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

[Report includes 16 plates]

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CONTENTS

CONTENTS

PLATES

CONTENTS

TABLES

LA PLATA 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 La Plata quadrangle, San Juan County, New Mexico and La Plata County, Colorado. These maps were compiled to provide a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA's) in the western United States. The work has been performed under contract with the Conservation Division of the U.S. Geological Survey (Contract No. 14-08-001-17172).

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 La Plata 7 1/2-minute quadrangle is located in north-central San Juan County, New Mexico; the northern border of the quadrangle extends into La Plata County, Colorado. The area is approximately 12 miles (19 km) due north of Farmington, New Mexico.

Accessibility

The La Plata quadrangle is accessible from New Mexico State Route 17 which trends north-south through the central part of the quadrangle. Light-duty roads extend from State Route 17 and provide further access to the quadrangle area. The Atchison, Topeka, and Santa Fe Railway operates a route approximately 104 miles (167 km) south of the area at Gallup, New Mexico.

Physiography

This quadrangle is in the northwestern portion of the Central Basin area (Kelley, 1950) of the structural depression known as the San Juan Basin. Elevations range from 5,580 ft (1,701 m) in the south along the La Plata River to 6,780 ft (2,066 m) in the northwest. The La Plata River Valley occupies the central portion of the area and trends north-south. The majority of the area has low relief; however, the western and northwestern parts of the area are characterized by a dissected steep slope which is the flank of the Hogback Monocline.

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 precipiation is received in July and August as intense afternoon thundershowers. Annual temperatures in the basin range from below 0°F (-18°C) to above 100°F (38°C). Snowfall may occur from November to April.

Land Status

Approximately 72 percent of the quadrangle is in the northwestern boundary of the San Juan Basin Known Recoverable Coal Resource area. The Federal Government owns the coal rights for approximately 74 percent of the KRCRA land within the quadrangle as shown on Plate 2 of the Coal Resource Occurrence Maps. A coal lease (NM 0135559) in the north covers approximately 6 percent of the quadrangle.

GENERAL GEOLOGY

Previous Work

Bauer and Reeside (1921) mapped the Fruitland Formation within the quadrangle with detailed emphasis on the outcrops of Fruitland coal and clinker. In 1924, Reeside mapped the various formations on a scale of 1:250,000 as part of a study of the Upper Cretaceous and Tertiary formations of the San Juan Basin. Hayes and Zapp (1955) published a geologic map of the Barker Dome-Fruitland area on a scale of 1:62,500. In addition to mapping the Upper Cretaceous rocks of the area, they mapped the outcrops of Fruitland and Menefee Formation coal beds and measured various coal-bearing sections.

More recently, Fassett and Hinds (1971) made subsurface interpretations of the Fruitland Formation coals in this area as part of a larger San Juan Basin coal study.

Geologic History

The San Juan Basin, an area of classic transgressive and regressive sedimentation, provided the ideal environment for formation of coals during Late Cretaceous time. At that time a shallow epeiric sea, which trended northwest-southeast, was northeast of the basin. The sea transgressed southwesterly into the basin area and regressed northeasterly numerous times; consequently, sediments from varying environments were deposited across the basin. Noncarbonaceous terrestrial deposition predominated during Paleocene and Eocene time.

After its first basin-wide retreat, the Late Cretaceous sea reversed the direction of movement. As a result, the transgressive sequence of paludal Menefee Formation, nearshore Cliff House Sandstone, and marine Lewis Shale was deposited in the quadrangle. Swamps (Menefee) formed southwest (shoreward) of the transgressing beaches (Cliff House). Organic matter deposited in these swamps ultimately formed coal in the Menefee Formation. Cliff House Sandstone beach sands were then deposited over the Menefee. 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 northwest. 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 north-south strandline in this part of the basin and their discontinuity perpendicular to it to the east.

The brackish-water swamp environment of the Fruitland moved northeast of the area as the regression continued in that direction. Terrestrial freshwater sediments then 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 deposits of the Nacimiento during continuous nonmarine deposition. The Nacimiento was later exposed to erosion.

