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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE SLIDE MOUNTAIN QUADRANGLE, ROUTT AND MOFFAT COUNTY, COLORADO

[Report includes 7 plates]

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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INTRODUCTION

Purpose

This text is to be used in conjunction with Coal Resource Occurrence and Coal Development Potential Maps of the Slide Mountain quadrangle, Routt and Moffat Counties, Colorado. This report was compiled to support the land planning work of the Bureau of Land Management (BLM) and to provide a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA's) in the western United States. This investigation was undertaken by Dames & Moore, Denver, Colorado, at the request of the United States Geological Survey under contract number 14-08-0001-15789. The resource information gathered for this report is in response to the Federal Coal Leasing Amendments Act of 1976 (P.L. 94-377). Published and unpublished public information was used as the data base for this study. No new drilling or field mapping was performed as part of this study, nor was any confidential data used.

Location

The Slide Mountain quadrangle is located in northwestern Colorado on the county line between eastern Routt County and western Moffat County. The quadrangle is 11 miles (18 km) north of the town of Hayden via an improved light-duty road and approximately 24 airline miles (39 km) northwest of the town of Steamboat Springs. With the exception of a few ranches, the area within the quadrangle is unpopulated.

Accessibility

Colorado Highway 13 (also called Colorado Highway 789) passes in a north-south direction approximately 8 miles (13 km) west of the quadrangle and is the closest major highway to the quadrangle. The southern part of the quadrangle is accessible from Hayden by an improved light-duty road. Another improved light-duty road provides access to the southern part of the quadrangle from Colorado Highway 13. The remainder of the quadrangle is served by numerous unimproved dirt roads and trails.

The nearest railway service to the quadrangle is located in Craig, approximately 11 miles (18 km) southwest of the quadrangle. This railway service is provided by the Denver and Rio Grande Railroad and is the major transportation route for coal shipped east from northwestern Colorado.

Physiography

The Slide Mountain quadrangle lies in the southern part of the Wyoming Basin physiographic province as defined by Howard and Williams (1972). The quadrangle is approximately 30 miles (48 km) west of the Continental Divide.

The landscape within the quadrangle is characterized by mountainous terrain. Steep slopes and narrow stream valleys dominate the northern three quarters of the quadrangle, while gentle slopes and wider stream valleys are more pronounced in the southern quarter of the quadrangle. Altitudes in the quadrangle range from approximately 6,520 feet (1,987 m), in the southeastern corner on the Elkhead Creek floodplain, to 9,400 feet (2,865 m) near the northwestern corner of the quadrangle.

In general, the western half of the Slide Mountain quadrangle is drained by Dry Fork Little Bear Creek that joins Fortification Creek to the west in the McInturf Mesa quadrangle. The eastern half of the Slide Mountain quadrangle is drained by Elkhead Creek and its tributary, North Fork. These major creeks flow in a south-southwestern direction and are fed by numerous intermittent streams that comprise a dentritic drainage pattern.

Climate and Vegetation

The climate of northwestern Colorado is semiarid. Clear, sunny days prevail with large daily temperature variations in the Slide Mountain area. Daily temperatures vary from 0° to 35° F (-18° to 2° C) in January to 42° to 80° F (6° to 27° C) in July. Annual precipitation in the area averages approximately 20 inches (51 cm), most of which occurs as snowfall during the winter months. However, rainfall from thundershowers during the spring and summer months also contributes to the total. Winds averaging 3 miles (5 km) per hour are generally from the west but tend to vary greatly depending on the local terrain (U.S. Bureau of Land Management, 1977).

Mountain shrubs are the predominant vegetation at higher altitudes in the quadrangle, although in some areas pinyon and juniper forests are dominant. In the stream valleys and lower altitudes, sagebrugh is the dominant vegetation (U.S. Bureau of Land Management, 1977).

Land Status

The Slide Mountain quadrangle lies on the north-central boundary of the Yampa Known Recoverable Coal Resource Area (KRCRA). Approximately one eighth of the quadrangle lies within the KRCRA boundary, and the Federal government owns the coal rights for approximately 50 percent of that area. One active coal lease is located within the KRCRA boundary in this quadrangle and is shown on plate 2.

