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COAL RESOURCE OCCURRENCE MAPS AND COAL DEVELOPMENT POTENTIAL MAPS OF THE PUEBLO ALTO TRADING POST QUADRANGLE, MCKINLEY AND SANDOVAL COUNTIES, NEW MEXICO

[Report includes 17 plates]

by

Dames & Moore

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PUEBLO ALTO TRADING POST 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 Pueblo Alto Trading Post quadrangle, McKinley and Sandoval Counties, 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 was 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 Pueblo Alto Trading Post 7 1/2-minute quadrangle is in northeastern McKinley County and northwestern Sandoval County, New Mexico. The area is approximately 65 miles (105 km) southeast of Farmington and 68 miles (109 km) northeast of Gallup, New Mexico.

Accessibility

The Pueblo Alto Trading Post quadrangle is accessible from the east by New Mexico State Routes 197 and 44. South of Cuba, State Route 197 extends southwest to the small town of Torreon. From there, a light-duty road provides access to remote areas of the quadrangle. The Atchison, Topeka and Santa Fe Railway operates a route which passes through Gallup approximately 68 miles (109 km) to the southeast.

Physiography

This quadrangle is in the southern portion of the Central Basin area and the northern portion of the Chaco Slope area (Kelley, 1950) of the structural depression known as the San Juan Basin. Elevations range from 6,500 ft (1,981 m) in the North Fork of Chaco Wash to 7,260 ft (2,213 m) in the southwest corner. Most of the quadrangle area is characterized by mildly dissected, gently-sloping plains. The streams of the North Fork of Chaco Wash and its tributaries flow intermittently to the west along wide, flat, sandy stream channels. Chaco Mesa is a prominent feature in the southwestern corner of the quadrangle, and has been deeply incised by streams which have formed steep-walled canyons. In this area, the relief is greater than 400 ft (122 m).

Climate

The climate of the San Juan Basin is arid to semi-arid. Annual precipitation is usually less than 10 inches (25 cm), but varies across the basin due to elevational differences. Rainfall is rare in the early summer and winter; most precipitation occurs in July and August as intense afternoon thundershowers. Annual temperatures range from below 0°F (-18°C) to over 100°F (38°C) in the basin. 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 43 percent of the quadrangle is in the southeastern part of the San Juan Basin Known Recoverable Coal Resource Area. The Federal Government owns the coal rights for approximately 60 percent of the KRCRA within the quadrangle as shown on Plate 2 of the Coal Resource Occurrence Maps. Preference Right Lease Applications (NM 8130 and NM 8715) in the north and northwest part of the KRCRA cover 14 percent of the area. A Federal coal lease (NM 2457) covers 12 percent of the southeast corner of the KRCRA. The Federal Government owns the coal rights for 68 percent of the land outside the San Juan Basin Known Recoverable Coal Resource Area in the quadrangle.

GENERAL GEOLOGY

Previous Work

Dane (1936) has mapped the Late Cretaceous and Tertiary strata in the area, with detailed emphasis on the Fruitland coal field which trends northwest-southeast across 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. Shomaker and Lease (1971) have evaluated the strippable coal reserves of the Fruitland Formation within the quadrangle as part of a 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.

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 the coal beds of the Hogback Mountain Tongue (Beaumont, 1971) in the upper part of the Menefee Formation. The transgressing northwest-southeast-trending strandline which was deposited over the Menefee 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 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 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 quadrangle as evidenced by the lacustrine, channel, and floodplain deposits of the Kirtland Shale. This sequence of events is evidenced by both an upward decrease in occurrence and thickness of Fruitland coals and a gradational change to noncarbonaceous deposits of the Kirtland. Continuous deposition during Late Cretaceous time ended with the Kirtland. The sea then retreated beyond the limits of the quadrangle area, and modern basin structure began to develop. An erosional unconformity developed in a relatively short time as part of the Cretaceous Kirtland Shale was removed.

Terrestrial deposition resumed in the Paleocene as represented by the Ojo Alamo Sandstone and the overlying Nacimiento Formation. Alluvial plain and floodplain deposits of the Ojo Alamo were followed by the thick, lithologically varied deposits of the Nacimiento during continuous nonmarine deposition. The Nacimiento was later exposed to erosion.

The Eocene San Jose Formation was subsequently deposited over the Nacimiento erosional surface, reflecting various nonmarine environments which developed across the basin. Deposition and structural deformation of the basin then ceased, and the warped strata of the San Juan Basin have been exposed to the present time. A significant amount of erosion has occurred, as indicated by the removal of the San Jose Formation, Nacimiento Formation, and some of the Ojo Alamo Sandstone from the area.

