this coal ranges from about 40 to 50 feet (12 to 15 m) in thickness and dips southeastward at a very gentle angle. The Dietz 2 and 3 coal beds merge together just east of the Bar V Ranch NE quadrangle in the Half Moon Hill quadrangle. For mapping convenience in the Bar V Ranch NE quadrangle, the two beds are mapped as one combined bed, with no interburden. Overburden on the combined Dietz 2 and 3 coal beds (pl. 15) ranges from about 200 to 500 feet (61 to 152 m) in thickness.

There is no known, publicly available chemical analysis of the Dietz 2 and 3 coal beds in the Bar V Ranch NE quadrangle. However, a chemical analysis of this coal from a depth of 111 to 120 feet (33.8 to 36.6 m) in coal test hole SH-722, sec. 35, T. 6 S., R. 39 E., about 3.75 miles (6.0 km) east-northeast of the Bar V Ranch NE quadrangle in the Kirby quadrangle (Matson and Blumer, 1973, p. 35) shows ash 4.395 percent, sulfur 0.246 percent, and heating value of 8,552 Btu per pound (19,892 kJ/kg) on an as-received basis. This heating value converts to about 8,945 Btu per pound (20,806 kJ/kg) on a moist, mineral-matter-free basis, indicating that the coal at that location is subbituminous C in rank. Because of the proximity of that location to the Bar V Ranch NE quadrangle, it is assumed that the Dietz 2 and 3 coal in this quadrangle is similar and is also subbituminous C in rank.

Local coal bed

A local coal bed, 4 feet (1.2 m) thick, occurs about 130 feet (40 m) above the Dietz 2 and 3 coal beds near Spring Creek in sec. 12, T. 8 S., R. 38 E., (Matson and Blumer, 1973, Appendix, SH-1707). Economic coal resources have not been assigned to this thin, local coal bed.

Anderson (Dietz 1) coal bed

The Anderson (Dietz 1) coal bed was first described by Baker (~~1912~~ 1929, p. 35) from exposures in the northern extension of the Sheridan coal field, although a type locality was not given. The type locality probably is along Anderson Creek in the southern part of the Spring Gulch quadrangle, about 14 miles (22.5 km) east of the Bar V Ranch NE quadrangle. In the Bar V Ranch NE quadrangle, the Anderson (Dietz 1) coal bed occurs about 140 feet (43 m) above the combined Dietz 2 and 3 coal beds. A clinker bed formed by the burning of this coal crops out on the lower slopes of the hills. The isopach and structure contour maps of the Anderson (Dietz 1) coal bed (pl. 11), based principally on measurements in adjacent quadrangles, shows that this coal ranges from 15 to 28 feet (4.6 to 8.5 m) in thickness and dips eastward or southeastward at a gentle angle. A small fault in the northeast part of T. 8 S., R. 38 E. interrupts the continuity of the beds. Overburden on the Anderson (Dietz 1) coal bed (pl. 12) ranges from 0 feet at the outcrop to 400 feet (0-122 m) in thickness.

There is no known, publicly available chemical analysis of the Anderson (Dietz 1) coal bed in the Bar V Ranch NE quadrangle. However, a chemical analysis of this coal from a depth of 72 to 97 feet (22 to 30 m) in coal test hole SH-56, sec. 18, T. 7 S., R. 39 E. in the Half Moon Hill quadrangle, about 0.3 mile (0.5 km) east of the Bar V Ranch NE quadrangle, shows ash 4.255 percent, sulfur 0.273 percent, and heating value 8,426 Btu per pound (19,599 kJ/kg) on an as-received basis (Matson and Blumer, 1973, p. 36). This heating value converts to about 8,800 Btu per pound (20,470 kJ/kg) on a moist, mineral-matter-free basis, indicating that the coal at that location is subbituminous C in rank. Because of the proximity of that location to the Bar V Ranch NE quadrangle, it is assumed that the Anderson (Dietz 1) coal in this quadrangle is similar and is also subbituminous C in rank.

