Text to Accompany

Open-File Report 80-115

1980

COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE SOUTHWEST QUARTER OF THE MT. ELLEN 15-MINUTE QUADRANGLE, GARFIELD COUNTY, UTAH

[Report includes 16 plates]

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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INTRODUCTION

Purpose

This text is to be used in conjunction with Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) Maps of the Southwest Quarter of the Mt. Ellen 15-minute quadrangle, Garfield County, Utah. These maps and report 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 the Henry Mountains Known Recoverable Coal Resource Areas (KRCRA's), Utah. Consequently, only those geologic features relevant to coal occurrences are described herein.

This investigation was undertaken by Dames & Moore, Salt Lake City, Utah at the request of the U.S. Geological Survey under contract number 14-08-0001-17489. The resource information gathered for this report is in response to the Federal Coal Leasing Amendments Act of 1976 (P.L. 94-377). Published and unpublished public information available through June 1979 was used as the data base for this study. Neither drilling nor field mapping was performed; nor were confidential data used.

Location

The Southwest Quarter of the Mt. Ellen 15-minute quadrangle is located in north-central Garfield County, Utah. Hanksville is about 20 miles (32 km) northeast of the map area's northern border. The area is unpopulated.

Accessibility

A number of unimproved roads and jeep trails braid the map area. Principal access is from the Halls Creek-Sandy Creek road along the Waterpocket Fold eastward, across the map area, to Mt. Ellen. Most roads are tied to this main collector. Winter access is subject to changing snow and wind conditions.

Physiography

Topography in the map area is varied. Gradual northwest sloping plains and incised benchlands in the north contrast with buttes, mesas and narrow steep canyons in the south. Steel Butte, in the central portion of the map area, is flanked by mass-wasting deposits in several places. Tarantula Mesa is the dominant topographic feature to the south. In the east half of the map area, cuestas and hogbacks parallel the regional north-south structural trend.

Elevations in the map area range from a low of 5,360 ft (1,634 m) along Sweetwater Creek in the northwest corner of the map area to a high of 7,520 ft (2,292 m) atop hogbacks along the east quadrangle boundary.

The principal drainage is Sweetwater Creek, flowing north along the west side of the map area. Drainages in a dendritic pattern throughout the map area are tributary to Sweetwater Creek. Stream flow is intermittent, occurring principally during late summer thunderstorms. Water quality reflects seasonal climatic changes. Surface water is often saline due to a high summer evaporation rate.

Climate and Vegetation

Climate in the map area is arid. Average annual precipitation is about 10 inches (25 cm), but yearly amounts vary widely due to the erratic nature of desert rainfall. Most moisture is brought to the area by localized, late summer thundershowers and light winter snows and rains.

Temperatures in the quadrangle range from greater than $100^{\circ}F$ ($38^{\circ}C$) during late summer to less than $0^{\circ}F$ ($-18^{\circ}C$) during the winter. The yearly average for the region is $56^{\circ}F$ ($18^{\circ}C$) (U.S. Bureau of Land Management, 1978). Temperatures tend to drop and precipitation increases with increasing elevation.

Winds commonly blow from the west and southwest. The highest seasonal wind velocities occur in the spring and early summer.

Principal types of vegetation in the area include grass, sagebrush, pinon, juniper, saltbrush and greasewood (U.S. Bureau of Land Management, 1978).

Land Status

The Southwest Quarter of the Mt. Ellen 15-minute quadrangle lies within the central portion of the Henry Mountains Known Recoverable Coal Resource Area. The Federal government owns surface and mineral rights over most of the map area, as shown on plate 2 of the Coal Resource Occurrence Map. State lands make up about 11.2 percent of the map area and 2.4 percent is fee land.

About 43.5 percent of the map area may be considered as coal bearing. No coal leases have been awarded within the area. However, a Preference Right Lease Application (PRLA 6733) is outstanding over sections 11, 14, 23 and 26, T. 31 S., R. 8 E., in the northwest corner of the map area.

GENERAL GEOLOGY

Previous Work

John Wesley Powell, one of the first explorers of the region, named the Henry Mountains in 1869 and made some of the first geologic comments on the area (Gilbert, 1877). G. K. Gilbert (Gilbert 1877) studied the Henry Mountains in 1875 and 1876. His report is considered one of the classics of geological literature. Gregory and Moore (1931) and later Smith and others (1963) and Davidson (1967) reported on parts of the Waterpocket Fold in the region.

