Text to Accompany:

Open-File Report 79-1034

1979

COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE BROWNS HILL QUADRANGLE CARBON COUNTY, WYOMING

[Report includes 29 plates]

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

By

DAMES & MOORE

DENVER, COLORADO

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

CONTENTS

ILLUSTRATIONS

Illustrations--Continued

TABLES

INTRODUCTION

Purpose

This text is to be used in conjunction with Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) Maps of the Browns Hill quadrangle, Carbon County, Wyoming. This report was compiled to support the land planning work of the Bureau of Land Management (BLM) 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 14-08-0001-17104. 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 Published and unpublished public information available through May, 1979, was used as the data base for this study. No new drilling or field mapping was performed, nor was any confidential data used.

Location

The Browns Hill quadrangle is located in southwestern Carbon County, Wyoming, approximately 7 miles (11 km) north of the town of Savery and 39 airline miles (63 km) southwest of the city of Rawlins, Wyoming. Except for seasonal sheepherder's camps, the quadrangle is relatively unpopulated.

Accessibility

No major routes pass through the quadrangle. However, an improved light-duty road, the Browns Hill Road, connects the town of Savery to the south and Wyoming Highway 71 to the northeast. This road passes diagonally from the southwestern to the northeastern corner of the quadrangle. Wyoming Highway 71, approximately 10 miles (16 km) east of the quadrangle, runs north to intersect Interstate Highway 80 at Rawlins. Numerous other secondary dirt roads and trails provide access to the rest of the area.

The main east-west line of the Union Pacific Railroad passes through Rawlins 39 airline miles (63 km) to the north. This line, which connects

Ogden, Utah, to the west with Omaha, Nebraska, to the east, provides railway service across southern Wyoming.

Physiography

The Browns Hill quadrangle lies on the western flank of the Sierra Madre uplift. The landscape is characterized by mesas and deeply incised canyons. Browns Hill, a large mesa, is located in the center of the quadrangle. Altitudes range from approximately 6,880 feet (2,097 m) in the southwestern corner of the quadrangle along Cottonwood Creek, to over 8,000 feet (2,438 m) on the southeastern edge of the quadrangle.

Loco Creek, Coal Gulch, and Bird Gulch drain the eastern half of the quadrangle and flow into Savery Creek east of the quadrangle boundary. Cherokee Creek, Deep Creek, and Cottonwood Creek drain the western half of the quadrangle. Cherokee Creek and Deep Creek are tributaries of Muddy Creek west of the quadrangle. Savery Creek, Muddy Creek, and Cottonwood Creek all flow into the Little Snake River, a major drainage of the region along the boundary between southwestern Wyoming and northwestern Colorado. All of the streams in the quadrangle are intermittent, flowing mainly in response to snowmelt in the spring.

Climate and Vegetation

The climate of south-central Wyoming is semiarid, characterized by low precipitation, rapid evaporation, and large daily temperature variations. Summers are usually dry and mild, and winters are cold. The annual precipitation in the area averages approximately 10 inches (25 cm). Approximately two thirds of the precipitation falls in the spring and summer during a seven-month period from April through October (Wyoming Natural Resources Board, 1966).

The average annual temperature in the area is 43°F (6°C). The temperature during January averages 21°F (-6°C) and typically ranges from 12°F (-11°C) to 31°F (-0.6°C). During July the average temperature is 68°F (20°C), and the temperature typically ranges from 51°F (11°C) to 84°F (29°C) (Wyoming Natural Resources Board, 1966).

Winds are usually from the southwest and the west-southwest with an average velocity of approximately 12 miles per hour (19 km per hr) (U.S. Bureau of Land Management, 1978).

Principal types of vegetation in the quadrangle include some pine, spruce, fir, cottonwood, willow, and abundant aspen; grasses, sagebrush, serviceberry, bitterbrush, saltbush, rabbitbrush, greasewood, and other desert shrubs.

Land Status

The Browns Hill quadrangle lies on the eastern edge of the proposed Rawlins Known Recoverable Coal Resource Area (KRCRA). Approximately two fifths of the quadrangle lies within the proposed KRCRA boundary, and the Federal government owns the coal rights for less than 90 percent of the land, as shown on plate 2. One preference right lease application (PRLA) area is in the quadrangle and within the KRCRA boundary.

