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COAL RESOURCE OCCURRENCE MAPS AND COAL DEVELOPMENT POTENTIAL MAPS OF THE KIRTLAND SE QUADRANGLE, SAN JUAN COUNTY, NEW MEXICO

[Report includes 8 plates]

by

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This report has not been edited for conformity with U.S. Geological Survey editorial standards or stratigraphic nomenclature.

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KIRTLAND SE 7 1/2-MINUTE QUADRANGLE

INTRODUCTION

Purpose

This text is to be used in conjunction with the Coal Resource Occurrence (CRO) Maps and Coal Development Potential (CDP) Map of the Kirtland SE quadrangle, San Juan County, New Mexico. These maps were com-iled 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 Kirtland SE 7 1/2-minute quadrangle is located in central San Juan County, New Mexico. The area is approximately 8 miles (13 km) southwest of Farmington and 70 miles (113 km) northeast of Gallup, New Mexico.

Accessibility

The area is accessible from the northeast by State Route 371, which connects with a light-duty road that extends into the northern part of the quadrangle. Numerous unimproved dirt roads extend across the area, and a light-duty road in the northeastern corner intersects the connecting road to State Route 371. The Atchison, Topeka, and Santa Fe Railway operates a route 70 miles (113 km) to the southwest at Gallup, New Mexico, which extends southeast and southwest.

Physiography

The quadrangle is located in the Central Basin area (Kelley, 1950) of the San Juan Basin, a structural depression in the Colorado Plateau physiographic province. Total relief in the quadrangle is 670 ft (204 m) with elevations ranging from 5,660 ft (1,725 m) in the northwestern corner to 6,330 ft (1,929 m) in the southeast. The topography of the area is characterized by dissected plains which gently slope to the west in this region of the Central Basin. Stabilized dune fields are numerous on the upland plains in the area. The southwestern corner of the quadrangle is highly dissected by several intermittent streams which flow west into Cottonwood Arroyo and eventually drain into the Chaco River 10 miles (16 km) to the east.

Climate

The climate of the San Juan Basin is arid to semi-arid. Annual precipitation is usually less than 10 inches (25 cm), with slight variations across the basin due to elevational differences. Rainfall is rare in the early summer and winter; most precipitation is received 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 occurs from November to April with an average of 18 inches (46 cm) in the southern part of the basin.

Land Status

Approximately 15 percent of the quadrangle is in the western boundary of the San Juan Basin Known Recoverable Coal Resource area, and 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 within the quadrangle.

GENERAL GEOLOGY

Previous Work

Reeside (1924) mapped the surficial geology in the area as part of a study of the Upper Cretaceous and Tertiary formations of the San Juan Basin. More recently, Fassett and Hinds (1971) made subsurface interpretations of the Fruitland Formation coals in this area as part of a larger San Juan Basin coal study.

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.

After its first basin-wide retreat the Late Cretaceous sea reversed the direction of movement. As a result, the transgressive sequence of paludal 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 the coal in the Menefee Formation. As the sea transgressed, a thin Cliff House sand was deposited over the Menefee sediments. Beach sands of the La Ventana Tongue (Cliff House Sandstone) were then deposited over this basal sand. Swamps (younger Menefee deposits) developed shoreward (southwest) and contemporaneously with some of the younger La Ventana beach deposits. Subsequently, coals formed in these deposits which are called the Hogback Mountain Tongue of the Menefee Formation (Beaumont, 1971). Interfingering of the La Ventana (Cliff House) and Hogback Mountain (Menefee) Tongues in the quadrangle occurred due to minor fluctuations of the sea. More La Ventana sands were later deposited over the Hogback Mountain Tongue as the transgression continued. 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 La Ventana Tongue of the Cliff House Sandstone, and marks the last advance of the Late Cretaceous sea.

The first depositional evidence of the final retreat of the Late Cretaceous sea is the nearshore regressive Pictured Cliffs Sandstone. Southwest (shoreward) of these beach sands, swamps, which were dissected by streams, accumulated organic matter which later became coals of the Fruitland Formation. 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 less continuous Fruitland coals appear to be noncorrelative, but are lithostratigraphically equivalent in terms of their relative position within the Fruitland Formation.