The first investigation of coal resources in the Henry Mountains was undertaken by C. B. Hunt, who commenced work on the region in 1935, completed field studies in 1939 and published the results in 1953 as U.S. Geological Survey Professional Paper 228. More recently, Henry Mountains coals were studied in detail by Doelling (1972) of the Utah Geological and Mineralogical Survey and Law (1977) of the U.S. Geological Survey. The results of these later investigations provided most of the data used in this coal resource evaluation. Additional publications which describe geologic features in the region are included in the bibliography.

Stratigraphy

Jurassic sandstones and shales, domed around small Tertiary intrusions, appear in the northeast corner of the map area. Jurassic strata are flanked by the Cretaceous Dakota Sandstone, the oldest known coal bearing unit in the Southwest Quarter of the Mt. Ellen 15-minute quadrangle. Overlying the Dakota Sandstone are the Tununk Shale, Ferron Sandstone, Blue Gate Shale, Emery Sandstone and Masuk Shale members of the Mancos Shale, all of Cretaceous age. A composite columnar section accompanied by lithologic descriptions on CRO plate 3 illustrates the stratigraphic relationships of these units.

The Dakota Sandstone represents a westward transgressive littoral sequence and lies uncomformably atop the Brushy Basin member of the Jurassic Morrison Formation. It consists of sandstone with interbeds of conglomerate, sandy shale, gray shale, clay and minor coal. The formation averages 35 feet (10.7 m) in thickness in the map area. It weathers to form a thin series of ledges and slopes in the northeast corner of the map area.

Conglomerate and crossbedded sandstones which occur at the base of the Dakota Sandstone in the map area may have been derived by reworking of underlying Morrison Formation strata in a fluvial environment (Hunt, Averitt, and Miller, 1953). Interbedded gray shale and clay reflect local marsh and lagoonal environments. A diagnostic 3 to 6 foot (.9 to 1.8 m) thick bed of fossils containing Gryphaea, Exogyra and Inoceramus occurs at the top of the formation. Gryphaea are most abundant and commonly form reefs.

The Mancos Shale lies conformably over the Dakota Sandstone and fills the sedimentary basin in this part of the Henry Mountains. The lowermost, Tununk Shale member of the Mancos Shale is gradational and interfingering with the underlying Dakota Sandstone. It is about 600 ft (183 m) thick in the map area and represents a continuation of the first westward transgression of the Cretaceous sea in which the Dakota Sandstone was deposited (Peterson and Ryder, 1975).

The Tununk Shale member is a gray to black fissile shale with subordinate bentonitic shale and thin medium-grained sandstone interbeds (Doelling, 1972). The sandstones are gray to yellowish-gray and become more abundant toward the top of the member, where it is transitional with the overlying Ferron Sandstone member. The top of the Tununk Shale member is placed beneath the first thick-bedded or massive sandstone ledge in the transition zone. A regressive sequence, partially the result of deltaic progradation, occurs in the upper part of the member (Peterson and Ryder, 1975), and the lowest few feet everwhere contain abundant oysters (Hunt, Averitt, and Miller, 1953). The Tununk Shale member weathers to a bluish-gray, is generally poorly exposed and forms broad benches or alluvial filled valleys (Peterson and Ryder, 1975).

The Ferron Sandstone member of the Mancos Shale, conformably overlying the Tununk Shale member, is a regressive unit composed of littoral and coastal plain facies. A lower, littoral unit is characterized by gray shale and gray to brown, fine-to medium-grained sandstone. The middle portion of the member is a coastal plain deposit of sandstone and minor shale with local, thin coal seams. An upper unit, again possibly of coastal plain origin, is composed of shale, brown, medium-grained sandstone and lenticular coal.

The Ferron Sandstone member averages 150 ft (46 m) thick in this map area. The contact with the overlying Blue Gate Shale member is an erosional unconformity. Detailed correlation of sandstone beds in the Ferron Sandstone member suggests that 50 to 100 ft (15 to 30 m) or more of the top of the member have been removed by erosion at the unconformity in the region (Peterson and Ryder, 1975).

Above the hiatus, the Blue Gate Shale member of the Mancos Shale, like the Tununk Shale member, represents a transgressive period of marine deposition. It is composed of blue-gray, finely laminated shale with thin beds of shaly sandstone and shaly limestone near the top of the unit (Hunt, Averitt, and Miller, 1953). The average thickness of the Blue Gate Shale member in this area is 1,500 ft (457 m). The member weathers to form smooth valleys or broad benches. The lower part is concealed by alluvium in many places, but the upper part is generally well exposed in cliffs that are capped by Emery Sandstone (Peterson and Ryder, 1975). The upper contact between Blue Gate Shale member and the overlying Emery Sandstone member is gradational and interfingering.

