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COAL RESOURCE OCCURRENCE MAPS AND COAL DEVELOPMENT POTENTIAL MAP OF THE MULE DAM QUADRANGLE, SANDOVAL COUNTY, NEW MEXICO

[Report includes 14 plates]

by

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MULE DAM 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 Mule Dam 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 Mule Dam 7 1/2-minute quadrangle is in northwestern Sandoval County, New Mexico. The southwestern corner of the Jicarilla Apache Indian Reservation is in the northeast part of the quadrangle. The area is approximately 60 miles (97 km) southeast of Farmington and 78 miles (126 km) northeast of Gallup, New Mexico.

Accessibility

The area is accesible from the north by a light-duty road which extends southward from New Mexico State Route 44. Numerous unimproved dirt roads provide further access to the quadrangle. The Atchison, Topeka, and Santa Fe Railway operates a route which passes through Gallup, 78 miles (126 km) to the south of the area.

Physiography

The Mule Dam quadrangle is in the southern portion of the Central Basin area (Kelley, 1950) of the larger structural depression known as the San Juan Basin. It also lies within the Largo Plains and the Penistaja Cuestas physiographic sectors, as described by Baltz (1967). Elevations range from 6,740 ft (2,054 m) in the Canada Corrales to 7,460 ft (2,274 m) in the northeast. Sisnathyel Mesa is a prominent, highly dissected mesa in the northeast portion of the area. To the south, the topography is characterized by gentle slopes, broken by south-facing cuestas. Drainage in the area is provided mainly by Canada Alamos in the west, and by Canada Corrales in the south. The Continental Divide crosses the southeastern corner of the quadrangle.

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 is received in July and August as intense afternoon thundershowers. Annual temperatures in the basin range from below 0°F (-18°C) to over 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

Ninety percent of the quadrangle is in the southeastern portion of the San Juan Basin Known Recoverable Coal Resources Area. The Federal Government owns the coal rights for 76 percent of the KRCRA within the quadrangle as shown on Plate 2 of the Coal Resource Occurrence Maps. No Federal coal leases occur in the area.

GENERAL GEOLOGY

Previous Work

A 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. Subsequently, several hundred feet of northwest-southeast trending beach sands of the La Ventana Tongue (Cliff House Sandstone) were deposited over the Menefee.

Onlap continued as the sea moved southwestward across the basin area. The transgressing northwest-southeast-trending strandline is represented in the lithologic record by the Chacra Tongue (informal name of local usage) of the Cliff House Sandstone. It is the seaward edge of the Chacra which overlies the La Ventana in this 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, swamps accumulated organic matter which became coals of the Fruitland Formation. Again, deposition of organic material was influenced by the strandline as shown by the continuity of the coal beds parallel to the northwest-southeast strandline and 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 freshwater 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.

Stratigraphy

The formations studied in this quadrangle range from Late Cretaceous to Eocene in age. They are, in order from oldest to youngest:

(two of the three formations of the Mesaverde Group), the Menefee Formation (undifferentiated) and the Cliff House Sandstone; the Lewis Shale, Pictured Cliffs Sandstone, Fruitland Formation, 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 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 950 to 1,000 ft (290-305 m) thick and is predominantly a gray carbonaceous to noncarbonaceous shale, interbedded gray sandstone, and random coal beds. An incomplete section of the Menefee Formation is present above the 3,000-foot (914-m) overburden study limit within the quadrangle area. Due to regional dip of 1° to 2° to the north-northeast, the entire Menefee Formation has more than 3,000 ft of overburden in the northern portion of the quadrangle as shown in drill hole 8 (refer to CRO Plate 1). However, the formation is higher in elevation to the southeast, such that in drill hole 5 (CRO Plate 1) 860 ft (262 m) of the Menefee Formation are above the 3,000-ft (914 m) overburden study limit.

