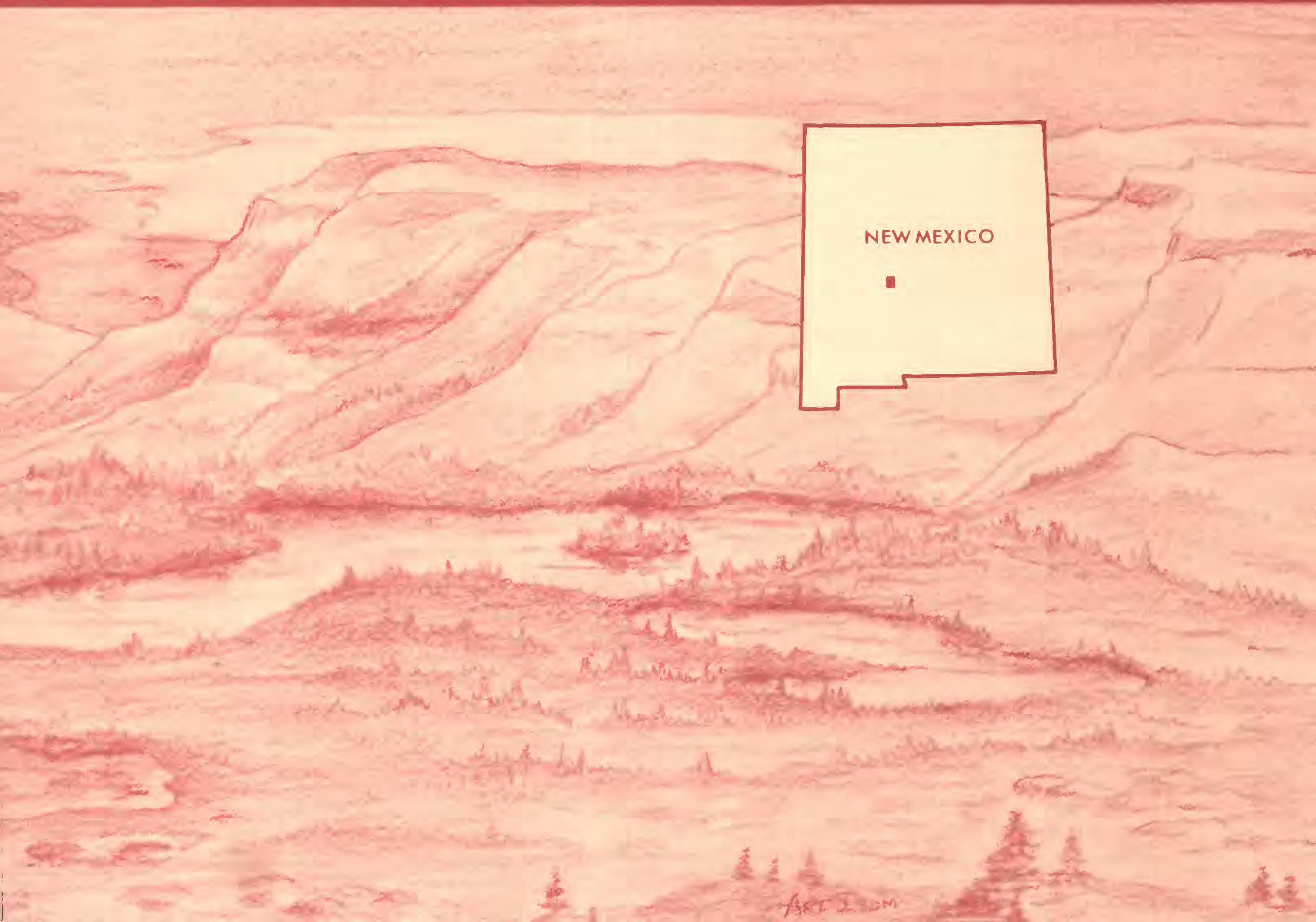
Mineral Resources of the Antelope Wilderness Study Area, Socorro County, New Mexico

U.S. GEOLOGICAL SURVEY BULLETIN 1734–B



Chapter B

Mineral Resources of the Antelope Wilderness Study Area, Socorro County, New Mexico

By DONALD H. RICHTER and RICHARD W. SALTUS
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U.S. GEOLOGICAL SURVEY BULLETIN 1734

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
WEST-CENTRAL NEW MEXICO

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

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STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94–579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of a part of the Antelope (NM-020–053) Wilderness Study Area, Socorro County, New Mexico.

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Mineral Resources of the Antelope Wilderness Study Area, Socorro County, New Mexico

By Donald H. Richter *and* Richard W. Saltus
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Stanley L. Korzeb
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SUMMARY

The USBM (U.S. Bureau of Mines) and USGS (U.S. Geological Survey) studied 9,892 acres of the Antelope (NM–020–053) Wilderness Study Area to appraise the mineral resources and assess the mineral resource potential. These investigations revealed (1) no identified mineral resources, (2) a high mineral resource potential for undiscovered sand in the southeastern part of the study area and a low resource potential for undiscovered sand in the rest of the study area, (3) a moderate mineral resource potential for undiscovered coal in the northern one-third of the study area and a low resource potential for undiscovered coal in the rest of the study area, and (4) a low mineral resource potential for undiscovered metals and oil and gas in the entire study area (fig. 1).

The Antelope Wilderness Study Area is 25 mi south of the city of Socorro in Socorro County, central New Mexico (fig. 2). The area overlies an extensive and relatively flat alluvial plain perched a few hundred feet above the modern flood plain of the Rio Grande. The alluvial deposits, which may be as much as 100 ft thick, cover sedimentary and volcanic rocks ranging from the fanglomerate of the Tertiary and Quaternary Santa Fe Group to the limestone of the Pennsylvanian Magdalena Group. Coal-bearing strata of the Cretaceous Mesaverde Group sandstone beds may underlie the northern part of the wilderness study area at relatively shallow depths.