GENERAL GEOLOGY

Previous Work

Ball and Stebinger described the geology and mineral resources of the eastern part of the Little Snake River coal field in 1910. The stratigraphy and depositional environments of Upper Cretaceous rocks in Wyoming and adjacent areas were described by Hale (1961), Haun (1961), Lewis (1961), and Weimer (1961). Welder and McGreevy (1966) conducted a ground-water reconnaissance of the Great Divide and Washakie Basins of southwestern Wyoming and their report contains a geologic map of the region. Gill and others (1970) described the stratigraphy and nomenclature of some of the Upper Cretaceous and Lower Tertiary rocks found in south-central Wyoming. Gill (1974) measured sections of the Mesaverde Group, Lewis Shale, Fox Hills Formation, and Medicine Bow Formation in Carbon County, Wyoming. Barclay and Shoaff (1977 and 1978) and Barclay (1979b and 1979c), in their reports on results of coal-drilling by the U.S. Geological Survey in the Doty Mountain, Browns Hill, Baggs, and Savery quadrangles during 1976, 1977 and 1978, presented coal correlation diagrams and stratigraphic descriptions of the Mesaverde Group. In a report on the minutes of the proposed revision of the

Rawlins (Little Snake River) KRCRA, Barclay and others (1978) included geologic maps showing the distribution of coal-bearing formations and a brief description of the stratigraphy and coal geology of the KRCRA. In conferences with Dames & Moore personnel and on various worksheets pertaining to the geology of the area, Barclay of the U.S. Geological Survey provided structural, stratigraphic, and coal resource information. Detailed geologic mapping in this quadrangle by Barclay of the U.S. Geological Survey is in progress.

Stratigraphy

The rock formations exposed in the Browns Hills quadrangle range in age from Late Cretaceous to Miocene and crop out across the quadrangle in northwest-trending bands. The Mesaverde Group of Late Cretaceous age is coal-bearing within this quadrangle.

The Steele Shale of Late Cretaceous age is present in the subsurface. In south-central Wyoming, it consists of dark-gray marine shale with sparse layers of gray-weathering limestone concretions and thin beds of very fine grained sandstone and siltstone (Gill and others, 1970). The upper part of the Steele Shale was encountered at depths ranging from approximately 1,400 to 1,900 feet (427 to 579 m) in oil and gas wells drilled in this quadrangle.

The Steele Shale is conformably overlain by and laterally intertongues with the Mesaverde Group of Late Cretaceous age. In south-central Wyoming, which includes the Little Snake River coal field, the Mesaverde Group is subdivided into four formations which are, in ascending order, the Haystack Mountains, the Allen Ridge, the Pine Ridge Sandstone, and the Almond (Gill and others, 1970).

The upper part of the Haystack Mountains Formation crops out in the northeastern corner of the quadrangle. Gill (1974) measured the formation in Bird Gulch and reported a total thickness of approximately 953 feet (290 m). In the Bird Gulch section, as in other areas of south-central Wyoming, the formation can be divided into four members which are, in ascending order, the Deep Creek Sandstone Member, the Espy Tongue, the

Hatfield Sandstone Member, and an upper unnamed member (Hale, 1961; Gill and others, 1970). In Bird Gulch, the Deep Creek Sandstone Member is approximately 125 feet (38 m) thick (Gill, 1974) and is composed almost entirely of sandstone. The Espy Tongue, genetically a tongue of the Steele Shale, is approximately 315 feet (96 m) thick, and consists of marine shale, some thin sandstone beds, and a few limestone-concretion horizons. The Espy Tongue has a sharp contact with the Deep Creek Sandstone Member, and a gradational contact with the overlying Hatfield Sandstone Member. The Hatfield Sandstone Member is about 153 feet (47 m) thick and consists of thick cliff-forming sandstone beds separated by thinner shale intervals. The upper unnamed member of the Haystack Mountains Formation is composed of two sequences of transgressive-marine slope-forming shale grading up into regressive-marine cliff-forming sandstone and is about 360 feet (110 m) thick.

