UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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1985

FEDERAL COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE SAN LUIS 7 1/2-MINUTE QUADRANGLE, SANDOVAL COUNTY, NEW MEXICO

[Report includes 24 plates]

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SAN LUIS QUADRANGLE
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INTRODUCTION

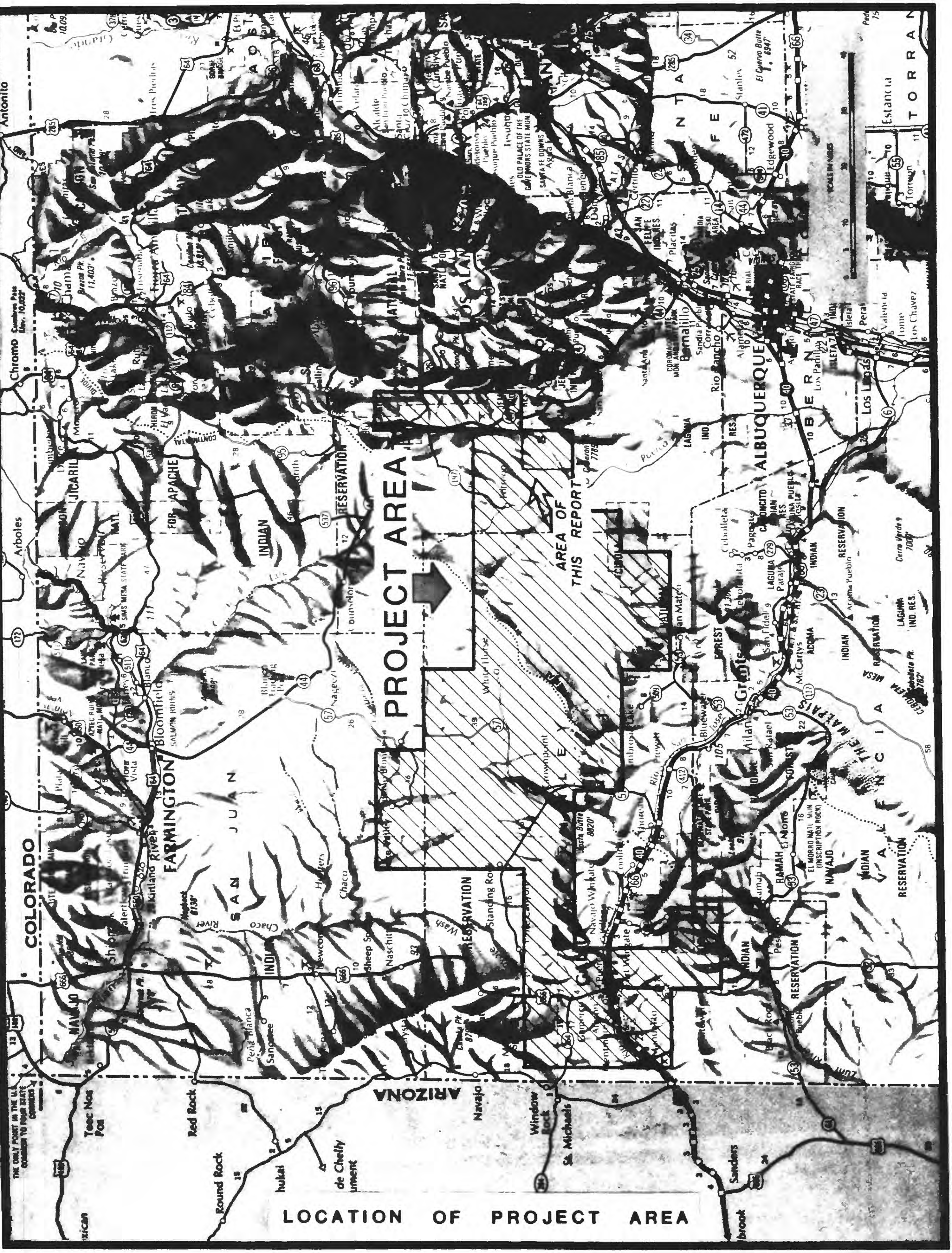
Purpose

This text complements the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) maps of the San Luis 7½ minute quadrangle, Sandoval County, New Mexico. These maps and report are part of an evaluation of a fifty-six 7½ minute quadrangles in northwestern New Mexico, which were completed under U. S. Geological Survey Contract No. 14-0001-17459 (see figs. 1 and 2).

The purpose of this Coal Resource Occurrence-Coal Development Potential program, which was conceived by Congress as part of its Federal Coal Leasing Amendments Act of 1976, is to obtain coal resource information and to determine the geographical extent of Federal coal deposits. In addition, the program is intended to provide information on the amount of coal recoverable by various mining methods and to serve as a guide for land-use planning.

The U. S. Geological Survey initiated the program by identifying areas underlain by coal resources. These areas were designated Known Recoverable Coal Resource Areas based on the presence of minable coal thicknesses, adequate areal extent of these coal deposits, and the potential for developing commercial quantities of coal at minable depths.

This report is limited to coal resources which are 3,000 feet (914 m) or less below ground surface. Published and unpublished public information was used as the data base for this study. No new drilling or field mapping was performed as part of this study, nor were any confidential data used.

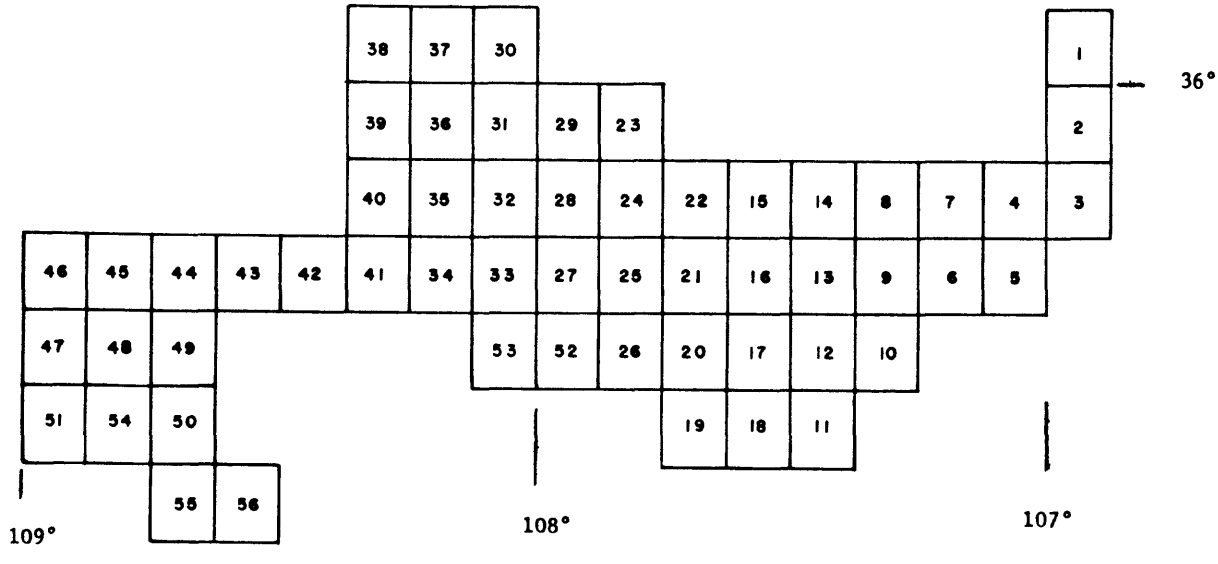


LOCATION OF PROJECT AREA

FIGURE 1

FIGURE 2.--Index to USGS 7 1/2-minute quadrangles and coal resource occurrence/ coal development potential maps for the southern San Juan Basin area, New Mexico

