Text to Accompany

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COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE NORTHEAST QUARTER OF THE WAGON BOX MESA 15-MINUTE QUADRANGLE, GARFIELD COUNTY, UTAH

[Report includes 14 plates]

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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Purpose

This text is to be used in conjunction with Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) Maps of the Northeast Quarter of the Wagon Box Mesa 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 Published and unpublished public information available through June 1979 was used as the data base for this study.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 Northeast Quarter of the Wagon Box Mesa 15-minute quadrangle is located at the southwest corner of the Henry Mountains coal field in east-central Garfield County, Utah. The center of the map area is 36 miles (58 km) southwest of

Hanksville in Wayne County. Boulder, Utah is roughly 30 miles (48 km) by road to the west.

Accessibility

The north edge of the Northeast Quarter of the Wagon Box Mesa 15-minute quadrangle is 18 miles (29 km) south of Utah Highway 24. A well graded road off Highway 24 extends southward to the town of Notom and along the Waterpocket Fold through the center of the area. The southwest quarter of the map area is accessible by unimproved dirt roads reached through Boulder and servicing uranium mines in the Circle Cliffs area. Winter access is limited by snow and wind during some years (Doelling, 1972).

Physiography

The plateau lands of Tarantula Mesa in the northeast and Circle Cliffs in the southwest portions of the map area dominate regional physiography. In these areas, erosion to the top of resistant sedimentary units has formed tablelands dissected into isolated mesas and buttes. Each resistant unit forms a cliff with a soft unit below it which has been mostly stripped by erosion from the next lower resistant unit.

Plateau lands in the area are divided by the Waterpocket Fold. The fold trends south-southeasterly through the center of the map area and marks the western boundary of the Henry Mountains structural basin. Along the fold, strata have been steeply tilted; soft units form strike valleys and resistant ones form ridges.

Higher elevations in the quadrangle occur on reefs along the west side of the Waterpocket Fold. The maximum local elevation is 7,360 ft (2,443 m) atop a reef in the northwest quarter of the map area. Lowest elevations, 5,040 ft (1,536 m), occur along Halls Creek, east of the Waterpocket Fold and within the Henry Mountains structural basin. Total relief is approximately 2,320 ft (707 m) (Doelling, 1972).

Runoff from the map area collects in a well developed dendritic drainage system which discharges to Halls Creek along the Waterpocket Fold. Halls Creek flows southward through Grand Gulch to enter Lake Powell near Bullfrog.

Water quality and stream flow reflect seasonal climatic changes. Most surface water is saline due to high evaporation rates during the summer. Halls Creek is perennial, but tributaries typically dry up in late summer.

Climate and Vegetation

Climate in the Northeast Quarter of the Wagon Box Mesa 15-minute quadrangle is arid. Average annual precipitation ranges around 10 inches (25 cm), but typical of desert regions, fluctuates from year to year. Extended drought periods are common. Most precipitation is in the form of local, late summer thundershowers and light winter snows and rain.

Temperatures in the map area range from more than 100°F (38°C) in the late summer months to less than 0°F (-18°C) in the winter. The yearly average for the region is 56°F (13°C)

(U.S. Bureau of Land Management, 1978). Temperatures decrease and precipitation increases with increasing elevation.

Winds are generally 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 Northeast Quarter of the Wagon Box Mesa 15-minute quadrangle encompasses the southwest central portion of the Henry Mountains Known Recoverable Coal Resource Area, principally coincident with Tarantula Mesa.

Thirty-nine percent of the Northeast Quarter of the Wagon Box Mesa 15-minute quadrangle may be considered coal land. Forty percent of this area is within the Capitol Reef National Park and is National Park Service property. The state of Utah holds about 3.5 percent of the land in the map area.

No outstanding coal leases occur within the map area. However, a Preference Right Lease Application (PRLA U67740), issued to the Cayman Corporation, covers approximately 2,160 acres in the southeastern portion of the map area.

GENERAL GEOLOGY

Previous Work

John Wesley Powell named the Henry Mountains in 1869 and made some of the first comments on the geology of the area (Gilbert, 1877). G. K. Gilbert studied the Henry Mountains during 1875 and 1876. His report (Gilbert, 1877) is considered a classic of geologic literature. Geologic mapping of the quadrangle was completed by Smith and others (1963) as part of their work on the Capitol Reef area for the U.S. Geologic Survey. C. B. Hunt began studying coal in the Henry Mountains in 1935. The results of his effort were published in 1953 as U.S. Geological Survey Professional Paper 228. More recently, coal studies were completed by Doelling (1972) of the Utah Geological and Mineralogical Survey and Law (1977) of the U.S. Geological Survey. The results of these 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

A series of Triassic red beds overlain by Jurassic sandstone with minor shale underlies areas west of the Waterpocket Fold. A few exposures of Permian rocks occur around Circle Cliffs, near the southwest corner of the map area.

