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

[Report includes 12 plates]

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CONTENTS

CONTENTS

PLATES

CONTENTS

TABLES

BISTI 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 the Coal Development Potential Maps of the Bisti Trading Post 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) in the western United States. The work has been performed under contract with the Conservation Division of the U.S. Geological Survey (Contract No. 14-08-0001-17172).

The resource information gathered in this program is in response to the Federal Coal Leasing Amendments Act of 1976 and is a part of the U.S. Geological Survey's coal program. The information provides basic data on coal resources for land-use planning purposes by the Bureau of Land Management, state and local governments, and the public.

Location

The Bisti Trading Post 7 1/2-minute quadrangle is in south-central San Juan County, New Mexico. The eastern boundary of the Navajo Indian Reservation is in the eastern half of the quadrangle. The area is approximately 26 miles (42 km) south of Farmington and 58 miles (93 km) northeast of Gallup.

Accessibility

The area is accessible from the north by a light-duty road which extends south from Farmington about 32 miles (51 km) to Bisti Trading Post. Numerous unimproved dirt roads provide access to remote parts of the quadrangle. The Atchison, Topeka, and Santa Fe Railway operates an east-west route 58 miles (93 km) southwest of the area at Gallup, New Mexico.

Physiography

This quadrangle is in the southwest portion of the Central Basin (Kelley, 1950) area of the larger structural depression known as the San Juan Basin. Elevations range from 5,600 ft (1,707 m) in the southwest to 6,240 ft (1,902 m) in the northeast portion of the area. The central part is characterized by sparsely vegetated, gently sloping plains. In the northwestern corner of the quadrangle the plains have been incised by intermittent streams and developed a badlands topography. Hunter Wash, an intermittent drainage in the southern part of the area, has also carved a drainage basin which is characterized by low relief and badlands topography.

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 fluctuate greatly in the basin. Annual temperatures in the basin range from below 0°F (-18°C) to over 100°F (38°C). Snowfall may occur from November to April with an average of 18 inches (46 cm) in the southwestern part of the basin.

Land Status

Approximately 22 percent of the quadrangle is in the western portion of the San Juan Basin Known Recoverable Coal Resource Area. The Federal Government owns the coal rights for 99 percent of the KRCRA land as shown on Plate 2 of the Coal Resource Occurrence Maps. A Preference Right Lease Application (NM 6801) in the south covers 8 percent of the KRCRA. Federal coal leases (NM 0186612, NM 0186613 and NM 19986) in the southern portion of the quadrangle cover 19 percent of the KRCRA Land.

GENERAL GEOLOGY

Previous Work

Bauer and Reeside (1921) have mapped the Fruitland Formation within the quadrangle with detailed emphasis on outcrops of Fruitland coal and clinker. Reeside (1924) has mapped the Upper Cretaceous and Tertiary formations of the San Juan Basin. Shomaker (1971) described in detail the surface coal occurrences of the Fruitland Formation within the area and estimated the strippable reserves by township and range. A publication by Fassett and Hinds (1971) includes subsurface interpretations of the Fruitland Formation coal deposits throughout the San Juan Basin.

Geologic History

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

The first basin-wide retreat of the Late Cretaceous sea is indicated by the nearshore deposits of the Point Lookout Sandstone. These ancient barrier beaches formed a generally northwest-southeast-trending strandline, behind which swamps developed. Organic material accumulated in the swamps and later became coal in the paludal deposits of the lower Menefee Formation. Deposition of materials which formed the coal beds was influenced by the strandline. This is shown by the more consistent thickness and greater lateral extent of the coals parallel to the strandline and also by the lack of continuity perpendicular to it, to the northeast, where the Menefee and underlying Point Lookout deposits interfinger. Streams which crossed the swamps also influenced deposition of organic matter; stream deposits may terminate even the most continuous coal beds.

During the continued retreat of the sea, the depositional environments in the quadrangle area became more terrestrial. This is evidenced by the transition within the lower Menefee from carbonaceous to noncoal-bearing deposits, in which there is an upward decrease in the occurrence and lateral continuity of the coals. As the sea retreated, the sediments of the Point Lookout Sandstone and overlying Menefee Formation were deposited in successively higher stratigraphic positions to the northeast.

