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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE FORT HOWES QUADRANGLE, ROSEBUD AND POWDER RIVER COUNTIES, MONTANA

(Report includes 54 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 Fort Howes quadrangle, Rosebud and Powder River Counties, Montana (52 plates) and (2) a Coal Development Potential (CDP) map of the Fort Howes quadrangle, Rosebud and Powder River Counties, Montana (1 plate). The maps are intended to support land-use planning and coal leasing activities of the Bureau of Land Management as required by their Energy Mineral Activities Recommendation System (EMARS), and to provide information leading to a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA's) in the western United States. The only coal beds considered are those 5 ft (1.5 m) or more thick, and under less than 1,000 ft (305 m) of overburden (Reserve Base for subbituminous coals); thinner or deeper beds that are present are not shown on the maps (CRO plates 1-52) or included in the resource estimates.

Location

The Fort Howes 7½-minute quadrangle is within the drainage of Otter Creek, a major north-flowing tributary of Tongue River. The nearest town is Ashland, about 25 mi (40 km) to the north.

Accessibility

An all-weather road extends northward across the quadrangle in the valley of Otter Creek. Secondary ranch and Forest Service roads branch from this road providing good access to most parts of the quadrangle. A paved east-west highway, Montana Route 212, passes through Ashland, about 10 mi (16 km) to the northwest.

Physiography

Most of the quadrangle is dissected by eastward trending tributaries of Otter Creek. Springs provide some water, principally for livestock, in a few side creeks which are otherwise dry. Elevations along the western part of the quadrangle are locally about 4,100 ft (1,250 m), and Otter Creek flows at an elevation of about 3,200 ft (975 m).

Climate

The region in the vicinity of the quadrangle has a semiarid climate. The average annual rainfall is about 14 in. (36 cm) and the annual range in temperature is from about 100°F to about -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. Except for a strip along Otter Creek totalling about 5 mi^2 (13 km^2), the Federal Government owns the coal rights.

In 1977 the Fort Howes 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 Fort Howes quadrangle at a scale of 1:63,360 as part of the Birney-Broadus coal field, Montana. Bryson and Bass (1973) mapped an east-west, mile-wide strip on the south side of the quadrangle at a scale of 1:63,360 as part of the Moorhead coal field. McKay (1976) mapped the quadrangle on a scale of 1:24,000 and incorporated on his map the results of the earlier work. McKay's

(1976) map is the principal source for coal-bed outcrops and boundaries of clinker (CRO pl. 1). Several revisions have been made, however, in the names of the coal beds as previously used by McKay (1976) and others.

One coal exploratory hole was drilled in the quadrangle in 1969-70 (hole SS-8). Areas suitable for strip mining of the Knobloch coal bed were outlined by Matson and others (1973, pl. 12), according to criteria established by them.

Three oil and gas test wells have been drilled in the quadrangle. Information on coals below the level of the Brewster-Arnold coal bed is from the electric logs of one of these wells; the others did not have logs adequate for determining occurrences of coal.

Coal bed names are from Baker (1929), Bass (1924, 1932), Warren (1959), and Culbertson and Klett (1976). Much of the stratigraphic control for coal beds in the subsurface is from Mapel, Martin, and Butler (1978) in the adjacent Poker Jim Butte 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 of Paleocene age.

The Tongue River Member is about 2,000 ft (610 m) thick in the quadrangle 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 and black carbonaceous shale, and persistent coal beds. The environment of deposition of rocks comprising the Tongue River was one of shifting streams, flood plains, and swamps in a region of low relief draining toward a sea in northeastern Montana and North Dakota.

Representative samples of the sedimentary rocks adjacent to 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). These results show that the rocks contain no greater amounts of trace elements of environmental concern than do similar types of rocks found throughout other parts of the western United States.

Structure

The quadrangle is on the east side of the Powder River structural basin axis. Regional dip is southward at less than 90 ft per mi (27 m per km). Structural relief within the quadrangle on the Cook coal bed is about 180 ft (85 m), as shown on CRO plate 14.

