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COAL RESOURCE OCCURRENCE MAPS OF THE CRAIG QUADRANGLE, MOFFAT COUNTY, COLORADO

[Report includes 4 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 Maps of the Craig 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 United States Geological Survey under contract number 14-08-0001-15789. The resource information gathered for this report is in response to the Federal Coal Leasing Amendments Act of 1975 (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 Published and unpublished public information was used as the data base for this study.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 done as part of this study, nor was any confidential data used.

Location

The Craig quadrangle is located in east-central Moffat County in northwestern Colorado, approximately 47 miles (75 km) north-northeast of Meeker along Colorado Highway 13 (also known as Colorado Highway 789), and 41 miles (66 km) west of Steamboat Springs along U.S. Highway 40. The city of Craig is in the south-central part of the quadrangle. The remainder of the quadrangle is relatively unpopulated with the exception of several ranches.

Accessibility

U.S. Highway 40 passes east-west through the southern part of the Craig quadrangle. Colorado Highway 13 (also known as Colorado Highway 789) intersects U.S. Highway 40 in Craig. From Craig, Colorado Highway 13 runs south toward Meeker, Colorado and north toward Baggs, Wyoming. This highway generally follows along Fortification Creek from Craig north to the east-central edge of the quadrangle, where it leaves the quadrangle.

Railway service for the Craig quadrangle is provided by the Denver & Rio Grande Western Railroad from Denver to the railhead at Craig. The rail line follows U.S. Highway 40, and runs from the southeastern corner of the quadrangle to the city of Craig, where it terminates. The rail line is the major transportation route for coal shipped eastward from northwestern Colorado.

Physiography

The Craig quadrangle lies in the southern part of the Wyoming Basin physiographic province, just off the northeastern edge of the Colorado Plateau physiographic province, as defined in Howard and Williams (1972). The quadrangle is approximately 5 miles (8 km) north of the Williams Fork Mountains and 44 miles (70 km) west of the Continental Divide.

Approximately 1,370 feet (418 m) of relief is present in the Craig quadrangle. Altitudes range from approximately 7,530 feet (2,295 m) at Cedar Mountain in the west-central portion of the quadrangle, to approximately 6,160 feet (1,878 m) along the Yampa River at the south-central edge of the quadrangle.

The landscape within most of the Craig quadrangle is dominated by moderate to gentle slopes and stream valleys, but the area near the Yampa River, along the southern edge of the quadrangle, is somewhat flatter. The slopes and stream valleys which surround Cedar Mountain in the west-central part of the quadrangle become steeper.

The major drainage system in the area is the Yampa River, which flows westward along the southern edge of the quadrangle. Fortification Creek flows south-southwest to join the Yampa River at Craig. Numerous southeastward-flowing intermittent streams drain the major part of the quadrangle, mainly in response to snowmelt in the spring. These streams generally flow into Fortification Creek.

Climate and Vegetation

The climate of northwestern Colorado is semiarid. Clear, sunny days prevail in the Craig area, and daily temperatures vary from 0° to 35° F (-18° to 2° C) in January to 42° to 80° F (6° to 27° C) in July. Annual precipitation in the area averages about 20 inches (51 cm), most of which occurs as snowfall during the winter months.

Two major areas in the quadrangle are used for agricultural purposes. One area trends diagonally across the quadrangle from northeast to southwest, and the other is the area along the Yampa River. The remaining parts of the quadrangle, including the northwestern and southeastern sections, are dominated by sagebrush.

Land Status

The Craig quadrangle lies in the north-central part of the Yampa Known Recoverable Coal Resource Area (KRCRA). Approximately 25 percent of the quadrangle's total area is within the KRCRA boundary. This includes the northeastern and southwestern corners of the quadrangle and approximately two sections along the eastern edge of the quadrangle. The Federal government owns the coal rights for approximately one quarter of the land within the KRCRA boundary in this quadrangle, as shown on plate 2. No outstanding coal leases, prospecting permits, or licenses occur within the quadrangle.