Map No.	Quadrangle	Open-file report	Map No.	Quadrangle	Open-file report
1	Cuba	79- 623	31	Nose Rock	79- 641
2	San Pablo	79- 624	32	Becenti Lake	79-1124
3	La Ventana	79-1038	33	Heart Rock	79- 642
4	Headcut Reservoir	79-1043	34	Crownpoint	79-1125
5	San Luis	79-1044	35	Antelope Lookout Mesa	79-1376
6	Arroyo Empedrado	79-1045	36	Milk Lake	79-1377
7	Wolf Stand	79-1046	37	La Vida Mission	79-1378
8	Tinian	79- 625	38	The Pillar 3 SE	79-1379
9	Canada Calladita	79- 626	39	Red Lake Well	79-1380
10	Cerro Parido	79- 627	40	Standing Rock	79-1381
11	El Dado Mesa	79- 628	41	Dalton Pass	80- 026
12	Mesa Cortada	79- 629	42	Oak Spring	80- 027
13	Mesita del Gavilan	79- 630	43	Hard Ground Flats	80- 028
14	Rincon Marquez	79- 631	44	Big Rock Hill	80- 029
15	Whitehorse Rincon	79- 632	45	Twin Lakes	80- 030
16	Mesita Americana	79- 633	46	Tse Bonita School	80- 031
17	El Dado	79- 634	47	Samson Lake	80- 032
18	Cerro Alesna	79- 635	48	Gallup West	80- 033
19	San Lucas Dam	79- 636	49	Gallup East	80- 034
20	Piedra de la Aguila	79-1039	50	Bread Springs	80- 035
21	Hospah	79- 637	51	Manuelito	80- 036
22	Whitehorse	79-1040	52	Borrego Pass	80- 037
23	Seven Lakes NE	79- 638	53	Casamero Lake	80- 038
24	Kin Nahzin Ruins	79- 639	54	Twin Buttes	80- 039
25	Orphan Annie Rock	79-1041	55	Pinehaven	80- 040
26	Mesa de los Toros	79-1122	56	Upper Nutria	80- 041
27	Laguna Castillo	79- 640			
28	Seven Lakes	79-1042			
29	Seven Lakes NW	79-1123			
30	Kin Klizhin Ruins	79-1047			



Location

The San Luis 7½ minute quadrangle includes acreage in Tps. 16, 17 and 18 N., Rs. 2 and 3 W. of the New Mexico Principal Meridian, Sandoval County, northwestern New Mexico (see figs. 1 and 2). The towns of San Luis and Cabezon are in the southwestern and central parts, respectively, of the quadrangle.

Accessibility

No paved roads pass through the San Luis quadrangle. A light-duty maintained road provides access to State Highway 44, 3.9 mi (6.3 km) east of the quadrangle. Unimproved dirt roads and jeep trails traverse most parts of the area. The Atchison, Topeka, and Santa Fe Railroad line passes about 33 mi (53 km) SE. of the quadrangle (see fig 1). An abandoned railroad line which served coal mines in the La Ventana area in the 1920's and 1930's is within 1 mi (1.6 km) east of the San Luis quadrangle.

Physiography

The San Luis quadrangle is in the Navajo section of the southernmost part of the Colorado Plateau physiographic province (U. S. Geological Survey, 1965). The topography of the quadrangle is characterized by mesas dissected by numerous arroyos and alluvial valley floors. San Luis Mesa is a prominent mesa in the central-northwestern part of the quadrangle.

No perennial streams are present in the quadrangle. Local drainage is provided by the Rio Puerco and its tributaries. Elevations within the quadrangle range from 6,020 ft (1,835 m) in the southeast corner to 6,986 ft (2,129 m) on Cerro Colorado along the northern quadrangle boundary.

Climate

The climate of this area is semiarid to arid. The following temperature and precipitation data were reported by the National Oceanic and Atmospheric Administration for the Torreon Navajo Mission Station. The San Luis quadrangle is about 7 mi (11 km) southeast of the Torreon Navajo Mission Station. Average total annual precipitation for thirteen of the previous fifteen years is 9.94 in. (25.25 cm). Intense thunderstorms in July, August, and September account for the majority of precipitation. The area is susceptible to flash flooding associated with these thunderstorms. Mean annual temperature for eleven of the previous fifteeen years is 49.5° F (9.7° C). The average daily temperatures in January and July are 27.4° F (-2.6° C) and 72.7° F (22.6° C), respectively.

Land status

The Federal Government holds the coal mineral rights to approximately 85 percent of the San Luis quadrangle. For the specific coal ownership boundaries, see plate 2. It is not within the scope of this report to provide detailed land-surface ownership. About 18,000 acres (7,285 ha) in the northwestern part of the quadrangle are within the La Ventana Known Recoverable Coal Resource

Area. Much of the remainder of the quadrangle lies within the M & S Montoya Grant or the Ojo del Espiritu Santo Grant. As of October 26, 1978, there were no Federal coal leases, coal preference right lease applications or coal exploration licenses within the San Luis quadrangle.

GENERAL GEOLOGY

Previous work

Early reports on the area include that of Gardner (1910) who measured coal outcrops in the area. Hunt and Dane (1936) mapped coal outcrops of the Cleary Coal Member of the Menefee Formation on San Luis Mesa. Dane also reported an Allison Member coal bed in the northwestern part of the area. Shomaker, Beaumont, and Kottlowski (1971) estimated Cleary Coal Member reserves of 11.30 million short tons (10.25 million t) at depths of less than 150 ft (46 m) in T. 17 N., R. 2 W. About 90 percent of this township-range is within the San Luis quadrangle. Woodward and Clyde (1977) conducted a drilling program in the area and identified several Menefee Coals. They concluded that an area in secs. 9, 10 and 16, T. 17 N., R. 2 W. was favorable for surface mining. Tabet and Frost (1979) mapped the surface geology including coal outcrops and conducted exploration drilling in the area. Their study was completed after the compilation of these maps and should be consulted for additional coal data in this area.

Stratigraphy

Within the San Juan Basin, the shoreline position of the Cretaceous seaways changed innumerable times. The overall regional alignment of the

of the shorelines trended N. 60° W. - S. 60° E. (Sears, Hunt, and Hendricks, 1941). The transgressive and regressive shoreline migrations are evidenced by the intertonguing relationships of continental and marine facies. Rates of trough (geosynclinal) subsidence and the availability of sediment supplies are the major factors that controlled the transgressive-regressive shoreline sequences.

Exposed rock units in the San Luis quadrangle include some of the sedimentary units of Upper Cretaceous age. There is Quaternary alluvium and terrace gravels along the Rio Puerco in this area.

The "main body" of the Mancos Shale crops out in the southeastern part of the quadrangle and is the oldest exposed unit in this area. Light to dark gray, silty shale with interbedded brown calcareous sandstones comprise the lithologies of the Mancos Shale. Thickness of the unit is as much as 2,000 ft (610 m) in this area. In other areas of the San Juan Basin, the Gallup Sandstone and various members of the Crevasse Canyon Formation overlie the Mancos Shale. These units were not deposited in this area, and the Mancos Shale represents continued marine sedimentation.

The Hosta Tongue of the Point Lookout Sandstone was deposited over the Mancos Shale during a transgressive shoreline sequence, and consists of light gray to reddish-brown, fine to medium grained, massive sandstone with interbedded light gray shales. It formed in a nearshore environment and is about 30 ft (9 m) thick locally. As the transgression proceded, the Satan Tongue of the Mancos Shale formed from the marine sands, silts and muds. The Satan Tongue is composed of light to dark gray, silty shale with interbedded tan to buff sandstone, and is about 180 ft (55 m) thick locally.

The Point Lookout Sandstone overlies the Satan Tongue, and represents nearshore or littoral deposits which formed during the most extensive north-

eastward retreat prior to the final withdrawal of the Cretaceous seaways in the San Juan Basin (Sears, Hunt, and Hendricks, 1941). The Point Lookout Sandstone is composed of light gray to reddish-brown, fine to medium grained sandstone with interbedded shales and is 100 ft (30 m) thick locally. The continental sediments deposited inland from the beach area during deposition of the Point Lookout Sandstone compose the overlying Menefee Formation.

The Menefee Formation consists of dark gray to brown, carbonaceous to noncarbonaceous shales, light gray sandstones and coal beds, and is divisible into the basal Cleary Coal Member and upper Allison Member. A massive channel sandstone sequence, which crops out in the northern portion of this quadrangle, defines the boundary between the two members. The Allison Member was defined as the Allison Barren Member (Sears, 1925), as containing thin, noncommercial coal beds, although the Allison Member contains relatively thick coal beds in nearby area.

All of the identified coal beds in this quadrangle are within the Cleary Coal and Allison Members. The Cleary Coal Member is 380 ft (166 m) thick locally, while the partially eroded Allison Member is about 280 ft (85 m) thick in the area.

Depositional environments

The Cretaceous System sedimentary units in the quadrangle represent transgressive and regressive depositional conditions. There were innumerable minor cycles of widely varying duration and extent within the major sedimentary sequences. The paucity of data in this quadrangle and the intended scope of this report permit only general interpretations of the depositional environments.

The Cretaceous coal deposits of the San Juan Basin are products of former coastal swamps and marshes. These swamps and marshes were supported by heavy precipitation and a climate conducive to rapid vegetal growth in moderately fresh water. Due to the relatively low sulfur contents of the San Juan Basin coals, Shomaker and Whyte (1977) suggest the coals formed in fresh water environments.