There has been no mineral production in the study area, nor are there any mineral prospects or claims. The study area has no identified mineral resources. The Carthage coal field, about 5 mi northeast of the study area, has produced high-volatile A bituminous coal. Similar rocks crop out within 2 mi of the northern part of the study area, and they may be present within a few hundred feet of the surface in the northern part of the study area. The northern one-third of the wilderness study area therefore has a moderate mineral resource potential for coal. The southeastern part of the study area contains active sand dunes. These areas have a high resource potential for sand. The rest of the study area has a low resource potential for sand. The entire wilderness study area has a low mineral resource potential for metals (including sedimentary uranium deposits) and oil and gas.

INTRODUCTION

The USGS and the USBM studied 9,892 acres of the Antelope Wilderness Study Area (NM–020–053) in 1985. The study of this acreage was requested by the BLM (U.S. Bureau of Land Management). In this report the studied area is referred to as the "wilderness study area" or simply the "study area."

The wilderness study area is approximately 25 mi south of the city of Socorro in central New Mexico, on the east side of the Rio Grande, contiguous to the Bosque del Apache National Wildlife Refuge (fig. 2). Access is by an occasionally improved dirt road that services remote ranches in the area; passage can be difficult during periods of inclement weather. The access road extends south from U.S. 380 about 6 mi east of the small town of San Antonio.

The wilderness study area is entirely within the Rio Grande rift valley. It overlies a broad plain, 4,700–4,900 ft in elevation, perched about 300 ft above the modern flood plain of the Rio Grande. The plain is completely overlain by alluvial and eolian deposits. The plain is underlain by older alluvial deposits of the upper Tertiary

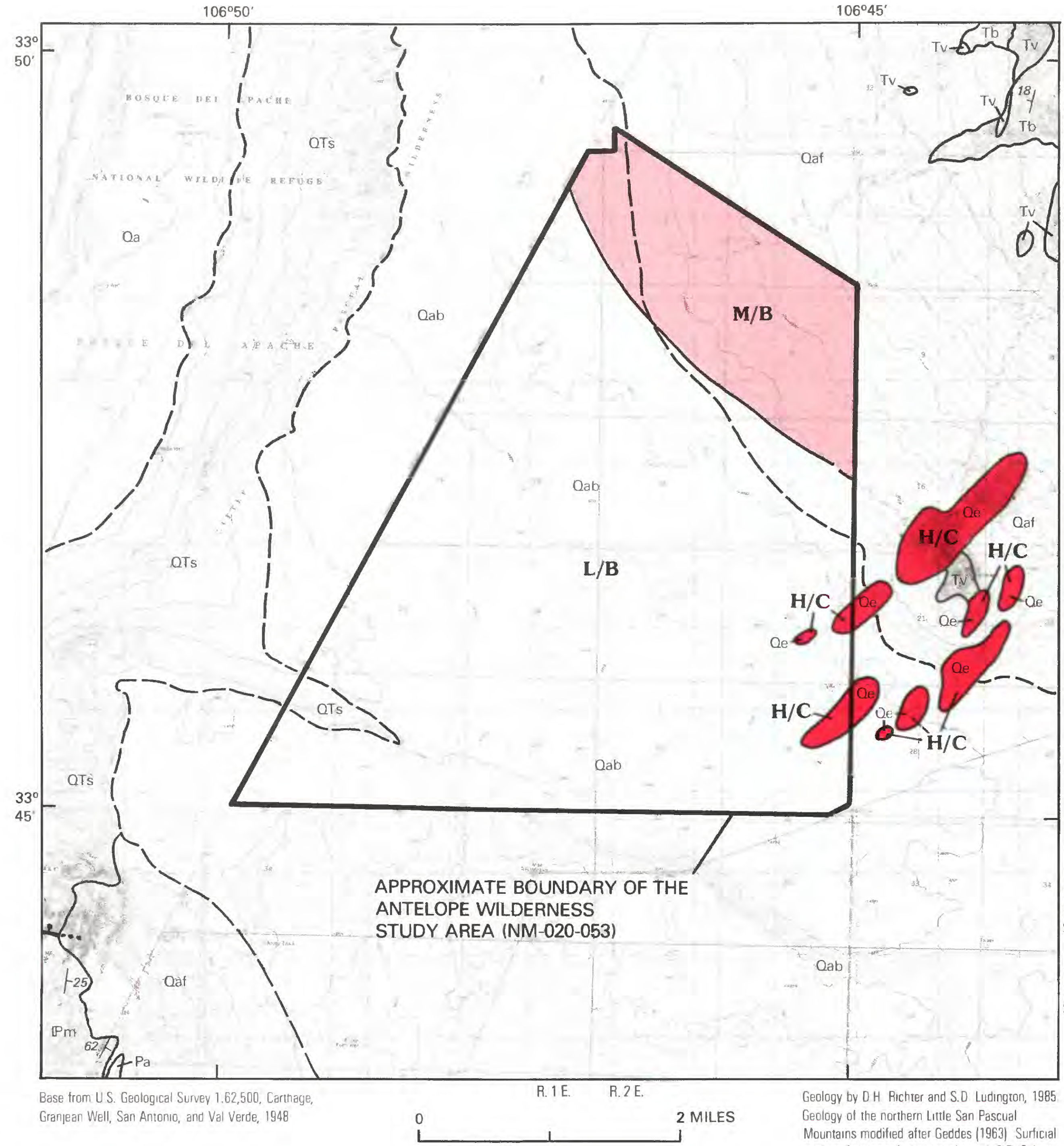


Figure 1 (above and facing page). Map showing mineral resource potential and geology of the Antelope Wilderness Study Area and vicinity, Socorro County, New Mexico.

