UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Text to accompany:

Open-File Report 79-899

1979

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

(Report includes 12 plates)

By

AAA Engineering And Drafting, Inc.

CONTENTS

ILLUSTRATIONS

(Plates are in pocket)

TABLES

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 (11 plates) and the Coal Development Potential (CDP) Map (1 plate) of the Northeast Quarter of the Hiawatha 15-minute quadrangle, Emery and Carbon Counties, Utah (U.S. Geological Survey Open-File Report 79-899).

Published and unpublished public information were used as data sources for this study.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 Hiawatha 15-minute quadrangle is located on the east side of the north-central part of the Wasatch Plateau coal field in central Utah. Part of the northeast quarter of the quadrangle lies in Carbon County and the rest of the quadrangle is in Emery County. The city of Price, the county seat of Carbon County, is 12 miles (19 km) northeast of the quadrangle. Price is approximately 120 miles (193 km), by highway, southeast of Salt Lake City, Utah. The town of Castle Dale, the county seat of Emery County, is 11 miles (18 km) south and the town of Huntington is 4 miles (6 km) southeast of the quadrangle.

Accessibility

The coal mining towns of Hiawatha and Mohrland are 3 miles (5 km) apart in the northeast corner of the quadrangle. Utah Highway 122 runs eastward from Hiawatha approximately 9 miles (14 km) where it joins Utah Highway 10 at a point approximately 7 miles (11 km) south of the city of Price. Utah Highway 10 provides accessibility to nearly all towns along the east side of the Wasatch Plateau. Utah Highway 236 extends from Mohrland to Huntington.

Utah Highway 31 passes through the southwest corner of the quadrangle in Huntington Canyon. This highway runs from the town of Huntington on the east side of the Wasatch Plateau to the town of Fairview and Sanpete Valley on the west side of the plateau.

Several unimproved dirt roads, jeep trails, and pack trails in some of the canyons provide access to the mountainous area for the local cattle ranchers and sportsmen.

The Utah Railway Company maintains a short railroad line from Mohrland to a junction near the city of Helper approximately 20 miles (32 km) to the northeast. There are sidings, spurs, and loading facilities at Mohrland, Hiawatha, and Wattis. Near Helper the Utah Railway joins a main line of the Denver and Rio Grande Western Railroad (D. & R. G. W.) which runs from Denver, Colorado to Salt Lake City. There are also single car rail-loading facilities on the D. & R. G. W. railroad at the city of Price.

Physiography

The Wasatch Plateau is a high and deeply dissected tableland, the eastern margin of which forms a sweeping stretch of barren sandstone cliffs about 80 miles (129 km) in length. The cliffs rise sharply above the flat, dry land of Castle Valley below. Elevations in the quadrangle range from 6,150 ft (1,875 m) at the southeast corner of the quadrangle to 9,900 ft (3,018 m) on Gentry Mountain at the north edge of the quadrangle. The total relief is 3,750 ft (1,143 m).

The gently sloping low areas below the steep cliffs on the east and southeast parts of the quadrangle consist of dissected pediments locally referred to as "benches." The pediments have developed on the Mancos Shale and are generally capped with a layer of gravel. Shallow washes and gulleys divide the sloping pediments into long narrow benches.

The coal beds in the quadrangle crop out in the irregular line of steep sandstone cliffs at elevations ranging from about 7,200 ft (2,195 m) to 8,500 ft (2,591 m).

Climate

The climate in the quadrangle ranges with altitude from semi-arid in the lower elevations to alpine in the highest. The normal annual precipitation ranges from 10 inches (25 cm) in the southeast corner of the quadrangle to 27 inches (69 cm) on the highest elevations at the northwest corner of the quadrangle (U.S. Department of Commerce, (1964)).

Temperatures in the high mountainous country are generally cold in winter with warm days and cool nights during the summer. On the high north side of the quadrangle the summer temperatures may reach 90 degrees F (32 degrees C) while the minimum winter temperatures could drop to -30 degrees F (-34 degrees C). At the lower elevations below the mountain front summer temperatures may reach 100 degrees F (38 degrees C) or more and the winter temperatures may drop as low as -20 degrees F (-29 degrees C).

