UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE FLAGSTAFF PEAK QUADRANGLE SANPETE, EMERY, AND SEVIER COUNTIES, UTAH

(Report includes 16 plates)

By

AAA Engineering And Drafting, Inc.

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 (15 plates) and the Coal Development Potential (CDP) Map (1 plate) of the Flagstaff Peak quadrangle, Sanpete, Emery, and Sevier Counties, Utah (U.S. Geological Survey Open-File Report 79-1007).

Published and unpublished public information were used as data sources for this study.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 Flagstaff Peak 7½-minute quadrangle is located in the south central part of the Wasatch Plateau coal field in central Utah. The quadrangle covers parts of Sanpete, Emery, and Sevier Counties. The city of Manti, the county seat of Sanpete County is 17 miles (27 km) northwest of the quadrangle. The city of Castle Dale is the county seat of Emery County and lies 14 miles (22.5 km) northeast of the quadrangle. The city of Richfield, the county seat of Sevier County, is 38 miles (61 km) west and 16 miles (26 km) south of Flagstaff Peak quadrangle. The town of Ferron is 6 miles (10 km) east and the town of Emery is 5 miles (8 km) south of the quadrangle.

Accessibility

Flagstaff Peak quadrangle is in a rugged, mountainous area and no paved roads cross the quadrangle. A light-duty graveled road connects the town of Ferron on the east side of the Wasatch Plateau with the town of Mayfield on the west side. In a direct line the two towns are 29 miles (47 km) apart, but the road distance is approximately 46 miles (74 km). This graveled road crosses the northeast corner of the quadrangle in Ferron Canyon and then cuts back into the quadrangle for several miles on the north central side.

Muddy Creek Canyon crosses the south half of the quadrangle diagonally from northwest to southeast. An unimproved dirt road and jeep trail go up the canyon to the Ricci mine. Other dirt roads and jeep trails traverse the upland area of the central, north central, and east central parts of the quadrangle.

Utah Highway 10 passes through the cities and towns along the east side of the Wasatch Plateau including Ferron which is 6 miles (10 km) east of Flagstaff Peak quadrangle. U.S. Highway 89 runs north and south along the west side of the Wasatch Plateau. The nearest railroad is a branch line of the Denver and Rio Grande Western Railroad that parallels U.S. Highway 89. In a direct line the railroad is 19 miles (31 km) west of the quadrangle and passes through or near most of the towns on the west side of the plateau.

Physiography

The Wasatch Plateau is a high and deeply dissected tableland. The eastern margin forms a sweeping stretch of barren sandstone cliffs some 80 miles (129 km) long. The strata have gentle dips generally less than 10 degrees and erosion has produced ledges and cliffs along the plateau front and on steep-walled re-entrant canyons.

Flagstaff Peak quadrangle lies near the east side of the Wasatch Plateau, but is not far enough east to include the steep mountain front along the eastern edge of the plateau. The quadrangle area is mountainous with the deeply entrenched canyons cut by Muddy Creek, Birch Creek, and Ferron Creek. The high peaks on Ferron Mountain as well as Flagstaff Peak attain elevations well over 10,000 ft (3,048 m) above sea level. The highest peak on Ferron Mountain in the northwest quarter of the quadrangle reaches an elevation of 10,573 ft (3,223 m). The lowest elevation in the quadrangle is 6,430 ft (1,960 m) in the northeast corner where Ferron Creek leaves the quadrangle. The total relief is approximately 4,140 ft (1,262 m).

A drainage divide formed by Ferron Mountain and the long ridge continuing to the southeast including Flagstaff Peak separates the drainage system of Ferron Creek to the northeast and the Muddy Creek drainage to the southwest. Ferron Creek flows eastward into the San Rafael River and Muddy Creek flows southeastward into the Dirty Devil River.

