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

[Report includes 16 plates]

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SOUTHWEST 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) Map of the southwest quarter of the Gould Pass 15-minute quadrangle, San Juan and Rio Arriba 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 southwest quarter of the Gould Pass 15-minute quadrangle is located in east-central San Juan County, New Mexico. The area is approximately 28 miles (45 km) southeast of Farmington and 91 miles (146 km) northeast of Gallup, New Mexico.

Accessibility

Two light-duty roads paralleling Blanco Wash and Canon Largo, respectively, extend across the area from south to north. They converge and parallel Canon Largo, joining with State Route 17, 9 miles (14 km) northeast of the area. Numerous unimproved dirt roads extend from the two light-duty roads within the area providing access to the surrounding mesas. The Atchison, Topeka, and Santa Fe Railway operates a route approximately 88 miles (142 km) to the southwest at Gallup, New Mexico, which extends southeast and southwest.

Physiography

The quadrangle is in the central portion of the Central Basin area (Kelley, 1950) of the larger structural depression, the San Juan Basin. Total relief in the area is 1,200 ft (366 m) with elevations which range from 5,800 ft (1,768 m) in Blanco Wash to 7,000 ft (2,134 m) on Blanco Mesa. Three major north-south-trending topographic features dominate the quadrangle area. Blanco Mesa, a northwesterly-trending linear feature, is the drainage divide between Blanco Canyon to the west and Canyon Largo to the east; streams west of the mesa flow into Blanco Wash, those to the east empty into Largo Wash which, in turn, drains into the San Juan River to the northwest. These two major intermittent washes and their tributaries have moderately dissected the gently-sloping plains which were graded to a former level of Canon Largo.

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 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

The quadrangle is in the east-central 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

Reeside (1924) mapped the surficial geology of the area on a scale of 1:250,000 as part of a study of the Upper Cretaceous and Tertiary formations of the San Juan Basin. More recently, Fassett and Hinds (1971) made subsurface interpretations of Fruitland Formation coal occurrences 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.

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 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 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 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 relationship 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 present throughout most of the San Juan Basin and easily recognized on geophysical logs, the top was used as the datum (CRO Plate 3) for Fruitland coal correlations. The formation consists of a cream to light gray, calcareous, slightly micaceous, kaolinitic, 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 is about 250 ft (76 m) in this quadrangle. Many authors have used 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 dark gray-green to dark brown carbonaceous shale, interbedded gray siltstone, and lenticular coal beds.

The Upper Cretaceous Kirtland Shale conformably overlies the Fruitland Formation and averages 500 ft (152 m) in thickness in this area. It is predominantly a freshwater, gray-green to brown, locally silty shale. 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 cream, medium- to coarse-grained, locally conglomeratic sandstone with interbedded gray siltstone and shale, and averages 140 ft (43 m) in thickness.

Approximately 1,120 ft (341 m) of the Paleocene Nacimiento Formation overlie the Ojo Alamo Sandstone. These rocks are exposed in the western part of the quadrangle where they consist of gray to brown, locally silty, slightly micaceous shale, white to gray, micaceous sandstone, and interbedded siltstone.

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

Structure

The southwest 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 18 miles (29 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 northeast.

COAL GEOLOGY

Three coal beds (Fruitland 1, Fruitland 2, Fruitland 3) 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. However, occasionally there is a local (L) coal bed directly above the Pictured Cliffs Sandstone which is discontinuous and less than reserve base thickness (5 ft [1.5 m]). Other thin and discontinuous local beds occur throughout the Fruitland Formation.

Above the Fruitland 1, separated by a rock interval of 9 to 49 ft (2.7-14.9 m), is the Fruitland 2 (Fr 2) coal bed. The Fruitland 3 (Fr 3) coal bed is above the Fruitland 2 separated by a rock interval of 33 to 88 ft (10.1-26.8 m) (CRO Plate 1). Although these coal beds have been correlated and mapped as consistent horizons, they may actually be several different coal beds that are lithostratigraphically equivalent but not laterally continuous.

