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COAL RESOURCE OCCURRENCE MAPS AND COAL DEVELOPMENT POTENTIAL MAPS OF THE OJO ENCINO MESA QUADRANGLE, McKINLEY AND SANDOVAL COUNTIES, NEW MEXICO

[Report includes 12 plates]

by

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OJO ENCINO MESA 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) Maps of the Ojo Encino Mesa quadrangle, McKinley and Sandoval Counties, New Mexico. These reports 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 Ojo Encino Mesa 7 1/2-minute quadrangle is in the northeast corner of McKinley County and the western portion of Sandoval County, New Mexico. The area is approximately 68 miles (109 km) northwest of Albuquerque and 72 miles (116 km) southeast of Farmington, New Mexico.

Accessibility

The Ojo Encino Mesa quadrangle is accessible from New Mexico State Route 44 to the east of the area and State Route 197 which extends east-west across the quadrangle. From these routes light-duty roads provide access to remote parts of the area. The Atchison, Topeka, and Santa Fe Railway operates a route which passes through Albuquerque approximately 68 miles (109 km) to the southeast of the quadrangle.

Physiography

The quadrangle is in the southeastern portion of the Central Basin area and the northeastern portion of the Chaco Slope area (Kelley, 1950) of the structural depression known as the San Juan Basin. It also is within the Penistaja Cuestas physiographic sector (Baltz, 1967). Elevations range from 6,540 ft (1,993 m) in Torreon Wash to 7,240 ft (2,207 m) on Ceja Pelon Mesa which is in the northeastern part of the quadrangle. Most of the topography is typified by gentle slopes and broad stream valleys; Cejita Blanca Ridge, Ceja Pelon Mesa, and Little Blue Mesa are areas of relatively high relief. These and other mesas in the area have been carved by numerous washes and arroyos. Torreon Wash and its tributaries comprise the major drainage system in 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 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 98 percent of the quadrangle is in the southeastern portion of the San Juan Basin Known Recoverable Coal Resource Area. The Federal Government owns the coal rights for lands covering approximately 84 percent of the area as shown on Plate 2 of the Coal Resource Occurrence Maps. Preference Right Lease Applications (NM 585 and NM 8717), in the southwest quarter of the quadrangle, cover approximately 6 percent of the area. The Federal Government owns the coal rights for 60 percent of the land outside the KRCRA.

GENERAL GEOLOGY

Previous Work

Dane (1936) has mapped the Upper Cretaceous and Tertiary strata within the quadrangle as part of a study of the geology and fuel resources of the southern San Juan Basin. Baltz (1967) has studied the stratigraphy of the east-central San Juan Basin and mapped the geology of the northern part 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 in the upper part of the Menefee Formation. Subsequently, beach sands of the La Ventana Tongue (Cliff House Sandstone) were deposited over the Menefee with several hundred feet in the northeast part of the quadrangle. Swamps, which were contemporaneous with the La Ventana beach deposits, developed above the basal La Ventana sands in the southwest part of the quadrangle. Coals later formed in these younger Menefee deposits of the Hogback Mountain Tongue

(Beaumont, 1971). Minor fluctuations of the sea resulted in interfingering of the La Ventana (Cliff House) and Hogback Mountain (Menefee) Tongues in the quadrangle.

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. 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 Sandstoneand the overlying paludal Fruitland Formation which were deposited in successively higher stratigraphic positions to the northeast. Southwest (shoreward) of the beach deposits, swamps, which were dissected by streams, 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 freshwater sediments then 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 erosional processes to the present time. A significant amount of erosion has occurred, as indicated by the removal of most of the San Jose Formation from the area.

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, and 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 Point Lookout Sandstone, the basal formation of the Mesaverde Group, consists of cream to gray, calcareous, slightly glauconitic sandstone interbedded near the base of the formation with gray shale which contains plant fossils. The unit is fairly massive, averages 125 ft (38 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, an unnamed upper coal-bearing member (Beaumont and others, 1956), and the informally named Hogback Mountain Tongue (Beaumont, 1971). The first three members are referred to as a single undifferentiated member of the Menefee for the purposes of this report only. This member is about 888 ft (271 m) thick in this area and is predominantly a gray, carbonaceous to noncarbonaceous, fossiliferous shale with silty stringers, interbedded gray, slightly calcareous sandstone and siltstone, and random coal beds.