Coal Geology

Fourteen coal beds ranging in thickness from 3 ft (1 m) to 33 ft (10 m) were identified on the surface or in the subsurface in the Fort Howes quadrangle (CRO pls. 1 and 3). The highest coal bed, the Anderson, is burned throughout the quadrangle (CRO pl. 1). The Anderson is underlain by a noncoal interval 50 ft (15 m) thick; the Dietz coal bed; and interval about 190 ft (58 m) thick containing a local coal in the middle; the Upper Canyon coal bed; a noncoal interval about 70 ft (21 m) thick; the Lower Canyon coal bed; a noncoal interval 75 ft (23 m) thick; the Cook coal bed; a noncoal interval about 65 ft (20 m) thick; the Otter coal bed; a noncoal interval about 140 ft (43 m) thick; the Brewster-Arnold coal bed; a noncoal interval 95 ft (29 m) thick; the King coal bed; a noncoal interval about 90 ft (27 m)

thick; the Knobloch coal bed; a noncoal interval 130 ft (40 m) thick; the Nance coal bed; a noncoal interval 160 ft (49 m) thick; the Flowers-Goodale coal bed; a noncoal interval about 130 ft (40 m) thick; the Terret coal bed; a noncoal interval about 20 ft (6 m) thick; and a local coal bed.

Coal bed thicknesses shown on the CRO maps are the bed thicknesses reported at outcrops or in drill holes, rounded to the nearest foot, excluding partings. The coal beds are generally free of partings.

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 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 names locally). In this quadrangle, clinker is as much as 100 ft (30 m) thick.

There have been no analyses made of coals in the Fort Howes quadrangle. However, analyses of coals in adjacent quadrangles suggest that the rank varies from subbituminous B to subbituminous C, and that the content, in general, is less for most elements of environmental concern than for coals in other areas of the United States (Hatch and Swanson, 1977, pl. 47).

Coal-bed Nomenclature

Uncertainties in correlation have resulted in different schemes of coal-bed nomenclature by different writers in the area of the Fort Howes quadrangle. The differences are summarized in the following table, and are discussed briefly in the discussions of individual beds that follow:

Names of coal beds used by different writers

This report	McKay (1976)	Warren (1959)
[1]		
Anderson	Anderson	Garfield zone
Dietz	Dietz	Garfield zone
Upper Canyon or Canyon	Canyon	Canyon
Lower Canyon	Cook	Ferry
Local	Wall	Cook
Cook	Wall or Lower Wall	Wall
Otter	Pawnee	Elk
Not shown	Local	Dunning
Brewster-Arnold	Cache	Odell
King	Sawyer	King

[1] Burned

Dietz coal bed

(CRO pls. 4-7)

The usage of the name Dietz for a coal bed in the Fort Howes quadrangle follows that of Bryson and Bass (1973) and Matson and others (1973). The Dietz coal bed of these writers was included in the Garfield zone by Warren (1959).

The Dietz coal bed underlies the southwestern part of the quadrangle. Its maximum thickness of 10 ft (3 m) is inferred from isopachs (CRO pl. 4) controlled by thicknesses measured in adjacent quadrangles.

The Dietz coal bed lies beneath less than 200 ft (61 m) of overburden, but as shown on CRO plate 6 the mining ratios in most areas are relatively high and the potential for surface mining is generally low.

Upper Canyon coal bed

(CRO pls. 8-12)

The Upper Canyon coal bed is the coal referred to by that name by Culbertson and Klett (1976) in the Browns mountain quadrangle. It was called the Canyon bed by Warren (1959), Bryson and Bass (1973), and Matson and others (1973) in the area of the Fort Howes and adjacent Poker Jim Butte quadrangles.

Only one coal bed thickness (9 ft (3 m)) was measured in the quadrangle but the isopachs on plate 8 are fairly well controlled by drill hole thicknesses in adjacent quadrangles. The coal thins northward from about 20 ft (6 m) at the south margin to 5 ft (1.5 m) or less near the middle of the quadrangle.

Coal in the Upper Canyon bed has good potential for surface mining in the southwestern part of the quadrangle where the bed is under less than 200 ft (61 m) of overburden where the bed has a thickness estimated to be in the range of 10 to 20 ft (3.0-6.1 m) (CRO pl. 10).

