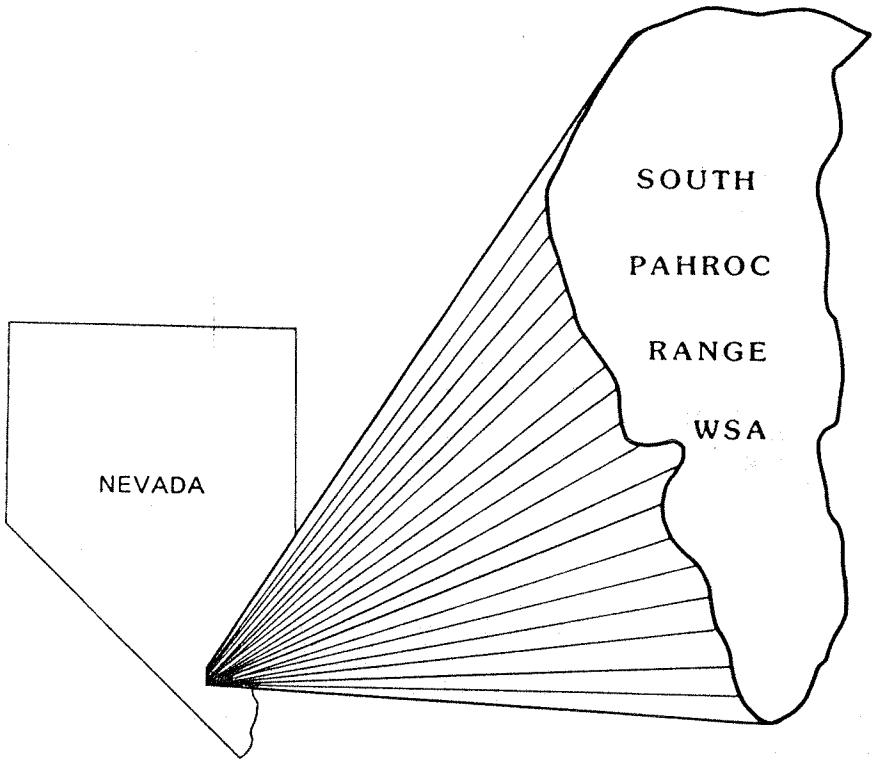
MLA 56-86

Mineral Land Assessment/1986
Open File Report

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



BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR

MINERAL RESOURCES OF THE SOUTH PAHROC RANGE WILDERNESS STUDY AREA, LINCOLN COUNTY, NEVADA

By
Terry R. Neumann

Western Field Operations Center
Spokane, Washington

UNITED STATES DEPARTMENT OF THE INTERIOR
Donald P. Hodel, Secretary

BUREAU OF MINES
Robert C. Horton, Director

PREFACE

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and U.S. Bureau of Mines to conduct mineral surveys on U.S. Bureau of Land Management administered land designated as Wilderness Study 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 Bureau of Mines mineral survey of the South Pahroc Range Wilderness Study Area (NV-050-0132), Lincoln County, NV.

This open-file report will be summarized in a joint report published by the U.S. Geological Survey. The data were gathered and interpreted by Bureau of Mines personnel from Western Field Operations Center, East 360 Third Avenue, Spokane, WA 99202. The report has been edited by members of the Branch of Mineral Land Assessment at the field center and reviewed at the Division of Mineral Land Assessment, Washington, DC.

CONTENTS

ILLUSTRATIONS

TABLE

SUMMARY

During 1984, at the request of the U.S. Bureau of Land Management, U.S. Bureau of Mines personnel conducted a mineral survey of the 28,600-acre South Pahroc Range Wilderness Study Area (NV-050-0132). The Wilderness Study Area is located in Lincoln County, NV, about 100 miles north of Las Vegas. Five mineral properties and two mineralized zones were examined during this study; of these, one mineralized zone, two small prospect pits, and part of two claims are within Wilderness Study Area boundaries. Perlite resources were identified in the study area; however, no significant metallic mineral values were noted at any of the sites.

The Wilderness Study Area is dominated by a Tertiary volcanic sequence consisting of an interlayered series of tuffs containing thin beds of volcanic pebble gravel, sandstone, and perlite. At the base of the exposed volcanic section, perlite occurs along a 2.4-mile-long zone that parallels the study area's northeastern boundary. The perlite is suitable for filtration, insulation, and soil conditioning purposes. Because of prohibitive operation and transportation costs, the estimated 6 million tons of perlite occurring inside the South Pahroc Range Wilderness Study Area are classified as an indicated subeconomic resource.

Minor gold was detected in a small jasperoid zone that straddles the study area's southeast boundary. No pathfinder elements that might indicate possible gold-silver mineralization were found, and no gold resources were identified.

INTRODUCTION

This report describes the USBM (U.S. Bureau of Mines) portion of a cooperative study with the USGS (U.S. Geological Survey) to evaluate mineral resources and potential of the South Pahroc Range WSA (Wilderness Study Area) at the request of the BLM (U.S. Bureau of Land Management). The USBM examines individual mines, prospects, claims, and mineralized zones and evaluates identified mineral and energy resources. The USGS evaluates potential for undiscovered resources based on areal geological, geochemical, and geophysical surveys. Results of the investigations will be used to help determine the suitability of the WSA for inclusion into the National Wilderness Preservation System. Although the immediate goal of this and other USBM mineral surveys is to provide data for the President, Congress, government agencies, and the public for land-use decisions, the long-term objective is to ensure the Nation has an adequate and dependable supply of minerals at a reasonable cost.

Setting

The 28,600-acre South Pahroc Range WSA is located in central Lincoln County, approximately 100 mi (miles) north of Las Vegas, NV (fig. 1).