The brackish-water swamp environment of the Fruitland moved farther to the northeast as the regression continued in that direction. Terrestrial freshwater sediments then covered the quadrangle 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 with the Ojo Alamo Sandstone and the overlying Nacimiento Formation. The Nacimiento was later exposed to erosion and the Eocene San Jose Formation was deposited over the Nacimiento erosional surface. Deposition and structural deformation of the basin then ceased, and the warped strata of the San Juan Basin have been exposed to erosional processes to the present time. A significant amount of erosion has occurred as indicated by the removal of the San Jose Formation and some of the Nacimiento Formation from the area.

Stratigraphy

The formations studied in this quadrangle range from Late Cretaceous to Paleocene in age. They are, in order from oldest to youngest: the Menefee Formation and the Cliff House Sandstone (two of the three formations of the Mesaverde Group); the Lewis Shale, Pictured Cliffs Sandstone, Fruitland Formation, Kirtland Shale, and Ojo Alamo Sandstone. 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 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, the unnamed upper coal-bearing member (Beaumont and others, 1956), and the Hogback Mountain Tongue (Beaumont, 1971). The first three members were grouped together as the undifferentiated member for the purposes of this report only. The Hogback Mountain Tongue occurs higher in the section intertonguing with the La Ventana Tongue of the Cliff House Sandstone.

The undifferentiated member of the Menefee Formation averages 1,075 ft (328 m) in thickness and is composed predominantly of gray to gray-brown, carbonaceous to noncarbonaceous shale with plant fossils and limy nodules; thin gray to gray brown siltstone with plant fossils, and interbedded white to cream, glauconitic, micaceous sandstone with interstitial kaolinite; and random coal beds. A large portion of the Menefee Formation is deeper than 3,000 ft (914 m) (the overburden study limit) within the study area. Due to the regional dip of less than 1° to the east, the lower 600 to 850 ft (183-259 m) of the Menefee Formation have more than 3,000 ft (914 m) of overburden in the eastern half of the quadrangle (drill holes 20 and 7 [refer to CRO Plate 1]).

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 50 ft (15 m) thick and consists of white to light gray, friable, slightly micaceous sandstone, with thin, interbedded gray to gray-brown shale. Overlying the basal member is the La Ventana Tongue which interfingers with the Hogback Mountain Tongue of the Menefee. This member is an approximately 670 ft (204 m) thick sequence of gray, slightly micaceous, calcareous sandstone with traces of glauconite, and interbedded gray, micaceous shale and siltstone which becomes more common in the lower portion.

From the west, extending eastward to the center of the quadrangle, the informally-named Hogback Mountain Tongue of the Menefee Formation represents thick paludal sediments deposited shoreward of and intertonguing with the massive marine sand of the La Ventana Tongue. This member is distinguished as a major coal-bearing unit as a result of its coastal swamp depositional environment. The stratigraphic equivalence and complex intertonguing of the Hogback Mountain Tongue with the La Ventana Tongue make it distinguishable in the area of intertonguing. The thickness of the Hogback Mountain Tongue is approximately 230 ft (70 m) in the west central part of the area; however, it thins in an easterly direction pinching out into the La Ventana. Similar in lithology to the underlying undifferentiated member, it is composed of gray to gray-brown, carbonaceous shale with plant fossils and limey nodules; interbedded gray to gray-brown siltstone with plant fossils; interbedded white to cream, kaolinitic, glauconitic and micaceous sandstone; and random coal beds. Overlying this Menefee tongue are more La Ventana deposits across the entire quadrangle.

The marine Lewis Shale conformably overlies the Mesaverde Group. In contrast to the underlying Cliff House Sandstone, it is comprised of gray, calcareous, soft, micaceous shale with plant fossils; interbedded thin, gray siltstone with plant fossils, and interbedded thin, gray to gray-brown, micaceous sandstone with scattered grains of glauconite. The Lewis averages 550 ft (168 m) in thickness throughout the quadrangle. The upper contact is gradational with the overlying Pictured Cliffs Sandstone and, therefore, a distinct contact is difficult to determine.

The Pictured Cliffs Sandstone consists of approximately 230 ft (70 m) of gray, kaolinitic sandstone with scattered glauconite and feldspar grains, commonly interbedded with thin, gray to gray-brown shale near the base of the formation where it grades into the Lewis. The upper contact is more sharply defined than the basal contact. Intertonguing with the overlying Fruitland Formation results in minor variations in the formation top. Nevertheless, the Pictured Cliffs is a fairly consistent formation throughout the basin. The authors used the consistency and distinctive characteristics of the formation on geophysical logs to establish the top of the Pictured Cliffs as a lithologic datum for correlation of Fruitland coals.