The principal coal bearing horizon in the Southwest Quarter of the Mt. Ellen 15-minute quadrangle is the Emery Sandstone member. This member of the Mancos Shale, like the Ferron Sandstone member, represents a regressive period of marine deposition. Above a transition zone of interbedded gray shale and sandstone, the Emery Sandstone member consists of tan to light brown, medium-grained, massive and resistant sandstone. The strata are even bedded to ripple laminated and typically form cliffs. The middle portion of the Emery Sandstone member is composed of gray shale, coal and occasional thin, lenticular sandstone beds. An upper unit consists of tan, medium-grained, massive sandstone with sandy and carbonaceous shale interbeds. The average thickness of the Emery Sandstone member in this map area is 370 ft (113 m). The member forms a broad outcrop zone through the center of the map area.

The Emery Sandstone member is conformably overlain by the Masuk Shale member of the Mancos Shale. The contact between the members occurs in a thick gradational zone and is difficult to place.

The Masuk Shale member is composed of lenticular, sandy, tan shale, carbonaceous shale and thin sandstone. The depositional environment for this member was a sand and mudflat that was subjected to repeated marine flooding. Beach deposits did not accumulate until near the end of the depositional period and are reflected by a gradual increase in littoral sandstone units which are transitional with the overlying Mesa Verde Formation (Hunt, Averitt, and Miller, 1953).

The Masuk Shale member of the Mancos Shale averages 610 ft (186 m) in this area. All exposures of the Masuk Shale member in the area occur as benches and slopes around mesas and buttes. Cliff-forming sandstones of the Mesa Verde Formation overlie Masuk Shales atop mesas and buttes in the southern part of the area.

Structure

The inferred axis of the Henry Mountains structural basin passes north-south through the west margin of the Southwest Quarter of the Mt. Ellen 15-minute quadrangle. Strata to the east across most of the map area are nearly flat-lying. Local apparent dips range around 2 degrees.

In the northeast corner of the map area bedding has been domed upward by emplacement of intrusives around the flanks of Mt. Ellen which lies further east. Dips on disturbed strata average 20 degrees westward but flatten quickly away from intrusive centers.

A few small faults occur in the immediate vicinity of doming, probably a response to forceful intrusion, and, according to offset formational contacts, appear to have suffered substantial movement. They do not, however, affect coal occurrences in the area.

Geologic History

Most pre-Cretaceous Mesozoic rocks in this part of the Colorado Plateau are continental in origin. Permian through Jurassic continental deposition was along coastal plains adjacent to principal seaways. The major types of depositional environments that existed during this period were eolian, intertidal mudflats, lacustrine, fluvial and flood plains (Hunt, Averitt, and Miller, 1953).

The Cretaceous history of the Henry Mountains coal field is similar to that of coal fields in central Utah and throughout the Colorado Plateau in general. The region is one in which classic transgressive and regressive sedimentation provided an environment for coal deposition.

During the early Cretaceous, the Henry Mountains region lay on a lowland plain over which neither subsidence nor uplift were occurring. However, sufficient erosion took place to remove lower Cretaceous strata and plane off the top of the Jurassic Morrison Formation.

Subsidence then resumed in the region and fluvial sand and clay were deposited to form the Dakota Sandstone. Broad flood plains with swamps, lakes and flourishing vegetation also developed. Resulting accumulations of carbonaceous material formed local, thin coal seams in the region.

In the meantime, as subsidence increased, a sea in which the Mancos Shale was to be deposited began its encroachment from the east. The sea eventually covered all the Henry Mountains region and extended westward to the present-day Wasatch Plateau area. The shoreline remained there throughout Mancos Shale deposition, except for two dramatic regressions which deposited the Ferron and Emery Sandstone members. Orogenic pulses to the west supplied clastics for these sandstone members faster than the area could subside (Doelling, 1972). Marine deposition changed to nearshore sand and finally to lagoonal and fluvial sand and shale. Forests flourished, dead vegetation accumulated and, in places, coal was produced. All of the thick coal seams in the Henry Mountains Basin were deposited during these two events.

After deposition of the Mancos Shale the Cretaceous sea retreated permanently eastward. Although sedimentation undoubtedly continued in the Henry Mountains region, continental rather than marine beds were deposited and these were later removed by erosion.

According to Hunt and others (1953) the Henry Mountains structural basin was formed between the close of Cretaceous time and the Eocene epoch. Undisturbed Eocene deposits are found in the basin.

Emplacement of the Henry Mountains intrusives may have occurred anytime after early to mid-Tertiary time. Thereafter the Colorado Plateau began its uplift and erosion instead of deposition dominated. This activity has continued to the present day.