Stratigraphy

The formations studied in this quadrangle range from Late Cretaceous to Paleocene in age. They are, in order from oldest to youngest: the Point Lookout Sandstone, Menefee Formation, and Cliff House Sandstone, (the three formations of the Mesaverde Group); the Lewis Shale, Pictured Cliffs Sandstone, Fruitland Formation, Kirtland Shale, and Ojo Alamo Sandstone. A composite columnar section on CRO Plate 3 illustrates the stratigraphic relationships of these formations and is accompanied by lithologic descriptions of the individual formations.

The Point Lookout Sandstone, the basal formation of the Mesaverde Group, is composed of white to cream, calcareous, kaolinitic sandstone, interbedded gray shale, and local coal beds which occur in tongues of the Menefee Formation. The Point Lookout is fairly massive, averages about 140 ft (43 m) in thickness, and displays a distinctive and consistent character on geophysical logs. This last characteristic was used by the authors in establishing the top of the formation 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 Hogback Mountain Tongue (Beaumont, 1971). The first three members are referred to a single undifferentiated member of the Menefee Formation for the purposes of this report only. The undifferentiated member is about 890 ft (271 m) thick and is predominantly a gray, carbonaceous to noncarbonaceous, soft, flaky shale with limy nodules, interbedded cream to brown calcareous sandstone, and random coal beds.

The informally-named Hogback Mountain Tongue of the Menefee Formation represents thick paludal deposits shoreward of and stratigraphically equivalent to the basal massive marine Cliff House Sandstone. The thickness of the Hogback Mountain Tongue in the area is approximately 600 ft (183 m). Similar in lithology to the underlying undifferentiated member, it is composed of gray, carbonaceous, soft flaky shale with plant fossils and limy nodules, interbedded cream to brown calcareous sandstone, and random coal beds.

The Chacra Tongue (informal name of local usage) of the Cliff House Sandstone conformably overlies the Hogback Mountain Tongue. It is a 380-ft (116-m) thick light gray kaolinitic sandstone with interbedded gray siltstone and dark gray shale. It is exposed in the type section at Chacra Mesa which trends northwest-southeast across the quadrangle.

The marine Lewis Shale conformably overlies the Mesaverde Group. In contrast to the underlying Cliff House Sandstone, it is predominantly a dark gray, fissile, calcareous shale with interbedded light brown, calcareous sandstone. The Lewis averages 145 ft (44 m) in thickness throughout the quadrangle. The upper contact is gradational with the overlying Pictured Cliffs Sandstone and, therefore, 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 underlying 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 is composed of 165 ft (50 m) of dark gray carbonaceous shale with local plant fossils, interbedded siltstone and sandstone, and coal beds of varying thicknesses. The thickest and most continuous coal beds occur near the base of the formation, while discontinuous and lenticular coals are characteristic of the upper portion. The upper contact is gradational from nonmarine lower coastal plain deposits of the Fruitland to upper coastal or alluvial plain deposits of the Kirtland Shale (Molenaar, 1977). 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. These deposits consist of brown to gray shale with local plant fossils and sandy stringers. An estimated thickness of 110 ft (34 m) is shown for the Kirtland on CRO Plate 3. 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 Late Cretaceous deposits in the northeastern portion of the quadrangle is an incomplete section of the Paleocene Ojo Alamo Sandstone. It is primarily white to light gray, coarse-grained to conglomeratic, friable sandstone and interbedded thin, gray to brown shale. An estimated thickness of 100 ft (31 m) is shown on CRO Plate 3.

A total of seven formations are exposed in the quadrangle. The outcrop pattern trends in a general northwest-southeast direction with the formations becoming successively younger to the northeast. The oldest formation exposed is the Chacra Tongue of the Cliff House Sandstone, which is the resistant sandstone of Chacra Mesa and crops out in the southwestern part of the quadrangle. The entire sections of the Lewis Shale, Pictured Cliffs Sandstone, Fruitland Formation, and Kirtland Shale crop out consecutively across the quadrangle in a northeasterly direction. The lowermost beds of the Ojo Alamo Sandstone, the youngest formation in the area, crop out in the extreme northeastern corner of the quadrangle.

Structure

The axis of the San Juan Basin is about 43 miles (69 km) northeast of the Pueblo Alto Trading Post quadrangle and trends in an arcuate pattern across the northern portion of the Central Basin (Baltz, 1967). Regional dip within the quadrangle is appproximately 1° to the northeast.