Analyses have not been made of the Upper Canyon bed in the quadrangle, but analyses in adjacent quadrangles show sulfur and ash under 1 percent, 8 percent, and Btu values greater than 8,000, respectively.

Lower Canyon coal bed

(CRO pls. 8-12)

The Lower Canyon coal bed was named by Culbertson & Klett (1976). It was called the Ferry bed by Warren (1959) in the vicinity of the Fort Howes quadrangle. The Lower Canyon bed is estimated to be 6 ft (2 m) thick in electric log on the Chandler 1 Stag Rock drill hole, and is within 200 ft (61 m) of the surface and thus has potential for strip mining in adjacent areas in the northeastern part of the quadrangle (CRO pl. 10).

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

Cook coal bed

(CRO pls. 13-17)

The Cook coal bed is the coal referred to as the Wall bed by Warren (1959) in the vicinity of the Fort Howes quadrangle. The usage of Warren (1959) was adopted by Bryson and Bass (1973) in the Otter quadrangle area. The Cook bed outcrops mostly west of Otter Creek and increases in thickness westward from about 5 ft (1.5 m) in sec. 29, T. 6 S., R. 46 E., near Otter Creek to an estimated 23 ft (7 m) in the subsurface in the southwestern part of the quadrangle. The coal has good potential for development by surface mining in wide areas in which the overburden is less than 200 ft (61 m) in the southern part of the quadrangle (CRO pl. 15).

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

Otter coal bed

(CRO pls. 18-22)

The Otter coal bed is a name applied by Bryson and Bass (1973) for a coal exposed in the vicinity of the Otter Post Office about 3 mi (5 km) south of the Fort Howes quadrangle. As shown by CRO plate 18 the Otter bed is at most about 7 ft (2 m) thick in the central and northwestern parts of the quadrangle. The Otter coal bed locally has potential for strip mining as shown by CRO plate 20 although the areas suitable for stripping are small, and the coal is relatively thin.

Chemical analyses have not been made of the Otter coal bed in the Fort Howes quadrangle.

Brewster-Arnold coal bed

(CRO pls. 23-27)

The Brewster-Arnold coal bed was named by Bass (1924) for a coal bed exposed at the Brewster-Arnold mine on Tongue River, about 15 mi (24 km) west of the Fort Howes quadrangle. The coal was called the Cache bed by McKay (1976), but it has not been traced continuously into the area where the Cache bed was named by Warren (1959) several miles to the east. The name Brewster-Arnold is preferred for this report, because W. C. Culbertson (unpublished mapping) has traced it into this area from its type locality.

One drill hole and several outcrops show the Brewster-Arnold coal to be about 5 ft (1.5 m) thick in narrow strips on the eastern and western margins of the quadrangle. Coal along the western margin is too deep for surface mining; coal along the eastern margin has limited potential for surface mining.

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

King coal bed

(CRO pls. 28-32)

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. The same bed was called the upper bench of the Knobloch coal bed by Matson and others (1973, pls. 11A and 33) along the Tongue River northeast of the adjacent Poker Jim Butte quadrangle, and it was called the Upper Knobloch bed by Culbertson and Klett (1976) in the northern part of the Browns Mountain quadrangle. It was called the Sawyer bed by McKay (1976) following the usage of Bass (1932) in nearby parts of the Ashland coal field. According to Matson and others (1973), the King and Knobloch beds (or upper and middle benches of the Knobloch bed in their usage) 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 northward along the Tongue River 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 bed as shown in the Ashland area by Bass (1932) and McKay (1976). The Sawyer bed lies about 225 ft (69 m) above the Knobloch bed near Ashland (Bass, 1932, p. 52), is within 60 ft (18 m) and masked by upper Knobloch clinker in the southern part of the King Mountain quadrangle. It is about 65 ft (20 m) above the Knobloch in the Chandler 1 Stag Rock well, and about 90 ft (27 m) above the Knobloch in the SS-8 drill hole in sec. 36, T. 5 S., R. 45 E.

The King coal bed is about 6 ft (2 m) thick in the Chandler 1 Stag Rock well, but is below the 200-ft (61-m) stripping limit. At the SS-8 well the King bed is 2 ft (0.6 m) thick at a depth of 45 ft (14 m).

