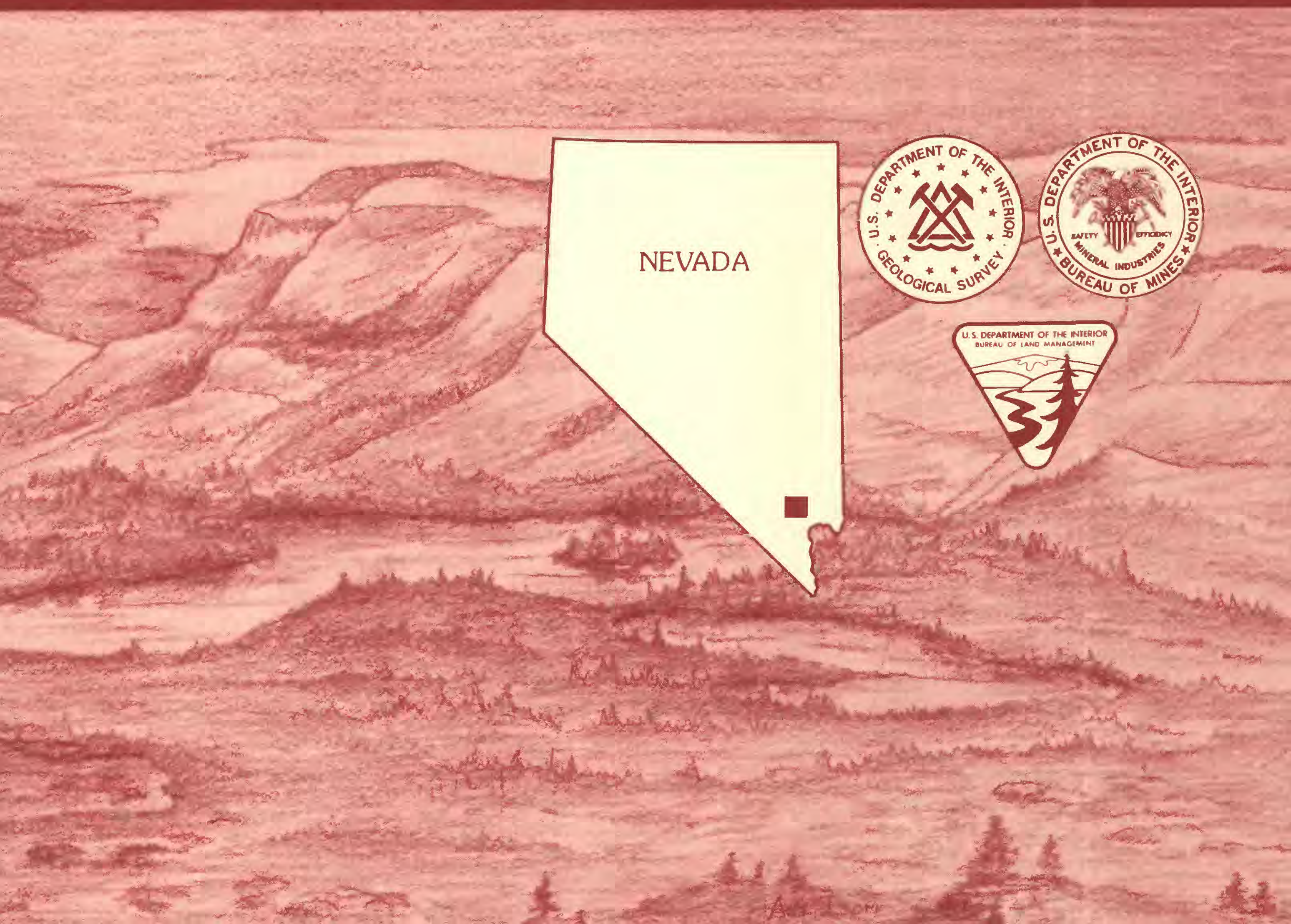
Mineral Resources of the Meadow Valley Range Wilderness Study Area, Lincoln and Clark Counties, Nevada

U.S. GEOLOGICAL SURVEY BULLETIN 1729–C



Chapter C

Mineral Resources of the Meadow Valley Range Wilderness Study Area, Lincoln and Clark Counties, Nevada

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U.S. GEOLOGICAL SURVEY BULLETIN 1729

MINERAL RESOURCES OF WILDERNESS STUDY AREAS:
SOUTHEASTERN NEVADA

DEPARTMENT OF THE INTERIOR
DONALD PAUL HODEL, Secretary

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

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STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Area

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U.S. Geological Survey and the U.S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a mineral survey of a part of the Meadow Valley Range (NV-050-156) Wilderness Study Area, Lincoln and Clark Counties, Nevada.

