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

[Report includes 27 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 southwest 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 Published and unpublished public information available through April, 1979, was used as the data base for this study.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 southwest quarter of the Doty Mountain 15-minute quadrangle, which is located in southwestern Carbon County approximately 25 miles (40 km) south of the town of Creston Junction and 15 miles (24 km) north of the town of Baggs, Wyoming. The quadrangle is unpopulated.

Accessibility

Wyoming Highway 789 crosses the southwestern corner of the quadrangle, connecting Creston Junction and Interstate Highway 80 to the north of the quadrangle with Baggs to the south of the quadrangle. An improved light-duty road, connecting Wyoming Highway 789 with the city of Rawlins approximately 38 miles (61 km) to the northeast of the quadrangle, crosses east-west through the northern half of the quadrangle. A branch of this road extends southeasterly across the quadrangle to connect with the town Savery, approximately 24 miles (39 km) to the southeast. Other unimproved dirt roads and trails provide access for the remainder of the quadrangle.

Interstate Highway 80 crosses east-west through southern Wyoming approximately 25 miles (40 km) north of the quadrangle.

The main east-west line of the Union Pacific Railroad lies approximately 24 miles (39 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 southwest quarter of the Doty Mountain 15-minute quadrangle lies on the eastern edge of the Washakie Basin. The landscape within the quadrangle is characterized by low, irregular terrain and isolated buttes. Altitudes range from approximately 6,440 feet (1,963 m), on Muddy Creek at the southern edge of the quadrangle, to approximately 7,080 feet (2,158 m), in the northwestern corner of the quadrangle.

Muddy Creek, a tributary of the Little Snake River to the south of the quadrangle, flows southeasterly through the southwestern corner of the quadrangle. Dry Cow Creek, Cow Creek, Wild Cow Creek and Blue Gap Draw drain the quadrangle into Muddy Creek. With the exception of Muddy Creek, which flows year-round, 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 southwest quarter of the Doty Mountain 15-minute quadrangle lies in the southwestern 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 90 percent of the 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). Masursky (1962) included a description of the depositional environments of the Wasatch Formation in a publication on uranium-bearing coal in the eastern part of the Red Desert area. Henderson (1962) described Cretaceous stratigraphy and the geology of the Doty Mountain-Dad area of Wyoming. 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. Roehler (1969) discussed the stratigraphy and depositional environments of Eocene rocks in the Washakie Basin. 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 this 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 during 1975 and 1976. Tyler (1978) prepared correlation diagrams of geophysical logs from drill holes in the Washakie Basin. Recent geologic mapping was performed by Hettinger in this quadrangle (1978a) and the adjacent northeast quarter of the Doty Mountain 15-minute quadrangle (1978b). Urangesellschaft U.S.A., Inc. (1978) and the U.S. Geological Survey (Hettinger, 1979) recently completed drilling programs in this and adjacent quadrangles.

Stratigraphy

The formations exposed in the southwest quarter of the Doty Mountain 15-minute quadrangle range in age from Late Cretaceous to Eocene and crop out in north-trending bands across the quadrangle. The Mesaverde Group and the Lance, Fort Union, and Wasatch Formations are known to be coal-bearing in the quadrangle.

The Steele Shale of Late Cretaceous age is present in the subsurface in the quadrangle and 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 upper part of the Steele Shale was encountered at depths ranging from approximately 2,750 to 4,400 feet (838 to 1,341 m) in oil and gas wells drilled in the northern half of the quadrangle.

The Mesaverde Group of Late Cretaceous age conformably overlies and laterally intertongues with the Steel Shale. 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 Haystack Mountains Formation is present in the subsurface and ranges from 750 to 860 feet (229 to 262 m) thick where measured in oil and gas wells drilled in this quadrangle. It is subdivided 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. The Deep Creek Sandstone Member averages 105 feet (32 m) thick and consists of well-developed, fine- to medium-grained sandstone (Hale, 1961). The Espy Tongue, genetically a tongue of the Steele Shale, is approximately 255 feet (78 m) thick and consists 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, approximately 120 feet (37 m) thick, 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 335 feet (102 m) of interbedded shale, siltstone, sandstone, and thin coal beds (Gill and others, 1970).

