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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE CASTOR GULCH QUADRANGLE, MOFFAT COUNTY, COLORADO

[Report includes 15 plates]

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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

CONTENTS

ILLUSTRATIONS

TABLES

INTRODUCTION

Purpose

This text is to be used in conjunction with Coal Resource Occurrence and Coal Development Potential Maps of the Castor Gulch quadrangle, Moffat County, 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 U.S. 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 Published and unpublished public information available through April, 1978, was used as the data base for this study.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 Castor Gulch quadrangle is located in southeastern Moffat County in northwestern Colorado, approximately 1 mile (2 km) south of the town of Craig via Colorado Highway 13 (also known as Colorado Highway 789), and approximately 43 miles (69 km) southwest of the town of Steamboat Springs via Colorado Highway 13 and U.S. Highway 40. The town of Craig South Highlands is in the north-central part of the quadrangle. A few scatterd ranches occur throughout the remainder of the quadrangle.

Accessibility

Colorado Highway 13 (Colorado Highway 789), a paved medium-duty road, passes through the northwestern part and the southeastern corner of the Castor Gulch quadrangle linking Craig, north of the quadrangle, with the town of Hamilton, 0.5 mile (0.8 km) south of the quadrangle. U.S. Highway 40 passes east-west through Craig approximately 1 mile (2 km) north of the quadrangle. Colorado Highway 394, a paved medium-duty road, crosses the northeastern part of the quadrangle, serving the Craig Municipal Airport. The remainder of the quadrangle is accessible by several improved light-duty roads and numerous unimproved dirt roads and trails.

Railway service for the Castor Gulch quadrangle is provided by the Denver and Rio Grande Western Railroad from Denver to the railhead at Craig. The railroad generally parallels U.S. Highway 40 north of the quadrangle, and ends approximately 1 mile (2 km) west of Craig. It is the major transportation route for coal shipped east from northwestern Colorado (U.S. Bureau of Land Management, 1977).

Physiography

The Castor Gulch quadrangle lies in the southern part of the Wyoming Basin physiographic province as defined by Howard and Williams (1972). The quadrangle is approximately 4 miles (6 km) northeast of the Axial Basin and approximately 45 miles (72 km) west of the Continental Divide. The Williams Fork Mountains cross the southern half of the quadrangle.

Approximately 1,600 feet (488 m) of relief is present in the Castor Gulch quadrangle. Altitudes range from 7,746 feet (2,361 m) in the Williams Fork Mountains in the south-central part of the quadrangle to approximately 6,140 feet (1,871 m) in the Big Bottom area along the Yampa River on the northwestern edge of the quadrangle.

The landscape in the southern half of the quadrangle is dominated by steep slopes and narrow canyons. The slopes become broader and more gentle approaching the Yampa River in the northern part of the quadrangle.

The Yampa River flows westward across the northern edge of the Castor Gulch quadrangle. The Williams Fork crosses the southwestern corner of the quadrangle and joins the Yampa River approximately 1.5 miles (2.4 km) west of the quadrangle. The Williams Fork Mountains form a drainage divide with streams in the northern half of the quadrangle flowing north into the Yampa River and streams in the southern half of the quadrangle flowing into the Williams Fork. Numerous intermittent streams in the quadrangle 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 Castor 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 14 inches (36 cm). Snowfall during the winter months accounts for the major part of the precipitation in the area, but rainfall from thundershowers during the summer months also contributes to the total. Winds, averaging approximately 3 miles per hour (4.8 km per hour), are generally from the west, but wind directions and velocities tend to vary greatly depending on the local terrain (U.S. Bureau of Land Management, 1977).

The predominate vegetation in the southern two thirds of the quadrangle, in the Williams Fork Mountains, is mountain shrub, which ranges from 2 to 8 feet (0.6 to 2.4 m) high. Pinyon and juniper also grow along the western edge of the Williams Fork Mountains. Cottonwood and willow are common along the Yampa River and Williams Fork. Much of the north-central part of the quadrangle is utilized as agricultural land (U.S. Bureau of Land Management, 1977).

