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# COAL RESOURCE OCCURRENCE MAPS OF THE MESA PORTALES QUADRANGLE, SANDOVAL COUNTY, NEW MEXICO

[Report includes 6 plates]

by

Dames & Moore

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# MESA PORTALES 7 1/2-MINUTE QUADRANGLE

## INTRODUCTION

### Purpose

This text is to be used in conjunction with the Coal Resource Occurrence (CRO) Maps of the Mesa Portales quadrangle, Sandoval County, New Mexico. These maps were compiled to provide a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA's) in the western United States. The work has been performed under contract with the Conservation Division of the U.S. Geological Survey (Contract No. 14-08-0001-17172).

The resource information gathered in this program is in response to the Federal Coal Leasing Amendments Act of 1976 and is a part of the U.S. Geological Survey's coal program. The information provides basic data on coal resources for land-use planning purposes by the Bureau of Land Management, state and local governments, and the public.

### Location

The Mesa Portales 7 1/2-minute quadrangle is in northeastern Sandoval County, New Mexico. The area is approximately 64 miles (103 km) northwest of Santa Fe and 84 miles (135 km) southeast of Farmington, New Mexico.

## Accessibility

The Mesa Portales quadrangle is accessible from New Mexico State Route 44, which is to the east, and State Route 197 which extends east-west across the area. Light-duty roads from the state routes provide further access to the area. The Atchison, Topeka, and Santa Fe Railway operates a route which passes through Albuquerque 70 miles (113 km) to the southeast.

## Physiography

The northern part of the quadrangle is in the southeastern corner of the Central Basin area, and the southern part of the quadrangle is part of the northeastern Chaco Slope area (Kelley, 1950) of the structural depression known as the San Juan Basin. The quadrangle is within the Penistaja Cuestas physiographic sector as described by Baltz (1967). Elevations range from 6,700 ft (2,073 m) in the southeast to 7,750 ft (2,362 m) on Mesa de Cuba in the northeast. An area of low relief extends from the west-northwest to the center of the quadrangle and is dominated by the San Isidio Valley. Mesa Portales slopes gently to the north, but is terminated by a steep scarp along its southern and eastern margins. Mesa de Cuba is a prominent feature in the northeastern portion of the quadrangle. Numerous washes and arroyos, notably Arroyo Chijuilla, provide drainage for the area.

## Climate

The climate of the San Juan Basin is arid to semi-arid. Annual precipitation is usually less than 10 inches (25 cm) but varies across the basin due to elevational differences. Rainfall is rare in the early summer; most precipitation occurs in July and August as intense afternoon thundershowers. Annual temperatures in the basin range from below 0°F (-18°C) to above 100°F (38°C). Snowfall may occur from November to April with an average of 18 inches (46 cm) in the southern part of the basin.

## Land Status

Approximately 2 percent of the quadrangle is in the southeastern corner of the San Juan Basin Known Recoverable Coal Resource Area. The Federal Government owns the coal rights for all of the KRCRA land as shown on Plate 2 of the Coal Resource Occurrence Maps. No Federal coal leases occur in this area. The Federal Government owns the coal rights for 92 percent of the land outside the KRCRA.

# GENERAL GEOLOGY

## Previous Work

Dane (1936) mapped the Upper Cretaceous and Tertiary strata within the quadrangle with emphasis on outcrops of the Fruitland Formation coal and clinker. Fassett (1966) has mapped the geology of the quadrangle on a scale of 1:24,000. Baltz (1967) published a Geological Survey Professional Paper on the stratigraphy and regional tectonic implications of the Upper Cretaceous and Tertiary rocks of the east-central San Juan Basin, which includes a geologic map of the northern two-thirds of the quadrangle. A more recent publication by Fassett and Hinds (1971) includes subsurface interpretations of the Fruitland Formation coal deposits throughout the San Juan Basin.

## Geologic History

The San Juan Basin, an area of classic transgressive and regressive sedimentation, provided the ideal environment for formation of coals during Late Cretaceous time. At that time a shallow epeiric sea, which trended northwest-southeast, was northeast of the basin. The sea transgressed southwesterly into the basin area and regressed northeasterly numerous times; consequently, sediments from varying environments were deposited across the basin. Noncarbonaceous terrestrial deposition predominated during Paleocene and Eocene time.

