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COAL RESOURCE OCCURRENCE MAPS AND COAL DEVELOPMENT POTENTIAL MAPS OF THE GONZALES MESA QUADRANGLE, RIO ARRIBA COUNTY, NEW MEXICO

[Report includes 16 plates]

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GONZALES MESA 7 1/2-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 Gonzales Mesa quadrangle, Rio Arriba 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) 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 Gonzales Mesa 7 1/2-minute quadrangle is located in western Rio Arriba County, New Mexico. The western boundary of the Jicarilla Apache Indian Reservation is in the eastern half of the quadrangle. The area is approximately 44 miles (70 km) southeast of Farmington and 90 miles (145 km) northeast of Gallup.

Accessibility

The area is accessible by a light-duty road originating from State Route 537 to the east. From this light-duty road numerous unimproved dirt roads branch out and provide access to remote parts of the area. The Atchison, Topeka, and Santa Fe Railway operates a route which is approximately 90 miles (145 km) to the southwest at Gallup, New Mexico, and connects Gallup with Grants and Albuquerque to the east.

Physiography

This quadrangle is located in the central portion of the Central Basin (Kelley, 1950) area of the larger structural depression, the San Juan Basin. Total relief of the area is moderate, ranging from 6,100 ft (1,859 m) in the Canon Largo stream channel to 6,982 ft (2,128 m) in the northeastern part of the area. In the canyons of Canon Largo and its tributaries local relief is great, commonly with up to 400 ft (122 m). Their streams have cut through resistant rock units forming nearly vertical canyon walls. Between the canyons, mesas slope gently toward the canyon edges. Before dissection these mesas were part of a broad valley at one time graded to the level of the San Juan River.

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 as intense afternoon thundershowers. Annual temperatures range from below 0°F (-18°C) to over 100° (38°C) in the basin. Snowfall may occur from November to April.

Land Status

Approximately 71 percent of the quadrangle is in the eastern boundary of the San Juan Basin Known Recoverable Coal Resource Area. The Federal Government owns the coal rights for approximately 87 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) have made subsurface interpretations of Fruitland Formation coal occurrences in the quadrangle 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 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 in the basin as the regression continued in that direction. Terrestrial freshwater sediments 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 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: 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 70 ft (21 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 used as the datum (CRO Plate 3) for Fruitland coal correlations. The formation consists of a white to light gray, slightly micaceous, kaolinitic sandstone with traces of siderite 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 Sandstone.

The major coal-bearing unit in the quadrangle, the Fruitland Formation, conformably overlies the Pictured Cliffs Sandstone. Wide variations in the reported thickness of the Fruitland are common due to an indistinct upper contact with the Kirtland Shale, but the average is about 180 ft (55 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 primarily consists of gray, carbonaceous shale, interbedded gray-green, micaceous siltstone, and lenticular coal beds.

The Upper Cretaceous Kirtland Shale conformably overlies the Fruitland Formation and averages 250 ft (76 m) in thickness in this area. It is predominantly freshwater, purple to gray-green shale and gray-green, micaceous 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 cream to light gray, kaolinitic, locally conglomera-sandstone, and interbedded gray siltstone and shale and averages 165 ft (50 m) thick in the area.

Approximately 1,270 ft (387 m) of the Paleocene Nacimiento Formation overlie the Ojo Alamo Sandstone. Nacimiento Formation rocks consist of cream to light gray, arkosic, kaolinitic, friable, micaeous, locally conglomeratic sandstone, interbedded purple to gray-green shale, and interbedded tan to gray-green, micaceous siltstone with plant fossils.

The San Jose Formation of Eocene age unconformably overlies the Nacimiento Formation and crops out over the entire quadrangle area. It is predominantly white to cream to light gray, kaolinitic, slightly calcareous, locally conglomeratic sandstone with traces of pyrite, interbedded tan to gray, micaceous siltstone, and interbedded gray-green shale.

Structure

The Gonzales Mesa quadrangle is located in the Central Basin area (Kelley, 1950) of the major structural depression, the San Juan Basin. The axis of the basin is about 11 miles (18 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

Five coal beds (Fruitland 1, 2, 3, 4, and 5) 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, separated by a rock interval varying from 9 to 39 ft (2.7-11.9 m). Another rock interval, which varies from 11 to 53 ft (3.4-16.2 m), separates the Fruitland 3 (Fr 3) coal bed from the Fruitland 2 coal bed. Throughout most of the quadrangle the Fruitland 3 is less than reserve base thickness (5 ft [1.5 m]) (an exception is drill hole 22, with a 5-ft [1.5-m] bed), so derivative maps were not constructed. Above the Fruitland 3 is the Fruitland 4 (Fr 4) coal bed. These coal beds are separated by a rock interval thickness which varies from 10 to 28 ft (3.0-8.5 m). The Fruitland 5 (Fr 5) coal bed is above the Fruitland 4; they are separated by a rock interval of 26 to 53 ft (7.9-16.2 m). Throughout most of the quadrangle the Fruitland 5 is less than the reserve base thickness (5 ft [1.5 m]); exceptions are a 6-ft (1.8-m) coal bed in drill hole 14 and a 5-ft (1.5-m) coal bed in drill hole 17. Therefore, derivative maps were not constructed. Although the Fruitland 1, 2, 3, 4, and 5 coal beds (informally named by the authors) are correlated as consistent horizons, they may, in fact, each be several different beds that are lithostratigraphically equivalent but not laterally continuous.

