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

[Report includes 28 plates]

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THE PILLAR 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 Pillar 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) of 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 Pillar 7 1/2-minute quadrangle is located in the central part of San Juan County, New Mexico. The area is approximately 17 miles (27 km) southwest of Farmington and 62 miles (100 km) northeast of Gallup, New Mexico.

Accessibility

The area is accessible by a light-duty road along the eastern border. This road connects with State Route 44, 29 miles (47 km) to the east, and extends to Bisti Trading Post, 7 miles (11 km) south of the southern edge of the quadrangle. Several unimproved dirt roads, which extend from the light-duty road, provide access to the more remote areas. The Atchison, Topeka, and Santa Fe Railway operates a route which is 62 miles (100 km) to the southwest at Gallup, New Mexico, and extends to the southeast and southwest.

Physiography

The quadrangle is in the Central Basin area (Kelley, 1950) of the San Juan basin, a structural depression in the Colorado Plateau physiographic province. Total relief in the quadrangle is 860 ft (262 m), with elevations which range from 5,700 ft (1,737 m) in the southwest to 6,560 ft (1,999 m) on Moncisco Mesa. Moncisco Mesa, in the northeast, slopes gently to the southwest, grading into heavily dissected plains in the west and southwest. Intermittent streams have eroded the less resistant strata of the plains to create badlands, which are separated from Moncisco Mesa by steep cliffs etched in the more resistant rock. Pinnabete Arroyo, Brinkall Wash, and most other intermittent streams in the area drain to the southwest.

Climate

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

Land Status

Approximately 15 percent of the quadrangle is in the western boundary of the San Juan Basin Known Recoverable Coal Resource Area. The Federal Government owns the coal rights for all 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 surficial geology of the area as part of a study of the Upper Cretaceous and Tertiary formations of the San Juan

Basin. More recently, Fassett and Hinds (1971) made subsurface interpretations of the Fruitland Formation coals 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 coal in the Menefee Formation. Subsequently, beach sands of the La Ventana Tongue (Cliff House Sandstone) were deposited over the Menefee deposits in the northeastern part of the quadrangle. Shoreward (southwest) and contemporaneous with the La Ventana beach deposits, swamps (Menefee) developed above the older Menefee deposits in the southwestern part of the area. Subsequently, coals formed in these deposits which are called the Hogback Mountain Tongue of the Menefee

(Beaumont, 1971). Later, another sequence of La Ventana beach sands was deposited over the area. Minor fluctuations of the sea resulted in interfingering of the La Ventana (Cliff House) and Hogback Mountain (Menefee) Tongues.

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.

The first 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 later became coals of the Fruitland Formation. Deposition of organic material was influenced by the strandline as shown by both the continuity of the coal beds parallel to the northwest-southeast strandline and their discontinuity perpendicular to it to the northeast. The less continuous Fruitland coals appear to be noncorrelative, but are 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 covered the quadrangle as indicated by the lacustrine, channel, and floodplain deposits of the Kirtland Shale. This sequence of events is evidenced by both an upward decrease in occurrence and thickness of

Fruitland coals and a gradational change to noncarbonaceous deposits of the Kirtland. Continuous deposition during Late Cretaceous time ended with the Kirtland. The sea then retreated beyond the limits of the quadrangle area, and modern basin structure began to develop. An erosional unconformity developed in a relatively short time as part of the Cretaceous Kirtland Shale was removed.

Terrestrial deposition resumed in the Paleocene 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 floodplain 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 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) 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, an unnamed upper coal-bearing member (Beaumont and others, 1956), and the coal-bearing Hogback Mountain Tongue (Beaumont, 1971). The first three members were grouped together as an undifferentiated member of the Menefee Formation for the purposes of this report only.

