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# COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE ROUGH DRAW QUADRANGLE, ROSEBUD COUNTY, MONTANA

[Report includes 22 plates]

By

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This report has not been edited for conformity with U.S. Geological Survey editorial standards or stratigraphic nomenclature.

CONTENTS


| | Page |
|---|---|
| Introduction | 1 |
| Purpose | 1 |
| Location | 1 |
| Accessibility | 1 |
| Physiography | 2 |
| Climate | 3 |
| Land status | 3 |
| General geology | 3 |
| Previous work | 3 |
| Stratigraphy | 4 |
| Structure | 5 |
| Coal geology | 5 |
| Robinson coal bed | 6 |
| Stocker Creek coal bed | 7 |
| McKay coal bed | 7 |
| Rosebud coal bed | 8 |
| Popham coal bed | 9 |
| Sawyer coal bed | 10 |
| Proctor coal bed | 11 |
| Richard coal bed | 11 |
| Local coal beds | 12 |
| Coal resources | 12 |
| Coal development potential | 14 |
| Development potential for surface-mining methods | 15 |
| Development potential for underground mining and in-situ gasification | 18 |
| References | 22 |

## ILLUSTRATIONS

[Plates are in pocket]

Plates 1-21. 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 Sawyer coal bed.
5. Overburden isopach and mining-ratio map of the Sawyer coal bed.
6. Areal distribution and tonnage map of identified resources of the Sawyer coal bed.
7. Isopach and structure contour map of the Popham coal bed.
8. Overburden isopach and mining-ratio map of the Popham coal bed.
9. Areal distribution and tonnage map of identified resources of the Popham coal bed.
10. Isopach map of the Rosebud coal bed and its splits.
11. Structure contour map of the Rosebud coal bed and its splits.
12. Overburden isopach and mining-ratio map of the Rosebud coal bed and the Upper Rosebud split of the Rosebud coal bed.
13. Overburden isopach and mining-ratio map of the Lower Rosebud split of the Rosebud coal bed.

Page

14. Areal distribution and tonnage map of identified and hypothetical resources of the Rosebud coal bed and the Upper Rosebud coal bed.
15. Areal distribution and tonnage map of identified and hypothetical resources of the Lower Rosebud split of the Rosebud coal bed.
16. Isopach and structure contour map of the Stocker Creek coal bed.
17. Overburden isopach and mining-ratio map of the Stocker Creek coal bed.
18. Areal distribution and tonnage map of identified resources of the Stocker Creek coal bed.
19. Isopach and structure contour map of the Robinson coal bed.
20. Overburden isopach and mining-ratio map of the Robinson coal bed.
21. Areal distribution and tonnage map of identified and hypothetical resources of the Robinson coal bed.

Plate 22. Coal development potential map for surface-mining methods.

## TABLES

Table 1. Surface-minable coal resource tonnage by development-potential category for Federal coal lands---------- 20

Table 2. Underground-minable coal resource tonnage by development potential-category for Federal coal lands----- 21

## 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 Rough Draw quadrangle, Rosebud County, Montana, (22 plates; U.S. Geological Survey Open-File Report 79-017). This set of maps was compiled to support the land planning work of the Bureau of Land Management in response to the Federal Coal Leasing Amendments Act of 1976, and to provide a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRAs) in the western United States. Coal beds considered in the resource inventory are only those beds 5 feet (1.5 m) or more thick and under less than 3,000 feet (914 m) of overburden.

## Location

The Rough Draw 7 1/2-minute quadrangle is in west-central Rosebud County, Montana, about 27 miles (43 km) south-southwest of Forsyth, Montana, a town in the Yellowstone River valley about 44 miles (70 km) south-southwest of Miles City and 105 miles (168 km) east of Billings. U.S. Interstate Highway 94 and the main east-west routes of the Chicago, Milwaukee, St. Paul and Pacific Railroad and the Burlington Northern Railroad follow the Yellowstone River and pass through Forsyth. The small town of Colstrip is 6 miles (9.6 km) east of the northeast corner of the quadrangle.