Climate

The climate of the Wasatch Plateau varies with altitude from semi-arid in the lowest elevations to alpine in the highest. The normal annual precipitation in the Flagstaff Peak quadrangle ranges from 11 inches (28 cm) in the lower part of Ferron Canyon that cuts through the northeast corner of the quadrangle to 28 inches (71 cm) on the top of Ferron Mountain in the northwest corner of the quadrangle (U.S. Department of Commerce (1964)). Much of the precipitation falls as snow during the winter months. Late summer cloudburst storms may cause flash floods in the steep, narrow canyons and washes.

Temperatures in the high areas of the quadrangle range from a summertime high of approximately 85 degrees F (29 degrees C) to a minimum wintertime low of -30 degrees F (-34 degrees C). The temperature extremes at the lowest elevations in Ferron Canyon and Muddy Creek Canyon are approximately 10 to 15 degrees F (5.6 to 8.3 degrees C) higher than those in the upper altitudes of the quadrangle.

Land Status

The quadrangle lies in the south central part of the Wasatch Plateau Known Recoverable Coal Resource Area (KRCRA). Approximately 25,100 acres in the quadrangle lie within the KRCRA. All the KRCRA lands in the quadrangle were unleased Federal coal lands at the time the data was obtained for this report (see plate 2).

GENERAL GEOLOGY

Previous Work

Spieker (1931) mapped the geology and coal outcrops of the Wasatch Plateau in detail. The stratigraphy of the area has also been described by Spieker and Reeside (1925), Katich (1954), and Hayes and others (1977). In 1972 Doelling summarized the geology and assembled the available coal data for the coal field.

The Flagstaff Peak quadrangle was more recently mapped by Sanchez and Hayes (1977) and detailed measurements and descriptions of closely spaced stratigraphic sections of the upper part of the Star Point Sandstone and the lower part of the Blackhawk Formation were made by Marley and Flores (1977). Marley, Flores, and Carovac (1978) presented in preliminary form some lithogenetic variations in the Blackhawk Formation and the Star Point Sandstone in the Wasatch Plateau. A detailed description of the stratigraphic variations in these two formations has been presented by Marley (1978).

Stratigraphy

The coal beds of economic importance in the Wasatch Plateau coal field are Upper Cretaceous in age and are confined to the Blackhawk Formation of the Mesaverde Group. The Mesaverde includes the following four formations in ascending order: the Star Point Sandstone, Blackhawk Formation, Castlegate Sandstone, and the Price River Formation. The Upper Cretaceous Mancos Shale underlies the Mesaverde Group and is exposed in the bottom of the southeastern part of Muddy Creek Canyon.

The Tertiary strata overlying the Mesaverde Group consist of two formations in the quadrangle: the North Horn Formation (Upper Cretaceous and Paleocene) and the Flagstaff Limestone of Paleocene Age.

The oldest unit exposed in the quadrangle is the Masuk Shale Member of the Mancos Shale which crops out in Muddy Creek Canyon. The Masuk consists of 900 ft (274 m) of dark gray marine shale which is not fully exposed in the quadrangle.

The Star Point Sandstone crops out in Muddy Creek Canyon and Ferron Canyon. It is from 350 to 450 ft (107 to 137 m) thick (Doelling, 1972) and is composed of very fine- to medium-grained sandstone, with lesser amounts of siltstone and shale (Marley and Flores, 1977).

The Blackhawk Formation is exposed in the walls of the main canyons in the quadrangle and consists of very fine- to medium-grained sandstone, siltstone, shale, coal, and limestone. Sandstone is the dominant rock type. Marley and Flores (1977, p. ii and iii) report that "the Blackhawk Formation interfingers laterally with and locally unconformably overlies the Star Point Sandstone. . . The characteristics of the rock types of the Blackhawk Formation suggest that they represent delta-plain deposits, which grade (seaward) into the underlying delta-front and prodelta deposits of the Star Point Sandstone."

