UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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1985

FEDERAL COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE TINIAN 7 1/2-MINUTE QUADRANGLE, McKINLEY AND SANDOVAL COUNTIES, NEW MEXICO

[Report includes 31 plates (32 sheets)]

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TINIAN QUADRANGLE

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INTRODUCTION

Purpose

This text complements the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) maps of the Tinian 7½ minute quadrangle, McKinley and Sandoval Counties, New Mexico. These maps and report are part of an evaluation of fifty-six 7½ minute quadrangles in northwestern New Mexico which were completed under U. S. Geological Survey Contract No. 14-08-0001-17459 (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 ft (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 Published and unpublished public information was used as the data base for this study.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.

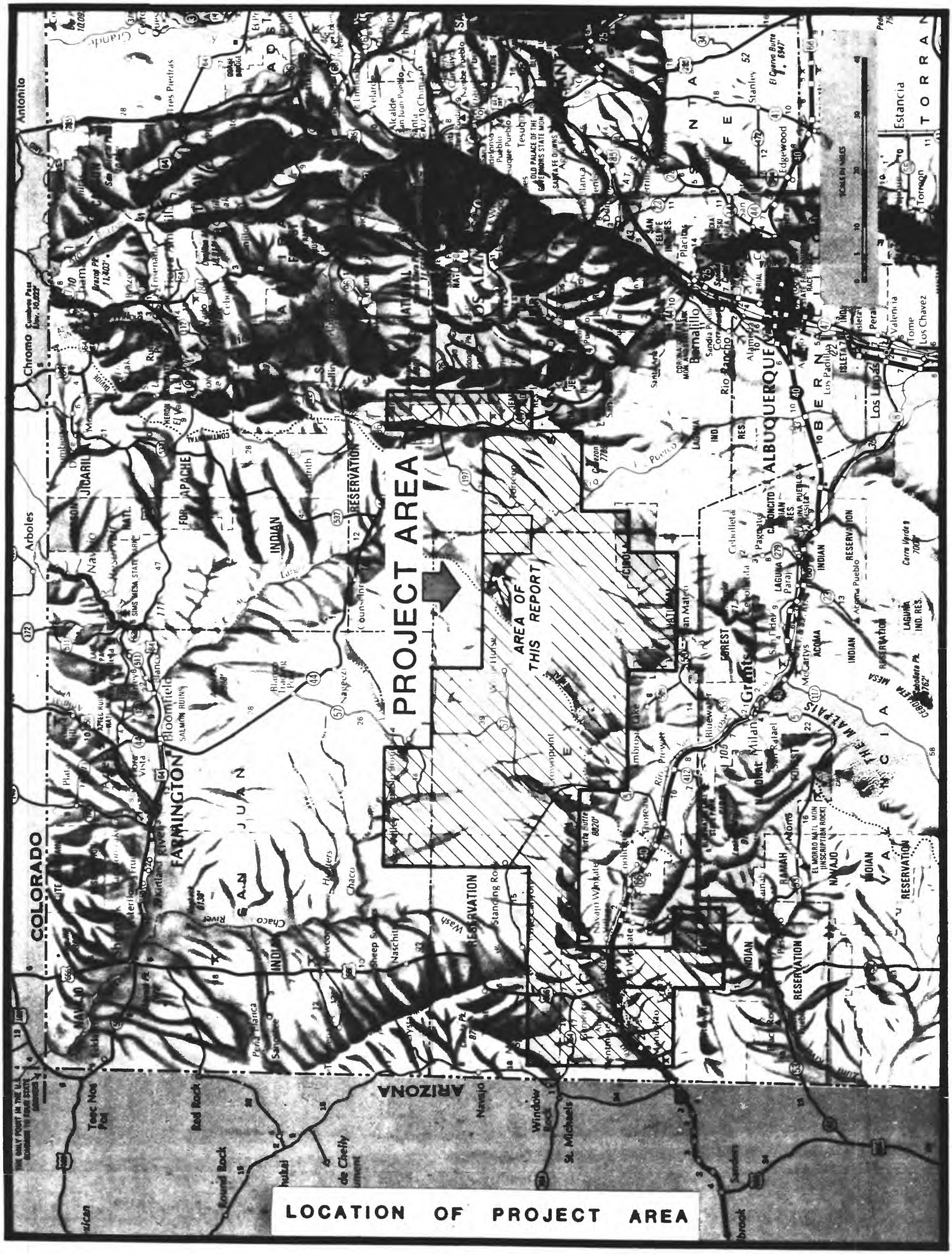
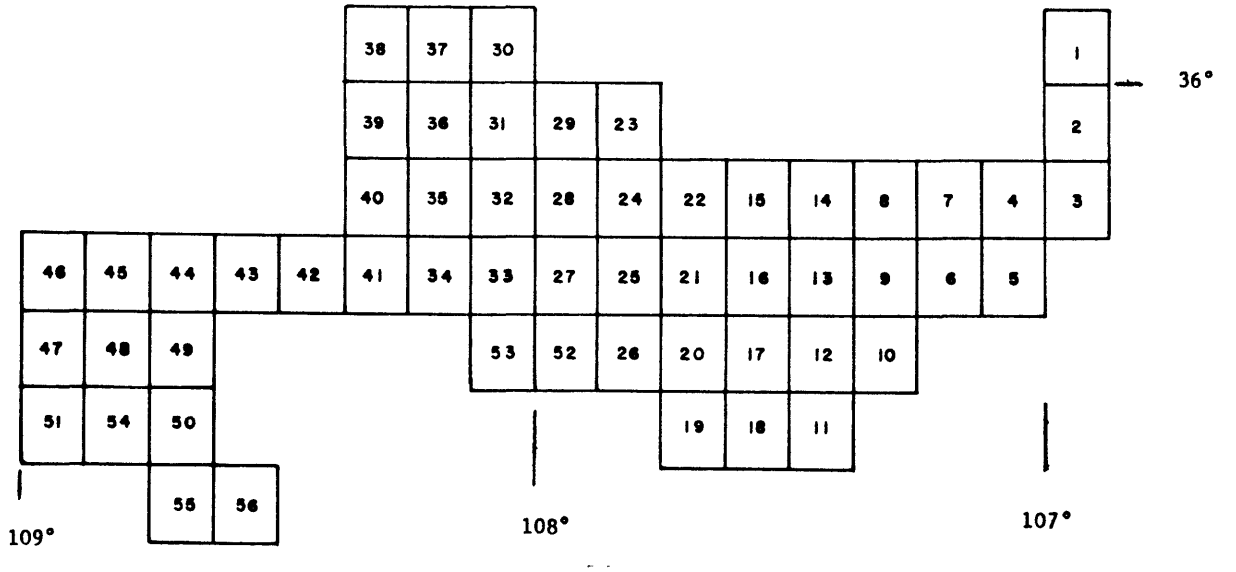

