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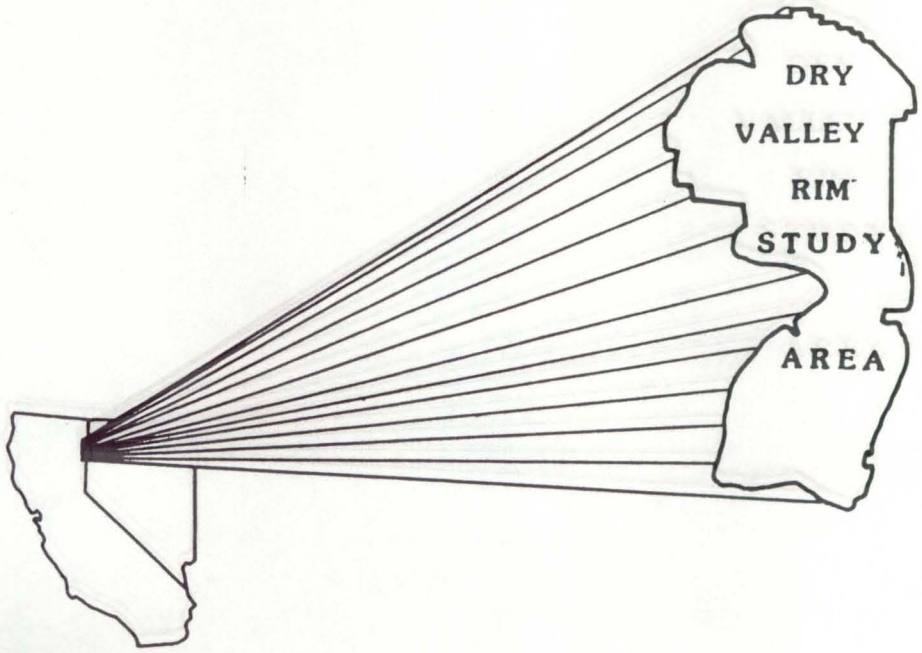
Mineral Resources of the Dry Valley Rim Study Area, Washoe County, Nevada and Lassen County, California



BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR

MINERAL RESOURCES OF THE DRY VALLEY RIM STUDY AREA, WASHOE COUNTY, NEVADA, AND LASSEN COUNTY, CALIFORNIA

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PREFACE

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and U.S. Bureau of Mines to conduct mineral surveys on U.S. Bureau of Land Management administered land designated as Wilderness Study Areas ". . . to determine the mineral values, if any, that may be present . . . ." Results must be made available to the public and submitted to the President and the Congress. This report presents the results of a Bureau of Mines mineral survey of a portion of the Dry Valley Rim Wilderness Study Area (CA-020-615), Washoe County, Nevada, and Lassen County, California.

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

CONTENTS

ILLUSTRATIONS

TABLE

SUMMARY

In 1985, at the request of Bureau of Land Management, the U.S. Bureau of Mines studied a 54,480-acre portion of the 93,205-acre Dry Valley Rim Wilderness Study Area (CA-020-615), in order to evaluate its identified resources. The area studied is in Washoe County, NV, and Lassen County, CA, about 35 miles east of Susanville, CA. No metallic resources were identified. The Red Rock and Willow Springs areas contain 85 million tons of altered basalt with zeolite amygdules. This material, averaging more than 50 percent chabazite, constitutes a subeconomic zeolite resource. This zeolite-bearing material would require beneficiation to upgrade it for higher value uses. Natural zeolites have a small market in the United States, which is presently supplied by other higher grade material. There is low probability that these resources will be mined in the foreseeable future.

The Capricorn claims, adjacent to the study area, are on alluvial sediments containing more than 30 percent montmorillonoid clays. The material is not usable as pozzolan and was not tested for other uses such as absorbency, oil clarification, or insecticide carrier. The term pozzolan refers to a number of siliceous materials which are combined with portland cement to enhance the physical properties of the resultant concrete. The area is remote from market and contains low value material. It is improbable that this occurrence will be mined in the foreseeable future.

A 100,000 ton occurrence of perlite is on the Broken Shovel claims. While usable for lightweight aggregate, the occurrence is too small to be mined. However, if considered for perlite production with other nearby deposits at Skedaddle Mountain (estimated 184,000 tons within 15 miles) and at Black Diamond Canyon (estimated 1 million tons within 3 miles), this occurrence could become a subeconomic resource.

INTRODUCTION

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

Setting

The study area consists of 54,480 acres within the 93,205-acre Dry Valley Rim Wilderness Study Area along the Nevada-California state line. The study area is in Washoe County, NV, and Lassen County, CA, about 45 mi (miles) east of Susanville, CA (fig. 1). The study area occupies an elevated rim along the west edge of the Smoke Creek Desert. The rim rises gradually from west to east, but drops about 1,500 ft (feet) steeply on the east edge. Elevations in the study area range from 4,020 ft at the base of the rim to 6,221 ft near Dry Lake Reservoir (fig. 2). Vegetation consists primarily of cheatgrass and sagebrush.

Previous Studies

Mineral resource studies encompassing all or parts of the study area have been conducted by Bonham (1969), Jones and Papke (1984), MINOBRAS (1973), and Qualheim (1979). Geothermal resources in this part of Nevada have been addressed by Garside (1974), Garside and Schilling (1979), and Horton (1964). Regional geology has been described by Stewart and Carlson (1976, 1977), Stewart (1980), and by Russell (1885). Aerial radiometric and magnetic surveys have been conducted by Geodata International, Inc. (1978) for the Department of Energy.