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

Stratigraphy

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

The oldest coal-bearing formation in the quadrangle is the Menefee Formation of the Mesaverde Group. In previous studies the Menefee has been divided into the Cleary Coal Member, the barren Allison Member, and an upper coal-bearing member (Beaumont and others, 1956). These members are referred to as the undifferentiated Menefee Formation for the purposes of this report only. The formation consists primarily of gray, carbonaceous to noncarbonaceous shale with plant fossils, light gray, kaolinitic sandstone, and lenticular coal beds. It has a total thickness of approximately 900 ft

(274 m) in this area. Coal beds of the Menefee Formation are exposed on the flanks of the Hogback Monocline. Due to the steep dip, however, a short distance to the east and southeast the Menefee Formation is more than 3,000 ft (914 m) deep (the study limit). Therefore, the total formational thickness is not shown on Plate 3 of the CRO maps.

The Cliff House Sandstone conformably overlies the Menefee Formation. This formation is about 200 ft (61 m) thick and consists of buff to light gray, micaceous, calcareous sandstone with a trace of glauconite and interbedded gray shale.

The marine Lewis Shale conformably overlies the Mesaverde Group. In contrast to the underlying Cliff House Sandstone, it is comprised predominantly of dark gray, micaceous, fossiliferous shale, interbedded gray, slightly calcareous siltstone, and interbedded gray sandstone. It averages 1,405 ft (428 m) in thickness in this area. The upper contact is gradational with the overlying Pictured Cliffs Sandstone, and, therefore, a definite and consistent contact is difficult to establish.

The Pictured Cliffs Sandstone consists of about 150 ft (46 m) of light gray, slightly kaolinitic sandstone interbedded with gray shale. The upper contact is more sharply defined than the basal contact, even though intertonguing with the overlying Fruitland Formation results in minor variations in the formational top and occurrence of local Fruitland coal beds in the sandstone. Since the formation is present throughout most of the basin and displays a distinctive character on geophysical logs, the authors have used the top as a lithologic datum for correlation of Fruitland coals.

The Fruitland Formation is the major coal-bearing unit in the quadrangle. It averages 480 ft (146 m) of gray to brown, carbonaceous to noncarbonaceous shale, gray, slightly micaceous sandstone, and coal beds of varying thicknesses. The thickest and most continuous coal beds occur near the base of the formation, while discontinuous and lenticular coals are characteristic of the upper portion. The upper contact is gradational from nonmarine, lower coastal plain deposits of the Fruitland to upper coastal or alluvial plain deposits of the Kirtland Shale (Molenaar, 1977).

The freshwater deposits of the Kirtland Shale average 1,300 ft (396 m) in thickness in this area and are composed of light gray to gray-green, micaceous shale with scattered subrounded siderite grains, and light gray, slightly micaceous, glauconitic sandstone beds. The formation has previously been divided into several members by various authors; however, for the purpose of this report it was not necessary to distinguish between the individual members.

Unconformably overlying the Upper Cretaceous rocks is the Paleocene Ojo Alamo Sandstone. It consists of about 80 ft (24 m) of an andesitic, tuffaceous conglomerate containing pebble- to boulder-size clasts, with interbedded variegated shale and sandstone.

The nonmarine Paleocene Nacimiento Formation conformably overlies the Ojo Alamo Sandstone. Erosion has removed hundreds of feet of the Nacimiento from the area. In contrast with the Ojo Alamo, it consists primarily of light gray to black shale, gray to gray-green claystone, and sandstone.

The dip of beds forming the structural feature, the Hogback Monocline, causes the exposure of successively younger strata in a southeasterly direction. The oldest unit exposed is the Menefee Formation. The Menefee, Cliff House Sandstone, Lewis Shale, Pictured Cliffs Sandstone, Fruitland Formation, Kirtland Shale, and Ojo Alamo Sandstone are all exposed in the northwestern part of the area along the flank of the Hogback Monocline. The Nacimiento, the youngest formation in the area, is exposed along the eastern margin of the Hogback Monocline and across the remainder of the quadrangle.

Structure

The La Plata quadrangle is in the Central Basin area (Kelley, 1950) of the major structural depression known as the San Juan Basin. The western end of the basin axis is about 3 miles (5 km) south of the quadrangle and trends eastward in an arcuate pattern across the northern part of the Central Basin area (Baltz, 1967). The Hogback Monocline trends north-south and east-west across the western and northern parts of the area, respectively. The dip direction of the strata is to the east and south, respectively. The dip of strata on the flanks of the monocline is steep, but a short distance to the east and southeast the dip angles decrease to approximately 1°. Reeside (1924) and Hayes and Zapp (1955) have measured the dip of the strata in this quadrangle, which ranges from 38° to 1°.