Most of the coal-bearing units were deposited in coastal plain environments. The majority of the peat deposits formed in a transition zone between lower and upper deltaic sediments during periods of relative shoreline stability. Coals also formed in lake margin swamps inland from the coastal area. Shoreline oscillations and the subsequent influx of continental or marine debris upon the peat accumulations produced the vertical buildup or "stacking" of peat deposits. This sediment debris represents variable ash contents, rock partings, and splits within the coal seams.

The peat accumulated in lenses or pods which were generally parallel to the ancient shorelines. The coals in the lower portions of the coal-bearing units represent regressive depositional conditions (Sears, Hunt, and Hendricks, 1941). The coals in the upper portions of these units are relatively sporadic in occurrence.

Structure

The San Luis quadrangle is in the Chaco Slope structural division in the southeastern portion of the structural depression known as the San Juan Basin (Kelley, 1950). The rock units dip from 1° to 2° NW. Hunt (1936) mapped several minor faults in the area. No localized folding has been mapped in the area.

COAL GEOLOGY

In this quadrangle, the authors identified six coal beds and two coal zones in coal test hole logs and Hunt's (1936) and Dane's (1936) surface mapping. These beds and zones are here informally called the Menefee Cleary No. 1, No. 2, No. 2A, No. 3 and No. 4 coal beds, the Menefee Cleary coal zone, the Menefee Allison No. 1 coal bed, and the Menefee Allison coal zone.

The Menefee Cleary No. 1 bed is the first persistent coal bed above the Point Lookout Sandstone. It occurs 0 to 9 ft (0 to 3 m) above the Point Lookout Sandstone in this quadrangle, although in nearby quadrangles it is up to 15 ft (5 m) above the Point Lookout Sandstone. The Menefee Cleary No. 2 coal bed is 13 to 18 ft (4 to 5 m) and the Menefee Cleary No. 2A coal bed is 25 to 48 ft (8 to 15 m) above the Point Lookout Sandstone. The Menefee Cleary No. 3 and No. 4 coal beds are 40 to 78 ft (12 to 24 m) and 95 to 101 ft (29 to 31 m), respectively, above the Point Lookout Sandstone.

These beds, with the exception of the Menefee Cleary No. 2A bed, are inferred to be continuous, although they may be several individual beds that are stratigraphically equivalent.

The Menefee Cleary coal zone contains up to five beds which are 32 to 304 ft (10 to 93 m) above the Point Lookout Sandstone. These zone beds may be correlated for limited distances in portions of the area but they lack sufficient continuity with poorly defined stratigraphic positions and cannot be designated as persistent coal beds.

In this quadrangle, the areally limited Menefee Allison No. 1 coal bed is about 35 ft (11 m) above the base of the Allison Member, while the equally limited Menefee Allison coal zone has up to seven beds which occur in the lower 200 ft (61 m) of the member.

Woodward-Clyde Consultants (1977) analyzed coals from the Menefee Cleary No. 1 coal bed in the San Luis quadrangle. These coals are high volatile C bituminous in rank, and the analyses are shown in table 1. Analyses of mine samples of Cleary Coal Member beds sampled 5 mi (8 km) N and 7 mi (11 km) NNW of the San Luis quadrangle have been reported by the U. S. Bureau of Mines (1936) and are shown in tables 2 and 3, respectively. Rank of these coals is subbituminous A to high volatile C bituminous in this area.

Table 1. - Analyses of coal samples from the Menefee Cleary No. 1 coal bed.

[Form of analysis; A, as received]

from Woodward-Clyde Consultants (1977)

Sample	Type of Sample	Location			Form of analysis	Proximate analysis (percent)				Sulfur	Heating value (Btu/lb)
		Sec.	T. N.	R. W.		Moisture	Volatile matter	Fixed carbon	Ash		
1	Drill cuttings	NE¼ NW¼ NE¼ 16	17	2	A	13.80	34.76	36.77	14.67	1.28	9,973
2	Drill cuttings	NE¼ NE¼ NE¼ 16	17	2	A	16.65	33.96	41.11	8.28	0.59	10,508
3	Drill cuttings	NE¼ NE¼ NE¼ 16	17	2	A	13.99	34.55	37.19	13.67	0.55	10,052

Remarks:

A moist, mineral-matter-free (MMMF) calculation, using the Parr Formula (American Society for Testing and Materials, (1973), yields heating values of 11,874 Btu/lb (27,619 kJ/kg; sample 1), 11,549 Btu/lb (26,863 kJ/kg; sample 2) and 11,803 Btu/lb (27,454 kJ/kg; sample 3). No agglomerating characteristics are available for these analyses.

Table 2. - Analyses of coal samples from the Cleary Coal Member of the Menefee Formation

[Form of analysis: A, as received; B, moisture free; C, moisture and ash free]

from U. S. Bureau of Mines, 1936

Sample	Type of Sample	Location			Form of analysis	Proximate analysis (percent)				Sulfur	Heating value (Btu/lb)
		Sec.	T. N.	R. W.		Moisture	Volatile matter	Fixed carbon	Ash		
1	Mine sample (San Juan Mine)	NE¼ NW¼ SW¼ 31	19	1	A	15.7	32.0	45.1	7.2	0.6	10,790
					B	----	38.0	53.5	8.5	0.7	12,800
					C	----	41.5	58.5	---	0.8	13,990
2	Prospect sample (Wilkins No. 2 prospect)	SW¼ SW¼ SW¼ 26	19	1	A	18.2	34.4	40.8	6.6	0.9	10,280
					B	----	42.0	49.9	8.1	1.0	12,570

Remarks:

A moist, mineral-matter-free (MMMF) calculation, using the Parr Formula (American Society for Testing and Materials, 1973), yields heating values of 11,709 Btu/lb (27,235 kJ/kg; sample 1) and 11,080 Btu/lb (25,772 kJ/kg; sample 2). No agglomerating characteristics are available for these analyses.

Table 3. - Analyses of coal samples from the Allison Member of the Menefee Formation.

[Form of analysis: A, as received; B, moisture free; C, moisture and ash free]

from U. S. Bureau of Mines, 1936

Sample	Type of Sample	Location			Form of analysis	Proximate analysis (percent)					Heating value (Btu/lb)
		Sec.	T. N.	R. W.		Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	
1	Mine sample (Rio Puerco Mine)	SE¼ 19	19	1	A	12.1	35.8	44.5	7.6	2.8	10,940
					B	----	40.7	50.6	8.7	3.2	12,460
					C	----	44.6	55.4	---	3.5	13,640
2	Mine sample (Anderson Mine)	NE¼NW¼ SE¼ 35	19	2	A	20.0	32.5	42.6	4.9	0.7	10,240
					B	----	40.7	53.2	6.1	0.8	12,790
					C	----	43.3	56.7	---	0.9	13,630

Remarks:

A moist, mineral-matter-free (MMMF) calculation, using the Parr Formula (American Society for Testing and Materials, 1973), yields heating values of 11,966 Btu/lb (27,833 kJ/kg; sample 1) and 10,819 Btu/lb (25,165 kJ/kg; sample 2). No agglomerating characteristics are available for these samples.

Menefee Allison coal zone

The Menefee Allison coal zone is identified in one outcrop where it contains eight beds and has a total thickness of 7.8 ft (2.4 m). Because the zone is limited in areal extent in this quadrangle to a small area along the northern boundary, the isopach, structure contour, and overburden isopach maps are not drawn on full-sized plates, but are illustrated in figures 3, 4 and 5, respectively.

Menefee Allison No. 1 coal bed

The Menefee Allison No. 1 coal bed was measured at two outcrops in the quadrangle, where it is 1.0 and 3.0 ft (0.3 and 0.9 m) thick. The bed is similarly limited in areal extent as the Menefee Allison coal zone, and is therefore not mapped on full-sized plates. The isopach, structure contour, and overburden isopach maps are illustrated in figures 6, 7 and 8, respectively.

Menefee Cleary No. 4 coal bed

The Menefee Cleary No. 4 coal bed was identified at four outcrop measurements in the San Luis quadrangle and ranges in thickness from 0 to 5.8 ft (0 to 1.8 m). The isopach, structure contour, and overburden isopach maps are based partially on coal bed data from the northern adjacent Headcut Reservoir quadrangle.