Present Study

Washoe and Lassen County records and BLM claim records were examined for mining claims in the study area; USBM library materials and production records were studied for additional information. A field search was conducted for mines, prospects, or mineralized zones in or near the study area. Two claim groups and three mineralized areas in and adjacent to the study area were examined. According to 1985 BLM records, only the Capricorn claim group was active. Traverses of the area were made by fixed-wing aircraft, helicopter, motorcycle, and on foot. Field examinations were conducted during May and June 1985.

Seven alluvial (placer) and 52 rock (lode) samples were collected. The seven grab samples of alluvium, consisting of one or two 14-in. (inch) pans each, were collected from some of the larger streams in the study area and concentrated in the field. These samples were further concentrated in the laboratory on a Wilfley table. Gold was extracted from the concentrates by amalgamation. The concentrates were also checked for other heavy minerals, radioactivity, and fluorescence.

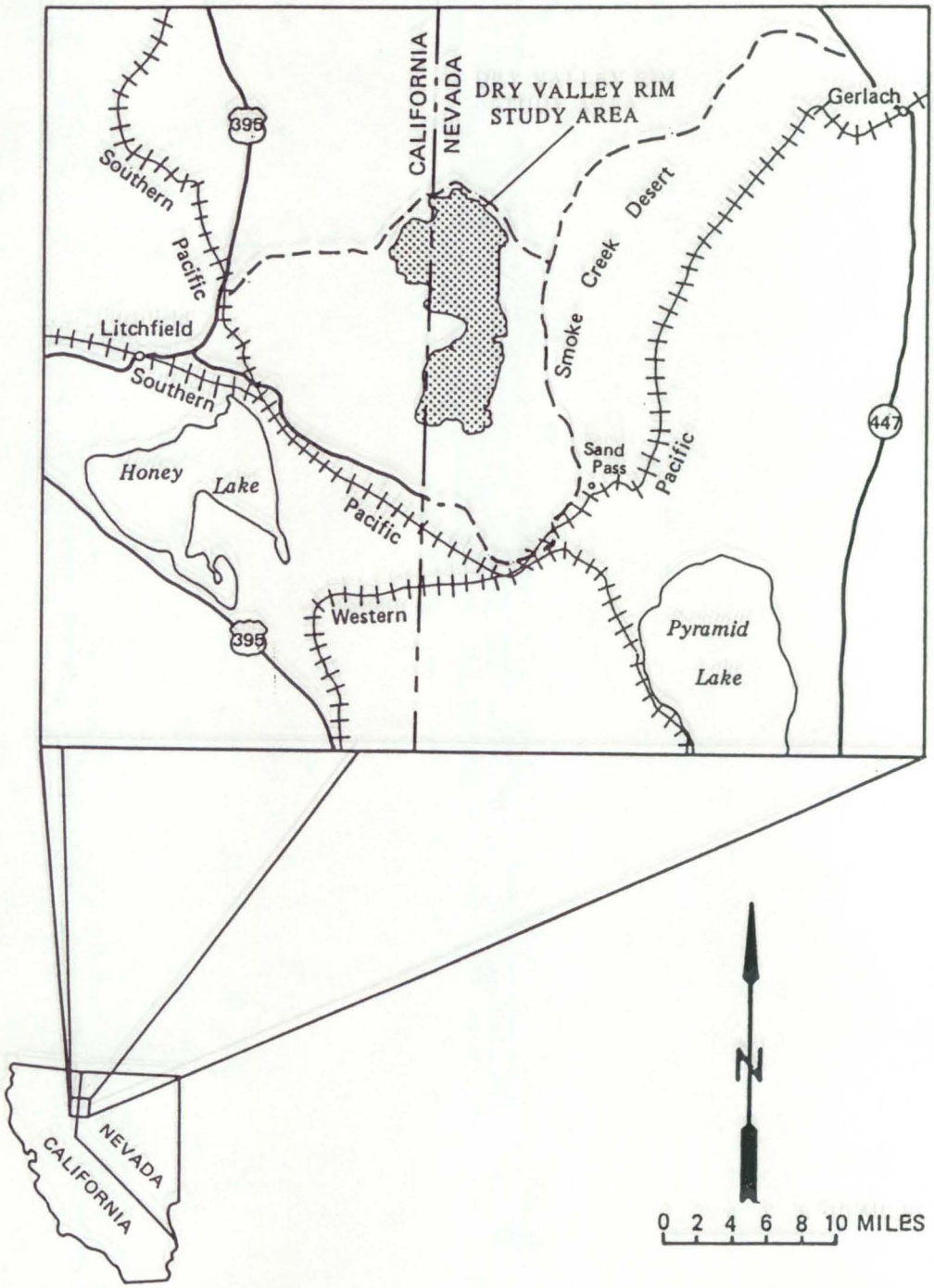

FIGURE 1.– Location of the Dry Valley Rim study area, Washoe County, NV and Lassen County, CA