The oldest known coal bearing unit in the map area is the Dakota Sandstone which, together with the underlying Brushy Basin member of the Jurassic Morrison Formation, forms a low, discontinuous ridge along the east side of the Waterpocket Fold. Overlying the Dakota Sandstone are the Tununk Shale, Ferron Sandstone, Blue Gate Shale, Emery Sandstone and Masuk Shale, all members of the Cretaceous Mancos Shale. A composite columnar section accompanied by lithologic descriptions on CRO plate 3 illustrates the stratigraphic relationships of these units.

The Dakota Sandstone is a westward trangressive littoral sequence and lies uncomformably atop the Morrison Formation. It consists of coarse sandstone and conglomerate interbedded with yellowish-brown to redish-brown shale, carbonaceous shale and lenticular coal (Doelling, 1972). The formation averages 60 feet (18 m) in thickness and, except for local alluvial cover, exhibits a persistent outcrop through the length of the map area.

Conglomeratic, cross-bedded sandstones which form the base of the Dakota Sandstone may have been derived by reworking of underlying Morrison Formation strata in a fluvial environment. Minor interbeds of carbonaceous shale and coal reflect local marsh and lagoonal environments. A diagnostic bed of fossils containing Gryphaea, Exogyra and Inoceramus occurs either at the top of the formation or in the lowermost beds of the overlying Tununk Shale member (Hunt, Averitt, and Miller, 1953). Gryphaea are most abundant and form a low discontinuous ridge known as Oyster Shell Reef along the Waterpocket Fold (Doelling, 1972).

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 Dakota Sandstone. It is about 970 ft (177 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 dark-bluish to greenish-drab, fissile shale with subordinate thin sandy shale interbeds. Sandy shales 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 (Doelling, 1972). A regressive sequence, partially the result of deltaic progradation, occurs in the upper part of the Tununk Shale member (Peterson and Ryder, 1975). The member is poorly exposed and forms a narrow, alluvial filled valley flanked by more resistant sandstone ridges in over and underlying members.

The Ferron Sandstone member of the Mancos Shale is a regressive unit composed of coastal plain facies. The lower part of the member is characterized by interbedded cliff-forming, tan to brown sandstone and gray to brown shale which is locally carbonaceous. The upper portion is composed of white, light-gray and light-brown, medium-grained, massive sandstone with thin gray to black, carbonaceous shale interbeds (Hunt, Averitt, and Miller, 1953).

Elsewhere in the Henry Mountains basin, notably just to the south, the Ferron Sandstone member has a central coal bearing, carbonaceous shale zone. The coal bearing zone and littoral facies of massive sandstone are absent from the Ferron Sandstone member in this area, where the member is only an average 120 ft (37 m) thick, one-half its usual thickness (Hunt, Averitt, and Miller, 1953).

The Ferron Sandstone member is unconformably overlain by the Blue Gate Shale. The contact between the Ferron Sandstone and the Blue Gate Shale member is sharp. 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 blueish-gray, finely laminated shale with a few thin beds of shaly sandstone and shaly limestone in the upper one-third of the unit (Hunt, Averitt, and Miller, 1953). The member weathers easily to form a broad linear bench east of and paralleling the Waterpocket Fold. The lower part of the member is concealed by alluvium filling a broad, shallow valley along most of the bench.

The average thickness of the Blue Gate Shale member in this quadrangle is 1,105 ft (337 m). The upper contact between the Blue Gate Shale and the overlying Emery Sandstone member is gradational and interfingering.

The Emery Sandstone member of the Mancos Shale, like the Ferron Sandstone member, represents a regressive sequence (Peterson and Ryder, 1975) and is the most important coal bearer in the quadrangle. It can be divided into three units. Above an interbedded shale and sandstone transition zone, the lower most unit, representing littoral deposition, consists of tan thick-bedded, medium-to coarse-grained sandstone with thin gray shale partings. Gypsum seamlets are present in the upper third of the unit. The middle, coal bearing unit consists of interbedded sandstone, tan sandy shale and coal. The upper unit consists of tan to brown medium-grained, massive and resistant sandstone (Doelling, 1972, Hunt, Averitt, and Miller, 1953). The average thickness of the Emery Sandstone member in the quadrangle is 345 ft (105 m). It forms a bench of variable width around the base of Tarantula Mesa in the eastern half of the quadrangle.

