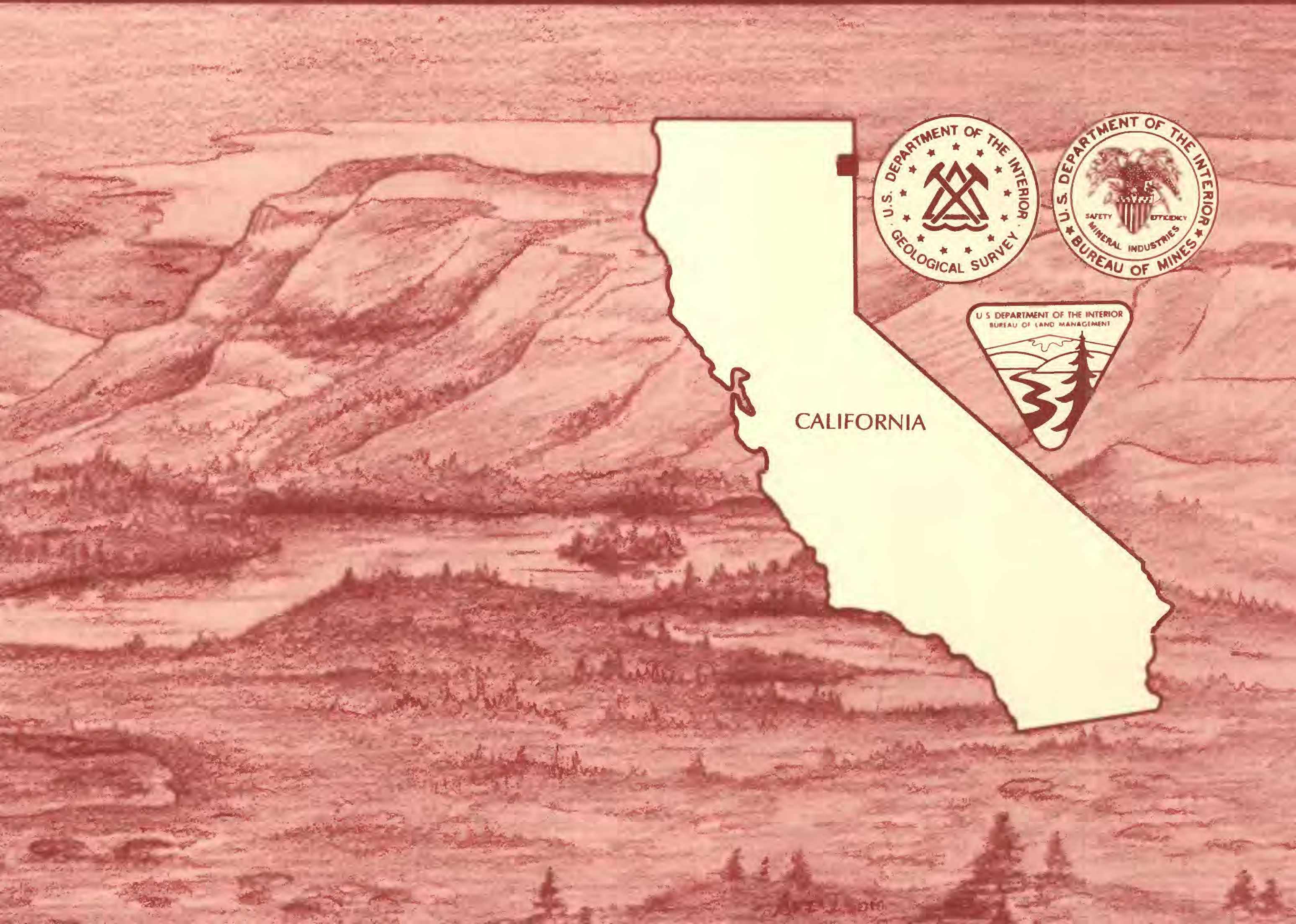
Mineral Resources of the Skedaddle Mountain Wilderness Study Area, Lassen County, California, and Washoe County, Nevada

U.S. GEOLOGICAL SURVEY BULLETIN 1706–C



Chapter C

Mineral Resources of the Skedaddle Mountain Wilderness Study Area, Lassen County, California, and Washoe County, Nevada

By MICHAEL F. DIGGLES, JAMES G. FRISKEN, and DONALD PLOUFF
U.S. Geological Survey

STEVEN R. MUNTS and THOMAS J. PETERS
U.S. Bureau of Mines

U.S. GEOLOGICAL SURVEY BULLETIN 1706

MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
NORTHEASTERN CALIFORNIA AND PART OF ADJACENT WASHOE COUNTY, NEVADA

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1988

For sale by the
Books and Open-File Reports Section
U.S. Geological Survey
Federal Center, Box 25425
Denver, CO 80225

Library of Congress Cataloging-in-Publication Data

Mineral resources of the Skedaddle Mountain Wilderness Study Area, Lassen County, California, and Washoe County, Nevada.

Mineral resources of wilderness study areas—north-eastern California and part of adjacent Washoe County, Nevada; ch. C, U.S. Geological Survey Bulletin 1706-C
Bibliography.
Supt. of Docs. No.: I 19.3:1706-C
1. Mines and mineral resources—Skedaddle Mountain Wilderness (Calif. and Nev.) 2. Skedaddle Mountain Wilderness (Calif. and Nev.) I. Diggles, M.F. II. Series. III. Series: U.S. Geological Survey Bulletin 1706-C.

QE75.B9 No. 1706-C	557.3s	87-600017
[TN25.S58]	[553'.09794'26]	

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 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 Skedaddle Mountain (CA-020-612) Wilderness Study Area, Lassen County, California, and Washoe County, Nevada.

CONTENTS

PLATE
[In Pocket]

FIGURES

TABLE

Mineral Resources of the Skedaddle Mountain Wilderness Study Area, Lassen County, California, and Washoe County, Nevada

By Michael F. Diggles, James G. Frisken, *and* Donald Plouff
U.S. Geological Survey

Steven R. Munts *and* Thomas J. Peters
U.S. Bureau of Mines

SUMMARY

Abstract

At the request of the U.S. Bureau of Land Management, approximately 39,420 acres of the Skedaddle Mountain Wilderness Study Area (CA-020-612) were evaluated for mineral resources (known) and mineral resource potential (undiscovered). In this report, the area studied is referred to as the "wilderness study area" or simply "the study area;" any reference to the Skedaddle Mountain Wilderness Study Area refers only to that part of the wilderness study area for which a mineral survey was requested by the U.S. Bureau of Land Management. Field work was carried out in 1985 to assess the mineral resource potential of the area. Demonstrated subeconomic perlite resources are about 184,000 short tons in and adjacent to the western part of the study area. There are six areas of mineral and (or) geothermal energy resource potential in the Skedaddle Mountain Wilderness Study Area. Geologic and geochemical evidence suggests that the study area has potential for the occurrence of silver, gold, mercury, and antimony metallic deposits. The central part of Spencer Basin, upper Thousand Springs Canyon, and the south fork of Wendel Canyon have high mineral resource potential for gold, silver, mercury, and antimony while the area surrounding these locations has moderate mineral resource potential for the same metals. An area in Wendel Canyon has moderate mineral resource potential for perlite, and an adjacent area to the south has low mineral resource potential for the same commodity. The Skedaddle Mountain Wilderness Study Area includes part of the Wendel-Amedee Known Geothermal Resource Area. The southwest corner of the study area has moderate resource potential for geothermal energy and much of the west half of the study area has low potential for geothermal energy. There is no oil or gas resource potential in the study area.

Character and Setting

The Skedaddle Mountain Wilderness Study Area is located in the eastern part of the Modoc Plateau in Lassen County, northeastern California, and Washoe County, northwestern Nevada (fig. 1). The study area encompasses 39,420 acres 25 mi east of Susanville, Calif. It is bounded on three sides by dirt roads; the south boundary parallels Wendel Road. The Skedaddle Mountains lie in the northern part and the Amedee Mountains lie in the southern part of the study area. Elevations range from 4,300 ft at the base of the Amedee Mountains to 7,680 ft at the summit of Hot Springs Peak in the Skedaddle Mountains. Steep rim-rock walls and talus-covered canyons are common along the west edge of the area; the rest of the study area is moderately sloping. Vegetation is sparse, consisting mainly of desert sage-scrub species. The rocks in the study area consist mostly of Tertiary (see appendixes for geologic time scale) basalt, andesite, dacite, rhyolite, and lahar deposits. South of the study area lakebed features, including tufa deposits and strandlines from Pleistocene Lake Lahontan, are present. The central part of

Spencer Basin is underlain by highly altered volcanic rocks which probably originally consisted of andesite, dacite, and lahar deposits.

Identified Mineral Resources

The identified resources in the Skedaddle Mountain Wilderness Study Area consist of 46,000 tons of measured subeconomic resources and about 138,000 tons of indicated subeconomic resources of perlite. Additional nonmetallic occurrences present in the study area consist of basalt, pozzolan, stone, and sand and gravel. There are no identified resources of these commodities and they are not currently of economic significance. There are no identified resources of metallic minerals in the study area, but metallic mineral occurrences present in and near the study area consist of small amounts of gold and mercury in vein-type deposits. The gold and mercury occurrences and the perlite resources are spatially related to a volcanic center in the Skedaddle Mountains.

There are no known mines or mining operations in the study area. None of the prospects or claims in or within 1 mi of the study area have recorded production. At least 276 recorded lode, 6 located but unrecorded lode, and 29 placer claim locations are present in and within about 1 mi of the study area. Approximately 191 of these are in the study area; four of these were actively held in 1985. None of the study area was being explored by private industry in 1985, but prospects in the Skedaddle Mountains may be targets for future exploration for both precious metals and perlite.

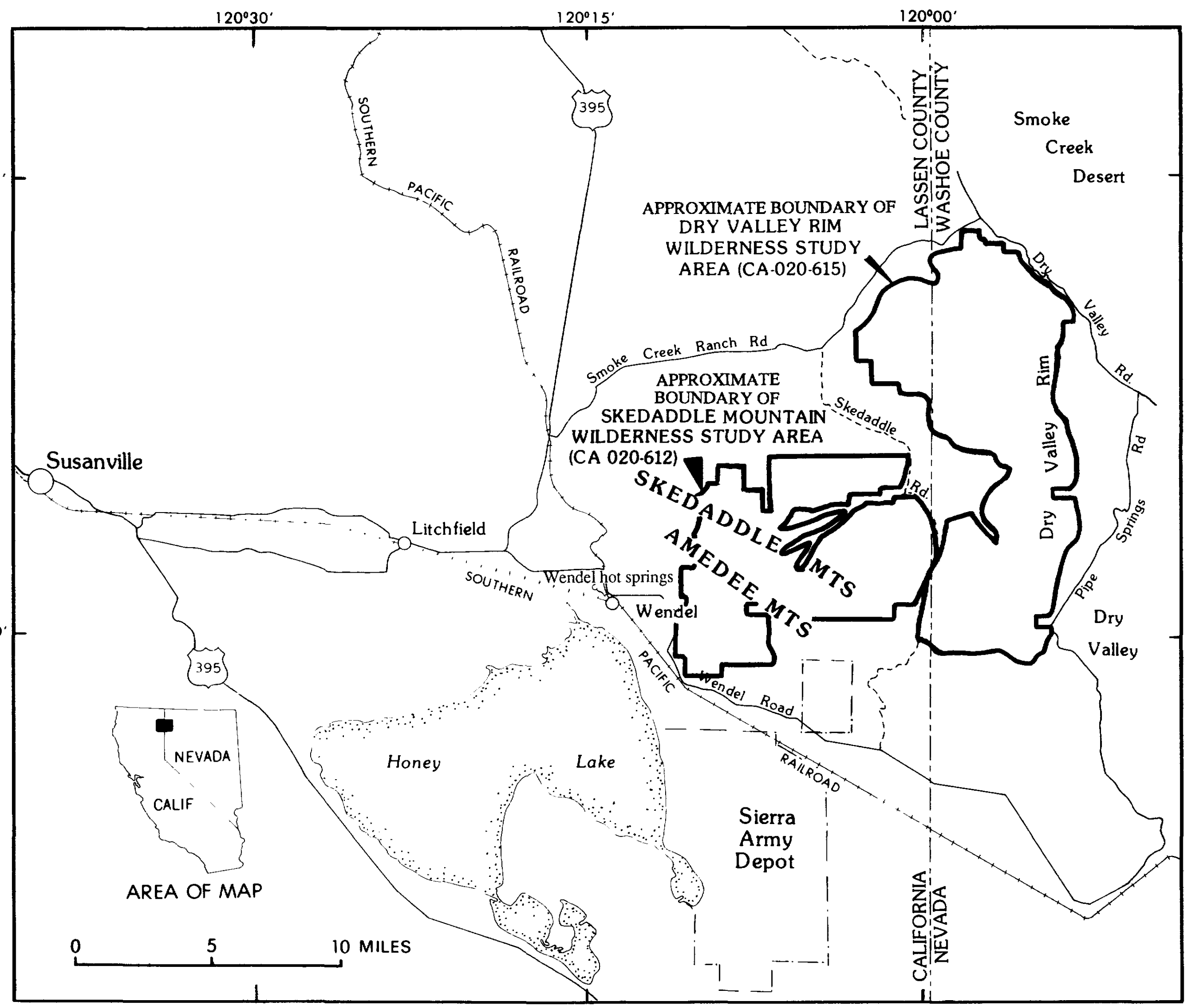


Figure 1. Index map showing location of the Skedaddle Mountain Wilderness Study Area, Lassen County, California, and Washoe County, Nevada.

