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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE POKER JIM BUTTE QUADRANGLE, ROSEBUD AND POWDER RIVER COUNTIES, MONTANA

(Report includes 64 plates)

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

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COAL RESOURCE OCCURRENCE

Introduction

Purpose

This text is for use in conjunction with two sets of maps: (1) Coal resource occurrence (CRO) maps of the Poker Jim Butte quadrangle, Rosebud and Powder River Counties, Montana (plates 1-63), and (2) a coal development potential (CDP) map of the Poker Jim Butte quadrangle, Rosebud and Powder River Counties, Montana (plate 64). The two sets of maps have been prepared as part of a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA's) in the western United States. They are intended to support land-use planning and coal leasing activities of the Bureau of Land Management as required by their Energy Minerals Activities Recommendation System (EMARS). Coal beds considered in the resource inventory are only those beds 5 feet (1.5 m) or more thick, and under less than 1,000 feet (305 m) of overburden (Reserve Base of subbituminous coals); thinner or deeper beds that are present are not shown by the maps (CRO plates 4-63) or included in the resource estimates.

Location

The Poker Jim Butte 7½-minute quadrangle is on the divide between the Tongue River and Otter Creek, a major north flowing tributary of the Tongue River. The nearest towns are Ashland about 15 miles (24 km) to the north, and Birney about 7 miles (11 km) to the west. The Otter Post Office lies about 5 miles (8 km) southeast.

Accessibility

An all-weather road crosses the southern part of the quadrangle connecting Birney on the west with points along Otter Creek on the east. Graded roads lead northward from this road in the central and eastern parts of the quadrangle. These roads and a network of unmaintained roads and trails provide good access to most parts of the quadrangle. Ashland, to the north, is served by Montana Route 212, a paved east-west highway.

The Burlington Northern Railroad operates east-west rail lines through Sheridan, Wyoming, about 45 miles (70 km) to the southwest, and Forsyth, Montana, about 60 miles (100 km) to the north.

Physiography

Most of the Poker Jim Butte quadrangle has a slightly undulating surface of fairly low relief that forms the high parts of a broad divide between the Tongue River on the west and Otter Creek on the east. Poker Jim, Horse Creek, and Wild Hog Buttes rise 200-300 feet (60-90 m) above the general level of this surface in the southern part of the quadrangle and are prominent local landmarks. The gently rolling surface is deeply dissected along the eastern, western, and most notably, the northern edges of the quadrangle by steep-walled valleys and canyons of streams tributary to the Tongue River and Otter Creek. The North Fork of Poker Jim Creek and several branching forks of O'Dell Creek, including Stocker Branch and Hay Creek, all of which are in the northern part of the quadrangle, are the major streams. Eastward flowing Horse Creek, which heads in the southeastern part of the quadrangle, and the westward flowing East Fork of Hanging Woman Creek, which heads in the west-central part, are other important streams in the quadrangle.

Maximum local relief is in the northern part of the quadrangle and is about 700 feet (215 m) in the canyon of the North Fork of Poker Jim Creek. The highest point has an elevation of 4,348 feet (1,326 m) on the summit of Poker Jim Butte, and the lowest point has an elevation of about 3,460 feet (1,005 m) along O'Dell Creek.

Climate

Southeastern Montana in the vicinity of the Poker Jim Butte quadrangle has a semiarid climate. Average annual precipitation at Ashland is about 14 inches (36 cm), and the annual variation in temperature is commonly from 100°F to -30°F (38°C to -34°C).

Land status

The quadrangle is in the central part of the Powder River Basin KRCRA, Montana. It is entirely within the Custer National Forest. The Federal Government owns the coal rights except for two tracts totaling less than 1 square mile (2.6 sq. km).

In 1977, the Poker Jim Butte quadrangle did not contain outstanding Federal coal leases, prospecting permits, or licenses.

General geology

Sources of information

Warren (1959) mapped most of the area of the Poker Jim Butte quadrangle at a scale of 1:63,360 as part of the much larger Birney-Broadus coal field, Montana. Bryson and Bass (1973) mapped the southern part of the quadrangle lying in T. 7 S., R's 44-45 E., at a scale of 1:63,360 as part of the Moorhead coal field, Montana. Coal-bed outcrops and the boundaries showing the extent of burning of near-surface coals (CRO pl. 1) are taken largely from the small-scale maps of these men.

Three coal exploratory holes were drilled in the quadrangle in 1969-70 and areas suitable for strip mining of the Anderson and Dietz coal beds were outlined (Matson and others, 1973, p. 46-49, pl. 8).

Four oil and gas test wells have been drilled in the quadrangle. Information on coals below the level of the Lower Canyon coal bed is largely from gamma ray logs of three of these holes.

