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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE SUNNYSIDE QUADRANGLE CARBON COUNTY, UTAH

(Report includes 12 plates)

By

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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 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 (12 plates) and the Coal Development Potential (CDP) Map (1 plate) of the Sunnyside quadrangle (Southeast Quarter of the Sunnyside 15-minute quadrangle) Carbon County, Utah (U.S. Geological Survey Open-File Report 79-491).

Published and unpublished public information were used as data sources for this study.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 information was used.

Location

The Sunnyside 7½-minute quadrangle is located in the south central part of Carbon County, Utah. The towns of Sunnyside and East Carbon City are located in the east central part of the quadrangle. The city of Price, 16 miles (26 km) east, is the county seat of Carbon County.

Accessibility

Utah Highway 123 connects Sunnyside and East Carbon City with U.S. Highway 50-6 approximately 8 miles (13 km) west of East Carbon City.

Utah Highway 124 runs south from East Carbon City to the Geneva mine in the adjoining quadrangle. A branch line of the Denver and Rio Grande Western Railroad provides rail service to the mining communities of Sunnyside and East Carbon City. The Carbon County Railway connects the railroad at East Carbon City to the town of Columbia and the Geneva Mine in the adjacent quadrangle to the south. The branch line of the railroad joins the main Denver and Rio Grande Western Railroad line at Mounds about 11 miles (18 km) southwest of East Carbon City.

A number of unimproved dirt roads and jeep trails provide access to many of the canyons and ridges in the mountainous area.

Physiography

The Book Cliffs form a bold southward-facing escarpment of barren sandstone cliffs from 1,000 to 2,000 ft (305 to 610 m) high which trend in a southeasterly direction across the Sunnyside quadrangle. The strata dip gently northeastward and erosion has carved parallel lines of cliffs and ledges along the mountain front and steep canyon walls. The lowlands below the cliffs occupy about two thirds of the quadrangle and consist of low hills, flat lands, and shallow washes. The mountainous area behind the cliffs coversthe northeast quarter of the quadrangle.

The main drainage system in the area is Grassy Trail Creek and its tributaries. It consists of the stream in Whitmore Canyon and all the washes in the northern two-thirds of the quadrangle which drain southwestward into Grassy Trail Creek. The washes south of Grassy Trail Creek drain into Icelander Creek. Both Grassy Trail Creek and Icelander Creek drain into Price River.

The lowest elevation in the quadrangle is 5,480 ft (1,670 m) where Icelander Creek leaves the south side of the quadrangle. The highest elevation is 8,987 ft (2,739 m) on a peak on West Ridge in the northeast part

of the quadrangle. The total relief in the quadrangle is approximately 3,507 ft (1,069 m).

Climate

The Book Cliffs coal field is located in a mid latitude steppe climate. Semi-arid conditions prevail over most of the area below the cliffs. The normal annual precipitation ranges from about 7 inches (18 cm) in the low areas in the southwest part of the quadrangle to a maximum of 18 inches (46 cm) in the high mountainous area in the northeast sector (U.S. Department of Commerce, (1964)). The precipitation at the elevation of the coal outcrops is approximately 10 to 12 inches (25 to 30 cm) per year.

Temperatures are also a function of altitude and the maximum summer temperatures range approximately from 105 degrees F (41 degrees C) at the lower elevations to 90 degrees F (32 degrees C) in the high mountainous area. The minimum winter temperatures range from approximately -20 degrees F (-29 degrees C) in the lower elevations to -30 degrees F (-34 degrees C) in the highest areas.

Land Status

The Sunnyside quadrangle is located in the east central part of the Book Cliffs Known Recoverable Coal Resource Area (KRCRA). Approximately 20 percent of the quadrangle area (7,400 acres) lies within the 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 Sunnyside quadrangle, Carbon County, Utah.

Category	Approximate Area (acres)	Percent of KRCRA (%)
Non-Federal land	2,600	35
Leased Federal coal land	3,200	43
Unleased Federal coal land	1,600	22
Total	7,400	100

GENERAL GEOLOGY

Previous Work

Clark (1928) mapped the geology and coal outcrops in western part of the Book Cliffs coal field and Fisher (1936) mapped most of that portion of the field lying east of the area mapped by Clark. The stratigraphy is futher described by Abbott and Liscomb (1956), Fisher, Erdmann, and Reeside (1960), Hayes and others (1977), Brodsky (1960), and Young (1955, 1957, and 1966). Osterwald (1962) has made a detailed study of the structural features in the area of the Sunnyside No. 1 mine. Doelling (1972) has summarized the geology and updated the coal information.

