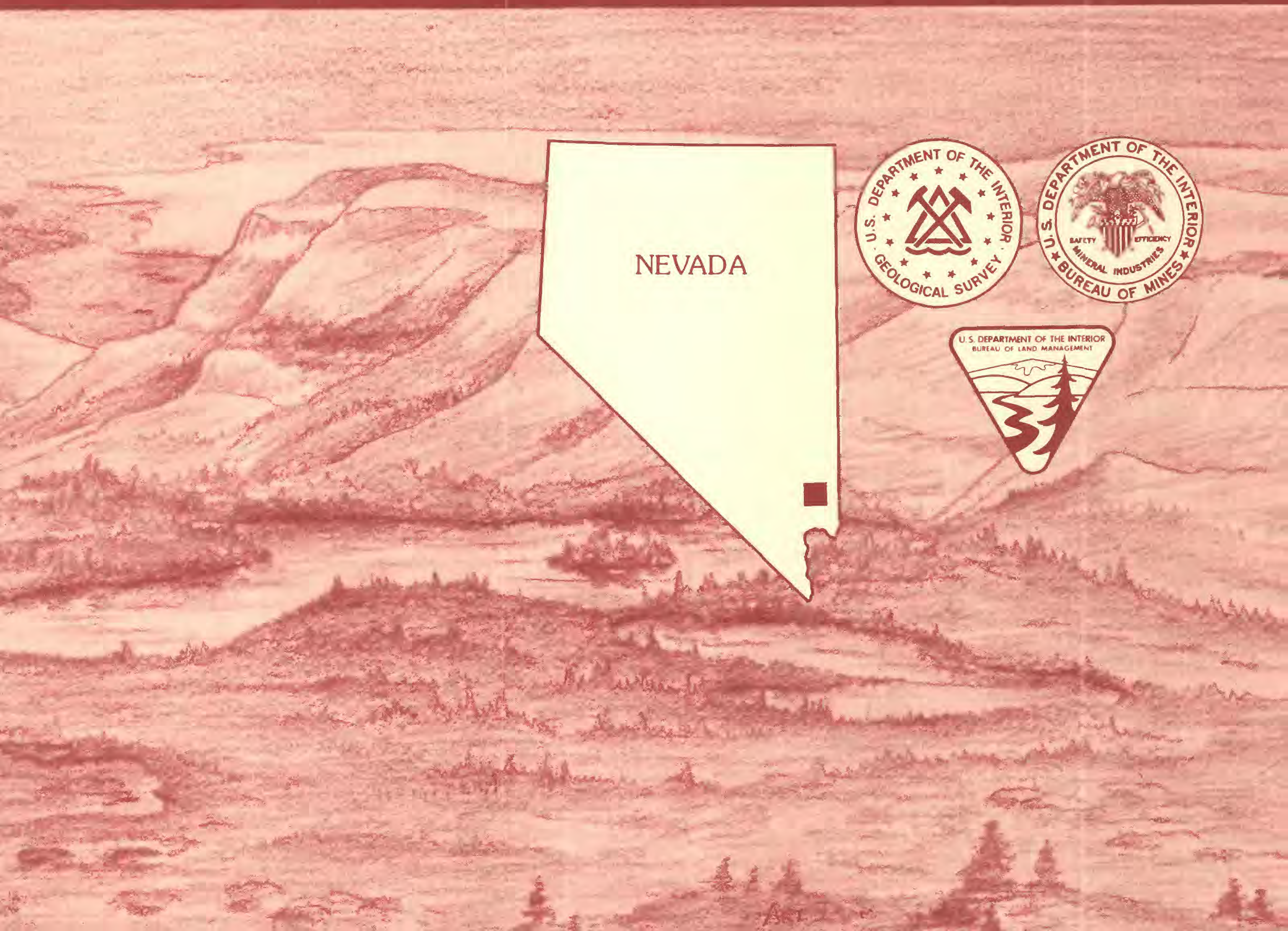
Mineral Resources of the South Pahroc Range Wilderness Study Area, Lincoln County, Nevada

U.S. GEOLOGICAL SURVEY BULLETIN 1729-A



Chapter A

Mineral Resources of the South Pahroc Range Wilderness Study Area, Lincoln County, Nevada

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U.S. GEOLOGICAL SURVEY BULLETIN 1729

MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
SOUTHEASTERN NEVADA

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 part of the South Pahroc Range Wilderness Study Area (NV-050-132), Lincoln County, Nevada.