## Accessibility

The graveled East Fork of Armells Creek road passes through the northern part of the quadrangle and provides access from Colstrip. Colstrip

is on paved State Highway 39 about 29 miles (46 km) south of Interstate Highway 94 near Forsyth. The nearest railroad is a spur of the Burlington Northern Railroad which parallels State Highway 39 and connects Colstrip with the main route of the railroad in the Yellowstone valley. The West Fork of Armells Creek road also provides access to the northern part of the quadrangle and intersects State Highway 39 about 17 miles (27 km) north of the quadrangle at a point 12 miles (19 km) south of Interstate Highway 94. A number of unimproved roads and trails provide access to the central and southern parts of the quadrangle.

## Physiography

The Rough Draw quadrangle is within the Missouri Plateau division of the Great Plains physiographic province. The land surface is maturely dissected. The northern part of the quadrangle is drained and dissected by tributaries of Armells Creek and the eastern and southern parts by tributaries of Rosebud Creek. The southwestern part of the quadrangle lies within the rough country composing the Little Wolf Mountains which form the divide between Sarpy Creek on the west and Armells and Rosebud Creeks on the east. The summits of the mountains stand 1,000 to 1,300 feet (305 to 396 m) above the surrounding country, and are capped by a thick clinker bed formed by the burning of an unnamed coal bed. The mountains are rough, heavily timbered, and unsettled. In the eastern part of the quadrangle, the principal tributaries of Rosebud Creek are separated by long, narrow, and level clinker-capped divides, which stand about 250 feet (76 m) above the narrow valley bottoms.

The lowest elevation, about 3,340 feet (1,018 m), is near the southeast corner of the quadrangle. The highest elevation, 4,770 feet (1,454 m), is in the Little Wolf Mountains in the western part of the quadrangle. Topographic relief is 1,430 feet (436 m).

### Climate

The climate of Rosebud 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 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 most of the Rough Draw quadrangle, as shown by the Boundary and Coal Data Map (pl. 2). This map also shows the land ownership status and the two small areas of Federal land which were covered by outstanding Federal coal leases as of 1977.

## GENERAL GEOLOGY

### Previous work

Dobbin (1930) mapped the Rough Draw quadrangle as part of the Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Montana. Kepferle (1954) mapped the Castle Rock strippable deposit, which is in the

northern part of the Rough Draw quadrangle. V. W. Carmichael in 1964 mapped most of the quadrangle as part of the Colstrip coal deposit (in Matson and Blumer, 1973, pl. 14).

## 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 upper member of the Paleocene (Tertiary) Fort Union Formation, the Tongue River Member. This member consists of light-colored sandstone, sandy shale, and important coal beds. The thicker coal beds have burned along the outcrop and have fused the overlying rock into reddish-colored slag or clinker. Dobbin (1930) reports that the Tongue River Member is about 1,700 feet (518 m) thick in the Forsyth coal field, but in the Rough Draw quadrangle, about 1,400 feet (427 m) of the member is exposed.

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 flood plains, sloughs, swamps, and lakes that occupied 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 trace element content by the U.S. Geological Survey and the results 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 rock types found throughout other parts of the

## Structure

The Rough Draw quadrangle is in the northwestern part of the Powder River structural basin. The strata dip southeastward at an angle of less than 1 degree. Structure contours on top of the Sawyer, Popham, Rosebud, Stocker Creek, and Robinson coal beds (pls. 4, 7, 11, 16, and 19) show that the regional dip is in places modified by gentle folding or interrupted by minor faulting.

# COAL GEOLOGY

Eight coal beds are exposed at the surface of the Rough Draw quadrangle, and two lower beds are projected into the subsurface from adjacent quadrangles. All ten coal beds belong to the Tongue River Member of the Fort Union Formation. They are shown in outcrop on the Coal Data Map (pl. 1) and in section on the Coal Data Sheet, plate 3.