Conformably overlying the Pictured Cliffs Sandstone is the Fruitland Formation, the major coal-bearing unit in the quadrangle. It is composed of about 420 ft (128 m) of gray to gray-green carbonaceous shale with local plant fossils; interbedded gray sandstone; and coal beds of varying thicknesses. The thickest and most continuous coal beds occur near the base of the formation, while discontinuous and lenticular coal beds are characteristic of the upper portion. The upper contact is gradational from nonmarine lower coastal plain deposits of the Fruitland to upper coastal or alluvial plain deposits of the Kirtland Shale (Molenaar, 1977). Many authors have utilized various criteria in establishing the upper contact but, in general, for the purposes of this report the uppermost coal in the Fruitland Formation was used (after Fassett and Hinds, 1971).

The freshwater deposits of the Kirtland Shale are the youngest Cretaceous strata in the San Juan Basin. These deposits average 875 ft (267 m) in thickness and consist of gray to gray-green siltstone with plant fossils and scattered pyrite crystals, and thin, interbedded cream to gray, slightly calcareous, micaceous sandstone. The formation has previously been divided into several members by various authors; however, for the purposes of this report it was not necessary to distinguish between the individual members. The Kirtland Shale is the oldest formation exposed in the area and crops out across the entire quadrangle except the southeastern corner.

Unconformably overlying the Upper Cretaceous strata is the Paleocene Ajo Alamo Sandstone, which is composed of white to tan, coarse-grained to conglomeratic sandstone. It is exposed in the southeast corner of the quadrangle.

Structure

The Kirtland SE quadrangle is in the Central Basin area (Kelley, 1950) of the major structural depression known as the San Juan Basin. The axis of the basin is about 15 miles (24 km) northeast of the quadrangle area near Farmington, New Mexico, and trends in an arcuate pattern across the northern portion of the Central Basin area (Baltz, 1967). Regional dip within the quadrangle is less than 1° to the east. Reeside (1924) measured the dip to the west of the area in Cottonwood Arroyo at 0° 30', and stated that the rocks to the east of the area are "nearly horizontal".

COAL GEOLOGY

Two coal zones (Menefee, Fruitland) and a coal bed (Fruitland 1) were identified in the subsurface of the quadrangle (CRO Plate 1). The Menefee Formation coal beds are grouped together as the Menefee coal zone (Me zone). These coals are generally noncorrelative, discontinuous, and less than reserve base thickness (5 ft [1.5 m]); exceptions are a 14-ft (4.3-m) and a 16-ft (4.9-m) coal bed in drill hole 2 (CRO Plate 3). Since these thicker coal beds are in a drill hole located outside the KRCRA, and the remaining coals of the Menefee are below reserve base thickness, derivative maps were not constructed.

Menefee Formation coals in the western portion of the San Juan Basin are considered subbituminous A to subbituminous B in rank. The rank of the coal has been determined on a moist, mineral-matter-free basis with calorific values averaging 10,837 Btu's per pound (25,207 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 (Bauer and Reeside, 1921; Dane, 1936). The "as-received" analyses indicate moisture content varying from 15.3 to 19.1 percent, ash content ranging from 6.6 to 22.7 percent, sulfur content less than 1.5 percent, and heating values averaging 9,515 Btu's per pound (22,132 kj/kg). Analyses of several Menefee coals are given in Table 1 (Shomaker, 1971).

The Fruitland 1 (Fr 1) coal bed is defined by the authors as the lower most coal of the Fruitland Formation; however, there may be a thin local coal bed (L) directly overlying the Pictured Cliffs Sandstone (CRO Plate 3). The remaining coals of the Fruitland Formation are grouped together as the Fruitland coal zone (Fr zone). These coals are noncorrelative, discontinuous, and less than reserve base thickness (5 ft [1.5 m]). Therefore, derivative maps were not constructed.