EXPLANATION OF MINERAL RESOURCE POTENTIAL

H/C **Geologic terrane having high mineral resource potential for sand, with certainty level** C

M/B **Geologic terrane having moderate mineral resource potential for coal, with certainty level B**

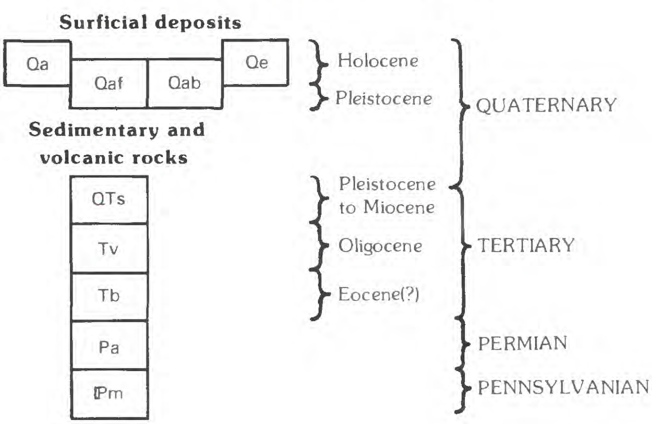
L/B **Geologic terrane having low mineral resource potential for metals (including sedimentary uranium deposits), oil and gas, coal (except as noted above), and sand (except as noted above), with certainty level B**—Applies to entire study area

Certainty levels

B **Data indicate geologic environment and suggest level of resource potential**

C **Data indicate geologic environment and resource potential but do not establish activity of resource-forming processes**

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Qe **Eolian deposits (Holocene)**—Active sand dunes. Maximum thickness about 25 ft

Alluvial fan deposits

Qa **Alluvium of Rio Grande flood plain (Holocene)**—Chiefly sand, silt, and mud. May include some coarser alluvium in fan deposits of side arroyos. Thickness unknown

Qaf **Alluvium in broad fans (Holocene and Pleistocene)**—Deposits marginal to upland areas consisting chiefly of rounded and poorly sorted sand, gravel, and boulders. Deposits locally reworked by small, intermittent streams. Maximum thickness about 100 ft

Qab **Alluvium of closed basins (Holocene and Pleistocene)**— Chiefly poorly indurated mudstone, siltstone, and sandstone. Gradational laterally into alluvial fan deposits (unit Qaf) and downward into younger deposits of the Santa Fe Group (unit QTs). Deposits locally veneered by eolian sands. Maximum thickness about 200 ft

QTs **Santa Fe Group, undivided (Pleistocene to Miocene)**—Chiefly flood-plain deposits of the ancestral Rio Grande and fanglomerate shed into Rio Grande valley from adjacent highlands. Deposits consist of buff, reddish-brown, and gray, moderately to poorly indurated conglomerate, sandstone, and minor siltstone and mudstone. Maximum exposed thickness about 100 ft; maximum thickness underlying wilderness study area may be as much as 2,000 ft

Tv **Volcanic rocks (Oligocene)**—Medium-gray to grayish-red, porphyritic, high-potassium, calc-alkaline andesite flows and shallow intrusives. Rocks contain 30-40 percent phenocrysts (2-5 mm) of plagioclase (15-25 percent), clinopyroxene (5-10 percent), hypersthene (0-5 percent) altered to serpentine, and opaque minerals (1-3 percent) in a pilotaxitic groundmass of feldspar laths and mafic minerals. Probably equivalent to the Datil Group (Osburn and Chapin, 1983). Maximum thickness about 200 ft

Tb **Baca Formation (Eocene?)**—Reddish-brown coarse conglomerate, reddish-brown and very light gray sandstone, and reddish-brown siltstone and mudstone. Conglomerate beds contain pebble- to cobble-size rounded clasts of Paleozoic limestone and sandstone and Precambrian crystalline rocks. Maximum exposed thickness about 1,000 ft

Pa **Abo Formation (Permian)**—Red, maroon, and dark-reddish-brown, fine-grained sandstone, siltstone, and mudstone. Maximum exposed thickness about 500 ft

IPm **Magdalena Group, undivided (Pennsylvanian)**—Chiefly light-gray to greenish-gray, thin- to massive-bedded limestone and minor interbeds of greenish-gray shale and sandstone. Maximum thickness about 1,500 ft