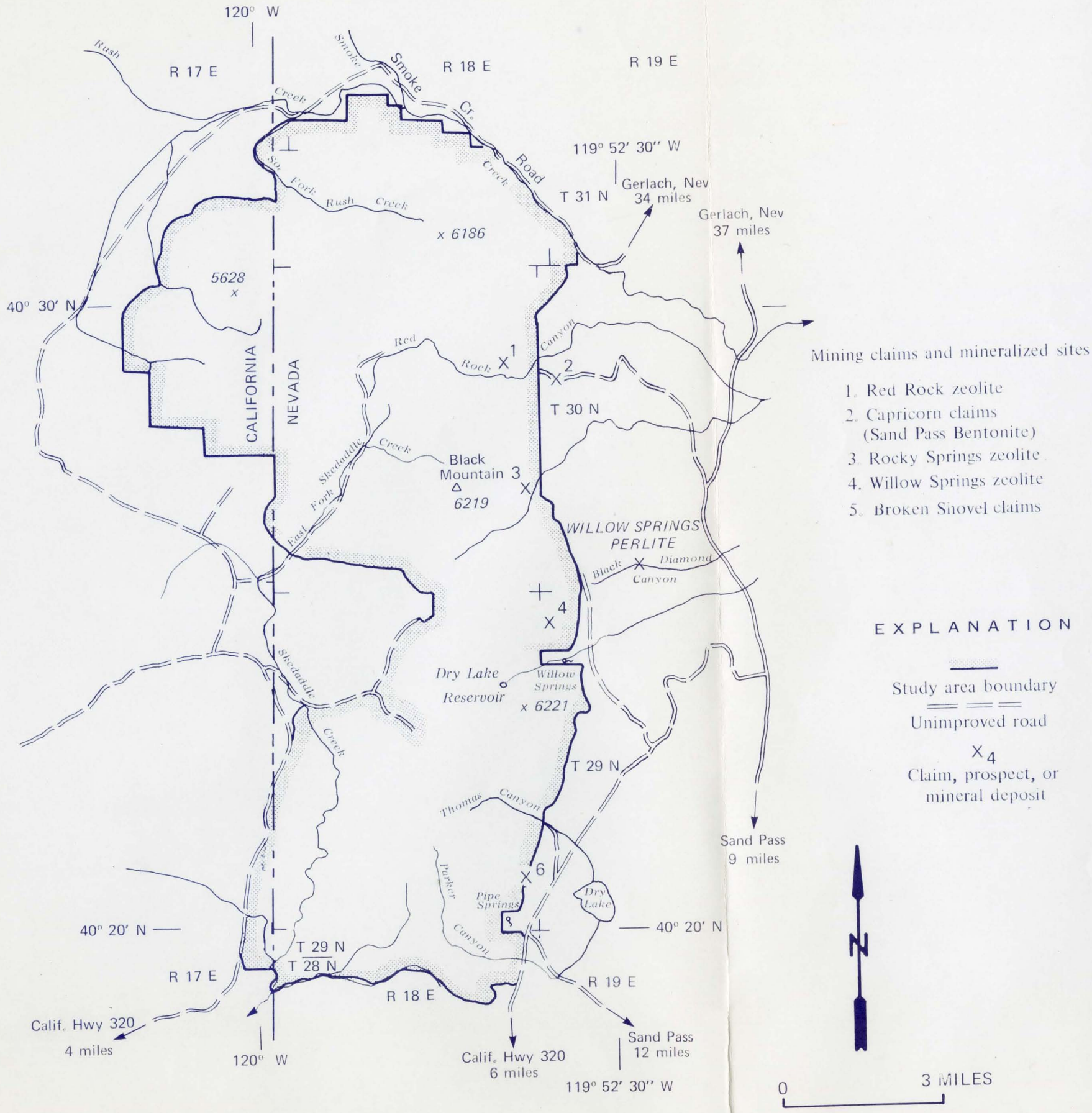

FIGURE 2.– Mining claims, and mineralized sites in and adjacent to the Dry Valley Rim study area, Washoe County, NV and Lassen County, CA

Rock samples of perlite, altered zeolitic basalt, and alluvial sediment consisted of four types: (1) chip - a series of continuous chips of rock across an exposure; (2) grab - randomly collected rock pieces from a stockpile, dump, or float; (3) random - chips taken at random intervals from an apparently homogenous exposure, and (4) select - pieces of rock generally chosen from the best mineralized parts of an exposure, or of any particular fraction (e.g., quartz, host rock). These samples were crushed, pulverized, thoroughly mixed, split, and checked for radioactivity and fluorescence; 27 rock samples were assayed for gold and silver by fire assay or by a combined fire assay-atomic absorption method. Several samples from each locality were analyzed for 40 elements 1/ by semiquantitative spectrography to detect unsuspected elements of possible significance.

Eleven perlite samples were checked under a petrographic microscope to determine index of refraction, perlitic texture, and percent glass. This procedure screened out any obviously substandard material. A representative sample was sent to the New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico, for expansion testing. This series of tests involves expansion of the material in a vertical furnace and subsequent determination of expanded density, furnace yield, percent sinkers, compacted density, and compaction resistance. These tests are used to determine the use for which perlite material is suitable (James M. Barker and John Hingtgen, Nevada Bureau of Mines and Mineral Resources, written commun., 1986).

Seventeen samples of altered zeolitic basalt were analyzed by x-ray diffraction to determine zeolite type and quantity. Cation exchange capacity was determined by chemical methods.

