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COAL RESOURCE OCCURRENCE MAPS AND COAL DEVELOPMENT POTENTIAL MAPS OF THE NORTHEAST QUARTER OF THE GOULD PASS 15-MINUTE QUADRANGLE, RIO ARRIBA AND SAN JUAN COUNTIES, NEW MEXICO

[Report includes 16 plates]

by

Dames & Moore

CONTENTS

CONTENTS

PLATES

CONTENTS

TABLES

NORTHEAST QUARTER OF THE GOULD PASS 15-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 northeast quarter of the Gould Pass 15-minute quadrangle, Rio Arriba and San Juan 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) of 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 northeast quarter of the Gould Pass 15-minute quadrangle is located in northeast San Juan County and northwest Rio Arriba County, New Mexico. The area is approximately 36 miles (58 km) east-southeast of Farmington, New Mexico.

Accessibility

The northeast quarter of the Gould Pass 15-minute quadrangle is accessible by New Mexico State Route 17 which extends across the area. Light-duty roads provide access to remote parts of the quadrangle. The Atchison, Topeka, and Santa Fe Railway operates a route approximately 105 miles (169 km) to the southwest at Gallup, New Mexico.

Physiography

This quadrangle is in the north-central portion of the Central Basin area (Kelley, 1950) of the structural depression known as the San Juan Basin. Total relief in the area is high, with elevations ranging from 5,954 ft (1,815 m) in Delgadito Canyon in the southwest to 6,972 ft (2,125 m) on Manzanares Mesa in the northwest. The topography is characterized by several large mesas and various steep-walled canyons of Carrizo Creek and its tributaries.

Climate

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

Land Status

Approximately 39 percent of the quadrangle is in the northeastern portion of the San Juan Basin Known Recoverable Coal Resource Area. The Federal Government owns the coal rights for approximately 95 percent of the KRCRA land within the quadrangle as shown on Plate 2 of the Coal Resource Occurrence Maps. No Federal coal leases occur in the quadrangle.

GENERAL GEOLOGY

Previous Work

Fassett and Hinds (1971) made subsurface interpretations of Fruitland Formation coal occurrences in the quadrangle 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.

The first depositional evidence of the final retreat of the Late Cretaceous sea is the nearshore regressive Pictured Cliffs Sandstone. Southwest (shoreward) of the beach deposits, swamps, which were dissected by streams, accumulated organic matter which later became coals of the Fruitland Formation. Deposition of organic material was influenced by the strandline as shown both by 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 less continuous Fruitland coals appear to be noncorrelative, but are stratigraphically equivalent in terms of their relative position within the Fruitland Formation.

The brackish-water swamp environment of the Fruitland moved farther to the northeast as the regression continued in that direction. Terrestrial freshwater sediments covered the quadrangle as indicated by the lacustrine, channel, and floodplain deposits of the Kirtland Shale. This sequence of events is evidenced by both an upward decrease in occurrence and thickness of Fruitland coals and a gradational change to noncarbonaceous deposits of the Kirtland. Continuous deposition during Late Cretaceous time ended with the Kirtland. The sea then retreated to the northeast 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.

Stratigraphy

The formations studied in this quadrangle range from Late Cretaceous to Eocene in age. They are, in order from oldest to youngest: the Pictured Cliffs Sandstone, Fruitland Formation, Kirtland Shale, Ojo Alamo Sandstone, Nacimiento Formation, and San Jose 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 Pictured Cliffs Sandstone averages 120 ft (37 m) thick in this area. Because the unit is persistent throughout most of the San Juan Basin and easily recognized on geophysical logs, the top was picked as the datum (CRO Plate 3) for Fruitland coal correlations. The formation consists of a cream to light gray, kaolinitic, slightly micaceous, friable sandstone, interbedded with gray shale near the base of the unit. Intertonguing with the overlying Fruitland Formation occurs throughout the entire basin, and, consequently, minor Fruitland coal beds commonly are present in the upper portion of the Pictured Cliffs.

The major coal-bearing unit in the quadrangle is the Fruitland Formation. Wide variations in reported thickness are common due to an indistinct upper contact with the Kirtland Shale, but the average thickness is about 300 ft (91 m) in this quadrangle. Many authors have utilized various criteria for establishing the upper contact, but, in general, for this study the uppermost coal was chosen (after Fassett and Hinds, 1971). The formation primarily consists of gray, carbonaceous shale with plant fossils, interbedded gray siltstone, and lenticular coal beds.