The sea then reversed the direction of movement, and the transgressive sequence of paludal upper Menefee Formation, nearshore Cliff House Sandstone, and marine Lewis Shale was deposited in the quadrangle. Swamps (Menefee) formed southwest (shoreward) of the transgressing beaches (Cliff House). Organic matter deposited in these swamps ultimately formed the coal beds in the upper part of the Menefee Formation. Subsequently, several hundred feet of beach sands of the La Ventana Tongue (Cliff House Sandstone) were deposited over the Menefee to the northeast of the quadrangle. A thin sand wedge of the La Ventana projects into the eastern part of the quadrangle, pinching out to the west and southwest.

Onlap continued as the sea moved southwestward across the basin area. The transgressing northwest-southeast-trending strandline is represented in the lithologic record by several hundred feet of the Chacra Tongue (informal name of local usage) overlying the La Ventana Tongue (both are members 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.

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, dissected by streams, accumulated organic matter which became coals of the Fruitland Formation. Again, deposition of organic material was influenced by the strandline as shown by the continuity of the coal beds parallel to the northwest-southeast strandline and discontinuity perpendicular to it to the northeast. The less continuous Fruitland coals appear to be noncorrelative, but are lithostratigraphically 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 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 erosional processes to the present time. A significant amount of erosion has occurred, as indicated by the removal of the San Jose Formation, Nacimiento Formation, Ojo Alamo Sandstone, and some of the Kirtland Shale from the area.

Stratigraphy

The formations studied in this quadrangle are Late Cretaceous in age. They are, in order from oldest to youngest: (the three formations of the Mesaverde Group) Point Lookout Sandstone, Menefee Formation, and Cliff House Sandstone; the Lewis Shale, Pictured Cliffs Sandstone, Fruitland Formation, and Kirtland Shale. 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 (based on log of oil and gas test hole of Davis Oil Co. No. 1, Perry-Navajo NE 1/4 Sec. 6, T. 24 N, R. 14 W).

The Point Lookout Sandstone, the basal formation of the Mesaverde Group, consists of cream to light gray, calcareous, kaolinitic, argillaceous sandstone. It is fairly massive and averages about 115 ft (35 m) in thickness.

The oldest coal-bearing formation in the quadrangle is the Menefee Formation of the Mesaverde Group. In previous studies the Menefee has been divided into the Cleary Coal Member, the barren Allison Member, and an unnamed upper coal-bearing member (Beaumont and others, 1956). These three members were grouped together as undifferentiated Menefee Formation for the purposes of this report only. The formation is about 1,730 ft (527 m) thick and is predominantly a dark gray, carbonaceous to noncarbonaceous, soft, flaky shale containing abundant plant fossils, interbedded white, coarse-grained with occassional pebbles, calcareous, poorly indurated sandstone, 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. It overlies the Menefee in the eastern portion of the quadrangle. However, toward the southwest it intertongues and is contemporaneous with, and wedges out into the Menefee. The La Ventana within the quadrangle is a thin wedge of sand projecting from a thicker sandstone sequence to the northeast. It consists of approximately 50 ft (15 m) of light gray, calcareous, friable sandstone.

The Chacra Tongue (informal name of local usage) of the Cliff House Sandstone is about 370 ft (113 m) thick in this area. It overlies the La Ventana Tongue in the eastern part of the quadrangle and the Menefee Formation in the west. It consists of thickly-bedded, light gray, calcareous sandstone with interbedded dark gray, calcareous, silty shale.

The marine Lewis Shale conformably overlies the Mesaverde Group. In contrast to the underlying Cliff House Sandstone, it is predominantly a gray, flaky, calcareous shale with siderite nodules. The Lewis averages 200 ft (61 m) in thickness in the northeastern part of the quadrangle, but thins to the southwest. The upper contact is gradational with the overlying Pictured Cliffs Sandstone and, therefore, a distinct contact is difficult to determine.

The Pictured Cliffs Sandstone consists of about 40 ft (12 m) of white, poorly indurated sandstone. The upper contact is more sharply defined than the basal contact, even though intertonguing with the overlying

Fruitland results in minor fluctuations 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 as a lithologic datum for correlation of the overlying Fruitland coals.