The Allen Ridge Formation conformably overlies the Haystack Mountains Formation and crops out in the southeastern and north-central parts of the quadrangle (Barclay, 1979a). This formation is estimated to be 1,200 to 1,300 feet (366 to 396 m) thick in this quadrangle and is largely composed of continental fluvial sequences of sandstone, siltstone, mudstone, and thin carbonaceous shale and coal beds (Barclay, 1979b). In most parts of the Little Snake River coal field, the uppermost part of the Allen Ridge consists of marginal-marine lagoonal-paludal deposits of thick, bioturbated organic-rich brown shales, thin sandstone beds, and coal (Barclay and Shoaff, 1978). The lower non-marine part of the formation is 1,000 to 1,200 feet (305 to 366 m) thick and the upper marginal-marine part is approximately 170 to 210 feet (52 to 64 m) thick (Barclay, 1979b).

The Pine Ridge Sandstone is reported by Barclay (1979b) to pinch out in the southern part of the quadrangle. Where the Pine Ridge Sandstone is absent, Barclay includes the marginal-marine member of the Allen Ridge Formation in the Almond Formation. In these areas, an areally-persistent marine sandstone, informally named the sandstone of Loco Creek, is used as the basal unit of the Almond Formation (Barclay and Shoaff, 1978). The sandstone of Loco Creek can be traced northward, from where it crops out in the southeastern part of the quadrangle, into areas where the Pine Ridge is recognized and becomes the base of the marine member of the Allen Ridge Formation. Gill and others (1970) believe that the Pine Ridge Sandstone is probably unconformable on the Allen Ridge is most places in southern Wyoming.

In the northern part of the quadrangle, the Pine Ridge Sandstone is approximately 50 feet (15 m) thick (Barclay, 1979b) and consists of fluviatile sandstone and a subordinate amount of interbedded carbonaceous siltstone and mudstone (Barclay and Shoaff, 1978). In the southern part of the quadrangle, the formation thins and is difficult to recognize on geophysical logs; however, it may be represented by part or all of a sandy interval that is about 43 feet (13 m) thick in drill hole BH-D7 (Barclay, 1979b).

The Almond Formation crops out in the western half of the quadrangle and is the most important coal-bearing formation of the Mesaverde Group (Barclay, 1979a). The formation is commonly 450 feet (137 m) thick in most parts of the Little Snake River coal field and may be as much as 930 feet (283 m) thick in the adjacent Savery quadrangle to the south (Barclay and Shoaff, 1978). The Almond Formation consists predominantly of marginal-marine, foreshore to coastal -plain paludal deposits. Most of the significant coal beds occur in the lower part of the formation.

The Lewis Shale of Late Cretaceous age conformably overlies the Almond Formation. The lower part of the formation crops out in the southwest quarter of the quadrangle (Barclay, 1979a). A representative thickness of 200 feet (61 m) is shown on plate 3 to indicate that the formation is present in the quadrangle. To the west, in the northeast quarter of the Baggs 15-minute quadrangle, the Lewis Shale is 2,245 to 2,380 feet (684 to 725 m) thick where measured in oil and gas wells. In south-central Wyoming, the shale of the Lewis is gray to olive-gray, silty to sandy, and locally, contains fossiliferous limestone or siltstone concretions. The middle and upper parts of the Lewis Shale contain a distinctive and widespread unit of interstratified sandstone and sandy shale called the Dad Sandstone Member, a tongue of the overlying Fox Hills Sandstone (Gill and others, 1970).

The Browns Park Formation of Miocene age is present in many areas of the quadrangle and unconformably overlies older formations. The maximum thickness of the formation is about 270 feet (82 m) in this quadrangle, and it consists of pebble and cobble conglomerate and conglomeratic sandstone in the lower part and sandstone in the upper part (Barclay, 1979, written communication).

Holocene deposits of alluvium cover the stream valleys of Bird Gulch, Coal Gulch, Deep Creek, Cottonwood Creek, and their tributaries. Quaternary landslide deposits are abundant, especially in terrain characterized by steep shale slopes capped by conglomerate and sandstone of the Browns Park Formation (Barclay, 1979, written communication).

The Upper Cretaceous formations in the Browns Hill quadrangle indicate the transgressions and regressions of a broad, shallow, north-south-trending seaway that extended across central North America. These formations accumulated near the western edge of the sea and reflect the location of the shoreline. More particurly, the formations in the Mesaverde Group reflect the many fluctuations of the shoreline in a series of marine, marginal-marine, and non-marine beds deposited on or near the eastwardly-prograding deltas (Weimer, 1961).

