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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE CRAIG NE QUADRANGLE, MOFFAT COUNTY, COLORADO

[Report includes 7 plates]

Prepared for

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GEOLOGICAL SURVEY

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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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Purpose

This text is to be used in conjunction with Coal Resource Occurrence and Coal Development Potential Maps of the Craig NE 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 14-08-001-15789. The resource information gathered for this report is in response to the Federal Coal Leasing Amendments Act of 1976 (P.L. 94-377). Published and unpublished public information was used as the data base for this study. No new drilling or field mapping was performed as part of this study, nor was any confidential data used.

Location

The Craig NE quadrangle is located in east-central Moffat County in northwestern Colorado. The quadrangle is 10 miles (16.1 km) north of the town of Craig, Colorado via a light-duty, all-weather road and 15 miles (24.1 km) from Craig via Colorado Highway 13 (also Colorado Highway 789). The quadrangle is very sparsely populated.

Accessibility

Colorado Highway 13 crosses the northeastern corner of the Craig NE quadrangle. A light-duty, all-weather road runs south from Colorado Highway 13 and provides access to the southeastern quarter of the quadrangle. Another light-duty, all-weather road cutting the southwestern corner of the quadrangle runs south for 8 miles (12.9 km) and meets U.S. Highway 40 approximately 2 miles (3.2 km) west of Craig. Numerous unimproved dirt roads provide access to the remainder of the quadrangle.

Physiography

The Craig NE quadrangle lies in the southern part of the Wyoming Basin physiographic province as defined by Howard and Williams (1972). The quadrangle is approximately 13 miles (20.9 km) north of the Williams Fork Mountains and 36 miles (57.9 km) west of the Park Range which forms the Continental Divide in northwestern Colorado.

Approximately 1,120 feet (341 m) of relief is present in the Craig NE quadrangle. Altitudes range from 7,560+ feet (2,304+ m) on a plateau in the extreme northeastern corner of the quadrangle to approximately 6,440 feet (1,963 m) near the confluence of Fortification and Blue Gravel Creeks on the east-central edge of the quadrangle.

The landscape of the quadrangle is divided into two distinct terrains. In the northeastern corner, to the north and east of Colorado Highway 13, steep slopes cut by narrow gulches flank the edge of a prominent plateau. The remainder of the quadrangle consists of a broad hilly terrain dissected by intermittent streams and a few creeks. Wide alluvial plains occur along the major creeks and in many places streams have been dammed to create small ponds.

The Craig NE quadrangle is drained by Fortification Creek and its tributaries, Blue Gravel and Little Cottonwood Creeks. Numerous intermittent streams feed these creeks and comprise a deridritic drainage pattern. Blue Gravel Creek, an intermittent stream, flows from west to east and meets Fortification Creek on the east-central edge of the quadrangle. Little Cottonwood Creek flows south of the plateau which is in the northeast corner of the quadrangle and joins Fortification Creek in the vicinity of its confluence with Blue Gravel Creek. Fortification Creek then flows south and drains into the Yampa River.

Climate and Vegetation

The climate of northwestern Colorado is semiarid. Clear, sunny days prevail in the Craig NE area with daily temperatures varying from 46° to 84°F (8° to 29°C) in July to 0° to 32°F (-18° to 0°C) in January. Annual precipitation in the Craig area averages 16 inches (40 cm), most of which occurs as snowfall during the winter months. However, rainfall from thundershowers during summer months also contributes to the total. In general winds blow from the southwest, although wind directions may be modified by local topography (U.S. Bureau of Land Management, 1977).

Mountain shrubbery and deciduous trees grow along and upon the plateau which is located in the northeastern corner of the quadrangle. Sagebrush is the principal vegetation throughout the remainder of the Craig NE quadrangle. However, scattered stands of deciduous trees occur locally and crops are grown along the valley floor of Fortification Creek (U.S. Bureau of Land Management, 1977).