Conformably overlying the Menefee Formation is the basal member of the Cliff House Sandstone, the La Ventana Tongue. The La Ventana represents a massive, 700-ft (213-m) thick sequence of white to cream, poorly indurated, calcareous sandstone, with interbedded thin shale and siltstone.

The uppermost member of the Cliff House Sandstone, the Chacra Tongue (informal name of local usage), is about 290 ft (88 m) thick and overlies the La Ventana Tongue. The Chacra Tongue within the quadrangle represents a lithology transitional from the massive sandstone at the Chacra type section to the south to the marine deposits of the Lewis Shale. The Chacra in this area is composed of thin, silty, argillaceous sandstone beds with interbedded shale and siltstone lenses.

The marine Lewis Shale conformably overlies the Mesaverde Group. In contrast to the underlying Cliff House Sandstone, it is predominantly a gray, fissile, calcareous shale with plant fossils and interbedded thin sandstone. The Lewis averages 230 ft (70 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 cream to light brown, poorly indurated, calcareous sandstone, interbedded with thin, 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 formational top and the occurrence of local Fruitland coals. 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 of the unit as a lithologic datum for correlation of the overlying Fruitland coals.

The Fruitland Formation is the major coal-bearing unit in the quadrangle. It is composed of approximately 200 ft (61 m) of light brown to gray, carbonaceous shale with local sands and plant fossils, interbedded 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). Authors have used various criteria in establishing the upper contact but, in general, for the purposes of this report, the uppermost coal was chosen (after Fassett and Hinds, 1971).

The freshwater deposits of the Kirtland shale are the youngest Cretaceous strata in the area. They average 240 ft (73 m) thick and consist of gray to green siltstone with local plant fossils and interbedded thin 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.

Unconformably overlying the Upper Cretaceous deposits is the Paleocene Ojo Alamo Sandstone which is about 150 ft (46 m) of white to gray, arkosic, slightly calcareous, locally conglomeratic sandstone with thin, interbedded siltstone and shale. The Ojo Alamo crops out in the extreme southwestern portion of the quadrangle.

The floodplain deposits of the Nacimiento Formation conformably overlie the alluvial plain deposits of the Ojo Alamo. Approximately 790 ft (241 m) of the Nacimiento are present, consisting predominantly of light gray, arkosic, poorly indurated, locally conglomeratic sandstone, and interbedded shale and siltstone. The Nacimiento crops out across the southwestern two-thirds of the quadrangle area.

The Eocene San Jose Formation unconformably overlies the Paleocene Nacimiento Formation. It is composed of buff to yellow, fine- to coarse-grained, locally conglomeratic, arkosic sandstone and interbedded brown to gray shale. The San Jose is the youngest formation in the quadrangle and crops out in the northeastern corner of the quadrangle area.

Structure

The axis of the San Juan Basin is about 27 miles (43 km) northeast of the Mule Dam quadrangle and trends in an arcuate pattern across the northern portion of the Central Basin (Baltz, 1967). Regional dip within the quadrangle is approximately 1° to 2° to the north-northeast.

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 were 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 columns and correlated based upon their position relative to the datum.

Two coal zones (Menefee and Fruitland) and a coal bed (Fruitland 1) were identified and mapped in the subsurface of this quadrangle. The Menefee coals are designated and mapped as the Menefee coal zone (Me zone). These coals are random, noncorrelative, and generally less than the reserve base thickness of 5 ft (1.5 m) as set by the U.S. Geological Survey; exceptions are an 8-ft (2.4-m) bed in drill hole 4, two 6-ft (1.8 m) beds in drill hole 5, and a 5-ft (1.5 m) bed in drill hole 10 (CRO Plate 1). Over most of the quadrangle area, the base of the Menefee Formation is deeper than the 3,000-ft (914-m) study limit, and the Menefee zone is, therefore, incomplete.