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 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 overlying Tertiary strata consist of two formations in the Wasatch Group, the North Horn Formation (Upper Cretaceous and Paleocene age) and the Colton Formation (Eocene age). The Green River Formation of Eocene age overlies the Colton Formation.

The Mancos Shale crops out or underlies a thin gravel layer of a large dissected pediment in about three-fourths of the quadrangle. The dark gray shale extends several hundred feet up the base of the Book Cliffs and the entire formation is estimated to exceed 4,000 ft (1,220 m) in thickness.

In this quadrangle the lowest bed of the Blackhawk Formation is the Kenilworth Sandstone Member. The lower section of this cliff-forming member is thin-bedded and divided by shale partings, but the major part is a massive sandstone body some 130 ft (40 m) thick. The coal-bearing part of the Blackhawk Formation lies above the Kenilworth Sandstone and has been divided roughly into three members recognized by Fisher (1936). The lower division consists of alternating sandstone, shaly sandstone, shale, and coal. It contains the Kenilworth, Gilson, and Rock Canyon coal beds. The middle division is dominated by massive cliff-forming sandstone near the top of which lagoonal deposits include the Sunnyside coal bed. The upper division is a sequence of shaly sandstone, shale, and coal. The entire Blackhawk Formation is about 700 ft (214 m) thick.

The cliff-forming Castlegate Sandstone overlies the Blackhawk Formation. It is about 180 ft (55 m) thick and is composed mainly of fine- to medium-grained light gray sandstone.

The Price River Formation overlies the Castlegate and is about 500 ft (153 m) thick. It consists of interbedded sandstone and shale. The sandstone is light colored, slightly calcareous to argilaceous, and is thin-bedded to massive. The shale is medium to dark gray, carbonaceous, and contains minor beds of bony coal.

The Tertiary formations are confined to the northeast corner of the quadrangle and include the North Horn Formation (Upper Cretaceous and Tertiary), Colton Formation and the Green River Formation. The North Horn Formation consists of interbedded yellowish-gray sandstone, light yellow to greenish-gray shale and limestone, and conglomeratic sandstone at the base of the formation. The Colton Formation is composed of interbedded sandstone, siltstone, and shale. The Green River Formation includes interbedded shale, oil shale, and impure limestone.

Structure

The structure within the quadrangle is that of a simple homocline with the beds dipping to the east and northeast from 6 to 12 degrees and averaging about 8½ degrees. Several faults with displacements exceeding 100 ft (30 m) cut the strata just south of Bear Canyon and just north of the mouth of Whitmore Canyon. These faults are widely spaced and have not excessively impeded mining in the past.

There are several normal faults in the area immediately north of the town of Sunnyside. The three faults in Sec. 31, T. 14 S., R. 14 E. are roughly parallel and strike nearly east-west and south of west. The vertical displacements of these faults and their splits range from 13 ft (4 m) to 110 ft (34 m) (Clark, 1928).

COAL GEOLOGY

The coal in the quadrangle crops out along a southwestward-facing escarpment in the northeast portion of the quadrangle. The five coal

beds that have been identified and named are, in ascending order, the Kenilworth, Gilson, Rock Canyon, Lower Sunnyside, and the Upper Sunnyside.

Kenilworth Coal Bed

The Kenilworth coal bed ranges in thickness from about 0.5 to 4.3 ft (0.2 to 1.3 m) but is split by partings in many places (Clark, 1928). The bed is thickest near the central eastern border of the quadrangle, but is thin or missing elsewhere and therefore is not an important resource in the area (Doelling, 1972).

Gilson Coal Bed

The Gilson coal bed occurs in the northern part of the quadrangle as a thin bed or beds generally less than 2 ft (0.6 m) in thickness. In the measured section of index number 6 (plate 1) the Gilson consists of two closely spaced beds 2 ft (0.6 m) and 1.7 ft (0.5 m) thick. In this quadrangle the Gilson bed is approximately 30 ft (9 m) above the Kenilworth coal bed.

