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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE BIRNEY QUADRANGLE, ROSEBUD COUNTY, MONTANA

[Report includes 44 plates]

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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 Birney quadrangle, Rosebud County, Montana (CRO plates 1-43), and (2) a coal development potential (CDP) map of the Birney quadrangle, Rosebud County, Montana (CDP plate 44). 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 4-43) or included in the resource estimates.

Location

The Birney 7½-minute quadrangle is in the valley of the Tongue River in southern Rosebud County, Montana, about 20 miles (32 km) southwest of Ashland. The settlement of Birney is near the eastern edge of the quadrangle at the junction of the Tongue River and Hanging Woman Creek, a major tributary stream.

Accessibility

An all-weather county road that forks from Montana Route 212 at Ashland connects Ashland with points to the south along the Tongue River in Montana. Roads and trails branching from this road provide access to the quadrangle.

The Burlington Northern Railroad operates and maintains an east-west route through Sheridan, Wyo., about 50 miles (80 km) to the south, and operates a spur line from Forsyth, Mont., southward to Colstrip, Mont., about 35 miles (56 km) to the north.

Physiography

The northeast-flowing Tongue River occupies a broad floodplain averaging about a half-mile (1 km) wide that bisects the Birney quadrangle from southwest to northeast. The land surface rises rather steeply away from the floodplain of the river to a high, dissected plateau, remnants of which form the main interstream divides. The highest divides are capped by resistant clinker formed by burning of coal. Steepsided gullies and washes intricately dissect the steeper slopes in the quadrangle.

Maximum local relief, from the Tongue River to the top of the Tongue River-Hanging Woman Creek divide south of Birney, is about 850 feet (260 m).

Climate

Southeastern Montana in the vicinity of the Birney quadrangle has a semi-arid 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 lies in the central part of the Powder River Basin KRCRA. The Federal government owns most of the coal rights.

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

General geology

Sources of information

Baker (1929) mapped the Birney quadrangle as part of the much larger northward extension of the Sheridan coal field, which lies mainly to the southwest. Baker's (1929) map was published at a scale of 1:62,500. Matson and others (1973) described strippable coal deposits in the Knobloch, Brewster-Arnold, and Wall coal beds within or adjacent to the western and northern margins of the quadrangle. Most recently, the quadrangle was remapped by Mapel (1976) at a scale of 1:24,000. Mapel's (1976) map, which incorporates earlier mapping and drilling, is the basis of the present work.

Coal-bed thicknesses that are used for the resource estimates were measured at outcrops, interpreted from logs of coal test holes, or interpreted from resistivity and (or) gamma ray logs of oil and gas test holes. Coal thicknesses at outcrops or in drill holes are rounded to the nearest foot, excluding partings. Detailed measurements of outcropping coal beds are given by Mapel (1976).

Stratigraphy

All the coal-bearing rocks exposed in the quadrangle, and rocks 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 remaining in the quadrangle is about 1,900 feet (580 m) thick, and consists of interbedded lenticular beds of yellowish gray to light-gray fine- to very fine grained sandstone, light- or 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 vast areas of shifting floodplains, 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 Mapel and Swanson (1977). 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 Powder River structural basin just about on the basin axis, which trends generally north or northeast. Regional dip is toward the south at less than 1 degree. Structural relief on the Brewster-Arnold coal bed is about 200 feet (60 m), as shown on CRO plate 15.

Coal geology

Twenty coal beds ranging in thickness from 5 to 25 feet (1.5 to 7.6 m) were either identified on the surface or in the subsurface in the Birney quadrangle (CRO pl. 3). The Terret coal bed is the stratigraphically lowest recognized coal bed. It is successively overlain by an interval that averages about 140 feet (43 m) thick and contains a local coal bed near the top; the Flowers-Goodale bed; a non-coal interval about 90-110 feet (27-33 m) thick; the Nance coal bed; a non-coal interval about 125-210 feet (38-63 m) thick; the Knobloch coal bed; a non-coal interval about 60-90 feet (18-28 m) thick; the

King coal bed; an interval about 150-180 feet (45-55 m) thick containing a local coal bed in the upper part; the Brewster-Arnold coal bed; an interval about 150-200 feet (45-61 m) thick containing at least two local coal beds in the upper part; the Pawnee coal bed; an interval about 100-120 feet (30-36 m) thick containing two local coal beds; the Wall coal bed; a non-coal interval about 50 feet (16m) thick; the Otter coal bed; an interval about 70-100 feet (21-30 m) thick containing a local coal bed near the top; the Cook coal bed; a non-coal interval about 90 feet (27 m) thick; the Canyon coal bed; and an interval as much as 300 feet (92 m) thick, which includes the Cox coal bed and a local coal bed within the lower 150 feet (45 m), and clinker as much as 150 feet (45 m) thick in the upper part resulting from burning of the Anderson and Dietz coal beds, combined.