Land Status

The Castor Gulch quadrangle lies in the west-central part of the Yampa Known Recoverable Coal Resource Area (KRCRA). Approximately ninety-six percent of the quadrangle lies within the KRCRA, and the Federal government owns the coal rights for approximately fifty percent of this area. Six active coal leases are present within the KRCRA boundary and occupy about 30 percent of the Federal land areas as shown on plate 2.

GENERAL GEOLOGY

Previous Work

The first geologic description of the general area in which the Castor 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 Hewett (1889), Hills (1893), and Storrs (1902). Fenneman and Gale (1906) conduted geologic studies of the Yampa Coal Field and included a description of the geology and coal occurrence in the Castor Gulch quadrangle in their report. Hancock (1925) includes the entire area within the Castor Gulch quadrangle and is the most comprehensive work on the area. Tweto (1976) compiled a generalized regional geologic map which included this quadrangle.

Stratigraphy

The rock formations that crop out in the Castor Gulch quadrangle are Late Cretaceous in age, and include the coal-bearing Iles and Williams Fork Formations of the Mesaverde Group.

The Mancos Shale occurs in the subsurface and crops out in a very small area along the southern edge of the quadrangle (Hancock, 1925). It is composed of a thick sequence of gray to dark-gray shale with a number of tan silty sandstones interbedded with sandy shale and shale in the upper 1,000 feet (305 m) of the formation (Hancock, 1925; Bass and others, 1955).

The Mesaverde Group conformably overlies the Mancos Shale and contains two formations, the Iles and the Williams Fork. The Iles Formation ranges from approximately 1,390 to 1,460 feet (424 to 445 m) in thickness where measured in oil and gas wells drilled in the Castor Gulch quadrangle and crops out in the southern quarter of the quadrangle (Hancock, 1925). The basal Tow Creek Sandstone Member averages approximately 60 feet (18 m) thick and consists of tan to brown massive sandstone. Overlying the Tow Creek Sandstone Member is approximately 1,230 to 1,300 feet (375 to 396 m) of light-colored thin-bedded sanstone, interbedded with gray sandy shale and coal. The coal beds found in this sequence, designated as the Lower Coal Group, were first described by Fenneman and Gale (1906). The overlying Trout Creek Sandstone Member consists of approximately 75 to 110 feet (23 to 34 m) of white fine-grained, thick-bedded to massive cliff-forming sandstone. The top of the Trout Creek Sandstone Member forms the contact between the Iles Formation and the conformably overlying Williams Fork Formation (Hancock, 1925; Bass and others, 1955).

The Williams Fork Formation crops out in the northern three quarters of the quadrangle. The formation is divided into three units: a lower coal-bearing unit; the Twentymile Sandstone Member; and an upper coal-bearing unit (Bass and others, 1955).

The lower coal-bearing unit of the Williams Fork Formation extends from the top of the Trout Creek Sandstone Member of the Iles Formation to the base of the Twentymile Sandstone Member. It ranges in thickness from approximately 740 to 880 feet (226 to 268 m) where measured in the oil and gas wells drilled in the quadrangle and consists of dark-gray to black sandy shale, sandstone, carbonaceous shale, and lenticular coal beds (Hancock, 1925; Bass and others, 1955). Fenneman and Gale (1906) have designated the coal in this lower unit as the Middle Coal Group.

The Twentymile Sandstone Member ranges from approximately 80 to 130 feet (24 to 40 m) thick where measured in the oil and gas wells and is, characteristically, a white fine-grained massive sandstone (Hancock, 1925; Bass and others, 1955).

The upper coal-bearing unit of the Williams Fork Formation, estimated to be about 820 feet (250 m) thick, overlies the the Twentymile Sandstone Member. It is composed of interbedded dark-gray shale, massive white sandstone, sandy shale, and coal beds (Bass and others, 1955). The coal beds in this upper unit, between the top of the Twentymile Sandstone Member and the base of the Lewis Shale, form the Upper Coal Group (Fenneman and Gale, 1906).