Smith coal bed

The Smith coal bed was first described by Taff (1909, p. 130 and 141) from exposures in the Smith mine in the Sheridan coal field, Wyoming, about 20 miles (32 km) south-southeast of the Bar V Ranch NE quadrangle in the Sheridan quadrangle, Wyoming. In the Bar V Ranch NE quadrangle, the Smith coal bed occurs about 40 to 160 feet (12 to 49 m) above the Anderson (Dietz 1) coal bed. Although the coal crops out along the eastern margin of the quadrangle, thickness measurements are lacking. The isopach and structure contour maps of the Smith coal bed (pls. 7 and 8) show that the Smith coal bed ranges from less than 5 to about 20 feet (1.5 to 6.1 m) in thickness and dips southwestward at a low angle. Overburden on the Smith coal bed (pl. 9) ranges from 0 feet at the outcrops to about 400 feet (0-122 m) in thickness.

There are no known, publicly available chemical analyses of the Smith coal in or close to the Bar V Ranch NE quadrangle. However, it is assumed that the Smith coal is similar to other closely associated coals in the quadrangle and is also subbituminous C in rank.

Local coal bed

A local coal bed ranging from 1 to 5.6 feet (0.3 to 1.7 m) in thickness occurs about 130 feet (39.7 m) above the Smith coal bed in sec. 12, T. 8 S., R. 38 E. (Matson and Blumer, 1973, Appendix, SH-7017). Economic coal resources have not been assigned to this local coal bed.

Roland of Baker (1929) coal bed

The Roland of Baker (1929) coal bed was first described by Baker (1929, p. 34), in the northward extension (Montana part) of the Sheridan coal field in a mistaken correlation with the Roland coal bed of Taff (1909) in the Sheridan, Wyoming, coal field. Baker's Roland coal bed reaches a maximum thickness of about 17 feet (5.2 m) at the John Bell coal mine in sec. 8, T. 9 S., R. 39 E. in the Pearl School quadrangle about 5 miles (8 km) south-southeast of the Bar V Ranch NE quadrangle. In the Bar V Ranch NE quadrangle, the Roland of Baker (1929) coal bed is about 250 feet (76 m) above the Smith coal bed. Outcrops of the Roland of Baker (1929) coal bed are shown on the Coal Data Map (pl. 1). The isopach and structure contour map (pl. 4) shows that the Roland of Baker (1929) coal bed ranges in thickness from 1.5 to 6 feet (0.5 to 1.8 m) and dips gently southeastward except where the coal bed is affected by low-relief folding. Overburden on the Roland of Baker (1929) coal bed (pl. 5) ranges from 0 feet at the outcrop to about 100 feet (0-30.5 m) in thickness.

A chemical analysis of the Roland of Baker (1929) coal from a depth of 42 to 46 feet (12.8 to 14 m) in coal test hole SH-7035, sec. 20, T. 8 S., R. 39 E., about 1 mile (1.6 km) southeast of the Bar V Ranch NE quadrangle in the Pearl School quadrangle (Matson and Blumer, 1973, p. 29) shows ash 3.508 percent, sulfur 0.292 percent, and heating value 8,265 Btu per pound (19,224 kJ/kg) on an as-received basis. This heating value converts to about 8,565 Btu per pound (19,922 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Roland coal at that location is subbituminous C in rank. Because of the proximity of that location to the Bar V Ranch NE quadrangle, it is assumed that the Roland of Baker (1929) coal in this quadrangle is similar and is also subbituminous C in rank.

COAL RESOURCES

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

A coal resource classification system has been established by the U.S. Bureau of Mines and the U.S. Geological Survey and published in U.S. Geological

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

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

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

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

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

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

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

Tonnages of coal resources were estimated using coal-bed thicknesses obtained from the coal isopach map for each coal bed (see list of illustrations). The coal resources, in short tons, for each isopached coal bed are the product of the acreage of coal (measured by planimeter), the average thickness in feet of the coal bed, and a conversion factor of 1,770 short tons of subbituminous coal per acre-foot (13,018 metric tons per hectare-meter). Tonnages of coal in Reserve

Base, Reserves, and Hypothetical categories, rounded to the nearest one-hundredth of a million short tons, for each coal bed are shown on the Areal Distribution and Tonnage maps (see list of illustrations).

As shown by table 1, the total tonnage of federally owned, surface-minable Reserve Base coal in this quadrangle is estimated to be 519.94 million short tons (471.69 million t). The total tonnage of federally owned, surface-minable Hypothetical coal is estimated to be 9.83 million short tons (8.92 million t). As shown by table 2, the total federally owned, underground-minable Reserve Base coal is estimated to be 159.21 million short tons (144.43 million t). The total federally owned, underground-minable Hypothetical coal is estimated to be 148.28 million short tons (34.52 million t). The total tonnage of surface- and underground-minable Reserve Base coal is 679.15 million short tons (616.12 million t), and the total of surface- and underground-minable Hypothetical coal is 158.11 million short tons (143.44 million t).