COAL GEOLOGY

Significant coal beds are exposed along Sweetwater Creek in the northwest quarter of the map area and along Emery Sandstone member hogbacks near the eastern quadrangle border. The Ferron Sandstone member and Dakota Sandstone beds are not adequately explored, but the few measured sections, drill hole intercepts and observations available for these beds show contained coals to be very thin. The thickest coal seam in the Ferron Sandstone member was noted as 2 ft (60cm) within section 22, T. 31 S., R. 9 E. (Doelling, 1972). Only 8 inches (20 cm) of coal have been reported in the Dakota Sandstone, within section 23, T. 31 S., R. 9 E.

Although often poorly exposed, burned and highly lenticular, Emery coal seams surrounding Sweetwater Wash in the northwest quarter of the map area maintain a 4.8 ft (1.5 m) average thickness in the larger beds. Thicker beds occur in section 30, T. 31 S., R. 9 E., in the vicinity of the Sweetwater Mine, and in sections 7 and 18, T. 31 S., R. 9 E. around the Dugout Mine.

The principal coal zone near the Sweetwater Mine contains an average 5.6 ft (1.7 m) of coal with .7 ft (21 cm) of rock partings. The largest single seam is 8.1 ft (2.5 m) thick. The average is 6.8 ft (2.1 m) of coal with .3 ft (9 cm) of rock partings around the Dugout Mine (Em-1). The maximum single seam, 8.0 ft (2.4 m) thick, occurs in the southeast corner of section 12, T. 31 S., R. 8 E., roughly 1,000 ft (305 m) northwest of the mine.

The Emery coal zone undoubtedly continues southward from Sweetwater Wash beneath Tarantula Mesa. Drill holes near the south border of T. 31 S. have penetrated coal seams in the Emery Sandstone member. However, the coal beds are thin.

Emery coals in north-south trending hogbacks in the northeast quarter of the map area are thin and highly lensoidal. Single seams locally achieve a thickness of 4 to 5 ft (1.2 to 1.5 m) over short distances, but the average coal bed thickness is 1.8 ft (55 cm). As many as seven thin seams occur in some measured sections.

Throughout the southern half of the map area single Emery coal beds seldom exceed a few feet in thickness and coals are totally absent in some locations.

Chemical Analyses of Emery Coal

Doelling (1972) reported analyses of nine outcrop samples of Emery coal from the map area. Most samples were taken in the vicinity of Sweetwater Creek. Analytical results of these samples are shown in table 1. These values indicate the coal to be subbituminous A in rank (ASTM, 1966).

The U.S. Geological Survey obtained seven Emery coal samples from drill holes scattered over the northern half of the quadrangle ~~(table 1)~~. Analytical results published in EMRIA Report No. 15 are shown in table 1, again showing subbituminous A rank coal (ASTM, 1966).

Table 1 -- Average proximate analyses of coal samples in percent

	Moisture	Volatile Matter	Fixed Carbon	Ash	Sulfur	Btu/lb
1. Outcrop Emery Coal Zone T.32S., R.9E.	10.5	38.2	48.5	10.8	0.8	9,590
2. Outcrop Emery Coal Zone Sec. 36, T.31S., R.8E.	13.5	37.08	43.23	20.28	0.71	9,015
3. Outcrop Emery Coal Zone Sec. 36, T.31S., R.8E.	13.9	39.89	47.97	11.27	0.58	10,204
4. Respect Pit South Creek Emery Coal Zone Sec. 27, T.31S., R.9E	7.4	40.0	51.8	6.1	0.7	11,130
5. Prospect Pit Sweet Water Creek Emery Coal Zone Sec. 30 T.31S., R.9E.	10.1	39.8	50.0	7.0	0.9	10,900
6. Outcrop Sweet Water Creek Emery Coal Zone Composite Sec. 30, T.31S., R.9E	7.70	38.50	40.80	11.50	1.50	12,491
7. Outcrop Sweet Water Creek Same as No. 6, upper 4 ft.	7.40	36.70	44.90	10.00	1.20	12,808
8. Outcrop Sweet Water Creek same as No. 6, 4 to 6 1/2 ft.	5.70	36.70	45.50	10.40	1.70	12,954
9. Outcrop Sweet Water Creek same as No. 6, lower 4 ft.	6.00	37.10	43.00	12.70	1.20	12,607
Average	9.2	38.7	47.7	10.6	0.9	11,300

Doelling (1972)

