UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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# COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE MELLEN HILL QUADRANGLE RIO BLANCO AND MOFFAT COUNTIES, COLORADO

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CONTENTS

Contents (Cont)



## ILLUSTRATIONS

Plates 1-5 Coal resource occurrence and coal development potential maps:

1. Coal data map
2. Boundary and coal data map
3. Coal data sheet
4. Coal development potential map for surface mining methods
5. Coal development potential map for subsurface mining methods and in situ coal gasification.

## FIGURES

## TABLES

# INTRODUCTION

## Purpose

These maps were compiled to support the land-use planning work of the Bureau of Land Management and to provide a systematic coal resource inventory of Federal coal lands in the Lower White River Known Recoverable Coal Resource Area (KRCRA) in response to the land-use planning requirements of the Federal Coal Leasing Amendments Act of 1976.

Published and unpublished non-proprietary information was used as the data sources for this study. No new drilling or field mapping was done to supplement this study. No confidential or proprietary data were used.

## Location

The Mellen Hill quadrangle is located in Rio Blanco and Moffat Counties in northwestern Colorado. The city of Craig, the county seat of Moffat County, is 74 miles (119 km) northeast of the quadrangle. The city of Meeker, the county seat of Rio Blanco County, is approximately 52 miles (84 km) southeast of the quadrangle and the Colorado-Utah state line is 2.5 miles (4 km) west. The Colorado-Wyoming state line is 52 miles (84 km) north and the city of Vernal, Utah is 32 miles (51 km) northwest of the quadrangle.

## ACCESSIBILITY

Colorado State Highway 64 crosses the south half of the quadrangle in a northwest-southeast direction and connects Rangely to U.S. Highway 40. U.S. Highway 40 runs in an east-west direction across the north side of the quadrangle and provides access to Vernal, Utah and Craig, Colorado. A medium-duty county road crosses into the east-central part of the quadrangle and connects Rangely and U.S. Highway 40. A number of light-duty oil well service roads occur in the southeastern part of the quadrangle in the Rangely oil field. Several unimproved dirt roads and jeep trails provide access to the more rugged areas of the quadrangle.

The nearest railhead is at Craig. This is the western terminus of a branch line of the Denver and Rio Grande Western Railroad connecting to Denver, Colorado. An airport is maintained near the town of Rangely and a landing strip is located in the northwest corner of the Mellen Hill quadrangle.

## PHYSIOGRAPHY

The general topography in the Mellen Hill quadrangle is hilly but not extremely rugged. The relief in the quadrangle is about 1,095 ft (334 m). The high point is approximately 6,365 ft (1,940 m) above sea level on a ridge on the north edge of the quadrangle. The elevation of the low point is about 5,270 ft (1,606 m) where an unnamed stream channel leaves the southeast corner of the quadrangle.

A broad depression called Coal Oil Basin in the south half of the quadrangle is bounded by an escarpment of sandstone beds dipping away from the axis of the Rangely anticline. Resistant rocks also form a series of hogback ridges on the north side of the quadrangle and on the north flank

of the Red Wash syncline. The hogbacks of Raven Ridge in the southwest corner of the quadrangle are resistant beds exposed on the southwest flank of the Rangely anticline.

Nearly all the drainage channels and shallow washes in the quadrangle contain only intermittent streams. The drainages on the east side of the quadrangle flow to the south and east. Those on the west side of the quadrangle flow south and west. All streams in the quadrangle drain into the White River a few miles to the south. The White River flows westward into the State of Utah were it joins the Green River.

## CLIMATE

The Mellen Hill quadrangle has a mid-latitude steppe climate and semi-arid conditions prevail in the area. The normal annual precipitation for the quadrangle is slightly less than 10 inches (25 cm). (U.S. Department of Commerce, (1964)).

The nearest weather data recording station is at Rangely where a record high temperature of 104 degrees F (40 degrees C) and a record low temperature of -37 degrees F (-38 degrees C) were recorded (National Weather Service Forecast Office, 1979, personal communication). The annual mean temperature at Rangely is 45.6$^{o}$ F (7.6 degrees C). The temperatures in the Mellen Hill quadrangle are expected to be a few degrees cooler than at Rangely (elevation, 5,240 ft (1,597 m) because of the higher altitudes in the quadrangle area.

## Land Status

The Mellen Hill quadrangle lies in the north-central part of the Lower White Rive Known Recoverable Coal Resource Area (KRCRA). The KRCRA covers approximately 1,660 acres (672 ha) of the quadrangle. The areas of non-Federal land and the KRCRA boundary are shown on plate 2. A comparison of the area of unleased Federal coal ownership and the non-Federal land in the quadrangle is shown in table 1.

Table 1.--Comparison of Federal and non-Federal land areas in the Mellen Hill quadrangle, Rio Blanco and Moffat Counties, Colorado.

| Category | Approximate Area (Acres)[1] | Percent of Quadrangle Area (%) |
|---|---|---|
| Non-Federal land | 4,050 | 11 |
| Unleased Federal coal ownership | 32,410[2] | 89 |
| Total | 36,460 | 100 |

[1]To convert acres to hectares, multiply acres by 0.4047.
[2]Coal is known to be present in only part of this area.

## Previous Work

Gale (1910) described the coal fields of northwestern Colorado and northeastern Utah including The Lower White River field. Cullins mapped the geology and coal exposures in the Mellen Hill quadrangle, (1969), and also the adjacent Banty Point quadrangle (1968) and Rangely quadrangle (1971).

