Text to accompany:

Open-File Report 79-608

1979

COAL RESOURCE OCCURRENCE MAPS AND COAL DEVELOPMENT POTENTIAL MAPS OF THE SOUTHWEST QUARTER OF THE LLAVES 15-MINUTE QUADRANGLE, RIO ARRIBA COUNTY, NEW MEXICO

[Report includes 12 plates]

by

Dames & Moore

CONTENTS

CONTENTS

PLATES

TABLES

SOUTHWEST QUARTER OF THE LLAVES 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 Llaves 15-minute 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 southwest quarter of the Llaves 15-minute quadrangle is located in southwestern Rio Arriba County, 2 miles (3 km) north of Sandoval County, New Mexico. The area is approximately 77 miles (124 km) southeast of Farmington and 87 miles (140 km) north of Albuquerque, New Mexico. Part of the Jicarilla Apache Indian Reservation is located in the extreme southwestern part of the quadrangle area.

Accessibility

The southwest quarter of the Llaves 15-minute quadrangle is accessible by New Mexico State Route 112 which crosses the southeastern part of the area. Light-duty roads extending from State Route 112 provide access to other areas of the quadrangle. The Atchison, Topeka, and Santa Fe Railway operates an east-west route 87 miles (140 km) southeast of the area at Albuquerque, New Mexico.

Physiography

This quadrangle is located in the east-central portion of the Central Basin area (Kelley, 1950) of the San Juan Basin. Elevations in the study area range from 7,921 ft (2,414 m) in the Yequas Mesas area in the north to 7,037 ft (2,145 m) in Arroyo Blanco in the southeast. Three physiographic divisions of Baltz (1967) are represented within the quadrangle boundaries. In the north-central part of the area is the Yequas Mesas division which is characterized by steep-walled canyons separating high, narrow mesas. The Tapicitos Plateau division encompasses the remaining portion of the quadrangle with the exception of the southeastern corner. This area of the quadrangle is a highly dissected plateau. In the southeastern corner of the area is the Northern Hogback Belt which is characterized by resistant hogbacks and intervening alluvial valleys which are parallel to the hogback ridges. The Nacimiento Monocline trends in a general north-south direction across the eastern part of the area, and the Continental Divide crosses the west-central part of the area from north to south.

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 0°F (-18°C) to over 100° (38°C) in the basin. Snowfall occurs from November to April with an average of 18 inches (46 cm) in the southern part of the basin.

Land Status

Approximately 31 percent of the quadrangle is in the central part of the isolated portion of the San Juan Basin Known Recoverable Coal Resource Area located to the east of the main KRCRA area. The Federal Government owns the coal rights to approximately 96 percent of the KRCRA land within 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

Baltz (1967) mapped the surficial geology of the quadrangle on a scale of 1:63,360. 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.

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 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 in the basin then ceased. Structural deformation related to the Nacimiento uplift subsequently warped the strata in a long, narrow belt along the Nacimiento Fault. Tectonic activity then subsided, 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, undivided Fruitland Formation and 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) in thickness. 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 light brown to gray 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 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 are common. Due to an indistinct upper contact the Fruitland Formation and the overlying Kirtland Shale are not divided. Together they average 110 ft (34 m) thick in this quadrangle and consist primarily of dark gray to olive gray, carbonaceous to noncarbonaceous shale, interbedded white to brown sandstone, and lenticular coal beds.

The Paleocene Ojo Alamo Sandstone, which unconformably overlies the undivided Fruitland Formation and Kirtland Shale, is a buff to light brown sandstone with conglomeratic lenses and interbedded gray to olive-gray shale. It averages 90 ft (27 m) in thickness in the area.

Approximately 1,000 ft (305 m) of the Paleocene Nacimiento Formation overlie the Ojo Alamo Sandstone. Nacimiento Formation rocks consist of gray to olive-gray shale and buff to tan, locally conglomeratic sandstone.

The San Jose Formation of Eocene age unconformably overlies the Nacimiento Formation. It consists of red to brown to variegated shale, buff to tan to red, locally conglomeratic sandstone, and red to brown siltstone. Baltz (1967) mapped the individual members of the San Jose Formation, but for the purposes of this report it was not necessary to distinguish between them.