Land Status

The Craig NE quadrangle lies on the north-central boundary of the Yampa Known Recoverable Coal Resource Area (KRCRA). Approximately 25 percent of the quadrangle lies within the KRCRA boundary, and the Federal Federal government owns the coal rights for approximately 75 percent of this area. The coal ownership status of land within the KRCRA boundary is shown on plate 2. No outstanding coal leases, prospecting permits, licenses, or preference right lease applications are located within the KRCRA in this quadrangle.

GENERAL GEOLOGY

Previous Work

The first geologic description of the general area in which the Craig NE quadrangle is located was published by Emmons (1877) as part of the Survey of the Fortieth Parallel. C. A. White compiled topographic and geologic maps of northwestern Colorado (1878 and 1889) and was the first geologist to note the extensive coal deposits in the Yampa and Danforth Hills area. 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). A more recent geologic investigation of the region to the east of this quadrangle was conducted by Bass and others (1955). The most recent and most comprehensive geologic map of the Craig NE area is by Tweto (1976).

Stratigraphy

The lowermost formation recognized as occurring at reasonable depths for mining of coal in the Craig NE quadrangle is the non-coal-bearing Upper Cretaceous-age Lewis Shale which consists of approximately 2,500 feet (762 m) of dark-gray to bluish marine shale.

The Fox Hills Sandstone of Upper Cretaceous age conformably overlies the Lewis Shale and is composed of approximately 300 feet (91 m) of massive white to gray sandstone interbedded with marine shales. A few thin coal beds are known to occur in the Fox Hills Sandstone in northwestern Colorado (Dobbin and Reeside, 1930).

The coal-bearing Lance Formation of Upper Cretaceous age conformably overlies the Fox Hills Sandstone and is the youngest Upper Cretaceous unit in the Yampa KRCRA. Approximately 650 feet (198 m) of Lance Formation is penetrated by drill holes in the Craig NE quadrangle. Drill hole geophysical logs indicate that this formation is composed of thick-bedded sandstones, shale, and minor coal. According to Masters (1959), the Lance Formation is comprised of a lower marine sandstone member, an overlying brackish and fresh-water coal-bearing member, and an upper fluvial member. The lower marine sandstone member described by Masters (1959) is equivalent to the Fox Hills Sandstone described above, and the middle and upper members correspond with the Lance Formation proper as portrayed by Dobbin and Reeside (1930).

A short-lived period of erosion preceded the deposition of the Paleocene-age Fort Union Formation which overlies the Lance Formation. This formation is approximately 1,450 feet (442 m) thick and is composed of brown, medium- to coarse-grained, immature sandstone interbedded with light-gray silty shale and lenticular coals. An arkosic conglomerate occurs at the base of the formation directly above the Cretaceous-Paleocene unconformity.

Approximately 750 feet (229 m) of the Wasatch Formation of Eocene age unconformably overlie the Fort Union Formation in the Craig NE quadrangle. The Wasatch Formation consists of conglomerate interbedded with brown to pink sandstone, mudstone, and claystone. The Wasatch Formation is not known to contain coal in the Yampa KRCRA.

The Upper Cretaceous-age rocks of the Yampa KRCRA 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 resulted in the deposition of a series of marine, near-shore marine, and non-marine sediments in the Craig NE quadrangle. The Fox Hills Sandstone, and Lance Formation were deposited during the final regression of the Cretaceous sea. Fine-grained silts and clays settled in an off-shore marine environment to form the Lewis Shale. As the sea retreated toward the east and north, the Fox Hills Sandstone was deposited over the Lewis Shale in a littoral and near-shore environment. In turn, the lower part of the Lance Formation was deposited in a tidal and supratidal zone and the upper part in a fluvial environment.

After a minor period of erosion, the Paleocene-age Fort Union Formation was deposited in fluvial and lacustrine environments in humid and swampy intermountain basins. During Paleocene time the Craig NE area was situated in a basin between two north-south-trending Larimide uplifts including the Park Range, 36 miles (57.9 km) to the east of the quadrangle. Erosion of the Park Range supplied the Precambrian, Paleozoic, and mesozoic detrital materials which now constitute the conglomerate, shales, and immature sandstones of the Fort Union Formation.