In south-central Wyoming, the thick marine sandstones (the Deep Creek and Hatfield Sandstone Members) found in the Haystack Mountains Formation of the Mesaverde Group were deposited in nearshore and offshore environments as marine beach or barrier bar deposits. These alternate with marine shale (Espy Tongue) deposited in a deeper-water marine environment. In most of the Little Snake River coal field, the upper unnamed member of the Haystack Mountains Formation contains deposits of marine shale, beach sandstone, and lagoonal sandstone and mudstone (Gill and others, 1970). In this quadrangle and adjacent areas, lagoonal sequences have been largely replaced by shale deposits in a more open-marine environment (Barclay, 1976; Barclay, 1979, oral communication).

All of the Allen Ridge Formation, except the upper marginal-marine member, and, perhaps, a coaly carbonaceous zone at the base which could contain brackish-water deposits, was deposited in a non-marine fluvial environment (Barclay, 1979, oral communication).

The Pine Ridge Sandstone was deposited by meandering streams over a broad area of uplifted and eroded non-marine and marine rocks (Gill and others, 1970).

The Almond Formation consists of a lower unit of beach, fluvial, and coastal swamp sandstones, shales, and coals. The upper unit is characterized by shale and sandstone deposited by alternating transgressive and regressive cycles of a Late Cretaceous interior sea (Barclay, 1979b).

Deposition of the Lewis Shale generally marks a landward progression of the Late Cretaceous sea. An exception is the Dad Sandstone Member which probably represents a later growth stage of the Rawlins delta within the Lewis Shale (Weimer, 1961, p. 27).

The basal conglomerate of the Browns Park Formation contains clasts derived from the Sierra Madre Range and was probably deposited as alluvial fans or pediment deposits in response to late Tertiary uplift (Barclay, 1979, written communication). Subsequent Late Cenozoic uplift and subsequent erosion has significantly reduced the amount of area originally covered by the formation.

Structure

The Browns Hill quadrangle is located to the west of the Sierra Madre uplift and to the east of the Washakie Basin. The formations found in the quadrangle dip to the southwest at approximately 10°.

The most prominent structure in the quadrangle is a fault located in the eastern half of the quadrangle that trends north-south from the southern edge to within a mile of the northern edge. Numerous faults have been mapped by Barclay (1979a) in the southeastern corner of the quadrangle.

COAL GEOLOGY

Both the Allen Ridge and Almond Formations contain coal in the Browns Hill quadrangle. Most of the coal beds of the Allen Ridge Formation occur in the upper 150 feet (46 m) of the marginal-marine member. The Almond Formation contains significant coal beds in the lowermost 150 feet (46 m) of the formation. Where coal beds exceeding Reserve Base thickness (5.0 feet or 1.5 meters) have been identified at one location only, they have been treated as isolated data points (see Isolated Data Points section of this report).

Chemical analyses of coal.--Chemical analyses were not available for coals in the Almond and Allen Ridge Formations in this quadrangle, but representative analyses from other parts of the proposed Rawlins (Little Snake River) KRCRA are listed in table 1. In general, coals of the Almond Formation rank as subbituminous A and coals from the Allen Ridge Formation rank as high-volatile C bituminous 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 and designated with bracketed numbers are not formally named, but have been given bracketed numbers for identification purposes in this quadrangle only. The same coal bed may have a different designation in another quadrangle. Coal beds that are local and of limited areal extent are designated with the letter L (Local) on plates 1 and 3.

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

Coal Beds of the Allen Ridge Formation

Coal beds of the Allen Ridge Formation crop out in the western half of the quadrangle. Of the numerous coal beds in the Allen Ridge

Formation, only two exceed Reserve Base thickness and appear to be local in areal extent.

Allen Ridge [Local 1] Coal Bed

The Allen Ridge [Local 1] coal bed (plate 4) is, stratigraphically, the lowest coal bed of Reserve Base thickness in the Allen Ridge Formation in this quadrangle. The coal bed ranges in thickness from 3 to 6 feet (0.9 to 1.8 m) where measured in three drill holes in the northeastern part of the quadrangle.

Allen Ridge [Local 3] Coal Bed

The Allen Ridge [Local 3] coal bed (plate 7) is approximately 125 feet (38 m) stratigraphically above the Allen Ridge [Local 1] coal bed and ranges in thickness from 4.5 feet (1.4 m) to a maximum of 9 feet (1.8 m), excluding a rock parting 1.0 feet (0.3 m) thick, where measured in four drill holes in the central part of the quadrangle.