The Lewis Shale conformably overlies the Williams Fork Formation and crops out in the northwestern part of the quadrangle along the axis of the Big Bottom syncline and along the northwestern edge of the quadrangle. It consists of dark-gray shale interbedded with a few thin beds of sandstone (Hancock, 1925). No information is available on the thickness of the Lewis Shale in this quadrangle. However, it ranges in thickness from 2,140 to 2,200 feet (652 to 671 m) where measured in the oil and gas wells in the Craig quadrangle to the north.

Holocene deposits of alluvium cover the stream valleys of the Yampa River and the Williams Fork in the northern and southwestern parts of the quadrangle.

The rock formations exposed in the Castor Gulch 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 Castor Gulch 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 sandstones of the Iles and Williams Fork Formations, including the Tow Creek, Trout Creek, and Twentymile Sandstone Members, were deposited in shallow marine and near-shore environments. The lenticular coal beds of the

Lower, Middle, and Upper Coal Groups 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).

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

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 38 miles (61 km) east-northeast of the Castor Gulch quadrangle, and on the southwest by the Axial Basin anticline, approximately 5 miles (8 km) southwest of the quadrangle.

Beds in the southern part of the Castor Gulch quadrangle generally dip northward. The southern edge of the quadrangle lies on the northern noses of the Badger Creek syncline and Beaver Creek anticline, both of which trend generally northwest. The southwestern corner of the quadrangle lies on the northeastern flank of the north-northwest-trending Williams Fork anticline. The Big Bottom syncline trends east-west across the northwestern part of the quadrangle. The Breeze anticline, in the northeastern part of the quadrangle, lies slightly to the north of the Big Bottom syncline and parallel to it (Hancock, 1925). Two east-west-striking faults were mapped by Hancock (1925) in the northern part of the quadrangle and a northwest-trending fault is in the southeastern corner of the quadrangle (Tweto, 1976).

The structure contour maps of the isopached coal beds are based on a regional structure contour map of the top of the Trout Creek Sandstone

Member by Hancock (1925), and it is assumed that the structure of the coal beds duplicates that of the Trout Creek Sandstone Member. Modifications were made where necessary in accordance with outcrop and drill hole data. Dips of the coal beds are generally to the north, ranging from approximately 7° to 11° in the southern half of the quadrangle to about 5° in the northern part of the quadrangle.

COAL GEOLOGY

Coal beds in the Lower, Middle and Upper Coal Groups of the Mesaverde Group have been identified in the Castor Gulch quadrangle. The Lower Coal Group includes all coal beds in the Iles Formation, between the Tow Creek and Trout Creek Sandstone Members. The Middle Coal Group includes the coal beds in the lower coal-bearing zone of the Williams Fork Formation below the Twentymile Sandstone Member, and the Upper Coal Group includes the coal beds in the upper Williams Fork Formation above the Twentymile Sandstone Member. Coal beds in the Lower, Middle and Upper Coal Groups are generally thin, lenticular, and limited in areal extent although coal beds in the Middle Coal Group tend to persist over larger areas, especially in quadrangles to the east. None of the coal beds in this quadrangle are formally named, but where coal beds exceed Reserve Base thickness (5.0 feet or 1.5 meters) they have been given bracketed numbers for identification purposes.

Chemical analyses of coal.--Analyses of the coals in this quadrangle are listed in table 1 and include those for the Middle Coal Group zone G and the undifferentiated Upper Coal Group. Chemical analyses were not available from the Lower Coal Group or the zones in the Middle and Upper Coal Groups other than the Middle Coal Group zone G. However, it is believed that the Lower Coal Group coals are similar in rank to those analyzed from a corehole in the Pagoda quadrangle to the southeast. The analyses shown in the table are believed to be representative of all the Middle and Upper Group coals. In general, the chemical analyses indicate that the coals in the Lower and Middle Coal Groups are high-volatile C bituminous and the coals in the Upper Coal Group probably range from subbituminous A to high-volatile C bituminous in rank on a moist, mineral-matter-free basis according to ASTM Standard Specification D 388-77 (American Society for Testing and Materials, 1977).