CONTENTS

FIGURES

TABLE

Mineral Resources of the Meadow Valley Range Wilderness Study Area, Lincoln and Clark Counties, Nevada[1]

By E.H. Pampeyan *and* H.R. Blank, Jr.
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SUMMARY

Abstract

The Meadow Valley Range Wilderness Study Area (NV-050-156) encompasses most of the Meadow Valley Mountains, Lincoln and Clark Counties, Nevada. At the request of the U.S. Bureau of Land Management, mineral surveys were conducted on 97,180 acres of the wilderness study area. In this report, references to the wilderness study area or the study area refer only to the area for which mineral surveys were requested. Fieldwork for this report was carried out between 1983 and 1986 to assess the identified resources (known) and mineral resource potential (undiscovered) of the study area. There are no mining districts, mines, or active claims within the study area. The Johnston and Fitchett prospect inside the northern part of the study area has more than 3 million tons of indicated and inferred marginal perlite reserves, and the surrounding area has high potential for perlite and moderate potential for zeolite minerals associated with the perlite; occurrences of agate, marekanite (Apache tears), and opaline rock, all traditionally of interest to mineral collectors, also are associated with the perlite and have a moderate resource potential. The Bradshaw vanadium prospect outside the west edge of the study area has 800,000 tons of black shale containing inferred subeconomic resources of cadmium, chromium, copper, molybdenum, nickel, phosphorous, silver, vanadium, and zinc that may extend down dip into the study area. There is a high potential for vanadium west of the study area and an unknown potential for vanadium immediately east of the outcrop in the study area. In the southernmost part of the study area silicified limestone at the D and D prospect contains trace amounts of silver and the Fry and Jeffers claim is on an insignificant radioactive anomaly. There is no potential for silver at the D and D prospect and no potential for uranium or thorium at the Fry and Jeffers claim.

Heavy-mineral concentrates from stream-sediment samples in the north half of the study area suggest a moderate potential area and a separate low potential area for rhyolite-hosted tin resources and a low potential for carbonate-hosted silver, copper, lead, and zinc resources. There is low potential for carbonate-hosted gold, silver, lead, and zinc resources in the southwestern part of the study area. In the southern part of the study area, an area has low potential for carbonate-hosted copper, lead, and zinc resources.

Evaporite deposits of gypsum are present adjacent to the east side of the study area but they do not extend into the area and have no resource potential there. Silica in the form of quartzite is present in the south half of the study area but has no resource potential. A small amount of ornamental stone has been quarried outside the west edge of the study area, but there is no resource potential for this stone within the area. The southern one-third of the study area has high resource potential for limestone inferred to be of high purity. The study area also has a high potential for resources of sand and gravel in the alluvial deposits. There is a moderate potential for oil and gas resources in the study area. There is no potential for geothermal resources in the study area.

Character and Setting

The Meadow Valley Range Wilderness Study Area includes most of the Meadow Valley Mountains, a narrow north-northeast-trending range in Lincoln and Clark Counties, southeastern Nevada (fig. 1). The study area is about 36 mi long and ranges from 2 to 7 mi in width, contains about 97,180 acres, and has a maximum topographic relief along the west edge of about 2,800 ft. The south end of the study area is about 50 mi north of Las Vegas. Access to much of the study area from the west side is limited or difficult owing to cliff-forming rock units; the east side can be reached by traversing dry washes branching from Meadow Valley Wash.

[1]Publication authorized by the Director, U.S. Geological Survey, January 20, 1988.

