UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Text to accompany:

OPEN-FILE REPORT 79-640

1985

# FEDERAL COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS OF THE LAGUNA CASTILLO 7 1/2-MINUTE QUADRANGLE, McKINLEY COUNTY, NEW MEXICO

[Report includes 8 plates]

Prepared by Berge Exploration, Inc.

LAGUNA CASTILLO QUADRANGLE
CONTENTS



ILLUSTRATIONS

TABLES (Continued)

# INTRODUCTION

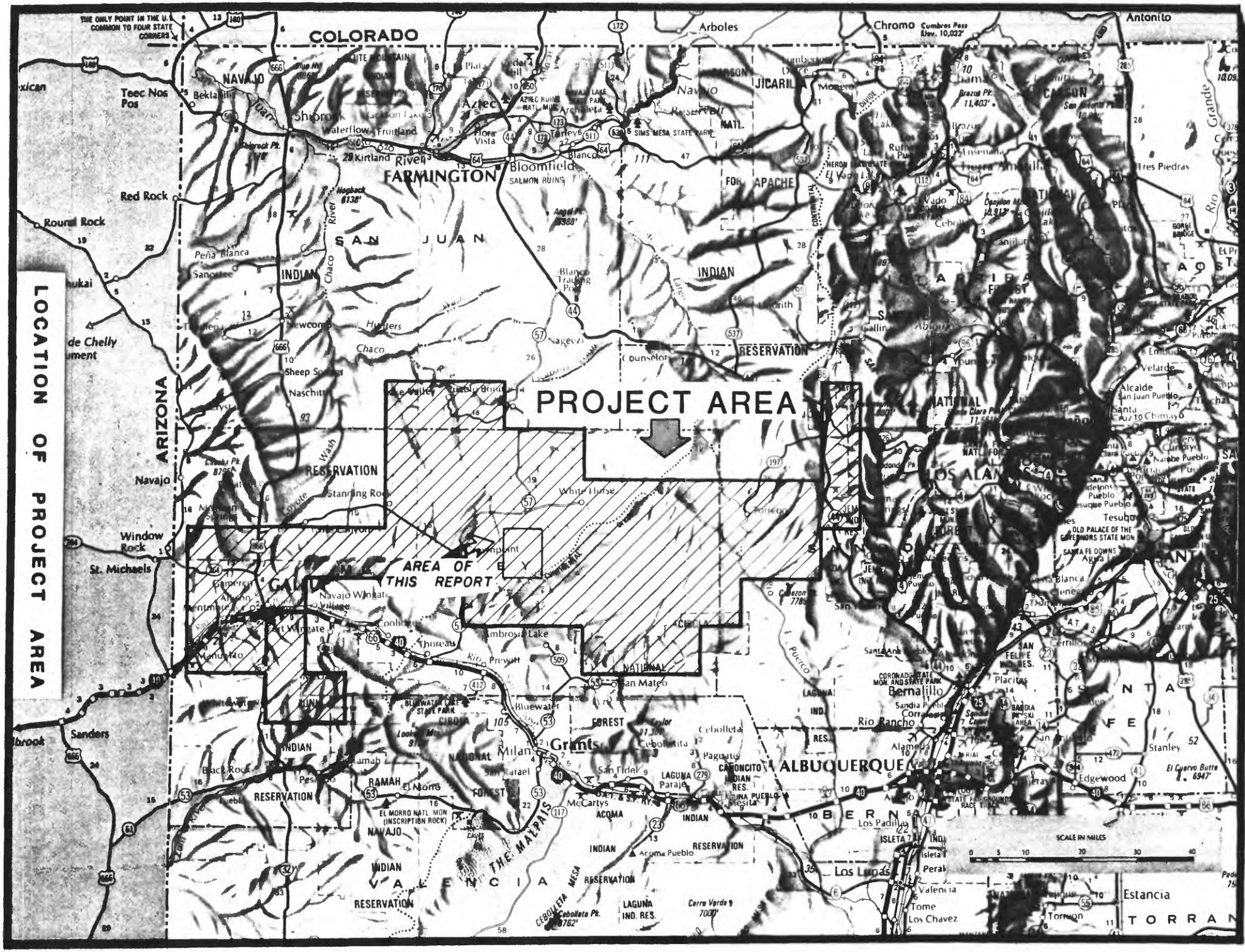
## Purpose

This text complements the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) maps of the Laguna Castillo 7 1/2 minute quadrangle, McKinley County, New Mexico. These maps and report are part of an evaluation of fifty-six 7 1/2 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 it 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 that 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 Published and unpublished public information was used as the data base for this study.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.

