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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE LESLIE CREEK QUADRANGLE, POWDER RIVER COUNTY, MONTANA

[Report includes 16 plates]

By

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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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ILLUSTRATIONS

[Plates are in pocket]

TABLES

Conversion table

To convert	Multiply by	To obtain
feet	0.3048	meters (m)
miles	1.609	kilometers (km)
acres	0.40469	hectares (ha)
tons (short)	0.9072	metric tons (t)
short tons/acre-ft	7.36	metric tons/hectare-meter (t/ha-m)
Btu/lb	2.326	kilojoules/kilogram (kJ/kg)

INTRODUCTION

Purpose

This text is for use in conjunction with the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) maps of the Leslie Creek quadrangle, Powder River County, Montana, (16 plates; U.S. Geological Survey Open-File Report 79-093). 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 Leslie Creek 7 1/2-minute quadrangle is in north-central Powder River County, Montana, about 53 miles (85.3 km) south of Miles City, a town in the Yellowstone River valley of eastern Montana. 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. The quadrangle is about 12 miles (19 km) northwest of Broadus, Montana, a town located in the Powder River valley and on east-west U.S. Highway 212.

Accessibility

The quadrangle is accessible from Broadus by traveling northwestward on U.S. Highway 212 for a distance of 14 miles (22.5 km) to the southern edge of the quadrangle. U.S. Highway 212 passes through the southwest corner of the quadrangle. A number of local roads and trails provide access to the remainder of the quadrangle.

Physiography

The Leslie Creek quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The western part of the quadrangle is drained by northwestward-flowing ephemeral tributaries of Pumpkin Creek which is located 1 to 5 miles (1.6 to 8 km) west of the quadrangle. The eastern part of the quadrangle is drained by southeastward-flowing, ephemeral tributaries of Mizpah Creek which flows northeastward across the southeast corner of the quadrangle. Pumpkin Creek is a northward-flowing tributary of the northward-flowing Tongue River, which joins the Yellowstone River at Miles City. Mizpah Creek is a northward-flowing tributary of the Powder River which joins the Yellowstone River about 30 miles (48 km) northeast of Miles City. The topography is quite rugged as the closely spaced ephemeral streams have dissected the quadrangle into a succession of narrow, steep-sided, northwestward-trending valleys and ridges. The divide between the Pumpkin Creek and Mizpah Creek drainages extends diagonally across the quadrangle from the southwest to the northeast corner of the quadrangle in a series of ridges cresting above 3,600 feet (1,097 m) in elevation. The highest elevation, 3,771 feet (1,149 m), is on Two Tree Butte near the southwest corner of the quadrangle. The lowest elevations, about 3,300 feet (1,006 m) occur along the creeks near the southeast and northwest corners of the quadrangle. Topographic relief is about 471 feet (144 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 the entire Leslie Creek quadrangle. There are no National Forest lands within the quadrangle. The Boundary and Coal Data Map (pl. 2) shows the land ownership status. There were no outstanding Federal coal leases or prospecting permits recorded as of 1977.

GENERAL GEOLOGY

Previous work

Bass (1932) mapped the westernmost tier of sections in the Leslie Creek quadrangle as part of the Ashland coal field. Bryson (1952) mapped most of the Leslie Creek quadrangle as part of the Coalwood coal field. Warren (1959) mapped the southern part of the quadrangle as part of the Birney-Broadus coal field. V. W. Carmichael in Matson and Blumer (1973, pl. 15) mapped the quadrangle as part of the Pumpkin Creek coal deposit.

Traces of coal bed outcrops shown by previous workers on planimetric maps which lack topographic control have been modified to fit the modern topographic map of the quadrangle.

Stratigraphy

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

The Tongue River Member is made up mainly of yellow sandstone, sandy shale, carbonaceous shale, and coal. Much coal has burned along outcrops, baking the overlying sandstone and shale and forming thick, reddish-colored clinker beds.

The upper part of the Tongue River Member has been removed from the quadrangle by erosion so that only about the lower 800 feet (244 m) remains.

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.

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 Leslie Creek quadrangle is in the northeastern part of the Powder River structural basin. Regionally the strata dip southward or southwestward at an angle of less than 1 degree. This dip is interrupted by minor, shallow folds as shown by the structure contour maps (pls. 5, 10, and 13). Some of the nonuniformity in structure may be due to differential compaction and to irregularities in deposition of the coals and other beds as a result of their continental origin.

