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COAL RESOURCE OCCURRENCE MAPS OF THE PUEBLO BONITO QUADRANGLE, SAN JUAN AND McKINLEY COUNTIES, NEW MEXICO

[Report includes 3 plates]

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CONTENTS

PLATES

CONTENTS

Page

TABLES

PUEBLO BONITO 7 1/2-MINUTE QUADRANGLE

INTRODUCTION

Purpose

This text is to be used in conjunction with the Coal Resource Occurrence (CRO) Maps of the Pueblo Bonito quadrangle, San Juan and McKinley Counties, New Mexico. These reports were compiled to provide a systematic coal resource inventory of Federal coal lands in Known Recoverable Coal Resource Areas (KRCRA's) in the western United States. The work has been performed under contract with the Conservation Division of the U.S. Geological Survey (Contract No. 14-08-0001-17172).

The resource information gathered in this program is in response to the Federal Coal Leasing Amendments Act 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 Bonito 7 1/2-minute quadrangle is located in the southeastern corner of San Juan County and the northernmost portion of McKinley County, New Mexico, with Sandoval County to the east. The area is approximately 43 miles (69 km) southeast of Farmington and 52 miles (84 km) northeast of Gallup, New Mexico.

Accessibility

The area is accessible by State Route 56 which passes from north to south through the quadrangle. Numerous light-duty and unimproved dirt roads lead to Chaco Canyon National Monument in the central part of the area. State Route 56 connects with U.S. Highway 66 at Thoreau, 59 road-miles (95 km) south of the quadrangle's southern boundary. The Atchison, Topeka, and Santa Fe Railway operates a route approximately 52 miles (84 km) southwest of the area at Gallup, New Mexico, which connects Gallup with Grants and Albuquerque.

Physiography

The quadrangle is at the southern edge of the Central Basin area (Kelley, 1950) of the larger structural depression known as the San Juan Basin. Total relief in the area is 760 ft (232 m), with elevations which range from 6,060 ft (1,847 m) in Chaco Wash to 6,820 ft (2,079 m) on Chacra Mesa in the southeastern corner of the quadrangle. Chaco Wash, an intermittent stream which cuts across the central part of the area from southeast to northwest, and its tributaries have carved buttes and mesas south of the river. To the north, numerous tributaries of Chaco Wash and Escavada Wash have dissected the northeasterly-sloping plain. Kimbeto and Betonnie Tsosie Washes in the northeast corner join Escavada Wash, which is the major drainage tributary from the area north of Chaco Wash.

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; the majority of moisture is received in July and August in the form of intense afternoon thundershowers. Annual temperatures in the basin range from below 0° F (-18° C) to above 100° F (38° C). Snowfall occurs from November to April with an average of 18 inches (46 cm) in the southern part of the basin.

Land Status

Approximately 8 percent of the quadrangle lies on the southern boundary of the San Juan Basin Known Recoverable Coal Resource Area, and the Federal Government owns coal rights for 60 percent of the KRCRA land as shown on Plate 2 of the Coal Resource Occurrence Maps. Preference Right Lease applications (NM 3918, NM 8745, and NM 9764) cover 40 percent of the KRCRA. No Federal coal leases occur within the quadrangle.

The Federal Government owns coal rights for 61 percent of the land outside the boundary of the San Juan Basin Known Recoverable Coal Resource Area in this quadrangle.

GENERAL GEOLOGY

Previous Work

Bauer and Reeside (1921) mapped the Fruitland Formation in the quadrangle, giving particular attention to the outcrops of Fruitland coal beds and clinker. In 1924, Reeside mapped the various formations within the quadrangle as part of a study of 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. 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. The most recent work in the area has been by Schneider (1978), in which he mapped the surficial geology, the Fruitland clinker, and various Fruitland Formation coal zones on a scale of 1:24,000.