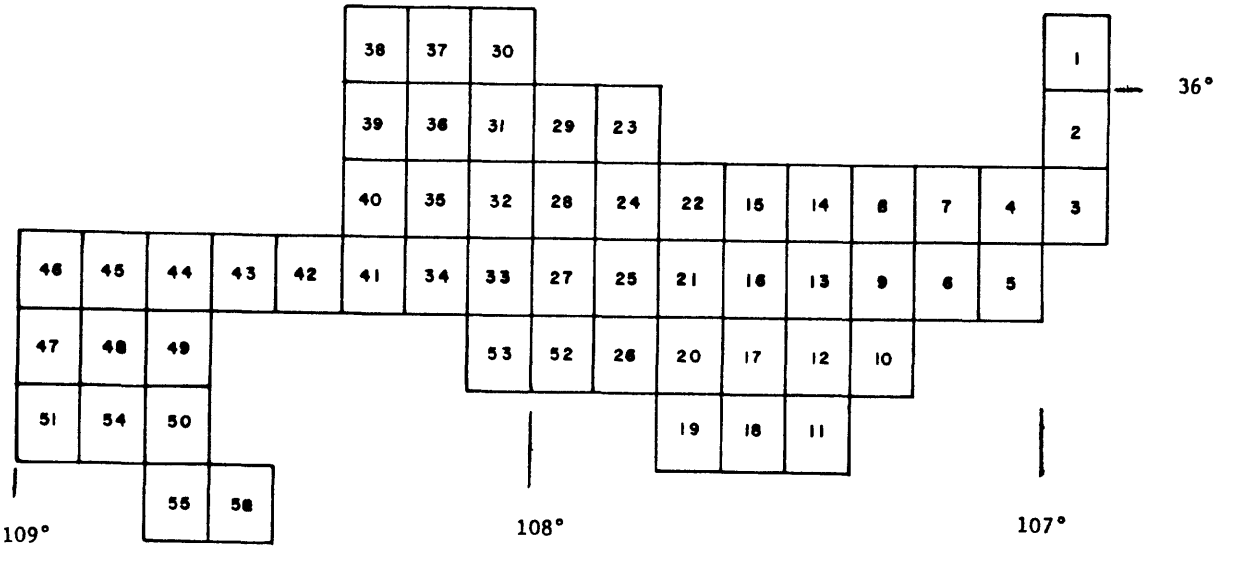



LOCATION OF PROJECT AREA

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 Laguna Castillo 7½ minute quadrangle includes acreage in Tps. 16, 17, and 18 N., Rs. 10 and 11 W. of the New Mexico Principal Meridian, McKinley County, northwestern New Mexico (see figs. 1 and 2).

## Accessibility

No paved roads pass through the Laguna Castillo quadrangle. A light-duty maintained road provides access to the town of Crownpoint, 10 mi (16 km) west of the Laguna Castillo quadrangle, via New Mexico Highway 57. Jeep trails and dirt roads traverse most parts of the area. The Atchison, Topeka, and Santa Fe Railroad line passes about 21 mi (34 km) south of the Laguna Castillo quadrangle (see fig. 1).

## Physiography

The Laguna Castillo 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 area is characterized by flatlands, rolling plains, and eroded mesas.

No perennial streams are present in the quadrangle. Local drainage is provided by intermittent arroyos. Elevations in the quadrangle range from less than 6,560 ft (2,000 m) in the northeast to over 7,160 ft (2,182 m) in the southeast corner.

## 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 Thoreau 5ENE Station. The Laguna Castillo quadrangle is about 20 mi (32 km) NE. of the Thoreau 5ENE Station. Average total annual precipitation for thirteen of the previous fifteen years is 10.84 in. (27.53 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 thirteen of the previous fifteen years is 49.4°F (9.7°C). The average daily temperatures in January and July are 30.8°F (-0.7°C) and 70.9°F (21.6°C), respectively.