Coal Beds of the Almond Formation

Coal beds of the Almond Formation crop out in the western half of the quadrangle. With the exception of the Robertson coal bed, bracketed numbers are used to identify seven coal beds that exceed Reserve Base thickness in this quadrangle.

Robertson Coal Bed

The Robertson coal bed, or zone of coal beds, is defined by Barclay (1979, oral communication) as the first areally persistant coal bed or zone of coal beds above the contact of the Almond Formation and the underlying Pine Ridge Sandstone. For the purpose of calculating Reserve Base tonnages, the Robertson bed is defined in this report as the first areally persistant coal bed above the Pine Ridge Sandstone that exceeds Reserve Base thickness. Other coal beds with an alpha-numeric designation may possibly be part of the Robertson zone of coal beds. The name of the coal bed was suggested by Barclay and was derived from the Robertson mine described by Ball and Stebinger (1910) in sec. 4, T. 17 N., R. 90 W.

In this quadrangle, the thickness of the Robertson coal bed ranges from 3.5 to 16 feet (1.1 to 4.9 m), as shown on plate 10, and averages approximately 9 feet (2.7 m). Thin shale partings from 0.5 to 3.5 feet (0.2 to 1.1 m) are not uncommon in this coal bed.

To the west, in the northeast quarter of the Baggs 15-minute quadrangle, the Robertson coal bed ranges in thickness from 2 to 11.5 feet (0.6 to 3.5 m) and averages approximately 6 feet (1.8 m).

Almond [1] Coal Bed

The Almond [1] coal bed (plate 14) is approximately 100 feet (30 m) stratigraphically above the Robertson coal bed and ranges in thickness from 2 to 12.5 feet (0.6 to 3.8 m) where penetrated by coal test holes in the northwest corner of the quadrangle. To the west in the northeast quarter of the Baggs 15-minute quadrangle, this coal bed varies from 3.5 to 13 feet (1.1 to 4.0 m) in thickness and averages about 8 feet (2.4 m).

Almond [2] Coal Bed

The Almond [2] coal bed (plate 18) is approximately 7 feet (2.1 m) stratigraphically above the Almond [1] coal bed and ranges from 2.5 to 12 feet (0.8 to 3.7 m) in thickness where measured in drill holes in the northwest corner of the quadrangle. The Almond [2] coal bed correlates with the Almond [Local 4] coal bed of the northeast quarter of the Baggs 15-minute quadangle where it ranges in thickness from 2 to 7 feet (0.6 to 2.1 m).

Almond [Local 6] Coal Bed

The Almond [Local 6] coal bed (plate 22) is 120 feet (37 m) stratigraphically above the Robertson coal bed. This coal bed was identified in three drill holes in the southwestern part of the quadrangle and could not be correlated with coal beds in other quadrangles. It ranges from 4.5 to 6 feet (1.4 to 1.8 m) thick and contains a parting 1 foot (0.3 m) thick in one of the drill holes.

Almond [3] Coal Bed

The Almond [3] coal bed (plate 22) is approximately 60 feet (18 m) stratigraphically above the Almond [2] coal bed. In this quadrangle, the Almond [3] coal bed ranges from 2 to 6 feet (0.6 to 1.8 m) in thickness and is not known to contain rock partings.

In the northeast quarter of the Baggs 15-minute quadrangle to the west, this coal bed is designated the Almond [2] and ranges in thickness from 3.5 to 11 feet (1.1 to 3.4 m) where measured in drill holes in the northeast part of the quadrangle. Thin rock partings, ranging from 1 to 2 feet (0.3 to 0.6 m) thick, were reported at isolated locations.

To the northeast in the southeast quarter of the Doty Mountain 15-minute quadrangle, this coal bed is also designated the Almond [2] and is relatively extensive. In that quadrangle, the coal bed is split by as much as 10 feet (3.0 m) of rock and has a maximum cumulative coal thickness of 10 feet (3.0 m).

Almond [4] Coal Bed

The Almond [4] coal bed (plate 25) is approximately 10 feet (3.0 m) stratigraphically above the Almond [3] coal bed and, in this quadrangle, ranges from 2.5 to 10 feet (0.8 to 3.0 m) in thickness. It commonly contains rock partings that vary from 1 to 2.5 feet (0.3 to 0.8 m) thick. This coal bed is equivalent to the Almond [3] coal bed of the northeast quarter of the Baggs 15-minute quadrangle where it has a maximum measured thickness of 5.5 feet (1.7 m).

