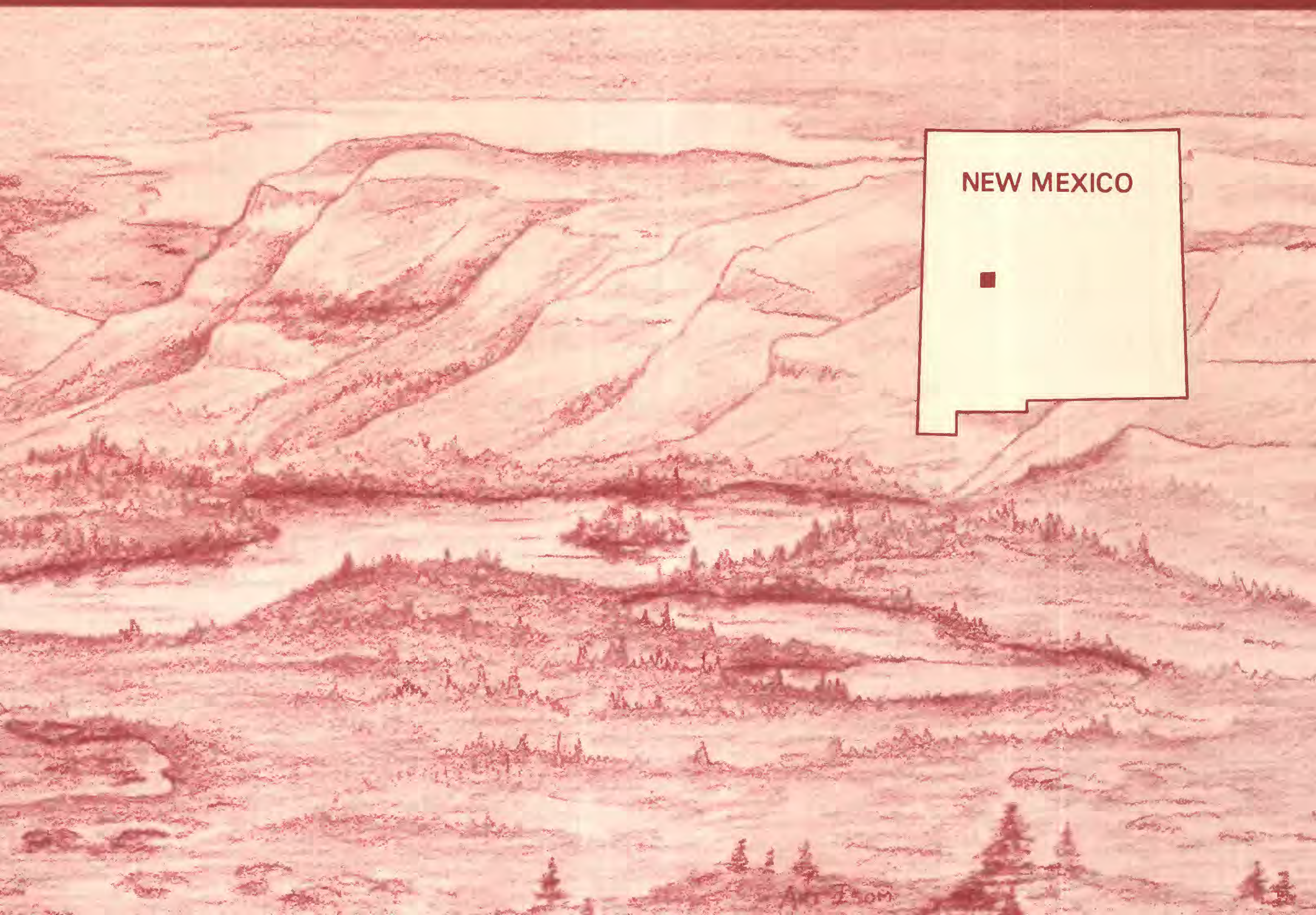
Mineral Resources of the Petaca Pinta Wilderness Study Area, Cibola County, New Mexico

U.S. GEOLOGICAL SURVEY BULLETIN 1734–H



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Chapter H

Mineral Resources of the Petaca Pinta Wilderness Study Area, Cibola County, New Mexico

By CHARLES H. MAXWELL, GARY A. NOWLAN, and VIKI BANKEY
U.S. Geological Survey

BRIAN J. HANNIGAN
U.S. Bureau of Mines

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
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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 value, 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 the Petaca Pinta Wilderness Study Area (NM-020–014), Cibola County, New Mexico.

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Mineral Resources of the Petaca Pinta Wilderness Study Area, Cibola County, New Mexico

By Charles H. Maxwell, Gary A. Nowlan, *and* Viki Bankey
U.S. Geological Survey

Brian J. Hannigan
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ABSTRACT

In 1987 the U.S. Bureau of Mines and the U.S Geological Survey conducted investigations to appraise the identified resources and assess the mineral resource potential of 11,668 acres of the Petaca Pinta Wilderness Study Area (NM-020-014), Cibola County, New Mexico. These investigations showed that the study area contains no identified (known) metallic mineral resources but has inferred subeconomic resources of sandstone and sand. The wilderness study area has a low resource potential for undiscovered deposits of metals, including uranium, and has a moderate resource potential for the occurrence of oil and gas. There is no resource potential for coal.

SUMMARY

The Petaca Pinta Wilderness Study Area is located in Cibola County, west-central New Mexico, about 50 mi (miles) west-southwest of Albuquerque. The area is bordered on the west by the Laguna Indian Reservation and part of the north boundary abuts the Acoma Indian Reservation. The area consists of about 11,668 acres. The area is accessible from Interstate Highway 40 via State Highway 6, old U.S. 66, State Road 55, and unimproved ranch roads (fig. 1).

Petaca Pinta is a small (30 acres) mesa with near-vertical 300-ft (foot) cliffs of Jurassic-age and Cretaceous-age (see geologic time chart in "Appendix") sandstone overlying Triassic-age shale that forms steep slopes a mile or two wide and 1,000 ft high. The slopes are almost completely covered by landslides, only a few small outcrops of the underlying Triassic shale show through the landslide debris.