Figure 3

ISOPACH MAP OF THE TOTAL COAL OF THE MENEFEE ALLISON COAL ZONE

(See explanation p. 19)

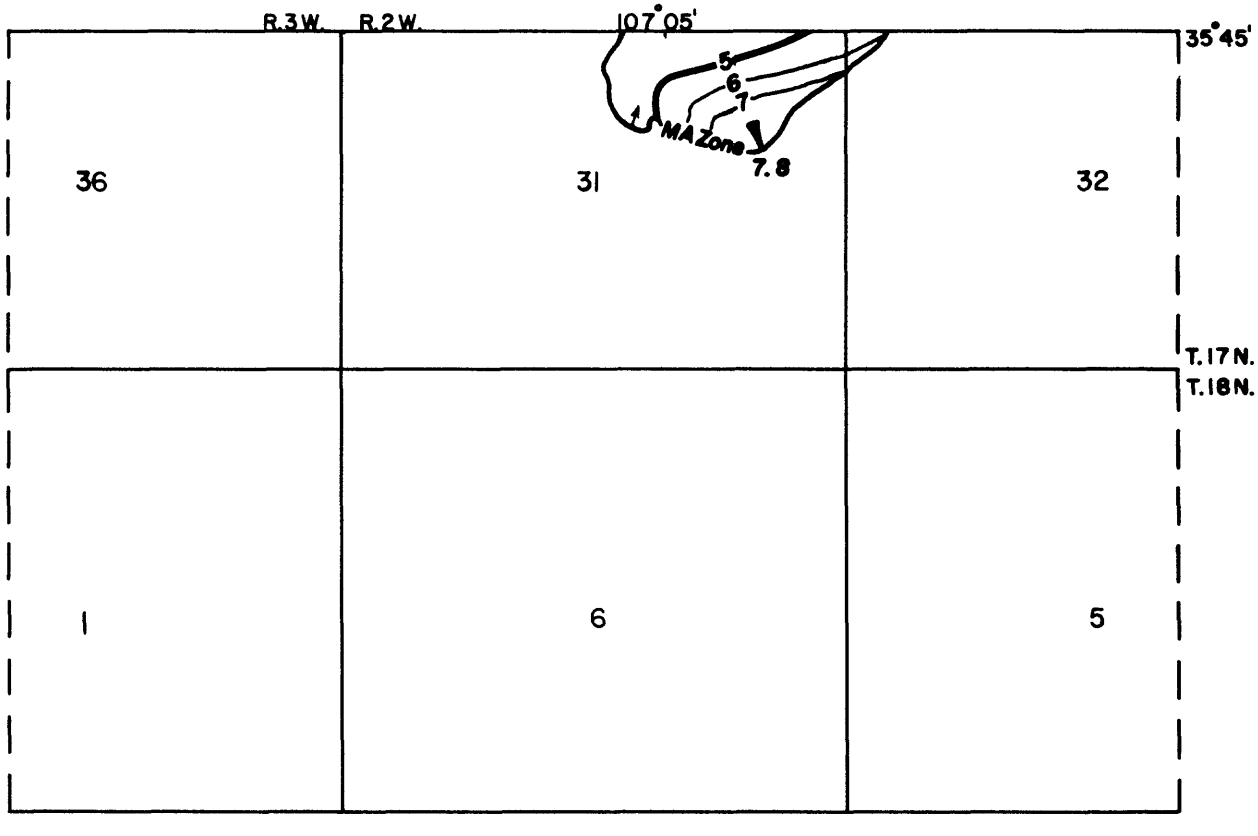


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Figure 4

STRUCTURE CONTOUR MAP OF THE MENEFEE ALLISON COAL ZONE

(See explanation p. 19)

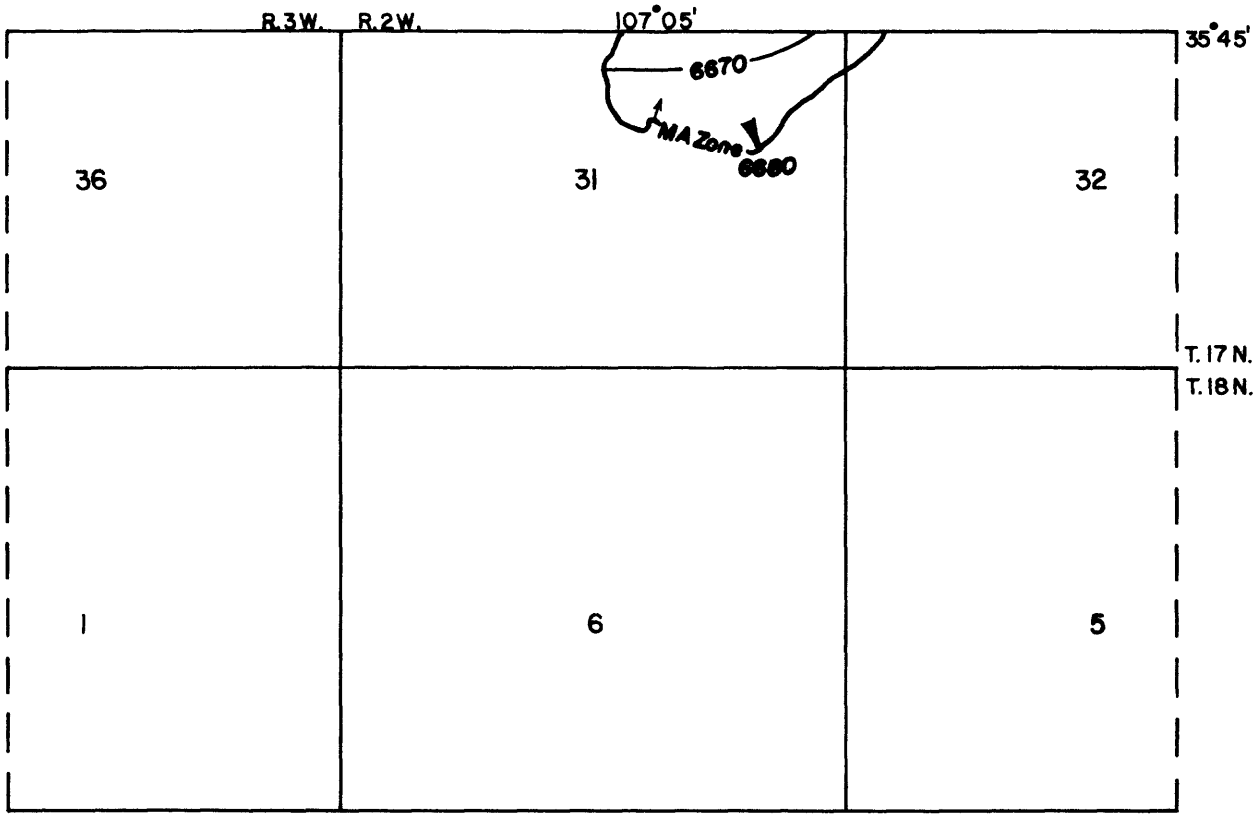

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Figure 5

ISOPACH MAP OF OVERBURDEN AND INTERBURDEN OF THE MENEFEE ALLISON COAL ZONE

(See explanation p. 19)

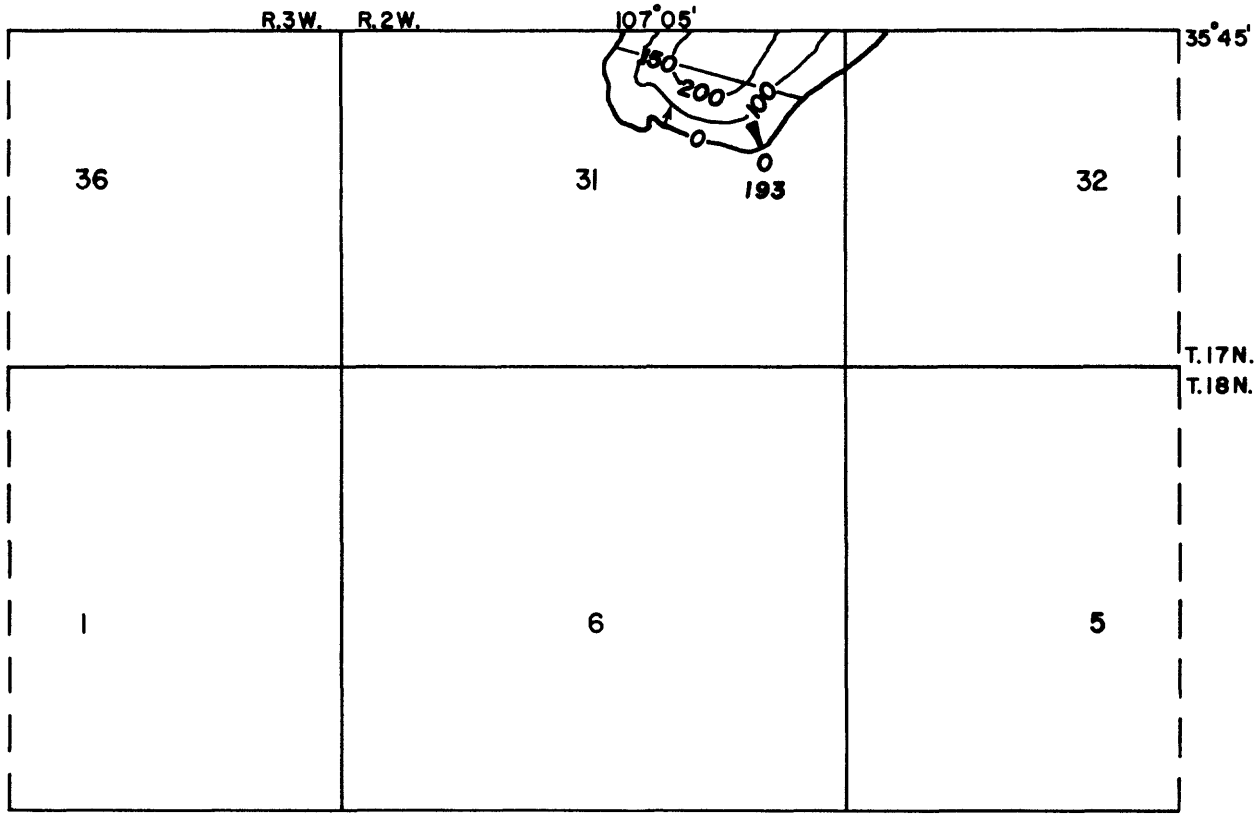

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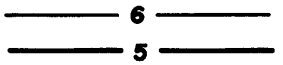
Figure 3