The Allen Ridge Formation conformably overlies the Haystack Mountains Formation and is present in the subsurface in the quadrangle. The formation ranges in thickness from 935 to 1,255 feet (285 to 383 m) where measured in oil and gas wells drilled in this 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 well logs in this quadrangle. Therefore, no differentiation has been made between them in the composite columnar section on plate 3. Barclay and Zimmerman (1976) estimated the lower non-marine member to be 1,000 to 1,200 feet (305 to 366 m) thick, and that the upper marginal-marine member may be from 140 to 170 feet (43 to 52 m) thick in the northeast quarter of the Doty Mountain 15-minute quadrangle. 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 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 50 to 90 feet (15 to 27 m) thick 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 340 to 480 feet (104 to 146 m) thick where measured in oil and gas wells drilled in this 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 eastern half of the quadrangle. The shale of the Lewis is dark-gray to olive-gray, silty to sandy, and, locally, contains fossiliferous limestone or siltstone concretions. The middle and upper parts of the Lewis Shale contains a distinctive and widespread unit of interstratified sandstone and sandy shale called the Dad Sandstone Member (Gill and others, 1970). Where penetrated by an oil and gas well in sec. 22, T. 15 N., R. 92 W., the Lewis is 2,250 feet (686 m) thick and the Dad Sandstone Member is 1,210 feet (369 m) thick. In oil and gas wells drilled in the Mexican Flats quadrangle to the west, the Lewis ranges in thickness from 2,190 to 2,350 feet (668 to 716 m) and the Dad Sandstone Member ranges from 850 to 1,450 feet (259 to 442 m) in thickness.

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 friable sandstone and thin units of olive-gray to dark-gray sandy shale (Gill and others, 1970). The formation contains minor coal beds where it crops out in the southern half of the northwest quarter of the Doty Mountain 15-minute quadrangle (Hettinger, 1978b). This formation is approximately 290 feet (88 m) thick where measured in an oil and gas well in sec. 22, T. 15 N., R. 92 W. It ranges in thickness from 200 to 308 m feet (61 to 94 m) where penetrated by oil and gas wells drilled in the Mexican Flats quadrangle to the west.

The Lance Formation conformably overlies the Fox Hills Sandstone and crops out across the central part of the quadrangle. In sec. 2, T. 15 N., R. 92 W., the Lance Formation is 1,400 feet (427 m) thick in an oil and gas well in this quadrangle and ranges in thickness from 920 to 1,400 feet (280 to 427 m) where measured in oil and gas wells drilled in the Mexican Flats 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 of Paleocene age crops out in the western half of the quadrangle and is 1,550 feet (472 m) thick where measured in an oil and gas well in sec. 22, T. 15 N., R. 92 W. The Fort Union Formation ranges in thickness from 1,460 to 1,880 feet (445 to 573 m) in oil and gas wells drilled in the Mexican Flats 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. Above the basal sandstone and conglomerate unit, the formation grades into from 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 unit.

The Wasatch Formation of Eocene age conformably overlies the Fort Union Formation and crops out in a northwest-trending band across the southwestern 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 main body of the Wasatch Formation is exposed in this quadrangle. The main body is approximately 2,000 feet (610 m) thick where it crops out in the quadrangle and consists primarily of fluviatile red mudstone and sandstone (Roehler, 1969).

The lacustrine Green River Formation is represented by the Tipton Tongue in this quadrangle. This member is overlain by the Cathedral Bluffs Tongue of the Wasatch Formation which crops out to the west and is underlain by the main body of the Wasatch Formation. A total section of this member is not present in this quadrangle. It maintains a thickness of approximately 160 feet (49 m) along the eastern margin of the Washakie Basin and consists largely of soft papery low-grade oil shale, but does contain a few thin, brownish fine-grained limy sandstone beds and layers of concretionary, sandy, coquinal or oolitic limestone (Bradley, 1964).

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

The Upper Cretaceous formations in the southwest 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.

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 environment (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, respecively, 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 environment of the Lewis Shale and the lagoonal and continental deposits of the Lance Formation (Gill and others, 1970). Deposition of the Fox Hills Sandstone sediments occurred in shallow marine, barrier bar, and beach environments.

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).

After the final withdrawal of the Cretaceous sea, thick sections of detrital material, eroded from older formations, were deposited as the Fort Union Formation. The coarse sandstones and conglomerates of the lower sandy unit indicate a braided stream environment, and the interbedded sandstones, siltstones, shales, and coal beds of 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 (Beaumont, 1979). The remainder of the main body was deposited in alternating swamp, lake, and stream environments (Masursky, 1962). The oil shale and limestone beds of the Tipton Tongue of the Green River Formation represent deposition in widespread lacustrine environments. This intertonguing of the Wasatch and Green River Formations represents a series of alternate withdrawals and flooding that interrupted otherwise continuous lacustrine Green River depositon (Roehler, 1969).

Structure

The southwest quarter of the Doty Mountain 15-minute quadrangle is located on the eastern edge of the Washakie Basin. Outcrops of beds in the quadrangle generally strike north and dip 8° to 27° to the west.