Mineral Resource Potential

Geologic and geochemical evidence suggests that the study area has potential for epithermal precious- and base-metal deposits of gold, silver, mercury, and antimony. Host rocks consist mostly of andesite. The mineralization is similar to that at bulk-tonnage gold deposits.

Extensive areas of alteration are present in and around Spencer Basin. There are 10 mineral claims within Spencer Basin. The stream-sediment geochemical data for the area in and around Spencer Basin include anomalous levels of gold, silver, mercury, antimony, and associated accessory elements. The central part of Spencer Basin, upper Thousand Springs Canyon, and the south fork of Wendel Canyon have high mineral resource potential for gold, silver, mercury, and antimony. The area surrounding these sites has moderate mineral resource potential for gold, silver, mercury, and antimony.

An area in Wendel Canyon underlain by silicic volcanic rocks contains the Dude Group of perlite claims. This area has moderate mineral resource potential for perlite. The area underlain by rhyolite south of the claims has low mineral resource potential for perlite.

The Skedaddle Mountain Wilderness Study Area includes areas within the Wendel-Amedee Known Geothermal Resource Area (KGRA). There is an active hot spring at Amedee Hot Springs located 1 mi outside the study area (fig. 2). Nearby, a 2-megaWatt (MW) geothermal power generation plant was under construction in 1985. The southwest corner of the study area has moderate resource potential for geothermal energy. Much of the west half of the study area has low resource potential for geothermal energy.

There is no oil or gas resource potential in the study area (Scott and Miller, 1983; Scott, 1983).

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 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 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, certainty of assessment, and classification of identified resources.

Location and Physiography

The Skedaddle Mountain Wilderness Study Area is located in the eastern part of the Modoc Plateau in Lassen County, northeastern California, and Washoe County, northwestern Nevada (fig. 1). The study area encompasses 39,420 acres of Bureau of Land Management-administered public land about 25 mi east of Susanville, California. The study area is bounded on the east by the Skedaddle Road and on the north by Smoke Creek Ranch Road. The south boundary parallels Wendel Road and the west boundary extends north-south past the mouth of Wendel Canyon. Access to the study area is provided by the boundary roads and connecting light-duty dirt roads. The north half of the study area is in the Skedaddle Mountains and the south half of the area is in the Amedee Mountains. Elevations range from 7,680 ft at the summit of Hot Springs Peak in the Skedaddle Mountains to 4,300 ft at the base of the Amedee Mountains. Steep rim-rock walls and talus-covered canyons are common along the west edge of the area; the rest of the study area is moderately sloping. Sagebrush and bunchgrass vegetation dominates the study area; the higher elevations support scattered aspen groves and the canyons support riparian vegetation including willows, wild rose, and berry shrubs. Wildlife includes pronghorn, deer, sage grouse, prairie falcons, golden eagles, red tail hawks, and great horned, long eared, and burrowing owls.

Procedures and Sources of Data

The U.S. Geological Survey conducted field investigations of the Skedaddle Mountain Wilderness Study Area in 1985. This work included detailed geologic mapping (Diggles and others, 1988a), field checking of existing maps, geochemical sampling, collection of gravity data, and inspecting outcrops for mineralization. The geology of the study area is shown in 1:250,000-scale published maps (Lydon and others, 1960; Bonham, 1969). Diggles and others (1986) mapped the geology, Linne (1987) described prospects and claims, and Diggles and others (1988b) described the mineral resources of the Dry Valley Rim Wilderness Study Area to the east of this study area. Adrian and others (1987) presented geochemical data for both study areas. Munts and Peters (1987) gave a detailed description of the U.S. Bureau of Mines study of the Skedaddle Mountain Wilderness Study Area. Aeromagnetic data are published for this area (U.S. Geological Survey, 1972) and radiometric data are given by Geodata International, Inc. (1978) and Western

Geophysical Company of America (1981). In addition to those collected for this study, gravity data are given by Snyder and others (1982).

The U.S. Bureau of Mines' study included prefield, field, and report preparation phases that spanned parts of years 1985 and 1986 and involved about 1 worker-year of work. A detailed description of prefield-phase and field-phase activities was given by Munts and Peters (1987). A total of 201 rock samples and 28 alluvial and placer samples were collected. Of these, 141 rock samples were collected at mines, prospects, and mining claims. Thirty of the remaining 60 were collected at mineralized sites, and 30 were collected as reference samples at unmineralized rock sites. Five of the 28 alluvial samples were collected on placer claims. A detailed description of sample-collection and sample-preparations techniques was given by Munts and Peters (1987). Results of the U.S. Bureau of Mines' work in the wilderness study area were given by Munts and Peters (1987).

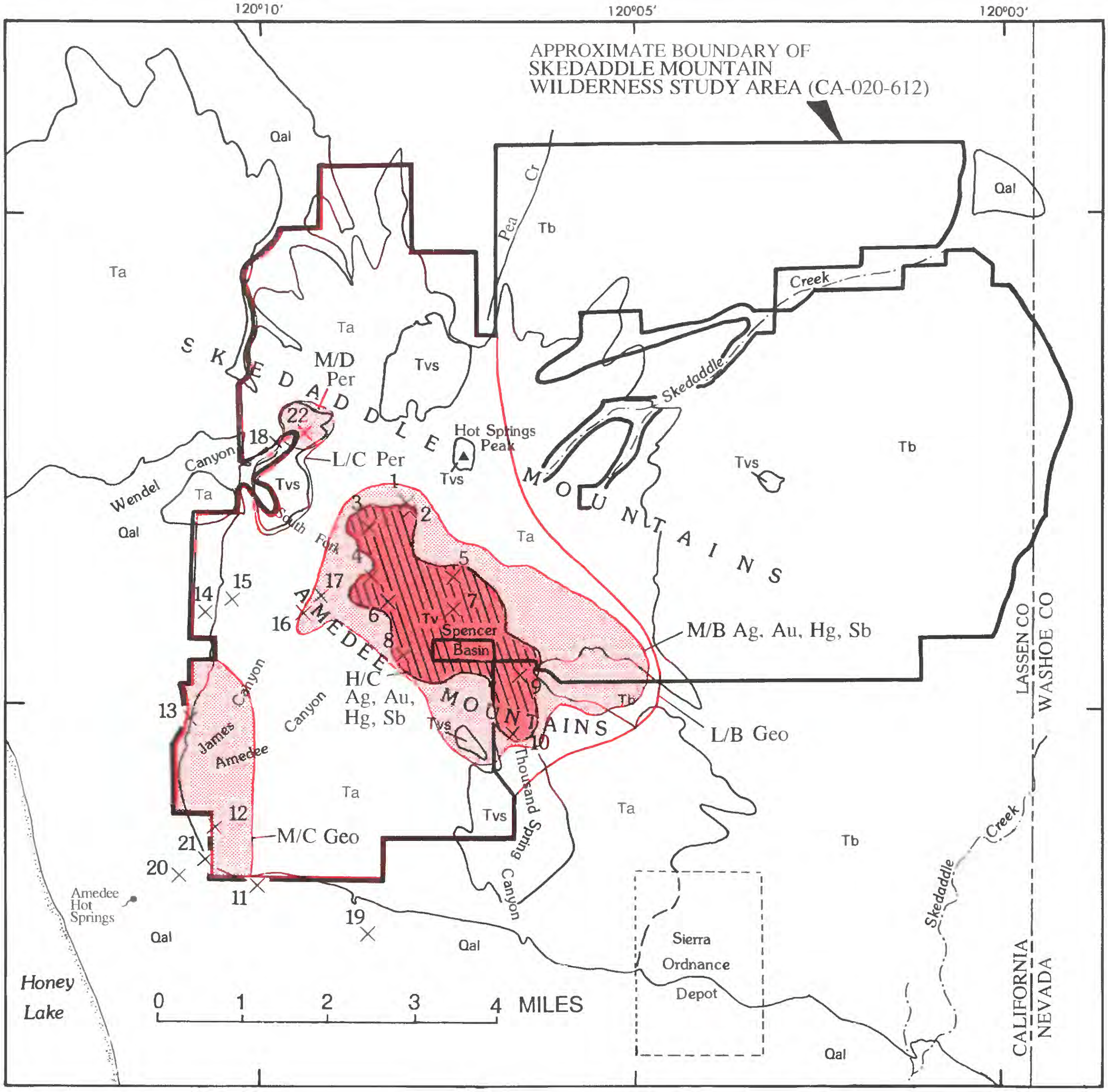


Figure 2. Map showing generalized geology and areas of mineral resource potential in the Skedaddle Mountain Wilderness Study Area, California and Nevada.

The U.S. Bureau of Mines' rock samples were analyzed for gold and silver by fire-assay or fire-assay-inductively coupled plasma methods. Quantitative analyses of identified or suspected elements of possible economic significance were determined by atomic absorption, colorimetric, radiometric, X-ray fluorescence, or other quantitative methods. At least one sample from each locality was analyzed for 40 elements by semiquantitative spectroscopy to detect unsuspected elements of possible significance. In the U.S. Bureau of Mines study, unless otherwise stated, the term "anomalous" is defined as a value of two or more times the average crustal abundance for a given element in a given rock type. Information on analytical techniques, specific detection limits, and analytical results are available at the U.S. Bureau of Mines Western Field Operations Center, E. 360 Third Ave., Spokane, WA 99202.

Tuffaceous material was screened for pozzolan suitability by analyzing major oxide content for whole rock composition by inductively coupled plasma analysis and loss on ignition. To meet American Society for Testing and Materials (ASTM) (1985) standards of suitability, samples must contain 70 percent combined aluminum oxide (Al_2O_3), ferric oxide (Fe_2O_3), silicon oxide (SiO_2) and have no more than 1.5 percent alkalies. The percentage of sulfate (SO_3), moisture, and loss on ignition were compared to ASTM standard maximums for those three characteristics of 4 percent, 3 percent, and 10 percent, respectively.

Acknowledgments

The authors gratefully acknowledge the help of Stanley Bates, Rex Cleary, Victor Dunn, Russell Elam, Frank Hilfer, Richard Morse, Robert Sherva, Larry Teter, and Richard Tscherra of the U.S. Bureau of Land Management District and Area office in Susanville, California, for providing logistical and helicopter support as well as general information about property owners. David A. Dellinger, L. Darlene Batatian, T.A. Delaney, J.L. Jones, and Robert P. Maddox helped to complete the field work.

APPRAISAL OF IDENTIFIED RESOURCES

By Steven R. Munts *and* Thomas J. Peters
U.S. Bureau of Mines

Mining History

Lassen County mining claim records indicate that at least 276 recorded lode and 29 recorded placer claims were located in the Skedaddle and Amedee Mountains; about 179 lode and 12 placer claims are located in the study area. There are no claims in the part of the study area situated in Washoe County, Nev. In 1985, U.S. Bureau of Land Management records indicated four active claims within or partly within the study area. Six unrecorded lode claims lie at the headwaters of Thousand Spring Canyon. No claims have been patented inside the study area. At least 80 percent of the lode claims were in areas of hydrothermal alteration. None of the study area had been leased for oil and gas, and about 3 percent of the study area was under geothermal lease.

Claim location and prospecting activity peaked during the years 1906, 1920, 1941, and 1958, in and near the study area. During these four years, over 50 percent of all known lode and placer claims were located. The first recorded lode claims were by a Mr. McKinsey, who located the NCO No. 1 claim, and by a Mr. Stout, who located the FMO claim on February 12, 1902. Both claims were recorded as being near Amedee, exact location unknown. By 1906, 45 lode claims had been recorded, all in the Amedee Mountains or on the south slope of the Skedaddle Mountains. However, no formal mining district was organized, and no placer claims were filed. Most claims were for gold; a few near Amedee Hot Springs were for mercury. Purdy (1983) described this early mining activity in the Skedaddle and Amedee Mountains and discussed an informal mining district.

