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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE EPSIE NE QUADRANGLE, POWDER RIVER COUNTY, MONTANA

[Report includes 11 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)	0.907	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 Epsie NE quadrangle, Powder River County, Montana, (11 plates; U.S. Geological Survey Open-File Report 79-087). 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 Epsie NE 7 1/2-minute quadrangle is in central Powder River County, Montana, about 64 miles (103 km) south-southeast of Miles City, a town in the Yellowstone River valley of eastern Montana, and 5 miles (8 km) west of Broadus, Montana, a small town in the Powder River valley. Miles City is on U.S. Interstate Highway 94 and the main east-west routes of the Burlington Northern Railroad and the Chicago, Milwaukee, St. Paul, and Pacific Railroad. Broadus is on U.S. Highway 212.

Accessibility

The quadrangle is accessible from Miles City, Montana, by going south on U.S. Highway 312 a distance of about 70.5 miles (113 km) to the northeastern corner of the quadrangle. The quadrangle is accessible from Broadus by going 5 miles (8 km) westward on U.S. Highway 212 which passes through the northern

part of the quadrangle. A number of local roads and trails provide access to all except the very rugged southern part of the quadrangle. This part of the quadrangle is accessible from the graveled Powder River Road which passes through the southeastern corner of the quadrangle about 6 miles (9.6 km) south west of Broadus.

Physiography

The Epsie NE quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The central and northern parts of the quadrangle are drained and dissected by tributaries of Mizpah Creek which flows through the extreme northwest corner of the quadrangle. Mizpah Creek joins the Powder River 55 miles (88 km) north-northeast of the quadrangle. The remainder of the quadrangle is drained by short, steep tributaries of the Powder River. The Powder River passes about 0.5 mile (0.8 km) southeast of the southeast corner of the quadrangle and flows northeastward and northward to join the Yellowstone River about 86 miles (138.3 km) north-northeast of the quadrangle.

In the central and northern parts of the quadrangle, the relief is moderate; the rounded hills rise about 150 feet (46 m) above the narrow valleys. In the southern part and most of the eastern part of the quadrangle, the topography is quite rugged. The narrow, sharp ridges rise 250 to 300 feet (76 to 91 m) and more above the steep-sided valleys, and in many places these ridges are carved into badlands.

The lowest point in the quadrangle, with an elevation of 3,140 feet (957 m), is along an intermittent stream channel near the southeastern corner of the quadrangle. The highest point in the quadrangle is an unnamed peak with an elevation of 4,048 feet (1,234 m). This peak is only 2.3 miles (3.7 km) northwest of the lowest point. The relief in the quadrangle is 908 feet (277 m).

Climate

The climate of Powder River 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 Northern Powder River Basin Known Recoverable Coal Resource Area (KRCRA) covers all of the Epsie NE quadrangle except for a narrow area along the east and north borders of the quadrangle. The Boundary and Coal Data Map (pl. 2) shows the location of the KRCRA tracts and the land ownership status. There were no outstanding Federal coal leases or prospecting permits recorded as of 1977.

GENERAL GEOLOGY

Previous work

Warren (1959) mapped all of the Epsie NE quadrangle as part of the Birney-Broadus coal field. Matson, Dahl, and Blumer (1968) mapped the strippable coal deposits on state land in Powder River County. Matson and Blumer (1973) mapped the northern part of the quadrangle as part of the Broadus coal deposit.

Stratigraphy

The exposed bedrock units in this quadrangle belong to two members of the Paleocene Fort Union Formation, the upper Tongue River Member, and the underlying Lebo Shale Member.

The Tongue River Member is made up mainly of yellow to gray sandstone, sandy shale, carbonaceous shale, and coal. Much of the coal has burned, baking the

overlying sandstone and shale and forming thick, reddish-colored clinker beds. The upper part of the Tongue River Member has been removed by erosion, leaving only about 900 feet (274 m) of the member.

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.

The Lebo Shale Member is predominantly dark-gray and light-gray claystone and brown to black, carbonaceous shale containing some beds of siltstone, but no coal. This member crops out only in valleys near the eastern border of the quadrangle.