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

Twelve samples of alluvial sediment were screened for pozzolan suitability as a cement constituent by whole rock analysis (Inductively Coupled Plasma method). Included were analyses of moisture, loss on ignition, and sulfate content. ASTM pozzolan standards (ASTM, 1985) require $Al_2O_3 + Fe_2O_3 + SiO_2$ to be greater than 70 percent, SO_3 less than 4 percent, and loss on ignition less than 10 percent. Two samples which met ASTM chemical standards (except moisture and loss on ignition) were sent to the U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS, for determination of the pozzolan activity index. Parameters measured include specific gravity, water requirement (as percent of control), compressive strength, and percent of control (strength). The ASTM standards for water requirement, compressive strength, and percent of control are maximum 115 percent, minimum 600 psi, and minimum 75 percent, respectively. Detailed information is available from the U.S. Bureau of Mines, WFOC (Western Field Operations Center), E. 360 Third Ave., Spokane, WA 99202.

ACKNOWLEDGEMENTS

The author thanks Harry Banfield and Bob Swinney of Lassenite Industries for their helpful technical advice on pozzolan occurrences in the area. Bureau of Land Management personnel assisted greatly with logistics and helicopter support. The author was assisted in the field by Mike Miller, physical scientist, WFOC.

GEOLOGIC SETTING

The Dry Valley Rim study area is within a high dissected plateau known as the Modoc Plateau, transitional between the Basin and Range and Columbia Plateau physiographic provinces (Bonham, 1969). The predominant rock type is Pliocene olivine basalt which reaches a thickness of 1,500 ft (Stewart and Carlson, 1976). Some perlite and volcanic ash deposits are interbedded with the basalt. Local areas of pre-Lake Lahontan (Tertiary - Quaternary) sediments occur along the eastern boundary of the study area. One major range front fault and several related faults with displacements up to several hundred feet trend north to northwest along the eastern boundary of the area (Bonham, 1969, p. 48).

MINING HISTORY

No mining activity has been recorded within the study area. The earliest recorded mining activity near the study area was extraction of salt from brines at Buffalo Springs in the Smoke Creek Desert from before 1885 (Russell, 1885, p. 232) to 1907 (Lincoln, 1923, p. 333). Buffalo Springs is approximately 20 mi (mile) northeast of the study area.

The Sand Pass mining district, located 22 mi north of Sand Pass is probably adjacent to but outside the study area on the northeast corner and may include the area of the Capricorn claims. The Sand Pass Bentonite (Rollin and others, 1971) may overlie the Capricorn claim area.

This area was originally claimed in 1935 as the Whitetail group and in 1969 as association placer claims Capricorn 11-13. The claims are currently being prospected by S. Hill and R. Bailey.

Standard Oil Company prospected fullers earth within the Sand Pass mining district, probably during the early 1920's (Lincoln, 1923, p. 238). Fullers earth is a term for a variety of mineral materials used for bleaching oils and as absorbants.

The Sheephead gold mining district, in which the Washoe Lassen Mining company reported work in 1907 (Yale, C. G., 1907, p. 382), has been noted as being adjacent to the southeastern end of the study area (Hill, 1912, p. 226 and plate IX), but no information about the district is available. The Art Wilson Company clay mine is approximately 10 mi southeast of the study area near Astor Pass (Schilling and Hall, 1980, p. 40). The Willow Springs perlite occurrence (Bonham, 1969, p. 126), located about 1 mi east of the study area boundary in Black Diamond Canyon was also known as the Silver Gray claims. A 25-ft shaft and one adit approximately 26 ft long are on this property.

COMMODITY HIGHLIGHTS

Subeconomic resources of zeolite are identified in the study area. Summarized below are significant characteristics, common uses, mining and processing methods for zeolites, and the present status of the zeolite industry.

Zeolite (Chabazite)

Zeolites are a unique group of minerals which are chemically classified as hydrated aluminosilicates. The arrangement of elements in their crystal structure is a lattice with interconnecting channels of a specific size. This structure yields the unique characteristics of zeolites. Some of these characteristics are a high ion exchange capacity, the ability to adsorb and desorb water without loss of crystal structure or physical dimension, and the rejection or acceptance of specific molecule sizes in the pore space (Lefond, 1983).

Natural zeolite is used as filler in the paper industry, as lightweight agrregate, as fertilizer and soil conditioners, as ion exchangers in pollution abatement, as dietary supplements in animal feed, as absorbants in drying and purifying natural gas, and as dimension stone. Natural zeolite is also used in separating oxygen and nitrogen from air, in removing cesium from radioactive wastes, and in municipal waste treatment (Mumpton, 1983, p. 1419-1431). Natural chabazite (a zeolite mineral) can remove hydrochloric acid from reformer hydrogen steams, water from chlorine, and carbon dioxide and hydrogen sulfide from other gases.

Many of these applications are satisfied presently by synthetic zeolites. Use of natural zeolites in the United States is limited to cesium removal, natural gas dessication, pozzolan, kitty litter, and some agricultural uses. Natural zeolites are used much more extensively in other countries, especially Japan.

National production figures for zeolites are not available. Production comes primarily from five mines located near Bowie, AZ; Hector and Ash Meadows, CA; Jersey Valley, NV; and Adrian, OR. All are located on tuffaceous deposits with minimal overburden and are mined by surface methods. At the Bowie mine, a high grade zone is selectively mined. Processing of natural zeolites consists of crushing and size classification. Use-specific value-added commodities are produced on a limited scale by acid treatment or by flooding a particular zeolite with a specific cation. Research into uses for and efforts toward marketing of natural zeolites are continuing.