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Mineral Resources of the South Pahroc Range Wilderness Study Area, Lincoln County, Nevada

By Barry C. Moring, H. Richard Blank, Jr., *and* Harlan N. Barton
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SUMMARY

Abstract

At the request of the U.S. Bureau of Land Management, approximately 28,395 acres of the South Pahroc Range Wilderness Study Area (NV-050-132) were evaluated for mineral resources (known) and mineral resource potential (undiscovered). The U.S. Geological Survey and the U.S. Bureau of Mines studied the area, located in southeastern Nevada near Caliente, between 1983 and 1985. In this report, any references to the "South Pahroc Range Wilderness Study Area," the "wilderness study area," or the "study area" refer only to that part of the study area for which the U.S. Bureau of Land Management requested mineral surveys. Five perlite placer claim groups lie near the study area. Three of these, including the underground workings of one, lie partly within the study area. That part of the study area contains an identified, subeconomic perlite resource of about 6 million tons. Apache tears, of interest to rock collectors, are common to slopes underlain by perlite. Geochemical analyses of jasperoid samples revealed that one part of the study area contains anomalous concentrations of gold, arsenic, and antimony and has a moderate mineral resource potential for disseminated gold. There is a low resource potential for oil and gas and no potential for geothermal energy resources in the study area.

Character and Setting

The study area, wholly within the South Pahroc Range, is located in southeastern Nevada about 30 mi west of Caliente (fig. 1). Basin and Range topography characterizes the region. The South Pahroc Range is characterized by a striking 2,000-ft-high east escarpment and a rugged, bouldery dip-slope surface topography. Elevation in the study area ranges from 4,500 ft in the south to nearly 8,000 ft at the range crest. More than 95 percent of the study area consists of volcanic and sedimentary rocks of Tertiary age (see appendix for geologic time chart). The remainder is Paleozoic quartzite and carbonate rock and Quaternary alluvium.

Identified Resources

No surface mining activity has occurred within the study area. However, the underground workings of the Mackie perlite mine extend beneath the northeast boundary (fig. 2). In the same vicinity, five placer claim groups are adjacent to or partly within the study area. Identified resources in the study area consist of an indicated resource of approximately 6 million tons of perlite. This deposit is classified as an identified subeconomic resource (see appendixes for resource/reserve classification).

Mineral Resource Potential

Fifty-nine stream-sediment samples, 59 heavy-mineral-concentrate samples, and 12 rock samples were collected from volcanic and volcaniclastic rocks in the study area for semiquantitative geochemical analysis (Barton and Day, 1984). The data obtained revealed no significant geochemical anomalies in the study area. Hydrothermal alteration of limestone and shale located along the southeastern border has formed jasperoid deposits. Fifteen samples of these jasperoids were collected for quantitative geochemical analysis for elements associated with disseminated gold deposits. One sample contains 3 parts per million (ppm) gold (Neumann, 1986) and two others contain anomalous concentrations of arsenic and antimony (F.E. Lichte, U.S. Geological Survey, written commun., 1986). These results indicate that this limestone and shale outcrop has a moderate resource potential for gold. Apache tears are common on slopes underlain by perlite. The entire study areas has low resource potential for oil and gas (Sandberg, 1983). There is no potential for geothermal energy resources in the study area.