GENERAL GEOLOGY

Previous Work

The first geologic description of the general area in which the Slide Mountain quadrangle is located was reported by Emmons (1877) as part of a Survey of the Fortieth Parallel. The decision to build a railroad into the region stimulated several investigations of coal between 1886 and 1905, including papers by Hewett (1889), Hills (1893), and Storrs (1902). Fenneman and Gale (1906) described the geology of the Yampa Coal Field, including a description of the geology and coal occurrence in most of the Slide Mountain quadrangle. In 1955, Bass and others expanded Fenneman and Gale's work in their report on the geology and mineral fuels of parts of Routt and Moffat Counties, and this is the most comprehensive work available on the area. In 1976, Tweto compiled a generalized regional geologic map which included this quadrangle.

Stratigraphy

The rocks exposed in the Slide Mountain quadrangle range in age from Late Cretaceous to Eocene and include the Lewis Shale, Fox Hills Sandstone, Lance, Fort Union and Wasatch Formations. Only the Lance and Fort Union Formations are known to contain coal in this quadrangle.

The Late Cretaceous-age Lewis Shale crops out in the southeastern corner of the quadrangle and has been identified in oil and gas test holes located in SE 1/4 SW 1/4, sec. 35, T. 9 N., R. 89 W., and SW 1/4 SW 1/4, sec. 22, T. 8 N., 89 W., in the western half of the quadrangle. The Lewis Shale consists of dark-gray to bluish homogeneous shale and is interbedded with fine-grained cross-bedded sandstone near the top of the formation (Bass and others, 1955). This formation is approximately 2,440 feet (744 m) thick as indicated from the geophysical logs of the oil and test wells.

Bass and others (1955) did not map the Fox Hills Sandstone as a separate rock unit in this quadrangle, but they did identify fossils in the sandstone at the top of the Lewis Shale as being of "Fox Hills age". Based on the geophysical logs from the oil and gas test holes in this quadrangle, these sandstone beds are correlative with the Fox Hills Sandstone as identified in other drill hole logs in the quadrangles to the west. Therefore, the sandstone beds at the top of the Lewis Shale have been designated as the Fox Hills Sandstone in this quadrangle as shown on plate 3. In general, the Fox Hills Sandstone is composed of grayish-brown fine-grained thin-bedded to massive sandstone with thin lenses of gray sandy shale (Dorf, 1938), and is approximately 290 feet (88 m) thick as indicated from the geophysical logs of the oil and gas test wells.

The Lance Formation of Late Cretaceous age conformably overlies and intertongues with the Fox Hills Sandstone (Haun, 1961). This formation crops out in a band 3 miles (4.8 km) wide trending northeast across the eastern part of the quadrangle. It consists of white to gray ledge-forming sandstone with thin shale and coal lenses, and tan to buff-colored fine-grained sandstone interbedded with gray shale (Bass and others, 1955). Oil and gas wells drilled in this quadrangle indicate that the formation ranges in thickness from approximately 960 to 1,060 feet (293 to 323 m).

The Fort Union Formation of Paleocene age unconformably overlies the Lance Formation and crops out in the western third of the quadrangle. Approximately 780 feet (238 m) of this formation has been penetrated by drill holes in this quadrangle; however, Bass and others

(1955) report that the Fort Union Formation may be as thick as 1,200 feet (366 m). This formation consists of interbedded medium- to coarse-grained massive brown sandstone, gray shale, and coal beds, including the Seymour coal bed (Bass and others, 1955). An arkosic conglomerate occurs at the base of the formation above the unconformity.

The Wasatch Formation of Eocene age unconformably overlies the Fort Union Formation and crops out in the northern third of the quadrangle. It consists of varicolored shale interbedded with brown coarse-grained, thin-bedded sandstone (Bass and others, 1955). The thickness of this formation could not be determined from available drill-hole data or literature. The thickness shown on Plate 3 is approximate and is used solely for descriptive purposes.

Recent deposits of alluvium cover the stream valleys within the quadrangle.

The Cretaceous sedimentary rocks in the Slide Mountain quadrangle accumulated close to the western edge of a Late Cretaceous epeirogenic seaway which covered part of the western interior of North America. Several transgressive-regressive cycles caused the deposition of a series of marine, near-shore marine, and non-marine sediments in the Slide Mountain area.

Deposition of the Lewis Shale marked a landward movement of the sea. The marine sediments of the Lewis Shale were deposited in water depths ranging from a few tens of feet to several hundred feet. Deposition of the Lewis Shale ended in the quadrangle with the regression of the sea.

