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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE ROCK SPRING GULCH QUADRANGLE, ROUTT AND MOFFAT COUNTIES, COLORADO

[Report includes 8 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 Rock Spring Gulch 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 Published and unpublished public information available through March, 1979, was used as the data base for this study.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 Rock Spring Gulch quadrangle is located in northwestern Colorado, approximately 10 airline miles (16 km) east of the town of Craig and approximately 21 airline miles (34 km) west of the town of Steamboat Springs, Colorado. The town of Hayden lies approximately 0.4 miles (0.6 km) south of the quadrangle boundary. The west-central edge and northwestern corner of the Rock Spring Gulch quadrangle are in eastern Moffat County, while the remainder of the quadrangle is located in western Routt County. With the exception of a few ranches, the area within the quadrangle is unpopulated.

Accessibility

South of the quadrangle boundary, U.S. Highway 40 passes through Hayden connecting Craig to the west with Steamboat Springs to the east. An improved light-duty road crosses the quadrangle from north to south following Long Gulch, Corral Gulch, and Coal Bank Gulch, and connects with U.S. Highway 40 at Hayden. Branches of this road follow Rock

Spring Gulch and Elkhead Creek northwest and northeast, respectively. Numerous unimproved dirt roads and trails provide access for the remainder of the quadrangle.

Railway service for the Rock Spring Gulch quadrangle is provided by the Denver and Rio Grande Western Railroad from Denver to the railhead at Craig. The rail line follows U.S. Highway 40, passing through the southwestern corner of the quadrangle and then paralleling the quadrangle boundary approximately 0.5 miles (0.8 km) south of the quadrangle. The rail line is the major transportation route for coal shipped east from northwestern Colorado (U.S. Bureau of Land Management, 1977).

Physiography

The Rock Spring Gulch quadrangle lies in the southern part of the Wyoming Basin physiographic province as defined by Howard and Williams (1972). The quadrangle is located approximately 5 miles (8 km) north of the Williams Fork Mountains and 30 miles (48 km) west of the Continental Divide.

The landscape within the quadrangle is characterized by north-northwest-trending ridges and gulches through the central part of the quadrangle. These drop off sharply into the Yampa River valley along the southern border of the quadrangle.

Approximately 1,200 feet (366 m) of relief is present in the Rock Spring Gulch quadrangle. Altitudes range from approximately 7,480 feet (2,280 m) on the ridge northeast of Jimmy Dunn Gulch along the east-central edge of the quadrangle to approximately 6,280 feet (1,914 m) in the Yampa River valley in the southwestern corner.

The Yampa River flows southwest across the southeastern corner of the quadrangle. Elkhead Creek and its numerous tributaries drain the northern three fourths of the quadrangle and empties into the Yampa River approximately 15 miles (24 km) west of the quadrangle. With the exception of the Yampa River and Elkhead Creek, streams throughout the quadrangle are intermittent and flow mainly in response to snowmelt in the spring.

Climate and Vegetation

The climate of northwestern Colorado is semiarid. Clear, sunny days prevail in the Rock Spring Gulch area, with daily temperatures typically varying from 0° to 35° F (-18° to 2° C) in January and from 42° to 80° F (6° to 27° C) in July. Annual precipitation in the area averages approximately 16 inches (41 cm). Snowfall during the winter months accounts for the major part of the precipitation, but rainfall from thundershowers during the summer months also contributes to the total. Winds averaging 3 miles per hour (4.8 km per hour) are generally from the west, but wind directions and velocities vary greatly, depending on the local terrain (U.S. Bureau of Land Management, 1977).

Mountain shrubs (including serviceberry, Gambel oak, and rabbitbrush), ranging from 2 to 8 feet (0.6 to 2.4 m) in height, are the characteristic vegetation in the eastern and northeastern parts of the quadrangle. In areas of lower elevation throughout the remainder of the quadrangle, the typical vegetation consists of sagebrush. Areas suitable for agriculture occur in the southeastern corner of the quadrangle in the Yampa River valley (U.S. Bureau of Land Management, 1977).

Land Status

The Rock Spring Gulch quadrangle lies in the north-central part of the Yampa Known Recoverable Coal Resource Area (KRCRA). The northwestern, southeastern, and southwestern corners of the quadrangle lie within the KRCRA boundary, and the Federal government owns the coal rights for approximately 45 percent of this area as shown on plate 2. No active coal leases are present in the quadrangle.