Coal bed names are partly from the authors listed above, and partly from Culbertson and Klett (1976) who mapped the adjacent Browns Mountain quadrangle to the west.

Stratigraphy

All the coal-bearing rocks exposed in the quadrangle, and those present to depths of several hundred feet, belong to the Tongue River member of the Fort Union Formation, and are Paleocene in age.

The part of the Tongue River Member of the Fort Union Formation remaining in the quadrangle is about 2,000 feet (610 m) thick, and consists of interbedded lenticular beds of yellowish gray to light-gray fine- to very fine grained mostly friable sandstone, light- to dark-gray siltstone and clayey siltstone, gray shale and claystone, brown carbonaceous shale, and persistent beds of coal. Rocks comprising the Tongue River Member were deposited at elevations of perhaps a few tens of feet above sea level in a vast area of shifting flood plains, sloughs, swamps, and lakes that occupied the Northern Great Plains in 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 trace element content by the U.S. Geological Survey and the results summarized by the 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 rock types found throughout other parts of the western United States.

Structure

The quadrangle is in the trough of the Powder River structural basin just east of the basin axis, which in Montana trends generally northward. Regional dip is generally toward the south at less than 1^{o}. Structural relief within the quadrangle on the Cook coal bed is about 230 feet (70 m), as shown on CRO plate 25.

Coal geology

Twenty-three coal beds ranging in thickness from 1 to 58 feet (0.3-17.7 m) were identified on the surface or in the subsurface in the Poker Jim Butte quadrangle (CRO plate 3). Of these, 15 are named, and the others are unnamed local beds, and the Smith bed is the highest coal bed in the stratigraphic section which has been named. This coal is successively underlain by an interval 110-130 ft (34-40 m) thick containing a local coal in the upper part; the Anderson coal bed; a non coal interval 0-60 ft (0-18 m) thick; the Dietz coal bed; an interval 110-180 ft (34-55 m) thick containing a local coal bed in the lower part; the Upper Canyon coal bed; a non coal interval about 25 ft (8 m) thick; the Lower Canyon coal bed; an interval 80-180 ft (24-55 m) thick containing a local coal bed near the middle; the Cook coal bed; a non coal

interval about 60 ft (18 m) thick; the Otter coal bed; a non coal interval about 50 ft (15 m) thick; the Wall coal bed; a non coal interval about 60 ft (18 m) thick; the Pawnee coal bed; a non coal interval as much as 130 ft (40 m) thick; the Poker Jim coal bed; a non coal interval from 50-150 ft (15-46 m) thick; the Brewster-Arnold coal bed; a non coal interval about 150 ft (46 m) thick; the King coal bed; a non coal interval about 60-100 ft (18-30 m) thick; the Knobloch coal bed; an interval about 100 ft (30 m) thick containing a local coal bed in the upper part; the Nance coal bed; an interval 95-180 ft (29-55 m) thick containing a local coal bed in the upper part; the Flowers-Goodale coal bed; an interval 140-215 ft (43-66 m) thick containing a local coal bed in the middle part; the Terret coal bed; an interval about 170 ft (52 m) thick containing a local bed in the upper part; and a local coal bed at the base of the coal-bearing strata.

Coal-bed thicknesses shown on the CRO maps are the bed thicknesses reported at outcrops or in the drill holes, rounded to the nearest foot, partings excluded. The coal beds generally are free of partings. For detailed measurements of beds exposed at the outcrop, see Warren (1959).

In the past, many of the thicker coal beds have caught fire at the outcrop, and have burned underground for varying distances, some for a mile (1.6 km) or more. The heat from the burning coal has baked and fused the overlying rocks to form a resistant reddish rock called clinker (also called scoria, red shale, and other names locally). In this quadrangle clinker is as much as 150 feet thick and caps many of the high interstream divides.

The only analyses of fresh coal in the Poker Jim Butte quadrangle are from drill cores of the Anderson bed and the combined Anderson and Dietz beds which were taken at localities 3, 4, and 6 (CRO pl. 1) (Matson and others, 1973, p. 43). Based on these analyses and on analyses of coal from drill holes in adjacent quadrangles (Matson and others, 1973), the rank of the coal in the Poker Jim Butte quadrangle varies from high in the range of subbituminous C to low in the range of subbituminous B. The trace element content of coal in the quadrangle has not been determined; however, coals in the Northern Great Plains, including those in the Fort Union Formation in Montana, generally contain lesser amounts of most elements of environmental concern than coals in other areas of the United States (Hatch and Swanson, 1977, p. 147).

