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COAL RESOURCE OCCURRENCE MAPS AND COAL DEVELOPMENT POTENTIAL MAPS OF THE FARMINGTON NORTH QUADRANGLE, SAN JUAN COUNTY, NEW MEXICO

[Report includes 11 plates]

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FARMINGTON NORTH 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) Map of the Farmington North quadrangle, San Juan 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 Farmington North 7 1/2-minute quadrangle is located in north-central San Juan County, New Mexico. The northern part of Farmington, New Mexico, is located at the center of the southern quadrangle boundary.

Accessibility

The Farmington North quadrangle is accessible from both New Mexico State Route 550, which extends across the southeastern corner of the area, and State Route 17, which trends north-south across the western part of the area. Various light-duty roads provide access to other parts of the quadrangle. The Atchison, Topeka and Santa Fe Railway operates a route approximately 96 miles (154 km) south of the area at Gallup, New Mexico.

Physiography

The quadrangle is in the northwestern part of the Central Basin area (Kelley, 1950) of the structural depression known as the San Juan Basin. Elevations range from approximately 5,300 ft (1,615 m) in the La Plata River Valley to 6,118 ft (1,865 m) in the northeast. Three major drainages are present within the area. The La Plata River flows south through the western part of the area, and the Animas River flows southwestward across the southeastern corner of the area. Farmington Glade, an intermittent stream system, drains to the south from the central part of the area. Mesas dissected by numerous arroyos and washes separate these drainages.

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

The quadrangle is in the northwestern part of the San Juan Basin Known Recoverable Coal Resource Area. The Federal Government owns the coal rights for approximately 79 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.

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 in 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 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. A significant amount of erosion has occurred, as indicated by the removal of the San Jose Formation 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: Pictured Cliffs Sandstone, Fruitland Formation, Kirtland Shale, Ojo Almo Sandstone, and Nacimiento 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 150 ft (46 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 white to gray to brown, friable, kaolinitic sandstone with traces of glauconite, interbedded with soft, gray shale with plant fossils. 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 350 ft (107 m) in this quadrangle. Many authors have used 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 tan to gray, soft, carbonaceous shale, thin, interbedded light gray, slightly calcareous siltstone, interbedded white, calcareous sandstone, and lenticular coal beds.

The Upper Cretaceous Kirtland Shale conformably overlies the Fruitland Formation and averages 1,150 ft (351 m) in thickness in this area. It is predominantly freshwater, green to gray shale with scattered subrounded siderite grains and finely disseminated mica, interbedded light gray, slightly micaceous sandstone, and minor beds of lithologies gradational between shale and sandstone. 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, conglomeratic, calcareous sandstone with chert nodules, and interbedded gray, locally sandy shale, and it averages 120 ft (37 m) in thickness in this area.

The majority of the Paleocene Nacimiento Formation has been removed from the area by erosional processes. The deposits consist of light gray to black shale and white to yellow-brown, fine-grained to conglomeratic, silty sandstone.

Three formations crop out in the quadrangle area. The oldest of these, the Kirtland Shale, is exposed along the western boundary of the area on both sides of the La Plata River. The Ojo Alamo Sandstone crops out in the southeastern and central parts of the area and as an isolated outcrop on Pinon Mesa along the western boundary. In the northeastern corner of the area are exposed the lower beds of the Nacimiento Formation, the youngest formation in the area.

Structure

The Farmington North quadrangle is located in the Central Basin area (Kelley, 1950) of the major structural depression known as the San Juan Basin. The western end of the basin axis is located within the northeast part of the quadrangle area and trends eastward in an arcuate pattern across the northern portion of the Central Basin area (Baltz, 1967). Regional dip within the quadrangle is to the west-northwest at approximately 1° (Reeside, 1924).

COAL GEOLOGY

Two coal beds (Fruitland 1 and Fruitland 2) 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 generally is directly above the Pictured Cliffs Sandstone. The Fruitland 2 (Fr 2) coal bed is above the Fruitland 1 separated by a rock interval averaging 8 ft (2.4 m). In this quadrangle the Fruitland 2 is less than reserve base thickness (5 ft [1.5 m]). Therefore, derivative maps were not constructed. Although these coal beds have been correlated as consistent horizons, they may actually be several different coal beds that are equivalent in lithostratigraphic position but not laterally continuous.