# GENERAL GEOLOGY

## Stratigraphy

Sedimentary rocks exposed in the Mellen Hill quadrangle range from late Jurassic to Tertiary in age. The Jurassic rocks crop out along the north edge of

the quadrangle and the Tertiary rocks occur in the southwest corner. The rest of the quadrangle is underlain by rocks of Upper Cretaceous age including the following formations in ascending order: Cedar Mountain Formation, Dakota Sandstone, Mancos Shale, tongue of Castlegate Sandstone, Buck Tongue of Mancos Shale, and Mesaverde Group (Cullins, 1969). The important coal beds in the quadrangle occur in the Mesaverde Group which is subdivided into the following units in ascending order: Sego Sandstone, minor coal unit, main coal unit, and upper unit (Cullins, 1969). The Wasatch Formation of Eocene age unconformably overlies the upper unit of the Mesaverde Group. The Wasatch is overlain by the Green River Formation of Eocene age.

The main body and the Buck Tongue of the Mancos Shale consist of brownish-gray, mainly noncalcareous marine shale. The Buck Tongue contains a thin brownish-gray, orange-weathering very fine-grained sandstone and the top 85 ft (26 m) is gypsiferous. The upper part of the tongue of the Castlegate Sandstone is composed of light-gray to gray, fine-grained, massive, limy, porous sandstone.

The Sego Sandstone ranges from 0 to 250 ft (76 m) thick and consists of grayish-tan, brownish-gray, and very light-gray, fine- to very fine-grained sandstone interbedded with brownish-gray shale. Minor local coal beds occur in this member.

The minor coal unit of the Mesaverde Group consists primarily of brown to yellowish-gray, fine- to very fine-grained, limy, sandstone interbedded with gray to light-brownish-gray and brown carbonaceous shale. This unit contains a few thin, lenticular coal beds and is approximately 750 ft (229 m) thick.

The main coal unit of the Mesaverde Group is approximatley 450 ft (137 m) thick and consists of coal and yellowish-gray to dirty-orange, very fine-grained to fine-grained, limy sandstone interbedded with gray and brown carbonaceous shale. The thickest coal beds are found in the lower part of the member.

The upper unit of the Mesaverde Group is approximately 1,100 ft (335 m) thick and is composed of brown to yellowish-gray, fine- to very fine-grained, limy, massive sandstone interbedded with yellowish-gray shale. Some minor coal beds are present in the upper part of this member.

The Wasatch Formation consists of green, grayish-green, purple, and red claystone and shale; and white to ash-gray, fine- to medium-grained sandstone. The Wasatch Formation is approximately 300 ft (91 m) thick.

The Green River Formation is composed of light-greenish-yellow, fine-grained sandstone, very light-gray and grayish-olive-green marlstone, grayish-green shale, and buff to brownish-gray limestone. The Green River Formation is approxiamtely 2,400 ft (732 m) thick.

## Structure

The axis of the Rangley anticline plunges northwestward through the southwest part of the Mellen Hill guadrangle as shown on plate 1. The axis is offset by a northeast-southwest trending normal fault. Cullins (1969) shows the segment of the anticlinal axis on the northwest side of the fault as the crestline at the top of the Castlegate Sandstone and the segment on the southeast side of the fault as the crestline at the top of the Dakota Sandstone. This largely accounts for the offset of the anticlinal axes shown on plate 1. The top of the Castlegate Sandstone is approximately 5,000 ft (1,524 m) above the Dakota Sandstone.

The datum on plate 3 is the base of the most persistant coal bed in the main coal unit mapped by Cullins (1969) and is called the Local 1 coal bed in this report. The vertical positions of isolated coal shown on plate 3 are relative and are not to scale. Because of the highly lenticular nature of coal beds in this quadrangle and the uncertainty of continuity, some of the correlation lines shown between the columns on plate 3 are dashed and many of the beds are uncorrelated. The thinner coal beds of very limited extent are called "local" coal beds. In this quadrangle two coal beds have been correlated over small areas and have been named the Local 1 (L1) and Local 2 (L2) beds (pl. 1 and 3).

Coal 5 ft (1.5 m) or more thick that lies less than 3,000 ft (914 m) below the ground surface is here called Reserve Base coal and is used in calculating Reserve Base tonnages discussed below under Coal Resources.

### Local 1 Coal Bed

The Local 1 coal bed in the main coal unit is 5 ft (1.5 m) or more thick in part of the southwest quarter of the quadrangle. The bed ranges from 2.5 ft (0.8 m) at index number 4 to a maximum thickness of 6.2 ft (1.9 m) at index number 3 (pl. 1). An insufficient data line has been drawn approximately ¼ mile (0.4 m) from known data points because of the sparseness of data and the lenticular nature of the coal beds in this area. The L1 bed possibly correlates with the coal bed called Local 1 in the adjoining Banty Point quadrangle to the south (AAA Engineering and Drafting, Inc., 1980a). It may also correlate with coal bed 1 of the main coal zone in the adjoining Dinosaur quadrangle to the west (AAA Engineering and Drafting, Inc., 1980b).

The Rangely anticline is asymmetric with the steep flank to the southwest, where surface measurements indicate the rocks dip up to 50° (pl. 1). The structure contours shown on figure 2, however, follow those drawn by Cullins (1969) and show dips only up to 39°. The other flank dips gently northeastward at approximately 3° (Cullins, 1969). The Red Wash syncline lies to the north of the Rangely anticline.

The normal fault that passes through the center of the quadrangle in a northeast-southwest direction (pl. 1) apparently has no great displacement and may split into several north-south trending faults on the south side of the quadrangle.