No mines or prospects were seen and no metallic mineral resources were identified in or near the wilderness study area. Large amounts of sand and sandstone in the area are classified as inferred subeconomic resources.

A reconnaissance geochemical survey of the area was conducted by the U.S. Geological Survey in 1987, and samples were collected at 22 sites on ephemeral streams. Analytical results show that very few anomalous concentrations of any element are present. Most samples contain amounts of elements near or below their average crustal abundance in shale and sandstone. Concentrate samples contain anomalous amounts of barium, strontium, and vanadium, probably all derived from a barite-rich zone that occurs throughout the region immediately below the unconformity at the base of the Upper Cretaceous rocks.

A broad positive gravity high east of the study area suggests that denser Pennsylvanian limestones are thicker and more widespread than indicated by surface mapping and existing boreholes. The study area is located on a steep gravity gradient along the west side of the positive anomaly.

A large C-shaped positive magnetic anomaly is present in the vicinity of the Petaca Pinta study area. The anomaly is caused by the magnetic source rock for the basalts in the region; the amplitude and shape of subsidiary anomalies suggest that the source of the basalts is deep and may be fault controlled.

No mineralized areas or occurrences of metallic minerals were found in the wilderness study area. No significant geochemical anomalies were found by stream-sediment and concentrate samples, and no anomalous radioactivity was found by the study. The resource potential is low for any undiscovered deposits of metals, including uranium. The potential for the occurrence of oil and gas resources is moderate, especially along the eastern side of the area. There is no potential for coal resources as coal-bearing units do not occur in the area.

Manuscript approved for publication, November 16, 1988.

INTRODUCTION

The Petaca Pinta Wilderness Study Area is located in Cibola County, west-central New Mexico, about 20 mi (miles) south of Laguna Pueblo and 50 mi west-southwest of Albuquerque. The area is bordered on the west by the Laguna Indian Reservation; part of the north boundary is the Acoma Indian Reservation. The studied area consists of 11,668 acres.

The study area is accessible from Interstate Highway 40 by turning south on State Highway 6, west on old U.S. Highway 66, and south on State Road 55 for about 7 mi, west on an unimproved dirt track along a fence line for about 3½ mi, then southwest about 13 mi on a private ranch road (fig. 1). There is no public access to the Petaca Pinta area.

A preliminary evaluation of the mineral resource potential of the Petaca Pinta Wilderness Study Area was prepared by the New Mexico Bureau of Mines and Mineral Resources in 1981 (Logsdon, 1981).

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 U.S. Bureau of Mines (USBM) and the U.S. Geological Survey (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, 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. The potential for undiscovered resources is studied by the USGS.

Investigations by the U.S. Bureau of Mines

A comprehensive literature search was made for information on mines, prospects, and mineralized areas, and Bureau of Land Management mining claim and oil and gas lease records were checked for claim and lease information pertaining to the study area. Foot and vehicle traverses were made in August 1987, in and near the study area in a search for mines and mineralized areas (Hannigan, 1988).

Investigations by the U.S. Geological Survey

The Petaca Pinta Wilderness Study Area was mapped previously by Maxwell (1979, 1988a, b, in press) at a scale of 1:24,000, and compiled at a scale of 1:100,000 for figure 2. Geophysical data were evaluated by Viki Bankey, and gamma-ray spectroscopy data were prepared by J.S. Duval. Geochemical sampling was done in August 1987, by Gary A. Nowlan.

APPRAISAL OF IDENTIFIED RESOURCES

By Brian J. Hannigan
U.S. Bureau of Mines

Mining Activity and Oil and Gas Leases

No mines or prospects were seen in or near the Petaca Pinta Wilderness Study Area during the field investigations. As of August 1987, Bureau of Land Management records show no mining claims in or near the study area, but oil and gas leases cover about 1,080 acres in and within 1 mi of the study area.

Resource Appraisal

No metallic mineral resources were identified in or near the study area. Several oil and gas exploration wells have been drilled 8–26 mi from the study area but no commercial production exists within 55 mi of the study area. Carbon dioxide was reported from one well 6 mi north of the area. No exploration wells have been drilled within or in the immediate vicinity of the study area (U.S. Bureau of Land Management, 1986).

Massive beds of sandstone occur in the area, but visual inspection indicates that they are generally too low in silica content to be suitable for any industrial purpose other than crushed rock. Sand is present in the drainages of the area but contains no unusual or unique properties. There are no gravel deposits in the area. The sandstone and sand are classified as inferred subeconomic resources, and, because vast quantities of similar material are available throughout the region, it is highly unlikely that these resources would ever be developed.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Charles H. Maxwell, Gary A. Nowlan, and Viki Bankey
U.S. Geological Survey

Geology

Petaca Pinta is a small (30 acres) mesa rising steeply about 1,300 ft (feet) above the flat valley floor of Arroyo Colorado. The western boundary of the study

