Text to Accompany

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

[Report includes 3 plates]

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

By

DAMES & MOORE

SALT LAKE CITY, UTAH

CONTENTS

INTRODUCTION

Purpose

This text is to be used in conjunction with Coal Resource Occurrence (CRO) Maps of the Southeast 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 Published and unpublished public information available through June 1979 was used as the data base for this study.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 map area is located in central Garfield County, Utah, in the mountainous east-central part of the Henry Mountains coal field. Hanksville is approximately 17.5 miles (28 km) northeast and Notom is approximately 16 miles (26 km) northwest of the area's northern boundary.

Accessibility

A complex network of unimproved roads provides access through the Southeast Quarter of the Mt. Ellen 15-minute quadrangle. Principal entry is via a dirt road which departs Highway 95 a few miles south of Hanksville and bears southward along the east base of the mountains in the map area. Rugged terrain and difficulty in upkeep restrict the roads' use to 4-wheel drive recreational vehicles. Winter access is limited by snow and wind.

Physiography

The gentle west dip of the Henry Mountains Basin's eastern flank is disrupted by igneous intrusions which form mountains throughout most of the map area. Each is a large structural dome consisting of a stock, around and above which laccoliths and other intrusions are grouped. Sedimentary strata rising onto the mountains are folded and domed near peaks; mountain flanks are fairly smooth.

Mt. Ellen, in the north part of the map area, is both the highest and largest structural dome in the range. Igneous rocks and mass-wasting sedimentary deposits on the flanks of Mt. Ellen cover the northern two-thirds of the area. In the southwest, however, sedimentary rocks dominate and exhibit a low, fairly continuous westward dip. The resulting land form is a monotonous, gently southwest sloping pediment.

Maximum relief is about 5,026 ft (1,532 m). Elevations range from 6,480 ft (1,975 m) in a small canyon in the extreme southwest map area to 11,506 ft (3,507 m) on Mt. Ellen peak.

Drainage on the east side of the mountains is northward to the Dirty Devil River. Runoff from the southwest pediment eventually reaches the Fremont River via Sweetwater Creek. The Fremont River joins with Muddy Creek near Hanksville to form the Dirty Devil River.

Water quality and stream flow in the quadrangle reflect seasonal climatic changes. Most surface water is saline due to high evaporation rates during the summer. Streams at elevations below 8,800 ft (2,682 m) typically dry up in the late summer months.

Climate and Vegetation

The quadrangle's climate is generally arid. However, average annual precipitation varies dramatically with elevation. Mt. Ellen and other high mountains receive about 20 to 30 inches (150 to 175 cm) of precipitation per year. Lower levels receive an average of 16 inches (41 cm) yearly. However, annual precipitation varies widely from year to year due to the erratic nature of desert rainfall. Droughts of three or more years are common. Most moisture comes as localized, late summer thundershowers and light winter snows and rains. Temperatures range from over $100^{\circ}F$ ($38^{\circ}C$) in the late summer months to less than $0^{\circ}F$ ($-18^{\circ}C$) during the winter.

Winds generally blow from the west and southwest. The highest seasonal 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

An isolated, 200 acre tract of the Henry Mountains Known Recoverable Coal Resource Area is located in the west central part of the Southeast Quarter of the Mt. Ellen 15-minute quadrangle. The Federal government owns the coal rights for lands over most of the area, as shown on plate 2 of the Coal Resource Occurrence Maps. The Bureau of Land Management supervises 86.4 percent of the land. The state of Utah owns 11.1 percent and private individuals own 2.5 percent of the property. There are no outstanding Federal coal leases, prospecting permits or licenses in 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 (Gilbert, 1877) on the area. G. K. Gilbert studied Henry Mountains geology from 1875 to 1876. His report (Gilbert, 1877) is considered a classic of geologic literature. The Henry Mountains coal resources were mapped and a thorough geologic study was completed by C. B. Hunt and others in 1939. The results of Hunt's investigation appeared in 1953 as U.S. Geological Survey Professional Paper 228 (Hunt, Averitt, and Miller, 1953). More recently the region's coal deposits were studied 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.

Stratigraphy

Igneous intrusions have domed and irregularly folded sedimentary rocks in the Southeast Quarter of the Mt. Ellen 15-minute quadrangle. Exposures of Tertiary diorite or monzonite prophyry, Quaternary alluvium and landslide and talus debris dominate the area's lithology. Gently dipping Jurassic and Cretaceous strata are present in the west and south, however.

