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

[Report includes 16 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 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 quadrangle, San Juan 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 Kirtland 7 1/2-minute quadrangle is located in northwestern San Juan County, New Mexico. The area is approximately 5 miles (8 km) west of Farmington, New Mexico. The Navajo Indian Reservation occupies the area south of the San Juan River.

Accessibility

The Kirtland quadrangle is accessible from the north by New Mexico State Route 550 and Route 489, both of which cross the northern part of the area. From these two routes light-duty roads provide access to other parts of the quadrangle. The Atchison, Topeka, and Santa Fe Railway operates a route approximately 88 miles (142 km) south of the area at Gallup, New Mexico.

Physiography

This quadrangle is in the northwestern portion of the Central Basin area (Kelley, 1950) of the structural depression known as the San Juan Basin. Elevations range from 5,130 ft (1,564 m) in the San Juan River Valley to 5,985 ft (1,824 m) in the east-central portion of the area. The San Juan River flows westerly across the northern portion of the area and is bounded by cliffs on both banks. Amarillo Canyon, a large steep-walled tributary canyon, trends southeast-northwest through the quadrangle area. The majority of the area south of the river has low relief and is characterized by occasional sand dunes and many small arroyos and washes.

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 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 may occur from November to April.

Land Status

Approximately 23 percent of the quadrangle is in the northwestern portion of the San Juan Basin Known Recoverable Coal Resource Area. The Federal Government owns the coal rights for approximately 78 percent of the KRCRA land within the quadrangle as shown on Plate 2 of the Coal Resource Occurrence Maps. No Federal coal leases occur in the quadrangle.

GENERAL GEOLOGY

Previous Work

Reeside (1924) mapped the various formations within the quadrangle on a scale of 1:250,000 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. Subsequently, a thin sand was deposited over the Menefee Formation. Several hundred feet of beach sands of the La Ventana Tongue (Cliff House Sandstone) were then deposited over the basal Cliff House sand. The marine facies which developed northeast of the strandline as it moved to the southwest is the Lewis Shale. This thick marine sequence, which thins to the southwest, overlies the Cliff House Sandstone and marks the last advance of the Late Cretaceous sea.

Depositional evidence of the final retreat of the Late Cretaceous sea is the nearshore regressive Pictured Cliffs Sandstone. Southwest (shoreward) of the beach deposits, swamps, which were dissected by streams, accumulated organic matter which 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 north-south strandline in this part of the basin and their discontinuity perpendicular to it to the east. The less continuous Fruitland coals appear to be noncorrelative but are stratigraphically 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 this 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 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. 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 erosional processes to the present time. A significant amount of erosion has occurred, as indicated by the removal of the San Jose Formation and most 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: (two of the three formations of the Mesaverde Group) the Menefee Formation and Cliff House Sandstone; Lewis Shale, Pictured Cliffs Sandstone, Fruitland Formation, Kirtland Shale, Ojo Alamo Sandstone, and Nacimiento 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 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 upper coal-bearing member (Beaumont and others, 1956). These three members were grouped together as undifferentiated Menefee Formation for the purposes of this report only.

The Menefee Formation consists primarily of gray, carbonaceous to noncarbonaceous shale, cream to light gray sandstone, and lenticular coal beds. It has a total thickness of approximately 900 ft (274 m). The depth of the formation is a result of the gentle regional dip of 1° to the east (Reeside, 1924). In the east-central portion of the quadrangle, the formation has more than 3,000 ft (914 m) of overburden (the study limit). To the northwest (in drill hole 16 in section 12, T. 29 N., R. 15 W.) the entire formation is less than 3,000 ft (914 m) deep.

The Cliff House Sandstone sequence conformably overlies the Menefee Formation. A thin, basal sand referred to as "the Cliff House Sandstone" by

Fassett (1977) correlates with the thin, undifferentiated Cliff House Sandstone to the northeast. It is about 65 ft (20 m) thick and consists of cream to light gray, slightly calcareous sandstone.

Overlying the basal member is the La Ventana Tongue. This member consists of about 615 ft (187 m) of gray, silty shale, interbedded gray, micaceous, locally calcareous siltstone, and cream to light gray, glauconitic sandstone.