The Castlegate Sandstone is a massive, cliff-forming, yellow to gray sandstone unit 150 to 200 ft (46 to 61 m) thick. The overlying Price River Formation is composed of fine- to medium-grained sandstone with some interbedded shale and ranges from 250 to 700 ft (76 to 213 m) in thickness (Doelling, 1972). The Price River Formation is less resistant to erosion than the Castlegate Sandstone and forms step-like ledges in its outcrop pattern.

The North Horn Formation is Upper Cretaceous and Paleocene in age. It consists of nearly 1,500 ft (457 m) of variegated shale and subordinate conglomerate, sandstone, and limestone. The Flagstaff Limestone overlies the North Horn Formation and forms the cliffs capping Ferron Mountain and Flagstaff Peak. It also occurs in the down-dropped fault block of Sage Flat on the southeast side of the quadrangle. The formation is composed of dominant light-colored resistant limestone with subordinate amounts of interbedded sandstone and shale.

Structure

The most significant structural feature in the Flagstaff Peak quadrangle is the Joes Valley fault zone which is about 2 miles (3.2 km) wide in the northeast corner of the quadrangle. The system is complex and consists of several prominant faults in that part of the quadrangle. The rocks between the east and west bounding faults have mostly collapsed to form a series of grabens and horsts. The Flagstaff Limestone has been displaced 2,000 ft (610 m) (Doelling, 1972) against the top of the Blackhawk Formation along the fault that cuts the west side of Sage Flat in Section 33, T. 20 S., R. 6 E.

Strata may be more steeply inclined in the fault blocks than in the unfaulted areas but generally in and outside the fault zone the beds dip less than 5 degrees. The beds in Muddy Creek Canyon have a gentle westward dip.

COAL GEOLOGY

The chief coal beds in the southern part of the Wasatch Plateau coal field occur in the lower section of the Blackhawk Formation. Spieker (1931) described the Hiawatha and Upper Hiawatha beds in the lower of two groups of coal beds, and the Muddy No. 1 and Muddy No. 2 beds in the upper group of coal beds. The Hiawatha bed was recognized as the one immediately above the Star Point Sandstone which was mapped as a continuous ledge-forming unit.

Sanchez and Hayes (1977) mapped the geology of the quadrangle and Marley and Flores (1977) made detailed measurements and descriptions of closely-spaced stratigraphic sections of the upper part of the Star Point Sandstone and the lower part of the Blackhawk Formation. During the course of this work a zone of intertonguing between these two formations was observed at several localities within a 6-mile (10-km)-long and 0.6-mile (1-km)-wide belt extending south-southeastward from the north wall of Muddy Creek Canyon to near the town of Emery. See figure 1. "As a result of this intertonguing, the contact between the two formations is about 20 m (66 ft) higher to the east than it is to the west and the coal-bed correlations of Spieker (1931) must be modified." (Flores and others, 1978).

As a result of the recognition of the intertonguing, a revision of the correlations of the lower Blackhawk Formation coal beds between the two sides of the intertonguing zone was suggested by Flores and others (1978). They point out, for example, that "the upper bed in the abandoned mine of Muddy Canyon and referred to as Muddy No. 2 coal bed by Spieker (1931) is apparently the Hiawatha coal bed . . ." and that "The coal bed mined in the abandoned Link Canyon mine . . . and identified by Doelling (1972) as the Upper Hiawatha coal bed merges laterally eastward into the Star Point Sandstone and must be about 20 m below the stratigraphic position of the Upper Hiawatha coal bed of areas to the east of the zone of intertonguing" (Flores and others, 1978). Generalized cross sections through the zone of intertonguing are shown in figure 2 and the correlated coal beds are listed in table 1.

Table 1. Correlation of coal beds between the east and west sides of the zone of intertonguing, Flagstaff Peak quadrangle, Sanpete, Emery, and Sevier Counties, Utah.