COAL GEOLOGY

The coal beds in the Leslie Creek 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 mapped coal beds occur in the Tongue River Member of the Fort Union Formation (Paleocene). No commercial coals are known to exist below the Tongue River Member.

The lowermost recognized coal bed is the Broadus coal bed which occurs about 150 to 200 feet (46 to 61 m) above the base of the Tongue River Member. The Broadus coal bed is overlain by a noncoal interval of about 75 to 125 feet (23 to 38 m), the Knobloch coal bed, a noncoal interval of 120 to 180 feet (37 to 55 m) containing a local coal bed, the Sawyer coal bed, a noncoal interval of 55 to 90 feet (17 to 27 m), the Mackin-Walker coal bed, a noncoal interval of about 90 to 130 feet (27 to 40 m) containing a local coal bed, the Stump coal bed, a noncoal interval of about 45 feet (14 m), and 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 coal analyses data available at the present time from this and adjacent quadrangles were considered in our decision to assign a rank of lignite A to the coal in this quadrangle. The lignite-subbituminous boundary may fall somewhere within this quadrangle, but not enough data are presently known to allow our drawing that boundary line with certainty. Therefore, a rank of lignite A has been arbitrarily assigned by us to all of the coal in the entire quadrangle. Additional data to be obtained in the future may make a more precise determination of the location of this boundary line possible.

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, which was first described by Warren (1959, p. 570), derives its name from exposures near the town of Broadus in the Broadus quadrangle about 10 miles (16 km) southeast of the Leslie Creek quadrangle. The Broadus coal bed occurs about 150 to 200 feet (46 to 61 m) above the base of the Tongue River Member. This coal bed does not crop out in the Leslie Creek quadrangle but has been penetrated by several drill holes (pls. 1 and 3). The isopach and structure contour map of the Broadus coal bed (pl. 13) shows that the Broadus coal ranges from about 10 to 30 feet (3.0 to 9.1 m) in thickness and dips westward and southwestward at an angle of less than 1 degree, although this dip is modified in places by minor, low-relief local folds. Overburden on the Broadus coal bed (pl. 14) ranges from about 200 to 700 feet (61 to 213 m) in thickness.

There is no known, publicly available chemical analysis of the Broadus coal in the Leslie Creek quadrangle. However, an analysis of the Broadus coal from a depth of 92 to 117 feet (28 to 36 m) in drill hole BR-6C, sec. 7, T. 3 S., R. 50 E., in the Olive quadrangle, about 1 mile (1.6 km) east of the Leslie Creek quadrangle (Matson and Blumer, 1973, p. 91), shows ash 6.90 percent, sulfur 0.24 percent, and heating value 7,550 Btu per pound (17,560 kJ/kg) on an as-received basis. This heating value converts to about 8,110 Btu per pound (18,864 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Broadus coal at that location is lignite A in rank. Because of the proximity of that location to the Leslie Creek quadrangle, it is assumed that the Broadus coal in the Leslie Creek quadrangle is similar and is also 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 32 miles (51 km) west-southwest of the Leslie Creek quadrangle. In the Leslie Creek quadrangle, the Knobloch coal bed occurs about 75 to 125 feet (23 to 38 m) above the Broadus coal bed. The Knobloch coal bed does not crop out in the Leslie Creek quadrangle but has been penetrated in several drill holes (pls. 1 and 3). The isopach and structure contour map (pl. 10) shows that the Knobloch coal bed ranges from about 4 to 10 feet (1.2 to 3.0 m) in thickness and has a general southwestward dip of less than half a degree. In places the general dip is modified by low-relief folding. Overburden on the Knobloch coal bed (pl. 11) ranges from about 200 to 600 feet (61 to 183 m) in thickness.

There is no known, publicly available chemical analysis of the Knobloch coal in the Leslie Creek quadrangle. A chemical analysis of the Knobloch coal from drill hole FC-6, sec. 29, T. 1 S., R. 48 E., in the Elk Ridge quadrangle, about 7 miles (11 km) northwest of the Leslie Creek quadrangle, shows ash 6.66 percent, sulfur 0.37 percent, and heating value 7,380 Btu per pound (17,166 kJ/kg) on an as-received basis (Matson and Blumer, 1973, p. 87). This heating value converts to about 7,906 Btu per pound (18,389 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Knobloch coal at that location is lignite A in rank. Because of the proximity of that location to the Leslie Creek quadrangle, it is assumed that the Knobloch coal in this quadrangle is also lignite A in rank.

