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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE NORTHWEST QUARTER OF THE DOTY MOUNTAIN 15-MINUTE QUADRANGLE CARBON COUNTY, WYOMING

[Report includes 32 plates]

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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

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INTRODUCTION

Purpose

This text is to be used in conjunction with Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) Maps of the northwest quarter of the Doty Mountain 15-minute 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 Published and unpublished public information available through April, 1979, was used as the data base for this study.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

In this report, the term "quadrangle" refers only to the northwest quarter of the Doty Mountain 15-minute quadrangle, which is located in southwestern Carbon County approximately 16 airline miles (26 km) south of the town of Creston Junction and 24 airline miles (39 km) north of the town of Baggs, Wyoming. In general, the quadrangle is unpopulated.

Accessibility

No major roads cross the quadrangle. However, Wyoming Highway 79 runs north-south less than one mile (1.6 km) west of the quadrangle boundary. It connects Creston Junction and Interstate Highway 80 to the north with Baggs to the south of the quadrangle boundary. One unimproved dirt road follows the old Overland Stage Route along Muddy Creek across the northern third of the quadrangle. Other unimproved dirt roads and trails provide access for the remainder of the quadrangle. Interstate Highway 80 crosses east-west through southern Wyoming approximately 16 miles (26 km) north of the quadrangle.

The main east-west line of the Union Pacific Railroad lies approximately 15 miles (24 km) north of the quadrangle. This line crosses southern Wyoming, providing railway service between Odgen, Utah, to the west and Omaha, Nebraska, to the east.

Physiography

The northwest quarter of the Doty Mountain 15-minute quadrangle lies on the northeastern rim of the Washakie Basin. The landscape within the quadrangle is characterized by a northeast-trending high buttes and ridges across the central part of the quadrangle, and relatively flat-lying valleys in both the northwestern and southeastern parts of the quadrangle. Altitudes range from approximately 6,600 feet (2,012 m) on Dry Cow Creek along the southern edge of the quadrangle to 7,668 feet (2,337 m) on Doty Mountain in the east-central part of the quadrangle. China Butte, located in the north-central part of the quadrangle, and Baldy Butte, in the northwestern part, rise approximately 430 feet (131 m) and 210 feet (64 m), respectively, above the Muddy Creek valley.

The northwestern part of the quadrangle is drained by Muddy Creek and its tributaries, Antelope Creek, Soap Hole Wash, Holler Draw and Cy Draw. Muddy Creek is a tributary of the Little Snake River south of the quadrangle boundary. The southeastern part of the quadrangle drains into Dry Cow Creek, which joins Muddy Creek in the southwest quarter of the Doty Mountain 15-minute quadrangle to the south. With the exception of Muddy Creek, 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 average annual precipitation in the area is 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 annual 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 juniper, cottonwood, willow, scrub oak, grasses, sagebrush, greasewood, serviceberry, bitterbrush, saltbush, rabbitbrush, and other desert shrubs.

Land Status

The northwest quarter of the Doty Mountain 15-minute quadrangle lies in the central part of the proposed Rawlins Known Recoverable Coal Resource Area (KRCRA). The entire quadrangle is within the proposed KRCRA boundary and the Federal government owns the coal rights for approximately half of this area as shown on plate 2. No outstanding Federal coal leases, prospecting permits or licenses occur within the quadrangle.

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 included a regional geologic map of the area. Gill and others (1970) described the stratigraphy and nomenclature of some of the Upper Cretaceous and Lower Tertiary rocks found in south-central Wyoming. Land (1972) discussed the depositional environments of the Fox Hills Sandstone and the Lance Formation. Edson (1976) and Edson and Curtiss (1976) reported on the geology and coal resources of the High Point, Seaverson Reservoir, and Fillmore Ranch quadrangles to the north of the quadrangle. Barclay and Zimmerman (1976) and Barclay and Shoaff (1977) discussed the stratigraphy of the formations that were drilled by the U.S. Geological Survey in the Doty Mountain area in 1975 and 1976. Tyler (1978) prepared correlation diagrams of geophysical logs from drill holes in the Washakie Basin. Unpublished subsurface data for coal test holes drilled by Rocky Mountain Energy Company (RMEC) and Arch Minerals were provided by RMEC. Additional unpublished data from reconnaisance mapping by Hettinger (1978b), and from drilling by the U.S. Geological Survey (Hettinger, 1979a and 1979b) have provided locations of coal outcrops and coal thickness information.

Stratigraphy

Formations exposed in the northwest quarter of the Doty Mountain 15-minute quadrangle range in age from Late Cretaceous to Paleocene and crop out in northeast-trending bands across the quadrangle. The Allen Ridge, Almond, Fox Hills Sandstone, and Lance Formations, all of Late Cretaceous age, and the Fort Union Formation of Paleocene age are coal-bearing within the quadrangle.

The Steele Shale is present in the subsurface in the quadrangle. It has an average thickness of 1,770 feet (539 m) where measured in two oil and gas wells drilled in the eastern half of the northeast quarter of the Doty Mountain 15-minute quadrangle. This formation consists of dark-gray shale with sparce layers of gray-weathering limestone concretions and thin beds of very fine grained sandstone and siltstone (Gill and others, 1970).

The Steele Shale is conformably overlain by and laterally intertongues with the Mesaverde Group of Late Cretaceous age. 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 along the eastern edge of the adjacent northeast quarter of the Doty Mountain 15-minute quadrangle. The formation ranges in thickness from 760 to 800 feet (232 to 244 m) where measured in oil and gas wells drilled in the quadrangle and is subdivided into four units which are, in ascending order, the Deep Creek Sandstone Member, the Espy Tongue, the Hatfield Sandstone Member, and an upper unnamed member. The Deep Creek Sandstone Member averages 110 feet (34 m) in thickness and consists of well-developed, fine- to medium-grained sandstone (Hale, 1961). Genetically, the Espy Tongue is a tongue of the Steele Shale measuring approximately 210 feet (64 m) thick and consisting of dark-gray marine shales and lenticular sandstones (Hale, 1961). The contact between the Espy Tongue and the Deep Creek Sandstone Member is sharp while the contact between the Espy Tongue and the overlying Hatfield Sandstone Member is gradational. The Hatfield Sandstone Member is approximately 150 feet (46 m) thick in the quadrangle and consists of pale-yellowish-gray cliff-forming sandstone (Gill and others, 1970). The upper unnamed member of the Haystack Mountains Formation is composed of approximately 315 feet (96 m) of interbedded shale, siltstone and sandstone (Gill and others, 1970). Although no coal beds were found in this member in this quadrangle, single thin coal beds do occur above the Hatfield Sandstone Member in quadrangles to the east and south.

