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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE NORTHEAST QUARTER OF THE WOODSIDE 15-MINUTE QUADRANGLE, EMERY AND CARBON COUNTIES, UTAH

(Report includes 8 plates)

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INTRODUCTION

Purpose

This report was compiled to support the land planning work of the Bureau of Land Management and to provide a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA's) in the Western United States. It supplements the land planning requirements of the Federal Coal Leasing Amendments Act of 1976 (Public Law 94-377) sec. (3)(B) which states, in part, that "Each land-use plan prepared by the Secretary [of the Interior] (or in the case of lands within the National Forest System, the Secretary of Agriculture pursuant to subparagraph (A)(i)) shall include an assessment of the amount of coal deposits in such land, identifying the amount of such coal which is recoverable by deep mining operations and the amount of such coal which is recoverable by surface mining operations."

This text is to be used in conjunction with the Coal Resource Occurrence (CRO) Maps (7 plates) and the Coal Development Potential (CDP) Map (1 plate) of the Northeast Quarter of the Woodside 15-minute quadrangle, Emery and Carbon Counties, Utah (U.S. Geological Survey Open-File Report 79-897.

Published and unpublished public information were used as data sources for this study. No new drilling nor field mapping were done to supplement this study. No confidential nor proprietary data were used.

Location

The Northeast Quarter of the Woodside 15-minute quadrangle is located in the northeast part of Emery and the southeast part of Carbon Counties in east-central Utah. The towns of Sunnyside and East Carbon City are 3.5 miles (5.6 km) northwest of the quadrangle. The city of Price, the county seat of Carbon County, is 25 miles (40 km) northwest of the quadrangle and Castle Dale,

the county seat of Emery County, is 37 miles (60 km) to the west. The town of Green River is approximately 27 miles (43 km) south of the quadrangle.

Accessibility

The only paved road in the quadrangle area is a short section of Utah Highway 124 about one mile (1.6 km) long in Horse Canyon. This highway leaves the west side of the quadrangle and continues northward approximately 6.5 miles (10.5 km) where it joins Utah Highway 123 at East Carbon City. Utah Highway 123 continues westward 8.7 miles (14.0 km) to its junction with U.S. Highway 50-6. This highway is the main vehicular route nearly paralleling the Book Cliffs from the city of Price to the Utah-Colorado state line. U.S. Highway 50-6 passes within 1.2 miles (1.9 km) of the southwest corner of the quadrangle and is reached from that part of the quadrangle by an unimproved dirt road.

The Carbon County Railway provides rail accessibility from the Geneva mine in Horse Canyon to a branch line of the Denver and Rio Grande Western Railroad at East Carbon City. The branch line continues westward 7 miles (11 km) and then southward 5 miles where it joins the main line of the Denver and Rio Grande Western Railroad at the Mounds station. This railroad provides rail service to Salt Lake City, Utah and Denver, Colorado.

Physiography

The Northeast Quarter of the Woodside 15-minute quadrangle lies near the central part of the Book Cliffs, a long bold arcuate escarpment of barren sandstone cliffs from 1,000 to 1,500 ft (305 to 457 m) high. The cliff front lies diagonally across the west half of the quadrangle. The area east of the cliffs is rugged and mountainous with surface elevations ranging up to 9,342 ft (2,847 m) on a peak northeast of the center of the quadrangle. The total relief in the quadrangle is approximately 4,200 ft (1,280 m) between the highest peak and the lowest point in the southwest corner of the quadrangle where the elevation is less than 5,100 ft (1,554 m).

The divide between the Range Creek drainage system on the east and the Price River drainage on the west lies diagonally across the east half of the quadrangle. Range Creek cuts through the far northeast corner of the quadrangle and flows southeastward to its confluence with the Green River. The canyons on the west side of the divide drain into Price River which also flows into Green River.

Climate

The quadrangle is located in the mid-latitude steppe climate with semi-arid conditions prevailing in the lower valley areas on the west side of the quadrangle. The normal annual precipitation in the quadrangle ranges from less than 8 inches (20 cm) in the southwest corner to approximately 18 inches (46 cm) on the northern part of the divide ridge (U.S. Department of Commerce, (1964)).