West Side		East Side	
This Report	Spieker (1931) and Doelling (1972)	This Report	Spieker (1931) and Doelling (1972)
Hiawatha "C" Bed "A" Bed	Muddy No. 2 Muddy No. 1 Hiawatha	Slide Hollow Muddy No. 1 Hiawatha	Slide Hollow Muddy No. 1 Hiawatha

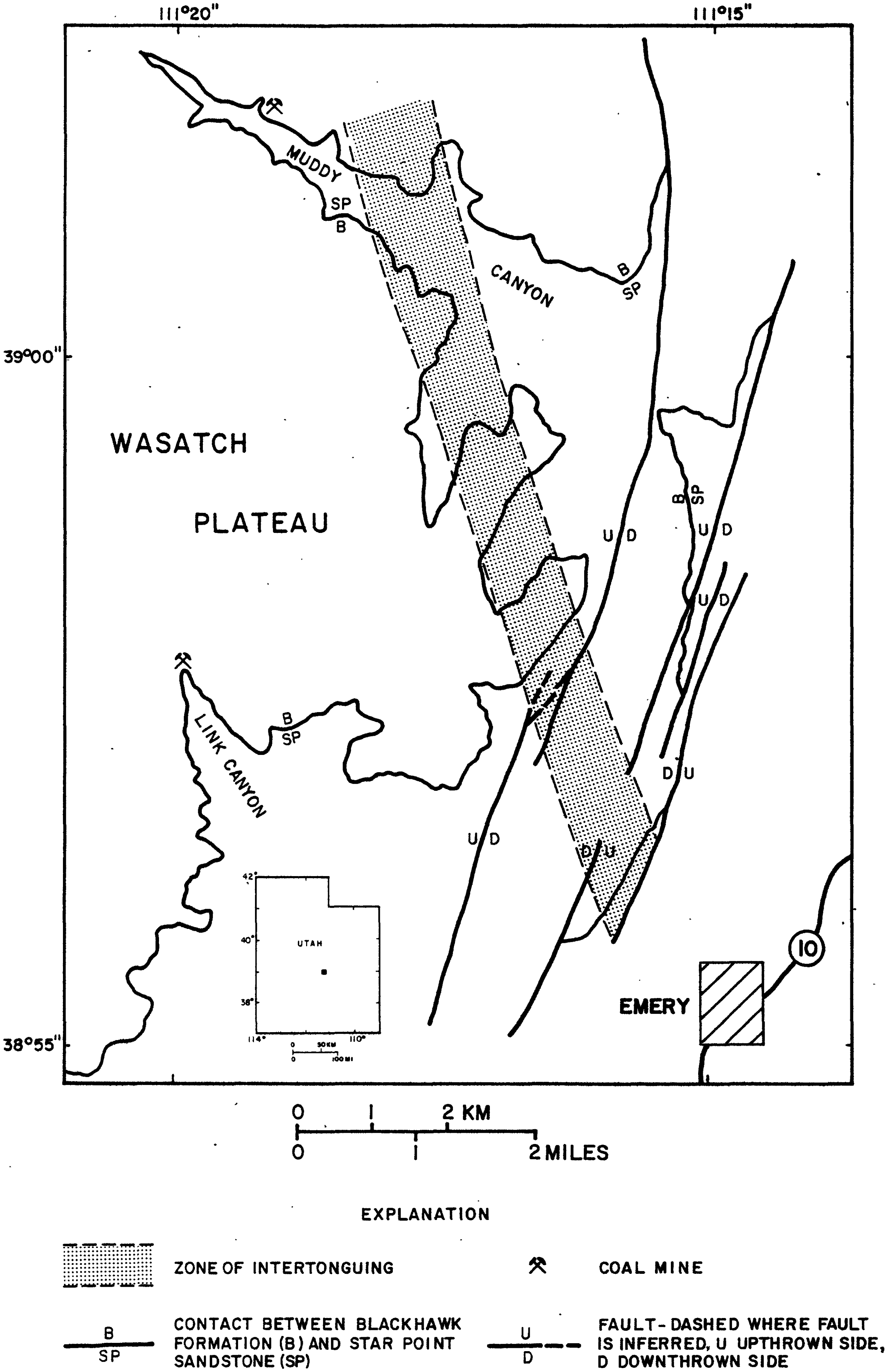

FIGURE 1. Map showing zone of intertonguing (after Flores and others, 1978).