Bed maps and resource estimates have been made for nine of the coal beds listed above, as shown by the CRO plates 4-43.

Coal has been analyzed at only a few places in the Birney quadrangle. Based on the few analyses, and on analyses of coal in nearby areas, the apparent rank of the coal varies from high in the range of subbituminous C to low in the range of subbituminous B.

Coals in the Northern Great Plains, including coal in the Fort Union Formation in Montana, generally contain lesser amounts of most elements of environmental concern than coal beds in other areas of the United States (Hatch and Swanson, 1977, p. 147).

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).

Canyon coal bed

[CRO plates 4-8]

The Canyon coal bed was named by Baker (1929). It correlates with the coal called the Upper Canyon coal bed by Culbertson and Klett (1976) in the adjacent Browns Mountain quadrangle to the east. The bed characteristically is marked by a band of clinker formed by near-surface burning of the coal. The Canyon bed locally attains a thickness of 14 feet (4.2 m) in the southwestern part of the quadrangle, and 15 feet (4.5 m) in the northwestern part (CRO plate 4). Where thickest, the bed commonly contains a shale parting 2-3 feet (0.6-0.9 m) thick in the lower part. The Canyon bed generally crops out on steep slopes, and the area available for stripping is a narrow band, 200-500 feet (60-150 m) wide immediately adjacent to the outcrop. Samples for chemical analyses have not been collected from the Canyon bed in the Birney quadrangle.

Wall coal bed

[CRO plates 9-13]

The Wall coal bed was named by Baker (1929), probably for exposures of the coal along Wall Creek in the southwestern corner of the Birney quadrangle. The bed contains at least 14 feet (4.2 m) of coal in a partial exposure along Wall Creek in the southwestern corner of the Birney quadrangle, and it contains 17 feet (5.2 m) of coal in the northern part of the quadrangle (Baker, 1929). The coal thins eastward, and a bed identified as the Wall bed along Hanging Woman Creek in the southeastern part of the quadrangle is only locally as much as 5 feet (1.5 m) thick (CRO plate 9). Fairly substantial resources of coal are available for stripping from the Wall bed in the northwestern and southwestern parts of the quadrangle (CRO plate 11).

Coal from the Wall bed in the Birney quadrangle has not been analyzed, although drill cores from the bed have been sampled for analysis from several nearby places to the west. The analyses of 42 of these samples have been reported by Matson and others (1973, p. 38-40). The analyses show an average of 0.30 percent sulfur, 4.6 percent ash, and a heat value of 9087 Btu per pound on the as-received basis, which indicates an average apparent rank of the coal low in the range of subbituminous B.

Local coal bed below the Wall bed

[CRO plates 19-23]

A coal bed, regarded by Baker (1929) as a lower split of the Wall coal bed and referred to in this report as a local coal bed below the Wall bed, crops out about 30-40 feet (9-12 m) below the Wall bed in the southern part of the Birney quadrangle. The coal locally thickens to 11 feet (3.3 m) in sec. 33, T. 6 S., R. 42 E. (CRO plate 19). Shale, siltstone, or sandstone partings commonly divide the coal into two or more benches. Coal in the local bed below the Wall bed are available for stripping mainly along Battle and Ebaugh Creeks in the southeastern part of T. 6 S., R. 42 E. The coal ranges in thickness from 8 to 11 feet (2.4 to 3.3 m) in a very irregularly shaped band aggregating about a square mile (2.6 square km) in area in this vicinity.

Analyses have not been made of the local coal bed below the Wall bed in the Birney quadrangle.

Pawnee coal bed

The Pawnee coal bed is less than 5 feet (1.5 m) thick in most parts of the Birney quadrangle, except in parts of secs. 18 and 19, T. 6 S., R. 43 E., where the bed locally is as thick as 7 feet (2.1 m) (CRO plate 1). The bed also may be 5 feet (1.5 m) or more thick in sec. 31 of the same township, and in sec. 6 of the township to the south, based on measurements of the bed by Culbertson and Klett (1976) in the Browns Mountain quadrangle to the east. Areas underlain by coal more than 5 feet (1.5 m) thick in the Pawnee bed are small and resources were not estimated for the bed.