The marine Lewis Shale conformably overlies the Mesaverde Group. In contrast to the underlying Cliff House Sandstone, it is predominantly gray to gray-green, slightly calcareous shale with plant fossils and interbedded sandstone. The thickness of the Lewis Shale averages 715 ft (218 m) in this area. The upper contact is gradational with the overlying Pictured Cliffs Sandstone and, therefore, a definite and consistent contact is difficult to establish.

The Pictured Cliffs Sandstone consists of about 220 ft (67 m) of white to cream sandstone commonly interbedded with gray shale near the base of the formation, where it grades into the Lewis. The upper contact is more sharply defined than the basal contact, even though intertonguing with the overlying Fruitland Formation results in minor variations in the formation top and the occurrence of local Fruitland coal beds in the upper portion. Because the Pictured Cliffs Sandstone is widespread throughout the basin and has a distinctive character on geophysical logs, the authors have used the top of the formation as a lithologic datum for correlation of Fruitland coals.

The Fruitland Formation is the major coal-bearing unit in the quadrangle. It averages 285 ft (87 m) of gray, carbonaceous shale, 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 coals 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).

The freshwater deposits of the Kirtland Shale average 495 ft (151 m) in thickness and are composed of light gray to green, locally sandy siltstone with occasional plant fossils, interbedded gray sandstone, and interbedded shale near the base of the unit. The formation has previously been divided into several members by various authors; however, for the purpose of this report it was not necessary to distinguish between the individual members.

Unconformably overlying the Upper Cretaceous rocks is the Paleocene Ojo Alamo Sandstone. It consists of about 180 ft (55 m) of white to gray, very coarse-grained to conglomeratic, arkosic, calcareous sandstone with interstitial kaolinite and thin interbedded siltstone.

Several hundred feet of the nonmarine Nacimiento Formation have been removed from the area. In contrast to the underlying Ojo Alamo, the Nacimiento Formation is primarily light green to brown siltstone with plant fossils, interbedded, white, arkosic, calcareous, friable sandstone with interstitial kaolinite.

Surface exposures in the quadrangle are influenced by the regional dip to the east, with the strata becoming younger in an easterly direction. The oldest unit exposed is the Fruitland Formation which crops out in the northwestern part of the area. The Kirtland Shale is exposed across most of the quadrangle. Both the Ojo Alamo and the basal beds of the Nacimiento, the youngest formation in the area, crop out in the east-central part of the area.

Structure

The Kirtland quadrangle is in the Central Basin area (Kelley, 1950) of the major structural depression known as the San Juan Basin. The western end of the axis of the basin is about 8 miles (13 km) northeast of the quadrangle area and trends eastward in an arcuate pattern across the northern portion of the Central Basin area (Baltz, 1967). Regional dip measured to the east and west of the quadrangle is 1° to the east (Reeside, 1924).

COAL GEOLOGY

Two coal zones (Menefee, Fruitland) and three coal beds (Menefee 5, Fruitland 1, Fruitland 2) were identified in the subsurface of this quadrangle (CRO Plate 1). The coals of the Menefee Formation have been designated as the Menefee coal zone (Me zone). These coals are generally noncorrelative, discontinuous, and less than reserve base thickness (5 ft [1.5 m]). Therefore, derivative maps were not constructed.

In the upper portion of the Menefee Formation there is a correlative coal which has been informally designated by the authors as the Menefee 5 (Me 5) coal bed. Although this coal bed has been correlated and mapped as a consistent horizon (extending into portions of the Fruitland and Waterflow 7 1/2-minute quadrangles), it may actually be several different coal beds which are lithostratigraphically equivalent but not laterally continuous.

Menefee Formation coals in the northwestern part of the San Juan Basin are considered high volatile C bituminous in rank, although they vary from borderline subbituminous A - high volatile C bituminous to high volatile B bituminous. The rank has been determined on a moist, mineral-matter-free basis with calorific values averaging 12,563 Btu's per pound (29,222 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 moisture content varying from 5.6 to 11.3 percent, ash content ranging from 3.1 to 6.3 percent, sulfur content less than 1 percent, and heating values on the order of 11,993 Btu's per pound (27,896 kj/kg). Analyses of several Menefee coals are given in Table 1 (Bauer and Reeside, 1921; Hayes and Zapp, 1955; Shomaker and Whyte, 1977).