The undifferentiated member of the Menefee Formation consists primarily of gray, carbonaceous to noncarbonaceous, soft, platy, flaky, fossiliferous shale, interbedded thin, light gray sandstone with traces of glauconite, and lenticular coal beds. It has a total thickness of approximately 1,200 ft (366 m); however, due to the regional dip of 1°to 2° to the northeast, the lower portion of the Menefee Formation has more than 3,000 ft (914 m) of overburden (the study limit) in the eastern part of the quadrangle area. In the northeastern corner of the area (in drill hole 4, section 7, T. 26 N., R. 13 W.), 982 ft (299 m) of the formation are more than 3,000 ft (914 m) deep; however, in the southwest (in drill hole 3 in section 21, T. 25 N., R. 14 W.), only the lower 192 ft (59 m) are below the study limit.

The informally-named Hogback Mountain Tongue of the Menefee Formation represents thick paludal sediments deposited shoreward of a massive marine sand of the La Ventana Tongue. This member is distinguished as a major coal-bearing unit as a result of its coastal swamp depositional environment. The stratigraphic equivalence and complex intertonguing of the Hogback Mountain with the La Ventana make it distinguishable in the area of intertonguing. The Hogback Mountain Tongue overlies the undifferentiated member in the southwest and the basal La Ventana in the northeast. The thickness of the Hogback Mountain Tongue is approximately 420 ft (128 m) in the southern portion of the area; however, it thins in a northeasterly direction as it wedges into the La Ventana Tongue to a thickness of 181 ft (55 m) in drill hole 4 in section 7, T. 26 N., R. 13 W. Similar in lithology to the underlying undifferentiated member of the Menefee, the Hogback Mountain Tongue consists of dark gray, carbonaceous shale and random coal beds.

Conformably overlying and intertonguing with the Menefee Formation is the basal member of the Cliff House Sandstone, the La Ventana Tongue, represented here by two sandstone wedges. In the northeastern portion of the quadrangle the basal sandstone tongue of the La Ventana overlies the undifferentiated member of the Menefee Formation. It thins to the west and pinches out into the Hogback Mountain Tongue along the western edge of the quadrangle. The upper tongue is more persistent and occurs throughout the quadrangle. The sandstone tongues of the La Ventana range from 145 to 237 ft (44-72 m) in thickness. They are composed of white to light gray, fine-to-medium grained, calcareous, kaolinitic sandstone with subangular to subrounded grains, and interbedded gray shale.

The uppermost member of the Cliff House Sandstone is the Chacra Tongue (informal name of local usage). The Chacra sandstone is transitional in lithology from massive nearshore sandstone southwest of the quadrangle at Chacra Mesa, the type section, to marine deposits of the Lewis Shale. The unit consists of cream to light gray sandstone interbedded with slightly fissile, platy, fossiliferous shale. This "transition" Chacra is about 420 ft (128 m) thick throughout the quadrangle.

The marine Lewis Shale conformably overlies the Mesaverde Group. In contrast to the underlying Cliff House Sandstone, it is predominantly gray, platy shale with local plant fossils and silty stringers interbedded with gray, argillaceous siltstone. The Lewis averages 210 ft (64 m) in thickness throughout the quadrangle. The upper contact is gradational with the overlying Pictured Cliffs Sandstone, and, therefore, a distinct contact is difficult to establish.

The Pictured Cliffs Sandstone averages 95 ft (29 m) in thickness throughout the quadrangle; it consists of white to light gray, kaolinitic, slightly calcareous sandstone commonly interbedded with shale near the base of the formation where it grades into the Lewis. The upper contact is more sharply defined than the basal contact. Intertonguing with the overlying Fruitland Formation results in minor variations in the formational top. Nevertheless, the Pictured Cliffs Sandstone is a fairly consistent formation throughout the basin. The authors have used the consistency and distinctive character of the formation on geophysical logs to designate the top of the Pictured Cliffs as a lithologic datum for correlation of the overlying Fruitland coals.