EXPLANATION



ISOPACHS OF THE MENEFEE ALLISON COAL ZONE-Showing thickness in feet. Isopach interval 1 foot (0.3 meter).

TRACE OF COAL ZONE OUTCROP-Showing coal thickness, in feet, measured at triangle. Arrow points toward the coal-bearing area.

To convert feet to meters, multiply feet by 0.3048.

Figure 4

EXPLANATION

STRUCTURE CONTOURS-Drawn on top of the lowermost zone coal of the Menefee Allison coal zone. Contour interval 10 feet (3 meters). Datum is mean sea level.

TRACE OF COAL ZONE OUTCROP-Showing altitude, in feet, measured at triangle. Arrow points toward the coal-bearing area.

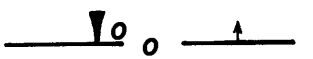
To convert feet to meters, multiply feet by 0.3048.

Figure 5

EXPLANATION

OVERBURDEN ISOPACHS-Showing thickness of overburden, in feet, from the surface to the top of the lowermost zone coal of the Menefee Allison coal zone (refer to CRO fig. 4). Isopach interval 100 feet (30.5 meters). Stripping limit is 200 feet (61 meters).

INTERBURDEN ISOPACHS-Showing rock thickness, in feet, between the Menefee Allison zone coal beds. Isopach interval 50 feet (15 meters).



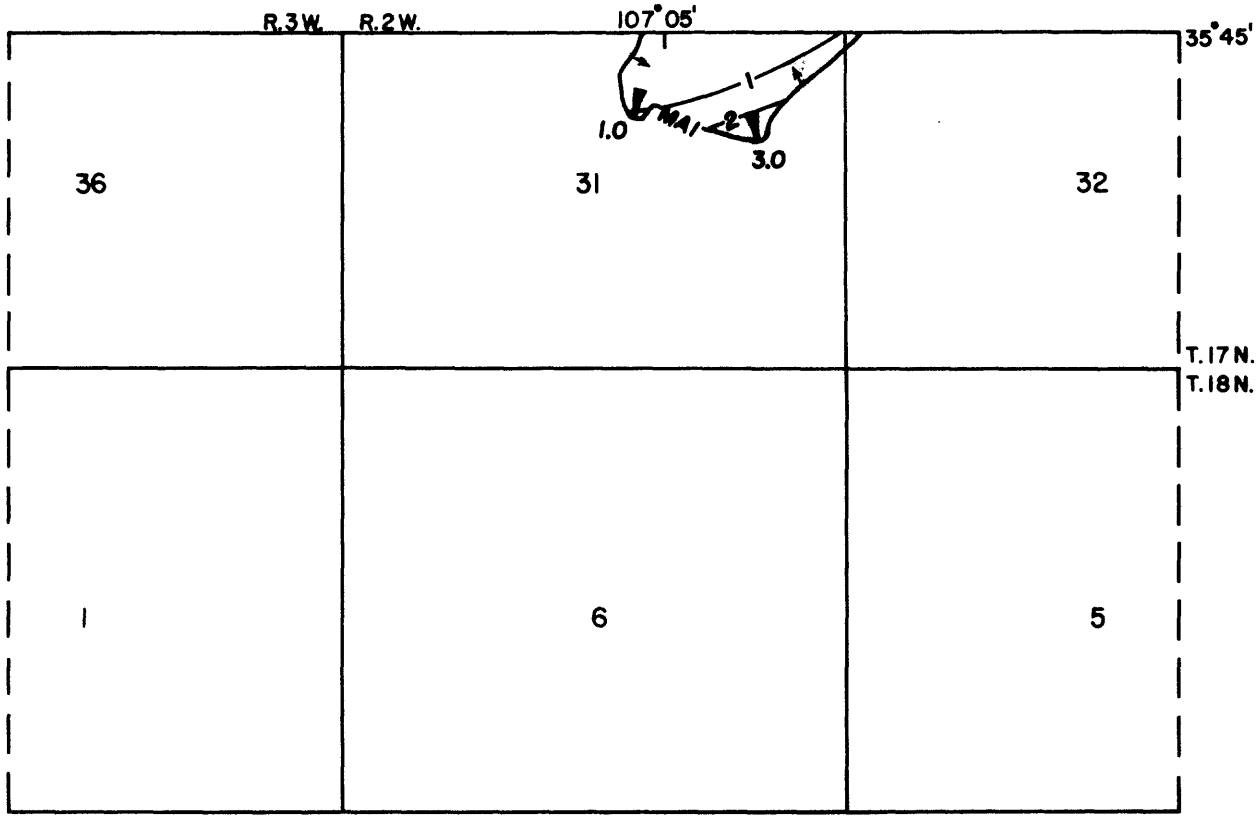
TRACE OF COAL ZONE OUTCROP-Showing no overburden at triangle (upper number) and thickness of interburden, in feet (lower number), between the coal beds of the coal zone. Arrow points toward the coal-bearing area. Dashed line indicates inferred outcrop.

To convert feet to meters, multiply feet by 0.3048.

Figure 6

ISOPACH MAP OF THE MENEFEE ALLISON NO. 1 COAL BED

(See explanation p. 23)



SCALE 1:24,000

Figure 7

STRUCTURE CONTOUR MAP OF THE MENEFEE ALLISON NO. 1 COAL BED

(See explanation p. 23)