Upper and lower splits of the Sawyer coal bed

The Sawyer coal bed was first described by Dobbin (1930, p. 28) from exposures in the Forsyth coal field, possibly in the Rough Draw or Black Spring quadrangles where the Sawyer is well exposed in the foothills of the Little Wolf Mountains. These quadrangles are about 50 miles (80 km) west-northwest of the Leslie Creek quadrangle.

In the southwest part of the Leslie Creek quadrangle, the rock interval between the upper and lower splits of the Sawyer coal bed is about 50 feet (15 m) thick. The rock-interval thickness decreases going northward and northeastward until the two splits merge and form one bed in the northern part of the quadrangle.

In this quadrangle, the lower split of the Sawyer coal bed (A coal bed of Bass) is about 120 to 180 feet (37 to 55 m) above the Knobloch coal bed. The lower split of the Sawyer coal bed crops out extensively within the quadrangle and in many places is burned, forming a reddish-colored clinker bed. The structure contour and isopach maps of the Sawyer coal bed and its splits (pls. 4 and 5) show the split line where the lower split of the Sawyer coal bed divides from the Sawyer coal bed and its upper split. This map shows that the lower split of the Sawyer coal bed ranges from about 6 to 16 feet (1.8 to 4.9 m) in thickness and has a general westerly dip of less than half a degree. In places the general dip is modified by low-relief folding. Overburden on the lower split of the Sawyer coal bed (pl. 8) ranges from 0 feet at the outcrops to about 400 feet (0-122 m) in thickness.

A chemical analysis of the lower split of the Sawyer coal from a depth of 112 to 124 feet (34 to 38 m) in drill hole PC-15 in sec. 32, T. 3 S., R. 49 E. in the southern part of the Leslie Creek quadrangle (Matson and Blumer, 1973, p. 83) shows ash 9.99 percent, sulfur 0.35 percent, and heating value of 7,140 Btu per pound (16,608 kJ/kg) on an as-received basis. This heating value converts to about 7,932 Btu per pound (18,451 kJ/kg) on a moist, mineral-matter-free basis, indicating that the lower split of the Sawyer coal in the Leslie Creek quadrangle is lignite A in rank.

North of the split line shown on plates 4 and 5 the interval between the upper and lower splits of the Sawyer is so small that it is not practical to show separate isopachs and structure contours for the upper and lower splits of the Sawyer coal bed. Therefore, north of the split line, the upper split of the Sawyer and the combined Sawyer are shown as one bed. The upper split of the Sawyer coal bed ranges from about 8 to 18 feet (2.4 to 5.5 m) in thickness, and the Sawyer coal bed ranges from about 24 to 32 feet (7.3 to 9.8 m) in thickness. These beds have a general westerly dip of less than half a degree. In places the general dip is modified by small faults and low-relief folds. Overburden on the upper split of the Sawyer and the Sawyer coal bed (pl. 6) ranges from 0 feet at the outcrops to about 300 feet (0-91 m) in thickness.

A chemical analysis of the upper split of the Sawyer coal from a depth of 52 to 64 feet (16 to 19 m) in drill hole PC-15 in sec. 32, T. 3 S., R. 49 E. in the southern part of the Leslie Creek quadrangle (Matson and Blumer, 1973, p. 83) shows ash 6.54 percent, sulfur 0.31 percent, and heating value 7,510 Btu per pound (17,468 kJ/kg) on an as-received basis. This heating value converts to about 8,035 Btu per pound (18,691 kJ/kg) on a moist, mineral-matter-free basis, indicating that the upper split of the Sawyer coal in the Leslie Creek quadrangle is lignite A in rank.

Mackin-Walker coal bed

The Mackin-Walker coal bed was first described by Bryson (1952, p. 76) from exposures at the Mackin-Walker coal mine in the Box Elder Creek quadrangle about 2 miles (0.6 km) north of the Leslie Creek quadrangle. The Mackin-Walker coal bed occurs about 55 to 90 feet (17 to 27 m) above the Sawyer coal bed in the Leslie Creek quadrangle. The Mackin-Walker coal bed crops out in the northern part of the quadrangle. At no place in the Leslie Creek quadrangle is the Mackin-Walker coal bed more than 5 feet (1.5 m) thick; therefore, economic resources have not been assigned to it.

