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

[Report includes 16 plates]

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SANTOS PEAK 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 Santos Peak 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 Santos Peak 7 1/2-minute quadrangle is located in west-central Rio Arriba County, New Mexico. The northwest corner boundary of the Jicarilla Apache Indian Reservation is in the southeast quarter. The area is approximately 42 miles (68 km) southeast of Farmington and 110 miles (177 km) northwest of Albuquerque.

Accessibility

The area is accessible by a light-duty road originating from New Mexico State Route 17, 2 miles (3.2 km) west of Gobernador, and extending 5 miles (8 km) south into the area. Numerous other light-duty and unimproved dirt roads provide access to the more remote areas. The nearest railway transportation is the Atchison, Topeka, and Santa Fe Railway, which is approximately 100 miles (107 km) to the southwest at Gallup, New Mexico, and connects Gallup with Grants and Albuquerque to the east.

Physiography

This quadrangle is in the central portion of the Central Basin area (Kelley, 1950) of the structural depression known as the San Juan Basin. Total relief in the area is moderate, ranging from 6,160 ft (1,878 m) in Cereza Canyon to 7,022 ft (2,141 m) on BS Mesa.

Climate

The climate of the San Juan Basin is arid to semi-arid. Annual precipitation is usually less than 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 southwestern part of the basin.

Land Status

Approximately 11 percent of the quadrangle lies within the northeastern boundary of the San Juan Basin Known Recoverable Coal Resource Area, and the Federal Government owns the coal rights for approximately 82 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

Fassett and Hinds (1971) have 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, lay 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 accumulated organic matter which became coals of the Fruitland Formation. Deposition of organic material was influenced by the strandline as shown by the continuity of the coal beds parallel to the north-south strandline and discontinuity perpendicular to it to the east. The less continuous Fruitland coals appear to be noncorrelative, but are lithostratigraphically 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 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: 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 90 ft (27 m) in thickness in the 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 reported thickness are common due to an indistinct upper contact, but the average is about 240 ft (73 m) in this quadrangle. Many authors have used various criteria to establish the upper Fruitland Formation boundary, but for this study the uppermost coal was generally chosen as the contact (after Fassett and Hinds, 1971). The formation primarily consists of gray, carbonaceous shale; interbedded gray-green, micaceous siltstone and sandstone; and lenticular coal beds.

The Upper Cretaceous Kirtland Shale conformably overlies the Fruitland Formation and averages 270 ft (82 m) in thickness in this area. It is predominantly freshwater, purple to gray-green shale and interbedded gray-green, micaceous siltstone with plant fossils. The Kirtland Shale 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, which unconformably overlies the Kirtland Shale, is a cream to light gray, kaolinitic, locally conglomeratic sandstone with interbedded gray siltstone and shale. It averages 170 ft (52 m) in thickness in this 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, micaceous, friable, 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 most of the quadrangle area. It consists of white to cream to light gray, kaolinitic, slightly calcareous, locally conglomeratic sandstone with traces of pyrite; interbedded gray-green shale; and interbedded tan to gray, micaceous siltstone.

Structure

The Santos Peak quadrangle is located in the Central Basin area (Kelley, 1950) of the major structural depression, the San Juan Basin. The axis of the basin lies about 7 miles (11 km) to the northeast of the quadrangle area and trends in an arcuate pattern across the northern portion of the Central Basin (Baltz, 1967). Regional dip within the quadrangle is approximately 1° to 2° to the northeast.

COAL GEOLOGY

Three coal beds (Fruitland 1, 2, and 3) and a coal zone (Fruitland) were identified in the subsurface of this quadrangle (CRO Plate 1). The Fruitland 1 (Fr 1) coal bed is herein defined as the lowermost coal of the Fruitland Formation; it generally lies directly above the Pictured Cliffs Sandstone. Above the Fruitland 1, separated by a rock interval varying from 14 to 55 ft (4.3-16.8 m), is the Fruitland 2 (Fr 2) coal bed. The Fruitland 3 (Fr 3) coal bed is above the Fruitland 2, separated by a rock interval of 3 to 15 ft (0.9-4.6 m).

Although the Fruitland 1, 2, and 3 coal beds, informally named by the authors, are correlated as consistent horizons, they may, in fact, be several different beds that are lithostratigraphically equivalent but not laterally continuous.