GENERAL GEOLOGY

Previous Work

The first geologic description of the general area in which the Craig quadrangle is located was published by Emmons (1877) as part of the 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) published a geologic report on the Yampa Coal Field, including a description of the geology and coal occurrence in the southern part of the Craig quadrangle. In 1909, the southwestern part of the Craig quadrangle was mapped in detail by John Allen Davis, but the map was never published (Hancock, 1925). Data available from the work done in the area south of the Craig quadrangle by Davis, and Fenneman and Gale were compiled and published by Hancock in 1925. The data in the immediate Craig area, however, were never published; therefore, the best information on the geology of the area is from Tweto (1976) and from the several oil/gas wells drilled by the U.S. Smelting, Mining, and Refining Company, the Carter Oil Company, and the Sun Oil Company.

Stratigraphy

The rocks which crop out in the Craig quadrangle are Upper Cretaceous and Tertiary in age. The formations included are the Cretaceous-age Williams Fork Formation, Lewis Shale, Fox Hills Sandstone, and Lance Formation, and the Tertiary-age Fort Union, Wasatch, and Browns Park Formations.

The Williams Fork Formation, which is the upper member of the Mesaverde Group, is exposed in a small area along the southern edge of the Craig quadrangle (Tweto, 1976). The Williams Fork Formation has not been identified in the several drill holes located in the Craig quadrangle, and is, therefore, not included in the columnar section on plate 3. Generally, the Williams Fork Formation contains three sequences: a lower shale sequence which is coal-bearing; the Twentymile Sandstone Member; and an upper shale sequence that also frequently contains coal. The top of the upper sequence appears to be the only part of the Williams Fork Formation which is exposed in the Craig quadrangle.

The Lewis Shale conformably overlies the Williams Fork Formation and crops out in the southern third of the quadrangle. Approximately 340 feet (104 m) of the Lewis Shale is recognized in drill holes in the Craig quadrangle. The Lewis Shale is usually approximately 1,500 to 1,900 feet (457 to 579 m) thick, and is composed of gray soft shale and fine-grained sandstone. The Lewis Shale is not known to contain coal in the Craig quadrangle.

The Fox Hills Sandstone overlies the Lewis Shale. It has been recognized in several drill holes and probably crops out from east to west across the center of the Craig quadrangle. It has not, however, been mapped by Tweto (1976). The Fox Hills Sandstone consists of gray-brown massive sandstone interbedded with shaly sandstone, gray sandy shale, and local coal beds. The Fox Hills Sandstone is approximately 390 feet (119 m) thick in the Craig area.

Overlying the Fox Hills Sandstone is the Lance Formation, which is exposed in the south-central area of the Craig quadrangle. The Lance Formation is approximately 960 feet (293 m) thick in the Craig quadrangle and consists of gray shale interbedded with siltstone, fine-grained sandstone, and local coal beds.

Unconformably overlying the Lance Formation is the Paleocene-age Fort Union Formation. The Fort Union Formation is exposed in the central and eastern parts of the Craig quadrangle. It is approximately 1,100 feet (335 m) thick in the Craig area and consists of light-colored sandstone, gray to dark-gray shale, and local coal. There is a conglomerate at the base of the Fort Union Formation which can be used as a convenient marker horizon in the quadrangle area.

The Eocene-age Wasatch Formation unconformably overlies the Fort Union Formation and is exposed in the northern one third of the quadrangle. Approximately 1,200 feet (366 m) of the Wasatch Formation crops out in the Craig area. The formation contains gray shale, light-colored sandstone, and local coal beds.

A layer of the Miocene-age Browns Park Formation rests unconformably on the Cretaceous- and Tertiary-age rocks in the west-central part of the quadrangle. The light-colored sandstone and conglomerate of the Browns Park Formation surrounds the volcanic basalt of Cedar Mountain. In the Craig quadrangle, the Browns Park Formation is approximately 200 feet (61 m) thick.

The Cretaceous-age rocks in the Craig quadrangle, including the Williams Fork Formation of the Mesaverde Group, the Lewis Shale, the Fox

Hills Sandstone, and the Lance Formation, accumulated close to the western edge of a Late Cretaceous-age epeirogenic seaway which covered part of the western interior of North America (O'Boyle, 1955). Several transgressive-regressive cycles caused the deposition of a series of marine, near-shore marine, and non-marine sediments.