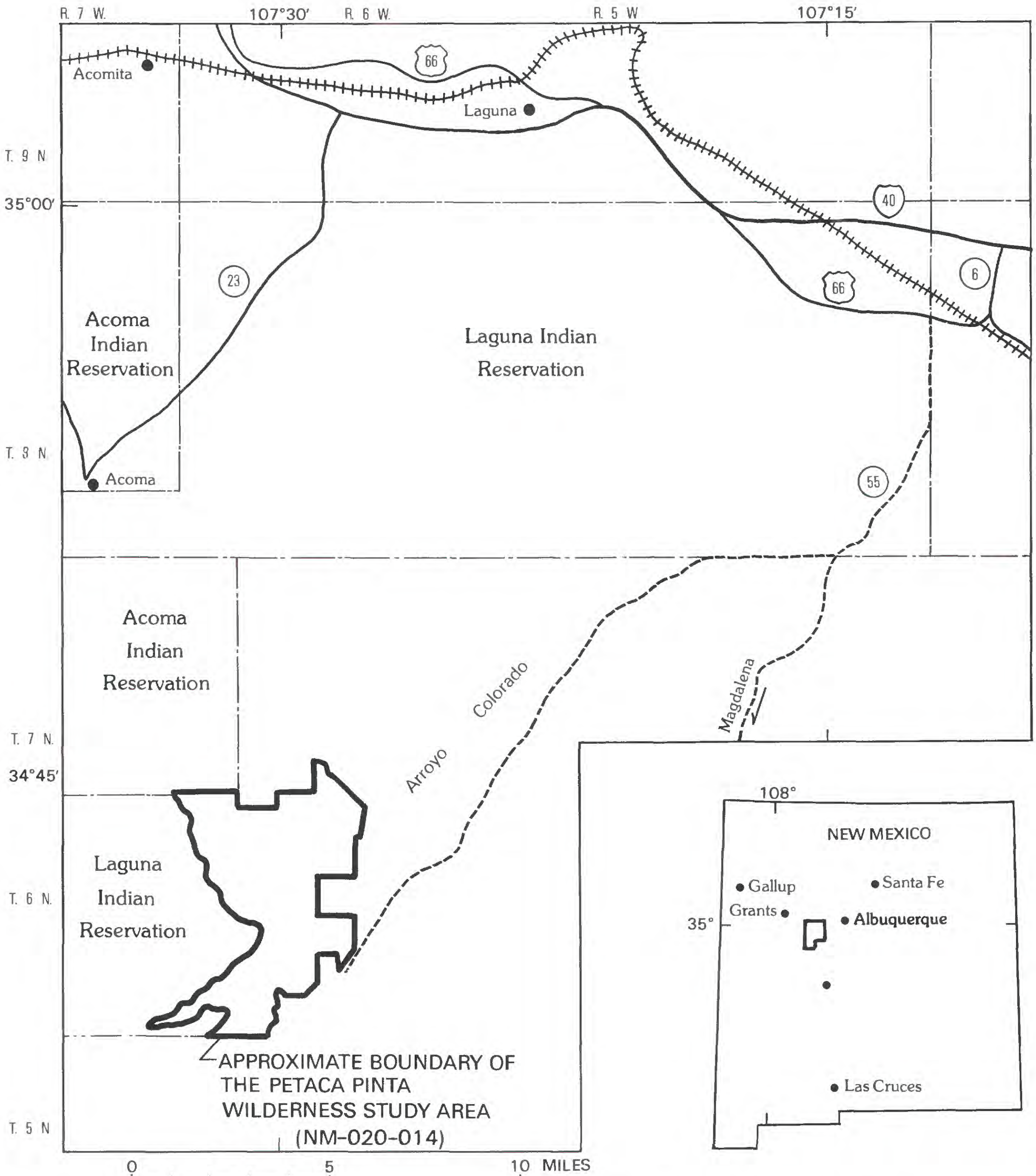


Figure 1. Map showing the location of the Petaca Pinta Wilderness Study Area, Cibola County, New Mexico.

area is the edge of Blue Water Mesa, at about the same elevation as Petaca Pinta and dropping as steeply to the valley floor (fig. 2). The most striking features of the area are the near-vertical 300-ft cliffs of the mesas and the tier upon tier of landslide blocks extending from the cliffs to the valley floor. The slides cover slopes a mile or two wide and as much as 1,000 ft high, with only a few small outcrops of the underlying Triassic Chinle Formation showing through.

Much of the landslides are composed of large rotated and tilted blocks of sandstone and basalt which have broken away from the cliffs and slid down the slope on the underlying soft shale. Some of the slides, especially in the northern part of the study area, are chaotic piles of rock debris. The landslides were formed during an early wet period, which was followed by progressive changes in climate to the present-day arid conditions. During the wet period large amounts of water percolated through the porous sandstones and basalt, soaked and weakened the underlying shales, and produced the numerous slide blocks that migrated downslope. Eventually, the slides stabilized and the valleys became choked with alluvium which covered many of the lower slides and filled the valleys to form broad flat floors. Parts of the slides were subsequently eroded away to expose the underlying shale.

Almost all of the bedrock underlying the study area is Chinle Formation, brick red and reddish-purple shale,