The Allen Ridge Formation conformably overlies the Haystack Mountains Formation and is present within the subsurface in the quadrangle. The formation ranges in thickness from 1,020 to 1,155 feet (311 to 352 m) where measured in oil and gas wells drilled in the quadrangle and is subdivided into two units, a lower non-marine member and an upper marginal-marine member (Barclay, oral communication, 1979). These members are indistinguishable in geophysical logs from oil and gas wells in this quadrangle. Therefore, the two members have not been differentiated in the composite columnar section on plate 3. As described by

Barclay and Zimmerman (1976), the Allen Ridge is predominantly a continental fluviatile deposit and consists mostly of thick, lenticular sandstone beds and thinly to thickly interbedded siltstone, sandstone, mudstone, and carbonaceous shale. The upper marine member consists of marginal-marine lagoonal-paludal deposits of thick, bioturbated organic-rich shale, thin sandstone beds and coal (Barclay and Shoaff, 1978).

Unconformably overlying the Allen Ridge Formation is the Pine Ridge Sandstone (Gill and others, 1970) which crops out to the east of the quadrangle. This formation ranges from 70 to 100 feet (21 to 30 m) thick where measured in oil and gas wells drilled in this quadrangle and consists mainly of fluviatile sandstone, with a subordinate amount of interbedded carbonaceous shale, and, in places, a few coal beds (Barclay and Shoaff, 1977).

The Almond Formation, conformably overlying the Pine Ridge Sandstone, occurs in the subsurface and ranges from approximately 460 to 500 feet (140 to 152 m) thick where measured in oil and gas wells drilled in the quadrangle. It consists predominantly of marginal-marine, beach and lower delta plain paludal deposits (Barclay, written communication 1979). Most of the coal beds occur in the lower part of the formation.

The Lewis Shale of Late Cretaceous age conformably overlies the Almond Formation and crops out in the southeastern quarter of the quadrangle. The formation averages approximately 2,300 feet (701 m) in thickness where measured in oil and gas wells drilled to the west of the quadrangle. 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 Fox Hills Sandstone of Late Cretaceous age intertongues with the underlying marine Lewis Shale and with the overlying brackish-water and fluviatile sandstone and shale of the Lance Formation. The Fox Hills Sandstone is composed of thick units of pale-yellowish-gray, thin-bedded to massive, very fine to fine-grained sandstone, and thin units of olive-gray to dark-gray shale (Gill and others, 1970). The formation contains minor coal beds where it crops out in the southern half of the quadrangle (Hettinger, 1978b). The thickness of the formation is unknown in this quadrangle, but it is believed to be between 150 and 250 feet (46 and 76 m) based on thicknesses measured in oil and gas wells to the west of the quadrangle and in a measured section by Gill and others (1970) in the Baggs 15-minute quadrangle to the south.

The Lance Formation conformably overlies the Fox Hills Sandstone and crops out across the central part of the quadrangle. The Lance Formation ranges from 1,165 to 1,456 feet (355 to 444 m) thick where measured in oil and gas wells drilled in the Duck Lake quadrangle to the west. The formation consists of a non-marine sequence of carbonaceous shale, sandstone, and siltstone with coal beds occurring immediately above the contact with the Fox Hills Sandstone (Haun, 1961).

Unconformably overlying the Lance Formation, the Fort Union Formation crops out in the northwestern half of the quadrangle. The Fort Union Formation ranges in thickness from 1,700 to 1,970 feet (518 to 600 m) where measured in oil and gas wells drilled in the Duck Lake quadrangle to the west. At the base of the formation is from 700 to 1,000 feet (213 to 305 m) of white to brown fine- to coarse-grained, massive to thin-bedded, generally cross-bedded sandstone, chert-pebble conglomerate, and ironstone (Henderson, 1962). Above the basal sandstone and conglomerate, the Fort Union Formation grades into 900 to 1,100 feet (274 to 335 m) of interbedded light-colored sandstone, brown siltstone, gray sandy shale, dark-gray carbonaceous shale, and coal (Henderson, 1962). All of the major coal beds occur in a zone that ranges from 650 to 800 feet (198 to 244 m) thick and lies immediately above the basal sandstone and conglomerate of the Fort Union Formation.

The Wasatch Formation of Eocene age conformably overlies the Fort Union Formation and crops out in a southwest-trending band across the northwestern quarter of the quadrangle. In quadrangles to the west, the Wasatch Formation is divided into several parts which are separated from each other by tongues of the Green River Formation. Only the lower part of the main body of the Wasatch Formation is exposed in this quadrangle and it consists primarily of fluviatile red mudstone and sandstone (Roehler, 1969).

Holocene deposits of alluvium cover the stream valleys of Muddy Creek, Dry Cow Creek, and their tributaries.

The Upper Cretaceous formations in the northwest quarter of the Doty Mountain 15-minute 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 particularly, 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 Rawlins delta which extended northeastward into the Cretaceous sea (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. 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).

All of the Allen Ridge Formation, except the upper marginal-marine member, was deposited in a non-marine fluvial environments (Barclay, oral communication, 1979).

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 predominantly of marginal-marine deposits. The lower part of the formation is characterized by thick coal beds, and the upper part by shale and sandstone deposited by alternating transgressive-regressive cycles, respectively, of a late Cretaceous interior sea (Barclay and Shoaff, 1978).

