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COAL RESOURCE OCCURRENCE MAPS AND COAL DEVELOPMENT POTENTIAL OF THE GRIEVE RESERVOIR QUADRANGLE, CARBON COUNTY, WYOMING, AND MOFFAT COUNTY, COLORADO

[Report includes 2 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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Purpose

This text is to be used in conjunction with Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) Maps of the Grieve Reservoir quadrangle, Carbon County, Wyoming, and Moffat County, Colorado. 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 Published and unpublished public information available through June, 1979, was used as the data base for this study. No new drilling or field mapping was performed, nor was any confidential data used.

Location

The Grieve Reservoir quadrangle is located in southwestern Carbon County, Wyoming, and northeastern Moffat County, Colorado, approximately 15 airline miles (24 km) east of the town of Baggs and 46 airline miles (74 km) south of the city of Rawlins, Wyoming.

Accessibility

Wyoming Highway 70 crosses northeasterly through the Grieve Reservoir quadrangle connecting the town of Savery, Wyoming to the west of the quadrangle with the town of Encampment, Wyoming to the northeast of the quadrangle. A branch of Wyoming Highway 70 in the southeast corner of the quadrangle is a well-used paved and gravel road to Steamboat Springs, Colorado. A U.S. Geological Survey topograpic map of the quadrangle (1961) shows Wyoming Highway 70 as an improved light-duty road crossing from the southwestern corner, through the Reader Basin in the central part of the quadrangle, to the northeastern edge of the quadrangle. Wyoming Highway 71, connecting with Interstate Highway 80 at Rawlins, approximately 45 miles (72 km) to the north, joins Wyoming Highway 70 approximately 5 miles (8 km) east of the quadrangle. An improved light-duty road also connects Wyoming Highway 70 at Reader Basin with Savery Creek in the northwestern part of the quadrangle. The remainder of the quadrangle is served by numerous unimproved dirt roads and trails.

The Denver & Rio Grande Western Railroad line, 35 airline miles (56 km) to the south, connects Craig and Denver, Colorado. The main east-west line of the Union Pacific Railroad passes 45 airline miles (72 km) to the north. This line crosses southern Wyoming connecting Ogden, Utah to the west with Omaha, Nebraska to the east.

Physiography

The Grieve Reservoir quadrangle lies on the western flank of the Sierra Madre uplift. The landscape within the quadrangle is characterized by high mesas, valleys, and ravines. In the middle of the quadrangle is a broad flat valley named the Reader Basin. A large mesa, Battle Mountain, dominates the southeastern corner of the quadrangle, while Horse Mountain and Little Horse Mountain are in the southwestern part. A small butte, Sugarloaf Mountain, is located in the south-central part of the quadrangle. Altitudes within the quadrangle range from approximately 6,560 feet (1,999 m) on the Little Snake River in the southwestern corner of the quadrangle, to 9,108 feet (2,776 m) on the crest of Battle Mountain.

The Little Snake River, the major drainage of the area, flows along the southern border of the quadrangle, and joins the Yampa River in northwestern Colorado. Grieve Reservoir is located in the south-central part of the quadrangle on East Sweetwater Gulch, which flows south from Reader Basin into the Little Snake River. Savery Creek, also a tributary of the Little Snake River, is a perennial stream that flows across the northwestern corner of the quadrangle. Its tributaries, Little Sandstone Creek and Big Gulch, drain the northwestern quarter of the quadrangle. Most of the streams within the quadrangle are intermittent, flowing mainly in response to snowmelt in the spring.

Climate and Vegetation

The climate of south-central Wyoming is semiarid, characterized by low precipitation, rapid evaporation, and large daily temperature variations. Summers are usually dry and mild, and winters are cold. The annual precipitation in the area averages approximately 10 inches (25 cm), and approximately two thirds of this 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 grasses, juniper, scrub oak, pine and other conifers, cottonwood, willow, aspen, mountain mahogany, sagebrush, greasewood, serviceberry, bitterbrush, saltbush, and rabbitbrush.

Land Status

The Grieve Reservoir quadrangle lies on the southern edge of the proposed Rawlins (Little Snake River) Known Recoverable Coal Resource Area (KRCRA). Approximately 15 percent of the quadrangle lies within the proposed KRCRA boundary and the Federal government owns the coal rights for approximately 75 percent of this land. Three preference right lease application (PRLA) areas are present within the KRCRA boundary in this quadrangle as shown on plate 2.