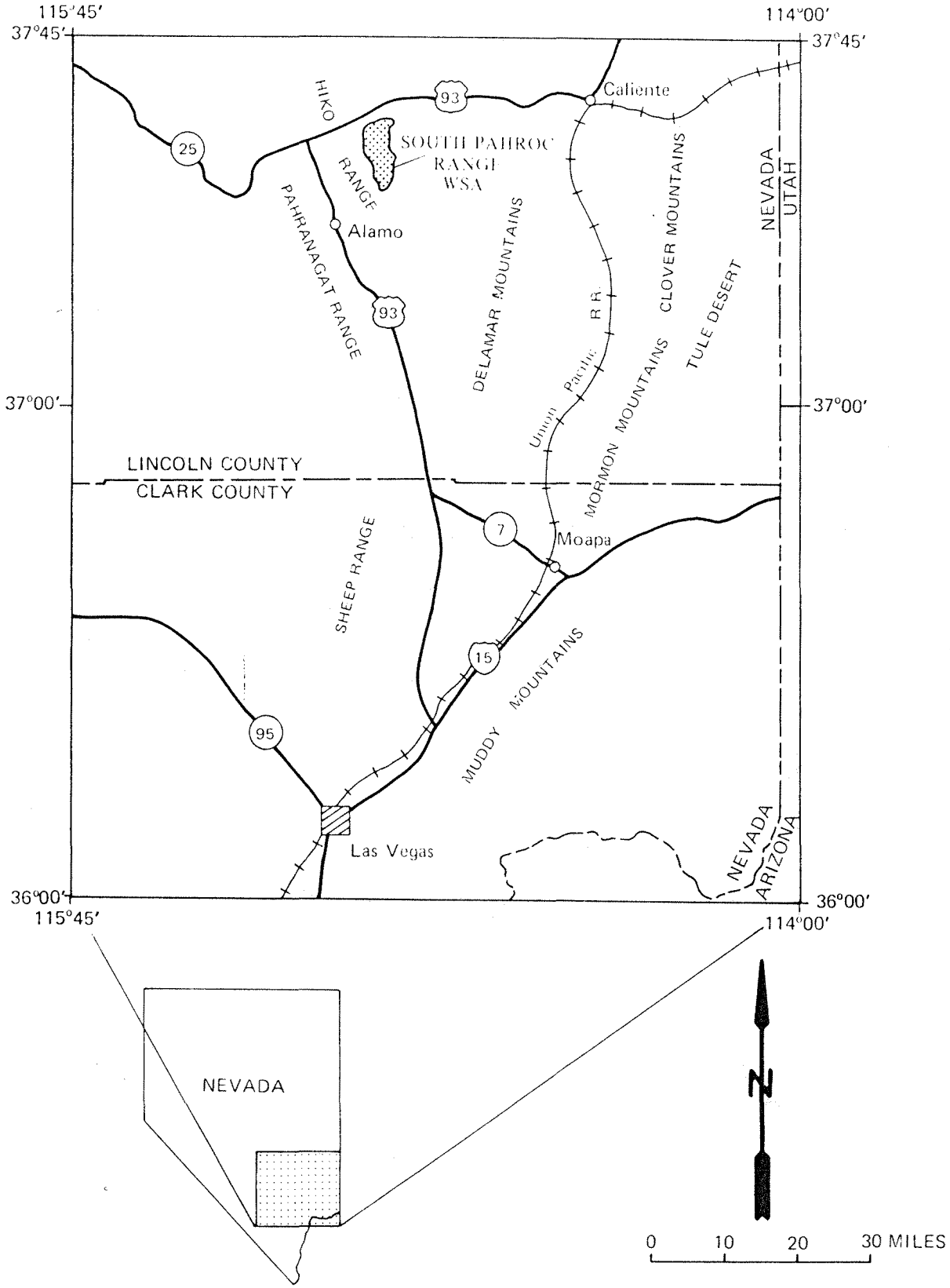


FIGURE 1. — Location of the South Pahroc Range Wilderness Study Area (NV-050-0132), Lincoln County, NV

The WSA is bounded on the east by Delamar Valley and on the west by Eightmile Valley and the Hiko Range. Access to the area is via State Highway 93 to the north and west and by peripheral improved and unimproved dirt roads.

The WSA straddles the South Pahroc Range, a typical fault-bounded mountain range of the Basin and Range Physiographic Province. The topography in the study area is rugged, controlled mainly by the Pahroc fault which runs along the eastern front of the range. Vertical displacement along the fault has resulted in a westward-tilted fault block (Ekren and others, 1977) bounded along its eastern rim by an imposing escarpment that rises over 2,000 ft (feet) above the valley floor. From the escarpment, the terrain is inclined about 15° W forming a tilted plateau characterized by distinctive exfoliating outcrop surfaces; this plateau encompasses most of the WSA. Maximum relief within the study area is about 3,000 ft, with elevations ranging from 7,950 ft at Hyko Peak on the plateau, to 4,929 ft on the northwest edge of the tilted block.

The WSA is sparsely vegetated on its flanks reflecting the low annual precipitation of this high desert country. In contrast, the escarpment displays a high plateau environment of pinon pine, juniper, and scattered stands of white fir.

Previous Studies

Geologic studies by Dolgoff (1963), Cook (1965), and Tschanz and Pampeyan (1970) discuss the volcanic stratigraphy and general geology of the area. Geologic mapping of the area has been done by Ekren, Orkild, Sargent, and Dixon (1977), and Barton and Day (1984).

Present Study

During the fall of 1984 and spring of 1985, USBM personnel conducted field examinations of the South Pahroc Range WSA. All available information on geology, mining, and mineral resources in the area, including Federal and Lincoln County mining claim records, was reviewed prior to fieldwork. Field examinations included mapping and sampling of mines, prospects, and mineralized zones.

Thirty samples were taken during the USBM study. Most were rock chip samples of perlite zones, ash layers, and jasperized areas. Suspected mineralized zones at or near fault contacts were also sampled. Grab samples of alluvium were taken in major drainages. All chip samples were crushed, pulverized, mixed, and split at the WFOC (Western Field Operations Center). The samples were then checked for radioactivity and fluorescence. A split of each sample was sent to the USBM Reno Research

Center and fire assayed for gold and silver. Most samples were analyzed by atomic absorption for a few selected elements and emission spectrography for anomalous content of 40 elements 1/. Those samples thought to contain zeolites were analyzed by x-ray diffraction. Alluvium samples were concentrated by hand panning then processed on a Wilfley table at WFOC. Perlite samples were petrographically analyzed at WFOC, then if they passed this initial screening, they were sent to the New Mexico Bureau of Mines perlite testing facility. Analyses included physical testing for expanded density, furnace yield, compaction resistance, and percent sinkers (unexpandable impurities).