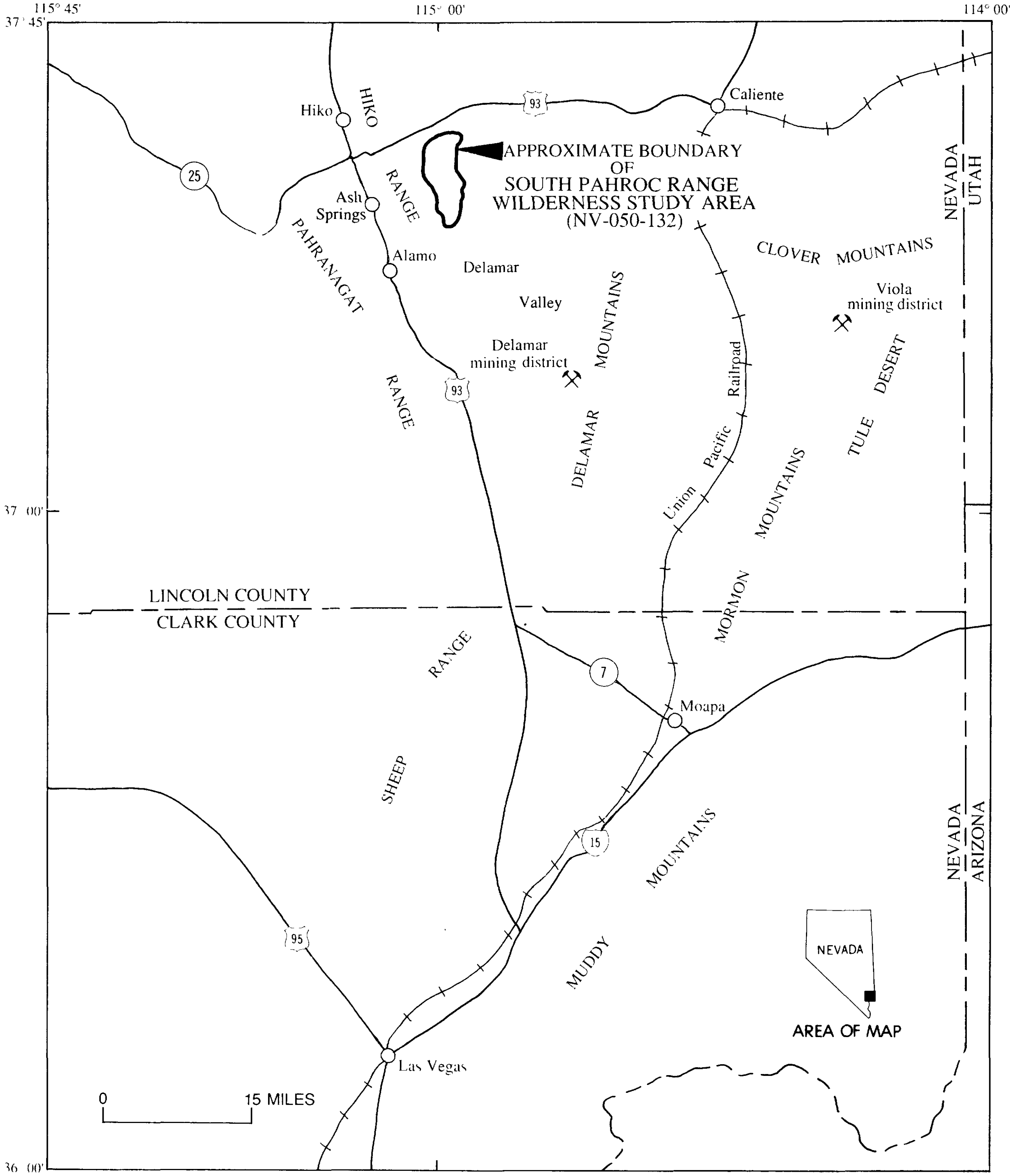

Figure 1. Index map showing location of South Pahroc Range Wilderness Study Area, Nevada.

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 were provided by Beikman and others (1983). The U.S. Bureau of Mines evaluates identified (known) 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 the system described by U.S. Bureau of Mines and U.S. Geological Survey (1980). Studies by the U.S. Geological Survey are designed to provide a reasonable scientific basis for assessing the mineral resource potential (undiscovered) by determining geologic units and structures, possible environments of mineral deposition, presence of geochemical and geophysical anomalies, and applicable ore-deposit models. Mineral assessment methodology and terminology as they apply to these surveys were discussed by Goudarzi (1984). See appendixes for the definition of levels of mineral resource potential and certainty of assessment and for the resource/reserve classification.

