DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

# MINERAL RESOURCES OF THE COUGAR CANYON/TUNNEL SPRING WILDERNESS STUDY AREA, WASHINGTON COUNTY, UTAH, AND LINCOLN COUNTY, NEVADA

By


**JAMES E. CONRAD[1], HARLEY D. KING[2], H. RICHARD BLANK[2], GREGORY P. MURPHY[1]**
*U.S. Geological Survey*

and

**GEORGE S. RYAN[2]**
*U.S. Bureau of Mines*



U.S. Geological Survey
Open-File Report 90-331

Prepared by the U.S. Geological Survey and the U.S. Bureau of Mines

for the U.S. Bureau of Land Management


This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards or with the North American stratigraphic code. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government


[1]Menlo Park, CA 94025 [2]Denver, CO 80225



1990

## STUDIES RELATED TO WILDERNESS

### Bureau of Land Management Wilderness Study Area

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 part of the Cougar Canyon/Tunnel Spring Wilderness Study Area (UT-040-123/NV-050-166), Washington County, Utah, and Lincoln County, Nevada.

## CONTENTS



## FIGURES

# MINERAL RESOURCES OF THE COUGAR CANYON/TUNNEL SPRING WILDERNESS STUDY AREA, WASHINGTON COUNTY, UTAH, AND LINCOLN COUNTY, NEVADA

*By* James E. Conrad, Harley D. King, H. Richard Blank, *and* Gregory P. Murphy
*U.S. Geological Survey*

George S. Ryan
*U.S. Bureau of Mines*

## SUMMARY

### Abstract

At the request of the U.S. Bureau of Land Management, approximately 6,408 acres of the Cougar Canyon/Tunnel Spring Wilderness Study Area (UT-040-123/NV-050-166) were evaluated for mineral resources (known) and mineral resource potential (undiscovered). In this report, the area studied is referred to as "Cougar Canyon," the "wilderness study area," or simply "the study area;" any reference to the Cougar Canyon Wilderness Study Area refers only to that part of the wilderness study area in both Nevada and Utah for which a mineral survey was requested by the U.S. Bureau of Land Management. The study area is located along the Nevada-Utah State line, 25 miles east of Caliente, Nev., and about 24 miles southeast of Panaca, Nev. No mineral resources were identified in the study area. There is low potential for gold, silver, copper, mercury, zeolite, and perlite in the study area.

### Character and setting

The Cougar Canyon Wilderness Study Area lies in the Bull Valley Mountains along the Nevada-Utah State line (fig. 1). The area is situated on a broad, elevated, and deeply dissected volcanic plateau. Elevations range from about 6,200 ft on the plateau to about 5,000 ft at the bottom of Beaver Dam Wash in the southwestern part of the study area. The climate is semiarid and most of the area is covered by piñon-juniper forests typical of the higher elevations in the Great Basin.

The study area is underlain by a thick section of dacitic to rhyolitic ash-flow and air-fall tuff of Miocene age (see appendixes for geologic time chart), derived from the nearby Caliente caldera complex. This volcanic complex consists of several overlapping collapse calderas and numerous eruptive vents that were active between at least 23 and 15 million years ago.

### Identified Resources

No prospect pits, adits, or shafts were found in the area during the field examination, and no mineral claims, oil and gas leases, or sand and gravel resources are located within the study area. There are no identified resources in the study area.

### Mineral Resource Potential

Geologic, geochemical, and geophysical studies give no indications of significant mineralization in the study area. The geologic setting, which includes minor hydrothermal alteration and local faulting that could provide pathways for metal-bearing hydrothermal solutions, is permissive for deposits of a number of base- and precious-metals, including copper, lead, zinc, mercury, molybdenum, and gold and silver, but there is no indication that any of these commodities are present in appreciable amounts in the study area. Therefore,