Resource tonnage of the perlite deposit was calculated by multiplying the projected area of the deposit by its thickness and dividing the resulting volume by a tonnage factor of 13.6 ft^3/ton (cubic feet per ton). The length of the perlite deposit was mapped in the field; the thickness and width were extrapolated from measurements taken underground at the Mackie mine.

Complete analytical results for all samples are available for public inspection at the USBM WFOC, Spokane, WA.

ACKNOWLEDGEMENTS

Arel B. McMahan, Ed McHugh, and Harry Campbell, geologists, and Dave Brink, field assistant, USBM WFOC, assisted with pre-field and field studies. The author gratefully acknowledges the cooperation provided by personnel of the BLM Caliente, NV, and Dr. Joseph Wilkin, operator of the Mackie mine.

GEOLOGIC SETTING

The South Pahroc Range WSA is underlain by a Tertiary volcanic sequence of Oligocene-Miocene welded and nonwelded siliceous ash flow tuffs (Tschanz and Pampeyan, 1970). An incomplete, approximately 2,000-ft-thick section of volcanic rocks is exposed in the Pahroc fault scarp along the eastern front of the range. At the base of the exposed volcanic section, a well-layered series of tuff contains interlayered volcanic pebble gravel, tuffaceous sandstone, and perlite. The perlite is discontinuously exposed along the eastern front of the South Pahroc Range in Sec. 3, T. 5 S., R. 62 E., and Secs. 27, 34, T. 4 S., R. 62 E. (fig. 2). Overlying the tuff series is a distinctive spheroidal weathering rhyodacite welded tuff that is exposed throughout the WSA.

1/ Aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium, cobalt, copper, gallium, gold, iron, lanthanum, lead, lithium, magnesium, manganese, molybdenum, nickel, niobium, palladium, phosphorus, platinum, potassium, scandium, silicon, silver, sodium, strontium, tantalum, tellurium, tin, titanium, vanadium, yttrium, zinc, and zirconium.

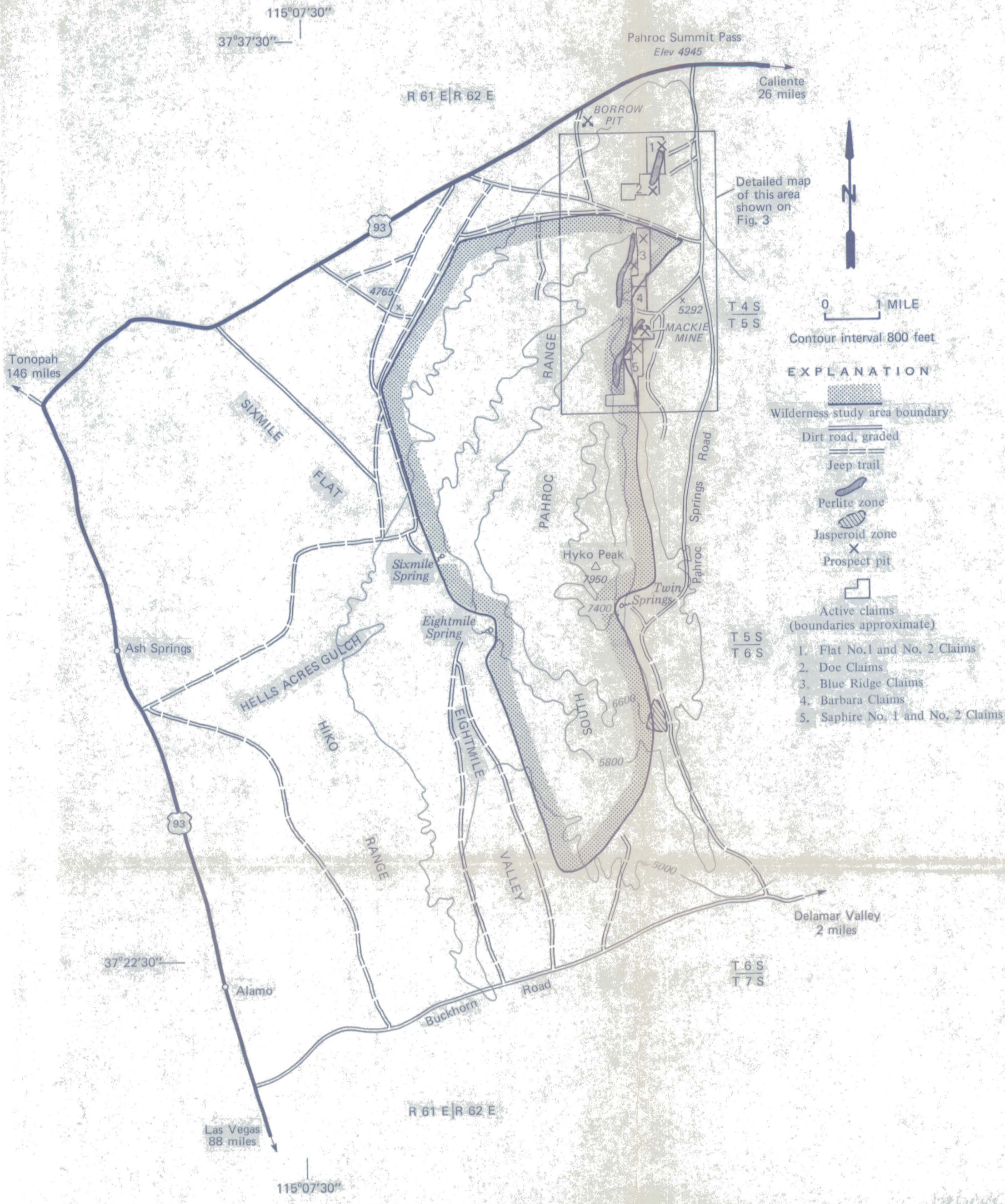


FIGURE 2. -- Mines, prospects, and mineralized zones in and adjacent to the South Pahroc Range Wilderness Study Area (NV-050-0132), Lincoln County, NV

The volcanic section masks underlying Paleozoic carbonate and clastic sedimentary rocks, represented by a small outcrop of jasperized limestone bordering the study area 2 mi south of Twin Springs. Mineralized zones in Paleozoic sediments at other locations in Lincoln County have produced gold and silver, but possible evidence of such occurrences in the WSA is shielded by the thick volcanic sequence.

