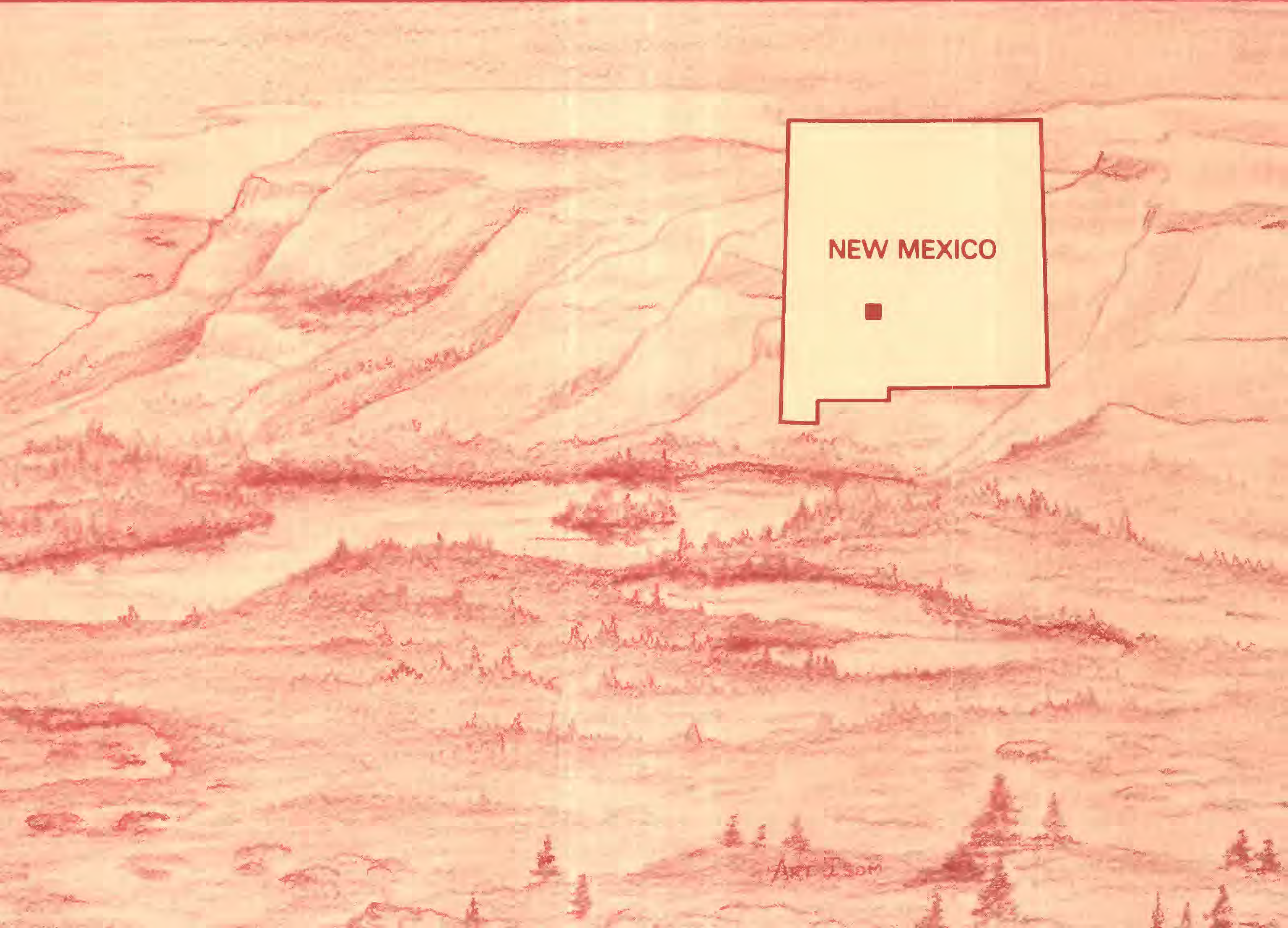
Mineral Resources of the Sierra de las Cañas Wilderness Study Area, Socorro County, New Mexico

U.S. GEOLOGICAL SURVEY BULLETIN 1734–D



Chapter D

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By SAMUEL L. MOORE, ROBERT L. TURNER, and
H.R. BLANK, JR.
U.S. Geological Survey

STANLEY L. KORZEB
U.S. Bureau of Mines

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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 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 the Sierra de las Cañas (NM–020–038) Wilderness Study Area, Socorro County, New Mexico.

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PLATE

[Plate is in pocket]

FIGURES

Mineral Resources of the Sierra de las Cañas Wilderness Study Area, Socorro County, New Mexico

By Samuel L. Moore, Robert L. Turner, *and* H.R. Blank, Jr.
U.S. Geological Survey

Stanley L. Korzeb
U.S. Bureau of Mines

ABSTRACT

In 1986 the U.S. Geological Survey and the U.S. Bureau of Mines conducted investigations to appraise the identified resources and assess the mineral resource potential of the Sierra de las Cañas (NM–020–038) Wilderness Study Area, Socorro County, New Mexico. These investigations showed that the wilderness study area contains small identified resources of gypsum in the Yeso Formation. The entire study area has high mineral resource potential for gypsum. A small area in the southeast part of the wilderness study area has moderate resource potential for undiscovered bismuth, tungsten, lead, and zinc. The wilderness study area has low resource potential for undiscovered uranium and other metals, oil and gas, coal, and geothermal energy (fig. 1).

SUMMARY

The Sierra de las Cañas Wilderness Study Area is about 8 mi (miles) east-southeast of Socorro in central New Mexico. The wilderness study area encompasses 12,838 acres and is characterized by north-trending hills and valleys cut by west-trending arroyos. Access to the wilderness study area is by dirt roads along the western and eastern sides. A series of east- and west-dipping tilted fault blocks and folds of Paleozoic (see geologic time chart in Appendix) and Mesozoic sedimentary rocks underlies the wilderness study area. Minor amounts of Tertiary volcanic rocks are in fault contact with the sedimentary rocks on the east. The wilderness study area lies between the Jornada del Muerto on the east and the Rio Grande trench on the west.