## Land status

The Federal Government holds coal rights to approximately 40 percent of the Laguna Castillo 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. Most of the quadrangle is within the Crownpoint and Hospah Known Recoverable Coal Resource Areas. As of October 26, 1978, there were no Federal coal leases, coal preference right lease applications or coal exploration licenses within the Laguna Castillo quadrangle.

# GENERAL GEOLOGY

## Previous work

Early reports on the area include that of Dobbin (1932) and Hunt (1936) both of whom mapped a Menefee Cleary coal outcrop traversing the quadrangle from southeast to northwest. Hunt described the Cleary Coal Member of the Menefee Formation as containing "few worth-while beds of coal", and noted the lenticular nature of the coals. Shomaker, Beaumont, and Kottlowski (1971) reported coals in the area of the Laguna Castillo quadrangle and described the Cleary Coal Member beds as lenticular, and thickening and thinning erratically. They outlined an area with surface mining potential in the eastern adjacent Orphan Annie Rock quadrangle. No coal resources were estimated by other authors within the Laguna Castillo quadrangle.

## 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. $60^{o}$ W. - S. $60^{o}$ 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 Laguna Castillo quadrangle include some

of the sedimentary units of Cretaceous age. Quaternary deposits, including alluvium and terrace gravels are present along the drainages in the area.

The Upper Cretaceous Dalton Sandstone Member of the Crevasse Canyon Formation crops out in the extreme southwestern corner of the quadrangle, and represents nearshore or littoral deposits which formed during a regression of the Cretaceous seaways. Yellowish-gray, very fine-grained, quartzose sandstone comprises the lithology of the Dalton Sandstone Member which ranges from 125 to 160 ft (38 to 49 m) thick in the Laguna Castillo quadrangle. The continental sediments that were deposited landward from the beach area compose the overlying Gibson Coal Member of the Crevasse Canyon Formation.

Medium gray, carbonaceous siltstone with interbedded gray to tan sandstones, and coal beds comprise the lithologies of the Gibson Coal Member, which ranges from 135 to 180 ft (41 to 55 m) thick in the area. When the Creataceous seas were relatively stable with an approximate balance between basinal subsidence and deposition, the remainder of the Gibson Coal Member was deposited. As this balance was overcome by increased subsidence, the Hosta Tongue of the Point Lookout Sandstone was deposited over the Gibson Coal Member as the seaways advanced southwestward. The Hosta Tongue is composed of light gray to reddish-brown, fine-to medium-grained sandstone with interbedded shales, and ranges from 40 to 75 ft (12 to 23 m) thick locally.

As the transgression proceeded and the Cretaceous seas deepened, the Satan Tongue of the Mancos Shale was deposited over the Hosta Tongue. The Satan Tongue formed from the marine muds, and is composed of light to dark gray, silty shales with interbedded tan to buff sandstones, and

ranges from 190 to 300 ft (58 to 91 m) thick locally. The Point Lookout Sandstone overlies the Satan Tongue, and 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). Lithology of the Point Lookout Sandstone is similar to the Hosta Tongue. Thickness of the Point Lookout Sandstone ranges from 130 to 160 ft (40 to 49 m) 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 defines the boundary between the two members. The Cleary Coal Member crops out along the northern quadrangle boundary where erosion has eliminated its upper strata. In this area, the incomplete thickness of the Cleary Coal Member is about 200 ft (61 m). The Allison Member is probably not present in the Laguna Castillo 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 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 coal in the upper portions of these units are relatively sporadic in occurrence.

## Structure

The Laguna Castillo quadrangle is in the Chaco Slope structural division in the southern portion of the structural depression known as the San Juan Basin (Kelley, 1950). Topography of low relief results from

the relatively low resistance to weathering afforded by the shale and sandstone bedrock. No major structural features have been previously mapped in the area. Dips of the rock units range from 1/2° to about 1 1/2° NE. to NW. No faulting has been identified by previous workers in the Laguna Castillo quadrangle.