MINING HISTORY

Although there has been no mining within the South Pahroc Range WSA, perlite has been mined since the late 1940's from the Mackie mine (also known as Paramount, Delamar, and Kopenite) just outside the WSA's northeastern boundary. The Mackie mine lies on the Barbara claims, one of five association placer claim groups staked in the middle to late 1940's on a perlite layer exposed at the base of the South Pahroc Range. The Barbara claims (fig. 2, no. 4) were originally located in 1945 by the Paramount Perlite Co., Paramount, CA, and A. J. Mackie of Caliente, NV.

Subsequent association placer claims, including the Blue Ridge claims (fig. 2, no. 3) and Flat No. 1 and No. 2 claims and Doe claim (fig. 2, nos. 1 and 2) were staked on the deposit in 1946 and 1949, respectively, by members of the Mackie family. The Wilkin family of Caliente, NV, has been involved in the ownership of the Mackie mine since 1951 and located the Saphire No. 1 and No. 2 claims (fig. 2, no. 5).

The nearest mining district to the WSA, the Delamar (Ferguson) district, is 12 mi to the east across Delamar Valley. Gold and silver deposits were discovered in the Delamar Mountains in 1891 and were mined intermittently through 1950. During the years of operation, the Delamar mines produced ore worth about $15 million, making the district one of Nevada's premier early gold producers (Callaghan, 1937). Most of the ore in the district occurs in brecciated quartzite. No extension of this deposit is known to occur in the WSA.

COMMODITY HIGHLIGHTS

Perlite, a glassy volcanic rock with 2 to 5 percent combined water (Kadey, 1983, p. 997) is the only identified resource within the study area. When particles of crushed perlite are heated, its combined water vaporizes, forming steam that expands each particle into a mass of glass foam (fig. 3). The original volume of the crude perlite may be expanded 4 to 20 times at temperatures between 1,400 and 2,000 ^{o}F (degree Fahrenheit) (Meisinger, 1985, p. 572).

The capacity to swell into light cellular particles makes perlite commercially valuable. Expanded perlite is a material of low density, low thermal conductivity, and high sound absorption; these properties are useful in a variety of industries, especially the construction industry. About 75 percent of expanded perlite produced in the United States is

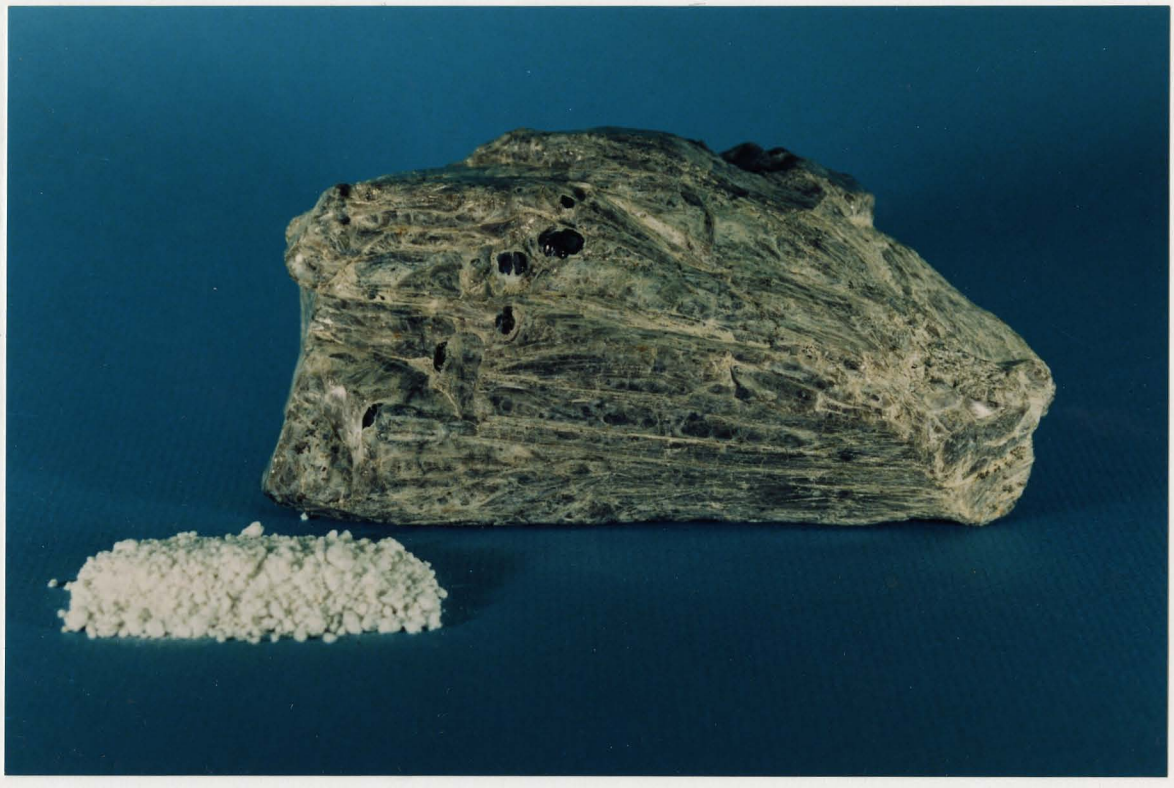


FIGURE 3.--Perlite and expanded perlite from the South Pahroc Range Wilderness Study Area.

used for construction purposes such as concrete and plaster aggregate, and as an insulating material. Perlite has found a growing acceptance in industrial filtration, horticultural uses, and as fillers, extenders, and carriers (Chesterman, 1975, p. 928).

Commercially acceptable perlite generally must have an expanded bulk density between 2 and 15 lb/ft^3 (pound per cubic foot) without the production of an excessive amount of fines or nonexpandables. Expansion has to occur in an economically defined temperature range since fuel costs are a major element in the processing of perlite (Naert, 1974, p. 66).