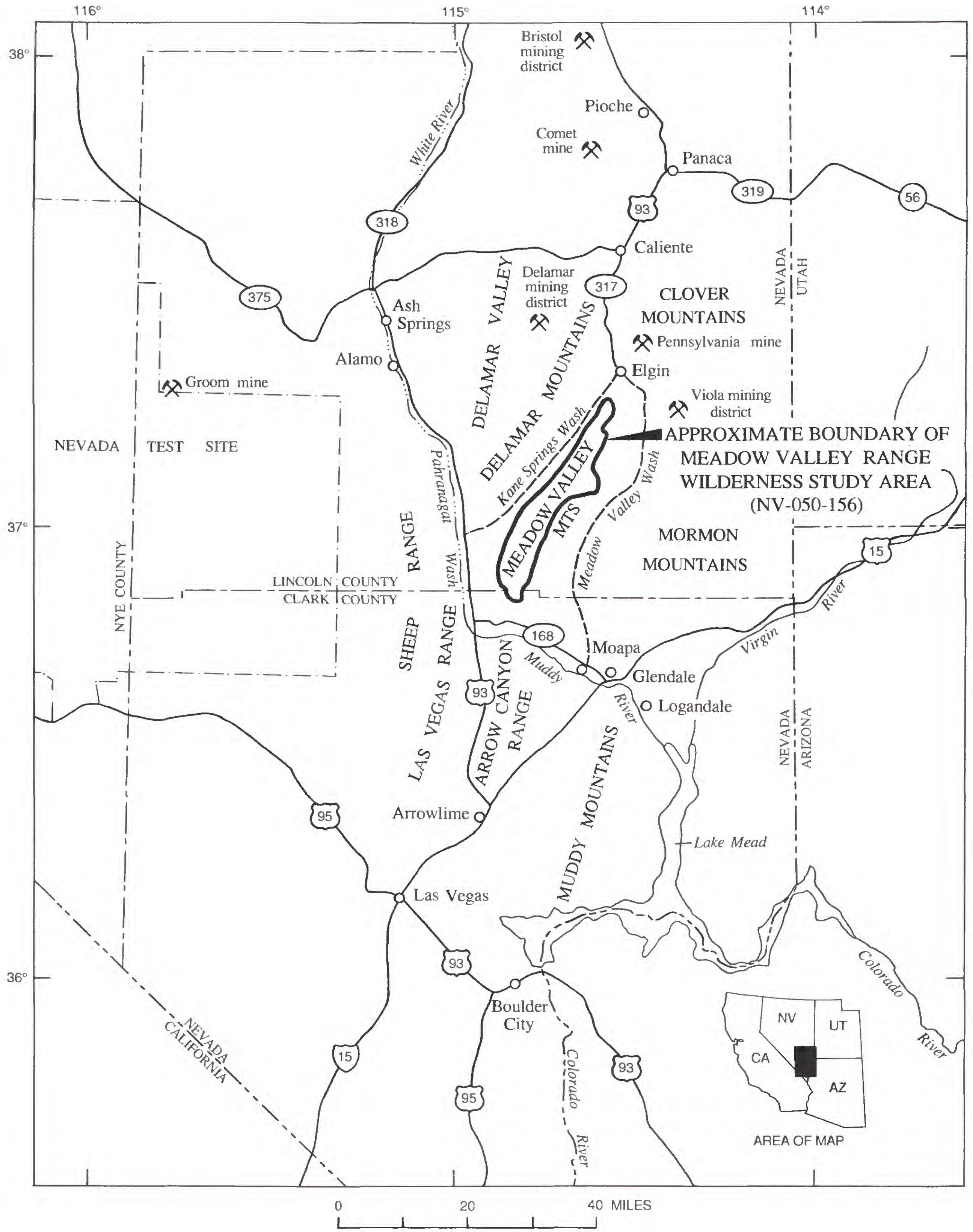


Figure 1. Index map showing location of the Meadow Valley Range Wilderness Study Area, Lincoln and Clark Counties, Nevada.

The south half of the study area is underlain by faulted and folded marine sedimentary rocks of Cambrian through Triassic age (see appendix for Geologic Time Chart). Limestone and dolomite are the dominant rock types, but some shale, sandstone, and siltstone are present near the top of the sedimentary sequence. In the north half of the area these rocks are overlain by volcanic rocks of Miocene age (24 to 11 million years before present, Ma), predominantly rhyolitic welded tuffs locally interlayered with rhyolitic and basaltic flows and cut by rhyolitic dikes. The sedimentary and volcanic rocks are overlapped by Miocene to Holocene nonmarine sediments.

Identified Mineral Resources

Perlite is the only identified mineral resource in the Meadow Valley Range Wilderness Study Area. The northern part of the study area is underlain by Tertiary volcanic rocks containing perlite deposits and associated zeolite occurrences. At least 2.6 million tons of indicated marginal perlite reserves and 1 million tons of inferred marginal perlite reserves, with little or no overburden, are present at the Johnston and Fitchett prospect (fig. 2, No. 2). Expansion tests in a laboratory-scale furnace suggest that this perlite is suitable for several commercial applications. Rock samples taken from the Johnston and Fitchett prospect contain the zeolite minerals clinoptilolite and mordenite in occurrences adjacent to the perlite deposits.

At the Bradshaw vanadium prospect, just outside the study area (fig. 2, No. 4), a lens of Paleozoic metalliferous black shale contains relatively high concentrations of cadmium, chromium, copper, molybdenum, nickel, phosphorous, silver, vanadium, and zinc. About 800,000 tons of black shale containing inferred subeconomic resources of these metals are at the Bradshaw prospect. This black shale may extend downdip eastward into the study area but its extent is unknown due to a thick cover of Tertiary rocks.

Mineral Resource Potential

Analyses of samples containing perlite and zeolites suggest a high potential for perlite and a moderate potential for zeolites, agate, marekanite (Apache tears), and opaline rock in the north end of the study area. A metalliferous black shale outcrop west of the study area has a high potential for vanadium, but the resource potential of vanadium immediately adjacent is unknown. In addition, geochemical analyses of nonmagnetic heavy-mineral stream-sediment concentrates show anomalously high values of tin in the northern part of the study area, where Tertiary peralkaline volcanic rocks are cut by rhyolite dikes. Although none was seen in place, topaz crystals and topaz-bearing rhyolite float were found in the area of high tin values. Other anomalies of antimony, lead, molybdenum, tungsten, and zinc in the volcanic terrane may represent a carbonate-hosted silver-lead-zinc-copper replacement deposit or less likely a tungsten skarn. The mineral potential for resources of silver, lead, zinc, and copper resources in the volcanic terrane is low; the high tin values, however, along with the presence of arsenic, antimony, beryllium, bismuth, and topaz suggest moderate and low potential respectively for resources of tin in two areas in the volcanic terrane.