Analyses have not been made of the coal from the King bed in the Fort Howes quadrangle.

Knobloch coal bed

(CRO pls. 33-37)

The Knobloch coal bed (spelled Knoblock in early reports) was named by Bass (1924) for exposures along the Tongue River about 10 mi (16 km) southwest of Ashland. The coal bed identified as Knobloch in this report was called the middle bench of the Knobloch by Matson and others (1973, pls. 11A and 33).

The Knobloch bed is 20 ft (6 m) thick in the Chandler Stag Rock well and 21 ft (6 m) thick in the SS-6 drill hole. Although the Knobloch contains large resources, the bed is covered by more than 200 ft (61 m) of overburden in most parts of the quadrangle. Much of the coal within the stripping limit (in the northeastern corner of the quadrangle) is under nonfederal ownership or is in the floodplain of Otter Creek (CRO pl. 35).

Analyses have not been made from the Knobloch coal bed in the quadrangle.

Nance coal bed

(CRO pls. 38-42)

The Nance coal bed was named for its occurrence in a Nance and Hayes drill hole in the Browns Mountain quadrangle (Culbertson and Klett, 1976, locality 1). A coal at the same horizon in holes drilled in the Tongue River valley was regarded by Matson and others (1973, pl. 33) as a lower bench of the Knobloch bed. The coal bed was referred to as the Lower Knobloch by Culbertson and Klett (1976) and McKay (1976) following a modification of the usage of Matson and others (1973).

The Nance bed is about 7 ft (2 m) thick in the Chandler 1 Stag Rock well and probably thickens to about 8 ft(2 m) at the northern margin of the quadrangle and thins southward to less than 5 ft (1.5 m) in the central part. Overburden is estimated to be 400 ft (122 m) or more in the quadrangle (CRO pl. 40), and the coal, therefore, does not have potential for surface mining.

Chemical analyses of coal are not available for the Nance bed, or for the lower bench of the Knobloch as the coal is referred to by Matson and others (1973).

Flowers-Goodale coal bed

(CRO pls. 43-47)

The Flowers-Goodale coal bed was named by Bass (1932, p. 53-54) for outcrops in the Ashland coal field. It is 33 ft (10 m) thick as identified on the electric log of the Chandler 1 Stag Rock well, but it is 600 to more than 1,000 ft (183-305 m) deep, and is inaccessible for surface mining (CRO pl. 45).

Chemical analyses are not available for the Flowers-Goodale bed in the Fort Howes quadrangle.

Terret coal bed

(CRO pls. 48-52)

The Terret coal bed is tentatively correlated with a coal bed of that name in the Ashland coal field.

The Terret bed is 10 ft (3 m) thick in the Chandler 1 Stag Rock well and is overlain by 600 to more than 1,000 ft (183-305 m) of overburden in the quadrangle.

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

Local coal bed below the Terret bed

A local bed about 20 ft (6 m) below the Terret bed in the Chandler 1 Stag Rock well is 7 ft (2 m) thick, and is also present locally under less than 1,000 ft (305 m) of overburden in the lower part of the valley of Otter Creek. Because CRO maps of this bed would duplicate those of the Terret, and because the coal lacks potential for surface mining, CRO maps were not prepared.

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 ft (1.5 m) or more thick, under less than 1,000 ft (305 m) of overburden, and within 3 mi (4.8 km) of a point of complete measurement of the coal bed. 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 with ¼ mi (0.4 km) of a point of measurement. Indicated coal extends ½ mi (0.8 km) beyond Measured coal to a distance of 3/4 mi (1.2 km) from a point of measurement, and Inferred coal extends 1¼ mi (2 km) beyond Indicated coal to a distance of 3 mi (4.8 km) from a point of measurement.

Reserves are the recoverable part of the Reserve Base. For strippable coal in this quadrangle the coal reserve is considered to be 85 percent of the part of the Reserve Base that is under less than 200 ft (61 m) of overburden.