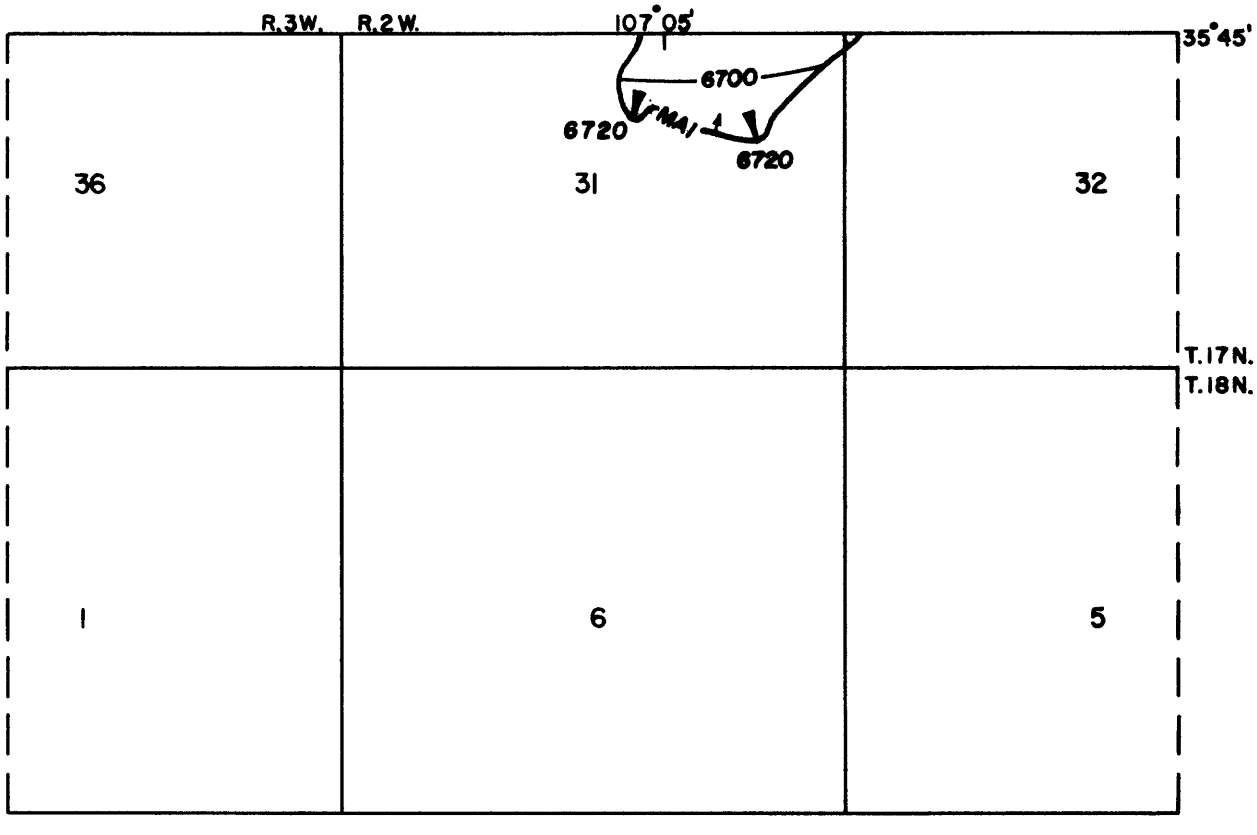


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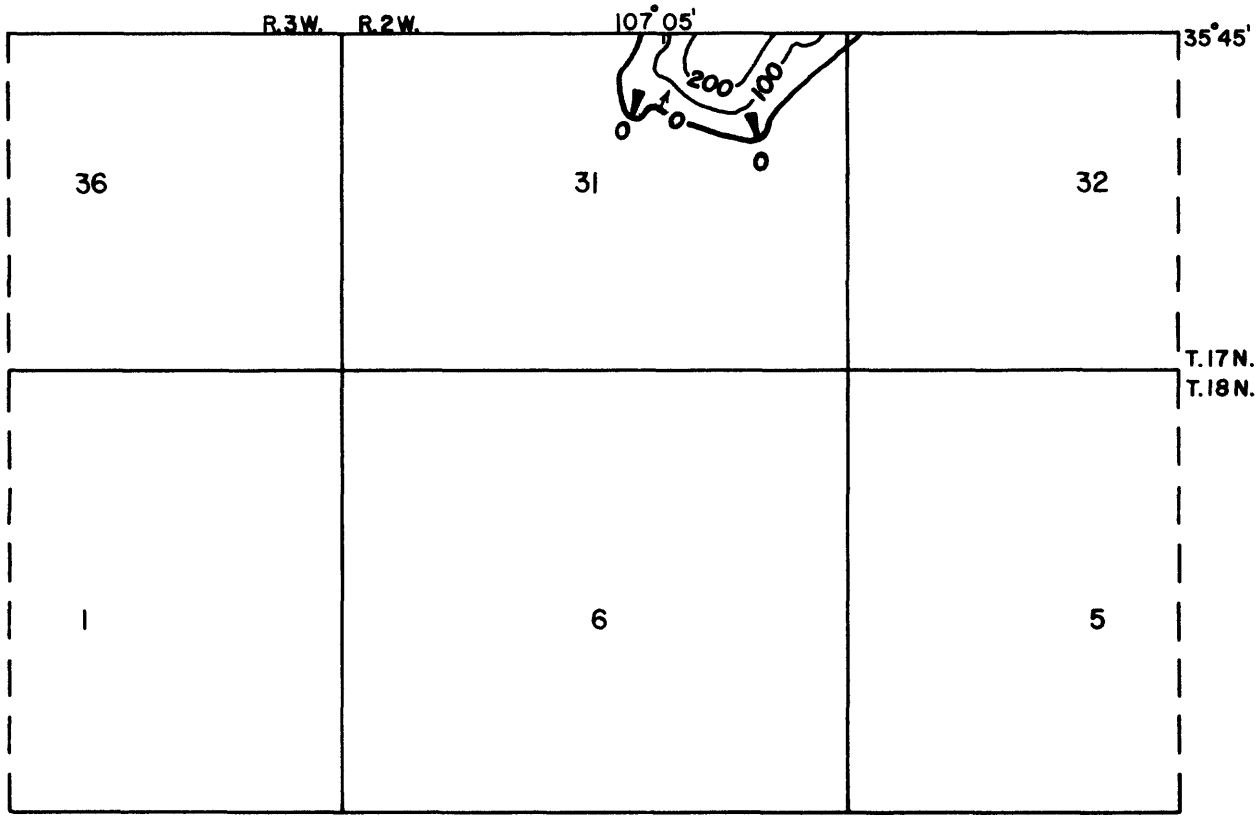
Figure 8

ISOPACH MAP OF OVERBURDEN OF THE MENEFEE ALLISON NO.1 COAL BED

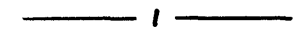
(See explanation p. 23)



SCALE 1:24,000

Figure 6

EXPLANATION



ISOPACHS OF THE MENEFEE ALLISON NO. 1 COAL BED-Showing thickness in feet. Isopach interval 1 foot (0.3 meter).

TRACE OF COAL BED OUTCROP-Showing coal thickness, in feet, measured at triangle. Arrow points toward the coal-bearing area.

To convert feet to meters, multiply feet by 0.3048.

Figure 7

EXPLANATION

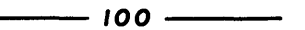
STRUCTURE CONTOURS-Drawn on top of the Menefee Allison No. 1 coal bed. Contour interval 100 feet (30.5 meters). Datum is mean sea level.

TRACE OF COAL BED OUTCROP-Showing altitude, in feet, measured at triangle. Arrow points toward the coal-bearing area.

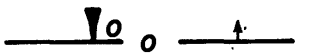
To convert feet to meters, multiply feet by 0.3048.

Figure 8

EXPLANATION



OVERBURDEN ISOPACHS-Showing thickness of overburden, in feet, from the surface to the top of the Menefee Allison No. 1 coal bed. Isopach interval 100 feet (30.5 meters). Stripping limit is 200 feet (61 meters).



TRACE OF COAL BED OUTCROP-Showing no overburden at triangle. Arrow points toward the coal-bearing area.

Mining ratios for the Menefee Allison No. 1 coal bed exceed 15 and are therefore not shown.

To convert feet to meters, multiply feet by 0.3048.

Menefee Cleary No. 3 coal bed

The Menefee Cleary No. 3 coal bed was measured at three outcrop points and two drill hole logs. It ranges from 0 to 5.5 ft (0 to 1.7 m) in thickness in this quadrangle. It is limited in extent to the northwest and north-central portions of the quadrangle. Existence and character of the bed are unknown in the remaining parts of the San Luis quadrangle.

Menefee Cleary No. 2A coal bed

The Menefee Cleary No. 2A coal bed was identified in five coal test hole logs and at one outcrop measurement. It consists of two small lenticular bodies which are 0 to 3+ ft (0 to 1+m) and 0 to 4+ ft (0 to 1.2+ m) thick. These coal lenses occur in the north-central part of the quadrangle.

Menefee Cleary No. 2 coal bed

The Menefee Cleary No. 2 coal bed was identified in two drill hole logs and two outcrop measurements. It ranges from 0 to 3.5 ft (0 to 1.1 m) in thickness. The bed forms an elongate lenticular body in the northeast corner of the quadrangle.

Menefee Cleary No. 1 coal bed

The Menefee Cleary No. 1 coal bed was identified in eight coal test hole logs and at five outcrop measurements. Thickness of the bed ranges from 1.7 to 8 ft (0.5 to 2.4 m). The bed outcrops in a relatively continuous band in the northern part of the quadrangle. An outcrop trace in SE¼ SE¼ Sec. 8, NE¼ Sec. 17 and the NW¼ Sec. 16, T. 17 N., R. 2 W. was inferred to be present because structural potential for outcrop exists in those areas. Dane (1936) did not map the above inferred outcrop. Existence and character of the bed are unknown in the northwestern part of the quadrangle because of insufficient data.

COAL RESOURCES

The U. S. Geological Survey requested resource evaluations of the Menefee Cleary No. 1, No. 2, No. 2A, No. 3, and No. 4 coal beds, where the beds are 3.0 ft (0.9 m) or more thick. The evaluation is restricted to Federal coal lands.