The Emery Sandstone member is conformably overlain by the Masuk Shale member. The contact between the members occurs in a thick gradational zone and is difficult to place. All local exposures of Masuk Shale member appear atop or as a bench around Tarantula Mesa in the map area's northeast quarter.

The Masuk Shale member consists of interbedded sandy and carbonaceous shale and light colored, fine-grained massive sandstone. It is generally continental but locally marine in origin, where littoral and lagoonal depositional environments are represented. The Masuk Shale member exhibits an average thickness of 810 ft (247 m) in the map area and is overlain by the Cretaceous Mesa Verde Formation atop Tarantula Mesa (Doelling, 1972).

Structure

Structure in the Northeast Quarter of the Wagon Box Mesa 15-minute quadrangle is dominated by eastward dipping beds along the Waterpocket Fold. This monoclinal feature, running the north-south length of the map area, separates the Henry Mountains structural basin on the east from the Circle Cliffs upward on the west.

Dips up to 40 degrees eastward are not uncommon in beds up to and including the Dakota Sandstone along the Waterpocket Fold. These dips persist westward until the axis of the Circle Cliffs anticline is reached, generally beyond the map area's western boundary (Doelling, 1972).

On the east side of the Waterpocket Fold, dips diminish and inclinations greater than 20 degrees in the Ferron Sandstone member and 10 degrees in the Emery Sandstone member are uncommon (Doelling, 1972).

Strata are nearly horizontal east of the Waterpocket Fold, within the Henry Mountains structural basin and beneath Tarantula Mesa. Slight dip reversals along the east side of Tarantula Mesa, beyond the map area's boundary, place the inferred axis of the Henry Mountains syncline through the center of the mesa, along a north-south trend, in the northeast quarter of the map area (Doelling, 1972).

No faults of consequence have been mapped in the area. A few small offsets are shown by Doelling (1972) in the southwest quarter of the area between the Waterpocket Fold and the Circle Cliffs anticline, but the structures are not described. Topographic expression of the fault traces and the small magnitude of separation along the faults suggest that they are of little importance.

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 a sheet of fluvial sand and clay was deposited to form the Dakota Sandstone. Broad flood plains with swamps and lakes provided an environment in which vegetation flourished. 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 shale 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 Waterpocket Fold and presumably the Henry Mountains structural basin were formed between the close of Cretaceous time and the Eocene epoch. Eocene deposits cover the fold at places in the region.

Emplacement of the Henry Mountains intrusives may have occurred anytime after early to mid-Tertiary. 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 appear in the Emery Sandstone member around the base of Tarantula Mesa and on Swap Mesa in the east half of the map area. The Ferron Sandstone member which bears thick coal elsewhere in the region is only locally coaliferous in the Northeast Quarter of the Wagon Box Messa 15-minute quadrangle; coal seams are poorly exposed and generally less than one foot (30 cm) thick.

The Dakota Sandstone has been only spot checked for coal in the map area; only two measured surface sections are available. Several test trenches across Dakota coal in section 17, T. 33 S., R. 8 E. revealed 7.9 ft (2.4 m) of coal in four seams separated by a total .5 ft (15 cm) of rock partings. About one quarter mile to the north, in section 7 (location 2 of the CRO plate 1) total coal is only 3.8 ft (1.2 m); several coal seams appearing to the south apparently grade into carbonaceous shale northward. Coal in Dakota Sandstone throughout the map area is known to be very lenticular. Additional local thickenings may be expected along the Waterpocket Fold.

Emery coal in the map area has been explored in Divide Canyon and above Bitter Creek around the base of Tarantula Mesa. Multiple seams occur in outcrops in these areas, ranging from 0.1 ft (3 cm) to 6.4 ft (1.95 m) and averaging 2.2 ft (70 cm) in thickness. Splitting rock intervals between multiple beds are often less than one foot thick (30 cm). For example, in the southwest quarter of section 5, T. 33 S., R. 8 E., a section aggregating 9.8 ft (3 m) of coal contains only two thin partings containing .8 ft (24 cm) of rock.

