UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

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1985

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

[Report includes 3 plates (7 sheets)]

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TWIN BUTTES QUADRANGLE
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INTRODUCTION

Purpose

This text complements the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) maps of the Twin Buttes 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 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 Published and unpublished public information was used as the data base for this study.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 confiedential data used.

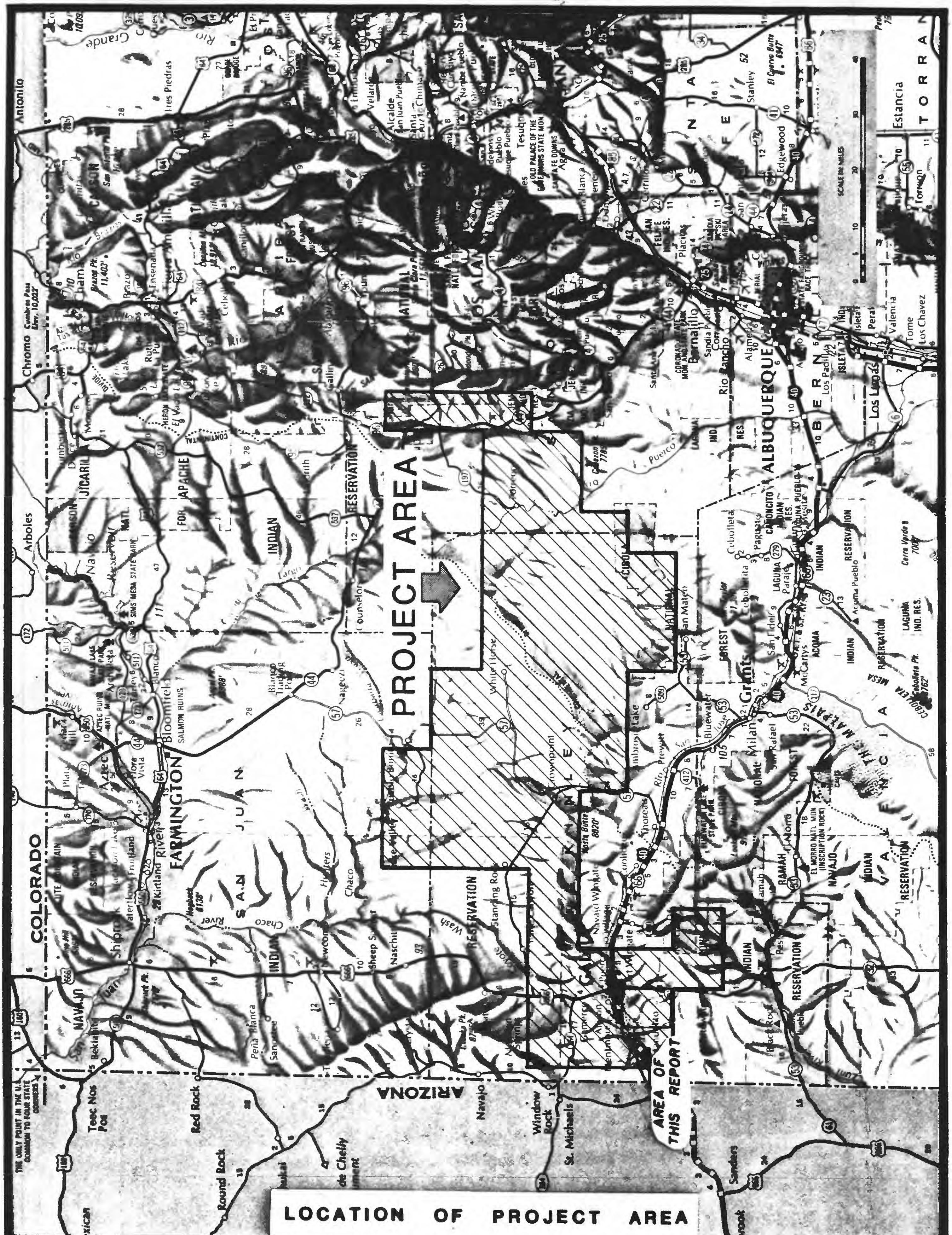
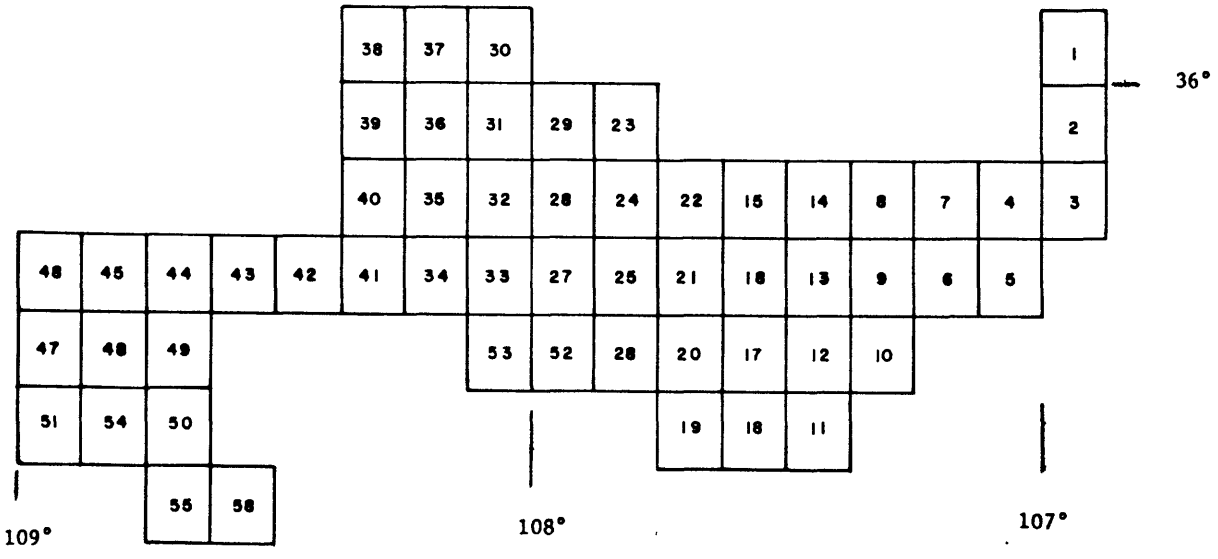