LOCATION OF PROJECT AREA
PROJECT AREA
AREA OF THIS REPORT
COLORADO
ARIZONA
FARMINGTON
ALBUQUERQUE
Grants
Bloomfield
Bernalillo
Los Lunas
Estancia

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
1	Cuba	79- 623
2	San Pablo	79- 624
3	La Ventana	79-1038
4	Headcut Reservoir	79-1043
5	San Luis	79-1044
6	Arroyo Empedrado	79-1045
7	Wolf Stand	79-1046
8	Tinian	79- 625
9	Canada Calladita	79- 626
10	Cerro Parido	79- 627
11	El Dado Mesa	79- 628
12	Mesa Cortada	79- 629
13	Mesita del Gavilan	79- 630
14	Rincon Marquez	79- 631
15	Whitehorse Rincon	79- 632
16	Mesita Americana	79- 633
17	El Dado	79- 634
18	Cerro Alesna	79- 635
19	San Lucas Dam	79- 636
20	Piedra de la Aguila	79-1039
21	Hospah	79- 637
22	Whitehorse	79-1040
23	Seven Lakes NE	79- 638
24	Kin Nahzin Ruins	79- 639
25	Orphan Annie Rock	79-1041
26	Mesa de los Toros	79-1122
27	Laguna Castillo	79- 640
28	Seven Lakes	79-1042
29	Seven Lakes NW	79-1123
30	Kin Klizhin Ruins	79-1047
31	Nose Rock	79- 641
32	Becenti Lake	79-1124
33	Heart Rock	79- 642
34	Crownpoint	79-1125
35	Antelope Lookout Mesa	79-1376
36	Milk Lake	79-1377
37	La Vida Mission	79-1378
38	The Pillar 3 SE	79-1379
39	Red Lake Well	79-1380
40	Standing Rock	79-1381
41	Dalton Pass	80- 026
42	Oak Spring	80- 027
43	Hard Ground Flats	80- 028
44	Big Rock Hill	80- 029
45	Twin Lakes	80- 030
46	Tse Bonita School	80- 031
47	Samson Lake	80- 032
48	Gallup West	80- 033
49	Gallup East	80- 034
50	Bread Springs	80- 035
51	Manuelito	80- 036
52	Borrego Pass	80- 037
53	Casamero Lake	80- 038
54	Twin Buttes	80- 039
55	Pinehaven	80- 040
56	Upper Nutria	80- 041



Location

The Tinian 7½ minute quadrangle includes acreage in Tps. 18 and 19 N., Rs. 4 and 5 W. of the New Mexico Principal Meridian, McKinley and Sandoval Counties, northwestern New Mexico (see figs. 1 and 2).

Accessibility

No paved roads pass through the Tinian quadrangle. A light-duty maintained road passes through the central portion of the quadrangle. State Highway 197 is the nearest paved road and passes 2.0 mi (3.2 km) east of the quadrangle. Unimproved dirt roads traverse most parts of the area. The Atchison, Topeka, and Santa Fe Railroad line passes about 46 mi (74 km) due south of the quadrangle (see fig. 1).

Physiography

The Tinian 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 mesa-and-canyon. Chaco Mesa is a prominent topographic feature in the southwestern part of the quadrangle.

No perennial streams are present in the quadrangle. Local drainage is provided by intermittent arroyos which include Naberto Sandoval Canon, Torreon Wash, San Isidro Wash, Vicente Arroyo, Pinon Canyon, and Julio Juan Canyon. Elevations within the quadrangle range from less than 6,260 ft (1,908 m) in the southeastern corner to over 7,340 ft (2,237 m) on Chaco Mesa.

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 Tinian quadrangle is about 4 mi (6 km) west 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 fifteen 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 75 percent of the Tinian quadrangle. For the specific coal ownerhip boundaries, see plate 2. It is not within the scope of this report to provide detailed land-surface ownership. About 680 acres (275 ha) in the northern portion of the quadrangle are within the San Juan Basin Known Recoverable Coal Resource Area. The remainder of the quadrangle is within the La Ventana Known Recoverable Coal Resource Area. As of October 26, 1978, there were no Federal coal leases, coal preference right lease applications or coal exploration licenses within the Tinian quadrangle.

GENERAL GEOLOGY

Previous work

Early reports on the area include that of Dane (1936) who measured coal outcrops of the Allison Member of the Menefee Formation and Fruitland Formation. Fassett and Hinds (1971) measured Fruitland Formation coals in the area. Shomaker, Beaumont, and Kottlowski (1971) reported that although Menefee Formation coals are present at strippable depths, they lacked sufficient thickness and continuity to be of economic value. 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 positions of the Cretaceous seaways changed innumerable times. The overall regional alignment 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 Tinian quadrangle include some of the sedimentary units of Upper Cretaceous age. There is Quaternary alluvium along

drainages in the area. The Point Lookout Sandstone and the overlying Cleary Coal Member of the Menefee Formation are present only in the subsurface in this area.