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 and 2 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 tops of the sandstone units have been used as datums for the oil and gas test holes (El Paso Natural Gas Co., 1978, unpublished data in well log library, Farmington, New Mexico) and the coals have been correlated based upon their position relative to the datum. Correlations of Fruitland and Menefee coals in measured sections (Bauer and Reeside, 1921; Hayes and Zapp, 1955) are based upon previous correlations and geologic maps (Bauer and Reeside, 1921; Hayes and Zapp, 1955).

Two coal zones (Menefee, Fruitland) and three coal beds (Fruitland 1, Fruitland 2, Fruitland 3) were identified in this quadrangle (CRO Plate 1). The coals of the Menefee Formation are designated as the Menefee coal zone (Me zone). Several of these coals crop out in the western part of the quadrangle. Since the Menefee coals are generally noncorrelative, discontinuous, and less than reserve base thickness (5 ft [1.5 m]) as set by the U.S. Geological Survey, derivative maps were not constructed.

Menefee Formation coals in the northwestern part of the San Juan Basin vary from borderline subbituminous A-high volatile C bituminous to high volatile B bituminous. The rank has been determined on a moist, mineral-matter-free basis with calorific values averaging 12,563 Btu's per pound (29,222 kj/kg) (Amer. Soc. for Testing and Materials, 1977). The coal is hard, brittle, and black with a bright luster. The coal readily slakes with exposure to weather; however, it stocks fairly well when protected. The "as received" analyses indicate moisture content varying from 5.6 to 11.3 percent, ash content ranging from 3.1 to 6.3 percent, sulfur content less than one percent, and heating values on the order of 11,993 Btu's per pound (27,896 kj/kg). Analyses of several Menefee coals are given in Table 1 (Bauer and Reeside, 1921; Hayes and Zapp, 1955; Shomaker and Whyte, 1977).

The Fruitland 1 (Fr 1) coal bed is defined by the authors as the lowermost coal of the Fruitland Formation; it is generally directly above the Pictured Cliffs Sandstone. The Fruitland 2 (Fr 2) coal bed occurs above the Fruitland 1. Both of these coal beds crop out in the northern and western portions of the quadrangle. The Fruitland 3 (Fr 3) coal bed occurs above the Fruitland 2 and crops out in the western part of the quadrangle. Since the Fruitland 3 is less than reserve base thickness (5 ft [1.5 m]) within the KRCRA, derivative maps were not constructed.

The remaining coals of the Fruitland Formation are designated as the Fruitland coal zone (Fr zone) which extends from the top of the Fruitland Formation to the base of the lowermost coal designated on CRO Plate 3 as a Fruitland zone coal bed. A coal bed of the Fruitland zone crops out in the north and west.

Fruitland Formation coals in the northwestern part of the San Juan Basin are considered high volatile B to high volatile A bituminous in rank. The rank has been determined on a moist, mineral-matter-free basis with

TABLE 1

Analyses of coal samples from the Menefee Formation

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

U.S. Bureau Mines Lab No.	Well or Other Source	Location			Approx. Depth Interval of Sample (ft.)	Form of Analysis	Proximate, percent					Heating Value (Btu)	Remarks
		Section	T.N.	R.W.			Mois-ture	Volatile matter	Fixed Carbon	Ash	Sulfur		
J-58561	Merrion & Bayless #1, Union	9	29	15	2,494-2,500	A	5.6	40.4	47.7	6.3	0.8	12,740	
						B	----	42.7	50.7	6.6	0.9	13,490	
						C	----	45.8	54.2	---	1.0	14,450	
17750	Shiprock School Mine(?) (100 ft from entry) (Government Mine)	SW¼ 21	30	16	----------	A	10.6	36.7	49.6	3.1	0.64	11,010	
						B	----	41.1	55.4	3.5	0.72	12,310	
						C	----	42.6	57.4	---	0.75	12,750	
A-46364	Shiprock School Mine (250 ft from entry)	21	30	16	----------	A	9.8	38.7	46.5	5.0	----	11,870	
						B	----	42.9	51.5	5.6	----	13,170	
						C	----	45.4	54.6	---	1.5	13,940	
29006	Shiprock School Mine (350 ft from entry) (Government Mine)	SW¼ 21	30	16	----------	A	10.1	39.9	45.8	4.2	0.85	12,010	
						B	----	44.4	50.9	4.7	0.95	13,370	
						C	----	46.6	53.4	---	1.00	14,020	
A-46365	Joe Duncan Mine (150 ft from entry)	21	30	16	----------	A	10.5	39.1	47.2	3.2	----	12,240	
						B	----	43.7	52.7	3.6	----	13,670	
						C	----	45.3	54.7	---	1.0	14,180	
C-31312	Davidson Mine (tipple)	22	30	16	----------	A	11.3	39.3	46.0	3.4	----	12,090	
						B	----	44.3	51.9	3.8	----	13,630	
						C	----	46.1	53.9	---	0.8	14,170	

