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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE THE MEEKER QUADRANGLE, RIO BLANCO COUNTY, COLORADO

[Report includes 20 plates]

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

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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 Meeker quadrangle, Rio Blanco 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 Published and unpublished public information available through February, 1979, was used as the data base for this study.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 Meeker quadrangle is located in north-central Rio Blanco County in northwestern Colorado, approximately 43 miles (69 km) southwest of the town of Craig, via Colorado Highway 13 (also known as Colorado Highway 789), and 53 miles (85 km) east of the town of Rangely, via Colorado Highway 64. The town of Meeker is located in the southeast corner of the quadrangle.

Accessibility

Colorado Highway 13 passes through the town of Meeker, crossing from the east-central to the southwestern edge of the quadrangle. It connects Craig with the town of Rifle, approximately 35 miles (56 km) to the south. Colorado Highway 132 joins Colorado Highway 13 approximately 1 mile (1.6 km) east of Meeker and connects Meeker with the town of Buford, approximately 19 miles (31 m) southeast of the quadrangle. Colorado Highway 64 joins Colorado Highway 13 approximately 2 miles (3.2 km) west of Meeker and continues to the west to Rangely. A medium-duty branches to the north from Colorado Highway 64 providing access to the western half of the quadrangle. The remainder of the quadrangle is accessible by several improved light-duty roads, unimproved dirt roads and trails.

Railway service for the Meeker quadrangle area is provided by the Denver and Rio Grande Western Railroad from Denver to Rifle or from Denver to Craig. The railroad at Craig is approximately 32 miles (51 km) north-northeast of the quadrangle and the railroad at Rifle is approximately 34 miles (55 km) south of the quadrangle. These railroads serve as the major transportation routes for coal shipped east from northwestern Colorado (U.S. Bureau of Land Management, 1977).

Physiography

The Meeker quadrangle lies at the western edge of the Southern Rocky Mountain physiographic province as defined by Howard and Williams (1972). The quadrangle is approximately 28 miles (45 km) southwest of the Williams Fork Mountains, 14 miles (23 km) south-southwest of the Axial Basin, and 70 miles (113 km) southwest of the Continental Divide.

The landscape in the western part and southeastern quarter of the quadrangle is characterized by gentle slopes and wide stream valleys. The landscape in the remainder of the quadrangle is dominated by the moderate to steep slopes and narrow stream valleys or gulches of the Danforth Hills. Altitudes range from 8,197 feet (2,498 m) in the northeastern part of the quadrangle to less than 6,080 feet (1,853 m) along the White River in the southwestern part of the quadrangle.

The major drainage system in the area is the White River, which flows west across the southern part of the quadrangle. Strawberry and Sulphur Creeks, both tributaries of the White River, drain approximately the northern two thirds of the quadrangle. Both creeks flow in a south-southwesterly direction, with Sulphur Creek joining the White River just east of Meeker and Strawberry Creek flowing into the White River approximately 2 miles (3.2 km) west of the quadrangle. Sheep Creek drains the southwestern part of the quadrangle, flowing north into the White River approximately 2 miles (3.2 km) west of Meeker. Flag Creek drains the southeastern corner of the quadrangle and flows north into the White River just southwest of Meeker. With the exception of the White River, Sulphur Creek, Flag Creek and Sheep Creek, the streams in 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 Meeker quadrangle, with daily temperatures typically varying from 9° to 36° F (-13° to 2° C) in January and from 45° to 84° F (7° to 29° 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 (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 predominant vegetation in the Meeker quadrangle is sagebrush. Vegetation at higher altitudes in the northeastern corner of the quadrangle is predominately mountain shrub, including serviceberry, Gambel oak, and rabbitbrush. Pinyon, Utah juniper, and Rocky Mountain juniper grow along Lion Canyon in the central part of the quadrangle and grasses are found along the stream valleys of the White River and Strawberry Creek (U.S. Bureau of Land Management, 1977).