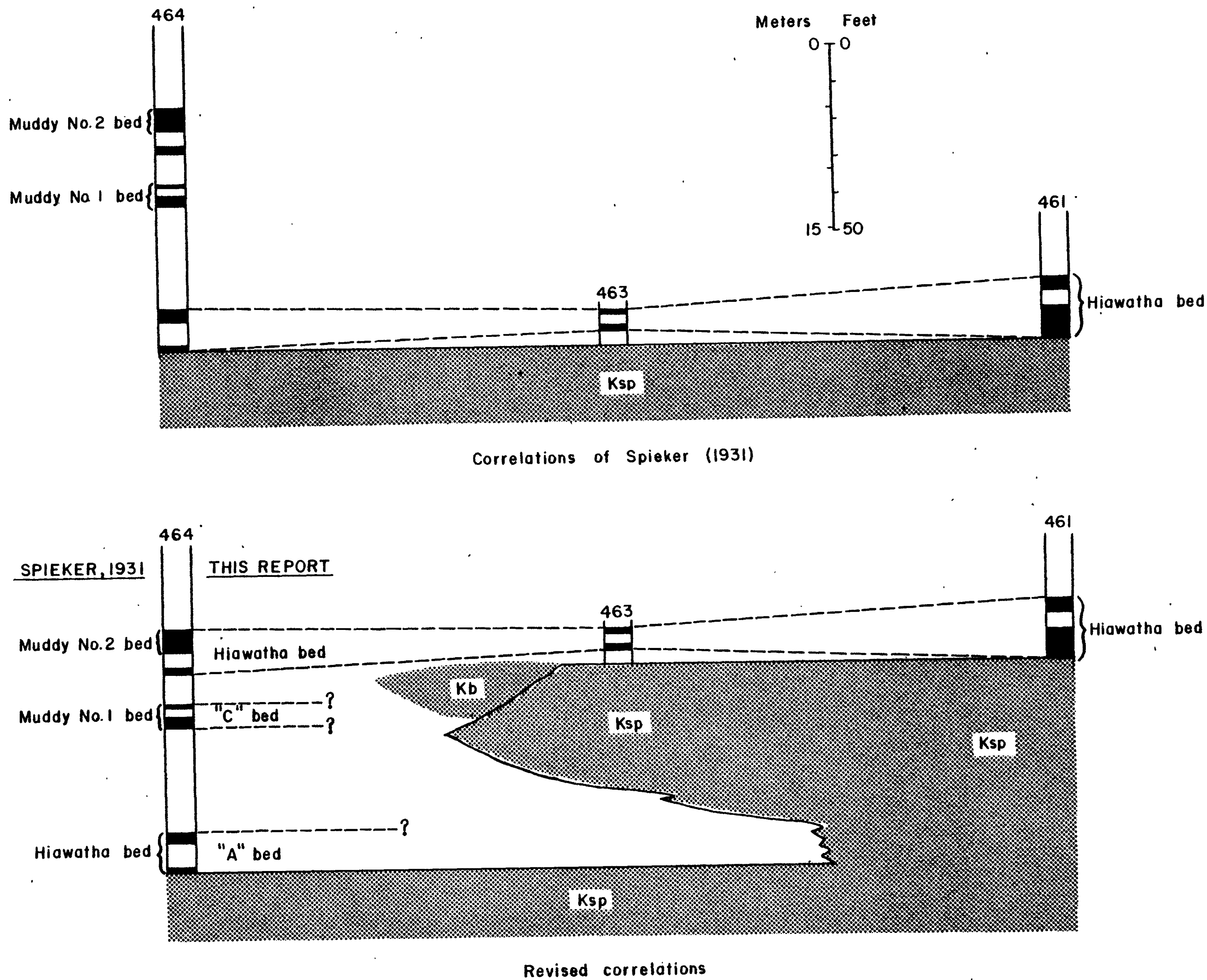

FIGURE 2. Generalized cross sections showing former and revised coal-bed correlations (after Flores and others, 1978).