## COAL GEOLOGY

The thickest coal beds in the Mellen Hill quadrangle occur in the main coal unit of the Mesaverde Group in the southwestern part of the quadrangle. The coal beds strike northwest and dip from 20° to 40° southwest. These coal beds are lenticular and are not as thick as equivalent coals farther southeast in the adjoining Banty Point quadrangle. The maximum measured coal thickness in the Mellen Hill quadrangle is 6.2 ft (1.9 m), whereas a coal bed as much as 12 ft (3.7 m) thick was measured in the Banty Point quadrangle (Cullins, 1968). The most persistant coal bed in the Mellen Hill quadrangle is at the base of the main coal unit of the Mesaverde Group. Most coal beds in the main coal unit are thin, highly lenticular, and cannot be correlated for any great distance. The main coal unit ranges in thickness from 410-510 ft (125-155 m) and contains only one known coal bed 5 ft (1.5 m) or more thick. The thicker coal beds of the main coal unit are concentrated near the base of the unit. The minor coal unit of the Mesaverde Group contains thin discontinuous coals no thicker than 2 feet (0.6 m).

## CHEMICAL ANALYSES OF THE COAL

No chemical analyses of coal samples from the Mellen Hill quadrangle are available. However, analyses of coal taken from an 11.9-ft (3.6-m) thick coal bed in the small abandoned J. W. Rector mine in the adjoining Rangely quadrangle were reported by Cullins (1971) and are shown in table 2.

Table 2.--Proximate analyses of coal samples from the J. W. Rector mine, NW¼SE¼ section 14, T. 1 N., R. 102 W., Rangely quadrangle, Rio Blanco County, Colorado (Cullins, 1971)

| Laboratory No. | 5519 | 5520 |
|---|---|---|
| Air drying loss sample received | 3.1 percent | 4.8 percent |
| Chemical analysis, air-dried basis | | |
| Moisture | 8.55 percent | 9.77 percent |
| Volatile matter | 33.40 Do. | 33.43 Do. |
| Fixed carbon | 49.99 Do. | 51.27 Do. |
| Ash | 8.06 Do. | 5.53 Do. |
| Sulfur | 0.46 Do. | 0.40 Do. |
| Heat valve | 11,080 Btu/lb[1] | 11,490 Btu/lb[1] |

[1]To convert Btu/lb to Kj/kg multiply 2.326.

On the basis of these analyses, the coal bed sampled in the J. W. Rector mine is ranked as high-voltile C bituminous coal (American Society for Testing and Materials, 1977). The coal in the Mellen Hill quadrangle is probably of similar quality.

## MINING OPERATIONS

Avaialable information indicates that no coal mining has taken place in the Mellen Hill quadrangle. There are two abandoned, unnamed coal mines in the adjoining Rangely NE quadrangle. One, located in the SE¼NE¼ sec. 16, T. 3 N., R. 102 W., apparently prospected a local coal bed. The other mine is located in the SW¼SE¼ sec. 10, T. 3 N., R. 102 W. on a coal bed that is not correlatable with any bed in the Mellen Hill quadrangle. The periods of operation for these mines are unknown, and no production figures are available.

The abandoned J. W. Rector mine referred to above (table 2) is located in the NW¼SE¼ sec. 14, T. 2 N., R. 102 W. in the adjoining Rangely quadrangle and the mined coal bed is reported to be 11.9 ft (3.6 m) thick (Cullins, 1971). The mine opened in 1898 and produced at least 100 short tons (91 metric tons) of coal. The total production figures for the mine are unknown (Gale, 1910).

## COAL RESOURCES

The principal source of data used in the construction of the coal isopach, structure contour, and coal-data maps was Cullins (1969).

The coal isopach map was constructed by using a point-data net derived from coal-thickness measurements of an individual coal bed obtained from surface exposures within the quadrangle boundary and a 3-mile (4.8-Km)-wide zone around the quadrangle. Measured coal thickness values were used directly in the point-data net and the principle of uniform variation in thickness between data points was used to establish the position of the isopach lines.

A structure contour map was constructed by using a point-data net derived from surface exposures. The elevation of the top of the contoured coal bed was based on surface altitude referenced to mean sea level.

The overburden isopach map was based on a point-data net of stratigraphic-interval thicknesses measured from the ground surface to the top of the isopached coal bed. The data points were generated by laying a structure contour map over the topographic contour map and calculating the apparent overburden thickness values at the intersections of structure contours and surface topographic contours.

Coal thickness data was obtained from the coal isopach map (fig. 1) for resource calculations. The coal-bed acreage (measured by planimeter) multiplied by the average isopach thickness of the coal bed multiplied by a conversion factor of 1,800 short tons of bituminous coal per acre-foot (13,238 metric tons of coal per hectare-meter) yields coal resources in short tons. Reserve Base and Reserve values for the Local 1 (L1) coal bed are shown on fig. 4 and are rounded to nearest tenth of a million short tons. The Reserve values are based on a subsurface mining recoverability factor of 50 percent and a surface mining recoverability factor of 85 percent.

The following criteria for coal resource determinations are given in U.S. Geological Survey Bullentin 1450-B: "Measured.--Resources are computed from dimensions revealed in outcrops, trenches, mine workings, and drill holes. The points of observation and measurement are so closely spaced and the thickness and extent of coals are so well defined that the tonnage is judged to be accurate within 20 percent of true tonnage. Although the spacing of the points of observation necessary to demonstrate continuity of the coal differs from region to region according to the character of the coal beds, the points of observation are no greater than ½ mile (0.8 km) apart. Measured coal is projected to extend as a ¼ mile (0.4 km) wide belt from the outcrop or points of observation or measurement.

"Indicated.--Resources are computed partly from specified measurements and partly from projection of visible data for a reasonable distance on the basis of geologic evidence. The points of observation are ½ (0.8 km) to 1½ miles (2.4 km) apart. Indicated coal is projected to extend as a ½ mile (0.8 km) wide belt that lies more than ¼ mile (0.4 km) from the outcrop or points of observation or measurement.