Along the western edge of the carbonate terrane, anomalous values of cobalt, copper, lead, molybdenum, nickel, and zinc may represent leakage along range-front faults from carbonate-hosted replacement copper-lead-zinc mineralization, and high values of arsenic, along with antimony and molybdenum, may represent leakage along the range-front faults of carbonate-hosted gold-silver-lead-zinc vein or lead-zinc replacement deposits. No evidence of metallic mineralization was seen, however, and the southwestern part of the study area is assigned a low mineral resource potential for gold, silver, lead, and zinc resources, and the southern part of the study area is assigned a low resource potential for copper, lead, and zinc. In the southernmost part of the study area at the D and D prospect, two samples from the contact between limestone and overlying volcanic rock contained trace amounts of silver. The geologic setting and sample analyses suggest that this area has no resource potential for silver. The Fry and Jeffers claim at the south edge of the study area is on an occurrence of low-level radioactivity. Sample analyses and geophysical data indicate that the area has no resource potential for uranium or thorium.

In the southern one-third of the study area, in areas underlain by pre-Tertiary sedimentary rocks (fig. 2), there is a high resource potential for limestone, some of which is expected to be of high purity; these rocks are exposed in outcrop for more than 9 mi. In addition, there is a high potential for resources of sand and gravel in alluvial deposits of the study area, but these deposits are quite far from markets relative to other large sources. Low-grade deposits of gypsum exist east of the study area in Permian red beds, but there is no resource potential for gypsum within the area. Color-banded siltstone (Nevada Wonder Rock) quarried near the west edge of the study area has no resource potential within the area. Silica in the form of quartzite is present in the study area but has no resource potential.

The entire study area is in a region previously designated as having medium potential for occurrence of oil and gas accumulation in Mississippian source rocks (Sandberg, 1983). According to A.K. Chamberlain (oral commun., 1987), however, structural, stratigraphic, and other data indicate high potential for oil and gas. On the basis of this information there is a moderate resource potential for oil and gas in the study area. In 1972, Texaco, Inc., drilled a well about 2 mi east of the study area to test the favorable zone, but the well subsequently was abandoned. There is no evidence of recent or currently active geothermal activity in the study area, and there is no potential for geothermal resources.