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 (CRO Plate 3). The Fruitland 2 (Fr 2) coal bed is above the Fruitland 1; the two beds are separated by a rock interval varying from 6 to 20 ft (1.8-6.1 m). Although these coal beds are correlated and mapped as consistent horizons, they may actually be several different coal beds that are lithostratigraphically equivalent but not laterally continuous.

The remaining coals of the Fruitland Formation have been grouped together and designated as the Fruitland coal zone (Fr zone). These coals are generally noncorrelative, discontinuous, and less than reserve base thickness (5 ft [1.5 m]); an exception is a 5-ft (1.5-m) coal in drill hole 5. Due to these characteristics, derivative maps were not constructed.

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-58561	Merrion & Bayless #1, Union	9	29	15	2,494-2,500	A	5.6	40.4	47.7	6.3	0.8	12,740	
						B	----	42.7	50.7	6.6	0.9	13,490	
						C	----	45.8	54.2	----	1.0	14,450	
17750	Shiprock School Mine(?) (100 ft from entry) (Government Mine)	SW¼ 21	30	16	----------	A	10.6	36.7	49.6	3.1	0.64	11,010	
						B	----	41.1	55.4	3.5	0.72	12,310	
						C	----	42.6	57.4	----	0.75	12,750	
A-46364	Shiprock School Mine (250 ft from entry)	21	30	16	----------	A	9.8	38.7	46.5	5.0	----	11,870	
						B	----	42.9	51.5	5.6	----	13,170	
						C	----	45.4	54.6	----	1.5	13,940	
29006	Shiprock School Mine (350 ft from entry) (Government Mine)	SW¼ 21	30	16	----------	A	10.1	39.9	45.8	4.2	0.85	12,010	
						B	----	44.4	50.9	4.7	0.95	13,370	
						C	----	46.6	53.4	----	1.00	14,020	
A-46365	Joe Duncan Mine (150 ft from entry)	21	30	16	----------	A	10.5	39.1	47.2	3.2	----	12,240	
						B	----	43.7	52.7	3.6	----	13,670	
						C	----	45.3	54.7	----	1.0	14,180	
C-31312	Davidson Mine (tipple)	22	30	16	----------	A	11.3	39.3	46.0	3.4	----	12,090	
						B	----	44.3	51.9	3.8	----	13,630	
						C	----	46.1	53.9	----	0.8	14,170	

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.

Fruitland Formation coals in the northwestern part of the San Juan Basin are considered high volatile C to high volatile B bituminous in rank. The rank has been determined on a moist, mineral-matter-free basis with calorific values averaging 12,900 Btu's per pound (30,005 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 moisture content varying from 4.1 to 11.6 percent, ash content ranging from 8.3 to 15.3 percent, sulfur content varying from 0.60 to 2.32 percent, and heating values on the order of 10,530 to 12,056 Btu's per pound (24,493-28,042 kj/kg). Analyses of several Fruitland Formation coals are given in Table 2 (Bauer and Reeside, 1921; Beach and Jentgen, 1978; Fassett and Hinds, 1971; Hayes and Zapp, 1955).

Menefee 5 Coal Bed

The coal bed has been mapped only in areas outside the Navajo Indian Reservation. As indicated by the structure contour map (CRO Plate 5) the coal bed dips less than 1° to the east. The overburden (CRO Plate 6) varies, due to topography and dip, from less than 2,000 ft (610 m) in the northwest, within the San Juan River Valley, to greater than 3,000 ft (914 m) in the east. The isopach map (CRO Plate 4) shows that the coal bed has a thickness of greater than 10 ft (3.0 m) in the north-central part of the quadrangle. The thickness decreases in all directions, and the coal is absent in portions of the northwest, northeast, and southeast.