LOCATION OF PROJECT AREA
PROJECT AREA
AREA OF THIS REPORT
COLORADO
ARIZONA
FARMINGTON
ALBUQUERQUE
Grants
Gallup

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 Twin Buttes 7½ minute quadrangle includes acreage in Tps. 13, 14, and 15 N., Rs. 18 and 19 W. of the New Mexico Principal Meridian, McKinley County, northwestern New Mexico (see figs. 1 and 2).

Accessibility

Interstate Highway 40 passes through the northwest corner of the Twin Buttes quadrangle and provides access to the city of Gallup, 6 mi (10 km) northeast, and to the village of Manuelito, 9 mi (14 km) west of the quadrangle. State Route 32 passes through the southeast corner of the quadrangle and provides access to Gallup, 9 mi (14 km) northeast, and to State Route 53, 19 mi (31 km) southeast of the quadrangle. Light-duty maintained and unimproved dirt roads traverse most parts of the area. The main line of the Atchison, Topeka, and Santa Fe Railroad passes through the northwest corner of the quadrangle. The Gallup-McKinley County Airport which is less than 1 mi (2 km) north of the Twin Buttes quadrangle provides small plane access to the area.

Physiography

The Twin Buttes quadrangle is in the Navajo section of the southernmost part of the Colorado Plateau physiographic province (U. S. Geologic Survey, 1965). The topography of the quadrangle is characterized by eroded mesas, alluvial valley floors, and rugged badlands. Torrivio Mesa is a prominent landform in the northwest part of the area.

No perennial streams are present in the quadrangle. Local drainage is provided by the Puerco River and several intermittent arroyos. Elevations within the quadrangle range from less than 6,380 ft (1,945 m) along the Puerco River in the northwest to over 7,280 ft (2,219 m) on Remnant Mesa in the central eastern part of the quadrangle.

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 Gallup 5E Station. The Twin Buttes quadrangle is about 5 mi (8 km) SW of the Gallup 5E Station. Average total annual precipitation for eleven of the previous fifteen years is 9.53 in. (24.21 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 seven of the previous fifteen years is 48.8 F (9.3°C). The average daily temperatures in January and July are 29.0°F (-1.7°C) and 71.3°F (21.8°C), respectively.

Land status

The Federal Government holds the coal mineral rights to approximately 85 percent of the Twin Buttes quadrangle. For specific coal ownership boundaries, see plate 2. It is not within the scope of this report to provide detailed land-surface ownership. About 20,780 acres (4,373 ha) in the southwestern part of the quadrangle are within the Gallup 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 Twin Buttes quadrangle.