Smith coal bed

The Smith coal bed was named by Baker (1929), in the northward extension of the Sheridan coal field and traced into the area of the Poker Jim Butte quadrangle by Bryson and Bass (1973). It crops out on Horse Creek Buttes in sec. 2, T. 7 S., R. 44 E., and parts of adjacent sections to the west and north. The coal has a maximum measured thickness of 6 feet (1.8 m) in the drill hole at locality 6 (CRO pl. 1). The coal everywhere in the quadrangle is under less than 200 feet (61 m) of overburden.

Chemical analyses have not been made of coal from the Smith bed in the quadrangle. The area underlain by coal more than 5 feet (1.5 m) thick is probably confined to the immediate vicinity of the drill hole at locality 6 (CRO pl. 1). The area is small and resources have not been calculated.

Anderson coal bed and Anderson and Dietz coal beds, combined

(CRO pls. 4-8)

The Anderson coal bed was named by Baker (1929) in the northward extension of the Sheridan coal field, west of the Poker Jim Butte quadrangle. The Anderson bed, together with the underlying Dietz coal bed, were called the Garfield beds by Warren (1959).

The Anderson coal bed is distinguishable as a separate coal bed in much of the southeastern half of the Poker Jim Butte quadrangle. It has a fairly uniform thickness of 30-34 feet (9.2-10.4 m) where measured at three places in the quadrangle, and is under less than 200 feet (61 m) of overburden for most of its extent (CRO pl. 6). Very large resources of coal are available for surface mining.

The Anderson coal bed apparently merges with the underlying Dietz coal bed in the northwestern part of the quadrangle to form a single coal bed as much as 58 feet (17.7 m) thick (Matson and others, 1973, pl. 8). Information is insufficient to locate accurately the split line of the Anderson and Dietz beds. Presumably the two coals form a single bed in an irregularly shaped area under and north of Poker Jim Butte, mostly in sec. 9, T. 6 S., R. 44 E., and in a somewhat smaller area east of the butte in the vicinity of sec. 14 of the same township (CRO pl.4). The Anderson and Dietz coal beds, combined, are beneath less than 200 feet (61 m) of overburden in most of these two areas.

The Anderson and the Anderson and Dietz beds, combined, are nearly everywhere surrounded by a band of clinker locally a mile (1.6 km) or more across, and a few feet to several tens of feet thick, caused by extensive burning of the coal under shallow cover.

Analyses have been made of two samples of coal from the Anderson coal bed collected from the drill cores at localities 4 and 6, and of four samples of coal from the Anderson and Dietz beds, combined, collected from a drill core at locality 3 (CRO pl. 1) (Matson and others, 1973, p. 47). Sulfur content ranges from 0.087-0.88 percent; ash ranges from 4.0-8.9 percent; and heat value ranges from 7,637-8,374 Btu per pound, on an as-received basis for the 6 samples as reported by Matson and others (1973, p. 47).

Dietz coal bed

(CRO pl. 9-13)

The usage of the name Dietz for a coal bed in the Poker Jim Butte quadrangle follows that of Bryson and Bass (1973) and Matson and others (1973). The Dietz coal bed of these writers was called the Garfield bed by Warren (1959).

The Dietz coal bed underlies the southeastern part of the quadrangle. It reportedly is 18 feet (5.5 m) thick in an outcrop in sec. 30, T. 6 S., R. 45 E., and is 25 feet (7.6 m) in a drill hole about 1½ miles to the northwest in sec. 24, T. 6 S., R. 44 E. (Matson and others, 1973; CRO pl. 9). A drill hole in the southeastern part of the adjacent Browns Mountain quadrangle failed to locate the Dietz coal bed. Based on the results of this drilling, the coal is thought to thin rapidly westward to less than 5 feet (1.5 m) thick in the southwestern corner of the Poker Jim Butte quadrangle (CRO pl. 9). The Dietz bed converges with the overlying Anderson coal bed towards the northwest, and the two coals merge in the northern part of the quadrangle, as already described.

The Dietz coal bed lies beneath less than 200 feet (61 m) of overburden in much of the southeastern part of the quadrangle, and contains substantial resources available for stripping.

Chemical analyses have not been made for coal in the Dietz bed in the quadrangle. Based on analyses from nearby areas as reported by Matson and others (1973), coal in the Dietz bed is low in sulfur and ash, and the quality is similar to that of the overlying Anderson coal bed.

Upper Canyon coal bed

(CRO pls. 14-18)

The Upper Canyon coal bed is the coal referred to by that name by Culbertson and Klett (1976) in the adjacent Browns Mountain quadrangle. It is the coal referred to as the Canyon bed in the southern part of the Poker Jim quadrangle and in areas to the south by other writers including Warren (1959), Bryson and Bass (1973), and Matson and others (1973).

