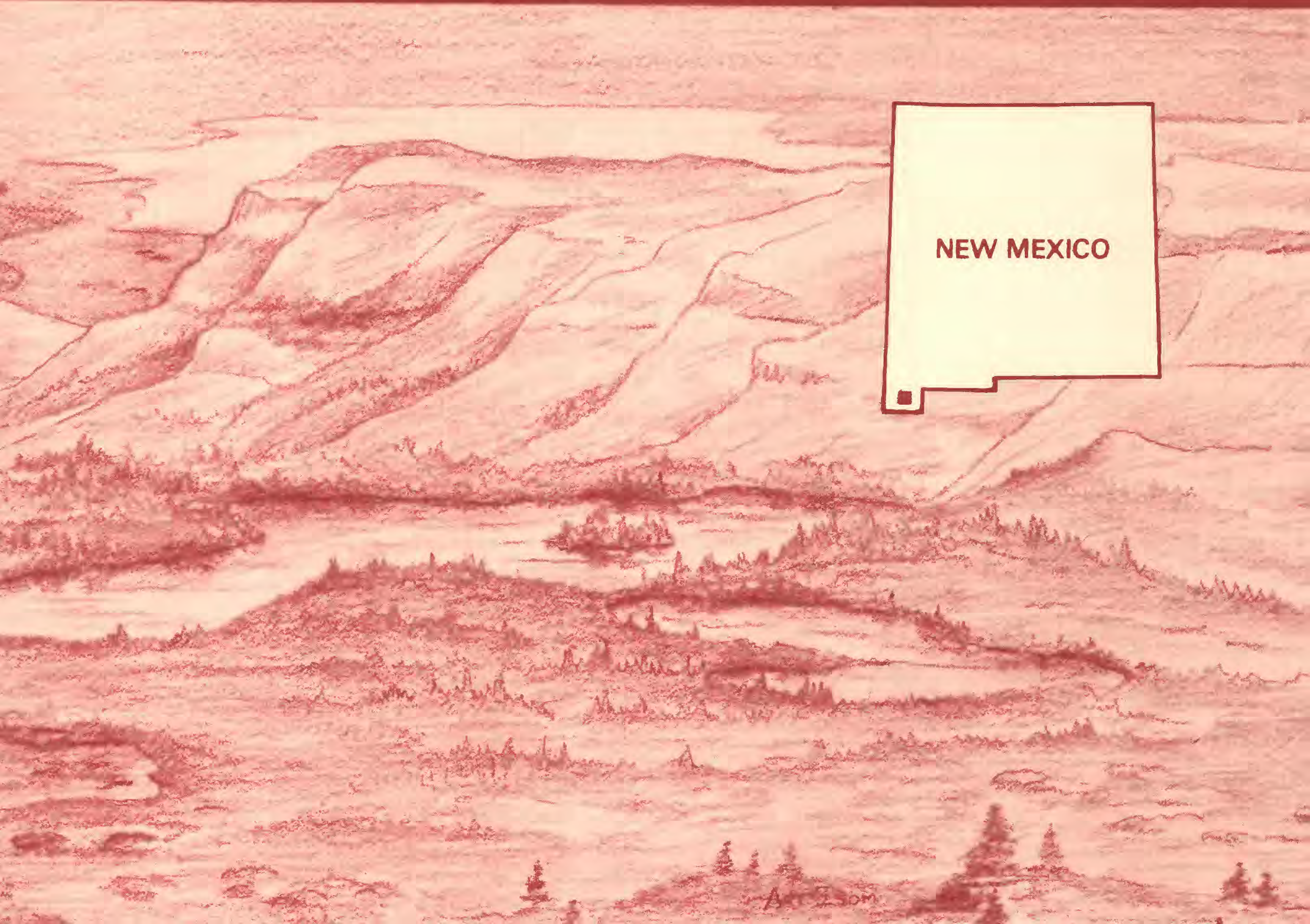
Mineral Resources of the Cowboy Spring Wilderness Study Area, Hidalgo County, New Mexico

U.S. GEOLOGICAL SURVEY BULLETIN 1735–F



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Chapter F

Mineral Resources of the Cowboy Spring Wilderness Study Area, Hidalgo County, New Mexico

by WILLIAM E. BROOKS, JERRY R. HASSEMER, JOSEPH S. DUVAL, and WILLIAM F. HANNA
U.S. Geological Survey

DAVID C. SCOTT
U.S. Bureau of Mines

U.S. GEOLOGICAL SURVEY BULLETIN 1735

MINERAL RESOURCES OF WILDERNESS STUDY AREAS—
SOUTHWESTERN NEW MEXICO

DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, JR., 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 a part of the Cowboy Spring (NM–030–007) Wilderness Study Area, Hidalgo County, New Mexico.

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Mineral Resources of the Cowboy Spring Wilderness Study Area, Hidalgo County, New Mexico

By William E. Brooks, Jerry R. Hassemer, Joseph S. Duval, *and* William F. Hanna
U.S. Geological Survey

David C. Scott
U.S. Bureau of Mines

ABSTRACT

The Cowboy Spring Wilderness Study Area (NM–030–007) is in the Animas Mountains in Hidalgo County, southwestern New Mexico. The 6,699-acre study area is about 15 mi (miles) north of the international border between the United States and Mexico. This area is sparsely populated and access to the study area is by light-duty roads leading to the study area and four-wheel-drive roads and trails within the study area.

No identified mineral resources, mines, prospects, mineralized areas, or mineral resources were found within the study area. Evaluation of geologic mapping, geophysical studies, and a reconnaissance stream-sediment geochemical survey indicate that the mineral resource potential for undiscovered metals, fluorspar, oil and gas, and geothermal energy in the Cowboy Spring Wilderness Study Area is low.