The Fruitland Formation is the major coal-bearing unit in the quadrangle. It consists of approximately 400 ft (122 m) of gray carbonaceous shale with plant fossils and limy nodules, interbedded light gray sandstone, gray siltstone, and coal beds of varying thicknesses. The thickest and most continuous coals occur near the base of the formation, while discontinuous and lenticular coals are characteristic of the upper portion. The upper contact is gradational from the nonmarine lower coastal plain deposits of the Fruitland to the upper coastal or alluvial plain deposits of the Kirtland Shale (Molenaar, 1977). Authors have used various criteria in establishing the upper contact but, in general, for the purposes of this report the uppermost coal was chosen (after Fassett and Hinds, 1971).

The freshwater deposits of the Kirtland Shale are the youngest Cretaceous strata in the area. They average 250 ft (76 m) in thickness and consist of gray, fissile shale with local plant fossils, and interbedded gray siltstone. 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.

Outcrop patterns in the quadrangle are influenced by the regional dip of 1° to 2° to the north, and progressively younger Cretaceous strata crop out in that direction. The oldest unit exposed is the Pictured Cliffs Sandstone in Hunter Wash in the southern part of the area. The entire

Fruitland Formation is exposed in the southern part. All but the uppermost part of the Kirtland Shale, the youngest formation, crops out in the northern half of the area.

Structure

The Bisti Trading Post quadrangle is in the Central Basin area (Kelley, 1950) of the San Juan Basin. The axis of the basin is about 33 miles (53 km) northeast of the quadrangle area and trends in an arcuate pattern across the northern portion of the Central Basin (Baltz, 1967). Regional dip, is 2° to the north, as measured by Reeside (1924) at approximately 0.5 miles (0.8 km) east of this quadrangle in T. 24 N., R. 13 W.

COAL GEOLOGY

One coal zone (Menefee) was identified in the subsurface and a coal bed (Fruitland 1) and a coal zone (Fruitland) were identified on the surface of this quadrangle (CRO Plates 1 and 3). The coals of the Menefee Formation have been designated as the Menefee coal zone (Me zone). These coals are generally discontinuous and less than reserve base thickness. In this quadrangle, subsurface information regarding Menefee coals was not available within the 3-mile study limit of the Known Recoverable Coal Resource Area (KRCRA). However, information from the log of the oil and gas test hole of Davis Oil Co. No. 1, Perry-Navajo (NE 1/4 6, T. 24 N, R. 14 W.) located in the quadrangle was used in determining the locations of Menefee coals (refer to CRO Plate 3, composite columnar section).

The Menefee Formation coals in the southwestern portion of the San Juan Basin vary from subbituminous B to high volatile C in rank. The rank has been determined on a moist, mineral-matter-free basis with calorific values ranging from 10,021 to 11,312 Btu's per pound (23,309-26,312 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 14.4 to 19.1 percent, sulfur content generally less than one percent, ash content ranging from 5.4 to 10.2 percent, and heating values on the average of 9,912 Btu's per pound (23,055 kj/kg). Analyses of several Menefee Formation coals are given in Table 1 (Bauer and Reeside, 1921; Dane, 1936; Lease, 1971; Shomaker, 1971b).

The Fruitland 1 coal bed (Fr 1) is defined by the authors as the lowermost coal of the Fruitland Formation; it is generally directly above the Pictured Cliffs Sandstone. This coal bed crops out in the southern portion of the quadrangle. In the southwest, the Fruitland 1 consists of two outcropping beds. This is due to the stratigraphic rise to the northeast of the coals. The coal beds in the upper portion of the Fruitland Formation were designated as the Fruitland coal zone (Fr zone) which extends from the top of the uppermost exposed Fruitland Formation coal to the base of the lowermost coal designated on CRO Plate 3 as a Fruitland zone coal bed. Several of these coal beds crop out in the southeast part of the quadrangle. These coals are generally random and less than reserve base thickness (5 ft [1.5 m]) as set by the U.S. Geological Survey. Therefore, these coals were mapped on a zone basis. The traces of outcrop of the Fruitland 1 and Fruitland zone 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	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
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	
23003	Mine Sample Blake's Mine	13	22	13	------------	A	19.0	32.4	43.2	5.4	0.92	10,190	
						B	----	40.0	53.3	6.7	1.14	12,590	
						C	----	42.9	57.1	----	1.22	13,490	
J-51245	Channel, Open Pit	NW¼ 9	22	14	------------	A	19.1	33.4	40.7	6.8	0.9	9,280	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	