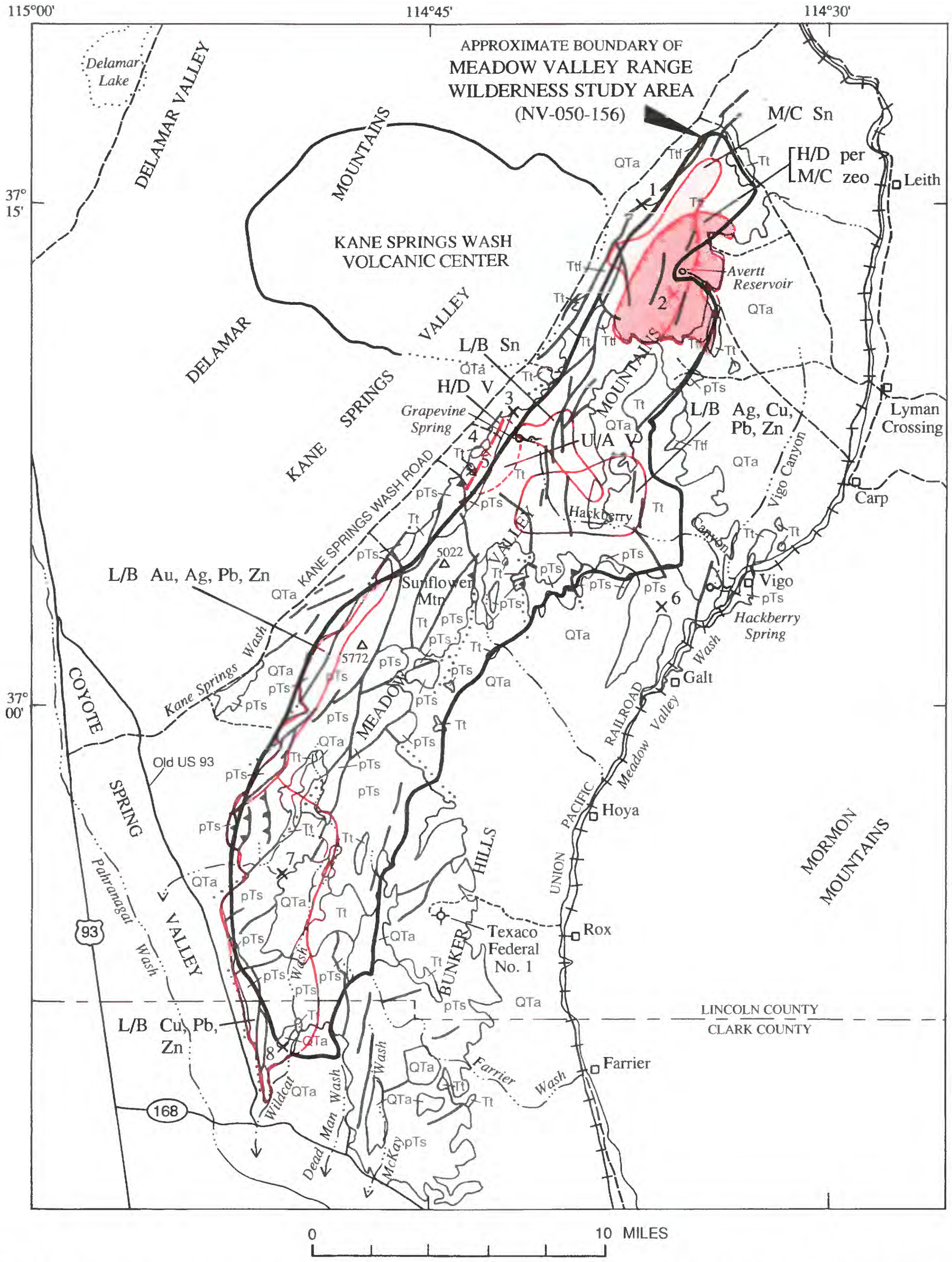


Figure 2. Mineral resource potential and generalized geology of the Meadow Valley Range Wilderness Study Area, Lincoln and Clark Counties, Nevada. Southern one-third of study area has high potential, certainty level C, for limestone resources; entire study area has moderate potential, certainty level B, for oil and gas resources; areas of Quaternary-Tertiary alluvial deposits have high potential, certainty level D, for sand and gravel.

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 the appendixes for the definition of levels of mineral resource potential, certainty of assessment, and classification of identified resources.

EXPLANATION

Area with high mineral resource potential

Area with moderate mineral resource potential

Area with low mineral resource potential

Area with unknown mineral resource potential

2 × Prospect with identified resource—See table 1 for description

See appendixes for definition of levels of mineral resource potential (L, M, H, U) and level of assessment (A, B, C, D)

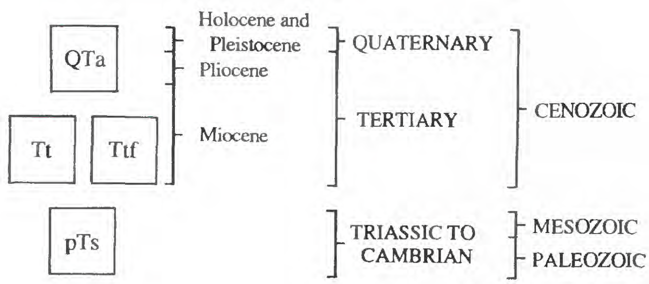
Commodities

Cu	Copper
Au	Gold
Pb	Lead
Ag	Silver
Sn	Tin
V	Vanadium
Zn	Zinc
per	Perlite
zeo	Zeolites, agate, marekanite (Apache tears), opaline rock

6 × Quarry, prospect, or claim

1. Sunshine prospect
2. Johnston and Fitchett prospect
3 Unnamed prospect
4. Bradshaw prospect
5. Wonder Rock quarry
6. Robb prospect
7. D and D prospect
8. Fry and Jeffers claim

Correlation of map units



Description of map units

Qta	Alluvial and lacustrine deposits (Holocene to Miocene)
Tt	Dacitic to rhyolitic welded tuffs with some interlayered rhyolitic and basaltic flows (Miocene)
Ttf	Interlayered rhyolitic welded tuffs and rhyolitic flows (Miocene)—Includes some rhyolitic dikes
pTs	Sedimentary rocks (pre-Tertiary)—Includes Cambrian to Triassic limestone and dolomite with minor amounts of shale, sandstone, and siltstone

Contact

Fault—Dotted where concealed

Thrust fault—Dotted where concealed; sawteeth on upper plate

Paved road

Graded gravel road

Unimproved road or jeep trail

5022 Elevation—In feet

Oil test well

Figure 2. Continued.

Area Description

The Meadow Valley Range Wilderness Study Area covers approximately 97,180 acres of the Meadow Valley Mountains north of Las Vegas in southern Nevada (fig. 1). The terrain is moderate to rugged with steep bedrock scarps on the the west side and sharply incised gentle to moderate alluviated slopes on the east side. The highest point is an unnamed ridge near the center of the study area that stands 5,772 ft above sea level, some 2,800 ft above the adjacent floor of Kane Springs Valley (fig. 2). The climate is arid and the vegetation sparse. Creosote bush, blackbrush, sagebrush, rabbit brush, several species of yucca, including Joshua tree and Mojave yucca, agave, nolina, and cholla, barrel and prickly pear cacti are common on the lower slopes; juniper and pinon are present but rare even in the higher parts of the study area. Following an occasional unusually wet winter the lower alluviated slopes are covered with many varieties of wild flowers and grasses. Bighorn sheep, Gila monsters, and other mammals and reptiles live in the area, and golden eagles, prairie falcons, and other raptors pass through or nest in the area. Endangered and protected species of plant and animal life that may exist in the area are described in reports by Mozingo and Williams (1980) and the U.S. Bureau of Land Management (1984a, b).

Access to the west side of the study area is by a few old jeep trails that lead eastward from Kane Springs Wash road, a graded gravel road that connects U.S. Highway 93 with Nevada Highway 317 at Elgin, and from old U.S. Highway 93 (fig. 2). The east side of the study area can be reached by arduous four-wheel-drive traverses up a few dry washes that drain into Meadow Valley Wash and intersect the Union Pacific railroad right-of-way. Travel within the study area is mainly by foot.