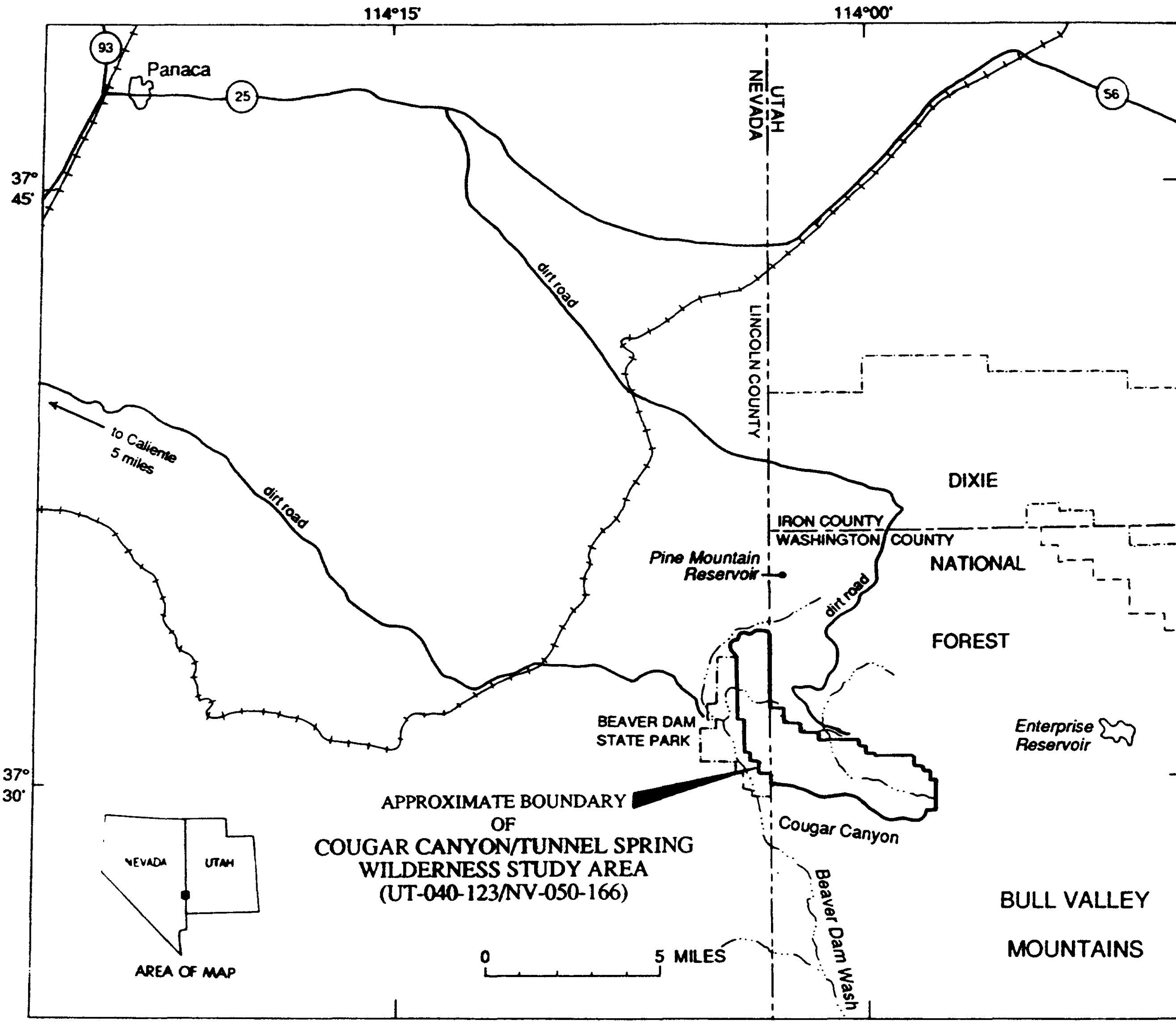
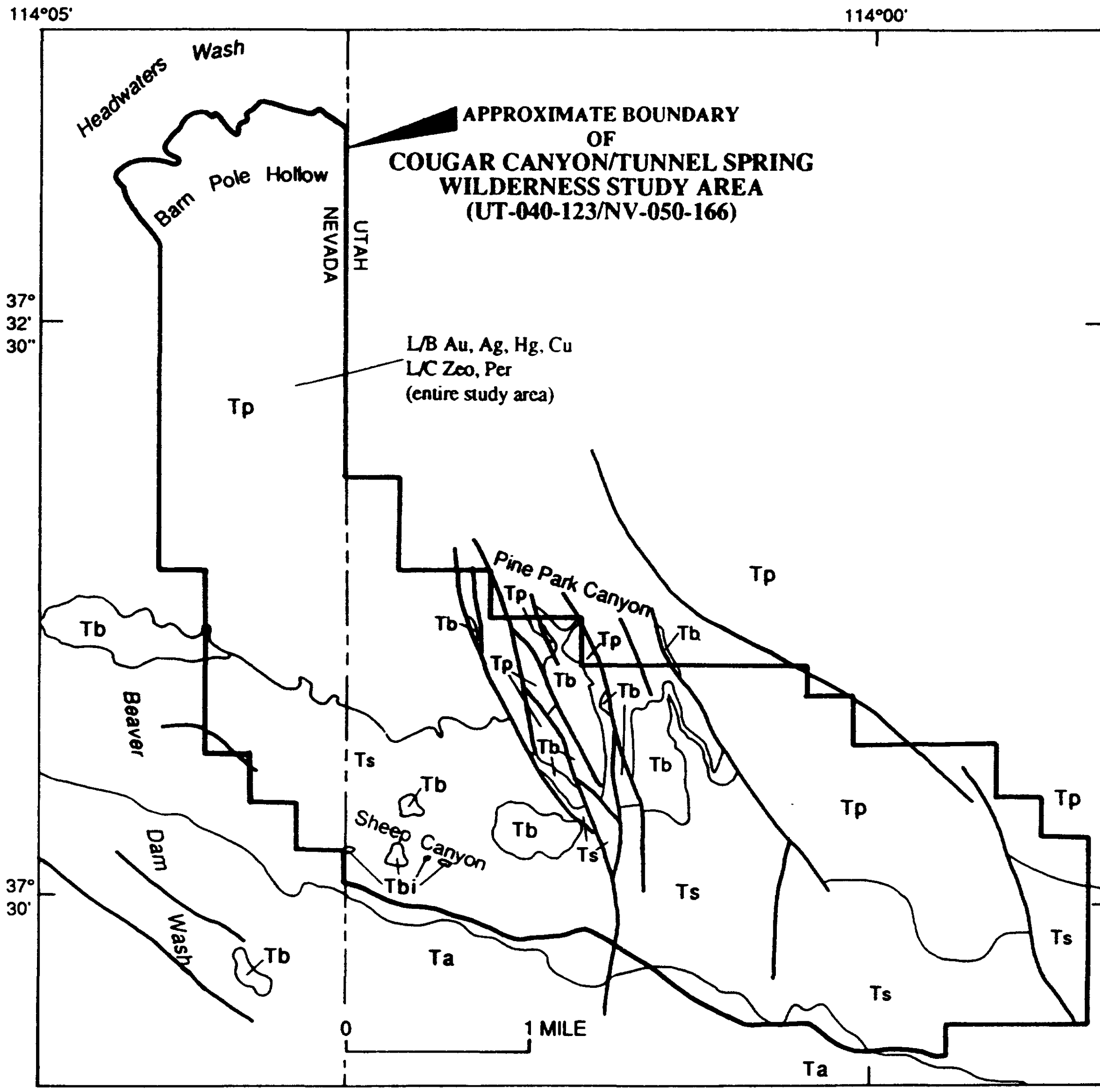



**Figure 1.** Index map showing location of Cougar Canyon Wilderness Study Area, Lincoln County, Nevada, and Washington County, Utah




EXPLANATION

Area having low resource potential (L)

Commodities

| | |
|---|---|
| Au | Gold |
| Ag | Silver |
| Cu | Copper |
| Hg | Mercury |
| Per | Perlite |
| Zeo | Zeolites |

Geologic map units

| | |
|---|---|
| Tp | Tuff of Pine Park Canyon (Tertiary)--Lithic-rich ash-flow tuff |
| Tb | Basalt (Tertiary) |
| Tbi | Intrusive basalt (Tertiary) |
| Ts | Tuffs of Sheep Canyon (Tertiary)--Welded and nonwelded lithic-rich and crystal-rich rhyolitic ash-flow and airfall tuffs |
| Ta | Andesite (Tertiary) |

Contact

Normal fault

**Figure 2.** Map showing mineral resource potential and generalized geology of Cougar Canyon Wilderness Study Area, Lincoln County, Nevada, and Washington County, Utah

there is only low resource potential for gold, silver, copper, and mercury in the study area (fig. 2). There is low potential for zeolite and perlite resources, but the area is located far from major markets. There is no potential for oil and gas.