Rock Canyon Coal Bed

The Rock Canyon coal bed, 70 to 75 ft (21 to 23 m) above the Gilson coal bed, has been measured at only one point in the northern part of the quadrangle. At that point (index number 3, plate 1) the bed is 4.8 ft (1.5 m) thick. According to Doelling (1972), the Rock Canyon is only present along the northern edge of the quadrangle and is therefore unimportant in this area.

Lower Sunnyside Coal Bed

The Lower Sunnyside coal bed occurs 120 to 140 ft (37 to 43 m) above the Rock Canyon coal bed (Clark, 1928). It is variable in thickness but is continuous and persistent, making it the most valuable bed in the area. The isopach map (plate 8) shows the bed is variable in thickness but

persistent along the outcrop. The maximum measured thickness is 14.8 ft (4.5 m) and the average thickness is betweem 8 to 9 ft (2 to 3 m). The coal isopach map (plate 8) shows that the bed generally thins towards the northeast. However, a drill hole near the northeast corner of the quadrangle encountered an 8.5 ft (2.6 m) bed of coal. Clark (1928) emphasises the continuity of the bed and believes the coal is thicker under cover than where it has been measured in outcrop.

Upper Sunnyside Coal Bed

The Upper Sunnyside coal bed is 25 to 35 ft (8 to 11 m) above the Lower Sunnyside bed. Clark (1928) notes that several beds of coal crop out in places above the Lower Sunnyside bed and it is difficult to tell which of them is the Upper Sunnyside bed. The coal isopach map (plate 4) shows a maximum measured thickness of 9.0 ft (2.7 m) near the eastern edge of the quadrangle. Along the outcrop the bed ranges in thickness from 1.7 ft (0.5 m) to 5.0 ft (1.5 m). In the northeast part of the quadrangle the bed thickens and several drill holes show 5.9 ft (1.8 m) or more of coal.

Intervals reported as "bony coal," "bone," "shaly coal," or other similar terms in the data sources 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 maps.

Chemical Analyses of the Coal

No chemical analyses are known to have been made of coal samples collected from outcrops in the quadrangle area. Doelling (1972) reports one coal analysis of the Lower Sunnyside bed encountered in a drill hole located in the SE¼ Sec. 18, T. 14 S., R. 14 E. as follows (moisture free basis):

Volatile matter	39.5
Fixed carbon	53.3
Ash	7.2
Sulfur	0.7
Btu/lb	13,790

Part of the Sunnyside No. 1 mine underlies the Sunnyside quadrangle and the average of the proximate values of analyses of coal samples from the mine (Lower Sunnyside coal bed) are shown in table 1 taken from Doelling (1972).

Table 2: Average proximate analyses of coal for the Sunnyside quadrangle, Carbon County, Utah.

	No. Analyses	Percent	
		Average	Range
Moisture	12	4.3	3.1-6.0
Volatile matter	10	38.0	36.8-39.0
Fixed carbon	10	51.3	48.2-52.8
Ash	12	6.4	4.2-11.9
Sulfur	12	1.21	0.5-3.0
Btu/lb*	9	13,058	12,420-13,660

* To convert Btu/lb to Kj/kg multiply by 2.326

The coal from the Sunnyside No. 1 mine has superior coking qualities and although the coal has a sulfur content of over one percent, it is washed to metallurgical grade standards for both sulfur and ash.

Based on the ASTM system of classification (American Society of Testing and Materials, 1977) coal with the average analysis shown in table 1 above is classified as high volatile A bituminous coal with a moist, mineral matter-free Btu content of 14,065 Btu/lb, just slightly above the volatile B bituminous rank. Doelling (1972, p. 324) states that "the ASTM system classifies the coal of the Book Cliffs coal field as bituminous high volatile B rank. The coal in the Sunnyside area is a coking coal, but must be blended with 15 to 20 percent of low- or

medium-volatile coals from other sources to achieve metallurgical grade."