Most exposures of Jurassic rock occur in the northwest quarter of the map area, around intrusive stocks. Represented

Jurassic units include the Carmel Formation, Entrada Sandstone, Curtis Formation, Summerville Formation and Morrison Formation, most of which, except the Morrison Formation, consist of sandstone. The Morrison Formation is composed of sandstone and conglomerate, with mostly clay and shale in its upper parts.

Sedimentary units unconformably overlying the Morrison Formation and related to coal occurrences in the area include the Dakota Sandstone and the Tununk Shale, Ferron Sandstone, Blue Gate Shale and Emery Sandstone 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 is a transgressive littoral deposit and is the oldest coal bearing unit in the Henry Mountains coal field. The formation consists of conglomerate; interbedded yellow to gray, friable sandstone; claystone; and gray, carbonaceous shale. Coal does not occur in the formation in the Southeast Quarter of the Mt. Ellen 15-minute quadrangle.

The Dakota Sandstone is thin throughout the map area, ranging from 14 ft (4.3 m) to 60 ft (18.3 m) where measured. The formation weathers to form a thin series of ledges and slopes at the base of broad slopes developed upon the overlying Tununk Shale member of the Mancos Shale (Peterson and Ryder, 1975).

The Dakota Sandstone is conformably and gradationally overlain by the Tununk Shale member. The transition zone is fossiliferous, with oyster shells, particularly Gryphaea newberri, being abundant (Hunt, Averitt, and Miller, 1953).

The Tununk Shale member is 600 ft (183 m) thick in the area and represents a continuation of a westward transgression of the late Cretaceous sea in which the Dakota Sandstone was deposited. It is a gray marine shale with occasional thin sandstone and bentonitic shale beds in the upper third. Sandstone increases toward the top of the member, where a regressive sequence evidences deltaic progradation (Hunt, Averitt, and Miller, 1953). The Tununk Shale member weathers to a bluish-gray, is generally poorly exposed and forms smooth broad valleys (Peterson and Ryder, 1975). At its upper contact the Tununk Shale member grades and intertongues into the Ferron Sandstone member.

The Ferron Sandstone member is the most important coal bearing unit in the map area. It is a littoral and coastal plain deposit reflecting eastward retreat of the late Cretaceous sea. This member of the Mancos Shale can be subdivided into three units. The lower unit is a transitional horizon composed of interbedded gray shale and gray to brown, fine- to medium-grained, thick- to thin-bedded sandstone. The middle unit, a coastal plain deposit, is a thick-bedded, reef-building, yellow to tan sandstone. An upper unit, possibly of coastal plain origin, consists of interbedded gray and carbonaceous shale, medium-grained, yellow to tan sandstone and coal.

The Ferron Sandstone member is 200 ft (61 m) thick in the map area and often forms cliffs or ridges. Its contact with the overlying Blue Gate shale 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 Ferron Sandstone 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, is a transgressive marine sequence. Dark-gray, laminated shale with interbeds of shaly sandstone and shaly limestone typify the unit (Doelling, 1972). The average thickness of the Blue Gate Shale member in the quadrangle is 1,500 ft (457 m). The member weathers easily 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 capped by Emery Sandstone. The Blue Gate Shale's upper contact with the overlying Emery Sandstone is gradational and conformable.

The Emery Sandstone member of the Mancos Shale is present in the southwest corner of the map area. It is, like the Ferron Sandstone member, a regressive sequence representing littoral and coastal plain deposition. The lower part of the member is a massive, cliff-forming, light-tan, medium-grained sandstone. Above this are a series of gray shales. A thin, lenticular coal zone occurs near the top of the gray shale series (Doelling, 1972).

Up to 100 ft (30 m) of tan, medium-grained, massive sandstone containing thin, gray, shale interbeds generally covers the Emery coal zone (Doelling, 1972). However, in several places the upper sandstone beds have been eroded away and coal up to 2 ft (61 cm) thick has been measured in resulting exposures. The Emery Sandstone member is roughly 300 ft (91 m) thick and is the youngest lithified unit in the area.