About 2 percent of the surface-minable Reserve Base tonnage is classed as Measured, 13 percent as Indicated, and 85 percent as Inferred. All of the underground-minable Reserve Base tonnage is Inferred.

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

COAL DEVELOPMENT POTENTIAL

There is a potential for surface-mining in the Northern Powder River Basin in areas where subbituminous coal beds 5 feet (1.5 m) or more thick are overlain by less than 500 feet (152 m) of overburden. This thickness of overburden is the assigned stripping limit for surface mining of multiple beds of subbituminous coal in this area. Areas having a potential for surface mining were assigned a high, moderate, or low development potential based on their mining-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 to high topographic relief, the area of moderate-development potential for surface mining of a coal bed (area having mining-ratio values of 10 to 15) is often restricted to a narrow band between the high and low development-potential areas. In fact, because of the 40-acre (16.2-ha) minimum size of coal development-potential tracts, the narrow band of moderate development-potential area often does not appear on the CDP map because it falls within the 40-acre (16.2-ha) tracts that also include areas of high development potential. The Coal Development Potential (CDP) map then shows areas of low development potential abutting against areas of high development potential.

The coal development potential that the Federal coal lands have for surface-mining methods is shown on the Coal Development Potential map (pl. 26). Most of the Federal coal lands have a high development potential for surface mining. Some have moderate development potential, and one small tract has low development potential for surface mining.

The Wall coal bed (pl. 24), the Cook coal bed (pl. 21), and the Canyon coal bed (pl. 18) have low development potentials for all of the Federal lands in the quadrangle within the stripping limit for each of these beds.

The combined Dietz 2 and 3 coal beds (pl. 15) have large areas of high development potential extending from the boundary to the 10 mining-ratio contour. This bed also has narrow bands of moderate development potential bounded by the 10 mining-ratio contour and the 500-foot (152-m) overburden isopach.

The Anderson (Dietz 1) coal bed has extensive areas of high development potential on the hill slopes extending from the boundary of the coal to the 10 mining-ratio contour. The Anderson (Dietz 1) coal bed also has bands of moderate development potential coal paralleling the high development-potential coal areas, and low-potential areas capping the hills.

The Smith coal bed (pl. 9) has a high development potential for most of the northern one-half of the quadrangle. The remainder of the quadrangle contains high, moderate, and low development potential coal.

The Roland of Baker (1929) coal bed in this quadrangle has about 80 acres (32.4 ha) of coal that is more than 5 feet (1.5 m) thick. The development potential in this area is divided roughly equally among high, moderate, and low development potentials.

About 83 percent of the Federal coal lands in the quadrangle has a high development potential for surface mining, 16 percent has a moderate development potential, and about 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 thick and 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 Bar V Ranch NE 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)	150,000	130,000	310,000	590,000
Smith	40,350,000	29,340,000	18,660,000	88,350,000
Anderson	67,080,000	42,800,000	37,600,000	147,480,000
Dietz 2 and 3	224,670,000	50,120,000	0	274,790,000
Canyon	0	0	2,580,000	2,580,000
Cook	0	0	570,000	570,000
Wall	0	0	5,580,000	5,580,000
Total	332,250,000	122,390,000	65,300,000	519,940,000
Hypothetical Resource tonnage				
Dietz 2 and 3	4,430,000	2,270,000	0	6,700,000
Canyon	0	0	3,020,000	3,020,000
Cook	0	0	110,000	110,000
Total	4,430,000	2,270,000	3,130,000	9,830,000
Grand Total	336,680,000	124,660,000	68,430,000	529,770,000

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

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

Coal bed	High Development potential	Moderate development potential	Low development potential	Total
Reserve Base tonnage				
Dietz 2 and 3	0	0	45,690,000	45,690,000
Canyon	0	0	12,670,000	12,670,000
Cook	0	0	11,170,000	11,170,000
Wall	0	0	89,680,000	89,680,000
Total	0	0	159,210,000	159,210,000
Hypothetical Resource tonnage				
Dietz 2 and 3	0	0	15,840,000	15,840,000
Canyon	0	0	12,410,000	12,410,000
Cook	0	0	8,820,000	8,820,000
Wall	0	0	111,210,000	111,210,000
Total	0	0	148,280,000	148,280,000
Grand Total	0	0	307,490,000	307,490,000

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