"Inferred.--Quantitative estimates are based largely on broad knowledge of the geologic character of the bed or region and where few measurements of bed thickness are available. The estimates are based primarily on an assumed continuation from Demonstrated coal [a collective term for the sum of coal in both Measured and Indicated Resources and Reserves] for which there is geologic evidence. The points of observation are 1½ (2.4 km) to 6 miles (9.6 km) apart. Inferred coal is projected to extend as a 2¼-mile (3.6 km) wide belt that lies more than 3/4 mile (1.2 km) from the outcrop or points of observation or measurement." (U.S. Bureau of Mines and U.S. Geological Survey, 1976, p. B6 and B7).

Coal resource tonnages were calculated for measured, indicated, and inferred categories in the unleased areas of Federal coal land where the coal is 5 ft (1.5 m) or more thick and lies within 3,000 ft (914 m) of the surface. The criteria cited above were used in calculating Reserve Base and Reserve data in this report and differ from those stated in U.S. Geological Survey Bullentin 1450-B, which calls for a minimum thickness of 28 in (71 cm) for bituminous coal and a maximum depth of 1,000 ft (305 m).

In this study, coal 5 ft (1.5 m) thick or greater lying between the ground surface and a depth of 200 ft (61 m) is considered amenable to surface mining methods; coal 5 ft (1.5 m) or more thick lying between 200 ft (61 m) and 3,000 ft (914 m) below ground level in beds having dips of less than $15^{o}$ is considered minable by conventional subsurface methods. However, the dip of the rocks in the isopached area of the L1 coal bed in this guadrangle is greater than $15^{o}$ and the coal 5 ft (1.5 m) or more thick lying between 200 ft (61 m) and 3,000 ft (914 m) below ground level

is considered to only be amenable to in situ coal gasification methods. The Reserve Base tonnage for in situ coal gasification of the L1 coal bed in this quadrangle is 1.4 million short tons (1.3 million metric tons) and has a low development potential. The Reserve Base tonnage for surface mining is 0.7 million short tons (0.6 million metric tons) with a high development potential. The criteria for development potential classification are discussed below.

AAA Engineering and Drafting, Inc. has not made any determination of economic recovery for any of the coal beds described in this report.

## COAL DEVELOPMENT POTENTIAL

Coal development potential areas are drawn (pl. 4 and 5) 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 (U.S. Bureau of Land Management), approximate 40-acre (16-ha) parcels have been used to show the limits of high-, moderate-, or low-development-potential areas.

The designation of a coal-development classification is based on the highest rated coal bearing area that may occur within any fractional part of a 40-acre (16-ha) BLM land-grid area, lot, or tract of unleased Federal coal land. For example, a certain 40- acre (16-ha) parcel is totally underlain by a coal bed of "moderate-" development-potential, but a small corner of the same 40-acre (16-ha) area is also underlain by another coal bed of "high-" development-potential rating. In this case the entire area would be rated "high-" development-potential even though most of the area is underlain by "moderate-" development-potential coal.

## Development Potential Using Surface Mining Methods

Areas where coal beds 5 ft (1.5 m) or more in thickness are overlain by 200 ft (61 m) or less of overburdern are considered to have a surface mining potential and were assigned a high-, moderate-, or low-development-potential on the basis of the mining ratio (cubic yards of overburden per ton of recoverable coal). The following formula is used to calculate mining ratios:

$$MR = \frac{t_o\ (0.896)}{t_c\ (rf)}$$

Where MR = mining ratio (cubic yards of overburden per ton of recoverable coal)

$t_o$ = thickness of overburden (in feet)

$t_c$ = thickness of coal (in feet)

rf = recovery factor

0.896 = factor for bituminous coal.

(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 here defined as areas underlain by coal beds having mining-ratio values of 0 to 10, 10 to 15, and greater than 15, respectively. These mining-ratio values for each development-potential category are based on economic and technological criteria and were provided by the U.S. Geological Survey (1979, unpublished data).

The coal development potential using surface mining methods is shown on plate 4. Approximately 1 percent of the unleased Federal land area in this quadrangle is classified as having a high-development-potential using surface mining methods. The remaining Federal land in the quadrangle is classified as having an unknown surface mining development potential or no development potential. Areas of unknown surface mining development potential are those not known to contain coal beds 5 ft (1.5 m) or more thick that are within 200 ft (61.0 m) of the surface; however, coal beds 5 ft (1.5 m) or more thick could be present in the area. Lands where it is known that no coal beds occur within 200 ft (61.0 m) of the surface have no surface-mining potential.

The tonnage of Reserves recoverable by surface mining methods are calculated on a recoverability factor of 85 percent (specified by the U.S. Geological Survey, unpublished data, 1979) of the Reserve Base tonnage.

### Development Potential Using Subsurface Mining and In Situ Coal Gasification Methods

There are no known areas in the Mellen Hill quadrangle where coal beds 5 ft (1.5 m) or more thick dip less than 15 degrees. Consequently, no areas in the quadrangle are known to be amenable to conventional subsurface mining methods. Areas in this quadrangle where coal beds dip more than 15 degrees, are 5 ft (1.5 m) or more thick, and are overlain by more than 200 ft (61 m) and less than 3,000 ft (914 m) of overburden are considered to have a low development potential for in situ coal gasification methods. The coal development potential for the area in which the mining of coal resources by in situ coal gasification may be possible is shown on plate 5. Areas that contain no known coal beds 5 ft (1.5 m) or more thick but do contain

coal-bearing units at depths less than 3,000 ft (914 m) are classified as areas of unknown coal development potential. Areas where it is known that no coal beds occur or where coal beds are present at depths greater than 3,000 ft (914 m) are assigned no coal development potential.

