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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE KETCHUM BUTTES QUADRANGLE, CARBON COUNTY, WYOMING

[Report includes 4 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.

CONTENTS

	Page
Introduction	1
Purpose	1
Location	1
Accessibility	1
Physiography	2
Climate and vegetation	2
Land status	3
General geology	3
Previous work	3
Stratigraphy	4
Structure	7
Coal geology	7
Coal beds of the Almond Formation	8
Robertson coal bed	8
Coal resources	9
Coal development potential	11
Development potential for surface mining methods	11
Development potential for subsurface and in-situ mining methods	12
References	19

ILLUSTRATIONS

Plates 1-4. Coal resource occurrence and coal development potential maps:

1. Coal data map

2. Boundary and coal data map

3. Coal data sheets

4. Isopach, structure contour, overburden and mining ratio maps of the Robertson coal bed

		Page
Figure 1.	Areal distribution and identified resources map of the Robertson coal bed........................	10
2.	Coal development potential map for surface mining methods of the Robertson coal bed.............	13
3.	Coal development potential map for subsurface mining methods of the Robertson coal bed.............	15

TABLES

Table 1.	Chemical analyses of coals in the Ketchum Buttes quadrangle, Carbon County, Wyoming......................	16
2.	Coal Reserve Base data for surface mining methods for Federal coal lands (in short tons) in the Ketchum Buttes quadrangle, Carbon County, Wyoming.......	17
3.	Sources of data used on plate 1..........................	18

INTRODUCTION

Purpose

This text is to be used in conjunction with Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) Maps of the Ketchum Buttes quadrangle, Carbon County, Wyoming. This report was compiled to support the land planning work of the Bureau of Land Management (BLM) to provide a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA's) in the western United States. This investigation was undertaken by Dames & Moore, Denver, Colorado, at the request of the U.S. Geological Survey under contract number 14-08-0001-17104. The resource information gathered for this report is in response to the Federal Coal Leasing Amendments Act of 1976 (P.L. 94-377). Published and unpublished public information available through May, 1979, was used as the data base for this study. No new drilling or field mapping was performed, nor was any confidential data used.

Location

The Ketchum Buttes quadrangle is located in southwestern Carbon County, Wyoming, approximately 19 miles (31 km) north of the town of Dixon, and 39 miles (63 km) southwest of the town of Rawlins, Wyoming. In general, the area is unpopulated.

Accessibility

No major routes pass through this area. However, a light-duty road connects Dixon with Wyoming Highway 71. This road runs diagonally from the southwestern to the northeastern corner of the quadrangle. Passing through the cities of Rock Springs and Rawlins, Interstate Highway 80 trends east-west 27 miles (43 km) to the north. Numerous unimproved dirt roads and trails provide access to the rest of the area.

The main east-west line of the Union Pacific Railroad runs 26 airline miles (42 km) to the north of the quadrangle. This line provides railway service across southern Wyoming, connecting Ogden, Utah, to the west with Omaha, Nebraska, to the east.

Physiography

The Ketchum Buttes quadrangle lies on the western flank of the Sierra Madre uplift. The landscape within the quadrangle is characterized by low, irregular terrain with isolated buttes in the southeastern corner, and high plateaus and ridges cut by deep, rock canyons through the remainder of the quadrangle. In the southern half of the quadrangle, Lone Butte and Ketchum Buttes are prominent, and Rendle Butte stands approximately 200 feet (61 m) above Rendle Rim in the northeastern part of the quadrangle. Altitudes range from approximately 7,000 feet (2,134 m) on the South Fork of Wild Cow Creek in the southwestern corner of the quadrangle, to 8,237 feet (2,511 m) on top of Rendel Butte.

The eastern half of the quadrangle is drained by Little Savery Creek, a tributary of Savery Creek. Tributaries of Muddy Creek drain the western half of the quadrangle. In the west-central part of the quadrangle, Wild Cow Creek flows west to Muddy Creek. The Middle and South Forks of Wild Cow Creek flow across the southwestern corner of the quadrangle. Deep Gulch, a tributary of Cow Creek, flows through the northwestern corner, and Cherokee Creek through the southwestern corner of the quadrangle into Muddy Creek. Several other minor streams drain the quadrangle. With the exception of Little Savery Creek and Wild Cow Creek, streams in the quadrangle are intermittent, flowing mainly in response to snowmelt in the spring.