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 Section	T.N.	R.W.	Approx. Depth Interval of Sample (ft.)	Form of Analysis	Proximate, percent Moisture	Volatile matter	Fixed Carbon	Ash	Sulfur	Heating Value (Btu)	Remarks
H-4051	Humble Oil & Gas Humble No. L-9	SE¼ 36	29	14	1,490-1,495	A	4.1	40.0	40.6	15.3	0.7	11,600	
						B	——	41.7	42.3	16.0	0.7	12,100	
						C	——	49.7	50.3	——	0.9	14,400	
22509	L.W. Henderickson (Smous) mine	SW¼ 3	29	15	————	A	10.5	38.6	41.7	9.2	0.60	11,210	
						B	——	43.1	46.6	10.3	0.67	12,530	
						C	——	48.0	52.0	——	0.75	13,970	
2464	Black Diamond Mine	SW¼ 4	29	15	————	A	9.9	38.4	41.5	10.2	0.64	11,300	
						B	——	42.7	46.0	11.3	0.71	12,540	
						C	——	48.1	51.9	——	0.80	14,140	
22508	Black Diamond Mine	SW¼ 4	29	15	————	A	11.6	38.6	39.9	9.9	0.60	10,990	
						B	——	43.6	45.2	11.2	0.68	12,430	
						C	——	49.2	50.8	——	0.77	14,000	
B-61218	Stalling mine (tipple)	4	29	15	————	A	10.1	39.1	41.7	9.1	——	11,460	
						B	——	43.5	46.3	10.2	——	12,750	
						C	——	48.4	51.6	——	——	14,200	
29026	Prospect Drift	NW¼ 16	30	15	————	A	9.6	37.2	40.5	12.7	2.36	10,530	
						B	——	41.2	44.8	14.0	2.61	11,660	
						C	——	47.9	52.1	——	3.04	13,560	
H-78945	N.M.P.S.C.C. Core Hole No. 7	21	30	15	69-70	A	5.6	39.7	43.3	11.4	0.7	11,850	Sample from core - not floated in CCl_4. A is air dried analysis
						B	——	42.0	46.0	12.0	0.7	12,540	
						C	——	47.8	52.2	——	0.8	14,260	
Number not available	Open File Report 78-960 drill hole SJ 23-4	23	30	15	589-590	A	4.6	42.6	41.1	11.7	0.6	12,056	
						B	——	44.7	43.1	12.2	0.6	12,639	
						C	——	50.9	49.1	——	0.7	14,402	
29025	Marcelius Mine	SW¼ 28	30	15	————	A	8.8	41.7	41.2	8.3	0.62	11,660	
						B	——	45.7	45.2	9.1	0.68	12,770	
						C	——	50.3	49.7	——	0.75	14,060	

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.

Chemical Analyses of the Menefee 5 Coal Bed - Analyses of several coals of the Menefee Formation from the area surrounding this quadrangle are given in Table 1 (Bauer and Reeside, 1921; Hayes and Zapp, 1955; Shomaker and Whyte, 1977).

Fruitland 1 Coal Bed

The coal bed has been mapped only in areas outside the Navajo Indian Reservation. The structure contour map (CRO Plate 9) shows that the coal bed dips less than 1° to the east. Due to topography and dip, the overburden (CRO Plate 10) ranges from less than 400 ft (122 m) in the northwest, within the San Juan River Valley, to greater than 1,400 feet (427 m) in the east. The isopach map (CRO Plate 8) indicates that the coal bed has a thickness of greater than 10 ft (3.0 m) in the north-central part of the quadrangle. The thickness decreases in all directions, and the coal is absent in the east-central part of the quadrangle.

Chemical Analyses of the Fruitland 1 Coal Bed - Analyses of several coals of the Fruitland Formation from the area surrounding this quadrangle are given in Table 2 (Bauer and Reeside, 1921; Beach and Jentgen, 1978; Fassett and Hinds, 1971; Hayes and Zapp, 1955).

Fruitland 2 Coal Bed

The coal bed has been mapped only in areas outside the Navajo Indian Reservation. As shown by the structure contour map (CRO Plate 13), the coal bed dips less than 1° to the east. As a result of topography and dip, overburden (CRO Plate 14) varies from less than 400 ft (122 m) in the northwest, within the San Juan River Valley, to greater than 1,400 ft (427 m) in the east. The isopach map (CRO Plate 12) shows that the coal bed has a thickness of greater than 5 ft (1.5 m) in the northeast and east. The thickness decreases in all directions, and the coal is absent in the southeast and northwest parts of the quadrangle.