Erosion preceded the deposition of the sandstones, mudstones, and conglomerates of the Eocene-age Wasatch Formation which were formed as the result of fluvial action in a terrestrial environment.

Structure

The Craig NE quadrangle lies in the southern extension of the Washakie/Sand Wash structural basin of south-central Wyoming. In the Craig area the basin is bordered on the south by the Axial Basin Anticline and on the east by the Park Range, a Larimide uplift of Late Cretaceous and early Paleocene age.

COAL GEOLOGY

Coal beds belonging to the Lance and Fort Union Formations have been identified in the Craig NE quadrangle. In the Craig NE area coals of the Lance and Fort Union Formations are characteristally lenticular and of limited areal extent and are thought to have been deposited in a fluvial environment. In the Lay area approximately 10 miles (16.1 km) to the west, a few Fort Union coals extend over an area of several tens of square miles and are thought to have been deposited in lowland swamps which were down paleoslope from the fluvial environment of the Craig NE area. Coal beds identified in this quadrangle have not been formally named but have been numbered with bracketed numbers for identification purposes in this quadrangle only.

Lance Coal Beds

One coal bed of the Lance Formation has been identified in a drill hole in the southeast quarter of the Craig NE quadrangle, where it is 4.0 feet (1.2 m) thick at a depth of 2,668 feet (813 m). This coal bed does not occur in a drill hole located only 0.5 miles (0.8 km) northwest of its point of measurement. Coal beds of the Lance Formation are characteristically of subbituminous rank in the Yampa KRCRA (Bass and others, 1955).

Fort Union Coal Beds

Several coal beds of the Fort Union Formation have been identified in drill holes in the southern third of the Craig NE quadrangle. Two of these beds, numbered FU[1] and FU[2], are known to equal or exceed Reserve Base thickness (5.0 feet or 1.5 meters). No chemical analyses are available on the Fort Union coal beds identified in this quadrangle.

However, an analysis of Fort Union coal from the Seick mine in the adjacent Pine Ridge quadrangle to the southwest (Fieldner and others, 1937) is shown in table 1 and indicates that the coal ranks subbituminous B on a moist, mineral-matter-free basis (ASTM, 1977). According to Bass and others (1955), the Fort Union coals of the Yampa area are characteristically subbituminous in rank.

Fort Union [1] Coal Bed

The FU[1] coal bed has been identified in two drill holes in the southwestern quarter of this quadrangle where it measures 4 and 5 feet (1.2 and 1.5 m) thick. This coal bed is approximately 600 feet (183 m) stratigraphically above the base of the Fort Union Formation. It has also been identified in a drill hole in the southeast quarter of the adjacent Craig NW quadrangle where it is 6.0 feet (1.8 m) thick. As calculated from plate 4 the FU[1] coal bed dips between 2° and 3° towards the north.

Fort Union [2] Coal Bed

The FU[2] coal bed has been identified in two drill holes in the southeast quarter of the Craig NE quadrangle where it measures 4 and 11 feet (1.2 and 3.4 m) thick and occurs approximately 600 feet (183 m) stratigraphically above the base of the Fort Union Formation. This bed has also been identified in a drill hole in the southwest quarter of the adjacent McInturf Mesa quadrangle to the east where it is 3.0 feet (0.9 m) thick. The FU[2] coal bed dips approximately 3° toward the northeast as calculated from plate 4.

COAL RESOURCES

Data from drill holes and from Bass and others (1955) were used to construct outcrop, isopach, and structure contour maps of the FU[1] and FU[2] coal beds. The source of each indexed data point shown on plate 1 is listed in table 3.

Coal resources of the FU[1] and FU[2] coal beds where they are greater than Reserve Base thickness (5.0 feet or 1.5 meters) were calculated using data obtained from the coal isopach maps on plate 4. The coal bed acreage (measured by planimeter) multiplied by the average isopached thickness of the coal bed, and by a conversion factor of 1,700 short tons of coal per acre-foot (13,018 metric tons per hectare-meter) for subbituminous coal, yields the coal resources in short tons (metric tons) for each isopached coal bed. Reserve Base and Reserve tonnages for the FU[1] and FU[2] coal beds are shown on plate 6 and are rounded to the nearest 10,000 short tons (9,072 metric tons).