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 Epsie NE quadrangle is in the northeastern part of the Powder River structural basin. Regionally the strata dip westward or southwestward at an angle of less than 1 degree. The regional dip is modified in places by minor local folding and faulting (pls. 4 and 8).

COAL GEOLOGY

The coal beds in the Epsie 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 coal

beds are in the Tongue River Member of the Fort Union Formation. The lowermost, important coal is the Broadus coal bed, which occurs about 120 to 180 feet (37 to 55 m) above the base of the Tongue River Member. As shown on plate 3 there are some thin, local coal beds below the Broadus, the lowest being about 90 feet (27 m) below the Broadus coal bed. The Broadus coal bed is overlain successively by a noncoal interval of about 110 to 125 feet (33.5 to 38.1 m), the Knobloch coal bed or a local coal bed, a noncoal interval of about 70 to 80 feet (21 to 24 m), the Lower Sawyer coal bed, a noncoal interval 40 to 80 feet (12 to 24 m), the Upper Sawyer coal bed, a noncoal interval of 135 to 180 feet (41 to 55 m) which in places contains thin, local coal beds, the Cache coal bed, an interval of 160 to 240 feet (49 to 73 m) which in places contains thin, local coal beds, and the Pawnee clinker bed formed by burning of the Pawnee coal bed.

The coal found along the eastern flank of the Powder River Basin in Montana increases in rank from lignite in the east to subbituminous in the deeper parts of the basin to the west. All available chemical analyses of coal from this and adjacent quadrangles were considered in our decision to assign a rank of lignite A to the coal in this quadangle. Analyses of coal are given in the description of the various coal beds.

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).

Broadus coal bed

The Broadus coal bed, first described by Warren (1959, p. 570), derives its name from the town of Broadus in the Broadus quadrangle just east of the Epsie NE quadrangle. The Broadus coal bed crops out in the eastern and northeastern parts

of the Epsie NE quadrangle but has been burned extensively along the outcrops forming a reddish-brown, erosion-resistant clinker bed. West of the outcrops the Broadus coal bed has been penetrated by two drill holes. The isopach map, plate 7, shows that the Broadus coal ranges from about 10 to 25 feet (3 to 7.6 m) in thickness. The structure contour map, plate 8, indicates that the bed dips westward at an angle of less than 1 degree, and that this dip is modified locally by minor folding. Overburden on the Broadus coal bed (pl. 9) ranges in thickness from zero at the outcrops to about 760 feet (232 m) in the southwestern part of the quadrangle.

A chemical analysis of the Broadus coal bed from the Peerless mine, sec. 23, T. 4 S., R. 50 E. in the Epsie NE quadrangle shows ash 8.7 percent, sulfur 0.3 percent, and a heating value of 7,240 Btu per pound (16,840 kJ/kg) on an as-received basis (Gilmour and Dahl, 1967, p. 16). This heating value converts to about 7,929 Btu per pound (17,702 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Broadus coal in the Epsie NE quadrangle is lignite A in rank.

Knobloch coal bed

The Knobloch coal bed was named by Bass (1924) from a small coal mine on the Knobloch Ranch in the Tongue River valley in the Birney Day School quadrangle, about 40 miles (64 km) west of the Epsie NE quadrangle. The previous workers have not mapped the Knobloch coal bed in the Epsie NE quadrangle. However, the compilers of this report believe that the Knobloch coal bed does occur in a drill hole. The gamma ray log of this hole in the SE¼, SE¼, sec. 13, T. 5 S., R. 49 E., shows a 4-foot (1.2-m) thick coal bed at a depth of 636 feet (194 m) which is 3,243 feet (988 m) above sea level. Because of its thickness and elevation this coal bed is believed to be part of the Knobloch coal bed which occurs in quadrangles to the west and north. In this test hole the Knobloch occurs 124 feet (38 m) above the Broadus coal bed. Local beds have been mapped on the surface at

about this stratigraphic position (see pls. 1 and 3, measured sections 5 and 7). Because of their positions, these local beds may correlate with the Knobloch coal bed. However, because the Knobloch coal bed and the associated local beds are below Reserve Base thickness, coal resources have not been assigned to them.

