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

[Report includes 12 plates]

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SOUTHEAST 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 southeast 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 southeast quarter of the Gould Pass 15-minute quadrangle is located in eastern San Juan County and west-central Rio Arriba County, New Mexico. The area is approximately 36 miles (67 km) southeast of Farmington and 94 miles (151 km) northeast of Gallup, New Mexico.

Accessibility

The area is accessible by three light-duty roads. One parallels Canon Largo and enters the quadrangle in the southwest corner. Another parallels Carrizo Creek and enters in the northwest corner. They intersect northwest of the quadrangle at Blanco, where Canon Largo joins the San Juan River. The third light-duty road crosses the central part of the area from east to west and connects with the road which parallels Canon Largo. The Atchison, Topeka, and Santa Fe Railway operates a route approximately 94 miles (151 km) to the southwest at Gallup, New Mexico, which extends to the southeast and southwest.

Physiography

The quadrangle is located in the Central Basin area (Kelley, 1950) of the San Juan Basin. The total relief in the area is 920 ft (280 m), with elevations ranging from 6,000 ft (1,829 m) in Canon Largo to 6,950 ft (2,118 m) southeast of Gould Pass. A broad, moderately dissected mesa separates Canon Largo in the southwest corner from one of its major tributaries, Carrizo Creek. Both are intermittent streams draining northwest into the San Juan River. The mesas were once part of broad plains graded to the former level of Canon Largo (Baltz, 1967). Tributary streams subsequently incised the plains, carving the resultant steep-walled canyons and mesas.

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 in the basin range from below 0°F (-18°C) to above 100° (38°C). Snowfall may occur from November to April.

Land Status

Approximately 68 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 91 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 by both the continuity of the coal beds parallel to the north-south strandline in this quadrangle 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 then covered this 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.

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 90 ft (27 m) thick in the 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 calcareous, friable sandstone with interbedded 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 of the Fruitland are common due to an indistinct upper contact with the Kirtland Shale, but the average is about 240 ft (73 m) in this quadrangle. Many authors have utilized various criteria to establish the upper contact, but, in general, for this study the uppermost coal was chosen (after Fassett and Hinds, 1971). The formation consists primarily of gray-green to brown, carbonaceous shale with plant fossils, interbedded siltstone, and lenticular coal beds.

The Upper Cretaceous Kirtland Shale conformably overlies the Fruitland Formation and averages 400 ft (122 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-green to brown shale and averages 200 ft (61 m) in thickness.

Approximately 1,120 ft (341 m) of the Paleocene Nacimiento Formation overlie the Ojo Alamo Sandstone. The Nacimiento consists of gray-green to brown shale; interbedded tan to gray, locally silty sandstone; and interbedded tan to gray-green, micaceous siltstone.

The San Jose Formation of Eocene age unconformably overlies the Nacimiento Formation and crops out over the entire quadrangle area. It is white to gray, locally conglomeratic sandstone, interbedded gray-green shale, and interbedded gray-green to maroon siltstone.

Structure

The southeast 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 13 miles (21 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 area is approximately 1° to 2° to the northeast.

COAL GEOLOGY

Four coal beds (Fruitland 1, 2, 3, and 4) 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. Above the Fruitland 1 coal bed is the Fruitland 2 (Fr 2) coal bed; they are separated by a rock interval varying from 4 to 36 ft (1.2-11 m). Throughout most of the quadrangle the Fruitland 2 is less than reserve base thickness (5 ft [1.5 m]); consequently, derivative maps were not constructed. However, outside of the KRCRA boundary, in drill hole 8 (CRO Plate 1), the coal bed is 8 ft (2.4 m) thick. The Fruitland 3 (Fr 3) coal bed is above the Fruitland 2 coal bed; a rock interval varying from 34 to 90 ft (10.4-27 m) separates them. The Fruitland 4 (Fr 4) coal bed is above the Fruitland 3 coal bed, separated by a rock interval varying from 5 to 46 ft (1.5-14 m). Throughout the quadrangle the Fruitland 4 is less than reserve base thickness (5 ft [1.5 m]). Therefore, derivative maps were not constructed. Although the Fruitland 1, 2, 3, and 4 coal beds, informally named by the authors, are correlated as consistent horizons, they may actually be several different beds that are lithostratigraphically equivalent but not laterally continuous.