GENERAL GEOLOGY

Previous work

Early reports on the area include detailed mapping by Sears (1925) for the northern one-fifth of the Twin Buttes quadrangle. He reported coal outcrop thicknesses from the Gallup Sandstone, and Dilco and Gibson Coal Member beds. Shomaker, Beaumont, and Kottlowski (1971) reviewed the area and reported small areas within the quadrangle that contain coal beds with thicknesses of greater than 3.0 ft (0.9 m). They did not estimate any strippable coal reserves for the area. Millgate (1972) prepared a detailed, preliminary geologic map including coal thicknesses for the Twin Buttes quadrangle. He measured coal beds within the Gallup Sandstone, the Dilco Coal Member, and Gibson Coal Member.

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 Twin Buttes quadrangle include some of the sedimentary units of Upper Cretaceous age. Millgate (1972) mapped Tertiary intrusives and areas of altered sedimentary rock units associated with the intrusives in the quadrangle. Quaternary deposits include alluvium and terrace gravels from the Puerco River and its tributaries, and talus and landslide blocks in the canyons.

The "main body" of the Mancos Shale is stratigraphically the lowest exposed unit in the quadrangle and represents transgressive marine deposits. Light to dark gray, silty shales with interbedded brown, calcareous sandstones comprise the lithologies of the Mancos Shale. Thickness of the unit averages 550 ft (168 m) locally, although only a partial section of 50 ft (15 m) is shown on plate 3.

A major northeastward regression of the Cretaceous seaways followed Mancos deposition and resulted in deposition of the Gallup Sandstone in a beach or littoral environment. The Gallup Sandstone, which ranges from 185 to 250 ft (56 to 76 m) thick locally, is composed of pink to gray, fine to very coarse-grained, massive sandstone, interbedded gray shales, and coal beds. The Dilco Coal Member of the Crevasse Canyon Formation overlies the Gallup Sandstone and represents the continental sediments which were deposited inland from the beach area during deposition of the Gallup Sandstone. Medium to dark gray siltstone with interbedded medium-grained, tan sandstones, and coal beds comprise the lithologies of the Dilco Coal Member, which averages 235 ft (72 m) thick in the area.

Approximately 330 ft (101 m) of the Bartlett Barren Member overlies the Dilco Coal Member in this area. Yellowish-brown to olive-gray siltstone, light gray shales, white to brown locally calcareous sandstones, and thin local coal beds comprise the lithologies of the Bartlett Barren

Member, which represents flood plain deposits. The Crevasse Canyon Gibson-Menefee Cleary undifferentiated unit overlies the Bartlett Barren Member, and was combined based on similar lithologies and stratigraphic continuity representing essentially continuous continental deposition. Light to medium gray, carbonaceous siltstone with interbedded gray to tan sandstones, gray shales, and coal beds comprise the lithologies of the Crevasse Canyon Gibson-Menefee Cleary unit, which ranges from 230 to 400 ft (70 to 122 m) thick in this area.

The Allison Member of the Menefee Formation overlies the Crevasse Canyon Gibson-Menefee Cleary unit, and represents continued continental deposition. Light gray to dark brown, carbonaceous to noncarbonaceous shales, light gray sandstones, and thin local coal beds comprise the lithologies of the Allison Member. The unit crops out in the northeast corner of the quadrangle and a partial thickness of 30 ft (9 m) is shown on plate 3.

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 Twin Buttes quadrangle is in the Gallup Sag structural division in the southern portion of the structural depression known as the San Juan Basin (Kelley, 1950). Millgate (1972) mapped the northwest-plunging Torrivio Anticline and Syncline in the western part of the quadrangle. Hackman and Olson (1977) mapped the Allison Syncline in the northeastern part of the Twin Buttes quadrangle. Millgate (1972) and Sears (1925) mapped several low displacement faults in the area. Dips of the rock units range from 2^{o} to 15^{o} NW to SW on the western flank of the Torrivio Anticline and 2^{o} to 7^{o} NE to SE in other parts of the quadrangle.

COAL GEOLOGY

In this quadrangle, the authors identified nine coal beds and three coal zones in outcrop measured sections by Sears (1925) and Millgate (1972). These coal beds and coal zones are here informally called the Gallup coal zone, Gallup No. 1 coal bed, Crevasse Canyon Dilco No. 2 coal bed, Crevasse Canyon Dilco coal zone, Crevasse Canyon Dilco No. 3, No. 4, and No. 5 coal beds, Crevasse Canyon Gibson coal zone, and the Crevasse Canyon Gibson No. 4, No. 6, No. 7, and No. 8 coal beds.