Structure

The Southeast Quarter of the Mt. Ellen 15-minute quadrangle is on the east flank of the Henry Mountains structural basin. Where not disturbed by igneous intrusion, sedimentary rocks in the area dip gently to the west, toward the basin axis. Dips on benches in the southern part of the map area are about 5 degrees westward.

In the northern part of the map area, intrusive rocks have domed and broken through Jurassic and Cretaceous strata. Generally, older rocks are closest to domes or stocks and younger rocks are further away. However, structural attitudes are often irregular due to the emplacement of dikes, sills and laccoliths. Beds near the stocks may be vertical to overturned. Elsewhere the inclination of strata ranges from 10 to 30 degrees away from intrusive centers.

Two faults occur in the southwest quarter of the map area. They define a minor graben, are of small displacement and do not appear to offset the Emery coal zone.

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 encountered in the 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 elsewhere 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 during which the Ferron and Emery Sandstone members were deposited. Orogenic pulses to the west supplied clastics for these sandstone members faster than the area could subside. 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 generated 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. 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

Coal has been mapped in the Emery Sandstone and Ferron Sandstone members of the Mancos Shale in the map area. Dakota Sandstone coals which occur elsewhere in the region, notably in Jet Basin in the Northeast Quarter of the Mt. Ellen 15-minute quadrangle, do not appear in this area.

A thin lenticular coal zone occurs near the top and within gray shale beds of the Emery Sandstone member in the southwest corner of the Southeast Quarter of the Mt. Ellen 15-minute quadrangle. A single coal seam measuring 2.0 ft (61 cm) and 2.4 ft (73 cm) at two locations roughly 800 ft (244 m) apart along the zone have been mapped.

Ferron coal crops outs near the southwest corner of the map area. Coal exposures are poor and erosion of the coal bearing zone makes the tracing of individual seams difficult. However, two beds aggregating 5 ft (1.5 m) of coal and containing .3 ft (9 cm) of rock parting located in a prospect pit in section 1, T. 32 S., R. 9 E. have been tentatively correlated with a 1.3 ft (40 cm) thick coal seam in another prospect pit 4,400 ft (1,341 m) to the south. This bed is identified as Fe-1.

Chemical Analyses of Ferron Coal

No analyses of coal from the map area are available. However, several analyses of Ferron Coal from the Southwest Quarter of the Mt. Ellen 15-minute quadrangle, adjoining this quadrangle on the west, were published by Doelling (1972) (table 1). Average analyses show the coal to be subbituminous B rank (ASTM, 1966).

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

	Moisture	Volatile Matter	Fixed Carbon	Ash	Sulfer	Btu/lb
Factory Butte Mine	5.5	33.6	44.9	16.0	2.5	10,840
Ferron Coal Zone	7.5	32.9	44.0	15.6	2.4	10,620
Sec 11, T.27S., R.9E.	--	35.6	47.5	16.9	2.6	11,470
	--	42.8	57.2	--	3.2	13,810
Average	6.5	36.2	48.4	16.2	2.7	11,685

Doelling (1972)

COAL RESOURCES

Data from one U.S. Geological Survey coal test hole and eight measured surface sections and surface mapping by Doelling (1972) of the Utah Geological and Mineralogical Survey were used to construct an outcrop and data map of coal zones in the map area, (CRO plate 1). Measured sections and drill hole intercepts were plotted on correlation diagrams in an attempt to establish continuity between thicker coal beds in the Ferron Sandstone member. Only one such correlation could be supported.

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, U.S. Geological Survey Bulletin 1450-B, 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. For this reason, such occurences are mapped and presented as isolated data points.

Coal resources in this quadrangle were calculated by measuring Federal coal land acreage within a one-half mile radius of the isolated data point in which coal thickness equalled the 5.0 ft (1.5 m) minimum recommended by the U.S. Geological Survey. The coal bed acreage multiplied by the measured section 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 the coal bed. Reserve Base for the Fe-1 coal bed is shown on CRO plate 2 and is rounded to the nearest tenth of a million short tons.

Source	Location	Coal Bed	Millions Short Tons	Thickness
Doelling (1972)	Section 1 T.32S., R.9E.	Fe-1	1.88	5.0 ft (1.5 m)

COAL DEVELOPMENT POTENTIAL

Areas where the coal data are absent or extremely limited are assigned unknown development potentials. 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, depth and attitude of the coals in these areas prevents accurate evaluation of the development potential in the high, moderate or low categories. Therefore, all Federal lands in this quadrangle are regarded as having unknown development potential.