The Upper Cretaceous Point Lookout Sandstone represents nearshore or littoral deposits which formed during the most extensive northeastward 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 ranges from 94 to 124 ft (29 to 38 m) thick locally. The continental sediments deposited inland from the beach area during the 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 the upper Allison Member. A massive channel sandstone sequence defines the boundary between the two members. An upper coal-bearing unit is present in the northeastern part of the quadrangle, and is termed the Hogback Mountain Tongue of the Menefee Formation (Shomaker, 1971). The Hogback Mountain Tongue represents continental deposits which formed during a regressive shoreline sequence, and is stratigraphically equivalent to the upper part of the Allison Member further south.

Total thickness of the Menefee Formation is about 1,700 ft (518 m) in the area, composed of 450 to 520 ft (137 to 158 m) of the Cleary Coal Member, 850 to 1,100 ft (259 to 335 m) of Allison Member, and about 80 ft (24 m) of the Hogback Mountain Tongue. The Hogback Mountain Tongue is defined by intertonguing with the La Ventana Tongue of the Cliff House Sandstone, which represents nearshore and beach deposits. The La Ventana Tongue is composed of light gray, medium-grained, locally calcareous, massive sandstone with

interbedded shales, and is up to 80 ft (24 m) thick in the northeastern part of the quadrangle. In this quadrangle, the upper part of the Allison Member grades northeastward into the La Ventana Tongue and associated Hogback Mountain Tongue.

The uppermost part of the La Ventana Tongue is stratigraphically equivalent to the Cliff House Sandstone farther west. The Cliff House Sandstone is commonly a massive sandstone unit, although it is represented as a much less defined unit of alternating sandstone and shale in this area. Beaumont and Shomaker (1974) note that the contact of the Cliff House Sandstone and overlying Lewis Shale is transitional in this area, indicating instability of the shorelines.

The Lewis Shale is composed of gray to black silty shale with interbedded light gray to buff, very fine-to fine-grained sandstones, and bentonite marker beds. Thickness of the unit ranges from 260 to 400 ft (79 to 122 m) in the area. The base of the Lewis Shale interfingers with the Cliff House Sandstone. Overlying the Lewis Shale, the Pictured Cliffs Sandstone represents nearshore or littoral deposits which formed during the final northeastward regression of the Cretaceous seaways in the San Juan Basin. Brown to yellow, thinly bedded, fine-to medium grained sandstone comprises the lithology of the Pictured Cliffs Sandstone, which is about 85 ft (25 m) thick locally. The continental sediments deposited inland from the beach area compose the overlying Fruitland Formation.

The Fruitland Formation is composed of dark gray to brown, locally calcareous shale with irregularly bedded, fine-grained, gray to buff sandstone, and coal beds. This unit is the primary coal-bearing formation in the San Juan Basin. Only a partial thickness of the Fruitland Formation is represented in this quadrangle.

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 is represented by 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 Tinian quadrangle is in the Chaco Slope and Central Basin structural divisions in the southern portion of the structural depression known as the San Juan Basin (Kelley, 1950). The rock units dip about 1 to 2 northwest to northwest. Dane (1936) mapped several faults in the quadrangle.

COAL GEOLOGY

In this quadrangle, the authors identified ten coal beds, a local bed, and two coal zones in oil and gas well logs and Dane's (1936) surface mapping. These beds and zones are here informally called the Menefee Cleary No. 1, No. 2, No. 3, No. 4, and No. 5 coal beds, Menefee Cleary coal zone, Menefee Allison coal zone, Menefee Allison No. 1, No. 2, and No. 2A coal beds, Menefee Hogback No. 1 coal bed, and the Fruitland No. 1 coal bed.

The Menefee Cleary No. 1 bed is the first persistent coal bed above the Point Lookout Sandstone. It occurs 2 to 6 ft (1 to 2 m) above the Point Lookout Sandstone in this quadrangle. The Menefee Cleary No. 2 bed occurs from 9 to 18 (3 to 5 m) above the Point Lookout Sandstone in this quadrangle, while the Menefee Cleary No. 3 and No. 4 beds are 42 to 43 ft (12.8 to 13.1 m) and 146 to 180 ft (45 to 55 m) above the Point Lookout Sandstone, respectively. The Menefee Cleary No. 5 bed ranges from 246 to 262 ft (75 to 80 m) and the Menefee Cleary coal zone is 25 to 430 ft (8 to 131 m) above the Point Lookout Sandstone. The local coal bed which is very limited in areal extent occurs from 501 to 602 ft (153 to 183 m)above the Point Lookout Sandstone.

