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

[Report includes 11 plates]

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<u>HORN CANYON 7 1/2-MINUTE QUADRANGLE</u>

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 Horn Canyon 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 Horn Canyon 7 1/2-minute quadrangle is located in northern San Juan County, New Mexico. The area is approximately 8 miles (13 km) east-southeast of Farmington, New Mexico.

Accessibility

The Horn Canyon quadrangle is accessible from New Mexico State Route 17, which passes east-west through the central part of the quadrangle. Light-duty roads diverging from State Route 17 provide access to other parts of the quadrangle. The Atchison, Topeka, and Santa Fe Railway operates a route approximately 82 miles (132 km) to the southwest at Gallup, New Mexico, which extends to the southwest and southeast.

Physiography

This quadrangle is in the northwestern portion of the Central Basin area (Kelley, 1950) of the structural depression known as the San Juan Basin. Elevations range from 5,320 ft (1,622 m) to 6,030 ft (1,838 m) in the western part of the San Juan River valley. The San Juan River flows east-west through the central part of the quadrangle and its terraces are present on both sides of the river. The remaining portion of the quadrangle is a plateau dissected by tributary streams which have carved canyons, notably Gallegos, Horn, and Kutz Canyons, which generally trend in a north-south direction in the southern part of the area.

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 above 100° (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 83 percent of the KRCRA land in the quadrangle as shown on Plate 2 of the Coal Resource Occurrence Maps. No Federal coal leases occur within 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 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 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 northwest-southeast strandline and their discontinuity perpendicular to it to the northeast. 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 erosional processes to the present time. A significant amount of erosion has occurred, as indicated by the removal of the San Jose Formation and part of the Nacimiento 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 Alamo 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 a thickness of 150 ft (46 m). Because the unit is persistent throughout most of the San Juan Basin and easily recognized on geophysical logs, the top of the Pictured Cliffs Sandstone was chosen as the datum (CRO Plate 3) for Fruitland coal correlations. The formation consists of a tan to gray, friable, kaolinitic, slightly glauconitic sandstone, with interbedded gray shale and siltstone.

Intertonguing with the overlying Fruitland Formation occurs throughout the entire basin; therefore, minor Fruitland coal beds are commonly 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 reported thickness of the Fruitland are common due to an indistinct upper contact with the Kirtland Shale, but the average is about 300 ft (91 m) in this quadrangle. Many authors have used various criteria to establish the upper boundary, but for this study the uppermost Fruitland coal was generally used as the contact (after Fassett and Hinds, 1971). The formation consists primarily of gray to brown, carbonaceous shale; interbedded tan to gray, calcareous, kaolinitic sandstone; interbedded tan to gray, calcareous siltstone with plant fossils; and lenticular coal beds.

The Upper Cretaceous Kirtland Shale conformably overlies the Fruitland Formation and averages 845 ft (258 m) in thickness in this area. It consists of freshwater, tan to gray-green, sandy siltstone, interbedded white to tan sandstone, and interbedded gray shale. The Kirtland Shale previously has 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, which unconformably overlies the Kirtland Shale, is a light gray, coarse-grained to conglomeratic, kaolinitic sandstone with interbedded green-gray shale. It averages 120 ft (37 m) in thickness and crops out in the west-central part of the area along the San Juan River.

A large portion of the Paleocene Nacimiento Formation has been removed from the area. Nacimiento Formation rocks are exposed across the majority of the quadrangle area, where they consist of gray, locally silty shale, interbedded light gray, locally conglomeratic sandstone, and interbedded gray-green claystone.

Structure

The Horn Canyon 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 lies about 7 miles (11 km) north of the quadrangle area and trends in an arcuate pattern across the northern portion of the Central Basin area (Baltz, 1967). Reeside (1924) stated that the rocks in this area are "nearly horizontal."

COAL GEOLOGY

One coal bed (Fruitland 1) and a coal zone (Fruitland) were identified and mapped 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 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 coals are generally noncorrelative and less than reserve base thickness (5 ft [1.5 m]); exceptions are a 5-ft (1.5-m) coal in drill hole 2 and a 7-ft (2.1-m) coal in drill hole 22 (CRO Plate 3).

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 1.8 to 5.7 percent, ash content averaging 13.7 percent, sulfur content less than one 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

Although the Fruitland 1 is correlated and mapped as a consistent horizon, it may actually be several different coal beds that are lithostratigraphically equivalent but not laterally continuous.

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 1,200 ft (366 m) in the San Juan River area at the western edge of the quadrangle to greater than 2,000 ft (610 m) in the extreme northeast corner. The isopach map indicates the coal bed is greater than 15 ft (4.6 m) thick in the northwest. The thickness decreases in all directions, and the coal is absent in parts of the east, southeast, west, and central portions of the quadrangle.

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 Mois-ture	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 Jones 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.

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 Coal Zone

The structure contour map of the coal zone was drawn on the top of the Fruitland Formation. As illustrated by the structure contour map (CRO Plate 9), the coal zone dips less than 1° in a northeasterly direction. Due to topography and dip, overburden (CRO Plate 10) varies from less than 900 ft (274 m) in the San Juan River area at the western edge of the quadrangle to greater than 1,600 ft (488 m) in the northeast. Also shown on CRO Plate 10 is the total amount of interburden within the Fruitland coal zone. The interburden is the noncoal-bearing portion of the zone. The thickness varies from zero to greater than 300 ft (91 m) and essentially reflects the stratigraphic spread of the coals within the zone. The isopach map (CRO Plate 8) of the total coal thickness indicates that the greatest accumulation occurs at the eastern edge of the quadrangle. In this area the coals total more than 10 ft (3.0 m). The thickness decreases in all directions, and the coal is absent in parts of the east, west, and central portions of the quadrangle.

Chemical Analyses of the Fruitland Zone Coal Beds - 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 for this quadrangle. All of the coals studied in the Horn Canyon quadrangle are more than 1,150 ft (351 m) below the ground surface and, thus, 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 zone were not evaluated because the thickness of the coal beds is generally less than the reserve base thickness (5 ft [1.5 m]).

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, for each category, in acres, then multiplied by 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 the Fruitland 1 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 230 million short tons (209 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 Horn Canyon 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.

TABLE 2

COAL RESOURCE DATA FOR UNDERGROUND MINING METHODS FOR FEDERAL COAL LANDS (in short tons) IN THE HORN CANYON 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	--	229,750,000	190,000	229,940,000
TOTAL	--	229,750,000	190,000	229,940,000

Development Potential for Surface Mining Methods

All coals studied in the Horn Canyon quadrangle occur more than 1,150 ft (351 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 north-northwest and in the southern half of the quadrangle (CDP Plate 11). The coal thickness ranges from 5 to 17 ft (1.5-5.2 m) in the north and 5 to 12 ft (1.5-37 m) in the southern part of the quadrangle (CRO Plate 4). Overburden increases from 1,325 ft (404 m) in the southwest to approximately 2,000 ft (610 m) in the northeast (CRO Plate 6).

The central and eastern parts of the quadrangle have unknown development potential where the Fruitland 1 is less than the reserve base thickness of 5 ft (1.5 m). Isolated areas in west-central, east-central, and extreme southwest parts of the quadrangle have no Fruitland 1 coal and, thus, have no development potential for subsurface mining methods.

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