Land Status

The Meeker quadrangle lies on the southwestern boundary of the Danforth Hills Known Recoverable Coal Resource Area (KRCRA). Approximately 49 percent of the quadrangle lies within the KRCRA boundary and the Federal government owns the coal rights for approximately 77 percent of this area as shown of plate 2. A Preference Right Lease Application (PRLA) lies in the northeast corner of the quadrangle and comprises approximately 12 percent of the Federally-owned land within the KRCRA boundary.

GENERAL GEOLOGY

Previous Work

The first geologic description of the general area in which the Meeker 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 1910, including papers by Hewett (1889), Hills (1893), Storrs (1902), and Gale (1907 and 1910). The most comprehensive work on the area is by Hancock and Eby (1930), who included the Meeker 7 1/2-minute quadrangle in their geologic report of the Meeker 15-minute quadrangle. Tweto (1976) compiled a generalized regional geologic map which included this quadrangle.

Stratigraphy

The rock formations which crop out in the Meeker quadrangle range in age from Late Cretaceous to Eocene and include the coal-bearing Iles and Williams Fork Formations of the Mesaverde Group.

The Mancos Shale of Late Cretaceous age crops out across the southeastern third of the quadrangle (in the Agency Park area in the southeast corner of the quadrangle and along Fourmile Gulch in the east-central part of the quadrangle). The formation is composed of gray to dark-gray marine shale with interbedded ledge-forming thin-bedded sandstone and sandy shale occurring locally in the upper part of the formation (Hancock and Eby, 1930). In this quadrangle the thickness of the formation is unknown; however, in the adjacent Devils Hole Gulch quadrangle to the north, the formation is approximately 5,200 feet (1,585 m) thick where measured in the oil and gas wells drilled in that quadrangle.

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

The Iles Formation crops out in a continuous belt along the western and northern sides of Agency Park (Hancock and Eby, 1930). It consists of fine-grained, thick-bedded to massive sandstone interbedded with shaly sandstone, sandy shale, carbonaceous shale, and coal and is approximately

1,600 feet (488 m) thick where measured in the bluffs immediately west of the town of Meeker (Hancock and Eby, 1930). The "rim rock" sandstone, the basal unit of the Iles Formation, is composed of light-brown massive sandstone with thin seams of sandy shale and is approximately 70 feet (21 m) thick in this quadrangle (Hancock and Eby, 1930). The Trout Creek Sandstone Member caps the formation and consists of approximately 110 feet (34 m) of white massive sandstone (Hancock and Eby, 1930). Two coal-bearing sequences, the "lower" coal group and Black Diamond coal group (Hancock and Eby, 1930), occur in the Iles below the Trout Creek Sandstone Member in this area.

The Williams Fork Formation crops out in a north-northeast-trending band which parallels the escarpment formed by the Iles Formation along the western side of Agency Park. In this quadrangle the formation is approximately 4,500 feet (1,372 m) thick, but it is as much as 5,050 feet (1,539 m) thick in the Devils Hole Gulch quadrangle to the north (Hancock and Eby, 1930). 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 is approximately 2,900 feet (884 m) thick in the quadrangle. It consists of interbedded sandstone, shale, sandy shale, carbonaceous shale, and coal. Two coal groups, the Fairfield Coal Group and the Goff Coal Group, occur in this unit (Hancock and Eby, 1930).

The Lion Canyon Sandstone Member is a light-yellowish-brown thick-bedded sandstone and is estimated to be at least 100 feet (30 m) thick in the quadrangle (Hancock and Eby, 1930).

The upper unit of the Williams Fork Formation, which may be equivalent to the Lance Formation (Pipiringos and Rosenlund, 1977), is approximately 1,500 feet (457 m) thick and consists of a series of yellowish-brown to white massive shaly sandstone, brown to black sandy carbonaceous shale, and coal beds. Coal beds in this unit have been designated the Lion Canyon coal group by Hancock and Eby (1930).

