Text to accompany:

Open-File Report 79-1112

1979

COAL RESOURCE OCCURRENCE MAPS AND COAL DEVELOPMENT POTENTIAL MAPS OF THE NORTHWEST QUARTER OF THE AZTEC 15-MINUTE QUADRANGLE, SAN JUAN COUNTY, NEW MEXICO

[Report includes 19 plates]

by

Dames & Moore

This report has not been edited for conformity with U.S. Geological Survey editorial standards or stratigraphic nomenclature.

CONTENTS

CONTENTS

PLATES

CONTENTS

TABLES

NORTHWEST QUARTER OF THE AZTEC 15-MINUTE QUADRANGLE

INTRODUCTION

Purpose

This text to be used in conjunction with the Coal Resource Occurrence (CRO) Maps and Coal Development Potential (CDP) Map of the northwest quarter of the Aztec 15-minute 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 northwest quarter of the Aztec 15-minute quadrangle is located in northeast San Juan County, New Mexico, immediately south of the Colorado border. The area is approximately 19 miles (31 km) northeast of Farmington, New Mexico.

Accessibility

The northwest quarter of the Aztec 15-minute quadrangle is accessible by New Mexico State Route 550 which extends across the area. Light-duty roads provide access to other parts of the quadrangle. The Atchison, Topeka, and Santa Fe Railway operates a route approximately 111 miles (179 km) south of the area at Gallup, New Mexico.

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 5,680 ft (1,731 m) in the Animas River Valley to 6,860 ft (2,091 m) in the northeast. The Animas River flows from northeast to southwest across the southeastern corner of the area. Low hills, which are characteristic of the topography in the north, slope gently toward the steep-walled canyons, which are characteristic of 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 over 100°F (38°C) in the basin. Snowfall may occur from November to April.

Land Status

Approximately 53 percent of the quadrangle is in the northern portion of the San Juan Basin Known Recoverable Coal Resource Area. The Federal Government owns the coal rights for approximately 72 percent of the KRCRA land in 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 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 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 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 northeast of the area 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 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 relationships of these formations and is accompanied by lithologic descriptions of the individual formations.

The Pictured Cliffs Sandstone averages 170 ft (52 m) in thickness. Because the unit is present 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 cream, micaceous, kaolinitic sandstone, with interbedded gray, platy shale. 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 435 ft (133 m) in this quadrangle. Many authors have utilized 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 consists primarily of gray, carbonaceous shale with plant fossils, interbedded cream sandstone, interbedded gray siltstone, and lenticular coal beds.

The Upper Cretaceous Kirtland Shale conformably overlies the Fruitland Formation and averages 870 ft (265 m) in thickness in this area. It consists predominantly of freshwater, green to gray, locally sandy shale with plant fossils, interbedded white to cream sandstone, and interbedded green to gray siltstone. 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 125-ft (38-m) thick, cream, very coarse-grained to conglomeratic sandstone with interbedded shale.

Approximately 1,210 ft (369 m) of the Paleocene Nacimiento Formation overlie the Ojo Alamo Sandstone. These rocks are exposed in the southern two-thirds of the quadrangle where they consist of light gray to black, locally sandy shale, interbedded buff to gray, locally conglomeratic sandstone, and interbedded gray siltstone.

The San Jose Formation of Eocene age unconformably overlies the Nacimiento Formation and crops out in the northern third of the quadrangle area. It consists of buff to gray, fine- to coarse-grained, locally conglomeratic, arkosic sandstone, interbedded gray shale, and lithologies gradational between them.

Structure

The northwest quarter of the Aztec 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 extends east-west through 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

Four coal beds (Fruitland 1, Fruitland 2, Fruitland 3, Fruitland 4) 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. The Fruitland 2 (Fr 2) coal bed is above the Fruitland 1 separated by a rock interval of 29 to 63 ft (8.8-19.2 m); the Fruitland 3 (Fr 3) coal bed is above the Fruitland 2 separated by a rock interval of 41 to 62 ft (12.5-18.9 m); the Fruitland 4 (Fr 4) coal bed is above the Fruitland 3 separated by a rock interval of 94 ft (28.7 m). 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 discontinuous, noncorrelative, and less than reserve base thickness (5 ft [1.5 m]); an exception is a 6-ft (1.8-m) coal in drill hole 20 (CRO Plate 3). Due to these characteristics, derivative maps were not constructed.