Land Status

The Northeast Quarter of the Hiawatha 15-minute quadrangle is located along the east-central side of the Wasatch Plateau Known Recoverable Coal Resource Area (KRCRA). The KRCRA covers approximately 33,900 acres of the quadrangle. A comparison of the leased and unleased Federal coal lands and the non-Federal lands within the KRCRA boundary are shown in table 1 and on plate 2.

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

Category	Approximate Area (acres)	Percent of KRCRA (%)
Non-Federal land	10,200	30
Leased Federal coal land	16,300	48
Unleased Federal coal land	7,400	22
Total	33,900	100

GENERAL GEOLOGY

Previous Work

Spieker (1931) mapped the geology and coal occurrences in the Wasatch Plateau and his maps represent the most detailed original work presently available. The stratigraphy of the area has also been described by Lupton (1916), Spieker and Reeside (1925), Katich (1954), and Hayes and others (1977). Doelling (1972) has summarized the geology and updated the coal information.

Stratigraphy

The coal beds of economic importance in the Wasatch Plateau field are Upper Cretaceous in age, and are confined to the Blackhawk Formation of the

Mesaverde Group. The Mesaverde consists of the following four formations in ascending order: the Star Point Sandstone, Blackhawk Formation, Castlegate Sandstone, and Price River Formation. The Upper Cretaceous Mancos Shale underlies the Mesaverde Group and consists of three shale members and two sandstone members. The Tunuk Shale Member at the base is succeeded upward by the Ferron Sandstone Member, Blue Gate Shale Member, Emery Sandstone Member, and the Masuk Shale Member.

The North Horn Formation of Upper Cretaceous and Paleocene ages is the youngest formation in the quadrangle and overlies the Mesaverde Group. The North Horn is the lowest member of the Wasatch Group which is more prevalent on the north end of the Wasatch Plateau.

The oldest stratigraphic unit exposed in the quadrangle is the Emery Sandstone Member of the Mancos Shale. The Emery Sandstone crops out at the lower elevations in the southeast corner of the quadrangle and consists of yellowish-gray littoral sandstone with some shaly partings. The overlying Masuk Member, a gray marine shale, is about 1,000 ft (305 m) thick and crops out over a large area below the steep sandstone cliffs of the Mesaverde Group.

The Star Point Sandstone forms a cliff above the Masuk Shale. It consists of massive yellowish-gray to white sandstone with interbedded subordinate shale and is approximately 500 ft (152 m) thick.

The Blackhawk Formation overlies the Star Point Sandstone and is composed of approximately 1,000 ft (305 m) of alternating shale, sandstone, and coal. The coal beds occur in the lower 350 ft (107 m) of the formation. The Blackhawk is successively overlain by the Castlegate Sandstone and the Price River Formation both of which have similar lithologies of gray to white gritty sandstone with subordinate interbeds of shale and conglomerate. The formations are resistant and cliff-forming. On Gentry Mountain the formations are thinner than elsewhere and the combined thickness of the two formations ranges from 350 to 500 ft (107 to 152 m).

The North Horn Formation caps Gentry Mountain and Gentry Ridge in the quadrangle and is composed of variegated shale, sandstone, and limestone. Doelling (1972) estimates that at least 750 ft (229 m) of the formation are present.

Structure

The principal structural features are the north-south trending normal faults in the western half of the quadrangle. These faults are extensions of components of the Pleasant Valley fault zone in the adjoining quadrangles on the north and south. The fault zone comprises 5 to 12 major faults many of which are accompanied by shear zones containing numerous smaller faults (Spieker, 1931, p. 144-145). The faults cut the coal beds and could hinder or limit mining depending on the amount of displacement. The displacement on the larger faults ranges up to 450 ft (137 m).

The coal-bearing strata in the unfaulted central and eastern parts of the quadrangle dip very gently southward at 3 degrees or less. There is a slight structural depression in the south central part of the quadrangle. The dips of the beds in the fault zone are erratic.

COAL GEOLOGY

Five named and several unnamed local coal beds occur in the quadrangle. The local beds are generally thin and insignificant. The named coal beds, in ascending order, are the Hiawatha, Blind Canyon, Third Bed, Bear Canyon, and Wattis.