The Wasatch Formation of Eocene age unconformably overlies the Williams Fork Formation and crops out in the western third of the quadrangle. It consists mainly of a lower unit of sandstone and sandy shale with local layers and lenses of conglomerate and an upper unit of variegated shale (Hancock and Eby, 1930). Hancock and Eby measured 4,180 feet (1,274 m) of Wasatch Formation in this quadrangle, but did not include the shales that underlie the Green River Formation in their measurement. Therefore, the total thickness of the formation in this quadrangle is unknown.

Holocene and Pleistocene deposits of alluvium cover the stream valleys throughout the quadrangle.

The Cretaceous sedimentary rocks in the 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 Meeker 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, 1979; Kucera, 1959).

The interbedded sandstone, shale, and coal of the Iles and Williams Fork Formations 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 in the area. The major sandstone beds in the Iles and Williams Fork Formations, including the "rim rock" sandstone, and the 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 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).

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, 1979).

Structure

The Danforth Hills KRCRA lies in the northern part of the Piceance structural basin of west-central Colorado (Howard and Williams, 1972). The Danforth Hills area is bordered on the northeast by the Axial Basin anticline and on the west by the Yampa Plateau (Grose, 1972). The Meeker quadrangle is approximately 10 miles (16 km) southwest of the Axial Basin anticline and approximately 31 miles (50 km) southeast of the Yampa Plateau.

The Meeker quadrangle lies on the Grand Hogback monocline which trends north through the center of the quadrangle. Two northwest-trending faults cut the monocline in the north-central part of the quadrangle. The western end of the east-trending Sulphur Creek syncline lies at the north-central edge of the quadrangle (Hancock and Eby, 1930).

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 by Hancock and Eby (1930) and it is assumed that the structure of the coal beds nearly duplicates that of the Trout Creek Sandstone Member. Modifications were made where necessary in accordance with outcrop data.

COAL GEOLOGY

Numerous coal beds in the Iles and Williams Fork Formations have been identified in outcrops in the Meeker area. Coal beds in the Iles Formation are confined in two groups: the "lower" coal group contains thin coal beds between 100 and 250 feet (30 and 76 m) above the base of the formation, and the Black Diamond coal group includes all coal beds within the interval from 150 to 350 feet (46 to 107 m) below the top of the Trout Creek Sandstone Member (Hancock and Eby, 1930). Coal beds exceeding Reserve Base thickness (5.0 feet or 1.5 meters) have not been identified in the lower coal group in this quadrangle.

According to Hancock and Eby (1930), coal beds in the Williams Fork Formation occur in the Fairfield, Goff, and Lion Canyon coal groups. The Fairfield coal group includes the coal beds that occur in the basal 1,300 feet (396 m) of the formation. The Goff coal group generally includes the coal beds in the 700 feet (213 m) of coal-bearing strata below the Lion Canyon Sandstone Member, and the Lion Canyon coal group contains all coal beds in the 1,000 feet (305 m) of the Williams Fork Formation above the Lion Canyon Sandstone Member.

Chemical analyses of coals.--Analyses of the coals in this area are listed in table 1 and include those from the Black Diamond, Fairfield, and Lion Canyon coal groups. Analyses were not available for any coal beds in the Goff coal group. However, the analysis from the Cornrike mine in the Ninemile Gap quadrangle is believed to be representative of the Goff coals in the Meeker quadrangle. In general, the analyses indicate that the coals in the Black Diamond, Fairfield, Goff, and Lion Canyon coal groups are 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).

Coal beds exceeding Reserve Base thickness in the Iles and Williams Fork Formations have been given bracketed numbers for identification purposes in this quadrangle only. In instances where coal beds have been identified at one location only and cannot be correlated with other coal beds, they are treated as isolated data points (see Isolated Data Points section of this report).

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.

Black Diamond Coal Group

Three coal beds in the Black Diamond Coal Group exceed Reserve Base thickness in the Meeker quadrangle. Of these, only the Pollard coal bed was isopached; the remaining beds, the Sulphur Creek and Wilson coal beds, were treated as isolated data points.