Temperatures at the lower elevations in Sunnyside and in the southwest corner of the quadrangle range from a summertime high of over 100 degrees F (38 degrees C) to a wintertime low of about -10 degrees F (-23 degrees C). Annual maximum and minimum temperatures in the high mountainous areas of the quadrangle are approximately 10 to 15 degrees F (5.6 to 8.3 degrees C) lower than the temperatures at elevations below 6,000 ft (1,829 m).

Land Status

Approximately 17,600 acres (7,123 ha) in the quadrangle lie in the Book Cliffs Known Recoverable Coal Resource Area (KRCRA). The distribution of Federal and non-Federal coal lands is shown on plate 2 and in the following table.

Table 1. Approximate distribution of coal lands within the KRCRA in the Northeast Quarter of the Woodside 15-minute quadrangle, Emery and Carbon Counties, Utah.

Category	Approximate Area (acres)	Percent of KRCRA (%)
Non-Federal land	6,300 (2,550 ha)	36
Leased Federal coal land	8,700 (3,521 ha)	49
Unleased Federal coal land	2,600 (1,052 ha)	15
Total	17,600 (7,123 ha)	100

GENERAL GEOLOGY

Previous Work

Clark (1928) mapped the geology and coal outcrops in the western part of the Book Cliffs coal field from the Standardville 7½-minute quadrangle on the west to the Patmos Head quadrangle on the east. The Patmos Head quadrangle joins the north side of the Northeast Quarter of the Woodside 15-minute quadrangle. Fisher (1936) mapped the area south and east of Clark's map along the Book Cliffs to the Utah-Colorado state line. The geology and coal deposits in the area have also been described by Abbot and Liscomb (1956), Fisher, Erdmann, and Reeside (1960), Hayes and others (1977), Brodsky (1960), and Young (1955, 1957, and 1966). Doelling (1972) has summarized and updated the geology and coal information reported in earlier writings.

Stratigraphy

The coal beds of economic importance in the Book Cliffs coal field are Upper Cretaceous in age, and are confined to the Blackhawk Formation of the Mesaverde Group. The Mesaverde in the quadrangle area consists of three formations which are, in ascending order, the Blackhawk Formation, Castlegate Sandstone, and the Price River Formation. The Upper Cretaceous Mancos Shale

underlies and intertongues with the Blackhawk Formation. The Mancos Shale was deposited in an offshore marine environment and the Blackhawk Formation in a mixed marine and continental environment. The Castlegate Sandstone and the Price River Formation were formed in a continental environment.

The bluish-gray shale of the Mancos Shale crops out in the southwest part of the quadrangle below the base of the Book Cliffs. Sandstone beds of the Blackhawk Formation crop out in steep and precipitous cliffs and ledges above the Mancos Shale.

Fisher (1936) divided the Blackhawk Formation into the following four members in ascending order: the Lower Sandstone Member 150 to 170 ft (46 to 52 m) thick; the Middle Shale Member 100 to 190 ft (30 to 58 m) thick; the Middle Sandstone Member 100 to 160 ft (30 to 49 m) thick; and the Upper Member 70 to 230 ft (21 to 70 m) thick.

The Lower Sandstone Member thins eastward and cannot be traced east of Green River. The Middle Shale Member is apparently a tongue of the Mancos Shale and cannot be distinguished from the Mancos east of Green River. The Sunnyside coal beds lie in the upper part of the Middle Sandstone Member. The Upper Member consists of sandstone, shale, and lenticular coal beds.

The Castlegate Sandstone thins eastward from 500 ft (152 m) of conglomeratic sandstone in the northern part of the Wasatch Plateau to a feather edge of siltstone near the Utah-Colorado state line (Fisher, 1936). In this quadrangle the Castlegate is approximately 170 ft (52 m) thick. Fisher (1936) places the Castlegate as a member of the Price River Formation. The Castlegate is overlain by the Buck Tongue of the Mancos Shale which is poorly developed in the quadrangle area, but which thickens eastward toward the Utah-Colorado state line where it is 350 ft (107 m) thick. The Price River Formation lies above the Castlegate Sandstone where the Buck Tongue is not

present. Fisher (1936) delineates three members of the Price River Formation above the Buck Tongue in the eastern part of the Book Cliffs, but which are not recognized northwest of the Beckwith Plateau which is southeast of the Woodside quadrangle. In this quadrangle the Price River Formation consists of interbedded sandstone, shale, carbonaceous shale, and coal streaks.

