UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Text to accompany:

Open-File Report 79-148

1979

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

(Report includes 23 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 text is to be used in conjunction with the Coal Resource Occurrence (CRO) Maps and Coal Development Potential (CDP) map of the Helper quadrangle, Carbon County, Utah (23 plates) U.S. Geological Survey Open-File Report 79-148. These reports were 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.

Location

The Helper quadrangle is located at the west end of the Book Cliffs coal field in Carbon County, Utah. The city of Helper lies on the west side, and the small coal mining town of Kenilworth is near the center of the quadrangle area. Price, the county seat, is approximately 2.5 miles (4 km) south of the quadrangle boundary.

Accessibility

The main line of the Denver and Rio Grande Western Railroad and U.S. Highway 6-50 cross the west side of the quadrangle in a north-south direction. The Utah Railway Company maintains a small railroad which connects the city of Helper to several coal mining areas to the west. Utah Highway 157 extends from the town of Kenilworth to Helper. Utah Route 33 runs eastward from U.S. Highway 6-50 near the former townsite of Castle Gate, then up Willow Creek Canyon about 2 miles (3 km) where it crosses the north side of the quadrangle. Several unimproved roads traverse the foothill area in the south half of the quadrangle.

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. The near parallel rock strata dip gently northward, and the physiographic features that have developed by erosion processes are typical of regions underlain by flat lying beds. The steep canyon walls are lined with precipitous sandstone cliffs and ledges separated by beds of soft shale. The west end of the Book Cliffs intersects a similar, but north-south trending mountainous area called the Wasatch Plateau approximately 7 miles (11 km) west of the Helper quadrangle.

The steep mountain-front lies across the middle of the Helper quadrangle dividing the north mountainous half from the south foothill area, which is characterized by shallow washes and low hills. The Price River enters the quadrangle at the northwest corner, flows southward along the western margin, and leaves the quadrangle near the southwest corner. Price River and its tributaries form the main drainage system in the area. The only perennial tributary to Price River in the Helper quadrangle is Willow Creek whose confluence is just below the former townsite of Castle Gate.

Climate

The Book Cliffs coal field is located in a mid-latitude steppe climate and semi-arid conditions prevail over most of the lowland area beneath mountain front. Annual precipitation ranges from 9 in (22.9 cm) at the lower elevations to a maximum of 18 in (45.7 cm) in the highlands (U.S. Dept. of Commerce, 1964).

Temperatures are also a function of altitude. In the lowland area below the Book Cliffs, the maximum temperatures range from a high of about 105 degrees F (41 degrees C) to a low of -25 degrees F (-32 degrees C). The annual temperature variations in the mountainous area range from approximately 90 degrees F (32 degrees C) to -35 degrees F (-37 degrees C).

Land Status

Approximately 40 percent of the Helper quadrangle lies within the Book Cliffs Known Recoverable Coal Resource Area (KRCRA). Nearly 6,400 acres (45 percent of the KRCRA) are Federal coal lands. Approximately 4,400 acres of those lands are covered by Federal coal leases and about 2,000 acreas are unleased. Over 7800 acres (55 percent) within the KRCRA are non-Federal coal lands. The KRCRA boundary and the distribution of Federal and non-Federal coal lands are shown on plate 2.

GENERAL GEOLOGY

Previous Work

Clark (1928) mapped the western part of the Book Cliffs coal field and his report is the most detailed original work presently available. Spieker (1931) mapped the Wasatch Plateau coal field and the northern part of his mapping is a westward continuation of Clark's map. The stratigraphy of the area is further described by Abbott and Liscomb (1956), Fisher, Erdmann, and Reeside (1960), and Young (1955, 1957, and 1966). Doelling (1972) has summarized the geology and updated the coal data.

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 Group consists of four formations which are, 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 a thick marine shale and an upper sequence of alternating and interfingering shale and sandstone members.