Pollard Coal Bed

The Pollard coal bed (Hancock and Eby, 1930)) crops out in the central part of the quadrangle and dips from approximately 13° to 63° to the west as shown on plate 4. It ranges in thickness from 3.7 to more than 14.0 feet (1.1 to more than 4.3 m) where measured at isolated outcrops and mine-measured sections. Rock partings ranging from 1.0 to 2.2 feet (0.3 to 0.7 m) in thickness occur locally. Two northwest-trending faults cut the coal bed near the central part of the quadrangle.

Fairfield Coal Group

Twelve coal beds exceeding Reserve Base thickness in the Fairfield coal group have been identified in the quadrangle. Only three of these coal beds, the Major, Fairfield [1], and Fairfield No. 1, were isopached. The nine remaining coal beds, including the Fairfield No. 2, Agency, Fairfield [2], [3], [4], [5], [6], [7], and [8] coal beds were treated as isolated data points. The Fairfield No. 2 coal bed was identified at two locations, approximately 5 miles (8 km) apart, and each measurement was treated as an isolated data point.

Major Coal Bed

The Major coal bed (plate 7) is named after the Major mine in sec. 28, T. 1 N., R. 94. (Hancock and Eby, 1930). It has been identified at many isolated outcrops from the northeastern part to the southwestern part of the quadrangle. The coal bed dips from approximately 16° to 68° west-northwest and is cut by two northwest-trending faults near the central part of the quadrangle. The coal bed ranges in measured thickness from 3.3 to 13.3 feet (1.0 to 4.1 m), attaining its maximum thickness in sec. 28, T. 1 N., R. 94 W., where it was mined in the Major mine. Rock partings ranging from 0.2 to 1.5 feet (0.1 to 0.5 m) in thickness occur locally.

Fairfield [1] Coal Bed

The Fairfield [1] coal bed (plate 10) exceeds Reserve Base thickness over small areas in secs. 35 and 36, T. 2 N., R. 94 W., where it ranges in thickness from 3.9 to 7.7 feet (1.2 to 2.3 m). The coal bed is lenticular and is not known to contain any rock partings. The coal bed dips at an average of about 21° northwest.

Fairfield No. 1 Coal Bed

The Fairfield No. 1 coal bed (plate 13) was named by Hancock and Eby (1920) after the Fairfield No. 1 mine in sec. 28, T. 1 N., R. 94 W. The coal bed dips in a west-northwesterly direction from approximately 18° to 68° and is cut by two northwest-trending faults near the central part of the quadrangle. The coal bed exceeds Reserve Base thickness in two areas. In one area, north of the northernmost fault in the northeastern part of the quadrangle, the coal bed ranges in thickness from 19.0 to 24.1 feet (5.8 to 7.3 m) where measured in two outcrops. A rock parting 2.8 feet (0.9 m) thick was reported in one of the outcrop measurements. The second area lies in the south-central part of the quadrangle where the coal bed ranges in thickness from 2.6 to 19.0 feet (0.8 to 5.8 m) and contains rock partings 2.1 feet (0.6 m) thick at two locations.

Goff Coal Group

Coal beds in the Goff coal group crop out in the north-central and southwestern parts of the quadrangle (Hancock and Eby, 1930). The Goff[9] coal bed is the only coal bed in this group that is known to exceed Reserve Base thickness in the Meeker quadrangle.

Goff [9] Coal Bed

The Goff [9] coal bed (plate 10) dips to the northwest at about 14° to 19° and is cut by a northwest-trending fault. Northeast of the fault the coal bed is 3.6 feet (1.1 m) thick where measured at one location. Southwest of the fault, the coal bed ranges in thickness from 4.8 to 7.1 feet (1.5 to 2.2 m) where measured at two outcrop locations. Rock partings 0.2 to 0.3 feet (0.1 m) thick were reported in the outcrop measurements.

Lion Canyon Coal Group

Six coal beds in the Lion Canyon coal group exceed Reserve Base thickness in the Meeker quadrangle. Four of the coal beds, the Grinsted, Montgomery, Lion Canyon [11] and [13], were isopached. Two other coal beds, the Lion Canyon [10] and [12], were each identified at one location only and they have been treated as isolated data points.