EXPLANATION

Area with high mineral resource potential

Area with moderate mineral resource potential

Area with low mineral resource potential

See appendix for definition of levels of mineral resource potential (L, M, H) and certainty of assessment (B, C, D)

Commodities

Ag	Silver
Au	Gold
Geo	Geothermal energy
Hg	Mercury
Per	Perlite
Sb	Antimony

Description of map units

Qal	Alluvium (Quaternary)
Tv	Volcanic rocks (Tertiary)—Hachured where silicified, or propylitically or potassically altered
Tvs	Silicic volcanic rocks (Tertiary)—Consists of dacite and rhyolite
Ta	Andesite and lahar deposits (Tertiary)
Tb	Basalt (Tertiary)
	Contact
×2	Prospect (Red symbol indicates identified resources)—Numbers refer to table 1 in appendix

Figure 2. Continued.

During 1906-07, gold fever struck many desert regions. In the summer of 1913, a small gold rush was experienced when J.F. Swan and Frank Spoon discovered gold on Skedaddle Mountain. A majority of the population joined in on the excitement and numerous claims were staked. There were enough claims filed to prompt the naming of it as the Hot Springs Mountain mining district. There were only a handful of hardy souls that pursued the prospecting enough to make it pay off for a short time. The gold rush died as quickly as it began. [Hot Springs Peak is in the Skedaddle Mountains].

Recorded mining activity stopped until 1920, when 105 claims were located. Five additional claims were located in 1921, and activity ceased until 1941, when 76 new lode claims were located. At least four of these claims, situated about 1 mi north of Wendel, were for mercury. Three claims had been located in the 10 years prior to 1941. Nine recorded placer claims were located during 1941 near Amedee, about 1 mi south of the study area. Between 1941 and 1958, 21 claims were filed, 17 of which were placer claims. In 1958, 44 new lode mining claims were located. The last mining claims recorded in or near the study area were three placer claims located in 1960.

Only minor exploration occurred in the Skedaddle Mountains and Amedee Mountains for nonmetallic commodities (mainly perlite). One location on Wendel Creek, near the west edge of the study area, has been explored for perlite. No mineral production has been recorded from within the study area. According to Purdy (1983), an unknown amount of gold may have been produced about 1913 from lode claims on the Skedaddle Mountains.

Mines, Prospects, Claims, and Mineralized and Altered Areas Examined

There are no mines or mining operations in the Skedaddle Mountain Wilderness Study Area. Fifty-five prospects, mineralized areas, mining claim sites and groups of mining claims, alluvial sample-collection sites, and background sample-collection sites were examined during this study (Munts and Peters, 1987). Twenty-two mineralized prospects are shown on figure 2, plate 1, and in table 1. The site locations on figure 2 and plate 1 are positioned near the center of the claim, claims groups, or mineralized area. Eight sites are outside or partly outside, and 14 are inside of the study area. Three wholly or partly outside the study area (Nos. 9, 10, and 22) contain mineralized zones that may extend into the study area. One site has identified subeconomic resources of perlite, and nine sites produced gold-bearing alluvial samples. Detailed data are given by Munts and Peters (1987) and selected data are included in table 1.

Six metallic (gold and mercury) and nonmetallic (perlite, basalt, pozzolan, sand and gravel) commodities occur within and adjacent to the study area. Only one site (No. 22; the Dude Group (perlite deposit)) contained identified resources.

Perlite Resources

The Dude Group (fig. 2, plate 1, and table 1, No. 22) is owned by Peter Alosi and is located on the north fork of Wendel creek in Wendel Canyon, straddling the west boundary of the study area. Elevations vary from 5,000 to 5,400 ft. Access is by a gravel road and a tractor trail along the north fork of Wendel Creek northeast from Wendel Road.

This perlite deposit is probably the one described by MacDonald (1966) and has been known for at least 45 years; the first recorded location was in 1946. Although the Dude Group has been prospected sporadically since 1946, no production has been recorded. Workings on the Dude Group claims are limited to one small 5-ft by 6-ft pit, 2 ft deep. The major perlite exposure is in the steep bank of Wendel Creek and has not been excavated.

The perlite deposit is situated northwest of the apparent center of a volcanic vent (Luedke and Smith, 1981; Diggles and others, 1988a). Lydon and others (1960) mapped this deposit as part of a Pliocene rhyolite unit in contact with andesite and intermediate-to-felsic pyroclastic rocks. As exposed, the perlite appears to lie on the edge of, but at the stratigraphic center of, a flow-dome complex. The perlite outcrop is about 0.5 mi west of the principal rhyolite outcrop sequence for the flow-dome complex and is surrounded by andesite. This unique relationship may be due to erosion of the flow-dome complex on one side exposing the perlite core; a later andesite flow may have then covered the complex. Alternatively the relationship may be due to intrusion of the perlite into and near the edge of a pre-existing flow-dome complex.

The flow-dome complex is composed of four layers; the outer layer (as much as 120 ft thick) is medium-gray, finely porphyritic flow-banded rhyolite. Below this layer is a 20- to 70-ft-thick rhyolite layer with as much as 20 percent botryoidal rhyolite inclusions. These two layers are locally separated by a pale-gray to white rhyolitic tuffaceous unit as much as 50 ft thick. The botryoidal rhyolite and the tuffaceous unit grade downward into a medium- to dark-gray perlite unit (as much as 100 ft thick). The perlite is about 80 ft thick in Wendel Canyon.

Some structural features and subsequent intrusions are also present in the flow-dome complex. Small-scale faults in the outermost layer of the flow-dome complex generally strike N. 45 W. and dip steeply to the northeast or southwest. A few major en echelon fractures are also present. The major fractures have been filled by dikes. Two porphyritic andesite dikes (5 and 10 ft thick) intruded such fractures and cut the flow-banded rhyolite in the eastern part of the dome. The dikes strike N. 45° W. and are vertical.

A 100-lb bulk channel sample was collected over an area 54 ft long and 31 ft high from the perlite exposure in Wendel Canyon. This sample was tested by the New Mexico Bureau of Mines and Mineral Resources with five standard tests (results in parenthesis): expanded density (4.52 lb/ft^3), furnace yield (95 percent), percent sinker (0.1), compacted density (5.96 lb/ft^3), and compaction resistance (30 lb/in.^{2} at 1 in.). These results indicate that the expanded perlite will retain its bulk even after repeated handling, has good furnace yield, yields an almost negligible sinker fraction, has a low compaction density value, and has average compaction resistance quality. It is best suited for lightweight end uses, such as filter aid or cryogenics (James Barker and John Hingten, written commun., 1986). The owner of the Dude Group has also sampled this deposit. The samples, analyzed in 1978 by The Perlite Corporation of Chester, Pennsylvania, were considered to be of commercial-quality (Peter Alosi, oral commun., 1985).

Metallic Occurrences

This study examined 282 active and historic lode claims and prospects in or within 1 mi of the study area. None of the sites had extensive workings. A total of 201 lode samples were collected from these claims, prospects, mineralized areas, and other lode sample sites in unidentified claim areas and analyzed for a variety of elements (Munts and Peters, 1987). Lode or rock samples were largely from areas of argillic alteration, siliceous sinter, a rhyolite flow-dome complex (Munts and Peters, 1987, No. 23), and seven traverses (Munts and Peters, 1987, Nos. 24-30) in dacite with quartz veins and unaltered basalt and andesite. The remaining samples were from mining claims in the Amedee Mountains and on the west border of the study area. Samples containing anomalous metal concentrations, as described by Munts and Peters (1987), contain gold, silver, barium, copper and zinc. Sporadic anomalous concentrations are related to areas of argillic or phyllic alteration and siliceous sinter. Many geochemical anomalies are accompanied by alteration, color anomalies, and iron-oxide stain. Areas of mines and prospects, alteration, and geochemical anomalies, are spatially related to the volcanic center suggesting a temporal or genetic relationship. There are two nearly adjacent, geologically similar sites with anomalous mineral concentrations. These consist of the argillic alteration areas north of Spencer Basin and the siliceous sinter in Spencer Basin. No mining activity has been recorded in either area, but a few claim posts were found in each; one (unreadable) claim notice was found in the Spencer Basin area (fig. 1, plate 1, table 1, No. 9). Both areas were examined in detail.

Four placer claim groups and all major streams and significant tributaries were evaluated and sampled for alluvial heavy mineral content (Munts and Peters, 1987). Twenty-eight alluvial samples were collected. Ten of the alluvial samples contained gold; none contained other important heavy minerals such as cinnabar, ilmenite, scheelite, or zircon. The gold content of the samples, except for one sample of 0.00527 troy ounce per cubic yard gold, was less than 0.001 troy ounce per cubic yard gold. The gold particles were bright in color, angular to rounded but generally subrounded, and measured 0.0029 to 0.0012 in. across. Gold-bearing alluvial samples occur in three areas: (1) the west end of the Amedee Mountains, (2) the Thousand Spring Canyon drainage, and (3) the upper part of Hot Springs Peak. The gold-bearing samples were mainly from streams and creeks which drain areas of past mining and prospecting activity and substantiate the presence of gold at those properties.

Nonmetallic Occurrences

Pliocene basalts make up much of the east half of the study area. Vesicle content is generally low, and areas with high vesicle content are rare, therefore the basalt is generally unsuitable for use as decorative stone. Hart and others (1984) evaluated a group of basalt flows in the northwestern United States for alumina content. None of the basalts in this study area have a high alumina content (greater than 16 percent).

Tuffaceous material (Munts and Peters, 1987, Nos. 31, 32) was examined for pozzolan and zeolite qualities. Pozzolan is any siliceous material such as diatomaceous earth, opaline chert, and certain tuffs, which can be finely ground and combined with portland cement, commonly in a proportion of 15 to 40 percent by weight (Bates and Jackson, 1980) to improve economic, mechanical, and (or) chemical properties in certain applications. Gay (1966) described several occurrences of pozzolan in Lassen County and concluded that deposits of vitric tuffs and siliceous volcanic sediments scattered through the region may also be suitable for use as pozzolan should a market develop. Several areas of tuffaceous rocks are exposed along the east edge of the study area. Two representative samples were collected (Munts and Peters, 1987, Nos. 31, 32) and analyzed for major-oxide content. Neither sample met minimum physical test specifications (ASTM Standard C 618 for Class N pozzolan).

Zeolites are hydrous aluminosilicates that are analogous in composition to feldspars (Bates and Jackson, 1980) and may form from tuffs. Two samples (Munts and Peters, 1987, Nos. 31 and 32) were collected from tuffs near the east side of the study area and tested for zeolite content using a chemical field test (Helfferich, 1964) and by X-ray diffraction. No zeolites were detected.

Lacustrine and alluvial sand and gravel deposits are present in or near the study area. Alluvial sand and gravel occur along some of the major drainages in the study area and along the south edge of the study area. The largest area of stream gravels is just west of the study area, in Wendel Canyon. A smaller deposit of sand and gravel is present along the lower portion of Spencer creek, in the east-central portion of the study area. Major deposits of sand and gravel are present outside and adjacent to the southwest corner of the study area in Quaternary lake terraces associated with Honey Lake and Pleistocene Lake Lahontan. Sand and gravel clasts in both deposit types range from sand to boulder size with generally less than 5 percent boulders and up to 50 percent sand. An unknown amount of sand and gravel has been produced from several gravel pits 1 to 2 mi south of the study area. These pits will probably produce all of the gravel necessary to meet nearby market demands in the foreseeable future.

Many hot springs occur throughout the Modoc Plateau region (Norris and Webb, 1976). Gay (1966) stated that the hot springs are related to recent extrusive activity and the abundance of faulting. Southwest and west of the study area, several springs form the Amedee and the Wendel groups of hot springs (also known as the Lower Hot Springs and the Upper Hot Springs, respectively (Purdy, 1983)). According to Majmundar (1983) this area is known or inferred to be underlain at depths less than 3,000 ft by thermal water of high enough temperature to be used for direct heat applications. The Wendel and the Amedee Hot Springs have been known and used by local residents since 1863 (Purdy, 1983). The primary historic use was for medical purposes. These springs are now part of an approximately 11,000 acres designated as a KGRA by the U.S. Geological Survey in 1970 (Lassen County, 1983). Current uses include power generation and space heating. The springs vary in character and size. These hot springs generally occur in groups of 2 to 10 and may be placid, ebullient, or geyser-like. Pool sizes range from 5 to 25 ft in diameter. The U.S. Bureau of Mines measured surface water temperatures up to 195° F. Hot springs occur in terrace gravels near Honey Lake, within 2 mi of the study area. However, north of Wendel Road, about 1 mi northeast of Amedee Hot Springs, andesite outcrops sporadically coated and encapsulated by tufa indicate sites of former hot spring activity closer to the study area. Somewhat older hot spring deposits, which include siliceous sinter, occur in the Amedee Mountains near the head of Thousand Spring Canyon. In general, hot spring activity has moved southward, away from the Amedee Mountains through time.