Hiawatha Coal Bed

The Hiawatha coal bed rests on or close to the Star Point Sandstone and is the most persistent and well-developed coal bed in the quadrangle. It ranges in thickness from 0.1 ft (0.03 m) in an erosional or non-depositional channel in the west south central part of the quadrangle to 21.0 ft (6.4 m) of coal in the east north central part. The bed generally thickens eastward from the west central part of the quadrangle and thins again to 1.7 ft (0.5 m) in the northeast quarter of the quadrangle (plate 8). The bed thickens to more than 10 ft (3 m) in a small area in the southwest corner of the quadrangle.

The Hiawatha coal bed has been produced in many of the mines that operated in the quadrnagle in the past. Spieker (1931, p. 116) reports that in the King No. 2 mine a maximum thickness of about 28 ft (8.5 m) for the Hiawatha coal bed was measured. He also stated that the coal bed was locally replaced by sandstone or bone in the King No. 1 and King No. 2 mines. The miners referred to these replacement deposits as "wants" and Spieker (1931, p. 116 and 63) described three different types of distinguishable "wants". "One type consists of simple 'islands' of bone and dirty coal, formed at muddy places in the original swamp. A second type is caused by local flexures in the rocks, as a result of which the coal is thinner in the synclines and thicker in the anticlines; 'wants' of this type were probably caused by slight local compression, and none are known to cut out the coal completely. The third type, . . . are probably old drainage channels in the original swamp into which fine sand was washed after depression had caused the submergence of the swamp. Less probably they represent channels cut by rivers shifting their courses during times of flood. In the King No. 2 mine the workings have blocked out enough of the 'wants' to indicate roughly the position of the drainage channel."

Blind Canyon Coal Bed

The Blind Canyon bed lies about 35 ft (11 m) above the Hiawatha coal bed in the southwest part of the quadrangle. It was measured in only five sections in the quadrangle with thicknesses of 0.8 to 6.7 ft (0.2 to 2.0 m). The coal bed is missing in the remainder of the measured sections. The areas where the bed is 6.7 ft (2.0 m) thick is covered by a coal lease and a Reserve Base tonnage was not calculated for this bed.

Third Coal Bed

The Third coal bed occurs about 40 ft (12 m) above the Hiawatha bed in the north part of the quadrangle. Plates 1 and 3 show two measured sections in which the bed is 4.0 and 5.0 ft (1.2 and 1.5 m) thick. The bed thickens northward into the adjoining Southeast Quarter of the Scofield 15-minute quadrangle where it is over 13 ft (4 m) thick.

Bear Canyon Coal Bed

The Bear Canyon coal bed is from 50 to 100 ft (15 to 30 m) above the Hiawatha bed. The Bear Canyon bed has its best development in the Bear Creek Canyon and Trail Canyon areas where it reaches a thickness of over 17 ft (5 m) for a single bed or a combined thickness of 18.4 ft (5.6 m) for two splits at index number 32 on plate 1.

The coal isopach map, plate 4, for the Bear Canyon bed is based on a limited number of measured sections, but suggests a southward and eastward thinning of the bed. There are no non-proprietary drill hole data in the central part of the quadrangle, but measurements of the bed in Huntington Canyon in the adjoining quadrangle to the west indicate that the bed thins northward from the thick section in the Bear Creek Canyon-Trail Canyon area.

Wattis Coal Bed

The Wattis coal bed was measured in two sections on the north side of the quadrangle in Miller Creek Canyon near the Hiawatha mine. The bed measurements at index numbers 2 and 3 (plate 1) are 1.7 and 5.5 ft (0.5 and 1.7 m) thick. The Wattis bed thickens northward into the adjoining Southeast Quarter of the Scofield 15-minute quadrangle where it reaches a thickness of 11.0 ft (3.4 m) or more. The Wattis bed is approximately 150 ft (46 m) above the Hiawatha coal bed.

Other Coal Beds

Several thin, unnamed, and non-correlatable coal beds occur in some of the measured sections in the quadrangle. These beds are generally very lenticular and are 5 ft (1.5 m) or less in thickness.

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

Doelling (1972) lists 388 analyses of coal samples from the quadrangle area. Most of the samples came from the Hiawatha and Mohrland mines operated by U.S. Fuel Company. Other samples came from the Bear Canyon, Co-op, Sea Gull, and Tie Fork mines. Most of the samples were taken from the Hiawatha coal bed, but some represent the Blind Canyon and Bear Canyon beds. These analyses are summarized in table 2.