Above the Fruitland 3 coal bed is the Fruitland coal zone (Fr zone) which extends from the top of the Fruitland Formation to the base of the lowermost coal designated on CRO Plate 3 as a Fruitland zone coal bed. The zone consists of several coal beds which are generally noncorrelative and less than 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 (Bauer and Reeside, 1921; Dane, 1936). 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 (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 coal bed has been mapped only in areas of less than 3,000 feet (914 m) of overburden (study limit).

As illustrated by the structure contour map (CRO Plate 5), the coal bed dips approximately 1° to the northeast. Consequently, overburden (CRO Plate 6) increases from less than 2,800 ft (853 m) in the southwest portion of the quadrangle to greater than 3,000 ft (194 m) to the north. The isopach

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

map (CRO Plate 4) indicates the greatest thickness of the coal bed occurs in a small part of the southwestern corner of the quadrangle. In this area the coal is over 15 ft (4.6 m) in thickness. The thickness decreases to the north, south, and east. The coal bed is absent at the eastern portion of the map.

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, informally named by the authors, occurs 14 to 55 ft (4.3-16.8 m) above the Fruitland 1. The coal bed has been mapped only in areas of 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 approximately 1° to the northeast. Consequently, overburden (CRO Plate 10) increases from less than 2,800 ft (853 m) in the southwest portion of the quadrangle to greater than 3,000 ft (914 m) to the north. The isopach map (CRO Plate 8) shows the coal bed is greater than 15 ft (4.6 m) in thickness in the northeast part of the map. The coal decreases in thickness to the east, south, and west. The coal bed is absent in part of the quadrangle along the west side.

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 3 Coal Bed

The Fruitland 3 coal bed, informally named by the authors, is above the Fruitland 2. The 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 approximately 1° to the northeast. Consequently, overburden (CRO Plate 14) increases from less than 2,800 ft (853 m) along the western edge of the quadrangle to greater than 3,000 ft (914 m) to the north and east. The isoach map (CRO Plate 12) shows the coal bed is greater than 10 ft (3.0 m) in thickness across the central portion of the map, extending from the northwest to the southeast. The coal thickness decreases to less than 5 ft (1.5 m) in the southwest.

Chemical Analyses of the Fruitland 3 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 Santos Peak quadrangle lie more than 2,600 ft (792 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 3 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 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. 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, and Fruitland 3 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 44.5 million short tons (40.3 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 Santos Peak 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 (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, and Fruitland 3 coal beds.

Development Potential for Surface Mining Methods

All coals studied in the Santos Peak quadrangle occur more than 2,600 ft (792 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 SANTOS PEAK 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 3	--	--	960,000	960,000
Fruitland 2	--	--	7,990,000	7,990,000
Fruitland 1	--	--	35,550,000	35,550,000
TOTAL	--	--	44,500,000	44,500,000

Development Potential for Subsurface Mining Methods

Underground coal of the Fruitland 1, Fruitland 2, and Fruitland 3 coal beds has low development potential in the southwest corner of the quadrangle (CDP Plate 16). The Fruitland 1 has development potential over most of the low potential area where the coal bed thickness varies from 5 to 15 ft (1.5-4.6 m) (CRO Plate 4) and the overburden ranges from 2,800 to 3,000 ft (853-914 m) (CRO Plate 6). Coal of the Fruitland 2 has development potential at the eastern edge of the low potential area. The coal bed thickness varies from 5 to 11 ft (1.5-3.3 m) (CRO Plate 8) and the overburden is 2,900 to 3,000 ft (883-914 m) thick (CRO Plate 10). The Fruitland 3 coal bed has development potential at the northern edge of the low potential area where the coal bed is 5 ft (1.5 m) thick (CRO Plate 12) and the overburden varies in thickness from 2,900 to 3,000 ft (883-914 m) (CRO Plate 14.)

The remainder of the area within the KRCRA has unknown coal development potential and includes areas with coal bed thickness less than 5 ft (1.5 m) and areas outside the 3,000-foot (914-m) overburden study limit.

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.

Dane, C.H., 1936, The La Ventana - Chacra Mesa coal field, pt. 3 of Geology and fuel resources of the southern part of the San Juan Basin, New Mexico: U.S. Geol. Survey Bull. 860-C, p. 137-138, [1937].

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.

U.S. Department of the Interior, 1951, Map of a portion of Rio Arriba County, New Mexico: U.S. Geol. Survey Oil and Gas Operations Map Roswell 67, revised 1974, 1:31,680.

________, 1953, Map of a portion of Rio Arriba County, New Mexico: U.S. Geol. Survey Oil and Gas Operations Map Roswell 62, revised 1972, 1:31,680.