Fruitland Formation coals in the northern part of the San Juan Basin are considered high volatile A bituminous in rank. The rank has been determined on a moist, mineral-matter-free basis with calorific values averaging 15,412 Btu's per pound (35,848 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 1.3 to 2.3 percent, ash content ranging from 11.0 to 29.2 percent, sulfur content less than one percent, and heating values on the order of 10,690 to 13,350 Btu's per pound (24,865-31,052 kj/kg). Analyses of several Fruitland Formation coals are given in Table 1 (Bauer and Reeside, 1921; 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 indicated by the structure contour map (CRO Plate 5) the coal bed dips less than 1° to the east-northeast. As a result of topography and dip, overburden (CRO Plate 6) varies from less than 2,400 ft (732 m) in the southwest within the Animas

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-50012	Delhi-Taylor Barrett No. 1	SW¼ 20	31	9	3,230-3,255	A	1.3	33.7	49.2	15.8	0.7	12,830	
						B	---	34.1	49.9	16.0	0.7	13,000	
						C	---	40.6	59.4	----	0.9	15,470	
H-15777	El Paso Nat. Gas Case No. 9	SW¼ 8	31	11	2,710-2,740	A	1.7	40.3	47.0	11.0	0.7	13,350	
						B	---	41.0	47.9	11.1	0.7	13,580	
						C	---	46.1	53.9	----	0.8	15,280	
H-46452	Atlantic Refn. Southern Ute 32-10 No. 15-1	NE¼ 15	32	10	2,825-2,890	A	2.3	23.6	54.6	19.5	0.7	12,070	
						B	---	24.2	55.9	19.9	0.7	12,360	
						C	---	30.2	69.8	----	0.9	15,440	
H-55381	Delhi-Taylor Wickens No. 1	NE¼ 24	32	10	3,370-3,400	A	1.5	24.4	44.9	29.2	0.7	10,690	
						B	---	24.8	45.5	29.7	0.7	10,860	
						C	---	35.3	64.7	----	1.0	15,440	

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.

River Valley, Tucker Canyon, and Bohanan Canyon to greater than 3,000 ft (914 m) on the mesas. The isopach map (CRO Plate 4) shows the coal bed thickness is greater than 20 ft (6.1 m) in the southwest and, in general, decreases in all directions.

Chemical Analyses of the Fruitland 1 Coal Bed - Analyses of several coals of the Fruitland Formation from the area surrounding this quadrangle 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). As indicated by the structure contour map (CRO Plate 9) the coal bed has a dip of less than 1° to the east-northeast. As a result of topography and dip, overburden (CRO Plate 10) varies from less than 2,200 ft (671 m) in the southwest within the Animas River Valley, to greater than 3,000 ft (914 m) on the mesas. The isopach map (CRO Plate 8) shows the coal bed is greater than 5 ft (1.5 m) thick in three small areas near the center of the quadrangle. The coal thins in all directions and is absent in the south and east-central portions of the quadrangle.

Chemical Analyses of the Fruitland 2 Coal Bed - Analyses of several coals of the Fruitland Formation from the area surrounding this quadrangle 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). As indicated by the structure contour map (CRO Plate 13) the coal bed dips less than 1° to the east-northeast. As a result of topography and dip, overburden (CRO Plate 14) varies from less than 2,300 ft (701 m) in the southwest within the Animas River Valley to greater than 3,000 ft (914 m) on the mesas. The isopach map (CRO Plate 12) shows the coal bed has a thickness of greater than 10 ft (3.0 m) in the southeast. The thickness decreases from this area, and the coal is absent in the vicinity of the Animas River and in a small area in the west.

Chemical Analyses of the Fruitland 3 Coal Bed - Analyses of several coals of the Fruitland Formation from the area surrounding this quadrangle are given in Table 1 (Fassett and Hinds, 1971).