## INTRODUCTION

This mineral survey was requested by the U.S. Bureau of Land Management and is the result of a cooperative effort by the U.S. Geological Survey and the U.S. Bureau of Mines. An introduction to the wilderness review process, mineral survey methods, and agency responsibilities was provided by Beikman and others (1983). The U.S. Bureau of Mines evaluates identified resources at individual mines and known mineralized areas by collecting data on current and past mining activities and through field examination of mines, prospects, claims, and mineralized areas. Identified resources are classified according to a system that is a modification of that described by McKelvey (1972) and the U.S. Bureau of Mines and U.S. Geological Survey (1980). U.S. Geological Survey studies are designed to provide a reasonable scientific basis for assessing the potential for undiscovered mineral resources by determining geologic units and structures, possible environments of mineral deposition, presence of geochemical and geophysical anomalies, and applicable ore-deposit models. Goudarzi (1984) discussed mineral assessment methodology and terminology as they apply to these surveys. See appendixes for the definition of levels of mineral resource potential and certainty of assessment and for the resource/reserve classification.

### Area Description

The Cougar Canyon Wilderness Study Area is located in the Bull Valley Mountains along the Nevada-Utah State line (fig. 1). Mineral surveys were requested for 6,408 acres (4,228 in Utah, 2,180 in Nevada) of this area by the U.S. Bureau of Land Management. The west boundary of the study area is adjacent to Beaver Dam State Park. The study area is situated on a broad, elevated, volcanic plateau incised by several deep and narrow canyons. Elevations range from about 6,200 ft on the plateau to about 5,000 ft at the bottom of Beaver Dam Wash in the southwestern part of the study area. The climate is semiarid and most the area is covered by piñon-juniper forests typical of the higher elevations in the Great Basin.

The study area is located about 25 mi east of Caliente, Nev., and 50 mi west of Cedar City, Utah. Access to the area from the west is from dirt roads leading from Caliente to Beaver Dam State Park. The east side of the study area can be reached from dirt roads leading from Nevada Highway 25 to Pine Park Canyon.

### Previous and Present Investigations

The part of the Cougar Canyon Wilderness Study Area in Nevada was included in a regional study of the geology and mineral deposits of Lincoln County, Nev. (Tschanz and Pampeyan, 1970). The part of the study area in Utah was included in a 1:125,000-scale geologic map by Cook (1960). Studies of the Tertiary volcanic rocks of the region include those by Noble and McKee (1972) and Ekren and others (1977). An evaluation of the energy resources of the study area was included in Oakes and others (1981).

The U.S. Geological Survey conducted field investigations of the Cougar Canyon Wilderness Study Area in the spring and fall of 1988. This work included geologic mapping at scales of 1:62,500 and 1:24,000, geochemical sampling, geophysical studies, and examining outcrops for evidence of mineralization. Rock and stream-sediment (including a fine fraction and heavy-mineral concentrate) samples were collected for the geochemical survey. These samples were analyzed for 35 and 37 elements by semiquantitative emission spectrography. Samples were analyzed for gold and silver by atomic-absorption methods and for arsenic, antimony, bismuth, cadmium, and zinc by inductively coupled argon plasma-atomic emission spectrography. Earlier geophysical data, which consisted of regional gravity and magnetic surveys, were compiled and analyzed. Additional gravity surveys were conducted for this study. Further details on analytical procedures used for this resource assessment are given in the sections that follow.

The U.S. Bureau of Mines investigation included a review of literature, maps, and unpublished material related to mineral resources and mining activities in or near the study area. Master title plats and U.S. Bureau of Land Management recordation were checked to ascertain that there were no mining claims, mineral leases, or oil and gas leases in the study area.

U.S. Bureau of Mines geologists conducted a field examination in the study area and vicinity in October 1988. Two rock-chip, 2 grab, and 34 stream-sediment samples were taken in the study area and prospect pits south of the area. All samples were analyzed for 32 elements by inductively coupled plasma-atomic emission spectrometry and for gold and silver by fire assay. All testing was done by the Chemex Labs, Inc., Sparks, Nev. Complete analytical data are available at the U.S. Bureau of Mines, Intermountain Field Operations Center, Building 20, Denver Federal Center, Denver, CO 80225.

### Acknowledgments

The authors would like to thank Mr. Ross Matthews for allowing access, via his property along Beaver Dam Wash, to sample sites located south of the study area and for his hospitality. Steve McDanal assisted in the sample collection.

## APPRAISAL OF IDENTIFIED RESOURCES

*By* George S. Ryan
*U.S. Bureau of Mines*

No surface mineralization nor evidence of mining claims or exploration work was found in the study area (Ryan, 1989).

High heat flow and faulting associated with volcanic activity of the Caliente caldera complex coupled with Basin and Range faulting and subsequent leakage preclude the accumulation of hydrocarbon resources. Molenaar and Sandberg (1983, p. K12) also suggest that oil and gas source rocks probably are not beneath the study area. There are no oil and gas leases in the study area.

There are no large deposits of sand and gravel or known mineral resources in the study area (Ryan, 1989).