Climate and Vegetation

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

The average annual temperature in the area is 43°F (6°C). The temperature during January averages 21°F (-6°C) and typically ranges from

12°F (-11°C) to 31°F (-0.6°C). During July the average temperature is 68°F (20°C), and the temperature typically ranges from 51°F (11°C) to 84°F (29°C) (Wyoming Natural Resources Board, 1966).

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

Principal types of vegetation in the quadrangle include juniper, pine, spruce, cottonwood, willow, aspen, scrub oak, grasses, sagebrush, greasewood, serviceberry, bitterbrush, saltbush, rabbitbrush, and other desert shrubs.

Land Status

The Ketchum Buttes quadrangle lies on the eastern edge of the proposed Rawlins Known Recoverable Coal Resource Area (KRCRA). Approximately 6 percent of the quadrangle lies within the proposed KRCRA boundary, with the Federal government owning the coal rights for all of that 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), Lewis (1961), Lewis (1961), and Weimer (1961). A ground-water reconnaissance of the Great Divide and Washakie Basins of southwestern Wyoming by Welder and McGreevy (1966) 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. Barclay and Zimmerman (1976) and Barclay and Shoaff (1977 and 1978) prepared lithologic and geophysical logs of coal test holes drilled by the U.S. Geological Survey in the southern part of the proposed Rawlins (Little Snake River) KRCRA during 1975, 1976, and 1977, and reported stratigraphic descriptions of the Mesaverde Group. More recent drilling in the area has been completed and geologic mapping in this quadrangle is in progress (Barclay, 1979a, 1979b, and 1979c).

Stratigraphy

The formations exposed in the Ketchum Buttes quadrangle range in age from Late Cretaceous to Miocene, and crop out across the quadrangle in north-south-trending bands. The Almond, Allen Ridge, and Haystack Mountains Formations, all of Late Cretaceous age, are coal-bearing within the quadrangle.

The Steele Shale crops out along the eastern edge of the quadrangle and consists of dark-gray marine 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.

The Haystack Mountains Formation crops out in the center of the quadrangle. Gill (1974), in a measured section in the Browns Hill quadrangle, reported that the Haystack Mountains Formation is approximately 938 feet (292 m) thick. The formation 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 measures 125 feet (38 m) thick in a measured section by Gill (1974), in the Browns Hill quadrangle to the south, 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 315 feet (96 m) thick in Gill's section and 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 measures 153 feet (47 m) thick in Gill's section and is described by Gill and others (1970) as consisting of pale-yellowish-gray cliff-forming sandstone. The upper unnamed member of the Haystack Mountains Formation is composed of 360 feet (110 m) of interbedded shale, siltstone, and sandstone (Gill and others, 1970). Single, thin coal beds occur above the Hatfield Sandstone Member in this quadrangle (Barclay, written communication, 1979).

The Allen Ridge Formation conformably overlies the Haystack Mountains Formation and crops out in the western half of the quadrangle. It is approximately 1,185 feet (361 m) thick and is subdivided into two members. The lower non-marine member is about 1,000 feet (305 m) thick, and the upper marginal-marine member is approximately 185 feet (56 m) thick (Barclay, oral communication, 1979). The lower non-marine member is largely composed of continental fluviatile deposits of thick lenticular sandstone beds, and thinly to thickly interbedded siltstone, sandstone, mudstone, and carbonaceous shale (Barclay and Shoaff, 1977). The upper member consists of marginal-marine lagoonal-paludal deposits of thick, bioturbated organic-rich brown shale, thin sandstone beds and coal (Barclay and Shoaff, 1978).