SUMMARY

Character and Setting

The Cowboy Spring Wilderness Study Area (NM–030–007) is in Hidalgo County in southwestern New Mexico, about 15 mi north of the border between the United States and Mexico (fig. 1). At the request of the U.S. Bureau of Land Management, the 6,699-acre Cowboy Spring Wilderness Study Area was examined. For convenience, this area is referred to in this report as the "study area." The study area is accessible by light-duty roads leading to the study area and four-wheel-drive roads and trails within the study area. Elevations range from 4,920 ft (feet) in the eastern part of the study area to 6,601 ft at Elephant Butte.

Cretaceous to Quaternary (see geologic time chart in Appendix) sedimentary rocks that include sandstone, limestone, and conglomerate are exposed just north of the study area and in a small area in the eastern part of the study area. Tertiary volcanic rocks are the chief rock types exposed in the study area. One of the rock units that is widely distributed in the Animas Mountains and south of the study area may be as thick as 3,000 ft. These rocks are associated with a large volcanic structure known as the Cowboy Rim cauldron.

Identified Mineral Resources

No mineral resources were identified nor were any mines, prospects, or mineralized areas found within the study area. However, modest amounts of silver, gold, copper, and fluorite were reported to have been produced from the Gillespie mine, approximately 1.5 mi northwest of the study area, and silver and lead were produced from the Red Hill mine, approximately 4 mi northeast of the study area. The mineralized rock formations at the Gillespie mine and the Red Hill mine do not crop out in the study area.

Mineral Resource Potential

Results of a stream-sediment geochemical survey yielded no evidence to indicate exposed mineralized rock in the study area. Similarly, a uniform gravity gradient and a low aeromagnetic gradient within the study area indicate little likelihood of the kinds of concealed structures that could be

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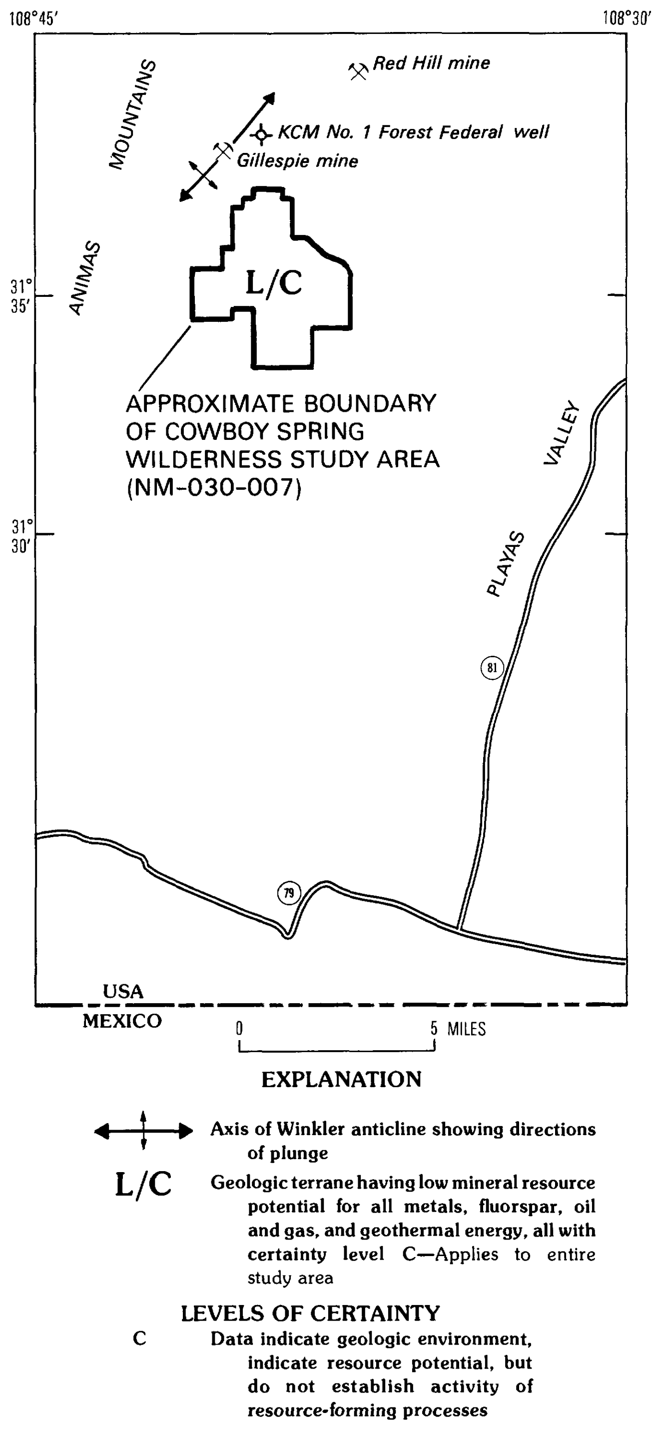


Figure 1. Summary and index map showing mineral resource potential and location of the Cowboy Spring Wilderness Study Area, New Mexico.

favorable sites for mineralization. A moderately strong thorium anomaly is suggested by airborne gamma-ray spectroscopy, but no mineralized rock was found.

The mineral resource potential for undiscovered metals is low because the rocks within the study area show little evidence of hydrothermal alteration, silicification, or faulting. Analyses of rock-chip and stream-sediment samples indicate no anomalous concentrations of metals.

The mineral resource potential for undiscovered fluorspar is low because of the absence of favorable host rock. Fluorspar occurrences near the study area are found in faulted and fractured Pennsylvanian and Permian Horquilla Limestone. This formation does not crop out within the study area.