Almond [Local 8] Coal Bed

The Almond [Local 8] coal bed (plate 4) is approximately 120 feet (37 m) stratigraphically above the Almond [Local 6] coal bed. This coal bed ranges in thickness from 2.5 to 6 feet (0.8 to 1.8 m) where penetrated by three drill holes in the southwestern part of the quadrangle and is not known to correlate with coal beds in other 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 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 beds. For this reason, isolated data points are included on a separate sheet (in U.S. Geological Survey files) for non-isopached coal beds. The isolated data points mapped in this quadrangle are listed below. Coal beds identified by bracketed numbers are not formally named, but are used for identification purposes in this quadrangle only.

Source	Location	Coal Bed	Thickness
Barclay and Shoaff, 1977	sec. 1, T. 13 N., R. 90 W.	AR[L7]	7 ft (2.1 m)
Barclay, 1979b	sec. 20, T. 14 N., R, 89 W.	AR[L5]	8 ft (2.4 m)
Barclay, 1979a	sec. 33, T. 14 N., R. 89 W.	AR[L4]	6.5 ft (2.0 m)

COAL RESOURCES

Information from coal test holes drilled by the U.S. Geological Survey (Barclay and Shoaff, 1977; Barcly, 1979b) and measured sections (Barclay, 1979a), were used to construct outcrop, isopach, and structure contour maps of the coal beds in the Browns Hill quadrangle.

Coal resources were calculated using data obtained from the coal isopach maps (plates 4, 7, 10, 14, 18, 22, and 25). The coal bed acreage (measured by planimeter) multiplied by the average isopached 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 isopached 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 used in calculating Reserve Base and Reserve tonnages as stated in U.S. Geological Survey Bulletin 1450-B which calls for a minimum thickness of 28 inches (70 cm) for bituminous coal and a maximum depth of 1,000 feet (305 m) for both bituminous and subbituminous coal.

Reserve Base and Reserve tonnages for the isopached beds are shown on plates 6, 9, 13, 17, 21, 24, and 27, 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 isolated data points. Coal Reserve Base tonnages per Federal section are shown on plate 2 and total approximately 244.03 million short tons (221.38 million metric tons) for the entire quadrangle, including tonnages from 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 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 potentials 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 in these areas prevents accurate evaluation of the development potential in the high, moderate, or low categories. The areas influenced by isolated data points in this quadrangle contain approximately 5.65 million short tons (5.13 million metric tons) of coal available for surface mining.

The coal development potential for surface mining methods is shown on plate 28. Of the Federal land areas having a known development potential for surface mining methods, 58 percent are rated high, 12 percent are rated moderate, and 30 percent are rated low. The remaining Federal lands within the proposed 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 are those areas where the coal beds of Reserve Base thickness 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 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 those areas influenced by isolated data points and to the 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 4.32 million short tons (3.92 million metric tons) of coal available for conventional subsurface mining.

The coal development potential for subsurface mining methods is shown on plate 29. 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 proposed 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°, all Federal land areas within the proposed KRCRA boundary have been rated as having unknown development potential for in-situ mining methods.

Table 1. -- Chemical analyses of coals in the Browns Hill quadrangle, Carbon County, Wyoming.

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
Average of 21 samples from Little Snake River coal field (Hatch and Barclay, 1979)	Almond Formation, undifferentiated	A	15.4	28.6	37.6	18.7	0.6	5.1	49.4	1.1	25.1	4,731	8,510
Southeastern part of the Rawlins KRCRA (Ball and Stebinger, 1910)	Allen Ridge Formation, undifferentiated	A	-	-	-	6.94	2.25	-	-	-	-	-	11,218

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 Browns Hill quadrangle, Carbon County, Wyoming.