Upper and Lower Sawyer coal beds

The Sawyer coal bed was first described by Dobbin (1930, p. 28) after exposures in the foothills of the Little Wolf Mountains in the Forsyth coal field, Rough Draw and Black Spring quadrangles, about 60 miles (96 km) northwest of the Epsie NE quadrangle.

In the Epsie NE quadrangle, the Sawyer coal bed is split into two coal beds with about 40 to 80 feet (12 to 24 m) of interburden (see pls. 1 and 3). The Upper and the Lower Sawyer coal beds crop out in the northern part of the quadrangle and have been penetrated by the oil and gas test hole in the southwestern part of the quadrangle. Because the thicknesses of the Sawyer beds range from 2 to 4 feet (0.6 to 1.2 m), coal resources have not been assigned to them.

Cache coal bed

The Cache coal bed was first described by Warren (1959, p. 572). This bed is named for Cache Creek in the Lonesome Peak and Yarger Butte quadrangles just south and southwest of the Epsie NE quadrangle. The Cache coal bed crops out in the southern part of the Epsie NE quadrangle where it occurs about 135 to 180 feet (41 to 55 m) above the Upper Sawyer coal bed and 340 to 440 feet (104 to 134 m) above the Broadus coal bed. As shown by the isopach and structure contour map (pl. 4) the Cache coal bed ranges from about 3 to 6 feet (0.9 to 1.8 m) in thickness and in general dips southwestward at an angle of less than 1 degree. This dip is modified by a small anticline of low relief in the southwestern part of the quadrangle. Warren (1959, p. 572) states that the Cache coal bed thins northward to less than 1.5 feet (0.46 m) thick and was not mapped. In the

south-central part of the quadrangle, there is a thin, discontinuous local coal bed from 8 to 15 feet (2.4 to 4.6 m) below the Cache which might be considered a lower bench of the Cache coal bed (pls. 1 and 3). This local bed is less than 5 feet (1.5 m) thick and is separated from the Cache bed by a rock interval that is thicker than the local coal bed. Consequently, coal resources have not been assigned to the local bed. Overburden on the Cache bed (pl. 5) where the bed is 5 feet (1.5 m) or more thick ranges from zero at the outcrop to about 390 feet (119 m) in thickness.

There is no known publicly available chemical analysis of the Cache coal in the Epsie NE quadrangle. Because other coals in this area are lignite A in rank, the Cache coal has also been assigned a rank of lignite A.

Pawnee coal bed

The Pawnee coal bed was first described by Warren (1959, p. 572) from exposures in the Birney-Broadus coal field, Montana, possibly from the Epsie quadrangle where the coal bed is quite thick. In the Epsie NE quadrangle the Pawnee coal appears to have been entirely burned, forming a thick clinker bed which caps hills in the southern part of the quadrangle. The Pawnee clinker bed ranges from about 160 to 240 feet (49 to 73 m) above the Cache coal bed.

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.

Coal resource classifications have been established by the U.S. Bureau of Mines and the U.S. Geological Survey in U.S. Geological Survey Bulletin 1450-B (1976). Coal resource is the estimated 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 lignite are in lignite beds which are 5 feet (1.5 m) or more thick, under less than 1,000 feet (305 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 of lignite that occurs in beds 5 feet (1.5 m) or more thick and under less than 1,000 feet (305 m) of overburden.

Reserve Base coal may be either surface-minable coal or underground-coal. In this report, surface-minable Reserve Base coal is lignite that is under less than 200 feet (61 m) of overburden. In this report, underground-minable Reserve Base coal is lignite that is under more than 200 feet (61 m), but less than 1,000 feet (305 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 factory of 85 percent). Therefore, 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 of the coal bed, and a conversion factor of 1,750 short tons of lignite per acre-foot (12,870 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, 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 319.38 million short tons (289.68 million t). There is no federally owned, surface-minable Hypothetical coal. As shown by table 2, the total federally owned, underground-minable

Reserve Base coal is estimated to be 659.86 short tons (598.49 million t). The total federally owned, underground-minable Hypothetical coal is estimated to be 7.84 million short tons (7.11 million t). The total tonnage of surface- and underground-minable Reserve Base coal is 979.24 million short tons (888.17 million t), and the total of surface- and underground-minable Hypothetical coal is 7.84 million short tons (7.11 million t).