Character and Setting

The South Pahroc Range Wilderness Study Area (NV-050-132) encompasses 28,395 acres and is located approximately 30 mi west of Caliente, Nev. (fig. 1), at the center of the Caliente 1° by 2° quadrangle. Access to the study area is provided by gravel and dirt roads from U.S. Highway 93 at Pahroc Summit Pass, Six Mile Flat, and near Alamo (figs. 1, 2). The elevation of the study area ranges from 4,500 ft at the southern end to 7,950 ft at the range crest. The range is a typical up-thrown block of the Basin and Range physiographic province. The oldest rocks exposed in the area, Paleozoic carbonate rocks and shale of the Pogonip(?) Group and the Eureka Quartzite, form small outcrops along the Pahroc fault. The rest of the area is composed of Oligocene and Miocene volcanic flows, tuffs, and sedimentary rocks. Faulting and erosion along the Pahroc fault has resulted in the formation of a magnificent east-facing escarpment rising more than 2,000 ft above the valley floor. The west slope of the range is underlain by a biotite-rich welded tuff, the Hiko Tuff. Spheroidal weathering of this tuff has resulted in a pronounced bouldery topography where access is difficult. At lower elevations, the study area is a desert brushland; at higher elevations the brush gives way to scattered stands of pinon pine, juniper, and white fir.

Procedures and Sources of Data

The U.S. Geological Survey carried out field investigations intermittently between June of 1983 and March of 1985. The work included geochemical sampling and analysis (F.E. Lichte, written commun., 1986; S.A. Wilson, written commun., 1987; and P.J. Aruscavage, written commun., 1987), geologic mapping (Moring, 1987), and interpretation of aeromagnetic, gravity, and aerial gamma-ray data. Previous general geologic studies of the South Pahroc Range and vicinity include those of Tschanz and Pampeyan (1970) and Ekren and others (1977). Two reports prepared for the U.S. Bureau of Land Management discuss geology, energy, and minerals (Great Basin GEM Joint Venture, 1983) and reconnaissance geochemistry (Barton and Day, 1984).

The U.S. Bureau of Mines conducted an investigation of all mines, prospects, and claims and conducted field studies in the fall of 1984 and spring of 1985 (Neumann, 1986). Federal and Lincoln County mining claim records were reviewed prior to field work.

Acknowledgments

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APPRAISAL OF IDENTIFIED RESOURCES

By Terry R. Neumann
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History and Production

Although there has been no mining within the South Pahroc Range Wilderness Study Area, mining has occurred adjacent to the study area's northeast boundary at the Mackie perlite mine (fig. 2). The Mackie mine (also known as Paramount, Delamar, and Kopenite) has been operating intermittently on a small scale since the late 1940's. The property lies on the Barbara claims, one of five placer claim groups staked during the late 1940's on a perlite layer that lies within the Tertiary rhyolite exposed along the base of the South Pahroc Range. Since 1955, the Mackie mine has produced about 108,000 tons of high-expansion perlite. Ore from the deposit continues to maintain a small foothold in the perlite market due to its exceptional expansion properties.

The nearest mining district, the Delamar (Ferguson) district (fig. 1), is 15 mi to the southeast across Delamar Valley. Gold and silver deposits were discovered in the Delamar Mountains in 1891 and were mined intermittently through 1950. Most activity took place during the years 1894-1909. The Delamar district mines produced ore worth about $15