Above the Fruitland 4 coal bed is the Fruitland coal zone (Fr zone). The zone consists of several coal beds which are generally noncorrelative and less than reserve base thickness (5 ft [1.5 m]). However, there are several coals which are thicker than reserve base within the zone: a 6-ft (1.8-m) coal in drill hole 6, a 7-ft (2.1-m) coal in drill hole 19, and a 5-ft (1.5-m) coal in drill hole 23 (CRO Plate 1). Since these coals are noncorrelative and discontinuous, derivative maps were not constructed.

Fruitland Formation coal beds in the southern part of the San Juan Basin are considered high volatile A bituminous in rank. The rank of the coal has been determined on a moist, mineral-matter-free basis with calorific values averaging 14,824 Btu's per pound (34,481 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 ranging from 1.3 to 3.6 percent, ash content varying from 14.8 to 30.5 percent, sulfur content less than one percent, and heating values averaging 11,234 Btu's per pound (26,130 kj/kg). Analyses of several Fruitland Formation coals are given in Table 1 (Bauer and Reeside, 1921; Dane, 1936; Fassett and Hinds, 1971).

Fruitland 1 Coal Bed

The Fruitland 1 coal bed has been mapped only in areas of less than 3,000 ft (914 m) of overburden (study limit). As illustrated by the structure contour map (CRO Plate 5), the coal bed dips approximately 1° in a northeasterly direction. Consequently, overburden (CRO Plate 6) increases from less than 2,100 ft (640 m) in the southwest to greater than 3,000 ft (914 m) in the northern portions of the quadrangle. As shown on the isopach map (CRO Plate 4), the Fruitland 1 is over 20 ft (6.1 m) thick in the south-central part of the map. The coal decreases in thickness in all directions and is absent in an area in the northwest part of the quadrangle.

Chemical Analyses of the Fruitland 1 Coal Bed - Analyses of several Fruitland Formation coal beds from this quadrangle and the surrounding area are given in Table 1 (Fassett 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 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-37832	Merrion & Associates Federal No. 3-35	SW¼ 35	25	6	2,455-2,465	A	3.6	36.3	35.6	24.5	0.8	10,440	
						B	----	37.7	36.9	25.4	0.8	10,830	
						C	----	50.5	49.5	----	1.1	14,510	
H-32698	Caulkins Oil State "A" MD No. 62	NE¼ 2	26	6	3,184-3,200	A	1.3	38.9	41.4	18.4	0.7	12,130	
						B	----	39.4	41.9	18.7	0.7	12,290	
						C	----	48.4	51.6	----	0.9	15,120	
H-5020	Key Kimbell Leibermen No. 5	SW¼ 19	26	7	2,105-2,150	A	2.5	38.1	41.2	18.2	0.6	11,760	
						B	----	39.1	42.2	18.7	0.6	12,060	
						C	----	48.1	51.9	----	0.8	14,830	
H-33317	El Paso Nat. Gas S.J.U. 27-5 No. 74	SE¼ 23	27	5	3,250-3,260	A	3.1	34.4	39.5	23.0	0.8	11,080	
						B	----	35.6	40.7	23.7	0.9	11,440	
						C	----	46.6	53.4	----	1.1	15,010	
H-33643	El Paso Nat. Gas Rincon Unit No. 171	SW¼ 21	27	6	3,165-3,180	A	1.4	39.3	44.5	14.8	0.9	12,690	
						B	---	39.8	45.2	15.0	0.9	12,870	
						C	----	46.9	53.1	----	1.1	15,150	
H-35788	El Paso Nat. Gas Rincon Unit No. 177	SE¼ 13	27	7	3,130-3,140	A	2.3	32.9	34.3	30.5	0.8	9,900	
						B	----	33.7	35.1	31.2	0.8	10,130	
						C	----	48.9	51.1	----	1.2	14,720	
H-7224	El Paso Nat. Gas S.J.U. 28-5 No. 50	SW¼ 28	28	5	3,323-3,345	A	2.6	31.6	39.0	26.8	0.6	10,640	
						B	----	32.5	40.0	27.5	0.6	10,920	
						C	----	44.8	55.2	----	0.9	15,070	