The energy resource potential for undiscovered oil and gas is low because the wilderness study area is in a volcanic complex. The great thickness of the volcanic rocks (3,000 ft), combined with the distribution and effects of plutonic and volcanic centers, creates a difficult environment for petroleum accumulation. A well drilled 1.25 mi north of the study area on the Winkler anticline was dry.

The absence of hot springs and other surface indications of geothermal activity in the study area, combined with only marginally favorable geothermal gradients in wells outside the study area, give it a low potential for undiscovered geothermal resources.

INTRODUCTION

The Cowboy Spring Wilderness Study Area (NM-030-007) is in the southern Animas Mountains northwest of Playas Valley in southwestern New Mexico. Light-duty roads provide access leading to the study area and four-wheel-drive roads and trails provide access within the study area. The study area is about 15 mi north of the international border between the United States and Mexico. Elevations range from 4,920 ft in the eastern part of the study area to 6,601 ft at Elephant Butte, a prominent feature found along Cowboy Rim (fig. 2).

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 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) and is classified according to the system of Goudarzi (1984) shown in the Appendix. Undiscovered resources are studied by the USGS.

An assessment of the mineral resource potential of the Cowboy Spring Wilderness Study Area was made by compiling geological, geochemical, and geophysical information from earlier published reports as well as from recent studies carried out by the USBM and USGS.

Investigations by the U.S. Bureau of Mines

During 1986, personnel from the USBM Intermountain Field Operations Center investigated the mineral resources of the Cowboy Spring Wilderness Study Area. Prior to field work, a review of publications on the geology, mineralization, and mining activity in and near the study area was completed. Field work included a search for mines, prospects, and mineral occurrences in the study area. Reconnaissance of the study area was by four-wheel-drive vehicle and foot traverse.

Two panned-concentrate samples were taken from Elephant Butte Canyon (fig. 2) and were analyzed for gold by fire assay/atomic absorption and for thirty additional elements by inductively coupled plasma-atomic emission spectroscopy. Results of analyses and sample localities are given in Scott (1987). Additional information is available from the Bureau of Mines, Branch of Mineral Land Assessment (MLA), Intermountain Field Operations Center, Box 25086, Denver, CO 80225.

Investigations by the U.S. Geological Survey

Geologic mapping, geochemical sampling, and geophysical studies were used to evaluate the mineral resource potential of the Cowboy Spring Wilderness Study Area in relation to the types of deposits likely to be found in this volcanic environment. Assessment of the mineral resource potential is based on Goudarzi (1984) (see Appendix).

Regional geologic maps that included the study area (Zeller and Alper, 1965; Erb, 1979) were used as part of this study. Remapping and sampling of the study area was done during 1987, and a geologic map of the study area was prepared (fig. 2).

During 1987, a stream-sediment geochemical survey of the Cowboy Spring Wilderness Study Area was conducted as part of the mineral resource evaluation.

APPRAISAL OF IDENTIFIED RESOURCES

By David C. Scott
U.S. Bureau of Mines

Mining and Mineral-exploration History

As of April 1987, no patented or unpatented mining claims were on file with the U.S. Bureau of Land Management for any acreage in the study area. No evidence of any type of mining activity was found during the field investigation. The entire area is covered by oil and gas leases.

Although no mining districts are in the study area, the Red Hill (Gillespie) mining district is about 1 mi north of the study area. This district includes the Gillespie and Red Hill mines and the Winkler anticline (fig. 1). Prospecting in the district and the general region of the study area began in 1880 when lead- and silver-bearing veins in Tertiary ash-flow tuff and Pennsylvanian and Permian Horquilla Limestone were found at the Gillespie mine. Most of the mineral production from the district came from the Red Hill mine from which 3,746 tons of ore, yielding 1,019,500 lbs (pounds) of lead and 14,249 oz (ounces) of silver were produced (Elston, 1965).

Production of fluorspar in southwestern New Mexico began in the 1880's, and the last significant production was in 1954 (Rothrock, 1970). More than 60 percent of the crude fluorspar production for the period 1909–1962 came from mines in the southwestern part of the state where only 42 percent of the deposits are located (Williams, 1966).

During the 1960's, several trenches and pits were excavated on fluorite-bearing outcrops on the Winkler anticline. The fluorspar occurs in concordant silicified limestone fault-breccia zones in both the Pennsylvanian and Permian Horquilla (Drewes and Thorman, 1980) and Cretaceous U-Bar Formations. In 1970–71, the Texas Lime Company conducted a fluorspar exploration project on the Winkler anticline. Approximately 150,000 tons of rock containing 25–35 percent CaF_2 (fluorite) were defined by drilling but no production is known (McAnulty, 1972).