The Fox Hills Sandstone repesents a transitional depositional environment between the deeper-water marine environment of the Lewis Shale and the lagoonal and continental environments of the Lance Formation. Deposition of the Fox Hills Sandstone sediments occurred in shallow marine barrier bar, beach, estuarine, and tidal channel environments.

Regional uplift west of the Yampa Basin area resulted in a regression of the Cretaceous sea and the close of Cretaceous time in the Slide Mountain Mesa quadrangle. The carbonaceous shale, mudstone, and coal beds of the Lance Formation were deposited in broad areas of estuarine, marsh, lagoonal, and coastal swamp environments.

After the final withdrawal of the Cretaceous sea, thick sections of detrital material, eroded from older deposits, were deposited as the coarse conglomerate and sandstone in the Fort Union Formation. The sandstone, shale, and coal of the Fort Union Formation were deposited in stream, lake, and swamp environments.

Depositional environments fluctuated between fluvial and lacustrine during the Eocene; however, the varicolored shale and brown sandstone of the Wasatch Formation are predominately fluvial deposits (Picard and McGrew, 1955).

The Seymour coal bed, which has wide areal extent in the Slide Mountain quadrangle, was deposited near the seaward margins of the non-marine environments, probably in large brackish-water lagoons or swamps. The slow migration of this depositional environment is responsible for the wide distribution of this coal bed. The remaining coal beds identified in this quadrangle are of limited areal extent and were generally deposited in environments associated with fluvial systems, such as back-levee and coastal-plain swamps, interchannel basin areas, and abandoned channels.

Structure

The Yampa KRCRA lies in the southern extension of the Washakie/Sand Wash structural basin of south-central Wyoming. The basin is bordered on the east by the Park Range, approximately 20 miles (32 km) northeast of the Slide Mountain quadrangle, and on the southwest by the Axial Basin Anticline, approximately 31 miles (50 km) southwest of the quadrangle.

The structure contour map of the Seymour coal bed (plate 4) is based on a regional structure map of the top of the Trout Creek Sandstone

Member constructed by Bass and others (1955). It is assumed that the attitude of the coal beds within the quadrangle duplicate that of the Trout Creek Sandstone Member. Minor modifications to this structure were made where necessary to accomodate outcrop and drill-hole data.

COAL GEOLOGY

Several coal beds have been identified in the Lance and Fort Union Formations within the Slide Mountain quadrangle. The coal beds in the Lance Formation are characteristically thin and lenticular, and are less than Reserve Base thickness (5 feet or 1.5 meters). Southwest of this quadrangle, Lance Formation coal beds remain lenticular and become slightly thicker, occasionally exceeding Reserve Base thickness. To the south in the Rock Spring Gulch and Ralph White Lake quadrangles, the Kimberly and Lorella coal beds of the Lance Formation exceed Reserve Base thickness and extend over a relatively wide area. In the Fort Union Formation, the Seymour coal bed and several unnamed thin lenticular coal beds have been identified, but only the Seymour coal bed exceeds Reserve Base thickness. In general, coal beds in the Fort Union Formation become more numerous and thicker to the west. In the Lay and Lay SE quadrangles several Fort Union coal beds exceed Reserve Base thickness and are continuous over a wide area. South of the Slide Mountain quadrangle, the Fort Union coal beds continue to be thin and very lenticular.

Chemical analyses of coal.--Chemical analyses are not available for the Seymour coal bed in the Slide Mountain quadrangle. However, four analyses from the Seymour coal bed in the McInturf Mesa quadrangle to the west (Fieldner and others, 1937, and Bass and others, 1955) indicate that the coal ranges from subbituminous B to subbituminous A in rank on a moist, mineral-matter-free basis (American Society for Testing and Materials, 1977). The analyses for the Seymour coal bed are listed in table 1.

Fort Union Formation Coal Beds

Coal beds of the Fort Union Formation crop out in the southwestern corner of the quadrangle (plate 1). The Seymour coal bed is the only major coal bed identified in the formation although many thin unnamed coals are also present.