Fruitland Formation coals in the western part of the San Juan Basin are considered high volatile A 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 averaging 13,666 Btu's per pound (31,787 kj/kg) (Amer. Soc. for Testing and Materials, 1977). The coal is hard, brittle, and black

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			Approx. Depth Interval of Sample (ft.)	Form of Analysis	Proximate, percent					Heating Value (Btu)	Remarks
		Section	T.N.	R.W.			Mois-ture	Volatile matter	Fixed Carbon	Ash	Sulfur		
J-52142	Channel, Open Pit	SW¼ 27	25	17	-------------	A	17.4	35.5	40.5	6.6	0.6	10,410	Coal may be slightly weathered.
						B	----	43.0	49.1	7.9	0.7	12,600	
						C	----	46.7	53.3	----	0.8	13,680	
J-51245	Channel, Open Pit	NW¼ 9	22	14	-------------	A	19.1	33.4	40.7	6.8	0.9	9,280	Coal probably weathered
						B	----	41.3	50.3	8.4	1.2	11,470	
						C	----	45.1	54.9	---	1.3	12,520	
J-51246	Channel, Open Pit	NE¼ 2	22	16	-------------	A	15.3	33.9	42.7	8.1	1.0	10,310	
						B	----	40.1	50.3	9.6	1.1	12,180	
						C	----	44.3	55.7	---	1.3	13,470	
J-61758	Core Sample	SW¼ 36	25	17	-------------	A	15.8	31.6	39.6	13.0	1.2	9,700	
						B	----	37.5	47.1	15.4	1.4	11,510	
						C	----	44.3	55.7	----	1.6	13,610	
J-61759	Core Sample	SW¼ 36	25	17	-------------	A	17.4	31.5	40.4	10.7	1.4	9,730	
						B	----	38.1	48.9	13.0	1.7	11,780	
						C	----	43.8	56.2	----	2.0	13,540	
J-61757	Core Sample	SW¼ 2	23	17	-------------	A	18.5	27.7	31.1	22.7	0.5	7,660	
						B	----	34.0	38.2	27.8	0.7	9,410	
						C	----	47.2	52.8	----	0.9	13,030	

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.

with a bright luster. The coal readily slakes with exposure to weather; however, it stocks fairly well when protected (Bauer and Reeside, 1921; Dane, 1936). The "as-received" analyses indicate moisture content ranging from 2.6 to 9.5 percent, ash content averaging 14.2 percent, sulfur content varying from 0.6 to 1.8 percent, and heating values on the order of 11,560 Btu's per pound (26,889 kj/kg). Analyses of several Fruitland Formation coals are given in Table 2 (Fassett and Hinds, 1971).

Fruitland 1 Coal Bed

Although the Fruitland 1 coal bed has been correlated and mapped as a consistent horizon, it may actually be several different beds that are lithostratigraphically equivalent but not laterally continuous. The maps of the coal bed have not been extended into the Navajo Indian Reservation.

As illustrated by the structure contour map (CRO Plate 5), the coal bed dips less than 1° to the northeast. As a result of topography and dip, overburden (CRO Plate 6) varies from less than 1,200 ft (366 m) in the northwest to greater than 1,400 ft (427 m) in the southeast of the mapped area. The isopach map (CRO Plate 4) shows that the coal bed is greater than 15 ft (4.6 m) thick in the central portion of the map. The thickness decreases in all directions, and the coal is absent in the southern part of the quadrangle.

Chemical Analyses of the Fruitland 1 Coal Bed - Analyses of several Fruitland Formation coals from this quadrangle and the surrounding area are given in Table 2 (Fassett and Hinds, 1971).

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		
H-40806	Standard of Texas State No. 1	SW¼ 16	25	13	1,156-1,208	A	9.5	30.9	43.3	16.3	1.8	10,270	Abnormal moisture content may be due to inadequate drying of sample during preparation process.
						B	---	34.1	47.9	18.0	2.0	11,340	
						C	---	41.6	58.4	----	2.5	13,820	
H-3031	Southwest Production Cambell No. 2	NE¼ 26	27	12	1,900-1,910	A	2.6	41.2	40.5	15.7	0.6	11,810	
						B	---	42.3	41.6	16.1	0.6	12,120	
						C	---	50.4	49.6	----	0.7	14,440	
H-36175	Royal Development Ojo Amarillo No. 2	SW¼ 6	27	13	1,214-1,245	A	4.3	39.7	44.6	11.4	0.7	11,970	
						B	---	41.4	46.7	11.9	0.7	12,500	
						C	---	47.0	53.0	----	0.8	14,190	
H-24567	Sunray Mid-Continent Gallegos No. 122	NW¼ 18	28	12	1,305-1,315	A	3.0	38.9	44.4	13.7	0.6	12,010	
						B	---	40.1	45.8	14.1	0.6	12,390	
						C	---	46.8	53.2	----	0.7	14,430	
H-7225	Pan American Holder No. 7	NW¼ 16	28	13	1,705-1,715	A	4.1	39.4	42.8	13.7	0.6	11,740	
						B	---	41.1	44.6	14.3	0.6	12,240	
						C	---	47.9	52.1	----	0.7	14,290	

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

COAL RESOURCES

Coal resource data from oil and gas wells and pertinent publications were utilized in the construction of isopach and structure contour maps for this quadrangle. All of the coals studied in the Kirtland SE quadrangle are more than 1,000 ft (305 m) below the ground surface and, thus, have no outcrop or surface development potential.