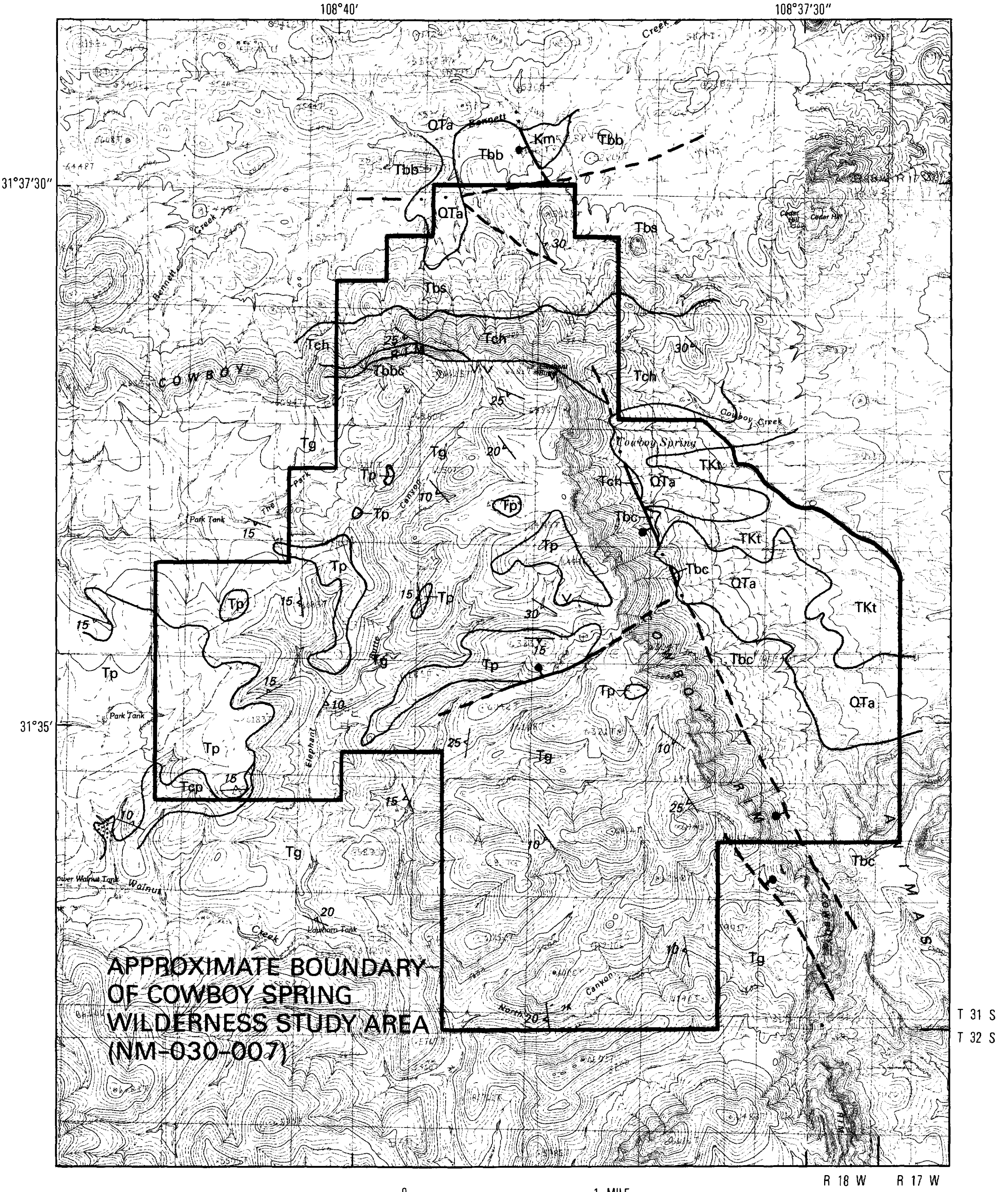
No mines, prospects, or mineral resources were found in the study area. The Pennsylvanian-, Permian-, and Cretaceous-age sedimentary rocks that make up the Winkler anticline, which hosts silicified limestone fault-breccia zones containing fluorspar, are not exposed in the study area. If these rocks are present in the study area, they are buried by accumulations of Tertiary Gillespie Tuff. No silver-lead vein-type occurrences, such as those at the Gillespie and Red Hill mines, were found in the Tertiary rocks of the study area.

ASSESSMENT OF POTENTIAL FOR UNDISCOVERED RESOURCES

By William E. Brooks, Jerry R. Hassemer, Joseph S. Duval, and William F. Hanna
U.S. Geological Survey

Geology

The Cowboy Spring Wilderness Study Area is in the Animas Mountains in southwestern New Mexico in

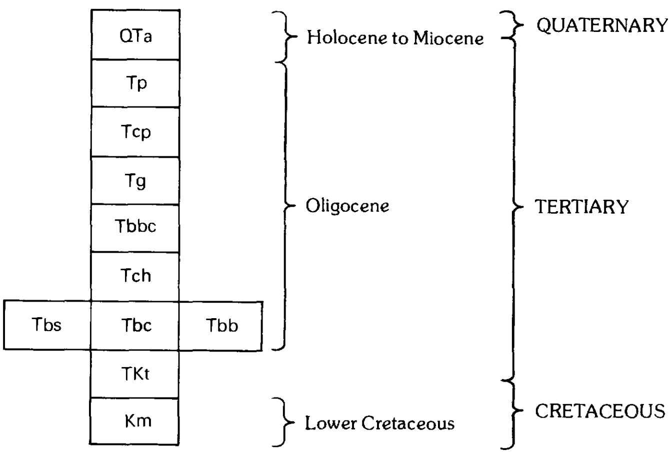


Base from U.S. Geological Survey, 1:24,000, 1982
Center Peak, Gillespie Mountain, Horse
Mountain, Walnut Wells NE

Geologic mapping by W.E. Brooks, 1987;
assisted by Ruben Martinez

Figure 2 (above and facing page). Geologic map of the Cowboy Spring Wilderness Study Area.