Geologic History

The San Juan Basin, an area of classic transgressive and regressive sedimentation, provided the ideal environment for depositon of coals during Late Cretaceous time. The first basin-wide retreat of the Late Cretaceous sea is indicated by the nearshore deposition of the regressive Point Lookout Sandstone. Coastal swamps developed behind the barrier beaches of the Point Lookout; in these swamps, beds of peat were deposited which later formed coal beds in the basal portion of the Menefee Formation. In a northeasterly direction, perpendicular to the depositional strandline, the coals wedge out rapidly, often intertonguing with the sandstone of the Point Lookout. The coals have a more consistent thickness and greater lateral extent parallel to the northwest-southeast-trending strandline; however, even the more continuous coal beds are often terminated abruptly by deposits from streams which crossed the floodplain and swamp environments. The retreat of the sea caused a gradual change in depositional environment and resulted in a transition in the lower Menefee from a carbonaceous interval directly overlying the Point Lookout to a noncoal-bearing interval. This is evidenced by the upward decrease in the occurrence and lateral continuity of the coals. Due to the gradual retreat of the sea, the Point Lookout Sandstone and overlying Menefee Formation rise in stratigraphic position to the northeast. Later, as the sea transgressed to the southwest, coastal swamps formed in front of the transgressive shoreline; organic matter was deposited in these swamps which ultimately formed coal beds in the upper portions of the Menefee Formation. This was followed by deposition of the Cliff House Sandstone sequence throughout the area which included several hundred feet of the Chacra Tongue (informal name of local usage) deposited conformably above the Menefee Formation. The main body of the Chacra sand buildup trends across the quadrangle in a northwest-southeast direction.

As transgression continued, the shoreline moved further to the southwest and a marine environment encroached upon the area with deposition of marine sediments of the Lewis Shale over the Chacra Tongue. The Lewis Shale thins in a southwesterly direction toward the shoreward margins, and marks the last transgressive advance of the Late Cretaceous sea.

The final retreat of the Late Cretaceous sea began with the deposition of nearshore sediments of the regressive Pictured Cliffs Sandstone. Large swamps, dissected by fluvial channels which flowed toward the sea, developed behind the regressive shoreline; organic matter which formed the coal beds of the Fruitland Formation was deposited in these swamps. Deposition of individual coal beds again appears to have been influenced by the northwest-southeast depositional strandline; the coals generally display a higher degree of continuity parallel to the strandline. In a northeasterly direction, perpendicular to the depositional strandline, the coals are discontinuous and wedge out rapidly. Many of the Fruitland coals appear to be noncorrelative, but are lithostratigraphically equivalent in terms of their relative position within the Fruitland Formation.

As the Cretaceous sea continued to retreat, the brackish-water swamp environment gradually shifted toward a freshwater environment with deposition of lacustrine, channel, and floodplain sediments. This is evidenced by both an upward decrease in occurrence and thickness of Fruitland coals and a gradational change into the noncarbonaceous deposits of the Kirtland Shale. Final deposition of the Kirtland Shale marked the end of continuous deposition during Late Cretaceous time. At this time the sea retreated to the northeast, and modern basin structure began to develop.

A relatively short period of erosion resulted in the development of an erosional unconformity due to the removal of portions of the Cretaceous Kirtland Shale. Deposition resumed during the Paleocene with alluvial plain and floodplain deposits of the Ojo Alamo Sandstone followed by deposition of the thick, lithologically varied, nonmarine Nacimiento Formation. The Nacimiento Formation was later exposed to erosion. The Eocene San Jose Formation was subsequently deposited over the Nacimiento erosional surface as various nonmarine environments 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 erosion to the present, with removal of the San Jose Formation, Nacimiento Formation, Ojo Alamo Sandstone, and the Kirtland Shale 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, the Menefee Formation (undifferentiated), and the Cliff House Sandstone, (the three formations of the Mesaverde Group); the Lewis Shale, Pictured Cliffs Sandstone, and Fruitland Formation. A composite columnar section on CRO Plate 3 illustrates the stratigraphic relationships of these formations and is accompanied by lithologic descriptions of the individual formations.

The Point Lookout Sandstone, the basal formation of the Mesaverde Group, consists of white to light gray, slightly calcareous sandstone with interstitial kaolinite, and interbedded gray shale near the base. The Point Lookout Sandstone, which is fairly massive in character, averages 170 ft (52 m) in thickness, in this area, and displays a distinctive and consistent character on geophysical logs. This last characteristic was used by the authors in establishing the top of the Point Lookout as a lithologic datum for correlation of the overlying Menefee coals.

The oldest coal-bearing formation in the quadrangle is the Menefee Formation of the Mesaverde Group. In previous studies the Menefee has been divided into the Cleary Coal Member, the barren Allison Member, and an unnamed upper coal-bearing member (Beaumont and others, 1956). These three members were not distinguished in this report because of the difficulty and inaccurate nature of determining a consistent division between them on geophysical logs. Therefore, the Cleary, Allison and unnamed upper coal-bearing members were grouped together as undifferentiated Menefee Formation for the purposes of this report only. The Menefee Formation in this area is about 860 ft (262 m) thick and is predominantly a medium to dark gray, carbonaceous to noncarbonaceous shale with abundant plant fossils, interbedded sandstone, and random coal beds.