Analyses are not available for coal in the Pawnee bed in the Birney quadrangle.

Brewster-Arnold coal bed

[CRO plates 14-18]

The Brewster-Arnold coal bed was named by Bass (1924) for the coal at the Brewster-Arnold mine near the center of the Birney quadrangle in sec. 23, T. 6 S., R. 42 E. The coal is about 10 feet (3 m) thick at the mine. It thickens from the vicinity of the mine westward, and is 20-25 feet (6.1-7.5 m) thick in the north-central part of the quadrangle, and as much as 20 feet (6.1 m) thick in the southwestern part. The bed probably contains less than 5 feet (1.5 m) of coal in the subsurface along Hanging Woman Creek in the southeastern part of the quadrangle.

Large resources of coal are available for stripping in the Brewster-Arnold bed along the sides of the Tongue River Valley, and in the valleys of streams tributary to the river, including, in particular, the valleys of Bull, Whitten, Zook, and Coal Bank Creeks in the northwestern part of the quadrangle.

An analysis of coal collected from the Brewster-Arnold mine was reported by Baker (1929, p. 39), and six analyses of the coal in drill cores from the Brewster-Arnold bed, collected at three places in the quadrangle (localities 4, 12, and 14, CRO plate 1), were reported by Matson and others (1973, p. 40, 43). The average of the six analyses reported by Matson and others (1973, p. 40, 43) shows 0.41 percent sulfur, 6.3 percent ash, and a heat value of 8789 Btu per pound on the as-received basis. These average values indicate an apparent rank high in the range of subbituminous C.

King coal bed

[CRO plates 19-23]

The King coal bed was named by Warren (1959, p. 571) presumably for outcrops of the coal along King Creek, a tributary of the Tongue River about 8 miles (13 km) northeast of the Birney quadrangle. The same coal bed was called the upper bench of the Knobloch coal bed by Matson and others (1973, pls. 11A and 33) in the vicinity of the Browns Mountain quadrangle, and was called the Upper Knobloch bed by Mapel (1976) in the northern part of the Birney quadrangle following a modification in the usage of Matson and others (1973). Regional subsurface relations, the mapping done by Warren (1959), and mapping done in 1977 by W. C. Culbertson along the Tongue River northeast of the Birney quadrangle lead to 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 mapped by Bass (1932) and McKay (1976) near Ashland. The Sawyer bed lies as much as 225 feet (39 m) above the Knobloch bed near Ashland (Bass, 1932, p. 52).

The King bed is about 6 feet (1.8 m) thick in outcrops in sec. 34, T. 5 S., R. 42 E., and in the adjacent sections to the east and south, but it thins rapidly southward, and was not recognized in drill holes or outcrops within a mile north of Birney or in parts of the quadrangle farther south. A small area of coal in the King bed is available for stripping in the southeastern corner of the quadrangle (CRO plate 21).

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

Knobloch coal bed

[CRO plates 24-28]

The Knobloch coal bed (spelled Knoblock in early reports) was named by Bass (1924) for exposures along the Tongue River about 2 miles (3.2 km) north of the Birney quadrangle. The coal bed identified in this report as the Knobloch was called the middle bench of the Knobloch by Matson and others (1973, plates 11A and 33), and the middle Knobloch bed by Mapel (1976). The coal is thickest in the northeastern part of the quadrangle where it is 19 feet (5.8 m) thick in a drill hole in sec. 35, T. 5 S., R. 42 E. (locality 2, CRO plate 1). The coal comes to the surface in the SE¼ sec. 34, T. 5 S., R. 42 E., where 9 feet (2.7 m) of coal is exposed at the top of the bed just above the waterlevel of the Tongue River. The coal probably is eroded away at places beneath the alluvium of the Tongue River in the vicinity of this outcrop, as indicated on CRO plate 1, although information is lacking to show accurately the extent of the area of erosion beneath the stream bed. Extremely sparse information from drilling suggests that the Knobloch bed thins southwestward, and that it is less than 5 feet (1.5 m) thick in the southern part of the quadrangle and along most of the western edge (CRO plate 24).

Coal in the Knobloch bed is available for stripping under and adjacent to the floodplain of the Tongue River in the northeastern part of the Birney quadrangle.