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

QTa **Alluvium (Quaternary and Tertiary)**—Unconsolidated sediment along watercourses and on slopes

Tp **Ash-flow tuff of the Park (Oligocene)**—Gray, rhyolitic, crystal-poor ash-flow tuff containing chatoyant sanidine (1 mm), quartz, minor plagioclase, and altered biotite; flattened white pumice is common. Locally has a thin (less-than-0.5-m-thick) pyroclastic unit at base (unmapped). K-Ar sanidine dates of 27.8± 0.6 (Elston and Erb, 1977) and 29.6± 0.6 Ma (Erb, 1979)

Tcp **Andesite of Center Peak (Oligocene)**—Gray andesite; porphyritic, contains hornblende (1.0 mm), also contains plagioclase, opaque minerals, and minor clinopyroxene. A well-sorted, crossbedded, pyroclastic lens occurs locally near the top and is less than 0.5 m thick

Tg **Gillespie Tuff (Oligocene)**—Pink to gray, rhyolitic, crystal-rich ash-flow tuff; contains abundant quartz, sanidine, plagioclase, biotite (as much as 3 mm across), and minor clinopyroxene, hornblende, zircon, and opaque minerals. Abundant pumice. Vitrophyre exposed near center of section 15. K-Ar biotite dates of 32.1± 0.7 (Elston and Erb, 1977) and 32.9± 0.7 Ma (Erb, 1979)

Tbbc **Tuff of Black Bill Canyon (Oligocene)**—Pink to gray, rhyodacitic to quartz latitic, crystal-rich ash-flow tuff; contains plagioclase, biotite (1 mm), minor clinopyroxene, quartz, sanidine, zircon, and opaque minerals

Tch **Cedar Hill Andesite (Oligocene)**—Red to pink, oxidized andesite; porphyritic, contains plagioclase (as much as 5 mm across); also contains clinopyroxene, rare biotite, hornblende, and opaque minerals. An intrusive contact is indicated by map relations in north part of sec. 14

Tbs **Tuff of Bennett Spring (Oligocene)**—Red, quartz latitic ash-flow tuff; contains quartz, biotite, and hornblende. Includes mudflow deposits. Massive cliffs (south part of sec. 11) at top of unit are composed of angular volcanic rock fragments 8–10 cm in diameter

Tbc **Tuff of Bluff Creek (Oligocene)**—White to gray to tan, rhyolitic ash-flow tuff having variable lithic and crystal content. Locally may be hydrothermally altered. Contains plagioclase, quartz, sanidine, biotite, zircon, and opaque minerals. Conspicuous flattened pumice in some locations. Zircon fission-track date of 36.5± 1.8 Ma (Erb, 1979)

Tbb **Bennett Creek Breccia (Oligocene)**—White to gray, bleached in places, contains blocks and large slabs of ash-flow tuff, sedimentary rock fragments, and andesite

TKt **Timberlake Fanglomerate (Tertiary) and Cowboy Spring Formation (Cretaceous)**—Cobble to boulder conglomerate containing fossiliferous limestone clasts; interbedded with sandstone and shale; clasts are as large as 0.5 m. Maximum thickness 3,000 ft southeast of Cowboy Spring (Elston and Erb, 1977)

Km **Mojado Formation (Lower Cretaceous)**—Brown to gray, well-sorted, fine-grained quartz sandstone; with interbedded shale

Contact

Fault—Dashed where inferred; dotted where concealed; ball and bar on downthrown side

25 **Strike and dip of compaction foliation**

V V **Vitrophyre**

Pyroclastic sand

the southern Basin and Range physiographic province. The study area was included in regional mapping by Zeller and Alper (1965) and described by Erb (1979) in a compilation of volcanic centers in Hidalgo County. Topography of the study area is dominated by a 500- to 800-ft-high cliff known as Cowboy Rim.

Conglomerate, sandstone, and shale of the Cretaceous Cowboy Spring Formation and Tertiary Timberlake Fanglomerate of Zeller and Alper (1965) are the oldest rocks exposed in the study area. Less than a mile north of the study area fine-grained quartz sandstone of the Early Cretaceous Mojado Formation is exposed.

Tertiary volcanic rocks that include andesite, ash-flow tuff, and heterogeneous breccia are the dominant lithology in the study area (Zeller and Alper, 1965). Of these units, the Gillespie Tuff is the most widespread. Other less voluminous units include the Bennett Creek Breccia, the tuff of Bennett Spring, the tuff of Bluff Creek, the andesite of Center Peak, the Cedar Hill Andesite, the tuff of Black Bill Canyon, and the tuff of The Park.

The study area is within the Cowboy Rim cauldron (Elston and others, 1976; Erb, 1979). A thick rhyolitic ash-flow tuff, the Gillespie Tuff, filled the Cowboy Rim cauldron, and outflow from this cauldron is widely distributed in the southern and central Animas Mountains. South of the study area, the Gillespie Tuff may be as thick as 3,000 ft (Erb, 1979).

Faults in the study area have minor displacements. However, there are quartz veins and iron and manganese staining along a northwest-trending fault in the eastern part of the study area.

Geochemistry

Introduction

The geochemical investigation included both a reconnaissance stream-sediment study and a rock-chip study of altered material. The stream-sediment study served to test broad parts of the study area for possible metal enrichment; the use of different stream-sediment sample types served to test a range of mineralogical possibilities. The rock-chip study supplemented the geochemical reconnaissance by testing specific sites where appearance or structure indicated the possibility of trace element enrichment.

The reconnaissance stream-sediment survey of the Cowboy Spring Wilderness Study Area was conducted in the spring of 1987. The stream-sediment survey included not only the 6,699-acre study area but also included an area of known mineralized rock which includes the Gillespie mine (fig. 1). Thirty-three sieved stream-sediment samples, 33 nonmagnetic heavy-mineral-concentrate samples, five paramagnetic heavy-mineral-concentrate samples, and eight panned heavy-mineral-concentrate samples were collected from first-, second-, and third-order drainages in and near the study area. Sample density in the study area is about one sample locality per square mile. Data from two panned heavy-mineral-concentrate samples collected in Elephant Butte Canyon by Scott (1987) were incorporated into this survey.