Seymour Coal Bed

The Seymour coal bed lies approximately 940 feet (287 m) above the base of the Fort Union Formation. Cumulative coal thickness ranges from 0.6 to 13.8 feet (0.2 to 4.2 m) in this quadrangle. Numerous small partings are common in this coal bed and attain a maximum cumulative thickness of 4.3 feet (1.3 m) in sec. 15, T. 8 N., R. 89 W. The partings thin to the west and are absent from most measurements recorded in the adjacent McInturf Mesa quadrangle where the coal bed reaches a maximum thickness of 17.7 feet (5.4 m) in sec. 17, T. 8 N., R. 89 W. In general, the Seymour coal bed thins to the south and southwest of the Slide Mountain quadrangle and thickens to the west. Dips average 2° to the east-southeast as calculated from plate 4.

COAL RESOURCES

Information from surface mapping by Bass and others (1955) was used to construct outcrop, isopach, and structure contour maps of the Seymour coal bed in this quadrangle.

Coal resources were calculated using data obtained from the coal isopach map (plate 4) and the areal distribution and identified resources (ADIR) map (plate 6). The coal-bed acreage (measured by planimeter), multiplied by the average thickness of the coal bed and by a conversion factor of 1,770 short tons of coal per acre-foot (13,018 metric tons per hectare-meter) for subbituminous coal yields the coal resources in short tons (metric tons) of coal for each isopached coal bed.

Reserve Base and Reserve tonnages for the Seymour coal bed are shown on plate 6, and are rounded to the nearest 10,000 short tons (9,072 metric tons). Reserve Base and Reserve tonnages are calculated for coal beds thicker than 5.0 feet (1.5 m) that lie less than 3,000 feet (914 m) below the ground surface. These criteria differ from those stated in U.S. Geological Survey Bulletin 1450-B which calls for a maximum depth of 1,000 feet (305 m) for subbituminous coal.

Coal Reserve Base tonnages per Federal section are shown on plate 2 and total approximately 470 thousand short tons (426 thousand metric tons) for the entire quadrangle. Reserve Base tonnages in the various development potential categories for surface mining methods are shown in table 2. The source of each indexed data point used on plate 1 is listed in table 3.

Dames & Moore has not made any determination of economic recoverability for any of the coal beds described in this report.

COAL DEVELOPMENT POTENTIAL

Coal development potential areas are drawn to coincide with the boundaries of the smallest legal land subdivisions shown on plate 2. In sections or parts of sections where no land subdivisions have been surveyed by the BLM, approximate 40-acre (16-ha) parcels have been used to show the limits of the high, moderate, or low development potentials. A constraint imposed by the BLM specifies that the highest development potential affecting any part of a 40-acre (16-ha) lot, tract, or parcel be applied to that entire lot, tract, or parcel. For example, if 5 acres (2 ha) within a parcel meet criteria for a high development potential, 25 acres (10 ha) a moderate development potential, and 10 acres (4 ha) a low development potential, then the entire 40 acres (16 ha) are assigned a high development potential.

Development Potential for Surface Mining Methods

Areas where coal beds of Reserve Base thickness are overlain by 200 feet (61 m) or less of overburden were considered to have potential for surface mining and can be assigned a high, moderate, or low development potential based on the mining ratio (cubic yards of overburden per ton of recoverable coal). The formula used to calculate mining ratios for surface mining of coal is shown on the following page:

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

where MR = mining ratio

t_o = thickness of overburden in feet

t_c = thickness of coal in feet

rf = recovery factor (85 percent for this quadrangle)

cf = conversion factor to yield MR value in terms of cubic yards of overburden per short tons of recoverable coal:
0.911 for subbituminous coal
0.896 for bituminous coal

Note: To convert mining ratio to cubic meters of overburden per metric ton of recoverable coal, multiply MR by 0.8428.

Areas of high, moderate, and low development potential for surface mining methods are defined as areas underlain by coal beds having respective mining-ratio values of 0 to 10, 10 to 15, and greater than 15. These mining-ratio values for each development potential category are based on economic and technological criteria and were provided by the U.S. Geological Survey.

Unknown development potentials have been assigned to those areas where coal data is absent or extremely limited.

The coal development potential for surface mining methods is shown on plate 7. Of those Federal land areas having a known development potential for surface mining methods, 60 percent are rated high and 40 percent are rated low. The remaining Federal lands within the KRCRA boundary are classified as having unknown development potential for surface mining methods.