Contact—Known and approximate; dashed where inferred

Fault—Dotted where concealed. Ball and bar on downthrown side

62 **Strike and dip of beds**

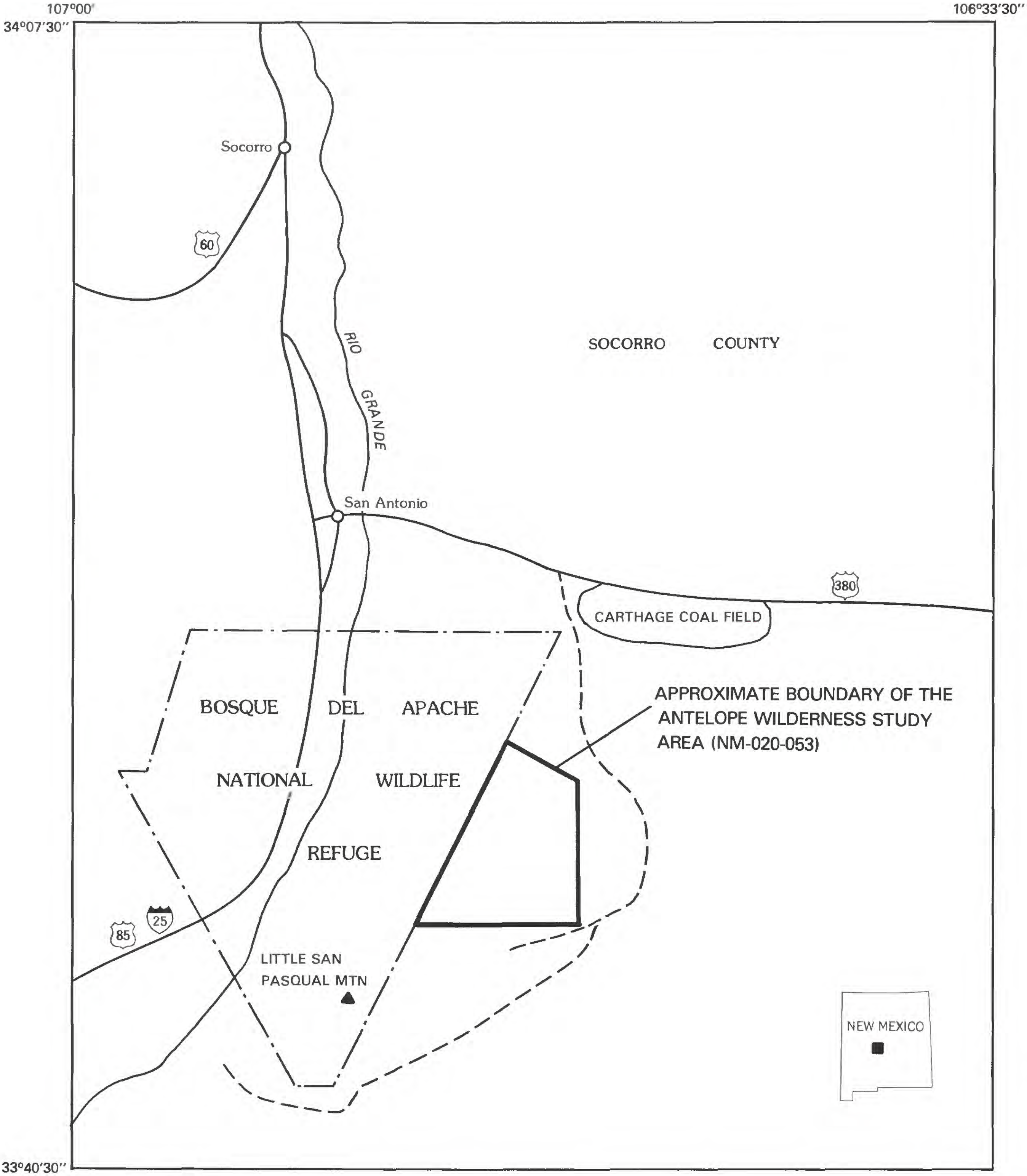


Figure 2. Index map showing location of the Antelope Wilderness Study Area, New Mexico. Dashes indicate unimproved roads.

and Quaternary Santa Fe Group (see geologic time chart in Appendix for explanation of relative ages); no bedrock (pre-Santa Fe Group) is exposed in the wilderness study area.

This report presents an evaluation of the mineral endowment (identified resources and mineral resource potential) of the study area and is the product of several separate studies by the USBM and the USGS. Identified resources are classified according to the system of the USBM and USGS (1980), which is shown in the Appendix of this report. Identified resources are studied by the USBM. Mineral resource potential is the likelihood of occurrence of undiscovered metals and nonmetals, of industrial rocks and minerals, and of undiscovered energy sources (coal, oil, gas, oil shale, and geothermal sources). It is classified according to the system of Goudarzi (1984) and is shown in the Appendix of this report. Undiscovered resources are studied by the USGS.

Investigations by the U.S. Bureau of Mines

The USBM reviewed Socorro County and BLM records for information regarding patented and unpatented claims, as well as federal mineral and oil and gas leases in or near the study area. No mineralized areas were found during the three days of field investigations in 1985; no samples were taken. Details of the study are provided in Korzeb (1986).

Investigations by the U.S. Geological Survey

Field investigations by the USGS in 1985 consisted of three days of geologic mapping and rock sampling of the wilderness study area and vicinity. No geochemical studies were undertaken. The lack of bedrock in the area, as well as the absence of alluvium known to be locally derived, ruled out the feasibility of a stream-sediment geochemical investigation. Large-scale gravity and aeromagnetic maps of the wilderness study area and vicinity were prepared from gravity data used for regional gravity maps of New Mexico and from a wide-spaced aeromagnetic survey flown for the NURE (National Uranium Resource Evaluation) program. No new geophysical data were acquired for this resource evaluation.

Acknowledgments.—Personnel of the BLM in Socorro, N. Mex., especially geologist Roy Dean, were extremely helpful in providing both background information on the wilderness study area and air photos of the area. Special thanks are also due to Glenn R. Osburn of the New Mexico Bureau of Mines and Mineral Resources in Socorro for providing a preliminary copy of the geologic map of Socorro County. A report on the geology, energy, and mineral resources of the Armendaris area, New Mexico (Krason, Jan, Wodzicki, Antoni, and Cruver, S.K., 1982, unpub. data) prepared for the BLM was a very useful guide for this assessment.

APPRAISAL OF IDENTIFIED RESOURCES

By Stanley L. Korzeb
U.S. Bureau of Mines

No mining has been done in the Antelope Wilderness Study Area nor are there any known deposits of either locatable or leasable minerals. The study area contains no identified resources. The Carthage coal field (Osburn, 1983), which was active from about 1856 to 1967, is approximately 5 mi northeast of the wilderness study area (fig. 2). Production from 1899 to 1960 was more than a million metric tons of high-volatile A bituminous coal. The minable coal occurs in a single bed, 5–6 ft thick, in the lower part of the Upper Cretaceous Crevasse Canyon Formation, a part of the Mesaverde Group. The coal bed dips 12–35° and is locally highly faulted. No detailed geologic mapping has been done in the coal field, and the coal resource is not known.

Sand and gravel occur in the study area, but the current likelihood of development is low. Similar deposits are more readily available elsewhere in the Rio Grande river valley.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Donald H. Richter and Richard W. Saltus
U.S. Geological Survey

Geology

The wilderness study area is almost entirely underlain by alluvial and eolian deposits of Quaternary age; no bedrock older than late Tertiary in age (pre-Santa Fe Group) is exposed. However, Cenozoic to Paleozoic rocks do crop out in three areas, 1–3 mi outside of the wilderness study area: (1) northeast of the study area, shale and sandstone of the Upper Cretaceous Mesaverde Group, sandstone and conglomerate of the Eocene(?) Baca Formation, and volcanic rocks of Oligocene age dip moderately both to the east and west; (2) at Sand Mountain about 1 mi east of the study area, Oligocene volcanic rocks are exposed; and (3) southwest of the study area in the northern part of the Little San Pascual Mountains, Paleozoic limestone (Magdalena Group) and Permian red beds (Abo Formation) dip steeply to the east.