Numerous claims were staked for uranium within the southern half of the wilderness study area in the 1950's, and evidence of location work on these claims is still visible. Claims were staked on alluvium, gravel, and Tertiary volcanic rocks. Mining activity in 1981 consisted of claim staking and assessment work for gypsum near the eastern boundary of the wilderness study area.

The Chupadero mining district is 2 mi northwest of the wilderness study area. Mining there consisted of work on a copper carbonate deposit in sandstone and on a fault-controlled barite and fluorite deposit in limestone. West of the wilderness study area, prospects in the Presilla mining district were for barite, fluorite, galena, and sphalerite in faulted granite, siltstone, and limestone. Two miles northeast of the wilderness study area, the Lucky Don mine produced uranium ore from vein-type deposits in limestone.

The only identified resource in the Sierra de las Cañas Wilderness Study Area is gypsum in the Cañas Gypsum Member of the Yeso Formation. At least 50,000 short tons of gypsum are exposed in two outcrops of San Andres limestone; however, additional resources may be present in the wilderness study area. The gypsum is suitable for cement, agriculture, industrial and building plasters, and for manufacture of wallboard.

As a part of this study, 26 stream-sediment samples and 3 rock samples were collected by the U.S. Geological Survey for geochemical analysis. One of the stream-sediment samples had anomalous concentrations of bismuth, tungsten, and lead and one other stream-sediment sample had anomalous concentrations of tungsten. One stream-sediment sample collected by the U.S. Bureau of Mines adjacent to these samples contained anomalous concentrations of zinc. None of the other samples showed anomalous concentrations of any other elements typical of mineral deposits. A small area in the southeast part of the wilderness study area has moderate mineral resource potential for undiscovered bismuth, tungsten, lead, and zinc. The mineral resource potential for all other undiscovered metals in the wilderness study area is low.

The wilderness study area has low overall radioactivity, and there are no anomalous radioactive areas within or near

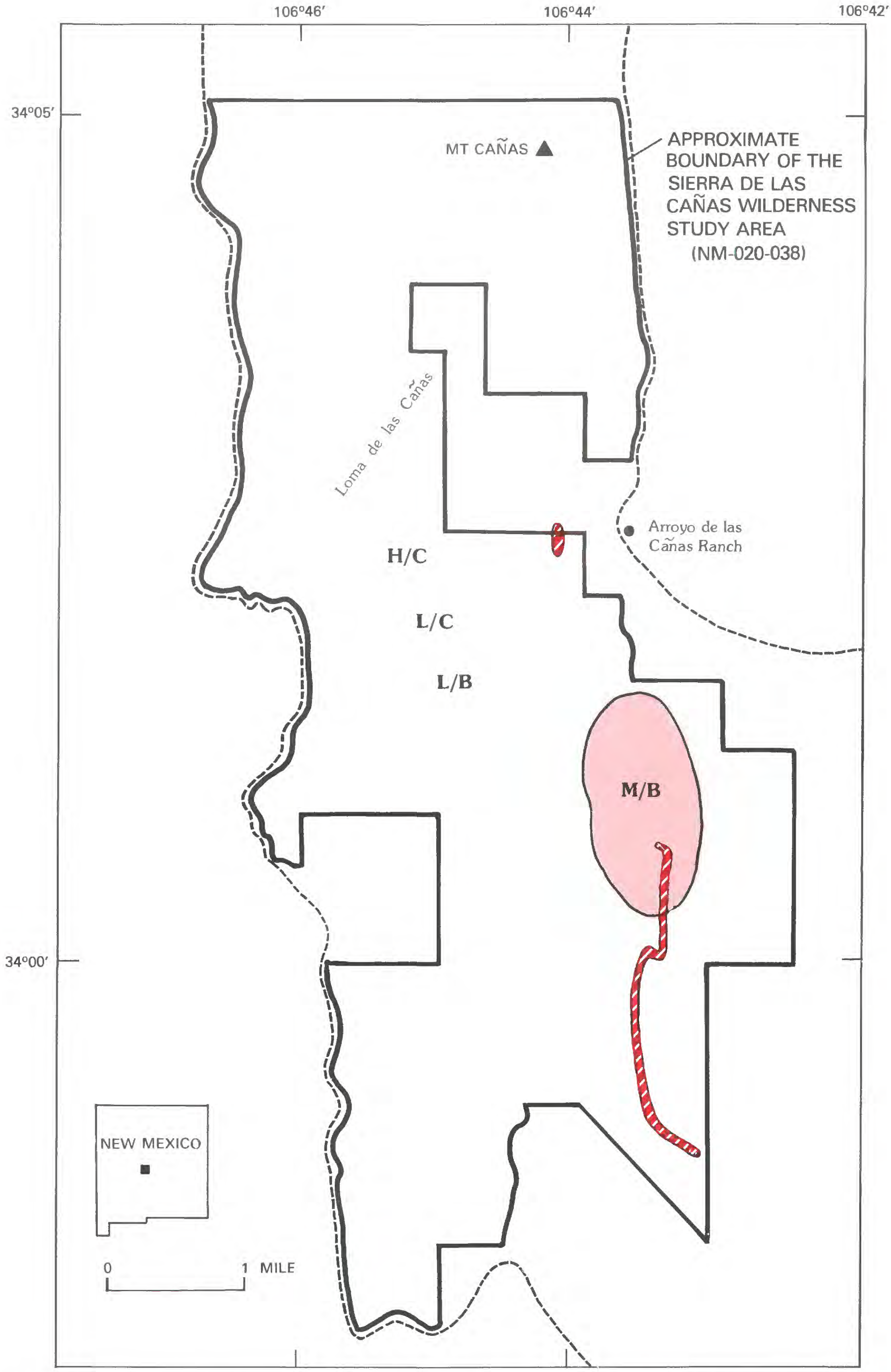

Figure 1 (above and facing page). Map showing mineral resource potential and identified resources of the Sierra de Las Cañas Wilderness Study Area, Socorro County, New Mexico.