Occasionally there is a local (L) coal bed within the Fruitland Formation which is noncorrelative and discontinuous. The remaining coals in the upper portion of the Fruitland Formation are grouped together as the Fruitland coal zone (Fr zone), extending from the top of the Fruitland Formation to the base of the lowermost coal which is designated on CRO Plate 3 as a Fruitland zone coal bed. These coal beds are generally noncorrelative, discontinuous, and less than reserve base thickness (5 ft [1.5 m]); exceptions are a 7-ft (2.1-m) coal in drill hole 13 and a 5-ft (1.5-m) coal in drill holes 3, 4, 17, and 22 (CRO Plate 1).

Fruitland Formation coals in the northwest part of the San Juan Basin are considered high volatile A to high volatile B bituminous in rank. The rank has been determined on a moist, mineral-matter-free basis with calorific values averaging 14,258 Btu's per pound (33,164 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 1.4 to 5.7 percent, ash content averaging

13.7 percent, sulfur content less than 1 percent, and heating values on the order of 12,131 Btu's per pound (28,217 kj/kg). Analyses of several Fruitland coals are given in Table 1 (Bauer and Reeside, 1921; Dane, 1936; Fassett and Hinds, 1971).

Fruitland 1 Coal Bed

As illustrated by the structure contour map (CRO Plate 5) the coal bed dips less than 1° to the northeast. Due to topography and dip, overburden (CRO Plate 6) varies from less than 1,000 ft (305 m) in the southwest within the La Plata River Valley to greater than 2,200 ft (671 m) in the northeast. The isopach map (CRO Plate 4) shows that the coal bed is greater than 15 ft (4.6 m) thick in a small area along the eastern edge of the quadrangle. The thickness decreases in all directions from this area, and the coal is absent in small portions of the northeast, north-central, and southwest.

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

Fruitland Coal Zone

The Fruitland coal zone extends from the top of the Fruitland Formation to the base of the lowermost coal which is designated on CRO Plate 3 as a Fruitland zone coal bed. The structure contour map of the Fruitland coal zone was drawn on top of the Fruitland Formation. As illustrated by 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 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-12704	Redfern & Herd Redfern & Herd No. 5	SW¼ 10	28	11	1,490-1,500	A	2.1	39.8	43.4	14.7	0.6	12,190	
						B	—	40.7	44.3	15.0	0.6	12,460	
						C	—	47.9	52.1	—	0.7	14,670	
H-24567	Sunray Mid-continent Gallegos No. 122	NW¼ 18	28	12	1,305-1,315	A	3.0	38.9	44.4	13.7	0.6	12,010	
						B	—	40.1	45.8	14.1	0.6	12,390	
						C	—	46.8	53.2	—	0.7	14,430	
H-7225	Pan American Holder No. 7	NW¼ 16	28	13	1,705-1,715	A	4.1	39.4	42.8	13.7	0.6	11,740	
						B	—	41.1	44.6	14.3	0.6	12,240	
						C	—	47.9	52.1	—	0.7	14,290	
H-3028	International Oil Fogelson No. 1-9	NW¼ 9	29	11	1,905-1,910	A	1.8	39.9	43.9	14.4	0.7	12,360	
						B	—	40.6	44.8	14.6	0.7	12,590	
						C	—	47.6	52.4	—	0.8	14,750	
H-13060	Tidewater N.M.-Fed. No. 12-E	SE¼ 12	29	11	2,065-2,070	A	2.1	38.7	47.9	11.3	0.6	12,830	
						B	—	39.5	48.9	11.6	0.6	13,100	
						C	—	44.7	55.3	—	0.7	14,820	
H-3030	Tennessee Oil & Gas Cornell Gas Unit A No. 1	NW¼ 10	29	12	1,740-1,750	A	2.1	40.0	44.8	13.1	0.5	12,340	
						B	—	40.9	45.7	13.4	0.5	12,600	
						C	—	47.2	52.8	—	0.6	14,560	
H-8360	Aztec Oil & Gas Hagood No. 21-G	SW¼ 20	29	13	1,125-1,140	A	5.6	39.0	41.3	14.1	0.6	11,580	
						B	—	41.3	43.8	14.9	0.6	12,260	
						C	—	48.5	51.5	—	0.7	14,420	
H-4052	Aztec Oil & Gas Hagood No. 13-G	SE¼ 34	29	13	1,635-1,640	A	3.5	39.6	43.2	13.7	0.5	11,910	
						B	—	41.0	44.8	14.2	0.6	12,330	
						C	—	47.8	52.2	—	0.6	14,370	
H-13062	Aztec Oil & Gas Ruby Jonas No. 1	NE¼ 7	30	11	2,020-2,030	A	1.4	37.2	44.1	17.3	0.6	12,010	
						B	—	37.7	44.8	17.5	0.6	12,180	
						C	—	45.7	54.3	—	0.7	14,770	
H-15140	Southwest Production Sullivan No. 1	NE¼ 22	30	12	1,713-1,742	A	2.2	38.8	45.3	13.7	0.6	12,370	
						B	—	39.7	48.3	14.0	0.6	12,640	
						C	—	46.1	53.9	—	0.7	14,700	
H-16308	R&G Drilling Lunt No. 62	NW¼ 18	30	13	1,425-1,440	A	2.8	40.4	44.7	12.1	0.6	12,390	
						B	—	41.6	45.9	12.5	0.6	12,750	
						C	—	47.5	52.5	—	0.7	14,570	
H-19399	Compass Exploration Federal No. 1-31A	NE¼ 31	30	13	1,070-1,080	A	5.7	38.8	43.0	12.5	0.6	11,840	
						B	—	41.2	45.5	13.3	0.6	12,540	
						C	—	47.4	52.6	—	0.7	14,460	