Fruitland 4 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 indicated by the structure contour map (CRO Plate 16) the coal bed dips less than 1° to the east-northeast. As a result of topography and dip, overburden (CRO Plate 17) varies from less than 2,200 ft (671 m) in the southwest within the Animas River Valley to greater than 3,000 ft (914 m) on the mesas. The isopach map (CRO Plate 15) shows the coal bed has a thickness of greater than

10 ft (3.0 m) in the southeast. The coal bed thickness decreases in all directions from this area. The coal bed is present only in the southeast, west, and central portions of the quadrangle.

Chemical Analyses of the Fruitland 4 Coal Bed - Analyses of several coals of the Fruitland Formation from the area surrounding this quadrangle 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 northwest quarter of the Aztec 15-minute quadrangle are more than 200 ft (61 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, Fruitland 3, 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, 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 18) 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, 12, and 15) and areal distribution maps (CRO Plates 7, 11, and 18) for each 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, Fruitland 3, and Fruitland 4 beds are shown on CRO Plates 7, 11, and 18, 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 267 million short tons (242 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 northwest quarter of the Aztec 15-minute quadrangle has development potential for subsurface mining methods only (CDP Plate 19).

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, Fruitland 3, and Fruitland 4 coal beds.

Development Potential for Surface Mining Methods

All coals studied in the northwest quarter of the Aztec 15-minute quadrangle occur more than 200 ft (61 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 bed has low development potential in most of the quadrangle area within the KRCRA boundary with the exception of the southeast corner (CDP Plate 19). Coal bed thickness of the Fruitland 1 varies from 5 to 22 ft (1.5-6.7 m) (CRO Plate 4), and the overburden thickness increases from approximately 2,400 ft (732 m) in the southwest to 3,000 ft (914 m) to the north (CRO Plate 6). Coal of the Fruitland 2, Fruitland 3, and Fruitland 4 beds has low development potential in isolated areas in the northwest (Fruitland 2 and Fruitland 3, shown on CRO Plate 11) and southeast (Fruitland 3 and Fruitland 4, shown on CRO Plates 11 and 18, respectively) of the KRCRA. The Fruitland 2 is approximately 5 ft (1.5 m) thick (CRO Plate 8), and the Fruitland 3 and Fruitland 4 are each 5

TABLE 2

COAL RESOURCE DATA FOR UNDERGROUND MINING METHODS FOR FEDERAL COAL LANDS (in short tons) IN THE NORTHWEST QUARTER OF THE AZTEC 15-MINUTE 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 4	--	--	16,580,000	16,580,000
Fruitland 3	--	--	12,420,000	12,420,000
Fruitland 2	--	--	2,400,000	2,400,000
Fruitland 1	--	--	235,410,000	235,410,000
TOTAL	--	--	266,810,000	266,810,000

to 10 ft (1.5-3.0 m) thick (CRO Plates 12 and 15). Overburden thicknesses range from 2,600 ft (792-853 m) for the Fruitland 2 and Fruitland 3 (CRO Plates 10 and 14) and approximately 2,400 to 2,750 ft (732-838 m) for the Fruitland 4 (CRO Plate 17).

The remainder of the Federal land within the KRCRA has unknown development potential and includes areas where the individual coal beds are less than 5 ft (1.5 m) thick and areas outside the 3,000-foot (914-m) overburden study limit. Unpatterned areas (CDP Plate 19) are outside the KRCRA.

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.

Bauer, C.M., and Reeside, J.B., Jr., 1921, Coal in the middle and eastern parts of San Juan County, New Mexico: U.S. Geol. Survey Bull. 716-G, p. 177-178.

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.

Reeside, J.B., Jr., 1924, Upper Cretaceous and Tertiary formations of the western part of the San Juan Basin of Colorado and New Mexico: U.S. Geol. Survey Prof. Paper 134, p. 1-70.

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.

U.S. Department of the Interior, 1950, Map of portion of San Juan County, New Mexico and of La Plata County, Colorado: U.S. Geol. Survey Oil and Gas Operations Map Roswell 91, revised 1972, 1:31,680.