No published analyses of the quality of Menefee Formation coals are available for this quadrangle. However, information on the quality of coals from surrounding areas is assumed to be similar to that of the coals from this quadrangle. There is no apparent consistent difference between the various Menefee Formation coals. In the southern part of the San Juan Basin the coals vary from subbituminous B to high volatile C bituminous. The rank is 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 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 about 12.1 to 20.0 percent, sulfur content ranging from 0.6 to 2.8 percent, ash content ranging from 4.9 to 9.9 percent, and heating values on the order of 10,325 Btu's per pound (24,016 kj/kg) (Bauer and Reeside, 1921; Dane, 1936; Lease, 1971; Shomaker, 1971).

The Pictured Cliffs Sandstone occasionally contains random Fruitland coal beds in the upper portion where the formations interfinger. They have been designated as local (L) beds because they are random, discontinuous, and generally less than the reserve base thickness of 5 ft (1.5 m).

The Fruitland 1 (Fr 1) coal bed is defined by the authors as being the lowermost coal of the Fruitland Formation; it is generally directly above the Pictured Cliffs Sandstone. The remaining Fruitland coals are designated as the Fruitland coal zone (Fr zone). These coals are generally noncorrelative and are less than the reserve base thickness of 5 ft (1.5 m); an exception is a 5-ft (1.5-m) coal bed in drill hole 5 (CRO Plate 1).

Fruitland Formation coal beds in the southern part of the San Juan Basin are considered high volatile C bituminous in rank, although they range from subbituminous A to high volatile B bituminous. The rank is determined on a moist, mineral-matter-free basis with calorific values ranging from 11,358 to 13,442 Btu's per pound (26,419-31,266 kj/kg) (Amer. Soc. for Testing Materials, 1977). The coal is hard, brittle and black with a bright luster. It readily slakes with exposure to weather; however, it stocks fairly well when protected. The "as received" analyses indicate moisture content varying from 5.8 to 13.48 percent, ash content ranging from 5.8 to

32.68 percent, sulfur content less than 1 percent, and heating values on the order of 9,358 Btu's per pound (21,767 kj/kg) (Dane, 1936; Fassett and Hinds, 1971; Shomaker and Lease, 1971).

Menefee Coal Zone

The Menefee coal zone extends from the top of the La Ventana Tongue of the Cliff House Sandstone to the base of the Menefee Formation. The La Ventana Tongue is contemporaneous with the coal-bearing Hogback Mountain Tongue of the Menefee Formation (Beaumont, 1971) in other quadrangles and exhibits a distinctive character on geophysical logs. Therefore, it portrays the upper boundary of the coal-bearing Menefee zone more consistently than the randomly occurring uppermost Menefee coal. The correlation of the top of the La Ventana with the top of the Menefee zone was established for use in the surrounding quadrangles and has been continued into this quadrangle for the purpose of consistency; however, the Hogback Mountain Tongue is indistinguishable in this area.

The structure contour map of the Menefee coal zone (CRO Plate 5) was constructed using the top of the La Ventana Tongue. As illustrated by this map, the coal zone dips approximately 1° to the northeast. As a result of topography and dip, overburden (CRO Plate 6) varies from less than 1,300 ft (396 m) in the southwest to more than 2,600 ft (792 m) in the northeast. Also shown on CRO Plate 6 is the total amount of interburden which is the noncoal portion of the coal zone. The interburden thickness varies from less than 1,500 ft (457 m) to more than 1,700 ft (518 m). These 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. The isopach map (CRO

Plate 4) illustrates the total combined thickness of the individual coal beds of Menefee zone. The total thickness varies from less than 5 ft (1.5 m) in the eastern and central parts to more than 25 ft (7.6 m) in the southwest part of the quadrangle. This difference is mainly due to the incomplete thickness of the Menefee Formation in the northern part of the quadrangle where the base of the Menefee is below the 3,000-foot (914-m) overburden study limit.

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 area. Analyses of several Menefee Formation coals are included in reports by Lease (1971) and Shomaker (1971). The results of these analyses are given in Table 1.