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

Fruitland Formation coal beds in the southwestern part of the San Juan Basin are considered high volatile C bituminous in rank, although the coals vary from subbituminous A to high volatile C bituminous. The rank has been determined on a moist, mineral-matter-free basis with calorific values ranging from 10,567 to 12,782 Btu's per pound (24,579-29,731 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 6.7 to 17.6 percent, ash content ranging from 10.1 to 27.7 percent, sulfur content generally less than one percent, and heating values on the order of 9,764 Btu's per pound (22,711 kj/kg). Analyses of several Fruitland Formation coals are given in Table 2 (Bauer and Reeside, 1921; Dane, 1936; Fassett and Hinds, 1971; Shomaker, 1971).

Fruitland 1 Coal Bed

For this study the Fruitland 1 coal bed has only been mapped to the boundary of the Navajo Indian Reservation. Although the Fruitland 1 is correlated and mapped as a consistent horizon, it may actually be several different beds that are lithostratigraphically equivalent but not laterally continuous. As illustrated by the structure contour map (CRO Plate 5) the Fruitland 1 coal bed dips approximately 1° to the north. Consequently, overburden (CRO Plate 6) increases from zero at the outcrop to greater than 500 ft (152 m) to the north. The isopach map (CRO Plate 4) illustrates a trend of increasing thickness to the southwest portion of the map. The

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	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
H-22722	N.M.P.S.C.C. DH-3-2	SW¼ 3	23	13	42-44	A	6.7	35.9	46.9	10.5	0.6	11,320	Coal core
						B	----	38.5	50.3	11.2	0.6	12,140	not floated
						C	----	43.4	56.6	----	0.7	13,680	in CCl_4
*53	Core Sample	SW¼ 4	23	13	33-40	A	17.6	20.7	34.0	27.7	0.71	8,098	
						B	----	25.1	41.3	33.6	0.86	9,828	
*54	Core Sample	SW¼ 4	23	13	132-140	A	16.4	27.8	45.7	10.1	0.70	10,075	
						B	----	33.2	54.7	12.1	0.84	12,051	
*63	Core Sample	SW¼ 8	23	13	72-81	A	13.2	26.0	47.8	12.3	0.63	9,851	
						B	----	30.2	55.5	14.3	0.73	11,349	
H-19885	N.M.P.S.C.C. DH-32-1	NW¼ 32	24	13	100-112	A	12.0	32.5	39.3	16.2	0.5	9,670	Coal core
						B	----	36.9	44.7	18.4	0.6	10,990	crushed and
						C	----	45.2	54.8	----	0.7	13,460	floated in CCl_4
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
						B	----	34.1	47.9	18.0	2.0	11,340	content may be
						C	----	41.6	58.4	----	2.5	13,820	due to inadequate drying of sample during preparation process
*28	Core Sample	SE¼ 32	24	13	17-21	A	14.4	31.8	40.7	13.1	0.58	9,067	
						B	----	37.1	47.6	15.3	0.68	10,592	

*New Mexico State Bureau of Mines and Mineral Resources

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 1 varies in thickness from less than 5 ft (1.5 m) in the northern part of the quadrangle to greater than 10 ft (3.0 m) in the southeast.

Chemical Analyses of the Fruitland 1 Coal Bed - Analyses of several Fruitland Formation coals from this quadrangle and the surrounding area are included in reports by Fassett and Hinds (1971) and Shomaker (1971). The results of these analyses are given in Table 2.

Fruitland Coal Zone

The Fruitland coal zone extends from the top of the uppermost exposed Fruitland Formation coal to the base of the lowermost coal designated on CRO Plate 3 as a Fruitland zone coal bed. The structure contour map (CRO Plate 9) was constructed using the uppermost exposed Fruitland zone coal bed. The coal zone dips approximately 0.7° to the north. Consequently, overburden (CRO Plate 10) increases from zero at the outcrop in the south to greater than 900 ft (274 m) in the north. The isopach map (CRO Plate 8) shows the total thickness of the coal beds of the Fruitland zone. The greatest thickness is in the central eastern part of the quadrangle where the coals total over 15 ft (4.6 m). The thickness decreases to the north and south where the total thickness is less than 5 ft (1.5 m).