The Upper Cretaceous Kirtland Shale conformably overlies the Fruitland Formation and averages 455 ft (139 m) in thickness in this area. It consists predominantly of freshwater, gray-green to brown shale and interbedded gray-green siltstone with plant fossils. 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.

The Paleocene Ojo Alamo Sandstone unconformably overlies the Kirtland Shale. It is a white to gray, locally conglomeratic sandstone with interbedded gray shale and averages 125 ft (38 m) in thickness.

Approximately 1,200 ft (366 m) of the Paleocene Nacimiento Formation overlie the Ojo Alamo Sandstone. These rocks consist of gray-green to brown shale, interbedded tan to gray-green, micaceous siltstone, and interbedded tan to gray silty sandstone.

The San Jose Formation of Eocene age unconformably overlies the Nacimiento Formation and crops out over most of the quadrangle area. It predominantly consists of gray-green to brown shale, interbedded white to cream, locally conglomeratic, kaolinitic, friable sandstone, and interbedded gray-green siltstone.

Structure

The northeast quarter of the Gould Pass 15-minute quadrangle is 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 8 miles (13 km) northeast of the quadrangle area and trends in an arcuate pattern across the northern portion of the Central Basin area (Baltz, 1967). Regional dip within the quadrangle is approximately 1° to 2° to the east.

COAL GEOLOGY

Seven coal beds (Fruitland 1, Fruitland 2, Fruitland 3, Fruitland 4, Fruitland 5, Fruitland 6, Fruitland 7) and a coal zone (Fruitland) were identified in the subsurface of this quadrangle (CRO Plate 1). 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 is above the Fruitland 1, separated by a rock interval of 28 to 40 ft (8.5-12.2 m). Since the Fruitland 2 is less than reserve base thickness (5 ft [1.5 m]) in this quadrangle, derivative maps were not constructed. The Fruitland 3 (Fr 3) coal bed is above the Fruitland 2 separated by a rock interval of 18 to 38 ft (5.5-11.6 m); the Fruitland 4 (Fr 4) coal bed is above the Fruitland 3 separated by a rock interval of 7 to 43 ft (2.1-13.1 m); the Fruitland 5 (Fr 5) coal bed is above the Fruitland 4 separated by a rock interval of 17 to 71 ft (5.2-21.6 m); the Fruitland 6 (Fr 6) coal bed is above the Fruitland 5 separated by a rock interval of 10 to 33 ft (3.0-10.1 m); and the Fruitland 7 (Fr 7) coal bed is above the Fruitland 6 separated by a rock interval of 18 to 53 ft (5.5-16.2 m). The Fruitland 5, 6, and 7 coal beds are less than reserve base thickness (5 ft [1.5 m]) within the KRCRA; therefore, derivative maps were not constructed.

Although the coal beds were correlated and mapped as consistent horizons, they may actually be several different coal beds that are litho-stratigraphically equivalent but not laterally continuous. Within this quad-rangle there are also several local (L) coal beds which are discontinuous and noncorrelative (CRO Plate 1).

The remaining coals in the upper portion of the Fruitland Formation are grouped together as the Fruitland coal zone (Fr zone). These coals are generally noncorrelative, discontinuous, and less than reserve base thickness (5 ft [1.5 m]); therefore, derivative maps were not constructed.

Fruitland Formation coals in the central part of the San Juan Basin are considered high volatile A bituminous in rank. The rank has been deter-mined on a moist, mineral-matter-free basis with calorific values averaging 15,371 Btu's per pound (35,753 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 of 1.2 to 1.7 percent, ash content ranging from 10.7 to 28.5 percent, sulfur content varying from 0.6 to 2.2 percent, and heating values on the order of 12,073 Btu's per pound (28,082 kj/kg). Analyses of several Fruitland Formation coals are given in Table 1 (Bauer and Reeside, 1921; Dane, 1936; Fasssett and Hinds, 1971).