Up to thirteen individual coal beds that occur from 450 to 1,090 ft (137 to 332 m) above the top of the Cleary Coal Member comprise the Menefee

Allison coal zone. These zone coals, as with all identified zone coals in this quadrangle, may be correlated for limited distances in portions of the area, but they lack sufficient continuity with poorly defined stratigraphic position and cannot be designated as persistent coal beds. The Menefee Allison No. 1, No. 2, and No. 2A coal beds occur from 470 to 520 ft (143 to 158 m), 625 to 665 ft (190 to 203 m), and 680 to 710 ft (207 to 216 m), respectively, above the top of the Cleary Coal Member.

The Menefee Hogback No. 1 coal bed was identified in two oil and gas well logs and occurs at the top of the Hogback Mountain Tongue, about 1,060 ft (323 m) above the top of the Cleary Coal Member. The Fruitland No. 1 coal bed was identified at outcrop in this quadrangle, and occurs from 5 to 15 ft (2 to 5 m) above the top of the Pictured Cliffs Sandstone.

There are several published coal quality analyses for coal beds from the Tinian quadrangle. Three analyses of core samples from the Allison Member of the Menefeee Formation in sec. 11, T. 18 N., R. 5 W., were reported by Shomaker and Whyte (1977) and are shown in table 1. The Allison Member coal beds analyzed are probably similar in quality to the other beds of the Menefee Formation in this quadrangle. Rank of the Cleary Coal Member and Allison Member seams is probably high volatile C bituminous in this area.

Menefee Allison No. 1 and No. 2A coal beds

The Menefee Allison No. 1 and No. 2A coal beds were mapped together on the same plates because they are both sufficiently limited in areal extent that they do not overlap. The isopach, structure contour, and overburden isopach lines are labeled by bed, so that the two beds may be more easily distinguished on plates 4, 5, and 6. The Menefee Allison No. 2A coal bed was identified in oil and gas well logs and is up to 9 ft (0 to 3 m) thick

Table 1. - Analyses of coal samples from the Allison Member of the Menefee Formation.

(Core sample from NE¼ NE¼ NE¼ sec. 11, T. 18 N., R. 5 W.)

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

from Shomaker and Whyte, 1977

Sample	Form of Analysis	Proximate analysis (percent) Moisture	Volatile Matter	Fixed Carbon	Ash	Sulfur	Heating Value (Btu/lb)
1	A	12.0	34.1	39.9	14.0	0.3	10,410
	B	----	38.7	45.4	15.9	0.4	11,830
	C	----	46.1	53.9	----	0.5	14,070
2	A	13.0	34.7	33.8	18.5	0.3	9,550
	B	----	39.8	39.0	21.2	0.4	10,980
	C	----	50.6	49.4	----	0.5	13,940
3	A	11.0	34.4	35.1	19.5	0.4	9,800
	B	----	38.7	39.4	21.9	0.5	11,020
	C	----	49.5	50.5	----	0.6	14,100

Remarks:

A moist, mineral-matter-free (MMMF) calculation, using the Parr formula (American Society for Testing and Materials, 1973), yields heating values of 12,270 Btu/lb (28,540 kJ/kg; sample 1), 11,940 Btu/lb (27,772 kJ/kg; sample 2), and 12,432 Btu/lb (28,917 kJ/kg; sample 3). No agglomerating characteristics are available for these analyses.

within the quadrangle. The Menefee Allison No. 1 coal bed was not identified at any point in the Tinian quadrangle, but is inferred to be up to 9.0 ft (2.7 m) thick based on Menefee Allison No. 1 coal data from the eastern adjacent Wolf Stand quadrangle. Existence and character of both beds are unknown in the northeastern part of the quadrangle because of insufficient data.