Perlite is usually quarried from open pits, using selective mining techniques to mine areas with the least amount of overburden and to avoid seams of impurities. The perlite is then crushed and sized at either the mine or shipping point before it is sent to an expanding plant. Expanding plants are near market areas because of the high freight costs for the lightweight and bulky expanded perlite.

The perlite industry in the United States is controlled by a few relatively large corporations that mine large deposits of uniform quality perlite; 83 percent of total production is from two large deposits in New Mexico (Meisinger, 1985, p. 571). Domestic mine production in 1984 was 500,000 tons, meeting all domestic demand. Domestic perlite reserves are conservatively estimated to be 50 million tons. The demand for perlite is expected to increase 3.0 percent annually through 1990 (Meisinger, 1985, p. 576).

MINES, PROSPECTS, AND MINERALIZED ZONES

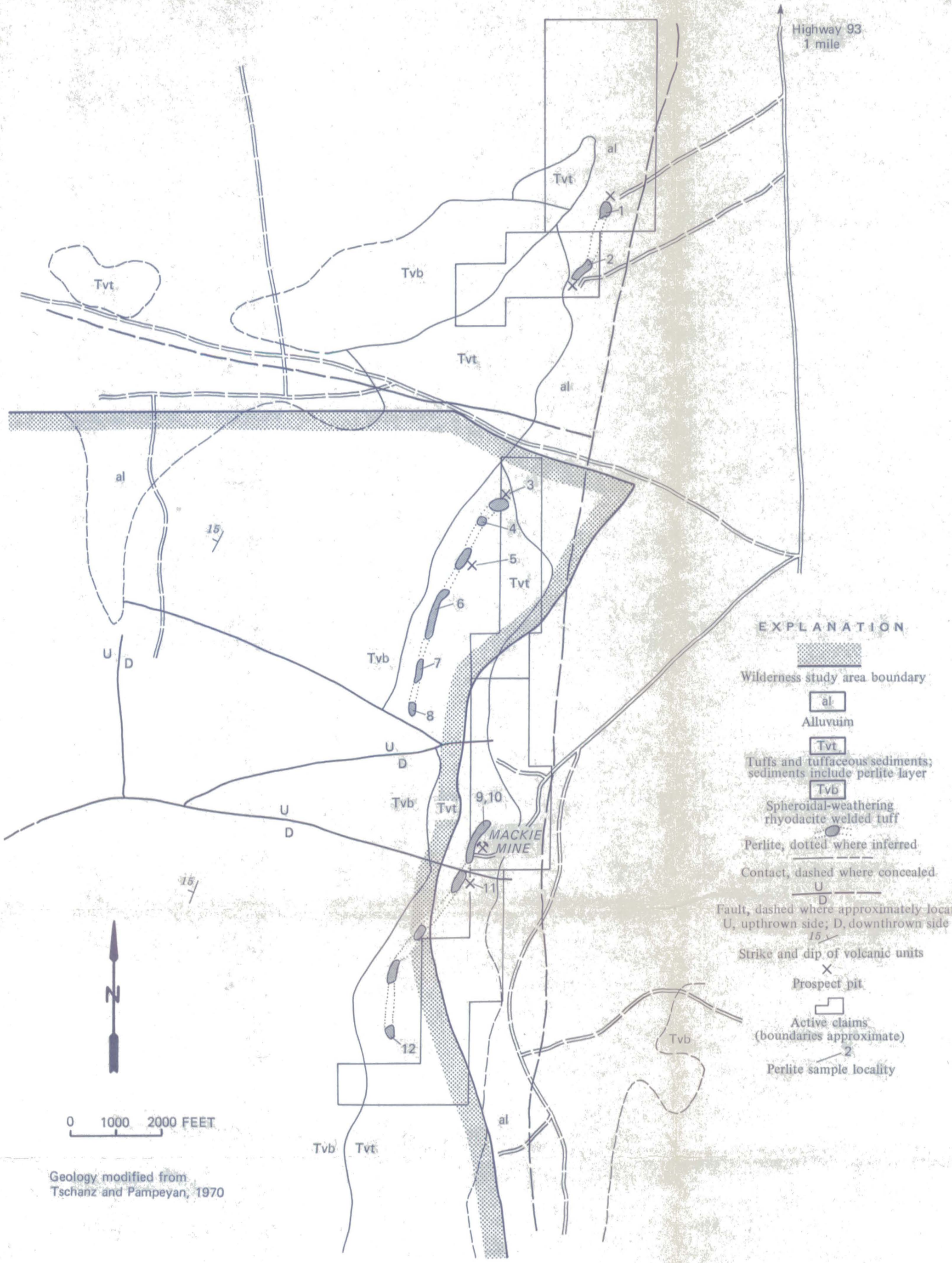
BLM mining records indicate five association placer claim groups covering 1,060 acres lie in and adjacent to the WSA. All claims, except for portions of the Blue Ridge and Saphire properties and a short extension of underground workings at the Mackie mine, are outside the study area. Mineral properties examined include the Flat No. 1 and 2, Doe, Blue Ridge, Barbara, and Saphire No. 1 and 2 association placer perlite claims (fig. 2, nos. 1-5). None of the claims are patented, and only the Barbara property is actively being worked. Descriptions of the prospects examined in this study are in table 1. A description of mineralized areas follows.

Perlite Zone

A north-trending perlite layer is intermittently exposed inside the WSA's northeastern boundary between the 5,600 and 6,200-ft elevations from near the Saphire No. 1 and No. 2 claims to the Blue Ridge claims, a distance of 2.4 mi; another 1.2 mi of the zone extends north of the study area boundary. Figure 4 shows the distribution of observed and inferred sections of the perlite zone. The zone pinches to the south.