TABLE 1

Analyses of coal samples from the Fruitland Formation

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

U.S. Bureau Mines Lab No.	Well or Other Source	Location			Approx. Depth Interval of Sample (ft.)	Form of Analysis	Proximate, percent					Heating Value (Btu)	Remarks
		Section	T.N.	R.W.			Mois-ture	Volatile matter	Fixed Carbon	Ash	Sulfur		
H-7560	El Paso Nat. Gas S.J.U. 29-6 No. 66	SW¼ 9	29	6	3,575-3,580	A	1.2	27.7	42.6	28.5	0.6	10,780	
						B	---	28.0	43.1	28.9	0.6	10,910	
						C	---	39.4	60.6	----	0.8	15,330	
H-16310	Aztec Oil & Gas Cain No. 16-D	SW¼ 30	29	9	1,985-2,005	A	1.6	41.1	46.6	10.7	0.7	13,310	
						B	---	41.7	47.5	10.8	0.7	13,520	
						C	---	46.8	53.2	----	0.7	15,160	
H-15142	El Paso Nat. Gas S.J.U. 30-6 No. 37	NE¼ 10	30	6	3,100-3,105	A	1.5	24.1	49.4	25.0	0.7	11,310	
						B	---	24.5	50.1	25.4	0.7	11,480	
						C	---	32.8	67.2	----	0.9	15,380	
H-50079	Delhi-Taylor Moore No. 6	NE¼ 5	30	8	2,800-3,028	A	1.7	32.6	41.4	24.3	1.8	11,250	
						B	---	33.2	42.1	24.7	1.8	11,440	
						C	---	44.0	56.0	----	2.4	15,190	
H-35925	El Paso Nat. Gas Turner No. 3	SE¼ 28	30	9	2,385-2,390	A	1.5	39.9	45.5	13.1	2.2	12,960	
						B	---	40.5	46.2	13.3	2.2	13,150	
						C	---	46.7	53.3	----	2.5	15,170	
H-50012	Delhi-Taylor Barrett No. 1	SW¼ 20	31	9	3,230-3,255	A	1.3	33.7	49.2	15.8	0.7	12,830	
						B	---	34.1	49.9	16.0	0.7	13,000	
						C	---	40.6	59.4	----	0.9	15,470	

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 Coal Bed

The coal bed has been mapped only in areas of less than 3,000 ft (914 m) of overburden (the study limit). As indicated by the structure contour map (CRO Plate 5) the coal bed dips less than 1° to the northeast. As a result of the topography and dip, overburden (CRO Plate 6) varies from less than 2,400 ft (732 m) in Carrizo Canyon in the southwest corner to greater than 3,000 ft (914 m) on Delgadito Mesa and the surrounding unnamed mesas. The isopach map (CRO Plate 4) illustrates that the coal bed is greater than 25 ft (7.6 m) thick in a part of the southwest and, in general, decreases in thickness in all directions.

<u>Chemical Analyses of the Fruitland 1 Coal Bed</u> - Analyses of several coals of the Fruitland Formation from the area surrounding this quadrangle are given in Table 1 (Fassett and Hinds, 1971).

Fruitland 3 Coal Bed

The coal bed has been mapped only in areas of less than 3,000 ft (914 m) of overburden (the study limit). As indicated by the structure contour map (CRO Plate 9) the coal bed dips less than 1° to the northeast. As a result of topography and dip, overburden (CRO Plate 10) varies from less than 2,400 ft (732 m) in Carrizo Canyon to greater than 3,000 ft (914 m) on Delgadito Mesa and the other unnamed mesas. The isopach map (CRO Plate 8) indicates the coal bed thickness is greater than 30 ft (9.1 m) in a portion of the northeast and, in general, decreases in thickness in all directions.

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

Fruitland 4 Coal Bed

The coal bed has been mapped only in areas of less than 3,000 ft (914 m) of overburden (the study limit). As indicated by the structure contour map (CRO Plate 13) the coal bed dips less than 1° to the northeast. As a result of topography and dip, overburden (CRO Plate 14) varies from less than 2,400 ft (732 m) in Carrizo Canyon to greater than 3,000 ft (914 m) on Delgadito Mesa and the surrounding unnamed mesas. The isopach map (CRO Plate 12) shows that the coal bed is greater than 5 ft (1.5 m) thick in the north and in a small section in the south-central part of the quadrangle. In general, the thickness decreases in all directions, and the coal is absent in several small areas throughout the quadrangle.