Numerous east-west trending normal faults were mapped by Hettinger (1978a) across the quadrangle.

COAL GEOLOGY

Seven formations contain coal in the southwest quarter of the Doty Mountain 15-minute quadrangle. They are, in ascending order, the Haystack Mountains, Allen Ridge, Almond, Lance, Fox Hills Sandstone, Fort Union, and Wasatch Formations. The Allen Ridge Formation contains several minor coal beds in the upper member underlying the Pine Ridge Sandstone and the Haystack Mountains Formation contains thin coal beds in the upper unit above the Hatfield Sandstone Member. 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. Eleven Almond Formation coal beds were isopached in this quadrangle. One thin coal bed in the Fox Hills Sandstone was identified and mapped by Hettinger (1978a), but this coal bed is less than Reserve Base thickness. The Lance Formation also contains numerous coal beds, only three of which exceed Reserve Base thickness. The Fort Union Formation is the most significant coal-bearing formation in the quadrangle. The coal beds occur in a zone immediately above the basal sandstone unit of this formation and five Fort Union coal beds have been isopached in this quadrangle. Several coal beds in the Wasatch Formation were encountered in an oil and gas well in the quadrangle. However, none of these beds are of Reserve Base thickness.

<u>Chemical analyses of coals</u>.--Chemical analyses were not available for coals in the Almond, Lance, and Fort Union Formations in this quadrangle,

but representative analyses from Ball (1909), Hatch and Barclay (1979), and Rocky Mountain Energy Company (RMEC) 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. 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 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

Coal beds of the Almond Formation are present in the subsurface in the quadrangle and were measured in oil and gas wells drilled in the northern part of the quadrangle. Barclay (written communication, 1979) has provided geophysical log interpretations and coal bed correlations from oil and gas wells that penetrate the Almond Formation.

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 14 feet (4.3 m) in sec. 21, T. 16 N., R. 91 W. (plate 4), and thins to 4 feet (1.2 m) in an oil and gas well located in sec. 13, T. 16 N., R. 92 W. In the northwest quarter of the Doty Mountain 15-minute quadrangle the coal bed has a maximum recorded thickness of 4 feet (1.2 m) in sec. 1, T. 16 N., R. 92 W. In the southeast quarter of the Doty Mountain 15-minute quadrangle, the coal bed has a maximum recorded thickness of 16 feet (4.9 m) in two measured sections located in sec. 9, T. 15 N., R. 90 W., and is a thick, persistent bed throughout that quadrangle and quadrangles to the south.

Almond [1] Coal Bed

The Almond [1] coal bed (plate 4) is designated the Almond [2] in the southeast quarter of the Doty Mountain 15-minute quadrangle. Measurements of this coal bed were not available in this quadrangle, but it is believed that the coal bed may be more than 10 feet (3.0 m) thick based on data projected from the adjacent southeast quarter of the Doty Mountain 15-minute quadrangle where the coal bed is 10.5 feet (3.2 m) near the quadrangle boundary.

Almond [2] Coal Bed

The Almond [2] coal bed (plate 7) is designated as the Almond [Local 3] bed in the southeast quarter of the Doty Mountain 15-minute quadrangle and as the Almond [2] coal bed in the northwest quarter. The Almond [2] coal bed lies approximately 30 feet (9.1 m) above the Robertson coal bed and ranges from 4 to 7 feet (1.2 to 2.1 m) in thickness where measured in oil and gas wells drilled in this quadrangle. In the southeast quarter of the Doty Mountain 15-minute quadrangle, the coal bed ranges from 1 to 6 feet (0.3 to 1.8 m) thick where measured in drill holes.

Almond [3] Coal Bed

The Almond [3] coal bed lies approximately 6 feet (1.8 m) above the Almond [2] coal bed and has a maximum recorded thickness of 7 feet (2.1 m) in sec. 7, T. 16 N., R. 91 W., as shown on plate 10. This coal bed thins to less than Reserve Base thickness in the northwest quarter of the Doty Mountain 15-minute quadrangle.

Almond [4] Coal Bed

The Almond [4] coal bed in this quadrangle correlates with the Almond [4] coal bed in the northwest quarter of the Doty Mountain 15-minute quadrangle, the Almond [1] coal bed in the southeast quarter and the Almond [2] coal bed in the northeast quarter. The Almond [4] coal bed lies approximately 30 to 120 feet (9 to 37 m) above the Robertson coal bed and ranges in thickness from 2 to 16 feet (0.6 to 4.9 m) where measured in oil and gas wells drilled in this quadrangle (plate 13). In sec. 22, T. 16 N., R. 91 W., the coal bed is approximately 12 feet (3.7 m) thick and includes a shale parting 2 to 3 feet (0.6 to 0.9 m) thick. Where measured in outcrops and drill holes, this coal bed ranges in thickness from 2 to 10 feet (0.6 to 3.0 m) in the northwest quarter, from 2.5 to 15 feet (0.8 to 4.6 m) thick in the southeast quarter, and from 8 to 14 feet (2.4 to 4.3 m) in the northeast quarter of the Doty Mountain 15-minute quadrangle.