Menefee Allison No. 2 coal bed

The Menfee Allison No. 2 coal bed was identified in five oil and gas well logs, and is up to 10 ft (3m) thick. Rock partings are present in three of the drill holes. The procedure prescribed by the U. S. Geological Survey regarding rock partings in coal beds with 200 ft (61 m) or more of overburden is that the rock parting must be thicker than one coal bench to discount the thinner bench from the total coal thickness. Following this procedure, coal benches of 1.0 and 2.0 ft (0.3 and 0.6 m) thick were discounted in drill holes No. 1 and No. 6, respectively (see plate 3). The maximum thickness mapped for the bed in this quadrangle is therefore 8.5 ft (2.6 m). Existence and character of the Menefee Allison No. 2 coal bed are unknown in the northeastern part of the quadrangle because of insufficient data.

Menefee Allison coal zone

The Menefee Allison coal zone contains from five to thirteen beds in which the total coal thicknesses range from 10.0 to 29.5 ft (3.0 to 9.0 m). These beds are identified in five drill holes and in all of the surface measured sections in the quadrangle. The total coal thickness of the zone is inferred to increase to greater than 60 ft (18 m) based on data from the

eastern adjacent Wolf Stand quadrangle. Existence and character of the Menefee Allison coal zone in the northeast, southwest, and extreme southeast corners of the quadrangle are unknown because of insufficient data.

Menefee Cleary coal zone

The Menefee Cleary coal zone was identified in four oil and gas well logs and contains from one to twenty-two beds. Total measured thicknesses of the zone range up to 59 ft (18 m). Existence and character of the zone coals are unknown in the southwestern part of the quadrangle because of insufficient data.

Menefee Cleary No. 4 coal bed

The Menefee Cleary No. 4 coal bed was identified in four oil and gas well logs and its thickness ranges from 0 to 5 ft (0 to 1.5 m). The bed is inferred to occur as an elongate lens which extends from the central to the northwestern part of the quadrangle. Existence and character of the Menefee Cleary No. 4 coal bed are unknown in the southern part of the quadrangle because of insufficient data.

Menefee Cleary No. 3 coal bed

The Menefee Cleary No. 3 coal bed was identified in four oil and gas well logs and is up to 7.5 ft (2.3 m) thick in the quadrangle. Existence and character of the Menefee Cleary No. 3 coal bed are unknown in the northeastern part of the quadrangle because of insufficient data.

Menefee Cleary No. 1 coal bed

The Menefee Cleary No. 1 coal bed was identified in five oil and gas well logs. Total measured thickness ranges from 2.0 to 5.0 ft (0.6 to 1.5 m). Rock partings are present in two of the logs. Following U. S. Geological Survey guidelines, coal benches of 0.5 and 1.0 ft (0.2 and 0.3 m) were discounted in drill holes 1 and 2, respectively (see plate 3). The isopached thickness therefore varies from 1.5 to 5 ft (0.4 to 1.5 m) (see plate 22). Existence and character of the Menefee Cleary No. 1 coal bed are unknown in the northeastern corner of the quadrangle because of insufficient data.

COAL RESOURCES

The U. S. Geological Survey reguested resource evaluations of the Menefee Cleary No. 1, No. 3, and No. 4 coal beds, and the Menefee Allison No. 1, No. 2, and No. 2A 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 and hypothetical resource categories. Reserve base was calculated for each category, by section, using data from the isopach and overburden maps (plates 4, 6, 7, 9, 16, 18, 19, 21, 22, and 24). The acreage in each category (measured by planimeter) multiplied by the average coal bed thickness and a 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. Reserve base and reserve data in the various categories are shown on plates 25, 26, 27, 28, and 29.

The U. S. Geological Survey also reguested resource evaluation of the Menefee Cleary coal zone and the Menefee Allison coal zone, where the total zone coal thickness is 5.0 ft (1.5 m) or greater. Total identified resources for the Menefee Cleary coal zone are 433.62 million short tons (393.38 million t). Total identified Menefee Allison coal zone resources are 801.16 million short tons (726.81 million t). Total hypothetical resources are tabulated separately on plate 2 and in table 3.