The Quaternary alluvial and eolian deposits, which underlie the wilderness study area, may be as much as 100 ft thick and consist of unconsolidated alluvium in closed basins, broad fans marginal to upland areas, and sand dunes. These surficial deposits overlie perhaps between 1,000 and 4,000 ft of older alluvial deposits of the upper Tertiary and Quaternary Santa Fe Group, which were deposited in the tectonically active Rio Grande rift valley. Rocks of the Santa Fe Group are moderately indurated fanglomerate and sandstone containing abundant volcanic debris, and unconformably overlie rocks ranging in age from middle Tertiary to Paleozoic. Oligocene volcanic rocks, along the east side of the study area, consist of flows and shallow intrusives chiefly of high-potassium andesitic composition. The volcanic rocks show no evidence of hydrothermal alteration. As much as 1,000 ft of conglomerate and sandstone of the Eocene(?) Baca Formation may be present between the Oligocene volcanic rocks and the sandstone, shale, and coal of the Upper Cretaceous Mesaverde Group. The Paleozoic rocks exposed in the Little San Pascual Mountains southwest of the wilderness study area are faulted and strongly folded. Dips at the north end of the Little San Pascual Mountains are steep to the east.

The complex structures apparent in the pre-Santa Fe Group rocks near the wilderness study area indicate that the distribution and attitude of these strata beneath the study area can be inferred in only a very general way. Paleozoic limestone undoubtedly underlies the entire study area, but depth to these rocks may vary from 2,000 ft to as much as 6,000 ft (fig. 4). Mesaverde Group rocks may occur within a few hundred feet of the surface in the northern one-third of the study area, based on bedding attitudes measured entirely on exposures outside the study area.

Geophysics

Gravity Data

An isostatic residual gravity map of an area encompassing the wilderness study area is shown on figure 3. This map was compiled using data from about 600 gravity stations assembled and edited for regional gravity maps of New Mexico by Cordell and others (1982), and emphasizes the gravity effect of density distributions in the upper crust (Simpson and others, 1986).

The wilderness study area is situated on the northern end of an elongate north-trending gravity high. This high is flanked on the west by steep gravity gradients leading down into the Rio Grande rift zone. On the east side of the high the gravity field drops to a very large closed gravity low (40 milliGals below the high) centered about 10.5 mi east of the wilderness study area.

The anomalies on the gravity map are probably primarily due to the relief on the contact between the relatively low density Santa Fe Group sedimentary rocks at the surface and the underlying higher density Paleozoic carbonate rocks. Thus, the central gravity ridge indicates a shallow depth to the Paleozoic rocks and the large closed low to the east is caused by a relatively thick Santa Fe section. If the Paleozoic limestone is assumed to have a bulk density of 2.7 grams per cubic centimeter, the largest reasonable density contrast between the Paleozoic rocks and the Santa Fe Group is probably 0.5 grams per cubic centimeter. Using this density contrast and the method of Cordell and Henderson (1968), a map showing minimum depth to Paleozoic basement has been derived from the gravity map (fig. 4). The map shows that the Paleozoic basement is within 1,600 ft of the surface near the wilderness study area but is at least 10,000 ft deep under the gravity low to the east.

The very steep gradient just west of the wilderness study area (best defined by a line of closely spaced gravity stations on fig. 3) is probably associated with graben faulting along the Rio Grande rift to the west.

Aeromagnetic Data

An aeromagnetic map of the wilderness study area and vicinity is shown on figure 5. Data for the map were obtained as part of the NURE program in 1982 (Berry and others, 1982). The survey was flown at an altitude of 400 ft above ground along flight lines spaced 3 mi apart. Because the flight lines are so widely spaced, short-wavelength features cannot be contoured reliably from line to line. In order to avoid false correlation of these features by automatic contouring, a grid was produced from the original data using the method of minimum curvature (Briggs, 1974) and was then continued upward 1,600 ft to remove the short-wavelength features.

The aeromagnetic map is dominated by a large semicircular closed low with a triangle-shaped high indenting it from the west. These broad long-wavelength features are probably due to relief on the contact between the Precambrian basement and the relatively nonmagnetic