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.

structure contour map (CRO Plate 9) the coal zone dips less than 1° to the northeast. As a result of topography and dip, overburden (CRO Plate 10) varies from less than 800 ft (244 m) in the southwest in the La Plata River Valley and Cottonwood Arroyo to greater than 1,800 ft (549 m) in the northeast. Also shown on CRO Plate 10 is the total amount of interburden which is the noncoal-bearing portion of the coal zone. It varies in thickness from zero to greater than 400 ft (122 m) and essentially reflects the stratigraphic spread of the Fruitland zone coals. The isopach map (CRO Plate 8) shows the total thickness of the coal. The maximum cumulative thickness is greater than 10 ft (3.0 m) and occurs in a small area in the southwest and also in the west. In general, the thickness decreases in all directions, and the coal is absent in the northwest and several areas along the eastern part of the quadrangle.

Chemical Analysis of the Fruitland Zone Coal Beds - Analyses of several Fruitland coals from this quadrangle and the surrounding area are given in Table 1 (Fasett 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 coal beds in the Farmington North quadrangle are more than 200 ft (61 m) below the ground surface and, therefore, have no outcrop or surface development potential.

The U.S. Geological Survey designated the Fruitland 1 coal bed for the determination of coal resources in this quadrangle. Coals of the

Fruitland 2 bed and Fruitland zone were not evaluated because they are generally less than the reserve base thickness (5 ft [1.5 m]). In addition, Fruitland zone coals are irregular, noncorrelative, and limited in areal extent.

For Reserve Base and Reserve calculations, the Fruitland 1 coal bed was areally divided into measured, indicated, and inferred resource categories (CRO Plate 7), 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 coal isopach (CRO Plate 4) and areal distribution maps (CRO Plate 7). The surface area of the isopached Fruitland 1 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 coal bed are shown on CRO Plate 7 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 278 million short tons (252 million metric tons).

The coal development potential for the Fruitland 1 bed is 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 Farmington North quadrangle has development potential for subsurface mining methods only (CDP Plate 11).

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 coal bed.

Development Potential for Surface Mining Methods

All coal beds of the Farmington North quadrangle occur 200 ft (61 m) or more below the ground surface and, therefore, have no development potential for surface mining methods.

Development Potential for Subsurface Mining Methods

Underground coal of the Fruitland 1 bed has moderate development potential in the central, west-northwest, and southeastern parts of the

TABLE 2

COAL RESOURCE DATA FOR UNDERGROUND MINING METHODS FOR FEDERAL COAL LANDS (in short tons) IN THE FARMINGTON NORTH QUADRANGLE, SAN JUAN 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 1	--	234,200,000	44,180,000	278,380,000
TOTAL	--	234,200,000	44,180,000	278,380,000

quadrangle (CDP Plate 11). The coal bed thickness varies from 5 ft (1.5 m) in the north and west to 15 ft (4.6 m) in the east (CRO Plate 4), and the overburden increases from 1,200 ft (366 m) thick at the western border of the quadrangle to 2,000 ft (610 m) thick in the east (CRO Plate 6). The Fruitland 1 has low development potential in the east-northeast where the coal is 5 to 14 ft (1.5-4.3 m) thick and the overburden ranges from 2,000 to more than 2,200 ft (610-671 m) thick.

Areas of unknown coal development potential occur in the west, southwest, and in the northern half of the quadrangle where the Fruitland 1 coal bed is less than the reserve base thickness of 5 ft (1.5 m). Three small areas with no development potential occur in the southwest, north-central, and northeast and include areas where there is no Fruitland 1 coal.

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