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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE SOUTHEAST QUARTER OF THE RAWLINS PEAK 15-MINUTE QUADRANGLE, CARBON COUNTY, WYOMING

[Report includes 8 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 southeast quarter of the Rawlins Peak 15-minute quadrangle, Carbon County, Wyoming. These reports were compiled to support the land planning work of the Bureau of Land Management 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. Published and unpublished public information was used as the data base for this study.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 southeast quarter of the Rawlins Peak 15-minute quadrangle is located in south-central Wyoming in the west-central portion of Carbon County, approximately 7 mi (11 km) west of Sinclair and 38 mi (61 km) east of Wamsutter, Wyoming. With the exception of the city of Rawlins, located on the southeastern edge of the quadrangle, the area is relatively unpopulated.

Accessibility

Interstate Highway 80 passes east-west across the southern portion of the quadrangle through the city of Rawlins. U.S. Highway 287 extends northward from Rawlins and cuts across the northeastern corner of the quadrangle. Graded dirt roads and trails branching from these major routes provide access through the rest of the quadrangle.

The main east-west line of the Union Pacific Railroad passes through the city of Rawlins. This line provides railway service across southern Wyoming, connecting Ogden, Utah to the west, and Omaha, Nebraska to the east.

Physiography

The southeast quarter of the Rawlins Peak 15-minute quadrangle lies on the southwestern flank of the Rawlins uplift, situated between the Great Divide Basin on the west and the Hanna Basin on the east. The landscape within the quadrangle is characterized by relatively low, broken hills, hogbacks, and valleys grading upward into higher peaks.

Elevations vary from approximately 6,800 ft (2,073 m) along Sugar Creek in the southeast corner of the quadrangle, to over 7,800 ft (2,378 m) at the top of Cherokee Peak in the central portion of the quadrangle. Two relatively flat-lying areas in the northeast and southwest corners of the quadrangle are separated by a wide northwest-trending band of hogbacks, peaks, and valleys. The eastern branch of the Continental Divide, which circles the Great Divide Basin, crosses the quadrangle (Welder and McGreevy, 1966).

Sugar Creek, with its tributaries Cherokee Creek and Coal Creek, drains the southern and central portions of the quadrangle and flows eastward, emptying into the North Platte River east of the quadrangle. The northern portion of the quadrangle is drained by Indian Springs Creek and Cold Draw, both tributaries of Separation Creek northwest of the quadrangle. All the streams in the area are intermittent, flowing mainly in response to snowmelt in the spring. Hogback Lake, located in a broad depression on the south-central border of the quadrangle, is a shallow alkaline lake which fluctuates in size with the seasons.

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 10.4 in. (26.4 cm). Approximately two-thirds of the precipitation falls in the spring and summer during a seven-month period between April and October.

The average annual temperature in the area is 43°F (6°C). The temperature during January averages 21°F (-6°C) and 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 ranges from 51°F (11°C) to 84°F (29°C).

The winds are usually from the southwest and the west-southwest with an average wind velocity of 12 miles per hour (19 km per hour).

The principal types of vegetation in the quadrangle include grasses, sagebrush, greasewood, saltbush, rabbitbrush, and other desert shrubs.

Land Status

The southeast quarter of the Rawlins Peak 15-minute quadrangle lies on the northeast edge of the Rawlins Known Recoverable Coal Resource Area. Only the southwest corner of the quadrangle, approximately one-eighth of the quadrangle's total area, lies within the KRCRA boundary. The Federal government owns the coal rights for approximately one-half of this area, as shown on plate 2 of the Coal Resource Occurrence Maps. No outstanding Federal coal leases, prospecting permits, or licenses occur within the quadrangle.

GENERAL GEOLOGY

Previous Work

Veatch (1907) described the Mesaverde Formation coals in the southeast quarter of the Rawlins Peak quadrangle in his preliminary report on the coal fields in east-central Carbon County. Ball (1909) described the coal-bearing formations in the southern portion of the quadrangle in his study of the western part of the Little Snake River coal field. Smith (1909) covered the same area in a portion of his investigation of the eastern part of the Great Divide Basin coal field. In 1952, Barlow published a report on the structure of the Rawlins uplift. A detailed investigation of the geology and groundwater resources of the Rawlins area was made by Berry in 1960. Unpublished U.S. Geological Survey data from 1977 reconnaissance mapping and drilling provided the location of coal outcrops and coal thickness in the southwest portion of the quadrangle.