Two wedges of the Hogback Mountain Tongue of the Menefee extend from southwest to northeast across half of the quadrangle area. They are thick paludal deposits shoreward of and intertonguing with the massive marine sand of the La Ventana Tongue. The Hogback Mountain Tongue is distinguished in this area as a major coal-bearing unit. The two wedges of the Hogback Mountain Tongue vary in thickness but average 130 ft (40 m) each. As a result of intertonguing with the La Ventana these wedges of carbonaceous shale progressively thin in a northeasterly direction and are not present in the central part of the quadrangle. Similar in lithology to the underlying undifferentiated member of the Menefee, the Hogback Mountain Tongue consists of gray carbonaceous shale, interbedded thin sandstone, and random coal beds.

The Cliff House Sandstone, of which two members are recognized in the area, conformably overlies the Menefee Formation. The La Ventana Tongue, the basal member, is about 625 feet (190 m) thick in the quadrangle. It is a thick sequence of gray, calcareous sandstone with siderite nodules and interbedded gray, calcareous siltstone.

The upper member, the Chacra Tongue (informal name of local usage), overlies the La Ventana Tongue and averages 315 ft (96 m) in thickness. The lithology of Chacra within the quadrangle area represents a seaward transition from the massive nearshore sandstone exposed at Chacra Mesa, the type section, to the overlying marine Lewis Shale. It consists of cream to gray, silty sandstone and interbedded gray siltstone and shale.

The Lewis Shale conformably overlies the Mesaverde Group. In contrast to the underlying Cliff House Sandstone, it is predominantly a gray to green to brown shale with local plant fossils and thin, interbedded sandstone. It averages 195 ft (59 m) in thickness throughout the quadrangle. The upper contact is gradational with the overlying Pictured Cliffs Sandstone and, consequently, is difficult to determine.

The Pictured Cliffs Sandstone consists of about 170 ft (52 m) of light gray, calcareous sandstone interbedded with thin, gray shale near the base of the formation where is 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. 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 has an average thickness of 155 ft (47 m) in this area and consists of gray carbonaceous shale with local 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). Several authors have used various criteria in establishing the upper contact, but, in general, for the purposes of this report the uppermost coal was used (after Fassett and Hinds, 1971).

The freshwater deposits of the Kirtland Shale are the youngest Cretaceous strata in the area. These deposits consist of about 230 ft (70 m) of gray to brown shale with local plant fossils and thin, interbedded siltstone. 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. It consists of about 100 ft (30.5 m) of gray, locally conglomeratic, poorly indurated sandstone with interbedded gray shale.

The Nacimiento Formation conformably overlies the Ojo Alamo. Approximately 1,200 ft (366 m) of the Nacimiento are present in the area; these rocks are predominantly gray shale with sandy stringers interbedded with light gray sandstone which is locally conglomeratic.

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 and brown to gray shale.

A total of seven formations crop out within the quadrangle. The outcrop pattern generally trends in a east-west direction with the formations becoming successively younger to the north. The oldest formation is the Lewis Shale which crops out in the extreme southwestern corner of the area. The entire sections of the Pictured Cliffs Sandstone, Fruitland Formation, Kirtland Shale, Ojo Alamo Sandstone, and the Nacimiento Formation are exposed consecutively across the quadrangle in a northerly direction. The lower part of the San Jose Formation, the youngest formation in the area, crops out in the northeastern portion of the quadrangle.

Structure

The axis of the San Juan Basin is about 28 miles (45 km) northeast of the Ojo Encino Mesa quadrangle and trends in an arcuate pattern across the northern portion of the Central Basin (Baltz, 1967). Regional dip measured within the quadrangle ranges from 1° to 2° to the north-northeast (Dane, 1936). A small, normal fault in the southwestern part of the quadrangle trends east-west and is down-dropped on the northern side (Dane, 1936).

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. The coals have been plotted in the column and correlated based upon their position relative to the datum. Correlation of coals in measured sections is based upon geologic maps (Dane, 1936).