## COAL GEOLOGY

In this quadrangle, the authors identified one coal bed and one coal zone from Dobbin's (1932) and Hunt's (1936) surface mapping. This bed and zone are here informally called the Menefee Cleary No. 3 coal bed and Menefee Cleary coal zone. An additional coal zone, the Crevasse Canyon Gibson zone, was identified in an oil and gas well log located in the southern adjacent Borrego Pass quadrangle, and was inferred to overlap into the Laguna Castillo quadrangle. Two additional local coal beds were identified at outcrop by both Dobbin and Hunt.

The Menefee Cleary coal zone contains, stratigraphically, the highest identified coal in the Laguna Castillo quadrangle. Two separate outcrops were mapped by Dobbin, one containing 3.0 ft (0.9 m) of coal and the other with unknown thickness (see plate 1). The zone bed occurs about 100 ft (30 m) above the Point Lookout Sandstone in this quadrangle. Two local coal beds which occur from 60 to 68 ft (18 to 21 m) above the Point Lookout Sandstone are from 1.0 to 1.4 ft (0.3 to 0.4 m) thick.

The Menefee Cleary No. 3 bed is the most persistent coal bed identified in the Laguna Castillo quadrangle, and ranges from 43 to 48 ft

(13 to 15 m) above the Point Lookout Sandstone. The Crevasse Canyon Gibson coal zone is inferred to contain up to 16 ft (5 m) of coal in this quadrangle. These zone coals 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. Because of the limited areal extent of the Menefee Cleary No. 3 bed and the Crevasse Canyon Gibson coal zone, they are mapped together on the same plates (plates 4, 5, and 6).

There are no published coal quality analyses for coal beds from the Laguna Castillo quadrangle. An analysis of a Cleary Coal Member core sample taken about 2 mi (3.2 km) east of the Laguna Castillo quadrangle has been reported by Shomaker, Beaumont, and Kottlowski (1971) and is shown in table 1. The Cleary Coal Member bed analyzed is probably similar in quality to the Cleary Coal Member beds in this quadrangle. Rank of the Cleary Coal Member seams is probably subbituminous A in this area. An analysis of a sample from the Crownpoint mine of Gibson Coal Member beds taken about 8 mi (13 km) west of the quadrangle has been reported by U. S. Bureau of Mines (1936), and is shown on table 2. The Gibson Coal Member bed analyzed is probably similar in quality to the Gibson Coal Member beds in this quadrangle. Rank of the Gibson Coal Member seams is probably high volatile C bituminous in this area.

Table 1. - Analysis of a coal sample from the Cleary Coal Member of the Menefee Formation.

(Core sample from sec. 36, T. 17 N., R. 10 W.)

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

from Shomaker, Beaumont, and Kottlowski, 1971

| Form of analysis | Proximate analysis (percent) | | | | Sulfur | Heating value (Btu/lb) |
|---|---|---|---|---|---|---|
| | Moisture | Volatile Matter | Fixed Carbon | Ash | | |
| A | 16.5 | 33.4 | 40.4 | 9.7 | 0.6 | 10,070 |
| B | ---- | 40.0 | 48.3 | 11.7 | 0.7 | 12,060 |
| C | ---- | 45.3 | 54.7 | ---- | 0.8 | 13,650 |

Remarks:

A moist, mineral-matter-free (MMMF) calculation using the Parr formula (American Society for Testing and Materials, 1973) yields a heating value of 11,256 Btu/lb (26,181 kJ/kg). The free-swelling index of the analysis shows the sample to be nonagglomerating.

Table 2. - Analysis of a coal sample from the Gibson Coal Member of the Crevasse Canyon Formation.

(Mine sample from sec. 30, T. 17 N., R. 12 W.)

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

from U. S. Bureau of Mines, 1936

| Form of analysis | Proximate analysis (percent) | | | | Sulfur | Heating value (Btu/lb) |
|---|---|---|---|---|---|---|
| | Moisture | Volatile Matter | Fixed Carbon | Ash | | |
| A | 14.3 | 37.1 | 38.9 | 9.7 | 1.4 | 10,700 |
| B | --- | 42.7 | 46.1 | 11.2 | 1.5 | 12,440 |
| C | --- | 48.0 | 52.0 | ---- | 1.7 | 14,010 |

Remarks:

A moist, mineral-matter-free (MMMF) calculation using the Parr formula (American Society for Testing and Materials, 1973) yields a heating value of 11,977 Btu/lb (27,858 kJ/kg). No agglomerating characteristics are included with the analysis.