Surface exposures within the quadrangle are greatly influenced by the Nacimiento Monocline which trends across the southeastern corner of the area. Due to the steep dips along the monocline, great thicknesses of the Upper Cretaceous and Tertiary formations are exposed over a relatively short distance. These exposures include the sequence from the Mesaverde Group through the San Jose Formation. In the extreme southeastern corner of the area, Baltz (1967) mapped a series of rocks which underlie the Mesaverde Group and designated them as Cretaceous and older sedimentary, igneous and metamorphic rocks. The Menefee Formation of the Mesaverde Group is a prominent coal-bearing formation in other parts of the San Juan Basin; however, published data indicate that no Menefee coal beds crop out in this area. Also, drill hole data indicate the absence of Menefee coals with less than 3,000 ft (914 m) of overburden (the study limit). For this reason, the oldest formation shown in the lithologic column on CRO (Plate 3) is the Pictured Cliffs Sandstone.

Structure

The southwest quarter of the Llaves 15-minute quadrangle is located in the Central Basin area (Kelley, 1950) of the major structural depression known as the San Juan Basin. The axis of the basin is west of the quadrangle and trends north and northwest in an arcuate pattern across the northern portion of the Central Basin area (Baltz, 1967).

The structure in this part of the basin is dominated by the generally north-south-trending Nacimiento Monocline. Dips along the monocline are in a westerly direction and range from 8° to 65°, decreasing westward (Baltz, 1967). This structure bends sharply to the southwest in the southeast corner of the quadrangle. Several tightly folded anticlines and synclines trend perpendicular (northwest-southeast) to the monocline and plunge northwest or southeast in this area. West of these structures the dips in the quadrangle decrease to 1°.

COAL GEOLOGY

Two coal beds (Fruitland 1, Fruitland 2) are identified and mapped in the subsurface of this quadrangle. The Fruitland 1 (Fr 1) coal bed is defined as the lowermost coal of the Fruitland Formation; it lies directly above the Pictured Cliffs Sandstone. Above the Fruitland 1 is the Fruitland 2 (Fr 2) coal bed; the two coal beds are separated by a rock interval averaging 8.5 ft (2.6 m) (CRO Plate 1). Although these coal beds are correlated and mapped as consistent horizons, they may each, in fact, be several different coal beds that are lithostratigraphically equivalent, but not laterally continuous.

Fruitland Formation coal beds in the southeastern portion 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 a calorific value of 14,545 Btu's per pound (33,832 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" analysis indicates a moisture content of 2.1 percent, an ash content of 22.5 percent, a sulfur content of less than one percent, and a heating value of 10,990 Btu's per pound (25,563 kj/kg). An analysis of a Fruitland Formation coal is given in Table 1 (Fassett and Hinds, 1971).

Fruitland 1 Coal Bed

The Fruitland 1 coal bed, informally named by the authors, represents the lowermost coal bed of the Fruitland Formation which occurs directly above the Pictured Cliffs Sandstone. The coal bed has only been mapped in areas of less than 3,000 ft (914 m) of overburden.

As illustrated by the structure contour map (CRO Plate 5), the coal bed dips approximately 1° to 11° in a westerly direction. Consequently, overburden (CRO Plate 6) varies substantially, ranging from less than 2,000 ft (610 m) at the eastern edge to greater than 3,000 ft (914 m) in the central portion of the quadrangle. As shown by the isopach map (CRO Plate 4), the Fruitland 1 coal bed attains a maximum thickness of greater than 10 ft (3.0 m) in the northwestern portion of the map. However, the coal bed decreases in thickness to the north, east, and south, and is absent in the southeastern portion 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			Approx. Depth Interval of Sample (ft.)	Form of Analysis	Proximate, percent					Heating Value (Btu)	Remarks
		Section	T.N.	R.W.			Moisture	Volatile matter	Fixed Carbon	Ash	Sulfur		
H-32405	El Paso Nat. Gas Lindrith No. 42	NE¼ 22	24	3	3,194-3,205	A	2.1	38.7	36.7	22.5	.7	10,990	
						B	----	39.5	37.5	23.0	.7	11,230	
						C	----	51.3	48.7	----	1.0	14,580	

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 Analysis of the Fruitland 1 Coal Bed - An analysis of a Fruitland Formation coal bed from the area surrounding this quadrangle is given in Table 1 (Fassett and Hinds, 1971). No other published analyses are known to be available, and this analysis is assumed to be similar to that of the coal in this quadrangle.

