UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Text to accompany:

Open-File Report 79-094

1979

# COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE LONESOME PEAK QUADRANGLE, POWDER RIVER COUNTY, MONTANA

[Report includes 21 plates]

By

Colorado School of Mines Research Institute

CONTENTS

## ILLUSTRATIONS

[Plates are in pocket]

Plates 1-20. Coal resource occurrence maps:

1. Coal data map.
2. Boundary and coal data map.
3. Coal data sheet.
4. Isopach and structure contour map of the Number 5 coal bed.
5. Overburden isopach and mining-ratio map of the Number 5 coal bed.
6. Areal distribution and tonnage map of identified resources of the Number 5 coal bed.
7. Isopach map of the Cache coal bed.
8. Structure contour map of the Cache coal bed.
9. Overburden isopach and mining-ratio map of the Cache coal bed.
10. Areal distribution and tonnage map of identified resources of the Cache coal bed.
11. Isopach and structure contour map of the Number 9a coal bed.
12. Overburden isopach and mining-ratio map of the Number 9a coal bed.
13. Areal distribution and tonnage map of identified resources of the Number 9a coal bed.
14. Isopach and structure contour map of the Number 9b coal bed.
15. Overburden isopach and mining-ratio map of the Number 9b coal bed.
16. Areal distribution and tonnage map of identified resources of the Number 9b coal bed.
17. Isopach map of the Broadus coal bed.

Page



## 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 Lonesome Peak quadrangle, Powder River County, Montana, (21 plates; U.S. Geological Survey Open-File Report 79-094). 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 Lonesome Peak 7 1/2-minute quadrangle is located in central Powder River County, Montana, about 73 miles (117.5 km) south-southeast of Miles City, a town in the Yellowstone River valley of eastern Montana; about 6 miles (10 km) southwest of Broadus, Montana, a small town in the Powder River valley; and about 66 miles (106 km) north of Gillette, Wyoming. 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 east-west U.S. Highway 212. Gillette is on U.S. Interstate Highway 90 and another branch of the Burlington Northern Railroad.

## Accessibility

The quadrangle is accessible from Broadus by going southwest for a distance of 7 miles (11 m) on the graveled Powder River Road, which roughly parallels the western bank of the Powder River, to the northeastern corner of the quadrangle.

A number of local roads and trails provide access to all areas of the quadrangle. The nearest railroad is the Burlington Northern Railroad near Kendrick, Wyoming, about 46 miles (74 km) airline up the Powder River valley southwest of the Lonesome Peak quadrangle.

## Physiography

The Lonesome Peak quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The quadrangle is dissected and drained by the Powder River which flows from the southwestern corner to the northeastern corner of the quadrangle. The Powder River flows northeastward to Broadus and then northward to join the Yellowstone River about 95 miles (153 km) north-northeast of the quadrangle.

Several tributaries of the Powder River dissect the quadrangle. Cache Creek, Rough Creek, and Cedar Creek flow southeastward to join the Powder River while Ernest Creek, Baking Powder Creek, and First Creek flow northwestward to join the Powder River.

The topography of the quadrangle is characterized by a broad flood plain about 1.5 miles (2.5 km) wide along the Powder River. Low-relief valleys drain the central and southeastern areas of the quadrangle. Rugged hills characterize the north-central, west-central, and south-central parts of the quadrangle.

The lowest point in the quadrangle, with an elevation of about 3,075 feet (937 m), is on the Powder River near the northeastern corner of the quadrangle. The highest point, with an elevation of about 4,010 feet (1,222 m), is located atop a ridge along the western edge of the quadrangle. Topographic relief in the quadrangle is about 935 feet (285 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 northwestern part and isolated areas along the southern edge of the Lonesome Peak quadrangle. The Boundary and Coal Data Map (pl. 2) shows the location of the KRCRA tracts and the land ownership status. There are no National Forest lands within the quadrangle. There were no outstanding Federal coal leases or prospecting permits recorded as of 1977.

## GENERAL GEOLOGY

### Previous work

Warren (1959) mapped the area west of the Powder River in the Lonesome Peak 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. Bryson and Bass (1973) mapped the area east of the Powder River as part of the Moorhead coal field.

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

### Stratigraphy

The exposed bedrock units in this quadrangle are the Tongue River and underlying Lebo Shale Members of the Fort Union Formation (Paleocene).

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 1,200 feet (366 m) of this member in the quadrangle.

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 along the eastern flank of the Powder River Basin is predominantly dark-gray to light-gray claystone and brown to black, carbonaceous shale containing some beds of siltstone, but no coal. This member crops out in the northeastern part 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 Lonesome Peak quadrangle is located along the eastern flank of the Powder River structural basin in Montana. 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, 8, 11, 14, and 18). Some

modifications in dip may also be caused by depositional variations as well as differential compaction common in continental strata.