Table 1 -- Continued

	Moisture	Volatile Matter	Fixed Carbon	Ash	Sulfur	Btu/lb
D189013	13.0	41.1	44.3	15.5	0.8	11,348
D189014	12.1	42.2	47.1	10.1	0.5	12,110
D189015	12.5	40.0	42.7	19.5	0.8	11,097
D189016	12.7	39.8	39.5	24.8	4.0	10,504
D189017	12.5	40.3	45.8	14.6	0.6	11,631
D189018	13.7	41.6	48.7	7.7	0.7	12,086
D189012	11.6	41.6	42.7	17.8	3.3	11,289
Average	12.6	40.9	44.4	15.7	1.5	11,438

U.S. Bureau of Land Management (1978)

COAL RESOURCES

Data from 18 coal test holes and 90 measured surface sections and surface mapping by Doelling (1972) of the Utah Geological and Mineralogical Survey and Law (1979) of the U.S. Geological Survey were used to construct outcrop, isopach and structure contour maps of coal zones and beds in the Southwest Quarter of the Mt. Ellen 15-minute quadrangle, (CRO plates 1 through 13).

Coal resources were calculated using data obtained from the coal isopach maps (CRO plates 4, 8 and 12). The coal-bed acreage (measured by planimeter) multiplied by the average isopached thickness of the coal bed times a conversion factor of 1,770 short tons of coal per acre-foot for subbituminous coal yielded the coal resources in short tons of coal for each isopached coal bed. Reserve Base for the Em-1, Em-2 Em-3 and Em-5 coal beds are shown on CRO plates 7, 11, and 14 and are rounded to the nearest tenth of a million short tons. Only that coal equal to or thicker than the 5.0 ft (1.5 m) minimum advocated in U.S. Geological Survey Bulletin 1450-B is included in the Reserve Base. Thinner beds presently being mined or for which there is evidence that they could be mined commercially at this time are not included in the Reserve Base calculation. Coal Reserve Base for all coal beds thicker than 5.0 ft (1.5 m), as shown on CRO plate 2, totals about 32.39 million short tons. Reserve Base (in short tons) in the various development potential categories for surface and underground mining methods is shown in tables 1 and 2.

Dames & Moore has not made any determination of economic recoverability for any of the coal beds described in this report.

Isolated Data Points

In instances where isolated measurements of coal beds of Reserve Base thickness (greater than 5 feet or 1.5 meters) are encountered, the standard criteria for construction of isopach, structure contour, mining ratio, and overburden isopach maps are not available. The lack of data concerning these beds limits the extent to which they can be reasonably projected in any direction and usually precludes correlations with other, better known, beds. For this reason, the isolated data points are mapped separately and are shown on figures 2 and 3. The isolated points mapped in this quadrangle are listed below.

Source	Location	Coal Bed	Millions Short Tons	Thickness
Doelling (1972)	Section 24 T.31S., R.8E.	Em-3	4.38	7.8 ft (2.4 m)
Law (1979)	Section 25 T.32S., R.8E.	Em-6	3.23	7.5 ft (2.3 m)

53

C 7.8(Em)[3]

POINT OF MEASUREMENT - Showing thickness of coal, in feet. Includes all points of measurement other than drill holes. Index number refers to hole on plate 1 of CRO map. Letters designate name of coal bed as listed below. Bracketed number identifies coal bed named on plates 1 or 3.

Em - Emery coal zone

COAL BED SYMBOL AND NAME - Coal bed identified by bracketed number is not formally named, but is numbered for identification purposes in this quadrangle only.

Em

TRACE OF COAL ZONE OUTCROP - Showing symbol of name of coal zone as listed above. Arrow points toward coal-bearing area. Dashed where inferred.

SL

STRIPPING-LIMIT LINE - Boundary for surface mining (in this quadrangle, the 100-foot-overburden isopach). Arrow points toward area suitable for surface mining.

A

BOUNDARY OF IDENTIFIED RESERVE BASE COAL - Drawn along the coal bed outcrop, an arc (A) drawn 2,640 feet from the nearest point of Reserve Base coal bed measurement, the PRLA boundary (P), the quadrangle boundary (Q), and the non-Federal coal ownership boundary (N). Arrow points toward area of identified Reserve Base coal.

RB

— (Measured)
— (Indicated)
0.77 (Inferred)

IDENTIFIED COAL RESOURCES - Showing totals for Reserve Base (RB), in millions of short tons, for each section or part(s) of section of non-leased Federal coal land, either within or beyond the stripping-limit. Dash indicates no resources in that category.

To convert short tons to metric tons, multiply short tons by 0.9072.

To convert feet to meters, multiply feet by 0.3048.

SCALE - 1:24,000 (1 inch = 2,000 feet)

FIGURE 1. - Explanation for FIGURES 2 and 3.