Mining Operations

The portals of the Sunnyside group of mines owned by Kaiser Steel Corporation are all located near the mouth of Whitmore Canyon in the adjoining Patmos Head quadrangle (Southeast Quarter of the Sunnyside 15-minute quadrangle). The main area of the Sunnyside No. 1 mine lies in the Sunnyside quadrangle (Southwest Quarter of the Sunnyside 15-minute quadrangle) as shown on plate 1. Recent annual production from the No. 1 mine is unknown, but Doelling (1972) reports a 1969 production of 959,730 short tons (870,667 metric tons). Doelling (1972, p. 387) also estimates that 13 million short tons (11.8 million metric tons) have been extracted from the Sunnyside coal beds in the quadrangle with a recoverability of 44.5 percent.

COAL RESOURCES

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

Coal resource tonnages were calculated for measured, indicated, and inferred categories in unleased areas of Federal coal land within the KRCRA boundary. Data obtained from the coal isopach maps (plates 4 and 8) were 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 each isopached coal bed. Reserve Base and Reserve values for the Upper Sunnyside and Lower Sunnyside beds are shown on plates 7 and 11 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.

"Inferred quantitative estimates are based largely on broad knowledge of the geologic character of the bed or region and where 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 1½ (2.4 km) to 6 miles (9.6 km) apart. Inferred coal is projected to extend as a 2¼-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 13.1 million short tons (11.9 million metric tons) for the unleased Federal coal lands within the KRCRA boundary in the Sunnyside quadrangle. The Reserve Base tonnages are also shown in the following tabulation.

Table 3: Coal Reserve Base data for subsurface mining methods for Federal coal lands (in short tons) in the Sunnyside quadrangle, Carbon County, 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
Upper Sunnyside	1,700,000	700,000	-0-	2,400,000
Lower Sunnyside	7,700,000	1,300,000	1,700,000	10,700,000
Total	9,400,000	2,000,000	1,700,000	13,100,000

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 12. 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 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 BLM land grid area or lot area of unleased Federal coal land. For example, a certain 40-acre area is totally underlain by a coal bed with a "moderate" development potential. If a small corner of the same 40-acre area is also underlain by another coal bed with a "high" development potential, the entire 40-acre 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 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 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 gasification include coal bed dips of 15 to 90 degrees and coal bed depths of 200-3,000 ft (61-914 m).

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

Table 4. Sources of data used on plate 1.

Source	Plate 1 Index Number	Data Base: Measured Section No.	Data Base: Page or Plate No.
Clark, F. R., 1928	1	236 and 254	pl. 5 and 9
	3	245	pl. 9
	6	224, 239, 260 and 276	pl. 5
	9	240, 262, and 279	pl. 5 and 9
	10	241, 263, and 280	pl. 5
	12	281 and 265	pl. 9 and 63
	14	266	63
	15	267 and 282	pl. 5
	16	268 and 283	pl. 9
	17	242, 269, and 284	pl. 5
	18	270 and 285	pl. 9
	19	225, 306, and 322	pl. 5
	20	226	pl. 9
	21	227	pl. 9
	22	287, 307, and 323	pl. 5
	23	308 and 324	pl. 10 and 70
	24	288 and 309	pl. 10
	25	289	pl. 10
	27	292, 313, and 326	pl. 5
	28	293	pl. 10
	31	296	pl. 10
	38	320 and 330	pl. 5
	44	332, 343, and 366	pl. 5
Doelling, H. H., 1972	2	22	386
	4	56 and 62	386 and 387
	5	23, 57, and 63	386 and 387
	7	4 and 25	386
	13	28	386
	26	72, 39, and 16	386 and 387
	29	18, 43, and 75	386 and 387
	32	20, 44, and 78	386 and 387
	33	45 and 79	386 and 387
	34	81	387
	35	82	387
	36	83	387
	37	84	387
	39	47	386
	40	48	386
	41	85	387
	42	50 and 86	386 and 387
	43	51	386
Brodsky, H., 1960	8	13	pl. 2
	11	17	pl. 2
	46	DDH 14, log no. 26	pl. 2
	50	DDH 17, log no. 19	pl. 2

Source	Plate 1 Index Number	Data Base Measured Section No.	Data Base Page or Plate No.
Brodsky, H., 1960	52	DDH B-1, log no. 18	pl. 2
	53	DDH B-2, log no. 15	pl. 2
	54	DDH B-4, log no. 12	pl. 2
	55	DDH B-6, log no. 10	pl. 2
Kaiser Steel Corp.	47	DDH 21	
	48	DDH 15	
	49	DDH 29	
	51	DDH 31	

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