The lowest unit of the Mesaverde Group, the Star Point Sandstone, is barren of coal and consists of three sandstone tongues which extend eastward and are separated by westward-projecting tongues of Mancos Shale. The eastward-thinning sandstone tongues are, in ascending order, the Panther, Storrs, and Spring Canyon. The Panther Tongue is 100 to 125 ft (30 to 38 m) thick along the west edge of the quadrangle. Some 150 ft (46 m) above the Panther are 15 to 30 ft (5 to 9 m) of sandstone assigned to the Storrs Tongue, and about 100 to 125 ft (30 to 38 m) higher is the Spring Canyon Tongue which is nearly 150 ft (46 m) thick in Spring Canyon.

The Blackhawk Formation overlies the Star Point Sandstone and contains the important coal beds. The main coal-bearing part of the Blackhawk consists of 900 to 1,300 ft (274 to 396 m) of massive gray to buff sandstone, sandy shale, shale, and coal beds. The coal beds occur in two main groups, the Spring Canyon and the Castlegate groups. The lower, or Spring Canyon Group, is underlain by the Spring Canyon Tongue of the Star Point Sandstone and is overlain by the Aberdeen Sandstone Member of the Blackhawk Formation. The Castlegate Coal Group lies between the Aberdeen Sandstone Member and the overlying Kenilworth Sandstone Member. Few significant coal beds occur in the upper part of the Blackhawk Formation which is dominantly sandstone.

The Castlegate Sandstone consists of a single bed of massive sandstone some 350 to 400 feet (107 to 122 m) thick in its type section at Castle Gate in the northwest corner of the quadrangle, but it thins eastward to about two thirds of this thickness at the eastern edge. It consists of fluvial coarse-grained gray to yellowish-gray sandstone which weathers brown and is believed to be disconformable with the underlying Blackhawk Formation (Doelling, 1972).

The Castlegate Sandstone is overlain by 900 to 1,000 ft (274 to 305 m) of Price River Formation. This formation consists of alternating resistant gray to yellowish-gray sandstone and non-resistant gray to olive-green shale.

The North Horn Formation of Upper Cretaceous and Tertiary age overlies the Price River Formation and consists of variegated shale, sandstone, and subordinate conglomerate and freshwater limestone. Remnants of the base of the Flagstaff Limestone occur on some ridges in the northeast corner of the quadrangle. This formation consists of thin-bedded limestone, variegated shale, and fine- to medium-grained, calcareous, reddish-brown sandstone.

Structure

The coal-bearing strata in the Helper quadrangle have a gentle northward dip of 5 to 6 degrees toward the synclinal axis of the Uinta Basin. Faults are practically non-existent and those that may occur are expected to be of small displacement.

COAL GEOLOGY

Of the eight coal beds, or groups of coal beds within the quadrangle, six are of sufficient thickness to be considered mineable or to have economic importance. The Castlegate "A", Castlegate "B", Castlegate "C", Castlegate "F", Royal Blue and Kenilworth beds are 5 ft (1.5 m) or more thick within the boundary of the quadrangle. However, the Castlegate "C" and Castlegate "F" beds occur in such a limited area where they are of reserve base thickness that only isolated data maps for file purposes were prepared instead of the standard series of maps made for the other coal beds. Also, the areas of reserve base thickness for the Castlegate "C" and Castlegate "F" beds do not underly unleased Fedral coal lands in the KRCRA of the Helper quadrangle and therefore no areal distribution and identified resources maps were made for these beds. The stratigraphic positions of the coal beds within the Blackhawk Formation are shown on the Composite Columnar Section of plate 3.

Intervals reported as "bony coal", "bone", or "shaly coal" in the source references 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.