An analysis of a sample of coal from the Knobloch bed collected from a drill hole at Birney (locality 6, CRO plate 1) was reported by Matson and others (1973, p.64) to show 0.16 percent sulfur, 5.9 percent ash, and a heat value of 8963 Btu per pound on the as-received basis. Coal having these analytical values ranks low in the range of subbituminous B.

Nance coal bed

[CRO plates 29-33]

The Nance coal bed is named for its occurrence in a Nance and Hayes drill hole in sec. 25, T. 5 S., R. 42 E., a few hundred feet east of the Birney quadrangle. The coal is 10 feet (3 m) thick, and occurs at a depth of 242 feet (74 m) in this hole (see Culbertson and Klett, 1976, locality 1). A coal at about the same horizon in holes drilled in the valley of the Tongue River was regarded by Matson and others (1973, plate 33) as a lower bench of the Knobloch bed. The coal bed was referred to as the Lower Knobloch bed by Culbertson and Klett (1976) and by Mapel (1976) following a modification of the usage of Matson and others (1973).

The Nance bed is estimated to be as much as 13 feet (4 m) thick in a drill hole at Birney (locality 6, CRO plate 1), thinning generally from this point westward and southward (CRO plate 29). A coal bed estimated to be 8 feet (2 m) thick in an oil and gas test well in sec. 34, T. 6 S., R. 42 E. (locality 16, CRO plate 1) has been correlated with the Nance bed, although it may be a local coal at a slightly lower stratigraphic horizon. Overburden is estimated to be slightly less than 200 feet (61 m) above the Nance bed in the northeastern corner of the Birney quadrangle where the coal may locally be at shallow enough depths for stripping.

Chemical analyses are not available for coal in the Nance bed in the Birney quadrangle or in 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 quadrangle.

Flowers-Goodale coal bed

[CRO plates 34-38]

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 Birney quadrangle. A coal identified as the Flowers-Goodale bed is estimated to be 21 feet (6.3 m) thick at a depth of about 470 feet (143 m) in a well in sec. 12, T. 6 S., R. 42 E., and is estimated to be 8 feet (2.4 m) thick at a depth of 760 feet (232 m) in a well about 4 miles (6.4 km) to the southwest in sec. 34 of the same township. Information about the Flowers-Goodale bed in the Birney quadrangle is limited to these two drill holes, and is inadequate to more than suggest a general southwestward trend of thinning of the coal within the quadrangle. The bed is everywhere beneath more than 200 feet (61 m) of overburden, and is thus regarded as inaccessible for stripping in the Birney quadrangle.

Analyses are not available for coal of the Flowers-Goodale bed in the Birney quadrangle. Matson and others (1973, p. 86) report that three samples of coal from the Flowers-Goodale bed collected by them in the Ashland field about 30 miles (50 km) northeast of the Birney quadrangle, showed a range in sulfur from 0.36-0.77 percent, ash from 7.27-9.02 percent, and heat value from 7540-7570 Btu per pound on an as-received basis.

Terret coal bed

The lowest identified coal bed, the Terret bed, is correlated with a coal bed of the same name that crops out in the Ashland coal field to the north. Subsurface information is very sparse on which to demonstrate continuity of the coal between the Birney quadrangle and outcrops of the Terret bed in the Ashland coal field, and the correlation, therefore, is regarded as tentative.

The Terret bed has been found in the Birney quadrangle only in the drill hole at locality 9 (CRO plate 1), where the coal is estimated to be 4 feet (1.2 m) thick. Coal in the Terret bed appears to be thicker than 5 feet (1.5 m) in drill holes northeast of the Birney quadrangle, and, assuming a northeastward thickening trend on this basis, the bed probably underlies at least a small area in the northwest corner of the Birney quadrangle with a thickness of about 5 feet (1.5 m) (CRO plate 39). The coal is too deep to be mined by stripping.

Analyses have not been made of coal in the Terret bed in the Birney 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 in the Birney quadrangle is coal that is more than 5 feet (1.5 m) thick, under less than 1,000 feet (305 m) of overburden, and within 3 miles (4.8 km) of a complete measurement of the coal bed. Reserve Base coal is further subdivided into categories according to its nearness to a measurement of the coal

bed. Measured coal is coal within 1/4 mile (0.4 km) of a measurement; Indicated coal extends 1/2 mile (0.8 km) beyond Measured coal to a distance of 3/4 mile from the measurement; and Inferred coal extends 1 1/4 miles (2 km) beyond Indicated coal to a distance of 3 miles (4.8 km) from the measurement.