Emery coals continue from outcrops eastward beneath Tarantula Mesa and probably extend beneath Swap Mesa. A single drill hole on Tarantula Mesa, in section 3, T. 33 S., R. 8 E. (location 40 of CRO plate 3, sheet 2) penetrated a number of coal seams in the Emery Sandstone member, the first of which lay 979 ft (298 m) below ground surface and was 13.4 ft (4 m) thick, the maximum found in the quadrangle. Emery coals have been drill tested elsewhere on Tarantula Mesa by private companies and, although specific data are not available, have been described as some of the better coal beds occurring in the Henry Mountains coal field.

Chemical Analyses of Emery Coal

No analyses of Dakota coal are available for the map area, nor from other areas sufficiently close to provide representative results.

Six samples of Emery coal were obtained by the Bureau of Land Management from the Southeast Quarter of the Wagon Box Mesa 15-minute quadrangle, bordering this area on the south, and analyses were published in EMRIA Report No. 15 (1978). The average of these analyses, presented in table 1, shows the coal to be subbituminous A in rank (ASTM, 1966).

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

	Moisture	Volatile Matter	Fixed Carbon	Ash	Sulfur	Btu/lb
D189019	11.5	40.6	46.4	13.8	0.9	11,289
D189020	11.0	41.4	43.2	17.7	0.5	11,019
D189021	9.5	39.4	40.2	25.8	2.4	10,264
D189022	11.6	41.4	48.3	9.7	0.7	12,002
D189023	10.3	42.0	42.3	18.4	0.8	10,947
D189024	10.9	42.8	47.5	9.0	1.1	12,086
Average	10.8	41.3	44.7	15.7	1.1	11,268

U.S Bureau of Land Management (1978).

COAL RESOURCES

Data from one U.S. Geological Survey coal test hole and 39 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 map area, (CRO plates 1 through 11).

Coal resources were calculated using data obtained from the coal isopach maps (CRO plates 4, 7 and 10). 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 yields the coal resources in short tons of coal for each isopached coal bed. Reserve Base for the Em-1 through Em-5 coal beds are shown on CRO plates 6, 9 and 12 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. Reserve Base for all coal beds thicker than 5.0 ft (1.5 m), as shown on CRO plate 2, totals about 20.2 million short tons. Reserve Base (in short tons) in the various development-potential categories for surface and underground mining methods are shown in tables 2 and 3.

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 or greater 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 coal beds limits the extent to which they can be reasonably projected in any direction and usually precludes correlations with other, better known coal beds. For this reason, isolated data points are mapped separately. The isolated points mapped in this quadrangle are listed below and are illustrated on figures 2 through 5.

Source	Location	Coal Bed	Millions Short Tons	Thickness
DOELLING (1979)	Section 32 T.32S., R.8E.	Em-3	0.08	5.0 ft (1.5 m)
DOELLING (1972)	Section 5 T.33S., R.8E.	Em-6	4.38	9.8 ft (3 m)
LAW (1979)	Section 3 T.33S., R.8E.	Em-7	11.46	13.4 ft (4.1 m)
DOELLING (1979)	Section 17 T.33S., R.8E.	Dak-1	2.64	7.9 ft (2.4 m)

C 13.4(Em)[7]

DRILL HOLE - Showing thickness of coal, in feet. 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.

C 5.0(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
Dak - Dakota coal zone

COAL BED SYMBOLS AND NAMES - Coal beds identified by bracketed numbers are not formally named, but are 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)
0.06 (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 through 5