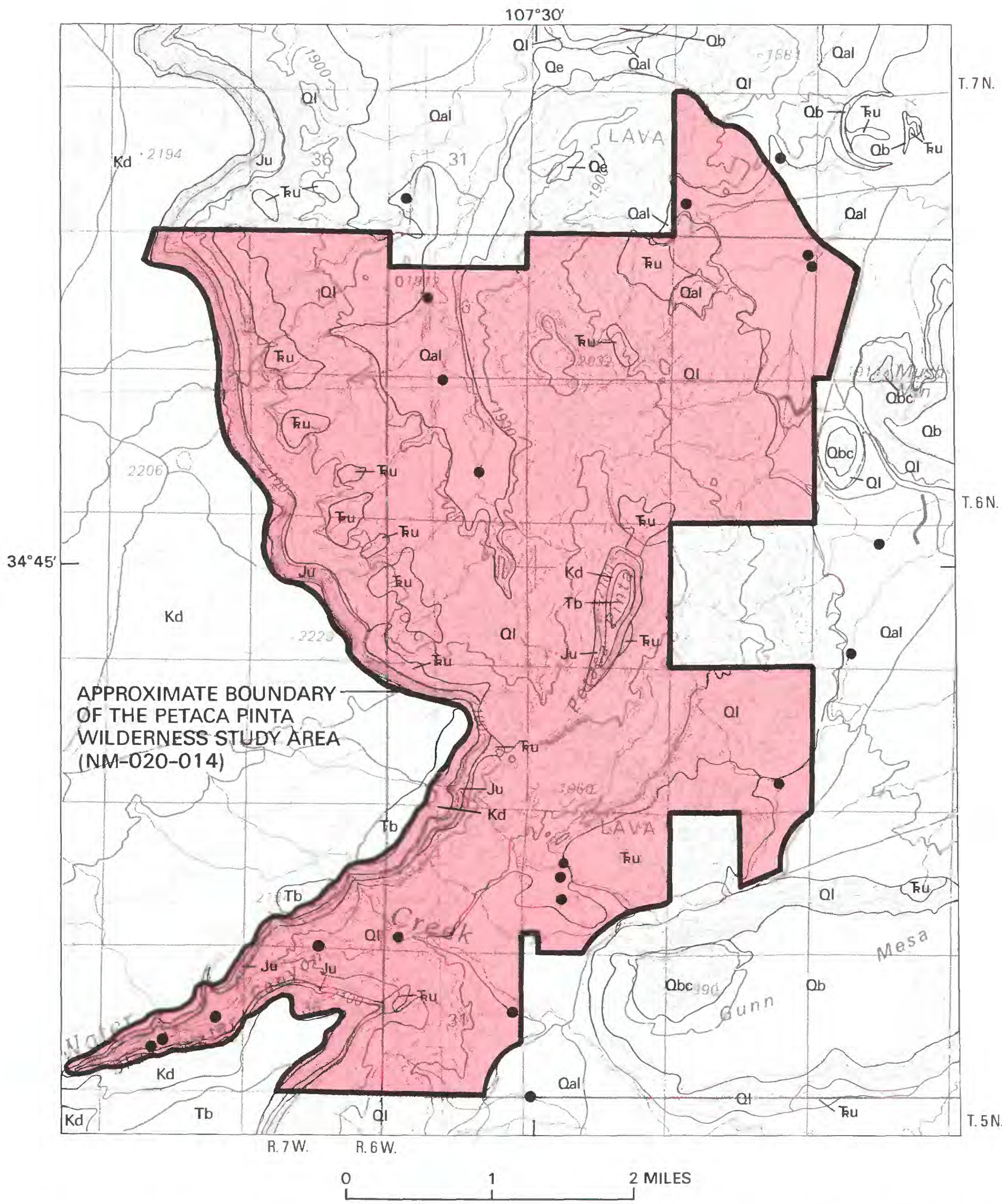


Figure 2 (above and facing page). Map showing geology and mineral resource potential of Petaca Pinta Wilderness Study Area.

EXPLANATION OF MINERAL RESOURCE POTENTIAL

M/B **Geologic terrane having moderate resource potential for oil, natural gas, and carbon dioxide, with certainty level B**—Applies to entire wilderness study area

L/C **Geologic terrane having low resource potential for metals, including uranium, and with certainty level C**—Applies to entire wilderness study area

N/D **Geologic terrane having no resource potential for coal, and with certainty level D**—Applies to entire wilderness study area

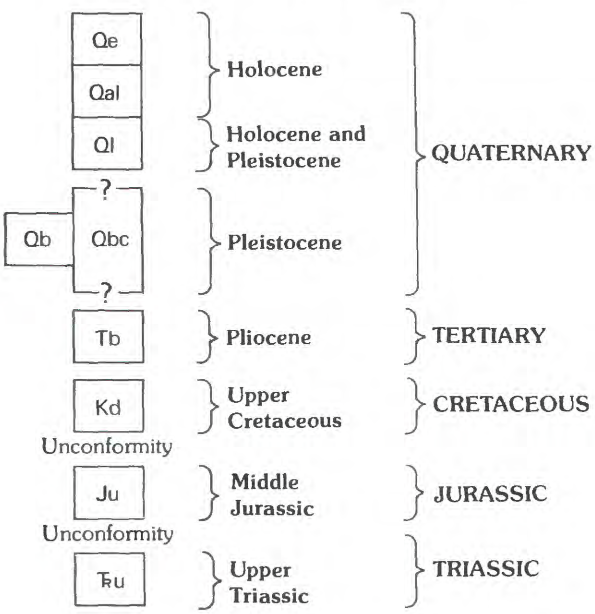
Levels of certainty

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

C **Data indicate geologic environment and indicate level of resource potential**

D **Data indicate geologic environment and clearly defines level of resource potential**

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Qe **Eolian deposits (Holocene)**—Recent windblown sand and silt in sheets and small longitudinal dunes

Qal **Alluvium (Holocene)**—Silt and fine sand, locally a few coarse grains of sand and pebbles; includes local small landslide deposits and minor eolian deposits

Ql **Landslide deposits (Holocene and Pleistocene)**—Mostly toreva block slides of basalt or sandstone and shale which have slid over Triassic shale and mudstone, locally rock slides and mudflows of chaotic debris

Qb **Basalt flows (Pleistocene)**—Black to dark-gray, fine-grained, slightly porphyritic basalt with small phenocrysts of olivine and feldspar

Qbc **Cinder cone, flow, and vent complex (Pleistocene)**—Red-brown and black basalt scoria, bombs, breccia, flows, and small basalt plugs

Tb **Basalt flows (Pliocene)**—On Blue Water Mesa and Petaca Pinta, continuation of flows from the southwest

Kd **Dakota Sandstone (Upper Cretaceous)**—Includes lower part of the Oak Canyon Member and the basal conglomeratic unit. The Oak Canyon is composed of dark-gray silty shale and light-gray siltstone and sandstone, the basal unit is composed of light-gray to white medium- to coarse-grained sandstone and conglomerate with festoon crossbedding; basal conglomerate truncates underlying units

Ju **Jurassic units undivided (Middle Jurassic)**—Includes Zuni Sandstone, Wanakah Formation, and Entrada Sandstone in northwestern part of map area. The unconformity at the base of the Dakota Sandstone truncates the Zuni near the mouth of Blue Water Canyon and truncates the Wanakah a short distance south of the study area. The Entrada Sandstone is truncated by the Wanakah Formation southwest of Petaca Pinta. All three units are white to pale-brown sandstone, form very steep slopes to vertical cliffs. The Zuni and Entrada are eolian, the Wanakah is fluviatile

TRu **Triassic units undivided (Upper Triassic)**—Includes Rock Point Member of Wingate Sandstone and Chinle Formation. The Rock Point is truncated by the Entrada Sandstone in the northwestern part of the study area, and by the Wanakah just south of the area; it is composed of pale- to moderate-red siltstone and mudstone, unconformable with the underlying Chinle Formation. The Chinle is composed of grayish-red to reddish-purple shaley siltstone and mudstone, interbedded locally near the valley floor with light-gray and tan fluviatile sandstone lenses

—— **Contact**

● **Location of geochemical samples**

mudstone, and sparse lenses of fine-grained sandstone. The uppermost 150 ft of the Triassic at Petaca Pinta and along the central part of the western boundary of the study area is red massive siltstone of the Rock Point Member of Wingate Sandstone (Maxwell, 1988a). It thins rapidly, both north and south, along the west boundary of the study area.