The Tertiary strata successively overlying the Price River Formation include the Tuscher, North Horn, Wasatch, and Green River Formations (Doelling, 1972). The Green River Formation caps the highest ridges in the quadrangle and consists of greenish-gray and white claystone and shale.

Structure

The strata dip generally eastward from less than 4 degrees to 7 degrees except in the vicinity of some faults where the dips may be greater than 7 degrees. The dips decrease eastward, at least at the surface, to average about 4 degrees (Doelling, 1972). The main faults in the quadrangle were mapped by Dunrud and Barnes (1972) and Osterwald and Mayberry (1974) and are shown on plate 1. The fault displacements range from a few feet up to 275 ft (84 m).

COAL GEOLOGY

Kenilworth Coal Bed

The lowest coal bed in the quadrangle is probably the Kenilworth. It is located directly above the lower sandstone member of the Blackhawk Formation. Although it does not appear in any of the available measured sections, Doelling (1972) believes the Kenilworth bed averages less than 2 ft (0.6 m) in thickness and is missing over part of the quadrangle area.

Lower Sunnyside Coal Bed

The main coal bed with commercial significance in the quadrangle is the Lower Sunnyside bed. It lies about 75 ft (23 m) below the top of the Middle Sandstone Member of the Blackhawk Formation, between 200 and 250 ft (61 and 76 m) above the Kenilworth bed.

The isopach map (plate 4) shows that the Lower Sunnyside bed is continuous but variable in thickness. It appears to be thickest in the northwest and central parts of the quadrangle with a maximum measured thickness of 18.2 ft (5.5 m). The bed appears to thin eastward and southward. However, a lack of drilling data east of the Geneva mine leaves this assumption questionable. The bed has been mined out under much of the northwestern part of the quadangle. Fisher (1936, p. 58) reports that "north of Horse Canyon the Lower Sunnyside coal bed is burned at the outcrop practically everywhere, and south of Horse Canyon it is burned for short distances at several places." He also notes (p. 59) that the bed in some places is "divided into two benches, a thick lower bench and a thin upper bench, separated by sandstone and shale."

Intervals reported as "bony coal," "bone," or "shaly coal," are shown as "rock" intervals in this report on plates 1 and 3. These intervals were not included in the coal thicknesses used to construct the coal isopach map.

Chemical Analyses of the Coal

Doelling (1972) lists 110 analyses of coal samples from the quadrangle. The samples were all taken from the Lower Sunnyside bed and the proximate analyses are summarized in the following table.

Table 2. Average proximate analysis of coal, Northeast Quarter of the Woodside 15-minute quadrangle, Emery and Carbon Counties, Utah.*

	No. Analyses	Percent Average	Range
Moisture	110	5.5	1.9 - 9.8
Volatile matter	96	37.5	16.4 - 44.7
Fixed carbon	96	50.1	41.6 - 74.3
Ash	99	6.7	3.8 - 10.7
Sulfur	91	0.70	0.5 - 1.1
Btu/lb.**	105	12,664	10,860 - 14,220

*Doelling, 1972, p. 406
**To convert Btu/lb to Kj/kg multiply by 2.326

Based on the ASTM system of classification, coal having the average analysis of the Lower Sunnyside coal shown in table 2 is ranked as high volatile B bituminous (American Society for Testing and Materials, 1977).

Mining Operations

A large area of the Lower Sunnyside coal bed has been mined in the quadrangle area (plate 1). The portal of the Columbia mine of U.S. Steel Corporation is in the adjoining quadrangle to the north (Sunnyside) but Doelling (1972) estimates that 10 million short tons (9 million metric tons) of coal were removed from the Northeast Quarter of the Woodside 15-minute quadrangle portion of the mine.

The Geneva mine, also called the Horse Canyon mine, was opened in 1943 and is operating at this writing (1979). The mine provides coking coal for U.S. Steel Corporation's Geneva steel plant at Provo, Utah. Doelling (1972, p. 407) reported the mine produced 23,425,000 short tons (21,251,160 metric tons) of coal through 1969. Production since that time is unknown. Doelling also reports that "the average extraction rate has been 10,709 tons per acre and compared with an average of 14 feet thickness, indicates a 43 percent recovery rate."

