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COAL RESOURCE OCCURRENCE MAPS AND COAL DEVELOPMENT POTENTIAL OF THE WHITE ROCK QUADRANGLE, RIO BLANCO AND MOFFAT COUNTIES, COLORADO

[Report includes 4 plates]

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INTRODUCTION

Purpose

This text is to be used in conjunction with Coal Resource Occurrence Maps of the White Rock quadrangle, Rio Blanco 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 Published and unpublished public information available through February, 1979, was used as the data base for this study.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 White Rock quadrangle is located in northwestern Colorado. The southern three quarters of the quadrangle are located in north-central Rio Blanco County and the northern quarter is in south-central Moffat County. The quadrangle is approximately 36 airline miles (58 km) east-northeast of the town of Rangely and 8 airline miles (13 km) northwest of the town of Meeker. With the exception of a few scattered ranches, the quadrangle is unpopulated.

Accessibility

A paved medium-duty and unimproved light-duty road crosses the northeastern part of the White Rock quadrangle following Strawberry Creek and Deep Channel Creek. This road connects with U.S. Highway 40 approximately 19 miles (31 km) to the north, and with Colorado Highway 64, approximately 11 miles (18 km) to the south. The remainder of the quadrangle is accessible by numerous unimproved dirt roads and trails.

Railway service is provided by the Denver and Rio Grande Western Railroad from Denver to the railhead at Craig approximately 30 airline miles (48 km) northeast of the quadrangle. This railroad is the major transportation route for coal shipped east from northwestern Colorado (U.S. Bureau of Land Managment, 1977).

Physiography

The White Rock quadrangle lies at the western edge of the Southern Rocky Mountain physiographic province as defined by Howard and Williams (1972), and is approximately 74 miles (118 km) west of the Continental Divide. The northeastern part of the quadrangle lies in the Danforth Hills.

The landscape in the northeastern part and in the southwestern two thirds of the quadrangle is characterized by moderate to steep slopes cut by numerous gulches. This relatively rugged topography is divided by a broad, relatively flat northwest-trending valley with gentle to moderate slopes. Deep Channel Creek flows through Coyote Basin in the northwestern part of the valley and Strawberry Creek flows through the southeastern part. The Danforth Hills are to the northeast of the valley and a prominent escarpment known as the Gray Hills is to the southwest. Altitudes range from more than 8,360 feet (2,548 m) along the northeastern edge of the quadrangle to less than 6,120 feet (1,865 m) in the southwest corner.

The northeastern half of the quadrangle is drained by Deep Channel Creek and Strawberry Creek, which flow in a northwesterly and southeasterly direction, respectively. Scenery, Smith, and Windy Gulches and their tributaries drain the area southwest of the Gray Hills. All of the creeks empty into the White River south of the quadrangle. The streams in the quadrangle are all 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 area, with daily temperatures typically varying from

3° to 36°F (-16° to 2°C) in Januray and from 46° to 88°F (8° to 31°C) in July. Annual precipitation in the area averages approximately 12 inches (30 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 approximately 3 miles per hour (5 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).

The typical vegetation in the northern half of the quadrangle is mountain shrub, which includes serviceberry, Gambel oak, and rabbitbrush. Vegetation in the southwestern half of the quadrangle includes pinyon, Utah juniper, and Rocky Mountain juniper (U.S. Bureau of Land Management, 1977).

Land Status

The White Rock quadrangle lies on the west-central boundary of the Danforth Hills Known Recoverable Coal Resource Area (KRCRA). Approximately two fifths of the quadrangle lies within the KRCRA boundary and the Federal government owns the coal rights for approximately 70 percent of this area as shown on plate 2. There are no active coal leases within the quadrangle.