Conformably overlying the Pictured Cliffs Sandstone is the Fruitland Formation, the major coal-bearing unit in the quadrangle. The Fruitland consists of an average of 350 ft (107 m) of gray to green carbonaceous shale, interbedded light gray, slightly calcareous sandstone, and coal beds of varying thicknesses. The thickest and most continuous coal beds occur near the base of the formation, while discontinuous and lenticular coal beds are characteristic of the upper portion. The upper contact is gradational from nonmarine lower coastal plain deposits of the Fruitland to upper coastal or alluvial plain deposits of the Kirtland Shale (Molenaar, 1977). Many authors have 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 San Juan Basin. They average 900 ft (274 m) in thickness and consist of gray to green soft shale with scattered secondary minerals, and interbedded light gray to tan, friable, calcareous sandstone. The formation has previously been divided into several members by various authors; however, for the purposes of this report the individual members were not differentiated.

Unconformably overlying the Upper Cretaceous strata is the Paleocene Ojo Alamo Sandstone. It consists primarily of about 100 ft (30 m) of white to tan, coarse-grained to conglomeratic sandstone.

The Nacimiento Formation gradationally overlies the Ojo Alamo. The lower one hundred feet of the Nacimiento Formation crop out within the quadrangle area and consist of yellow-brown to gray claystone and interbedded gray shale.

A total of three formations crop out within the quadrangle. The outcrop pattern trends in a general north-south direction with the formations becoming successively younger to the east. The oldest formation exposed is the upper portion of the Kirtland Shale, which is present in the western part of the quadrangle. The entire section of the Ojo Alamo

Sandstone crops out across the eastern edge of the quadrangle. The lowermost beds of the Nacimiento Formation, the youngest formation in the area, are exposed in the east-central part of the quadrangle.

Structure

The quadrangle is located in the Central Basin area (Kelley, 1950) of the major structural depression known as the San Juan Basin. The axis of the basin is about 24 miles (39 km) northeast of the quadrangle near Farmington, New Mexico, and trends in an arcuate pattern across the northern portion of the Central Basin area (Baltz, 1967). Regional dip within the quadrangle ranges from 1° to 2° to the northeast, as inferred from dips measured by Reeside (1924) in surrounding quadrangles.

COAL GEOLOGY

Two coal zones (Menefee, Fruitland) and six coal beds (Menefee 1, Menefee 2, Menefee 3, Menefee 4, Fruitland 1, Fruitland 2) were identified in the subsurface of this quadrangle (CRO Plate 1). The coals of the Menefee Formation are designated as the Menefee coal zone (Me zone). These coals are generally noncorrelative and less than reserve base thickness (5 ft [1.5 m]); exceptions are a 16-ft (4.9-m) and a 20-ft (6.1-m) coal bed in drill hole 22 (CRO Plate 1). Due to these characteristics, derivative maps were not constructed.

Within the Hogback Mountain Tongue of the Menefee Formation there are several correlative coal beds. These have been designated as the Menefee

1 (Me 1), Menefee 2 (Me 2), Menefee 3 (Me 3), and Menefee 4 (Me 4). Although these beds have been correlated and mapped as consistent horizons, they may actually be several different coal beds that are lithostratigraphically equivalent but not laterally continuous.

Menefee Formation coals in the western portion of the San Juan Basin are considered subbituminous A to subbituminous B in rank. The rank of the coal has been determined on a moist, mineral-matter-free basis with calorific values averaging 10,837 Btu's per pound (25,207 kg/kg) (Amer. Soc. for Testing and Materials, 1977). The coal is hard, brittle, and black with a bright luster. The coal readily slakes with exposure to weather; however, it stocks fairly well when protected (Bauer and Reeside, 1921; Dane, 1936). The "as-received" analyses indicate moisture content varying from 15.3 to 19.1 percent, ash content ranging from 6.6 to 22.7 percent, sulfur content less than 1.5 percent, and heating values averaging 9,515 Btu's per pound (22,132 kj/kg). Analyses of several Menefee coals are given in Table 1 (Shomaker, 1971).