"A" Coal Bed

The "A" coal bed occurs on the west side of the zone of intertonguing (plate 1) and the name is tentatively used here by the present authors because of the lack of another name. The bed in this area is the one formerly called the "Hiawatha" coal bed by Spieker (1931) and Doelling (1972). Based on findings interpreted by Flores and others (1978) the bed merges laterally into the Star Point Sandstone in the zone of intertonguing and is approximately 65 ft (20 m) stratigraphically below the Hiawatha coal bed on the east side of the zone.

In the Flagstaff Peak quadrangle the "A" bed crops out in the central part of Muddy Canyon and is generally split into two or more thin sub-beds separated by less than 1 to more than 10 ft (0.3 to 3.0 m) of rock. Spieker (1931) has called some of the beds the Upper Hiawatha bed, but because of the closeness of the beds Doelling (1972) includes all the beds together in the Hiawatha. The beds are generally less than 5 ft (1.5 m) in thickness where they have been measured. Two Reserve Base thickness measurements of 5.0 and 5.8 ft (1.5 and 1.8 m) for the main sub-bed may suggest a slight thickening of the bed northward. See coal isopach map, plate 12.

In the Muddy Canyon area Spieker (1931) notes that some of the beds on the north side of Muddy Canyon are burned and no data are available in that area.

"C" Coal Bed

The "C" coal bed generally is split into several thin sub-beds and is roughly from 20 to 30 ft (6 to 9 m) above the "A" bed. In the quadrangle to the south (Emery West) an intermediate bed called the "B" bed (formerly the Upper Hiawatha coal bed of Spieker, 1931) is distinguishable between the "A" and "C" beds in that quadrangle. Like the "A" bed, the "C" coal bed occurs on the west side of the zone of intertonguing (plate 1) and the name of the bed is tentatively used here by the present authors because of the lack of another name. The "C" bed was formerly called the Muddy No. 1 by Spieker (1931) and Doelling (1972). Based on the findings interpreted by Flores and others (1978) this bed also merges laterally into the Star Point Sandstone in the zone of intertonguing.

The "C" bed ranges from 0.6 to 10.0^{+} ft (0.2 to 3.0^{+} m) in thickness in the Muddy Canyon area. The coal isopach map, plate 8, suggests a possible channel-like thickening of the coal bed along a northwest-southeast trending axis (plate 8).

Hiawatha Coal Bed

Based on findings interpreted by Flores and others (1978) the Hiawatha coal bed on the east side of the zone of intertonguing correlates with the coal bed formerly called the Muddy No. 2 coal bed on the west side of the zone by Spieker (1931) and Doelling (1972).

The Hiawatha bed in the Muddy Canyon area is generally less than 5 ft (1.5 m) thick on the west side of the zone of intertonguing except for one small area where the bed thickness ranges from 5.2 to 5.5 ft (1.6 to 1.7 m). See coal isopach map, plate 4. On the east side of the intertonguing zone the bed thickens to 12.6 ft (3.8 m) in Muddy Canyon on the west side of South Sage Flat. The bed appears to thicken northeastward in this area under South Sage Flat.

Muddy No. 1 Coal Bed

The Muddy No. 1 coal bed in the quadrangle occurs 30 to 35 ft (9 to 11 m) above the Hiawatha bed. The Muddy No. 1 was identified by Spieker (1931) in outcrop measured sections at index numbers 31 and 33 in the southeast corner of the quadrangle and at index number 34 in the northeast quarter. The coal bed at these locations is less than 3 ft (1 m) thick and without additional points of measurement in the quadrangle, the thickness trends and depositional pattern of the coal bed cannot be determined.