Dotted lines shown on some of the derivative maps represent a limit of confidence beyond which isopach, structure contour, overburden isopach, and areal distribution and identified resources maps are not drawn because of insufficient data, even where it is believed that the coal beds may continue to be greater than Reserve Base thickness beyond the dotted lines.

Lower Coal Group

The coal beds in the Lower Coal Group have been identified in outcrops in the southern part of the quadrangle and are usually thin and discontinuous. The LG[3] (i.e., Lower Coal Group, coal bed [3]), LG[4], and LG[5] coal beds were isopached in the southeastern and south-central parts of the quadrangle and are shown on plates 4A and 4B. These coal beds range in thickness from 2.7 to 7.0 feet (0.8 to 2.1 m). Thin rock partings 0.1 to 0.4 feet (0.03 to 0.1 m) occur locally in two of the coal beds. Another local coal bed, the LG[1] coal bed, was identified in the southwestern part of the quadrangle at only one location and is treated as an isolated data point (see Isolated Data Points section of this report).

Middle Coal Group

The Middle Coal Group contains numerous relatively thin coal beds, and only a few of these coal beds can be correlated between outcrops. In quadrangles to the east, Bass and others (1955) indicate that most of the coal beds can be placed in three main zones (zones F, G and H), and that two other coal beds (I and J), which may also be zones farther west, overlie the zones in the coal-bearing sequence of strata. In this quadrangle, the discontinuous coal beds cannot be assigned to zones with stratigraphic accuracy and are just designated as belonging to the Middle Coal Group with a bracketed number for identification purposes. However, two coal beds that are relatively extensive in the adjacent Breeze

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.

in the Upper Coal Group in quadrangles to the east can usually be placed into six coal zones (zones K, L, M, N, O, and P), sometimes referred to as beds by Bass and others (1955), it is not possible to assign the coal beds to particular zones in this quadrangle. An exception is the UGN[34] coal bed that has been projected into this quadrangle based on geologic data in the Breeze Mountain quadrangle to the east.

Four local Middle Coal Group coal beds, the UG[22], UG[24], UG[27], and UG[33], have been isopached in the northwestern part of the quadrangle and are shown on plates 4A and 4B. These coal beds range from less than 5.0 feet (1.5 m) thick up to a maximum reported thickness of 8.5 feet (2.6 m) excluding rock partings which occur locally and vary from 0.1 to 1.5 feet (0.03 to 0.5 m) in thickness. Nine other coal beds exceeding Reserve Base thickness have been measured in drill holes or outcrops at one location only and have been treated as isolated data points.

Upper Coal Group, Zone N, Coal Bed 34

The UGN[34] coal bed (plate 4B) is quite extensive in the Breeze Mountain quadrangle to the east and has been projected from that quadrangle into the east-central edge of this quadrangle. In the Breeze Mountain quadrangle, the coal bed ranges in thickness from 2.5 feet (0.8 m) to a maximum reported thickness of 9.0 feet (2.7 m) in sec. 4, T. 5 N., R. 90 W., in a drill hole just east of the quadrangle boundary. Based on that drill-hole information, the UGN[34] coal bed is inferred to range in thickness from 5 to 9 feet (1.5 to 2.7 m) where the coal bed has been isopached in this quadrangle.

Isolated Data Points

In instances where isolated measurements of coal beds thicker than 5 feet (1.5 m) are encountered, the standard criteria for construction of isopach, structure contour, mining ratio, and overburden isopach maps are not available. The lack of data concerning these beds limits the extent to which they can be reasonably projected in any direction and usually precludes correlations with other, better known coal beds. For this reason, isolated data points occurring in this quadrangle and the influences from isolated data points in adjacent quadrangles are included on a separate plate for non-isopached coal beds (plate 10).

COAL RESOURCES

Data from drill holes, mine measured sections, and outcrop measurements (Hancock, 1925; U.S. Geological Survey, 1922, 1925) were used to construct outcrop, isopach and structure contour maps of the coal beds in the Castor Gulch quadrangle. Where coal beds of Reserve Base thickness exist entirely on non-Federal lands or on lands already leased for coal mining, areal distribution and identified resources maps are not constructed and Reserve Base tonnages are not calculated, as is the case for the LG[5], MG[22], and MG[24] coal beds.