Grinsted Coal Bed

The Grinsted coal bed (plate 16) has been identified in many isolated outcrops in the western half of the quadrangle, and it is named after the Grinsted prospect located in NE 1/4 sec. 32, T. 1 N., R. 94 W. (Hancock and Eby, 1930). The coal bed dips from about 27° to 51° to the west-northwest and is cut by two northwest-trending faults near the central part of the quadrangle. The thickness of the coal bed ranges from 4.6 to 10.5 feet (1.4 to 3.2 m), with rock partings from 0.4 to 0.8 feet (0.1 to 0.2 m) thick occuring locally.

Montgomery Coal Bed

The Montgomery coal bed (plate 4) ranges from 6.0 to 8.5 feet (1.8 to 2.6 m) thick where measured at two locations in the southwestern part of the quadrangle. The maximum reported thickness occurs in the Montgomery mine in sec. 29, T. 1 N., R. 94 W., and the coal bed has been named after the mine (Hancock and Eby, 1930). The dip of the coal bed ranges from approximately 29° to 51° to the west.

Lion Canyon [11] Coal Bed

The Lion Canyon [11] coal bed (plate 7) is 2.7 and 6.3 feet (0.8 and 1.9 m) where measured at two locations along the outcrop. This coal bed exceeds Reserve Base thickness over only a small area in secs. 20 and 29, T. 1 N., R. 94 W., and dips to the west from about 36° to 40°.

Lion Canyon [13] Coal Bed

The Lion Canyon [13] coal bed (plate 10) is 6.0 feet (1.8 m) thick where measured in one outcrop and in the Lion Canyon mine in sec. 29, T. 1 N., R. 94 W. The coal bed dips to the west at an average of about 38° to 40°.

Isolated Data Points

In instances where single or 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 they can be reasonably projected in any direction and usually precludes correlations with other, better known beds. For this reason, isolated data point maps are included on a separate sheet (in U.S. Geological Survey files) for non-isopached coal beds. Because of the extreme lenticularity of the coal beds in this quadrangle, it is assumed that these coal beds maintain their measured thickness for only 1,000 feet (305 m) in all directions from their points of measurement. Descriptions and Reserve Base tonnages for the isolated data points occurring in this quadrangle are listed in table 5.

COAL RESOURCES

Data from mine measured sections and outcrop measurements (Hancock and Eby, 1930) were used to construct outcrop, isopach, and structure contour maps of the coal beds in this quadrangle. The source of each indexed data point shown on plate 1 is listed in table 6.

Coal resources for Federal land were calculated using data obtained from the coal isopach maps (plates 4, 7, 10, 13, and 16) and the areal distribution and identified resources maps (plates 6, 9, 12, 15, and 18). The coal bed acreage (measured by planimeter), multiplied by the average thickness of the coal bed and by a conversion factor of 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 thicker than 5 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) and a maximum depth of 1,000 feet (305 m) for bituminous coal.

Reserve Base and Reserve tonnages for the isopached coal beds are shown on plates 6, 9, 12, 15, and 18, 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 187.27 million short tons (169.89 million metric tons) for the entire quadrangle, including the tonnages for the isolated data points.

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 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 below:

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

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 2.19 million short tons (1.99 million metric tons) of coal available for surface mining.

The coal development potential for surface mining methods is shown on plate 19. Of those Federal land areas having a known development potential for surface mining, 90 are rated high, 4 percent are rated moderate, and 6 percent are rated low. The remaining Federal lands within the KRCRA boundary are classified as having unknown development potential for surface mining methods. Reserve Base tonnages in the various development potential categories for surface mining methods are listed in table 2.

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 the coal beds are between 200 and 3,000 feet (61 and 914 m) below the ground surface and 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 a development potential for in-situ mining methods.