## Menefee Cleary No. 3 coal bed

The Menefee Cleary No. 3 bed crops out in the central and central western portions of the Laguna Castillo quadrangle, and ranges in thickness from 0.9 to 4.0 ft (0.3 to 1.2 m). In measured sections #6 and #8 (see plate 3) the bed is split into two coal benches separated by rock partings. The procedure prescribed by the U. S. Geological Survey regarding rock partings in coal beds with 200 ft (61 m) or less of overburden was to add all of the coal benches together as a total coal thickness. The Menefee Cleary No. 3 coal bed was inferred to pinch out in the northeast part of the quadrangle (plate 4).

## Crevasse Canyon Gibson coal zone

The Crevasse Canyon Gibson coal zone was inferred to extend into the Laguna Castillo quadrangle based on Gibson coal zone data from the southern adjacent Borrego Pass quadrangle. Because the Gibson Coal Member underlies most of the Laguna Castillo quadrangle, there is potential for additional Gibson Coal Member beds in the area. However, due to insufficient data, existence and character of the Crevasse Canyon Gibson coal zone are unknown in the northern three-fourths of the quadrangle.

## COAL RESOURCES

The U. S. Geological Survey requested a resource evaluation of the Menefee Cleary No. 3 coal bed, where the bed is 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 bed 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 (plates 4 and 6). 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) for the Gibson Coal Member seams and a subbituminous coal conversion factor (1,770 tons of coal per acre-ft) for the Cleary Coal Member seams 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 a recovery factor of 85 percent for coal beds 0 to 200 ft (0 to 61 m) deep. All reserve base and reserve values are rounded to the nearest 10,000 short tons (9,072 t).

Total reserve base data for the Menefee Cleary No. 3 coal bed, 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 plate 7.

The U. S. Geological Survey also requested a resource evaluation of the Crevasse Canyon Gibson coal zone, where the total coal thickness is 5.0 ft (1.5 m) or greater. Total identified resources for the Crevasse Canyon Gibson coal zone in the Laguna Castillo quadrangle are 74.53 million short tons (67.61 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 practices, 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 a 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 potential 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.

The no and unknown development potential boundaries for surface mining methods (plate 8) are defined at the contacts of the coal-bearing Gibson Coal Member of the Crevasse Canyon Formation and Menefee Formation with the underlying noncoal-bearing Dalton Sandstone Member of the Crevasse Canyon Formation and 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 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 mining methods is shown in table 3.

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 Laguna Castillo quadrangle is shown on plate 8. All Federal coal lands, where the Menefee Cleary No. 3 coal bed is 3.0 ft (0.9 m) or more thick, have high, moderate, low, unknown or no development potential for surface mining. 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

Based on all presently available data, the Menefee Cleary No. 3 coal bed does not underlie Federal coal lands in the Laguna Castillo quadrangle with thickness of 3.0 ft (0.9 m) or greater. Nearly all of the quadrangle is underlain by the Gibson Coal Member of the Crevasse Canyon Formation. Based on coal development potential criteria, all Federal coal land in the Laguna Castillo quadrangle has unknown development potential for subsurface mining methods.

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 3. - Reserve base data (in short tons) for surface mining methods for Federal coal lands in the Laguna Castillo quadrangle, McKinley 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 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 Cleary No. 3 | 1,980,000 | 1,470,000 | 3,130,000 | 6,580,000 |
| Total | 1,980,000 | 1,470,000 | 3,130,000 | 6,580,000 |

Table 4. - Reserves and planimetered acreage, by section, for Federal coal lands in the Laguna Castillo quadrangle with surface mining potential.