Deposition of the Lewis Shale generally marks a landward progression of the Lewis sea, the final transgression of the Cretaceous. 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 Fox Hills Sandstone represents a transitional depositional environment between the deep-water marine environments of the Lewis Shale and the lagoonal and continental environments of the Lance Formation (Gill and others, 1970). Deposition of the Fox Hills Sandstone occurred in shallow marine, barrier bar, and beach, estuarine, and tidal-channel environments (Land, 1972).

During the gradual recession of the last Cretaceous sea, marking the close of Cretaceous time, carbonaceous shales, mudstones, and coal beds of the lower part of the Lance Formation were deposited in broad areas of estuarine, marsh, lagoonal, and coastal swamp environments (Land, 1972), while the uppermost sandstones and siltstones represent the accumulation of sediments in continental-fluvial environments (Beaumont, 1979).

The Fort Union Formation is composed of sediments deposited in a continental-fluvial setting. The coarse sandstones and conglmerate beds in the lower part of the formation indicate a braided stream environment, and the interbedded sandstones, siltstones, shales, and coal beds in the upper part of the formation represent the development of broad, thick floodplain and backswamp deposits (Beaumont, 1979).

The coarse sediments at the base of the main body of the Wasatch Formation were deposited in a fluvial environment that resulted from renewed tectonic uplift to the southwest (Beaument, 1979). The remainder of the main body was deposited in alternating swamp, lake, and stream environments (Masursky, 1962).

Structure

The northwest quarter of the Doty Mountain 15-minute quadrangle is located at the eastern end of the Wamsutter Arch which divides the Washakie Basin to the south from the Great Divide Basin to the north. Outcrops of beds in the quadrangle strike northeasterly and dip 3° to 40° to the northwest.

Numerous east-west trending normal faults were mapped by Hettinger (1978b) across the southern half of the quadrangle.

COAL GEOLOGY

Five formations contain coal in the northwest quarter of the Doty Mountain 15-minute quadrangle. They are, in ascending order, the Allen Ridge, Almond, Fox Hills Sandstone, Lance, and Fort Union Formations. The Allen Ridge Formation contains several minor coal beds in the upper member, underlying the Pine Ridge Sandstone. These coal beds were not isopached because they are less than Reserve Base thickness (5 feet or 1.5 meters). The Almond Formation is an important coal-bearing formation in the quadrangle and coal beds generally occur throughout the formation, but the most significant and widespread coals are found in the lowermost 150 feet (46 m), directly above the Pine Ridge Sandstone. Five Almond Formation coal beds were isopached in this quadrangle. Several thin coal beds in the Fox Hills Sandstone were identified and measured by Hettinger (1978b). However, because these coal beds are less than Reserve Base thickness, they have not been isopached. The Lance Formation also contains numerous coal beds, only two of which exceed Reserve Base thickness. The Fort Union Formation is the most significant coal-bearing formation in this quadrangle. The coal beds occur in a zone immediately above the basal sandstone unit of the formation and ten Fort Union coal beds have been isopached in this quadrangle.

Chemical analyses of coals.--Representative chemical analyses of coals in the Fort Union Formation taken from this quadrangle are listed in table 1 (RMEC, no date). Chemical anlayses were not available for coals in the Almond and Lance Formations in this quadrangle, but representative analyses from Ball (1909) and Hatch and Barclay (1979) are listed in table 1. In general, these coals rank as subbituminous A, B, or C on a moist, mineral-matter-free basis according to ASTM Standard Specification D 388-77 (American Society for Testing and Materials, 1977).

Isopached coal beds that are not formally named have been given bracketed numbers for identification purposes in this quadrangle only. The same coal bed may have a different designation in another quadrangle.

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, 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 Almond Formation

The Almond Formation is present in the subsurface of the quadrangle, and the coal beds were measured from geophysical logs of oil and gas wells drilled along the south-central edge of the quadrangle. Barclay (written communication, 1979) provided geophysical log interpretations and coal bed correlations from oil and gas wells that penetrate the Almond coal beds.

Robertson Coal Bed

The Robertson coal bed or zone of coal beds is defined by Barclay (oral communication, 1979) 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 here defined as the first areally persistant coal bed above the Pine Ridge Sandstone that has thickness measurements exceeding 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.

The coal bed has a maximum reported thickness of 4 feet (1.2 m) in sec. 1, T. 16 N., R. 92 W. Although this coal bed has not been mapped in this quadrangle because it is less than Reserve Base thickness, it is mentioned because it thickens and becomes more extensive in quadrangles to the south and east. In the southwest quarter of the Doty Mountain 15-minute quadrangle to the south, this coal bed has a maximum reported thickness of 14 feet (4.3 m) in sec. 21, T. 16 N., R. 91 W.

Almond [3] Coal Bed

The Almond [3] coal bed in this quadrangle is also designated Almond [3] in the adjacent southwest quarter of the Doty Mountain 15-minute quadrangle. The coal bed lies approximately 30 feet (9 m) above the Robertson coal bed. The Almond [3] coal bed (plate 3) was 5 feet (1.5 m) thick where measured in an oil and gas well in sec. 6, T. 16 N., R. 91 W.; in the southwest quarter of the Doty Mountain 15-minute quadrangle, the coal bed has a maximum measured thickness of 7 feet (2.1 m) in sec. 7, T. 16 N., R. 91 W.

Almond [4] Coal Bed

The Almond [4] coal bed in this quadrangle correlates with the Almond [4] in the southwest, the Almond [1] in the southeast, and the Almond [2] in the northeast quarters of the Doty Mountain 15-minute quadrangles. The Almond [4] coal bed lies from 30 to 60 feet (9.1 to 18.3 m) above the Robertson coal bed, and as shown on plate 8, ranges in thickness from 2 to 10 feet (0.6 to 3.0 m) where measured in oil and gas wells drilled in the quadrangle. In the southwest quarter of the Doty Mountain 15-minute quadrangle, the coal bed thickens to 16 feet (4.9 m) in sec. 13, T. 16 N., R. 92 W. In drill holes in sec. 22, T. 16 N., R. 91 W. in that quadrangle, the coal bed includes a shale parting 2 to 3 feet (0.6 to 0.9 m) thick.