EXPLANATION

	Areas having identified resources of gypsum
H/C	Geologic terrane having high resource potential for gypsum, with certainty level C—Applies to entire wilderness study area
M/B	Geologic terrane having moderate mineral resource potential for bismuth, tungsten, lead, and zinc, with certainty level B
L/C	Geologic terrane having low energy resource potential for coal and oil and gas, with certainty level C—Applies to entire wilderness study area
L/B	Geologic terrane having low resource potential for uranium and other metals (except those mentioned above) and geothermal energy, with certainty level B—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, indicate resource potential, but do not establish activity of resource forming processes
-----	Unimproved dirt road

the wilderness study area. Aeromagnetic data indicate the wilderness study area is within a broad magnetic low. A north- to northeast-trending aeromagnetic gradient 1 mi east of the wilderness study area indicates the presence of fault blocks of Datil tuff.

Gravity data show that a northwest-trending gravity gradient traverses the wilderness study area in the vicinity of the anomalous geochemical samples. Although surface rocks are not displaced by northwest-trending faults in this vicinity, a concealed basement fault may be present.

Although there is ample evidence of prospecting for uranium minerals in the eastern part of the wilderness study area, only a few of the prospect pits showed levels of radioactivity above background. The energy resource potential for undiscovered uranium is low.

All the sedimentary rocks which are in the wilderness study area are marine deposits, which do not contain coal. There is therefore a low energy resource potential for undiscovered coal. Oil and gas leases partially cover the north and south parts of the wilderness study area, but there are no exploratory drill holes in the wilderness study area. The tilted rock units in the wilderness study area are not good reservoir rocks for the accumulation of oil and gas in the subsurface. The energy resource potential for undiscovered oil and gas is low.

A warm spring (79 °F (degrees Fahrenheit)) is 4 mi west of the wilderness study area, but no surface evidence of warm spring water was noted in the wilderness study area. A shallow magma body is about 8 mi west of the wilderness study area beneath Socorro, and high temperature gradients and high heat flows in this area are related to the buried magma body. The wilderness study area has low energy resource potential for undiscovered geothermal energy.

The Cañas member of the Yeso Formation is 130–150 ft thick and consists of thick beds of gypsum interbedded with limestone and gypsiferous siltstone. Because the Yeso Formation is either exposed at the surface or underlies the study area, the entire wilderness study area has high resource potential for gypsum, with certainty level C.

INTRODUCTION

The Sierra de las Cañas Wilderness Study Area is 8 mi east-southeast of Socorro, New Mexico (fig. 2). The area is named for the Loma de las Cañas, a prominent north-trending hill north of Arroyo de las Cañas in the central part of the map area. The boundary of the wilderness study area encloses 12,838 acres or about 24 mi^2 (square miles). Elevations range from 6,206 ft (feet) on Cañas in the northern part of the wilderness study area to 5,100 ft in the southwestern part of the wilderness study area.

The western part of the wilderness study area is accessible through a network of narrow unimproved ranch roads that lead eastward from the Rio Grande along the major arroyos and ridges to a road along the western part of the boundary. This road is maintained by the U.S. Bureau of Land Management and leads northward to the Rio Grande valley and Socorro. Southward this road joins a ranch road that leads to U.S. Highway 380. The eastern part of the wilderness study area is accessible through all-weather improved ranch roads that lead northward from U.S. Highway 380 about 20 mi to the Sierra de las Cañas and the Arroyo Tinajas Ranches.

This report presents an evaluation of the mineral 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 U.S. Bureau of Mines and U.S. Geological Survey (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. Undiscovered resources are studied by the USGS.

Investigations by the U.S. Bureau of Mines

The U.S. Bureau of Mines investigations were done in 1986 by S.L. Korzeb (1986) and included a