Chemical Analyses of the Fruitland 2 Coal Bed - Analyses of several coals of the Fruitland Formation from the area surrounding this quadrangle are given in Table 2 (Bauer and Reeside, 1921; Beach and Jentgen, 1978; Fassett and Hinds, 1971; Hayes and Zapp, 1955).

COAL RESOURCES

Coal resource data from oil and gas wells and pertinent publications were utilized in the construction of isopach and structure contour maps of coals in this quadrangle. All of the coals studied in the Kirtland quadrangle are more than 200 ft (61 m) below the ground surface and, thus, have no outcrop or surface development potential.

The U.S. Geological Survey designated the Menefee 5, Fruitland 1, and Fruitland 2 coal beds for the determination of coal resources in this quadrangle. Coals of the Fruitland and Menefee zones were not evaluated because they are discontinuous, noncorrelative, and generally less than the reserve base thickness (5 ft [1.5 m]).

For Reserve Base and Reserve calculations, each coal bed was areally divided into measured, indicated, and inferred resource categories (CRO Plates 7, 11, and 15) 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 respective coal isopach (CRO Plates 4, 8, and 12) and areal distribution maps (CRO Plates 7, 11, and 15) for each coal bed. The surface area of each isopached bed was measured by planimeter, in acres, for each category, then multiplied by both 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 each coal bed. In order to calculate Reserves, a recovery factor of 50 percent was applied to the Reserve Base tonnages for underground coal.

Reserve Base and Reserve values for measured, indicated, and inferred categories of coal for the Menefee 5, Fruitland 1, and Fruitland 2 beds are shown on CRO Plates 7, 11, and 15, respectively, 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 74.3 million short tons (67.4 million metric tons).

The coal development potential for each bed was 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 quadrangle has development potential for subsurface mining methods only (CDP Plate 16).

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 (305-610 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 Menefee 5, Fruitland 1, and Fruitland 2 coal beds.

Development Potential for Surface Mining Methods

All coals studied in the Kirtland quadrangle occur more than 200 ft (61 m) below the ground surface and, thus, they have no development potential for surface mining methods.

Development Potential for Subsurface Mining Methods

Underground coal of the Fruitland 1 and Fruitland 2 coal beds has high development potential in the north-central part of the quadrangle (CDP Plate 16). Coal bed thickness ranges from 5 to 12 ft (1.5-3.7 m) for the Fruitland 1 (CRO Plate 8), and overburden thickness increases from 400 ft (122 m) in the northwest to 1,000 ft (610 m) in the north-central area (CRO Plate 10). In this area the Fruitland 2 coal bed has a thickness of 5 to 6 ft (1.5-1.8 m) (CRO Plate 12) and an overburden thickness of 750 to 1,000 ft (229-305 m) (CRO Plate 14). The northeastern part of the quadrangle has moderate potential for the Fruitland 1 and Fruitland 2 coal beds, where the thickness of each bed is approximately 5 ft (1.5 m), and the overburden is more than 1,000 ft (305 m) thick. The Fruitland 2 also has moderate

TABLE 3

COAL RESOURCE DATA FOR UNDERGROUND MINING METHODS FOR FEDERAL COAL LANDS (in short tons) IN THE KIRTLAND 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 2	3,900,000	7,980,000	--	11,880,000
Fruitland 1	43,300,000	7,940,000	--	51,240,000
Menefee	--	10,000	11,160,000	11,170,000
TOTAL	47,200,000	15,930,000	11,160,000	74,290,000

potential in the east-central part of the KRCRA. The coal bed thickness in this area varies from 5 to 6 ft (1.5-1.8 m), and the overburden is approximately 1,400 ft (427 m) thick.

Underground coal of the Menefee 5 coal bed has low development potential in the north-central and east-central parts of the quadrangle (CDP Plate 16) where the coal bed thickness varies from 5 to 10 ft (1.5-3.0 m) (CRO Plate 4), and the overburden ranges in thickness from 2,300 ft (710 m) in the north-central to 3,000 ft (914 m) in the east-central (CRO Plate 6). The remainder of the quadrangle area in the northwest, northeast, and southeast has unknown development potential and includes areas where the Menefee 5, Fruitland 1, and Fruitland 2 coal beds are less than the reserve base thickness of 5 ft (1.5 m) and areas outside the 3,000-foot (914-m) overburden study limit.

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