Almond [5] Coal Bed

The Almond [5] coal bed (plate 16) is equivalent to the Almond [5] coal bed in the northwest quarter of the Doty Mountain 15-minute quadrangle. This coal bed lies from 18 to 27 feet (5.5 to 8.2 m) above the Almond [4] coal bed and ranges in thickness from 6 to 12 feet (1.8 to 3.7 m) where measured in oil and gas wells in this quadrangle. In the northwest quarter of the Doty Mountain 15-minute quadrangle, the coal bed ranges in thickness from 5 to 14 feet (1.5 to 4.3 m).

Almond [6] Coal Bed

The Almond [6] coal bed (plate 19) is approximately 40 to 60 feet (12 to 18 m) above the Almond [4] coal bed and ranges in thickness from 5 to 13 feet (1.5 to 4.0 m) where measured in oil and gas wells drilled in this quadrangle. Shale partings are common, but not always present in the coal bed. In the southeast quarter of the Doty Mountain 15-minute quadrangle, the coal bed correlates with the Almond [Local 4] and is 10 feet (3.0 m) thick in an oil and gas well in sec. 22, T. 16 N., R. 91 W.

Almond [7] Coal Bed

The Almond [7] coal bed (plate 23) lies approximately 40 to 115 feet (12 to 35 m) above the Almond [4] coal bed and ranges from 2 to 12 feet (0.6 to 3.7 m) thick where measured in oil and gas wells drilled in this quadrangle. In the northwest quarter of the Doty Mountain 15-minute quadrangle, this coal bed is designated the Almond [6] and ranges from 4 to 10 feet (1.2 to 3.0 m) thick in oil and gas wells.

Almond [8] Coal Bed

The Almond [8] coal bed (plate 23) lies approximately 60 feet (18 m) above the Almond [7] coal bed and ranges in thickness from 4 to 8 feet (1.2 to 2.4 m) where measured in two oil and gas wells in this quadrangle. The Almond [8] coal bed is of limited areal extent and does not correlate with coal beds in adjacent quadrangles.

Almond [9] Coal Bed

The Almond [9] coal bed (plate 23) was penetrated by three oil and gas wells in this quadrangle and ranges in thickness from 4 to 6 feet (1.2 to 1.8 m). It is located approximately 60 feet (18 m) above the Almond [8] coal bed. In the northwest quarter of the Doty Mountain 15-minute quadrangle, this coal bed is designated the Almond [7] and is 4 feet (1.2 m) thick where measured in an oil and gas well located in sec. 1, T. 16 N., R. 92 W.

Almond [10] Coal Bed

The Almond [10] coal bed (plate 23) is of limited areal extent and does not correlate to coal beds in adjacent quadrangles. This coal bed lies approximately 160 feet (49 m) above the Almond [7] coal bed and ranges from 5 to 6 feet (1.5 to 1.8 m) thick where measured in oil and gas wells.

Almond [12] Coal Bed

The Almond [12] coal bed (plate 19) lies from about 60 to 85 feet (18 to 26 m) above the Almond [9] coal bed and ranges from 3 to 6 feet (0.9 to 1.8 m) thick where measured in oil and gas wells drilled in this quadrangle. This coal bed correlates with the Almond [9] in the northwest quarter of the Doty Mountain 15-minute quadrangle, but drill-hole data indicate that the coal bed is less than Reserve Base thickness in that quadrangle.

Coal Beds of the Lance Formation

Several Lance Formation coal beds crop out in the central part of the quadrangle where they were measured by Hettinger (1978a). 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.

Lance [1] Coal Bed

The Lance [1] coal bed is the first coal bed above the contact between the Lance Formation and the Fox Hills Sandstone. As shown on plate 13, the coal bed is generally thin and of limited areal extent. The bed ranges in thickness from 3.1 to 5.3 feet (0.9 to 1.6 m) where measured in surface sections in the central part of the quadrangle (Hettinger, 1978a).