The coal beds in the Spring Canyon Group, the principal coal-bearing interval in the Standardville quadrangle immediately to the west, thin eastward and disappear in the western part of the Helper quadrangle. Therefore, the lowest coal beds of economic importance are the Castlegate "A" and Castlegate "B". The Castlegate "A" bed rests upon the Aberdeen Sandstone of the Blackhawk Formation. This bed is separated from the overlying Castlegate "B" bed by a noncoal interval about 40 ft (12 m) thick. Above the Castlegate "B", and separated from it by a 25 ft (7.5 m) non-coal interval, is the lenticular Royal Blue coal bed. Perhaps the most important coal bed in the quadrangle is the Kenilworth bed which lies 80 to 128 ft (24 to 39 m) above the Royal Blue. The Castlegate "C" bed occurs between the Royal Blue and the Kenilworth but is below reserve base thickness except in the immediate area of Castle Gate. In the northwest corner of the quadrangle two drill holes encountered a coal bed above the Kenilworth which has been designated the Castlegate "F" bed. Because of limited drilling in the area the lateral extent of the bed is unknown.

Mining Operations

Doelling (1972) has reviewed the coal mining history in the area and reports that the earliest mining in the quadrangle was done in the Castlegate mine beginning in 1889. The coal was used to produce a low-grade coke until 1907 when coal from the Sunnyside area to the east proved to be of superior coking quality. Between 1890 and 1907 1,590,322 short tons (1,442,740 metric tons) of coal were mined from four to five seams in the Castlegate Mine. This coal came from the Castlegate coal group, the Kenilworth and Castlegate "F" beds and was used to produce 720,843 short tons (653,949 metric tons) of coke. In 1901 the Castlegate Mine was the largest mine in the state. Total production to 1969, when the mine became inactive, has been reported variously from 27.4 to 34 million short tons (24.9 to 30.8 million metric tons).

The Kenilworth mine started production in 1906 or 1907. Most of the coal has come from the Castlegate "A" and Kenilworth beds, but some other beds were mined including the Royal Blue. Production is variously reported from 27 to 36.2 million short tons (24.5 to 32.8 million metric tons). By 1970 the Kenilworth mine was the only active mine in the quadrangle. In early 1979 there were no active mines in the quadrangle area. However, the old Utah Fuel No. 1 mine was being used as a haulage tunnel to remove coal from the Braztah mines in the Standardville quadrangle to the west.

The Panther mine was active from 1913 to 1938 and produced coal mainly from the Castlegate "B" seam. About 1.4 million short tons (1.3 m) of coal were removed before the mine was permanently closed. Doelling (1972) estimated that the total coal production from mines in the Helper quadrangle through 1969 was about 65 million short tons (59.0 million metric tons).

Chemical Analyses of the Coal

Doelling (1972) reports that over 300 analyses of coal samples mostly from the Castlegate and Kenilworth mines show that little difference exists between coals from one bed to the next or from one area in the quadrangle to another. Doelling (1972) has averaged these analyses together in the following table.

Table 1. Average proximate analyses of coal, Helper quadrangle.

	No. Analyses	Percent	
		Average	Range
Moisture	312	4.7	2.5-10.4
Volatile matter	306	41.7	25.7-64.3
Fixed carbon	306	47.2	28.3-52.1
Ash	311	6.3	3.8-12.7
Sulfur	295	0.44	0.1- 0.8
Btu/lb	303	12,755	11,840 - 13,370

Based on the ASTM system of classification, the coal mined in the Helper quadrangle is classified as bituminous high-volatile B rank. Trace-element analyses indicate that no abnormally high content of toxic trace elements are present (Doelling, 1972).

Castlegate "A" Coal Bed

The Castlegate "A" bed overlies the prominant Aberdeen Sandstone and is one of the more important coal beds in the western part of the Book Cliffs coal field. However, in the Helper quadrangle it thins eastward and finally pinches out in the adjoining Deadman Canyon quadrangle. As shown on the isopach map (plate 19), in the area of its maximum development near the center of the quadrangle the Castlegate "A" bed consists of a lens which attains a maximum thickness of 19.2 ft (5.8 m). The characteristics of this bed toward the north are not known because of the lack of drilling data along the north side of the quadrangle.