Reserve Base tonnages (fig. 4) have been calculated for the area where the Local 1 coal bed is known to be 5 ft (1.5 m) or more thick on the coal isopach map (fig. 1). The recoverability of resources from coal beds with dips greater than $15^{o}$ is unknown, and because the isopached area of the L1 coal bed in this quadrangle is in this category, coal Reserves have not been calculated for that bed. However, Reserve Base tonnages for measured and indicated resources have been determined and are shown on fig. 4. These tonnages are also shown on plate 2 by Federal land section. In areas where the dip of a coal bed is greater than $25^{o}$, the Reserve Base tonnage has been adjusted for dip by multiplying the apparent bedding-plane area by the secant of the dip of the bed to obtain the true bedding-plane area.

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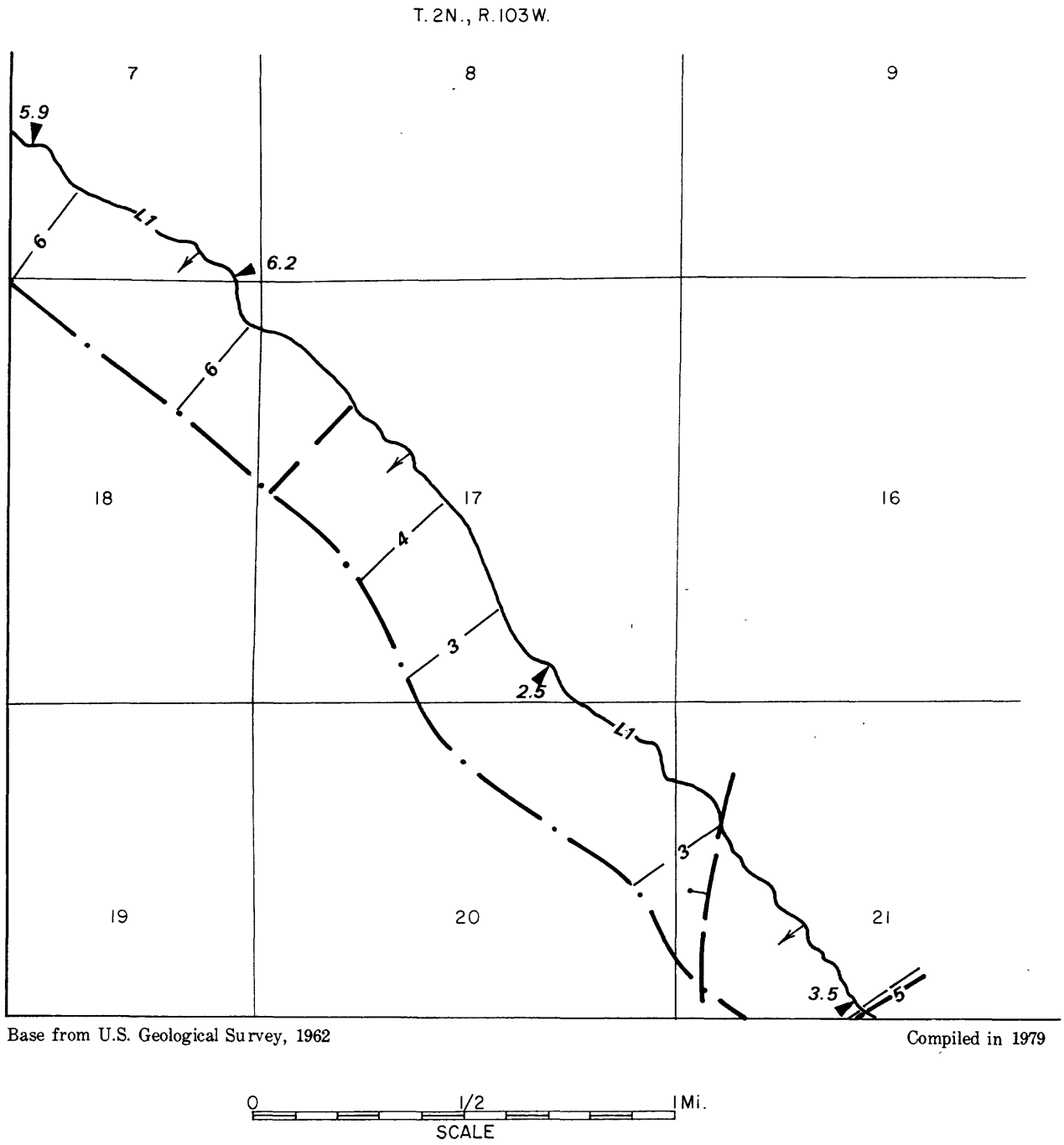
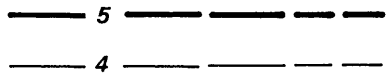
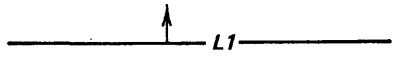



Figure 1. -- Isopach map of Local 1 coal bed




ISOPACHS–Showing thickness of coal, in feet. Long dashed where inferred, short dashed where projected above land surface. Isopach interval 1 foot.




TRACE OF COAL BED OUTCROP–Showing symbol of name of coal bed. Arrow points toward coal-bearing area.


POINT OF MEASUREMENT–Showing thickness of coal, in feet. Includes all points of measurement other than drill holes.

FAULT – Dashed where approximately located: bar and ball on downthrown side.



INSUFFICIENT DATA LINE–Coal thickness cannot be determined beyond line shown because of insufficient data.