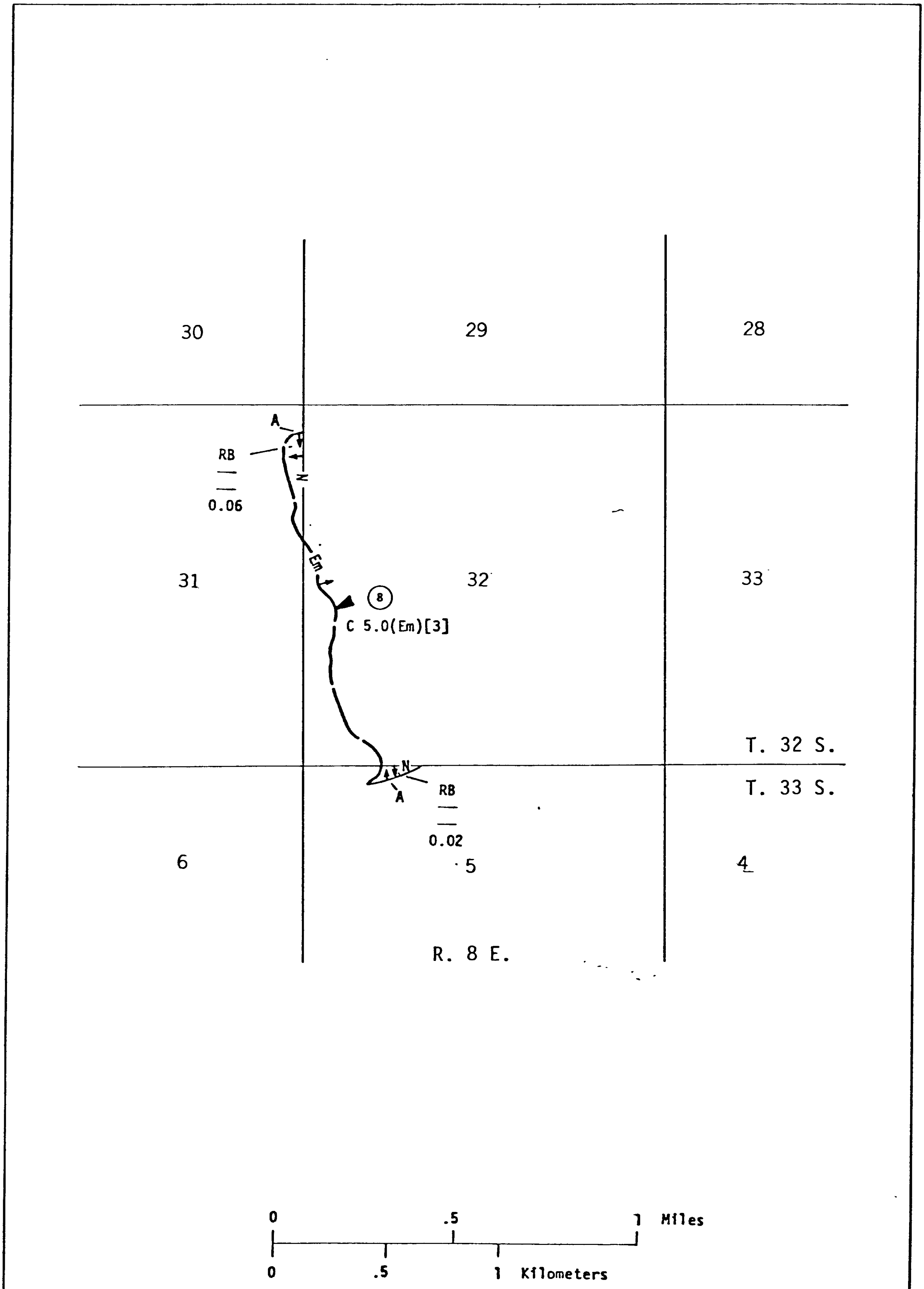

FIGURE 2. - Isolated data point map of the Emery [3] coal bed.