## COAL GEOLOGY

The coal beds in the Lonesome Peak 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 (Paleocene). No commercial coal beds are known to exist below the Tongue River Member. The lowermost coal is the Contact coal bed whose base marks the base of the Tongue River Member. The Contact coal bed is overlain successively by a noncoal interval of about 40 to 50 feet (12 to 15 m), the Number 12b coal bed, a noncoal interval of about 40 to 60 feet (12 to 18 m), the Number 12a coal bed, a noncoal interval of about 20 to 30 feet (6 to 9 m), the Broadus coal bed, a noncoal interval with two thin local coal beds of about 40 to 60 feet (12 to 18 m), the Number 11 coal bed, a noncoal interval of about 40 to 60 feet (12 to 18 m), the Number 9c coal bed, a noncoal interval of about 20 to 30 feet (6 to 9 m), the Number 9b coal bed, a noncoal interval of about 10 to 15 feet (3 to 4.5 m), the Number 9a coal bed, a mainly noncoal interval of about 50 to 60 feet (15 to 18 m) containing local coal beds, the Cache coal bed, a noncoal interval of about 140 feet (43 m), the Pawnee clinker bed, a noncoal interval of about 50 to 60 feet (15 to 18 m), the Number 5 coal bed, a noncoal interval of about 45 to 55 feet (14 to 17 m), and the Upper Cook clinker 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 quadrangle. Analyses of coal are given in the descriptions 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).

### Contact coal bed

The Contact coal bed, the basal bed of the Tongue River Member, was first described by Bass (1932, p. 53) from exposures in the Kirkpatrick Hill quadrangle about 41 miles (66 km) north of the Lonesome Peak quadrangle.

The Contact coal bed has been mapped locally in the northeastern part of the Lonesome Peak quadrangle, where it is less than 5 feet (1.5 m) thick. For this reason, it has not been assigned economic coal resources.

### Number 12a and 12b coal beds

The Number 12a and Number 12b coal beds, first described by Bryson and Bass (1973, p. 90), crop out at an elevation slightly above the Powder River flood plain. Both beds are less than 5 feet (1.5 m) thick in this quadrangle and have not been assigned economic coal resources.

### Broadus coal bed

The Broadus coal bed, first described by Warren (1959, p. 570), derives its name from exposures in the Epsie NE quadrangle, near the town of Broadus, about 6 miles (10 km) north of the Lonesome Peak quadrangle. The Broadus coal bed is about 20 to 30 feet (6 to 9 m) above the Number 12a coal bed. The Broadus coal bed crops out along the flood plain of the Powder River. It has been burned in places, forming a reddish-brown clinker bed. The isopach map (pl. 17) shows that the Broadus coal ranges from about 4 to 15 feet (1.2 to 4.5 m) in thickness. The structure contour map (pl. 18) indicates that the bed dips generally westward at an angle of less than 1 degree. Overburden on the Broadus coal bed (pl. 19) ranges in thickness from 0 feet at the outcrops to about 700 feet (213 m).

A chemical analysis of the Broadus coal from the Peerless mine, sec. 23, T. 4 S., R. 50 E. about 6 miles (10 km) north of the Lonesome Peak quadrangle in the Epsie NE quadrangle, shows ash 6.4 percent, sulfur 0.2 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 7,735 Btu per pound (17,992 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 Lonesome Peak quadrangle, it is assumed that the Broadus coal in this quadrangle is similar and is also lignite A in rank.

### Number 11 coal bed

The Number 11 coal bed, first described by Bryson and Bass (1973, p. 100), is about 40 to 60 feet (12 to 18 m) above the Broadus coal bed in this quadrangle. Because the Number 11 coal bed is less than 5 feet (1.5 m) thick, economic coal resources have not been assigned to it.

### Number 9c coal bed

The Number 9c coal bed was first described by Warren (1959, pl. 24) as a local bed and later named by Bryson and Bass (1973, p. 91). The Number 9c coal bed crops out locally in the south-central part of the quadrangle where it is less than 5 feet (1.5 m) thick. Because this bed is less than 5 feet (1.5 m) thick in this quadrangle, it has not been assigned economic coal resources.

### Number 9b coal bed

The Number 9b coal bed was first described by Warren (1959, pl. 24) as a local bed, and later named the Number 9b bed by Bryson and Bass (1973, p. 91). The Number 9b coal bed is about 100 to 150 feet (40 to 46 m) above the Broadus coal bed in the Lonesome Peak quadrangle. The isopach and structure contour map (pl. 14) shows that the Number 9b coal bed ranges in thickness from about 4 to 7 feet (1.5 to 2 m) and dips generally to the east at an angle of less than 1

degree. Overburden on the Number 9b coal bed (pl. 15) ranges in thickness from 0 feet at the outcrops to about 500 feet (0-152 m).