The interbedded sandstones, shales, and coals of the Williams Fork Formation were deposited as a result of minor changes in the position of the shoreline. During the deposition of the Williams Fork Formation, near-shore marine, littoral, brackish tidal, brackish and fresh water supratidal, and fluvial environments existed in the Yampa KRCRA.

A large rise in sea level caused a landward movement of the shoreline, which resulted in the end of deposition of the near-shore and continental sediments of the Mesaverde Group. After this rise in sea level, the marine Lewis Shale was deposited in the Craig quadrangle area.

Regional uplift west of the Yampa Basin area caused a regression of the Cretaceous sea. The Fox Hills Sandstone marked the edge of the Cretaceous sea after the regression (Weimer, 1977). As the sea regressed further, the sediments in the Craig area became increasingly terrestrial. These terrestrial sediments which overlie the Fox Hills Sandstone are designated as the Lance Formation. The Lance Formation is the uppermost of the Cretaceous-age strata.

An unconformity separates the Cretaceous-age Lance Formation and the Paleocene-age Fort Union Formation, which was deposited in a humid, swampy, low-lying basin (Ritzma, 1955). The Wasatch Formation, which unconformably overlies the Fort Union Formation, is predominantly a fluvial deposit (Picard and McGrew, 1955).

During the Miocene, the Browns Park Formation blanketed the Craig quadrangle area. The Browns Park Formation is postulated to have been deposited during a Miocene climate change from temperate to more arid (Carey, 1955).

Coals of limited areal extent, such as those identified in the Fox Hills Sandstone, Lance Formation, Fort Union Formation, and Wasatch Formation in the Craig quadrangle, were generally deposited in environments associated with fluvial systems, such as back-levee and coastal plain swamps, interchannel basin areas, and abandoned channels.

Igneous Rocks

A basalt flow caps Cedar Mountain in the west-central part of the Craig quadrangle (Tweto, 1976). This Miocene- and Pliocene-age basalt appears to overlie the Fort Union Formation, but the Browns Park Formation blankets the basalt/country rock contact. Therefore, the true areal extent of the basalt is unknown.

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, some 35 miles (56 km) east of the Craig quadrangle, and on the southwest by the Axial Basin Anticline, approximately 13 miles (21 km) southwest of the quadrangle. Several northwest-trending faults offset the Cretaceous- and Tertiary-age rocks in the west-central portion of the quadrangle (Tweto, 1976).

COAL GEOLOGY

Several coal beds have been identified in the five drill holes in the northeastern corner of the Craig quadrangle. Coal is recognized in the Fox Hills Sandstone, and the Lance and Fort Union Formations. None of the recognized coal beds have been formally named; therefore, in this report the beds greater than the Reserve Base thickness of 5.0 feet (1.5 m) are numbered with bracketed numbers for identification purposes in this quadrangle only (plates 1 and 3).

Coal Beds in the Fox Hills Sandstone

The Fox Hills Sandstone locally contains coal. The FH[1] coal bed was identified in two drill holes in the northeastern corner of the Craig quadrangle. The FH[1] coal bed reaches its known maximum thickness of 6 feet (1.8 m) in sec. 31, T. 8 N., R. 90 W., and thins to 5 feet (1.5 m) toward the east in sec. 32, T. 8 N., R. 90 W. Because of the lenticular nature of coal in the Fox Hills Sandstone and the limited areal extent of the FH[1] coal bed, it is treated as an isolated data point at each of the places where it was identified (see Isolated Data Points section of this report).

No known chemical analyses have been made on the coal in the Fox Hills Sandstone in the Craig quadrangle or in any of the adjacent quadrangles. However, coal in the Fox Hills Sandstone has been ranked as subbituminous and coal in the coal-bearing formations stratigraphically above and below the Fox Hills Sandstone has also been ranked as subbituminous by Bass, Eby, and Campbell (1955). The depositional environment of the Fox Hills Sandstone, which is primarily that of a shoreline area, contributes to the development of thin lenticular coal beds with abundant terrigenous contamination.

Coal Beds in the Lance Formation

Coal beds in the Lance Formation were recognized in three drill holes in the northeastern corner of the Craig quadrangle. The coal beds are of limited areal extent and range in thickness from 3 to 4.5 feet (0.9 to 1.4 m). These beds do not appear to correlate with other coal beds identified in the Lance Formation in the Craig quadrangle or the adjacent quadrangles.