The U.S. Geological Survey designated the Fruitland 1 coal bed for the determination of coal resources in this quadrangle. Coals of the Fruitland and Menefee zones were not evaluated because the thickness of the Fruitland zone coal beds is generally less than the reserve base thickness (5 ft [1.5 m]), and the Menefee and Fruitland zone coals are irregular, noncorrelative, and limited in areal extent.

For Reserve Base and Reserve calculations, the Fruitland 1 coal bed was areally divided into measured, indicated, and inferred resource categories (CRO Plate 7) according to criteria established in U.S. Geological Survey Bulletin 1450-B. Data for calculation of Reserve Base and Reserves for each category were obtained from the coal isopach (CRO Plate 4) and areal distribution maps (CRO Plate 7). The surface area of the isopached Fruitland 1 bed was measured by planimeter, for each category, in acres, then multiplied by the average isopached thickness of the coal bed and 1,800 short tons of coal per acre-foot (13,239 tons/hectare-meter), the conversion factor for bituminous coal. This yields the Reserve Base coal, in short tons, for the Fruitland 1 coal bed.

In order to calculate Reserves, a recovery factor of 50 percent was applied to the Reserve Base tonnages for underground coal. However, in areas of underground coal exceeding 12 ft (3.7 m) in thickness, the Reserves (mineable coal) were calculated on the basis of a maximum coal bed thickness of 12 ft (3.7 m) which represents the maximum economically mineable thickness for a single coal bed in this area by current underground mining technology.

Reserve Base and Reserve values for measured, indicated, and inferred categories of coal for the Fruitland 1 coal bed are shown on CRO Plate 7, and are rounded to the nearest hundredth of a million short tons. The total coal Reserve Base, by section, is shown on CRO Plate 2 and totals approximately 40.6 million short tons (36.8 million metric tons).

The coal development potential for the Fruitland 1 bed is calculated in a manner similar to the Reserve Base, from planimetered measurements, in acres, for areas of high, moderate, and low potential for subsurface mining methods. The Kirtland SE quadrangle has development potential for subsurface mining methods only (CDP Plate 8).

COAL DEVELOPMENT POTENTIAL

Coal beds of 5 ft (1.5 m) or more in thickness which are overlain by 200 to 3,000 ft (61-914 m) of overburden are considered to have potential for underground mining, and are designated as having high, moderate, or low development potential according to the overburden thickness: 200 to 1,000 ft (61-305 m), high; 1,000 to 2,000 ft (360-610 m), moderate; and 2,000 to 3,000 ft (610-914 m), low. Table 3 summarizes the coal development potential, in short tons, for underground coal of the Fruitland 1 coal bed.

TABLE 3

COAL RESOURCE DATA FOR UNDERGROUND MINING METHODS FOR FEDERAL COAL LANDS (in short tons) IN THE KIRTLAND SE QUADRANGLE, SAN JUAN COUNTY, NEW MEXICO

(To convert short tons to metric tons, multiply by 0.9072)

Coal Bed	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Fruitland 1	--	40,620,000	--	40,620,000
TOTAL	--	40,620,000	--	40,620,000

Development Potential for Surface Mining Methods

All coals studied in the northeast quarter of the Kirtland SE quadrangle occur more than 1,000 ft (305 m) below the ground surface and, thus, they have no coal development potential for surface mining methods.

Development Potential for Subsurface Mining Methods

Underground coal of the Fruitland 1 coal bed has moderate development potential in the northeast, east-central and extreme southeastern parts of the quadrangle. The coal bed thickness in these areas varies from 5 to 14 ft (1.5-4.3 m) (CRO Plate 4), and the overburden thickness ranges from approximately 1,200 ft (366 m) in the east to more than 1,400 ft (427 m) in the southeast (CRO Plate 6).

The northeast and east-central parts of the area have unknown development potential where the Fruitland 1 coal bed is less than the reserve base thickness of 5 ft (1.5 m). The Fruitland 1 is not present in the southeastern part of the quadrangle; therefore, this area has no development potential for subsurface mining methods.

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