The remaining coals in the upper portion of the Fruitland Formation are designated as the Fruitland coal zone (Fr zone). These coals are generally noncorrelative, discontinuous, and less than reserve base (5 ft [1.5 m]) thickness; an exception is a 9-ft (2.7-m) coal bed in drill hole 11 (CRO Plate 3). Due to these characteristics, derivative maps were not constructed.

Fruitland Formation coals in the central portion of the San Juan Basin are considered high volatile B to 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 14,696 Btu's per pound (34,183 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 (Bauer and Reeside, 1921; Dane, 1936; Fassett and Hinds, 1971). The "as received" analyses indicate moisture content ranging from 1.4 to 4.2 percent, ash content varying from 13.4 to 31.0 percent, sulfur content less than 1 percent, and heating values on the order of 10,857 Btu's per pound (25,253 kj/kg). Analyses of several Fruitland Formation coals are given in Table 1 (Fassett and Hinds, 1971).

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 illustrated by the structure contour map (CRO Plate 5) the coal bed dips less than 1° to the northeast. As a result of topography and dip, overburden (CRO Plate 6) varies from less than 2,000 ft (610 m) at Blanco Canyon to greater than 3,000 ft (914 m) in the northeast part of the quadrangle. The isopach map (CRO Plate 4) shows that the coal bed is greater than 20 ft (6.1 m) thick in the northeast portion of the quadrangle. The thickness decreases in all directions, and the coal is absent in various areas in the southwest, northwest, and northeast.

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

Fruitland 2 Coal Bed

The coal bed has been mapped only in areas of less than 3,000 ft (914 m) of overburden (the study limit). The structure contour map (CRO Plate 9) illustrates 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 1,800 ft (549 m) at Blanco Canyon to greater than 3,000 ft (914 m) in the

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-16695	Century Exploration Mobil-Rudman No. 2	SW¼ 21	25	9	1,620-1,625	A	4.2	31.5	33.3	31.0	0.9	9,280	
						B	---	32.8	34.8	32.4	0.9	9,680	
						C	---	48.6	51.4	----	1.4	14,310	
H-15776	Aztec Oil & Gas Hanks No. 14-D	SW¼ 12	27	10	1,900-1,905	A	2.2	40.4	44.0	13.4	0.6	12,520	
						B	---	41.3	45.1	13.6	0.6	12,790	
						C	---	47.9	52.1	----	0.7	14,820	
H-13063	Aztec Oil & Gas Hudson No. 5-D	NW¼ 29	27	9	2,135-2,145	A	2.7	38.3	40.4	18.6	0.8	11,650	
						B	---	39.3	41.6	19.1	0.8	11,970	
						C	---	48.6	51.4	----	1.0	14,800	
H-12705	Aztec Oil & Gas Whitley No. 6-D	SW¼ 8	27	9	2,215-2,230	A	2.2	36.7	41.2	19.9	0.8	11,440	
						B	---	37.5	42.1	20.4	0.8	11,700	
						C	---	47.1	52.9	----	1.1	14,700	
H-21490	El Paso Nat. Gas Schwerdtfeger No. 20-A	NE¼ 8	27	8	2,800-2,820	A	1.9	29.5	32.9	35.7	0.6	9,170	
						B	---	30.0	33.6	36.4	0.6	9,350	
						C	---	47.2	52.8	----	1.0	14,700	
H-13061	Aztec Oil & Gas Reid No. 23-D	SW¼ 17	28	9	1,985-1,990	A	1.4	36.1	42.1	20.4	0.8	11,670	
						B	---	36.6	42.7	20.7	0.8	11,830	
						C	---	46.2	53.8	----	1.0	14,920	
H-13779	El Paso Nat. Gas Florence No. 10-C	NE¼ 30	28	8	2,185-2,195	A	1.9	33.7	35.1	29.3	0.6	10,270	
						B	---	34.3	35.8	29.9	0.7	10,460	
						C	---	48.9	51.1	----	0.9	14,920	

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.

northeast part of the quadrangle. As shown by the isopach map (CRO Plate 8), the coal bed is greater than 10 ft (3.0 m) thick in a small area in the northwest and in the east-central portion of the map. The coal decreases in thickness in all directions, and the coal is absent in portions of the south, the east, and the center of the mapped area.