Almond [5] Coal Bed

The Almond [5] coal bed is also designated as the Almond [5] coal bed in the southwest quarter of the Doty Mountain 15-minute quadrangle. The coal bed occurs from 18 to 35 feet (5.5 to 10.6 m) above the Almond [4] coal bed in this quadrangle. Drill-hole measurements show that the coal bed ranges in thickness from 5 feet (1.5 m) in sec. 6, T. 16 N., R. 91 W., to 14 feet (4.3 m) in sec. 11, T. 16 N., R. 92 W. (plate 12). In the southwest quarter of the Doty Mountain 15-minute quadrangle, the coal bed ranges up to 12 feet (3.7 m) thick.

Almond [6] Coal Bed

The Almond [6] coal bed lies from approximately 40 to 100 feet (12 to 30 m) above the Almond [5] coal bed. It has been designated the Almond [7] coal bed in the southwest quarter of the Doty Mountain 15-minute quadrangle. The isopach map for the Almond [6] coal bed is shown on plate 16. It ranges from 4 feet (1.2 m) thick in sec. 11, T. 16 N., R. 92 W., to 10 feet (3.0 m) thick in sec. 6, T. 16 N., R. 91 W., and in sec. 1, T. 16 N., R. 92 W. In the southwest quarter of the Doty Mountain 15-minute quadrangle this coal bed is 12 feet (3.7 m) thick where measured in oil and gas wells drilled in secs. 12 and 13, T. 16 N., R. 92 W.

Almond [8] Coal Bed

The Almond [8] coal bed (plate 19) lies approximately 200 feet (61 m) above the Almond [6] coal bed in this quadrangle. It correlates with the Almond [11] coal bed in the southwest quarter of the Doty Mountain 15-minute quadrangle. The Almond [8] coal bed is of limited areal extent and was encountered in only two oil and gas wells in this quadrangle. The coal bed measures 3 feet (0.9 m) in sec. 11, T. 16 N.,

R. 92 W., and 6 feet (1.8 m) in sec. 1, T. 16 N., R. 92 W. One drill hole penetrated this coal bed in the southwest quarter of the Doty Mountain 15-minute quadrangle where the bed is 5 feet (1.5 m) thick.

Coal Beds of the Lance Formation

Several Lance coal beds crop out in the south-central part of the quadrangle where they were measured by Hettinger (1978b). These coal beds occur immediately above the contact between the Lance Formation and underlying Fox Hills Sandstone. The coal beds are generally thin and contain numerous thin shale partings, and only the thickest coal beds containing a minimum amount of rock partings were isopached.

Lance [1] Coal Bed

The Lance [1] coal bed correlates with the Lance [2] coal bed in the southwest quarter of the Doty Mountain 15-minute quadrangle and is the first coal bed above the contact between the Lance Formation and the Fox Hills Sandstone. The isopach map of this coal bed is shown on plate 12. Surface measurements of the coal bed range from 3.1 feet (0.9 m) thick on the northern edge of sec. 2, T. 16 N., R. 92 W., to 10.2 feet (3.1 m) thick (including 2.6 feet or 0.8 meters of rock parting) in the southwest quarter of the same section (Hettinger, 1978b). The coal bed thins to 3.2 feet (1.0 m) in sec. 11, T. 16 N., R. 92 W., in the southwest quarter of the Doty Mountain 15-minute quadrangle, but attains Reserve Base thickness in several areas to the south along the outcrop in that quadrangle (Hettinger, 1978a).

Lance [2] Coal Bed

The Lance [2] coal bed lies from 11 to 44 feet (3.4 to 13.4 m) above the Lance [1] coal bed and is designated the Lance [3] coal bed in the southwest quarter of the Doty Mountain 15-minute quadrangle. In this quadrangle, the coal bed has a maximum measured thickness of 8.2 feet (2.5 m) in sec. 11, T. 16 N., R. 92 W. Except for this measurement and a measured section in the northern part of sec. 2, T. 16 N., R. 92 W., the coal bed does not reach Reserve Base thickness elsewhere in the quadrangle (plate 23). The coal bed thickens to 9.8 feet (3.0 m) in sec. 11,

T. 16 N., R. 92 W., in the southwest quarter of the Doty Mountain 15-minute quadrangle.

Coal Beds of the Fort Union Formation

The Fort Union Formation is the most important coal-bearing unit in this and adjacent quadrangles to the north, west and south. Coal beds in the Fort Union crop out in a northeast-trending band across the central part of the quadrangle. Generic names (e.g., Red Rim) are used to identify Fort Union coal beds where possible.

Red Rim Coal Bed

The Red Rim coal bed is named for Red Rim ridge located in T. 20 N., R. 90 W., in the northwest quarter of the Bridger Pass 15-minute quadrangle (Edson, 1976). This is, stratigraphically, the lowest coal bed of Reserve Base thickness in the Fort Union Formation in this quadrangle. It lies approximately 700 to 1,000 feet (213 to 305 m) above the unconformable contact between the Fort Union Formation and the underlying Lance Formation. The coal bed ranges in thickness from 1.1 feet (0.3 m) to a maximum of 12 feet (3.7 m) where measured in sec. 5, T. 16 N., R. 92 W., and in sec. 7, T. 17 N., R. 91 W. (plate 4). In the Seaverson Reservoir quadrangle to the north, the coal bed has a maximum measured thickness of 21 feet (6.4 m) in an RMEC drill hole in sec. 27, T. 18 N., R. 91 W. Where penetrated by an oil and gas well drilled in the Mexican Flats quadrangle, the Red Rim coal bed is 12 feet (3.7 m) thick and contains a shale parting 2 feet (0.6 m) thick. In a U.S. Geological Survey coal test hole in the southwest quarter of the Doty Mountain 15-minute quadrangle, the Red Rim coal bed has a maximum measured thickness of 16.9 feet (5.2 m) with a shale parting 1.6 feet (0.5 m) thick (Hettinger, 1978a). This coal bed has been identified at depth in oil and gas wells drilled in the western half of the Duck Lake and Mexican Flats quadrangles, and the coal bed is prominent and widespread in adjacent quadrangles to the north and south.