One coal zone (Menefee) was identified in the subsurface, and a coal bed (Fruitland 1) and coal zone (Fruitland) were mapped on the surface of this quadrangle (CRO Plate 1). The Menefee Formation coal beds are designated as the Menefee coal zone (Me zone) which extends from the top of the La Ventana Tongue or Hogback Mountain Tongue (whichever is uppermost) to the base of the Menefee. These coal beds are generally noncorrelative and less than the reserve base thickness of 5 ft (1.5 m) as set by the U.S. Geological Survey; exceptions are a 9-ft (2.7-m) bed in drill hole 2, a 7-ft (2.1-m) bed in drill hole 3, a 6-ft (1.8-m) bed in drill hole 5, and two 5-ft (1.5-m) beds in drill hole 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 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 included 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 across the southern portion of the quadrangle (CRO Plate 1). The trace of the outcrop has been modified from the original data source to conform with modern topographic maps.

The remaining Fruitland Formation coal beds are designated as the Fruitland coal zone (Fr zone). One coal bed of the Fruitland zone crops out

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.			Moisture	Volatile matter	Fixed Carbon	Ash	Sulfur		
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	

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

in the southwestern portion of the quadrangle. Since these coals are generally noncorrelative and less than reserve base thickness (5 ft [1.5 m]), derivative maps were not constructed.

Fruitland Formation coal beds in the southeastern part of the San Juan Basin are considered high volatile C bituminous in rank, although the coals vary from subbituminous A to high volatile B bituminous. The rank of the coal has been determined on a moist, mineral-matter-free basis with calorific values ranging from 11,358 to 13,442 Btu's per pound (26,419-31,226 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 5.8 to 13.48 percent, ash content ranging from 19.86 to 29.60 percent, sulfur content less than one percent, and heating values on the order of 8,725 Btu's per pound (20,294 kj/kg). Analyses of several Fruitland Formation coal beds are given in Table 2 (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 or the Hogback Mountain of the Menefee Formation to the top of the Point Lookout Sandstone. The structure contour map of the Menefee coal zone (CRO Plate 5) was constructed using the top of either the La Ventana Tongue or Hogback Mountain Tongue, whichever is uppermost. The La Ventana and Hogback Mountain intertongue in the area and are stratigraphically equivalent. The surface represented by the tops of these units was

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.			Mois-ture	Volatile matter	Fixed Carbon	Ash	Sulfur		
+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	
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	

+analysis by Commercial Testing and Eng. Co.

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

chosen for the structure contour map because it portrays the upper boundary of the coal-bearing zone more consistently than the top of the randomly occurring uppermost Menefee coal.

As illustrated by the structure contour map (CRO Plate 5), the coal zone dips approximately 1° to the north. As a result of topography and dip, overburden (CRO Plate 6) varies from less than 600 ft (183 m) in the south to greater than 2,000 ft (610 m) in the northeast part of the quadrangle. The large interburden values are the result of the stratigraphic spread of the coal beds and reflect the thickness of the Menefee Formation plus the interfingering La Ventana and Hogback Mountain Tongues. The isopach map (CRO Plate 4) illustrates the total combined thickness of the individual coal beds of the Menefee zone. The greatest combined thickness occurs in the southeast and southwest where the coals total over 30 ft (9.1 m). From these areas the thickness decreases in all directions.

<u>Chemical Analyses of the Menefee Zone Coal Beds</u> - No published analyses of the quality of Menefee Formation coals are known to be available for this quadrangle. However, information from surrounding areas is assumed to be similar to that for the coals from this quadrangle. Analyses of several Menefee Formation coals are included in a report by 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 north. As a result of topography and dip, overburden (CRO Plate 9) varies from zero at the outcrop in the south to greater than 1,400 ft (427 m) on Ceja Pelon Mesa in the northeast. The isopach map (CRO Plate 7) shows the coal bed is greater than 15 ft (4.6 m) thick in a portion of the west. From this area the coal thickness decreases.

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

COAL RESOURCES

Coal resource data from oil and gas wells (El Paso Natural Gas Co., 1978, unpublished data in well log library, Farmington, New Mexico), coal test holes (Jentgen and Fassett, 1977), and geologic maps (Dane, 1936) were utilized in the construction of outcrop, isopach, and structure contour maps of the Fruitland 1 coal bed in this quadrangle. Outcrop traces of the Fruitland 1 coal bed in the southern half of the quadrangle (CRO Plate 1) were modified from Dane (1936), and are shown as concealed beyond the inferred outcrop for purposes of establishing boundaries for the coal development potential maps.

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 they are discontinuous, noncorrelative, and generally less than the reserve base thickness (5 ft [1.5 m]).