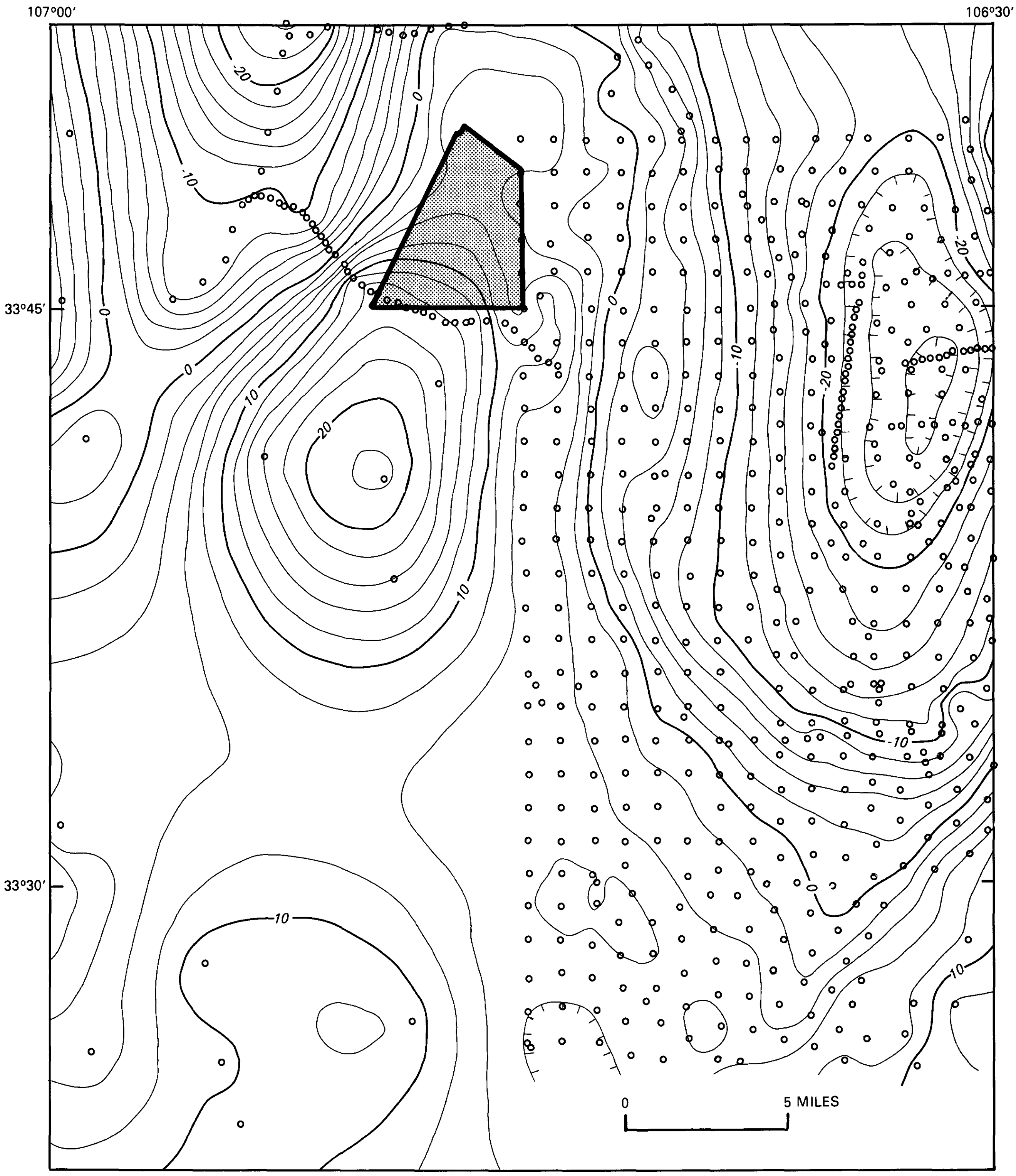


Figure 3. Isostatic residual gravity map of the Antelope Wilderness Study Area (shaded) and vicinity, New Mexico. Contour interval 2 milliGals. Hachures indicate closed gravity low. Gravity station indicated by o. Reduction density 2.67 grams per cubic centimeter.

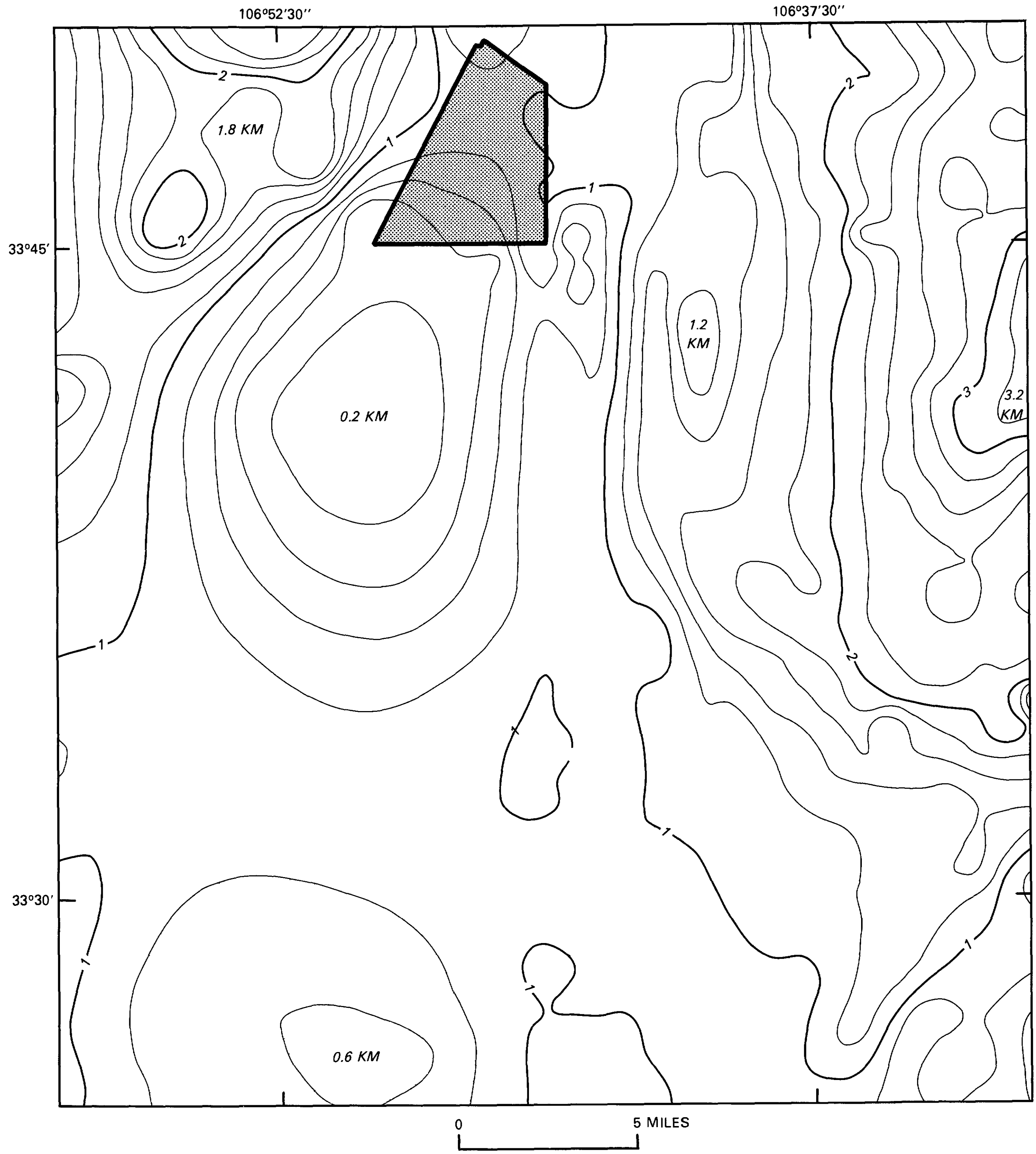


Figure 4. Depth to Paleozoic basement below Santa Fe Group rocks in the Antelope Wilderness Study Area (shaded) and vicinity, New Mexico. Contour interval 200 (650 ft) meters.

rocks above. A two-dimensional model constructed along two flight lines crossing the broad low gives an estimated depth of about 20,000 ft to the Precambrian under the low part of the anomaly along the east edge of the wilderness study area. This model assumes a 0.001 emu/cm^3 (electromagnetic units per cubic centimeter) intensity of magnetization for a normally polarized basement. The same model yields depths of about 7,000 ft to Precambrian basement under the magnetic highs flanking the west edge of the wilderness study area.

