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GEOLOGICAL SURVEY

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1985

FEDERAL COAL RESOURCE OCCURRENCE MAPS  
OF THE KIN KLIZHIN RUINS 7 1/2-MINUTE QUADRANGLE,  
SAN JUAN AND MCKINLEY COUNTIES, NEW MEXICO

[Report includes 2 plates]

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## INTRODUCTION

### Purpose

This text complements the Coal Resource Occurrence (CRO) and Coal Development Potential (CDP) maps of the Kin Klizhin Ruins 7½ minute quadrangle, McKinley County, 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.

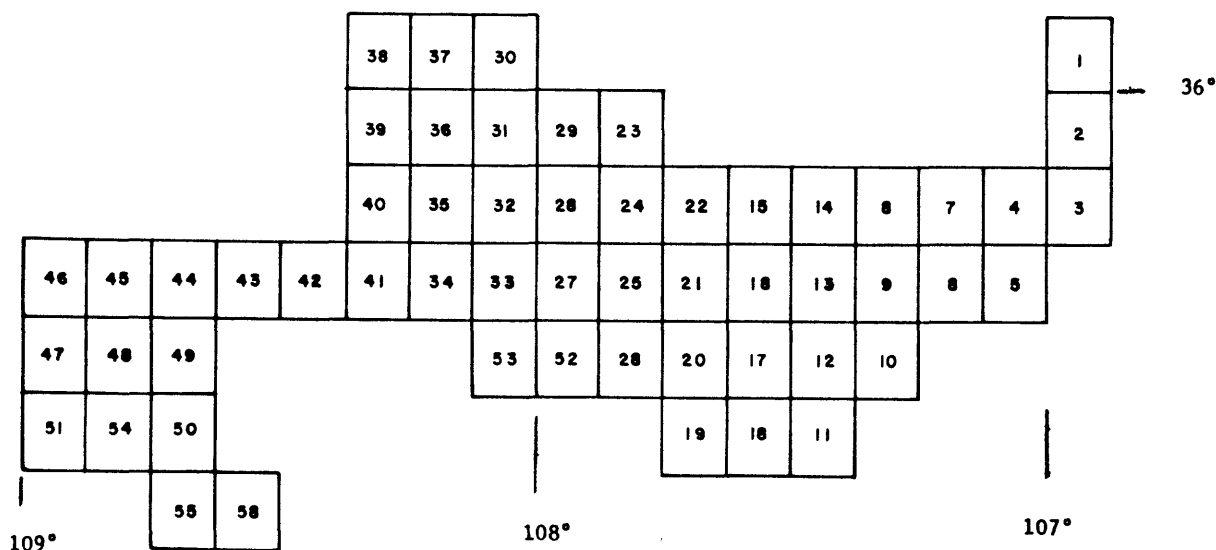
The U. S. Geological Survey initiated the program by identifying areas underlain by coal resources. These areas were designated Known Recoverable Coal Resource Areas based on the presence of minable coal thicknesses, adequate areal extent of these coal deposits, and the potential for developing commercial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

This report is limited to coal resources 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 Published and unpublished public information was used as the data base for this study.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.



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	Borrogo 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 Kin Klizhin Ruins 7½ minute quadrangle includes acreage in Tps. 20, 21 and 22 N , Rs. 11 and 12 W of the New Mexico Principal Meridian, San Juan and McKinley Counties, northwestern New Mexico (see figs. 1 and 2). The Chaco Canyon National Monument is present in the eastern part of the quadrangle.

## Accessiblity

No paved roads pass through the Kin Klizhin Ruins quadrangle. Unimproved dirt roads traverse most parts of the area, and provide access to State Highway 57 and the town of Pueblo Bonito, about 2 mi (3 km) east of the quadrangle. The Atchison, Topeka, and Santa Fe Railroad line passes about 42 mi (68 km) due south of the Kin Klizhin Ruins quadrangle (see fig. 1).

## Physiography

The Kin Klizhin Ruins 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. West Mesa is a prominent mesa near the eastern quadrangle boundary.

No perennial streams are present in the area. The Chaco River is the major drainage in the area, and local drainage is provided by several intermittent arroyos. Elevations within the quadrangle range from less than 5,920 ft (1,804 m) along the Chaco River in the northwest to over 6,620 ft (2,018 m) on West 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 Chaco Canyon National Monument Station. The Kin Klizhin Ruins quadrangle is about 6 mi (10 km) west of the Chaco Canyon National Monument Station. Average total annual precipitation for the last thirteen years is 8.75 in. (22.23 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 the last thirteen years is 48.4<sup>0</sup> F (9.1<sup>0</sup> C). The average daily temperatures in January and July are 26.3<sup>0</sup> F (-3.2<sup>0</sup> C) and 72.5<sup>0</sup> F (22.5<sup>0</sup> C), respectively.