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 mining methods (plate 30) are defined at the contact of the coal-bearing Allison Member of the Menefee Formation with the overlying noncoal-bearing Cliff House Sandstone. Additional no and unknown development potential boundaries for surface mining methods are defined at the contact of the coal-bearing Fruitland Formation with the noncoal-bearing Pictured Cliffs Sandstone. These contacts are approximate 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 acres or lot). When a land subdivision contains areas with different development potentials, the potential shown on the map is that of the areally largest component area. 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 2 and 3, 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 surface mining methods in the Tinian quadrangle is shown on plate 30. Based on coal development criteria, all Federal coal lands have low, unknown or no surface mining potentials. Refer to table 4 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 Tinian quadrangle is shown on plate 31. Based on coal development criteria all Federal coal lands have high, moderate, low or unknown subsurface mining potentials. Refer to table 5 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 2.- Reserve base data (in short tons) for surface mining methods for Federal coal lands in the Tinian quadrangle, McKinley and Sandoval Counties, 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 to 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 Allison No. 2	---	---	540,000	540,000
Total	---	---	540,000	540,000

Table 3. - Reserve base data (in short tons) and hypothetical resources for subsurface mining methods for Federal coal lands in the Tinian quadrangle, McKinley and Sandoval Counties, 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'-1,000' overburden)	Moderate Development Potential (1,000'-2,000' overburden)	Low Development Potential (2,000'-3,000' overburden)	Total
Menefee Allison No. 2A	10,980,000	---	---	10,980,000
Menefee Allison No. 2	104,830,000	---	---	104,830,000
Menefee Allison No. 1	8,480,000	---	---	8,480,000
Menefee Cleary No. 4	---	13,550,000	---	13,550,000
Menefee Cleary No. 3	100,000	104,180,000	170,000	104,450,000
Menefee Cleary No. 1	---	79,610,000	2,860,000	82,470,000
Total	124,390,000	197,340,000	3,030,000	324,760,000

Table 3. - (Continued) Reserve base data (in short tons) and hypothetical resources for subsurface mining methods for Federal coal lands in the Tinian quadrangle, McKinley and Sandoval Counties, 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'-1,000' overburden)	Moderate Development Potential (1,000'-2,000' overburden)	Low Development Potential (2,000'-3,000' overburden)	Total
Hypothetical Resources				
Menefee Allison No. 2	40,000	---	---	40,000
Menefee Cleary No. 3	---	200,000	---	200,000
Menefee Cleary No. 1	---	4,000,000	---	4,000,000
Total	40,000	4,200,000	---	4,240,000

Table 4. - Reserves and planimetered acreage, by section, for Federal coal lands in the Tinian 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)
Low	Menefee Allison No. 2	16	18	4	15.2	70,000
		17			22.8	130,000
		20			30.0	210,000
		21			7.0	30,000

Table 5. - Reserves and planimetered acreage, by section, for Federal coal lands in the Tinian 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 Allison No. 2A	16	19	5	80.6	380,000
		15			115.3	540,000
		21			54.0	220,000
		22			582.2	3,270,000
		26			156.6	640,000
		27			100.3	420,000
	Menefee Allison No. 2	16	19	5	45.6	130,000
		21			338.9	1,070,000
		22			30.4	80,000
		24			322.2	960,000
		25			320.8	1,200,000
		26			600.4	2,040,000
		27			83.6	240,000
		28			489.5	1,760,000
		34			569.7	1,750,000
		35			633.8	2,400,000
		29	19	4	79.0	260,000
		31			320.0	1,440,000
		32			160.0	650,000
		33			3.0	10,000
		1	18	5	635.9	3,490,000
		2			611.6	2,420,000
		3			615.6	1,940,000
		4			463.7	1,580,000
		9			85.6	230,000
		10			418.1	1,320,000
		11			638.6	2,700,000
		12			640.0	3,630,000