The first basin-wide retreat of the Late Cretaceous sea is indicated by the nearshore deposits of the Point Lookout Sandstone. These ancient barrier beaches formed a generally northwest-southeast-trending strandline, behind which swamps developed. Organic material accumulated in the swamps and later became coal in the paludal deposits of the lower Menefee Formation. Deposition of materials which formed the coal beds was influenced by the strandline. This is shown by the more consistent thickness and greater lateral extent of the coals parallel to the strandline and also by the lack of continuity perpendicular to it, to the northeast, where the Menefee and underlying Point Lookout deposits interfinger. Streams which crossed the swamps also influenced deposition of organic matter; stream deposits may terminate even the most continuous coal beds.

During the continued retreat of the sea, the depositional environments in the quadrangle area became more terrestrial. This is evidenced by the transition within the lower Menefee from carbonaceous to noncoal-bearing deposits, in which there is an upward decrease in the occurrence and lateral continuity of the coals. As the sea retreated, the sediments of the Point Lookout Sandstone and overlying Menefee Formation were deposited in successively higher stratigraphic positions to the northeast.

The sea then reversed the direction of movement, and the transgressive sequence of paludal upper Menefee Formation, nearshore Cliff House Sandstone, and marine Lewis Shale was deposited in the quadrangle. Swamps (Menefee) formed southwest (shoreward) of the transgressing beaches (Cliff House). Organic matter deposited in these swamps ultimately formed coal beds in the upper part of the Menefee Formation. A thin wedge of the Cliff House sand was deposited conformably over the Menefee Formation. Subsequently, several hundred feet of beach sands of the La Ventana Tongue (Cliff House Sandstone) were deposited over the basal Cliff House member.

Onlap continued as the sea moved southwestward across the basin area. The marine facies which developed northeast of the strandline as it moved to the southwest is the Lewis Shale. This thick sequence, which thins to the southwest, overlies the Cliff House Sandstone, and marks the last advance of the Late Cretaceous sea.

Evidence of the final retreat of the Late Cretaceous sea are the nearshore regressive Pictured Cliffs Sandstone and the overlying paludal Fruitland Formation which were deposited in successively higher stratigraphic positions to the northeast. Southwest (shoreward) of the beach deposits, which were dissected by streams, swamps accumulated organic matter which became coals of the Fruitland Formation. Again, deposition of organic material was influenced by the strandline as shown by both the continuity of the coal beds parallel to the northwest-southeast strandline and their discontinuity perpendicular to it to the northeast.

The brackish-water swamp environment of the Fruitland moved northeast of the quadrangle as the regression continued in that direction. Terrestrial sediments covered the area as indicated by the lacustrine, channel, and floodplain deposits of the Kirtland Shale. This sequence of events is evidenced by both an upward decrease in occurrence and thickness of Fruitland coals and a gradational change to noncarbonaceous deposits of the Kirtland. Continuous deposition during Late Cretaceous time ended with the Kirtland. The sea then retreated beyond the limits of the quadrangle area, and modern basin structure began to develop. An erosional unconformity developed in a relatively short time as part of the Cretaceous Kirtland Shale was removed.

Terrestrial deposition resumed in the Paleocene as represented by the Ojo Alamo Sandstone and the overlying Nacimiento Formation. Alluvial plain and floodplain deposits of the Ojo Alamo were followed by the thick, lithologically varied deposits of the Nacimiento during continuous nonmarine deposition (Powell, 1973). The Nacimiento was later exposed to erosion.

The Eocene San Jose Formation was subsequently deposited over the Nacimiento erosional surface, reflecting various nonmarine environments which developed across the basin. Deposition and structural deformation of the basin then ceased, and the warped strata of the San Juan Basin have been exposed to the present time.

## Stratigraphy

The formations studied in this quadrangle range from Late Cretaceous to Eocene in age. They are, in order from oldest to youngest: (the three formations of the Mesaverde Group) the Point Lookout Sandstone, Menefee Formation (undifferentiated), and Cliff House Sandstone; the Lewis Shale, Pictured Cliffs Sandstone, undivided Fruitland Formation and Kirtland Shale, Ojo Alamo Sandstone, Nacimiento Formation, and San Jose Formation. A composite columnar section on CRO Plate 3 illustrates the stratigraphic relationships of these formations and is accompanied by lithologic descriptions of the individual formations.