The thickness of subsurface units under the study area is inferred, projected from outcrops 15–20 mi east and from wells around the area 8–26 mi distant. The inferred thickness of Pennsylvanian rocks is projected to be about 1,200 ft in the Petaca Pinta area (Kottlowski, 1961). However, if the gravity high at and east of the area (fig. 4) is due to a thick limestone section as postulated, then the Pennsylvanian rocks could be 2,000–2,200 ft thick but thinning rapidly to the west, as indicated by the steep gravity gradient. Wengerd (1959) postulated massive carbonate rocks, possibly of reef origin, across the break in slope between the Lucero basin east of the study area and the Zuni positive area to the west, the type of rocks that could produce the gravity anomaly. Biostromal limestones are prominent in outcrops 20 mi east of the study area. Permian rocks in the subsurface of the study area are probably about 2,200 ft thick, composed of about 550 ft of Abo Formation, 1,000+ ft of Yeso Formation, 200 ft of Glorieta Sandstone, and 450+ ft of San Andres Limestone (Baars, 1961). About 600 ft of Triassic rocks are exposed on the flanks of Petaca Pinta, and an additional 1,000 ft is probable in the subsurface, to the top of the San Andres Limestone.

Other units exposed near the top of Petaca Pinta and on the cliffs along the western boundary of the study area are shown on the geologic map (fig. 2) taken from Maxwell (1979, 1988a, b, in press) as Jurassic undivided and Dakota Sandstone. The Jurassic units include Entrada Sandstone, Wanakah Formation, and Zuni Sandstone. The Entrada is white- to greenish-white eolian sandstone, 0–200 ft thick, grading at the base into about 10 ft of crossbedded pebble conglomerate. The basal conglomerate cuts into and across bedding of the Rock Point Member of Wingate Sandstone and the Chinle Formation and is truncated in turn by the basal conglomerate of the overlying Wanakah Formation, both at angles of about 30°. The Wanakah Formation, 0–80 ft thick, is white to pale-brown fluviatile sandstone with lenses of grayish-green siltstone and pale-brown pebble conglomerate. It is gradational into the overlying eolian Zuni Sandstone. The lower 10–20 ft of the Zuni is thin- to massive-bedded fluviatile sandstone grading upward into white to yellowish-gray massive sandstone with large-scale eolian crossbedding. The Zuni is about 300 ft thick in the northern part of the study area and thins to about 20 ft at the south edge because of erosional truncation prior to deposition of the overlying Dakota Sandstone. The basal unit of the Dakota Sandstone is light-gray to white, poorly sorted, fluviatile sandstone and conglomerate, with rounded to angular grains and festoon crossbeds. Basal conglomerate truncates underlying formations, with local channels that cut into underlying rocks as much as 50 ft; thickness is 10–100 ft. The overlying Oak Canyon Member of the Dakota is exposed on Petaca Pinta and along parts of Blue Water Arroyo and is composed of interbedded dark-gray silty shale, light-gray siltstone, and grayish-tan fine-grained sandstone.

About 10 ft of vesicular and porphyritic basalt and olivine basalt caps Petaca Pinta and the mesa along the southwestern boundary of the study area. The flows were dated at 3.5 m.y. (million years) by Baldridge and others (1987).

Quaternary basalt flows cap several low mesas around the study area, on the south, east, and north sides; none are within the area.

Geochemistry

A reconnaissance geochemical survey of the Petaca Pinta Wilderness Study Area was conducted in August 1987. Samples of drainage sediment were collected at 22 sites on ephemeral streams draining the study area and vicinity. Drainage-sediment samples represent a composite of material eroded from the drainage basin of the stream sampled; panned concentrates represent the heavy-mineral component found in the sediment load.

Methods

Two samples were collected at each site. One of the samples was air dried and screened through an 80-mesh (0.177 mm) stainless-steel sieve to obtain the stream-sediment sample, which was then pulverized to minus-100 mesh (0.149 mm) for analysis. For the second sample at each site, about 20 lb (pounds) of sediment was collected and panned to remove most of the quartz, feldspar, clays, and organic matter. Treatment with bromoform (specific gravity 2.8) removed the remaining quartz, feldspar, and other lower density minerals. Finally, a magnetic separation removed the magnetite and any other strongly magnetic minerals to produce a concentrate sample. The concentrate samples include nonmagnetic ore minerals, iron and manganese oxides, ferromagnesian silicates, and accessory minerals, such as titanite, zircon, apatite, and rutile. Concentrate samples were also pulverized to minus-100 mesh for analysis.

The stream-sediment and concentrate samples were analyzed for 35 elements by semiquantitative emission spectrography. In addition, the concentrate samples were analyzed by emission spectrography for platinum and palladium. The stream-sediment samples were analyzed for uranium by fluorometry and for arsenic, bismuth, cadmium, antimony, and zinc by inductively coupled plasma spectroscopy. Analytical data, sample-site map, and references to analytical methods are presented by Bullock and others (1989).

Results

Results from the geochemical studies show that very few distinctly anomalous concentrations of any element are present. Most stream-sediment samples contain near or below the average crustal abundance for a mixture of sandstone and shale. A few samples contain concentrations of barium, cadmium, chromium, and vanadium slightly above average. One stream-sediment sample has a highly anomalous concentration of silver, 7 ppm (parts per million), but other element concentrations in the sample were not anomalous, and the corresponding concentrate sample contained no detectable silver. The sample, however, was collected from a stream that drains the vicinity of a prominent zone of alteration in the Wanakah Formation and Zuni Sandstone. Small deposits of travertine in the upper levels of the alteration indicate that it was formed by warm spring activity; no other mineralization was observed in the area. Concentrate samples contain high concentrations of barium, strontium, and vanadium, and several contain detectable molybdenum. Only 1 of the 22 concentrate samples contains less than 10,000 ppm barium; 17 contain greater than 10,000 ppm. These consistently high concentrations of barium, as well as the strontium and vanadium, are probably derived from a thin but regionally extensive barite-rich zone in the Zuni Sandstone immediately below the unconformity at the base of the Dakota Sandstone. The minerals were deposited from meteoric and ground water, probably mediated by organic material on the unconformity.