The Pine Ridge Sandstone unconformably overlies the Allen Ridge Formation (Gill and others, 1970) and is believed to crop out along the western edge of the quadrangle. According to Barclay and Shoaff (1978), the Pine Ridge is a continental fluviatile deposit consisting of sandstone and a subordinate amount of carbonaceous siltstone and mudstone. Because of the difficulty in recognizing this formation in outcrop, it has not been mapped in detail. An average thickness of about 55 feet (17 m) in this quadrangle is reported by Barclay (oral communication, 1979).

The Almond Formation crops out along the western edge of the quadrangle and only about 60 feet (18 m) of the lower part of the formation is exposed, as estimated from the geologic map by Barclay (1979c). It consists predominantly of marginal-marine, beach and lower delta plain paludal deposits (Barclay, written communication, 1979). One significant coal bed occurs near the bottom of the formation.

The Browns Park Formation of Miocene age is the youngest formation in the quadrangle and unconformably overlies older formations. The maximum thickness of the formation ranges between 830 and 970 feet (253 and 296 m) in the northeastern part of the quadrangle where it consists mostly of yellowish-orange and grayish-yellow to white sandstone. In the eastern part of the quadrangle, the basal conglomerate is as much as 65 to 75 feet (20 to 23 m) thick and consists of pebbles and cobbles weathering to a greenish-gray color. The basal conglomerate is only 20 feet (6.1 m) thick in the western part of the quadrangle and consists of pebble conglomerate and conglomeratic sandstone. Some thin limestone beds can also be found in the formation between 75 and 145 feet (23 and 44) above the base (Barclay, written communication, 1979).

Holocene deposits of alluvium cover the stream valleys of Wild Cow Creek, Little Savery Creek, Bird Gulch, and their tributaries.

The Upper Cretaceous formations in the Ketchum Buttes 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, 1960 and 1961).

In south-central Wyoming, the thick marine sandstones (the Deep Creek and Hatfield Sandstone Members) occurring in the Haystack Mountains Formation 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, respectively, of a Late Cretaceous interior sea (Barclay and Shoaff, 1978).

Structure

The Ketchum Buttes quadrangle is located to the west of the Sierra Madre uplift and to the east of the Washakie Basin. The beds in the quadrangle generally strike to the southeast and dip at an average of 10° to the southwest.

Several faults were mapped by Barclay (1979c) in the quadrangle, four in the southern half and one along the northern edge.

COAL GEOLOGY

Two formations are coal-bearing in this quadrangle, the Allen Ridge Formation and the Almond Formation. None of the coal beds in the Allen Ridge Formation were isopached in this quadrangle, but two measurements greater than Reserve Base thickness (5 feet or 1.5 meters) occur outside the KRCRA boundary. Only the lower part of the Almond coal zone crops out in this quadrangle. The lowermost coal bed of the Almond coal zone, the Robertson bed, is the only isopached coal bed in this quadrangle.

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).