TABLE 1.--Mine and claims in and adjacent to the South Pahroc Range Wilderness Study Area

Map no. (fig. 2)	Name	Summary	Workings and production	Sample and resource data
1	Flat No. 1 and 2 claims	Onionskin perlite is partially exposed near a tuff unit. The perlite bed strikes N. 45° E. and dips 5° NW. The perlite contains marekanites (prominent obsidian pellets).	One bulldozer cut is 75 ft long and 30 ft wide.	Optical petrographic examination of one sample verified perlite.
2	Doe claims	Perlite occurs in an overturned block of tuff. A 28-ft-thick section of onion-skin perlite strikes N. 35° W., dips 35° to 90° NE. Portions of the perlite sequence are contaminated by narrow bands of rhyodacite.	One bulldozer trench is 90 by 10 by 6 ft deep following a downdip extension of the perlite layer.	One chip sample had expanded density of 2.73 lb/cu ft.
3	Blue Ridge claims	A layer of dark gray vitreous perlite, approximately 75 ft thick, has well developed spherulitic texture.	One trench is 40 by 8 by 5 ft deep. Prospect pit just off western edge of claim inside the WSA is 10 by 12 by 5 ft deep.	One select sample had an expanded density of 3.56 lb/cu ft, suitable for "lighter weight" end uses such as filter aid, cryogenics, or soil conditioning.
4	Mackie mine (Barbara claims)	A perlite flow averaging 20 ft thick is capped by tuff. Onionskin perlite strikes N-NE, dips 10° to 38° NW. Marekanites interspaced throughout the perlite body have no deleterious effect upon the expanded product.	Two adits, one 525 ft long, the other 300 ft long. The east adit is abandoned because of falling rock. The west adit was stoped upward creating a glory hole on the surface. Mine is operated intermittently, producing 108,000 tons since late 1940's.	Two chip samples were taken: both contained commercial grade perlite, one had an expanded density of 1.63 lbs/cu ft. USBM estimates reserves occurring within claim boundaries at 1 million tons.
5	Saphire No. 1 and 2 claims	Thin bands of perlite are exposed in drainages. The perlite is interlayered with tuffaceous sandstone.	One small prospect pit.	One sample had an expanded density of 4.56 lb/cu ft.



Geology modified from Tschanz and Pampeyan, 1970

FIGURE 4.-- Sample localities at perlite deposit along the northeast boundary of the South Pahroc Range Wilderness Study Area

The perlite occurs at the base of a thick section of well-layered tuffs and appears to constitute a flow of highly viscous magma extruded between phases of tuff deposition. The perlite probably originated through the hydration of an obsidian flow, indicated by obsidian pellets (marekanites, "Apache tears") appearing as vestiges within the flow. Other units associated with the perlite include a tuffaceous sandstone bed and a volcanic pebble gravel. Most of the perlite zone is concordant with the volcanic sequence, striking north and dipping 15° to 20° W. easterly trending faults have offset the unit near the Mackie mine, resulting in northeast strikes and 10° to 30° northwest dips. Because of its uniform western dip, the perlite undoubtedly extends beneath the WSA.

Twelve samples taken at perlite outcrops (fig. 4) were composed predominantly of onionskin perlite 2/. Preliminary testing by petrographic microscope determined that the refractive indices and glass percentages of the samples were within optimum ranges of commercial-grade perlite. The highest quality samples determined by preliminary tests were further tested by the New Mexico Bureau of Mines (appendix A).

Based on field observations, approximately 6 million tons of perlite are within the WSA. This conservative estimate is based on an 8,100-ft observed deposit length, and the 500-ft width and 20-ft thickness exposed at the Mackie mine. No inferences of downdip extensions were made due to the unpredictable nature of this type of deposit. Cochran (1951, p. 23) estimated indicated and inferred reserves in the deposit to be 15,460,000 tons; this estimate includes perlite outside the WSA.

Mackie Mine

The Mackie mine, located in sec. 34, T. 4 S., R. 62 E., produces perlite from a segment of perlite that has been faulted off the main deposit exposed along the WSA's northeast boundary. Although the mine's surface workings are outside the WSA boundary, underground development appears to go into the study area (fig. 5). Two adits, one 525 ft long, the other 300 ft long, explore a 20-ft-thick section of onionskin perlite capped by tuff. The capping precludes open-pit mining. Perlite from the mine had an expanded density of 1.63 lb/ft^3 (appendix A, sample 9), an expansion well above that of standard perlite. The USBM estimates reserves of perlite at the Mackie mine to be about 1 million tons in a deposit 1,300 ft long, 500 ft wide, and 20 ft thick.

Since the late 1940's, the Mackie mine has produced 108,000 tons of perlite. The perlite is trucked to Caliente, NV, for crushing and sizing then shipped to Paramount, CA, for expanding. The expanded perlite is sold exclusively to plant nurseries in the Los Angeles area for use as a

---

2/ Onionskin perlite: classical pearl-gray perlite with concentric parting (Kadey, 1983, p. 999).