Areas of high, moderate, and low development potential for conventional 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. This applies to the areas where coal beds of Reserve Base thickness are not known, but may occur, and to those areas influenced by isolated data points. The areas influenced by isolated data points in this quadrangle contain approximately 0.46 million short tons (0.42 mllion metric tons) of coal available for conventional subsurface mining.

The coal development potential for conventional subsurface mining methods is shown on plate 20. Of the Federal land areas having known development potential for conventional subsurface mining methods, 38 percent are rated high and 62 percent are rated moderate. The remaining Federal lands within the KRCRA boundary are classified as having unknown development potentials for conventional subsurface mining methods. Reserve Base tonnages in the various development potential categories for conventional subsurface mining methods are listed in table 3.

Based on criteria provided by the U.S. Geological Survey, coal beds of Reserve Base thickness dipping between 35° and 90° with a minimum Reserve Base of 50 million short tons (45.4 million metric tons) of bituminous coal have a moderate potential for in-situ development; coal beds dipping from 15° to 35°, regardless of tonnage, and coal beds dipping from 35° to 90° with less than 50 million short tons (45.4 million metric tons) of coal have a low development potential for in-situ mining methods. Coal lying between the 200-foot (61 m) overburden line and the outcrop is not included in the total coal tonnages available as it is needed for cover and containment in the in-situ process.

Areas where faulted coal beds of Reserve Base thickness dip greater than 15° between 200 and 3,000 feet (61 and 914 m) below the ground surface are classified as having an unknown development potential for in-situ mining methods. These criteria also apply to those areas influenced by isolated data points where the coal beds are not faulted. The areas influenced by isolated data points in this quadrangle contain approximately 5.53 million short tons (5.02 million metric tons) of coal available for in-situ mining.

Coal development potential for in-situ mining methods is shown on plate 20. All of the Federal land areas classified as having known development potential for in-situ mining methods are rated low. The remaining Federal lands within the KRCRA boundary are classified as having unknown development potential for in-situ mining methods. Reserve Base tonnages in the various development potential categories for in-situ mining methods are listed in table 4.

Table 1. -- Chemical analyses of coals in the Meeker quadrangle, Rio Blanco 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
SW¼ sec. 3, T. 1 N.,	Sulphur Creek	A	10.4	36.6	44.7	8.3	0.59	-	-	-	-	-	11,260
R. 94 W., Sulphur Creek Mine	(Black Diamond	B	8.1	37.5	45.9	8.5	0.60	-	-	-	-	-	11,550
(Hancock and Eby, 1930)	coal group)	C	-	40.8	49.9	9.3	0.66	-	-	-	-	-	12,570
NE¼ sec. 15, T. 1 N.,	Black Diamond	A	10.8	37.2	44.0	8.0	0.49	-	-	-	-	-	11,220
R. 94 W., Black Diamond Mine	coal group	B	8.5	38.2	45.1	8.2	0.50	-	-	-	-	-	11,510
(Hancock and Eby, 1930)		C	-	41.8	49.3	8.9	0.55	-	-	-	-	-	12,580
SW¼ sec. 28, T. 1 N.,	Fairfield No. 1	A	9.4	38.0	45.4	7.2	0.75	-	-	-	-	-	11,320
R. 94 W., Fairfield No. 1	(Fairfield coal	B	7.2	38.9	46.5	7.4	0.76	-	-	-	-	-	11,600
(Hancock and Eby, 1930)	group)	C	-	40.9	50.1	8.0	0.83	-	-	-	-	-	12,500
SW¼ sec. 10, T. 2 N.,	Cornrike	A	13.9	42.0	41.9	2.2	0.28	-	-	-	-	-	11,270
R. 93 W., Cornrike Mine	(Goff coal	B	10.6	43.6	43.5	2.3	0.29	-	-	-	-	-	11,700
(Hancock and Eby, 1930) from Ninemile Gap quadrangle	group)	C	-	48.8	48.6	2.6	0.33	-	-	-	-	-	13,000
NW¼ sec. 29, T. 1 N.,	Lion Canyon	A	12.4	38.6	42.9	6.1	0.71	-	-	-	-	-	10,790
R. 94 W., Montgomery Mine	coal group	B	10.6	39.4	43.7	6.3	0.72	-	-	-	-	-	11,010
(Hancock and Eby, 1930)		C	-	44.1	48.9	7.0	0.81	-	-	-	-	-	12,320