GENERAL GEOLOGY

Previous Work

Ball and Stebinger (1910) described the geology and mineral resources of the eastern part of the Little Snake River coal field. Christensen (1942) described the igneous rocks of the Elkhead Mountains of Colorado, adjacent to the quadrangle. Weimer (1961) described the location and extent of the Late Cretaceous Rawlins delta in southern Wyoming and northwestern Colorado, and Hale (1961) described the stratigraphy of the Upper Cretaceous formations in the eastern Washakie Basin. In a ground-water study of the Great Divide and Washakie Basins of southwestern Wyoming, Welder and McGreevy (1966) included a map of the regional geology in southwestern Wyoming. A description of some of the volcanic rocks in the quadrangle was included by Buffler (1967) in a thesis on the Browns Park Formation and its relationship to Late Tertiary geologic history of the Elkhead region in northwestern Colorado and south-central Wyoming. Gill and others (1970) described the stratigraphy and nomenclature of some of the Upper Cretaceous and lower Tertiary rocks of south-central Wyoming. In a report on the minutes of the proposed revision of the Rawlins (Little Snake River) KRCRA, Barclay and others (1978) included a brief description of the stratigraphy and coal geology of the KRCRA. Barclay and Shoaff (1978) included a description of the local stratigraphy in a report on drilling by the U.S. Geological Survey in the adjacent Savery quadrangle to the west. In a conference with Dames & Moore personnel and on various worksheets pertaining to a geologic map of the area that is currently in preparation, Barclay (oral and written communications, 1979) provided structural, stratigraphic, and coal resource information. Additional field mapping of the quadrangle by C. S. V. Barclay of the Convervation Division, U.S. Geological Survey, is in progress.

Stratigraphy

The formations exposed in the Grieve Reservoir quadrangle range in age from Late Cretaceous to Miocene and are shown in a composite columnar section in figure 1. The Almond and Allen Ridge Formations of Late Cretaceous age are the only known coal-bearing formations within the