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

COAL RESOURCES

Coal resource data from geologic maps (Bauer and Reeside, 1921) was utilized in the construction of outcrop, isopach, and structure contour maps of coals in this quadrangle. Outcrops of the Fruitland 1 and Fruitland zone coal beds in the southeastern part of the quadrangle (CRO Plate 1) are modified from Bauer and Reeside (1921).

The U.S. Geological Survey designated the Fruitland 1 coal bed for the determination of coal resources in this quadrangle. Coals of the Fruitland zone were not evaluated because they are randomly occurring and generally less than the reserve base thickness of 5 ft (1.5 m).

For Reserve Base and Reserve calculations, the Fruitland 1 coal bed was areally divided into measured, indicated, and inferred resource categories (CRO Plate 7) 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 coal isopach (CRO Plate 4) and areal distribution maps (CRO Plate 7) for the Fruitland 1 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 the coal bed. In order to calculate Reserves, recovery factors of 85 percent and 50 percent were applied to the Reserve Base tonnages for strippable and underground coals, respectively.

Reserve Base and Reserve values for measured, indicated, and inferred categories of coal for the Fruitland 1 bed are shown on CRO Plate 7 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 14.2 million short tons (12.9 million metric tons).

The coal development potential for the Fruitland 1 bed was calculated in a manner similar to the Reserve Base, from planimetered measurements, in acres, for areas of high, moderate, and low potential for surface and/or subsurface mining methods. The Bisti Trading Post quadrangle has development potential for both surface and subsurface mining methods (CDP Plates 11 and 12).

COAL DEVELOPMENT POTENTIAL

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

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

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

Based on economic and technological criteria, the U.S. Geological Survey has established standards for the determination of high, moderate, and low coal development potentials for surface and subsurface coal beds of reserve base thickness (5 ft [1.5 m]) or greater. Mining ratio values for strippable coal (overburden less than 200 ft [61 m] thick) are: 0 to 10, high; 10 to 15, moderate; and greater than 15, low. Underground coal beds (overburden 200 to 3,000 ft [61-914 m] thick) are assigned high, moderate, and low development potential according to the overburden thickness: 200 to 1,000 ft (61-305 m), high; 1,000 to 2,000 ft (306-610 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 coal bed.

Development Potential for Surface Mining Methods

Strippable coal of the Fruitland 1 coal bed has high development potential in the extreme southeast corner of the quadrangle (CDP Plate 11) where the Fruitland 1 is approximately 8 ft (2.4 m) thick. Small areas of moderate and low development potential for the Fruitland 1 occur approximately 1 mile (1.6 km) north of the high potential area where the coal bed thickness varies from 7 to 10 ft (2.1-3.0 m) (CRO Plate 4) and the overburden ranges from 100 to 200 ft (30-61 m) (CRO Plate 6). The remainder of the area within the KRCRA has no development potential for surface mining and includes those areas which are outside the 200-foot (61 m) stripping limit.

Development Potential for Subsurface Mining Methods

Underground coal of the Fruitland 1 coal bed has high development potential in a small area south of the PRLA land (east central border) (CDP

TABLE 3

STRIPPABLE COAL RESOURCES FOR FEDERAL COAL LANDS (in short tons) IN THE BISTI TRADING POST QUADRANGLE, SAN JUAN COUNTY, NEW MEXICO

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

Coal Bed	High Development Potential (0-10 mining ratio)	Moderate Development Potential (10-15 mining ratio)	Low Development Potential (15 mining ratio)	Total
Fruitland 1	520,000	1,300,000	2,790,000	4,610,000
TOTAL	520,000	1,300,000	2,790,000	4,610,000

TABLE 4

COAL RESOURCE DATA FOR UNDERGROUND MINING METHODS FOR FEDERAL COAL LANDS (in short tons) IN THE BISTI TRADING POST 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 1	8,200,000	--	--	8,200,000
TOTAL	8,200,000	--	--	8,200,000

Plate 12). In this area the coal is 5 to 7 ft (1.5-2.1 m) thick and the overburden ranges from 200 to 350 ft (61-107 m). North of this area the Fruitland 1 has unknown development potential, because the coal is less than 5 ft (1.5 m) thick and there is insufficient data to determine the thickness of the Fruitland 1 farther to the north. The remainder of the area within the KRCRA (southeast corner) has no coal development potential for subsurface mining and includes areas of strippable coal.

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