MINING CLAIMS AND MINERALIZED SITES

Mining claims and mineralized sites examined during this study are shown on figure 2 and described in table 1. Two sites, the Red Rock and Willow Springs, contain subeconomic resources of zeolites. These deposits are described in detail in the following section. Three sites have occurrences of clay, perlite, and zeolite. Methods and criteria for mineral resource classification are presented in U.S. Geological Survey Circular 831 (U.S. Geological Survey, 1980).

Identified Zeolite Resources

Red Rock

Alteration and mineralization appear to center on a basalt dike striking north and dipping vertically (fig. 3) and also lies near a major north-trending range front fault. Chabazite fills voids in a red altered basalt; the red coloration results from a high concentration of iron oxide. Altered basalt occurs in a roughly circular 150-acre area between 4,500 ft and 4,800 ft elevation in the shape of a dissected dome. Average thickness is estimated at 200 ft. The density factor for the material is approximately 19.5 ft^3 per ton. Eleven samples collected from this deposit and analyzed by x-ray diffraction contained between 36 percent and 70 percent chabazite with a sample weighted average of 53 percent (table 2). Ammonia CEC (cation exchange capacities) for two samples were 1.5 (50 percent chabazite) and 1.84 (70 percent chabazite) meq per gm (millequivalents per gram). Seventy million tons of subeconomic resources of chabazite-bearing altered basalt are estimated for this site.

These resources have not been reported in any of the literature searched and do not appear to have been claimed or worked. Access to the property is by an all-weather road north from Sand Pass, NV, approximately 20 mi, then a vehicle trail northwest for 5 mi to within 3 mi of the site.

TABLE 1.--Mining claims and mineralized sites in and adjacent to the Dry Valley Rim study area, NV and CA

Map no.	Name	Summary	Workings and production	Sample and resource data
1	Red Rock zeolite	Chabazite fills voids in altered basalt over an area of about 150 acres with estimated thickness of 200 ft. Deposit centers on basalt dike and may be related to a north-trending fault. Road access is within 3 mi. Not previously reported in literature.	None.	Eleven samples were taken; the samples contained between 36% and 70% chabazite with a sample weighted average of 53%. Ammonia cation exchange capacities for two samples were 1.5 (50% chabazite) and 1.84 (70% chabazite) meq per gm. The deposit contains an estimated 70 million tons of subeconomic zeolite-bearing resources.
*2	Capricorn claims (Sand Pass Bentonite)	Remnant pediment or fan of Pre-Lake Lahontan alluvial sediments over an area of about 300 acres with an estimated thickness of 50 ft. Material consists of more than 30% montmorillonoid clay, less than 30% feldspar, and less than 10% each calcite, gypsum, and diatoms.	Three trenches between 20 and 100 ft long and up to 3 ft deep and one pit 2 ft deep and 5 ft in diameter. No production.	Twelve samples of alluvial sediment were taken; ten of these samples analyzed by X-ray diffraction contained over 30% montmorillonoid clay. All twelve samples were analyzed for oxide content by whole rock analysis (ICP) and for loss on ignition (wet chemical) as a screen for pozzolan suitability. Only one sample passed all chemical standards. Other samples had excess moisture and loss on ignition. Two samples submitted for pozzolan activity index; both failed ASTM standards. None of the samples had visible bentonitic character.
3	Rocky Springs zeolite	Chabazite fills voids in altered basalt over an area of about 20 acres with estimated thickness of 25 ft. The deposit may be related to a north-trending fault.	None.	Four samples taken contained between 10% and 45% chabazite with a weighted average of 29%.
4	Willow Springs zeolite	Chabazite fills voids in altered basalt over an area of about 70 acres with estimated thickness of 100 ft. The deposit may be related to a north-trending fault.	None.	Three samples taken contained from 35% to 65% chabazite with a weighted average of 52%. One sample had an ammonia cation exchange capacity of 1.46 meq/gm (63% chabazite). The deposit contains an estimated 15 million tons of subeconomic zeolite-bearing resources.
5	Broken Shovel claims	Perlite zone up to 125 ft thick, 100 ft wide, and 700 ft long outcrops in basalt. Perlite outcrops locally over a distance of 1 1/4 mi with a northerly trend along the range front.	No apparent recent work on these claims located in 1955.	Eleven samples of perlitic material were taken and checked optically. Eight had good perlitic texture and estimated glass content ranged from 50% to 95%. One sample tested for expansion had a furnace yield of 95.5%, a negligible sinker fraction, compacted density of 12 lb/cu ft, and high compaction resistance of 97 and 270 lb/sq in of 1 in. and 2 in. pressure, respectively. The largest exposed portion of the deposit contains an estimated 100,000 tons of perlite that would be suitable for lightweight aggregate.

*Outside study area boundary.