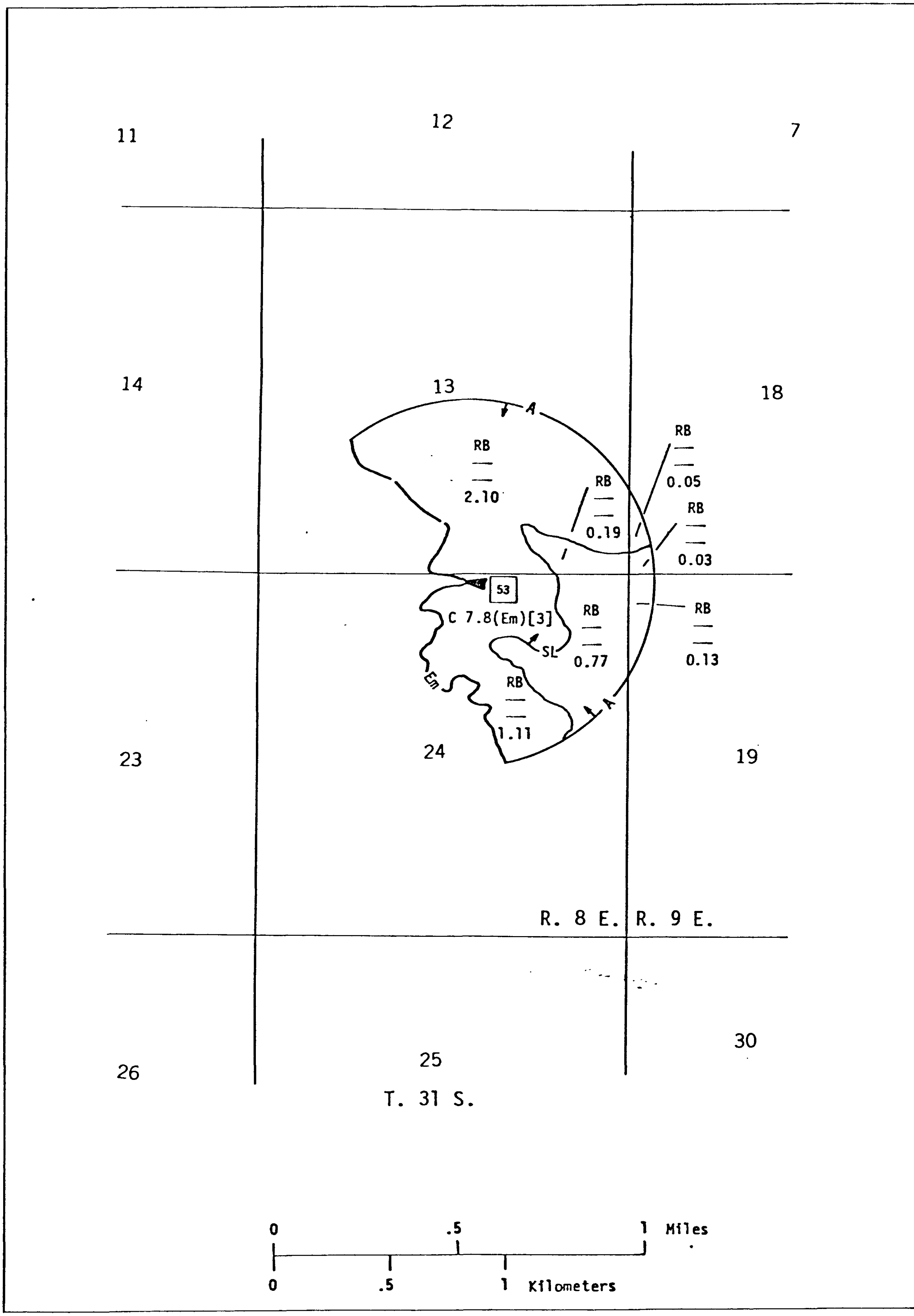

FIGURE 2. - Isolated data point map of the Emery [3] coal bed.