The Castlegate "A" coal is massive, brittle, and bright. It contains some thin shale partings and bands of dull coal, but otherwise shows few or no bedding marks. The bed exhibits prominant jointing and in places contains streaks of resin and sulfur balls (Doelling, 1972).

Castlegate "B" Coal Bed

The Castlegate "B" bed is generally thin in outcrop exposures as shown by the data on the coal isopach map (plate 15). The contours indicate possible thickening of the bed to the north, but the lack of data prevents making any projections in that direction. The maximum measured thickness of 6.8 ft (2.1 m) occurs in the northwest part of the quadrangle, but in most of the measured sections the bed is less than 5 ft (1.5 m) thick. The physical characteristics of the Castlegate "B" coal are similar to those of the "A" bed.

Royal Blue Coal Bed

The Royal Blue coal bed, which is separated from the Castlegate "B" bed by a 25 ft (7.5 m) non-coal interval, is lenticular and is important only in a small area near the town of Kenilworth where it reaches a thickness of 8.8 ft (2.7 m). At all other localities in the quadrangle where measurements have been made it is below reserve base thickness.

Kenilworth Coal Bed

The Kenilworth coal bed is perhaps the most important coal bed in the Helper quadrangle. This bed has been mined nearly from the west side of the quadrangle to the east side where it thins and becomes unworkable. The coal isopack map (plate 4) indicates that the bed generally thicknes northward from its outcrop trace. It attains a thickness of over 20 ft (6.2 m) in a small area near the town of Kenilworth. The lack of drilling data along the north edge of the quadrangle prevents projections of thickness trends in that direction.

The kenilworth coal is brittle and massive, contains no visible bedding planes, and is characterized by bands of dull coal which contain a higher percentage of ash than the brighter coal. It also contains bony and shaly partings and streaks of resin and sulfur (Doelling, 1972).

Castlegate "C" Coal Bed

The Castlegate "C" coal bed is reserve base thickness in a small area in the northwest corner of the quadrangle. The area where the bed is 5 ft (1.5 m) thick or greater, however, do not underlie unleased Federal coal lands. Consequently, an areal distribution and identified resources map of the bed was not prepared.

Castlegate "F" Coal Bed

The Castlegate "F" coal bed has been mined in the northwest part of the Helper quadrangle. Two holes drilled in the northwest corner of the quadrangle encountered this coal bed where it was 6.3 ft (1.9 m) and 9 ft (2.7 m) thick. The bed lies 50 to 90 ft (15 to 27 m) above the Kenilworth and may correlate with other coal beds to the east. No CRO maps were prepared for this coal bed because of insufficient data and the two drill holes referred to above occur on non-Federal coal lands.

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 Clark (1928). Nearly all recent drilling in the area is classified as proprietary information and was not available to the present 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, 11, 15, and 19, 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 coal for each isopached coal bed. Reserve Base and Reserve values for the Kenilworth, Royal Blue, Castlegate "B" and Castlegate "A" beds are shown on plates 7, 14, 18, and 22 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.

The Castlegate "C" bed is reserve base thickness in some parts of the quadrangle, but none of those areas lie within unleased Federal coal land boundaries. Therefore, no reserve base and reserve values were calculated for the Castlegate "C" bed and an areal distribution and identified resources map was not made for that bed.

"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 ½ (0.8 km) to 1½ miles (2.4 km) apart. Indicated coal is projected to extend as a ½-mile (0.8 km) wide belt that lies more than ¼ 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 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 6.9 million short tons (6.3 million metric tons) for the unleased Federal coal lands within the KRCRA boundary in the Helper quadrangle.

Table 2: Coal Reserve Base data for underground mining methods for Federal coal lands (in short tons) in the Helper 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
Kenilworth	1,400,000	-0-	-0-	1,400,000
Royal Blue	100,000	-0-	-0-	100,000
Castlegate "B"	400,000	-0-	-0-	400,000
Castlegate "A"	5,000,000	-0-	-0-	5,000,000
Total	6,900,000	-0-	-0-	6,900,000

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 Underground Mining and In Situ Gasification

The coal development potential for the underground mining of coal is shown on plate 23. In this quadrangle the areas where coal beds 5 ft (1.5 m) or more in thickness are overlain by less than 1000 ft (305 m) of overburden are considered to have a high development potential for underground mining.