GENERAL GEOLOGY

Previous Work

The first geologic description of the general area in which the Rock Spring Gulch 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 Chisholm (1887), Hewett (1889), Hills (1893), Storrs (1902), and Parsons and Liddell (1903). Fenneman and Gale (1906) described the geology of the Yampa coal field, including a description of the geology and coal occurrence in the eastern part of the Rock Spring Gulch quadrangle. Bass and others (1955) expanded Fenneman and Gale's work in their comprehensive report on the geology and mineral fuels of parts of Routt and Moffat Counties. Tweto (1976) compiled a generalized regional geologic map of northwestern Colorado that includes this quadrangle.

Stratigraphy

Formations cropping out in the Rock Spring Gulch quadrangle include the Lewis Shale and Lance Formation, both of Late Cretaceous age, and the Fort Union Formation of Paleocene age. Only the Lance Formation is known to contain coal in this quadrangle.

The Lewis Shale crops out in the northeastern and southeastern corners of the quadrangle and is composed of dark-gray to bluish marine shale (Bass and others, 1955). The Lewis Shale is approximately 2,695 feet (821 m) thick where measured in the Sunray Mid-Continent and Richfield Oil Corporation well drilled in the east-central part of the quadrangle.

Bass and others (1955) did not map the Fox Hills Sandstone as a separate rock unit in this quadrangle, but have indicated that fossils of Fox Hills age are at the top of the basal sandstone sequence in the Lance Formation. Based on the geophysical log from the Sunray Mid-Continent and Richfield Oil Corporation well drilled in sec. 21, T. 7 N., R. 88 W., the basal sandstone sequence of the Lance is about 270 feet (82 m) thick in this quadrangle and appears to be correlative with the Fox Hills Sandstone as identified in other geophysical logs from wells drilled in quadrangles to the northwest. However, in keeping with Bass and others (1955), the Fox Hills Sandstone has not been shown as a separate rock unit in the composite columnar section on plate 3. In general, the Fox Hills Sandstone consists of grayish-brown, fine-grained, thin-bedded to massive sandstone with lenses of gray sandy shale and coal (Dorf, 1942).

The Lance Formation conformably overlies the Lewis Shale and crops out over most of the quadrangle. It consists of gray shale interbedded with light-yellow-brown and light-tan fine-grained sandstone and a few thin coal beds (Bass and others, 1955). The total thickness of the formation in this quadrangle is not known, but Bass and others indicate that it is about 1,050 to 1,500 feet (320 to 457 m) thick in the area they mapped.

The Fort Union Formation unconformably overlies the Lance Formation and crops out in the northeastern corner of the quadrangle. It consists of approximately 1,200 feet (366 m) of brown sandstone interbedded with gray shale and a basal arkosic silt-to-boulder sized conglomerate (Bass and others, 1955). Although coal beds are often present in the Fort Union Formation, none have been identified in this quadrangle.

Holocene deposits of alluvium cover the Yampa River valley in the southeastern and southwestern corners of the quadrangle.

The Cretaceous sedimentary rocks in the Rock Spring Gulch quadrangle accumulated close to the western edge of a Late Cretaceous-age 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 Rock Spring Gulch quadrangle (Masters, 1959; Ryer, 1977).

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. Regional uplift west of the Yampa Basin area caused a regression of the sea and ended the deposition of the Lewis Shale in the quadrangle (Kucera, 1959).

The basal sandstone sequence of the Lance Formation (Fox Hills Sandstone) represents a transitional depositional environment between the deeper-water marine environment of the Lewis Shale and the lagoonal and continental environments of the Lance. Deposition of this basal sequence occurred in shallow-marine barrier bar, beach, estuarine, and tidal channel environments (Weimer, 1961).

As the sea regressed further, the sediments became increasingly terrestrial and the carbonaceous shale, mudstone, and coal comprising the Lance Formation were deposited in broad areas of estuarine, marsh, lagoonal, and coastal swamp environments (O'Boyle, 1955; Weimer, 1961).

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 of the Fort Union Formation. The conglomerates, sandstones, and shales of the Fort Union Formation were deposited in braided-stream, flood-plain and backswamp environments (Beaumont, 1979).

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 21 miles (34 km) east of the Rock Spring Gulch quadrangle, and on the southwest by the Axial Basin anticline, approximately 20 miles (32 km) southwest of the quadrangle.

The structure contour maps of the isopached coal beds are based on a regional structure map of the top of the Trout Creek Sandstone Member constructed by Bass and others (1955), and it is assumed that the structure of the coal beds duplicate that of the Trout Creek Sandstone Member. Modifications were made where necessary in accordance with outcrop data. In general, the strata dip regionally to the west at approximately 7° to 8°. No faults have been identified in the quadrangle.