Lance [2] Coal Bed

The Lance [2] coal bed (plate 13) lies from 9 to 22 feet (2.7 to 6.7 m) above the Lance [1] coal bed and correlates with the Lance [1] coal bed in the northwest quarter of the Doty Mountain 15-minute quadrangle. Surface measurements of the coal bed range in thickness from 2.5 feet (0.8 m) in sec. 18, T. 15 N., R. 91 W., to a maximum of 8.8 feet (2.7 m) in sec. 7, T. 15 N., R. 91 W. (Hettinger, 1978a), and thicknesses may vary substantially over short distances along the outcrop. In the northwest quarter of the Doty Mountain 15-minute quadrangle, the coal bed ranges from 3.1 to 10.2 feet (0.9 to 3.1 m) thick where measured along the outcrop (Hettinger, 1978b).

Lance [3] Coal Bed

The Lance [3] coal bed lies approximately 13 to 40 feet (4 to 12 m) above the Lance [2] coal bed and has a maximum measured thickness of 9.8 feet (3.0 m) in sec. 11, T. 16 N., R. 92 W. (plate 4). The coal bed is generally less than Reserve Base thickness in this quadrangle. In the northwest quarter of the Doty Mountain 15-minute quadrangle, this coal bed is designated the Lance [1] and has a maximum reported thickness of 8.2 feet (2.5 m).

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. The coal beds crop out in a north-northwest-trending band across the western part of the quadrangle (Hettinger, 1978a). Generic names (e.g., Red Rim) are used to identify coal beds in this formation where possible, and five coal beds of Reserve Base thickness have been isopached in this quadrangle. Another unidentified Fort Union coal bed exceeding Reserve Base thickness was encountered at one location only and has been treated as an isolated data point (see Isolated Data Points section of this report).

Red Rim Coal Bed

The Red Rim coal bed (plate 4) 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 the lowermost coal bed in the Fort Union Formation in this quadrangle and lies approximately 700 to 1,000 feet (213 to 305 m) above the unconformable contact of the Fort Union Formation and the underlying Lance Formation. The outcrop of this coal bed in the western half of sec. 10, T. 16 N., R. 92 W. has been projected based on subsurface data and differs somewhat from the outcrop shown on plate 1. It ranges in thickness from 1.6 feet (0.5 m) in sec. 2, T. 15 N., R. 92 W., to a maximum of 16.9 feet (5.2 m), with a shale parting 1.6 feet (0.5 m) thick, in sec. 34, T. 16 N., R. 92 W. In the adjacent Mexican Flats quadrangle to the west, the Red Rim coal bed has a maximum thickness of 12 feet (3.7 m) thick and contains a shale parting 2 feet (0.6 m) thick where measured in an oil and gas well. This coal bed has also been identified at depth in oil and gas wells drilled in the western half of the Duck Lake quadrangle and is prominent and widespread in the adjacent quadrangles to the north and south.

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 98 to 254 feet (30 to 77 m) of interbedded sandstone, siltstone, and shale. In this quadrangle, the coal bed ranges from 2 feet (0.6 m) to a maximum 13.2 feet (4.0 m), with a shale parting 2.8 feet (0.9 m) thick, where measured at the outcrop in sec. 15, T. 16 N., R. 92 W. Shale partings in this coal bed are common, but tend to become less prevalent to the north. In the northwest quarter of the Doty Mountain 15-minute quadrangle to the north, the Olson Draw coal bed ranges from 2.3 to 10.8 feet (0.7 to 3.3 m) thick in drill holes and measured sections. This coal bed has also been identified in oil and gas wells at depths greater than 3,000 feet (914 m) in the Duck Lake and Mexican Flats quadrangles to the northwest and west, respectively.

Separation Creek Coal Bed

This coal bed is named after Separation Creek in the northeast corner of the Fillmore Ranch quadrangle (Edson, 1976). The coal bed is located 76 to 279 feet (23 to 85 m) stratigraphically above the Olson Draw coal bed and ranges in thickness from 1 to 6.4 feet (0.3 to 2.0 m) where measured in drill holes and along the outcrop in this quadrangle (plate 10). In the northwest quarter of the Doty Mountain 15-minute quadrangle, coal beds designated as Separation Creek are difficult to correlate with the Separation Creek coal bed in this quadrangle because of faulting and poor surface exposures, although they lie in the same stratigraphic interval (Hettinger, oral communication, 1979).

Muddy Creek Coal Bed

The Muddy Creek coal bed (plate 13) was named by Edson (1976) for Muddy Creek, which flows westward across the northern part of the northwest quarter of the Doty Mountain 15-minute quadrangle. The coal bed lies from approximately 40 to 120 feet (12 to 37 m) above the Separation Creek coal bed and has a maximum thickness of 9.3 feet (2.8 m) thick in sec. 19, T. 15 N., R. 91 W., thinning to 2.1 feet (0.6 m) in sec. 16, T. 16 N., R. 92 W. This coal bed is generally thin and less than Reserve Base thickness throughout most of the quadrangle. It remains thin in the southern part of the northwest quarter of the Doty Mountain 15-minute quadrangle, but becomes thicker and more widespread to the north. Shale partings are common but are not always present within this coal bed.