Stratigraphically, the Gallup coal contains the lowest identified coal beds in the Twin Buttes quadrangle. Up to three individual coal beds that occur from 85 to 180 ft (26 to 55 m) below the top of the Gallup Sandstone comprise the Gallup coal zone. The Gallup No. 1 coal bed ranges in thickness from 0.3 to 2.6 ft (0.1 to 0.8 m) and occurs from 62 to 75 ft (19 to 23 m) below the top of the Gallup Sandstone.

The Crevasse Canyon Dilco No. 2 coal bed is the lowest identified Dilco Coal Member bed that occurs about 40 ft (12 m) above the top of the Gallup Sandstone in this quadrangle. Several coal beds that occur from 45 to 185 ft (14 to 56 m) above the top of the Gallup Sandstone comprise the Crevasse Canyon Dilco coal zone. The zone coals, as with all zone coals identified 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 Crevasse Canyon Dilco No. 3, No. 4, and No. 5 coal beds occur 95 ft (29 m), 130 ft (40 m), and 165 ft (50 m), respectively, above the top of the Gallup Sandstone.

The Crevasse Canyon Gibson coal zone contains up to seven individual coal beds that occur from 4 to 130 ft (1 to 40 m) above the top of the Bartlett Barren Member. The Crevasse Canyon Gibson No. 4, No. 6, No. 7, and No. 8 coal beds are 8 ft (2 m), 95 ft (29 m), 122 ft (37 m), and 135 ft (41 m), respectively, above the top of the Bartlett Barren Member. These coal beds, as with all numerically designated coal beds in this quadrangle, are inferred to be continuous, although they may be several individual coal beds that are stratigraphically equivalent.

Because most of the identified coal beds in this quadrangle are less than 3.0 ft (0.9 m) thick and limited in areal extent, the U. S. Geological Survey did not prescribe the construction of additional Coal Resource Occurrence maps.

COAL RESOURCES

The U. S. Geological Survey specified that coal beds 3.0 ft (0.9 m) or greater in thickness be included in reserve base and reserve data rather than the 28 in. (71 cm) minimum thickness presribed in U. S. Geological Survey Bulletin 1450-B. No reserve base or reserves were calculated for any of the identified coal beds in the Twin Buttes quadrangle because most of the coal beds did not qualify for resource estimates based on U. S. Geological Survey criteria.

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.