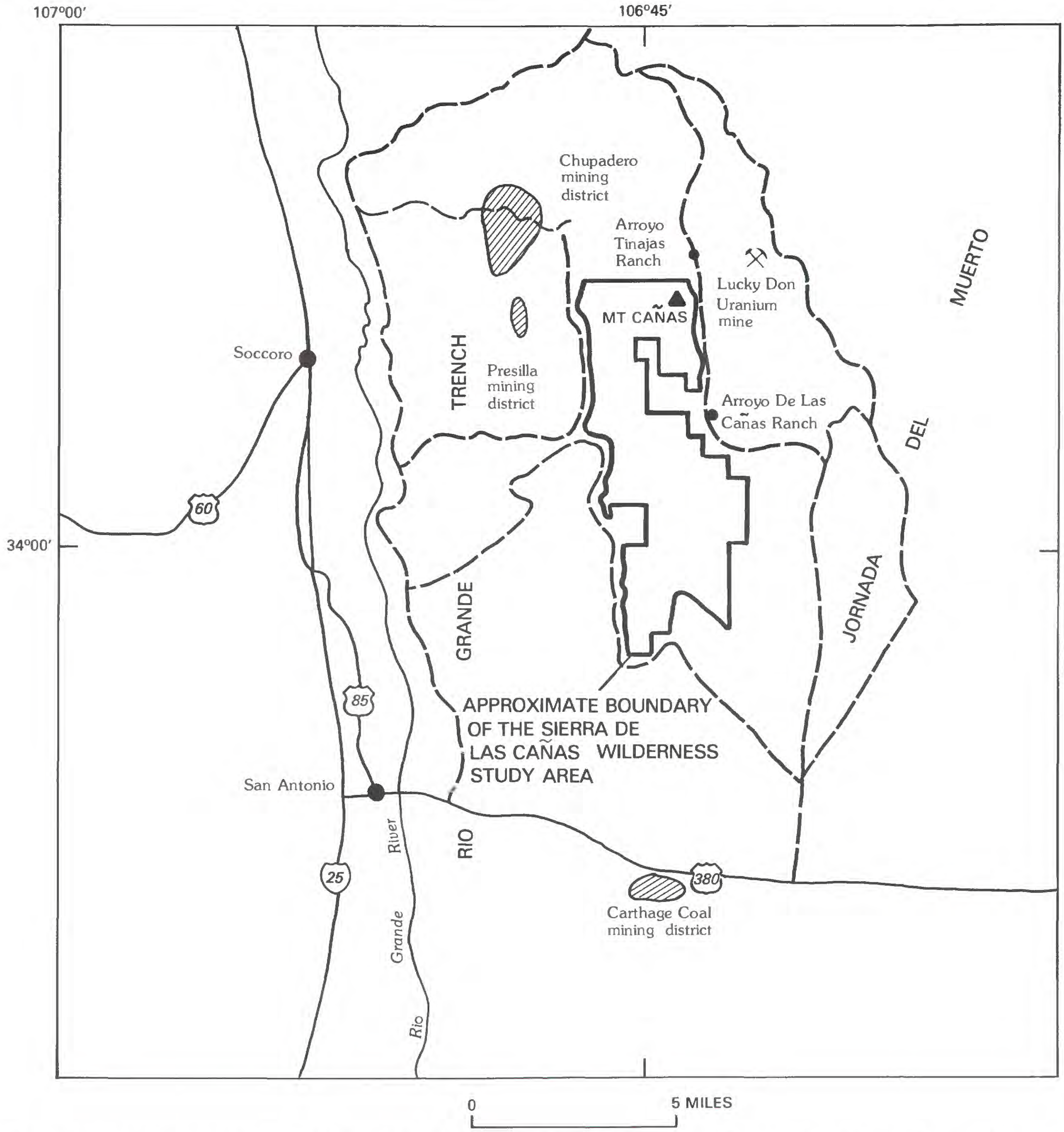

Figure 2. Index map of the Sierra de las Cañas Wilderness Study Area, Socorro County, New Mexico. Dashed lines are secondary roads.

review of published material, a check of the files of the Bureau of Land Management for mining claims and oil leases in the Socorro County courthouse records in Socorro, and sampling of prospect pits in the southeastern part of the map area.

Investigations by the U.S. Geological Survey

The Sierra de las Cañas Wilderness Study Area was mapped previously as part of a larger regional geologic survey by Wilpolt and Wanek (1951) that covered the Socorro, San Antonio, and Chupadera Mesa areas in Socorro County, New Mexico. The present U.S. Geological Survey investigation of the Sierra de las Cañas Wilderness Study Area consists of geologic mapping compiled at a scale of 1:24,000 on parts of four U.S. Geological Survey 7½-minute topographic maps. Geochemical sampling of the major stream sesdiments was done by R.L. Turner, and geophysical data were evaluated by H.R. Blank, Jr.

APPRAISAL OF IDENTIFIED RESOURCES

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

Mining and Mineral Exploration History

County courthouse records show that in the 1950's numerous claims were staked for uranium within the southern half of the wilderness study area. Evidence of location work on these claims, consisting of bulldozer cuts in alluvium, Pleistocene and Pliocene pediment gravel of the Santa Fe Formation and (or) Palomas Gravel, and Oligocene Datil Formation, is still visible in the wilderness study area. Mining activity in 1981 consisted of claim staking and assessment work in and near the eastern part of the wilderness study area.

The Chupadero mining district is 2 mi northwest of the wilderness study area. Mining activity in the district consisted of development work on a copper carbonate deposit in a Permian sandstone bed (Lasky, 1932) and on a fault-controlled barite and fluorite deposit hosted by Pennsylvanian limestone of the Magdalena Group (Williams, 1966). Copper production from the district has not been recorded. The size of the deposit was not indicated in the reports.

Fluorite, barite, and copper minerals also occur about 1.5 mi west of the map area in limestone along north- to northwest-trending faults at the Gonzales, La Bonita, and Tajo mines in the Presilla mining district (fig. 2). These faults have displaced Pennsylvanian strata against post-Pennsylvanian granite plugs along upper reaches of Arroyo de la Presilla, Arroyo de Tio Bartolo, and Arroyo del Tajo west of the map area. These post-Pennsylvanian granite plugs have zones of radioactivity attributable to the normal regional background radiation (McLemore, 1983).

Two miles northeast of the wilderness study area, the Lucky Don mine produced 875 metric tons of uranium ore with a grade of 0.22 percent U_3O_8 from a vein-type deposit in limestone of the Lower Permian San Andres Limestone. Periods of production were 1955–1956, 1960, and 1962–1963 (McLemore, 1983).

Oil and gas leases partially cover the north and south parts of the wilderness study area (pl. 1), but there are no exploratory drill holes. Three dry holes were drilled into underlying Paleozoic rocks 20 mi southwest of the wilderness study area (Broadhead, 1983).

Gravel is available for road metal and aggregate in conglomerate of the Miocene to Pleistocene Santa Fe Group, in Pliocene to Pleistocene Palomas Gravel, and in Quaternary alluvial deposits in major arroyos. Because of the distance to market and lack of unique qualities, the gravel does not constitute a resource.

Identified Resources

Permian sandstone and Pennsylvanian limestone and siltstone beds similar to the beds that host a copper deposit in the Chupadero mining district northwest of the wilderness study area and at other locations in Socorro County crop out in the wilderness study area; however, no evidence of copper mineralization was identified in outcrop in the wilderness study area.

Three faults were sampled for possible fault-controlled metal occurrences. The analytical results showed no gold and silver and only 0.001–0.003 percent zinc. A panned-concentrate sample from sample locality 5 had 0.1 percent zinc (pl. 1, Korzeb, 1986). The source of the zinc was not identified.

A 10-ft-thick gypsum bed crops out on an unpatented claim in the east-central part of the wilderness study area and 3 mi to the south in the southeast part of the wilderness study area (fig. 1 and pl. 1). The bed, which is in the Canas Gypsum Member of the Yeso Formation, strikes north and dips about 17° west under the wilderness study area. The gypsum-bearing beds are discontinuous because of faulting; the gypsum occurs as lenses. Four chip samples collected from the gypsum outcrops were analyzed and contained 97–99 percent calcium sulfate and combined water.

By using an assumed minable thickness of 10 ft, a measured width of 20 ft, and a measured length of 11,000 ft, the USBM calculated an inferred resource of 43,000 st (short tons) in the southeast part of the wilderness study area. The average overburden thickness is 300 ft. At the unpatented claim in the east-central part of the wilderness study area the assumed thickness is 10 ft, width 100 ft, and length 100 ft, resulting in an inferred resource of 7,200 st. The resource at this unpatented claim is at the surface. A tonnage factor of 13.9 ft^3/st (cubic feet per short ton) was used to calculate the resources.