The Cliff House Sandstone is represented by the Chacra Tongue (informal name of local usage) which is about 340 ft (104 m) thick in this area and overlies the Menefee Formation. The Chacra Tongue is exposed at Chacra Mesa, the type section, which trends northwest-southeast across the quadrangle. The type section represents the thick sand buildup which resulted from the Cliff House transgressive advance across the area. The Chacra Tongue consists of thickly-bedded, light gray, silty, slightly calcareous sandstone with interbedded gray to brown shale and siltstone.

The marine Lewis Shale conformably overlies the Mesaverde Group. In contrast to the underlying Cliff House Sandstone, it is predominantly a dark gray, calcareous shale with local plant fossils. The Lewis averages 345 ft (105 m) in thickness in the northeastern part of the quadrangle; it thins in a southwesterly direction, toward the shoreward margin of the last transgressive-regressive cycle of the Late Cretaceous sea. The upper contact of the Lewis Shale is gradational with the overlying Pictured Cliffs Sandstone; therefore, a distinct contact between the two is difficult to establish.

The Pictured Cliffs Sandstone is a regressive sandstone of near-shore marine origin. It consists of about 110 ft (34 m) of white to light gray, calcareous sandstone with scattered dark siderite grains, interbedded with thin, gray-green shale near the base of the formation where it grades into the Lewis. The upper contact of the Pictured Cliffs Sandstone is more sharply defined than the basal contact. Intertonguing with the overlying Fruitland results in minor fluctuations in the formation top; however, the Pictured Cliffs is fairly consistent throughout the basin. The authors have used the consistency and distinctive character of this formation on geophysical logs to establish the top of the Pictured Cliffs as a lithologic datum for correlation of the overlying Fruitland coals.

Conformably overlying the Pictured Cliffs Sandstone is the Fruitland Formation, the major coal-bearing unit in the quadrangle. The Fruitland averages 250 to 300 ft (76-91 m) thick in this area and consists of gray to brown, carbonaceous shale with plant fossils, interbedded gray sandstone, and coal beds of varying thickness. The thickest and most continuous coal beds of the Fruitland occur near the base of the formation, while discontinuous and lenticular coal beds are characteristic of the upper portion of the formation.

Surface exposures in the quadrangle are influenced by the regional dip of 1° to the northeast, which results in exposure of the younger Cretaceous strata in a northeasterly direction. The oldest unit exposed in the quadrangle is the Menefee Formation, which crops out in the southwestern corner of the area. The Chacra Tongue of the Cliff House Sandstone is exposed in the canyon walls of Chaco Wash. The younger Lewis Shale has been stripped from the resistant sandstone beds around Chaco Wash, but crops out along a wide belt across the northeastern portion of the quadrangle. The entire section of the Pictured Cliffs Sandstone is exposed in the northeastern corner of the quadrangle. The youngest formation exposed in the quadrangle is the Fruitland Formation. It crops out across the northeastern corner of the quadrangle; however, the uppermost portion of the formation is missing.

Structure

The Pueblo Bonito quadrangle is located in the Central Basin area (Kelley, 1950) of the major structural depression known as the San Juan Basin. The axis of the basin is about 48 miles (77 km) to the northeast of the quadrangle and trends in an arcuate pattern across the northern portion of the Central Basin (Baltz, 1967). Measured regional dip within the quadrangle in T. 21 N., R. 10 W. is 1° to the northeast (Reeside, 1924).

COAL GEOLOGY

One coal zone (Menefee) was identified in the subsurface, and one coal zone (Fruitland) was mapped on the surface of this quadrangle. The coal beds of the Menefee Formation have been combined as the Menefee coal zone (Me zone). These coals are correlative only over short distances, and, in this quadrangle, the coals are less than reserve base thickness of 5 ft (1.5 m) as set by the U.S. Geological Survey. Therefore, derivative maps were not constructed.

The Menefee Formation coals in the southern portion of the San Juan Basin are considered subbituminous A in rank. The rank has been determined on a moist, mineral-matter-free basis with calorific values ranging from 11,103 to 11,256 Btu's per pound (25,825-26,181 kj/kg) (Amer. Soc. for Testing and Minerals, 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 17.5 percent, sulfur content less than 2.5 percent, ash content ranging from 7.5 to 10.2 percent, and heating values on the order of 10,053 Btu's per pound (23,383 kj/kg). Analyses of several Menefee Formation coals are given in Table 1 (Bauer and Reeside, 1921; Dane, 1936; Lease, 1971; Shomaker, 1971a; Shomaker and Lease, 1971).