Even though altered rocks and a barite-rich zone are present in the study area, concentrations of elements other than barium, strontium, and vanadium, and the one anomalous silver concentration, are near the average crustal abundance for shale and sandstone.

Geophysics

Aeromagnetic Data

The total intensity aeromagnetic anomaly map (fig. 3) was compiled from two separate surveys. West of 107°30' W. long., the survey was flown at 8,500 ft barometric elevation along east-west flight lines spaced 1 mi apart (U.S. Geological Survey, 1979). The 1975 IGRF (International Geomagnetic Reference Field) field, updated to the month flown, was removed. East of 107°30' W. long., the survey was flown at 8,000 ft barometric elevation along east-west flight lines spaced 1 mi apart (U.S. Geological Survey, 1975). This survey was upward-continued to 8,500 ft using the technique described in Hildenbrand (1983) and the 1975 IGRF was removed.

The aeromagnetic map (fig. 3) shows variations in the magnetic field that are associated with increasing or decreasing magnetic minerals in the rocks, measured as magnetic susceptibility. A change in magnetic susceptibility will often generate a magnetic high that may be an order of magnitude greater than an anomaly caused by significant offset in subsurface structure. This can limit structural interpretation but enhance separation of sources having different composition.

West of the study area the magnetic field is relatively undisturbed. A large 400 nT (nanoTesla), C-shaped positive magnetic anomaly is located in the Petaca Pinta area. Two local maxima, north and southeast of the study area, occur on this regional positive anomaly and are not correlated with mapped geology or topography. This anomaly is located on the southwestern end of magnetic terrane that trends northeast from the study area for 40 mi, is about 25 mi wide, and is spatially associated with a northeast-trending gravity gradient. The magnetic terrane is delineated by positive magnetic anomalies that are similar in shape and magnitude. These positive magnetic values are caused by the magnetic source rock for the Quaternary basalts that crop out in the region; their amplitude and shape suggest that the source is deep and may be fault controlled. Although a few of the highs are associated with outcropping basalt, others do not correlate with the mapped geology, and some mapped basalt outcrops show no associated anomalies. This inconsistency reflects varying source rock geometry or magnetization, or both.

Gravity Data

The Bouguer gravity map (fig. 4) was made from data for 106 stations extracted from the Defense Mapping Agency gravity data base. These stations were reduced using a density of 2.67 grams per cubic centimeter and terrain corrected at a radius of 100 mi from each station. The map shows variations in the gravity field that are associated with changing rock densities or structure. The gravity map often shows subsurface structural detail more clearly and is less weighted toward compositional changes than the magnetic anomaly map. However, the large station spacing (no closer than 2 mi and sometimes as great as 12 mi) gives the gravity map only a regional character; the broad or deep features are enhanced and shallow, high-frequency anomalies are missing.

A broad, 20 mGal (milligal) gravity high located 15 mi east of Petaca Pinta is centered over Pennsylvanian