Explanation for coal isopach map (fig. 1)

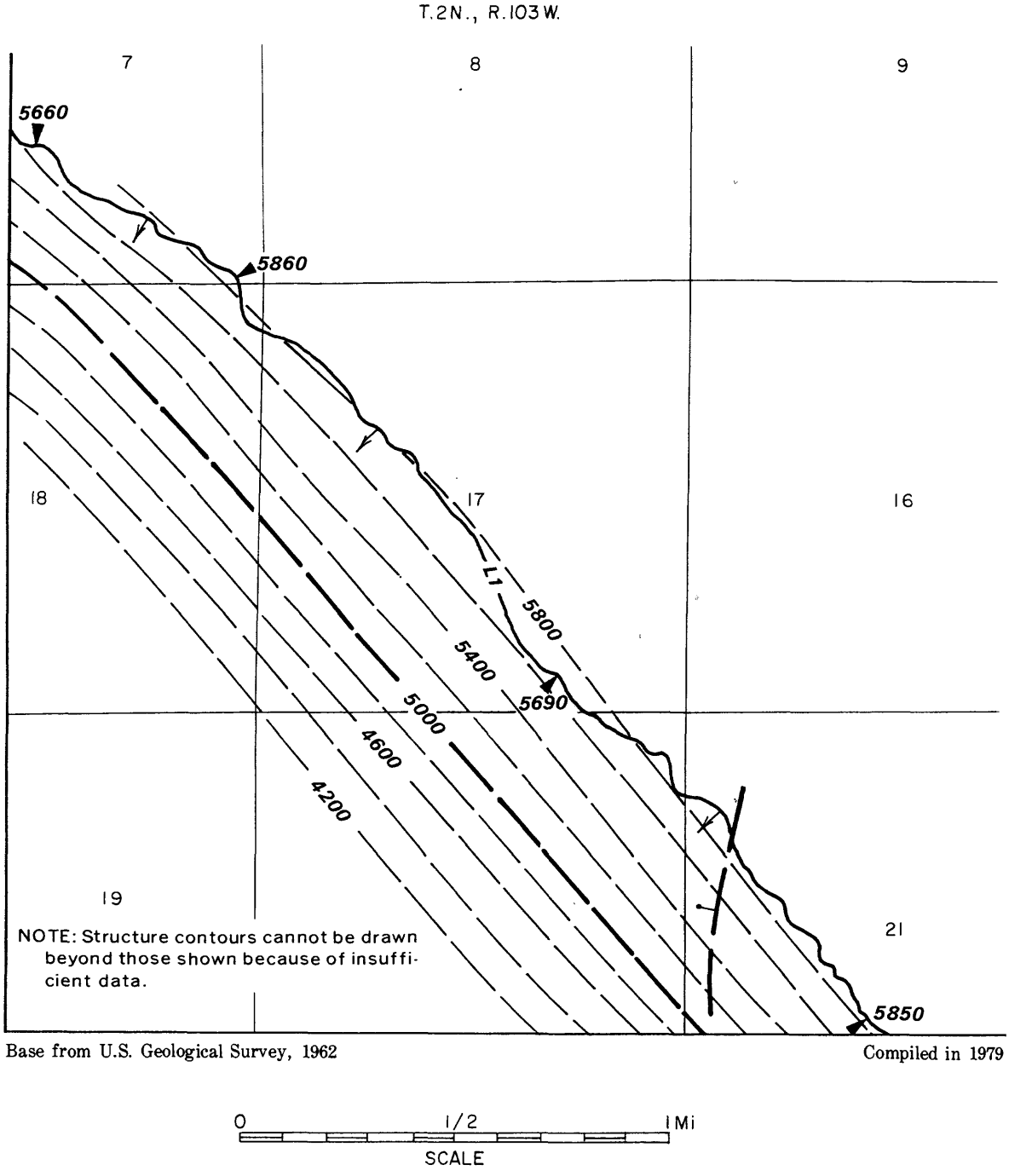
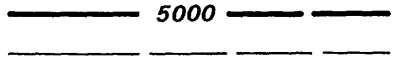
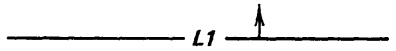



Figure 2. -- Structure contour map of Local 1 coal bed .




STRUCTURE CONTOURS–Drawn on top of coal bed. Solid where vertical accuracy within 100 feet; long dashed where vertical accuracy possibly not within 100 feet; short dashed where projected above land surface. Contour interval is 200 feet (61.0 m). Datum is mean sea level.




TRACE OF COAL BED OUTCROP–Showing symbol of name of coal bed. Arrow points toward coal-bearing area.


POINT OF MEASUREMENT – Showing altitude of top of coal bed, in feet.

FAULT – Dashed where approximately located: bar and ball on downthrown side.

Explanation for structure contour map (fig. 2)