Also used in the geochemical evaluation of the study area were data from 14 rock samples collected along faults or from areas of altered rocks (Brooks and others, 1988). An additional seven rock samples were collected during the course of the stream-sediment survey. Three of the samples came from outside the study area, two from near the Gillespie mine to ascertain the suite of metals present there, and one from a possible hot spring occurrence southwest of the study area. Four samples were float samples having minor iron staining.

Analytical data, descriptions of analytical procedures, and sample localities are given in Brooks and others (1988) and Scott (1987).

Analytical Methods

The sieved stream-sediment samples were obtained by passing 1–2 lbs of raw stream sediment through 80-mesh stainless-steel screens. The fine fraction was retained for analysis. Rock samples were crushed, pulverized, and then analyzed.

The nonmagnetic heavy-mineral-concentrate samples were collected by panning a composite sample of stream sediment to an approximate composition of half dark-colored (mostly heavy) minerals and half light-colored (mostly quartz and feldspar) minerals. The sample size was the amount of material, minus large pebbles and cobbles, that filled a 14-inch-diameter gold pan. The partially panned concentrate was then separated into light and heavy fractions by immersion in bromoform (a heavy liquid having a specific gravity of 2.8), and a magnetic separator was used to obtain a nonmagnetic heavy-mineral concentrate for analysis. A few of the concurrently derived paramagnetic heavy-mineral fractions were analyzed; the remainder were archived.

Panned heavy-mineral-concentrate samples were obtained by panning larger samples of stream sediment in a larger gold pan (16-inch diameter) until the sample was reduced to 100 percent heavy minerals. This larger sample size filled the 16-inch-diameter gold pan, a sample amount that is sometimes called the "standard pan." The recovered heavy-mineral samples, reflecting bedrock geology of the drainage basin sampled, ranged in weight between 17 and 415 grams. The heavier samples were collected within the study area. Dominant mineralogy of these samples was iron-oxide minerals, mostly leucoxene-coated, oxidized pseudomorphs of magnetite. A small portion of sample material, weighing about 0.1 gram, was analyzed spectrographically; the remainder of the sample was analyzed for gold and platinum.

All sediment and rock samples were analyzed for 31 elements by a semiquantitative six-step, direct-current arc, optical-emission spectrographic method (Grimes and Marranzino, 1968). Rock samples were also analyzed for arsenic, antimony, bismuth, and cadmium by an inductively coupled plasma-atomic emission spectroscopic method (Crock and others, 1987), for gold and platinum by an atomic absorption spectroscopic method (J.R. Hassemer, unpub. method), and for mercury by an atomic absorption spectroscopic method (Crock and others, 1987). The minus-80-mesh stream-sediment samples were analyzed for uranium by an ultraviolet fluorescence method (O'Leary and Meier, 1986).

Results

The results of the geochemical survey yielded scant evidence indicative of mineralization within the study area.

The terms "enrichment" and "anomalous" are used in the general sense to indicate samples of unusual composition, but the terms do not necessarily imply the presence of mineral deposits. The term "threshold" indicates a value or amount at which an element might be classed as anomalous for a given sample type. Specific values are not given for most stream-sediment samples because several different stream-sediment sample media are discussed.

Throughout the area covered by the geochemical survey there is a weak enrichment of beryllium and tin that is sometimes accompanied by lanthanum, thorium, and yttrium. This is a suite of elements that suggests that the source, if in fact present, for some of the felsic volcanic units might be classified as a geochemically specialized granitoid. Such bodies, and their extrusive equivalents, can be hosts for metal deposits. Arguing against such deposits, either exposed or near the surface, is the fact that, excluding the Gillespie mine area, only a few scattered anomalies of these metals were found.

The only anomalous concentration of gold detected outside the Gillespie mine area was in a nonmagnetic-concentrate sample collected in lower Park Canyon. This sample also had an anomalous concentration of silver. Although the sample locality derives some sediment from the study area, most material comes from outside the study area. A more likely source for this gold and silver may be the Tertiary Walnut Wells Monzonite (more specifically the contact zone between the monzonite and adjacent wall rock), an intrusive plug exposed on the north side of Park Canyon (Zeller and Alper, 1965). The sample also contained anomalous threshold-level concentrations of beryllium and tin. Analysis of a paramagnetic-concentrate fraction from the same locality found only weakly anomalous amounts of cobalt and zinc.

Additional stream-sediment anomalies include a threshold-level molybdenum anomaly found near Lower Walnut Creek Tank and a threshold-level silver anomaly found in a tributary to Elephant Butte Canyon.

Although some specialized granitoid bodies are frequently hosts to deposits of radioactive elements, there is little indication for such deposits in the surveyed area. Uranium in sieved sediments did not exceed 3 ppm in any of the samples. Anomalous concentrations of thorium were found in none of the sieved-sediment samples and only at threshold levels in a few of the nonmagnetic-concentrate samples. An occasional thorium-rich mineral grain is likely to be found in most felsic rocks.

There is no geochemical evidence of exposed mineralized rock in the study area. Furthermore, there is little evidence for mineralized rock at depth beneath the study area on the basis of the geochemical model proposed by Watts and Hassemer (1987, 1988) for Tertiary volcanic centers in the neighboring Silver City $1° \times 2°$ quadrangle.

Additional evidence for the absence of mineralization at depth is the fact that fault zones, where tested, were essentially devoid of anomalous concentrations of any elements. Such zones would be expected to act as conduits for mineralizing fluids or for trace-element-mobilizing ground water. Of fourteen rock samples collected principally along faults and altered areas (Brooks and others, 1988), one sample contained an anomalous amount of arsenic (300 ppm (parts per million)) and another contained threshold-level mercury (0.06 ppm). For comparison, two samples from the Gillespie mine area contained 0.3 and 1.2 ppm mercury, respectively. Two other samples collected outside the study area, between the study area and the Gillespie mine, contained only threshold-level silver (0.5 ppm).

