

UNITED STATES DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY

Text to accompany:

OPEN-FILE REPORT 79-639

1985

FEDERAL COAL RESOURCE OCCURRENCE AND COAL DEVELOPMENT POTENTIAL MAPS  
OF THE KIN NAHZIN RUINS 7 1/2-MINUTE QUADRANGLE,  
MCKINLEY COUNTY, NEW MEXICO

[Report includes 19 plates]

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KIN NAHZIN RUINS QUADRANGLE  
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## INTRODUCTION

### Purpose

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 Published and unpublished public information was used as the data base for this study.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

FIGURE 1



## Location

The Kin Nahzin Ruins 7½ minute quadrangle includes acreage in Tps. 18 and 19 N., Rs. 9 and 10 W. of the New Mexico Principal Meridian, McKinley County, northwestern New Mexico (see figs. 1 and 2).

## Accessibility

A light-duty paved road traverses the quadrangle and connects to the town of Whitehorse, 0.2 mi (0.3 km) east, and to State Highway 57, 3.5 mi (5.6 km) west of the quadrangle. Another light-duty road in the southeast part of the area provides access to the town of Hospah, 1.3 mi (2.1 km) southeast of the quadrangle. Unimproved dirt roads traverse most parts of the area. The Atchison, Topeka, and Santa Fe Railroad line parallels Interstate Highway 40 about 42 mi (68 km) south of the Kin Nahzin Ruins quadrangle (see fig. 1).

## Physiography

The Kin Nahzin Ruins quadrangle is in the Navajo section of the southernmost part of the Colorado Plateau physiographic province (U. S. Geological Survey, 1965). The quadrangle is characterized by eroded mesas and flatland topography. The Continental Divide passes through the southeastern corner of the quadrangle.

Drainage is provided by several intermittent arroyos in the area. There are no perennial streams in the area. Elevations within the quadrangle

range from less than 6,480 ft (1,975 m) in the northwest corner to 7,260 ft (2,213 m) near the Continental Divide in the southeastern corner of the area.

#### 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 Nahzin Ruins quadrangle is about 15 mi (24 km) southeast of the Chaco Canyon National Monument Station. Average total annual precipitation for thirteen of the previous fifteen 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 eleven of the previous fifteen years is 48.4<sup>0</sup>F (9.1<sup>0</sup>C). The average daily temperatures in January and July are 26.2<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 coal rights to approximately 25 percent of the Kin Nahzin Ruins 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. All of the quadrangle is 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 Nahzin Ruins quadrangle.

## GENERAL GEOLOGY

### Previous work

Early reports on the area include fieldwork by Gardner (1909) covering portions of the Kin Nahzin Ruins quadrangle, although he reported no coals. Dobbin (1932) mapped the area but did not report any coal outcrops. Shomaker, Beaumont, and Kottowski (1971) noted the area but did not estimate any strip-pable reserves. Shomaker and Whyte (1977) estimated Menefee Formation coal resources with 0 to 500 ft (152 m) of overburden in T. 18 N., R. 10 W. and T. 19 N., Rs. 9 and 10 W. Portions of these areas are within the Kin Nahzin Ruins 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° W. - S. 60° E. (Sears, Hunt, and Hendricks, 1941). The transgressive and regressive shoreline migrations are evidenced by the intertonguing relationships of the 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 Nahzin Ruins quadrangle include some of the sedimentary units of Upper Cretaceous age. There is Quaternary alluvium along drainages in the 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). Light gray to reddish-brown, fine-to-medium-grained massive sandstone with interbedded shales comprise the lithologies of the unit, which ranges from 95 to 145 ft (29 to 44 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 contains the thickest and most extensive coal beds in this quadrangle. Average thickness of the Cleary Coal Member is 375 ft (114 m) in this quadrangle. Erosion has locally eliminated the upper strata of the Cleary Coal Member and Allison Member. The Allison Member averages 230 ft (70 m) thick locally, and increases in thickness to over 480 ft (146 m) at the northern quadrangle boundary.

#### 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 Kin Nahzin Ruins quadrangle is in the Chaco Slope structural division in the southern portion of the structural depression known as the

San Juan Basin (Kelley, 1950). The Hospah Dome is the major structural feature which is present in the southeastern part of the quadrangle. Dips range from  $1^{\circ}$  to  $2^{\circ}$  NE. to NW., with local variations. No faulting has been identified by Dobbin (1932) within the Kin Nahzin Ruins quadrangle.

## COAL GEOLOGY

In this quadrangle, the authors identified three coal beds and one coal zone in oil and gas well logs. The beds and the zone are here informally called the Menefee Cleary No. 1, No. 2, and No. 3 coal beds, and the Menefee Cleary coal zone. Two additional coal beds were designated local coal beds because of their limited extent.

The Menefee Cleary No. 1 coal bed is stratigraphically the lowest coal identified, and occurs from 1 to 10 ft (0.3 to 3 m) above the Point Lookout Sandstone in this quadrangle. The Menefee Cleary No. 2 coal bed was not identified in the Kin Nahzin Ruins quadrangle, but was inferred to be present based on Menefee Cleary No. 2 coal data from the eastern adjacent Whitehorse quadrangle. In surrounding quadrangles, the Menefee Cleary No. 2 bed occurs from 20 to 30 ft (6 to 9 m) above the Point Lookout Sandstone. The Menefee Cleary No. 3 bed was identified in seven of the eight well logs, and ranges from 71 to 112 ft (22 to 34 m) above the Point Lookout Sandstone in this quadrangle. These coal beds are inferred to be continuous, although they may be several individual coal beds that are stratigraphically equivalent.