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 Meeker quadrangle, Rio Blanco County, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Lion Canyon {13}	20,000	30,000	70,000	-	120,000
Lion Canyon {11}	10,000	20,000	60,000	-	90,000
Montgomery	10,000	10,000	20,000	-	40,000
Grinsted	990,000	1,110,000	1,260,000	-	3,360,000
Goff {9}	30,000	30,000	120,000	-	180,000
Fairfield {1}	40,000	50,000	80,000	-	170,000
Fairfield No. 1	3,740,000	590,000	170,000	-	4,500,000
Major	910,000	890,000	1,410,000	-	3,210,000
Pollard	650,000	770,000	960,000	-	2,380,000
Isolated Data Points	-	-	-	2,190,000	2,190,000
Totals	6,400,000	3,500,000	4,150,000	2,190,000	16,240,000

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 Meeker quadrangle, Rio Blanco County, Colorado.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Goff {9}	110,000	-	-	-	110,000
Fairfield No. 1	10,000	400,000	-	-	410,000
Major	130,000	30,000	-	-	160,000
Pollard	-	3,750,000	130,000	-	3,880,000
Isolated Data Points	-	-	-	460,000	460,000
Totals	250,000	4,180,000	130,000	460,000	5,020,000

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

Table 4. -- Coal Reserve Base data for in-situ mining methods for Federal coal lands (in short tons) in the Meeker quadrangle, Rio Blanco County, Colorado.

Coal Bed or Zone	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Lion Canyon {13}	390,000	180,000	-	570,000
Lion Canyon {11}	-	110,000	-	110,000
Montgomery	-	1,180,000	-	1,180,000
Grinsted	44,200,000	140,000	-	44,340,000
Goff {9}	-	230,000	-	230,000
Fairfield {1}	-	160,000	-	160,000
Fairfield No. 1	8,440,000	34,640,000	-	43,080,000
Major	10,320,000	21,680,000	-	32,000,000
Pollard	9,890,000	28,920,000	-	38,810,000
Isolated Data Points	-	-	5,530,000	5,530,000
Totals	74,530,000	85,950,000	5,530,000	166,010,000

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

Table 5.--Descriptions and Reserve Base tonnages (in million short tons) for isolated data points

				Reserve Base Tonnages		
Coal Bed	Source	Location	Thickness	Surface	Subsurface	In-Situ
Sulphur Creek	Hancock and Eby (1930)	sec. 3, T. 1 N., R. 94 W.	6.6 ft (2.0 m)	0.07	0	0
Wilson	Hancock and Eby (1930)	sec. 15, T. 1 N., R. 94 W.	5.5 ft (1.7 m)	0.13	0	0.22
Fairfield[2]	Hancock and Eby (1930)	sec. 3, T. 1 N., R. 94 W.	6.0 ft (1.8 m)	0.16	0	0.27
Fairfield[3]	Hancock and Eby (1930)	sec. 10, T. 1 N., R. 94 W.	7.6 ft (2.3 m)	0.15	0	0.40
Fairfield[4]	Hancock and Eby (1930)	sec. 10, T. 1 N., R. 94 W.	15.3 ft (4.7 m)	0.30	0	0.88
Fairfield[5]	Hancock and Eby (1930)	sec. 10, T. 1 N., R. 94 W.	16.0 ft (4.9 m)	0.31	0	0.91
Fairfield[6]	Hancock and Eby (1930)	sec. 3, T. 1 N., R. 94 W.	5.5 ft (1.7 m)	0.06	0	0.15
Fairfield[7]	Hancock and Eby (1930)	sec. 3, T. 1 N., R. 94 W.	6.8 ft (2.1 m)	0.03	0	0.21
Fairfield[8]	Hancock and Eby (1930)	sec. 3, T. 1 N., R. 94 W.	16.0+ ft (4.9+ m)	0.43	0	1.12
Fairfield No. 2	Hancock and Eby (1930)	sec. 28, T. 1 N., R. 94 W.	8.0 ft (2.4 m)	0.01	0	0.24
	Hancock and Eby (1930)	sec. 3, T. 1 N., R. 94 W.	6.8 ft (2.1 m)	0.16	0	0.31
Agency	Hancock and Eby (1930)	sec. 29, T. 1 N., R. 94 W.	6.0 ft (1.8 m)	0.14	0	0.50