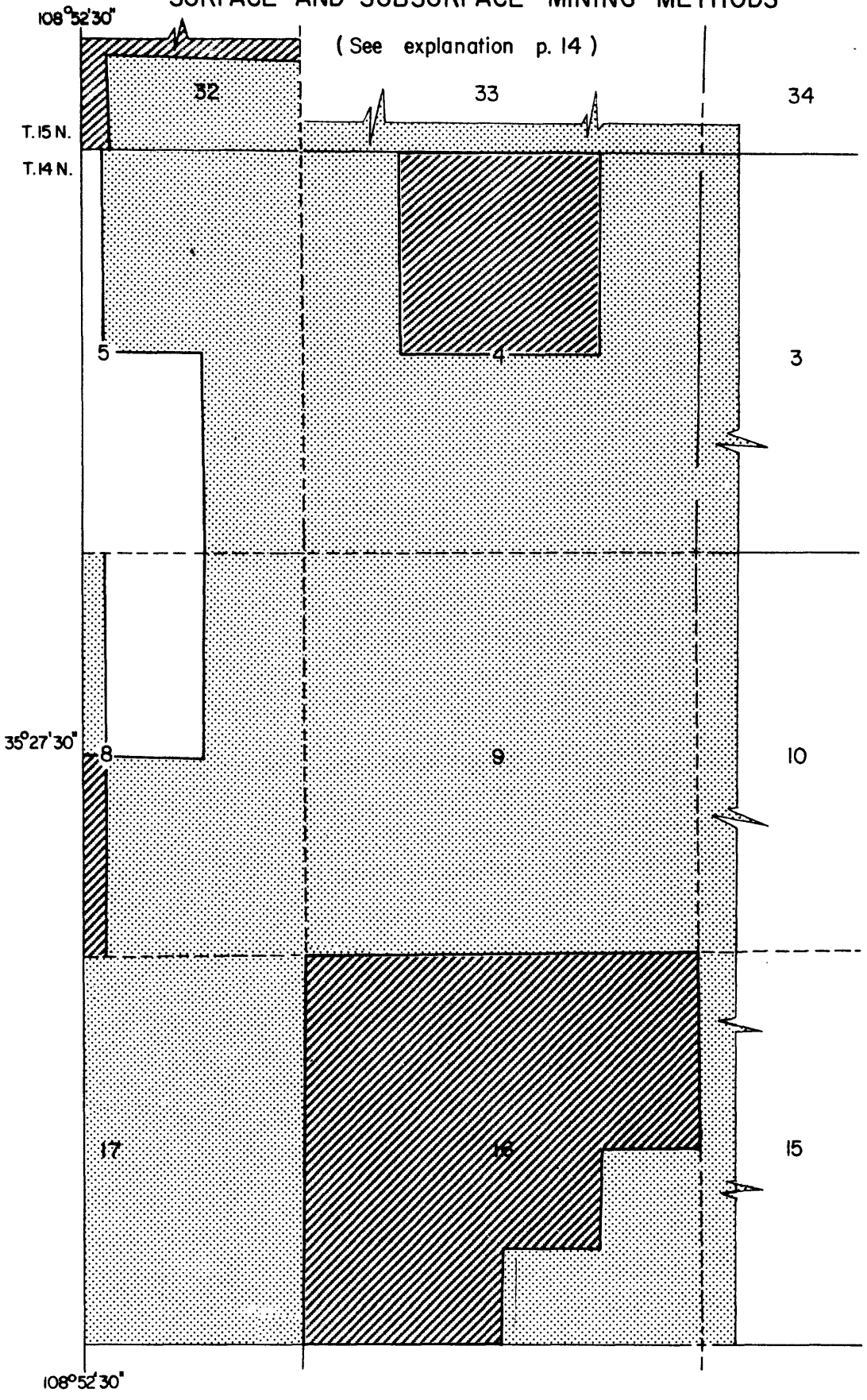
Any area underlain by a potentially coal-bearing formation with 200 ft (61 m) or less of overburden has potential for surface mining. The U. S. Geological Survey designated the 200 ft (61 m) maximum depth as the stripping limit. Areas where a potentially coal-bearing formation is overlain by more than 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.

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.

The no and unknown development potential boundaries for both surface and subsurface mining methods are defined at the contact of the coal-bearing Gallup Sandstone with the underlying noncoal-bearing "main body" of the Mancos Shale. Because of the limited areas where the no and unknown potential boundaries exist, the coal development potential for surface and subsurface mining methods are combined and shown in fig. 3.

Figure 3

COAL DEVELOPMENT POTENTIAL FOR SURFACE AND SUBSURFACE MINING METHODS

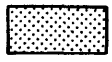


SCALE 1:24,000

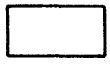
Figure 3

EXPLANATION

NON-FEDERAL COAL LAND-Land for which the Federal Government does not own the coal rights, and for which the coal development potential is not rated.



AREA OF UNKNOWN COAL DEVELOPMENT POTENTIAL FOR SURFACE AND SUBSURFACE MINING METHODS-Includes areas where the overburden is less than 3.0 feet (0.9 meters), areas with insufficient data, areas outside the coal outcrop or limit of coal beds within the Crevasse Canyon Formation or Gallup Sandstone.



AREA OF NO COAL DEVELOPMENT POTENTIAL FOR SURFACE AND SUBSURFACE MINING METHODS-Includes areas outside the Crevasse Canyon Formation and Gallup Sandstone.

To convert feet to meters, multiply feet by 0.3048.

These development potential contacts are approximated due to the inaccuracies of adjusting old geologic maps and preliminary surveys to modern topographic bases.

Boundaries of the 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. Where an area is underlain by more than one bed, the potential shown on the map is that of the bed with the highest potential.

The coal development potential of this quadrangle is subject to revision. As further coal information becomes available, it is possible that correlative coal beds with sufficient thicknesses may be identified. Additional coal data will likely define areas of Federal coal lands with development potentials other than no and unknown.

Development potential for surface and subsurface mining methods, and in situ gasification

The coal development potential for surface and subsurface mining methods in the Twin Buttes quadrangle is shown in fig. 3. Based on coal development potential criteria, all Federal coal lands have unknown development potential for surface and subsurface mining methods, except a small area of no development potential in the northwestern part of the quadrangle.

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.

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GLOSSARY

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.