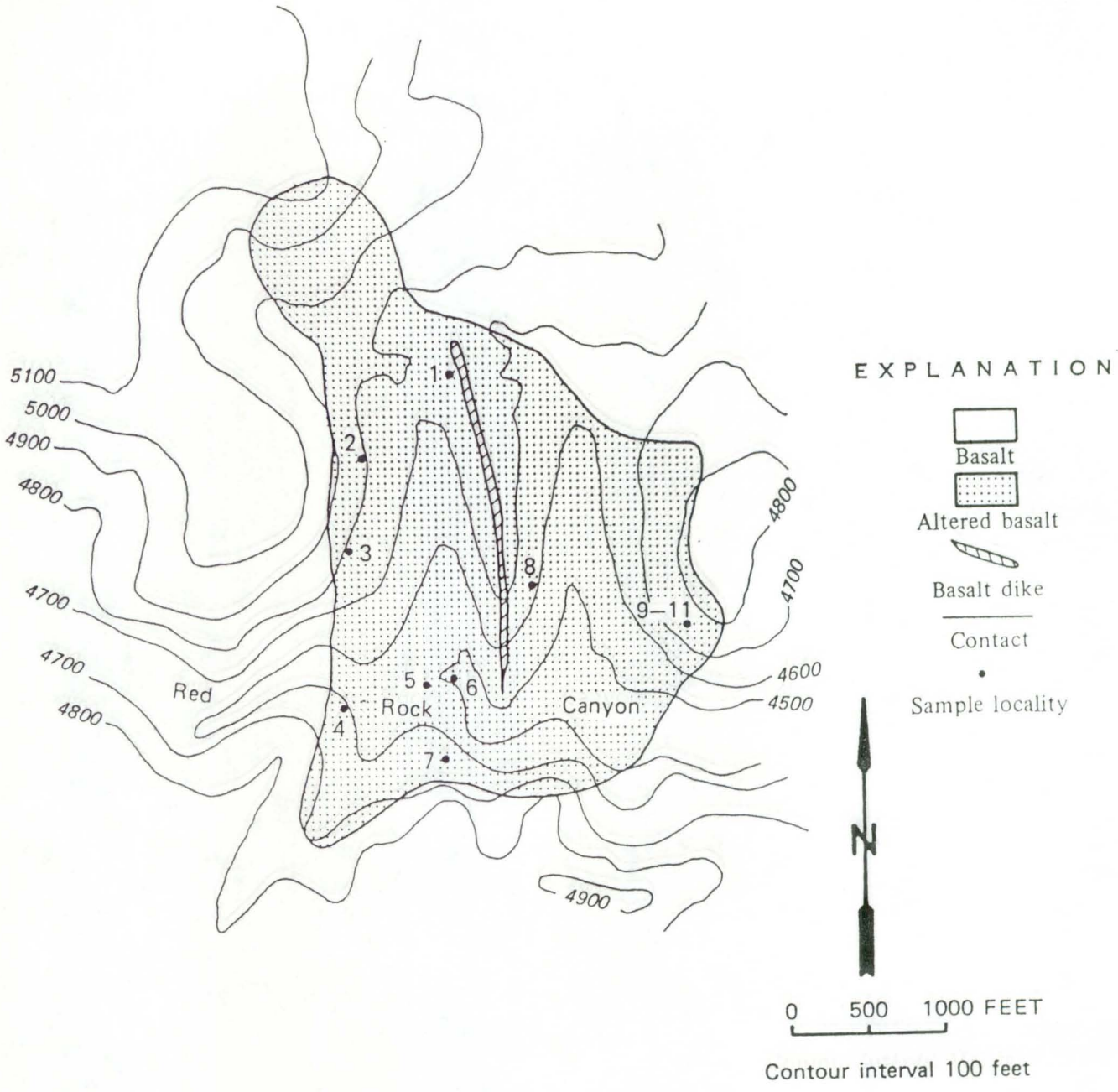

FIGURE 3.– Red Rock zeolite site

TABLE 2.--Sample analysis, Red Rock zeolite site

[NA, not applicable; --, not analyzed]

Sample				Chabazite (%)	CEC (meq/gm)
No.	Type	Length (ft)	Description		
1	Grab	NA	Brown altered basalt with chabazite amygdules	36	--
2	Chip	2.0	Gray to purple altered basalt with chabazite amygdules	42	--
3	do--	.5	Red altered basalt with chabazite amygdules	59	--
4	do--	20	Gray to purple altered basalt	40	--
5	do--	37	Red altered basalt breccia with chabazite amygdules	50	--
6	do--	6.5	Red altered basalt with chabazite amygdules	45	--
7	do--	42	Gray to purple altered basalt with chabazite amygdules	70	1.84
8	do--	3	Red to gray altered basalt with chabazite amygdules	45	--
9	do--	20	Green to purple altered basalt	50	1.5
10	do--	40	Red-orange altered basalt with chabazite amygdules	60	--
11	do--	75	Red altered basalt with chabazite amygdules	45	--

Willow Springs

The geology of this site is nearly identical to the Red Rock; however, no basalt dike is evident. A range front fault is less than 1 mi east of the site. The material appears to be flat lying and is kidney-shaped in plan view covering an area of approximately 70 acres between 4,800 ft and 5,100 ft elevation (fig 4). Average thickness is about 100 ft. Three samples analyzed by x-ray diffraction contained from 35 to 65 percent chabazite with a weighted average of 52 percent (table 3). Ammonia cation exchange capacity for one sample was 1.46 meq per gm (65 percent chabazite) . Fifteen million tons of subeconomic resources of chabazite-bearing altered basalt are estimated to be present. Because of its small size, this deposit's potential for development is dependent upon development of the Red Rock resource.

As with the Red Rock resource, these resources have not been reported in any of the literature searched and do not appear to have been claimed or worked. Access to this area is by an all-weather road which leads north from Sand Pass, NV, about 10 mi to where a vehicle trail leads about 7 mi east to Willow Springs. The site is about 0.5 mi northwest from Willow Springs.