Further negative evidence for mineralized rock at depth is found by applying zirconium:tin and vanadium :niobium ratios as criteria for distinguishing productive (as opposed to barren of ore) granitoid bodies (Beus and Grigorian, 1977, tables 20 and 21). Only one rock sample had a vanadium:niobium ratio that met the criteria.

In contrast to the study area, rock samples collected in this study from the Gillespie mine area had anomalous concentrations of gold (as much as 2 ppm), silver (2 ppm), arsenic (700 ppm), antimony (30 ppm), molybdenum (50 ppm) with bismuth (11 ppm), cadmium (5 ppm), and threshold-level zinc (110 ppm); platinum values were below the detection limit (0.001 ppm). Minor amounts of gold and copper have also been reported from the mine (Hazen Research, Inc., 1979). Stream-sediment samples, in various media, also contained anomalous amounts of cobalt, copper, nickel, and lead. The threshold-level beryllium and tin anomalies found throughout the volcanic rocks are also present in the mine area. Tertiary quartz latite dikes are known to occur in the mine area (Zeller and Alper, 1965), and it is not known if they are the source of the beryllium and tin anomaly.

Fluorite was found in the nonmagnetic concentrate samples from the Gillespie mine area, but none was observed in any of the samples from the study area.

Most of the nonmagnetic-concentrate samples collected north and west of the study area had anomalous concentrations of barium due to the presence of the mineral barite. These concentrations reflect the presence of pre-Tertiary sedimentary rocks or rock fragments.

Geophysics

Aerial Gamma-ray Spectroscopy

From 1975 to 1983 the U.S. Department of Energy contracted for aerial gamma-ray surveys that covered almost all of the conterminous United States and much of Alaska. As part of this mapping project, data for New Mexico were compiled and processed to produce a series of 1:1,000,000-scale maps that include the composite-color maps by Duval (1983). From these maps the percent potassium (K), parts per million equivalent uranium (eU), and parts per million equivalent thorium (eTh) for the study area were estimated. The occurrence or absence of anomalous radioelement concentrations was also noted. The definition of an anomaly requires that the K concentration and its ratios to the eU and eTh all be high values.

Moderate radioactivity (concentrations of 2.6–3.0 percent K, 2.6–3.1 ppm eU, and 11.3–13.9 ppm eTh) was found in the study area. A moderate thorium anomaly covers most of the study area, as well as a large part of the surrounding area. This anomaly suggests some thorium enrichment in the exposed rocks but does not indicate mineralization. The uranium content is slightly enriched.

Gravity and Magnetic Data

The Cowboy Spring Wilderness Study Area is sparsely covered by gravity and aeromagnetic data, which are suitable only for regional interpretations (figs. 3 and 4). Contours of complete (terrain corrected) Bouguer gravity anomalies are defined by 2 gravity stations near the study area (fig. 3) and 7 stations farther away from the study area (Cordell and others, 1982; Defense Mapping Agency Aerospace Center, 1974, 1975). Aeromagnetic anomalies are defined by measurements made along 3 east-west flight lines spaced 3 mi apart at a nominal height of 400 ft above the terrain (Cordell, 1983; Texas Instruments, Inc., 1979).

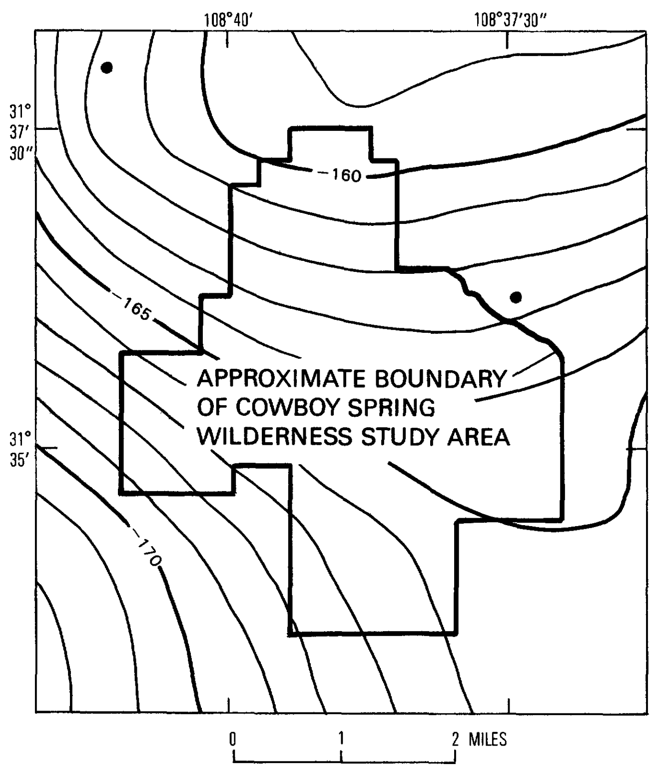


Figure 3. Bouguer gravity anomaly map of the Cowboy Spring Wilderness Study Area and vicinity. Contour interval, 1 mGal; dots represent gravity stations.