Stump coal bed

The Stump coal bed was first described by Bryson (1952, p. 76) from exposures along the ridge between Pumpkin and Mizpah Creeks in the southern part of the Box Elder Creek quadrangle and the northern part of the Leslie Creek quadrangle. The Stump coal bed occurs about 230 to 250 feet (70 to 76 m) above the Sawyer coal bed in the Leslie Creek quadrangle. The Stump coal bed is tentatively correlated with the C coal bed in the Ashland field to the west. The Stump bed is characterized by the presence in it, and in the beds below, of silicified, partly carbonized tree stumps. Several small areas of Stump coal remain in the northern part of the quadrangle. Because the Stump coal bed is less than 5 feet (1.2 m) in thickness in this quadrangle, economic resources have not been assigned to it.

Pawnee coal bed

The Pawnee coal bed was first described by Warren (1959, p. 572) from exposures in the Birney-Broadus coal field which lies immediately south of the Leslie Creek quadrangle. In this quadrangle, the Pawnee coal bed occurs about 45 feet (14 m) above the Stump coal bed. Exposures of the Pawnee coal bed are limited to a small area in the southwestern part of the quadrangle. Because the Pawnee coal bed is less than 5 feet (1.5 m) thick in the Leslie Creek quadrangle, economic resources have not been assigned to it.

Local coal beds

The local coal beds shown on plates 1 and 3 are thin and of very limited extent; consequently, they have not been assigned economic coal resources.

COAL RESOURCES

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

A coal resource classification system has been established by the U.S. Bureau of Mines and the U.S. Geological Survey and published in U.S. Geological Survey Bulletin 1450-B (1976). Coal resource is the estimated gross quantity of coal in the ground that is now economically extractable or that may become so. Resources are classified as either Identified or Undiscovered. <u>Identified Resources</u> are specific bodies of coal whose location, rank, quality, and quantity are known from geologic evidence supported by specific measurements. <u>Undiscovered Resources</u> 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 that occurs in beds 5 feet (1.5 m) or more thick and under less than 1,000 feet (305 m) of overburden for lignite.

Reserve Base coal may be either surface-minable coal or underground-minable 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 factor of 85 percent). Thus, these Reserves amount to 85 percent of the surface-minable Reserve Base coal. For economic reasons coal is not presently being mined by underground methods in the Northern Powder River Basin. Therefore, the underground-mining recovery factor is unknown and Reserves have not been calculated for the underground-minable Reserve Base coal.

Tonnages of coal resources were estimated using coal-bed thicknesses obtained from the coal isopach map for each coal bed (see list of illustrations). The coal resources, in short tons, for each isopached coal bed are the product of the acreage of coal (measured by planimeter), the average thickness in feet of the coal bed, and a conversion factor of 1,750 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, for each coal bed are shown on the Areal Distribution and Tonnage maps (see list of illustrations).

As shown by table 1, the total tonnage of federally owned, surface-minable Reserve Base coal in this quadrangle is estimated to be 513.47 million short tons (465.82 million t). As shown by table 2, the total federally owned, underground-minable Reserve Base coal is estimated to be 749.90 million short tons (680.3 million t). The total tonnage of surface- and underground-minable Reserve Base coal is 1,263.37 million short tons (1,146.13 million t).

About 18 percent of the surface-minable Reserve Base tonnage is classed as Measured, 65 percent as Indicated, and 17 percent as Inferred. About 6 percent of the underground-minable Reserve Base tonnage is Measured, 31 percent is Indicated, and 63 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 (the stripping limit), or where lignite beds of the same thickness are overlain by 200 feet (61 m) or less of overburden (the stripping limit). 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 <u>high</u>, <u>moderate</u>, and <u>low development potential</u>, respectively. This grouping of mining-ratio values was provided by the U.S. Geological Survey and is based on economic and technological criteria. Mining-ratio contours and the stripping-limit overburden isopach, which serve as boundaries for the development-potential areas, are shown on the overburden isopach and mining-ratio contour plates. Estimated tonnages of surface-minable Reserve Base and Hypothetical coal resources in each development-potential category (high, moderate, and low) are shown in table 1.

Estimated tonnages of underground-minable coal resources are shown in table 2. Because coal is not presently being mined by underground mining in the Northern Powder River Basin for economic reasons, for purposes of this report all of the underground-minable coal resources are considered to have low development potential.