Previous and Present Investigations

The pre-Tertiary sedimentary rocks of the Meadow Valley Mountains were mapped in reconnaissance in the late 1950's as part of a geologic study of Lincoln (Tschanz and Pampeyan, 1970) and Clark (Longwell and others, 1965) Counties, Nevada, and include studies that described the geology and mineral deposits of the study area. Detailed geologic mapping of small areas in the Meadow Valley Mountains was done by Duley (1957), as part of a stratigraphic study of Mississippian rocks, and by Heston (1982; written commun., 1982), who studied the distribution of trace elements in the Chainman Shale near Grapevine Spring. The Tertiary volcanic rocks were examined by Cook (1965; unpub. data, 1968), who measured stratigraphic sections in the Meadow Valley Mountains, and by Ekren and others (1977), as part of a regional study that refined the Tertiary stratigraphy of Lincoln County. Studies of the Kane Springs Wash volcanic center in the adjacent southern Delamar Mountains were made by Noble (1968) and Novak (1984; 1985). The studies by Cook and Novak provided stratigraphic information useful in the volcanic terrane of the Meadow Valley Mountains. Gypsum resources of the region were described by Jones and Stone (1920) and perlite deposits in and near the Meadow Valley Mountains were evaluated by K.L. Cochran (written commun., 1951). The oil and gas potential of the region including the study area was evaluated by Sandberg (1983).

The U.S. Geological Survey carried out field investigations in the study area from 1983-1986. The work included geochemical sampling of rocks and stream sediments, compilation and analysis of land-based gravity and airborne magnetometer and gamma-ray surveys, and new geologic mapping.

The U.S. Bureau of Mines conducted a library search for information on mines and prospects in and adjacent to the study area. Information was obtained from U.S. Bureau of Land Management mining claim recordation indices, Lincoln and Clark County courthouse records, and the U.S. Bureau of Mines Mineral Industry Location System. Field studies by U.S Bureau of Mines personnel were conducted during 1984 and 1985 to examine and sample prospects in and near the study area. Rock samples were checked for radioactivity and fluorescence and were analyzed for a variety of elements by fire-assay, inductively coupled plasma, chemical, and semiquantitative spectrographic methods. Perlite samples were sent to the New Mexico Bureau of Mines and Mineral Resources for preliminary laboratory-scale evaluation. Zeolite samples were evaluated at the U.S. Bureau of Mines Reno Research Center by X-ray diffraction and chemical methods. Detailed sample analysis methods and results are given in Campbell (1987). Complete results of sample analyses are available from the U.S. Bureau of Mines, Western Field Operations Center, E. 360 Third Avenue, Spokane, WA 99202.

Acknowledgments

The authors gratefully acknowledge James Bradshaw of Caliente, Nevada, for providing information concerning the Bradshaw vanadium prospect, and Paul Henrie and Donald Bradshaw, Caliente, and Henry Rice, Logandale, and other local residents who supplied information on the history of and access to the study area. Richard Gundry of the Caliente district office of the U.S. Bureau of Land Management is thanked for advice on access to the study area and for making records available. J.C. Schulters, D.A. Plume, and J.C. Monroe of the U.S. Geological Survey assisted with the geological mapping, and Terry Neumann, Richard Rains, and Clayton Rumsey of the U.S. Bureau of Mines assisted in the study and sampling of prospects. Randy Wilson of the U.S. Department of Agriculture Soil Conservation Service, Caliente district office, provided information on soil surveys of the Meadow Valley Mountains and surrounding region, and S.D. Ludington of the U.S. Geological Survey was consulted

for information on rhyolite-hosted tin deposits. The oil and gas potential of the region was discussed with A.K. Chamberlain, consulting petroleum geologist, who has conducted detailed stratigraphic studies of Mississippian rocks in Nevada and Utah.

APPRAISAL OF IDENTIFIED RESOURCES

By H.W. Campbell
U.S. Bureau of Mines

Mineral Exploration History

There are no mining districts, mines, or active claims in the study area; the nearest active mine in 1986 was in the Pennsylvania district, about 11 mi north of the study area. No mining claims were held in the study area in 1985; the study area, however, was leased for oil and gas exploration. One quarry and seven prospects were visited during this study (fig. 2, table 1). Two of the prospects are within the study area. One, the Johnston and Fitchett prospect, was located on perlite deposits in the northern part of the study area, and the other, the D and D prospect, was located on an occurrence of silicified limestone in the southern part of the study area. A third prospect, the Fry and Jeffers claim, is on the south boundary of the study area on an insignificant uranium anomaly in black limestone. Two other prospects, the Bradshaw vanadium and the Sunshine, are partly inside the study area. Perlite is the only identified resource within the study area.

Although the Meadow Valley Mountains were prospected many years earlier, the first claims were recorded in December 1945 when Samuel Johnston and O.E. Fitchett of Carp, Nev., began locating placer claims on perlite deposits inside the northernmost part of the study area (fig. 2, No. 2). Only limited discovery work was done on this group of claims, and the prospect was unclaimed at the time of this study. Gypsum deposits in the southeastern part of Lincoln County have been known to exist for many years (Jones and Stone, 1920). These deposits were extensively prospected in the mid-1950's (Tschanz and Pampeyan, 1970, p. 124). The Robb prospect (fig. 2, No. 6) is on the gypsum deposit described by Jones and Stone (1920, p. 158) as being the most promising in the area. No gypsum has been mined from this or other deposits adjacent to the study area. Claims were located in 1962 on outcrops of variegated siltstone of the Mississippian Chainman Shale (fig. 2, No. 5), about 1.5 mi south of Grapevine Spring. A small amount of ornamental stone (Nevada Wonder Rock) was mined at this site, but the deposit has not been worked for many years.