The property of the Book Cliffs mine was mined out by 1966 and had produced 1,698,513 short tons (1,540,891 metric tons) of coal. A small mine called the Blue Diamond mine may have been incorporated into the adjoining Book Cliffs mine (Doelling, 1972). Several prospects in the quadrangle never advanced beyond that stage. Doelling (1972, p. 407) reports that the total coal production from the quadrangle by 1970 was a little less than 33.5 million short tons (30.4 million metric tons). Table 2 lists the mines and prospects in the quadrangle.

Table 3. Mines and prospects in the Northeast Quarter of the Woodside 15-minute quadrangle, Emery and Carbon Counties, Utah*

Mine Name(s)	Approximate Location	Period(s) of Activity
Book Cliffs mine (Prentiss, Utah Blue Diamond, Blue Diamond, Heiner)	SW¼ NW¼ Sec. 10, T. 16 S., R. 14 E.	1938-1948, 1949-1966
Calkins prospect	SE¼ Sec. 10, T. 16 S., R. 14 E.	Unknown
Geneva mine (Horse Canyon, U.S. Steel)	NW¼ SW¼ Sec. 3, T. 16 S., R. 14 E.	1941-
Lila Canyon prospect	C. N½ Sec. 15, T. 16 S., R. 14 E.	Unknown
Prentiss prospect	SE¼ Sec. 9, T. 16 S., R. 14 E.	Unknown

*After Doelling, 1972, p. 407

COAL RESOURCES

The principal sources of data used in the construction of the coal isopach, structure contour, and coal data maps were Doelling (1972), Brodsky (1960), Fisher (1936), and Clark (1928).

Coal resource tonnages were calculated for measured, indicated, and inferred categories in unleased areas of Federal coal land within the KRCRA boundary where the coal is 5 ft (1.5 m) or more thick. Data obtained from the coal isopach map (plate 4) was used to calculate the Reserve Base values. The coal-bed acreage (measured by planimeter) multiplied by the average isopached thickness of the coal bed times a conversion factor of 1,800 short tons of coal per acre-foot of bituminous coal yields the coal resources in short tons of coal for the isopached coal bed. Reserve Base and Reserve values for the Lower Sunnyside coal bed are shown on plate 7 and are rounded to the nearest tenth of a million short tons. The Reserve values are based on a subsurface mining recoverability factor of 50 percent.

"Measured resources are computed from dimensions revealed in outcrops, trenches, mine workings, and drill holes. The points of observation and measurement are so closely spaced and the thickness and extent of coals are so well defined that the tonnage is judged to be accurate within 20 percent of true tonnage. Although the spacing of the points of observation necessary to demonstrate continuity of the coal differs from region to region according to the character of the coal beds, the points of observation are no greater than ½ mile (0.8 km) apart. Measured coal is projected to extend as a ¼-mile (0.4 km) wide belt from the outcrop or points of observation or measurement.

"Indicated resources are computed partly from specified measurements and partly from projection of visible data for a reasonable distance on the basis of geologic evidence. The points of observation are 1/2 (0.8 km) to 1 1/2 miles (2.4 km) apart. Indicated coal is projected to extend as a 1/2-mile (0.8 km) wide belt that lies more than 1/4 mile (0.4 km) from the outcrop or points of observation or measurement.

"Inferred quantitative estimates are based largely on broad knowledge of the geologic character of the bed or region and where a few measurements of bed thickness are available. The estimates are based primarily on an assumed continuation from Demonstrated coal for which there is geologic evidence. The points of observation are 1 1/2 (2.4 km) to 6 miles (9.6 km) apart. Inferred coal is projected to extend as a 2 1/4-mile (3.6 km) wide belt that lies more than 3/4 mile (1.2 km) from the outcrop or points of observation or measurement." (U.S. Bureau of Mines and U.S. Geological Survey, 1976).