The total Reserve Base for Federally-owned coal in beds thicker than 5 feet (1.5 m) that lie less than 1,000 feet (305 m) below the ground surface is estimated to be about 1.8 billion short tons as shown on CRO plate 2, and as listed in table 1. Of this total amount, 5 percent is regarded as Measured, 26 percent as Indicated, and 69 percent as Inferred (table 1).

Reserves are the recoverable part of the Reserve Base. Reserves have been estimated only for the coal that lies under less than 200 feet (61 m) of overburden, which is the coal considered available for stripping. In the Birney quadrangle, reserves are considered to be 85 percent of the resources of strippable coal, and are estimated to total 420 million short tons.

COAL DEVELOPMENT POTENTIAL

Development potential for surface mining methods

Areas where the coal beds are more than 5 feet (1.5 m) thick and are overlain by 200 feet (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:

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

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

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 Birney quadrangle, Rosebud County, Montana

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

Coal bed name	Overburden 0-200 feet				Overburden 200-1,000 feet				Grand Total (rounded)
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	
Canyon	12,400	35,800	22,400	70,600	3,800	34,100	19,300	57,200	128,000
Wall	15,100	38,700	42,800	96,600	6,100	42,500	73,100	121,700	218,000
Local below Wall	6,500	14,500	3,200	24,200	60	4,800	3,500	8,300	32,500
Brewster-Arnold	21,800	88,500	83,200	193,500	430	27,500	287,900	315,800	509,000
King	2,300	11,000	2,500	15,800	90	1,900	1,200	3,200	19,000
Knobloch	10,700	48,500	30,800	90,000	2,700	38,200	224,800	265,700	356,000
Nance	590	2,000	1,100	3,700	4,400	31,200	71,300	107,000	111,000
Flowers-Goodale	---	---	---	---	8,200	58,900	389,300	456,400	456,000
Terret	---	---	---	---	---	---	4,800	4,800	4,800
Total (rounded)	69,400	239,000	186,000	494,000	25,800	239,000	1,075,000	1,340,000	1,830,000

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. 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 feet (61 m) of overburden in the various development-potential categories total 494 million short tons, as shown in table 2. Each quarter section or lot underlain by Federally owned coal is classified according to its development potential for surface mining on CDP plate 44.

Development potential for underground mining methods

The Reserve Base for Federally-owned coal beneath 200-1,000 feet (61-305 m) of overburden is estimated to be 1.34 billion short tons, as shown in 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.

Table 2.--Development potential of the estimated Reserve Base for surface mining methods (0-200 feet overburden) for Federal coal lands in the Birney quadrangle, Rosebud County, 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 tonnes, multiply by 0.9072; to convert mining ratios in yd^3/ton coal to m^3/t, multiply by 0.842]

Coal bed	High development potential (0-10 mining ratio)	Moderate development potential (10-15 mining ratio)	Low development potential (>15 mining ratio)	Total (rounded)
Canyon	36,500	22,200	11,900	70,600
Wall	63,000	17,600	16,000	96,600
Local below Wall	8,800	6,000	9,400	24,200
Brewster-Arnold	142,000	43,000	8,500	193,500
King	2,900	4,800	8,100	15,800
Knobloch	58,000	24,800	7,200	90,000
Nance	———	———	3,700	3,700
Total (rounded)	311,200	118,400	64,800	494,000

REFERENCES CITED

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

Bass, N. W., 1924, Coal in the Tongue River Valley, Montana: U.S. Geol. Survey Press Mem. 16748, Feb. 12, 1924.

_____1932, The Ashland coal field, Rosebud, Powder River, and Custer Counties, Montana: U.S. Geol. Survey Bull. 831-B, p. 19-105.

Culbertson, W. C., and Klett, M. C., 1976, Geologic map and coal sections of the Browns Mountain quadrangle, Rosebud County, Montana: U.S. Geol. Survey Misc. Field Studies Map MF-814.

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

Mapel, W. J., 1976, Geologic map and coal sections of the Birney quadrangle, Rosebud County, Montana: U.S. Geol. Survey Misc. Field Studies Map MF-813.

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

Matson, R. E., Blumer, J. W., and Wegelin, L. A., 1973, Quality and reserves of strippable coal, selected deposits, southeastern Montana: Montana Bur. Mines and Geology Bull. 91, 135 p.

McKay, E. J., 1976, Geologic map and coal sections of the King Mountain quadrangle, Powder River and Rosebud Counties, Montana: U.S. Geol. Survey Misc. Field Studies Map MF-817.

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

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