Fruitland 1 Coal Bed

As illustrated by the structure contour map (CRO Plate 8), the coal bed dips approximately 1° to the northeast. Due to topography and dip, overburden (CRO Plate 9) varies from less than 600 ft (183 m) in the southwest to over 1,800 ft (549 m) in the northeast. The isopach map (CRO Plate 7) shows the coal bed is greater than 5 ft (1.5 m) thick in the east-central, northeast, and southwest parts of the quadrangle. The thickness decreases from these areas, and the coal is absent in the north-central and a small portion of the southwest.

Chemical Analyses of the Fruitland 1 Coal Bed - Analyses of several Fruitland Formation coal beds from the Mule Dam 7 1/2-minute quadrangle and surrounding area were published by Fassett and Hinds (1971) and Shomaker and Lease (1971). The results of these analyses are given in Table 2.

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: Moisture	Proximate, percent: Volatile matter	Proximate, percent: Fixed Carbon	Proximate, percent: Ash	Proximate, percent: Sulfur	Heating Value (Btu)	Remarks
A47085	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	
A46366	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	
A47084	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	
A60026	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	
A64268	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	
A46367	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	
3823	Mine Sample	14	20	11	----	A	17.5	32.9	41.2	8.4	2.2	----	
23004	Outcrop Sample	14	20	11	----	A	14.4	34.8	42.3	7.5	1.5	10,220	
						B	----	40.7	50.5	8.8	1.8	11,940	

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

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		
I-53220	Pit Sample	SE¼ 9	19	5	----	A	5.8	35.8	31.0	27.4	0.6	9,450	
						B	-----	38.1	32.8	29.1	0.6	10,040	
						C	-----	53.7	46.3	----	0.9	14,160	
*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	
*TH-54419	Cuttings Sample	----	19	6	----	A	12.38	28.21	26.73	32.68	0.46	7,393	
						B	-----	32.20	30.51	37.29	0.52	8,438	
*TH-54321	Cuttings Sample	----	19	6	----	A	11.88	35.58	33.37	19.17	0.40	9,455	
						B	-----	40.37	37.87	21.76	0.45	10,730	
*TH-53401	Core Sample	----	19	6	----	A	11.98	35.63	36.43	15.96	0.48	9,915	
						B	-----	40.48	41.39	18.13	0.55	11,265	
+C-14106	Core Sample	----	19	6	----	A	9.2	34.5	39.5	16.8	0.57	10,141	
						B	-----	38.0	43.5	18.5	0.63	11,168	
						C	-----	46.7	53.3	----	0.77	13,701	
*TH-53399	Core Sample	----	19	6	----	A	11.23	35.86	36.05	16.86	0.49	10,030	
						B	-----	40.40	40.61	18.99	0.55	11,299	
+C-14107	Core Sample	----	19	6	----	A	10.00	34.3	38.8	16.9	0.57	10,042	
						B	-----	38.1	43.1	18.8	0.63	11,163	
						C	-----	46.9	53.1	----	0.77	13,738	
A-23141	Outcrop Sample	NW¼ 11	19	6	----	A	11.2	40.0	43.0	5.8	0.5	11,360	
						B	----	45.1	48.4	6.5	0.5	12,800	
						C	----	48.2	51.8	----	0.6	13,690	
*TH-53400	Core Sample	----	20	6	----	A	12.44	34.95	34.05	18.56	0.56	9,499	
						B	----	39.91	38.89	21.20	0.64	10,848	
+C-14108	Core Sample	----	20	6	----	A	10.7	33.4	37.5	18.4	0.65	9,667	
						B	----	37.4	42.0	20.6	0.72	10,826	
						C	----	47.1	52.9	----	0.91	13,637	

*analysis by Commercial Testing and Eng. Co.
+analysis by Illinois Geological Survey