The Point Lookout Sandstone, the basal formation of the Mesaverde Group, consists of gray to brown fine- to medium-grained calcareous sandstone and interbedded shale. It is fairly massive in character, averages 190 ft (58 m) in thickness, and displays a distinctive character on geophysical logs. This last characteristic was used by the authors in establishing the top of the Point Lookout as a lithologic datum for correlation of the overlying Menefee coals.

The oldest coal-bearing formation in the quadrangle is the Menefee Formation of the Mesaverde Group. In previous studies the Menefee has been divided into the Cleary Coal Member, the barren Allison Member, and an unnamed upper coal-bearing member (Beaumont and others, 1956). These three members are referred to as the undifferentiated Menefee Formation for the purposes of this report only. The Menefee in this area is about 665 ft (203 m) thick and is predominantly a gray to brown carbonaceous to noncarbonaceous shale with interbedded siltstone and sandstone, and random coal beds.

The Cliff House Sandstone sequence conformably overlies the Menefee Formation. A thin basal sand member, referred to as "the Cliff House Sandstone" by Fassett (1977), correlates with the thin undifferentiated Cliff House Sandstone to the northeast. It is about 40 ft (12 m) thick and consists of white to buff calcareous sandstone.

Overlying the basal member in the southern half of the area is the La Ventana Tongue. This member of the Cliff House Sandstone is about 690 ft (210 m) thick and represents a thick sandstone sequence composed primarily of white to buff sandstone and thinly-interbedded gray shale and siltstone.

The marine Lewis Shale conformably overlies the basal Cliff House in the northern part of the quadrangle and the La Ventana in the southern part. In contrast to the underlying Cliff House Sandstone, the Lewis Shale is predominantly a gray, locally silty, fossiliferous, calcareous shale with interbedded thin, gray, calcareous siltstone. It averages 720 ft (219 m) in thickness throughout the quadrangle. The upper contact of the Lewis Shale is gradational with the overlying Pictured Cliffs Sandstone and, therefore, it is difficult to determine.

The Pictured Cliffs Sandstone consists of approximately 110 ft (34 m) of gray to brown, fine-grained calcareous sandstone interbedded with thin shale near the base of the formation where it grades into the Lewis. The upper contact of the Pictured Cliffs Sandstone is more sharply defined than the basal contact, even though intertonguing with the overlying Fruitland Formation results in minor variations in the formational top. Since the Pictured Cliffs is present throughout most of the basin and displays a distinctive character on geophysical logs, the authors have used the top as a lithologic datum for correlation of the overlying Fruitland coals.

Conformably overlying the Pictured Cliffs Sandstone is the undivided Fruitland Formation and Kirtland Shale, the lower portion of which is the major coal-bearing unit in the quadrangle. The average combined thickness of the units is 220 ft (67 m). It consists of gray to green to greenish-brown carbonaceous to noncarbonaceous shale, interbedded white to brown sandstone and siltstone, and coal beds of varying thicknesses. The thickest and most continuous coal beds of the Fruitland occur near the base of the formation, while discontinuous and lenticular coal beds are characteristic of the upper portion.

The Paleocene Ojo Alamo Sandstone unconformably overlies the Upper Cretaceous deposits. It consists of about 50 ft (15 m) of light to dark brown, fine- to coarse-grained sandstone with interbedded thin, gray to green shale.

Approximately 1,200 ft (366 m) of the Nacimiento conformably overlie the Ojo Alamo in the area. These rocks are predominantly light gray to black shale with interbedded sandstone.

The Eocene San Jose Formation unconformably overlies the Paleocene Nacimiento Formation. The San Jose consists of buff to yellow, fine- to coarse-grained, locally conglomeratic, arkosic sandstone with interbedded brown to gray shale.

A total of eight formations crop out within the quadrangle. The outcrop pattern trends in a east-west direction, the formations becoming successively younger to the north. The oldest formation is the La Ventana Tongue (Cliff House Sandstone) which crops out in the southeastern corner of the area. The entire sections of the Lewis Shale, Pictured Cliffs Sandstone, Fruitland Formation, Kirtland Shale, Ojo Alamo Sandstone, and Nacimiento Formation crop out consecutively across the quadrangle. The basal part of the San Jose Formation, the youngest formation, crops out along the northern boundary of the quadrangle as a caprock on various mesas.