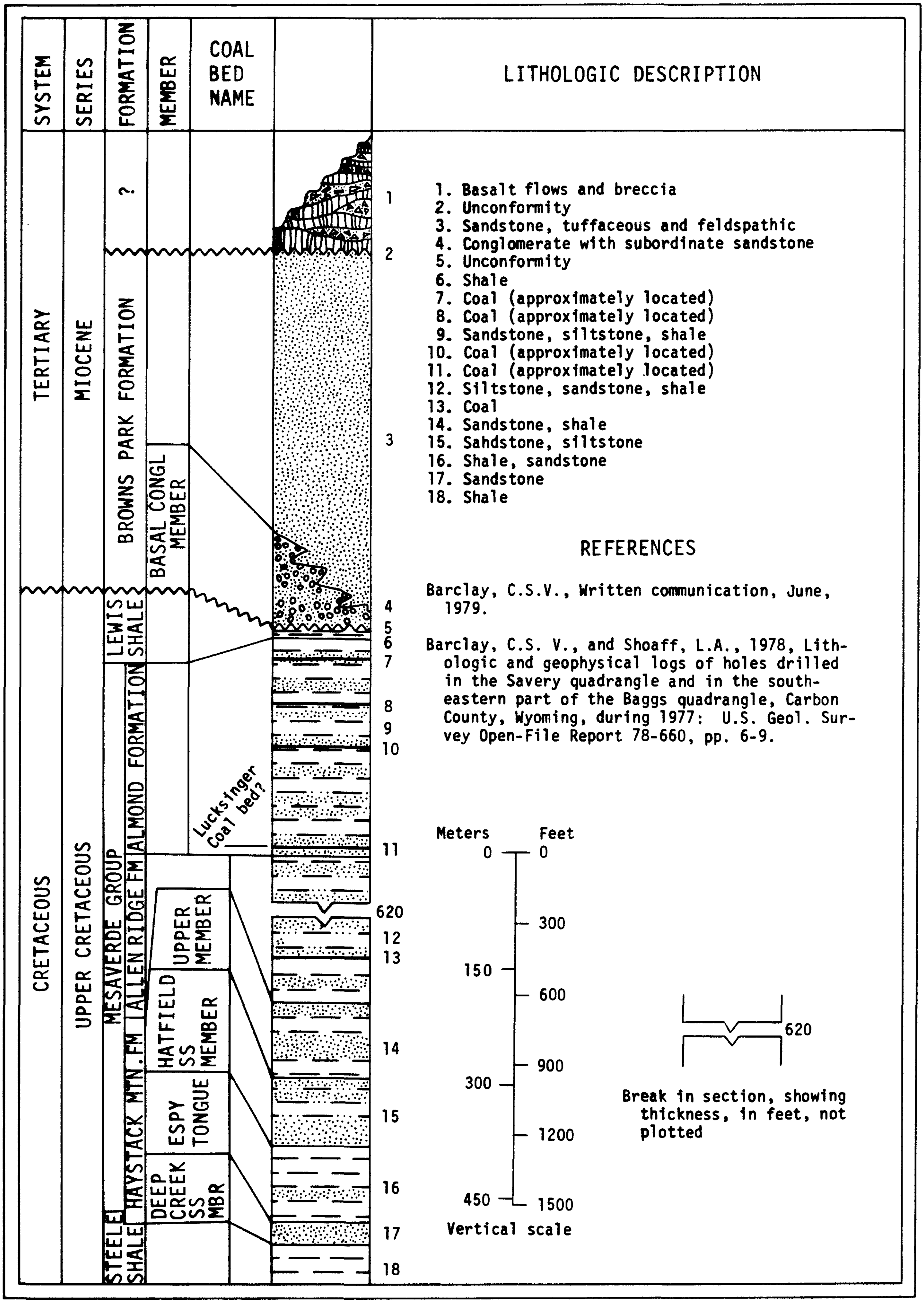

FIGURE 1. — Composite columnar section.

quadrangle. Very little detailed mapping or drill-hole data were available to accurately describe the stratigraphy of the lithologic units present.

The Browns Park Formation of Miocene age unconformably overlies all older formations in the quadrangle, and outcrops of the older formations are restricted to the sides of major valleys and to some dissected upthrown fault blocks.

In most of the Little Snake River coal field the Mesaverde Group of Late Cretaceous age can be subdivided into four formations which are, in ascending order, the Haystack Mountains, the Allen Ridge, the Pine Ridge Sandstone, and the Almond. In the southeastern part of the coal field where this quadrangle is located, the Pine Ridge Sandstone is believed to be missing (Barclay and Shoaff, 1978).

The Steele Shale occurs in the subsurface of this quadrangle and consists of dark-gray shale with sparce layers of limestone concretions and thin beds of very fine grained sandstone and siltstone (Gill and others, 1970).

The Steele Shale grades into the overlying Haystack Mountains Formation with the contact located at the base of the first persistant marine sandstone (Gill and others, 1970). The only exposures of the Haystack Mountains Formation occur in the canyon of Little Sandstone Creek along the northern edge of the quadrangle. Geophysical logs from oil and gas wells drilled in this quadrangle were used by Barclay (oral communication, 1979) to estimate the approximate thicknesses of the formation and its members. The total thickness of approximately 995 feet (303 m) 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 75 feet (23 m) thick and is composed of well-developed, fine-to medium-grained sandstone (Hale, 1961). The Espy Tongue is, genetically, a tongue of the Steele Shale and is approximately 310 feet (94 m) thick.

It consists of dark-gray marine shales and lenticular sandstones (Hale, 1961). The Espy Tongue has a sharp contact with the Deep Creek Sandstone Member, and a gradational contact with the overlying Hatfield Sandstone Member. The Hatfield Sandstone Member averages 290 feet (88 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 320 feet (98 m) of interbedded shale, siltstone, and sandstone (Gill and others, 1970).

In this quadrangle, the Allen Ridge Formation is composed of continental fluviatile sequences of sandstone, siltstone, mudstone, and thin carbonaceous shale and coal beds and is about 1,180 feet (360 m) thick (Barclay, oral communication, 1979). In those parts of the Little Snake River coal field where the Pine Ridge Sandstone occurs, some marginal-marine lagoonal-paludal deposits of thick, bioturbated organic-rich brown shales, thin sandstone beds and coal (included in the Almond Formation in this quadrangle) are assigned to an upper informal marine member of the Allen Ridge Formation (Barclay and Shoaff, 1978).

In the central and northern parts of the Little Snake River coal field, the Pine Ridge Sandstone is composed of continental fluviatile deposits of sandstone and a minor amount of carbonaceous siltstone and mudstone (Barclay and Shoaff, 1978). Gill and others (1970) believe that the Pine Ridge Sandstone rests unconformably on top of the Allen Ridge Formation.

The Almond Formation crops out in the southern part of this quadrangle and is the most important coal-bearing formation. It consists predominantly of marginal-marine, beach and lower delta-plain paludal deposits. Most of the coal is found in the lower part of the formation.