The lowermost of the ten beds in the Rough Draw quadrangle is the Robinson coal bed which is about 180 feet (55 m) above the base of the Tongue River Member. The Robinson coal bed is overlain successively by a noncoal interval of about 25 feet (8 m), the Stocker Creek coal bed, a noncoal interval of about 60 feet (18 m), the Rosebud coal bed, a noncoal interval of 150 to 250 feet (46 to 76 m), the Popham coal bed, a noncoal interval of about 50 feet (15 m), the Sawyer coal bed, a noncoal interval of 50 to 90 feet (15 to 27 m), the Proctor coal bed, a noncoal interval of 50 to 100 feet (15 to 30 m), the Richard coal bed, a noncoal interval of about 225 feet (69 m), a thin, local

coal bed, a noncoal interval of 110 to 200 feet (34 to 61 m), another thin, local coal bed, a noncoal interval of about 100 feet (30 m), and the clinker bed that caps the Little Wolf Mountains.

The trace element content of coals in the Rough Draw 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).

### Robinson coal bed

The Robinson coal bed was first described by Dobbin (1930, p. 27) from outcrops on the Robinson Ranch in the Forsyth coal field (McClure Creek quadrangle). There are no outcrop or drill-hole data points of control for the Robinson coal bed in the Rough Draw quadrangle. The thickness of the bed and its attitude are projected into the quadrangle from the west, north, and south. The projected thickness of the Robinson coal bed in the Rough Draw quadrangle ranges from less than 5 feet (1.5 m) to over 7 feet (2.1 m), and the projected dip is eastward or southward less than 1 degree (pl. 19). Overburden on the Robinson coal bed ranges in thickness from about 360 feet (110 m) to about 1,560 feet (475 m), as shown on plate 20. This overburden includes the coal beds which overlie the Robinson coal bed.

There are no known published chemical analyses of the Robinson coal bed. It is assumed that the Robinson coal is similar in rank to associated coal beds in this quadrangle and is subbituminous B.

### Stocker Creek coal bed

The Stocker Creek coal bed was described by Dobbin (1930, p. 27) from outcrops near the head of Stocker Creek in the Forsyth coal field (Colstrip West and Trail Creek School quadrangles). There are no outcrop or drill-hole data points of control for the Stocker Creek coal bed in the Rough Draw quadrangle. The thickness of the bed and its attitude are projected into the quadrangle from the west and north. The projected thickness of the Stocker Creek coal bed in the Rough Draw quadrangle ranges from less than 5 feet (1.5 m) to more than 7 feet (2.1 m), as shown on plate 16. The dip of the bed is eastward or southward less than 1 degree (pl. 16). Overburden on the Stocker Creek coal bed ranges in thickness from about 80 feet (24 m) to about 900 feet (274 m), as shown on plate 17. This overburden includes the coal beds which overlie the Stocker Creek coal bed.

There are no known published chemical analyses of the Stocker Creek coal. It is assumed that the Stocker Creek coal is similar in rank to the associated coals in this quadrangle and is subbituminous B.

### McKay coal bed

The McKay coal bed was first described by Dobbin (1930, p. 27) from exposures on the McKay Ranch (Colstrip East quadrangle) in the Forsyth coal field. Dobbin states that the McKay coal bed may be considered a split of the Rosebud coal bed because the interval between them in several places is less than 7 feet (2.1 m). The outcrop of the McKay coal bed follows very closely that of the Rosebud coal bed, and where the Rosebud coal bed has been burned, the McKay coal bed is usually concealed by the Rosebud clinker.

In the Rough Draw quadrangle, the McKay coal bed does not crop out, nor is it penetrated by coal test holes. The nearest data control points are a considerable distance from the quadrangle. Therefore, the McKay coal bed is not shown on the CRO maps of the Rough Draw quadrangle. If the McKay coal bed does occur in the Rough Draw quadrangle, it is probably less than 5 feet (1.5 m) thick and would not contain economic coal resources.

### Rosebud coal bed

The Rosebud coal bed was described by Dobbin (1930, p. 27) from outcrops along Rosebud Creek in the Forsyth coal field. A specific type locality was not given.