A fault trending southwest-northeast cuts across the northwest part of the quadrangle. The area northwest of the fault is downdropped with outcrops of the Fruitland 1 and Fruitland 2 coal beds on each side of the fault. The amount and direction of actual offset were not determined.

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 coal beds have been correlated and mapped as if each 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 top of the Point Lookout Sandstone has been used as a datum for each oil and gas test hole; the Menefee coals have been plotted in the column and correlated based upon their position relative to the datum. Correlations of Fruitland coals in coal test holes (Beaumont and Speer, 1977; Chaco Energy, unpublished data; Texas Utilities Fuel Company, unpublished data) and measured sections (Beaumont and Speer, 1977) were based upon previous correlations and geologic maps (Beamont and Speer, 1976; 1977).

One coal zone (Menefee) was identified in the subsurface and three coal beds (Fruitland 1, Fruitland 2, Fruitland 3) were mapped on the surface of this quadrangle (CRO Plate 1). The Menefee Formation coals were designated as the Menefee coal zone (Me zone). Since these coals are discontinuous, noncorrelative, and less than reserve base thickness (5 ft [1.5 m]) as set by the U.S. Geological Survey, derivative maps were not constructed.

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 in this quadrangle. There is no apparent consistent difference between the various Menefee Formation coal beds (Dane, 1936). In the southern part of the San Juan Basin, the coals vary from subbituminous B to high volatile C bituminous in rank. 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 12.1 to 20.0 percent, sulfur content generally less than two percent, ash content ranging from 4.9 to 10.2 percent, and heating values on the order of 10,269 Btu's per pound (23,886 kj/kg) (Bauer and Reeside, 1921; Dane, 1936; Lease, 1971; Shomaker, 1971). Analyses of several Menefee Formation coals were included in reports by Lease (1971) and Shomaker (1971). The results of these analyses are given in Table 1.

The Point Lookout Sandstone occasionally contains random Menefee coal beds in the upper portion, which are part of a Menefee tongue. They have been designated as local coals because they are random, discontinuous, and below the reserve base thickness of 5 ft (1.5 m) as set by the U.S. Geological Survey.

The Fruitland 1 (Fr 1) coal bed is defined by the authors as the lowermost coal of the Fruitland Formation; generally it is directly above the Pictured Cliffs Sandstone. The Fruitland 2 (Fr 2) coal bed overlies the Fruitland 1 coal bed. The rock interval between them varies in thickness from 11.0 ft (3.4 m) in drill hole 12 to 110.2 ft (33.6 m) in drill hole 19 (CRO Plate 1). These coal beds crop out in the northern part of the quadrangle. The Fruitland 3 (Fr 3) coal bed crops out in the northwest and extends westward into the eastern corner of the Pueblo Pintado 7 1/2-minute quadrangle. The coal bed is present only in the northwest part of the quadrangle on the western side of the fault. The rock interval between the Fruitland 3 and the Fruitland 2 coal beds varies from 61.4 ft (18.7 m) in drill hole 11 to 73.1 ft (22.3 m) in drill hole 10 (CRO Plate 1). The traces of outcrop of all Fruitland coal beds have been modified from the original data source to conform with modern topographic maps.

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
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	
J-57562	Pit Sample	SW¼ 11	22	13	——	A	14.4	32.6	42.8	10.2	0.9	9,870	
						B	——	38.1	50.0	11.9	1.0	11,530	
						C	——	43.3	56.7	——	1.2	13,090	

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

The remaining Fruitland Formation coal beds were designated as local coal beds. Each of these beds is less than reserve base thickness (5 ft [1.5 m]) and is limited in areal extent; therefore, derivative maps were not constructed.

Fruitland Formation coal beds in the southeastern part of the San Juan Basin are considered high volatile C bituminous, although they vary in rank from subbituminous A to high volatile C bituminous. The rank of the coal has been determined on a moist, mineral-matter-free basis with calorific values ranging from 11,435 to 12,401 Btu's per pound (26,598-28,845 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 9.2 to 12.44 percent, ash content between 5.8 and 32.68 percent, sulfur content less than one percent, and heating values averaging 9,722 Btu's per pound (22,613 kj/kg) (Dane, 1936; Shomaker and Lease, 1971).

Fruitland 1 Coal Bed

As illustrated by the structure contour map (CRO Plate 5) the bed dips approximately 1° to the northeast. Due to topography and dip, overburden (CRO Plate 6) ranges from zero at the outcrop to greater than 500 ft (152 m) in the north. The isopach map (CRO Plate 4) shows the coal bed is greater than 15 ft (4.5 m) thick in portions of the northeast and east. In general, the thickness decreases from these areas and the coal is absent in a small portion of the north-central part of the quadrangle.