Chemical Analyses of the Fruitland 2 Coal Bed - Analyses of several Fruitland Formation coals from this quadrangle and the surrounding area 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). The structure contour map (CRO Plate 13) shows that the coal bed dips less than 1° to the northeast. Overburden (CRO Plate 14) varies as a result of dip and topography from less than 1,800 ft (549 m) at Blanco Canyon to greater than 3,000 ft (914 m) in the northeast. As illustrated by the isopach map (CRO Plate 12) the coal bed is greater than 10 ft (3.0 m) thick in the northeast and southwest portions of the quadrangle. The coal bed decreases in thickness in all directions, and is absent in the south, center, and northwest.

Chemical Analyses of the Fruitland 3 Coal Bed - Analyses of several Fruitland Formation coals 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 southwest quarter of the Gould Pass 15-minute quadrangle are more than 1,700 ft (518 m) below the ground surface and, thus, have no outcrop or surface development potential.

The U.S. Geological Survey designated the Fruitland 1, Fruitland 2, 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, noncorrelative, and 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 2, and Fruitland 3 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 679 million short tons (616 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 southwest quarter of the Gould Pass 15-minute quadrangle has development potential for subsurface mining methods only (CDP Plate 16).

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 2, and Fruitland 3 coal beds.

TABLE 2

COAL RESOURCE DATA FOR UNDERGROUND MINING METHODS FOR FEDERAL COAL LANDS (in short tons) IN THE SOUTHWEST 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	--	53,210,000	106,420,000	159,630,000
Fruitland 2	--	50,390,000	133,890,000	184,280,000
Fruitland 1	--	30,300,000	305,220,000	335,520,000
TOTAL	--	133,900,000	545,530,000	679,430,000

Development Potential for Surface Mining Methods

All coals studied in the southwest quarter of the Gould Pass 15-minute quadrangle occur more than 1,700 ft (518 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 coal bed has moderate development potential in the northwest and southwest parts of the quadrangle (CDP Plate 16) where the coal bed thickness varies from 5 to 11 ft (1.5-3.4 m) (CRO Plate 4), and the overburden thickness is approximately 1,850 to 2,000 ft (564-610 m) thick (CRO Plate 6). The Fruitland 2 coal bed has moderate potential in the southwest, west-central, northwest, and central areas. Coal bed thickness in these areas ranges from 5 to 12 ft (1.5-3.7 m) (CRO Plate 8), and the overburden varies from 1,800 to 2,000 ft (549-610 m) thick (CRO Plate 10). The Fruitland 3 coal bed has moderate potential in the northwest, southwest, and central to north-central parts of the quadrangle. The coal bed thickness varies from 5 to 10 ft (1.5-3.0 m) (CRO Plate 12), and overburden thickness ranges from 1,800 to 2,000 ft (549-610 m) (CRO Plate 14).

Coal of the Fruitland 1 and Fruitland 3 beds has low potential in the southeast, northwest, and northeast. The Fruitland 1 also has low potential in the east-central part of the quadrangle. Coal bed thicknesses are 5 to 20 ft (1.5-6.1 m) for the Fruitland 1 and 5 to 10 ft (1.5-3.0 m) for the Fruitland 3, and the overburden increases from 2,000 to 3,000 ft (610-914 m) in a northeasterly direction. The Fruitland 2 coal bed has low development potential in the northwest, central, northeast, and extreme southeast parts of the quadrangle. The Fruitland 2 thickness in these areas ranges from 5 to 11 ft (1.5-3.4 m), and overburden increases from 2,000 to 3,000 ft (610-914 m). Coal of moderate and low potential along the south-central border of the quadrangle is the result of the Fruitland 4 coal bed in the northwest quarter of the Nageezi 15-minute quadrangle to the south. Areas of unknown development potential occur in the south, central, northwest, and northeastern parts of the quadrangle where the evaluated coal beds are less than reserve base thickness (5 ft [1.5 m]) and outside the 3,000-ft (914-m) overburden study limit. A small area in the south-central part of the quadrangle has no development potential where the Fruitland 1, Fruitland 2, and Fruitland 3 coal beds are not present.

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