In the early 1960's several exploration companies began geothermal exploration of the Amedee and the Wendel hot springs area. During 1962, Magma Power Co. drilled two shallow geothermal wells, one in the Wendel Area and another in the Amedee Area (Lassen County, 1983). Six geothermal wells were drilled in 1963. Two wells were drilled to depths of 6,000 and 4,012 ft (Parmentier, 1985) in 1964 by GeoProducts and Honey Lake Exploration, respectively. At least 14 wells have been drilled in the Wendel-Amedee KGRA (Zeisloft and others, 1984). Thirty greenhouses at Wendel hot springs are using geothermal heat for space heating with which to grow tomatoes and cucumbers (Majmundar, 1983). Majmundar estimated that the operation may eventually expand to 200 greenhouses. The 30 greenhouses were in full operation in 1985. In the same general location, a 2-MW geothermal power generation plant was under construction in 1985. Construction also started for a combination waste-wood and geothermal power plant of 18.7 MW at Honey Lake (Parmentier, 1985).

According to 1985 U.S. Bureau of Land Management records, no petroleum or natural-gas leases have been issued in the study area. The nearest lease is approximately 3.5 mi south of the study area. Six wells were drilled south of the study area between 1980 and 1984 (Alldredge and Meigs, 1984). Less than 5 percent of the test wells drilled in northeastern California had "petroleum shows" (Warner, 1980).

Mineral Economics

The Skedaddle Mountains area has a history of mineral prospecting and exploration primarily for gold and mercury. Although 311 mining claims have been located in or near the study area, the only identified resource is perlite.

The identified resources of perlite consist of 46,000 tons of measured subeconomic resources and about 138,000 tons of indicated subeconomic resources. The total demonstrated subeconomic perlite resources are about 184,000 short tons in and adjacent to the study area.

On the basis of these resources, and assuming a 225 short tons/day production for 250 days a year and loss of 35 percent during open-pit mining, the mine would have an expected mine life of almost five years. A preliminary cost evaluation of the deposit, based on January 1986 prices, indicated a total capital and operating cost of $42.46 per ton. The average price for perlite in 1985 was $34.00 (Meissinger, 1986). If resources were increased through additional exploration, or a nearby market evolved, this deposit could become economic. Although two areas, one in the Spencer Basin-Thousand Spring Canyon area and the other near the headwaters of the south fork of Wendel Canyon, have characteristics similar to some large-tonnage, low-grade gold and silver deposits, no resources are identified.

Metallic Occurrences

Twenty of the lode prospects, claims, and claim groups in or immediately adjacent to the study area were located for gold or mercury. These mines and prospects generally form a large cluster in the west-central part of the study area. This is an area associated with extrusive, intrusive, and hydrothermal activity. Another mineralization feature (fig. 2, Nos. 9, 10) of significance is siliceous sinter near the head of Thousand Springs Canyon and in the southern part of Spencer Basin to the north. At least 2 mi^2 of siliceous sinter outcrop is exposed. There is no currently known major mineral exploration occurring in the study area. None of the mines, prospects, claims, or mineralized areas in the study area exposed rock with sufficient extent and grades to support major vein-type mining operations at current metal prices. Small amounts of gold in alluvial samples indicate the presence of gold-bearing lithologies upstream from the sampling sites. These lithologies have characteristics similar to large-tonnage, low-grade, gold and silver deposits. Some of these areas contain lode mining claim locations. Of the 201 rock samples assayed, 25 contained detectable gold (Munts and Peters, 1987). The maximum value was 0.065 parts per million (ppm) (0.0021 oz/ton), far below minimum economic cutoff grades of about 0.4 ppm at operating mines. However, the gold concentrations that were detected suggest exploration targets. Silver was detected in 15 samples, the maximum value being 9.3 ppm (0.27 oz/ton), also below economic grade, except as a by-product. Assays for the base metals lead, zinc, copper, and molybdenum were a maximum of 0.0007 percent, 0.019 percent, 0.025 percent, and 0.014 percent, respectively, also far below economic values.

Forty percent of the sampled streams contained gold (Munts and Peters, 1987, Nos. 1, 33, 34, 35, 36, 37, 38, 39, 40) with values as high as $1.59/cubic yard (at a gold price of $300/oz) (Munts and Peters, 1987). The size, shape, and color of the particles indicate they may have originated as fine particles and traveled only a moderate distance. None of the placer claims (fig. 2, placer prospect Nos. 18, 19, 20, 21) contained sufficient quantities of gold to warrant large-scale commercial gold mining.

Nonmetallic Occurrences

In addition to perlite, other common nonmetallic commodities in the study area consist of building stone and construction stone. A small area near Pea Creek contains flaggy basalt composed of 4- to 6-in.-thick slabs useful for ornamental building stone. Limited access and local market conditions preclude current mining of this commodity. Much of the study area is covered by basalt or andesite of sufficient quality for commercial construction needs. However, other sources of construction stone are currently available closer to local markets. Therefore, these occurrences will probably not be mined in the near future. Basalt in the study area is not high in alumina. Thus, they are not satisfactory for any uses requiring high alumina content, including possible future aluminum ore (Munts and Peters, 1987, Nos. 25, 27, 28). Tuffaceous material was examined for zeolite and pozzolan qualities on the east boundary of the study area (Munts and Peters, 1987, Nos. 31, 32); however, there were no positive test results for zeolites, and the material was unsuitable for pozzolan. Hot springs occur within 2 mi of the study area. Geologic evidence indicates the southwest corner of the study area is a likely region for geothermal activity and exploration.

Recommendations for Further Work

The Skedaddle Mountain Wilderness Study Area contains three areas which warrant further study; all are in or along the boundary of the study area.

1. Perlite is in a group of rhyolite and rhyolitic units in Wendel Canyon. The perlite occurrence and surrounding area need to be investigated in greater detail in order to determine tonnage and grade with certainty and to look for extensions.
2. Near the headwaters of the south fork of Wendel Canyon an area of about 1 mi^2 contains pervasive argillic alteration, bleaching, extensive limonite staining, quartz veins and veinlets, felsic dikes, some sulfides, geochemical anomalies, and minor amounts of gold. These characteristics are typical of some bulk-tonnage, low-grade, gold and silver deposits. This area should be examined in greater detail for precious metals, especially gold, in either vein (at depth) or bulk-tonnage deposits. Work should include detailed geologic mapping, sampling, induced polarization (IP), magnetometer, and EM16 geophysical surveys, followed by drilling if appropriate.
3. A 2 mi-long area of siliceous-sinter outcrops occurs near the head of Thousand Spring Canyon, and along the south edge of Spencer Basin. This area contains extensive sinter which has been bleached, contains limonite, and has locally anomalous trace-element concentrations. Additional work is needed to determine the significance, extent, and character of this occurrence as a possible indicator of disseminated gold and silver deposits. Detailed work should include geologic mapping, sampling, geophysical studies (IP, resistivity, EM16, and magnetometer) followed by drilling if appropriate.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

By Michael F. Diggles, James G. Frisken, *and*
Donald Plouff
U.S. Geological Survey

Geology

The rocks in the study area consist mostly of Tertiary basalt, andesite, dacite, and lahar deposits; minor amounts of rhyolite are also present. This suite of volcanic rocks is subalkaline and moderately potassic. The intermediate rocks are high-potassium andesites and dacites according to the classification of Peccerillo and Taylor (1976). Surficial deposits consist of colluvium, alluvium, talus, and lacustrine deposits. South of the study area are lakebed features including tufa deposits and strandlines from Pleistocene Lake Lahontan (Morrison and Frye, 1965).

Andesite flows, commonly including intercalated basalt, are exposed mostly at higher elevations in the study area. In addition, an older hornblende andesite crops out in the western part of the study area. The andesite flows generally contain phenocrysts of calcic plagioclase, clinopyroxene (augite), and minor orthopyroxene (hypersthene and bronzite) in a fine-grained to aphanitic plagioclase-rich matrix. The silica (SiO_2) content of these rocks ranges from 53 to 62 weight percent. Whole-rock potassium-argon determinations of 11.8 ± 0.6 Ma (Grose and McKee, 1986) and 11.7 ± 0.2 Ma (Diggles and others 1988a) were made on samples collected from the flows.

Olivine basalt flows, exposed in the eastern part of the area, are composed of fine-grained to aphanitic or glassy matrix and phenocrysts of olivine (less than 0.1 in.), typically altered to or rimmed with iddingsite. These rocks have SiO_2 contents of between 50 and 53 weight percent. Whole-rock potassium-argon age determinations of 12.8 ± 0.2 and 11.6 ± 0.2 Ma were made on the lower and upper layers, respectively, of the basalt flows (Diggles and others, 1988a).

Thick lahar deposits are exposed in the western and southern parts of the study area. Lahars are volcanic debris flows containing at least 80 weight percent solids (Fisher and Schmincke, 1984). The lahar deposits are well exposed in Wendel Canyon and the south flank of the Amedee Mountains. They consist of volcanic mud-flow breccia occurring as flows filling channels and as crusts on sides of channels. The flows contain poorly sorted, angular to subrounded clasts of basalt, andesite, and dacite, locally mixed with ashy matrix. They followed pre-existing valleys and are commonly interstratified with alluvium. The lahar deposit unit crops out as resistant ridges and is commonly intercalated with andesite flows.

Two dacite flow-dome complexes crop out along and north of the crest of the Skedaddle Mountains. Dacite flows are also present in Thousand Spring Canyon. The domes appear to have intruded the surrounding andesite flows. These rocks consist of fine-grained biotite-porphyritic dacite and have a SiO_2 content ranging from 63 to 70 weight percent. A potassium-argon (biotite) age of 12.5 ± 0.6 Ma was determined for this unit (Diggles and others, 1988a). This age falls within the error range for the age of the nearby andesite, The age data are consistent with an intrusive origin for the domes.

The central part of Spencer Basin is underlain by volcanic rocks which probably were andesite, dacite, and lahar deposits, but which have been silicified, propylitized, and potassically altered to an extent that original lithologies were unrecognizable, and so they are shown as undivided silicified volcanic rocks on plate 1.

The relations between SiO_2 and other major elements (Diggles and others, 1988a) indicate that the content of alkali elements increases and iron and calcium decrease with increasing silica. The data suggest that at least the mafic and intermediate volcanic rocks in the study area may have been derived from chemically similar source magmas. Both the oldest and youngest ages determined in this study are from samples of basalt flows. These data indicate that at least two periods of basaltic eruption took place in the Skedaddle Mountains. The youngest rock dated is basalt sampled from flows located in the southeastern part of the study area. Its radiometric age is 0.7 Ma younger than that of the dacite domes north of the Skedaddle Mountains (Diggles and others, 1988a).

Geochemistry

Methods and Background

A reconnaissance geochemical study of the Skedaddle Mountain Wilderness Study Area was undertaken in June of 1985 by the U.S. Geological Survey. Two primary sample media were selected based on their ability to reveal metallic mineral anomalies where present. Fifty-four minus-80-mesh stream sediments and 55 nonmagnetic panned concentrates were prepared from stream-sediment material collected from first- and second-order, primarily dry stream beds. These samples represent eroded bedrock material from drainage basins that collectively comprise most of the surface area of the study area. The minus-80-mesh stream-sediment medium reflects bedrock geochemistry and can indicate major areas of mineralization. The prepared nonmagnetic fraction of panned concentrates is used because this medium concentrates many minerals associated with mineralization and alteration and is more likely to reveal small or poorly exposed areas of mineralization. In addition to the sediments and concentrates, 60 rock samples were collected as float, stream cobbles, or outcrop samples from areas thought to be mineralized or altered. Fifty-four additional rock samples, mostly unmineralized and unaltered andesites and basalts but including some dacites and rhyolites, were collected from outcrops during geologic mapping studies and were analyzed to provide background geochemical data.

The samples were analyzed for 31 elements, including antimony, arsenic, barium, cadmium, cobalt, chromium, copper, gold, iron, lanthanum, lead, magnesium, manganese, molybdenum, nickel, silver, thorium, tin, titanium, tungsten, yttrium, vanadium, and zinc, using a six-step semiquantitative emission spectrographic method (Grimes and Marranzino, 1968). The samples were analyzed for gold by a modified atomic-absorption method (Thompson and others, 1976) with a lower level of determination of 0.1 ppm. The minus-80-mesh stream sediments and the mineralized rocks were also analyzed for certain elements by nonspectrographic procedures (procedure references in parentheses): arsenic, antimony, bismuth, cadmium, zinc (Crock and others, 1987), mercury (Koirtyohann and Khalil, 1976), tellurium, (U.S. Geological Survey, unpub. data, 1986), thallium (Simon and others, 1977), thorium, and uranium (Millard, 1976). In addition, 49 selected rock samples and minus-80-mesh sediments were analyzed for gold by a graphite furnace atomic-absorption method (Meier, 1980) with a lower level of determination of 0.002 ppm. The nonspectrographic analyses were done to provide data on elements not determined spectrographically or to provide data at lower levels of determination. Seventeen water samples were collected mostly from springs in and near the study area during the study, including three samples from two hot springs located near the west boundary of the wilderness study area. These samples were analyzed for gold (McHugh, 1984), arsenic, copper, molybdenum, zinc, lithium (Perkin-Elmer Corp., 1976; 1977), uranium (Scintrex Corp., 1987), fluoride (F^-), chloride (Cl^-), nitrate (NO_3^-), sulfate ($SO_4^=$) (Fishman and Pyen, 1979), pH, and specific conductance (Skougstad and others, 1979). A sample-location map, tables of analytical data, and a description of sample-collection, preparation, and analytical methods are presented by Adrian and others (1987).