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. Data for calculation of Reserve Base and Reserves for each category were obtained from the respective coal isopach (CRO Plate 7) and areal distribution (CRO Plate 10) maps for each coal bed. The surface area of the isopached Fruitland 1 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 the coal bed.

In order to calculate Reserves, recovery factors of 85 percent and 50 percent were applied to the Reserve Base tonnages for strippable and underground coals, respectively. 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 each category of coal for the Fruitland 1 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 75.4 million short tons (68.4 million metric tons).

The coal development potential for the Fruitland 1 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 surface and/or subsurface mining methods. The Ojo Encino Mesa quadrangle has development potential for both surface and subsurface mining methods (CDP Plates 11 and 12).

COAL DEVELOPMENT POTENTIAL

Coal beds of 5 ft (1.5 m) or more in thickness which are overlain by 200 ft (61 m) or less of overburden are considered to have potential for strip mining and are designated as having high, moderate, or low development potential according to the mining ratios (cubic yards of overburden per ton of recoverable coal). The formula utilized in the calculation of mining ratios for bituminous coal is:

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

where MR = mining ratio
t_o = thickness of overburden
t_c = thickness of coal
rf = recovery factor

Based on economic and technological criteria, the U.S. Geological Survey has established standards for the determination of high, moderate, and low coal development potentials for surface and subsurface coal beds of reserve base thickness (5 ft [1.5 m]) or greater. Mining ratio values for strippable coal (overburden less than 200 ft [61 m] thick) are: 0 to 10, high; 10 to 15, moderate; and greater than 15, low. Underground coal beds (overburden 200 to 3,000 ft [61-914 m] thick) are assigned high, moderate, and 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. Tables 3 and 4 summarize the coal development

TABLE 3

STRIPPABLE COAL RESOURCES FOR FEDERAL COAL LANDS (IN SHORT TONS) IN THE OJO ENCINO MESA QUADRANGLE, MCKINLEY AND SANDOVAL COUNTIES, NEW MEXICO

[Development potentials are based on mining ratios (cubic yards of overburden/ton of underlying coal). To convert short tons to metric tons, multiply by 0.9072; to convert mining ratios in yd^3/ton coal to m^3/ton, multiply by 0.842]

Coal Bed	High Development Potential (0-10 mining ratio)	Moderate Development Potential (10-15 mining ratio)	Low Development Potential (15 mining ratio)	Total
Fruitland 1	9,490,000	9,940,000	3,160,000	22,590,000
TOTAL	9,490,000	9,940,000	3,160,000	22,590,000

TABLE 4

COAL RESOURCE DATA FOR UNDERGROUND MINING METHODS FOR FEDERAL COAL LANDS
(in short tons) IN THE OJO ENCINO MESA QUADRANGLE,
MCKINLEY AND SANDOVAL COUNTIES, 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	52,790,000	-	-	52,790,000
TOTAL	52,790,000	-	-	52,790,000

potential, in short tons, for surface and underground coal, respectively, of the Fruitland 1 coal bed.

Development Potential for Surface Mining Methods

Strippable coal of the Fruitland 1 coal bed has high, moderate, and low development potential in the southwest portion of the quadrangle area (CDP Plate 11). The Fruitland 1 coal thickness in the high potential area is approximately 5 ft (1.5 m) near the outcrop, increasing northward to 11 ft (3.4 m) (CRO Plate 7). Coal bed thickness in the moderate and low potential areas increase from 5 ft (1.5 m) near the outcrop to 15 ft (4.5 m) in the west.

The two areas with unknown development potential in the southern half of the quadrangle are areas of strippable coal that is less than the reserve base thickness of 5 ft (1.5 m). The remainder of the quadrangle area has no potential for development in areas beyond the stripping limit and areas outside the outcrop of the Fruitland 1 coal bed.

Development Potential for Subsurface Mining Methods

Underground coal of the Fruitland 1 coal bed has high development potential in the west-central part of the quadrangle (CDP Plate 12). In this area the coal bed thickness ranges from 5 to 16 ft (1.5-4.9 m) (CRO Plate 7), and the overburden thickness increases from 200 to approximately 450 ft (61-137 m) (CRO Plate 9). The majority of the quadrangle area has unknown development potential, because the Fruitland 1 coal bed is less than reserve base thickness. The southern half of the quadrangle includes areas of strippable coal and areas beyond the Fruitland 1 outcrop; therefore, it has no development potential for subsurface mining methods.

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