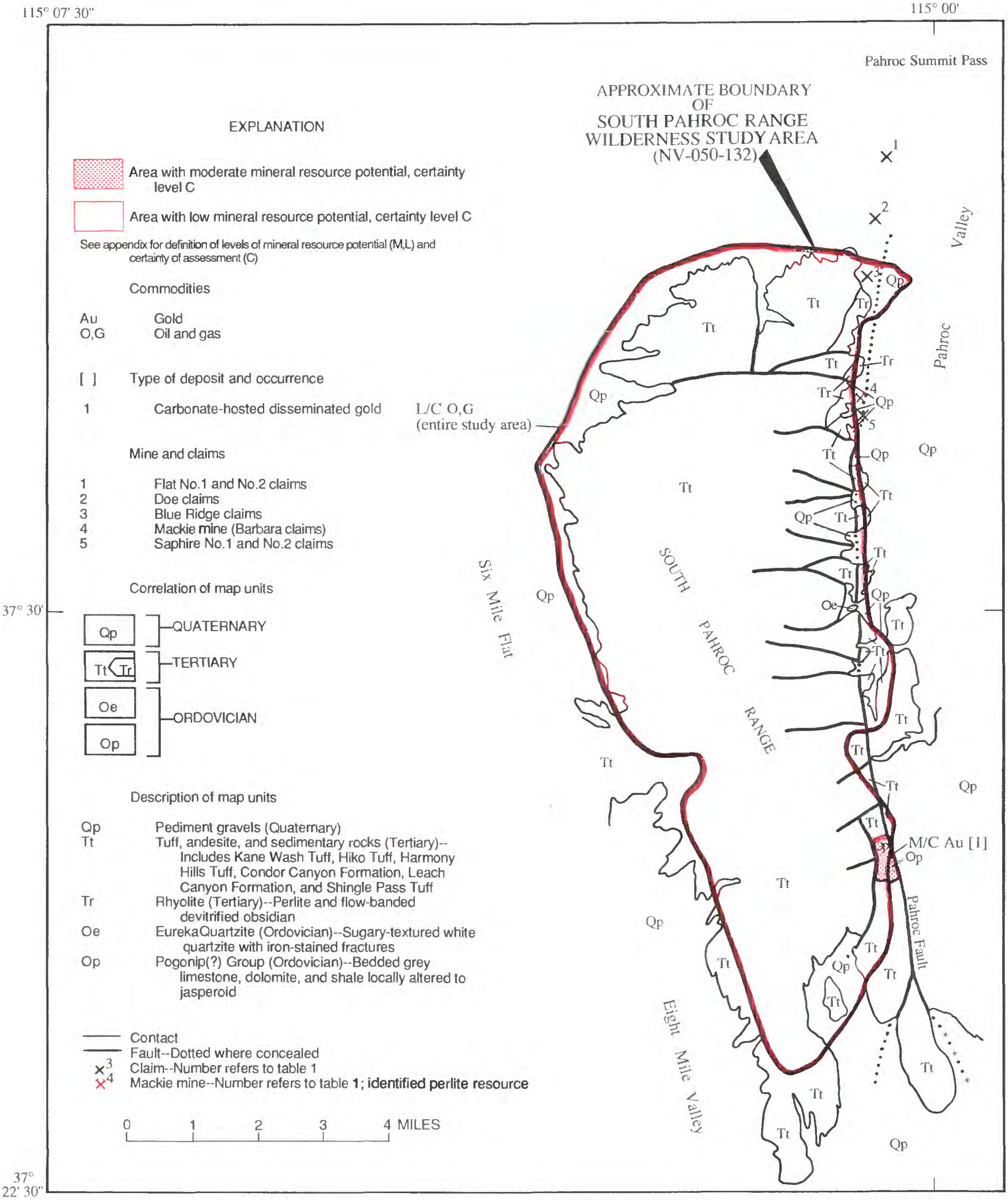

Figure 2. Map showing mineral resource potential of South Pahroc Range Wilderness Study Area, Nevada.

million, making the district one of Nevada's premiere early gold producers (Callaghan, 1937).

Mines, Prospects, Mining Claims, and Mineralized Zones

U.S. Bureau of Land Management records indicate that five placer claim groups, covering 1,060 acres, lie adjacent to and partly within the study area. The Flat No. 1 and 2, Doe, Blue Ridge, Barbara (Mackie mine), and Saphire No. 1 and 2 placer perlite claims (fig. 2, Nos. 1-5) were examined during this study. All claims, except for parts of the Blue Ridge and Saphire properties and a short extension of underground workings at the Mackie mine, are outside the study area. None of the claims are patented, and only the Mackie mine is active. Descriptions of the mine, claims, and mineralized zones are listed in table 1.

Identified Resources

An indicated perlite resource of about 6 million tons is present just inside the study area's northeast boundary. Most of the resource is not amenable to surface-mining methods because of its position on a steep cliff beneath a dense cap rock. Detailed laboratory tests by the New Mexico Bureau of Mines and Mineral Resources show that the perlite has exceptional expansion characteristics; expanded densities range from 1.63 to 4.56 lb/ft^3 (pounds per cubic foot). This expansion is two to three times greater than that of a standard perlite. However, because it does expand so well, the compaction resistance is very low, precluding it from use in aggregate and concrete. Due to its excellent expansibility, a good furnace yield, and a negligible nonexpandable fraction, the New Mexico Bureau of Mines summarized the tests on the perlite as follows: "As an overall evaluation, the 'light weight' end uses, for example, filter aid or cryogenics, would be well served with these samples."