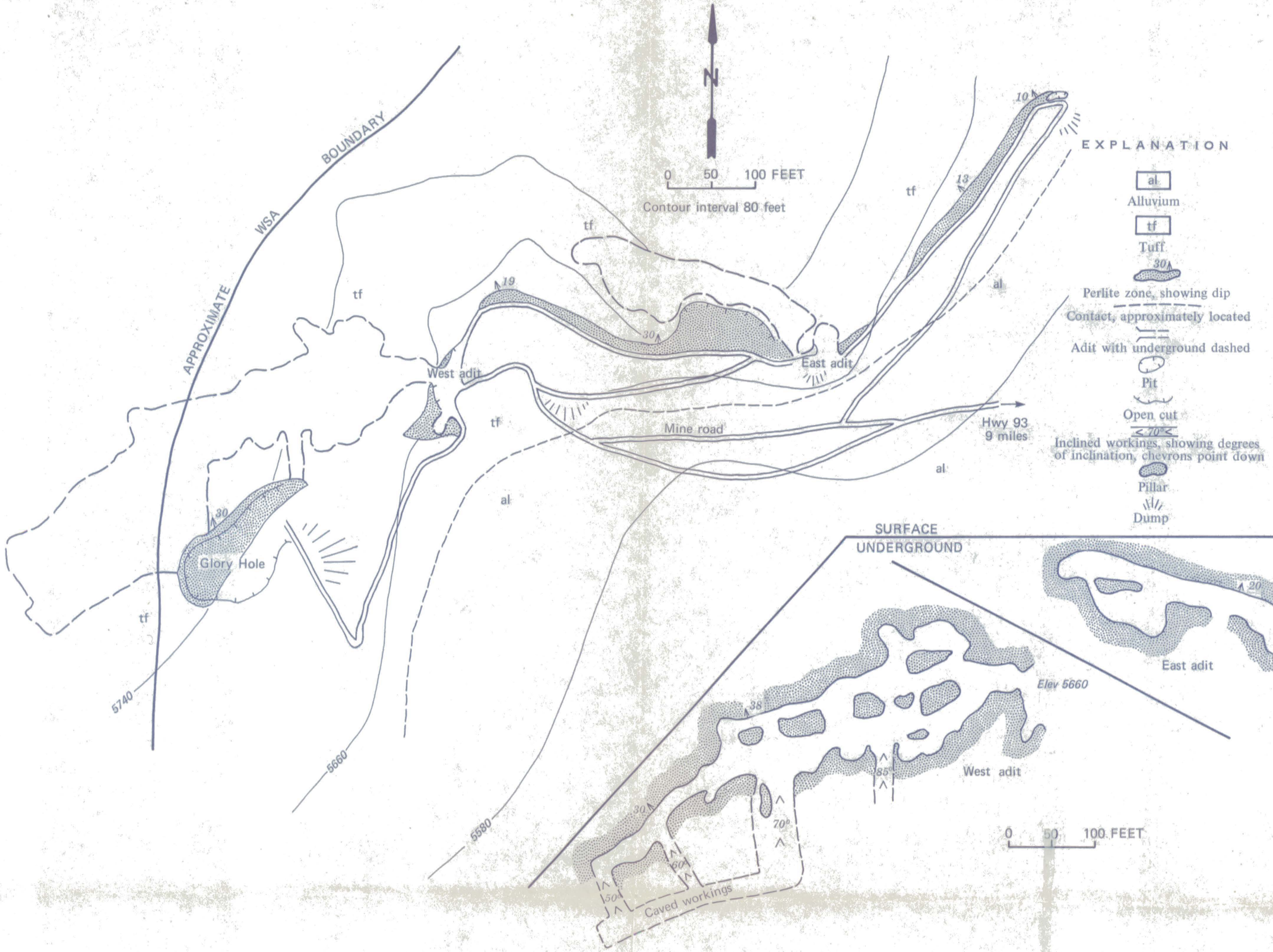


FIGURE 5. — Mackie perlite mine

soil conditioner. The Mackie mine annual production of about 4,000 tons easily meets the nursery market need in the Los Angeles area (Joseph Wilkin, written commun., 1985). Ore from the deposit continues to maintain a small foothold in the perlite market due to its exceptional expansion properties.

Jasperoid Zone

A small body of jasperoid breccia straddles the WSA's southeast boundary (fig. 2). This zone is comprised of Paleozoic limestone that has been brecciated and altered metasomatically by siliceous hydrothermal fluids. Jasperoid breccias are considered good targets for gold exploration because they: (1) indicate the introduction of siliceous epithermal fluids, (2) offer favorable sites for fluid circulation due to increased permeability, and (3) offer a porous receptacle for ore deposition. Jasperoids are commonly associated with sulfide replacement deposits in carbonate rocks (Carlin, NV; Bingham, UT; Bisbee, AZ).

Eight chip samples of quartz-bearing jasperoid and two alluvial samples were taken from an intermittent stream draining the area. One chip sample contained 0.096 oz/ton (ounce per ton) gold; no significant amounts of precious or base metals were detected in the remaining samples.

APPRAISAL OF MINERAL RESOURCES

Perlite

An indicated perlite resource of 6 million tons exists within the study area. Most of the resource is not minable by surface methods due to 15^{o} to 20^{o} dips, high slope angles, and a dense cap rock overlying sections of the perlite body. Detailed tests showed that the perlite displays exceptional expansion characteristics, with expanded densities ranging from 1.63 to 4.56 lb/ft^3; these values are 2 to 3 times greater than a standard perlite. However, because it does expand so well, the compaction resistance is very low--negating aggregate and concrete applications. Due to excellent expansiblity, a good furnace yield, and a negligible sinker (nonexpandable) fraction, the New Mexico testing facility summarized the tests as follows: "As an overall evaluation, the 'light weight' end uses, for example, filter aid or cryogenics, would be well served with these samples."

To determine the minability of the South Pahroc Range WSA perlite, a hypothetical mining and processing operation was designed. Costs were based on the USBM (STRAAM Engineers, Inc.) cost estimating system (Clement and others, 1978) using a 100 tons/day (tons per day) room and pillar mine plan. Overall production costs of the hypothetical operation were estimated as follows:

	Production Cost ($/ton)	
Mine Operation	$11.11	
Capital Costs	7.20	
Processing	3.10	
Truck, 31 mi to Caliente, NV	3.00	
Subtotal	$24.41	(f.o.b. processing plant)
Rail and handling (to Paramount, CA)	19.17	
Total	$43.58	(f.o.b. expansion plant)

Rail freight and handling costs to Salt Lake City, UT, are $16.82; to Las Vegas, NV, $10.37. The 1984 average unit value per ton of perlite was $33.05 f.o.b. processing plant (U.S. Bureau of Mines, 1985, p. 112) In 1985, the unit value per ton of perlite was $36.25 f.o.b. Paramount expansion plant (Paramount Perlite Co., oral commun., 1985).

Most high-bulk, low cost commodities such as perlite depend on low cost open-pit mining methods and on low transportation costs. Because of prohibitive underground mining costs and large transportation expenditures, the South Pahroc Range perlite deposit cannot compete on a large scale with established open-pit deposits closer to major markets. Also, because of prohibitive capital start-up costs, the deposit cannot compete with the established Mackie deposit, which supplies regional demands for high-expansion perlite. For these reasons, the deposit is classified as an indicated subeconomic resource (appendix B). A substantial increase in demand for high-expansion perlite, especially in the Las Vegas, NV, area, could change the classification to that of marginal reserve. It seems unlikely that the deposit within the WSA would be exploited in the near future.

Other Occurrences

One sample from a jasperoid outcrop on the WSA's southeast border contained a significant gold value. However, certain elements which serve as pathfinders for possible Carlin-type gold and silver mineralization were absent. No gold resources were identified in this area.

Apache tears, prized by rock collectors and often sold in rock shops, are abundant in the WSA.