In the Rough Draw quadrangle, the Rosebud coal bed crops out at low elevations in the northeastern part of the quadrangle (pl. 1). In the central part of the quadrangle, the Rosebud coal bed is concealed by higher strata, but has been penetrated in a number of coal test holes. In the northern and central parts of the quadrangle, the coal bed is a single unit and is 5 to 27 feet (1.5 to 8 m) thick (pls. 3 and 10). In the southern part of the quadrangle, the Rosebud coal bed splits into two beds along the line indicated on the isopach map, plate 10, and the two beds are designated Upper Rosebud (Lee) and Lower Rosebud. The Upper Rosebud split, which crops out in the southern part of the quadrangle, ranges from about 4 to 7 feet (1.2 to 2.1 m) in thickness (pl. 10). The Lower Rosebud split does not crop out in the Rough Draw quadrangle but is projected into the subsurface from the quadrangles to the east and south. The Lower Rosebud ranges from about 1 to 9 feet (0.3 to 2.74 m) in thickness (pl. 10). The two splits are separated in places by as

much as 100 feet (30 m) of sandstone and sandy shale. Dobbin (1930) identified the upper split as the Lee coal bed and the lower split as the Rosebud coal bed, but coal test holes drilled since 1930 demonstrate the equivalence of the Lee coal bed and the upper part of the Rosebud coal bed.

The Rosebud coal bed and its equivalents dip southward less than 1 degree, but the regularity of the dip is interrupted by minor local folds (pl. 11). Overburden on the Rosebud coal bed, or the Upper Rosebud coal bed where applicable, ranges in thickness from zero to over 1,400 feet (427 m), as shown on plate 12. The overburden on the Lower Rosebud coal bed, where the bed is more than 5 feet (1.5 m) thick, ranges in thickness from 100 to 320 feet (30 to 97 m), as shown by plate 13. This overburden includes the coal beds which overlie the Rosebud coal bed and its splits.

A chemical analysis of the Rosebud coal from drill hole RB-69, sec. 5, T. 1 N., R. 40 E. in the Rough Draw quadrangle (Matson and Blumer, 1973, p. 79) shows ash 9.34 percent, sulfur 0.95 percent, and a heating value of 8,800 Btu per pound (20,469 kJ/kg) on an as-received basis. This heating value converts to about 9,700 Btu per pound (22,560 kJ/kg) on a moist, mineral-matter-free basis, indicating that the coal is subbituminous B in rank.

### Popham coal bed

The Popham coal bed was first described by Dobbin (1930, p. 28) from exposures in the Rough Draw quadrangle, although an exact type locality was not given. The Popham coal bed crops out in the northern and central parts of the quadrangle where it occurs from 200 to 290 feet (61 to 88 m) above

the Rosebud coal bed (pls. 1 and 3). The thickness of the Popham coal bed ranges from 3 to 5 feet (0.91 to 1.52 m), as shown on plate 7. Structure contours on top of the Popham coal bed (pl. 7) show a general southeastward dip of less than 1 degree. Overburden on the Popham coal bed (pl. 8) ranges in thickness from about 40 to 200 feet (12 to 61 m). This overburden includes the Sawyer coal bed and in places two local, thin coal beds.

There is no known published chemical analysis of the Popham coal bed. It is assumed that the Popham coal is similar in rank to the associated coals in this quadrangle and is subbituminous B.

### Sawyer coal bed

The Sawyer coal bed was described by Dobbin (1930, p. 28) from exposures in the foothills of the Little Wolf Mountains in the Forsyth coal field (Rough Draw and Black Spring quadrangles).

The Sawyer coal bed crops out in a broad zone in the foothills of the Little Wolf Mountains extending from the south border to the northern part of the Rough Draw quadrangle (pl. 1). The thickness of the Sawyer coal ranges from 2.1 to 8.9 feet (0.64 to 2.71 m), as shown by the isopach map, plate 4. Structure contours on top of the Sawyer coal bed show a southward dip of less than 1 degree. This dip is interrupted in the southern part of the quadrangle by a small local anticline (pl. 4). Overburden on the Sawyer coal bed (pl. 5) ranges from zero to about 700 feet (213 m) in thickness.