Barclay and Shoaff (1978) use an areally-persistant marine sandstone, informally named the sandstone of Loco Creek, as the basal unit of the Almond Formation in the southeastern part of the Little Snake River coal field. This sandstone becomes the base of the marine member of the Allen Ridge Formation where it can be traced into areas where the Pine Ridge Sandstone is identified. The Almond Formation is approximately 930 feet thick (283 m) in the adjacent Savery quadrangle (Barclay and Shoaff, 1978) and is probably about the same thickness in the Grieve Reservoir quadrangle (Barclay, oral communication, 1979).

The Lewis Shale conformably overlies the Almond Formation. Only 100 to 150 feet (30 to 46 m) of the basal part crops out in the bluff north of Slater, Colorado. A representative thickness of 50 feet (15 m) is shown on plate 3 to indicate that the formation is present in the quadrangle (Barclay, oral communication, 1979). To the west in the southeast quarter of the Baggs 15-minute quadrangle, oil and gas well logs indicate that the Lewis Shale is approximately 2,200 to 2,370 feet (671 to 722 m) thick. The shale of the Lewis is gray to olive-gray, silty and sandy, and, locally, contains a distinctive and widespread unit of interstratified sandstone and sandy shale called the Dad Sandstone Member, a tongue of the overlying Fox Hills Sandstone (Gill and others, 1970).

The Browns Park Formation of Miocene age is approximately 1,600 feet (488 m) thick where it lies below the basalt cap of Battle Mountain. It consists of pebble and cobble conglomerate and conglomeratic sandstone in the lower 50 to 400 feet (15 to 122 m) and sandstone in the upper part (Barclay, written communication, 1979).

Flood plain alluvium and alluvial fan deposits of Holocene age cover the valleys of Savery Creek, the Little Snake River, and their tributaries. Holocene deposits are common on steep slopes throughout the area.

Igneous rocks of the northern edge of the Elkhead Mountain volcanic region occur in the southern part of the quadrangle (Christensen, 1942; Buffler, 1967). Olivine basalt and olivine trachybasalt flows are on top of Battle Mountain and some summits in the Horse Mountains. At the southern end of Battle Mountain the flows are intercalated with basaltic breccia (Christensen, 1942, p. 60). The thickness of the basalt cap on

Battle Mountain ranges from about 75 feet (23 m) in a single flow in the northern edge to as much as 400 to 500 feet (122 to 152 m) in a series of flows and breccia layers exposed on the southwestern side (Barclay, written communication, 1979). Buffler (1967) reports that the flow on the northern edge of Battle Mountain is 10.83 million years old. Circular masses of breccia are found on Sugarloaf Mountain and on an unnamed butte southeast of Sugarloaf Mountain. They are composed of basaltic lapilli and bombs and sandstone fragments in a sand matrix, are intruded by basalt, and are believed to be diatremes by Buffler (1967). These diatremes appear to occur along a northwest-trending zone of basalt dikes which extend from the Little Snake River to Little Horse Mountain (Barclay, written communication, 1979).

The Upper Cretaceous formations in the Grieve Reservoir 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 eastwardly-prograding deltas (Weimer, 1961).

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

All of the Allen Ridge Formation in this quadrangle was deposited in a non-marine fluvial environment (Barclay, oral communication, 1979).

The Almond Formation in this quadrangle consists of a basal transgressive-regressive sandstone beach deposit; a middle lagoonal bay-fill sequence of carbonaceous shale, coal, and channel sandstone deposits; and an upper sequence of thick sandstone beach deposits, lagoonal deposits of carbonaceous shales and channel sandstone, and open-marine shale deposits (Barclay, written communication, 1979).

Deposition of the Lewis Shale generally marks a landward progression of the Lewis sea, the final marine 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 Browns Park Formation is a continental formation consisting mostly of fluvial and eolian deposits. It once covered the entire quadrangle, but has been deeply dissected as a result of late Cenozoic uplift and erosion (Barclay, written communication, 1979).

Structure

The Grieve Reservoir quadrangle is located adjacent to the southwestern corner of the Sierra Madre uplift and along the northern edge of the Elkhead volcanic region. According to Barclay (oral communication, 1979), the Upper Cretaceous rocks in most of the quadrangle dip south-southwest at angles less than 10°. Steeper dips and some folding occurs along the northern edge of the Elkhead Mountains.

Several normal faults with west-northwest trends have been mapped in the northern half and along the southern edge of the quadrangle by Buffler (1967), Barclay and others (1978), and Barclay (written communication, 1979).

COAL GEOLOGY

Two formations within the Grieve Reservoir quadrangle are believed to contain coal. In the southern part of the quadrangle, several coal thickness measurements indicate the presence of potentially significant deposits of coal in the Almond Formation. Along the western edge of the quadrangle, minor deposits of coal in the Allen Ridge Formation are indicated by coal thickness measurements in the Savery quadrangle, to the west (Barclay, written communication, 1979).