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 is the thickest and most extensive coal bed in the Fort Union Formation in this quadrangle. It lies from approximately 80 to 240 feet (24 to 73 m) above the Muddy Creek coal bed and is split by a rock parting that ranges in thickness from 2.1 to 19 feet (0.6 to 5.8 m). The lower split of the Fillmore Ranch coal bed (plate 16) ranges in thickness from 6 to 10.9 feet (1.8 to 3.3 m) while the upper split of the coal bed (plate 19) ranges from 2.3 to 10.9 feet (0.7 to 3.3 m). The rock parting becomes thinner and less prominent to the north and the upper and lower splits of the Fillmore Ranch coal bed become thicker. For this reason, the Fillmore Ranch coal bed has not been mapped as a split coal bed in the northwest quarter of the Doty Mountain 15-minute quadrangle.

In the Mexican Flats quadrangle, the upper split of the coal bed ranges in thickness from 2 to 10 feet (0.6 to 3.0 m), the parting ranges from 4 to 49 feet (1.2 to 14.9 m), and the lower split varies from 6 to 14 feet (1.8 to 4.3 m). In the Duck Lake quadrangle, the upper split ranges in thickness from 2 to 9 feet (0.6 to 2.7 m), the parting ranges from 5 to 54 feet (1.5 to 16.5 m), and the lower split of the coal bed varies from 10 to 14 feet (3.0 to 4.3 m).

Isolated Data Points

In instances where single or isolated measurements of coal beds thicker than 5 feet (1.5 m) are encountered, the standard criteria for construction of isopach, structure contour, mining ratio, and overburden isopach maps are not available. The lack of data concerning these beds limits the extent 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 point occurring in this quadrangle and the influences from isolated data points in an adjacent quadrangle are listed below. Coal beds identified by bracketed numbers are not formally named, but have been given bracketed numbers for identification purposes in this and adjacent quadrangles only.

Source	Location	Coal Bed	Thickness
Hettinger (1978a)	sec. 22, T. 16 N., R. 90 W.	FU]1]	5.8 ft (1.8 m)
	From SE 1/4 Doty Mountain Quadrangle		
U.S. Natural Gas Corp.	sec. 10, T. 15 N., R. 91 W.	Al[L7]	8.0 ft (2.4 m)
Davis Oil Co.	sec. 22, T. 16 N., R. 91 W.	Al[L5]	7.0 ft (2.1 m)

COAL RESOURCES

Information from geophysical logs of oil and gas wells, coal test holes drilled by Urangesellschaft U.S.A., Inc. (1978), and the U.S. Geological Survey (Hettinger, 1979), as well as measured sections by Ball and Stebinger (1910) and Hettinger (1978a), were used to construct outcrop, isopach, and structure contour maps of the coal beds in the southwest quarter of the Doty Mountain 15-minute quadrangle. 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 7, 10, 13, 16, 19, and 23). 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 6, 9, 15, 18, 22, 21, and 25, 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 447.06 million short tons (405.57 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.

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 coals 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 0.67 million short tons (0.61 million metric tons) of coal available for surface mining.

The coal development potential for surface mining methods is shown on plate 26. Of the Federal land areas having a known development potential for surface mining methods, 93 percent are rated high, 4 percent are rated moderate, and 3 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, and to those areas influenced by isolated data points. The areas influenced by isolated data points in this quadrangle contain approximately 0.96 million metric tons (0.87 million metric tons) of coal available for conventional subsurface mining.

The coal development potential for subsurface mining methods is shown on plate 27. Of the Federal land areas having a known development potential for conventional subsurface mining methods, 59 percent are rated high, 30 percent are rated moderate, and 11 percent are rated low The remaining Federal lands within the quadrangle are 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 only approximately 109.19 million short tons (99.06 million metric tons) of coal distributed through five 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 southwest 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 southwest 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	12,760,000	3,920,000	1,550,000	-	18,230,000
Muddy Creek	350,000	220,000	550,000	-	1,120,000
Separation Creek	250,000	170,000	940,000	-	1,360,000
Olson Draw	1,510,000	530,000	1,700,000	-	3,740,000
Red Rim	7,340,000	2,440,000	1,800,000	-	11,580,000
Lance {3}	500,000	220,000	340,000	-	1,060,000
Lance {2}	940,000	400,000	980,000	-	2,320,000
Lance {1}	60,000	20,000	10,000	-	90,000
Almond {12}	-	-	-	-	-
Almond {10}	-	-	-	-	-
Almond {9}	-	-	-	-	-
Almond {8}	-	-	-	-	-
Almond {7}	-	-	-	-	-
Almond {6}	-	-	-	-	-
Almond {5}	-	-	-	-	-
Almond {4}	-	-	-	-	-
Almond {3}	-	-	-	-	-
Almond {2}	-	-	-	-	-
Almond {1}	-	-	-	-	-
Robertson	-	-	-	-	-
Isolated Data Points	-	-	-	670,000	670,000
Totals	23,710,000	7,920,000	7,870,000	670,000	40,170,000