A chemical analysis of the Sawyer coal from the small abandoned mine in sec. 30, T. 1 N., R. 40 E. in the Rough Draw quadrangle (Gilmour and Dahl, 1967, p. 16) shows ash 6.8 percent, sulfur 1.8 percent, and a

heating value of 8,080 Btu per pound (18,794 kJ/kg). This heating value converts to about 8,670 Btu per pound (20,177 kJ/kg) on a moist, mineral-matter-free basis, indicating that the coal is subbituminous C in rank.

### Proctor coal bed

The Proctor coal bed was first described by Dobbin (1930, p. 28) from outcrops in the Forsyth coal field, probably from the Rough Draw quadrangle, although a type locality was not designated. The Proctor bed is 50 to 90 feet (15 to 27 m) above the Sawyer coal bed. Several measurements in the Rough Draw quadrangle (pls. 1 and 3) indicate that the thickness ranges from 3 to 3.5 feet (0.91 to 1.07 m). Because this thickness is less than the minimum for Reserve Base coal, no maps or calculations of coal resources have been made for the Proctor coal bed.

### Richard coal bed

The Richard coal bed was first described by Dobbin (1930, p. 28) from outcrops in the Forsyth coal field (Rough Draw quadrangle). The Richard coal bed crops out for about 3 miles (4.8 km) on the eastern slopes of the Little Wolf Mountains in the central part of the Rough Draw quadrangle (pl. 1). One outcrop measurement shows a thickness of 6.3 feet (1.9 m); all other measurements are less than 4 feet (1.2 m), as shown on plates 1 and 3. Dobbin (1930, p. 28) describes the Richard coal bed as having an average thickness of 3.5 feet (1.07 m), which is below Reserve Base thickness. No maps or calculations of coal resources have been made for the Richard bed.

### Local coal beds

Two clinker beds formed from the burning of unnamed local coal beds have been mapped on the slopes of the Little Wolf Mountains, but no measurements of the coal thicknesses have been made. The position of their outcrop lines as shown on plate 1 is only approximate. Another prominent clinker bed caps the Little Wolf Mountains. It is assumed that the local, unnamed coal bed which formed this clinker has been entirely burned.

## COAL RESOURCES

Data from all publicly available drill holes and 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 tonnages shown in this report are the Reserve Base (RB) part of the Identified Resources and the Hypothetical (HYP) part of the Undiscovered Resources, as discussed in U.S. Geological Survey Bulletin 1450-B.

The Reserve Base for subbituminous coal is coal that is 5 feet (1.5 m) or more thick, under 3,000 feet (914 m) or less of overburden, and located within 3 miles (4.8 km) of a point of coal-bed measurement. Reserve Base is further subdivided into reliability categories according to their nearness to measurement of the coal bed. Measured coal is coal within 0.25 mile (0.4 km) of a measurement, 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.

Hypothetical Resources are undiscovered coal resources in beds that may reasonably be expected to exist in known mining districts under known geologic conditions. In general, Hypothetical Resources are located in broad areas of coal fields where no points of observation are present, and the evidence for the 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. For purposes of this report, tonnages were calculated for only those Hypothetical coal resources in beds that are estimated to be 5 feet (1.5 m) or more thick and to be under less than 3,000 feet (914 m) of overburden.

Reserves are the recoverable part of the Reserve Base coal. For surface-minable coal in this quadrangle, the coal reserves are considered to be 85 percent (the recovery factor for this area) of that part of the Reserve Base that is beneath 500 feet (152 m) or less of overburden, the stripping limit for multiple, thin (5 to 40 feet or 1.5 to 12 m thick) beds of subbituminous coal in this area.

Estimated resources in the Rough Draw quadrangle were calculated using data obtained from the coal isopach maps (pls. 4, 7, 10, 16, and 19). The coal-bed acreage (measured by planimeter) multiplied by the average

isopached thickness of the coal bed, times a conversion factor of 1,770 short tons of coal per acre-foot (13,028 metric tons per hectare-meter) for subbituminous coal yields the coal resources in short tons of coal for each isopached coal bed. Reserve Base and Reserve tonnage values for the Sawyer, Popham, Rosebud, Stocker Creek, and Robinson coal beds are shown on plates 6, 9, 14, 15, 18, and 21, and are rounded to the nearest one-hundredth of a million short tons.