Ball and Stebinger (1910) measured thicknesses of coal beds in this quadrangle at mines that were open during their study. Barclay (oral communication, 1979) recently tried to substantiate the original measurements at the locations reported by Ball and Stebinger. Barclay believes that the location of the Linde opening, where Ball and Stebinger measured a coal bed that was 8 feet (2.4 m) thick, is incorrect and that the opening is, most likely, where indicated on plate 1 in sec. 8, T. 12 N., R. 89 W. Also, according to Barclay, the Lucksinger opening is actually located in sec. 17 (Colorado) rather than in sec. 18 (Colorado), T. 12 N., R. 88 W., where Ball and Stebinger reported a coal bed to be 12.2 feet (3.7 m) thick.

Barclay (written communication, 1979) reported thicknesses of a coal bed in the Almond Formation that range from 4.5 to 5.0 feet (1.4 to 1.5 m) in sec. 13 (Wyoming), T. 12 N., R. 89 W. This coal bed crops out in West Sweetwater Gulch south of a normal fault that has brought the Almond Formation into contact with the younger Browns Park Formation.

Barclay (oral communication, June, 1979) believes that any attempt to quantify the coal resources in this quadrangle with existing data would result in unacceptable errors and misleading conclusions and that coal resource evaluation should not be performed until more extensive field mapping and drilling are done. Therefore, because of Barclay's recommendation and the lack of geologic data on coal beds in this quadrangle, Reserve Base tonnages have not been calculated.

The source of each indexed data point shown on plate 1 is listed in table 2.

Chemical analyses of coals.--Chemical analyses were not available from this quadrangle for coals in the Almond and Allen Ridge Formations, but representative analyses from other parts of the Rawlins (Little Snake River) KRCRA are listed in table 1. In general, coals of the Almond Formation rank as subbituminous A and coals from the Allen Ridge Formation rank as high-volatile C bituminous, on a moist, mineral-matter-free basis according to ASTM Standard Specification D 388-77 (American Society for Testing and Materials, 1977).

COAL DEVELOPMENT POTENTIAL

Areas where coal beds of Reserve Base thickness (5 feet or 1.5 meters) or greater are overlain by 3,000 feet (914 m) of overburden are considered to have development potential for either surface or subsurface mining methods. In the Grieve Reservoir quadrangle, coals of Reserve Base thickness or greater are known to exist within 3,000 feet (914 m) below the ground surface. Because of the lack of geologic and drill-hole data available, as well as the complex and uncertain geologic structures of the area, all Federal lands within the proposed KRCRA boundary have been classified as having an unknown development potential for surface and subsurface mining methods.

Table 1. -- Chemical analyses of coals in the Grieve Reservoir quadrangle, Carbon County, Wyoming, and Moffat County, Colorado.

Location	COAL BED NAME	Form of Analysis	Proximate				Ultimate					Heating Value	
			Moisture	Volatile Matter	Fixed Carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen	Calories	Btu/Lb
Average of 21 samples from Little Snake River coal field (Hatch and Barclay,1979)	Almond Formation, undifferentiated	A	15.4	28.6	37.6	18.7	0.6	5.1	49.4	1.1	25.1	4,731	8,510
Southeastern part of the Rawlins KRCRA (Ball and Stebinger, 1910)	Allen Ridge Formation, undifferentiated	A	-	-	-	6.94	2.25	-	-	-	-	-	11,218

Form of Analysis: A, as received
B, air dried
C, moisture free

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

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

Plate 1 Index Number	Source	Data Base
1	Ball and Stebinger, 1910, U.S. Geological Survey Bulletin 381-B, p. 203	Measured Section No. 3
2	↓	Measured Section No. 4
3	Barclay, (in preparation), U.S. Geological Survey	Measured Section
4	↓	Measured Section
5	↓	Measured Section
6	Humble Oil & Refining	Oil/gas well No. 1 Gov't
7	Universal Resources Corp.	Oil/gas well No. 1-17 Husky-Federal
8	Sun Oil Co.	Oil/gas well No. 2 Gov't Cramer
9	Woodward and Co.	Oil/gas well No. 1 Jack Boyer
10	Leonard Hay	Oil/gas well No. 1 Empire State
11	Savery Oil and Gas	Oil/gas well No. 1 State-A
12	Kenneth D. Luff, Martinets, Alpine	Oil/gas well No. 1 Boyer
13	Woodward and Co.	Oil/gas well No. 2 Jack Boyer

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