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

calorific values averaging 14,196 Btu's per pound (33,020 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; however, it stocks fairly well when protected. The "as received" analyses indicate moisture content varying from 1.7 to 6.9 percent, ash content ranging from 8.4 to 16.2 percent, sulfur content varying from 0.5 to 1.32 percent, and heating values on the order of 11,490 to 13,350 Btu's per pound (26,726-31,052 kj/kg). Analyses of several Fruitland Formation coals are given in Table 2 (Bauer and Reeside, 1921; Fassett and Hinds, 1971; Hayes and Zapp, 1955).

Fruitland 1 Coal Bed

The Fruitland 1 coal bed dips, in general, to the southeast as shown on the structure contour map (CRO Plate 5). The dip varies from as much as 45° at the outcrop to less than 1° in the eastern and southern portions of the map. Because of topography and dip, the overburden (CRO Plate 6) values range from zero at the outcrop to more than 2,400 ft (732 m) in the extreme southeastern corner of the map. The isopach map (CRO Plate 4) shows that the coal bed has a thickness of more than 30 ft (9.1 m) in the northeast part of the map. The thickness decreases in all directions, and the coal bed is absent from portions of the west, southwest, and southeast.

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

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: Moisture	Proximate, percent: Volatile matter	Proximate, percent: Fixed Carbon	Proximate, percent: Ash	Sulfur	Heating Value (Btu)	Remarks
H-15777	El Paso Nat Gas Case No. 9	SW¼ 8	31	11	2,710-2,740	A	1.7	40.3	47.0	11.0	0.7	13,350	
						B	—	41.0	47.9	11.1	0.7	13,580	
						C	—	46.1	53.9	—	0.8	15,280	
H-19884	Consolidated Oil & Gas Mitchell No. 1-5	SW¼ 5	31	12	2,215-3,000	A	2.4	39.4	47.3	10.9	0.5	13,090	
						B	—	40.4	48.5	11.1	0.5	13,410	
						C	—	45.5	54.5	—	0.6	15,100	
H-15141	Consolidated Oil & Gas Freeman No. 1-11	NE¼ 11	31	13	1,776-1,782	A	2.3	37.9	43.6	16.2	1.3	12,040	
						B	—	38.8	44.7	16.5	1.3	12,320	
						C	—	46.5	53.5	—	1.6	14,760	
17749	New Mexico Mine	7	32	12	—	A	6.6	35.4	44.9	13.1	0.66	11,490	
						B	—	37.9	48.0	14.1	0.71	12,300	
						C	—	44.1	55.9	—	0.83	14,310	
B-61247	Morgan Mine (tipple)	15	32	13	—	A	5.4	38.6	46.0	10.0	—	12,320	
						B	—	40.9	48.6	10.5	—	13,030	
						C	—	45.7	54.3	—	—	14,560	
B-61248	W.H. Thomas Mine (tipple)	15	32	13	—	A	5.4	40.0	46.2	8.4	—	12,650	
						B	—	42.2	48.9	8.9	—	13,380	
						C	—	46.4	53.6	—	—	14,680	
29250	Jones Mine (500 ft from entry)	SE¼ 21	32	13	—	A	6.9	38.1	43.1	11.9	1.32	11,630	
						B	—	41.0	46.2	12.8	1.42	12,500	
						C	—	47.0	53.0	—	1.63	14,330	
29249	W.H. Thomas Mine (500 ft from entry)	NW¼ 22	32	13	—	A	5.9	39.1	44.0	11.0	0.63	12,050	
						B	—	41.5	46.8	11.7	0.67	12,810	
						C	—	47.0	53.0	—	0.76	14,510	

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

Fruitland 2 Coal Bed

The Fruitland 2 coal bed dips in a southeasterly direction, as indicated by the structure contour map (CRO Plate 9). The dip varies from as much as 45° along parts of the outcrop to less than 1° in the east and south. As a result of topography and dip, the overburden (CRO Plate 10) varies in thickness from zero at the outcrop to more than 2,000 ft (610 m) in the eastern part of the map. As illustrated by the isopach map (CRO Plate 8) the coal bed is more than 25 ft (7.6 m) thick in the west-central portion of the map. In general, the thickness decreases in all directions, and the coal bed is absent from areas in the west and southeast parts of the map.