Slide Hollow Coal Bed

The Slide Hollow coal bed is exposed in the faulted area in the northeast corner of the quadrangle. The bed is about 8 ft (2.4 m) thick and is exposed in three prospect pits and an old mine in the lower part of Slide Hollow on Birch Creek. The proximity of the exposures of the bed to the normal faults has greatly restricted the potentially mineable area of the bed (Spieker, 1931). Because of the limited number of measured points on the bed, an isopach map was not made, but the Reserve Base tonnage was calculated for the area of the bed between the outcrop, the limiting faults, the KRCRA boundary, and a ¼-mile (0.4 km) boundary from the measured points. The Reserve Base tonnage for this bed of 0.9 million short tons (0.8 million metric tons) is listed in table 3 as a non-isopached coal bed.

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 Analysis of the Coal

Only one coal analysis for the Flagstaff Peak quadrangle is available. This one is listed in Doelling (1972, p. 96), and the as-received proximate analysis is shown in table 2.

Table 2. Proximate coal analysis of the "C" coal bed (formerly Muddy No. 1 coal bed of Spieker, 1931) from the Ricci mine in the Flagstaff Peak quadrangle, Sanpete, Emery, and Sevier Counties, Utah.

	As-received (percent)
Moisture	8.4
Volatile matter	39.1
Fixed carbon	45.2
Ash	7.3
Sulfur	0.47
Btu/lb	11,922

Based on the above analysis, the "C" bed coal is ranked on the borderline between high volatile C bituminous and high volatile B bituminous (American

Society of Testing and Materials, 1977). Several proximate analyses of coal samples taken from the Hiawatha coal bed in the quadrangle to the northeast (the Northwest Quarter of the Castle Dale 15-minute quadrangle) show that the Hiawatha coal is high volatile B bituminous in rank (Doelling, 1972).

Mining Operations

Two known mines have been opened in the quadrangle. The Ricci mine also known as the Muddy Creek mine is located near the mouth of Last Water Canyon on the north side of Muddy Canyon. Doelling (1972, p. 179) reports that the mine "has two mineable seams, the Muddy No. 1 and No. 2. The lower is at least 12 feet thick and the upper 4 feet thick with 12 to 18 feet between them." However, information from the U.S. Geological Survey inactive lease file of the mine reports a 10.0^{+} ft (3.0^{+}m) thickness for Muddy No. 1 bed that was mined and no mention was made of the upper bed. The Muddy No. 1 bed in the mine is now correlated with the "C" bed discussed above. This mine operated from 1941 to 1953 when a mine fire ended the operation after producing a little over 31,000 short tons (28,123 metric tons) of coal.

In the northeast corner of the quadrangle the Slide Hollow mine produced an undetermined quantity of coal from the Slide Hollow coal bed. The exact location of the mine is unknown, but Spieker (1931, p. 175) described it as being "in the little gorge of Birch Creek, part of the large depression known as Slide Hollow." Spieker visited the abandoned mine in 1922 and reported it (p. 175) by saying "The main entry of the mine has been driven about 250 feet S. 20° E. and five rooms have been turned. In the mine the coal dips 9° W., and the strike is about N. 25° W. The entry has been driven approximately on the strike of the rocks. At the end of the entry the roof dips down suddenly, in manner similar to that common in 'wants,' and the coal thins abruptly from 8 feet to 3½ feet. The coal here is friable and powdery, and the upper part of the bed has the appearance of burned coal."

Doelling (1972) estimates that less than 5,000 short tons (4,536 metric tons) of coal were produced from the Slide Hollow mine, and that not more than 40,000 short tons (36,288 metric tons) have been removed from the quadrangle.