GENERAL GEOLOGY

Previous Work

The first geologic description of the general area in which this 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). Gale (1910) reported on the coal fields and geology of northwest Colorado and Sears also described the geology of this area in 1924. Reheis (1975) compiled a generalized geologic map of the Danforth Hills KRCRA, which includes only the area within and immediately adjacent to the KRCRA boundary. Pipiringos and Rosenlund (1977) prepared a preliminary geologic map of the White Rock quadrangle and Rowley and others (1978) compiled a preliminary geologic map of the Vernal 1° x 2° quadrangle that includes the White Rock quadrangle.

Stratigraphy

The rock formations which crop out in the White Rock quadrangle range in age from Late Cretaceous to Eocene and include the coal-bearing Williams Fork Formation of the Mesaverde Group and the Fort Union Formation.

The Mancos Shale of Late Cretaceous age does not crop out within the quadrangle, but it is present in the subsurface. The formation is composed of gray to dark-gray marine shale with ledge-forming thin-bedded sandstone occurring locally in the upper part (Hancock and Eby, 1930). According to Tweto (1976), the Mancos Shale is approximately 5,000 feet (1,524 m) thick in northwestern Colorado. However, its total thickness in this quadrangle is unknown.

The Mesaverde Group of Late Cretaceous age conformably overlies the Mancos Shale and contains two formations, the Iles and Williams Fork.

The Iles Formation does not crop out within the quadrangle, but occurs in the subsurface. It consists of fine-grained thick-bedded to massive sandstone interbedded with shaly sandstone, sandy shale, and black carbonaceous shale (Hancock and Eby, 1930) and may be about 1,450 feet (442 m) thick in the vicinity of the Tennessee Gas Transmission No. 1 USA Chorney well drilled in the northeast corner of the quadrangle. The Tow Creek Sandstone Member (Bass and others, 1955), the basal unit of the Iles Formation, is a light-brown to white massive sandstone, approximately 90 feet (27 m) thick where measured in the No. 1 USA Chorney well. The Trout Creek Sandstone Member caps the formation and consists of white massive sandstone. It is estimated to be about 110 to 120 feet (34 to 37 m) thick. Two coal-bearing sequences, the "lower" coal group and Black Diamond coal group (Hancock and Eby, 1930), occur in the Iles Formation below the Trout Creek Sandstone in the Meeker area, but these coal groups have not been identified in this quadrangle.

The Williams Fork Formation crops out in the northeastern part of the quadrangle and is estimated to be 4,000 feet (1,219 m) thick (Pipiringos and Rosenlund, 1977). The formation is generally divided into three units: a lower coal-bearing unit, the Lion Canyon Sandstone Member, and an upper unit that also contains coal.

The lower unit extends from the top of the Trout Creek Sandstone Member of the Iles Formation to the base of the Lion Canyon Sandstone Member and ranges in thickness from 1,700 to 2,100 feet (518 to 640 m). It consists of interbedded sandstone, siltstone, claystone, carbonaceous shale and coal (Pipiringos and Rosenlund, 1977). Two coal groups, the Fairfield coal group and the Goff coal group, occur in the lower unit of the Williams Fork Formation (Hancock and Eby, 1930), but coals in the Goff coal group have not been identified in this quadrangle.

The Lion Canyon Sandstone Member is a light-gray to white fine-grained sandstone and may contain, locally, thin beds of shale and siltstone (Pipiringos and Rosenlund, 1977). The maximum thickness of this sequence is about 200 feet (61 m) in this quadrangle.

The upper unit of the Williams Fork Foramtion, which may be a Lance equivalent, is probably between 1,100 and 1,800 feet (335 and 549 m) thick (Pipiringos and Rosenlund, 1977). It consists of interbedded light-gray to brown to white, massive and shaly sandstone, brown to black sandy and carbonaceous shale, and coal beds. Coal beds in this unit have been designated the Lion Canyon Coal Group by Hancock and Eby (1930).