Four samples collected from gypsum outcrops and analyzed for purity showed 97–99 percent pure calcium sulfate. Gypsum is used for portland cement, agriculture, industrial and building plasters, and wallboard (Pressler, 1984). The gypsum in the wilderness study area meets the grade for all of the above uses.

Vast amounts of developable gypsum are available outside the wilderness study area. The gypsum deposits in the wilderness study area occur in the upper part of the Yeso Formation and would have to be mined by surface methods. They may be mined on a small scale for local use but are probably too remote to be profitably mined and shipped to other markets. The average gypsum mine in New Mexico produces 100,000 st per year, which makes the 50,200 st in the wilderness study area insignificant.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By Samuel L. Moore, Robert L. Turner, and H.R. Blank, Jr.
U.S. Geological Survey

Geology

The geographic features of the Sierra de las Cañas Wilderness Study Area are characterized by a series of north-trending hills, hogbacks, and valleys that are cut by two major west-southwest-trending arroyos that drain the map area westward into the Rio Grande. From north to south these arroyos are the Arroyo de las Cañas and an unnamed arroyo that drains the southwestern part of the wilderness study area. The southeastern part of the wilderness study area drains southward through Cañon Agua Buena into the Rio Grande.

The geology of the Sierra de las Cañas Wilderness Study Area consists of upper Paleozoic and some Mesozoic sedimentary rocks in fault contact with Tertiary volcanic rocks in the eastern part of the wilderness study area. Detailed rock descriptions are given on plate 1. The sedimentary rocks consist of, from oldest to youngest, the Madera Limestone of the Magdalena Group; sandstone, shale, and conglomerate of the Abo Formation; siltstone, limestone, and gypsum of the Yeso Formation; the Glorieta Sandstone; the San Andres Limestone; sandstone of the Dockum Formation; and sandstone of the Dakota Formation. The Oligocene Datil Formation is made up of volcanic flows and volcaniclastic conglomerate, sandstone, and rhyolitic tuff. Pliocene and Pleistocene pediment gravel caps the older rock units, and minor amounts of Holocene alluvium are present in some drainages.

Hills of the map area are underlain by resistant limestone of the San Andres Limestone and the Glorieta Sandstone. The intervening valleys are underlain by easily eroded interbedded shale, siltstone, gypsum, thin-bedded limestone, and sandstone of the Lower Permian Yeso Formation.

The structural geology of the Sierra de las Cañas Wilderness Study Area consists of north-south-trending, branching and anastomosing, steeply dipping to vertical faults that displace the Paleozoic, Mesozoic, and Cenozoic rocks into tilted eastward-dipping fault blocks and open folds (pl. 1). These faults are crosscut and displaced by younger, north-, northeast-, and northwest-trending faults. Most of the north-south-trending faults are downthrown to the east, placing younger Permian, Triassic, and Tertiary rocks at the surface in the eastern part of the map area. Older Pennsylvanian, Permian, and Triassic rocks crop out at the surface in the western part of the map area.

The fault zones consist of 6–8-in.-wide breccia zones in Permian limestone and sandstone and 4–8-in.-wide shear zones in Permian shale and gypsum. No metallic minerals were observed in either the breccia or shear zones or the tilted fault blocks.

Geochemistry

Methods

A reconnaissance geochemical survey was conducted in the Sierra de las Cañas Wilderness Study Area in the fall of 1984. Heavy-mineral concentrates from 26 stream-sediment samples and 3 rock samples were selected as the sample media in this study. The heavy-mineral concentrates were collected from alluvium in the active stream channel. Each sample was composited from several localities along channel lengths of approximately 50 ft. The heavy-mineral concentrates were sieved through a 10-mesh screen and then panned until most of the quartz, feldspar, clay-sized material, and organic matter were removed. The heavy minerals were then separated from the remaining light minerals by submersion in a heavy liquid (bromoform, specific gravity 2.8), the magnetite and ilmenite were removed with an electromagnet, and the remaining concentrates were ground to a fine powder before analysis. The heavy-mineral concentrate represents a concentration of some elements that are not easily detected in bulk stream sediments.

Rock samples were taken from outcrop, and float rock samples were collected in stream beds. These rock samples were collected to provide information on geochemical background values. The rocks were crushed and pulverized to a fine powder before analysis. The heavy-mineral concentrates from the stream-sediment samples and the rock samples were analyzed for 31 elements by direct-current arc semiquantitative emission spectrographic analysis (Grimes and Marranzino, 1968; Crock and others, 1983). The rocks were also analyzed for arsenic, bismuth, cadmium, antimony, and zinc by atomic absorption spectrometry (O'Leary and Viets, 1986).

Results

The heavy-mineral concentrates from sample locality 17 contained anomalous amounts of bismuth (>2,000 ppm (parts per million)), lead (200 ppm), and tungsten (20,000 ppm), and the concentrate from sample locality 16 contained anomalous amounts of tungsten (500 ppm). Scheelite, a tungsten-bearing mineral, was optically identified in both samples with an ultraviolet lamp. A concentrate sample collected by the U.S. Bureau of Mines (Korzeb, 1986) about 0.25 mi downstream from sample locality 16 contained 1,000 ppm zinc. The anomalous concentrations of bismuth, tungsten, lead, and zinc may indicate that some of the rocks in the drainage basin to the east are mineralized. These two sample localities are in Arroyo de las Cañas, which drains an area east of the wilderness study area through a north-trending fault zone in the eastern part of the wilderness study area.

Sample locality 4, in the northwestern part of the wilderness study area, contained anomalous concentrations of lead (200 ppm), but the source of the lead is unknown. None of the other concentrate samples had anomalous concentrations of elements associated with mineral deposits.

None of the rock samples had anomalous concentrations of any elements.

Geophysics

Radiometric Data

Aeroradiometric data were obtained as a product of the National Uranium Resource Evaluation (NURE) program in which aircraft traverses were made 400 ft above the terrain along east-west flight lines spaced, in this area, 3 mi apart. The NURE data were evaluated by J.S. Duval of the U.S. Geological Survey. He reported that the wilderness study area has low radioactivity, containing 0–1 percent potassium, 2–3 ppm eU (equivalent uranium), and 3–7 ppm eTh (equivalent thorium). There are no anomalies within or near the wilderness study area, although an area of higher uranium (2.5–4.0 ppm eU) and thorium (8–11 ppm eTh) values is located approximately 4–6 mi southeast of the wilderness study area. The higher values of uranium and thorium to the southeast may be related to anomalies detected through geochemical sampling, as noted above.