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 southwest 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	17,030,000	33,040,000	24,800,000	35,930,000*	110,800,000
Muddy Creek	480,000	-	-	4,720,000*	5,200,000
Separation Creek	1,400,000	2,210,000	1,170,000	9,340,000*	14,120,000
Olson Draw	5,990,000	480,000	5,790,000	8,670,000*	20,930,000
Red Rim	10,990,000	230,000	9,040,000	50,530,000*	70,790,000
Lance {3}	1,370,000	-	-	-	1,370,000
Lance {2}	900,000	-	-	-	900,000
Almond {12}	260,000	3,420,000	-	-	3,680,000
Almond {10}	1,180,000	1,090,000	-	-	2,270,000
Almond {9}	-	980,000	-	-	980,000
Almond {8}	-	750,000	-	-	750,000
Almond {7}	910,000	13,880,000	40,000	-	14,830,000
Almond {6}	21,460,000	600,000	-	-	22,060,000
Almond {5}	-	14,110,000	8,790,000	-	22,900,000
Almond {4}	22,430,000	40,810,000	1,470,000	-	64,710,000
Almond {3}	-	2,030,000	-	-	2,030,000
Almond {2}	11,770,000	12,320,000	-	-	24,090,000
Almond {1}	2,120,000	-	-	-	2,120,000
Robertson	14,930,000	6,470,000	-	-	21,400,000
Isolated Data Points	-	-	-	960,000	960,000
Totals	113,220,000	132,420,000	51,100,000	110,150,000	406,890,000

NOTE: To convert short tons to metric tons, multiply by 0.9072.
*Tonnages are 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	Hettinger, 1978a, U.S. Geological Survey, unpublished data	Measured Section No. 117
2		Measured Section No. 118
3	Ball and Stebinger, 1910, U.S. GeologicalSurvey Bulletin 381-B, p. 204	Measured Section
4	Hettinger, 1978a, U.S. Geological Survey, unpublished data	Measured Section Nos. 120 and 121
5		Measured Section Nos. 122 and 123
6		Measured Section No. 124
7		Measured Section No. 125
8		Measured Section No. 126
9		Measured Section No. 127
10		Measured Section No. 119
11		Measured Section No. 87
12		Measured Section Nos. 88 and 89
13		Measured Section No. 90
14		Measured Section Nos. 91 and 92
15		Measured Section No. 128
16		Measured Section No. 46
17		Measured Section No. 47

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
18	Hettinger, 1978a, U.S. Geological Survey, unpublished data	Measured Section No. 49
19		Measured Section No. 48
20		Measured Section No. 53
21		Measured Section Nos. 50, 51, and 52
22		Measured Section No. 54
23		Measured Section Nos. 55 and 56
24	Hettinger, 1979, U.S. Geological Survey, unpublished data	Drill hole No. DM-7
25	Hettinger, 1978a, U.S. Geological Survey, unpublished data	Measured Section Nos. 57 and 58
26		Measured Section No. 59
27		Measured Section Nos. 60, 61, and 62
28		Measured Section No. 64
29	Hettinger, 1979, U.S. Geological Survey, unpublished data	Drill hole No. DM-8
30	Ball, 1909, U.S. Geological Survey Bulletin 341-B, p. 253	Measured Section
31	Hettinger, 1978a, U.S. Geological Survey, unpublished data	Measured Section Nos. 63, 65, 66, 67, and 68
32	Urangesellschaft, U.S.A., Inc., 1978, unpublished data	Drill hole Cow No.57-1