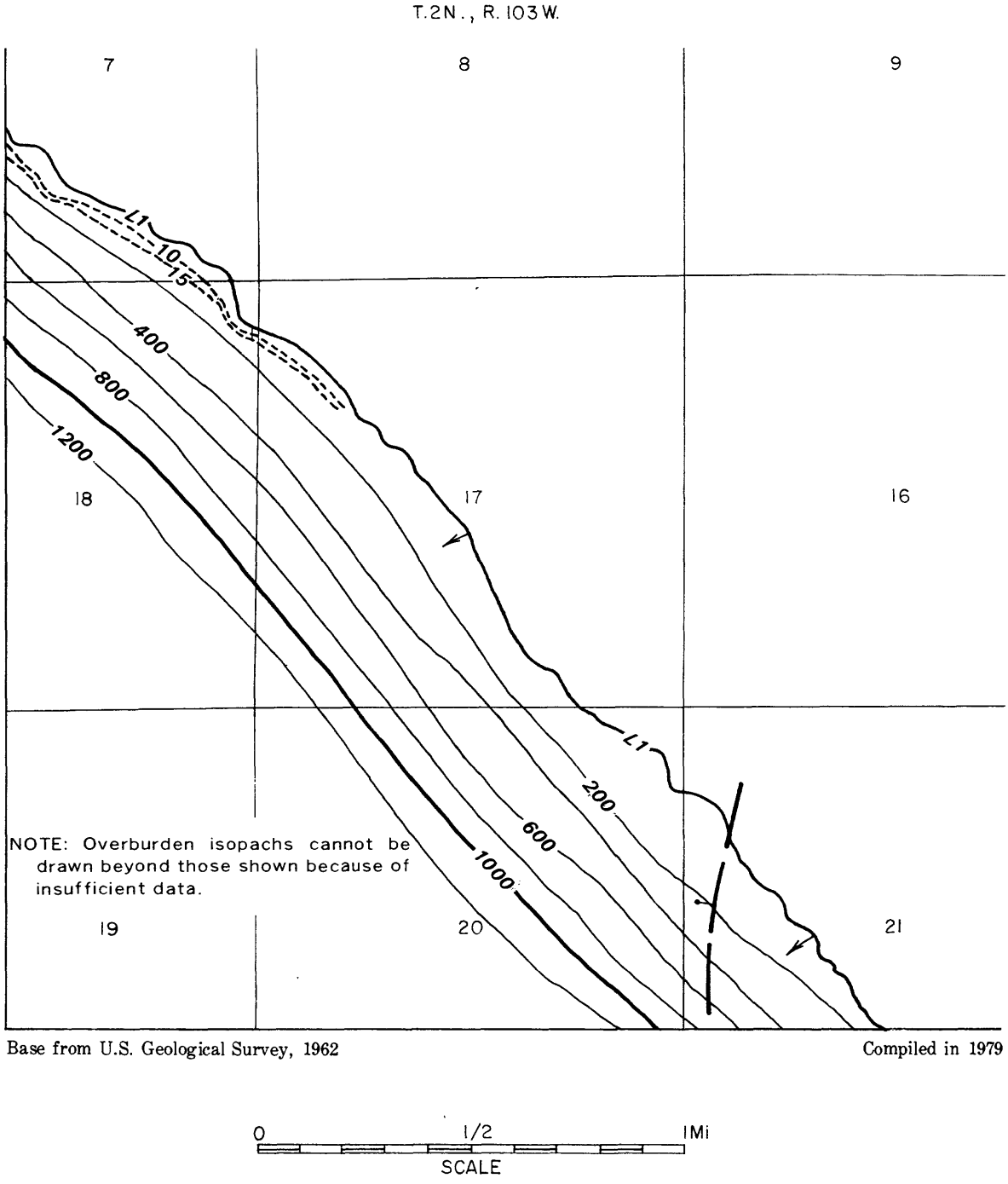
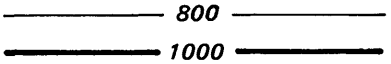
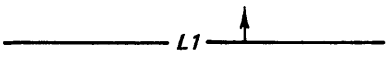


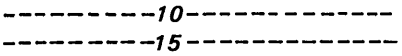

Figure 3. -- Overburden isopach map of Local 1 coal bed




OVERBURDEN ISOPACHS – Showing thickness of overburden, in feet, from the surface to top of the L 1 coal bed. Isopach interval 200 feet (61.0 m).




TRACE OF COAL BED OUTCROP–Showing symbol of name of coal bed. Arrow points toward coal-bearing area.




MINING-RATIO CONTOURS–Number indicates cubic yards of overburden per ton of recoverable coal by surface mining methods. Contours shown only in areas suitable for surface mining within the stripping limit.

FAULT– Dashed where approximately located: bar and ball on downthrown side.

Explanation for overburden isopach map (fig. 3)

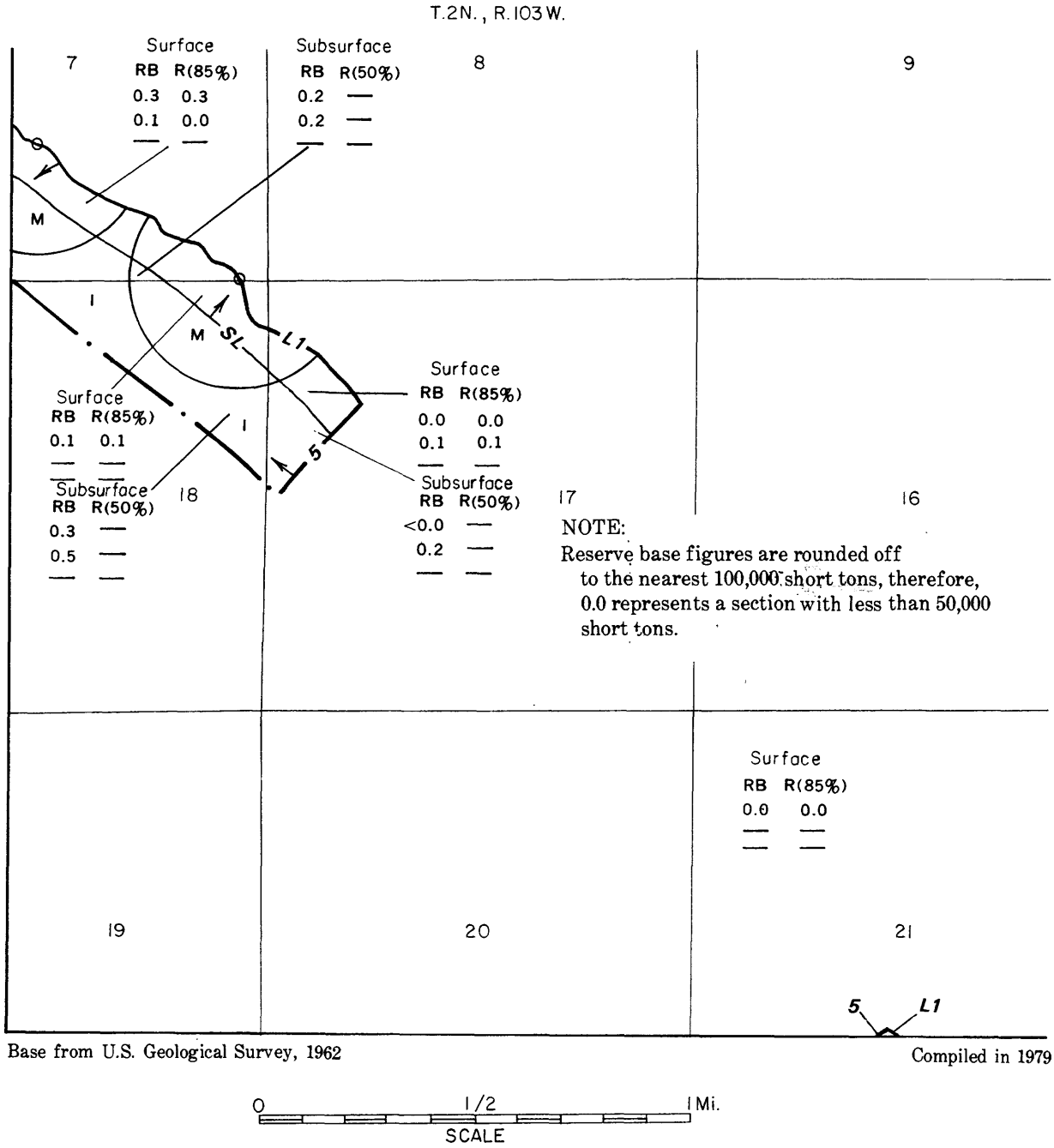
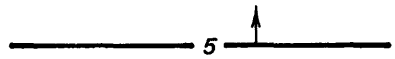
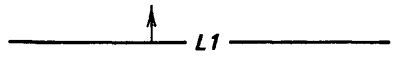