The Fruitland 1 (Fr 1) coal bed is defined by the authors as the lowermost coal of the Fruitland Formation. However, occasionally a local (L) coal occurs directly above the Pictured Cliffs Sandstone. The Fruitland 2 (Fr 2) coal bed is above the Fruitland 1; they are separated by a rock interval of 13 to 45 ft (4.0-13.7 m). Although these beds have been correlated and mapped as consistent horizons, they may actually be several different coal beds that are lithostratigraphically equivalent but not laterally continuous (CRO Plate 3).

Fruitland Formation coals in the western part of the San Juan Basin are considered high volatile A to high volatile C bituminous in rank. The

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

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

rank of the coal has been determined on a moist, mineral-matter-free basis with calorific values averaging 13,666 Btu's per pound (31,787 kj/kg) (Amer. Soc. for Testing and Materials, 1977). The coal is hard, brittle, and black, with a bright luster. The coal readily slakes with exposure to weather; however, it stocks fairly well when protected (Bauer and Reeside, 1921; Dane, 1936). The "as-received" analyses indicate moisture content ranging from 2.6 to 9.5 percent, ash content averaging 14.2 percent, sulfur content varying from 0.6 to 1.8 percent, and heating values on the order of 11,560 Btu's per pound (26,889 kj/kg). Analyses of several Fruitland Formation coals are given in Table 2 (Fassett and Hinds, 1971).

Menefee 1 Coal Bed

The Menefee 1 coal bed is present only in a portion of the northeast part of the quadrangle and has been mapped only outside the Navajo Indian Reservation. The coal bed dips less than 1° in a northeasterly direction as shown by the structure contour map (CRO Plate 5). As a result of the topography and dip, the overburden (CRO Plate 6) varies in thickness from less than 2,600 ft (792 m) in the southwest part of the coal-bearing area to more than 2,700 ft (823 m) in the northeast. The isopach map (CRO Plate 4) indicates that the coal bed attains a thickness of greater than 5 ft (1.5 m) in two small areas and thins in all directions.

Chemical Analyses of the Menefee 1 Coal Bed - Analyses of several coals of the Menefee Formation from the area surrounding this quadrangle are given in Table 1 (Shomaker, 1971).

TABLE 2

Analyses of coal samples from the Fruitland Formation

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

U.S. Bureau Mines Lab No.	Well or Other Source	Location			Approx. Depth Interval of Sample (ft.)	Form of Analysis	Proximate, percent					Heating Value (Btu)	Remarks
		Section	T.N.	R.W.			Mois-ture	Volatile matter	Fixed Carbon	Ash	Sulfur		
H-40806	Standard of Texas State No. 1	SW¼ 16	25	13	1,156-1,208	A	9.5	30.9	43.3	16.3	1.8	10,270	Abnormal moisture content may be due to inadequate drying of sample during preparation process.
						B	---	34.1	47.9	18.0	2.0	11,340	
						C	---	41.6	58.4	----	2.5	13,820	
H-3031	Southwest Production Cambell No. 2	NE¼ 26	27	12	1,900-1,910	A	2.6	41.2	40.5	15.7	0.6	11,810	
						B	---	42.3	41.6	16.1	0.6	12,120	
						C	---	50.4	49.6	----	0.7	14,440	
H-36175	Royal Development Ojo Amarillo No. 2	SW¼ 6	27	13	1,214-1,245	A	4.3	39.7	44.6	11.4	0.7	11,970	
						B	---	41.4	46.7	11.9	0.7	12,500	
						C	---	47.0	53.0	----	0.8	14,190	
H-24567	Sunray Mid-Continent Gallegos No. 122	NW¼ 18	28	12	1,305-1,315	A	3.0	38.9	44.4	13.7	0.6	12,010	
						B	---	40.1	45.8	14.1	0.6	12,390	
						C	---	46.8	53.2	----	0.7	14,430	
H-7225	Pan American Holder No. 7	NW¼ 16	28	13	1,705-1,715	A	4.1	39.4	42.8	13.7	0.6	11,740	
						B	---	41.1	44.6	14.3	0.6	12,240	
						C	---	47.9	52.1	----	0.7	14,290	