Most high-bulk, low-cost commodities such as perlite depend on low-cost open-pit mining and low transportation costs. Because of prohibitively high underground mining and transportation costs, the perlite deposit within the study area could not effectively compete with established open-pit deposits closer to major markets. Opening a new mine would not be feasible, either, because the Mackie mine already meets regional demands for high-expansion perlite. For these reasons, the perlite deposit in the study area is classified as an indicated subeconomic resource. A substantial increase in demand for high-expansion perlite, especially in the Las Vegas area, could change the classification to that of a marginal reserve. It seems unlikely that the deposit within the study area would be exploited in the near future.

One sample from a jasperoid outcrop on the study area's southeast border contained a significant amount of gold (Neumann, 1986). No gold resources were identified in this area.

Apache tears (marekanite nodules), prized by rock collectors and often sold in rock shops, are abundant in the northeast corner of the wilderness study area. They weather out of the perlite and litter slopes below the outcrops.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Barry C. Moring, H. Richard Blank, Jr., *and*
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U.S. Geological Survey

Geology

The South Pahroc Range Wilderness Study Area lies in the southeastern part of the Basin and Range physiographic province. The range primarily consists of a slightly west-dipping sequence of partially to completely welded ash-flow tuff that ranges in composition from dacite to comendenite and rhyolite and in age from 14 to 25 million years before present (Ma). These ash flows consist of the Kane Wash, Hiko, and Harmony Hills Tuffs, the Condor Canyon and Leach Canyon Formations, and the Shingle Pass Tuff (Ekren and others, 1977; Moring, 1987). Rhyolite and andesite flows and volcaniclastic sedimentary rocks are intercalated with the ash flow sheets. The Tertiary rocks have a total thickness of about 2,000 ft. The rhyolite flows commonly have been hydated to perlite. Tertiary strata unconformably overlie Paleozoic quartzite, shale, and carbonate rocks that are exposed in two places in the study area, both adjacent to the Pahroc fault at the base of the range. The northern exposure consists of a pod of broken Eureka Quartzite less than 100 yd across. The southern exposure consists of interbedded cherty limestone and shale of the Pogonip(?) Group. This unit has been locally altered to jasperoid.

The tilting and unroofing of the Paleozoic bedrock prior to the deposition of the 25-Ma Shingle Pass Tuff (Ekren and others, 1977) is probably the earliest evidence for Tertiary tectonic activity in the South Pahroc Range. Basin-and-Range style faulting along the Pahroc fault system that formed the present range probably was initiated after deposition of the 19-Ma Hiko Tuff (Noble and McKee, 1972) and before the 14-Ma Kane Wash Tuff (Noble, 1968). Movement along this fault system appears to have ceased prior to the development of Quaternary pediments that surround the range.

Geochemistry

The U.S. Geological Survey collected 12 rock samples, 59 stream-sediment samples, and 59 nonmagnetic heavy-mineral concentrate samples from the study area in 1983. The stream-sediment and heavy-mineral concentrate samples represent material eroded from drainage basins, and chemical analyses of such samples are useful in identifying areas with mineral resource potential by delineating geochemically anomalous basins. Samples were analysed for 31 elements including silver, arsenic, barium, copper, molybdenum, tin, and zinc using a six-step semiquantitative emission spectrographic method (Grimes and Marranzino, 1968). Statistical treatment of these analyses indicate the presence of minor barium, lead, and tin anomalies scattered throughout the study area. These anomalies are probably due to lithologic variation or minor leakage along fault zones and do not fit a currently known resource model (Barton and Day, 1984).

Following the discovery of jasperoid and iron-stained, recrystallized limestone during field mapping in the fall of 1984, 15 rock samples (8 collected by the U.S. Bureau of Mines and 7 by the U.S. Geological Survey) and 2 sediment samples were analyzed by quantitative methods for pathfinder elements commonly associated with epithermal gold deposits: arsenic, gold, mercury, and antimony. One sample contains 3 ppm gold but no pathfinder elements (Neumann, 1986). Two samples contain arsenic (8 and 25 ppm) and antimony (3 and 5 ppm) (F.E. Lichte, U.S. Geological Survey, written commun., 1986), three samples contain mercury (0.02 to 0.04 ppm) (S.A. Wilson, U.S. Geological Survey, written commun., 1987), and four samples contain tungsten (1.4 to 4.3 ppm) (P.J. Aruscavage, written commun., 1987). The gold, tungsten, antimony, and higher arsenic concentrations appear to be anomalous as they are significantly above background values for unmineralized Preble Limestone at the Preble disseminated-gold mine in northern Nevada (W.C. Bagby, U.S. Geological Survey, written commun., 1987).