The remaining coals of the Fruitland Formation have been grouped together as the Fruitland coal zone (Fr zone). The zone extends from the top of the Fruitland Formation to the base of the lowermost coal which is designated (CRO Plate 3) as a Fruitland zone coal bed. The zone consists of several coal beds which are discontinuous, noncorrelative, and less than the reserve base thickness (5 ft [1.5 m]). Therefore, 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 represents the lowermost Fruitland Formation coal bed which generally occurs directly above the Pictured Cliffs Sandstone. The Fruitland 1 has been mapped only in the southeastern portion of the quadrangle (CRO Plate 1). The coal bed is present in other areas of the quadrangle; however, in those areas it is less than reserve base thickness (5 ft [1.5 m]) or has more than 3,000 ft (914 m) of overburden (study limit).

As illustrated by the structure contour map (CRO Plate 5), the coal bed dips less than 1° to the northeast. Consequently, overburden (CRO Plate 6) increases from less than 2,400 ft (732 m) in the southwest to greater than 2,900 ft (884 m) in the northeast part of the map. The isopach map (CRO Plate 4) shows the greater thickness of the coal bed occurs in the eastern portion of the map. In this area the coal is greater than 15 ft (4.6 m) thick. The thickness decreases in all directions, and the coal is absent in the northwest portion of the map.

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-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	Kay Kimbell Leiberman 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

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 Fruitland 2 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 less than 1° to the northeast. Consequently, overburden (CRO Plate 10) increases from less than 2,200 ft (671 m) in the southwest to greater than 3,000 ft (914 m) in the northern part of the quadrangle. The isopach map (CRO Plate 8) shows that the coal bed is greater than 5 ft (1.5 m) thick in the eastern and central portions of the map. The coal decreases in thickness to the south, west, and north, and is absent in the west and part of the north.

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 4 Coal Bed

The Fruitland 4 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 13), the coal bed dips less than 1° to the northeast. Consequently, overburden (CRO Plate 14) increases from less than 2,200 ft (670 m) in the southwest to greater than 3,000 ft (914 m) in the northern portions of the quadrangle. The isopach map (CRO Plate 12) indicates that the coal is thickest in the central part of the area where it is greater than 5 ft (1.5 m) thick. It thins in all directions and is absent in the southern and western portions of the quadrangle.

Chemical Analyses of the Fruitland 4 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 Gonzales Mesa quadrangle occur more than 2,170 ft (661 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 4 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. In addition, the Fruitland 3 and Fruitland 5 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, 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.

Reserve Base and Reserve values for measured, indicated, and inferred categories of coal for the Fruitland 1, Fruitland 2, 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 69.8 million short tons (63.3 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 Gonzales Mesa 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 (306-610 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 4 coal beds.

Development Potential for Surface Mining Methods

All coals studied in the Gonzales Mesa quadrangle occur more than 2,170 ft (661 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 low development potential in the south-central part of the quadrangle (CDP Plate 16) where coal bed thickness is 5 to 9 ft (1.5-2.7 m) (CRO Plate 4) and the overburden thickness ranges from 2,400 ft (732 m) in the south to 2,800 ft (853 m) in the center of the quadrangle (CRO Plate 6). The Fruitland 2 coal bed has low potential in the south-central area coincident with the Fruitland 1 and near the center of the quadrangle. Coal bed thickness in these areas varies from 5 to 9 ft (1.5-2.7 m) (CRO Plate 8) and the overburden thickness ranges from 2,400 ft (732 m) in the south to 3,000 ft (914 m) in the north (CRO Plate 10). Coal of the Fruitland 4 bed has low development potential in the center of the quadrangle where coal bed thickness varies between 5 and 9 ft (1.5-2.7 m) (CRO Plate 12) and overburden is approximately 2,600 to 2,800 ft (792-853 m) thick (CRO Plate 14). Low potential in the extreme northwest is the result of the Fruitland 1 bed in the northeast quarter of the Nageezi 15-minute quadrangle located to the west.

TABLE 2

COAL RESOURCE DATA FOR UNDERGROUND MINING METHODS FOR FEDERAL COAL LANDS (in short tons) IN THE GONZALES MESA QUADRANGLE, RIO ARRIBA 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 4	--	--	15,280,000	15,280,000
Fruitland 2	--	--	42,190,000	42,190,000
Fruitland 1	--	--	12,290,000	12,290,000
TOTAL	--	--	69,760,000	69,760,000

Most of the quadrangle area inside the KRCRA has unknown development potential where there is insufficient data for the Fruitland 1, or the coal beds are less than the reserve base thickness of 5 ft (1.5 m) or outside the 3,000-foot (914-m) overburden study limit (CDP Plate 16). An area with no development potential occurs along the western border of the quadrangle where there is no Fruitland 1, Fruitland 2, or Fruitland 4 coal.

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