## ASSESSMENT OF MINERAL RESOURCE POTENTIAL

*By* James E. Conrad, Harley D. King, H. Richard Blank, *and* Gregory P. Murphy
*U.S. Geological Survey*

### Geology

The study area is underlain entirely by volcanic rocks of varying composition, including welded and nonwelded ash-flow tuff and basalt, and associated sedimentary rocks. Volcanic rocks within the study area are about 1,500 ft thick and dip about 10 to 20° NNW. The study area lies along the east boundary of the Caliente caldera complex (Noble and McKee, 1972; Ekren and others, 1977), although the precise location of caldera boundaries are obscured by multiple eruptions, collapse of the calderas, and subsequent faulting. All the rocks exposed in the study area, however, are probably associated with this caldera complex, which consists of several overlapping calderas that were active between at least 15-23 Ma (P.D. Rowley, oral commun., 1988).

### Older andesite flows

The oldest rocks exposed in the study area are andesite flows that crop out along the extreme southern boundary of the study area. These rocks are comprised of thin flows of slightly altered, aphyric to slightly porphyritic andesite and basaltic andesite.

### Tuffs of Sheep Canyon

The lower volcanic unit consists of approximately 1,000 ft of welded and nonwelded ash-flow and air-fall tuffs and associated tuffaceous sedimentary rocks, here termed the tuffs of Sheep Canyon. The lower part of this unit is exposed in Sheep Canyon and consists of mostly nonwelded to slightly welded air-fall and ash-flow tuffs and lapilli tuffs. These tuffs are from 30 to about 200 ft in thickness and are generally white to buff in color. Quartz, feldspar, biotite, and minor hornblende are common phenocrystic constituents. A potassium-argon analysis on hornblende from one of the tuffs in Sheep Canyon gave an age of 19.9 ± 0.6 Ma, indicating that the unit is of Miocene age.

Many of the tuffs in the study area contain a sizable number of exotic lithic fragments that are typically older volcanic rock types generally less than 1 in. across. Several of the tuffs in Sheep Canyon contain abundant lithic fragments 6 in. or more across; one lithic fragment about 8 ft in diameter was noted. The upper part of this unit consists of densely welded rhyolitic lithic-rich and crystal-rich ash-flow tuffs containing phenocrysts of quartz, sanidine, biotite, and hornblende.

### Basalt

Basalt flows are discontinuously exposed between the upper and lower tuff units in the study area. The basalt has a maximum thickness of about 150 ft in the eastern part of the study area in Sheep Corral Canyon. The unit consists mainly of dark-gray to brown aphyric and sparsely porphyritic olivine basalt containing small phenocrysts of olivine and plagioclase. Exposures in the western part of the study area in Beaver Dam Wash consist of reddish-weathering, highly vesicular fragments that are probably part of an eroded cinder cone. Several small intrusive bodies of basalt are exposed along the northern side of Sheep Canyon and apparently represent pipe-like feeder dikes.

### Tuff of Pine Park Canyon

The youngest volcanic unit exposed in the study area, here termed the tuff of Pine Park Canyon, is approximately 500 ft thick and underlies the northern part of the study area. It consists of a series of similar, buff-colored ash-flow tuffs generally 30 ft or more thick containing abundant lithic fragments consisting of older volcanic rock types, mostly rhyolitic in composition. These lithic fragments, which make up more than 50 percent of the rock, often define a marked fining-upward sequence within individual flows. Basal parts of the flows contain lithic fragments as much as 1 ft across at the base; these fragments fine upward to about 1/2-1 in. across. The lithic fragments are contained in a white ashy matrix containing crystals of quartz and feldspar.

The abundance and large size of lithic fragments in the tuff of Pine Park Canyon as well as some of the tuffs exposed in Sheep Canyon suggests that these tuffs were deposited very near their eruptive vents. They may represent flows erupted near the caldera prior to collapse or they may be younger flows deposited in the collapse caldera basin. The great thickness (over 500 ft) and monotonous character of the tuff of Pine Park Canyon suggests the latter--that it is a ponded intracaldera flow.

## Geochemical Studies

A reconnaissance geochemical survey was conducted in the Cougar Canyon Wilderness Study Area in May 1988. Minus-80-mesh stream sediments, nonmagnetic heavy-mineral concentrates of stream sediments, and rock samples were used as the sample media in this survey. Thirty four minus-80-mesh stream-sediment, 32 nonmagnetic heavy-mineral-concentrate, and 26 rock samples were collected from 37 sites. The stream sediments and the stream sediments from which the concentrates were derived were taken from active alluvium in the stream channel.

Stream sediments were selected as a sample medium because they represent a composite of the rock and soil exposed upstream from the sample site. Nonmagnetic heavy-mineral-concentrate samples provide information about the distribution of a limited number of minerals in rock material eroded from the drainage basin upstream from each sample site. Many of the minerals found in the nonmagnetic fraction of heavy-mineral concentrates may be ore or ore-related. The selective concentration of minerals permits determination of some elements that are not easily detected in bulk stream-sediment samples.

Most rock samples appeared fresh and unaltered and were collected to provide information on background concentrations of elements. A few of the rock samples appeared altered and possibly mineralized and were collected to determine the suite of elements associated with the observed alteration and (or) mineralization.

### Analytical Methods

Stream-sediment samples were sieved using 80-mesh stainless-steel sieves, and the minus-80-mesh fraction was used for analysis. The heavy-mineral concentrate was produced by panning minus-10-mesh stream sediment to remove most of the quartz, feldspar, organic materials, and clay-size material. Bromoform (specific gravity 2.86) was then used to remove remaining light mineral grains not removed by panning. The resultant heavy-mineral concentrate was separated, by use of an electromagnet, into three fractions: a magnetic fraction, chiefly magnetite; and intermediate magnetic fraction consisting largely of mafic rock-forming minerals, and a nonmagnetic fraction which is composed predominantly of light-colored rock-forming accessory minerals and primary and secondary ore-forming and ore-related minerals. Using a microsplitter, the nonmagnetic fraction was split into two fractions. One of these splits was used for analysis and the other for visual examination with a binocular microscope. In some instances, the sample volume was too small to provide a split for visual examination. These samples were examined visually prior to grinding for analysis; archived reference material for these samples contains no material not ground to fine powder. Rock samples were crushed and pulverized to less than 100-mesh grain size prior to analysis.