Measurements of the Upper Canyon bed are sparse in the quadrangle, and the isopachs shown on CRO plate 14 illustrating variations in the thickness are highly generalized. Based on data from a nearby drill hole in the adjacent Hamilton Draw quadrangle to the south, the coal is perhaps as much as 26 feet (7.9 m) thick along the southern edge of the quadrangle. The coal generally thins to less than 5 feet (1.5 m) in the northern part of the Poker Jim Butte quadrangle.

Coal in the Upper Canyon bed has good potential for surface mining in the southeastern part of the quadrangle in the headwaters area of Horse Creek. In this area the bed is beneath less than 200 feet (61 m) of overburden and has a thickness estimated to range 10-19 feet (3.0-5.8 m) (CRO pl. 14 and 16). Small areas along the south edge of the quadrangle are also underlain by relatively thick coal at a depth of less than 200 feet (61 m) (CRO pl. 16).

Analyses have not been made of the Upper Canyon coal bed in the quadrangle; however, analyses of three samples of coal collected from the bed in a drill hole about 1 mile (1.6 km) south of the quadrangle show sulfur in the range of 0.16-0.66 percent, ash in the range of 3.8-7.3 percent, and heat value in the range of 7,862-8,801 Btu per pound on the as-received basis (Matson and others, 1973, p. 47, hole SH 7038).

Lower Canyon coal bed

(CRO pls. 19-23)

The Lower Canyon coal bed, as it is referred to in this report following the usage of Culbertson and Klett (1976), is the coal called the Canyon bed by Warren (1959) in the northern part of the Poker Jim Butte quadrangle. The Lower Canyon coal bed is as much as 11 feet (3.4 m) thick in the subsurface in the northwestern part of the Poker Jim Butte quadrangle, and is 10 feet (3.0 m) thick in the southeastern part, thinning to less than 5 feet (1.5 m) thick along the eastern edge and in the southwestern part of the quadrangle (CRO pl. 19). The bed is within 200 feet (61 m) of the surface and, thus, has potential for strip mining along the valley sides and in the headwaters areas of most of the major streams in the quadrangle including Horse Creek, the East Fork of Hanging Woman Creek, the North Fork of Poker Jim Creek, and the headwaters of O'Dell Creek and its tributaries (CRO pl. 21).

Chemical analyses have not been made for coal in the Lower Canyon coal bed in the quadrangle.

Cook coal bed

(CRO pls. 24-28)

Cook is a name first used by Bass (1932) for a coal bed in the Ashland coal field. The bed crops out in the northern part of the Poker Jim Butte quadrangle on the valley sides of O'Dell Creek and the North Fork of Poker Jim Creek and extends underground from these places southward to the south edge of the quadrangle. It ranges in thickness from slightly more than 5 feet (1.5 m) to as much as 24 feet (7.3 m); the thickness increases generally southeastward (CRO pl. 24). The coal has possibilities for stripping in a narrow band along its outcrop in the northern part of the quadrangle and along the western side of the valley of the East Fork of Hanging Woman Creek; but in most of the quadrangle, including the southeastern part where the coal is thickest, the coal is more than 200 feet (61 m) below the surface, and locally the coal is more than 600 feet (183 m) below the surface (CRO pl. 26).

Chemical analyses have not been made of the Cook coal bed in the quadrangle.

Otter coal bed

(CRO pl. 29-33)

The Otter coal bed is a name used by Bryson and Bass (1973) for a coal exposed in the valley of Otter Creek and its tributaries in the vicinity of the Otter Post Office a few miles southeast of the Poker Jim Butte quadrangle. A coal thought to represent the same bed is present in the subsurface in the three oil and gas tests in the Poker Jim Butte quadrangle, and it crops out at one locality in the valley of Hay Creek at the north edge of the quadrangle (CRO pl. 29). The coal along Hay Creek was correlated with the Wall coal bed by Warren (1959). The Otter bed as mapped in the Poker Jim Butte quadrangle is presumed to be continuous with the Lower Otter coal bed of Culbertson and Klett (1976) in the southeastern part of the adjacent Browns Mountain quadrangle to the west.

The Otter coal bed is 6-10 feet (1.8-3.0 m) thick at the four localities where measured in the Poker Jim Butte quadrangle. Based on a measurement of the Lower Otter coal bed in the Browns Mountain quadrangle, it locally may be as much as 13 feet (3.9 m) thick in the subsurface along the western edge of the Poker Jim Butte quadrangle (CRO pl. 29). The Otter coal bed has possibilities for stripping adjacent to its outcrop along the North Fork of Poker Jim Creek, along O'Dell Creek and its tributaries, and in a small area along the East Fork of Hanging Woman Creek (CRO pl. 31).