The coals of the Fruitland Formation have been grouped together as the Fruitland coal zone (Fr zone). These coals are generally noncorrelative and less than reserve base thickness (5 ft [1.5 m]). Therefore, derivative maps were not constructed. Several Fruitland zone coal beds crop out in the northeastern part of the quadrangle. The traces of the outcrop have been modified from the original data source to conform with modern topographic maps.

Coal beds of the Fruitland Formation in the southern part of the San Juan Basin are considered to be high volatile C bituminous in rank, although the coals vary from subbituminous A to high volatile B bituminous. The rank of the coal has been determined on a moist, mineral-matter-free basis with calorific values ranging from 11,246 to 13,211 Btu's per pound (26,158-30,729 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 4.52 to 14.6 percent, ash content ranging from 16.0 to 35.14 percent, sulfur content less than one percent, and heating values on the order of 9,456 Btu's per pound (21,995 kj/kg). Analyses of several undesignated Fruitland Formation coals are given in Table 2 (Dane, 1936; Shomaker, 1971b).

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-63534	Core Sample	NE¼ 36	17	10	----	A	16.5	33.4	40.4	9.7	0.6	10,070	
						B	----	40.0	48.3	11.7	0.7	12,060	
						C	----	45.3	54.7	----	0.8	13,650	
3823	Mine Sample	14	20	11	----	A	17.5	32.9	41.2	8.4	2.2	----	
23004	Pueblo Bonito Mine	14	20	11	----	A	14.4	34.8	42.3	7.5	1.54	10,220	Allison Member
						B	----	40.7	50.5	8.8	1.80	11,940	
						C	----	44.6	55.4	----	1.97	13,090	
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.

TABLE 2

Analyses of coal samples from the Fruitland Formation

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

U.S. Bureau Mines Lab No.	Well or Other Source	Location			Approx. Depth Interval of Sample (ft.)	Form of Analysis	Proximate, percent					Heating Value (Btu)	Remarks
		Section	T.N.	R.W.			Mois-ture	Volatile matter	Fixed Carbon	Ash	Sulfur		
*29	Drill Cuttings	NW¼ 5	22	10	----	A	4.52	-----	-----	13.65	0.59	11,035	
						B	----	-----	-----	14.30	0.62	11,577	
						C	----	-----	-----	-----	----	13,485	
*34	Drill Cuttings	SE¼ 9	22	10	----	A	9.28	29.26	38.42	23.04	0.54	9,240	
						B	----	32.25	42.35	25.40	0.60	10,185	
						C	----	-----	-----	-----	----	13,653	
J-63526	Core Sample	NE¼ 15	22	10	269.0-290.2	A	12.4	33.9	37.6	16.1	0.49	9,630	
						B	----	38.7	42.9	18.4	0.56	10,990	
						C	----	47.5	52.5	----	0.68	13,470	
*27	Drill Cuttings	NW¼ 12	22	11	104-110	A	5.01	-----	-----	35.14	0.44	7,740	May be
						B	----	-----	-----	36.99	0.46	8,148	weathered
						C	----	-----	-----	-----	----	12,931	sample
*	Drill Cuttings	NW¼ 12	22	11	155-159	A	5.42	-----	-----	19.41	0.66	10,427	
						B	----	-----	-----	20.52	0.70	10,835	
						C	----	-----	-----	-----	----	13,634	
J-63220	Core Sample	NE¼ 29	23	11	252.5-283.0	A	12.7	31.9	34.3	21.2	0.3	8,680	
						B	----	36.5	39.3	24.2	0.4	9,940	
						C	----	48.2	51.3	----	0.5	13,120	
J-61645	Core Sample	NE¼ 29	23	11	321.5-330.0	A	14.6	30.8	38.6	16.0	0.34	9,440	
						B	----	36.1	45.2	18.7	0.40	11,050	
						C	----	44.4	55.6	----	0.49	13,600	

*analysis by 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.

COAL RESOURCES

Coal resources were not calculated for the Fruitland coal zone and Menefee coal zone because the coals are discontinuous, noncorrelative, and less than the reserve base thickness of 5 ft (1.5 m).

COAL DEVELOPMENT POTENTIAL

Coal development potential maps were not developed for this quadrangle because the coal beds are less than the reserve base thickness (5 ft [1.5 m]) and, therefore, have unknown coal development potential.

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