Unconformably overlying the Williams Fork Formation, the Fort Union Formation of Paleocene age crops out in a north-northwest-trending band across the northeastern part of the quadrangle. The formation is composed predominantly of light-gray to brown sandstone with minor amounts of interbedded siltstone, claystone, carbonaceous shale, and thin coal beds. Several conglomerate beds occur in the basal 40 to 70 feet (12 to 21 m) of the formation, and the formation ranges in thickness from about 1,200 to 1,400 feet (366 to 427 m) on the surface in this quadrangle (Pipiringos and Rosenlund, 1977).

The Wasatch Formation of Eocene age crops out in a north-northwest-trending band from the northwestern part to the southeast corner of the quadrangle; it is also exposed in the southwest corner of the quadrangle. The contact between the Wasatch and the underlying Fort Union strata is probably unconformable (Gale, 1907) in this area. The Wasatch is composed of sandy claystone and siltstone containing lenses and channels of medium- to coarse-grained cross-bedded sandstone and ranges in thickness from about 2,300 to 3,300 feet (701 to 1,006 m) where mapped by Pipiringos and Rosenlund (1977).

Conformably overlying and intertonguing with the Wasatch Formation (Pipiringos and Rosenlund, 1977), the lacustrine Green River Formation is exposed over much of the western half and south-central parts of the quadrangle. The basal Anvil Points Member consists of predominantly fluviatile sandstone with some siltstone and shale interfingering with the Garden Gulch and Parachute Creek Members (Robinson, 1972). The Garden Gulch Member consists primarily of dark-gray shale and olive-gray claystone while the Parachute Creek Member consists mostly of light-gray to white platy marlstone with minor amounts of papery oil shale and thin-bedded fine-grained sandstone (Pipiringos and Rosenlund, 1977).

Holocene deposits of alluvium cover the stream valleys, flood-plain and slope-wash areas in this quadrangle.

The Cretaceous formations cropping out in the White Rock 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 offshore-marine, shallow-marine, marginal-marine, and non-marine sediments in the White Rock area (Ryer, 1977).

The Mancos Shale was deposited in an offshore marine environment which existed east of the shifting strand line. Deposition of the Mancos Shale in the quadrangle area ended with the eastward migration of the shoreline, and the subsequent deposition of the Iles Formation (Konishi, 1959; Kucera, 1959).

The interbedded sandstone, shale, and coal of the Mesaverde Group were deposited as a result of minor changes in the position of the shoreline. Near-shore marine, littoral, brackish-tidal, brackish and fresh-water supratidal, and fluvial environments existed during the deposition of the Iles and Williams Fork Formations. The major sandstone members of the Iles and Williams Fork Formations, including the Tow Creek, Trout Creek, and Lion Canyon Sandstone Members, were deposited in shallow-marine and near-shore marine environments as the shoreline fluctuated. Coal beds of limited areal extent were generally deposited in environments associated with fluvial systems, such as back-levee and coastal plain swamps, interchannel basin areas, and abandoned channels (Konishi, 1959; Kucera, 1959).

After the final withdrawal of the Cretaceous sea, thick sections of detrital material, eroded from older deposits, were deposited as the Fort Union Formation. The conglomerates, sandstones, shales, and coals were deposited in braided-stream, flood-plain and backswamp environments (Beaumont, 1979).

The coarse sediments at the base of the Wasatch Formation were deposited in a fluvial environment and the upper sediments were deposited in alternating swamp, lake and stream environments (Beaumont, 1977).

Depositional environments fluctuated between fluvial and lacustrine during deposition of the Green River Formation. The Anvil Points Member is a lake shoreline facies characterized by a lacustrine-fluvial transition zone while the Garden Gulch and Parachute Creek Members represent deeper-water lacustrine deposits (Robinson, 1972).

Structure

The Danforth Hills KRCRA lies in the northern part of the Piceance structural basin of west-central Colorado. The Danforth Hills area is bordered on the northeast by the Axial Basin anticline and on the west by the Yampa Plateau. The White Rock quadrangle is approximately 6 miles (10 km) southwest of the Axial Basin anticline and approximately 20 miles (32 km) southeast of the Yampa Plateau (Grose, 1972).