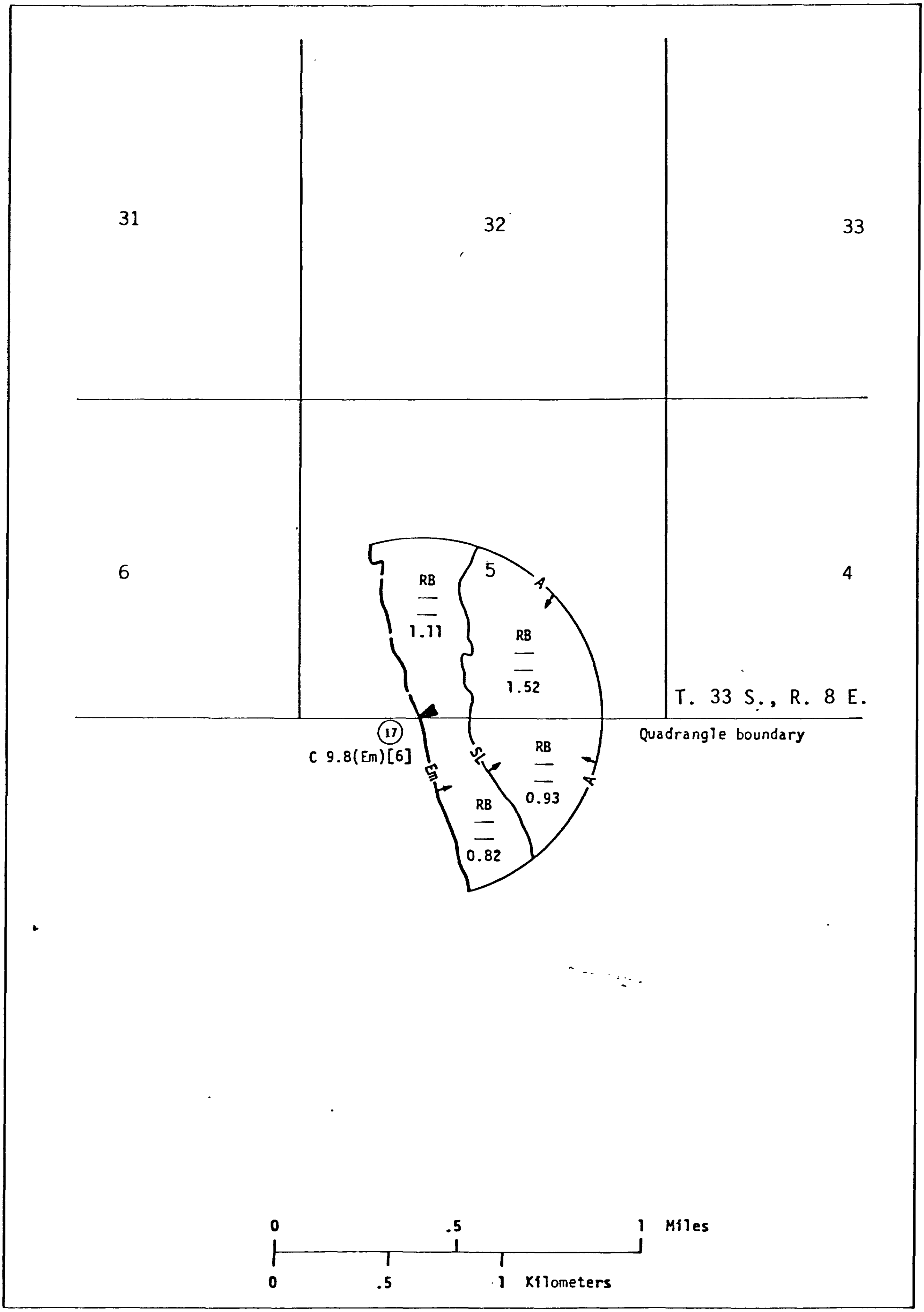

FIGURE 3. - Isolated data point map of the Emery [6] coal bed.