All samples were analyzed semiquantitatively, rock and stream-sediment samples for 35 elements and nonmagnetic heavy-mineral-concentrate samples for 37 elements, using a direct-current arc emission spectrographic method (Grimes and Marranzino, 1968). Stream-sediment and rock samples were also analyzed by other methods for certain elements of special interest or which have high lower limits of determination by emission spectrography. Antimony, arsenic, bismuth, cadmium, and zinc were determined by inductively coupled argon plasma-atomic emission spectrography (ICAP-AES) (Crock and others, 1987). Atomic absorption methods were used to determine gold (O'Leary and Meier, 1986) and mercury (Crock and others, 1987).

### Results

Anomalous values of tin (1,000 to 2,000 parts per million (ppm)) were found in three nonmagnetic heavy-mineral-concentrate samples. One of these samples was collected on a tributary to Barn Pole Hollow in the northern part of the study area. The two other samples were collected outside the study area, about 1 mi to the southwest and 1 mi to the northeast of this site. A single grain of the tin mineral cassiterite (variety "wood tin") was found in the concentrates; sparse grains of wood tin in small concentrate samples probably accounts for the anomalous tin values in all three of the concentrates. The anomalous tin values are not considered evidence of tin in sufficient quantity to constitute a mineral deposit.

No other notably anomalous values of metals were found in any samples collected within the study area or in any samples collected adjacent to the study area containing materials eroded from the study area. Geochemical anomalies were indicated by the results of sampling to the north and south of the study area and are discussed briefly below.

A nonmagnetic heavy-mineral concentrate from a site located 0.2 mi north of the study area, on a northern tributary of Headwaters Wash, contained anomalous amounts of antimony (300 ppm) and copper (1,500 ppm). The highest tin concentration (2,000 ppm) was also found in this sample. Antimony or copper bearing minerals were not identified in the concentrate to explain the high antimony or copper concentrations. These anomalies could reflect a small exposure of mineralized rock. They might also be due to contamination of the sample resulting from man's activities in the upper part of the drainage, including construction and maintenance of the Pine Mountain Reservoir and land clearing.

South of the study area, anomalous amounts of barium (10,000 ppm or more) were found in seven nonmagnetic heavy-mineral-concentrate samples in an area extending more than 4 mi to the southeast from the Nevada-Utah border and just southeast of the mouth of Sheep Canyon. A few of these samples were collected at or near prospects in altered rock, about 1.5 mi south of the study area. These concentrate samples contain small amounts of barite, which explains the barium anomalies. The absence of anomalous barium in stream-sediment and rock samples and the small amounts found in the concentrates suggested that significant amounts of barite are not present in the area.

Stream-sediment samples collected from three sites at or near the prospects contained anomalous values of copper (100 ppm). A rock sample from one of the prospects contained a slightly anomalous silver value (0.5 ppm), and another rock sample from the same site contained an anomalous amount of mercury (0.68 ppm). A concentrate collected just downstream from one of the prospects contained about 20 percent pyrite.

### Geophysical Studies

Regional gravity, aeromagnetic, and aeroradiometric data for the Cougar Canyon Wilderness Study Area and vicinity have been examined for clues to lithologic distributions and concealed structures that might affect the mineral resource evaluation. The main source of gravity data was the National Solar-Terrestrial and Geophysical Data Center in Boulder, Colo., which supplied principal facts for more than 120 stations in the area of interest. These data were supplemented by about 50 stations established in October 1988 by the U.S. Geological Survey. Aeromagnetic data were available from two USGS surveys, one flown on north-south headings at 9,000 ft barometric elevation and at 2-mi traverse spacings in Utah (USGS, 1972), and the other at similar heading and elevation but at 1-mi spacings in Nevada (USGS, 1973). Coverage provided by these surveys leaves a significant gap in the vicinity of the Wilderness Study Area. Aeromagnetic data for the entire area, along with aeroradiometric data, were obtained from surveys of the National Uranium Resource Evaluation (NURE) program. NURE traverses in this region were made along east-west headings at 3-mi spacings and a nominal 400 ft above ground (Geodata International, Inc., 1980).

#### Gravity Data

The complete-Bouguer gravity anomaly field, terrain-corrected to a distance of 167 km (Hayford-Bowie zone A-O), is shown in figure 3. All data reductions and terrain corrections employed a standard density of 2.67 $g/cm^3$ and followed conventional U.S. Geological Survey procedures (Cordell and others, 1982). The contour interval on the map is 2 mGals; gravity stations are indicated by open circles. The anomaly field is characterized by a general decrease