Fort Union [1] Coal Bed

The Fort Union [1] coal bed (plate 19) is a local bed of limited areal extent that lies approximately 190 feet (58 m) above the Red Rim coal bed. It was measured in two surface sections and one drill hole in the quadrangle and ranges in thickness from 6.4 feet (2.0 m) to a maximum of 6.8 feet (2.1 m) in sec. 3, T. 16 N., R. 92 W. The coal bed does not correlate with coal beds in adjacent quadrangles.

Olson Draw Coal Bed

This coal bed is named for Olson Draw located in T. 18 N., R. 91 W. (Edson, 1976). The Olson Draw coal bed is stratigraphically above and separated from the Red Rim coal bed by 90 to 220 feet (27 to 67 m) of interbedded sandstone, siltstone and shale. In this quadrangle, the Olson Draw coal bed has a maximum measured thickness of 10.8 feet (3.3 m) where penetrated by a RMEC drill hole in sec. 7, T. 17 N., R. 91 W., as shown on plate 8. To the north, in the Seaverson Reservoir quadrangle, it attains a maximum thickness of 10 feet (3.0 m) in sec. 30, T. 18 N., R. 92 W., but thins northward from that location. In the Duck Lake and Mexican Flats quadrangles, the coal bed was identified in oil and gas wells at depths greater than 3,000 feet (914 m). In the southwest quarter of the Doty Mountain 15-minute quadrangle the coal bed is 13.2 feet (4.0 m) with a parting 2.8 feet (0.9 m) thick in a surface measurement. The coal bed contains numerous partings in this and adjacent quadrangles to the west and south, but becomes more continuous to the north. Thin coal beds that are separated from the main bed by partings thicker than the split coals have not been included in the isopached thickness (plate 8).

Separation Creek Coal Zone

This coal zone is identified as a single bed in quadrangles to the north. However, the coal bed is split in this quadrangle and has been isopached as three separate coal beds (plates 12, 16, and 18). The coal zone is named after Separation Creek in the northeastern corner of the Fillmore Ranch quadrangle (Edson, 1976) and occurs approximately 240 feet (73 m) above the Olson Draw coal bed. Each coal bed has been assigned a bracketed number for identification purposes. Because of faulting and poor surface exposures, the individual coal beds of the Separation Creek zone are difficult to trace into the adjacent quadrangle to the south (Hettinger, oral communication, 1979).

The Separation Creek [1] coal bed is, stratigraphically, the lowest bed in the zone and, where encountered in drill holes and measured sections, ranges from 1.4 feet (0.4 m) thick to a maximum recorded thickness of 13.3 feet (4.1 m) that includes 1.3 feet (0.4 m) of rock parting.

The Separation Creek [2] coal bed lies from 10 to 40 feet (3.0 to 12.2 m) above the Separation Creek [1] coal bed and ranges from 1 foot (0.3 m) to a maximum reported thickness of 7.8 feet (2.4 m) in an RMEC drill hole located in sec. 5, T. 17 N., R. 91 W.

The Separation Creek [3] coal bed is the most important bed in the zone because it correlates with the Separation Creek coal bed in the Seaverson Reservoir quadrangle to the north. The coal bed lies above and is separated from the Separation Creek [2] coal bed by approximately 17 feet (5.2 m) of rock. The Separation Creek [3] coal bed ranges in thickness from 1.7 feet (0.5 m) in sec. 13, T. 17 N., R. 92 W., to 17.3 feet (5.3 m) where encountered in a coal test hole in sec. 33, T. 17 N., R. 91 W.

Muddy Creek Coal Bed

The Muddy Creek coal bed was named by Edson (1976) for Muddy Creek, which flows westward across the northern part of the quadrangle. The coal bed lies approximately 90 feet (27 m) above the Separation Creek [3] coal bed. The Muddy Creek coal bed (plate 23) is 11 feet (3.4 m) thick where measured in an RMEC drill hole in sec. 32, T. 18 N., R. 91 W. However, the coal bed thins southward along the outcrop and all measurements in the southern part of the quadrangle are less than Reserve Base thickness. The Muddy Creek coal bed thickens, and is more widespread, to the north in the Seaverson Reservoir quadrangle where it has a maximum measured thickness of 12 feet (3.7 m). Thin shale partings are common, but are not always present.

Fillmore Ranch Coal Bed

This coal bed was named for Fillmore Ranch (Edson, 1976) located in sec. 6, T. 18 N., R. 90 W. The Fillmore Ranch coal bed (plate 27) is the thickest and most extensive coal bed in the Fort Union Formation in this quadrangle. It lies approximately 160 feet (49 m) above the Muddy Creek coal bed and ranges from 14.7 feet (4.5 m) thick in a surface measurement located in sec. 34, T. 17 N., R. 92 W., to a maximum reported thickness of 31.7 feet (9.7 m) where penetrateed by a RMEC drill hole in sec. 5, T. 17 N., R. 91 W. The coal bed commonly contains a rock parting that ranges in thickness from 0.3 to 15 feet (0.1 to 4.6 m). The coal below the parting ranges from 7 to 23 feet (2.1 to 7.0 m) thick while the upper part of the coal bed ranges from 5 to 10 feet (1.5 to 3.0 m) thick. In the Seaverson Reservoir quadrangle the Fillmore Ranch coal bed has a maximum recorded thickness of 28 feet (8.5 m) in sec. 15, T. 18 N., R. 91 W. The rock parting becomes thicker and more prominent to the west and south, and the upper and lower splits of the Fillmore Ranch bed become thinner.

COAL RESOURCES

Information from oil and gas wells, coal test holes from RMEC and the U.S. Geological Survey, and measured sections by Ball and Stebinger (1910) and Hettinger (1978b) were used to construct outcrop, isopach, and structure contour maps of the coal beds in the northwest quarter of the Doty Mountain 15-minute quadrangle. At the request of RMEC, coal-rock data for some of their drill holes have not been shown on plate 1 or on the derivative maps. However, data from these drill holes have been used to construct the derivative maps. These data may be obtained by contacting RMEC. The source of each indexed data point shown on plate 1 is listed in table 4.