Development Potential for Subsurface and In-Situ Mining Methods

Areas considered to have a development potential for conventional subsurface mining methods include those areas where coal beds of Reserve Base thickness are between 200 and 3,000 feet (61 and 914 m) below the ground surface and have dips of 15° or less. Coal beds lying between 200 and 3,000 feet (61 and 914 m) below the ground surface, dipping greater than 15°, are considered to have a development potential for in-situ mining methods.

Areas of high, moderate, and low development potential for subsurface mining methods are defined as areas underlain by coal beds at depths ranging from 200 to 1,000 feet (61 to 305 m), 1,000 to 2,000 feet (305 to 610 m), and 2,000 to 3,000 feet (610 to 914 m), respectively. Areas where the coal data is absent or extremely limited between 200 and 3,000 feet (61 and 914 m) below the ground surface are assigned unknown development potentials.

Because there are no known coal beds within the KRCRA boundary that are greater than Reserve Base thickness and lie at depths between 200 and 3,000 feet (61 and 914 m) below the ground surface, all Federal land within the KRCRA has been classified as having unknown development potential for conventional subsurface mining methods.

Because the coal beds in this quadrangle have dips less than 15°, all Federal land areas within the KRCRA have been rated as having an unknown development potential for in-situ mining methods.

Table 1 - Chemical analyses of coals in the Slide Mountain quadrangle, Routt and Moffat Counties, Colorado.

Location	COAL BED NAME	Form of Analysis	Proximate				Ultimate						Heating Value	
			Moisture	Volatile Matter	Fixed Carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen		Calories	Btu/Lb
NE¼ SE¼ sec. 18, T. 8 N., R. 89 W., Little Bear (Richards) Mine, McInturf Mesa quadrangle (Fieldner and others, 1937)	Seymour bed	A	19.4	31.8	43.6	5.2	0.2	--	--	--	--		5,378	9,680
		B	--	39.4	54.2	6.4	0.2	--	--	--	--		6,672	12,010
SE¼ sec. 17, T. 8 N., R. 89 W., Seymour Mine, McInturf Mesa quadrangle (Bass and others, 1955)	Seymour bed	A	17.9	33.4	44.4	4.3	0.2	--	--	--	--		5,540	9,970
		B	14.9	34.7	46.0	4.4	0.2	--	--	--	--		5,744	10,340
		C	--	40.7	54.1	5.2	0.3	--	--	--	--		6,745	12,140
SW¼ sec. 18, T. 8 N., R. 89 W., Bridges Mine, McInturf Mesa quadrangle (Bass and others, 1955)	Seymour bed	A	18.4	31.2	46.5	3.9	0.2	--	--	--	--		5,560	10,010
		B	15.4	32.3	48.3	4.0	0.3	--	--	--	--		5,760	10,370
		C	--	38.2	57.1	4.7	0.3	--	--	--	--		6,810	12,260
SE¼ sec. 17, T. 8 N., R. 89 W., Star Mine, McInturf Mesa quadrangle (Bass and others, 1955)	Seymour bed	A	17.1	32.2	42.9	7.8	0.4	--	--	--	--		5,360	9,650
		B	14.7	33.1	44.2	8.0	0.4	--	--	--	--		5,510	9,920
		C	--	38.8	51.8	9.4	0.4	--	--	--	--		6,460	11,630

Form of Analysis: A, as received
B, air dried
C, moisture free

Note: To convert Btu/pound to kilojoules/kilogram, multiply by 2.326

Table 2 - Coal Reserve Base data for surface mining methods for Federal coal lands (in short tons) in the Slide Mountain quadrangle, Moffat and Routt Counties, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Seymour	220,000	150,000	100,000	--	470,000
TOTALS	220,000	150,000	100,000	--	470,000

Note: To convert short tons to metric tons, multiply by 0.9072.

Table 3. -- Sources of data used on plate 1

Plate 1 Index Number	Source	Data Base
1	U.S. Geological Survey, 1966, Inactive Coal Prospecting Permit No. Colorado 0125989, Peabody Coal Co.	Measured Section
2	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 24	Measured Section No. 343
3		Measured Section No. 344
4		Measured Section No. 345
5		Measured Section No. 346
6		Measured Section No. 347
7		Measured Section No. 348
8		Measured Section No. 350
9		Measured Section No. 349
10		Measured Section No. 368
11	Forest Oil Corp.	Oil/gas well No. Pana K No. 22-1
12	Murfin & Sutton	Oil/gas well No. 1 Gov't.

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