Geophysics

The regional aeromagnetic coverage of the study area and vicinity is provided by a residual total-intensity anomaly map of the Caliente 1° by 2° quadrangle (Saltus and Snyder, 1986), which incorporates maps previously released by the U.S. Geological Survey (1973, 1976). The area of interest was flown at 1-mi traverse spacing and at a barometric altitude of 9,000 ft. Regional gravity coverage is provided by a complete Bouguer anomaly map of the Caliente quadrangle (Healy and others, 1981); a geologic interpretation of the gravity map was done by Snyder (1983). Widely spaced (3 mi) aeroradiometric and aeromagnetic traverses were also flown across the range during the National Uranium Resource Evaluation (NURE) program.

The South Pahroc Range straddles an east-trending belt of steep aeromagnetic gradients associated with the northern limit of strongly magnetized anomaly sources near the south boundary of the study area. As virtually all exposures in the range are silicic volcanic rocks, the source rocks are likely to be more mafic in composition than rocks farther north, or else they are substantially thicker. They may include hypabyssal intrusions, which typically produce intense anomalies if they have even a moderate magnetic content. By contrast, the range is situated on a north-trending Bouguer gravity gradient that is nearly perpendicular to the aeromagnetic gradient. This gradient is relatively weak and irregular; the drop in Bouguer levels across the range is only about 10 milligals. It can be ascribed to the dense carbonate rocks exposed to the west of, and in the shallow subsurface of, the Hiko Range and to thick, low-density alluvium in Delamar Valley to the east. Neither the numerous faults nor the strongly magnetized rocks of the South Pahroc Range produce density contrasts of sufficient magnitude to be reflected in the regional gravity field.

The NURE data have been examined by J.S. Duval (written commun., 1985) of the U.S. Geological Survey, who reports evidence of "moderate" radioactivity within the wilderness study area, indicating concentration of 2.5 to 3.0 percent potassium, 3.0 to 4.0 ppm equivalent uranium, and 11 to 15 ppm equivalent thorium. These values are typical of silicic to intermediate volcanic rocks, and no anomalous concentrations of the radioelements were detected.

MINERAL AND ENERGY RESOURCE POTENTIAL

Several disseminated gold deposits in central and northern Nevada have formed in Paleozoic strata similar to that of the Pogonip(?) Group found along the southeast border of the study area. The gold typically occurs as micron-sized grains disseminated in irregular bodies of limestone, carbonaceous shale, and jasperoid with widely varying gold grades. The gold in these deposits is associated with anomalous concentrations of arsenic, mercury, antimony, thallium, and tungsten (Berger, 1986). These deposits are often highly silicified, are associated with fracture systems, or are present at contacts with overlying volcanic rocks as in the nearby Viola district (Tschanz and Pampeyan, 1970) and Atlanta district 90 mi northeast of the study area (E.H. Pampeyan, U.S. Geological Survey, written commun., 1987).

Of the 15 jasperoid samples collected and analyzed for this project, 4 contain higher concentrations of gold, arsenic, tungsten, or antimony than those expected for unmineralized limestones found in Nevada (W.C. Bagby, oral commun., 1987). In addition, mercury (found in only three samples) was found in both samples that have anomalous arsenic and antimony. Because these values and the geologic setting are consistent with a carbonate-hosted disseminated-gold deposit, the rocks of the Pogonip(?) Group in the study area have a moderate resource potential for gold with a certainty level of C.

No oil or gas production has occurred near the study area, but Paleozoic sedimentary rocks that lie beneath the Tertiary volcanic rocks of the study area may be potential petroleum sources. Sandberg (1983) includes this area in his "cluster 10," much of which has been thermally overmatured but may still contain petroleum products. Accordingly, the entire study area has a low resource potential for oil or gas with a certainty level of C.

The only geothermal activity in the region is the thermal springs at Ash Springs and Caliente, 6 mi west and 30 mi east of the study area, respectively (fig. 1). However, no thermal springs are known to be present in the South Pahroc Range. Therefore, the study area has no potential for geothermal energy.