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

Fruitland Coal Zone

The Fruitland coal zone extends from the top of the Fruitland Formation to the lowermost coal designated on CRO Plate 3 as a Fruitland zone coal bed. Therefore, the structure contour map (CRO Plate 13) is drawn on the top of the Fruitland Formation. It shows the coal zone dips toward the southeast, varying from as much as 45° in the west to less than 1° in the east. As a result of topography and dip, overburden (CRO Plate 14) varies from zero at the outcrop to greater than 2,000 ft (610 m) in the southeast. noncoal-bearing portion of the zone. Also shown on CRO Plate 14 is the total amount of interburden which is the noncoal portion of the zone. The interburden values range from zero to greater than 500 ft (152 m) and reflect the stratigraphic spread of the coals in the formation. The isopach map (CRO Plate 12) shows the total coal thickness which is greater than 15 ft (4.6 m) in parts of the central, western, and northwestern portions of the quadrangle. The thickness decreases from these areas, and the coal is absent in the southwest, north-central, and northeast.

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

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) and geologic maps (Hayes and Zapp, 1955; Bauer and Reeside, 1921) were utilized in the construction of outcrop, isopach, and structure contour maps of coal beds in this quadrangle. Outcrops of the Fruitland 1, Fruitland 2, Fruitland 3, and Fruitland and Menefee zone coals in the north, northwest, and eastern parts of the quadrangle (CRO Plate 1) are modified from Hayes and Zapp (1955) and Bauer and Reeside (1921). The U.S. Geological Survey designated the Fruitland 1 and Fruitland 2 coal beds for the determination of coal resources in this quadrangle. Coals of the Fruitland zone and Menefee Formation were not evaluated because they are generally discontinuous and less than the reserve base thickness of 5 ft (1.5 m). The Fruitland 3 coal bed was not evaluated since it is less than 5 ft (1.5 m) thick within the KRCRA.

For Reserve Base and Reserve calculations, each coal bed was areally divided into measured, indicated, and inferred resource categories (CRO Plates 7 and 11) 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 and 8) and areal distribution (CRO Plates 7 and 11) maps 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 and Fruitland 2 beds are shown on CRO Plates 7 and 11, respectively, and are rounded to the nearest hundredth of a million short tons. Reserve values were not calculated for areas where the dip of the coal beds is greater than 15°. The total coal Reserve Base by section is shown on CRO Plate 2 and totals approximately 388 million short tons (352 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 subsurface mining methods and moderate or low potential for in-situ gasification. The La Plata quadrangle has development potential for surface mining methods (CDP Plate 15), and subsurface mining and in-situ gasification methods (CDP Plate 16).

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, subsurface, and in-situ 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 [610-914 m] thick) with a dip of less than 15° are evaluated for subsurface mining methods. They 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.

Underground coal beds with dips ranging from 15° to 90° are evaluated for in-situ gasification methods. They are assigned moderate or low potential according to the dip angle and coal tonnages. Single coal beds or multiple, closely spaced bituminous coal bed(s) have moderate potential if the dip is 35° to 90° and there is a minimum reserve base of 50 million short tons (45 million metric tons) of coal. Single coal beds or multiple, closely spaced bituminous coal bed(s) have low development potential if: 1) the dip is 35° to 90° and the reserve base is less than 50 million short tons (45 million metric tons), or 2) the dip is 15° to 35°, regardless of the reserve base coal present. The areal distribution maps for this quadrangle (CRO Plates 7 and 11) show two lines connecting points of equal dip (15° and 35°) for the purpose of determining the in-situ coal development potential. Data for constructing these lines are taken from Hayes and Zapp (1955). Tables 3, 4, and 5 summarize the coal development potential, in short tons, for surface, underground, and in-situ (underground) coal, respectively, of the Fruitland 1 and Fruitland 2 coal beds.