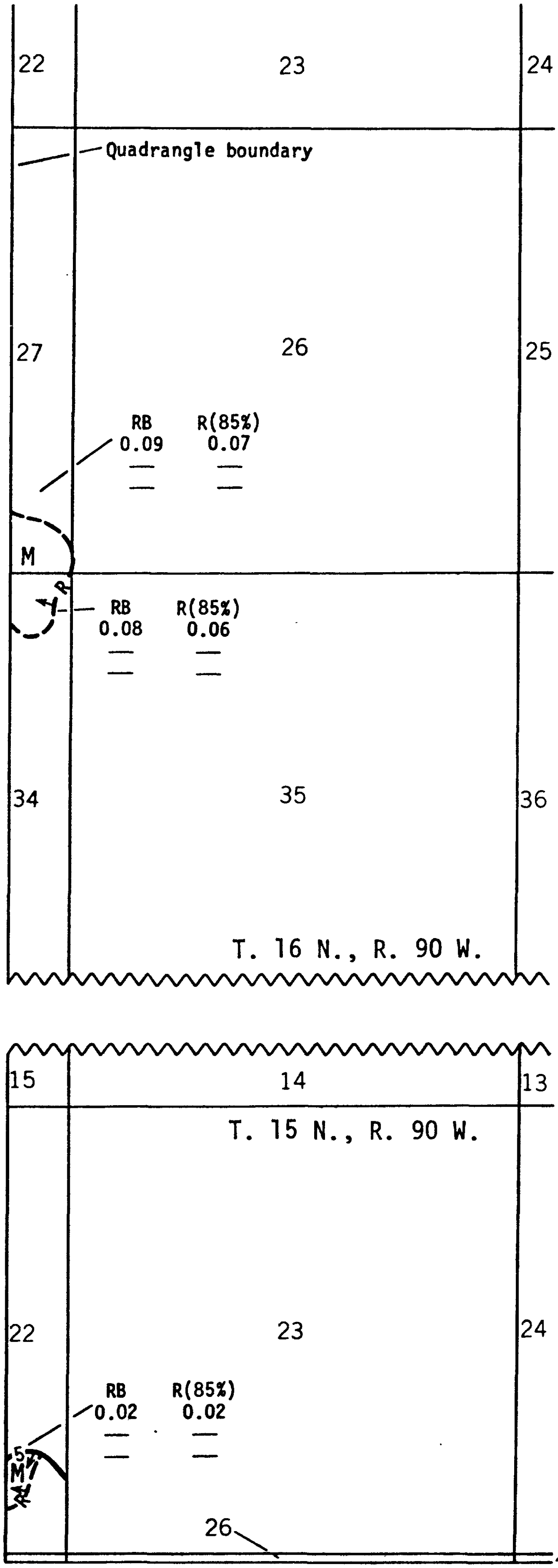
Coal Beds of the Almond Formation

The lower part of the Almond Formation crops out along the western edge of the quadrangle. The most significant coal beds in the Almond Formation occur directly above the contact with the underlying Pine Ridge Sandstone.

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 Almond Formation-Pine Ridge Sandstone contact. For the purpose of calculating Reserve Base tonnages, the Robertson bed is defined in this report as the first areally persistant coal bed. It should be noted that, as Barclay defines the Robertson coal bed or zone of coal beds, other coal beds named with an alpha-numeric designation may technically be considered part of the Robertson zone of coal beds.

In this quadrangle, the Robertson coal bed was identified at three locations; two drill holes and one measured section. The thickest measurement of 5.5 feet (1.7 m) was obtained from a drill hole in sec. 27, T. 16 N., R. 90 W. Two other measurements of 4.8 feet (1.5 m) and 4 feet (1.2 m) are located in secs. 15 and 23, T. 15 N., R. 90 W., respectively. An area in sec. 22, T. 15 N., R. 90 W. is shown (plate 4) as containing Robertson coal 5 feet (1.5 m) or more thick based on data projected from the southeast quarter of the Doty Mountain 15-minute



EXPLANATION

5

ISOPACH - Showing thickness of coal, in feet. Arrow points toward area where coal bed is 5 feet or more thick.

R - Robertson bed of the Almond

COAL BED SYMBOL AND NAME

R

TRACE OF COAL BED OUTCROP - Showing symbol of name of coal bed as listed above. Arrow points toward coal-bearing area. Dashed where inferred; short dashed where inferred by present authors.

RB	R(85%)	
0.09	0.07	(Measured)
—	—	(Indicated)
—	—	(Inferred)

IDENTIFIED COAL RESOURCES - Showing totals for Reserve Base (RB) and Reserves (R), in millions of short tons, for each section or part of section of non-leased Federal coal land. Reserve (R) tonnage is calculated by multiplying the Reserve Base (RB) tonnage by the appropriate recovery factor. Dash indicates no resource in that category. Measured resources (M) extend 0.25 miles beyond the point of measurement. Indicated resources are defined between 0.25 and 0.75 miles from the point of measurement. Inferred resources extend from 0.75 to 3 miles from the point of measurement.

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

To convert feet to meters, multiply feet by 0.3048.

To convert miles to kilometers, multiply miles by 1.6093.

Quadrangle boundary

FIGURE 1. — Areal distribution and identified resources map of the Robertson coal bed.

quadrangle to the west. There, the Robertson coal bed has been identified in outcrops and drill holes over most of the quadrangle and averages approximately 10 feet (3.0 m) in thickness.