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

| Potential category | Coal bed | Sec. | T. N. | R. W. | Acres (planimetered) | Reserves (in short tons) |
|---|---|---|---|---|---|---|
| High | Menefee Cleary No. 3 | 11 | 17 | 11 | 102.8 | 610,000 |
| | | 12 | | | 97.4 | 560,000 |
| | | 13 | | | 82.5 | 420,000 |
| | | 14 | | | 16.2 | 80,000 |
| Moderate | Menefee Cleary No. 3 | 1 | 17 | 11 | 23.0 | 110,000 |
| | | 2 | | | 63.6 | 360,000 |
| | | 11 | | | 36.5 | 220,000 |
| | | 12 | | | 70.3 | 360,000 |
| | | 13 | | | 37.9 | 180,000 |
| | | 14 | | | 1.0 | less than 10,000 |
| Low | Menefee Cleary No. 3 | 1 | 17 | 11 | 52.8 | 280,000 |
| | | 2 | | | 362.6 | 1,880,000 |
| | | 11 | | | 1.0 | less than 10,000 |
| | | 12 | | | 96.1 | 480,000 |

SELECTED REFERENCES
(LAGUNA CASTILLO QUADRANGLE)

#27


American Society for Testing and Materials, 1973, Standard specification for classification of coals by rank, in American Society for Testing and Materials Standards for coal and coke: Designation D388-66, p. 54-57.

Baltz, E. H., 1967, Stratigraphy and regional tectonic implications of part of Upper Cretaceous and Tertiary rocks, east-central San Juan Basin, New Mexico: U.S. Geological Survey Professional Paper 552, 101 p.

Chapman, Wood, and Griswold, Inc., 1977, Geologic map of the Grants uranium region: New Mexico Bureau of Mines and Mineral Resources Geologic Map 31.

Dobbin, C. E., 1932, U.S. Geological Survey unpublished mapping.

Gardner, J. H., 1909, The coal field between Gallup and San Mateo, New Mexico, in Coal fields of Colorado, New Mexico, Utah, Oregon, and Virginia: U.S. Geological Survey Bulletin 341-C, p. 364-378.

Hunt, C. B., 1936, The Mount Taylor coal field, part 2 of Geology and fuel resources of the southern part of the San Juan Basin, New Mexico: U.S. Geological Survey Bulletin 860-B, p. 31-80.

Kelley, V. C., 1950, Regional structure of the San Juan Basin, in New Mexico Geological Society Guidebook of the San Juan Basin, New Mexico and Colorado, 1st Field Conference, 1950: p. 101-108.

Keroher, G. C., and others, 1966, Lexicon of geologic names of the United States for 1936-60: U.S. Geological Survey Bulletin 1200, 4341 p.

National Oceanic and Atmospheric Administration, 1964-78, Climatological data, New Mexico: National Climatic Center, Asheville, N. C., v. 68-82.

Petroleum Information Well Log Library: Denver, Colo.

Rocky Mountain Well Log Service, 1974, Catalog of electrical, radioactivity and hydrocarbon surveys: Electrical Log Services, 1974, 819 p.

Sears, J. D., 1934, The coal field from Gallup eastward toward Mount Taylor, part 1 of Geology and fuel resources of the southern part of the San Juan Basin, New Mexico: U.S. Geological Survey Bulletin 860-A, p. 1-30.

Sears, J. D., Hunt, C. B., and Hendricks, T. A., 1941, Transgressive and regressive Cretaceous deposits in southern San Juan Basin, New Mexico: U.S. Geological Survey Professional Paper 193-F, p. 101-121.

Shomaker, J. W., Beaumont, E. C., and Kottlowski, F. E., 1971, Strippable low-sulfur coal resources of the San Juan Basin in New Mexico and Colorado: New Mexico Bureau of Mines and Mineral Resources Memoir 25, 189 p.

Shomaker, J. W., and Whyte, M. R., 1977, Geologic appraisal of deep coals, San Juan Basin, New Mexico: New Mexico Bureau of Mines and Mineral Resources Circular 155, 39 p.

U.S. Bureau of Mines, 1936, Analyses of New Mexico coals: U.S. Bureau of Mines Technical Paper 569, 112 p.

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. Geological Survey Bulletin 1450-B, 7 p.

U.S. Geological Survey, 1965, Mineral and water resources of New Mexico: New Mexico Bureau of Mines and Mineral Resources Bulletin 87, 437 p.

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.