A broad, north-northwest-trending syncline crosses the western half of the quadrangle, forming a basin in the west-central part of the quadrangle. A northwest-trending fault in the northeastern part of the quadrangle cuts the coal-bearing strata of the Williams Fork Formation (Pipiringos and Rosenlund, 1977).

COAL GEOLOGY

Three coal beds in the Williams Fork Formation and one in the Fort Union Formation exceed Reserve Base thickness (5.0 feet or 1.5 meters) where measured along their outcrops. All of these coal beds have been measured at isolated locations and cannot be correlated between outcrops. In instances where a single or an isolated measurement thicker than Reserve Base is encountered, such as the coal beds in this quadrangle, the standard criteria for construction of isopach, structure contour, mining ratio, and overburden isopach maps are not available. The lack of data concerning these coal beds limits the extent to which they can be reasonably projected in any direction and usually preclude correlations with other coal beds. For this reason, isolated data point maps are included on a plate for non-isopached coal beds (plate 4).

The coal beds identified in this quadrangle are not formally named, but where they exceed Reserve Base thickness they have been given bracketed numbers for identification purposes.

<u>Chemical analyses of coal</u>.--Chemical analyses were not available for coals from the Fairfield or Lion Canyon coal groups or the Fort Union Formation in this quadrangle. However, it is believed that these coals

are similar in rank to coal from the Fairfield and Lion Canyon coal groups mined, respectively, at the Ed Collum mine in the Easton Gulch quadrangle to the east, at the Montgomery mine in the Meeker quadrangle to the southeast, and at the Grassie mine in the Lay SE quadrangle to the northeast. Analyses of these coals are listed in table 1. In general, coal from the Fairfield and Lion Canyon coal groups are ranked as high-volatile C bituminous, and coal from the Fort Union Formation as subbituminous A on a moist, mineral-matter-free basis according to ASTM Standard Specification D 388-77 (American Society for Testing and Materials, 1977).

Fairfield Coal Group

The Fairfield coal group is located in the lower part of the Williams Fork Formation and only one coal bed in this group has been identified in this quadrangle. This coal bed, the Fairfield [1], is 24.0 feet (7.3 m) thick where measured in the NE 1/4 SE 1/4 NE 1/4 sec. 14, T. 3 N., R. 95 W. This coal bed dips approximately 3° to the southwest as calculated from the map by Pipiringos and Rosenlund (1977).

Lion Canyon Coal Group

The Lion Canyon coal group includes all coal beds in the Williams Fork Formation that lie above the Lion Canyon Sandstone Member. Several coal beds in this group were identified by Pipiringos and Rosenlund (1977) but only two, the Lion Canyon [2] and Lion Canyon [3], are known to exceed Reserve Base thickness. The Lion Canyon [2] coal bed is 12 feet (3.7 m) thick where measured in the NW 1/4 NE 1/4 NE 1/4 sec. 35, T. 3 N., R. 95 W., and the Lion Canyon [3] is 7 feet (2.1 m) thick in the NE 1/4 SW 1/4 SW 1/4 sec. 9, T. 3 N., R. 95 W. The dips of the two coal beds are about 40° and 38°, respectively, to the southwest.

Coal Beds of the Fort Union Formation

Only one Fort Union coal bed was identified in the White Rock quadrangle. This coal bed, the Fort Union [4] coal bed, lies in the

NW 1/4 NE 1/4 SW 1/4 sec. 35, T. 3 N., R. 95 W., and dips about 50° to the southwest. It is 6.0 feet (1.8 m) thick where measured at one location along the outcrop.

COAL RESOURCES

Data from outcrop measurements (Reheis, 1975; Pipiringos and Rosenlund, 1977) were used to construct an areal distribution and identified resources map of the non-isopached coal beds (plate 4). The source of each indexed data point shown on plate 1 is listed in table 4.