About 5 percent of the surface-minable Reserve Base tonnage is classed as Measured, 32 percent as Indicated, and 63 percent as Inferred. About 1 percent of the underground-minable Reserve Base tonnage is Measured, 13 percent is Indicated, and 86 percent is Inferred.

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

COAL DEVELOPMENT POTENTIAL

There is a potential for surface-mining in the Northern Powder River Basin in areas where subbituminous coal beds 5 feet (1.5 m) or more thick are overlain by less than 500 feet (152 m) of overburden, or where lignite beds of the same thickness are overlain by 200 feet (61 m) or less of overburden. 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 lignite is:

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

where MR = mining ratio
t_o = thickness of overburden, in feet
t_c = thickness of lignite, in feet
rf = recovery factor = 0.85 in this area
cf = conversion factor = 0.922 cu. yds./ short ton for lignite

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. 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 for surface-mining methods is shown on the CDP map (pl. 11). Most of the Federal lands in the southern, eastern, and northwestern parts of the quadrangle have a high development potential for surface mining of coal because of the Broadus coal bed.

The Broadus coal bed (pl. 9) has a wide area of high development potential extending from the boundary of the coal to the 10 mining-ratio contour or to the 200-foot overburden isopach which is the arbitrarily assigned stripping limit. There is a narrow band of moderate development potential between the 10 and 15 mining-ratio contours or between the 10 mining-ratio contour and the 200-foot overburden isopach. There are limited areas of low development potential between the 15 mining-ratio contour and the 200-foot overburden isopach.

The Cache coal bed (pl. 5) has development potential for surface mining in small areas in the southern part of the quadrangle. There are narrow bands of high and moderate development potential on the hill slopes and wider areas of low development potential under the crests of the hills.

The Federal lands in the central, west-central, and some of the southwestern parts of the quadrangle have no development potential for surface mining because the Cache bed has been removed by erosion and the Broadus coal bed has more than 200 feet (61 m) of overburden.

Development potential for underground mining and in-situ gasification

Lignite beds 5 feet (1.5 m) or more in thickness lying more than 200 feet (61 m) but less than 1,000 feet (305 m) below the surface are considered to have development potential for underground mining. Estimates of the tonnage of underground-minable coal are listed in table 2 by development-potential category for each coal bed. Coal is not currently being mined by underground methods in the Northern Powder River Basin because of poor economics. Therefore, the coal development potential for underground mining of these resources for purposes of this report is rated as low, and a Coal Development Potential map for underground mining was not made.

In-situ gasification of coal on a commercial scale has not been done in the United States. Therefore, the development potential for in-situ gasification of coal found below the surface-mining limit in this area is rated as low, and a Coal Development Potential map for in-situ gasification of coal was not made.

Table 1.--Surface-minable coal resource tonnage (in short tons) by development-potential category for Federal coal lands in the Epsie NE quadrangle, Powder River 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				
Cache	1,120,000	760,000	2,250,000	4,130,000
Broadus	279,190,000	33,390,000	2,670,000	315,250,000
Total	280,310,000	34,150,000	4,920,000	319,380,000

Note: No strippable hypothetical resources.

Table 2.--Underground-minable coal resource tonnage (in short tons) by development-potential category for Federal lands in the Epsie NE quadrangle, Powder River 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				
Cache	0	0	1,700,000	1,700,000
Broadus	0	0	658,160,000	658,160,000
Total	0	0	659,860,000	659,860,000
Hypothetical Resource tonnage				
Broadus	0	0	7,840,000	7,840,000
Total	0	0	7,840,000	7,840,000
Grand Total	0	0	667,700,000	667,700,000

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