The geochemical threshold values for rocks and minus-80-mesh sediments have been calculated at three times the arithmetic means of element concentrations of local unmineralized rocks, those rocks consisting predominantly of andesites and basalts. For elements with calculated mean values in other studies below the lower level of determination in this study, the lower level of determination is assigned as the threshold value. The threshold values for the nonmagnetic concentrates are chosen based on experience with the medium. Threshold values for water samples were chosen at twice the average abundance values for river waters (Levinson, 1974), or at twice the geometric means for hot springs waters from 38 selected hot springs located in the western United States (Ficklin and others, 1986).

Mineral-Deposit Models

Several mining districts with historic gold production are present near the Skedaddle Mountain Wilderness Study Area. The nearest is the Diamond Mountain district located about 30 mi to the west-southwest. This district produced over 21,800 ounces of gold but not from an epithermal volcanic-hosted deposit (Koschmann and Bergendahl, 1968). The other districts have volcanic-hosted, epigenetic deposits with geologic and geochemical similarities to the rocks in the Skedaddle Mountain Wilderness Study Area. The Hayden Hill district, located about 45 mi northwest of the Skedaddle Mountains, and the Winters and High Grade districts farther north, are classified as Sado (Japan) type epithermal vein deposits (Mosier and others, 1986a). The Hayden Hill mines produced about 116,000 oz of gold from fault gouge, hydrothermal volcanic breccia and quartz veins in rhyolite tuffs. An estimated 1,224,000 tons of rock at Hayden Hill containing 0.13 oz/ton of gold remain (Koschmann and Bergendahl, 1968), and heap-leach operations are presently underway.

As part of this study, samples were collected at and 1 mi downstream from the Hayden Hill mine to geochemically characterize this type of deposit. Four composite ore samples were collected and analyzed for 31 elements by emission spectrographic methods and for gold by atomic absorption. A sample composed primarily of quartz vein material showed 20 ppm gold, 20 ppm silver, approximately 150 ppm arsenic, and 10 ppm molybdenum. Brecciated, limonitic tuff contained 1.4 ppm gold, 30 ppm silver, and 5 ppm molybdenum. The unbrecciated tuff showed 2 ppm gold but no detectable silver. Finely brecciated, argillic outcrops showing no limonitic staining had 0.12 ppm gold and 30 ppm silver. A sieved concentrate sample panned from mud along the mine road crossing the south face of Hayden Hill contained much free gold including wires 0.12 in. in length. The prepared nonmagnetic concentrate contained 1,000 ppm silver, 7,000 ppm manganese 2,000 ppm lead, 200 ppm antimony, and 200 ppm tin. Spectrographic analysis of the minus-80-mesh stream sediment from the same site showed 2.2 ppm gold, 20 ppm silver, and 2,000 ppm manganese. A mile downstream, the nonmagnetic concentrate contained about 10-20 ppm gold, 3 ppm silver, and 100 ppm lead. The minus-80-mesh stream sediment from the same site contained 0.05 ppm gold and 2 ppm silver.

The Hog Ranch epithermal gold deposit is being evaluated by mining interests northeast of the Skedaddle Mountain Wilderness Study Area in western Nevada. Deposits in the Seven Troughs mining district, located approximately 50 mi east-southeast of the Skedaddle Mountain Wilderness Study Area, produced 160,182 ounces of gold by 1960 (Koschmann and Bergendahl, 1968) from quartz veins and breccia zones or fissures in andesites, rhyolites, and basalt underlain by slate intruded by granodiorite. These deposits are classified as Comstock (Nevada) type epithermal vein deposits (Mosier and others, 1986b). Clastic sedimentary basement rocks and intrusive centers, characteristic of Comstock-type deposits, are not exposed in or adjacent to the Skedaddle Mountain Wilderness Study Area, but active, mineralized hot springs occur near the southwest corner of the study area, suggesting near-surface plutonic rocks beneath the study area. The mineral system in the Skedaddle Mountains could fit either the Sado or Comstock epithermal-vein model. Both deposit types are characterized by the presence of gold, electrum, sulfosalts, and argentite in vuggy quartz veins cutting felsic to intermediate volcanic rocks, with mineralization related to calc-alkaline or bimodal volcanism in a tectonic setting of through-going fracture system, major normal faults, fractures relating to doming, or ring fracture zones. Associated minerals include tellurides, chalcopyrite, pyrite, barite, chalcedony, alunite, and kaolinite. Alteration resulted in bleached rock, silicified zones, and pervasive propylitic alteration.

Results and Interpretation

Samples collected within or downstream from the most altered and mineralized area, Spencer Basin, (fig. 2) are anomalous in gold, silver, mercury, tellurium, arsenic, thallium, antimony, bismuth, molybdenum, tin, boron, $SO_4^=$, barium, thorium, and uranium, a suite of elements characteristic of epithermal gold-silver deposits (Berger and Eimon, 1983; Bonham and Giles, 1983). The most intense anomalies are situated above 5,400 ft in Spencer Basin, above 5,600 ft in the south part of the Wendel drainage basin, above 5,400 ft in upper Amedee Canyon, and in upper Thousand Spring Canyon, probably above 5,400 ft (but sampled at a lower elevation).

Sixteen sample-collection sites, most located within the altered areas or along the northeast side of the west-central Skedaddle Mountains, contained detectable gold in one or more media. The highest gold value (0.25 ppm) is from Spencer Basin and was measured in a sample of iron oxide stained breccia. This concentration is accompanied by 11 ppm tellurium, 150 ppm arsenic, and 1.1 ppm mercury. The only silver value was 20 ppm in a concentrate sample from Thousand Spring Canyon. After microscopic and spectrographic analyses, the remaining part of each nonmagnetic concentrate was analysed for gold by atomic absorption. Five of the concentrate samples have low-level detectable gold although no visible gold was observed under the microscope. Using larger samples and a different concentration method, the U.S. Bureau of Mines detected find free gold in some samples (Munts and Peters, 1987). The difficulty in detecting visible gold in the concentrate samples and the generally low gold and silver concentrations of all of the collected samples suggest that economic placer deposits are unlikely to be present.

In discussing conceptual models of epithermal precious-metal deposits, Berger and Eimon (1983) stated that the nature and economics of such deposits are determined by the (1) geometry of the fracture system, (2) permeability and composition of the host rocks, and (3) hydrodynamics of the fluid system. They also stated that barren quartz-barite veins carrying anomalous concentrations of arsenic, antimony, and mercury can extend hundreds of feet above the ore zone. Most of the nonmagnetic concentrations collected in the altered area and those collected along the south side of the Amedee Mountains from Thousand Spring Canyon to Amedee Canyon contained from 1 to 30 percent barite, perhaps derived from veins of this type.

Mercury is commonly associated with epithermal precious-metal deposits and is present in anomalous concentrations of 0.12 to 4.0 ppm in rocks and stream sediments at 13 sites within the mineralized part of the Skedaddle Mountains and in concentrations of 3.4 to 29 ppm in rocks and sediments collected at the Amedee Hot Springs and Wendel hot springs. The concentrate samples were not analyzed for mercury but cinnabar was identified in concentrates from Wendel Canyon and from Amedee Hot Spring.

The two hot springs are located near the west boundary of the wilderness study area and were sampled to compare the geochemistry of these hydrothermal systems with the geochemical anomalies produced by the hydrothermal system in the Skedaddle Mountains. The hot springs are both boiling, and siliceous sinter in the form of porous opal occurs in the springs. The water sample from Wendel hot spring contained 0.005 parts per billion (ppb) gold, 60 ppb molybdenum, and 300 ppb arsenic. The minus-80-mesh sediment collected from the edge of the hot spring contained 29 ppm mercury, 0.46 ppm thallium, 500 ppm boron, and 34 ppm arsenic. Copper anomalies of 300 ppm in sediment and 10,000 ppm in concentrate and a zinc anomaly of 25,000 ppm in the concentrate may be natural but may be due to man-made contamination. Similar anomalies were not recorded at the Amedee Hot Spring. Pipes, galvanized metal, and a corroded copper penny were observed in the Wendel hot springs. The Amedee Hot Spring sample contains 0.006 ppb gold, 52 ppb molybdenum, and 160 ppb arsenic in the water and 13 ppm mercury, 0.43 ppm thallium, 70 ppm boron, 13 ppm arsenic 24 ppm thorium, and 4.6 ppm uranium in the sediments and 15 ppm molybdenum, 150 ppm tin, 500 ppm vanadium, 500 ppm thorium, visible cinnabar and visible pyrite in the concentrates. Gold values for siliceous sinter and for sediments from both hot springs were less than 0.002 ppm. Water analyses reported by White (1981) for Amedee Hot Spring agree with the values we obtained. White (1981) also reported values of 96 ppm SiO_2, 0.5 ppm H_2S, and 10 ppb antimony in the water. In addition, cinnabar, metacinnabar, and liquid mercury were detected in spring sediments, including 0.1 in. cinnabar lining on the orifices of many springs. Tunell (1970) estimated that about 400 lb of precipitated HgS may occur in Amedee Hot Springs.

Tufa deposits located adjacent to the Wendel hot springs were deposited in Pleistocene Lake Lahontan. The tufa, in the form of poorly consolidated limestone, contains 3,000 ppm barium, 2,000 ppm strontium, 0.02 ppm tellurium, 31 ppm arsenic, and 3.4 ppm mercury, which may have been derived from the hot springs. Tufa deposits along cliffs 1 mi east of Amedee Hot Springs, in contrast, had only 700 ppm barium and 8 ppm arsenic (associated with 3,000 ppm Strontium) and neither mercury nor tellurium were detected. This deposit was probably not strongly affected by hot springs. Apparently hydrothermal solutions are a likely source of at least the gold, mercury, arsenic, thallium, tellurium, barium, and pyrite anomalies and probably of the boron, tin, molybdenum, thorium, and uranium anomalies. Cold water springs located in the mineralized area or along the north slope of the central Skedaddle Mountains are anomalous in molybdenum (2.1-2.9 ppb), $SO_4^=$ (57-122 ppb), uranium (0.9-1.0 ppb); six of the cold springs samples contain gold (0.001-0.002 ppb).

The exposed part of the epithermal mineral system in the Skedaddle Mountains has many similarities to shallow parts of active hydrothermal systems, such as Broadlands, New Zealand, and Steamboat Springs, Nevada. These areas have a relative abundance of arsenic, antimony, mercury, and tellurium, a relative scarcity of lead, copper, and zinc, and a low intensity of alteration of wall rocks of depths exceeding 300 ft unless leached by H_2SO_4 from oxidizing H_2S above the water table (White, 1981). A deep lead-copper-zinc sulfide zone with a high silver content occurs in the Broadlands active system at depths below 1,800 ft. A similar situation could exist in the Skedaddle Mountains, with gold concentration increasing to shallow depths and with silver and lead-copper-zinc concentrations dominant at greater depth.

Diggles and others (1988a) mapped discontinuous cap rocks that exhibit various intensities of silicification, brecciation, and cementation near the 6,000-ft elevation in Spencer Basin and extend to upper Amedee Canyon, Thousand Spring Canyon, and Wendel Canyon. At about the 5,600-ft elevation, where many of the most anomalous geochemical samples were collected, precipitated silica probably capped the hydrothermal system. The volcanic rocks of the altered part of the study area have been subjected to varying intensities of argillic and propylitic alteration. Alteration intensity is related to relative permeability, proximity to solution channels, and juxtaposition to the zone of boiling. Acid-leached, kaolinite- and alunite-rich rocks presumably lie above former zones of boiling.

Bleached, most alunitized, and silicified rocks have typically been found to be emplaced as linear "ledges" within or parallel to inclined, pre-alteration fracture systems and breccia zones at Goldfield, Nevada (Garside and Bonham, 1984) and other epithermal gold deposits. Hydrothermal solutions could spread out along permeable, flat-lying strata and form strataform bleached-altered layers if conditions were permissive.