Chemical Analyses of the Fruitland 1 Coal Bed - Several analyses of Fruitland coals from the Pueblo Alto Trading Post 7 1/2-minute quadrangle and the surrounding areas were published by Shomaker and Lease (1971). The results of these analyses are given in Table 2.

Fruitland 2 Coal Bed

As illustrated by the structure contour map (CRO Plate 9) the coal bed dips approximately 1° to the northeast. Due to topography and dip, overburden (CRO Plate 10) varies from zero at the outcrop to over 500 ft (152 m) in the northern part of the quadrangle. The isopach map (CRO Plate 8) shows the coal bed is greater than 25 ft (7.6 m) thick in the northwest, to the west of the fault, and greater than 20 ft (6.1 m) thick in the central part of the quadrangle, to the east of the fault. In general, the thickness decreases from these areas and the coal is absent in the northeast.

Chemical Analyses of the Fruitland 2 Coal Bed - Several analyses of Fruitland coals from the Pueblo Alto Trading Post 7 1/2-minute quadrangle and surrounding areas were published by Shomaker and Lease (1971). The results of these analyses are given in Table 2.

Fruitland 3 Coal Bed

As illustrated by the structure contour map (CRO Plate 13) the coal bed dips approximately 1° to the northeast. As a result of topography and dip, overburden (CRO Plate 14) varies from zero at the outcrop to over 300 ft

(91 m) in the north. The isopach map (CRO Plate 12) shows that the coal bed is present exclusively on the west side of the fault where its maximum thickness is greater than 5 ft (1.5 m) thick.

Chemical Analyses of the Fruitland 3 Coal Bed - Several analyses of Fruitland coals from the Pueblo Alto Trading Post 7 1/2-minute quadrangle and surrounding areas were published by 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, Farmington, New Mexico) coal test holes (Beaumont and Speer, 1977; Chaco Energy, unpublished data; Texas Utilities Fuel Company, unpublished data), and geologic maps (Beaumont and Speer, 1976 and 1977) were used in the construction of outcrop, isopach, and structure contour maps of coal beds in this quadrangle. Outcrops of the Fruitland 1 and Fruitland 2 coal beds in the eastern half of the quadrangle (CRO Plate 1) and parts of the Fruitland 3 in the northwest are modified from Beaumont and Speer (1976, 1977); however, the Fruitland 1 and Fruitland 2 outcrops on the northwest side of the fault are inferred from structural and topographic information.

The U.S. Geological Survey designated the Fruitland 1, Fruitland 2, and Fruitland 3 coal beds for the determination of coal resources in this quadrangle. Coals of the Menefee Formation were not evaluated because they are less than the reserve base thickness of 5 ft (1.5 m).

TABLE 2

Analyses of coal samples from the Fruitland Formation

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

U.S. Bureau Mines Lab No.	Well or Other Source	Location Section	Location T.N.	Location R.W.	Approx. Depth Interval of Sample (ft.)	Form of Analysis	Proximate, percent: Mois-ture	Proximate, percent: Volatile matter	Proximate, percent: Fixed Carbon	Proximate, percent: Ash	Proximate, percent: Sulfur	Heating Value (Btu)	Remarks
*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	NW¼11	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.

For Reserve Base and Reserve calculations, each coal bed was areally divided into measured, indicated, and inferred resource categories (CRO Plates 7, 11, and 15) according to criteria established in U.S. Geological Survey Bulletin 1450-B. Data for calculation of Reserve Base and Reserves for each category were obtained from the respective coal isopach (CRO Plates 4, 8, and 12) and areal distribution maps (CRO Plates 7, 11, and 15) for each coal bed. The surface area of each isopached bed was measured by planimeter, in acres, for each category, then multiplied by both the average isopached thickness of the coal bed and 1,800 short tons of coal per acre-foot (13,239 tons/hectare-meter), the conversion factor for bituminous coal. This yields the Reserve Base coal, in short tons, for each coal bed.

In order to calculate Reserves, 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 measured, indicated, and inferred categories of coal for the Fruitland 1, Fruitland 2, and Fruitland 3 beds are shown on CRO Plates 7, 11, and 15, respectively, and are rounded to the nearest hundredth of a million short tons. The total coal Reserve Base by section is shown on CRO Plate 2 and totals approximately 216 million short tons (196 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 surface and/or subsurface mining methods. The Pueblo Alto Trading Post quadrangle has development potential for both surface and subsurface mining methods (CDP Plates 16 and 17).