In the southeastern part of the wilderness study area the Oligocene Datil volcanic rocks have narrow north-south-trending zones of slightly higher radioactivity than regional background radioactivity. Evidence for uranium prospecting in these linear zones consists of a series of bulldozer cuts north of the Ranchito Windmill in the headwaters of the Cañon Agua Buena and south and southwest of the Arroyo de las Cañas Ranch (pl. 1).

North of the Ranchito Windmill along the eastern slopes of the Cañon Agua Buena, a north-south line of 14 prospect pits (pl. 1) have moderately high radioactivity as compared to the regional background radioactivity. These higher radioactivity levels in the Datil volcanic rocks may be due to either minor amounts of thorium minerals or to potassium decay in feldspar or other minerals in the Datil volcanic rocks. No visible radioactive minerals were observed in these prospect pits. Another line of 4 prospect pits along the west slopes of the Cañon Agua Buena northwest of the Ranchito Windmill do not have anomalously high radioactivity. All prospect pits in gravel of the Santa Fe Group south and southwest of the Arroyo de las Cañas Ranch do not have higher than regional background radioactivity.

Aeromagnetic Data

Two aeromagnetic surveys published by the U.S. Geological Survey (1974, 1975) were made over the northwest and northeast parts of the wilderness study area at 1-mi flight-line spacings and elevations of 10,000 ft and 8,000 ft above sea level, respectively. For the area immediately south of lat 34° N., only data from the NURE flights are available. The two sets of data were composited by techniques described in Cordell (1983). Figure 4 is taken directly from the state map (Cordell, 1983) and shows the residual total-intensity magnetic anomaly field in the context of regional field disturbances. Evidently no strongly polarized sources are present within the wilderness study area, which occupies a broad anomaly low. A string of weak positive anomalies (near A, fig. 3; not seen at the 50-nT (nanoTesla) contour interval of this map) northwest of the wilderness study area is spatially associated with outcrops of Precambrian crystalline rock. Stronger positive anomalies of unknown origin occur about 2 mi to the southwest (B) and 4 mi to the east-northeast (C) of the wilderness study area. A weak, generally north- to north-northeast-trending magnetic gradient (D) about 1 mi east of the wilderness study area delimits the western edge of the moderately strongly polarized, tilted and faulted Datil volcanic rocks along the western margin of the Jornada del Muerto. This gradient probably reflects structural relief on faulted Datil volcanic rocks. The nearest outcrops of Phanerozoic intrusive rock, 5–8 mi northeast, northwest, and south of the wilderness study area, are on the flanks of weak to intense magnetic highs.

Gravity Data

Gravity data for the area shown on figure 1 were obtained from 35 stations, although none of the stations were within the wilderness study area. Observed gravity at these stations has been reduced to Bouguer values and computer-terrain-corrected out to a radius of 100 mi at a density of 2.67 g/cm^3 (grams per cubic centimeter), according to standard USGS procedures (for example, see Cordell and others, 1982). Figure 3 shows the resulting anomaly field as depicted on the Bouguer gravity anomaly map of New Mexico (Keller and Cordell, 1984). The pattern of gravity anomalies bears little resemblance to the pattern of magnetic anomalies dis-