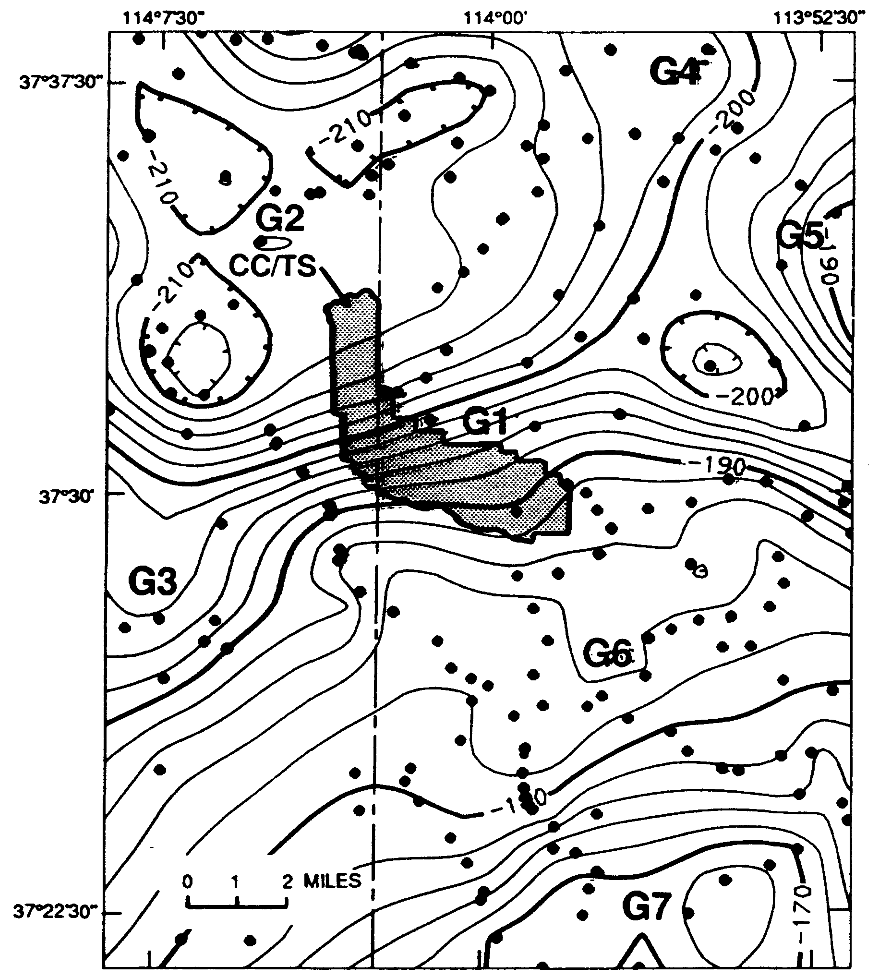



**Figure 3.** Complete-Bouguer anomaly map of Cougar Canyon Wilderness Study Area and vicinity, Nevada and Utah. Dots, gravity stations; CC/TS, Cougar Canyon/Tunnel Spring Wilderness Study Area. Contour interval, 2 mGal; hachured in direction of gravity low. See text for discussion of areas G1-G7.

in gravity values to the north; and east-west-trending step, gradient G1 (fig. 3), approximately bisects the map area at the latitude of the study area. This same gradient belt extends across the entire southern Great Basin and well into the Colorado Plateau. It roughly coincides with the southern limit of domains of high regional elevation and great thicknesses of volcanic rocks. It was interpreted by Eaton and others (1978) as a first-order crustal discontinuity delineating the southern margin of a region of voluminous silicic crustal magmatism. Anomaly G2 is near the center of a broad low marked by several -210-mGal closures. This low reflects accumulations of low-density material in the easternmost caldera of the Caliente caldera complex. The -200-mGal contour that crosses the study area is inferred to be in approximately the same location as the caldera ring fracture. Anomaly G3, south of the main east-west gradient belt (G1), is a gravity low, superimposed on the regional field and hence not closed, which is produced by a thick volcanic pile in the eastern Clover Mountains. Anomaly G4, in the northeastern part of the map, is also a negative perturbation on the regional field and is similarly produced by low density volcanic rocks. A gravity anomaly high, G5, to the southeast of G4, is associated with a latitic intrusive center (Hogback and vicinity).

Anomaly G6, another negative gravity embayment in the regional field is probably due to the Mineral Mountain hypabyssal granitic intrusion. On the basis of its aeromagnetic signature, this intrusion is inferred to have a very substantial lateral subsurface extent. Hydrothermal alteration of Paleozoic carbonate and Tertiary volcanic rocks in the vicinity of anomaly G6 may be related to the silicic magmatism; Tenneco's gold workings are located near the southern flank of the inferred subsurface body.

Anomaly G7 is a local crest of the northernmost extension of a broad anomaly high over the Beaver Dam Mountains in the southwest corner of Utah. This high in large part reflects a north-south-trending regional uplift of the Precambrian crystalline basement.

### Aeromagnetic data

Figure 4 shows the anomalous aeromagnetic field, after removal of appropriate International Geomagnetic Reference Fields at a contour interval of 20 nanoteslas (nT). The field was computed from data of the USGS surveys. Addition of NURE data results in delineation of a magnetic high projecting into the study area near M1 (fig. 4) and better delineation of the eastern margin of the Caliente caldera complex.

Gradient belts immediately west and east of anomaly M1, marked approximately by the -200-nT and -360-nT contours, respectively, roughly coincide with gravity gradient G1 and probably reflect the same structural discontinuity. The strong anomaly high 6 mi west of M1 and M1 itself are both associated with a thick sequence of andesitic rocks in the eastern Clover Mountains (compare negative gravity anomaly G3). Sharp local anomalies in the vicinity of M2, in the northwest corner of the map, may be expressions of caldera ring structures and intracaldera volcanic rocks; the gradient between the -300- and -200-nT contours in this vicinity may delineate the north wall of the easternmost caldera of the Caliente caldera complex. Anomaly high M3 and an unlabeled high immediately to the east, in the extreme northeast corner of the map, are both produced by basalt flows that cap rhyolites (compare negative gravity anomaly G4 in fig. 3). Anomaly M4 is a low marking a structural depression southeast of the Enterprise Reservoir.

Anomaly M5 is probably the most significant aeromagnetic feature of the map with respect to mineral resource potential, due to its association with the mineralized Mineral Mountain intrusion. This anomaly provides more evidence of the concealed lateral extent of the intrusion than the much weaker gravity signature (anomaly G6). It is possible that the aeromagnetic anomaly in part reflects buried crystalline basement rock but this interpretation is not supported by the gravity data. The broad low to the north of M5 is interpreted as a polarization low.