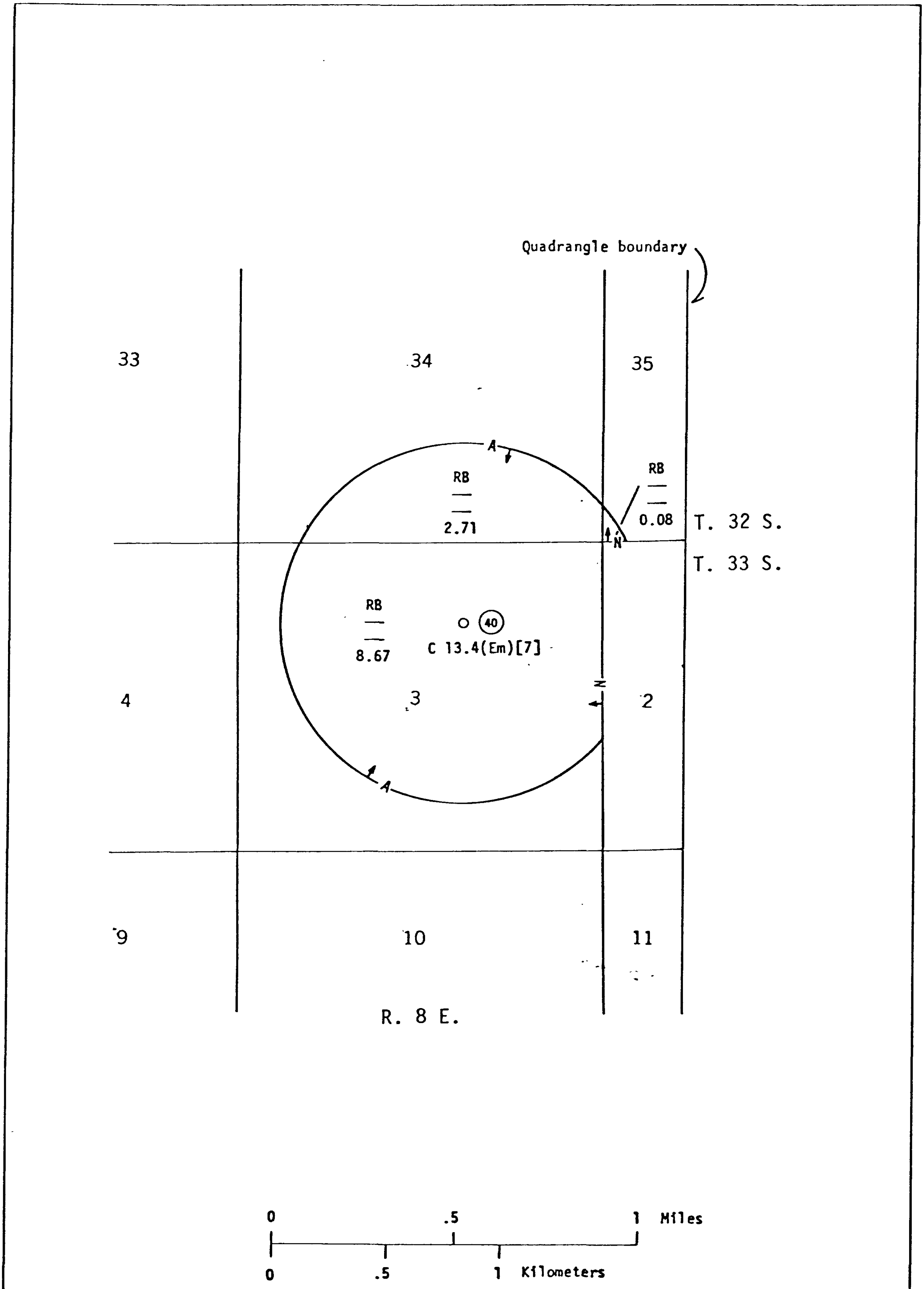

FIGURE 4. - Isolated data point map of the Emery [7] coal bed.