Coal resources were calculated using data obtained from the coal isopach maps (plates 4, 8, 12, 16, 19, 23, and 27). 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, 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 maximum depth of 1,000 feet (305 m) for subbituminous coal.

Reserve Base and Reserve tonnages for the isopached beds are shown on plates 7, 11, 15, 18, 22, 26, and 30, and are rounded to the nearest 10,000 short tons (9,072 metric tons). Coal Reserve Base tonnages per Federal section are shown on plate 2 and total approximately 322.68 million short tons (292.74 million metric tons) for the entire quadrangle. Reserve Base tonnages in the various development potential categories for surface and subsurface mining methods are shown in tables 2 and 3.

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

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 of 5 feet (1.5 m) or more thick are not known, but may occur. Limited knowledge pertaining to the areal distribution, thickness, depth, and attitude of the coals in these areas prevents accurate evaluation of the development potential in the high, moderate, or low categories.

The coal development potential for surface mining methods is shown on plate 31. Of the Federal land areas having a known development potential for surface mining methods, 95 percent are rated high, 3 percent are rated moderate, and 2 percent are rated low. The remaining

Federal lands within the quadrangle 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 areas where coal beds of Reserve Base thickness are not known, but may occur.

The coal development potential for subsurface mining methods is shown on plate 32. Of the Federal land areas having a known development potential for conventional subsurface mining methods, 91 percent are rated high and 9 percent are rated moderate. The remaining Federal land within the quadrangle is classified as having unknown development potential for conventional subsurface mining methods.

Based on criteria provided by the U.S. Geological Survey, coal beds of Reserve Base thickness dipping between 15° and 35°, regardless of tonnage, have low development potential for in-situ mining methods. Coal lying between the 200-foot (61-m) overburden isopach and the outcrop is not included in total coal tonnages available because it is needed for cover and containment in the in-situ process.

All of the Federal lands where the dip of the coal beds exceeds 15° are rated low for in-situ development potential because faults are present and only approximately 18.36 million short tons (16.66 million metric tons) of coal distributed through six different coal beds are believed to be available for in-situ mining. The remaining Federal lands within the proposed KRCRA boundary are classified as having unknown development potential for in-situ mining methods.

Table 1. -- Chemical analyses of coals in the northwest quarter of the Doty Mountain 15-minute 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
SW¼, NW¼, sec. 5, T. 17 N., R. 91 W., (RMEC, CB-96)	Fillmore Ranch	A	22.7	30.4	42.1	4.8	0.2	-	-	-	-	-	9,206
		C	0.0	39.3	54.5	6.2	0.3	-	-	-	-	-	11,902
NE¼, NW¼, sec. 33, T. 18 N., R. 91 W., (RMEC, CB-77)	Muddy Creek	A	22.9	30.1	41.7	5.4	0.3	-	-	-	-	-	9,043
		C	0.0	39.0	54.0	6.9	0.4	-	-	-	-	-	11,726
NE¼, NE¼, sec. 5, T. 17 N., R. 91 W., (RMEC, CB-86)	Separation Creek	A	22.3	0.0	0.0	10.1	0.8	-	-	-	-	-	8,699
		C	0.0	0.0	0.0	13.0	1.1	-	-	-	-	-	11,193
NE¼, SE¼, sec. 33, T. 18 N., R. 91 W., (RMEC, CB-81)	Red Rim	A	24.3	29.7	33.5	7.6	0.7	-	-	-	-	-	8,646
		C	0.0	39.2	50.8	10.1	0.9	-	-	-	-	-	11,416
NE¼, SW¼, sec. 6, T. 20 N., R. 88 W., Old Nebraska Mine, (Ball, 1909)	Lance-Fox Hills Formation, undifferentiated	A	19.2	36.46	40.56	3.78	0.34	5.74	58.88	1.34	29.92	5,401	9,722
		B	17.3	37.32	41.51	3.87	0.35	5.61	60.27	1.37	28.53	5,528	9,951
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

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 northwest quarter of the Doty Mountain 15-minute quadrangle, Carbon County, Wyoming.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Fillmore Ranch	35,880,000	330,000	0	0	36,210,000
Muddy Creek	810,000	1,260,000	2,610,000	0	4,680,000
SC {3}	2,700,000	870,000	1,510,000	0	5,080,000
SC {2}	20,000	40,000	60,000	0	120,000
SC {1}	690,000	1,010,000	1,440,000	0	3,140,000
Olson Draw	190,000	180,000	920,000	0	1,290,000
Red Rim	2,160,000	1,560,000	2,740,000	0	6,460,000
FU {1}	60,000	50,000	210,000	0	320,000
La {2}	110,000	110,000	160,000	0	380,000
La {1}	350,000	310,000	430,000	0	1,090,000
Totals	43,170,000	5,720,000	10,080,000	0	58,770,000

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 northwest quarter of the Doty Mountain 15-minute quadrangle, Carbon County, Wyoming.

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential*	Total
Fillmore Ranch	129,200,000	13,840,000	0	6,040,000	149,080,000
Muddy Creek	5,320,000	4,290,000	0	0	9,610,000
SC {3}	12,720,000	0	0	130,000	12,850,000
SC {2}	90,000	0	0	0	90,000
SC {1}	6,310,000	0	0	2,960,000	9,270,000
Olson Draw	3,080,000	0	0	830,000	3,910,000
Red Rim	21,730,000	1,710,000	0	7,980,000	31,420,000
FU {1}	0	0	0	420,000	420,000
La {2}	480,000	0	0	0	480,000
La {1}	730,000	0	0	0	730,000
Al {8}	0	380,000	0	0	380,000
Al {6}	0	16,260,000	140,000	0	16,400,000
Al {5}	600,000	13,430,000	3,410,000	0	17,440,000
Al {4}	0	10,360,000	0	0	10,360,000
Al {3}	0	1,470,000	0	0	1,470,000
Totals	180,260,000	61,740,000	3,550,000	18,360,000	263,910,000

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

*Tonnages for coal beds dipping greater than 15 degrees.