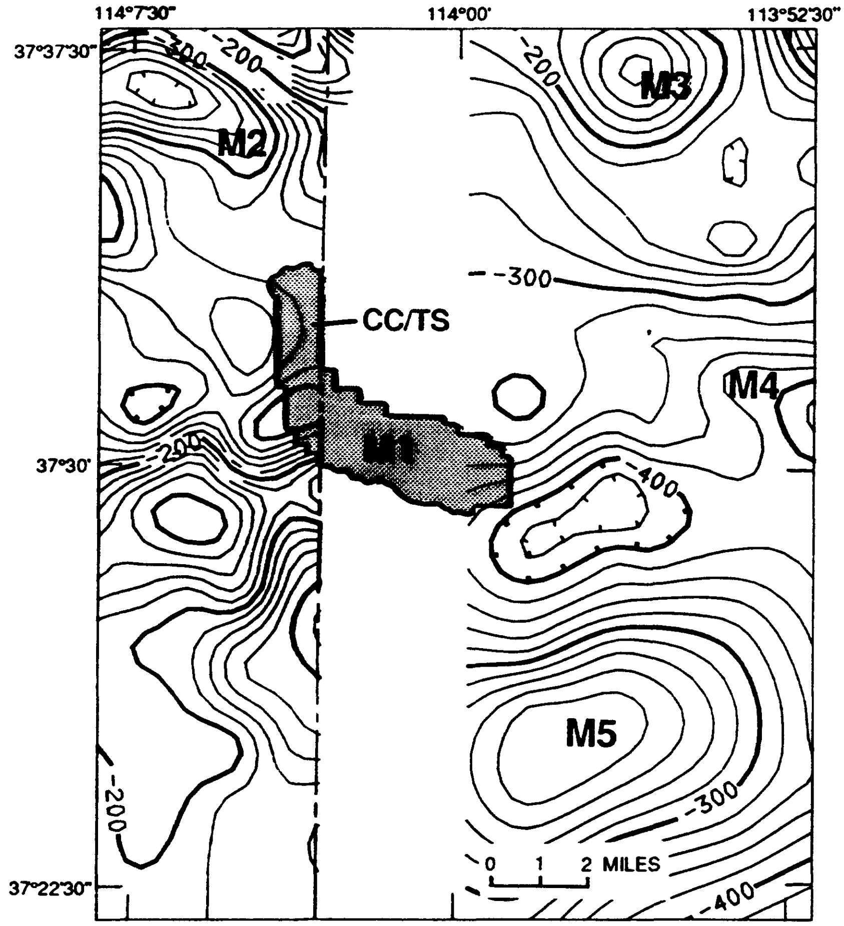



**Figure 4.** Residual total-intensity aeromagnetic map of Cougar Canyon Wilderness Study Area and vicinity, Nevada and Utah. Contour interval, 20 gammas; hachured in direction of magnetic low. CC/TS, Cougar Canyon/Tunnel Spring Wilderness Study Area. See text for discussion of areas M1-M5.

Radiometric data

Examination of the NURE radiometric data has been carried out by J.S. Duval of the USGS (written commun., 1989). He reports that the Cougar Canyon Wilderness Study Area has overall low radioactivity, with concentrations of 1.5-2.4 percent potassium, 1.0-3.0 ppm equivalent uranium, and 8-16 ppm equivalent thorium. No gamma-ray anomalies were detected within or near the wilderness study area. It should be borne in mind, however, that with 3-mi traverse spacing and rough topography the existing radiometric data are reconnaissance in nature.

### Mineral and Energy Resource Potential

Geologic, geochemical, and geophysical studies give no indication of significant mineralization in the study area. Field examination of outcrops did not show evidence of any extensive or pervasive alteration that might be associated with mineralization. The geologic setting, including minor hydrothermal alteration south of the study area and local faulting that could provide pathways for metal-bearing hydrothermal fluids, is permissive for deposits of base and precious metals, including copper, lead, zinc, mercury, molybdenum, and gold and silver. Although geochemical studies provide no evidence of mineralization in the study area, small deposits of some of these metals occur in the region (Tschanz and Pampeyan, 1970). All available geologic indicators suggest that there is low potential for gold, silver, copper, and mercury resources in the study area, certainty level B (fig. 2). The presence of welded and nonwelded ash-flow tuff that underlies most of the study area indicates that there is low potential for zeolite and perlite resources, certainty level C, but the area is located far from major markets.

The oil and gas potential of the region including the study area is rated by Sandberg (1983) and Molenaar and Sandberg (1983) to be low. Within the study area, however, igneous activity associated with the nearby Mineral Mountains intrusion and the Caliente caldera complex (which may include the study area) would most likely have driven off any pre-existing hydrocarbons. Therefore, there is no potential for oil and gas resources in the study area, certainty level D.

## REFERENCES CITED

Beikman, H.M., Hinkle, M.E., Frieders, Twila, Marcus, S.M., and Edward, J.R., 1983, Mineral surveys by the Geological Survey and the Bureau of Mines of Bureau of Land Management Wilderness Study Areas: U.S. Geological Survey Circular 901, 28 p.

Cook, E.F., 1960, Geologic map of Washington County, Utah (1:125,000), supplement to the geologic atlas of Utah, Washington County: Utah Geological and Mineralogical Survey Bulletin 70, 119 p.

Cordell, Lindrith, Keller, G.R., and Hildenbrand, T.C., 1982, Bouguer gravity map of the Rio Grande rift, Colorado, New Mexico, and Texas: U.S. Geological Survey Geophysical Investigations Map GP-949, scale 1:1,000,000 (with text).

Crock, J.G., Briggs, P.H., Jackson, L.L., and Lichte, F.E., 1987, Analytical methods for the analysis of steam sediments and rocks from wilderness study areas: U.S. Geological Survey Open-File Report 87-84, 35 p.

Ekren, E.B., Orkild, P.P., Sargent, K.A., and Dixon, G.L., 1977, Geologic map of Tertiary rocks, Lincoln County, Nevada: U.S. Geological Survey Miscellaneous Investigations Map I-1041, scale 1:250,000.

Eaton, G.P., Wahl, R.R., Prostka, H.J., Mabey, D.R., and Kleinkopf, M.D., 1978, Regional gravity and tectonic patterns--their relation to late Cenozoic epeirogeny and lateral spreading in the western Cordillera, *in* Smith, R.B., and Eaton, G.P., eds., Cenozoic tectonics and regional geophysics of the western Cordillera: Geological Society of America Memoir 152, p. 51-92.

Geodata International, Inc., 1980, Aerial radiometric and magnetic survey, Cedar City, Utah: U.S. Department of Energy Publication GJBX-93, map scales 1:500,000.

Goudarzi, G.H., 1984, Guide to preparation of mineral survey reports on public lands: U.S. Geological Survey Open-File Report 84-787, 51 p.

Grimes, D.J., and Marranzino, A.P., 1968, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials: U.S. Geological Survey Circular 591, 6 p.