Chemical analyses have not been made of the Otter coal bed in the Poker Jim Butte quadrangle.

Wall coal bed

(CRO pls. 34-38)

The Wall coal bed was named by Baker (1929) for outcrops of coal in the northward extension of the Sheridan coal field a few miles west of the Poker Jim Butte quadrangle. The Wall bed is identified in the subsurface in only the northwestern corner of the quadrangle (CRO pl. 34) where it is 7 feet (2.1 m) thick. A coal called the Wall bed by Warren (1959) in the valley of Hay Creek in the northeastern part of the quadrangle is correlated in the present report with the stratigraphically higher Otter coal bed. The Wall coal bed has stripping possiblities adjacent to its outcrop in the valley of the North Fork of Poker Jim Creek, but the area is small, the coal is thin, and the resources are limited.

Chemical analyses have not been made of the Wall coal bed in the quadrangle.

Poker Jim coal bed

(CRO pls. 39-43)

The Poker Jim coal bed was named by Culbertson and Klett (1976) for a bed exposed along Poker Jim Creek in the northern part of the Browns Mountain quadrangle. The same coal was called the Pawnee coal bed by Warren (1959); however, Warren (1959) also called a stratigraphically higher coal bed the Pawnee bed in the southern part of the Browns Mountain quadrangle, according to Culbertson and Klett (1976). The nomenclature followed in the present report is that of Culbertson and Klett (1976).

The Poker Jim bed is 5-9 feet (1.5-2.7 m) thick as identified in three drill holes in the Poker Jim Butte quadrangle (CRO pl. 39). Isopachs based on these three measurements, and on sparse data in drill holes and outcrops adjacent to the quadrangle, suggest that the bed is thickest in a northtrending band extending across the central part of the quadrangle, thinning to less than 5 feet (1.5 m) along the western and eastern sides. Coal in small areas in the valley of the North Fork of Poker Jim and O'Dell Creeks are potentially available for stripping; however, the coal is deeply buried in most parts of the quadrangle (CRO pl. 41).

Analyses have not been made of coal in the Poker Jim bed in the quadrangle.

Brewster-Arnold coal bed

(CRO pls. 34-38)

The Brewster-Arnold coal bed was named by Bass (1924) for a coal bed exposed at the Brewster-Arnold mine a few miles west of the quadrangle. Subsurface correlations made during the present work and surface mapping by W. C. Culbertson (personal communication, 1977) along the east side of the Tongue River between Birney and Ashland indicate that the Brewster-Arnold bed extends from the vicinity of the Brewster-Arnold mine eastward

into the area of the Poker Jim Butte quadrangle where the bed is called the Odell bed by Warren (1959). It also appears to correlate with the Cache coal bed as that name is used by McKay (1976) in the King Mountain quadrangle northeast of the Poker Jim Butte quadrangle.

The Brewster-Arnold coal bed is 5 feet (1.5 m) thick in a drill hole in the northeastern part of the quadrangle, and 9 feet (2.7 m) thick in a drill hole in the southeastern part of the quadrangle. On the basis of these two measurements the bed is presumed to underly most of the southeastern half of the quadrangle with a thickness between 5 and 9 feet. The coal everywhere in the quadrangle is beneath more than 200 feet (61 m) of overburden and is therefore considered too deep for surface mining.

Chemical analyses have not been made for coal in the Brewster-Arnold bed in the quadrangle.

King coal bed

(CRO pls. 44-48)

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, a few miles northwest of the Poker Jim Butte quadrangle. The same coal bed was called the upper bench of the Knobloch coal bed by Matson and others (1973, pls. 11A and 33) along the Tongue River northwest of the Poker Jim Butte quadrangle, and it was called the Upper Knobloch bed by Culbertson and Klett (1976) in the Browns Mountain quadrangle. According to Matson and others (1973), the King and Knobloch beds (or upper and middle benches of the Knobloch bed in their nomenclature) converge northward along the valley of the Tongue River and join to form the Knobloch coal bed near Ashland. Regional subsurface relations, the mapping done by Warren (1959), and unpublished mapping done by W. C. Culbertson in 1977 along the Tongue River northwest of the Poker

Jim Butte quadrangle suggest a different interpretation of the stratigraphic relations; namely, that the King bed does not join the Knobloch bed but instead is continuous with the Sawyer coal bed as shown in the Ashland area by Bass (1932) and McKay (1976). The Sawyer bed lies as much as 225 feet (69 m) above the Knobloch bed near Ashland (Bass, 1932, p. 52).