Additional field examination of silicified-alunitized outcrops in the study area and detailed soil or rock-chip geochemical sampling and attention to zonal patterns of alteration intensity would be useful. They might reveal if the outcrops of strongly altered rock are emplaced along structures that might host mineral deposits below the silicified cap rocks. Further studies could also locate the primary hydrothermal solution channels that probably contributed most heavily to the major geochemical anomalies of the altered area. Prediction of the depth or grade of potential mineralized bodies may be difficult. At Goldfield, for example, only 6 percent of the exposed lode areas were ore-grade with very little ore found below the 1,000-ft level. The important ore-forming feature at Goldfield was the andesite-dacite volcanic center. The structural control at Goldfield was interpreted to be a 3-to 5-mi ring-fracture zone of a caldera (Garside and Bonham, 1984). In the Skedaddle Mountains, the maximum areal extent of the intensely altered rocks is an elliptical area of about 1 mi by 2 mi. including the periphery of Spencer Basin and the south half of the Wendel drainage basin. Small bodies of rhyolite and dacite crop out outside the altered and mineralized area to the north, east, and south but they do not appear to be strongly mineralized.

Many samples collected within the study area, but outside of the area of epithermal mineralization are anomalous in one or more elements in one or more sample media. Samples collected within 2 mi of the epithermal mineralized area are collectively anomalous in gold, barium, arsenic, antimony, bismuth, cadmium, copper, lead, zinc, cobalt, tin, and thorium. Samples collected in the east half of the study area from drainages along the eastern flank of the Skedaddle Mountains collectively are anomalous in barium, copper, lead, cadmium, tin, thorium, uranium; two samples contain low-level gold concentrations. Anomalies outside the altered area contain lower concentration, are dominated by barite, lead, copper, antimony, and zinc and may represent a widespread geochemical halo. No altered rocks were observed outside of the main altered area.

Low-level anomalies of lanthanum and yttrium mostly are located in the eastern part of the study area. These anomalies, mainly apparent in the concentrates, probably represent lanthanum- and yttrium-bearing trace minerals disseminated in volcanic rocks. Scattered low-level nickel, chromium, and vanadium anomalies probably represent isomorphic substitution of these elements in mafic minerals locally derived from basalts. Therefore, volcanic rocks of the study area are not likely host rocks for nickel, chromium, and vanadium deposits.

Contamination from metallic refuse occurs in Wendel hot springs (25,000 ppm Zn and 10,000 ppm Cu) and probably at the mouth of Amedee Canyon (50,000 ppm lead, 1,500 ppm copper, and 700 ppm antimony). Lead gunshot was observed in five nonmagnetic concentrates and increased lead concentrations to 700 to 50,000 ppm. These metal concentrations were not considered in the geochemical interpretive studies.

Geophysics

Geophysical evaluation of the mineral resources of the study area was based on interpretations of: aerial gamma-ray, aeromagnetic, and gravity surveys.

Aerial Gamma-Ray Data

Radiometric data were compiled by Western Geophysical Company of America (1981) in California and by Geodata International, Inc. (1978) in Nevada for the National Uranium Resource Evaluation (NURE) program of the Department of Energy. The coverage in California, totaling about 15 line miles, consists of one east-west flightline near the center of the study area and one north-south flightline located about 1.3 mi east of the west edge of the study area. No flightlines crossed the part of the study area in Nevada. Flight altitudes varied from about 300 to 500 ft above the ground along the east-west flightline. Flight altitudes varied from 400 to 600 ft along the north-south line with excursions beyond 800 ft over Wendel and Amedee Canyons. Gamma-ray flux from radioactive isotopes of uranium, thorium, and potassium were recorded. Count rates generally exceeded one standard deviation above regional mean background level and count rates exceeded two standard deviations above regional mean background level over small parts of the study area for all three radioactive isotopes. Also, the ratio of uranium to thorium exceeded two standard deviations above mean background level in the center half of the north-south flightline and the east third of the east-west flightline. The cause of the apparent enrichment of radioactive elements is probably related to the hot spring or hydrothermal activity discussed above.

Aeromagnetic Data

A regional aeromagnetic survey was flown over the Nevada part of the study area (U.S. Geological Survey, 1972). The survey was flown at a barometric elevation of 9,000 ft above sea level along east-west flightlines spaced about 2 mi apart. Less that 1 mi of flightline covers the study area, however, and only provides a regional magnetic framework to the east of the study area. The west 4.5 mi of the study area is covered by an aeromagnetic survey used for an assessment of geothermal resources of the Wendel-Amedee KGRA (U.S. Geological Survey, 1977). The survey was flown at a barometric elevation of 8,000 ft above sea level with an east-west flightline spacing of about 1 mi. The most conspicuous anomaly on the aeromagnetic map is a magnetic high with an amplitude of about 800 nanotesla (nT) (gamma), which covers all except the southernmost 3 mi of the part of the study area surveyed. The crest of the high is located 1.1 mi north-northwest of Hot Springs Peak. The position of the anomaly, however, is uncertain because the innermost contour unrealistically covers an area of 0.8 by 1.3 mi, a conspicuous north-south seam interrupts the contours, and there is a lack of geographic coordinates. Also, the shape of the magnetic-intensity contours is not reflected by the surface topography. An aeromagnetic map of the Susanville 1° by 2° quadrangle was prepared from the NURE data by the Bendix Field Engineering Corp. (1983). The map shows a north-south-elongated magnetic low with an amplitude of about 200 nT centered on the study area. The shape and consequent interpretation of the anomaly is uncertain because the map was prepared by interpolating data collected along flightlines spaced at intervals of about 6 mi. Profiles show that observed magnetic intensities vary over a range of 1,500 nT in the study area (Western Geophysical Company of America, 1981), and the prominent magnetic high in the northwestern part of the study area is barely discernible.

Gravity Data

In 1985, Donald Plouff and John Mariano established three gravity stations in the study area, two stations along the border, and nine stations within 3 mi outside the border of the study area (Plouff, 1987). Twenty-five stations were previously established within 3 mi outside the study area in California (Snyder and others, 1982). Peterson and Hassemer (1976) established two stations in the study area and 11 stations within 3 mi outside the border for a study of the Wendel-Amedee KGRA. The most conspicuous anomaly on a preliminary Bouguer gravity anomaly map of the study area (Donald Plouff, unpub. data, 1986) is a northwest-trending, 4-mgal (milligal) gravity low about 4 mi in width and centered near the crest of the Skedaddle Mountains. The low is superimposed on a 15-mgal, 13- by 30-mi regional gravity high that is elongated to the northwest. Data coverage is too sparse to determine if the gravity low forms a single closure or if the northwest corner of the study area is slightly high relative to two separate minima of the gravity low. The gravity low may reflect a bowl-shaped accumulation of Cenozoic volcanic rocks that are less dense than surrounding basement rocks. The gravity low merges eastward with a north-elongated gravity high centered about 1 mi east of the study area. A northwest-trending gravity high is centered near the crest of the Amedee Mountains in the southwest corner of the study area. The high may reflect thinning of Cenozoic rocks over denser pre-Cenozoic basement rocks. Northeastward downdropping along the prominent northwest-trending normal fault that is located near the crest of the high also indicates subsidence and associated thickening of Cenozoic volcanic rocks toward the gravity low over the Skedaddle Mountains. A steep gravity gradient, largely located southwest of the study area borders the northeast edge of a 50-mgal gravity low (Oliver and others, 1982), and reflects the steeply faulted edge of the major subsidence basin at Honey Lake.

Mineral Resource Potential

Geologic and geochemical evidence suggests that the Skedaddle Mountain Wilderness Study Area has potential for the occurrence of epithermal gold, silver, mercury, and antimony deposits. Host rocks, mostly andesite, range in composition from basalt to rhyolite. In the region between the Skedaddle and Amedee Mountains (Spencer Basin) extensive areas of silicic, argillic, and propylitic alteration are present and are associated with fracture zones and hydrothermal brecciation. Some local, highly altered outcrops mostly located along fracture zones are bleached white and are composed of alunite, kaolinite, and cristobalite or consist almost entirely of chalcedony, crystalline quartz, jasper, and (or) opal. There are ten mineral claims in Spencer Basin, all of which were sampled in this study. Three claims contain anomalous concentrations of gold, two contain anomalous concentrations of silver, nine contain anomalous concentrations of barium, and five contain anomalous concentrations of accessory ore-related minerals. The geochemical data for Spencer Basin include anomalous concentrations of gold in rock, stream-sediment, panned concentrate, and water samples, anomalous concentrations of silver, mercury, tellurium, thallium, arsenic, antimony, bismuth, barium, thorium, uranium, and barite in panned concentrates. The central part of Spencer Basin, upper Thousand Springs Canyon, and the south fork of Wendel Canyon have high resource potential for gold, silver, mercury, and antimony with a certainty of C. The area surrounding these locations has moderate mineral resource potential for gold, silver, mercury, and antimony with a certainty of B.

The area in Wendel Canyon is underlain by silicic volcanic rocks. The Dude Group of perlite claims in the upper end of the canyon contains demonstrated subeconomic resources of perlite. The area near the Dude Group claims has moderate mineral resource potential for perlite with a certainty of D. The area underlain by rhyolite south of the claims contains rocks with a permissive silica content and source and hence has low mineral resource potential for perlite with a certainty of C.

The Skedaddle Mountain Wilderness Study Area includes areas within the Wendel-Amedee Known Geothermal Resource Area and is in an area of geothermal resource potential (Higgins, 1981). There is an active hot spring at Amedee Hot Springs located 1 mi outside the study area. Thirty greenhouses at Wendel hot springs, 4 mi west of the study area, use geothermal heat for space heating. There is a potential to add 170 greenhouses. Nearby, a 2-MW geothermal power generation plant was under construction in 1985. Hot springs tufa deposits are present near Wendel hot springs. The southwest corner of the study area has moderate mineral resource potential for geothermal energy and direct heat with a certainty of C. Most of the west half of the study area has low mineral resource potential for geothermal energy with a certainty of B.

The geologic setting of the study area is not conducive to the accumulation of oil and gas. The study area contains volcanic vents under which magma chambers may be located. The feeder systems for these magma chambers may extend to greater depth. As opposed to flood basalt areas under which extensive thicknesses of sedimentary layers may exist, this study area is probably not underlain by such strata. Rocks in study area underwent extensive heating during the hydrothermal events that caused the gold mineralization. The study area is presently underlain by a thermal system that is responsible for its geothermal energy potential. Therefore, even if there is an underlying sedimentary sequence that could have provided source or reservoir beds for oil and gas, the high temperatures associated with hydrothermal activity would have likely driven the hydrocarbons off. There is no oil and gas resource potential in the Skedaddle Mountain Wilderness Study Area with a certainty of D. Scott and Miller (1983) and Scott (1983) also concluded that the area has no resource potential for oil and gas because of the thin sedimentary section there.

REFERENCES CITED

Adrian, B.M., Frisken, J.G., Malcolm, M.J., Bradley, L.A., and Briggs, Paul, 1987, Location of stream sediments (S), heavy-mineral concentrates (C), rocks (R), and water samples (W) from the Skedaddle (CA-020-612) and Dry Valley Rim (CA-020-615) Wilderness Study Areas, Lassen County, California and Washoe County, Nevada: U.S. Geological Survey Open-File Report 87-494, 44 p.

Alldredge, M.H., and Meigs, J.V., 1984, N.E. California area drawing interest: Oil and Gas Journal, v. 82, p. 83-87.

American Society for Testing and Materials, 1985, Standard specifications for fly ash and raw or calcined natural pozzolan for use as a mineral admixture in portland cement concrete: Concrete and mineral aggregates, ASTM Annual Book of Standards, v. 04.02, designation C 618-85, 4 p.

Bates, R.L., and Jackson, J.A., 1980, Glossary of geology, 2nd ed.: Falls Church, Virginia, American Geological Institute, 749 p.

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.

Bendix Field Engineering Corp., 1983, Susanville quadrangle: U.S. Department of Energy Grand Junction Office Open-File Map GJM-483, 4 plates.

Berger, B.R., and Eimon, P.I., 1983, Conceptual models of epithermal precious metal deposits, *in* Shanks, W.C., III, ed., Cameron volume on unconventional mineral deposits: Society of Mining Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers, p. 191-205.

Bonham, H.F., 1969, Geology and mineral deposits of Washoe and Storey Counties, Nevada: Nevada Bureau of Mines Bulletin 70, 140 p.

Bonham, H.F., Jr., and Giles, D.L., 1983, Epithermal gold/silver deposits: the geothermal connection: Geothermal Resources Council, Special Report no. 13, p. 257-262.

Cox, D.P., and Singer, D.A., eds. 1986, Mineral deposit models: U.S. Geological Survey Bulletin 1693, 379 p.

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

Diggles, M.F., Batatian, L.D., and Dellinger, D.A., 1986, Geologic map of the Dry Valley Rim Wilderness Study Area, Lassen County, California and Washoe County, Nevada: U.S. Geological Survey Open-File Report 86-83, scale 1:48,000.