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 potential in short tons, for surface and underground coal, respectively, of the Fruitland 1, Fruitland 2, and Fruitland 3 coal beds.

Development Potential for Surface Mining Methods

Strippable coal of the Fruitland 2 and Fruitland 3 coal beds has high development potential in the northwestern corner of the quadrangle (CDP Plate 16). Individual coal bed thicknesses in this area are 6 to more than 25 ft (1.8-7.6 m) for the Fruitland 2, which is present throughout the high potential area (CRO Plate 8), and 5 ft (1.5 m) for the Fruitland 3 (CRO Plate 12). The Fruitland 2 coal with high development potential has overburden ranging in thickness from zero at the outcrop to 200 ft (61 m) (CRO Plate 10); however, the Fruitland 3 coal with high potential is overlain by approximately 100 ft (30 m) of overburden (CRO Plate 14).

The Fruitland 2 bed forms small isolated areas with moderate development potential in the northwest and northeast where the coal bed thickness is 10 ft (3.6 m) and 15 ft (4.6 m), respectively, and the overburden varies from 100 to 200 ft (30-61 m) thick.

Coal of the Fruitland 2 bed has low potential in a small area in the northeast corner adjacent to the moderate potential area. The coal bed thickness in this area is 13 ft (4.0 m), and the overburden is slightly less than 200 ft (61 m) thick. The Fruitland 3 has low potential in the northwest where the coal is 5 to 6 ft (1.5-1.8 m) thick and the overburden is 100 to

TABLE 3

STRIPPABLE COAL RESOURCES FOR FEDERAL COAL LANDS (in short tons) IN THE PUEBLO ALTO TRADING POST 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 minng ratio)	Moderate development potential (10-15 mining ratio)	Low development potential (15 mining ratio)	Total
Fruitland 3	120,000	530,000	3,660,000	4,310,000
Fruitland 2	62,200,000	3,710,000	1,430,000	67,340,000
Fruitland 1	--	--	1,790,000	1,790,000
TOTAL	62,320,000	4,240,000	6,880,000	73,440,000

TABLE 4

COAL RESOURCE DATA FOR UNDERGROUND MINING
METHODS FOR FEDERAL COAL LANDS
(in short tons) IN THE PUEBLO ALTO TRADING POST
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 3	140,000	--	--	140,000
Fruitland 2	104,880,000	--	--	104,880,000
Fruitland 1	37,650,000	--	--	37,650,000
TOTAL	142,670,000	--	--	142,670,000

170 ft (30-52 m) thick. The Fruitland 1 coal has surface development potential (low) only in a small area in the northwest corner of the quadrangle; however, it is overlain by coal of the Fruitland 2 bed with moderate development potential and, thus, does not appear on CDP Plate 16.

Several small areas with unknown coal development potential occur in the northwestern part of the quadrangle where the Fruitland 3 coal bed is less than 5 ft (1.5 m) thick, and the Fruitland 1 and Fruitland 2 have more than 200 ft (61 m) of overburden. The west-southwest and northeastern parts of the area have no potential for development, because these areas are outside the coal bed outcrop (west, southwest) or outside the 200-foot (61-m) stripping limit (northeast).

Development Potential for Subsurface Mining Methods

Underground coal of the Fruitland 1 and Fruitland 2 coal beds has high development potential along the northern border and in the northeast corner of the quadrangle, and the Fruitland 3 bed has high potential in a very small area along the northern boundary of the quadrangle (CDP Plate 17). In the areas with high potential the overburden thickness varies for each coal bed from 200 ft (614 m) for the Fruitland 3 to 200 to 400 ft (61-122 m) for the Fruitland 1 and Fruitland 2 coal beds (CRO Plates 6, 10, and 14). Coal bed thicknesses are 5 to 15 ft (1.5-4.6 m) for the Fruitland 1 (CRO Plate 4), 5 to 25 ft (1.5-7.6 m) for the Fruitland 2 (CRO Plate 8), and approximately 6 ft (1.8 m) for the Fruitland 3 (CRO Plate 12).

Adjacent to the high potential area in the northwest, the Fruitland 1 is the only coal bed with more than 200 ft (61 m) of overburden in the quadrangle; however, the coal is less than 5 ft (1.5 m) thick and, thus, has unknown development potential for subsurface mining methods. The remainder of the quadrangle has no subsurface coal development potential in areas within the 200-foot (61-m) stripping limit and areas outside the coal bed outcrops.

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