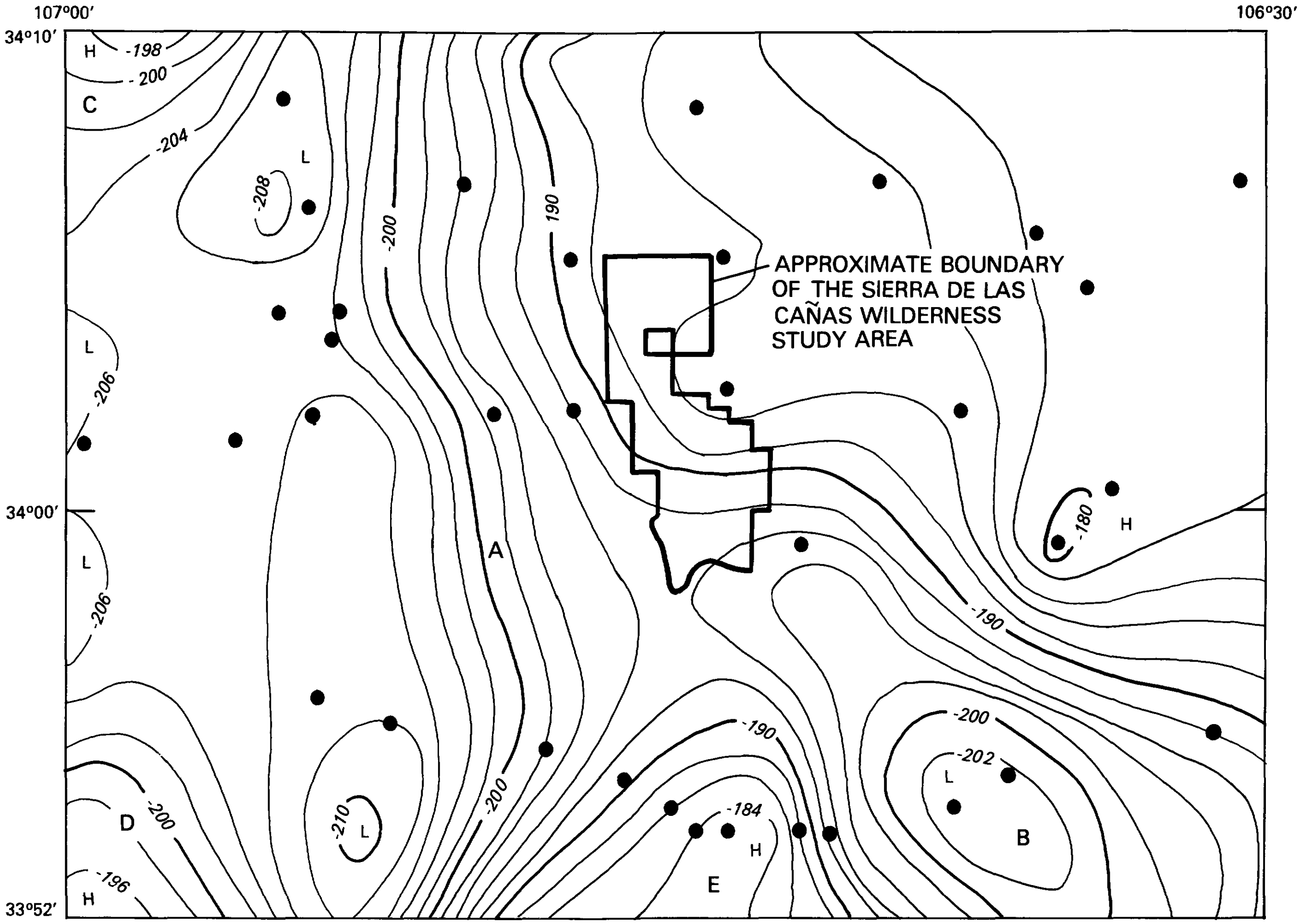

Figure 3. Bouguer gravity anomaly map of the Sierra de las Cañas Wilderness Study Area and vicinity, Socorro County, New Mexico. Contour interval 2 milliGals; L, gravity low; H, gravity high; small circles are gravity stations. Gravity features A-E are discussed in the text. Data from Keller and Cordell (1984).

cussed previously. Its principal features are a strong east-west gradient (A, fig. 3) across the basement structural discontinuity on the eastern margin of the Rio Grande rift and a troughlike gravity low (B) southeast of the wilderness study area. The latter feature is bounded by pronounced gradients that generally coincide with the limits of outcrops of Paleozoic and Mesozoic rocks on its flanks; it probably reflects the presence of low-density rocks and alluvial deposits in a northwest-trending Cenozoic basin or grabenlike structure. One of the two gradients flanking anomaly B crosses the wilderness study area in the vicinity of the two sample localities having anomalous metal concentrations. Although surface rocks are not displaced by northwest-trending faults in this vicinity, a concealed basement fault may be present. Both gradients flanking anomaly B merge with the Rio Grande rift margin gradient (A) west of the wilderness study area, suggesting possible truncation of their source structures by north-south rift faults. Incompletely delineated gravity highs on the northwest, southeast, and south-central edges of the map (C, D, and E, fig. 4) all occur in areas where at least some Precambrian rock is exposed and probably represent relative structural highs in the basement rocks.

Mineral and Energy Resources

Metals

There are no mines in the Sierra de las Cañas Wilderness Study Area. In the eastern part of the wilderness study area, one heavy-mineral-concentrate sample contained anomalous concentrations of bismuth, lead, and tungsten; another sample contained an anomalous concentration of tungsten; scheelite was identified in both samples. One other concentrate sample contained an anomalous concentration of zinc. The sedimentary rocks in the wilderness study area have been extensively faulted, and gravity data suggest the presence