McKelvey, V.E., 1972, Mineral resource estimates and public policy: American Scientist, v. 60, p. 32-40.

Molenaar, C.M., and Sandberg, C.A., 1983, Petroleum potential of wilderness lands in Utah, *in* Miller, B.M., ed., Petroleum potential of wilderness lands in the western United States: U.S. Geological Survey Circular 902 A-P, p. K1-K14.

Noble, D.C., and McKee, E.H., 1972, Description and K-Ar ages of volcanic rocks of the Caliente volcanic field, Lincoln County, Nevada, and Washington County, Utah: Isochron/West, no. 5, p. 17-24.

Oakes, Ed, Wedow, Helmuth, Poling, Robert, and Voelker, Al, 1981, The Department of Energy's energy-resource evaluation of wilderness study areas administered by the Bureau of Land Management, Cedar City district, Utah: Prepared for: Leasing Policy Development Office, Department of Energy, 317 p.

O'Leary, R.M., and Meier, A.L., 1986, Analytical methods used in geochemical exploration, 1984: U. S. Geological Survey Circular 948, 48 p.

Ryan, G.S., 1989, Mineral investigation of a part of the Cougar Canyon Wilderness Study Area (UT-040-123/NV-050-166), Washington County, Utah, and Lincoln County, Nevada: U.S. Bureau of Mines Open-File Report MLA 21-89, 7 p.

Sandberg, C.A., 1983, Petroleum potential of wilderness lands in Nevada, *in* Miller, B.M., ed., Petroleum potential of wilderness lands in the western United States: U.S. Geological Survey Circular 902 A-P, p. H1-H11.

Tschanz, C.M., and Pampeyan, E.H., 1970, Geology and mineral resources of Lincoln County, Nevada: Nevada Bureau of Mines and Geology Bulletin 73, 183 p.

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, 5 p.

U.S. Geological Survey, 1972, Aeromagnetic map of parts of the Richfield and Cedar City 1° x 2° quadrangles, Utah: U.S. Geological Survey Open-File Report 72-385 or 387, scale 1:250,000.

U.S. Geological Survey, 1973, Aeromagnetic map of the southeastern part of the Lund and eastern half of the Caliente 1° x 2° quadrangle, Nevada: U.S. Geological Survey Open-File Report 73-298, scale 1:250,000.

# APPENDIXES

# DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

## LEVELS OF RESOURCE POTENTIAL

H **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.

M **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 reasonable likelihood for resource accumulation, and (or) where an application of mineral-deposit models indicates favorable ground for the specified type(s) of deposits.

L **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 permissive. This broad category embraces areas with dispersed but insignificantly mineralized rock, as well as areas with little or no indication of having been mineralized.

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

U **UNKNOWN** mineral resource potential is assigned to areas where information is inadequate to assign a low, moderate, or high level of resource potential.

## LEVELS OF CERTAINTY

A Available information is not adequate for determination of the level of mineral resource potential.

B Available information only 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.

LEVEL OF RESOURCE POTENTIAL →

<table>
<tr><th>A</th><th>B</th><th>C</th><th>D</th></tr>
<tr><td rowspan="4">U/A<br>UNKNOWN POTENTIAL</td><td>H/B<br>HIGH POTENTIAL</td><td>H/C<br>HIGH POTENTIAL</td><td>H/D<br>HIGH POTENTIAL</td></tr>
<tr><td>M/B<br>MODERATE POTENTIAL</td><td>M/C<br>MODERATE POTENTIAL</td><td>M/D<br>MODERATE POTENTIAL</td></tr>
<tr><td rowspan="2">L/B<br>LOW POTENTIAL</td><td rowspan="2">L/C<br>LOW POTENTIAL</td><td>L/D<br>LOW POTENTIAL</td></tr>
<tr><td>N/D<br>NO POTENTIAL</td></tr>
</table>

LEVEL OF CERTAINTY →

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.

Taylor, R.B., Stoneman, R.J., and Marsh, S.P., 1984, An assessment of the mineral resource potential of the San Isabel National Forest, south-central Colorado: U.S. Geological Survey Bulletin 1638, p. 40-42.

Goudarzi, G.H., compiler, 1984, Guide to preparation of mineral survey reports on public lands: U.S. Geological Survey Open-File Report 84-0787, p. 7, 8.

## RESOURCE/RESERVE CLASSIFICATION

| | IDENTIFIED RESOURCES | | | UNDISCOVERED RESOURCES | |
|---|---|---|---|---|---|
| | Demonstrated | | Inferred | Probability Range | |
| | 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, V.E., 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 by the U.S. Geological Survey in this report

| EON | ERA | PERIOD | EPOCH | AGE ESTIMATES OF BOUNDARIES IN MILLION YEARS (Ma) |
|---|---|---|---|---|
| Phanerozoic | Cenozoic | Quaternary | Holocene | 0.010 |
| | | | Pleistocene | 1.7 |
| | | Tertiary — Neogene Subperiod | Pliocene | 5 |
| | | | Miocene | 24 |
| | | Tertiary — Paleogene Subperiod | Oligocene | 38 |
| | | | Eocene | 55 |
| | | | Paleocene | 66 |
| | Mesozoic | Cretaceous | Late | 96 |
| | | | Early | 138 |
| | | Jurassic | Late<br>Middle<br>Early | 205 |
| | | Triassic | Late<br>Middle<br>Early | ~240 |
| | Paleozoic | Permian | Late<br>Early | 290 |
| | | Carboniferous Periods — Pennsylvanian | Late<br>Middle<br>Early | ~330 |
| | | Carboniferous Periods — Mississippian | Late<br>Early | 360 |
| | | Devonian | Late<br>Middle<br>Early | 410 |
| | | Silurian | Late<br>Middle<br>Early | 435 |
| | | Ordovician | Late<br>Middle<br>Early | 500 |
| | | Cambrian | Late<br>Middle<br>Early | [1]~570 |
| 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 Ma also called Precambrian, a time term without specific rank.
[2]Informal time term without specific rank.