COAL GEOLOGY

Several coal beds in the Lance Formation have been identified in the Rock Spring Gulch quadrangle. Coal beds in the Lance are characteristically thin and lenticular, and are usually less than Reserve Base thickness (5.0 feet or 1.5 meters), but the Lorella and Kimberley coal beds, located near the base of the formation, are exceptions. Although the Fort Union Formation is known to contain coal in adjacent quadrangles to the north, northwest and west, coal beds have not been identified in the Fort Union in this quadrangle.

Chemical analyses of coal.--Analyses of coals in the Lance Formation taken from this and the adjacent Ralph White Lake quadrangle are listed in table 1, and include samples from the Lorella and Kimberley coal beds. Chemical analyses were not available for the Kimberley coal bed in this quadrangle, but it is believed that the coal is similar in rank to the Kimberley coal mined at the White and Haughy mines in the Ralph White Lake quadrangle to the west. In general, chemical analyses of coal in the Lance Formation indicate that the coal ranks subbituminous A or B on a moist, mineral-matter-free basis according to ASTM Standard Specification D 388-77 (American Society for Testing and Materials, 1977).

Coal Beds of the Lance Formation

Coal beds in the Lance Formation crop out sporadically over the eastern half of the quadrangle, and only the Lorella coal bed is known to exceed Reserve Base thickness. The Kimberley coal bed has not been identified in this quadrangle, but has been projected into the southwestern corner of the quadrangle based on geologic data from the adjacent Ralph White Lake quadrangle.

Lorella Coal Bed

The Lorella coal bed crops out in the southeastern corner of the quadrangle (plate 1) and lies about 50 feet (15 m) above the base of the Lance Formation. It ranges in thickness from 3.3 to 9.9 feet (1.0 to 3.0 m), excluding rock partings, as shown on plate 4. The partings vary from 0.7 feet (0.2 m) thick in the Lorella mine to a maximum of 5.0 feet (1.5 m) where measured in an outcrop south of the mine.

Kimberley Coal Bed

The Kimberley coal bed has not been identified in the Rock Spring Gulch quadrangle, but is is isopached in the southwest corner of the quadrangle (plate 4) based on data projected from the adjacent Ralph White Lake quadrangle to the west. In that quadrangle, the coal bed is 8.8 feet (2.7 m) thick where measured the White mine in sec. 4, T. 6 N., R. 89 W., and it is believed that the coal bed thins eastward to approximately 7 feet (2.1 m) in sec. 34, T. 7 N., R. 89 W., in the Rock Spring Gulch quadrangle. The dotted line on plates 4, 5, and 6 represents a limit of confidence beyond which isopach, structure contour, overburden isopach and mining ratio, and areal distribution and identified resources maps are not drawn because of insufficient data, although the coal bed may continue to exceed Reserve Base thickness beyond the dotted line.

COAL RESOURCES

Data from outcrop measurements and mine-measured sections (Bass and others, 1955) were used to construct outcrop, isopach, and structure contour maps of the coal beds in the Rock Spring Gulch quadrangle.

Coal resources for Federal lands were calculated using data obtained from the coal isopach maps (plate 4) and the areal distribution and identified resources (ADIR) maps (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 of coal for each isopached coal bed. Coal beds thicker than 5.0 feet (1.5 m) that lie less than 3,000 feet (914 m) below the ground surface are included. These criteria differ somewhat from those stated in U.S. Geological Survey Bulletin 1450-B which call for a maximum depth of 1,000 feet (305 m) for subbituminous coal.

Reserve Base and Reserve tonnages for the Lorella and Kimberley coal beds are shown on plate 6, and are rounded to the nearest 10,000 short tons (9,072 metric tons). Coal Reserve Base tonnages per Federal section are shown on plate 2 and total approximately 2.15 million short tons (1.95 million metric tons) for the entire quadrangle. Reserve Base tonnages in the various development potential categories for surface and subsurface mining methods are shown in tables 2 and 3. The source of each indexed data point shown on plate 1 is listed in table 4.

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 the coal beds of Reserve Base thickness are overlain by 200 feet (61 m) or less of overburden are 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 less than 200 feet (61 m) of overburden and 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.

Areas where the coal data is absent or extremely limited between the 200-foot (61-m) overburden line and the outcrop are assigned unknown development potential for surface mining methods. This applies to areas where coal beds 5.0 feet (1.5 m) or more thick are not known, but may occur. Limited knowledge of the areal distribution, thickness, depth, and attitude of the coal beds prevents accurate evaluation of development potential in the high, moderate, and low categories.