In December 1972 Texaco, Inc., completed a well, the Texaco Federal No. 1 (fig. 2) (Garside and others, 1977, p. 10). The well was spudded on the axis of an anticline in Pennsylvanian and Permian strata of the Bird Spring Formation and bottomed in Lower Mississippian limestone at a total depth of 7,030 ft. No oil or gas shows were reported, and the well subsequently was plugged and abandoned. Since that time all of the study area has been leased for oil and gas exploration, but no other wells have been drilled.

James Bradshaw discovered a metalliferous black shale lens in the Mississippian Chainman Shale near Grapevine Spring and located 14 claims along the 3-mi length of the outcrop in 1978 (fig. 2, No. 4). In 1979, Newmont Mining Co., Noranda Explorations, Inc., and Cominco American, Inc., examined the prospect. The prospect was deemed smaller than expected, and an option to purchase the property was cancelled. The prospect was relocated by Hecla Mining Company in 1985, adjacent to but outside the study area.

Mineral Deposits

Two main types of mineral deposits were examined by the U.S. Bureau of Mines in and adjacent to the study area: (1) nonmetallic mineral materials in volcanic rocks, and (2) sedimentary deposits of metallic and nonmetallic minerals. The volcanic materials include deposits of perlite and occurrences of zeolite minerals, obsidian nodules (marekanites or "Apache tears"), banded agate, and opaline rock. The sedimentary deposits include metalliferous black shale, beds of gypsum, and oxidized sandstone.

Perlite deposits in the study area were examined by K.L. Cochran (written commun., 1951) who estimated 2.68 million tons of indicated marginal and 1 million tons of inferred marginal perlite reserves at the Johnston and Fitchett prospect but reported that at no place was there sufficient concentration to allow mining of more than a few thousand tons from one operation. U.S. Bureau of Mines field observations indicate perlite tonnages in the study area are actually higher than this estimate. For example, more than 3 million tons of marginal reserves (see appendix; U.S. Bureau of Mines and U.S. Geological Survey, 1980, p. 2, 5, fig. 1) of perlite are estimated to exist at a sample site on the Johnston and Fitchett prospect, 1.5 mi southwest of Avertt Reservoir (fig. 2); this site has 52 acres of perlite about 20 ft thick with little or no overburden. In addition, large tonnages are present at several other nearby sites.

Zones of zeolitized rhyolite lava and tuff interlayered with the perlite crop out extensively in the study area. Tests indicate that clinoptilolite is the dominant zeolite mineral but that mordenite also is present in the altered rock.

A lens of metalliferous black shale, a facies of the Mississippian Chainman Shale, is present at the Bradshaw vanadium prospect (fig. 2, No. 4) west of the study area. The black shale has an average thickness of about 12 ft, extends downdip eastward at least 50 ft and is exposed discontinuously in a northeast-southwest direction over a distance of about 3 mi (Heston, 1982, p. 54). There are 800,000 tons of black shale on the Bradshaw prospect containing inferred subeconomic

Table 1. Quarry, prospect, and claim descriptions in and adjacent to the Meadow Valley Range Wilderness Study Area
[*, outside the study area; **, prospect straddles study area boundary]