Stratigraphy

The rocks exposed in the southeast quarter of the Rawlins Peak 15-minute quadrangle range in age from Precambrian to Recent. Only the Upper Cretaceous age Mesaverde Formation and Lance Formation (exposed in the southwestern one-third of the quadrangle) are known to contain coal. The Precambrian to Upper Cretaceous age rocks exposed in the remaining two-thirds of the quadrangle are non-coal-bearing.

The Upper Cretaceous age Frontier Formation consists of gray to gray-brown calcareous shale interbedded with lenses of fine-to medium-grained sandstone. The shale is generally silty to sandy and contains bentonitic lenses. Three distinct sandstone beds occur within the unit. The formation is approximately 600 ft (183 m) thick, with individual sandstone beds ranging in thickness from a few feet to as much as 120 ft (37 m). Differential weathering of the beds forms hogbacks where the formation is exposed in the quadrangle. No coal is present in the formation.

The Niobrara Formation and Steele Shale of Upper Cretaceous age overlie the Frontier Formation. Berry (1960) mapped the two formations as a single unit in the quadrangle due to similarities in color, composition, and weathering characteristics. The Niobrara Formation and Steele Shale are composed of dark-gray calcareous shale; fossiliferous, massive gray shale; and argillaceous limestone, grading upward into gray-brown sandy shale interbedded with gray to gray-green glauconitic sandstone. The two formations reach a combined thickness of 5,050 ft

(1,539 m) where measured in sec. 5, T. 21 N., R. 88 W. on the western edge of the quadrangle. Both formations are non-coal-bearing.

The Niobrara Formation and Steele Shale are conformably overlain by the Upper Cretaceous age Mesaverde Formation. The Mesaverde Formation is composed primarily of light-gray to brown, fine- to medium-grained sandstone with local lenses of carbonaceous sandy shale. The sandstone is massive and forms prominent bluffs across the southwestern corner of the quadrangle. The shale beds are gray to dark-gray, calcareous to noncalcareous, and contain thin lenses of lignite and thick sections of coal. Although it has not been subdivided in this quadrangle, the Mesaverde has been mapped as three distinct units in the adjacent northwest quarter of the Bridger Pass 15-minute quadrangle. These are, in ascending order, the Haystack Mountains Formation, the Allen Ridge Formation, and the Almond Formation. All are known to be coal-bearing. A fourth unit, the Pine Ridge Sandstone, may be present between the Allen Ridge Formation and the Almond Formation. South of the city of Rawlins, the Pine Ridge Sandstone has lost its characteristic blanketlike form and is probably represented by thick channel-filling sandstones that grade laterally into the rocks of the underlying Allen Ridge Formation (Gill and others, 1970). The Mesaverde Formation is approximately 2,640 ft (805 m) thick just west of the quadrangle boundary.

The Upper Cretaceous age Lewis Shale conformably overlies the Mesaverde Formation. It is composed of dark-gray to olive-gray fissile shale which grades into a buff colored sandy shale. The shale contains sporadic lenses of calcareous sandy siltstone that are gray to buff. Thin bentonite beds, brown sandstone concretions, and lenses of dark-gray to brown carbonaceous shale and calcareous sandstone occur throughout the formation. The middle or upper part of the formation often contains a distinctive and widespread unit of interbedded sandstone and sandy shale called the Dad Sandstone Member. The Dad Sandstone Member, a tongue of the overlying Fox Hills Sandstone, is not present in the section of the Lewis Shale measured just west of the quadrangle (Berry, 1960), although it occurs in the upper portion of the Lewis Shale 4 mi (6.4 km) to the northwest (Gill and others, 1970). The Lewis Shale is approximately 1,900 ft (579 m) thick on the western edge of the quadrangle. No coals are present in the Lewis Shale.

The transitional and marine sandstone of the Upper Cretaceous age Fox Hills Sandstone intertongues with the underlying marine Lewis Shale and with the overlying brackish-water and fluvial shale and sandstone of the Lance Formation. The Fox Hills Sandstone is composed of thick units of pale yellowish-gray, very fine to fine-grained, friable sandstone and thin units of olive-gray to dark-gray sandy shale. The sandstone units are thin-bedded to massive, cross-bedded, and ripple marked. They commonly contain fossiliferous sandstone concretions. Thin units of carbonaceous shale containing brackish-water fossils or thin impure coal beds also occur in the formation. The sandstone beds are generally nonresistant, but can locally be well-cemented and ridge-forming. The Fox Hills Sandstone is approximately 170 ft (52 m) thick a few miles northwest of the quadrangle.