Coal Reserve Base tonnages per Federal section are shown on plate 2 and total approximately 10.6 million short tons (9.6 million metric tons) for the unleased Federal coal lands within the KRCRA boundary in the northeast quarter of the Woodside 15-minute quadrangle. These Reserve Base figures are summarized in the following tabulation.

Table 4. Coal Reserve Base data for subsurface mining methods for Federal coal lands (in short tons) in the Northeast Quarter of the Woodside 15-minute quadrangle, Emery and Carbon Counties, Utah.

(To convert short tons to metric tons, multiply by 0.9072)

Coal Bed Name	High development potential	Moderate development potential	Low development potential	Total
Lower Sunnyside	8,800,000	1,800,000	-0-	10,600,000

AAA Engineering and Drafting, Inc. has not made any determination of economic mineability for any of the coal beds described in this report.

COAL DEVELOPMENT POTENTIAL

Development Potential for Surface Mining Methods

No development potential for surface mining methods exists in the area of this quadrangle because of the rugged topography, steep-sided canyons, extreme relief, and thick overburden. There may be very small areas where some rim stripping could be done, but in general the area is not conducive to surface mining methods.

Development Potential for Subsurface Mining and In Situ Coal Gasification Methods

The coal development potential for the subsurface mining of coal is shown on plate 8. In this quadrangle the areas where coal beds 5 ft (1.5 m) or more in thickness are overlain by less than 1,000 ft (305 m) of overburden are considered to have a high development potential for subsurface mining.

Areas where such beds are overlain by 1,000 to 2,000 ft (305 to 610 m) and 2,000 to 3,000 ft (610 to 914 m) of overburden are rated as having a moderate and a low development potential respectively. Areas that contain no known coal in beds 5 ft (1.5 m) or more thick, but coal-bearing units are present at depths of less than 3,000 ft (914 m) are classified as areas of

unknown coal development potential. Areas where no coal beds are known to occur or where coal beds are present at depths greater than 3,000 ft (914 m) have no coal development potential. The areas of unleased Federal coal land within the KRCRA in the Northeast Quarter of the Woodside 15-minute quadrangle fall within the "high," "moderate," "unknown," and "no" development potential classifications.

The designation of a coal development potential classification is based on the occurrence of the highest-rated coal-bearing area that may occur within any fractional part of a 40-acre (16 ha) BLM land grid area or lot area of unleased Federal coal land. For example, a certain 40-acre (16 ha) area is totally underlain by a coal bed with a "moderate" development potential. If a small corner of the same 40-acre (16 ha) area is also underlain by another coal bed with a "high" development potential, the entire 40-acre (16 ha) area is given a "high" development potential rating even though most of the area is rated "moderate" by the lower coal bed. Another possibility is a 40-acre (16 ha) area devoid of any coal except a small corner where a 5-ft (1.5 m) coal bed crops out. In this case the 40-acre (16 ha) area will have a "high" development potential rating.

The in situ coal gasification methods of development potential classification are based on the dip and depth of coal beds having a minimum thickness of 5 ft (1.5 m). There are only two development potential classifications--moderate and low. The criteria for in situ classification include coal bed dips of 15 to 90 degrees and coal bed depths of 200 to 3,000 ft (61 to 914 m).

Inasmuch as the coal beds dip less than 15 degrees in the Northeast Quarter of the Woodside 15-minute quadrangle, the in situ coal gasification methods of development potential classification do not apply.

Table 5. Sources of data used on plate 1.

Source	Plate 1 Index Number	Data Base Measured Section No.	Data Base Page or Plate No.
Fisher, 1936	2	1	pl. 12
	3	2	pl. 12
	4	3	pl. 12
	6	4	pl. 12
	7	5	pl. 12
	9	6	pl. 12
	11	7	pl. 12
	12	8	pl. 12
	13	9	pl. 12
	15	10	pl. 12
	16	11	pl. 12
	17	12	pl. 12
	18	13	pl. 12
Doelling, 1972	5	7	406
	8	12	406
	25	25	406
	26	26	406
	27	27	406
Osterwald and Mayberry, 1974	10		
	14		
	23		
	24		
Brodsky, 1960	19	52	pl. 2
	20	51	pl. 2
	21	54	pl. 2
	22	58	pl. 2
Clark, 1928	1	365 and 379	pls. 5 and 11

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