COAL RESOURCES

Information from coal test holes drilled by the U.S. Geological Survey, as well as measured sections by Barclay, were used to construct isopach and structure contour maps of the coal bed in the Ketchum Buttes quadrangle.

Coal resources were calculated using data obtained from the coal isopach map (plate 4). 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 of Reserve Base thickness (5 feet or 1.5 meters) or greater 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 Robertson coal bed are shown on figure 1, 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 190,000 short tons (170,000 metric tons) for the entire quadrangle. Reserve Base tonnages in the various development potential categories for surface mining methods are shown in table 2. The source of each indexed data point shown on plate 1 is listed in table 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 are 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 as follows:

$$MR = \frac{t_o\ (cf)}{t_c\ (rf)}$$

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.

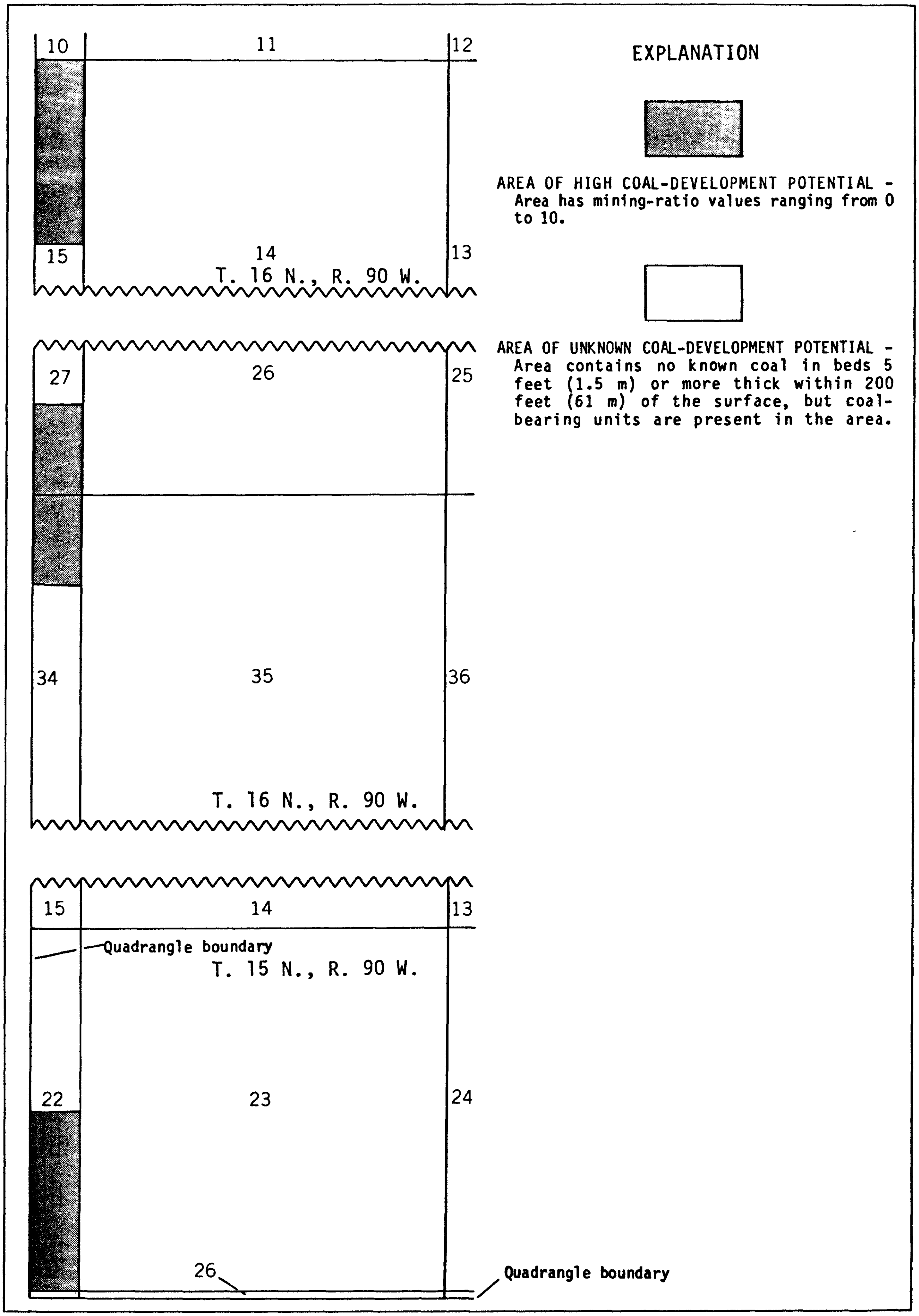


FIGURE 2. — Coal development potential map for surface mining methods of the Robertson coal bed.

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 no coal beds of 5 feet (1.5 m) or more thick are 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 in figure 2. All of the Federal land areas having a known development potential for surface mining methods are rated high. The area in sec. 22, T. 15 N., R. 90 W. is rated high for surface mining methods based on data projected from the adjacent southeast quarter of the Doty Mountain 15-minute quadrangle to the west. The remaining Federal lands within the KRCRA boundary are classified as having unknown development potential for surface mining methods.

Development Potential for Subsurface and In-Situ Mining Methods

Areas with development potential for conventional subsurface mining methods are defined as those areas containing coal beds of Reserve Base thickness that are between 200 and 3,000 feet (61 and 914 m) below the ground surface and have dips of 15° or less. Coal beds of Reserve Base thickness 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 no known coal beds of Reserve Base thickness occur.

The coal development potential for subsurface mining methods is shown in figure 3. The area in sec. 22, T. 15 N., R. 90 W. is rated high for subsurface mining methods based upon data projected from the adjacent southeast quarter of the Doty Mountain 15-minute quadrangle to the west. The remaining Federal land is classified as having unknown development potential for conventional subsurface mining methods.

Because the coal beds in this quadrangle have dips less than 15°, all Federal land areas within the KRCRA boundary have been rated as having an unknown development potential for in-situ mining methods.