Table 4. -- Sources of data used on plate 1

Plate 1 Index Number	Source	Data Base
1	U.S. Natural Gas Corp.	Oil/gas well No. 23-6 Cow Creek-McCulloch Unit 1
2	↓	Core hole No. 1-A
3	Roger A. Ready, Champion Ventures and others	Oil/gas well Federal No. 43-1
4	Sohio Petroleum	Oil/gas well No. 3 Unit
5	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section Nos. 131 and 132
6	↓	Measured Section No. 133
7	↓	Measured Section Nos. 134 and 135
8	↓	Measured Section Nos. 136, 137 and 138
9	↓	Measured Section Nos. 79, 81, and 82
10	↓	Measured Section Nos. 83, 84, 85, and 86
11	↓	Measured Section No. 90
12	↓	Measured Section Nos. 92, 100-103
13	↓	Measured Section No. 91
14	↓	Measured Section Nos. 88 and 89

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Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
15	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section No. 95
16	Hettinger, 1979b, U.S. Geological Survey, unpublished data	Drill hole No. DM-5
17	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section No. 94
18	↓	Measured Section No. 93
19	Ball and Stebinger, 1910, U.S. Geological Survey Bulletin 381-B	Measured Section
20	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section No. 96
21	↓	Measured Section No. 97
22	↓	Measured Section No. 98
23	↓	Measured Section No. 99
24	↓	Measured Section Nos. 139 and 140
25	U.S. Natural Gas Corp.	Oil/gas well No. 41-11 Unit
26	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section Nos. 11 and 12
27	RMEC, (no date), unpublished data - China Buttes	Drill hole No. CB 88
28	↓	Drill hole No. CB 90
29	↓	Drill hole No. CB 91

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
30	RMEC, (no date), unpublished data - China Buttes	Drill hole No. CB 92
31	↓	Drill hole No. CB 93
32	↓	Drill hole No. CB 86
33	↓	Drill hole No. CB 94
34	↓	Drill hole No. CB 95
35	↓	Drill hole No. CB 87
36	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section Nos. 15 and 16
37	↓	Measured Section Nos. 14, 17, 18, 20, and 21
38	RMEC, (no date), unpublished data - China Buttes	Drill hole No. CB 97
39	↓	Drill hole No. CB 96
40	↓	Drill hole No. CB 98
41	↓	Drill hole No. CB 104
42	↓	Drill hole No. CB 99
43	↓	Drill hole No. CB 103
44	↓	Drill hole No. CB 100
45	↓	Drill hole No. CB 101
46	↓	Drill hole No. CB 102
47	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section Nos. 22, 23, and 24
48	Arch Minerals-RMEC, (no date), unpublished data	Drill hole No. AM 687

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
49	Arch Minerals-RMEC, (no date), unpublished data	Drill hole No. AM 686
50	↓	Drill hole No. AM 685
51	↓	Drill hole No. AM 684
52	RMEC, (no date), unpublished data - Union Pacific Coal inventory	Drill hole No. 1AS
53	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section Nos. 26, 27, 29, 29, and 30
54	RMEC, (no date), unpublished data - Union Pacific Coal Inventory	Drill hole No. 2AS
55	↓	Drill hole No. 3AS
56	↓	Drill hole No. 4AS
57	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section Nos. 32, 33, 34, and 36
58	↓	Measured Section No. 35
59	Arch Minerals-RMEC, (no date), unpublished data	Drill hole No. AM 692
60	↓	Drill hole No. AM 691
61	↓	Drill hole No. AM 690
62	↓	Drill hole No. AM 688
63	↓	Drill hole No. AM 689
64	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section No. 110

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
65	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section No. 112
66	↓	Measured Section No. 113
68	RMEC, (no date), unpublished data - Union Pacific Coal Inventory	Drill hole No. 1AD
69	↓	Drill hole No. 3AD
70	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section Nos. 37, 38 and 39
71	│	Measured Section Nos. 41, 42, 43, and 44
72	│	Measured Section Nos. 45, 46, and 47
73	│	Measured Section Nos. 114 and 115
74	│	Measured Section No. 116
75	│	Measured Section No. 117
76	│	Measured Section No. 124
77	│	Measured Section Nos. 125 and 126
78	│	Measured Section No. 118
79	│	Measured Section Nos. 119, 120, and 121
80	↓	Measured Section No. 123

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
81	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section No. 122
82	↓	Measured Section No. 127
83	↓	Measured Section Nos. 128 and 129
84	↓	Measured Section No. 130
85	RMEC, (no date), unpublished data - Union Pacific Coal Inventory	Drill hole No. 1AS
86	↓	Drill hole No. 2AS
87	Arch Minerals-RMEC, (no date), unpublished data	Drill hole No. AM 693
88	RMEC, (no date), unpublished data - Union Pacific Coal Inventory	Drill hole No. 1AS
89	↓	Drill hole No. 4AS
90	↓	Drill hole No. 3AS
91	↓	Drill hole No. 2AS
92	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section Nos. 49, 50 and 51
93	RMEC, (no date), unpublished data - Union Pacific Coal Inventory	Drill hole No. 5AS
94	Arch Minerals-RMEC, (no date), unpublished data	Drill hole No. AM 670
95	↓	Drill hole No. AM 672
96	↓	Drill hole No. AM 671

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Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
97	Arch Minerals-RMEC, (no date), unpublished data	Drill hole No. AM 669
98	↓	Drill hole No. AM 668
99	↓	Drill hole No. AM 667
100	↓	Drill hole No. AM 666
101	↓	Drill hole No. AM 665
102	↓	Drill hole No. AM 664
103	↓	Drill hole No. AM 663
104	RMEC, (no date), unpublished data - Union Pacific Coal Inventory	Drill hole No. 4AS
105	↓	Drill hole No. 1AS
106	↓	Drill hole No. 3AS
107	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section No. 56
108	Arch Minerals-RMEC, (no date), unpublished data	Drill hole No. AM 696
109	↓	Drill hole No. AM 674
110	↓	Drill hole No. AM 673
111	RMEC, (no date), unpublished data - Union Pacific Coal Inventory	Drill hole No. 2AS
112	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section No. 57
113	Arch Minerals-RMEC, (no date), unpublished data	Drill hole No. AM 694
114	↓	Drill hole No. AM 695