Figure 4. -- Areal distribution and identified resources map of Local 1 coal bed



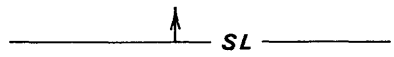

ISOPACH–Showing thickness of coal, in feet. Arrow points toward area where coal bed is 5 feet or more thick.




TRACE OF COAL BED OUTCROP–Showing symbol of name of coal bed. Arrow points toward coal-bearing area.



POINT OF MEASUREMENT –Point from which boundary lines for measured, indicated, and inferred coal resources were drawn.




STRIPPING-LIMIT LINE–Boundary for surface mining (in this quadrangle, the 200-foot-overburden isopach). Arrow points toward the area suitable for surface mining where the recovery factor is 85 percent, and away from the area suitable for subsurface mining (down dip to the 3,000-foot-overburden isopach) where the recovery factor is 50 percent.

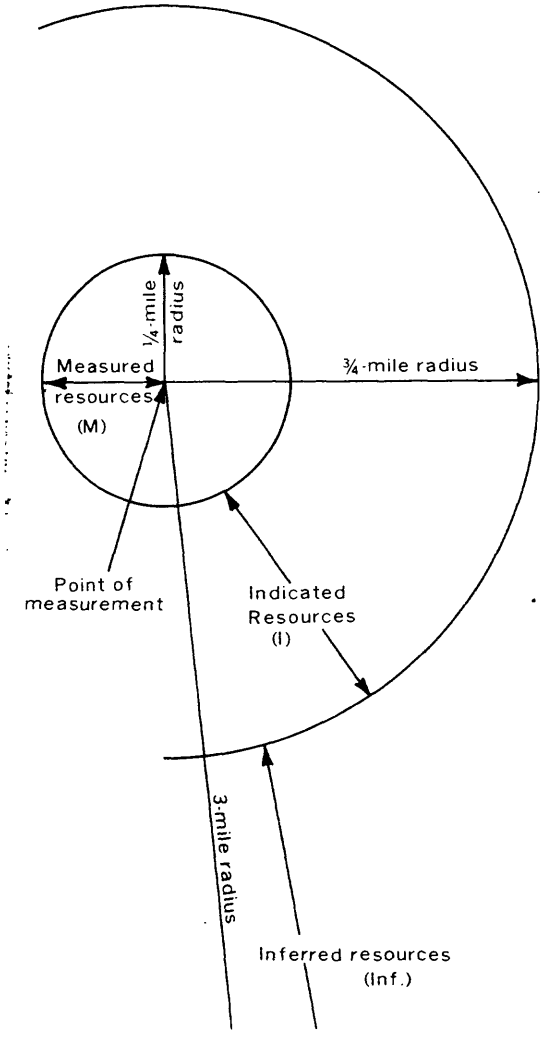


INSUFFICIENT DATA LINE–Coal thickness cannot be determined beyond line shown because of insufficient data.

Explanation for areal distribution and identified resources map (fig. 4)

| Surface | | Subsurface | | |
|---|---|---|---|---|
| RB | R(85%) | RB | R(50%) | |
| 0.3 | 0.3 | 0.2 | — | (Measured) |
| 0.1 | 0.0 | 0.2 | — | (Indicated) |
| — | — | — | — | (Inferred) |

IDENTIFIED COAL RESOURCES–Showing totals for Reserve Base (RB) and Reserves (R), in millions of short tons, for each section or part of section of non-leased Federal coal land, both within and beyond the stripping-limit line. Reserve (R) tonnage is calculated by multiplying the Reserve Base (RB) tonnage by the appropriate recovery factor. Dash indicates no resource in that category. Underground Reserves have been calculated for only that part of the Reserve Base that is suitable for underground mining, and do not include Reserves for areas where the dip of the coal bed exceeds 15°.




BOUNDARY LINES–Enclosed areas of measured, indicated, and inferred coal resources of the coal bed.

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

To convert feet to meters, multiply feet by 0.3048

Explanation for areal distribution and identified resources map (fig. 4) -- (Cont)