The Fox Hills Sandstone grades into the overlying Upper Cretaceous age Lance Formation. The Lance Formation is composed of light-brown to dark-gray sandy carbonaceous shale containing beds of lignite and coal which grades upward into dark-gray fissile carbonaceous shale. The shale is interbedded with brown to light-brown, very fine to fine-grained sandstone. The sandstone may occur in intervals up to 20 ft (6 m) thick throughout the formation. Several fossiliferous zones are present in the upper portion of the formation. The Lance Formation is approximately 4,540 ft (1,384 m) thick where measured just west of the quadrangle boundary (Berry, 1960).

Recent deposits of gravel and alluvium cover the stream valley of Sugar Creek.

Upper Cretaceous age sediments in the Rawlins area indicate regression and transgression of a widespread Cretaceous sea. The sediments exposed in the quadrangle accumulated near the western edge of the sea and reflect the location of the shoreline.

The lignites, coals, and sandstones of the Mesaverde Formation were deposited in the marsh, brackish-water lagoon and coastal swamp environments present in the Rawlins delta which extended northeastward into the Cretaceous sea (Weimer, 1961).

Deposition of the Lewis Shale marked a landward movement of the sea. The marine sediments of the Lewis Shale were deposited in water depths ranging from a few tens of feet to several hundred feet. Deposition of the Lewis Shale ended in the quadrangle with the regression of the sea.

The sediments of the Fox Hills Sandstone represent a transitional depositional environment between the deeper-water marine environment of the Lewis Shale, and the lagoonal and continental environments of the Lance Formation. Environments of deposition of the Fox Hills sediments include shallow marine, barrier bar, beach, estuarine, and tidal channel.

During the gradual recession of the last Cretaceous sea, marking the close of Cretaceous time in the Rawlins area, the carbonaceous shale, mudstone, and coal beds of the Lance Formation were deposited in broad areas of estuarine, marsh, lagoonal, and coastal swamp environments.

Structure

The southeast quarter of the Rawlins Peak 15-minute quadrangle is located on the southwestern flank of the Rawlins uplift between the Great Divide Basin on the west and the Hanna Basin on the east. The Rawlins uplift is a large northwest-trending asymmetric anticline. The Precambrian age crystalline rocks exposed in the center of the uplift are surrounded by hogbacks formed by the resistant strata of younger formations. The beds on the western flank of the uplift are highly faulted and fractured, and dip steeply toward the southwest or are locally overturned. The beds on the eastern flank dip moderately toward the northeast.

The initial uplift is characterized by tight folds and high-angle reverse faults. A secondary system of normal faults is superimposed on the primary structure. The Rawlins-Belle Springs fault, a major reverse fault on the western flank of the uplift, cuts through the central portion of the quadrangle, bringing Precambrian and Paleozoic age beds in fault contact with the upper portion of the Upper Cretaceous age Steele Formation. A maximum vertical displacement of approximately 5,000 ft (1,524 m) occurs along the central portion of the fault. This displacement rapidly decreases as the fault is traced southward (Barlow, 1955).

Three major transverse reverse faults cut the core of the Rawlins uplift in the northeastern portion of the quadrangle. Although displacement on these faults is limited to a few hundred feet, the faults have caused differential uplift of individual blocks across the axis of the anticline. Displacement is greatest in the Precambrian age rocks and diminishes in the Paleozoic strata. The folding and reverse faulting probably occurred in late Paleocene or early Eocene time.

A general subsidence of the Rawlins uplift occurred in post-Miocene time, causing a system of normal faults to be superimposed on the uplift. In many places, the normal fault movement occurred along reverse fault planes; in others, new faults developed. The uplift subsided approximately 1,000 ft (305 m) vertically (Barlow, 1955).

A minor asymmetric syncline is located in the southern portion of the quadrangle. It begins near the Dillon mine and plunges in a northwesterly direction across the quadrangle.