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
33	Urangellschaft, U.S.A., Inc. 1978, unpublished data	Drill hole Cow No. 47-1
34	Hettinger, 1979, U.S. Geological Survey, unpublished data	Drill hole No. DM-10
35	Hettinger, 1978a, U.S. Geological Survey, unpublished data	Measured Section Nos. 69 and 70
36		Measured Section No. 71
37		Measured Section Nos. 73 and 74
38		Measured Section No. 72
39		Measured Section No. 75
40		Measured Section Nos. 76 and 77
41	Urangesellschaft, U.S.A., Inc., 1978, unpublished data	Drill hole Cow No. 29-1
42	Hettinger, 1978a, U.S. Geological Survey, unpublished data	Measured Section Nos. 79 and 80
43		Measured Section No. 78
44		Measured Section No. 81
45	Urangesellschaft, U.S.A., Inc., 1978, unpublished data	Drill hole Cow No. 20-1
46	Hettinger, 1978a, U.S. Geological Survey, unpublished data	Measured Section No. 82
47	Hamilton Brothers Oil Co.	Oil/gas well No. 15-1 Federal-Tertelling
48	Sinclair Oil Co.	Oil/gas well No. 22-1 Sinclair-Hamilton-Federal

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
49	Sinclair Oil Co.	Oil/gas well No. 23-1 Sinclair-Hamilton-Federal
50	Hettinger, 1978a, U.S. Geological Survey, unpublished data	Measured Section Nos. 83 and 84
51		Measured Section No. 85
52		Measured Section No. 86
53	Hettinger, 1979, U.S. Geological Survey, unpublished data	Drill hole No. DM-9
54	Urangesellschaft, U.S.A., Inc., 1978, unpublished data	Drill hole Cow No. 8-1
55	M.E. Thrash Co.	Oil/gas well No. 1-7 Government
56	Mountain Fuel Supply Co.	Oil/gas well No. 1 Doty Mountain Unit
57	Mesa Petroleum Co.	Oil/gas well No. 1-17 Bosco-Federal
58	Continental Oil Co.	Oil/gas well No. 2-21
59	U.S. Natural Gas Corp.	Oil/gas well No. 32-21 Federal
60		Oil/gas well No. 1-22 Unit
61	Exeter Exploration and Equity Oil Co.	Oil/gas well No. 13-22x Ashland-Federal
62	Exeter Drilling & Exploration Co.	Oil/gas well No. 13-22 Ashland-Federal
63	Anschutz Corp.	Oil/gas well No. 1 Federal 297

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
64	Hettinger, 1978a, U.S. Geological Survey, unpublished data	Measured Section Nos. 1 and 2
65		Measured Section No. 3
66	Ball and Stebinger, 1910, U.S. Geological Survey Bulletin 381-B, p. 206	Measured Section
67	Hettinger, 1978a, U.S. Geological Survey, unpublished data	Measured Section Nos. 93 and 94
68		Measured Section No. 95
69	True Oil Co.	Oil/gas well No. 23-11 CFT-Federal
70	Zoller and Danneberg Exploration, Ltd.	Oil/gas well No. 2-12 Cow Creek Unit
71	Sohio Petroleum Co.	Oil/gas well No. 1-12
72	U.S. Natural Gas Corp.	Oil/gas well No. 1-X Cow Creek Unit
73		Oil/gas well No. 22-13 Cow Creek Unit
74	Sohio Petroleum Co.	Oil/gas well No. 2 Unit
75	Hettinger, 1978a, U.S. Geological Survey, unpublished data	Measured Section Nos. 6, 7, 11, and 12
76		Measured Section No. 18
77		Measured Section No. 8
78		Measured Section Nos. 9 and 10

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
79	Hettinger, 1978a, U.S. Geological Survey, unpublished data	Measured Section Nos. 19, 20, and 21
80		Measured Section Nos. 13 and 14
81		Measured Section Nos. 16 and 17
82		Measured Section No. 15
83		Measured Section No. 22
84		Measured Section No. 24
85		Measured Section No. 26
86		Measured Section No. 27
87		Measured Section No. 28
88		Measured Section Nos. 29, 30, 31, and 32
89		Measured Section Nos. 96 and 97
90		Measured Section No. 102
91		Measured Section Nos. 103, 104, and 105
92		Measured Section No. 98
93		Measured Section No. 99
94		Measured Section Nos. 100 and 101
95		Measured Section Nos. 33 and 34

Table 4. -- Continued

Plate 1 Index Number	Source	Data Base
96	Hettinger, 1978a, U.S. Geological Survey, unpublished data	Measured Section No. 35
97		Measured Section No. 36
98	Hettinger, 1979, U.S. Geological Survey, unpublished data	Drill hole No. DM-6
99	Hettinger, 1978a, U.S. Geological Survey, unpublished data	Measured Section No. 37
100		Measured Section No. 38
101		Measured Section No. 40
102		Measured Section No. 39
103		Measured Section No. 42
104		Measured Section No. 41
105		Measured Section No. 43
106		Measured Section No. 44
107		Measured Section No. 45
108		Measured Section Nos. 106 and 107
109		Measured Section Nos. 111, 112, and 113
110		Measured Section Nos. 114, 115, and 116

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