There is no known, publicly available chemical analysis of the Number 9b coal in or near the Lonesome Peak quadrangle. Because other coals in this area are lignite A in rank, the Number 9b coal has also been assigned a rank of lignite A.

### Number 9a coal bed

The Number 9a coal bed was first described by Warren (1959, pl. 24) as a local bed and later named by Bryson and Bass (1973, p. 91). The isopach and structure contour map (pl. 11) shows that the Number 9a coal bed ranges in thickness from less than 3 to 8 feet (0.9 to 2.1 m) and dips generally to the north at an angle of less than 1 degree. Overburden on this bed (pl. 12) ranges from 0 feet at the outcrops to about 400 feet (0-122 m) in thickness.

There is no known, publicly available chemical analysis of the Number 9a coal in or near the Lonesome Peak quadrangle. Because other coals in this area are lignite A in rank, the Number 9a coal has also been assigned a rank of lignite A.

### Cache coal bed

The Cache coal bed, first named by Warren (1959, p. 572), derives its name from Cache Creek in the northwestern part of the Lonesome Peak quadrangle. The Cache coal bed is about 50 to 60 feet (15 to 18 m) above the Number 9a coal bed in this quadrangle. The Cache coal bed is marked in places by a clinker bed, formed by the burning of the coal. The isopach map (pl. 7) shows that the Cache coal bed ranges in thickness from less than 4 to 15 feet (1.2 to 4.6 m). The structure contour map (pl. 8) shows that the Cache coal bed dips generally to the southwest at an angle of less than 1 degree. The overburden thickness (pl. 9) ranges from 0 feet at the outcrops to at least 300 feet (0-91 m).

A chemical analysis of the Cache coal from drill hole SH-713, sec. 6, T. 8 S., R. 51 E., from a depth of 103 to 112 feet (31 to 34 m) (Matson and Blumer, 1973, p. 93) located about 6.2 miles (10 km) south of the Lonesome Peak quadrangle in the Baldy Peak quadrangle, shows ash 4.601 percent, sulfur 0.741 percent, and heating value 7,208 Btu per pound (16,766 kJ/kg) on an as-received basis. This heating value converts to about 7,556 Btu per pound (17,575 kJ/kg) on a moist, mineral-matter-free basis, indicating that the Cache coal at that location is lignite A in rank. Because of the proximity of that location to the Lonesome Peak quadrangle, it is assumed that the Cache coal in this quadrangle is similar and is also lignite A in rank.

### Pawnee coal bed

The Pawnee coal bed, first named by Warren (1959, p. 572) is marked by a clinker bed in the Lonesome Peak quadrangle. It is found about 140 feet (43 m) above the Cache coal bed. Economic coal resources have not been assigned to it.

### Number 5 coal bed

The Number 5 coal bed was first described and named by Bryson and Bass (1973, p. 91). In places the coal bed has been burned, forming a clinker bed. The isopach and structure contour map (pl. 4) shows that the Number 5 coal bed ranges in thickness from about 11 to 18 feet (3.4 to 5.6 m) and dips to the northwest at an angle of about 1 degree. Overburden on the Number 5 coal bed (pl. 5) ranges from 0 feet at the outcrops to about 100 feet (0-30 m) in thickness.

There is no known, publicly available chemical analysis of the Number 5 coal in or near the Lonesome Peak quadrangle. Because other closely associated coals in this area are lignite A in rank, it has been assigned a rank of lignite A.

### Upper Cook coal bed

The Upper Cook coal bed is entirely burned in the Lonesome Peak quadrangle. Therefore, no coal resources have been assigned to it.

## 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. 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 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, 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 subbituminous coal 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 173.57 million short tons (157.46 million t). There is no federally owned, surface-minable Hypothetical coal in this quadrangle. As shown by table 2, the total federally owned, underground-minable Reserve Base coal is estimated to be 123.29 million short tons (111.85 million t). The total tonnage of surface- and underground-minable Reserve Base coal is 296.86 million short tons (269.31 million t).

About 16 percent of the surface-minable Reserve Base tonnage is classed as Measured, 55 percent as Indicated, and 29 percent as Inferred. About 2 percent of the underground-minable Reserve Base tonnage is Measured, 27 percent is Indicated, and 71 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 beds of lignite 5 feet (1.5 m) or more thick are overlain by less than 200 feet (61 m) of overburden. This thickness of overburden is the assigned stripping limit for surface mining of lignite in this area. Areas having a

potential for surface mining were assigned a high, moderate, or low development potential based on their mining-ratio values (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. 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 is shown on the CDP map (pl. 21). Approximately 34 percent of the Federal land in this quadrangle has a high development potential for surface-mining of coal because of the Broadus coal bed.