C 5.0(Fe)[1]

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.

Fe - Ferron 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.

Fe

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)
0.02	(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 FIGURE 2.

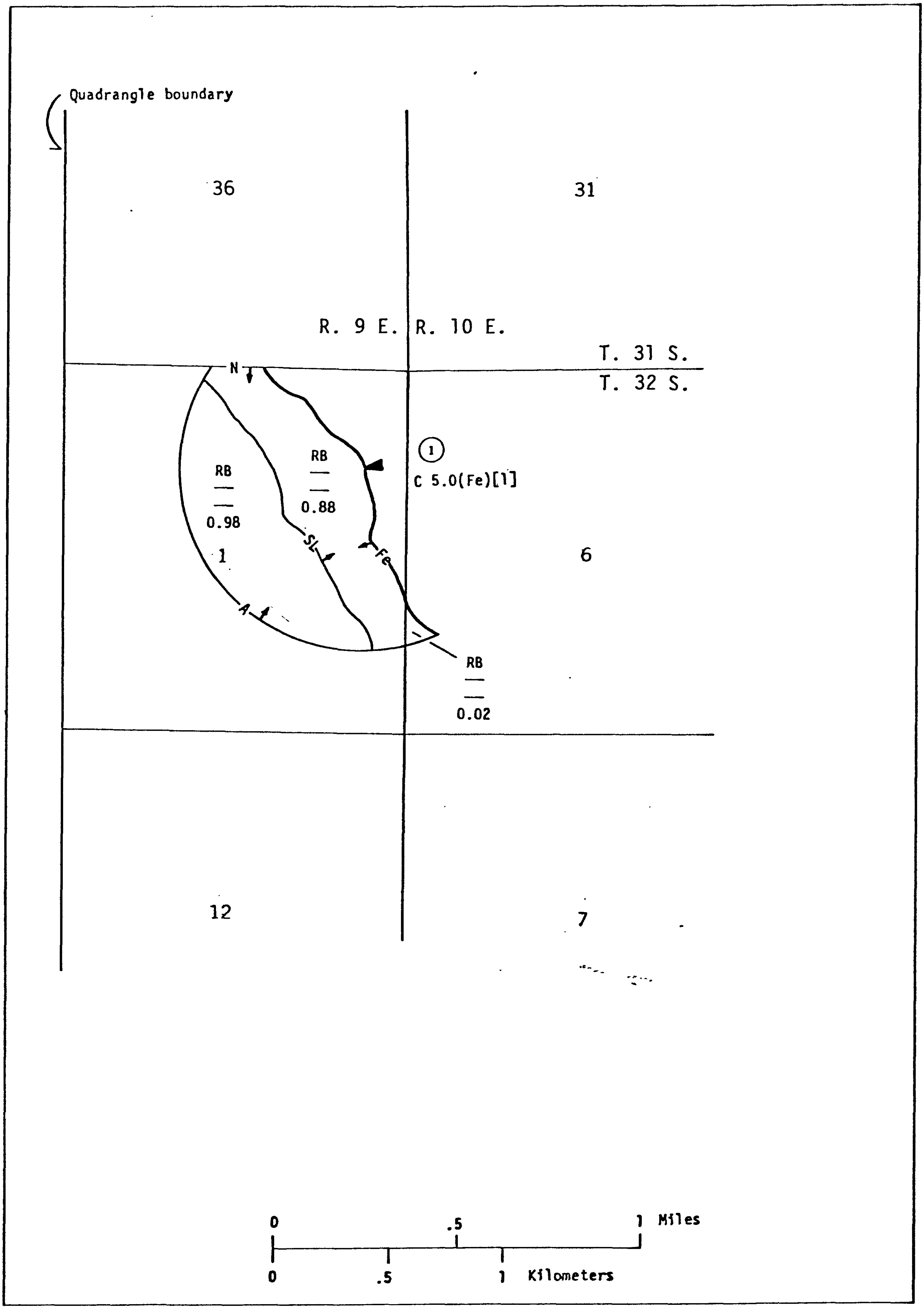

FIGURE 2. - Isolated data point map of the Ferron [1] coal bed.

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