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 3 Coal Bed

The Fruitland 3 coal bed has been mapped only in areas with less than 3,000 ft (914 m) of overburden (study limit). As illustrated by the structure contour map (CRO Plate 9), the coal bed dips approximately 1° to the northeast. As a result of topography and dip, overburden (CRO Plate 10) increases from less than 2,000 ft (610 m) in the southwest to more than 3,000 ft (914 m) to the northeast. As shown on the isopach map (CRO Plate 8) the coal bed is greater than 10 ft (3.0 m) thick in the northern and northeastern portions of the quadrangle. The coal decreases in thickness to the south and west where it is absent in several areas.

Chemical Analyses of the Fruitland 3 Coal Bed - Analyses of several Fruitland Formation coal beds from this quadrangle and the surrounding area 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 southeast quarter of the Gould Pass 15-minute quadrangle occur more than 1,960 ft (597 m) below the ground surface and, thus, have no outcrop or surface development potential.

The U.S. Geological Survey designated the Fruitland 1 and Fruitland 3 coal beds for the determination of coal resources in this quadrangle. Coals of the Fruitland zone were not evaluated because they are discontinuous and noncorrelative. The Fruitland 2 and Fruitland 4 coal beds 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 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 maps (CRO Plates 7 and 11) 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 and Fruitland 3 beds are shown on CRO Plates 7 and 11, 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 455 million short tons (413 milion 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 southeast quarter of the Gould Pass 15-minute quadrangle has development potential for subsurface mining methods only (CDP Plate 12).

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 and Fruitland 2 coal beds.

Development Potential for Surface Mining Methods

All coals studied in the southeast quarter of the Gould Pass 15-minute quadrangle occur more than 1,960 ft (597 m) below the ground surface and, thus, they have no coal development potential for surface mining methods.

TABLE 2

COAL RESOURCE DATA FOR UNDERGROUND MINING METHODS FOR FEDERAL COAL LANDS (in short tons) IN THE SOUTHEAST QUARTER OF THE GOULD PASS 15-MINUTE QUADRANGLE, SAN JUAN AND RIO ARRIBA COUNTIES, NEW MEXICO

(To convert short tons to metric tons, multiply by 0.9072)

Coal Bed	High Development Potential	Moderate Development Potential	Low Development Potential	Total
Fruitland 3	--	170,000	112,740,000	112,910,000
Fruitland 1	--	--	342,540,000	342,540,000
TOTAL	--	170,000	455,280,000	455,450,000

Development Potential for Subsurface Mining Methods

Underground coal of the Fruitland 1 coal bed has low development potential in the west-central, the northwest portion, and the southern half of the quadrangle (CDP Plate 12) where the coal bed thickness varies from 5 to 20 ft (1.5-6.1 m) (CRO Plate 4) and overburden thickness ranges from approximately 2,200 ft (671 m) along the west border to 3,000 ft (914 m) in the center of the area (CRO Plate 6). The Fruitland 3 coal bed has low potential in the central and northwestern areas where the coal bed thickness varies from 5 to 14 ft (1.5-4.3 m) (CRO Plate 8) and overburden thickness increases from 2,200 ft (671 m) to 3,000 ft (914 m) (CRO Plate 10). Areas of unknown potential in the southwest, west-central, and northwest parts of the quadrangle occur where the Fruitland 1 and Fruitland 3 coal beds are less than the reserve base thickness of 5 ft (1.5 m). The remaining parts of the quadrangle with unknown potential include areas where the Fruitland 1 and Fruitland 3 are outside the 3,000-foot (914-m) overburden study limit.

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