COAL GEOLOGY

Coals of the Lance-Fox Hills transition zone and Mesaverde Formation were either mapped on the surface or identified in the subsurface in this quadrangle (plate 1). The coal zones in the Mesaverde Formation are the lowest stratigraphically of the recognized coals in this quadrangle. Only the Middle Zone was measured by Smith (1909) and Ball (1909) although both Smith and Ball have indicated the presence of an Upper and Lower Zone. The Mesaverde Zones are separated from the Lance-Fox Hills Zone by a non-coal interval approximately 2,500 ft (762 m) thick.

Chemical analyses of coal.--Chemical analyses for coals in the Mesaverde Middle Zone are given in Table 1. The single sample evaluated for Btu content gave a questionable rank of bituminous C. This rank is believed to be quite high and more sample testing will be needed for statistically sound results. Analyses have not been obtained for the coals of Lance-Fox Hills transition zone, but they are believed to be low-sulfur, subbituminous B in rank, as are the Mesaverde Zone coals.

Upper, Middle, and Lower Mesaverde Zones

As characterized by Smith (1909), "the coal occurs in three zones - one near the middle of the formation (Lower Zone), immediately overlying the lower heavy sandstone member; another in the base of the upper sandstone member (Middle Zone), and a third at the top of the formation (Upper Zone)." If this description is compared with recent geologic mapping of the Mesaverde Formation by C.S.V. Barclay (1978) south of this area, the Upper Zone could correlate with Almond Formation coal, the Middle Zone could be either lower Almond Formation or upper Allen Ridge Formation coal, and the Lower Zone is most likely made up of Haystack Mountains Formation coal.

The two sandstone members referred to by Smith (1909) might possibly be the Pine Ridge Sandstone and the Hatfield Sandstone Member of the Haystack Mountains Formation. The Pine Ridge Sandstone, according to Barclay (oral communication, 1978), occurs at the base of the Almond Formation and the Hatfield Sandstone Member is located near the top of the Haystack Mountains Formation.

Smith (1909) describes the Lower Coal Zone as four to six thin, poorly exposed, irregular beds of impure coal. The Middle Coal Zone, the only coal zone that has been mapped or mined in this area, thickens toward the south and near Ferris in sec. 22, T. 21 N., R. 88 W., the coal attains a thickness of 8.3 ft (2.5 m). Farther south, in sec. 36, T. 21 N., R. 88 W., Middle Zone coal has been mined at the old Dillon Mine. The Upper Zone consists of four or more thin beds in this quadrangle.

The Mesaverde coal is radically affected by an assymetrical syncline trending east-west across the southern part of the area. Dips range from 35° to 85° on the northern limb but average about 12° on the southern limb of the syncline. As steep dips severely limit subsurface mining, the 15° dip line is shown on plate 4, beyond which underground mining is not considered feasible due to technological restraints.

Lance-Fox Hills Coal Zone

Lance-Fox Hills coal beds crop out near the western boundary of the quadrangle. The coal beds are stratigraphically located at or near the transtional contact between the fluvial deposits of the Lance Formation and the marine beach sands of the Fox Hills Formation. The trend and dips of the zone are strongly affected by the assymetrical syncline located in the southern part of the quadrangle. Coal thicknesses are not known for this area but there is evidence from Rocky Mountain Energy Company's Continental Divide project that the coals thicken considerably to the south.

COAL RESOURCES

Data from a coal test hole drilled by the U.S. Geological Survey in 1977, as well as surface mapping by Smith (1909), Ball (1909), and Edson (1977) were used to construct outcrop, isopach, and structure contour maps of the coal beds in this 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 times a conversion factor of 1,770 short tons of coal per acre-foot (1,204 metric tons per hectare-meter) for subbituminous coal yields the coal resources in short tons of coal for each isopached coal bed. Reserve Base and Reserve values for the Mesaverde Middle Zone are shown on plate 6, and are rounded to the nearest 10,000 short tons (9,072 metric tons). Coal beds thicker than 5.0 ft (1.5 m) that lie less than 3,000 ft (914.4 m) below the ground surface are included although this criteria differs somewhat from that used in calculating Reserve Base and Reserve data as stated in U.S. Geological Survey Bulletin 1450-B, which calls for a maximum depth of 1,000 ft (304.8 m) for subbituminous coal. Coal Reserve Base tonnages per Federal section are shown on plate 2 and total approximately 5,340,000 short tons (4,840,000 metric tons) for the entire quadrangle. Reserve Base tonnages in the various development potential categories for surface and underground 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

Development Potential for Surface Mining Methods

Areas where the coal beds are overlain by 200 ft (61.0 m) or less of overburden are considered to have potential for strip 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 is as follows:

$$MR = \frac{t_o\ (0.911)}{t_c\ (rf)}$$

where MR = mining ratio

t_o = thickness of overburden

t_c = thickness of coal

rf = recovery factor

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 are here defined as areas underlain by coal beds having respective mining ratio values of 0 to 10, 10 to 15, and greater than 15, as shown on plate 5. 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. Unknown development potentials have been assigned to those areas where coal data is absent or extremely limited.