COAL RESOURCES

The principal sources of data used in the construction of the coal isopach, structure contour, and the coal-data maps were Doelling (1972) and Spieker (1931).

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, 8, and 12) 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 the isopached coal bed. Reserve Base and Reserve values for the Hiawatha, "C", and "A" beds are shown on plates 7, 11, and 15 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 34.8 million short tons (31.6 million metric tons) for the unleased Federal coal lands within the KRCRA boundary in the Flagstaff Peak quadrangle. These data are shown in table 3.

Table 3. Coal Reserve Base data for subsurface mining methods for Federal coal lands (in short tons) in the Flagstaff Peak quadrangle, Sanpete, Emery, and Sevier Counties, Utah.

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

Coal Bed Name	High development potential	Moderate development potential	Unknown development potential	Total
Hiawatha	20,700,000	800,000	-0-	21,500,000
"C" Bed	8,700,000	1,000,000	-0-	9,700,000
"A" Bed	2,700,000	-0-	-0-	2,700,000
Non-isopached coal bed	-0-	-0-	900,000	900,000
Total	32,100,000	1,800,000	900,000	34,800,000

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 16. 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 coal gasification 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 Flagstaff Peak quadrangle, the criteria for the classification of in situ coal gasification methods of development potential 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.
Spieker, 1931	1	471 a, b, and c	pl. 28
	4	474 a and b	pl. 28
	10	468	pl. 28
	11	467	pl. 28
	12	466	pl. 28
	13	464 a, b, and c	pl. 28
	14	477 and lower part of 476	pl. 28
	15	478 a and b	pl. 28
	26	459	pl. 28
	27	458	pl. 28
	28	457	pl. 28
	29	456	pl. 28
	30	455	pl. 28
	31	453	pl. 28
	32	454	pl. 28
	33	451	pl. 28
	34	421	pl. 25
	35	420	pl. 25
	36	419	pl. 25
	37	418	pl. 25
	38	417	pl. 25
Doelling, 1972	2	41	178
	3	13	178
	9	39	178
	19	34	178
	20	33	178
	24	32	178
	25	30	178
	39	1	178
Marley and Flores, 1977	6	WM-93	191 and 192
	7	WM-92	189 and 190
	8	WM-91	187 and 188
	16	WM-89	184 and 185
	17	WM-88	183
	18	WM-87	181 and 182
	21	WM-86	178 - 180
	22	WM-85	176 and 177
	23	WM-84	173 - 175
USGS Inactive lease file SL-063016	5		

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.

Flores, R. M., and others, 1978, Newly delineated intertonguing between the Star Point Sandstone and the coal-bearing Blackhawk Formation requires revision of some coal-bed correlations in southern part of Wasatch Plateau, Utah: U.S. Geol. Survey unpublished report.

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.

Marley, W. E., III, 1978, Lithostratigraphy of portions of the Upper Cretaceous Blackhawk Formation and Star Point Sandstone in the Wasatch Plateau, Utah: Unpublished M. S. thesis, North Carolina State Univ.

Marley, W. E., III, and Flores, R. M., 1977, Descriptions of stratigraphic sections, Upper Cretaceous Blackhawk Formation and Star Point Sandstone in the Emery West and Flagstaff Peak quadrangles, Utah: U.S. Geol. Survey Open-File Report 77-833.

Marley, W. E., Flores, R. M., and Cavaroc, V. V., 1978, Lithogenetic variations of the Upper Cretaceous Blackhawk Formation and Star Point Sandstone in the Wasatch Plateau, Utah: Geol. Soc. America Abstracts with Programs, Rocky Mountain Sec. 31st Annual Mtg.

Sanchez, J. D., and Hayes, P. T., 1977, Preliminary geologic map of the Flagstaff Peak quadrangle, Emery, Sanpete, and Sevier Counties, Utah: U.S. Geol. Survey Open-File Report 77-823.

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.