The King coal bed is 5 feet (1.5 m) thick in each of two drill holes in the northern part of the Poker Jim Butte quadrangle, and has been mapped as extending a short distance into the northwestern and eastern parts of the quadrangle with a thickness of about 5 feet (1.5 m) on this basis. Depth to the coal ranges from about 600 feet (183 m) to more than 1,000 feet (300 m); none of the coal is available for stripping.

Analyses have not been made of the coal from the King bed in the Poker Jim Butte quadrangle, however, Matson and others (1973, p. 65) report that a sample of the coal from the King bed (upper bench of the Knobloch of their nomenclature) collected near the quadrangle in sec. 30, T. 5 S., R. 43 E., contains 0.59 percent sulfur, 4.8 percent ash, and has a heat value of 9,135 Btu on an as-received basis.

Knobloch coal bed

(CRO pls. 49-53)

The Knobloch coal bed (spelled Knoblock in early reports) was named by Bass (1924) for exposures along the Tongue River about 5 miles (8 km) northwest of the Poker Jim Butte quadrangle. The coal bed identified in this report as the Knobloch was called the middle bench of the Knobloch by Matson and others (1973, pls. 11A and 33), and the Middle Knobloch bed by Culbertson and Klett (1976).

The Knobloch bed is as much as 22 feet (6.7 m) thick in a drill hole in the northeastern part of the quadrangle and is nearly as thick in drill holes in the northwestern and southern parts (CRO pl. 49). The coal probably thins southwestward and is estimated to be less than 10 feet (3 m) thick in the southwestern part of the quadrangle. The Knobloch bed contains very large resources of coal, but in this quadrangle the bed is everywhere under more than 400 feet (120 m) of overburden and at many places is under more than 1,000 feet (300 m) of overburden (CRO pl. 51).

Analyses have not been made of coal from the Knobloch bed in the quadrangle. A summary of analyses of the Knobloch coal from core holes drilled about 20 miles (16 km) north of the quadrangle near Ashland are given in table 1. The rank of the coal based on the average of these analyses is subbituminous C.

Nance coal bed

(CRO pls. 54-58)

The Nance coal bed is named for its occurrence in the Nance and Hayes drill hole in the Browns Mountain quadrangle, sec. 25, T. 5 S., R. 42 E., where the coal is 10 feet (3 m) thick and occurs at a depth of 242 feet (74 m) Culbertson and Klett, 1976). A coal at about the same horizon in holes drilled in the valley of the Tongue River was regarded by Matson and others (1973, pl. 33) as a lower bench of the Knobloch bed. The coal bed is referred to as the Lower Knoblock bed by Culbertson and Klett (1976) following a modification of the usage of Matson and others (1973).

The Nance bed is as much as 10 feet (3.1 m) thick in the northwestern part of the Poker Jim Butte quadrangle, thinning generally southward to less than 5 feet (1.5 m) in the southern part (CRO pl. 54). Overburden is estimated to be more than 600 feet (183 m) in most of the quadrangle (CRO pl. 56), so the coal does not have potential for surface mining.

Chemical analyses of coal are not available for the Nance bed, or of the lower bench of the Knobloch as the coal is referred to by Matson and others (1973). Presumably the coal is similar in quality to other coals in the lower part of the Fort Union Formation in the vicinity of the Poker Jim Butte quadrangle.

Flowers-Goodale coal bed

(CRO pls. 59-63)

The Flowers-Goodale coal bed was named by Bass (1932, p. 53-54) for outcrops in the Ashland coal field more than 20 miles (32 km) north of the Poker Jim Butte quadrangle. An 18-20 foot (5.5-6.1 m) thick coal bed identified in the logs of the three deep drill holes in the quadrangle (CRO pl. 59) is believed to be the same bed. In most parts of the quadrangle, this coal is beneath more than 1,000 feet (305 m) of overburden and is everywhere so deeply buried as to be inaccessible for surface mining (CRO pl. 61).

Matson and others (1973, p. 86) report that in three samples of coal from the Flowers-Goodale bed collected in the Ashland coal field about 30 miles (48 km) northeast of the Poker Jim Butte quadrangle, sulfur ranged from 0.36-0.77 percent, ash from 7.27-9.02 percent, and heat value from 7,540-7,570 Btu per pound on an as-received basis. Other analyses of coal found in drill holes near Ashland are summarized on table 1. Analyses have not been made of coal in the quadrangle.

Table 1.--Composition of coal in the Knobloch and Flowers-Goodale beds, Ashland area, Montana.

(Analyses by Coal Analysis Section, U.S. Bureau of Mines, Pittsburgh, Pa. based on standard coal analyses (proximate, ultimate, Btu, and forms-of-sulfur analyses) reported in percent on as-received basis.)