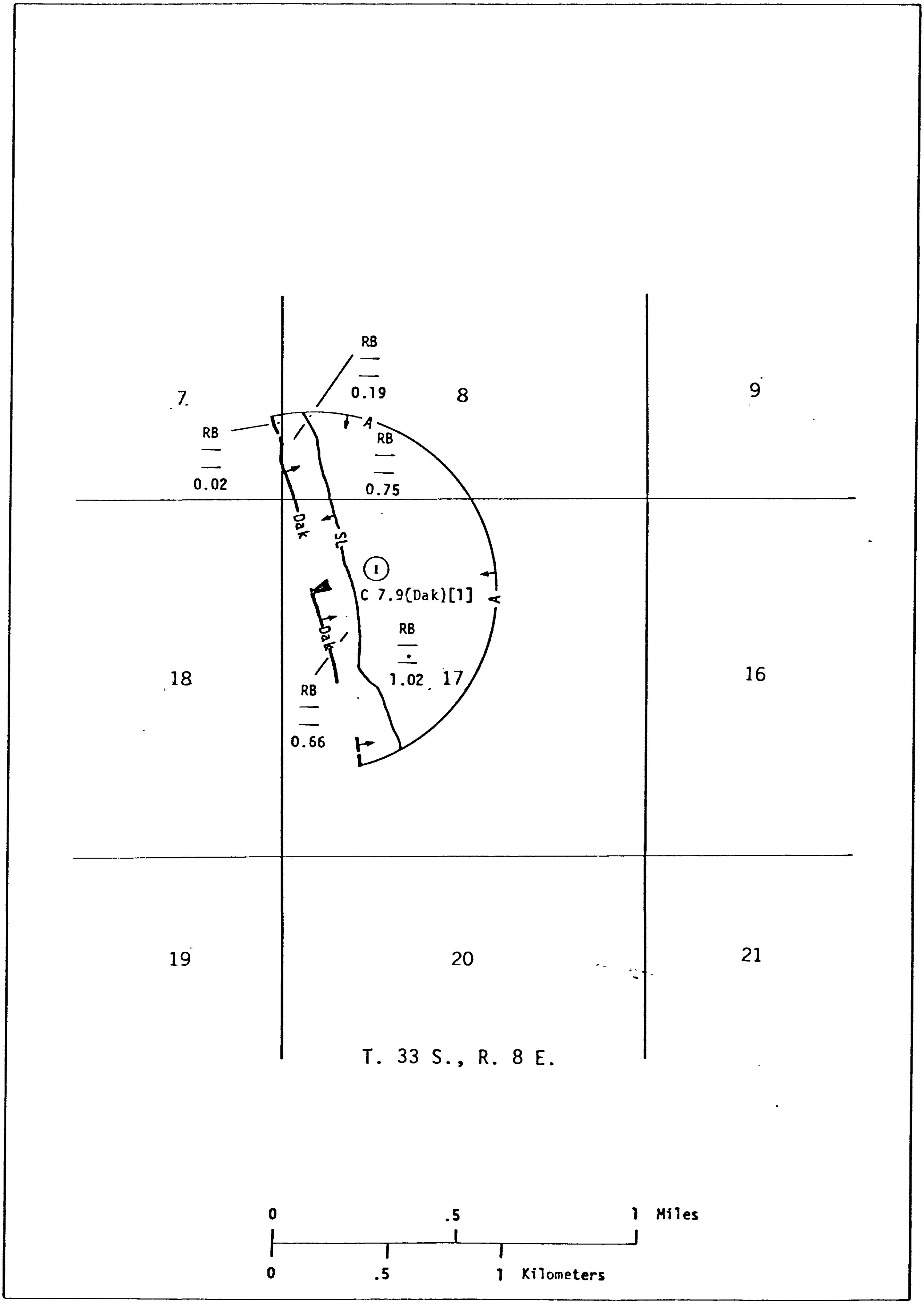

FIGURE 5. - Isolated data point map of the Dakota [1] coal bed.

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 development 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 ton 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 methods are defined as areas underlain by coal beds having respective mining ratio values of 0 to 10, 10 to 15, and greater than 15. 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 13. Of the Federal land areas assigned a development potential for surface mining methods, 10 percent are rated high, 6 percent are rated moderate, 8 percent are rated low and 76 percent are rated unknown. The remaining Federal lands within the KRCRA boundary are classified as having unknown development potential for surface mining methods.

Development Potential for Subsurface Mining Methods

Areas considered to have a development potential for conventional subsurface mining methods include those areas where the coal beds of Reserve Base thickness are between 100 and 3,000 feet (30 and 914 m) below the ground surface and have dips of 15° or less. Coal beds lying between 100 and 3,000 feet (30 and 914 m) below the ground surface, dipping greater than 15°, are considered to have a 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 100 and 3,000 feet (30 and 914 m) below the ground surface are assigned unknown development potentials. Even though these areas may contain coal thicker than 5 feet (1.5 m), 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 areas influenced by isolated data points in this quadrangle contain approximately 15.68 million short tons 14.22 million metric tons of coal which may be available for subsurface mining.

The coal development potential for conventional subsurface mining methods is shown on plate 14. Of those Federal land areas having known development potential for conventional subsurface mining methods, 100 percent are rated high. The remaining Federal lands within the KRCRA boundary are classified as having unknown development potential for subsurface mining methods.

Table 2 -- Coal Reserve Base data for surface mining mehtods for Federal coal lands (in short tons) in the Northeast Quarter of the Wagon Box Mesa 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-1	100,000	90,000	140,000	---	330,000
Em-2	170,000	150,000	160,000	---	480,000
Em-3	---	---	---	80,000	80,000
Em-4	100,000	---	---	---	100,000
Em-5	---	---	---	---	---
Em-6	---	---	---	1,930,000	1,930,000
Em-7	---	---	---	---	---
Dak-1	---	---	---	870,000	870,000
Total	370,000	240,000	300,000	2,880,000	3,790,000

Table 3 -- Coal Reserve Base data for subsurface mining methods for Federal coal lands (in short tons) in the Northeast Quarter of the Wagon Box Mesa 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-1	540,000	---	---	---	540,000
Em-2	160,000	---	---	---	160,000
Em-3	---	---	---	---	---
Em-4	---	---	---	---	---
Em-5	30,000	---	---	---	30,000
Em-6	---	---	---	2,450,000	2,450,000
Em-7	---	---	---	11,460,000	11,460,000
Dak-1	---	---	---	1,770,000	1,770,000
Total	730,000	---	---	15,680,000	16,410,000

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