Oil and gas leases cover a small section of the study area's western flank. Most of the study area consists of a thick section of Tertiary volcanics--unlikely hosts for oil and gas accumulations. Sandberg (1983) gives the study area a low potential for oil and gas resources.

REFERENCES

Barton, H. N. and Day, G. W., 1984, Reconnaissance geochemistry of the South Pahroc/Hiko Bureau of Land Management Wilderness Study Area (NV-050-0132), Lincoln County, Nevada: U.S. Geological Survey Open-File Report 84-362, 26 p.

Callaghan, Eugene, 1937, Geology of the Delamar district, Lincoln County Nevada: University of Nevada Bulletin, v. 31, no. 5, 72 p.

Chesterman, C. W., 1975, Perlite, in Industrial minerals and rocks (4th ed.): New York, American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., p. 927-934.

Clement, G. K., Jr., Miller, R. L, Avery, Louis, and Seibert, P. A., 1978, Capital and operating cost estimating system handbook, mining and benefication of metallic and nonmetallic minerals except fossil fuels in the United States and Canada: prepared by STRAAM Engineers, Inc., (contract J0255026) U.S. Bureau of Mines Open-File Report 10-78 (revised 1979), 374 p.

Cochran, K. L., 1951, Perlite resources, Meadow Valley Wash area, Clark and Lincoln Counties, Nevada; Beaver and Millard Counties, Utah: Union Pacific Railroad Company, 23 p.

Cook, E. F., 1965, Stratigraphy of Tertiary volcanic rocks in eastern Nevada: Nevada Bureau of Mines Report 11, 61 p.

Dolgoff, Abraham, 1963, Volcanic stratigraphy of the Pahranagat area, Lincoln County, southeastern Nevada: Geological Society of America Bulletin, v. 74, p. 875-900.

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.

Kadey, F. L., Jr., 1983, Perlite in Industrial minerals and rocks (5th ed.): New York, Society of Mining Engineers of the American Institute of Mining, Metallurgical and Petroleum Engineers, Inc., v. 2, p. 997-1015.

Meisinger, A. C., 1985, Perlite, in Mineral facts and problems: U.S. Bureau of Mines Bulletin 675, p. 571-577.

Naert, K. A., 1974, Geology, extrusion history and analysis of characteristics of perlites from No Agua, New Mexico: Unpublished Ph.D. thesis, Pennsylvania State University, 236 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. H-1 to H-11.

Tschanz, C. M., and Pampeyan, E. H., 1970, Geology and mineral deposits of Lincoln County, Nevada: Nevada Bureau of Mines Bulletin 73, 188 p.

U.S. Bureau of Mines, 1985, Perlite, in Mineral commodity summaries, p. 112-113.

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.

APPENDIX A.--Results of laboratory tests of perlite samples from South Pahroc Range WSA

Optical petrographic analysis

Sample no. (fig. 4)	Refraction index*	% glass
1	1.497	90
2	1.497	90
3	1.496	80
4	1.496	90
5	1.496	90
6	1.496	90
7	1.496	80
8	1.497	90
9	1.497	90
10	1.497	90
11	1.497	90
12	1.497	60

Expansibility tests

Sample no. (fig. 4)	Furnace temperature (°F)	Expanded density (lb/ft^3)	Furnace yield (%)	Sinkers (%)	Compaction resistance (lb/in^2)
2	1450	2.73	98	6.1	1.7**
3	1340	3.56	91.9	.3	18†
9	1450	1.63	96	4.1	1.7**
11	1330	4.56	101.3	2.0	14†

* Refractive index range of commercially acceptable perlite is between 1.495 and 1.500; best values are between 1.496-1.498.

** Test on 7-9 lb/ft^3 material

† Compaction resistance at 1 in.

APPENDIX B.: RESOURCE/RESERVE DEFINITIONS

(From U.S. Geological Survey Circular 831, 1980)

RESOURCE.--A concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible.

IDENTIFIED RESOURCES.--Resources whose location, grade, quality, and quantity are known or estimated from specific geologic evidence. Identified resources include economic, marginally economic, and subeconomic components. To reflect varying degrees of geologic certainty, these economic divisions can be subdivided into measured, indicated, and inferred.

MEASURED.--Quantity is computed from dimensions revealed in outcrops, trenches, workings, or drill holes; grade and (or) quality are computed from the results of detailed sampling. The sites for inspection, sampling, and measurement are farther apart or are otherwise less adequately spaced. The degree of assurance, although lower than that for measured resources, is high enough for continuity between points of observation to be assumed.

INDICATED.--Quantity and grade and (or) quality are computed from information similar to that used for measured resources, but the sites for inspection, sampling, and measurement are farther apart or are otherwise less adequately spaced. The degree of assurance, although lower than that for measured resources, is high enough to assume continuity between points of observation.

INFERRED.--Estimates are based on an assumed continuity beyond measured and (or) indicated resources for which there is geologic evidence. There may be no samples or measurements.

RESERVE BASE.--That part of an identified resource that meets specified minimum physical and chemical criteria related to current mining and production practices, including those for grade, quality, thickness, and depth.

RESERVES.--That part of the reserve base which could be economically 1/ extracted or produced at the time of determination. The term reserves need not signify that extraction facilities are in place and operative. Reserves include only recoverable materials; thus, terms such as "extractable reserves" and "recoverable reserves" are redundant and are not a part of this classification system.

1/ In this report, reserves are expected to yield at least 20 percent rate of return.

MARGINAL RESERVES.--That part of the reserve base which, at the time of determination, borders on being economically producible 2/.

ECONOMIC.--This term implies that profitable extraction or production under defined investment assumptions has been established, analytically demonstrated, or assumed with reasonable certainty.

SUBECONOMIC RESOURCES--The part of identified resources that does not meet the economic criteria 3/ of reserves and marginal reserves.

OCCURRENCES 4/.--Not defined in U.S. Geological Survey Circular 831, 1980.

2/ In this report, marginal reserves are expected to yield less than a 20 percent rate of return, but to return at least the production expenditures.

3/ In this report, subeconomic resources are expected to return at least 20 percent but less than 100 percent of production expenditures.

4/ In this report, an occurrence is expected to return less than 20 percent of expenditures necessary to produce the commodity.