Diggles, M.F., Dellinger, D.A., and Batatian, L.D., 1988a, Geologic map of the Skedaddle Mountain Wilderness Study Area, Lassen County, California, and Washoe County, Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-2006, scale 1:48,000 [in press].

Diggles, M.F., Frisken, J.G., Plouff, Donald, and Linne, J.M., 1988b, Mineral resources of the Dry Valley Rim Wilderness Study Area, Washoe County, Nevada and Lassen County, California: U.S. Geological Survey Bulletin 1706-D [in press].

Ficklin, W.H., Smith, C.L., and Matouka, J.R., 1986, Analytical results for 38 hot springs samples collected in the western United States: U.S. Geological Survey Open-File Report 86-283.

Fisher, R.V., and Schmincke, H.-U. 1984, Pyroclastic rocks: Berlin, Springer-Verlag, 472 p.

Fishman, M.J., and Pyen, G., 1979, Determination of selected anions in water by ion chromatography: U.S. Geological Survey Water Resources Investigation 79-101, 30 p.

Garside, L.J., and Bonham, H.F., Jr., 1984, Precious metal districts in southern and western Nevada, *in* Johnson, J.L., ed., Exploration for ore deposits of the North American Cordillera - field trip guidebook: Symposium of the Association of Exploration Geochemists, Reno, Nevada.

Gay, T.E., Jr., 1966, Economic mineral deposits of the Cascade Range, Modoc Plateau, and Great Basin region of northeastern California, *in* Bailey, E.H., ed., Geology of northern California: California Division of Mines and Geology Bulletin 190, p. 97-104.

Geodata International, Inc., 1978, Aerial radiometric and magnetic survey Lovelock national topographic map, Nevada: U.S. Department of Energy Grand Junction Office Open-File Report GJBX-125 (78), v. 2, 69 p.

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.

Grose, T.L.T., and McKee, E.H., 1986, Potassium-argon ages of late Miocene to late Quaternary volcanic rocks in the Susanville-Eagle Lake area, Lassen County, California: Isochron West, no. 45, p. 5-11.

Hart, W.K., Aronson, J.L., and Mertzman, S.A., 1984, Areal distribution and age of low-K, high-alumina olivine tholeiite magmatism in the northwestern Great Basin: Geological Society of America Bulletin v. 95, p. 186-195.

Helfferich, H., 1964, Perlite, *in* Lefond, S.J., editor-in-chief, Industrial minerals and rocks, 5th ed.: New York, American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., p. 997-1015.

Higgins, C.T., compiler, 1981, Geothermal resources of California: California Division of Mines and Geology, Geologic Data Map No. 4, scale 1:750,000.

Koirtyohann, S.R., and Khalil, Moheb, 1976, Variables in the determination of mercury by cold vapor atomic absorption: Analytical Chemistry, v. 48, p. 136-139.

Koschmann, A.H., and Bergendahl, M.H., 1968, Principal gold-producing districts of the United States: U.S. Geological Survey Professional Paper 610, 283 p.

Lassen County, 1983, Wendel Planning Area, master environmental assessment: Susanville, Calif., Lassen County Planning Department, 154 p.

Levinson, A.A., 1974, Introduction to exploration geochemistry: Calgary, Canada, Applied Publishing Ltd., p. 43-44.

Linne, J.M., 1987, Mineral resources of the Dry Valley Rim study area, Washoe County, Nevada and Lassen County, California: U.S. Bureau of Mines Open-File Report MLA 18-87, 18 p.

Luedke, R.G., and Smith, R.L., 1981, Map showing distribution, composition, and age of Late Cenozoic volcanic centers in California and Nevada: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-1091-C, 2 sheets.

Lydon, P.A., Gay, T.E., Jr., and Jennings, C.W., 1960, Geologic map of California, Westwood (Susanville) sheet: California Division of Mines and Geology scale 1:250,000.

MacDonald, G.A., 1966, Geology of the Cascade Range and Modoc Plateau: *in* Bailey, E.H., ed., Geology of northern California: California Division of Mines and Geology Bulletin 190, p. 65-96.

Majmundar, H.H., 1983, Technical map of the geothermal resources of California: California Division of Mines and Geology, Geologic Data Map 5, scale 1:750,000.

McHugh, J.B., 1984, Gold in natural water—a method of determination by solvent extraction and electrothermal atomization: Journal of Geochemical Exploration, v. 20, p. 303-310.

Meissinger, A.C., 1986, Perlite: U.S. Bureau of Mines Mineral Commodity Summaries, p. 114-115.

Meier, A.L., 1980, Flameless atomic absorption of gold in geologic materials: Journal of Geochemical Exploration, v. 13, p. 77-85.

Millard, T.H., Jr., 1976, Determination of uranium and thorium in the U.S. Geological Survey standard rocks by the delayed neutron technique: U.S. Geological Survey Professional Paper 840, p. 61-65.

Morrison, R.B., and Frye, J.C. 1965, Correlation of the middle and late Quaternary successions of the Lake Lahontan, Lake Bonneville, Rocky Mountain (Wasatch Range), southern Great Plains and eastern Midwest area: Nevada Bureau of Mines Report 9, 45 p.

Mosier, D.L., Berger, B.R., and Singer, D.A., 1986a, Descriptive model of Sado epithermal veins *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 154.

Mosier, D.L., Singer, D.A., and Berger, B.R., 1986b, Descriptive model of Comstock epithermal veins *in* Cox, D.P., and Singer, D.A., eds., Mineral deposit models: U.S. Geological Survey Bulletin 1693, p. 150.

Munts, S.R., and Peters, T.J., 1987, Mineral resources of the Skedaddle study area, Lassen County, California, and Washoe County, Nevada: U.S. Bureau of Mines Open-File Report MLA 22-87, 53 p.

Norris, R.M., and Webb, R.W., 1976, Geology of California: New York, John Wiley and Sons, 378 p.

Oliver, H.W., Robbins, S.L., and Griscom, Andrew, 1982, Bouguer gravity map of California - Westwood sheet: California Division of Mines and Geology, 2 sheets, scale 1:250,000.

Parmentier, P.P., 1985, 1984 geothermal well drilling summary: Geothermal Energy, v. 13, p. 7-10.

Peccerillo, A., and Taylor, S.R., 1976, Geochemistry of Eocene calc-alkaline volcanic rocks from the Kastamonu area, northern Turkey: Contributions to Mineralogy and Petrology, v. 58, p. 63-81.

Perkin-Elmer Corp., 1976, Analytical methods for atomic absorption spectrophotometry: Norwalk, Conn., Perkin-Elmer Corp., 586 p.

____1977, Analytical methods for atomic absorption spectrophotometry using the HGA graphite furnace: Norwalk, Conn., Perkin-Elmer Corp., 200 p.

Peterson, D.L., and Hassemer, J.H., 1976, Principal facts for a gravity survey of Wendel-Amedee Known Geothermal Resource Area, California: U.S. Geological Survey Open-File Report 76-702B, 3 p.

Plouff, Donald, 1987, Gravity observations by the U.S. Geological Survey in northwest Nevada, southeast Oregon, and northeast California, 1984-1986: U.S. Geological Survey Open-File Report 87-639, 33 p.

Purdy, T.I., 1983, Sagebrush reflections, the history of Amedee and Honey Lakes: Stamford, Conn., Distributor Publications, Inc., 62 p.

Scintrex Corp., 1978, UA-3 Uranium Analyzer: Toronto, Canada, Scintrex Corp., 45 p.

Scott, E.W., 1983, Petroleum potential of wilderness lands in California, *in* Miller, B.M., ed., Petroleum potential or wilderness lands in the western United States: U.S. Geological Survey Circular 902-D, p D1-D12.

Scott, E.W., and Miller, B.M., 1983, Petroleum potential of wilderness lands, California: U.S. Geological Survey Miscellaneous Investigations Map I-1538, scale 1:1,000,000.

Simon, F.O., Campbell, E.Y., and Aruscavage, P.J., 1977, Thallium contents of 16 USGS standard rocks: Journal of Research of the U.S. Geological Survey, v. 5, p. 579-581.

Skougstad, M.W., Fishman, M.J., Friedman, L.C., Erdman, D.E., and Duncan, S.S., 1979, Methods for determination of inorganic substances in water and fluvial sediments: Techniques of Water-Resource Investigations of the United States Geological Survey, Chapter A-1.

Snyder, D.B., Roberts, C.W., Saltus, R.W., and Sikora, R.F., 1982, Magnetic tape containing the principal facts of 64,026 gravity stations in the state of California: National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161, PB-82-168279, description, 30 p., PB-82-168287, magnetic tape.

Thompson, C.E., Nakagawa, H.M., and Van Sickle, G.H., 1968, Rapid analysis for gold in geologic materials: U.S. Geological Survey Professional Paper 600-B, p. B130-B132.

Tunell, George, 1970, Mercury, in Wedepohl, K.H., ed., Handbook of geochemistry: Berlin, Springer-Verlag, v. 11/5, chap. 80 F-H.

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 Lovelock, Reno, and Millet 1° by 2° quadrangles, Nevada: U.S. Geological Survey Open-File Report 72-386, 1 plate, scale 1:250,000.

_____1977, Aeromagnetic map of the Wendel area, California: U.S. Geological Survey Open-File Report 77-795, scale 1:62,500.

Warner, M.M., 1980, S. Idaho, N. Nevada, southeastern Oregon - prime exploration target: Oil and Gas Journal, v. 78, p. 331-341.

Western Geophysical Company of America, 1981, National gamma-ray spectrometer and magnetometer survey, Susanville quadrangle, California - Final report: U.S. Department of Energy Grand Junction Office Open-File Report GJBX-410 (81), v. 2, 95 p.

White, D.E., 1981, Active geothermal system and hydrothermal ore deposits: Economic Geology, 75th anniversary issue, 1981, p. 392-423.

Zeisloft, Jon, Sibbett, B.S., and Adams, M.C., 1984, Case study of the Wendel-Amedee exploration drilling project, Lassen County, California, User Coupled Confirmation Drilling Program: Earth Science Laboratory/ University of Utah Research Institute Report ESL-125, prepared for U.S. Department of Energy - Idaho operations, DOE/ID/12079-127, 97 p.5

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.

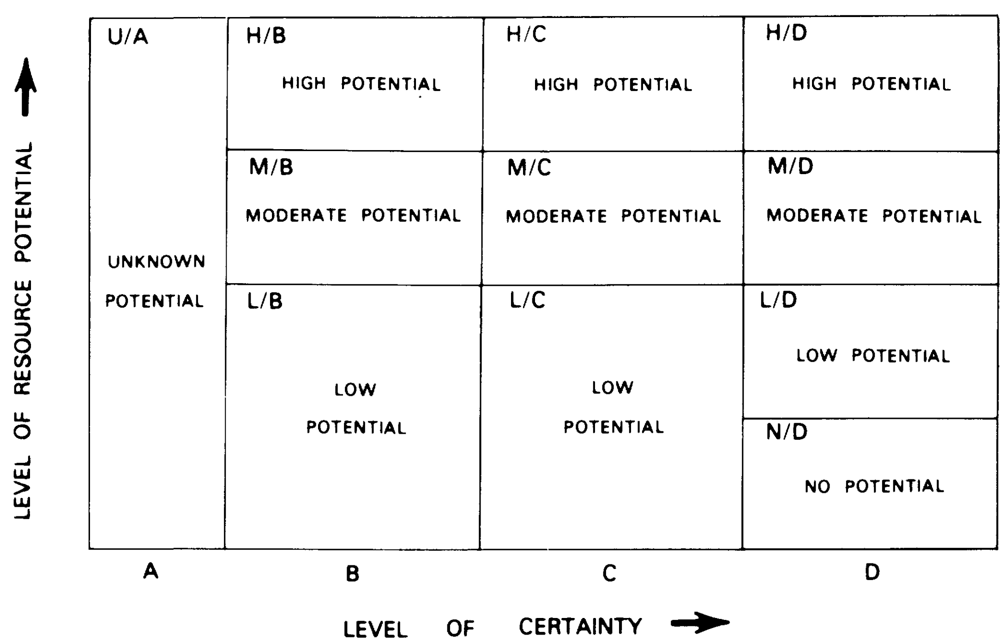
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate reasonable likelihood of resource accumulation, and (or) where an application 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



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	96
				Early	138
		Jurassic		Late Middle Early	205
		Triassic		Late Middle Early	~240
	Paleozoic	Permian		Late Early	290
		Carboniferous Periods	Pennsylvanian	Late Middle Early	~330
			Mississippian	Late Early	360
		Devonian		Late Middle Early	410
		Silurian		Late Middle Early	435
		Ordovician		Late Middle Early	500
		Cambrian		Late Middle Early	~570[1]
Proterozoic	Late Proterozoic				900
	Middle Proterozoic				1600
	Early Proterozoic				2500
Archean	Late Archean				3000
	Middle Archean				3400
	Early Archean				(3800?)
pre-Archean[2]					4550

[1]Rocks older than 570 Ma also called Precambrian, a time term without specific rank.