Coal resources for Federal land were calculated using data obtained from the coal isopach maps (plates 4A, 4B, and 7), the areal distribution and identified resources maps (plates 6A, 6B, and 9), and the isolated data point maps (plate 10). 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 of coal for each coal bed. Coal beds greater than Reserve Base thickness 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.

Reserve Base and Reserve tonnages for the isopached coal beds are shown on plates 6A, 6B and 9, and are rounded to the nearest 10,000 short tons (9,072 metric tons). Only Reserve Base tonnages (designated as inferred resources) are calculated for areas influenced by the isolated data points. Coal Reserve Base tonnages per Federal section are shown on plate 2 and total approximately 33.97 million short tons (30.82 million metric tons) for the entire quadrangle, including the tonnages for the isolated data points. 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 so as 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 were 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.

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 feet (1.5 m) or more thick are not known, but may occur, and to those areas influenced by isolated data points. Limited knowledge pertaining to 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 areas influenced by isolated data points in this quadrangle total approximately 5.87 million short tons (5.33 million metric tons) of coal available for surface mining.

The coal development potential for surface mining methods is shown on plate 11. Of the Federal land areas having a known development potential for surface mining, 87 percent are rated high, 6 percent are rated moderate, and 7 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 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 the areas influenced by isolated data points and to those areas where coal beds of Reserve Base thickness are not known, but may occur. The areas influenced by isolated data points in this quadrangle contain approximately 17.09 million short tons (15.50 million metric tons) of coal available for conventional subsurface mining.

The coal development potential for conventional subsurface mining methods is shown on plate 12. All of the Federal land areas having a 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 Castor Gulch quadrangle, Moffat County, 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 sec. 29, T. 5 N., R. 89 W., Corehole (Bass and others, 1955) from Pagoda quadrangle	Lower Group	A	9.1	34.9	49.0	7.0	0.6	5.5	66.3	1.4	19.2	--	11,560
		B	5.7	36.3	50.8	7.2	0.6	5.3	68.8	1.5	16.6	--	12,000
		C	--	38.5	53.8	7.7	0.6	5.0	72.9	1.6	12.2	--	12,720
lot 12 sec. 11, T. 5 N., R. 91 W., Miller Mine (George and others, 1937)	Middle Group Zone G	A	10.5	37.1	43.9	8.5	0.6	5.7	62.3	1.1	21.8	6,056	10,900
		C	--	41.4	49.1	9.5	0.6	5.0	69.6	1.2	14.1	6,761	12,170
		D	--	45.8	54.2	--	0.7	5.6	76.9	1.4	15.4	7,478	13,460
SE¼ sec. 17, T. 6 N., R. 90 W., Walker Mine (Fieldner and others, 1914)	Upper Group	A	15.5	37.4	39.6	7.5	1.0	--	--	--	--	5,751	10,352
		C	--	44.3	46.8	8.9	1.2	--	--	--	--	6,809	12,256
		D	--	48.6	51.4	--	1.3	--	--	--	--	7,471	13,448
SE¼ sec. 20, T. 6 N., R. 90 W., Joe Knez Mine (Hancock, 1925)	Upper Group	A	16.2	31.8	47.8	4.2	0.5	--	--	--	--	5,789	10,420
		B	10.8	33.8	50.9	4.5	0.6	--	--	--	--	6,165	11,100
		C	--	37.9	57.1	5.0	0.6	--	--	--	--	6,910	12,440
SE¼ sec. 9, T. 6 N., R. 91 W., Mount Evans Mine (George and others, 1937)	Upper Group	A	11.4	31.3	50.5	3.8	0.8	5.8	63.5	1.6	24.5	6,167	11,100
		C	--	36.6	59.0	4.4	0.9	4.9	74.2	1.8	13.8	7,206	12,970
		D	--	38.3	61.7	--	1.0	5.2	77.6	1.9	14.3	7,539	13,570