APPRAISAL OF MINERAL RESOURCES

No metallic mineral resources were identified within or adjacent to the study area. However, subeconomic zeolite (chabazite) resources and occurrences of perlite and alluvial sediment containing montmorillonoid clay were identified. These commodities are industrial minerals and, therefore, are very market sensitive.

The Red Rock and Willow Springs zeolite areas contain an estimated 85 million tons of identified subeconomic resources. Upgrading this material from its approximate 50 percent chabazite to a level near 95 percent might make it competitive with synthetic zeolites having molecular sieve properties similar to chabazite. A nearby market for animal husbandry or soil amendment could make the material valuable in its present form. However, the high level of red iron coloration is not a desirable quality. The occurrence of chabazite at Rocky Springs is too low grade to constitute a resource.

A preliminary estimate of mining costs indicates that the zeolite-bearing material at Red Rock and Willow Springs could be mined by surface methods at a rate of 50 tons per day, crushed to 1/4 in., and transported to a railhead at Sand Springs at a cost of about $20 per ton. Rail transportation costs would depend on destination. Some work has been done on upgrading zeolite deposits in Arizona (Mondale and others, 1978). The process consists of grinding to liberation size and gravity concentration. The zeolite concentration occurs in the

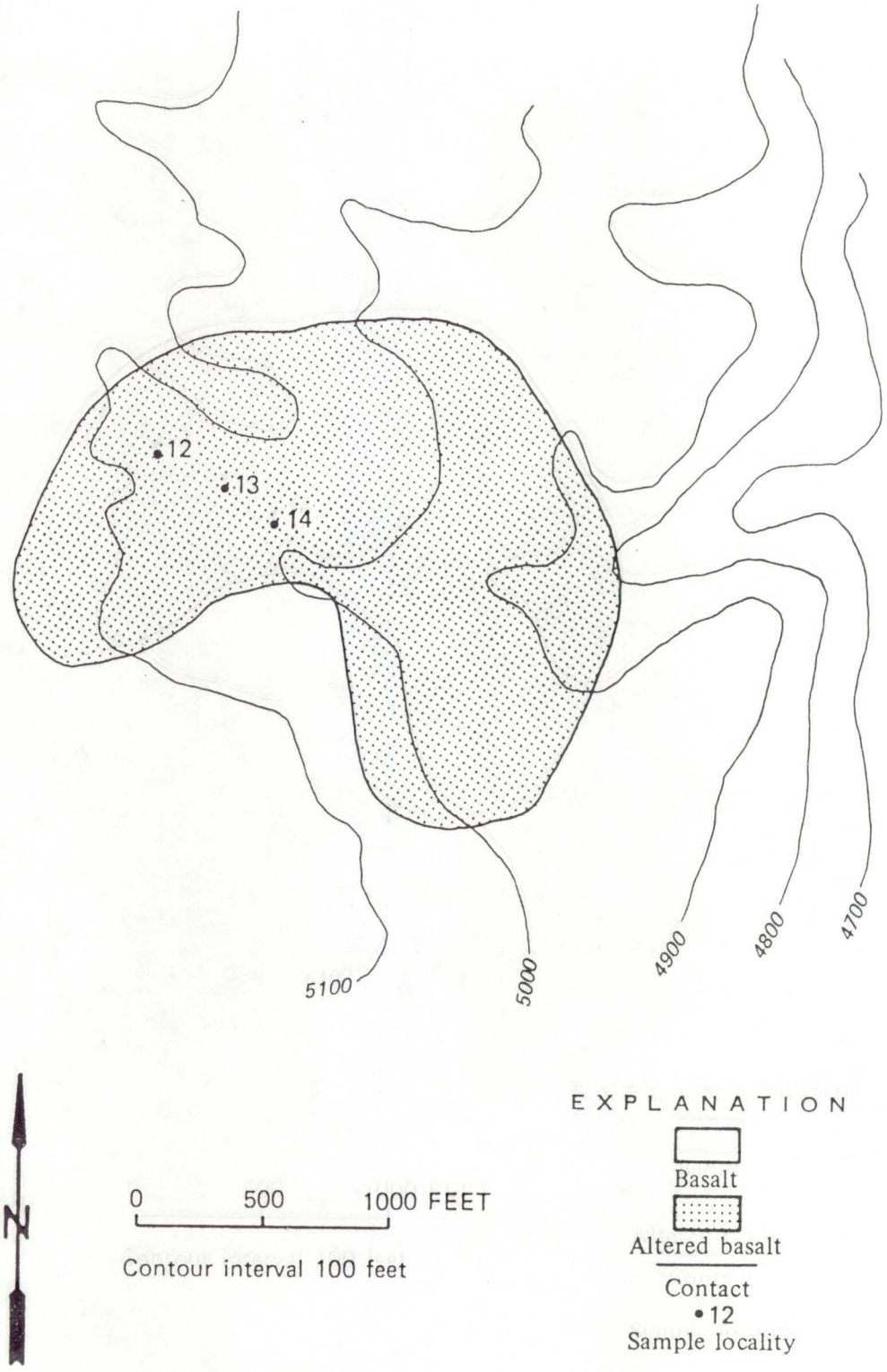

FIGURE 4.– Willow Springs zeolite site

TABLE 3.--Sample analyses, Willow Springs zeolite site

[--, not analyzed]