[2]Informal time term without specific rank.

Table 1. Prospects, mineralized areas, and mining claims in and adjacent to the Skedaddle Mountain Wilderness Study Area, California and Nevada

[Only significant sample data given here. See Munts and Peters (1987) for complete sample data. *, wholly or partly outside study area; <, less than; ppm, parts per million]

Map No. (fig. 2, plate 1)	Name	Summary	Workings and production	Sample data and resource estimate
1	Big Indian group	Basalt and andesite outcrops are propylitically altered. Locally, these volcanic rocks are altered to clay with <10 percent sericite. These rocks are weakly fractured and display traces of iron-oxide.	No workings	Three random chip samples contained no detectable gold or silver. Barium values ranged from 0.043 to 0.077 percent.
2	Silver Springs group	Aphanitic andesite outcrops show with chlorite and epidote alteration, and are cut by occasional epidote-filled fractures. Occasionally, near major fractures, the andesite is bleached to a cream white color, and altered to clay with minor sericite and some silicification. These bleached areas also contain a trace of pyrite and minor limonite. Major fractures trend N. 10° W. and dip 45° SW.	No workings	One random chip and one grab sample. No gold or silver was detected.
3	Golden Leaf group	Host rocks consist of minor basalt, andesite, vitrophyre, some pyroclastic rocks and minor sinter. The vitrophyre displays flow banding with a N. 58° W. strike and vertical dip. Clasts in the pyroclastic unit range up to 10 in. in diameter and are well rounded. A 3-ft-thick basalt dike cuts the andesite, strikes N. 65° W. and dips vertically. Opaque white quartz veinlets (<1 in. thick) cut the sinter and contain limonite after pyrite. No other quartz veins were found. Alteration type and intensity varies with location, and ranges from propylitic to argillic or advanced argillic type. Alteration minerals include chlorite after biotite, epidote after hornblende, sericite after biotite or feldspars, clay and quartz after feldspars, clay alteration of matrix minerals, and silica flooding. Quartz in zones of silicification are opaque to translucent and white to blue. Fracture density increases near and in areas of silicification.	One small (2-ft-deep) pit.	Nine random chip, 6 chip and 1 grab sample were collected. No gold or silver was detected. Barium content ranged from 0.02 percent to 0.15 percent.

Table 1. Prospects, mineralized areas, and mining claims in and adjacent to the Skedaddle Mountain Wilderness Study Area, California and Nevada—*Continued*

Map No. (fig. 2, plate 1)	Name	Summary	Workings and production	Sample data and resource estimate
4	Snowstorm group	Host rocks consist primarily of finely porphyritic andesite with minor pyroclastic flows and crystal lithic tuff. Three dikes cut these units. The dikes include a 10-ft-thick dacite dike which trends N. 20° W. and dips 50° SW.; a 15-ft-thick andesite dike which trends N. 70° E and dips 80° NW., and an 18-ft-thick basalt dike which trends east-west and dips 15° S. The dacite and basalt dike are unaltered; the andesite dike has some clay and chlorite alteration. The host rocks show propylitic to phyllic alteration. Alteration minerals include some epidote, and chlorite, clay, sericite, and silicification. In several locations silicification is pervasive and may contain rounded quartz phenocrysts up to 1/8" in diameter. Silicification generally increases near fractures. Schorl tourmaline occurs locally in silicified zones. Many host rocks are bleached. Sulfides include pyrite (up to 8 percent), a trace of chalcopyrite, and a trace of cinnabar. Limonite after pyrite occurs in fractures in the silicified host. Andesite contains veinlets (up to 1/2 in. thick) of clear to opaque white quartz. Fractures generally trend N. 78° W. and dip 70° to 86° NE.	Three pits as much as 4 ft deep and one 12-ft-long trench.	Eleven chip and 7 grab samples were collected. None contained gold and only one (a grab sample) contained silver (0.031 ppm). Barium values range from 0.078 percent to 0.18 percent. One sample (chip) contained anomalous zinc (100 ppm).
5	Who-Who group	Veinlets of clear white to blue quartz, and a 6-ft-thick silicified breccia zone cut andesite. The breccia zone has angular clasts up to 2 in. in diameter, in an aphanitic matrix trends N. 30° E. and dips vertically. Some andesite is altered to clay with sericite. Large areas of andesite are pervasively silicified with some sericite; these areas are intensely bleached. Sulfide minerals occur in the silicified areas and include trace amounts of pyrite and cinnabar.	Three trenches, 15 ft, 30 ft, and 40 ft long, respectively. One 5-ft-deep pit.	Eight chip and 6 grab samples. No silver was detected and only one sample (a chip) contained gold (0.044 ppm). Barium values ranged from 0.04 to 0.18 percent. One chip sample contained 78 ppm molybdenum and one grab sample contained 150 ppm copper.

Table 1. Prospects, mineralized areas, and mining claims in and adjacent to the Skedaddle Mountain Wilderness Study Area, California and Nevada—*Continued*

Map No. (fig. 2, plate 1)	Name	Summary	Workings and production	Sample data and resource estimate
6	Southern Star group	A 30-ft-thick silicified vein-like structure cuts porphyritic andesite, strikes N. 20° W, and dips 66° NE. Veinlets of gray opaque chalcedony and buff-colored opalite cut andesite with a N. 54° E. trend and dip 80° SE. Three dikes also cut the andesite. These include a 10-ft-thick andesite dike (strikes N. 10° W. with vertical dip), an 8-ft-thick basalt dike (with a N. 60 W. strike and vertical dip) and a 1-ft-thick pebble dike (strikes N. 20° W. with a 75° SW dip). Alteration varies from epidote and chlorite through clay ± sericite with local silicification to total silicification. Schorl tourmaline is also present in trace amounts. Sulfide minerals include as much as 2 percent pyrite (locally altered to limonite) and trace amounts of cinnabar.	Three pits (less than 7 ft deep), two trenches (20-ft- and 40-ft-long, respectively) and one 10-ft-deep cut.	Fourteen chip samples and 3 grab samples were collected. No gold or silver was detected. Barium values ranged from 0.01 percent to 0.12 percent. One sample (a 2.5 ft chip sample) contained 200 ppm copper.
7	Friends group	Host rocks include basalt, andesite, pyroclastics, and vitrophyre. The andesite is locally brecciated; this breccia is altered to clay and minor sericite with some silicification and is bleached to a cream white. Some breccia clasts contain clear blue quartz veinlets. Other alteration ranges from epidote to silicification with some clay and sericite. One pit exposes silicified andesite cut by clear white quartz veinlets. The only visible sulfide is pyrite; some limonite is present, especially near pyrite.	Two pits (each 4 ft deep) and one 10-ft-long trench.	Four chip, one random chip and one grab sample were collected. None contained detectable gold or silver and only two (chip samples) contained anomalous barium (0.019 percent each).
8	Luilla Queen group	Host rock lithologies consist of dacite, and vitrophyre. The andesite is aphanitic to finely porphyritic and is cut by a black vitrophyre dike 50 ft thick which strikes N. 5° E. and dips 85° SE. The dacite displays flow bands trending N-S and dipping 35° E. The andesite and vitrophyre are bleached locally and display propylitic to phyllic alteration. Alteration minerals include epidote, clay sericite, and silica as silica flooding. The rhyolite is locally altered to clay and epidote with rare silicification; the dacite is relatively unaltered. Pyrite is the only visible sulfide and is often altered to limonite. Float of vein quartz is banded with bands of translucent blue quartz, clear quartz, opaque white comb quartz, and occasionally chalcedony.	One 3-ft-deep pit.	Ten samples were collected; these included 5 chip and 5 grab samples. No gold or silver was detected. Barium content ranged from 0.075 percent to 0.25 percent.

Table 1. Prospects, mineralized areas, and mining claims in and adjacent to the Skedaddle Mountain Wilderness Study Area, California and Nevada—*Continued*

Map No. (fig. 2, plate 1)	Name	Summary	Workings and production	Sample data and resource estimate
9*	Ace Chief group	An aerially extensive 30- to 100-ft-thick siliceous opaline breccia zone is interbedded with flows of basalt and andesite. Surrounding host rocks show epidote and chlorite alteration. The breccia zone is strongly bleached with minor amounts of limonite and iron oxide. Breccia clasts are silicified and occasionally show multiple tectonic events.	No workings	Twenty-four chip and 3 grab samples. Three chip samples contained 0.38 to 8.1 ppm silver; five chip samples contained 0.017 to 0.38 ppm gold. Barium values ranged from 0.02 percent to 0.18 percent. Two chip samples contained 2.4 and 7.6 ppm tin, respectively. Fluorine values for 1 grab and 5 chip samples ranged from 0.039 to 0.33 percent.
10*	Unknown	Extensive area of tabular opal and silica deposits interbedded with intertonguing basalt and andesite flows. The opal/silica unit, as much as 75 ft thick, appears to be horizontally bedded, and locally contains silicified rhyolite breccia. Silica flooding and silica cementation of breccia is the dominant alteration. Iron oxides stain the rocks near fractures. Some rocks within the unit appear bleached. However, beds both above and below show only epidote and chlorite alteration. The opal/silica unit thins to the south and intertongues with an andesite tuff breccia.	No workings	Ten chip and 2 grab samples. No silver was detected. Two chip samples contained 0.063 and 0.131 ppm gold, respectively. Fluorine values ranged from 0.039 percent to 0.30 percent and barium values ranged from 46 ppm to 0.19 percent. One chip sample contained 0.12 ppm beryllium.
11*	Skedaddle claim	Porphyritic platy andesite is locally encrusted by tufa. Neither display visible alteration.	No workings	One 2-ft chip sample of tufa contained 0.017 ppm gold, no detectable silver, 0.07 percent barium, and 10 ppm tin.
12*	Hot Rock group	Host rock includes andesite and pyroclastic flows. The andesite is occasionally porphyritic, and massive to flow banded. Flow bands form plates 1/4 in. to 2 in. thick, which strike N. 55° E. and dips 45° W. Some exposures are draped with layers of tuffa.	No workings	Six chip samples were collected; no gold was detected; one sample had detectable silver (9.3 ppm) and barium values ranged from 0.077 to 0.11 percent
13	Hillside claim	Porphyritic andesite flows over a bedded pyroclastics unit. Andesite contains fractures up to 3 in. thick filled with tuffa. Near these fractures andesite is bleached to a light gray with clay and chlorite alteration. Silicification is also present locally.	No workings	One random chip sample of andesite contained no detectable gold or silver, and 0.11 percent barium.
14	Lava Cave claim	Small exposure of unaltered porphyritic biotite andesite.	No workings	One 4-ft-chip sample contained no detectable gold or silver.
15	Lost Cave group	Cliff face composed of multiple flows of porphyritic unaltered andesite.	No workings	One 3.2-ft chip sample contained no detectable gold or silver.
16	Divide group	Vesicular porphyritic andesite with minor epiclastic basal breccia. Some outcrops are encrusted with tuffa, and occasionally show some silicification and chloritization.	No workings	Three random chip samples contained no detectable gold or silver and barium values ranged from 0.10 to 0.12 percent.

Table 1. Prospects, mineralized areas, and mining claims in and adjacent to the Skedaddle Mountain Wilderness Study Area, California and Nevada—*Continued*

Map No. (fig. 2, plate 1)	Name	Summary	Workings and production	Sample data and resource estimate
17	Shamrock	Host rock includes porphyritic vesicular andesite and laharic pyroclastic rocks. Andesite is occasionally altered to chlorite and epidote with minor limonite. The pyroclastics are altered to clay (50-60 percent) and sericite (25-35 percent) with some silicification (25-50 percent). Opaque white vein quartz float occurs nearby.	No workings	Three random chip samples contained no detectable gold or silver.
18	Wendel Group	Four unpatented claims. Two samples collected from dry creek beds. Less than 100 yd^3 of gravel is exposed in this darinage	No workings	Two samples, 0.00527 and 0.00063 oz/yd^3 gold no production, no reserves.
19*	Pomroy	One unpatented claim. One sample of terrace gravels with 40 percent of the particles greater than 1/4 in. in diameter. Exposed gravel at least 40 ft thick.	No workings	One sample. No significant values.
20*	Square Peak	Two unpatented claims. One sample of terrace gravels with 35 percent of the particles in the material greater than 1/4 in. in diameter.	No workings	One sample. No significant values.
21*	Black Diamond	Three unpatented claims. One sample from a dry creek bed. Sample consists of both alluvial and elluvial material; 20 percent of the particles greater than 1/4 in. in diameter.	No workings	One sample No significant values.
22*	Dude Group (perlite)	See text.	No wokings	See text.

GPO 585-045/78041