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 Castor Gulch quadrangle, Moffat County, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
UG {27}	100,000	70,000	320,000	-	490,000
UG {30}	190,000	30,000	-	-	220,000
UGN {34}	190,000	100,000	320,000	-	610,000
MGJ {26}	290,000	140,000	670,000	-	1,100,000
MG {15}	10,000	-	-	-	10,000
MGH {19}	50,000	30,000	60,000	-	140,000
MG {12}	110,000	80,000	120,000	-	310,000
MG {7}	100,000	50,000	70,000	-	220,000
LG {4}	90,000	30,000	110,000	-	230,000
LG {3}	50,000	30,000	60,000	-	140,000
Isolated Data Points	-	-	-	5,870,000	5,870,000
Totals	1,180,000	560,000	1,730,000	5,870,000	9,340,000

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 Castor Gulch quadrangle, Moffat County, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
UG {27}	910,000	-	-	-	910,000
UGN {34}	420,000	-	-	-	420,000
MGJ {26}	2,990,000	-	-	-	2,990,000
MGH {19}	1,900,000	-	-	-	1,900,000
MG {12}	210,000	-	-	-	210,000
MG {7}	620,000	-	-	-	620,000
LG {4}	490,000	-	-	-	490,000
Isolated Data Points	-	-	-	17,090,000	17,090,000
Totals	7,540,000	-	-	17,090,000	24,630,000

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	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 12 and 18	Measured Section Nos. 275, 277-280, 282, 284
2	↓	Measured Section Nos. 267, 269, 271-273, 299, 302, 304
3	↓	Measured Section Nos. 292-297
4	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 11 and 18	Measured Sections 348, 352-354, 379-381, 384-386, 388
5	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 11	Measured Section No. 334
6	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl 11 and p. 90	Measured Section Nos. 335-336
7	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl 11	Measured Section No. 337
8	↓	Measured Section No. 338
9	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 11 and 18	Measured Section No. 346
10	↓	Measured Section No. 347
11	U.S. Geological Survey, 1925, Inactive Coal License No. Glenwood Springs 020070, Arkmadis Miller	Mine Measured Section (Miller Mine)
12	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 11 and 18	Measured Section Nos. 339-340, 357-360, 364
13	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 11 and p. 93	Measured Section Nos. 355 and 357

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
14	Trend Exploration Co.	Oil/gas well No. 1 Voloshin-Morton
15	Hancock, 1925, U.S. Geological Survey Bulletin 757, fig. 5 and p. 55, 56	Mine-Measured Section No. 442 (Walker Mine)
16	↓	Measured Section Nos. 435, 437-439
17	Cabeen Exploration Corp.	Oil/gas well No. 1 Seeley
18	U.S. Geological Survey, 1922, Inactive Coal Lease No. Glenwood Springs 021786A, John E. Daley	Drill hole No. 8
19	↓	Drill hole No. A
20	↓	Drill hole No. B
21	Hancock, U.S. Geological Survey Bulletin 757, pl. 7 and 18	Measured Section No. 496
22	U.S. Geological Survey, 1922, Inactive Coal Lease No. Glenwood Springs 021786A, John E. Daley	Drill hole No. 7
23	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 7 and 18	Measured Section No. 487
24	U.S. Geological Survey, 1922, Inactive Coal Lease No. Glenwood Springs 021786A, John E. Daley	Drill hole No. 6
25	Continental Oil Co.	Oil/gas well No. 1 Yost
26	Shawnee Oil Development Co.	Oil/gas well No. 3 Yost

Page 2 of 3

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
27	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 7 and 18	Measured Section Nos. 484-485, 489, 492, 495, 498, 503, 511
28	Vaughn Petroleum Co.	Oil/gas well No. 15-1 State
29	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 7	Measured Section No. 477
30	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 7 and p. 61	Measured Section No. 478
31	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 7 and 11, p. 61	Measured Section Nos. 473-475, 479
32	Hancock, 1925, U.S. Geological Survey Bulletin 757, pl. 12 and 18	Measured Section No. 274
33	↓	Measured Section No. 300

Page 3 of 3

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