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

	No. Analyses	As-received (percent) Average	Range
		Bear Canyon Coal Bed	
Moisture	6	6.8	4.5-10.9
Volatile matter	6	43.8	37.4-46.0
Fixed carbon	6	45.7	44.9-46.0
Ash	6	4.5	3.8-5.8
Sulfur	6	0.53	0.5-0.6
Btu/lb**	6	13,014	10,840-13,530
		Blind Canyon Coal Bed	
Moisture	10	4.8	3.8-5.3
Volatile matter	9	41.7	40.2-44.7
Fixed carbon	9	44.3	39.2-48.3
Ash	10	8.9	5.8-12.4
Sulfur	8	0.58	0.5-0.6
Btu/lb**	9	12,492	11,700-13,080
		Hiawatha Coal Bed	
Moisture	370	5.6	0.7-11.0
Volatile matter	357	42.3	36.3-46.4
Fixed carbon	357	45.7	38.3-52.7
Ash	359	6.2	3.3-11.2
Sulfur	330	0.61	0.29-1.1
Btu/lb**	365	12,719	11,521-13,600

*Doelling, 1972, p. 187
**To convert Btu/lb to Kj/kg multiply by 2.326

Based on the ASTM system of classification (American Society of Testing and Materials, 1977) coal with the average analyses shown in table 2 above for each of the three beds is ranked as high volatile B bituminous. Some of the coal mined by U.S. Fuel Company in the quadrangle contained considerable resin. It is not known which coal bed contained the resin.

Mining Operations

Coal mining in the quadrangle began as early as 1896. U.S. Fuel Company owned the largest group of mines in the quadrangle. These included the King, Hiawatha, Blackhawk, and Mohrland mines and the Miller Canyon prospects. At the time of this report (1979) the King No. 4 and No. 5 mines were operating. Doelling (1972, p. 187) reports that the King mine was the largest producer of the Wasatch Plateau coal field and had produced an estimated 51 million short tons (46 million metric tons) by the end of 1969. Spieker (1931, p. 118) described the mining conditions in the King No. 2 mine where 90 to 96 percent of the coal was extracted from the Hiawatha bed. A tramway about 1.25 miles (2.0 km) long was used to lower the coal 530 ft (162 m) from the mine to the tipple.

The Bear Canyon mine produced over 150,000 short tons (136,080 metric tons) of coal mainly from the Bear Canyon coal bed in two periods of activity from 1896 to 1906 (intermittent) and from 1938 to 1957 (Doelling, 1972). The Sea Gull mine produced over 26,000 short tons (23,587 metric tons) from the Blind Canyon coal bed. Production from the Reichert mine and the Tie Fork prospects are unknown. The Co-op mine began operating in 1938 and was active in 1979. Doelling (1972) reported the the Co-op had produced at least 600,000 short tons (544, 320 metric tons) of coal at the date of his writing. He also estimated that the total production from all portals in the quadrangle was 51,776,000 short tons (46,971,187 metric tons).

Table 3 lists the mines in the quadrangle, and their approximate locations and periods of activity.

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

Mine Name(s)	Approximate Location	Period of Activity
Bear Canyon mine	SW¼ SW¼ Sec. 24, T. 16 S., R. 7 E.	1896-1906, 1938-1957
Community mine	SW¼ NE¼ Sec. 22, T. 16 S., R. 7 E.	1921
Co-op mine (Trail Gulch)	SE¼ NE¼ Sec. 22, T. 16 S., R. 7 E.	1938-
Hiawatha mine No. 1 No. 2	NW¼ Sec. 29, T. 15 S., R. 8 E.	1905-1931
Blackhawk mine (King)	NW¼ NW¼ Sec. 3, T. 16 S., R. 8 E.	1898-1970
Mohrland mine (King No. 2, Cedar Creek, Howard)	SE¼ Sec. 8, T. 16 S., R. 8 E.	1896-1938
King No. 3	C. N½ Sec. 32, T. 15 S., R. 8 E.	?
King No. 4	SE¼ NE¼ Sec. 30, T. 15 S., R. 8 E.	1975-
King No. 5	SE¼ NE¼ Sec. 30, T. 15 S., R. 8 E.	1978-
Miller Creek prospects	NW¼ Sec. 32, T. 15 S., R. 8 E.	Joins with King mines in subsurface
Reichert mine	NW¼ SE¼ Sec. 20, T. 16 S., R. 8 E.	1940's
Sea Gull mine (Beehive)	NW¼ SE¼ Sec. 32, T. 16 S., R. 7 E.	1943-1956
Tie Fork prospect	Sec. 34, T. 15 S., R. 7 E.	Unknown

*After Doelling (1972)

COAL RESOURCES

The principal sources of data used in the construction of the coal isopach maps, structure contour maps, and the coal data maps were Doelling (1972) and Spieker (1931). No recent non-proprietary drilling data was available to the authors.