The following procedures were prescribed by the U. S. Geological Survey for the calculation of reserve base. Criteria established in U. S. Geological Survey Bulletin 1450-B were used to areally divide the beds into measured, indicated, and inferred reserve base categories. Reserve base was calculated for each category, by section, using data from the isopach and overburden maps (plate 4, 6, 7, 9, 10, 12, 13, 15, 16, and 18. The acreage in each category (measured by planimeter) multiplied by the average coal bed thickness and bituminous coal conversion factor (1,800 tons of coal

per acre-ft) yields the reserve base for that category. Coal beds with 3.0 ft (0.9 m) minimum thickness are included in reserve base and reserve data rather than the 28 in. (71 cm) minimum thickness prescribed in U. S. Geological Survey Bulletin 1450-B. Reserve figures are derived from reserve base totals by applying recovery factors of 85 percent and 50 percent for coal beds 0 to 200 ft (0 to 61 m) and 200 to 3,000 ft (61 to 914 m) deep, respectively. All reserve base and reserve values are rounded to the nearest 10,000 short tons (9,072 t).

Total reserve base data, which include all reserve base categories, are shown by section on plate 2. The Menefee Cleary No. 2A and Menefee Cleary No. 4 coal beds are incorporated on the same areal distribution and identified resources plate (plate 19). Reserve base and reserve data in the various categories are shown on plates 19, 20, 21, and 22.

The U. S. Geological Survey also requested resource evaluations of the Menefee Allison coal zone, where the total zone coal thickness is 5.0 ft (1.5 m) or greater. Total identified Menefee Allison coal zone resources are 0.42 million short tons (0.38 million t).

COAL DEVELOPMENT POTENTIAL

The factors used to determine the development potential are the presence of a potentially coal-bearing formation, and the thickness and overburden of correlative coal beds. The U. S. Geological Survey supplied the criteria to evaluate the coal development potential for Federal lands in this quadrangle. These criteria are based on current industry practice,

U. S. Geological Survey Bulletin 1450-B, and anticipated technological advances. All available data were utilized for the surface and subsurface coal development potential evaluations.

Any area underlain by a potentially coal-bearing formation with 200 ft (61 m) or less of overburden has potential for surface mining. The U. S. Geological Survey designated the 200 ft (61 m) maximum depth as the stripping limit. Areas where a potentially coal-bearing formation is overlain by more than 200 ft (61 m) of overburden have no potential for surface mining. Areas with no correlative coal bed or a correlative coal bed less than 3.0 ft (0.9 m) in thickness and overlain by 200 ft (61 m) or less of overburden have unknown surface mining potential. Areas which have a correlative coal bed 3.0 ft (0.9 m) or more thick with surface mining potential are assigned a high, moderate or low development potential based on the mining ratio (cubic yards of overburden per short ton of recoverable coal). The formula used to calculate mining ratios is:

$$MR = \frac{t_o\ (C)}{t_c\ (Rf)}$$

Where MR = Mining ratio

t_o = Thickness of overburden in feet

t_c = Thickness of coal in feet

Rf = Recovery factor

C = Volume-weight conversion factor

(.896 yd^3/short ton for bituminous coal)

(.911 yd^3/short ton for subbituminous coal)

High, moderate, and low development potential areas have respective surface mining ratio values of 0 to 10, 10 to 15, and greater than 15.

Any area underlain by a potentially coal-bearing formation with 200 to 3,000 ft (61 to 914 m) of overburden has potential for subsurface mining. Areas where a potentially coal-bearing formation is overlain by more than 3,000 ft (914 m) of overburden have no subsurface mining potential. Development potential for subsurface mining is unknown where a potentially coal-bearing formation within 200 to 3,000 ft (61 to 914 m) of the surface contains no identified correlative coal bed or a correlative coal bed less than 3.0 ft (0.9 m) thick. High, moderate, and low development potential areas have respective overburden values of 200 to 1,000 ft (61 to 305 m), 1,000 to 2,000 ft (305 to 610 m), and 2,000 to 3,000 ft (610 to 914 m). The no and unknown development potential boundaries for surface and subsurface mining methods (plates23 and 24) are defined at the contact of the coal-bearing Menefee Formation with the underlying noncoal-bearing Point Lookout Sandstone. These contacts are approximated due to the inaccuracies of adjusting old geologic maps to modern topographic bases.

Boundaries of coal development potential areas coincide with the boundaries of the smallest legal land subdivision (40 acre or lot). When a land subdivision contains areas with different development potentials, the potential shown on the map is that of the areally largest of the component areas. When an area is underlain by more than one bed, the potential shown on the map is that of the bed with the highest potential.

Reserve base (in short tons) in the various development potential categories for surface and subsurface mining methods are shown in tables 4 and 5, respectively.

The coal development potential maps are subject to revision. Map boundary lines and reserve base values are based on coal resource occurrence map isopachs, overburden isopachs and coal bed correlations that are

interpretive and subject to change as additional coal information becomes available.

Development potential for surface mining methods

The coal development potential for sufrace mining methods in the San Luis quadrangle is shown on plate 23. Based on coal development criteria, all Federal coal lands have high, moderate, low, unknown or no surface mining potentials. Refer to table 6 for reserves and planimetered acreage, by section, for Federal coal lands with surface mining potential.

Development potential for subsurface mining methods and in situ gasification

The coal development potential for subsurface mining methods in the San Luis quadrangle is shown on plate 24. Based on coal development criteria, all Federal coal lands have high, unknown or no subsurface mining potentials. Refer to table 7 for reserves and planimetered acreage, by section, for Federal coal lands with subsurface mining potential.

In situ gasification of coal has not been done on a commercial scale in the United States and criteria for rating the development potential of this method are unknown.

Table 4. - Reserve base data (in short tons) for surface mining methods for Federal coal lands in the San Luis quadrangle, Sandoval County, New Mexico.

[Development potentials are based on mining ratios (cubic yards of overburden/ton of underlying coal). To convert short tons to metric tonnes, multiply by 0.9072; to convert mining ratios in yds^3/ton coal by m^3/t, multiply by 0.842].

Coal Bed	High Development Potential (0-10 Mining Ratio)	Moderate Development Potential (10-15 Mining Ratio)	Low Development Potential (greater than 15 Mining Ratio)	Total
Menefee Cleary No. 4	220,000	120,000	350,000	690,000
Menefee Cleary No. 3	2,310,000	990,000	3,090,000	6,390,000
Menefee Cleary No. 2A	210,000	80,000	710,000	1,000,000
Menefee Cleary No. 2	-------	130,000	1,050,000	1,180,000
Menefee Cleary No. 1	16,990,000	9,780,000	23,960,000	50,730,000
Total	19,730,000	11,100,000	29,160,000	59,990,000

Table 5. - Reserve base data (in short tons) for subsurface mining methods for Federal coal lands in the San Luis quadrangle, Sandoval County, New Mexico.

[Development potentials are based on thickness of overburden. To convert short tons to metric tonnes, multiply by 0.9072].

Coal Bed	High Development Potential (200'-1000' overburden)	Moderate Development Potential (1000'-2000' overburden)	Low Development Potential (2000'-3000' overburden)	Total
Menefee Cleary No. 4	10,000	------	------	10,000
Menefee Cleary No. 3	680,000	------	------	680,000
Menefee Cleary No. 2A	140,000	------	------	140,000
Menefee Cleary No. 2	360,000	------	------	360,000
Menefee Cleary No. 1	9,300,000	------	------	9,300,000
Total	10,490,000	------	------	10,490,000

Table 6. - Reserves and planimetered acreage, by section, for Federal coal lands in the San Luis quadrangle with surface mining potential.

[To convert acres to hectares, divide acres by 2.471; to convert short tons to metric tonnes (t), multiply short tons by 0.9072].

Potential category	Coal Bed	Sec.	T. N.	R. W.	Total Acres (planimetered)	Reserves (in short tons)
High	Menefee Cleary No. 4	34	18	2	7.7	50,000
		35	18	2	16.2	120,000
	Menefee Cleary No. 3	8	17	2	128.1	1,040,000
		9	17	2	120.7	880,000
		18	17	2	6.7	30,000
	Menefee Cleary No. 2A	18	17	2	28.8	180,000
	Menefee Cleary No. 1	35	18	2	124.1	860,000
		3	17	2	26.9	240,000
		8	17	2	49.9	570,000
		9	17	2	19.0	210,000
		10	17	2	227.1	1,710,000
		11	17	2	9.4	80,000
		18	17	2	265.4	3,070,000
		17	17	2	146.8	1,430,000
		15	17	2	197.5	1,170,000
		24	17	3	145.5	1,040,000
		19	17	2	350.7	3,710,000
		20	17	2	55.2	280,000
		21	17	2	7.0	30,000
Moderate	Menefee Cleary No. 4	34	18	2	7.4	40,000
		35	18	2	8.1	50,000
	Menefee Cleary No. 3	8	17	2	79.4	590,000
		9	17	2	30.4	200,000
		18	17	2	4.0	20,000
		5	17	2	2.0	10,000

Table 6. - Reserves and planimetered acreage, by section, for Federal coal lands in the San Luis quadrangle with surface mining potential (continued).