The total Reserve Base tonnage of federally owned, surface- and underground-minable coal in the Rough Draw quadrangle is estimated to be 509.54 million short tons (462.03 million t). The total Hypothetical tonnage of surface- and underground-minable coal is estimated to be 116.72 million short tons (105.87 million t). The Reserve Base and Hypothetical tonnage totals per section are shown in the northwest corner of each section of CRO plate 2 and by development-potential category in tables 1 and 2. All numbers are rounded to the nearest one-hundredth of a million short tons. About 12 percent of the Reserve Base tonnage is classed as Measured, 39 percent as Indicated, and 49 percent as Inferred.

## COAL DEVELOPMENT POTENTIAL

Areas where coal beds are 5 feet (1.5 m) or more thick and are overlain by 500 feet (152 m) or less of overburden are considered to have potential for surface mining and were assigned a high, moderate, or low development potential based on the mining ratio (cubic yards of overburden per short ton of recoverable coal). The formula used to calculate mining-ratio values for subbituminous coal is as follows:

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

where MR = mining ratio

$t_o$ = thickness of overburden

$t_c$ = thickness of coal

rf = recovery factor = 0.85

0.911 = conversion factor (cu. yds./ton)

Areas of high, moderate, and low development potential are here defined as areas underlain by coal beds having respective mining-ratio values of 0 to 10, 10 to 15, and greater than 15, as shown on CRO maps, plates 5, 8, 12, 13, 17, and 20 for the Sawyer, Popham, Rosebud and Upper Rosebud, Lower Rosebud, Stocker Creek, and Robinson coal beds, respectively. These mining-ratio values for each development-potential category are based on economic and technological criteria and were provided by the U.S. Geological Survey. Estimated tonnages in each development-potential category (high, moderate, and low) of both Reserve Base and Hypothetical coal, for surface mining are shown in table 1. Estimated tonnages for underground mining are shown in a like manner in table 2.

Development potential for surface-mining methods

The Coal Development Potential (CDP) map included in this series of maps (pl. 22) 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). 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, etc.

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, due to the 40-acre (16.2-ha) minimum size of coal development-potential tracts, the narrow band of moderate development-potential area often is absorbed into the 40-acre (16.2-ha) tracts of high development-potential category. 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 (less than 500 feet or 152 m of overburden) is shown on the CDP map (pl. 22). In the eastern part of the quadrangle, most of the Federal coal lands have a high development potential for surface mining; a few tracts have a moderate or low development potential. In the western part of the quadrangle, most of the Federal coal lands have a moderate or low development potential, and many tracts have no development potential. The development-potential categories are determined mainly by the mining ratios of the Rosebud coal bed and its splits (pls. 12 and 13) and to a lesser extent by the mining ratios of the overlying Popham (pl. 8) and Sawyer (pl. 5) coal beds.

In the eastern part of the quadrangle at lower elevations, there are wide areas where the mining-ratio values for the Rosebud coal bed and its splits are less than 10, and the development potential for surface mining is therefore high (pls. 12 and 13). Farther west, in the central part of the quadrangle, the mining ratios for the Rosebud coal bed are above 10 or above

15, so the development potential for surface mining for Rosebud coal is moderate or low. Still farther west, near the west margin of the quadrangle, the overburden is thicker than the stripping limit of 500 feet (152 m), and the Rosebud coal therefore has no development potential for surface mining.

The Popham coal bed, which is about 150 to 200 feet (46 to 76 m) above the Rosebud coal bed, has only a small area of Reserve Base coal in the east-central part of the quadrangle. This coal imparts a high development potential to small tracts of Federal coal land (pl. 8).