NOTE: To convert short tons into metric tons, multiply short tons by 0.9072

Table 5.--Continued

				Reserve Base Tonnages		
Coal Bed	Source	Location	Thickness	Surface	Subsurface	In-Situ
Lion Canyon[10]	Hancock and Eby (1930)	sec. 32, T. 1 N., R. 94 W.	9.5 ft (2.9 m)	0.11	0.46	0
Lion Canyon[12]	Hancock and Eby (1930)	sec. 27, T. 2 N., R. 94 W.	6.2 ft (1.9 m)	0.13	0	0.32

Table 6. -- Sources of data used on plate 1

Plate 1 Index Number	Source	Data Base
1	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 24 and 26	Mine-Measured Section No. 74
2	↓	Mine-Measured Section No. 32, Sulfur Creek Mine
3		Measured Section No. 35
4		Composite Section Nos. 83-84
5		Measured Section No. 122
6		Measured Section No. 106
7		Measured Section No. 71
8		Measured Section No. 72
9		Composite Section Nos. 67-70
10		Measured Section No. 27
11		Composite Section Nos. 59-62
12		Composite Section Nos. 63-66
13		Measured Section No. 25
14		Measured Section No. 58
15		Measured Section No. 13
16		Composite Section Nos. 54-56
17		Composite Section Nos. 103-105

Table 6. -- Continued

Plate 1 Index Number	Source	Data Base
18	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 24 and 26	Measured Section No. 12
19	↓	Measured Section No. 76
20	↓	Composite Section Nos. 36-43
21	↓	Composite Section Nos. 100-102
22	↓	Composite Section Nos. 96-99
23	↓	Composite Section Nos. 89-92
24	↓	Measured Section No. 94
25	↓	Measured Section No. 88
26	↓	Measured Section No. 86
27	Hancock and Eby, 1930, U.S. Geological Surey Bulletin 812-C, pl. 24 and 27	Composite Section Nos. 218-225
28	↓	Composite Section Nos. 213-217
29	↓	Composite Section Nos. 206-212
30	↓	Composite Sections Nos. 194-200
31	↓	Composite Section Nos. 201-205
32	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 24 and 26	Composite Section Nos. 79-82

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Table 6. -- Continued

Plate 1 Index Number	Source	Data Base
33	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 24 and 27	Measured Section No. 138
34	↓	Measured Section No. 137
35	↓	Composite Section Nos. 140-142
36	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 24 and 26	Composite Section Nos. 47-51
37	↓	Measured Section No. 95
38	↓	Measured Section No. 73
39	↓	Measured Section No. 75
40	↓	Measured Section No. 33
41	↓	Measured Section No. 77
42	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 26	Measured Section No. 77a
43	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 24 and 26	Measured Section No. 24
44	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 24 and 27	Composite Section Nos. 129-131
45	↓	Composite Section Nos. 226-234
46	↓	Composite Section Nos. 235-237
47	↓	Composite Section Nos. 186-188

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Table 6. -- Continued

Plate 1 Index Number	Source	Data Base
48	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 24 and 27	Composite Section Nos. 189-191
49	↓	Composite Section Nos. 192-193
50	↓	Composite Section Nos. 183-185
51	Hancock and Eby, 1930, U.S. Geological Survey Bulletin 812-C, pl. 24 and 26	Composite Section Nos. 123-125
52	↓	Measured Section No. 44
53	↓	Composite Section Nos. 114-118

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