Up to five individual beds which occur from 9 to 330 ft (3 to 101 m) above the Point Lookout Sandstone comprise the Menefee Cleary coal zone. The zone contains up to 18.5 ft (5.6 m) of total coal. 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.

There are no published coal quality analyses for coal beds from the Kin Nahzin Ruins quadrangle. An analysis of a Cleary Coal Member core sample taken about 6 mi (10 km) south of the quadrangle has been reported by Shomaker, Beaumont, and Kottowski (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.

#### Menefee Cleary coal zone

The Menefee Cleary coal zone was identified in six of the eight drill holes in the Kin Nahzin Ruins quadrangle. The thickest individual zone bed is 5.0 (1.5 m) thick, but it is laterally discontinuous. The 5 ft (1.5 m) isopach line (plate 4) in the extreme southwestern corner of the quadrangle is derived from Menefee Cleary zone data in the eastern adjacent Whitehorse quadrangle. Existence and character of the Menefee Cleary zone coals are unknown in the northeastern portion of the quadrangle because of insufficient data

#### Menefee Cleary No. 3 coal bed

The Menefee Cleary No. 3 coal bed is the third persistent coal bed above the Point Lookout Sandstone. In this quadrangle, the Menefee Cleary No. 3 bed is up to 7 ft (2.1 m) thick and eventually pinches out (see plate 7). Due to inadequate control, existence and character of the Menefee Cleary No. 3 bed are unknown in the northeastern portion of the quadrangle.

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.

### Menefee Cleary No. 2 coal bed

The Menefee Cleary No. 2 coal bed is the second persistent coal bed above the Point Lookout Sandstone. All Menefee Cleary No. 2 coal bed data was inferred from the Whitehorse quadrangle (see plate 10). Existence and character of the bed are unknown in the northeastern portion of the quadrangle because of insufficient data.

### Menefee Cleary No. 1 coal bed

The Menefee Cleary No. 1 coal bed is the first persistent coal bed above the Point Lookout Sandstone. The Menefee Cleary No. 1 bed is up to 5.0 ft (1.5 m) thick within the quadrangle. Coal bed data from the surrounding quadrangles influence the configuration of the isopach, structure contour, and overburden isopachs. Existence and character of the coal bed are unknown in the northeastern part of the quadrangle because of insufficient data.

## COAL RESOURCES

The U. S. Geological Survey requested resource evaluations of the Menefee Cleary No. 3, No. 2, and No. 1 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 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 7, 9, 10, 12, 13, and 15). The acreage in each category (measured by planimeter) multiplied by the average coal bed thickness and subbituminous coal conversion factor (1,770 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 a recovery factor of 50 percent for coal beds 200 to 3,000 ft (61 to 914 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, No. 2, and No. 1 coal beds, 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 16, 17, and 18.

The U. S. Geological Survey also requested a resource evaluation of the Menefee Cleary coal zone. Total identified resources were calculated only where the total zone coal thickness is 5.0 ft (1.5 m) or greater. The Menefee Cleary coal zone has identified resources totaling 24.81 million short tons (22.51 million t) in the Kin Nahzin Ruins quadrangle.

#### 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 strip-ping 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 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).

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) for the high development potential category for subsurface mining methods is shown in table 2.

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

Based on coal development potential criteria, all Federal coal land has unknown development potential for surface mining methods in the Kin Nahzin Ruins quadrangle.

#### Development potential for subsurface mining methods and in situ gasification

The coal development potential for subsurface mining methods in the Kin Nahzin Ruins quadrangle is shown on plate 19. Based on coal development criteria, all Federal coal lands have subsurface mining potentials of high or unknown. Refer to table 3 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 subsurface mining methods for Federal coal lands in the Kin Nahzin Ruins quadrangle, McKinley County, New Mexico.

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

Coal Bed	High Development Potential (200'-1,000' overburden)	Moderate Development Potential (1,000'-2,000' overburden)	Low Development Potential (2,000'-3,000' overburden)	Total
Menefee Cleary No. 1	5,790,000	---	---	5,790,000
Menefee Cleary No. 2	770,000	---	---	770,000
Menefee Cleary No. 3	4,190,000	---	---	4,190,000
Total	10,750,000	---	---	10,750,000

Table 3. - Reserves and planimetered acreage, by section, for Federal coal lands in the Kin Nahzin Ruins quadrangle with subsurface 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. 1	20	18	9	21.3	62,000
		24			1.5	less than 10,000
		26			576.2	2,000,000
		32			138.3	500,000
		34			95.8	290,000
	Menefee Cleary No. 2	14	18	9	52.2	130,000
		24			60.8	240,000
	Menefee Cleary No. 3	22	18	9	579.2	1,820,000
		24			50.1	150,000
		26			47.2	120,000

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(KIN NAHZIN RUINS QUADRANGLE)

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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 particulate 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.