Reserve Base tonnages are calculated for coal beds that lie less than 3,000 feet (914 m) below the ground surface and exceed 5.0 feet (1.5 m) in thickness. These criteria differ from those used in calculating Reserve Base and Reserve tonnages as described in U.S. Geological Survey Bulletin 1450-B, which calls for a maximum depth of 1,000 feet (305 m) for subbituminous coal. Total coal Reserve Base per Federal section are shown on plate 2 and total approximately 4,540,000 short tons (4,119,000 metric tons) for all Federal land within the KRCRA boundaries in this quadrangle. Reserve Base tonnages in the various development potential categories for subsurface mining methods are shown in table 2.

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

COAL DEVELOPMENT POTENTIAL

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

(2 ha) within a parcel meet criteria for a high development potential, 25 acres (10 ha) a moderate development potential, and 10 acres (4 ha) a low development potential, then the entire 40 acres (16 ha) are assigned a high development potential.

Development Potential for Surface Mining Methods

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

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

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 with high, moderate, or low development potential for surface mining methods have not been identified in the Craig NE quadrangle. An unknown develpment potential has been assigned to areas that are underlain by coal-bearing formations but for which coal data is either absent or does not comply with the development potential criteria established for surface mining methods by the U.S. Geological Survey. All Federal coal land within the KRCRA in the Craig NE quadrangle is classified as having unknown development potential for surface mining methods.

Development Potential for Subsurface and In-Situ Mining Methods

The coal development potential for subsurface mining methods is shown on plate 7. Areas of high, moderate, or low development potential for conventional subsurface mining are defined as areas underlain by coal beds of Reserve Base thickness which dip at 15° or less that occur at depths ranging from 200 feet to 1,000 feet (61 m to 305 m), 1,000 feet to 2,000 feet (305 m to 610 m), and 2,000 feet to 3,000 feet (610 m to 914 m) below the ground surface, respectively. Coal beds lying between 200 feet (61 m) and 3,000 feet (914 m) below the ground surface, dipping greater than 15°, are subject to in-situ mining methods.

Of the Federal land areas classified as having known development potential for subsurface mining methods, 20 percent are rated high , 35 percent are rated moderate, and 45 percent are rated low. The remaining Federal coal lands are classified as having unknown development potential, implying that no known coal beds 5 feet (1.5 m) or more thick occur at depths ranging from 200 feet to 3,000 feet (61 m to 914 m) below the ground surface but that coal-bearing units are present.

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

TABLE 1 -- Chemical analysis of coal in the Craig NE 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
SE¼ NE¼ sec. 2, T. 7 N., R. 92 W., Seick Mine, Pine Ridge quadrangle (Fieldner and others, 1937)	Fort Union undifferentiated	A	23.3	29.6	40.0	7.1	0.7	5.8	54.0	0.7	31.7	4,928	8,870

Form of Analysis: A, as received

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

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

Plate 1 Index Number	Source	Data Base
1	George Aubrey and R. W. Portis	Oil/gas well No. 1 William Spetter
2	Forest Oil Corp.	Oil/gas well No. 16-1
3	C & K Petroleum, Inc.	Oil/gas well #1 Stouffer Federal
4	Colorado Oil Co. and Anodarko Production Co.	Oil/gas well No. 33-16 Colorado State
5	Mountain Fuel Supply Co.	Oil/gas well No. 1 Cottonwood Gulch
6	Carter Oil Co.	Oil/gas well #2 North Craig Unit
7	U.S. Smelting, Refining & Mining	Oil/gas well #2-22 Carter Mobley

Table 2 -- Coal Reserve Base data for subsurface mining methods for Federal coal lands (in short tons) in the Craig NE quadrangle, Moffat County, Colorado

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Fort Union {2}	370,000	2,350,000	0	0	2,720,000
Fort Union {1}	0	0	1,820,000	0	1,820,000
Total	370,000	2,350,000	1,820,000		4,540,000

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

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