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

Menefee 2 Coal Bed

The Menefee 2 coal bed is present only in the northeast part of this quadrangle and has been mapped in areas outside the Navajo Indian Reservation. As shown by the structure contour map (CRO Plate 9), the coal bed dips less than 1° to the northeast. Due to topography and dip, the overburden (CRO Plate 10) varies from less than 2,600 ft (792 m) in the southwest to more than 2,700 ft (823 m) thick in the northeast part of the coal-bearing area. The isopach map (CRO Plate 8) illustrates that the coal bed is more than 10 feet (3.0 m) thick in the center of the coal-bearing area and thins in all directions.

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

Menefee 3 Coal Bed

The Menefee 3 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° in a north-northeasterly direction. As a result of topography and dip, the overburden (CRO Plate 14) ranges in thickness from less than 2,100 ft (640 m) in Brimhall Wash to more than 2,600 ft (792 m) on Moncisco Mesa. The isopach map (CRO Plate 12) shows that the coal bed is more than 5 ft (1.5 m) thick in part of the southern half of the mapped area. The thickness gradually decreases to zero in the extreme southern and northern portions of the mapped area.

Chemical Analyses of the Menefee 3 Coal Bed - Analyses of several coals of the Menefee Formation from the area surrounding this quadrangle are given in Table 1 (Shomaker, 1971).

Menefee 4 Coal Bed

The Menefee 4 coal bed has been mapped only in areas outside the Navajo Indian Reservation. As illustrated by the structure contour map (CRO Plate 17), the coal bed dips less than 1° in a north-northeasterly direction. As a result of the topography and dip, the overburden (CRO Plate 18) varies in thickness from less than 2,000 ft (610 m) in Brimhall Wash to more than 2,600 ft (792 m) on Moncisco Mesa. The isopach map (CRO Plate 16) shows two areas (in the northeast and the southeast) in which the coal bed is greater than 5 ft (1.5 m) thick. From these areas the coal thins in all directions, and the coal is absent in the northern and southern portions of the mapped area.

Chemical Analyses of the Menefee 4 Coal Bed - Analyses of several coals of the Menefee Formation from the area surrounding this quadrangle are given in Table 1 (Shomaker, 1971).

Fruitland 1 Coal Bed

The Fruitland 1 coal bed has been mapped only in areas outside the Navajo Indian Reservation. The structure contour map (CRO Plate 21) indicates that the coal bed dips less than 1° in a northerly direction. Because of topography and dip, the overburden (CRO Plate 22) ranges from less than

1,000 ft (305 m) in thickness in Brimhall Wash to more than 1,600 ft (488 m) in thickness on Moncisco Mesa. As illustrated by the isopach map (CRO Plate 20), the coal is greater than 10 ft (3.0 m) thick in the southern part of the mapped area. The coal thickness decreases to less than 5 ft (1.5 m) to the south and north, but increases to more than 5 ft (1.5 m) in the extreme northern portion of the mapped area.

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 (Fassett and Hinds, 1971).

Fruitland 2 Coal Bed

The Fruitland 2 coal bed has been mapped only in areas outside the Navajo Indian Reservation. The structure contour map (CRO Plate 25) shows that the coal bed dips less than 1° to the north. Due to the topography and dip, the overburden (CRO Plate 26) varies in thickness from less than 1,000 ft (305 m) at the southern edge of the quadrangle to more than 1,600 ft (488 m) on Moncisco Mesa. The isopach map (CRO Plate 24) indicates that the coal thickness is greater than 10 ft (30 m) in the central part of the mapped area and in a small portion in the northeast. In general, the thickness decreases to the south and north, and the coal bed is absent from a small section of the northwestern part of the mapped area.

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 (Fassett and Hinds, 1971).

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 Pillar quadrangle occur more than 1,100 ft (335 m) below the ground surface and, thus, have no outcrop or surface development potential.