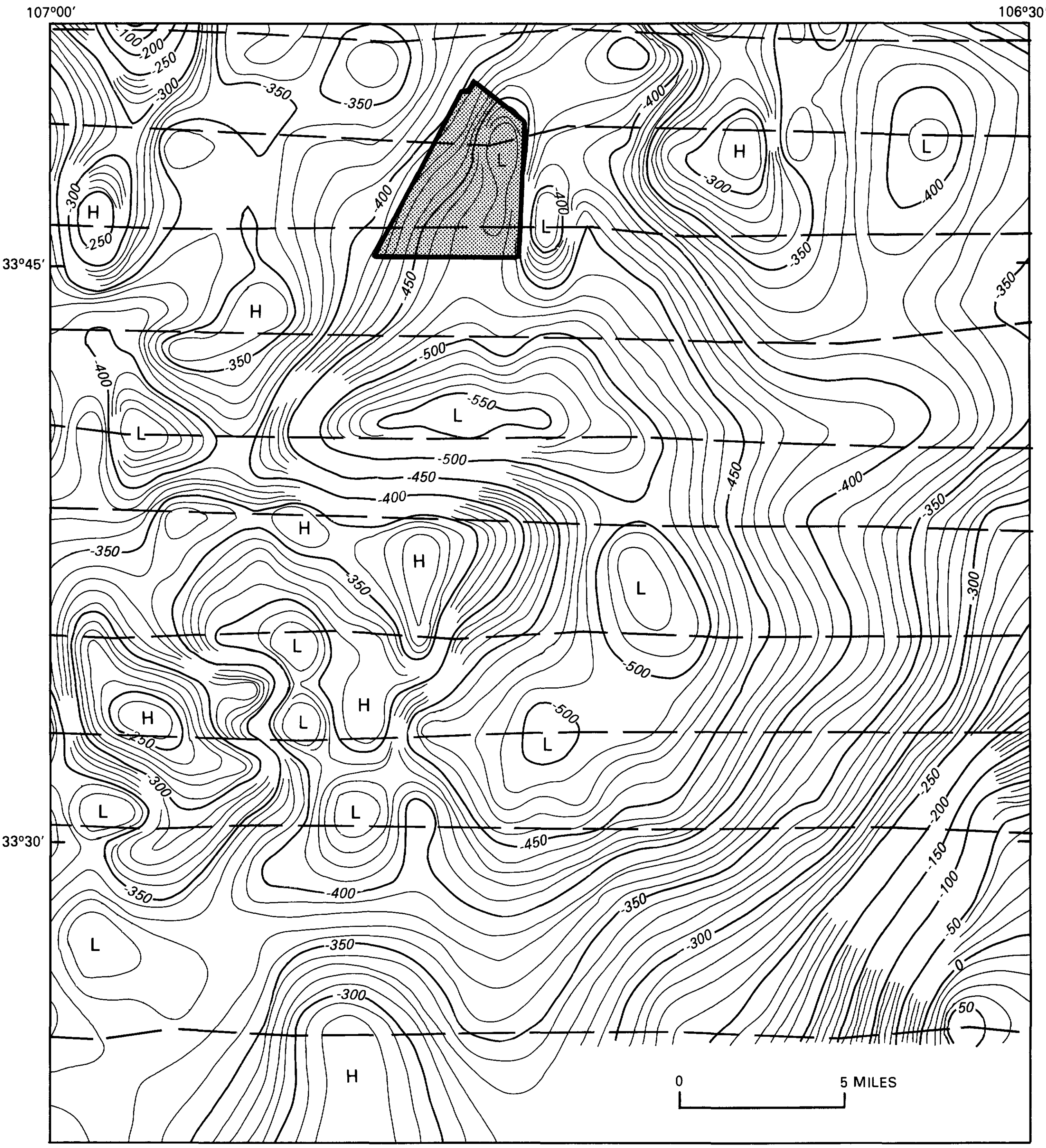


Figure 5. Aeromagnetic map of the Antelope Wilderness Study Area (shaded) and vicinity, New Mexico. Dashed lines indicate flight lines. Contour interval 10 nanoTesla. H, aeromagnetic high; L, aeromagnetic low.

Aerial Radiometric Survey Data

The Antelope Wilderness Study Area has low overall radioactivity. The aerial radiometric survey indicated values of 1.3–1.8 ppm (parts per million) equivalent uranium, 3.5–5.0 ppm equivalent thorium, and 1.6–2.1 percent potassium (J.S. Duval, USGS, written commun., 1986). No anomalous radioactivity values are within or near the study area.

Mineral and Energy Resource Potential

Coal

The inactive Carthage coal field (Osburn, 1983), 5 mi northeast of the Antelope Wilderness Study Area, has produced high-volatile A bituminous coal from a 4- to 6-ft coal bed in the lower part of the Crevasse Canyon Formation, a formation of the Mesaverde Group of Late Cretaceous age. Mesaverde Group rocks crop out within 2 mi of the northern part of the study area, and their attitudes and those of the overlying rocks of the Baca Formation suggest that Mesaverde strata may be present within a few hundred feet of the surface in parts of the study area. The northern one-third of the study area is therefore given a moderate potential for coal resources, with certainty level B. The rest of the study area has a low potential for coal resources, with certainty level B.

Metals

Occurrences of uranium minerals are occasionally found in upper Tertiary and Quaternary sedimentary rocks of the Santa Fe Group throughout New Mexico (Hilpert, 1965). These deposits have been small and too low grade to mine. In the uranium assessment of the Tularosa, N. Mex., 1°×2° quadrangle, Berry and others (1982) indicated that the Santa Fe Group is unfavorable for either uraniferous calcrete or sandstone uranium deposits. Despite these negative aspects, we believe that the presence of known deposits, adequate source terrane (Tertiary volcanic rocks), and local accumulations of organic debris in the host sediments are criteria that suggest locally favorable geologic environments, especially for sandstone-hosted deposits. In addition, the Baca Formation of Eocene(?) age, which probably underlies most of the northern part of the study area, locally hosts uranium minerals to the north and west of the study area (S.L. Moore, USGS, written commun., 1986) and should be considered a potential uranium source. The entire study area is given a low potential for uranium resources, with certainty level B. The study area lacks the rocks and geologic environment favorable for metallic mineral deposits, and no mineralized areas were observed. The study area is therefore given a low mineral resource potential for metals, with certainty level B.