Coal Bed	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Almond [Local 8]	270,000	150,000	570,000	-0-	990,000
Almond [Local 6]	-0-	-0-	-0-	-0-	-0-
Almond [4]	2,400,000	1,520,000	5,330,000	-0-	9,250,000
Almond [3]	320,000	70,000	590,000	-0-	980,000
Almond [2]	2,240,000	1,230,000	2,070,000	-0-	5,540,000
Almond [1]	2,390,000	2,340,000	3,250,000	-0-	7,980,000
Robertson	12,690,000	7,710,000	4,700,000	-0-	25,100,000
Allen Ridge [Local 3]	-0-	-0-	490,000	-0-	490,000
Allen Ridge [Local 1]	20,000	40,000	1,370,000	-0-	1,430,000
Isolated Data Points	-0-	-0-	-0-	5,650,000	5,650,000
Totals	20,330,000	13,060,000	18,370,000	5,650,000	57,410,000

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 Browns Hill quadrangle, Carbon County, Wyoming.

Coal Bed	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Almond [Local 8]	2,410,000	-0-	-0-	-0-	2,410,000
Almond [Local 6]	6,270,000	-0-	-0-	-0-	6,270,000
Almond [4]	21,310,000	-0-	-0-	-0-	21,310,000
Almond [3]	-0-	-0-	-0-	-0-	-0-
Almond [2]	2,870,000	-0-	-0-	-0-	2,870,000
Almond [1]	20,930,000	-0-	-0-	-0-	20,930,000
Robertson	101,910,000	-0-	-0-	-0-	101,910,000
Allen Ridge [Local 3]	22,040,000	-0-	-0-	-0-	22,040,000
Allen Ridge [Local 1]	3,080,000	-0-	-0-	-0-	3,080,000
Isolated Data Points	-0-	-0-	-0-	4,320,000	4,320,000
Totals	182,300,000	-0-	-0-	4,320,000	186,620,000

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	Barclay, 1979b, U.S. Geological Survey open-file report [in press]	Drill hole No. BH-D11
2	↓	Drill hole No. BH-D15A
3	↓	Drill hole No. BH-D6
4	↓	Drill hole No. BH-D8
5	↓	Stratton water well
6	↓	Drill hole No. BH-D14
7	Texas Oil and Gas Corp.	Oil/gas well No. 1 Loveland Sheep Co.
8	↓	Oil/gas well No. 1 Federal N
9	Barclay, 1979a, U.S. Geological Survey open-file report, in preparation	Measured Section SE-1
10	↓	Measured Section SE-8
11	Barclay, 1979b, U.S. Geological Survey open-file report [in press]	Drill hole No. BH-D10
12	↓	Drill hole No. BH-D16
13	Barclay and Shoaff, 1977, U.S. Geological Survey Open-File Report 77-171	Drill hole No. BH-D3
14	Barclay, 1979b, U.S. Geological Survey open-file report [in press]	Drill hole No. BH-D4
15	↓	Drill hole No. BH-D9
16	Deleted	
17	Barclay, 1979b, U.S. Geological Survey open-file report [in press]	Drill hole No. BH-D13

Page 1 of 2

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
18	Barclay and Shoaff, 1977, U.S. Geological Survey Open-File Report 77-171	Drill hole No. BH-D5
19	Barclay, 1979b, U.S. Geological Survey open-file report [in press]	Drill hole No. BH-D7
20	Walter Fees	Oil/gas well No. 1 Stratton Sheep Co.
21	Barclay and Shoaff, 1977, U.S. Geological Survey Open-File Report 77-171	Drill hole No. BH-D1
22	Barclay, 1979b, U.S. Geological Survey open-file report [in press]	Drill hole No. BH-D1D
23	↓	Drill hole No. BH-D1H
24		Drill hole No. BH-D2A
25		Drill hole No. BH-D1C
26		Drill hole No. BH-D1K
27		Drill hole No. BH-D1G
28		Drill hole No. BH-D1A
29		Drill hole No. BH-D1O
30		Drill hole No. BH-D1E
31		Drill hole No. BH-D1V
32		Drill hole No. BH-D2B
33		Drill hole No. BH-D2

Page 2 of 2

REFERENCES

American Society for Testing and Materials, 1977, Standard specification for classification of coals by rank, in Gaseous fuels; coal and coke; atmospheric analysis: ASTM Standard Specification D 388-77, pt. 26, p. 214-218.

Ball, M. W., and Stebinger, Eugene, 1910, The eastern part of the Little Snake River coal field, Wyoming, in Coal fields in Wyoming: U.S. Geological Survey Bulletin 381-B, p. 186-213.

Barclay, C. S. V., 1976, Preliminary geologic map of the Tullis quadrangle, Carbon County, Wyoming: U.S. Geological Survey Open-File Report 76-794, 3 sheets.