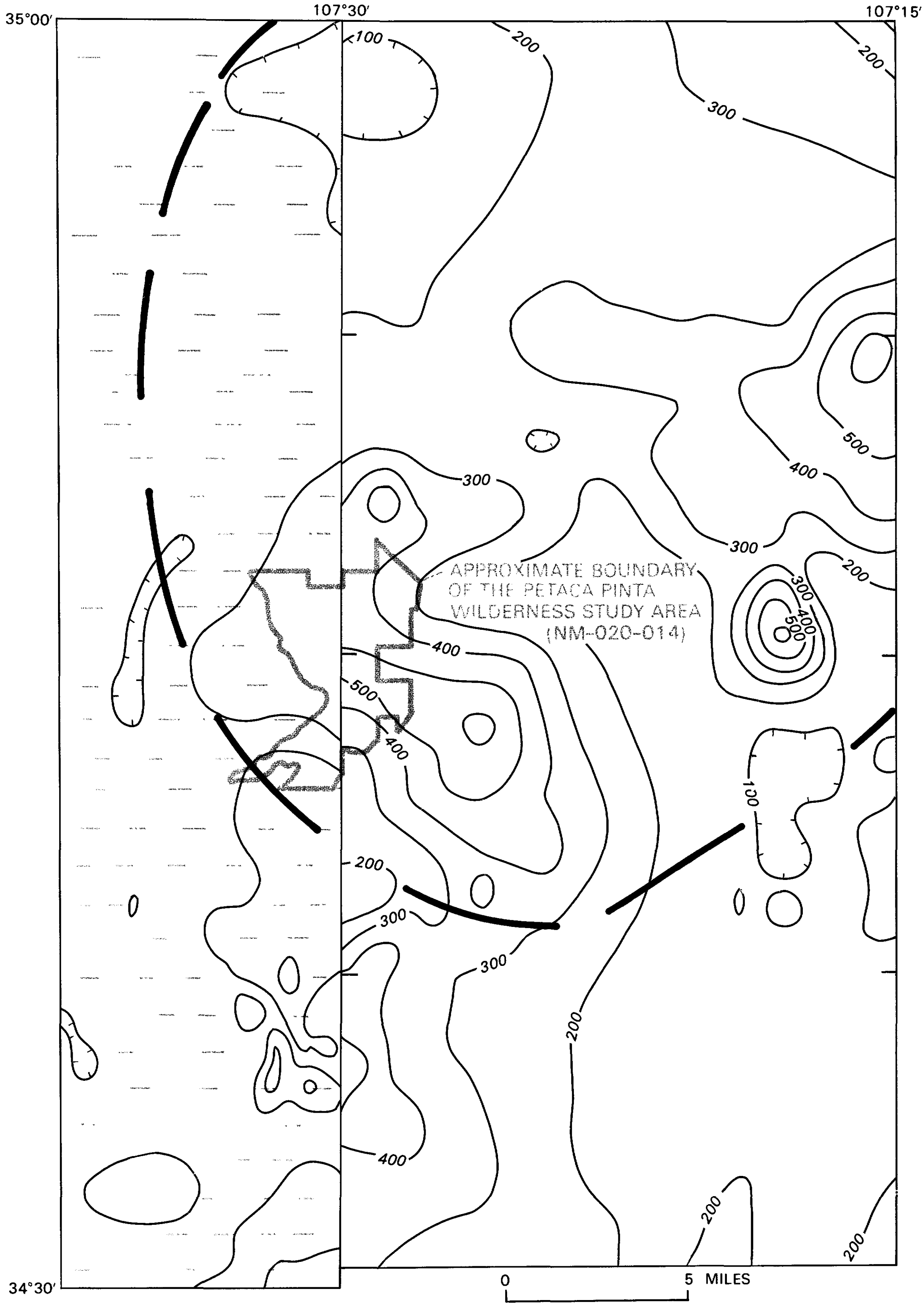


Figure 3 (above and facing page). Aeromagnetic map of the Petaca Pinta Wilderness Study Area and vicinity.

EXPLANATION OF SYMBOLS

Aeromagnetic contour—Hachured where contours enclose magnetic low. Contour interval 20 nanoTeslas

— — — Flight line location (available for 1979 survey only)

Boundary of magnetic terrane (see text)

limestone and shale. This high suggests that a thick section of the the denser Pennsylvanian sedimentary rocks is more widespread than appears on the surface and in the existing boreholes north and south of the study area. The study area is located on a 15 mGal north-south gravity gradient that marks the western extent of the large gravity high. A local positive deflection just east of the study area corresponds to a magnetic low and suggests a smaller feature, possibly a compositionally distinct source for some of the less magnetic basalts that crop out in the area.

Radiometric Data

Aerial gamma-ray spectroscopy is a technique that provides estimates of the near surface (0–20 in. (inches) depth) concentrations of percent potassium (K), parts per million equivalent uranium (eU), and parts per million equivalent thorium (eTh). Because the uranium and thorium measurements utilize radioactive daughter nuclei that are chemically distinct from the parent nuclei, the uranium and thorium are described as equivalent concentrations. These data (K, eU, eTh) provide us with a partial geochemical representation of the near-surface materials. For a typical aerial survey each measurement reflects average concentrations for a surface area on the order of 60,000 square meters to an average depth of about 12 in.

From 1975 to 1983 the U.S. Department of Energy contracted for aerial gamma-ray surveys that covered almost all of the coterminous United States and much of Alaska. The flight line spacings of these surveys vary from 1 mi (rare) to 10 mi and are, in general, only suitable for producing regional scale maps.

As part of a State mapping project, the data for New Mexico were compiled and processed to produce a series of 1:1,000,000-scale maps. These maps include the composite-color maps described by Duval (1983). These maps were examined to estimate the K, eU, and eTh concentrations for the wilderness area and the occurrence or absence of anomalous radioelement concentrations were noted. The definition of an anomaly requires that the element concentration as well as its ratios to the other two elements all be high values in the context of the map.

The Petaca Pinta Wilderness Study Area has overall low radioactivity with concentrations of 1.0–1.5 percent K, 1.7–2.3 ppm eU, and 6–8 ppm eTh. There are no anomalies within or near the study area.

MINERAL AND ENERGY RESOURCES

Metals

No mineralized areas or occurrences of metallic minerals were found in the wilderness study area. No significant anomalies were found by the stream-sediment and concentrate samples; the one silver-bearing sample was not substantiated by the concentrate sample, nor by the presence of commonly associated elements. Slightly anomalous concentrations of barium, strontium, and vanadium are probably related to a thin, regionally extensive, barite-rich zone in the Zuni Sandstone. However, barite does not constitute a resource. The wilderness study area has a low potential for the occurrence of metallic mineral resources, with a certainty level of C.