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

COAL RESOURCES

Coal resource data from oil and gas wells and pertinent publications were utilized in the construction of isopach and structure contour maps of coals in this quadrangle. All of the coals studied in the northeast quarter of the Gould Pass 15-minute quadrangle are more than 2,200 ft (671 m) below the ground surface and, thus, have no outcrop or surface development potential.

The U.S. Geological Survey designated the Fruitland 1, Fruitland 3, and Fruitland 4 coal beds for the determination of coal resources in this quadrangle. Coals of the Fruitland 2, Fruitland 5, Fruitland 6, and Fruitland 7 were not evaluated because they are generally less than the reserve base thickness (5 ft [1.5 m]).

For Reserve Base and Reserve calculations, each coal bed was areally divided into measured, indicated, and inferred resource categories (CRO Plates 7, 11, 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, a recovery factor of 50 percent was applied to the Reserve Base tonnages for underground coal. However, in areas of underground coal exceeding 12 ft (3.7 m) in thickness, the Reserves (mineable coal) were calculated on the basis of a maximum coal bed thickness of 12 ft (3.7 m), which represents the maximum economically mineable thickness for a single coal bed in this area by current underground mining technology.

Reserve Base and Reserve values for measured, indicated, and inferred categories of coal for the Fruitland 1, Fruitland 3, and Fruitland 4 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 307 million short tons (279 million metric tons).

The coal development potential for each bed was calculated in a manner similar to the Reserve Base, from planimetered measurements, in acres, for areas of high, moderate, and low potential for subsurface mining methods. The northeast quarter of the Gould Pass 15-minute quadrangle has development potential for subsurface mining methods only (CDP Plate 20).

COAL DEVELOPMENT POTENTIAL

Coal beds of 5 ft (1.5 m) or more in thickness which are overlain by 200 to 3,000 ft (61-914 m) of overburden are considered to have potential for underground mining and are designated as having high, moderate, or low development potential according to the overburden thickness: 200 to 1,000 ft (61-305 m), high; 1,000 to 2,000 ft (305-610 m), moderate; and 2,000 to 3,000 ft (610-914 m), low. Table 2 summarizes the coal development potential, in short tons, for underground coal of the Fruitland 1, Fruitland 3, and Fruitland 4 coal beds.

TABLE 2

COAL RESOURCE DATA FOR UNDERGROUND MINING METHODS FOR FEDERAL COAL LANDS (in short tons) IN THE NORTHEAST QUARTER OF THE GOULD PASS 15-MINUTE QUADRANGLE, RIO ARRIBA AND SAN JUAN 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 4	--	--	890,000	890,000
Fruitland 3	--	--	152,340,000	152,340,000
Fruitland 1	--	--	154,130,000	154,130,000
TOTAL	--	--	307,360,000	307,360,000

Development Potential for Surface Mining Methods

All coals studied in the northeast quarter of the Gould Pass 15-minute quadrangle occur more than 2,200 ft (671 m) below the ground surface and, thus, they have no coal development potential for surface mining methods.

Development Potential for Subsurface Mining Methods

Underground coal of the Fruitland 1, Fruitland 3, and Fruitland 4 beds has low development potential in the southwestern and south-central parts of the quadrangle (CDP Plate 16). Fruitland 4 coal with subsurface development potential occurs only in a limited area in the south. Coal bed thicknesses are 5 to 28 ft (1.5-8.5 m) for the Fruitland 1 (CRO Plate 4) and Fruitland 3 (CRO Plate 8) beds, and 5 ft (1.5 m) (CRO Plate 12) for the Fruitland 4. The overburden increases from 2,400 to 3,000 ft (732-914 m) thick from southwest to northeast for the Fruitland 1 and Fruitland 3 beds (CRO Plates 6 and 10, respectively), and it is 2,800 to 3,000 ft (853-914 m) thick (CRO Plate 14) for the Fruitland 4 coal bed.

The remainder of the area inside the KRCRA has unknown development potential and includes areas with coal thickness less than 5 ft (1.5 m) and areas outside the 3,000-foot (914-m) overburden study limit. Unpatterned areas to the north are outside the KRCRA.

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