### Structure

The axis of the San Juan basin is about 22 miles (35 km) northeast of the Mesa Portales quadrangle area and trends in an arcuate pattern across the northern portion of the Central Basin (Baltz, 1967). Regional dip measured within the quadrangle ranges from 2° to 3° to the north, northeast and west (Dane, 1936). Several small-scale faults are in the south-central portion of the quadrangle; the amount of displacement was not determined.

## COAL GEOLOGY

Individual coal beds are not continuous across the San Juan Basin because the coal related strata are progressively younger from southwest to northeast; the strata rise in steps due to minor transgressions which occurred during the overall retreat of the sea. However, for the exclusive purpose of reserve and reserve base calculations, the Fruitland 1 coal bed has been correlated and mapped as if it was a single bed, continuous throughout the basin.

A lithologic datum was used for correlation of the coals (CRO Plate 3). The primarily marine sandstone units (Point Lookout, Pictured Cliffs) which underlie the coal-bearing formations (Menefee, Fruitland) were used as datums since they represent a more laterally continuous boundary than any of the overlying paludal, fluvial, and lacustrine deposits of the coal-bearing formations. Also, the sandstone units are generally more easily recognized on geophysical logs. As shown on CRO Plate 3, the tops of the sandstone units have been used as datums for each drill hole, and the coals have been plotted in the column and correlated based upon their position relative to the datum. Correlations of Fruitland coals in measured sections are based upon the geologic maps of this quadrangle (Fassett, 1966).

One coal zone (Menefee) was identified in the subsurface, and a coal bed (Fruitland 1) was mapped on the surface of this quadrangle (CRO Plate 1). The Menefee Formation coal beds are designated as the Menefee coal zone (Me zone). These coal beds are generally noncorrelative and less than reserve base thickness (5 ft [1.5 m]) as specified by the U.S. Geological Survey; however, there is a 5-ft (1.5-m) coal bed in drill holes 7 and 10 (CRO Plate 1).

Menefee Formation coal beds in the southeastern part of the San Juan Basin vary from subbituminous B to high volatile C bituminous in rank. The rank of the coal has been determined on a moist, mineral-matter-free basis with calorific values ranging from 9,983 to 11,966 Btu's per pound (23,220-27,833 kj/kg) (Amer. Soc. for Testing and Materials, 1977). The coal is hard, brittle, and black with a bright luster. The coal readily slakes with exposure to weather; however, it stocks fairly well when protected. The "as received" analyses indicate a moisture content varying from 12.1 to 20.0 percent, ash content ranging from 4.9 to 9.9 percent, sulfur content generally less than one percent, and heating values on the order of 10,343 Btu's per pound (24,058 kj/kg). There is no apparent consistent difference between the various Menefee Formation coal beds (Dane, 1936; Shomaker, 1971). Analyses of several Menefee Formation coal beds are published in a report by Shomaker (1971). The results of these analyses are given in Table 1.

The Fruitland 1 (Fr 1) coal bed is defined by the authors as the lowermost coal of the Fruitland Formation; it is generally directly above the Pictured Cliffs Sandstone. The Fruitland 1 coal bed crops out in the southeastern part of the quadrangle and is offset by two minor faults (Fassett, 1966). Since the Fruitland 1 coal bed is less than reserve base thickness (5 ft [1.5 m]) in this quadrangle, derivative maps were not constructed.

Fruitland Formation coal beds in the southeastern part of the San Juan Basin vary from subbituminous A to high volatile A bituminous in rank. The rank of the coal has been determined on a moist, mineral-matter-free basis with calorific values ranging from 11,358 to 14,545 Btu's per pound (26,419-33,832 kj/kg) (Amer Soc. for Testing and Materials, 1977). The coal is hard, brittle, and black with a bright luster. The coal readily slakes with exposure to weather; however, it stocks fairly well when protected. The "as received" analyses indicate a moisture content varying from 2.1 to 13.48 percent, ash content ranging from 19.86 to 30.49 percent, sulfur content less than one percent, and heating values on the order of 8,888 Btu's per pound (20,673 kj/kg). Analyses of several Fruitland Formation coal beds are given in Table 2 (Dane, 1936; Fassett and Hinds, 1971; Shomaker and Lease, 1971).