Areas where such beds are overlain by 1,000-2,000 ft (305-610 m) and 2,000-3,000 ft (610-914 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. There are no areas of unleased Federal coal land within the KRCRA in the Helper quadrangle that are known to fall within the "moderate", "low", or "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 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.

In the Helper quadrangle approximately 1,025 acres of unleased Federal land in the KRCRA have a high development potential rating and 955 acres have an unkown development potential.

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 200-3,000 ft (61-914 m). Inasmuch as coal beds dip less than 15 degrees in the Helper quadrangle, the in situ coal gasification methods of development potential classification do not apply.

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

Source	Plate 1 Index Number	Data Base: Measured Section No.	Data Base: Plate or Page No.
Clark, F.R., 1928, Economic geology of the Castlegate, Wellington, and Sunnyside quadrangles, Carbon County, Utah: U.S. Geol. Survey Bull. 793.	1	478	pl. 19
	2	480	pl. 19
	3	548	p. 144
	4	481	pl. 19
	5	486, 553 a,b,c,& d	pl. 5
	7	483, 648, and 648 a	pl. 5
	8	552, 552a, 602, 615, and 649	pl. 5
	9	549	pl. 20
	12	550	pl. 20
	16	554	pl. 20
	17	555	pl. 21
	18	603	pl. 21
	19	556 and 603a	pl. 21
	20	557	pl. 20
	21	485	pl. 19
	22	604	pl. 21
	23	487, 558, 616, and 616a	pl. 5
	24	605	pl. 21
	25	560	pl. 21
	26	561	pl. 21
	27	562	p. 150
	28	488, 559, and 606	pl. 5
	29	563	p. 151
	30	564	pl. 21
	31	565	pl. 21
	32	566	pl. 21
	33	567	pl. 21
	34	568	pl. 21
	35	558a	pl. 20
	36	569	pl. 21
	38	607, 617, 652, and 652 a, b, c & d	pl. 5
	39	572	pl. 21
	40	573	pl. 21
	42	574	pl. 21
	43	571a and 575	pl. 5
	44	19710	pl. 21
	45	19682	pl. 21
	46	576	p. 151
	47	577, 609, 610, & 618	pl. 5
	48	578, 611, and 619	pl. 5
	50	580	p. 151
	51	581	p. 151
	52	582	p. 151

Source	Plate 1 Index Number	Data Base: Measured Section No.	Data Base: Plate or Page No.
Clark, F.R., 1928, Economic geology of the Castlegate, Wellington, and Sunnyside quadrangles, Carbon County, Utah: U.S. Geol. Survey Bull. 793.	53	583 and 620	pl. 5
	54	584, 612, and 621	pl. 5
	55	586	p. 152
	56	587 and 622	pl. 5
	57	588	pl. 21
	58	591	pl. 21
	59	592	pl. 5
	60	590	pl. 21
	62	589, 613, 623, 655, and 656	pls. 5 and 21
	63	593	pl. 21
	64	594	pl. 21
	65	595 and 595a	pl. 5
	66	596 and 624	pl. 5
	67	599, 599a, 627, 627a, and 657	pl. 5
	68	598, 598a, and 626	pl. 5
	69	597 and 625	pl. 5
Doelling, H.H., 1972, Book Cliffs coal field, in Doelling, H.H., Central Utah coal fields: Utah Geol. and Min. Survey Mon. Ser. no. 3.	6	149b	p. 359
	10	38	p. 357
	11	13	p. 356
	13	11, 36, 44, 80, and 143	p. 356-358
	14	12, 37, 45, 81, and 144	p. 356-358
	15	14 and 63	p. 356 and 357
	37	108	p. 358
	41	76	p. 357
	49	117	p. 358
	61	30	p. 357

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