The Broadus coal bed (pl. 19) has limited areas of development potential for surface mining in the northwestern and southeastern parts of the quadrangle. High development potential areas generally run adjacent to the Powder River flood plain on the west and east sides and also include the Cache Creek and Baking Powder Creek flood plains. Areas of high development potential coal (0-10 mining-ratio values) extend from the coal outcrop to the 10 mining-ratio contours. Moderate development potential coal is found in narrow bands between the 10 mining-ratio and the 15 mining-ratio or the 200-foot (61 m) overburden isopach. These bands surround most of the high development potential areas higher up in the valleys of all the smaller streams. On the sides of the valleys, narrow areas of low development potential lie between the 15 mining-ratio contour and the 200-foot (61-m) overburden isopach. There are large areas of no development potential extending from the 200-foot (61 m) overburden isopachs to the crests of the hills.

The Number 9b coal bed (pl. 15) has very limited areas of development potential for surface mining in the north-central part of the quadrangle. Narrow bands of high development potential are found below the lower hill areas, extending from the coal outcrop to the 10 mining-ratio contour. Moderate development potential coal is present in smaller bands surrounding the high development potential areas. Low potential development coal is found near the crests of the hills. There are large areas of no development potential.

The Number 9a coal bed (pl. 15) has very limited and narrow bands of high and moderate development potential for surface mining of the coal in the south-central part of the quadrangle. Low and no development potential areas of coal are found in larger areas on the tops of hills in this area.

The Cache coal bed (pl. 9) has areas of high development potential for surface mining in small bands outlined by moderate development potential on the

hilltops. Low development potential bands, above the moderate potential areas, are also quite limited. Areas of no development potential for surface mining of the Cache coal are the most extensive.

The Number 5 coal bed (pl. 4) has several small outliers in the southern part of the quadrangle. All of these outliers are of high development potential for surface mining.

About 34 percent of the Federal coal lands has a high development potential for surface mining, 10 percent has a moderate development potential, 5 percent has a low development potential, and 51 percent has no development potential.

### 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 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 Lonesome Peak 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 | | | | |
| Number 5 | 1,770,000 | 0 | 0 | 1,770,000 |
| Cache | 8,640,000 | 6,610,000 | 4,800,000 | 20,050,000 |
| Number 9a | 3,070,000 | 1,390,000 | 3,440,000 | 7,900,000 |
| Number 9b | 1,240,000 | 1,340,000 | 2,730,000 | 5,310,000 |
| Broadus | 64,860,000 | 42,880,000 | 30,800,000 | 138,540,000 |
| Total | 79,580,000 | 52,220,000 | 41,770,000 | 173,570,000 |

Table 2.--Underground-minable coal resource tonnage (in short tons) by development-potential category for Federal lands in the Lonesome Peak 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 | | | | |
| Number 5 | 0 | 0 | 0 | 0 |
| Cache | 0 | 0 | 12,130,000 | 12,130,000 |
| Number 9a | 0 | 0 | 2,170,000 | 2,170,000 |
| Number 9b | 0 | 0 | 10,710,000 | 10,710,000 |
| Broadus | 0 | 0 | 98,280,000 | 98,280,000 |
| Total | 0 | 0 | 123,290,000 | 123,290,000 |

## REFERENCES


Bass, N. W., 1932, The Ashland coal field, Rosebud, Powder River, and Custer Counties, Montana: U.S. Geological Survey Bulletin 831-B, p. 19-105.

Bryson, R. P., and Bass, N. W., 1973, Geology of Moorhead coal field, Powder River, Big Horn, and Rosebud Counties, Montana: U.S. Geological Survey Bulletin 1338, 116 p.

Gilmour, E. H., and Dahl, G. G., Jr., 1967, Montana coal analyses: Montana Bureau of Mines and Geology Special Publication 43, 21 p.

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

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. Geological Survey Open-File Report 77-292.

Matson, R. E., and Blumer, J. W., 1973, Quality and reserves of strippable coal, selected deposits, southeastern Montana: Montana Bureau of Mines and Geology Bulletin 91, 135 p.

Matson, R. E., Dahl, G. G., Jr., and Blumer, J. W., 1968, Strippable coal deposits on state land, Powder River County, Montana: Montana Bureau of Mines and Geology Bulletin 69, 81 p.

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. Geological Survey Bulletin 1450-B, 7 p.

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

Warren, W. C., 1959, Reconnaissance geology of the Birney-Broadus coal field, Rosebud and Powder River Counties, Montana: U.S. Geological Survey Bulletin 1072-J, p. 561-585.