	Knobloch Bed[1] (22 samples)		Flowers-Goodale Bed[1] (3 samples)	
	Arithmetic mean	Range	Arithmetic mean	Range
Moisture	30.3	26.0-35.1	27.6	26.4-28.8
Vol. Matter	28.8	26.4-32.5	27.6	26.2-28.7
Fixed C	35.2	31.3-37.9	36.6	34.4-39.1
Ash	5.7	4.0- 7.4	8.2	5.8-11.9
Hydrogen	6.7	6.4- 6.9	6.2	5.6- 6.5
Carbon	47.6	43.3-49.8	48.4	45.8-51.2
Nitrogen	.7	.6- .8	.8	.7- .9
Oxygen	39.2	37.4-41.7	35.9	35.0-37.2
Sulfur	.2	.1- .3	.5	.4- .6
Btu/lb	8,140	7,270-8,480	8,240	7,790-8,710
Sulfate S	0.01	0.00- .07	0.01	0.01- .01
Pyritic S	.06	.01- .12	.10	.07- .15
Organic S	.10	.01- .26	.36	.29- .43

[1] Sample data from U.S. Bureau of Land Management (1975).

Terret coal bed

and local coal bed below the Terret bed

The Terret coal bed was named by Bass (1932) for outcrops of the coal in the Ashland coal field to the north. A coal bed occurs at about the same stratigraphic position as the Terret bed of the Ashland field in the oil and gas test wells in the northern part of the Poker Jim Butte quadrangle and it is called the Terret bed on that basis. Subsurface information is very sparse on which to demonstrate continuity of the coal between the Poker Jim Butte quadrangle and outcrops of the Terret bed in the Ashland coal field 20 miles (32 km) or more to the north; therefore, the correlation is regarded as tentative.

The Terret bed is 12 feet (3.7 m) thick in both of the drill holes in the northern part of the quadrangle (CRO pl. 1). The coal is beneath more than 1,000 feet (305 m) of overburden everywhere in this quadrangle, except for small areas in sec. 25, 27 and 34, T. 5 S., R. 44 E. along the valley bottoms of the North Fork of Poker Jim and O'Dell Creeks. A local coal below the Terret is 7-9 feet (2.1-2.7 m) thick in the same drill holes. It is also present under less than 1,000 feet (305 m) of overburden along the North Fork of Poker Jim and O'Dell Creeks, but it has a more restricted distribution than the Terret bed. Because these areas underlain by the coals are small, CRO maps illustrating the occurrences of the coal are not included with this report. Resources calculated for the coals are shown on table 2.

Analyses have not been made for these coals in the Poker Jim Butte quadrangle.

Coal Resources

Coal resource estimates in this report are restricted to the Reserve Base part of the Identified Coal Resource, which is the part most likely to be developed in the foreseeable future. (See U.S. Geol. Survey Bull. 1450-B for a discussion of these terms). The Reserve Base for subbituminous coal is coal that is 5 feet (1.5 m) or more thick, under less than 1000 feet (305 m) of overburden, and within 3 miles (4.8 km) of a point at which a complete measurement of the coal bed was made. Reserve Base coal is further subdivided into categories according to its nearness to a point of measurement of the coal bed. Measured coal is coal within 1/4 mile (0.4 km) of a point of measurement, Indicated coal extends 1/2 mile (0.8 km) beyond Measured coal to a distance of 3/4 mile (1.2 km) from the point of measurement, and Inferred coal extends 2 1/4 miles (3.6 km) beyond Indicated coal to a distance of 3 miles (4.8 km) from the point of measurement.

Reserves are the recoverable part of the Reserve Base. For strippable coal in this quadrangle, the coal reserves are considered to be 85 percent of the part of the Reserve Base that is under less than 200 feet (61 m) of overburden for beds 5-40 feet (1.5-12.2 m) thick, or that is under less than 500 feet (152.5 m) of overburden for beds more than 40 feet (12.2 m) thick.

The total Reserve Base for federally owned coal is estimated to be about 3.7 billion short tons (3.4 billion metric tons) as shown listed by section on CRO plate 2 and by individual coal bed and resource category on table 2. About 2 percent of this large amount is classified as Measured; 18 percent as Indicated; and 80 percent as Inferred.

Table 2.--Estimated Reserve Base for surface-mining methods and for underground mining methods, Federal coal lands, Poker Jim Butte quadrangle.