Table 5. - Reserves and planimetered acreage, by section, for Federal coal lands in the Tinian quadrangle with subsurface 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)
High	Menefee Allison No. 2	13	18	5	634.5	3,430,000
		14			482.7	1,780,000
		15			91.2	250,000
		23			304.0	960,000
		24			635.0	2,570,000
		25			68.4	190,000
		5	18	4	156.6	630,000
		7			305.4	2,060,000
		9			412.0	1,410,000
		16			76.0	200,000
		17			459.0	2,210,000
		18			156.5	1,140,000
		19			635.4	2,860,000
		20			357.2	1,120,000
		21			1.5	less than 10,000
		30			76.0	230,000
	Menefee Allison No. 1	22	18	4	169.1	880,000
		16			123.1	500,000
		21			385.2	1,690,000
		27			13.7	40,000
		15			178.2	1,050,000
		10			10.6	30,000
		9			12.2	30,000
	Menefee Cleary No. 3	33	18	4	17.5	50,000
Moderate	Menefee Cleary No. 4	22	19	5	173.6	550,000
		27			14.0	40,000
		26			500.8	1,860,000
		25			39.2	120,000
		35			247.2	930,000

Table 5. - Reserves and planimetered acreage, by section, for Federal coal lands in the Tinian quadrangle with subsurface 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. 4	2	18	5	11.2	30,000
		1			505.1	2,140,000
		12			221.2	860,000
		7	18	4	72.8	220,000
	Menefee Cleary No. 3	26	19	5	152.0	450,000
		24			36.5	100,000
		25			275.0	900,000
		22			223.5	620,000
		19	19	4	7.6	20,000
		29			81.2	280,000
		31			320.0	1,550,000
		32			107.9	330,000
		18	18	4	143.5	510,000
		7			255.4	1,190,000
		17			65.3	190,000
		20			625.1	2,810,000
		21			101.5	320,000
		19			640.0	3,570,000
		28			138.0	430,000
		29			640.0	2,880,000
		30			631.0	2,990,000
		31			206.7	690,000
		33			19.0	50,000
		25	18	5	585.0	2,100,000
		26			175.0	550,000
		23			620.0	2,230,000
		24			640.0	3,400,000
		14			479.0	2,150,000
		13			637.0	3,720,000
		15			415.0	1,380,000
		10			552.0	1,790,000
		11			629.0	3,460,000

Table 5. - Reserves and planimetered acreage, by section, for Federal coal lands in the Tinian quadrangle with subsurface 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. 3	12	18	5	639.6	3,840,000
		1			613.8	3,560,000
		2			608.0	2,350,000
		3			307.0	1,020,000
		35	19	5	175.0	560,000
	Menefee Cleary No. 1	26	19	5	454.5	1,310,000
		25			315.4	1,070,000
		35			524.6	1,590,000
		33	19	4	3.0	10,000
		31			320.0	1,150,000
		32			160.0	570,000
		29			68.8	200,000
		5	18	4	160.0	570,000
		7			320.0	1,150,000
		9			640.0	2,010,000
		10			63.4	170,000
		15			1.3	less than 10,000
		16			153.9	450,000
		17			480.5	1,810,000
		18			160.0	680,000
		19			640.0	2,450,000
		20			556.2	1,750,000
		21			52.6	150,000
		29			91.8	270,000
		30			584.5	1,840,000
		31			89.1	260,000
		33			6.1	10,000
		1	18	5	594.0	1,870,000
		2			133.6	390,000
		12			298.3	870,000
		13			499.5	1,750,000
		14			4.0	10,000
		24			640.0	2,760,000
		23			623.7	2,240,000
		22			388.8	1,230,000
		21			164.3	510,000

Table 5. - Reserves and planimetered acreage, by section, for Federal coal lands in the Tinian quadrangle with subsurface 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. 1	28	18	5	164.3	1,040,000
		27			544.8	2,080,000
		26			369.9	1,660,000
		25			577.8	2,340,000
		35			17.5	70,000
		34			195.7	770,000
		33			156.9	560,000
Low	Menefee Cleary No. 3	19	19	4	28.9	80,000
	Menefee Cleary No. 1	22	18	5	40.5	130,000
		21			80.9	230,000
		28			152.5	530,000
		27			95.1	360,000
		26			37.8	170,000

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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.