Development potential for surface-mining methods

The Coal Development Potential (CDP) map included in this series of maps pertains only to surface mining. It depicts the highest coal development-potential category which occurs within each smallest legal subdivision of land (normally about 40 acres or 16.2 ha). For example, if such a 40-acre (16.2-ha) tract of land contains areas of high, moderate, and low development potential, the entire tract is assigned to the high development-potential category for CDP mapping purposes. Alternatively, if such a 40-acre (16.2-ha) tract of land contains areas of moderate, low, and no development potential, the entire tract is assigned to the moderate development-potential category for CDP mapping purposes. For practical reasons, the development-potential categories of areas of coal smaller than 1 acre (0.4 ha) have been disregarded in assigning a development potential to the entire 40-acre (16.2-ha) tract.

In areas of moderate to high topographic relief, the area of moderate development potential for surface mining of a coal bed (area having mining-ratio values of 10 to 15) is often restricted to a narrow band between the high and low development-potential areas. In fact, because of the 40-acre (16.2-ha) minimum size of coal development-potential tracts, the narrow band of moderate development-potential area often does not appear on the CDP map because it falls within the 40-acre (16.2-ha) tracts that also include areas of high development potential. The Coal Development Potential (CDP) map then shows areas of high development potential abutting against areas of low development potential.

The coal development potential for surface-mining methods on Federal coal lands is shown on the Coal Development Potential map (pl. 16). Most of the Federal coal lands in the Leslie Creek quadrangle have a high development potential.

The surface-mining potential of the Broadus coal bed (pl. 14) is limited to the southeastern part of the quadrangle. Some areas of high development potential extend from the eastern border of the quadrangle to the 200-foot (61-m) overburden isopach, the arbitrarily assigned stripping limit in this quadrangle. There are no areas of moderate or low development potential.

The Knobloch coal bed (pl. 11) has development potential for surface mining in the southeastern and northwestern parts of the quadrangle. Relatively small areas of high development potential occur along the stream valleys and extend up the slopes to the 10 mining-ratio contour. Small areas of moderate development potential occur as bands between the 10 and 15 mining-ratio contours. Relatively large areas of low development potential extend up the hill slopes from the 15 mining-ratio contours to the arbitrary stripping limit of 200 feet (61 m). Most of the Knobloch coal in the Leslie Creek quadrangle has no development potential for surface mining because the overburden is greater than 200 feet (61 m), the arbitrary assigned stripping limit for lignite.

The lower split of the Sawyer coal bed (pl. 8) has development potential for surface mining in the southern part of the quadrangle. Large areas of high development potential occur along the stream valleys and extend up the slopes to the 10 mining-ratio contour. Large areas of moderate development potential occur as bands of varying widths between the 10 and 15 mining-ratio contours. Relatively small areas of low development potential extend from the 15 mining ratio contour to the arbitrary stripping limit of 200 feet (61 m). Relatively large areas have no development potential for surface mining because the overburden is greater than 200 feet (61 m).

The upper split of the Sawyer coal bed and the Sawyer coal (pl. 6) have development potential for surface mining over all of the quadrangle except the southeastern part. Very large areas of high development potential extend from the outcrops to the 10 mining-ratio contour or the 200-foot (61-m) overburden isopach. Large areas of moderate development potential occur as bands between the 10 and 15 mining-ratio contours. Small areas of low development potential extend up the slopes from the 15 mining-ratio contour to the arbitrary stripping limit of 200 feet (61 m). Small areas of no development potential for surface mining occur in the southwestern part of the quadrangle where the overburden is greater than 200 feet (61 m).

About 83 percent of the Federal coal lands within the quadrangle has a high development potential for surface mining, 9 percent has a moderate development potential, 4 percent has a low development potential, and 4 percent has no development potential for surface mining.

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 Leslie Creek 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				
Upper Sawyer	336,390,000	30,440,000	2,480,000	369,310,000
Lower Sawyer	33,200,000	26,390,000	9,560,000	69,150,000
Knobloch	6,310,000	10,960,000	37,010,000	54,280,000
Broadus	14,390,000	0	6,340,000	20,730,000
Total	390,290,000	67,790,000	55,390,000	513,470,000

Table 2.--Underground-minable coal resource tonnage (in short tons) by development-potential category for Federal lands in the Leslie Creek 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				
Upper Sawyer	0	0	34,330,000	34,330,000
Lower Sawyer	0	0	22,250,000	22,250,000
Knobloch	0	0	130,100,000	130,100,000
Broadus	0	0	563,220,000	563,220,000
Total	0	0	749,900,000	749,900,000

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