Coal resources for Federal land were calculated using data obtained from plate 4. 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, or 1,800 short tons of coal per acre-foot (13,238 metric tons per hectare-meter) for bituminous coal, yields the coal resources in short tons for each 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 minimum thickness of 28 inches (70 cm) for bituminous coal and a maximum depth of 1,000 feet (305 m) for both subbituminous and bituminous coal.

Only Reserve Base tonnages (designated as inferred resources) are calculated for the non-isopached coal beds. These are shown on plate 4, and are rounded to the nearest 10,000 short tons (9,072 metric tons). Coal Reserve Base tonnages per Federal section are shown on figure 2 and total approximately 2,410,000 short tons (2,190,000 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.

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

COAL DEVELOPMENT POTENTIAL

The standard criteria for classifying coal resource development potential by surface and subsurface mining methods were not applied to the White Rock quadrangle. Unknown development potentials are assigned to those areas where coal data is absent or extremely limited, such as those areas influenced by isolated data points in this quadrangle. Even though these areas may contain coal thicker than 5 feet (1.5 m), limited knowledge of the areal distribution, thickness, depth, and attitude of the coal bed prevents accurate evaluation of development potential in the high, moderate, and low categories. Coal tonnages included in the unknown potential category for the isolated data points in this quadrangle are believed to total approximately 1,460,000 short tons (1,320,000 metric tons) for surface mining methods and approximately 950,000 short tons (860,000 metric tons) for conventional subsurface and in-situ mining methods.

Table 1. -- Chemical analyses of coals in the White Rock quadrangle, Rio Blanco 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
SW¼ sec. 13, T. 4 N., R. 94 W., Ed Collum Mine (Hancock, 1925) from Easton Gulch quadrangle	Fairfield coal group coal bed {33}	A	14.8	38.7	42.7	3.82	0.66	-	-	-	-	-	10,780
		B	13.1	39.5	43.5	3.90	0.67	-	-	-	-	-	11,000
		C	-	45.4	50.1	4.49	0.78	-	-	-	-	-	12,660
NW¼ sec. 29, T. 1 N., R. 94 W., Montgomery Mine (Hancock and Eby, 1930) from Meeker quadrangle	Lion Canyon coal group	A	12.4	38.6	42.9	6.1	0.71	-	-	-	-	-	10,790
		B	10.6	39.4	43.7	6.3	0.72	-	-	-	-	-	11,010
		C	-	44.1	48.9	7.0	0.81	-	-	-	-	-	12,320
NW¼ SE¼ sec. 27, T. 8 N., R. 93 W., Grassie Mine (George and others, 1937) from Lay SE quadrangle	Fort Union Formation	A	15.9	32.5	46.6	5.0	0.5	-	-	-	-	-	10,140
		C	-	38.6	55.5	5.9	0.6	-	-	-	-	-	12,060
		D	-	41.0	59.0	-	0.6	-	-	-	-	-	12,820

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 White Rock quadrangle, Rio Blanco and Moffat Counties, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Isolated Data Points	-	-	-	1,460,000	1,460,000
Totals	-	-	-	1,460,000	1,460,000

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 White Rock quadrangle, Rio Blanco and Moffat Counties, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Isolated Data Points	-	-	-	950,000*	950,000
Totals	-	-	-	950,000	950,000

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

*Includes 890,000 short tons dipping greater than 15°.

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

Plate 1 Index Number	Source	Data Base
1	Pipiringos and Rosenlund, 1977, U.S. Geological Survey Miscellaneous Field Studies Map MF-837	Measured Section
2	Reheis, compiler, 1975, U.S. Geological Survey, unpublished map	Measured Section
3	Pipiringos and Rosenlund, 1977, U.S. Geological Survey Miscellaneous Field Studies Map MF-837	Measured Section
4	Reheis, compiler, 1975, U.S. Geological Survey, unpublished map	Measured Section
5	↓	Measured Section

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