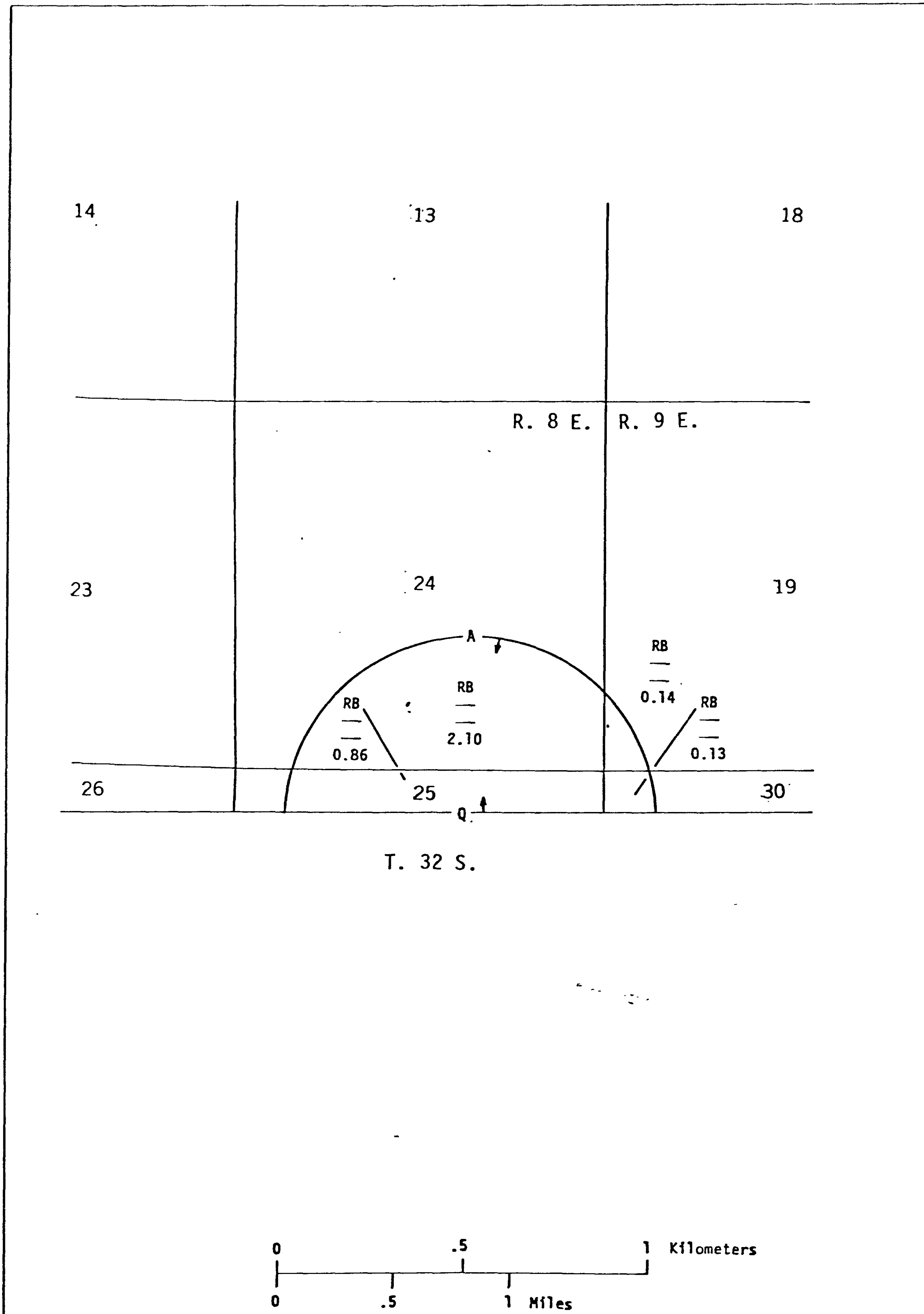

FIGURE 3. - Isolated data point map of the Emery [6] coal bed projected from Northwest Mt. Pennell 15-minute quadrangle.

COAL DEVELOPMENT POTENTIAL

Coal development potential areas are drawn so as to coincide with the boundaries of the smallest legal land subdivisions shown on plate 2. In sections or parts of sections where no land subdivisions have been surveyed by the BLM, approximate 40-acre (16-ha) parcels have been used to show the limits of the high, moderate, or low development potentials. A constraint imposed by the BLM specifies that the highest development potential affecting any part of a 40-acre (16-ha) lot, tract, or parcel be applied to that entire lot, tract, or parcel. For example, if 5 acres (2 ha) within a parcel meet criteria for a high development potential, 25 acres (10 ha) a moderate development potential, and 10 acres (4 ha) a low development potential, then the entire 40 acres (16 ha) are assigned a high development potential.

Development Potential for Surface Mining Methods

Areas where the coal beds of reserve base thickness are overlain by 100 ft (30 m) or less of overburden are considered to have potential for surface mining and were assigned a high, moderate, or low development potential based on the mining ratio (cubic yards of overburden per ton of recoverable coal). The formula used to calculate mining ratios is as follows:

$$MR = \frac{t_o\ (cf)}{t_c\ (rf)}$$

where MR = mining ratio

t_o = thickness of overburden in feet

t_c = thickness of coal in feet

rf = recovery factor (85 percent for this quadrangle)

cf = conversion factor to yield MR value in terms of cubic yards of overburden per short tons of recoverable coal:

0.911 for subbituminous coal

Note: To convert mining ratio to cubic meters of overburden per metric ton of recoverable coal, multiply MR by 0.8428.