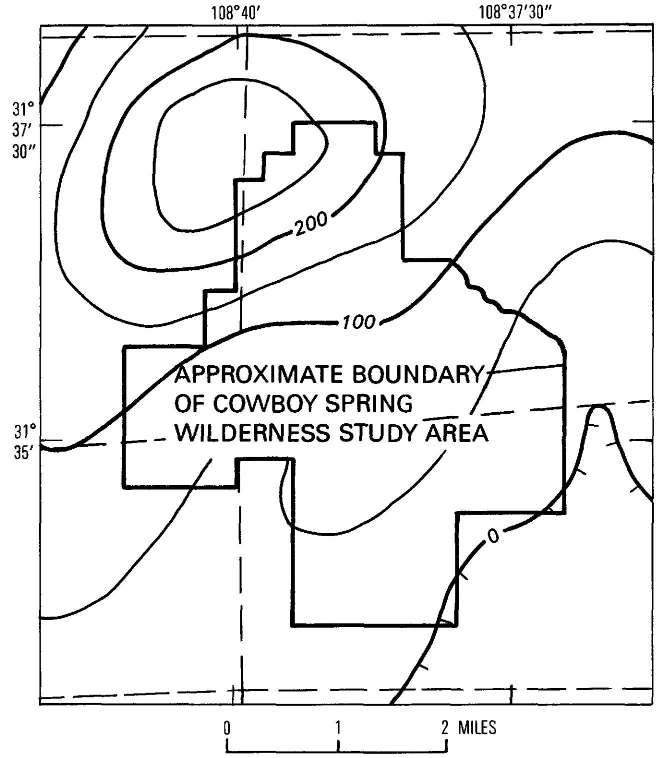


Figure 4. Aeromagnetic anomaly map of the Cowboy Spring Wilderness Study Area and vicinity. Contour interval, 50 nT; hachures indicate closed low; dashed lines indicate flight lines.

A uniform gravity gradient crosses the study area and gravity values increase northeastward (fig. 3). This gradient forms the flank of a broad high which is centered a few miles north-northeast of the area. This high appears to be caused mostly by exposed and near-surface sedimentary rocks, including carbonate-rich rocks, which are higher in density than tuff and tuffaceous sediment that surround or abut them. The decrease in gravity values southwestward indicates a general thickening of the tuff units in that direction.

The aeromagnetic anomaly map (fig. 4) shows a broad high centered over the northwest margin of the study area. This high appears to be generated mostly by intrusive rocks of andesitic composition, partly exposed and partly buried beneath gravel and alluvial deposits. The low magnetic values over the central and southern parts of the study area indicate that most of the mapped tuff is relatively nonmagnetic. Local, more highly mafic phases of the tuff cause local increases of magnetic intensity.

Mineral and Energy Resources

Metals

Association of mineral deposits with mid-Tertiary volcanic centers in southwestern New Mexico (Elston, 1970) suggests that the Cowboy Spring Wilderness Study Area, which is in the Cowboy Rim cauldron of Erb (1979), is an excellent exploration target. However, location of the study area in a complex volcanic center having a variety of flow rocks is only one of the attributes stated by Silberman (1982) that is associated with hot-spring-type gold and silver deposits. Other important features, such as thermal spring activity, repeated fracturing and veining, and anomalous concentrations of gold, silver, and arsenic, are not present.

With the exception of the altered rocks and minor concentration of arsenic noted in one analysis of a sample taken near the fault in the eastern part of the study area, the volcanic rocks in the remainder of the study area have not been altered, silicified, or faulted. No anomalous concentrations of metals were found in analyses of stream sediment. Therefore, a low mineral resource potential with certainty level C for all metals is assigned to the study area.

Fluorspar

The Cowboy Spring Wilderness Study Area is approximately a mile south of the Winkler anticline where several fluorspar prospects are located, primarily in faulted Horquilla Limestone (Williams, 1966; McAnulty, 1972). The absence of outcrops of faulted sedimentary rocks, specifically the Horquilla Limestone, and the thickness of the Tertiary volcanic rocks found in the study area indicate that the occurrence of fluorspar within the study area is unlikely. Therefore, the mineral resource potential for fluorspar in the study area is rated low, with certainty level C.

Oil and Gas

The Cowboy Spring Wilderness Study Area is one of a cluster of twelve wilderness study areas in southwestern New Mexico rated as having a low potential for oil and gas resources (Ryder, 1983a; 1983b). All of the Cowboy Spring Wilderness Study Area is covered by oil and gas leases.

No oil and gas wells have been drilled in the study area, but in 1974–75 the KCM No. 1 Forest Federal well was drilled about 1.25 mi north of the study area on the Winkler anticline. The well penetrated the Earp Formation (Permian) and the Horquilla Limestone (Permian to Pennsylvanian) and bottomed in quartz monzonite at a total depth of 4,464 ft. No significant shows of oil or gas were encountered during drilling and the well was classified as a dry hole (Thompson, 1977). The thickness of the volcanic rocks, as much as 3,000 ft (Erb, 1979), combined with the distribution and effects of plutonic and volcanic centers near the study area (Elston and Erb, 1977) creates an unfavorable environment for petroleum accumulation.

The energy resource potential for oil and gas in the study area is rated low, with certainty level C.

Geothermal Energy

The study area is approximately 30 mi southeast of the Lightning Dock KGRA (Known Geothermal Resource Area) studied by Elston and others (1983) and is in a part of the Basin and Range province where the heat flow is known to be 2.0–2.5 HFU (heat flow units). However, there is no indication of a geothermal anomaly in either the Animas Valley to the west or in the Playas Basin to the east of the study area (Stone and Mizell, 1977). In the KCM No. 1 Forest Federal well, an above normal geothermal gradient was measured but it may only indicate a marginal source of geothermal energy (Thompson, 1977). In addition, there are no hot springs or evidence of other geothermal activity within the study area. Therefore, the resource potential for geothermal resources is rated low, with certainty level C.

RECOMMENDATIONS FOR FUTURE WORK

Because of the altered rock, the anomalous concentrations of arsenic, and the threshold concentrations of mercury found in samples near the northwest-trending fault in the eastern part of the study area, detailed sampling in this area is suggested.

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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.

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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 estimetes 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/raserve 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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[Letters designate the chapters]

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