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
115	RMEC, (no date), unpublished data - Union Pacific Coal Inventory	Drill hole No. 1AS
116	↓	Drill hole No. 4AS
117	↓	Drill hole No. 3AS
118	↓	Drill hole No. 2AS
119	Hettinger, 1979b, U.S. Geological Survey, unpublished data	Drill hole No. DM-4
120	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section Nos. 58, 59, 60, and 61
121	↓	Measured Section No. 64
122	↓	Measured Section Nos. 62 and 63
123	RMEC, (no date), unpublished data - Union Pacific Coal Inventory	Drill hole No. 1AS
124	↓	Drill hole No. 3AS
125	Hettinger, 1979b, U.S. Geological Survey, unpublished data	Drill hole No. DM-3
126	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section Nos. 70 and 71
127	↓	Measured Section No. 75
128	↓	Measured Sections Nos. 65, 66, 67, 68 and 69
129	RMEC, (no date), unpublished data - Union Pacific Coal Inventory	Drill hole No. 3AS
130	↓	Drill hole No. 1AS
131	↓	Drill hole No. 2AS

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
132	RMEC, (no date), unpublished data - China Buttes	Drill hole No. CB 73
133	Hettinger, 1979a, U.S. Geological Survey Open-File Report 79-326	Drill hole No. D-4
134	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section No. 1
135	Hettinger, 1979a, U.S. Geological Survey Open-File Report 77-326	Drill hole No. D-5
136	RMEC, (no date), unpublished data - China Butte	Drill hole No. CB 89
137	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section No. 2
138	RMEC, (no date), unpublished data - China Butte	Drill hole No. CB 76
139	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section Nos. 3 and 4
140	RMEC, (no date), unpublished data - China Butte	Drill hole No. CB 77
141	↓	Drill hole No. CB 75
142	↓	Drill hole No. CB 78
143	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section Nos. 6 and 7
144	RMEC, (no date), unpublished data - China Butte	Drill hole No. CB 84
145	↓	Drill hole No. CB 79
146	↓	Drill hole No. CB 80

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Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
147	RMEC (no date), unpublished data - China Butte	Drill hole No. CB 81
148	↓	Drill hole No. CB 85
149	Ball and Stebinger, 1910, U.S. Geological Survey Bulletin 381-B	Measured Section
150	RMEC, (no date), unpublished data - China Butte	Drill hole No. CB 82
151		Drill hole No. CB 83
152	↓	Drill hole No. CB 70
153	Hettinger, 1978b, U.S. Geological Survey, unpublished data	Measured Section No. 8A

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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.

Arch Minerals-Rocky Mountain Energy Company, (no date), Unpublished drill-hole data.

Ball, M. W., 1909, The western part of the Little Snake River coal field, Wyoming, in Coal fields of Wyoming: U.S. Geological Survey Bulletin 341-B, p. 243-255.

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., and Zimmerman, S. C., 1976, Lithologic and geophysical logs of holes drilled in the eastern part of the Doty Mountain quadrangle, Carbon County, Wyoming, by the U.S. Geological Survey during 1975: U.S. Geological Survey Open-File Report 76-510, 108 p.

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.

Beaumont, E. A., 1979, Depositional environments of Fort Union sediments (Tertiary, northwest Colorado) and their relation to coal: American Association of Petroleum Geologists Bulletin, v. 63, No. 2, p. 194-217.

Edson, G. M., 1976, Preliminary geologic map and coal sections of the Seaverson Reservoir quadrangle, Carbon County, Wyoming: U.S. Geological Survey Conservation Division, unpublished maps, sheets 1 and 2, scale 1:24,000.

References--Continued

Edson, G. M., and Curtiss, G. S., 1976, Lithologic and geophysical logs of holes drilled in High Point, Seaverson Reservoir, and Fillmore Ranch quadrangles, Carbon County, Wyoming: U.S. Geological Survey Open-File Report 76-272, 55 p.

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.

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.

Henderson, D. K., 1962, Geology of the Doty Mountain-Dad area, Carbon County, Wyoming, Emphasis on stratigraphy of uppermost Cretaceous rocks: Colorado School of Mines, Golden, unpublished M.S. thesis.

Hettinger, R. D., 1978a, Preliminary geologic map and coal correlations of the southwest quarter of the Doty Mountain 15-minute quadrangle, Carbon County, Wyoming: U.S. Geological Survey, unpublished map, scale 1:24,000.

_______1978b, Preliminary geologic map and coal correlations of the northwest quarter of the Doty Mountain 15-minute quadrangle, Carbon County, Wyoming: U.S. Geological Survey, unpublished map, scale 1:24,000.

_______1979a, Geophysical and lithologic logs of 1977 coal drilling on the Fort Union Formation, Carbon and Sweetwater Counties, Wyoming: U.S. Geological Survey Open-File Report 79-326.

_______1979b, Unpublished drill-hole data from 1978 drilling program: U.S. Geological Survey.

References--Continued

Land, C. B., Jr., 1972, Stratigraphy of Fox Hills Sandstone and associated formations, Rock Springs uplift and Wamsutter Arch area, Sweetwater County, Wyoming: A shoreline-estuary sandstone model for the Late Cretaceous: Colorado School of Mines Quarterly, v. 67, no. 2, 69 p.

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.

Rocky Mountain Energy Company, (no date), Unpublished drill-hole data from the China Butte project.

______ (no date), Unpublished drill-hole data from the Union Pacific Coal Inventory of 1971.

Tyler, T. F., 1978, Preliminary chart showing electric log correlation section A-A' of some Upper Cretaceous and Tertiary rocks, Washakie Basin, Wyoming: U.S. Geological Survey Open-File Report 78-703.

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.