Areas of high, moderate, and low development potential for surface mining are here defined as areas underlain by coal beds having respective mining-ratio values of 0 to 10, 10 to 15, and greater than 15, as shown on CRO plates 6, 10 and 13. These mining-ratio values for each development-potential category are based on economic and technological criteria; they are applicable only to this quadrangle and were derived in consultation with J. Moffit, Area Mining Supervisor, U.S. Geological Survey.

Areas where the coal data are absent or extremely limited between the 100-foot (30-m) overburden line and the outcrop are assigned unknown development potentials for surface mining methods. This applies to those areas where no known coal beds 5 feet (1.5 m) or more thick occur or where coal exceeds 5 feet (1.5 m) but data is insufficient to properly evaluate coal development potential. Limited knowledge pertaining to the areal distribution, thickness, depth and attitude of the coal beds prevents accurate evaluation of the development potential in the high, moderate or low categories.

The coal development potential for surface mining methods is shown on plate 15. Of the Federal land areas assigned a development potential for surface mining methods, 74 percent are rated high, 19 percent are rated moderate and 7 percent are rated low.

Development Potential for Subsurface Mining Methods

Areas where the coal beds of Reserve Base thickness lie between 100 and 3,000 feet (30 and 914 m) below the ground surface with dips of 15° or less are considered to have development potential for conventional subsurface mining methods. Coal beds of Reserve Base thickness lying between 100 and 3,000 feet (30 and 914 m) below the ground surface, dipping greater than 15°, are considered to have development potential for in-situ mining methods.

Areas of high, moderate and low development potential for subsurface mining methods are defined as areas underlain by coal beds at depths ranging from 100 to 1,000 feet (30 to 305 m), 1,000 to 2,000 feet (305 to 610 m), and 2,000 to 3,000 feet (610 to 914 m), respectively.

Areas where the coal data are absent or extremely limited between the 100-foot (30 m) overburden line and the outcrop are assigned unknown development potentials for surface mining. This applies to those areas influenced by isolated data points and the areas where no known coal beds of Reserve Base thickness occur. Limited knowledge pertaining to the areal distribution, thickness, deth and attitude of the coals in these areas prevents accurate evaluation of the development potential in the high, moderate or low categories. The area influenced by an isolated data point in this quadrangle contains, approximately 4.38 million short tons (3.97 million metric tons) of coal available for subsurface mining.

The coal development potential for subsurface mining methods is shown on plate 16. All of the Federal land areas assigned a development potential for conventional subsurface mining methods are assigned a high development potential.

Table 2 -- Coal Reserve Base data for surface mining methods for Federal coal lands (in short tons) in the Southwest Quarter of the Mt. Ellen 15-minute quadrangle, Garfield County, Utah

[Development potentials are based on mining ratios (cubic yards of overburden/ton of underlying coal). To convert short tons to metric tons, multiply by 0.9072; to convert mining ratios in yd^3/ton coal to m^3/t, multiply by 0.842]

Coal bed	High development potential (0-10 mining ratio)	Moderate development potential (10 - 15 mining ratio)	Low development potential (>15 mining ratio)	Unknown development potential	Total
Em-5*	-	20,000	50,000	-	70,000
Em-3*	-	-	-	-	-
Em-3	-	-	-	3,260,000	3,260,000
Isolated Data Point					
Em-2	4,380,000	2,830,000	390,000	-	7,600,000
Em-1	1,930,000	1,030,000	650,000	-	3,610,000
Total	6,310,000	3,880,000	1,090,000	3,260,000	14,540,000

* Projected from the Southeast Quarter of the Notom 15-minute quadrangle.

Table 3 -- Coal Reserve Base data for subsurface mining methods for Federal coal lands (in short tons) in the Southwest Quarter of the Mt. Ellen 15-minute quadrangle, Garfield 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	Unknown development potential	Total
Em-6**	-	-	-	3,230,000	3,230,000
Em-5*	380,000	-	-	-	380,000
Em-3	0	-	-	1,120,000	1,120,000
Isolated data point					
Em-2	11,410,000	-	-	-	11,410,000
Em-1	1,710,000	-	-	-	1,710,000
Total	13,500,000	-	-	4,350,000	17,850,000

*Projected from the Southeast Quarter of the Notom 15-minute quadrangle.
**Projected from the Northwest Quarter of the Mt. Pennell 15-minute quadrangle.

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