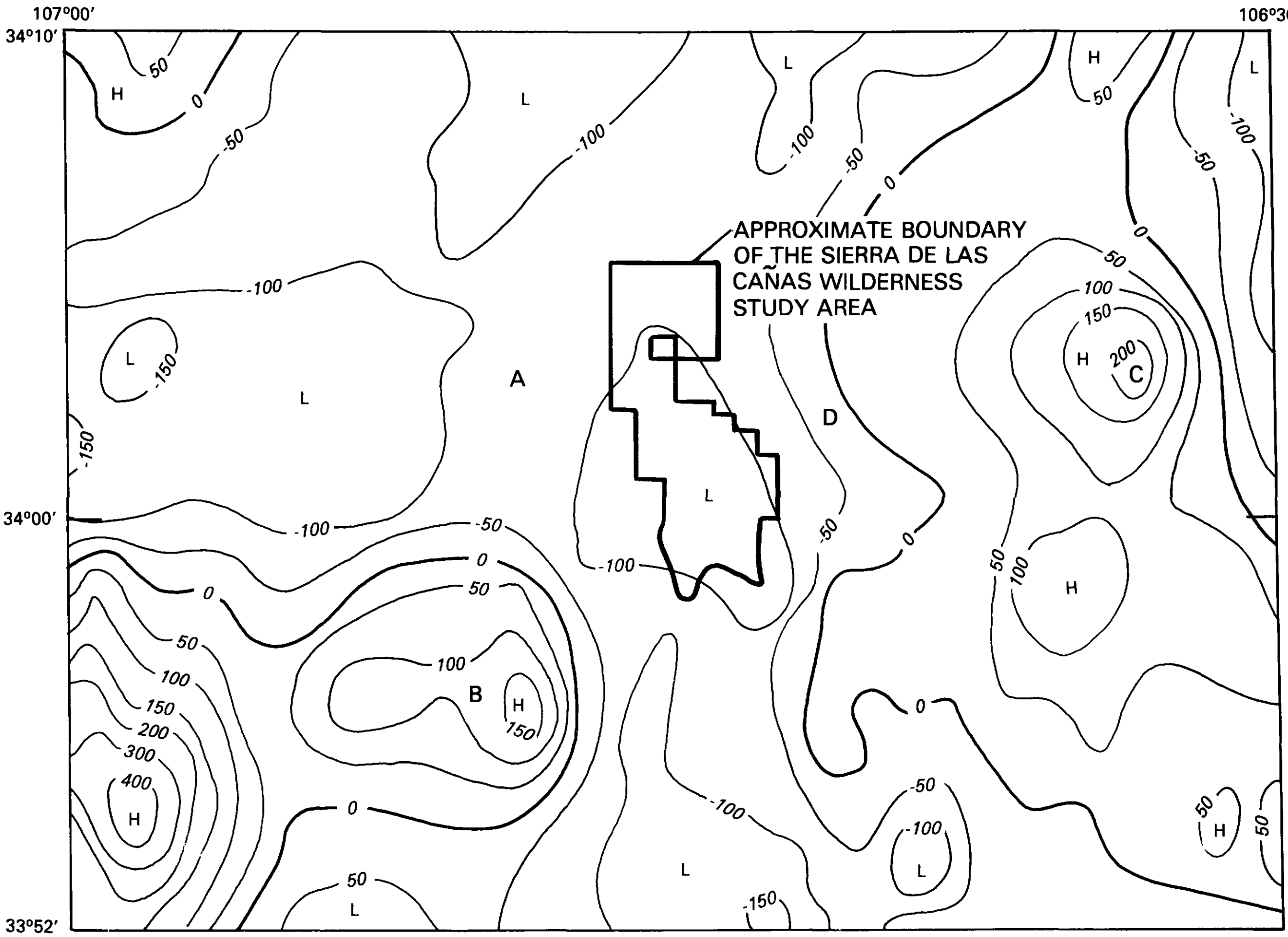

Figure 4. Aeromagnetic map of the Sierra de las Cañas Wilderness Study Area and vicinity, Socorro County, New Mexico. Total intensity magnetic field of the earth relative to arbitrary datum. Contour interval 50 and 100 gammas; L, magnetic low; H, magnetic high. Magnetic features A-D are discussed in the text. North of lat 34° N. the survey was flown in an east-west direction with 1-mi flight-line spacing; flight elevation of 8,000-ft barometric between long 106°30' W. and 106°45' W. and 10,000-ft barometric between long 106°45' W. and 107° W. South of lat 34° N. the survey was flown in an east-west direction with 3-mi flight-line spacing at 400 ft above the terrain. Data from Cordell (1983).

of a buried major fault that traverses the area of geochemical anomalies. Intrusive rocks are exposed 5–8 mi north, northeast, and northwest of the wilderness study area, and Sanford (1978) indicates that shallow magma bodies are present 8 mi west of the wilderness study area near Socorro. However, geophysical work from this wilderness study area does not indicate the presence of a buried pluton. The source of the anomalous mineralization is not known. The mineral resource potential for bismuth, tungsten, lead, and zinc is moderate in a small area in the southeast part of the wilderness study area (defined by the drainage basins of the anomalous stream-sediment samples), with certainty level B. The mineral resource potential for all other metals in the wilderness study area is low, with certainty level B.

Uranium

Evidence of uranium prospecting in the southeastern part of the wilderness study area consists of about 20 prospect pits (pl. 1) that were dug by bulldozers in gravel of the Miocene to Pleistocene Santa Fe Group and Pliocene to Pleistocene Palomas Gravel and in the Oligocene Datil volcanic rocks. Some of these prospect pits have moderately high radioactivity as compared to regional background radioactivity. These zones of slightly elevated radioactivity in the southeastern part of the wilderness study area are probably due either to potassium decay in feldspar in the Datil volcanic rocks that underlie the southeastern part of the area or to traces of either thorium or uranium in the Oligocene Datil volcanic rocks. There is low mineral resource potential for uranium in the wilderness study area, with certainty level B.

Coal

Cretaceous coal has been mined about 5 mi south of the wilderness study area in the Carthage coal mining district (fig. 2), but no coal beds of Cretaceous age crop out at the surface or are known to occur in the subsurface within the wilderness study area. Cretaceous rock within the wilderness study area has been removed by erosion except for a small outcrop of Dakota Sandstone in the eastern part of the wilderness study area. The Dakota Sandstone in this region of New Mexico is a marine unit and does not contain coal beds. Pennsylvanian rocks are marine limestone and shale and do not contain coal. There is low energy resource potential for coal in the wilderness study area, with certainty level C.

Oil and Gas

Oil and gas leases in the northern and southern parts of the wilderness study area were never drilled. Three dry holes were drilled into underlying Paleozoic rocks 20 mi southwest of the wilderness study area (Broadhead, 1983). The Paleozoic and Mesozoic sedimentary rocks in the study area are not good reservoirs for the accumulation of oil and gas in the subsurface because of the abundant faulting; any hydrocarbons that might have been present would likely be flushed out along these structures. Ryder (1983) indicated that the wilderness study area has low energy resource potential for oil and gas in the block-faulted Paleozoic and Mesozoic sedimentary rocks. The wilderness study area has low energy resource potential for oil and gas, with certainty level C.

Geothermal Energy

The wilderness study area is in the Socorro Peak Known Geothermal Resource Area, but there are no geothermal leases within the wilderness study area. A warm spring (79 °F) with a 2.2 thermal flow units rating (U.S. Geological Survey, 1981) occurs 4 mi west of the wilderness study area (Krason and others, 1982); however, no surface evidence of warm spring water was noted in the wilderness study area. Sanford and others (1977) and Sanford (1978) have indicated the presence of a shallow magma body 8 mi west of the wilderness study area beneath Socorro. They also note high temperature gradients and heat flows in the Socorro area, probably related to the intrusion of magma into the crust. The wilderness study area has low energy resource potential for geothermal energy, with certainty level B.

Gypsum

The Permian Yeso Formation contains the Cañas Gypsum Member, which consists chiefly of thick beds of white gypsum interbedded with beds of medium-gray limestone and gypsiferous siltstone. The member is 130–160 ft thick. Geochemical studies (Korzeb, 1986) indicate that the gypsum is of useable grade for portland cement, agriculture, industrial and building plasters, and wallboard. The Yeso Formation is either exposed at the surface or underlies all of the study area. The mineral resource potential for gypsum is high, with certainty level C.

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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

LEVEL OF RESOURCE POTENTIAL →

<table>
<tr><td rowspan="4">U/A

UNKNOWN
POTENTIAL</td><td>H/B
HIGH POTENTIAL</td><td>H/C
HIGH POTENTIAL</td><td>H/D
HIGH POTENTIAL</td></tr>
<tr><td>M/B
MODERATE POTENTIAL</td><td>M/C
MODERATE POTENTIAL</td><td>M/D
MODERATE POTENTIAL</td></tr>
<tr><td rowspan="2">L/B

LOW
POTENTIAL</td><td rowspan="2">L/C

LOW
POTENTIAL</td><td>L/D
LOW POTENTIAL</td></tr>
<tr><td>N/D
NO POTENTIAL</td></tr>
<tr><td>A</td><td>B</td><td>C</td><td>D</td></tr>
</table>

LEVEL 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 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.

*U.S. GOVERNMENT PRINTING OFFICE: 1988-0-573-047/66035