Sample				Chabazite	CEC
No.	Type	Length (ft)	Description	(%)	(meq/gm)
12	Chip	8	Red altered basalt with chabazite amygdules	45	--
13	do--	6	Red and green altered basalt with chabazite and calcite amygdules	35	--
14	do--	13	Gray altered basalt with chabazite amygdules	65	1.46

lightweight "tailings" fraction. Before milling costs for the Red Rock and Willow Springs deposits can be determined, beneficiation tests are needed. A detailed marketability study of these particular deposits is also neccessary before the economics of minability can be accurately determined. Depending on end use, the resource has a value of between $30 and $2,000 per ton f.o.b. the mine (unpublished USBM studies). The most probable uses for such material would be agricultural such as a soil amendment or as an ammonia absorbant in animal husbandry. These uses would not require beneficiation, and cation exchange capacities indicate the material is well suited to these uses.

A 100,000 ton occurrence of perlite is on the Broken Shovel claims. Although the perlite material is suitable for use as lightweight aggregate, the occurrence is small in comparison to major producers and is distant from expanding plants in southern California. Over 80 percent of U.S. production of raw perlite comes from mines with reserves of tens of millions of tons. The average production from smaller mines is about 5,000 tons per year, and because of losses in mining and milling, the actual production of material is between 15,000 and 20,000 tons per year (E. C. Meisinger, USBM, personal commun.). This level of production at the Broken Shovel property would yield a mine life between five and seven years. If considered for perlite production combined with other nearby deposits at Black Diamond canyon (estimated 1 million tons) and Skedaddle Mountain (184,000 tons) (Munts, 1987), this occurrence might become a resource.

Perlite from the Broken Shovel claims could be mined at a rate of 50 tons per day (10,000 tons per year), crushed to minus 5/8 in. and transported to a railhead at Sand Springs for about $17 per ton. This would yield a usable product of 15 tons per day (3,000 tons per year) at a cost of $57 per ton of usable product. The average price for raw perlite during 1985 was $34 per ton f.o.b. the mine. The cost to transport perlite from Sand Springs to an expander in Portland, OR or Los Angeles, CA, would be approximately $30 to $40 per ton, respectively. Because the market for perlite is currently being met by established producers with large reserves, production of perlite from this area is not expected within the foreseeable future.

The size and accessibility of the montmorillonoid clay in alluvial sediment on the Capricorn claims are positive factors for development should the material prove suitable and marketable. Because of the proximity of the Lassenite pozzolan plant and the similarity of material at the Capricorn claims with that being processed at the plant, the material was tested for pozzolanic properties. Of 12 samples analyzed for pozzolan according to ASTM standards, only one had suitable chemical properties. Development of this property is not expected in the near future.

Seven reconnaissance placer samples were taken from streams in the study area. One of these samples from Skedaddle Creek near the California-Nevada state line contained 0.018 mg gold. No other samples including those above or below this point on Skedaddle Creek contained any gold. Therefore, a gold resource is not indicated.

REFERENCES

ASTM, 1985, 1985 Annual book of ASTM standards--section 4, construction: vol. 04.02, Concrete and mineral aggregates, designation CG18-85, fly ash and raw or calcined natural pozzolan for use as a mineral admixture in portland cement concrete, 4 p.

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

Geodata International, Inc., 1978, Aerial radiometric and magnetic survey, Lovelock national topographic map, Nevada, v. 1: U.S. Department of Energy GJBX - 125 '78, 54 p. with maps

Garside, L. J., 1974, Geothermal exploration and development in Nevada through 1973: Nevada Bureau of Mines and Geology Report 21, 12 p.

Garside, L. J. and Schilling, J. H., 1979, Thermal waters of Nevada: Nevada Bureau of Mines and Geology Bulletin 91, 163 p.

Hill, J. M., 1912, The mining districts of the western United States: U.S. Geological Survey Bulletin 507, 309 p.

Horton, R. C., 1964, Hot springs, sinter deposits, and volcanic cinder cones in Nevada: Nevada Bureau of Mines Map 25, scale 1:1,000,000.

Jones, R. B., and Papke, K. G., 1984, Active mines and oil fields in Nevada - 1983: Nevada Bureau of Mines and Geology Map 84, scale 1:1,000,000.

Lefond, S. J., ed., 1983, Industrial minerals and rocks, 5th edition, vol. 2: New York, New York, American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., p. 723-1446.

Lincoln, F. C., 1923, Mining districts and mineral resources of Nevada: Nevada Newsletter Publishing Company, 280 p.

MINOBRAS, 1973, Nevada industrial minerals, 62 p.

Mondale, K. D., Mumpton, F. A., and Aplan, F. F., 1978, Beneficiation of natural zeolites from Bowie, Arizona: A preliminary report in Sand, L. B. and Mumpton, F. A. eds., Natural zeolites, occurrence, properties, use: Oxford, Pergammon Press, p. 527-537.

Mumpton, F. A., 1983, Commerical utilization of natural zeolites, in Lefond, S. J., ed., Industrial minerals and rocks, 5th edition, vol. 2: New York, New York, American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc., p. 1418-1431.

Munts, S. R., 1987, Mineral resources of the Skedaddle Mountains study area, Lassen County, CA, and Washoe County, NV: U.S. Bureau of Mines Open-File Report MLA ___-87.