Fruitland 2 Coal Bed

The Fruitland 2 coal bed, informally named by the authors, is an average of 8.5 ft (2.6 m) above the Fruitland 1 coal bed (when present). The coal bed has been mapped only in areas of less than 3,000 ft (914 m) of overburden.

As illustrated by the structure contour map (CRO Plate 9), the coal bed dips approximately 1° to 11° in a westerly direction. Consequently, overburden (CRO Plate 10) varies from less than 2,400 ft (731 m) at the eastern edge to greater than 3,000 ft (914 m) at the central part of the quadrangle. The isopach map (CRO Plate 8) indicates the greatest thickness of the coal bed occurring in the northwestern part of the map where the coal is greater than 5 ft (1.5 m) thick. The thickness decreases to the north, east, and south, and is absent along the eastern and southeastern edges of the quadrangle.

Chemical Analysis of the Fruitland 2 Coal Bed - No analyses of Fruitland Formation coals are known to be available for this quadrangle. However, an analysis from the surrounding area is assumed to be similar to that for the coal of this quadrangle. An analysis of a Fruitland coal is 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 Llaves 15-minute quadrangle are more than 2,300 ft (701 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 2 coal beds for the determination of coal resources in this quadrangle.

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.

Reserve Base and Reserve values for measured, indicated, and inferred categories of coal for the Fruitland 1 and Fruitland 2 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 63.8 million short tons (57.9 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 Llaves 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 (350-610 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 southwest quarter of the Llaves 15-minute quadrangle occur more than 1,100 ft (335 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 SOUTHWEST QUARTER OF THE LLAVES 15-MINUTE 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 2	--	--	4,670,000	4,670,000
Fruitland 1	--	--	59,160,000	59,160,000
TOTAL	--	--	63,830,000	63,830,000

Development Potential for Subsurface Mining Methods

Underground coal of the Fruitland 1 coal bed has low development potential in the north-central and central parts of the quadrangle (CDP Plate 12) where the coal bed thickness ranges from 5 to 11 ft (1.5-3.4 m) (CRO Plate 4), and the overburden in these areas ranges from approximately 2,600 ft (792 m) to 3,000 ft (914 m) (CRO Plate 6). The Fruitland 2 coal bed has low development potential in small areas to the northwest and south of the non-Federal coal land. Thickness of the Fruitland 2 in these areas is 5 to 6 ft (1.5-1.8 m) (CRO Plate 8) and the overburden ranges from approximately 2,700 ft (823 m) to 3,000 ft (914 m) (CRO Plate 10). The north-central and south-central parts of the quadrangle have unknown development potential. In the north the coal beds are outside the 3,000 ft (914 m) overburden study limit, and in the south they are less than the reserve base thickness of 5 ft (1.5 m). The extreme south-central part of the quadrangle has no Fruitland 1 or Fruitland 2 coal and, thus, has no coal development potential.

REFERENCES

American Soc. for Testing and Materials, 1977, Gaseous fuels; coal and coke; atmospheric analysis, _in_ Annual book of ASTM standards, part 26: p. 214-218.

Baltz, E.H., Jr., 1967, Stratigraphy and regional tectonic implications of part of Upper Cretaceous and Tertiary rocks, east-central San Juan Basin, New Mexico: U.S. Geol. Survey Prof. Paper 552, p. 12.

El Paso Natural Gas Co., Well log library, Farmington, New Mexico.

Fassett, J.E., and Hinds, J.S., 1971, Geology and fuel resources of the Fruitland Formation and Kirtland Shale of the San Juan Basin, New Mexico and Colorado: U.S. Geol. Survey Prof. Paper 676, 76 p.

Kelley, V.C., 1950, Regional structure of the San Juan Basin _in_ New Mexico Geol. Soc. Guidebook of the San Juan Basin, New Mexico and Colorado, 1st Field Conf., p. 102.

U.S. Bureau of Mines and U.S. Geological Survey, 1976, Coal resource classification system of the U.S. Bureau of Mines and U.S. Geological Survey: U.S. Geol. Survey Bull. 1450-B, 7 p.