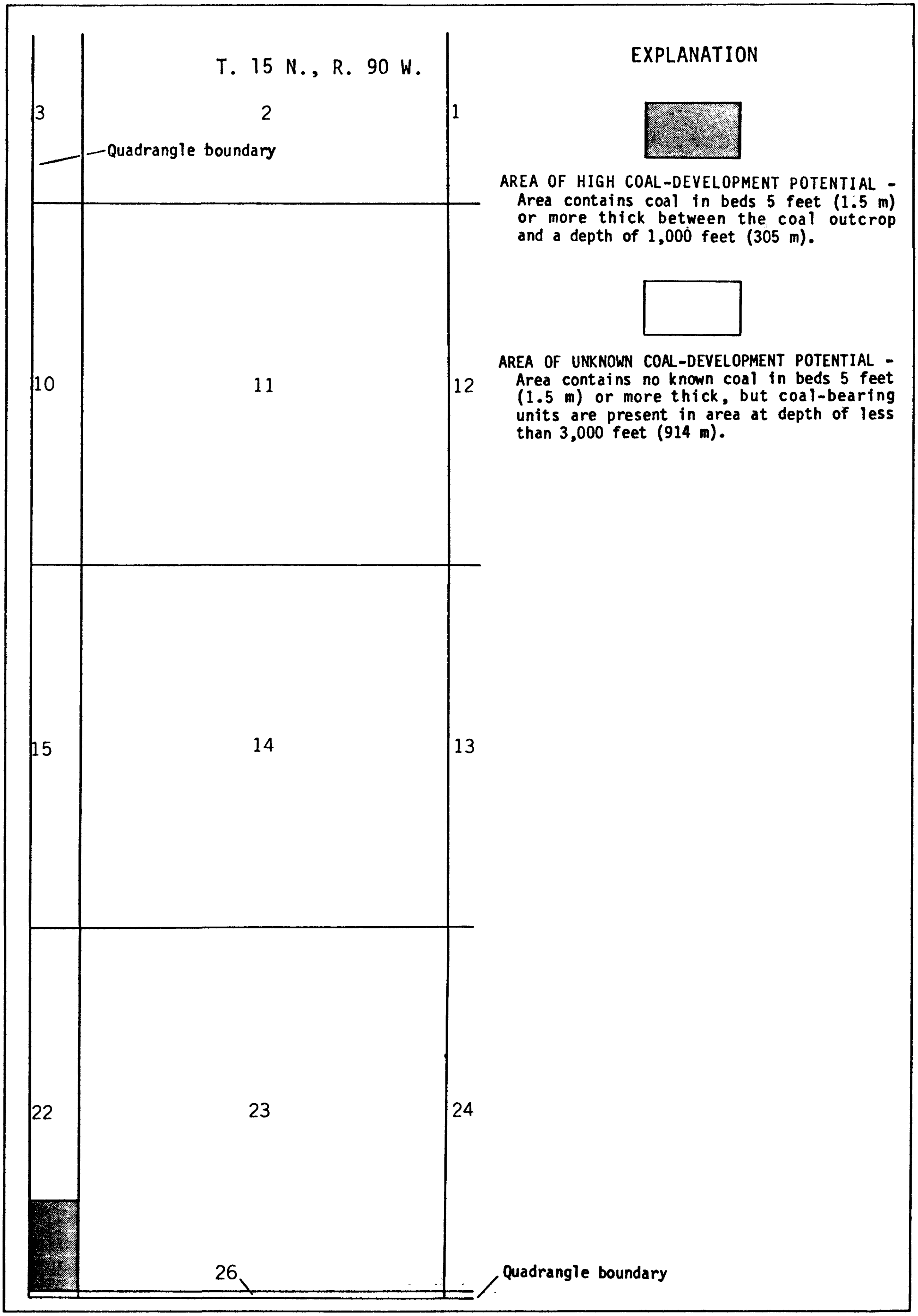


FIGURE 3. — Coal development potential map for subsurface mining methods.

Table 2. Coal Reserve Base data for surface mining methods for Federal coal lands (in short tons) in the Ketchum Buttes quadrangle, Carbon County, Wyoming.

Coal Bed	High Development Potential	Moderate Development Potential	Low Development Potential	Unknown Development Potential	Total
Robertson	180,000	0	10,000	0	190,000
Totals	180,000	0	10,000	0	190,000

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

Table 1. -- Chemical analyses of coals in the Ketchum Buttes quadrangle, Carbon County, Wyoming.

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

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

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

Table 3. -- Sources of data used on plate 1

Plate 1 Index Number	Source	Data Base
1	Barclay, 1979, U.S. Geological Survey, written communication	Measured Section No. SW-5
2	Barclay, 1979b, U.S. Geological Survey, unpublished data	Drill hole No. KB-D1
3	↓	Drill hole No. KB-D4
4	Barclay, 1979a, U.S. Geological Survey, unpublished data	Drill hole No. KB-D3
5	↓	Drill hole No. KB-D5
6	↓	Drill hole No. KB-D2

REFERENCES

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

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

Barclay, C. S. V., 1979a, Geophysical logs and coal sections of holes drilled in T. 16 N., Rs. 90-91 W., in the Doty Mountain and Ketchum Buttes quadrangles, Carbon County, Wyoming, during 1977 and 1978: U.S. Geological Survey, unpublished report.

______1979b, Geophysical logs and coal sections of holes drilled in T. 15 N., Rs. 90-91 W., in the Doty Mountain and Ketchum Buttes quadrangles, Carbon County, Wyoming, during 1977 and 1978: U.S. Geological Survey, unpublished report.

______1979c, Preliminary geologic map of the Ketchum Buttes quadrangle, Carbon County, Wyoming: U.S. Geological Survey, unpublished map, scale 1:24,000.

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.

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

References--Continued

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

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

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

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

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

Weimer, R. J., 1960, Upper Cretaceous stratigraphy, Rocky Mountain area: American Association of Petroleum Geologists Bulletin, v. 44, no. 1, p. 1-20.

______ 1961, Uppermost Cretaceous rocks in central and southern Wyoming, and northwest Colorado, in Symposium on the Late Cretaceous rocks in 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.