Perlite and Apache tears are restricted to hydrated parts of ancient glassy-rhyolite flows. Neumann (1986) estimated that an indicated, subeconomic perlite resource of about 6 million tons is present in Tertiary rhyolite flows just inside the northeast boundary of the study area. However, as these are the only rhyolite flows that crop out in the study area there is no mineral resource potential for perlite outside of those reserves. Additional Apache tears probably await discovery in the vicinity of the Tertiary rhyolite. These, however are not considered a resource, but may be of continued intermittent, casual interest.

Aeroradiometric studies indicate that the radioactivity of the area is typical for silicic to intermediate volcanic rocks. No anomalous concentration of radioactive elements was detected.

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Table 1. Mine, claims, and mineralized zones adjacent to South Pahroc Range Wilderness Study Area, Nevada

Map No. (fig. 2.)	Name	Summary	Workings and production	Sample and resource data
1.	Flat No. 1 and 2 claims	Onionskin perlite partially exposed near a tuff unit. Perlite bed strikes N. 45° E., dips 5° NW. Perlite contains marekanites (Apache tears).	One bulldozer cut 75 ft long and 30 ft wide	Optical petrographic examination of one sample verified perlite.
2.	Doe claims	Perlite in overturned block of tuff. A 28-ft-thick section of onionskin perlite strikes N. 35° W., dips 35° to 90° NE. Parts of perlite sequence contaminated by narrow bands of rhyodacite.	One bulldozer trench 90 by 10 by 6 ft deep follows a downdip extension of perlite layer.	One chip sample has expanded density of 2.73 lb/ft^3
3.	Blue Ridge claims	Layer of dark-gray vitreous perlite, approximately 75 ft thick; well-developed spherulitic texture.	One trench 40 by 8 by 5 ft deep. Prospect pit 10 by 12 by 5 ft deep just off west edge of claim inside study area.	One select sample has expanded density of 3.56 lb/ft^3, suitable for "lighter weight" end uses such as filter aid, cryogenics, or soil conditioning.
4.	Mackie mine (Barbara claims)	Perlite flow averaging 20 ft thick, capped by tuff. Onionskin perlite strikes north-northeast, dips 10° to 38° NW. Marekanites interspersed throughout perlite body have no deleterious effect upon expanded product.	Two adits, 525 ft and 300 ft long. East adit abandoned because of falling rock. West adit stoped upward creating a glory hole on surface. Mine operated intermittently. Produced 108,000 tons since late 1940's.	Two chip samples taken; both contain commercial-grade perlite, one has expanded density of 1.63 lbs/ft^3. U.S. Bureau of Mines estimated reserves within claim boundaries at 1 million tons.
5.	Saphire No. 1 and 2 claims	Thin bands of perlite exposed in drainages. Perlite interlayered with tuffaceous sandstone.	One small prospect pit	One sample has expanded density of 4.56 lb/ft^3
--	Perlite zone	North-trending perlite layer within the Tertiary rhyolite unit. Intermittently exposed inside northeastern study-area boundary between 5,600- and 6,200-ft elevations from near Saphire No. 1 and No. 2 claims to Blue Ridge claims, a distance of 2.4 mi (fig. 2). Perlite at base of thick section of well-layered tuffs was a flow of highly viscous magma extruded between phases of tuff deposition.	None	Twelve samples contain perlite having expanded densities between 1.63 to 4.56 lb/ft^3. On basis of observed 8,100-ft length, 500-ft width, and 20-ft thickness, an estimated 6 million tons of indicated subeconomic perlite resource exists within wilderness study area.
--	Jasperoid zone	Small body of jasperoid breccia in Pogonip(?) Group. Straddles southeastern study-area boundary (fig. 2). Paleozoic limestone brecciated and metasomatically altered by hydrothermal fluids.	None	Eight chip samples and seven grab samples of quartz-bearing jasperoid and two alluvial samples taken. One chip sample contains 0.096 oz/ton gold; no significant amounts of precious or base metals detected in remaining samples.

APPENDIXES

DEFINITION OF LEVELS OF MINERAL RESOURCE POTENTIAL AND CERTAINTY OF ASSESSMENT

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 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 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 occurence, where interpretations of data indicate a high degree of likelihood for resource accumulation, where data supports 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.

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 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 Ma)
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 Early	96 138
		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 Ma also called Precambrian, a time term without specific rank.

[2]Informal time term without specific rank.

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March 3, 1849