[To convert acres to hectares, divide acres by 2.471; to convert short tons to metric tonnes (t), multiply short tons by 0.9072].

Potential category	Coal Bed	Sec.	T. N.	R. W.	Total Acres (planimetered)	Reserves (in short tons)
Moderate	Menefee Cleary No. 2A	18	17	2	11.1	60,000
	Menefee Cleary No. 2	35	17	2	22.9	110,000
	Menefee Cleary No. 1	34	18	2	13.5	90,000
		35	18	2	82.8	540,000
		3	17	2	60.6	550,000
		7	17	2	31.0	340,000
		8	17	2	40.4	490,000
		9	17	2	10.7	90,000
		10	17	2	111.5	810,000
		11	17	2	2.5	20,000
		13	17	3	6.7	60,000
		18	17	2	234.2	2,880,000
		17	17	2	198.1	1,600,000
		15	17	2	42.1	270,000
		24	17	3	45.4	280,000
		20	17	2	28.3	150,000
		21	17	2	13.0	60,000
Low	Menefee Cleary No. 4	34	18	2	26.4	180,000
		35	18	2	20.2	110,000
	Menefee Cleary No. 3	5	17	2	117.2	710,000
		4	17	2	37.7	190,000
		12	17	3	4.6	20,000
		7	17	2	16.7	80,000
		8	17	2	41.5	280,000
		9	17	2	188.6	1,200,000
		18	17	2	27.0	120,000

Table 6. - Reserves and planimetered acreage, by section, for Federal coal lands in the San Luis quadrangle with surface mining potential (continued).

[To convert acres to hectares, divide acres by 2.471; to convert short tons to metric tonnes (t), multiply short tons by 0.9072].

Potential category	Coal Bed	Sec.	T. N.	R. W.	Total Acres (planimetered)	Reserves (in short tons)
Low	Menefee Cleary No. 2A	7	17	2	15.2	90,000
		13	17	3	1.3	less than 10,000
		18	17	2	76.0	500,000
	Menefee Cleary No. 2	34	17	2	26.9	120,000
		35	17	2	76.8	370,000
		4	17	2	4.0	10,000
		9	17	2	75.5	360,000
	Menefee Cleary No. 1	34	18	2	240.2	1,440,000
		35	18	2	176.9	1,100,000
		5	17	2	32.3	170,000
		4	17	2	9.0	60,000
		3	17	2	414.9	3,430,000
		7	17	2	258.7	2,370,000
		8	17	2	240.4	2,030,000
		9	17	2	393.3	2,450,000
		10	17	2	165.1	1,150,000
		11	17	2	4.0	30,000
		13	17	3	171.3	1,150,000
		18	17	2	122.6	1,180,000
		17	17	2	168.4	1,500,000
		15	17	2	1.8	less than 10,000
		24	17	3	169.7	960,000
		20	17	2	125.3	710,000
		21	17	2	94.3	510,000

Table 7. - Reserves and planimetered acreage, by section, for Federal coal lands in the San Luis quadrangle with subsurface mining potential.

[To convert acres to hectares, divide acres by 2.471; to convert short tons to metric tonnes (t), multiply short tons by 0.9072].

Potential category	Coal Bed	Sec.	T. N.	R. W.	Total Acres (planimetered)	Reserves (in short tons)
High	Menefee Cleary No. 4	34	18	2	1.0	less than 10,000
	Menefee Cleary No. 3	5	17	2	33.7	10,000
		12	17	3	12.2	30,000
		7	17	2	6.1	20,000
		8	17	2	52.5	160,000
		4	17	2	4.5	10,000
		9	17	2	26.8	80,000
	Menefee Cleary No. 2A	12	17	3	18.2	50,000
		7	17	2	3.0	10,000
		13	17	3	3.0	10,000
	Menefee Cleary No. 2	4	17	2	2.7	less than 10,000
		9	17	2	56.5	170,000
	Menefee Cleary No. 1	33	18	2	160.8	460,000
		34	18	2	169.8	550,000
		35	18	2	9.4	30,000
		6	17	2	25.9	70,000
		5	17	2	218.3	690,000
		4	17	2	555.5	1,950,000
		3	17	2	138.0	560,000
		12	17	3	97.0	330,000
		7	17	2	264.1	950,000
		8	17	2	294.4	1,610,000
		9	17	2	193.4	740,000
		13	17	3	231.7	830,000
		18	17	2	17.5	90,000
		17	17	2	59.3	390,000

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coal bed--A stratified sequence of coal, composed of relatively homogeneous material, exhibiting some degree of lithologic unity and separated from the rocks above and below by physically rather well defined boundary planes.

coal bed separation line--A line on a map plate separating areas where different coal beds or zones are mapped.

coal bench--One of two or more divisions of a coal bed separated by rock.

coal conversion factor--A factor used to convert acre-feet of coal into short tons of coal; bituminous coal is 1800 tons/acre-ft; subbituminous coal is 1770 tons/acre-ft.

coal development potential--A subjective determination of the comparative potential of Federal coal lands for development of a commercially viable coal mining operation.

coal exploration license--An area of Federal coal lands in which the licensee is granted the right, after outlining the area and the probable methods of exploration, to investigate the coal resources. An exploration license has a term not to exceed 2 years and does not confer rights to a lease.

coal lease--An area of Federal coal lands in which the Federal Government has entered into a contractual agreement for development of the coal deposits.

coal split--A coal bed resulting from the occurrence of a noncoal parting within the parent coal bed which divides the single coal bed into two or more coal beds.

coal zone--A distinctive stratigraphic interval containing a sequence of alternating coal and noncoal layers in which the coal beds may so lack lateral persistence that correlating individual beds in the zone is not feasible.

Federal coal land--Land for which the Federal Government holds title to the coal mineral rights, without regard to surface ownership.

hypothetical resources--Undiscovered coal resources in beds that may reasonably be expected to exist in known mining districts under known geologic conditions. In general, hypothetical resources are in broad areas of coal fields where points of observation are absent and evidence is from distant outcrops, drill holes or wells. Exploration that confirms their presence and reveals quantity and quality will permit their reclassification as a Reserve or Identified Subeconomic Resource.

identified resources--Specific bodies of coal whose location, rank, quality, and quantity are known from geologic evidence supported by engineering measurements.

indicated--Coal for which estimates for the rank, quality, and quantity have been computed partly from sample analyses and measurements and partly from reasonable geologic projections.

inferred--Coal in unexplored extensions of demonstrated resources for which estimates of the quality and quantity are based on geologic evidence and projections.

isopach--A line joining points of equal bed thickness.

Known Recoverable Coal Resource Area (KRCRA)--Formerly called Known Coal Leasing Area (KCLA). Area in which the Federal coal land is classified (1) as subject to the coal leasing provisions of the Mineral Leasing Act of 1920, as amended, and (2) by virtue of the available data being sufficient to permit evaluation as to extent, location, and potential for developing commercial quantities of coal.

measured--Coal for which estimates for rank, quality, and quantity can be computed, within a margin of error of less than 20 percent, from sample analyses and measurements from closely spaced and geologically well known sample sites.

mining ratio--A numerical ratio equating the in-place volumes, in cubic yards, of rocks that must be removed in order to recover 1 short ton of coal by surface mining.

overburden--A stratigraphic interval (composed of noncoal beds and coal beds) lying between the ground surface and the top of a coal bed. For coal zones, overburden is the stratigraphic interval lying between the ground surface and the structural datum used to map the zone.

parting--A noncoal layer occurring along a bedding plane within a coal bed.

Preference Right Lease Application (PRLA)--An area of Federal coal lands for which an application for a noncompetitive coal lease has been made as a result of exploration done under a coal prospecting permit. PRLA's are no longer obtainable.

quality or grade--Refers to measurements such as heat value; fixed carbon; moisture; ash; sulfur; phosphorus; major, minor, and trace elements; coking properties; petrologic properties; and particular organic constituents.

rank--The classification of coal relative to other coals, according to degree of metamorphism, or progressive alteration, in the natural series from lignite to anthracite (Classification of coals by rank, 1973, American Society for Testing and Materials, ASTM Designation D-388-66).

recovery factor--The percentage of total tons of coal estimated to be recoverable from a given area in relation to the total tonnage estimated to be in the Reserve Base in the ground.

reserve--That part of identified coal resource that can be economically mined at the time of determination. The reserve is derived by applying a recovery factor to that component of the identified coal resource designated as the reserve base.

reserve base--That part of identified coal resource from which Reserves are calculated.

stripping limit--A vertical depth, in feet, measured from the surface, reflecting the probable maximum, practical depth to which surface mining may be technologically feasible in the forseeable future. The rock interval, expressed in feet, above the stripping limit is the "strippable interval."

structure contour--A line joining points of equal elevation on a stratum or bed.