TABLE 3

STRIPPABLE COAL RESOURCES FOR FEDERAL COAL LANDS (IN SHORT TONS) IN THE LA PLATA QUADRANGLE, SAN JUAN COUNTY, NEW MEXICO, AND LA PLATA COUNTY, COLORADO

[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 2	30,000	50,000	90,000	170,000
Fruitland 1	4,830,000	660,000	250,000	5,740,000
TOTAL	4,860,000	710,000	340,000	5,910,000

TABLE 4

COAL RESOURCE DATA FOR SUBSURFACE MINING METHODS FOR FEDERAL COAL LANDS (in short tons) IN THE LA PLATA QUADRANGLE, SAN JUAN COUNTY, NEW MEXICO, AND LA PLATA COUNTY, COLORADO

(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	6,260,000	13,150,000	—	19,410,000
Fruitland 1	31,300,000	161,320,000	73,570,000	266,190,000
TOTAL	37,560,000	174,470,000	73,570,000	285,600,000

TABLE 5

COAL RESOURCE DATA FOR IN-SITU GASIFICATION (UNDERGROUND) MINING METHODS FOR FEDERAL COAL LANDS (in short tons) IN THE LA PLATA QUADRANGLE, SAN JUAN COUNTY, NEW MEXICO, AND LA PLATA COUNTY, COLORADO

(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	--	--	35,380,000	35,380,000
Fruitland 1	--	--	61,550,000	61,550,000
TOTAL	--	--	96,930,000	96,930,000

Development Potential for Surface Mining Methods

Small sections of strippable coal of the Fruitland 1 bed have high development potential in the western part of the quadrangle (CDP Plate 15) where the coal bed thickness ranges from 5 to 25 ft (1.5-7.6 m) (CRO Plate 4), and the overburden increases from zero at the outcrop to 200 ft (61 m) to the east (CRO Plate 6). A small area of unknown potential occurs in the northwest where the Fruitland 2 coal bed has less than 200 ft (61 m) of overburden (CRO Plate 10), however, it is less than the reserve base thickness of 5 ft (1.5 m) (CRO Plate 10). Remaining areas along the western to northwestern border of the area contain steeply dipping and strippable coal, however, it is limited in areal extent and, thus, was not evaluated for development potential. The remainder of the quadrangle area within the KRCRA contains coal with more than 200 ft (61 m) of overburden and has no development potential for surface mining methods.

Development Potential for Subsurface Mining Methods

Underground coal of the Fruitland 1 bed has high development potential in an east-west-trending strip in the northeastern part of the area (CDP Plate 16). The coal thickness in this area is 20 to 28 ft (6.1-8.5 m) (CRO Plate 4) and the overburden is approximately 800 to 1,000 ft (244-305 m) thick (CRO Plate 6). The Fruitland 2 coal bed has high potential in an area in the southwest corner of the quadrangle where the coal bed is 5 to 13 ft (1.5-4.0 m) thick (CRO Plate 8), and the overburden thickness ranges from 200 to 1,000 ft (61-305 m) (CRO Plate 10).

Areas with moderate and low development potential for the Fruitland 1 bed occur in the eastern half of the quadrangle (CDP Plate 16). The thickness of the Fruitland 1 in these areas ranges from 5 to 30 ft (1.5-9.1 m) thick (CRO Plate 4), and the overburden is 1,000 to 2,000 ft (305-610 m) thick (CRO Plate 6) in the moderate potential areas and 2,000 to more than 2,140 ft (610-652 m) thick in the areas with low development potential. The overburden generally increases in thickness toward the east to southeast. Coal of the Fruitland 2 bed has moderate potential in the southwest corner of the quadrangle where the coal bed is 5 to 10 ft (1.5-3.0 m) thick (CRO Plate 8), and the overburden ranges from 1,000 to 1,600 ft (305-488 m) thick (CRO Plate 10).

Several areas with unknown development potential occur in the southern half of the quadrangle area where the Fruitland 1 and Fruitland 2 coal beds are less than the reserve base thickness of 5 ft (1.5 m). Areas with no coal development potential occur just inside the KRCRA boundary where the Fruitland 1 crops out and the Fruitland 2 has been removed by erosion, inside the stripping limit, and in the extreme southeast corner of the quadrangle where there is no Fruitland 1 or Fruitland 2 coal.

Development Potential for In-Situ (Underground) Gasification Methods

Coal of the Fruitland 1 and Fruitland 2 beds has low potential for in-situ gasification in the west-central part of the quadrangle (CDP Plate 16) where each of the coal beds dip between 15° and 35°. In part of the west-central area the coal beds dip greater than 35° and have less than 50 million short tons (45.4 metric tons) of coal. These areas are also rated low development potential for in-situ gasification.

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