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

Fruitland Coal Zone

The Fruitland coal zone extends from the top of the Fruitland Formation to the top of the lowermost coal designated on CRO Plate 3 as a Fruitland zone coal bed. The structure contour map (CRO Plate 12) was, therefore, constructed using the top of the Fruitland Formation. The formation dips approximately 1° to the northeast. Due to dip and topography, overburden (CRO Plate 13) varies from less than 500 ft (152 m) in the southwest to over 1,800 ft (549 m) in the northeast. Also shown on Plate 13 is the total amount of interburden which is the noncoal portion of the zone. The interburden thickness varies greatly across the area, ranging from zero to over 200 ft (61 m). This variation is the result of the number of coal beds and their stratigraphic positions within the Fruitland zone. The isopach map (CRO Plate 11) shows the total combined thickness is greater than 5 ft (1.5 m) in the northeast, southeast, northwest, and southwest. The thickness decreases from these areas, and the coal is absent in a small portion of the north.

Chemical Analyses of the Fruitland Zone Coal Beds - Analyses of several Fruitland Formation coal beds from this quadrangle and surrounding area were published by Fassett and Hinds (1971) and Shomaker and Lease (1971). The results of these analyses are given in Table 2.

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) were utilized in the construction of isopach and structure contour maps of the coals in this quadrangle. All the coal beds evaluated in the Mule Dam quadrangle are more than 200 ft (61 m) below the ground surface and, therefore, 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 Menefee Formation and Fruitland zone were not evaluated because the thickness of these coals is generally less than the reserve base thickness (5 ft [1.5 m]). In addition, the Menefee zone coals are irregular and noncorrelative; the Fruitland zone coals are 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 10) according to criteria established in U.S. Geological Survey Bulletin 1450-B. Coal outside the 3-mile (4.8-km) inferred radius is designated as a hypothetical resource; however, reserves were not calculated for hypothetical coal resources. Data for calculation of Reserve Base and Reserves for each category were obtained from the coal isopach (CRO Plate 7) and areal distribution (CRO Plate 10) maps. The surface area of the isopached Fruitland 1 bed was measured by planimeter, for each category, in acres, 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 Fruitland 1 coal bed are shown on CRO Plate 10, 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 89 million short tons (81 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 Mule Dam quadrangle has development potential for subsurface mining methods only (CDP Plate 14).

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 Fruitland 1 coal bed.

Development Potential for Surface Mining Methods

All coal beds in the Mule Dam quadrangle occur more than 200 ft (61 m) below the ground surface, and, therefore, they have no coal development potential for surface mining methods.

TABLE 3

COAL RESOURCE DATA FOR UNDERGROUND
MINING METHODS FOR FEDERAL COAL LANDS
(IN SHORT TONS) IN THE MULE DAM QUADRANGLE
SANDOVAL 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	19,380,000	69,920,000	--	89,300,000
Total	19,380,000	69,920,000	--	89,300,000

Development Potential for Subsurface Mining Methods

Underground coal of the Fruitland 1 coal bed has high development potential in the extreme southwest corner and in the south-central part of the quadrangle (CDP Plate 14). The thickness of the Fruitland 1 is 5 ft (1.5 m) in the southwest and 5 to 6 ft (1.5-1.8 m) in the south-central area (CRO Plate 7); the overburden thickness in the southwest corner is about 600 ft (183 m) and ranges from 800 to 1,000 ft (244-305 m) in the south-central part of the quadrangle (CRO Plate 9).

The remainder of the Fruitland 1 coal bed of greater than reserve base thickness (5 ft [1.5 m]) has moderate development potential and occurs in the northwest corner, at the center, and along the east-central border of the quadrangle. Coal bed thickness in these areas varies from 5 to 7 ft (1.5-2.1 m) in the northwest and 5 to 6 ft (1.5-1.8 m) in the central and eastern areas, and overburden ranges from 1,000 to 1,600 ft (305-488 m).

The Fruitland 1 coal bed has unknown development potential in much of the southern and western parts of the quadrangle where the coal is less than the reserve base thickness of 5 ft (1.5 m). Two areas with no development potential are shown (CDP Plate 14) where there is no Fruitland 1 coal (north-central and southwest).

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