TABLE 1

Analyses of coal samples from the Menefee Formation

(Form of analysis: A, as received; B, moisture free; C, moisture and ash free)

| U.S. Bureau Mines Lab No. | Well or Other Source | Location Section | Location T.N. | Location R.W. | Approx. Depth Interval of Sample (ft.) | Form of Analysis | Proximate, percent Mois-ture | Proximate, percent Volatile matter | Proximate, percent Fixed Carbon | Proximate, percent Ash | Sulfur | Heating Value (Btu) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A-47085 | Mine Sample San Juan Mine | SW¼ 31 | 19 | 1 | ---- | A | 15.8 | 34.5 | 43.8 | 5.9 | 0.6 | 10,900 | Cleary Member |
| | | | | | | B | ---- | 41.0 | 52.0 | 7.0 | 0.7 | 12,950 | |
| A-46366 | Mine Sample San Juan Mine | SW¼ 31 | 19 | 1 | ---- | A | 15.7 | 32.0 | 45.1 | 7.2 | 0.6 | 10,790 | Cleary Member, |
| | | | | | | B | ---- | 38.0 | 53.5 | 8.5 | 0.7 | 12,800 | |
| | | | | | | C | ---- | 41.5 | 58.5 | ---- | 0.8 | 13,990 | |
| A-47084 | Prospect Pit Wilkins No.2 Prospect | SW¼ 26 | 19 | 1 | ---- | A | 18.2 | 34.4 | 40.8 | 6.6 | 0.9 | 10,280 | Cleary Member |
| | | | | | | B | ---- | 42.0 | 49.9 | 8.1 | 1.0 | 12,570 | |
| A-60026 | Mine Sample Rio Puerco Mine | SE¼ 19 | 19 | 1 | ---- | A | 12.1 | 35.8 | 44.5 | 7.6 | 2.8 | 10,940 | Allison Member |
| | | | | | | B | ---- | 40.7 | 50.6 | 8.7 | 3.2 | 12,460 | |
| | | | | | | C | ---- | 44.6 | 55.4 | ---- | 3.5 | 13,640 | |
| A-64268 | Mine Sample Anderson Mine | SE¼ 35 | 19 | 2 | ---- | A | 20.0 | 32.5 | 42.6 | 4.9 | 0.7 | 10,240 | Allison Member |
| | | | | | | B | ---- | 40.7 | 53.2 | 6.1 | 0.8 | 12,790 | |
| | | | | | | C | ---- | 43.3 | 56.7 | ---- | 0.9 | 13,630 | |
| A-46367 | Prospect Drift | 35 | 19 | 2 | ---- | A | 14.8 | 33.9 | 41.4 | 9.9 | 1.2 | 8,910 | Allison Member; Sample may have been somewhat weathered |
| | | | | | | B | ---- | 39.8 | 48.6 | 11.6 | 1.4 | 10,460 | |
| | | | | | | C | ---- | 45.1 | 54.9 | ---- | 1.6 | 11,840 | |

To convert Btu's/lb to kj/kg, multiply Btu's/lb by 2.326.
To convert feet to meters, multiply feet by 0.3048.

## TABLE 2

Analyses of coal samples from the Fruitland Formation

(Form of analysis: A, as received; B, moisture free; C, moisture and ash free)