______1979a, Preliminary geologic map of the Browns Hill quadrangle, Carbon County, Wyoming: U.S. Geological Survey open-file report, in preparation.

______1979b, Geophysical logs and coal sections of holes drilled during 1977 and 1978 in the Browns Hill quadrangle, Carbon County, Wyoming: U.S. Geological Survey open-file report [in press].

______1979c, Geophysical logs and coal sections of holes drilled during 1977 and 1978 in the northeastern part of the Baggs quadrangle, Carbon County, Wyoming: U.S. Geological Survey open-file report [in press].

Barclay, C. S. V., and Shoaff, L. A., 1977, Lithologic and geophysical logs of holes drilled in the Doty Mountain, Browns Hill, and Baggs quadrangles, Carbon County, Wyoming, during 1976: U.S. Geological Survey Open-File Report 77-171, 77 p.

______1978, Lithologic and geophysical logs of holes drilled in the Savery quadrangle and in the southeastern part of the Baggs quadrangle, Carbon County, Wyoming, during 1977: U.S. Geological Survey Open-File Report 78-660, 50 p.

Barclay, C. S. V., Jobin, D. A., and Storrs, J. P., 1978, Minutes for the revision of the Rawlins (Little Snake River) Known Recoverable Coal Resource Area, Carbon and Sweetwater Counties, Wyoming, January 31, 1978: U.S. Geological Survey Conservation Division, unpublished report, 15 p.

Gill, J. R., 1974, Stratigraphic sections of the Mesaverde Group, Lewis Shale, Fox Hills Formation, and Medicine Bow Formation, Carbon County, Wyoming: U.S. Geological Survey Open-File Report 74-1038.

Gill, J. R., Merewether, E. A., and Cobban, W. A., 1970, Stratigraphy and nomenclature of some Upper Cretaceous and Lower Tertiary rocks in south-central Wyoming: U.S. Geological Survey Professional Paper 667, 53 p.

References--Continued

Hale, L. A., 1961, Late Cretaceous (Montanan) stratigraphy, eastern Washakie Basin, Carbon County, Wyoming, in Symposium on the Late Cretaceous rocks of Wyoming and adjacent areas, Wyoming Geological Association Guidebook, 16th Annual Field Conference, 1961: p. 129-137.

Hatch, J. R., and Barclay, C. S. V., 1979, Chemical analyses of deep core coal and shale samples from the Almond Formation, Washakie Basin, Sweetwater County, Wyoming: U.S. Geological Survey Open-File Report 79-1249, 16 p.

Haun, J. D., 1961, Stratigraphy of post-Mesaverde Cretaceous rocks, Sand Wash Basin and vicinity, Colorado and Wyoming, in Symposium on the Late Cretaceous rocks of Wyoming and adjacent areas, Wyoming Geological Association Guidebook, 16th Annual Field Conference, 1961: p. 116-124.

Lewis, J. L., 1961, The stratigraphy and depositional history of the Almond Formation in the Great Divide Basin, Sweetwater County, Wyoming, in Symposium on the Late Cretaceous rocks of Wyoming and adjacent areas, Wyoming Geological Association Guidebook, 16th Annual Field Conference, 1961: p. 87-95.

U.S. Bureau of Land Management, 1978, Draft environmental statement, proposed domestic livestock grazing management program for the Seven Lakes area: U.S. Bureau of Land Management, Rawlins district, Wyoming, v. 1.

U.S. Bureau of Mines and U.S. Geological Survey, 1976, Coal resource classification system of the U.S. Bureau of Mines and U.S. Geological Survey: U.S. Geological Survey Bulletin 1450-B, 7 p.

Weimer, R. J., 1961, Uppermost Cretaceous rocks in central and southern Wyoming, and northwest Colorado, in Symposium on the Late Cretaceous rocks of Wyoming and adjacent areas, Wyoming Geological Association Guidebook, 16th Annual Field Conference, 1961: p. 17-28.

Welder, G. E., and McGreevy, L. J., 1966, Ground-water reconnaissance of the Great Divide and Washakie Basins and some adjacent areas, southwestern Wyoming: U.S. Geological Survey Hydrologic Investigations Atlas HA-219.

Wyoming Natural Resources Board, 1966, Wyoming weather facts: Cheyenne, p. 14-15.