Oil and Gas

The wilderness study area is underlain at depth by upper Paleozoic sandstone and limestone that are highly productive reservoir and source rocks in southeastern New Mexico. However, in the Rio Grande rift valley these rocks have been structurally disturbed and intruded by igneous rocks, factors that do not enhance the rocks' ability to hold significant quantities of oil and gas. Three exploratory holes testing the Paleozoic section have been drilled about 6 mi west of the study area; all were dry (U.S. Geological Survey, 1981). The entire study area is assessed as having a low potential for oil and gas resources, with certainty level B.

Sand

The southeastern part of the study area contains active sand dunes with a maximum thickness of 25 ft. These areas have a high resource potential for sand, with certainty level C. The other Quaternary deposits in the area are heterogeneous and poorly sorted; they have a low mineral resource potential for sand, with certainty level B.

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APPENDIX

DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

Definitions of Mineral Resource Potential

LOW mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics define a geologic environment in which the existence of resources is unlikely. This broad category embraces areas with dispersed but insignificantly mineralized rock as well as areas with few or no indications of having been mineralized.

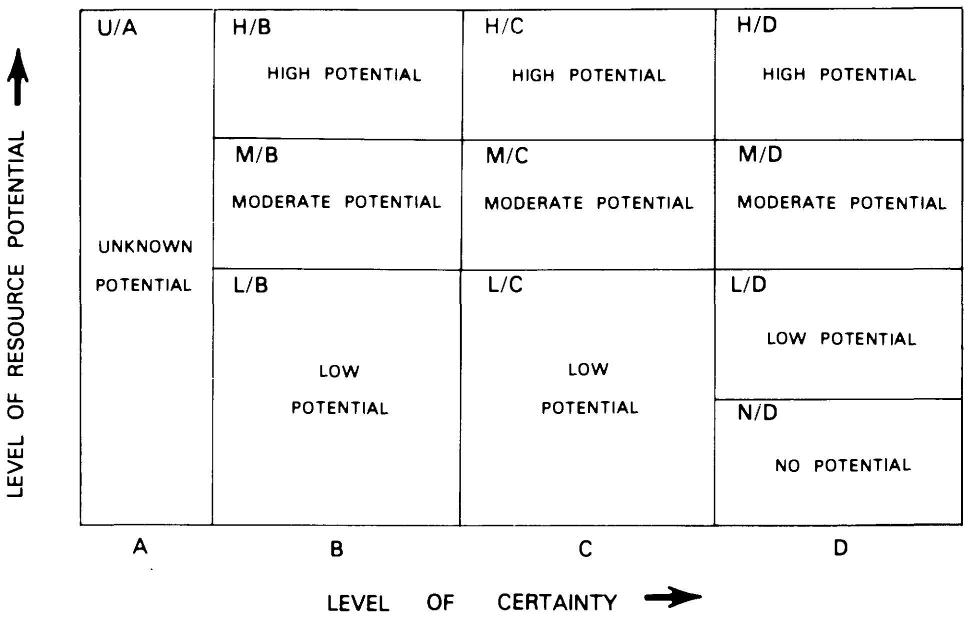
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application of mineral-deposit models indicates favorable ground for the specified type(s) of deposits.

HIGH mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a high degree of likelihood for resource accumulation, where data support mineral-deposit models indicating presence of resources, and where evidence indicates that mineral concentration has taken place. Assignment of high resource potential to an area requires some positive knowledge that mineral-forming processes have been active in at least part of the area.

UNKNOWN mineral resource potential is assigned to areas where information is inadequate to assign low, moderate, or high levels of resource potential.

NO mineral resource potential is a category reserved for a specific type of resource in a well-defined area.

Levels of Certainty



A. Available information is not adequate for determination of the level of mineral resource potential.
B. Available information suggests the level of mineral resource potential.
C. Available information gives a good indication of the level of mineral resource potential.
D. Available information clearly defines the level of mineral resource potential.

Abstracted with minor modifications from:

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RESOURCE / RESERVE CLASSIFICATION

	IDENTIFIED RESOURCES			UNDISCOVERED RESOURCES	
	Demonstrated		Inferred	Probability Range (or)	
	Measured	Indicated		Hypothetical	Speculative
ECONOMIC	Reserves		Inferred Reserves		
MARGINALLY ECONOMIC	Marginal Reserves		Inferred Marginal Reserves		
SUB-ECONOMIC	Demonstrated Subeconomic Resources		Inferred Subeconomic Resources		

Major elements of mineral resource classification, excluding reserve base and inferred reserve base. Modified from U. S. Bureau of Mines and U. S. Geological Survey, 1980, Principles of a resource/reserve classification for minerals: U. S. Geological Survey Circular 831, p. 5.

GEOLOGIC TIME CHART

Terms and boundary ages used in this report

EON	ERA	PERIOD		EPOCH	BOUNDARY AGE IN MILLION YEARS
Phanerozoic	Cenozoic	Quaternary		Holocene	0.010
				Pleistocene	1.7
		Tertiary	Neogene Subperiod	Pliocene	5
				Miocene	24
			Paleogene Subperiod	Oligocene	38
				Eocene	55
				Paleocene	66
	Mesozoic	Cretaceous		Late	96
				Early	138
		Jurassic		Late Middle Early	205
		Triassic		Late Middle Early	~ 240
	Paleozoic	Permian		Late Early	290
		Carboniferous Periods	Pennsylvanian	Late Middle Early	~ 330
			Mississippian	Late Early	360
		Devonian		Late Middle Early	410
		Silurian		Late Middle Early	435
		Ordovician		Late Middle Early	500
		Cambrian		Late Middle Early	~ 570[1]
Proterozoic	Late Proterozoic				900
	Middle Proterozoic				1600
	Early Proterozoic				2500
Archean	Late Archean				3000
	Middle Archean				3400
	Early Archean				3800?
pre-Archean[2]					4550

[1] Rocks older than 570 m.y. also called Precambrian, a time term without specific rank.

[2] Informal time term without specific rank.

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