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 Bear Canyon and Hiawatha coal 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 of coal beds 5 to 12 ft (1.5 to 3.7 m) thick. Where a coal bed exceeds 12 ft (3.7 m) in thickness as the Hiawatha bed does in this quadrangle, the Reserves (shown on plate 11) are calculated for a constant thickness of 12 ft (3.7 m) where the coal bed exceeds 12 ft (3.7 m).

"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 coal 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 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 31.6 million short tons (28.7 million metric tons) for the unleased Federal coal lands within the KRCRA boundary in the quadrangle.

Table 4. Coal Reserve Base data for subsurface mining methods for Federal coal lands (in short tons) in the Northeast Quarter of the Hiawatha 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
Bear Canyon	3,100,000	-0-	-0-	3,100,000
Hiawatha	18,500,000	10,000,000	-0-	28,500,000
Total	21,600,000	10,000,000	-0-	31,600,000

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 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 classification include coal bed dips of 15 to 90 degrees and coal bed depth 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 Hiawatha 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.
Doelling, 1978	3	25 and 61	184 and 185
	4	66	185
	6	27 and 68	184 and 185
	7	69	185
	8	70	185
	10	72	185
	11	73	185
	13	75	185
	15	77	185
	16	78	185
	17	79	185
	19	85	185
	20	86	185
	21	87	185
	27	94	185
	28	95	185
	29	96	186
	31	35 and 97	184 and 186
	33	38, 48, and 104	184, 185, and 186
	34	105	186
	37	109	186
	39	111	186
	41	113	186
	42	114	186
	43	116	186
	44	115	186
	45	117	186
	46	118	186
	48	53	185
Spieker, 1931	1	133	pl. 18
	2	140	pl. 18
	5		
	9	150	pl. 19
	12	153	pl. 19
	14	155	pl. 19
	18	159	pl. 19
	22	165	pl. 19
	23	166	pl. 19
	24	167	pl. 19
	25	168	pl. 19
	26	169	pl. 19
	30	256	pl. 22
	32	253	pl. 22
	35	250	pl. 22
	36	249	pl. 22
	38	242	pl. 22
	40	240	pl. 22
	47	264	pl. 22

REFERENCES

American Society for Testing and Materials, 1977, Standard specifications for classification of coals by rank, in Gaseous fuels, coal, and coke; atmospheric analysis: ASTM Publication D 388-77.

Doelling, H. H., 1972, Wasatch Plateau coal field, in Doelling, H. H., Central Utah coal fields: Utah Geol. and Min. Survey Mon. Ser. no. 3.

Hayes, P. T., and others, 1977, Summary of the geology, mineral resources, engineering geology characteristics, and environmental geochemistry of east-central Utah: U.S. Geol. Survey Open File Report 77-513.

Katich, P. J., Jr., 1954, Cretaceous and early Tertiary stratigraphy of central and south-central Utah with emphasis on the Wasatch Plateau area: Intermtn. Association of Petroleum Geologists Guidebook, 5th Ann. Field Conf.

Lupton, C. T., 1916, Geology and coal resources of Castle Valley in Carbon, Emery, and Sevier Counties, Utah: U.S. Geol. Survey Bull. 628.

Spieker, E. M., 1931, The Wasatch Plateau coal field, Utah: U.S. Geol. Survey Bull. 819.

Spieker, E. M., and Reeside, J. B., Jr., 1925, Cretaceous and Tertiary formations of the Wasatch Plateau, Utah. Geol. Soc. of America Bull., v. 36.

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. Geol. Survey Bull. 1450-B.

U.S. Department of Commerce, (1964), Normal annual precipitation in inches, 1931-1960, State of Utah: U.S. Dept. of Commerce Weather Bureau Map WR-1210-A.