The Sawyer coal bed, about 50 feet (15 m) above the Popham coal bed, has Reserve Base coal in a considerable area in the south-central part of the quadrangle (pl. 5). Narrow bands of high development potential (mining-ratio values 0 to 10) and of moderate development potential (mining-ratio values 10 to 15) are present above the outcrops along stream valleys. Farther west where the overburden is thicker the Sawyer coal underlies a wide area of low development potential (mining-ratio values greater than 15).

The Stocker Creek coal bed, which is about 60 feet (18 m) below the Rosebud coal, has Reserve Base coal in the northern and eastern parts of the quadrangle (pl. 17), but this coal has only small areas of high and moderate development potential near the northeast corner of the quadrangle. Most of the Stocker Creek coal has a low development potential, and some in the northwest quarter of the quadrangle has no development potential because it is below the stripping limit of 500 feet (152 m).

The Robinson coal bed, which is about 25 feet (7.6 m) below the Stocker Creek coal bed, is more than 5 feet (1.5 m) thick in the western part

of the quadrangle (pl. 20). However, because of its depth below the surface, the Robinson coal bed has no development potential for surface mining except near the south border of the quadrangle, where it has a low development potential.

Approximately 48 percent of the Federal coal lands in the quadrangle has a high development potential for surface mining. These lands of high development potential are located in the eastern part of the quadrangle, where the superimposed Robinson, Stocker Creek, Rosebud, Popham, and Sawyer coal beds are at moderate depths. Federal coal lands in the central part of the quadrangle have a moderate development potential (10 percent) or a low development potential (18 percent) because the coal beds are at greater depths. Twenty-four percent of the Federal coal lands located in the western part of the quadrangle have no development potential because the coals are below the stripping limit of 500 feet (152 m).

### Development potential for underground mining and in-situ gasification

The tonnage of identified (Reserve Base) coal resources and Hypothetical coal resources for each coal bed lying below the stripping limit of 500 feet (152 m) is shown in table 2. 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 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.

Table 1.--Surface-minable coal resource tonnage by development-potential category for Federal coal lands (in short tons) in the Rough Draw quadrangle, Rosebud 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 | | | | |
| Sawyer | 10,040,000 | 2,940,000 | 13,600,000 | 26,580,000 |
| Popham | 2,930,000 | 1,500,000 | 30,000 | 4,460,000 |
| Rosebud and its upper split | 99,350,000 | 76,240,000 | 131,730,000 | 307,320,000 |
| Lower Rosebud | 0 | 270,000 | 3,000,000 | 3,270,000 |
| Stocker Creek | 1,490,000 | 4,180,000 | 33,020,000 | 38,690,000 |
| Robinson | 0 | 0 | 9,610,000 | 9,610,000 |
| Total | 113,810,000 | 85,130,000 | 190,990,000 | 389,930,000 |
| Hypothetical Resource tonnage | | | | |
| Rosebud and its upper split | 0 | 0 | 6,220,000 | 6,220,000 |
| Lower Rosebud | 0 | 0 | 7,660,000 | 7,660,000 |
| Robinson | 0 | 0 | 6,840,000 | 6,840,000 |
| Total | 0 | 0 | 20,720,000 | 20,720,000 |
| Grand Total | 113,810,000 | 85,130,000 | 211,710,000 | 410,650,000 |

Table 2. --Underground-minable coal resource tonnage by development-potential category for Federal coal lands (in short tons) in the Rough Draw quadrangle, Rosebud 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 | | | | |
| Rosebud and its upper split | 0 | 0 | 92,250,000 | 92,250,000 |
| Stocker Creek | 0 | 0 | 2,410,000 | 2,410,000 |
| Robinson | 0 | 0 | 24,950,000 | 24,950,000 |
| Total | 0 | 0 | 119,610,000 | 119,610,000 |
| Hypothetical Resource tonnage | | | | |
| Rosebud and its upper split | 0 | 0 | 51,630,000 | 51,630,000 |
| Lower Rosebud | 0 | 0 | 10,000 | 10,000 |
| Robinson | 0 | 0 | 44,360,000 | 44,360,000 |
| Total | 0 | 0 | 96,000,000 | 96,000,000 |
| Grand Total | 0 | 0 | 215,610,000 | 215,610,000 |

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