The total Reserve Base for federally owned coal is estimated to be about 1.6 billion short tons (1.4 billion metric tons) as shown listed by section on CRO plate 2 and by individual coal bed and resource category on table 1. About 1 percent of this large amount is classified as Measured, 11 percent as Indicated, and 88 percent as Inferred as summarized in the tabulation below:

Summary of estimated Reserve Base for Federal coal lands according to reliability of the estimate, Fort Howes quadrangle

(To convert to metric tons, multiply by 0.907)

	Millions of short tons		
	Overburden 0-200 feet	Overburden 200-1,000 feet	Percent of total
Measured-----	12	10	1
Indicated----	59	118	11
Inferred-----	318	1,107	88

Table 1.--Estimated Reserve Base for surface-mining (0-200 feet overburden) and underground-mining (200-1,000 feet overburden) methods for Federal coal lands in the Fort Howes Quadrangle, Montana

[In thousands of short tons, rounded. Multiply by 0.91 to convert to metric tons.]

Coal bed name	Overburden 0-200 feet			Total (rounded)	Overburden 200-1,000 feet			Total (rounded)	Grand total (rounded)
	Measured	Indicated	Inferred		Measured	Indicated	Inferred		
Dietz	------	------	29,000	29,000	-----	-------	-------	---------	29,000
Upper Canyon	820	9,100	66,000	76,000	-----	2,100	59,000	61,000	140,000
Lower Canyon	850	3,700	4,600	9,200	1,300	6,600	5,800	14,000	23,000
Cook	4,200	18,000	143,000	170,000	4,400	51,000	280,000	340,000	500,000
Otter	3,600	11,000	690	15,000	2,200	21,000	12,000	35,000	50,000
Brewster-Arnold	1,100	6,200	3,200	11,000	540	2,800	5,600	8,900	19,000
King	-----	------	-------	-------	460	8,000	29,000	37,000	37,000
Knobloch	1,200	9,900	73,000	84,000	630	23,000	470,000	490,000	580,000
Nance	-----	------	-------	-------	-----	3,400	56,000	59,000	59,000
Flowers-Goodale	-----	------	-------	-------	-----	460	160,000	160,000	160,000
Terret	-----	------	-------	-------	-----	------	25,000	25,000	25,000
Total (rounded)	12,000	58,000	320,000	390,000	9,500	120,000	1,100,000	1,200,000	1,600,000

COAL DEVELOPMENT POTENTIAL

Development potential for surface mining methods

Areas where the coal beds are 5 ft (1.5 m) or more thick and are overlain by 200 ft (61 m) or less of overburden are considered to have potential for strip mining and were 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:

$$MR = \frac{t_o(0.91)}{t_c(rf)}$$

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, 10, 15, 20, 25, and 35. These mining-ratio values for each development-potential category are based on economic and technological criteria; they are applicable only to this quadrangle, and were derived in consultation with A. F. Czarnowsky, Area Mining Supervisor, U.S. Geological Survey.

Reserve Base for federally owned coal beneath less than 200 ft (61 m) of overburden in the various development-potential categories totals about 390 million short tons (355 million metric tons) as shown in table 2.

Table 2.--Estimated Reserve Base by development potential for surface mining methods (0-200 ft overburden) for Federal coal lands in the Fort Howes quadrangle, Montana.

(In thousands of short tons. Development potentials are based on mining ratios (cubic yards of overburden/ton of underlying coal). To convert short tons to metric tons, multiply by 0.9072; to convert mining ratios in yd^3/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)	Total (rounded)
Dietz	12,000	11,000	5,700	29,000
Upper Canyon	820	9,100	66,000	76,000
Lower Canyon	3,100	1,600	4,500	9,200
Cook	120,000	35,000	16,000	170,000
Otter	1,900	2,400	11,000	15,000
Brewster-Arnold	2,300	2,100	6,000	10,000
King	-------	------	------	-------
Knobloch	73,000	11,000	------	84,000
Nance	-------	------	------	-------
Flowers-Goodale	-------	------	------	-------
Terret	-------	------	------	-------
TOTAL (rounded)	210,000	72,000	110,000	390,000

Development potential for underground mining methods

The Reserve Base for federally owned coal beneath 200-1,000 ft (61-305 m) of overburden is estimated to be about 1.2 billion short tons (1.1 billion metric tons), as shown on table 1. 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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