[In thousands of short tons, rounded. Multiply by 0.907 to convert to metric tons]

Coal bed name	Surface mining methods				Underground mining methods				Grand total (rounded)
	Measured	Indicated	Inferred	Total (rounded)	Measured	Indicated	Inferred	Total (rounded)	
Anderson	12,500	87,600	191,000	291,000	6,100	28,200	9,400	43,700	335,000
Anderson-Dietz	12,000	92,000	122,000	226,000	-----	-----	-----	-----	-----
Dietz	7,900	78,300	187,000	273,000	7,300	29,600	31,400	68,300	341,000
Upper Canyon	3,600	23,800	87,300	115,000	2,400	24,700	278,000	305,000	420,000
Lower Canyon	4,000	24,900	53,800	82,700	4,700	41,000	209,000	255,000	338,000
Cook	1,200	11,200	27,300	39,700	9,000	69,300	634,000	712,000	752,000
Otter	800	5,900	13,300	20,000	5,900	34,200	252,000	292,000	312,000
Wall	-----	2,400	1,800	4,200	1,700	9,200	38,800	49,700	53,900
Poker Jim	-----	-----	4,100	4,100	3,200	29,900	251,000	284,000	288,000
Brewster-Arnold	-----	-----	-----	-----	2,200	17,500	185,000	205,000	205,000
King	-----	-----	-----	-----	800	3,400	6,400	10,600	10,600
Knobloch	-----	-----	-----	-----	5,300	37,500	297,000	340,000	340,000
Nance	-----	-----	-----	-----	400	8,500	41,300	50,200	50,200
Flowers-Goodale	-----	-----	-----	-----	-----	6,700	53,200	59,900	59,900
Terret	-----	-----	-----	-----	-----	-----	2,200	2,200	2,200
Local below Terret	-----	-----	-----	-----	-----	-----	1,100	1,100	1,100
Total (rounded)	42,000	326,000	688,000	1,060,000	49,000	340,000	2,290,000	2,680,000	3,740,000

COAL DEVELOPMENT POTENTIAL

Development potential of coal recoverable by surface mining methods

Areas are considered to have potential for surface mining as follows: (1) areas where the coal beds are from 5 to 40 feet (1.5-12.5 m) thick and overlain by 200 feet (61 m) or less of overburden and (2) areas where the coal beds are more than 40 feet (12.2 m) thick and overlain by 500 feet (153 m) or less of overburden. The areas having potential for surface mining are assigned a high, moderate, or low development potential based on the mining ratio (cubic yards of overburden per ton of recoverable coal). The formula used to calculate mining ratios for subbituminous coal is as follows:

$$MR = \frac{t_o\ (0.911)}{t_c\ (rf)}$$

where MR = mining ratio
t_o = thickness of overburden
t_c = thickness of coal
rf = recovery factor (0.85)

Areas of high, moderate, and low development potential are here defined as areas underlain by coal beds having respective mining-ratio values of 0 to 10, 10 to 15, and greater than 15, as shown on CRO plates 6, 11, 16, 21, 26, 31, and 36. The mining-ratio values for each development-potential category are based on economic and technological criteria, and were derived in consultation with A. F. Czarnowsky, Area Mining Supervisor, U.S. Geological Survey.

Reserve Base for federally owned coal in the various development-potential categories beneath less than 200 feet (61 m) for the thinner coals, and beneath less than 500 feet (153 m) of overburden for the thick Anderson and Dietz bed, combined, totals about 1 billion short tons in the Poker Jim Butte quadrangle, as shown in table 3.

The development potential for surface mining that has been assigned to each quarter section or lot underlain by federally owned coal in the Poker Jim Butte quadrangle is shown by CDP plate 64.

Table 3.--Estimated Reserve Base for Federal coal lands in the Poker Jim Butte quadrangle having development potential for surface mining methods.

(In millions of short tons, rounded. Development potentials are based on mining ratios (cubic yards of overburden/short ton of underlying coal). To convert short tons to metric tons, multiply by 0.907; to convert mining ratios in yds^3/short ton coal to m^3/t, multiply by 0.842)

	High development potential (0-10 mining ratio)	Moderate development potential (10-15 mining ratio)	Low development potential (>15 mining ratio)
Anderson	290	----	----
Anderson-Deitz	226	----	----
Dietz	206	62	5
Upper Canyon	39	42	34
Lower Canyon	11	15	57
Cook	15	10	15
Otter	3.6	5.0	11.4
Wall	0.5	0.7	3.0
Poker Jim	----	0.3	3.8
Total (rounded)	791	135	129

Development potential of coal recoverable by underground mining methods

The Reserve Base for federally owned coal more deeply buried than the limits established for surface-minable coal is estimated to be about 2.7 billion short tons, as shown on table 2. Coal at these depths is available for underground mining. Coal is not now being mined underground in the Powder River Basin, and recovery factors have not been established. The development potential was not evaluated.

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