The coal development potential for surface mining methods (<200 ft or 61.0 m of overburden) is shown on plate 7. For that part of sec. 26, T. 21 N., R. 88 W. that lies within the KRCRA boundary, only approximately 25 percent of the area is rated high for development potential, 8 percent is rated as moderate, and 67 percent is rated as low.

Development Potential for Underground and In-Situ Mining Methods

The coal development potential for underground mining is shown on plate 8. Areas of high, moderate, and low development potential are defined as areas underlain by coal beds of Reserve Base thickness at depths ranging from 200 to 1,000 ft (61.0 to 304.8 m), 1,000 to 2,000 ft (304.8 to 609.6 m), and 2,000 to 3,000 ft (609.6 to 914.4 m), respectively.

Reserve Base tonnages have been completed for all areas where the coal beds are of Reserve Base thickness or greater. However, underground Reserves have been calculated for only that part of the Reserve Base considered to be suitable for underground mining. An arbitrary dip limit of 15° is assumed to be the maximum dip suitable for conventional underground mining methods, and Reserves have not been calculated for those areas where the dip of the coal beds exceed 15°.

For that part of sec. 26, T. 21 N., R. 88 W. that lies within the KRCRA boundary, approximately 92 percent of the area is rated as having high development potential while the remaining area is rated as having moderate development potential. Unknown development potentials have been assigned to other Federal lands within the KRCRA because coal-bearing units are present at depths of less than 3,000 ft (914.4 m) but coal data is absent or extremely limited.

All Federal lands within the KRCRA in this quadrangle have been rated low for in-situ development because of the limited areal extent of the coal beds and the low Reserve Base tonnages known to be available for in-situ mining.

Table 1. -- Chemical analyses of coals in the southeast quarter of the Rawlins Peak 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
NE1/4, NW1/4, sec. 36, T. 21 N., R. 88 W. (Veatch, 1907)	Mesaverde (Middle Zone)	A	13.23	33.57	46.37	6.83	0.63	--	--	--	--	--	---
Same	Same	A	14.12	32.95	46.37	6.56	0.49	--	--	--	--	--	---
NE1/4, NW1/4, sec. 36, T. 21 N., R. 88 W. (Ball, 1909)	Same	A	10.14	33.87	47.55	8.44	0.49	5.17	63.75	1.32	20.83	6,116	11,009
		B	7.93	34.70	48.72	8.65	0.50	5.02	65.32	1.35	19.16	6,266	11,280

Form of analysis: A, as received
B, air dried

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

Table 2. -- Strippable coal Reserve Base data for Federal coal lands (in short tons) in the southeast quarter of the Rawlins Peak 15-minute quadrangle, Carbon County, Wyoming

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Middle Zone (MZ)	90,000	80,000	190,000	360,000
Total	90,000	80,000	190,000	360,000

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

Table 3. -- Coal Reserve Base data for underground mining methods for Federal coal lands (in short tons) in the southeast quarter of the Rawlins Peak 15-minute quadrangle, Carbon County, Wyoming

Coal Bed or Zone	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Middle Zone (MZ)	3,390,000	1,560,000	0	4,950,000
Total	3,390,000	1,560,000	0	4,950,000

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

Table 4. -- Sources of data used on plate 1 (CRO Map)

Plate 1 Index Number	Source	Data Base
1	U.S. Geological Survey, 1977, unpublished data	Drill No. RP-D3
2	Smith, 1909, U.S. Geological Survey Bulletin 341-B, p. 227	Surface prospect
3	Smith, 1909, U.S. Geological Survey Bulletin 341-B, p. 227	Abandoned coal mine
4	Ball, 1909, U.S. Geological Survey Bulletin 341-B, p.253	Dillon mine

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