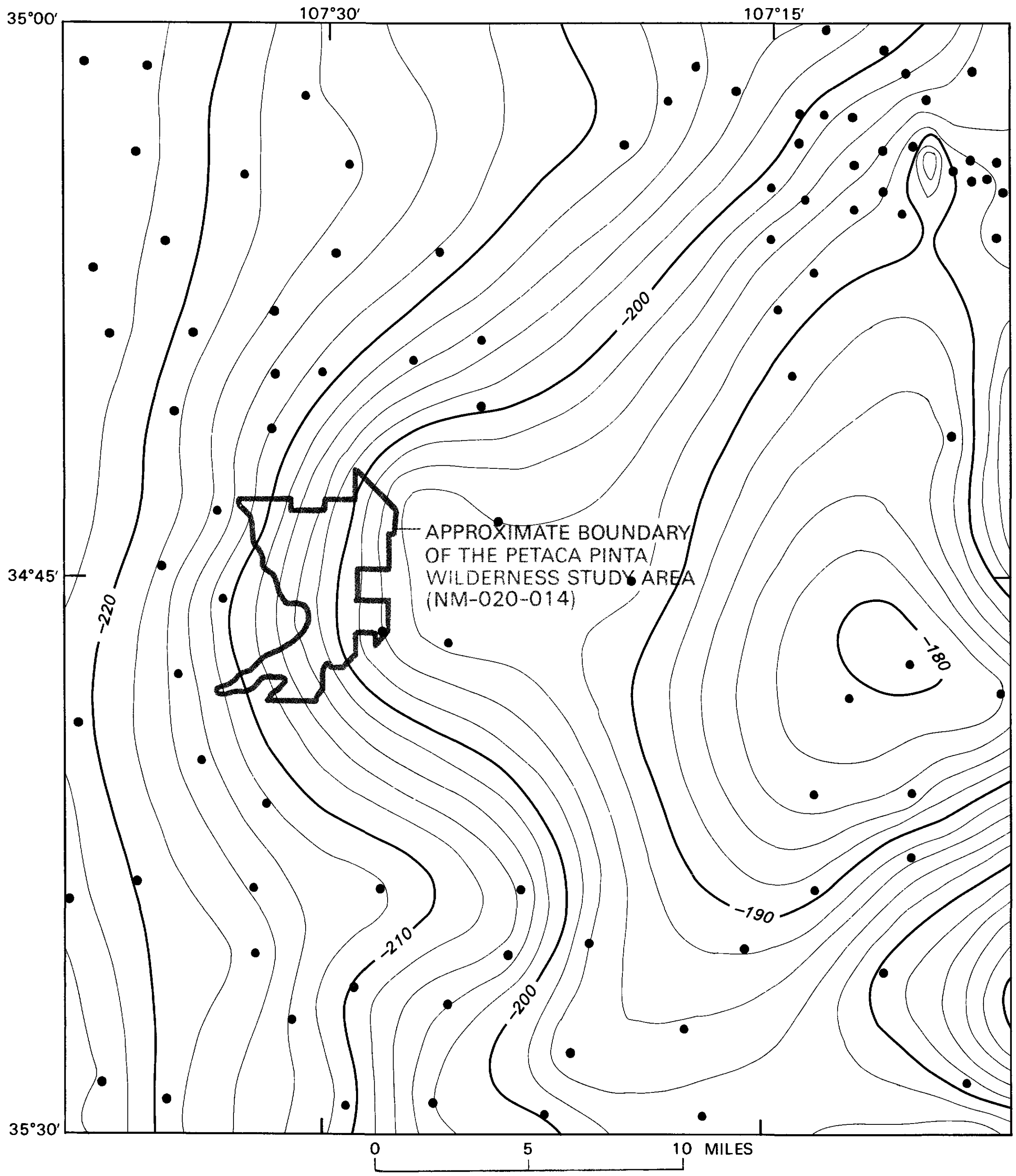
Aerial gamma-ray spectroscopy of the region indicated no areas of anomalous radioactivity within or near the wilderness study area. Results of analysis of stream-sediment samples for uranium ranged from 0.35 to 1.10 ppm, somewhat less than the average crustal abundance for sandstone and shale. The study area has a low potential for the occurrence of uranium, with a certainty level of C.

Oil and Gas

The area is classified by the U.S. Bureau of Land Management (1986) as having a moderate potential for the occurrence of oil, natural gas, and carbon dioxide. No test wells have been drilled in or near the study area, but wells 8 mi or more north and south of the area indicate a rapid eastward thickening of the Pennsylvanian sedimentary rocks which have a potential for both source and reservoirs for oil and gas. Gravity data suggest that the Pennsylvanian section may be even thicker in and east of the study area than indicated by the drilling and may contain reef facies that are favorable for the accumulation of oil and gas. The wilderness study area has a moderate energy resource potential for oil, natural gas, and carbon dioxide, with certainty level B.

Coal

Coal-bearing units do not occur within or near the wilderness study area, either on the surface or projected into the subsurface. There is no potential for coal resources in the study area, with a certainty level of D.



EXPLANATION OF SYMBOLS

-190 **Gravity contour**—Hachured where contours enclose gravity low. Contour interval 2 milliGals

● **Gravity station location**

Figure 4. Bouguer gravity anomaly map of the Petaca Pinta Wilderness Study Area and vicinity.

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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.

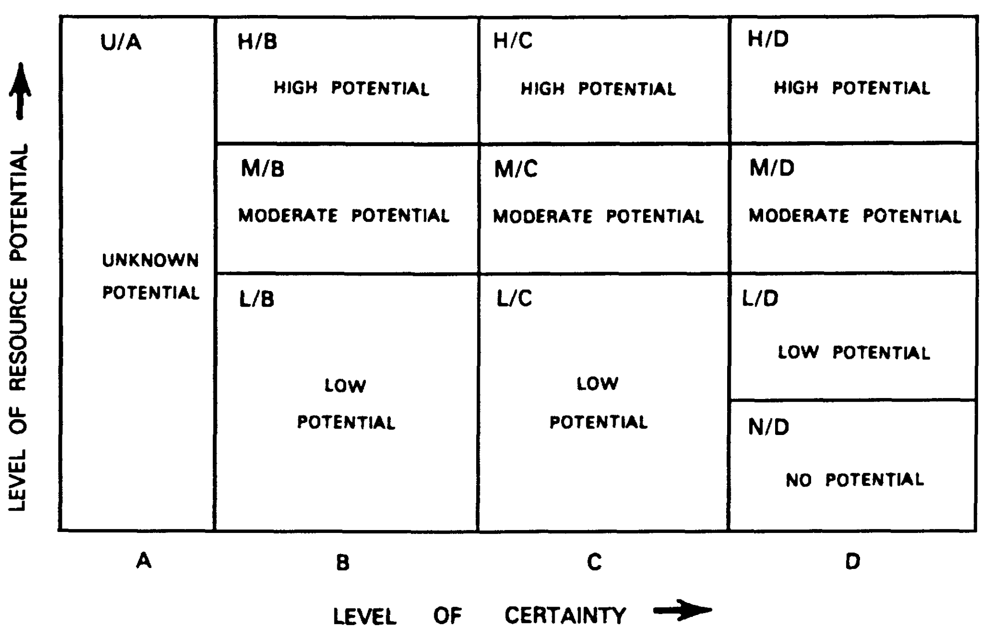
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable likelihood of resource accumulation, and (or) where an application 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:

Taylor, R. B., and Steven, T. A., 1983, Definition of mineral resource potential: Economic Geology, v. 78, no. 6, p. 1268–1270.

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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 McKelvey, 1972, Mineral resource estimates and public policy: American Scientist, v.60, p.32-40, and 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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Mineral Resources of Wilderness Study Areas—West-Central New Mexico

This volume was published as
separate chapters A-H

U.S. GEOLOGICAL SURVEY BULLETIN 1734

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[Letters designate the chapters]

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