Coal Beds in the Fort Union Formation

Coal beds in the Fort Union Formation were identified in four drill holes in the northeastern portion of the Craig quadrangle. The coal beds vary in thickness from 2 to 5 feet (0.6 to 1.5 m) and are limited in areal extent. They are not known to correlate with other coal beds in the Craig quadrangle or in adjacent quadrangles.

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 is 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 beds. The FH[1] coal bed is the only bed in the Craig quadrangle which is treated as an isolated data point. The map of the FH[1] coal bed is shown on plate 4.

COAL RESOURCES

Data from drill holes (plate 1) were used to construct an Areal Distribution and Identified Resource (ADIR) Map (plate 4) of the FH[1] coal bed where the thickness of the bed is equal to or is greater than the Reserve Base thickness of 5.0 feet (1.5 m). The sources of information for the data points used on the Coal Data Map (plate 1) are listed in table 2.

Coal resources of the FH[1] coal bed were calculated using the data obtained from the ADIR map. The coal-bed acreage (measured by planimeter), multiplied by the average thickness of the coal bed, times a conversion factor of 1,770 short tons of coal per acre-foot (13,018 metric tons per hectare-meter) for subbituminous coal yields the coal resources in short tons of coal. The total coal Reserve Base tonnages for the FH[1] coal bed are listed on plate 2 and are rounded to the nearest 10,000 short tons (9,072 metric tons). This amount, approximately 1.08 million short tons (0.98 million metric tons), is also the total coal Reserve Base tonnage for the quadrangle.

The criteria used in calculating Reserve Base data in this report differ from those stated in U.S. Geological Survey Bulletin 1450-B, which calls for a maximum depth of 1,000 feet (305 m) for subbituminous coal. The FH[1] coal bed is below the 200-foot (61-m) stripping limit and is amenable to mining by subsurface methods only. Because of the lenticularity of this coal bed and limited geologic data, Reserve Base tonnages have been designated as inferred resources.

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

COAL DEVELOPMENT POTENTIAL

Areas where the coal beds of Reserve Base thickness are overlain by 200 feet (61 m) or less of overburden are ordinarily considered to have potential for surface mining and are assigned a high, moderate, or low development potential based on the mining ratio (cubic yards of overburden per ton of recoverable coal). The areas of high, moderate, and low development potential 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.

For subsurface mining methods, areas of high, moderate, and low development potential are defined as areas underlain by coal beds of Reserve Base thickness at depths ranging from 200 to 1,000 feet (61 to 305 m), 1,000 to 2,000 feet (305 to 610 m), and 2,000 to 3,000 feet (610 to 914 m), respectively.

Unknown development potentials are assigned to those areas where coal data is absent or extremely limited, including areas influenced by isolated data points. Even though these areas contain coal thicker than 5 feet (1.5 m), limited knowledge pertaining to the areal distribution of the coal prevents accurate evaluation of development potential.

All Federal land within the KRCRA in this quadrangle is classified as having unknown development potential for surface and subsurface mining methods, implying that no known coal beds 5 feet (1.5 m) or more thick, excluding isolated data points, occur within 200 feet (61 m) of the ground surface or between 200 and 3,000 feet (61 and 914 m) below the ground surface, but that coal-bearing units are present.

TABLE 1

COAL RESERVE BASE DATA FOR SURFACE AND SUBSURFACE

MINING METHODS FOR FEDERAL COAL LANDS, (IN SHORT TONS)

CRAIG QUADRANGLE, MOFFAT COUNTY, COLORADO

Coal Bed Name	SURFACE Unknown Development Potential	SUBSURFACE Unknown Development Potential	Total
FH {1} (Isolated Data Points)	0	1,080,000	1,080,000

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

Table 2. -- Sources of data used on plate 1

Plate 1 Index Number	Source	Data Base
1	U.S. Smelting, Mining, and Refining Co.	Drill hole No. 1-29 McWilliams
2	Carter Oil Co.	Drill hole No. 1 North Craig Unit
3	Sun Oil Co.	Drill hole No. 1 McWilliams A
4	U.S. Smelting, Mining, and Refining Co.	Drill hole No. 1 Brunner
5		Drill hole No. 2-32 Carpenter

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