The coal development potential for surface mining methods is shown on plate 7. Of the Federal land areas having a known development potential for surface mining, 82 percent are rated high and 18 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 which have dips of 15° or less. Unfaulted 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 development potential for in-situ mining methods.

Areas of high, moderate, and low development potential for conventional subsurface mining are defined as areas underlain by coal beds of Reserve Base thickness 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) below the ground surface, 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. This applies to areas where coal beds exceeding Reserve Base thickness are not known, but may occur.

The coal development potential for conventional subsurface mining methods is shown on plate 8. All of the Federal land areas classified as having known development potential for conventional subsurface mining methods are rated high. The remaining Federal land within the KRCRA boundary is classified as having unknown development potential for conventional subsurface mining methods.

Because the coal beds in this quadrangle have dips less than 15°, the development potential for in-situ mining methods is rated as unknown for all Federal lands within the KRCRA boundary.

Table 1. -- Chemical analyses of coals in the Rock Spring Gulch 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
NW¼ sec. 5, T. 7 N., R. 88 W., Ghosthole Mine, (Bass and others, 1955)	Lance Formation, undifferentiated	A	16.7	31.3	46.4	5.6	0.4	-	-	-	-	5,755	10,360
		B	12.4	32.9	48.8	5.9	0.4	-	-	-	-	6,055	10,900
		C	-	37.6	55.7	6.7	0.5	-	-	-	-	6,910	12,440
		D	-	40.3	59.7	-	0.5	-	-	-	-	7,410	13,340
SE¼ sec. 32, T. 5 N., R. 88 W., Lorella Mine, (Bass and others, 1955)	Lance Formation, Lorella	A	19.6	29.3	44.6	6.5	0.5	-	-	-	-	5,370	9,670
		B	14.6	31.2	47.3	6.9	0.6	-	-	-	-	5,710	10,280
		C	-	36.5	55.4	8.1	0.7	-	-	-	-	6,685	12,030
		D	-	39.7	60.3	-	0.7	-	-	-	-	7,265	13,080
NE¼ sec. 4, T. 6 N., R. 89 W., White Mine, (George and others, 1937) from Ralph White Lake quadrangle	Lance Formation, Kimberley	A	20.7	32.4	42.9	4.0	0.5	-	-	-	-	5,405	9,730
		B	13.1	35.5	47.0	4.4	0.5	-	-	-	-	5,920	10,660
		C	-	40.9	54.1	5.0	0.6	-	-	-	-	6,815	12,270
		D	-	43.0	57.0	-	0.6	-	-	-	-	7,180	12,920
SW¼ sec. 33, T. 7 N., R. 90 W., Haughy Mine, (Bass and others, 1955) from Ralph White Lake quadrangle	Lance Formation, Kimberley	A	21.8	31.6	42.5	4.1	0.7	6.1	55.8	1.3	32.0	5,367	9,660
		B	13.5	35.0	47.0	4.5	0.8	5.6	61.7	1.4	26.0	5,940	10,690
		C	-	40.5	54.3	5.2	0.9	4.7	71.4	1.7	16.1	6,867	12,360
		D	-	42.7	57.3	-	1.0	5.0	75.3	1.8	16.9	7,239	13,030

Form of Analysis: A, as received
B, air dried
C, moisture free
D, moisture and ash 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 Rock Spring Gulch quadrangle, Routt and Moffat Counties, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Kimberley	310,000	190,000	160,000	-	660,000
Lorella	280,000	110,000	470,000	-	860,000
Totals	590,000	300,000	630,000	-	1,520,000

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

Table 3. -- Coal Reserve Base data for subsurface mining methods for Federal coal lands (in short tons) in the Rock Spring Gulch quadrangle, Routt and Moffat Counties, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Lorella	630,000	-	-	-	630,000
Totals	630,000	-	-	-	630,000

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

Table 4. -- Sources of data used on plate 1

Plate 1 Index Number	Source	Data Base
1	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 25	Measured Section No. 241
2	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 24	Measured Section No. 251
3	↓	Measured Section No. 250
4	↓	Measured Section No. 249
5	↓	Measured Section No. 252
6	Sunray-Mid-Continent-Richfield Oil Corp.	Oil/gas well, No. 1 Windner Land Co.
7	Bass and others, 1955, U.S. Geological Survey Bulletin 1027-D, pl. 24	Measured Section No. 257
8	↓	Measured Section No. 259
9	↓	Measured Section No. 258
10	↓	Measured Section No. 373

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