## Land status

The Federal Government holds the coal mineral rights to approximately 45 percent of the Kin Klizhin Ruins quadrangle. For 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 western one-third of the quadrangle is within the Tsaya Known Recoverable Coal Resource Area. About 85 acres (34 ha) along the eastern edge of the quadrangle in sec. 34, T. 21 N., R. 11 W. and sec. 3, T. 20 N., R. 11 W. are within the Hospah 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 Kin Klizhin Ruins quadrangle.

## GENERAL GEOLOGY

### Previous work

Early reports on the area include that of Bauer and Reeside (1921) who mapped coals near the Kin Klizhin Ruins quadrangle. Dobbin (1932) mapped the surface geology of the area, indicating Menefee Formation coal outcrops but reported no coal measurements. O'Sullivan, et. al., 1972, summarized the stratigraphic relationships of the Upper Cretaceous and lower Tertiary rock units in the area. O'Sullivan, Scott, and Weide (1979) mapped the surface geology of the Kin Klizhin Ruins quadrangle, but did not include coal occurrences in their report. O'Sullivan (1980) measured nineteen coal sections within the quadrangle. His work became publicly available 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 Kin Klizhin Ruins quadrangle include some of the sedimentary units of Upper Cretaceous age. There is Quaternary alluvium and terrace gravels along the Chaco River and other drainages in this area.

The Point Lookout Sandstone is a prominent sandstone marker in most of the San Juan Basin 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). The unit is composed of light gray to reddish-brown, fine to medium grained sandstone with interbedded shales and is 80 to 100 ft (24 to 30 m) thick locally. The continental sediments deposited inland from the beach area during deposition of the Point Lookout Sandstone compose the overlying Menefee Formation.

The Menefee Formation consists of dark gray to brown, carbonaceous to noncarbonaceous shales, light gray sandstones, and coal beds, and is divisible into the basal Cleary Coal Member and upper Allison Member. A massive channel sandstone sequence defines the boundary between the two members. The Cleary Coal Member ranges from 375 to 425 ft (114 to 130 m) thick locally, and the Allison Member is about 1,125 to 1,175 ft (343 to 358 m) thick where the full section is present. Intertonguing of the Allison Member with the overlying Cliff House Sandstone indicates the instability of the Cretaceous shorelines during transition from regressive to transgressive depositional conditions in this area.

The Cliff House Sandstone formed in a marine, nearshore environment as the Cretaceous seaways advanced southwestward during the final transgression in the San Juan Basin. Light gray, medium grained, occasionally calcareous sandstone with interbedded shales comprise the lithologies of the Cliff House Sandstone, which is about 370 ft (113 m) thick locally.

As the advancing seaways deepened, the Lewis Shale was deposited from the marine sands, silts, and muds. The Lewis Shale overlies the Cliff House Sandstone and is composed of gray to black, silty shale with interbedded light gray to buff, very fine to fine grained calcareous sandstones and bentonite marker beds. The Lewis Shale crops out along the northern quadrangle boundary and is about 100 ft (30 m) thick locally. 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 comprise the lithology of the Pictured Cliffs Sandstone. A partial section of the Pictured Cliffs Sandstone is present in the northeastern corner of the 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 of 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 Kin Klizhin Ruins 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 from  $1^{\circ}$  to  $2^{\circ}$  N to NE. No local faulting has been mapped in the area.

### COAL GEOLOGY

In this quadrangle, the authors identified one coal zone in Dobbin's (1932) surface mapping. The zone is here informally called the Menefee Allison coal zone. Because Dobbin did not report coal outcrop measurements,

coal data are insufficient for constructing additional maps. O'Sullivan (1980) measured upper Allison Member coals in the area, but his work was not incorporated in these maps.

## COAL RESOURCES

Because there are no identified correlative coal beds on Federal coal lands in the Kin Klizhin Ruins quadrangle, no reserve base or reserves have been calculated.

## 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.

The Menefee Formation is potentially coal-bearing in this area and based on coal development potential criteria, all Federal coal land has unknown development potential for surface and 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.

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 thickness may be identified. These coal data will likely define areas of Federal coal lands which will have development potentials other than 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 foreseeable 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.