The U.S. Geological Survey designated the Menefee 1, Menefee 2, Menefee 3, Menefee 4, Fruitland 1, and Fruitland 2 coal beds for the determination of coal resources in this quadrangle. Coals of the Menefee and Fruitland 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, 15, 19, 23, and 27) 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, 12, 16, 20, and 24)) and areal distribution maps (CRO Plates 7, 11, 15, 19, 23, and 27) 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 a conversion factor for bituminous or subbituminous coal. This yields the Reserve Base coal, in short tons, for each coal bed. The conversion factor for bituminous coal (Fruitland 1 and Fruitland 2) is 1,800 short tons of coal per acre-foot (13,239 tons/hectare-meter), and that of subbituminous coal (Menefee 1, Menefee 2, Menefee 3, and Menefee 4) is 1,770 short tons of coal per acre-foot (13,018 tons/hectare-meter).

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

Reserve Base and Reserve values for each category of coal for the Menefee 1, Menefee 2, Menefee 3, Menefee 4, Fruitland 1, and Fruitland 2 beds are shown on CRO Plates 7, 11, 15, 19, 23, and 27, 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 186.6 million short tons (169.3 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 Pillar quadrangle has development potential for subsurface mining methods only (CDP Plate 28).

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 1, Menefee 2, Menefee 3, Menefee 4, Fruitland 1, and Fruitland 2 coal beds.

Development Potential for Surface Mining Methods

All coals studied in The Pillar quadrangle occur 1,100 ft (335 m) below the ground surface and, thus, they have no coal development potential for surface mining methods.

Development Potential for Subsurface Mining Methods

Underground coal of the Fruitland 1 coal bed has high development potential in two small areas in the southeast corner of the quadrangle where the coal varies in thickness from 5 to 7 ft (1.5-2.1 m) (CRO Plate 20) and the overburden is approximately 1,000 ft (305 m) thick (CRO Plate 22). This is the only area with high development potential within the KRCRA limits of the quadrangle. The Fruitland 1 and Fruitland 2 beds have moderate development potential along the eastern side of the quadrangle. The coal bed thicknesses are 5 to 10 ft (1.5-3.0 m) (CRO Plate 20) and 5 to 12 ft (1.5-3.7 m) (CRO Plate 24), respectively, and overburden for both coal beds increases from 1,000 ft (305 m) in the southeast to more than 1,600 ft (488 m) in the northeast (CRO Plates 22 and 26).

The small area of low development potential in the northeastern part of the quadrangle is the result of the Menefee 1 and Menefee 2 coal beds. The Menefee 1 is 5 to 6 ft (1.5-1.8 m) thick (CRO Plate 4) in this

TABLE 3

COAL RESOURCE DATA FOR UNDERGROUND MINING METHODS FOR FEDERAL COAL LANDS
(in short tons) IN THE PILLAR 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	30,000	88,970,000	--	89,000,000
Fruitland 1	1,280,000	61,580,000	--	62,860,000
Menefee 4	--	--	10,580,000	10,580,000
Menefee 3	--	--	10,270,000	10,270,000
Menefee 2	--	--	12,330,000	12,330,000
Menefee 1	--	--	1,550,000	1,550,000
TOTAL	1,310,000	150,550,000	34,730,000	186,590,000

area and the overburden is approximately 2,660 ft (811 m) thick (CRO Plate 6). The Menefee 2 is 10 to 12 ft (3.0-3.7 m) thick (CRO Plate 8) and the overburden is approximately 2,630 ft (802 m) thick (CRO Plate 10). Coals of the Menefee 3 and Menefee 4 beds have low development potential in the southeast; however, they are overlain by Fruitland 1 and Fruitland 2 coals of moderate potential.

The isolated areas of unknown development potential in the southeast and northeast are areas in which the individual coal beds are less than 5 ft (1.5 m) thick. Unpatterned areas to the west are outside the KRCRA.

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