| U.S. Bureau Mines Lab No. | Well or Other Source | Location | | | Approx. Depth Interval of Sample (ft.) | Form of Analysis | Proximate, percent | | | | | Heating Value (Btu) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Section | T.N. | R.W. | | | Moisture | Volatile matter | Fixed Carbon | Ash | Sulfur | | |
| +TH-55298 | Core Sample | ------ | 19 | 3 | ---- | A | 9.44 | 27.40 | 32.67 | 30.49 | 0.57 | 8,161 | |
| | | | | | | B | ---- | 30.26 | 36.07 | 33.67 | 0.63 | 9,012 | |
| +TH-55672 | Core Sample | ------ | 19 | 4 | ---- | A | 11.50 | 36.57 | 32.07 | 19.86 | 0.67 | 9,473 | |
| | | | | | | B | ---- | 41.32 | 36.24 | 22.44 | 0.76 | 10,704 | |
| +TH-57167 | Core Sample | ------ | 19 | 5 | ---- | A | 13.13 | 32.63 | 32.46 | 21.75 | 0.49 | 9,003 | |
| | | | | | | B | ---- | 37.56 | 37.37 | 25.07 | 0.56 | 10,364 | |
| +TH-57168 | Core Sample | ------ | 19 | 5 | ---- | A | 12.05 | 30.39 | 27.96 | 29.60 | 0.59 | 7,870 | |
| | | | | | | B | ---- | 34.55 | 31.79 | 33.66 | 0.67 | 8,948 | |
| +TH-57166 | Cuttings Sample | ------ | 19 | 5 | ---- | A | 13.48 | 29.55 | 28.05 | 28.92 | 0.50 | 7,829 | |
| | | | | | | B | ---- | 34.15 | 32.42 | 33.43 | 0.58 | 9,049 | |
| H-32405 | El Paso Nat. Gas Lindrith No. 42 | NE¼ 22 | 24 | 3 | 3,194-3,205 | A | 2.1 | 38.7 | 36.7 | 22.5 | 0.7 | 10,990 | |
| | | | | | | B | ---- | 39.5 | 37.5 | 23.0 | 0.7 | 11,230 | |
| | | | | | | C | ---- | 51.3 | 48.7 | ---- | 1.0 | 14,580 | |

+analysis by Commercial Testing and Eng. Co.

To convert Btu's/lb to kj/kg, multiply Btu's/lb by 2.326.
To convert feet to meters, multiply feet by 0.3048.

## Menefee Coal Zone

The Menefee coal zone extends from the top of the La Ventana Tongue (Cliff House) to the base of the Menefee Formation. Correlation of the top of the La Ventana, which is easily recognized on geophysical logs, with the top of the Menefee Formation was established for use in the surrounding quadrangles, where they interfinger and are contemporaneous, and has been continued into the quadrangle for the purpose of consistency.

Consequently, the structure contour map of the Menefee coal zone (CRO Plate 5) was constructed using the top of the La Ventana Tongue of the Cliff House Sandstone. The structure contour map shows that the Menefee coal zone dips from approximately 3.5° to less than 1° in a northerly direction. As a result of topography and dip, overburden (CRO Plate 6) varies from less than 400 ft (122 m) in the southwest to over 2,400 ft (732 m) on Mesa de Cuba. Included on CRO Plate 6 is the total amount of interburden, the noncoal portion of the coal zone. The interburden thickness varies from less than 1,300 ft (396 m) in the north to greater than 1,550 ft (472 m) in the southern part of the quadrangle. The large values are the result of the stratigraphic spread of the coal beds and reflect the thickness of the Menefee Formation plus the La Ventana Tongue. The isopach map (CRO Plate 4) shows the total combined thickness of the individual coal beds of the Menefee zone. The greatest combined thickness occurs in the northwestern portion of the quadrangle where the coals total more than 30 ft (9.1 m). In general, the thickness decreases from this area, and there is no coal present in a small portion of the central part of the quadrangle.

Chemical Analyses of the Menefee Zone Coal Beds - No published analyses of the quality of Menefee Formation coals are available for this quadrangle. However, information from surrounding areas is assumed to be similar to that of the coals from this quadrangle. Analyses of several Menefee Formation coals are presented in a report by Shomaker (1971). The results of these analyses are given in Table 1.

## COAL RESOURCES

Coal resource data from oil and gas wells (El Paso Natural Gas Co., 1978, unpublished data in well log library in Farmington, New Mexico) and geologic maps (Fassett, 1966) were used in the construction of the isopach and structure contour map for this quadrangle. Coal resources were not calculated for the Fruitland 1 coal bed or the Menefee zone coal beds. The Fruitland 1 coal bed is discontinuous and less than the reserve base thickness of 5 ft (1.5 m). Coal beds of the Menefee zone are noncorrelative and generally less than 5 ft (1.5 m) thick.

## COAL DEVELOPMENT POTENTIAL

Coal development potential maps were not constructed for this quadrangle because the coal beds within the KRCRA are less than the reserve base thickness (5 ft [1.5 m]) and, therefore, have unknown coal development potential.

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