Map No. (fig. 2)	Name	Summary	Workings	Sample and resource data
1*	Sunshine prospect	A rhyolite dike striking N. 5° E., with a vertical dip, is about 8 ft thick. Yellow devitrified volcanic glass about 0.5 ft wide is along margin of dike.	Bulldozer cut about 20 ft by 30 ft by 6 ft deep.	A chip sample across margin of rhyolite dike contained no gold or silver.
2	Johnston and Fitchett prospect	Perlite occurs as flows, and as irregular bodies in flows that cover several square miles and are associated with thick accumulations of Tertiary volcanic rocks. Zeolite minerals in alteration zones associated with perlite deposits. Apache tears and banded agate abundant near weathered perlite outcrops.	None	Twenty-one perlite and 13 zeolite samples taken. It is inferred that more than 3 million tons of perlite resources are inside study area. Results of extensive testing of 5 perlite samples suggests that these deposits have properties falling within range of commercial deposits. Zeolite mineral clinoptilolite was detected in 12 samples, and 1 sample had mordenite. Agate, Apache tears opaline rock may be of interest to mineral collectors.
3*	Unnamed prospect	Thin veinlets of manganese minerals in altered Leach Canyon Formation (welded tuff). Veinlets sparse and less than 0.25 in. wide.	One prospect pit	Not sampled. Significant as an occurrence but not as a resource.
4**	Bradshaw prospect	A black phosphatic shale zone in Mississippian Chainman Shale contains anomalous concentrations of several metals. Shale unit strikes about N. 10° E. and dips 25° SE. and is composed of black shale and phosphorite intercalated with limestone beds. Metalliferous zone averages about 12 ft thick over a 3-mi strike length.	Six prospect pits	Five samples were taken. An estimated 800,000 tons of subeconomic resources are outside the study area. Average grade of resources is 0.62 oz/ton silver, 0.27 percent vanadium, 4.8 percent P_2O_5, 0.01 percent molybdenum, 0.19 percent zinc, and 0.04 percent nickel (Heston, 1982a). A sixth (grab) sample also contained 300 ppm cadmium, 1,200 ppm chromium, and 130 ppm copper.
5*	Wonder Rock quarry	A siltstone of Mississippian Chainman Shale has yellow, orange, red, and purple Liesegang banding. Small amounts of ornamental stone were quarried.	A quarry 100 ft by 20 ft and two prospect pits about 0.5 mi SSE of the quarry.	Color-banded siltstone of Chainman Shale was not seen inside study area.
6*	Robb prospect	Gypsum in a Permian red-bed unit. The deposit is about 3,600 ft long and 1,000 ft wide (Jones and Stone, 1920). Gypsum beds dip about 60° NW. and range in thickness from a few inches to 20 ft.	None	A 3-ft chip sample across a gypsum bed contained 92.6 percent total $CaSO_4xH_2O$; 0.12 percent free H_20, 19.1 percent combined H_2O, 90.7 percent $CaSO_4 2H_2O$, and 1.9 percent $CaSO_4 \cdot 1/2H_20$.
7	D and D prospect	Silicified and iron-stained limestone of Devonian Guilmette Formation in contact zone beneath partially eroded, thick, canyon-filling rhyolite ignimbrite of Kane Wash Tuff. Quartz veinlets in silicified limestone. Margin of rhyolite contains crystals of labradorite feldspar as much as 0.5 in. long.	None	Two samples taken. A 6-ft chip sample across rhyolite margin and grab sample of silicified limestone contained 0.01 and 0.02 oz/ton silver, respectively. No gold detected. Feldspar crystals may be of interest to mineral collectors.
8**	Fry and Jeffers claim	Slight radioactivity associated with black Paleozoic limestone. No veins or other conspicuous geologic structures are associated with occurrence (U.S. Atomic Energy Commission, 1954).	None	Chemical analyses of two soil samples from top and base of range front had 0.009 percent and 0.011 percent U_3O_8, respectively. Highest scale reading was 100 counts per second (background was 60 counts per second) on a Halrass scintillometer (U.S. Atomic Energy Commission, 1954).

resources of cadmium, chromium, copper, molybdenum, nickel, phosphorous, silver, vanadium, and zinc. Complex faulting and folding makes prediction of the lateral extent of the metalliferous zone in the Chainman Shale difficult without subsurface data, as plastic deformation of the incompetent shale beds may have thickened, thinned, or caused lateral discontinuities, but the 25° SE.-dip of surrounding strata and the proximity to the study area boundary suggest that the zone may extend into the study area beneath Tertiary rocks. An aerial reconnaissance by helicopter and two ground traverses across the formation within the study area failed to identify any metalliferous black shale in poorly exposed and weathered shale units.

Slight radioactivity associated with black Paleozoic limestone near the south boundary of the study area (fig. 2, No. 8) was reported. (U.S. Atomic Energy Commission, 1954; Garside, 1973) at the Fry and Jeffers claim but was not considered to be significant.

Gypsum occurs in Permian red beds at the Robb prospect (fig. 2, No. 6) east of the study area. No evidence of gypsum resources extending into the study area was found. Ornamental stone (Nevada Wonder Rock), which was quarried west of the study area (fig. 2, No. 5), does not extend into the study area.

Sand and gravel, and other industrial minerals such as possibly high-calcium limestone and silica as quartzite, are abundant in the study area, but these occurrences are not unique and other suitable deposits are closer to prospective markets. They are therefore not classified as identified resources. An occurrence of scattered crystals of labradorite feldspar of possible interest to mineral collectors is at the D and D prospect (fig. 2, No. 7); banded agate, opaline rock, and Apache tears, also of interest to collectors, are present at the Johnston and Fitchett prospect (fig. 2, No. 2).

Appraisal of Mineral Resources

Perlite is abundant within the study area at and near the Johnston and Fitchett prospect. At least 3 million tons of indicated and inferred marginal reserves of perlite, with little or no overburden, are identified. Expansion tests in a laboratory-scale furnace suggest that this perlite compares favorably with commercial perlite ores and is suitable for several commercial applications. Perlite is used in a variety of densities in a variety of products; therefore, less-than-maximum values of expanded density can be profitable provided a market exists or can be developed (Barker and Hingten, 1985, p. 1).

A preliminary feasibility estimate suggests that perlite could be mined, processed, and transported to the railroad at Carp for roughly $20/ton (Campbell, 1987). The estimated average value of perlite at the mine in 1985 was $34/ton (Meisinger, 1986, p. 114). Although this estimate suggests perlite could be mined profitably from the study area, it is unlikely that these perlite deposits will be mined in the forseeable future because higher quality deposits of large size are already developed. For example, the Mackie mine, 30 mi northwest of the study area, has about 1 million tons of perlite reserves and supplies the regional demand for perlite (Neumann, 1986, p. 13, 16).

Rock samples taken from the Johnston and Fitchett prospect inside the study area contained the zeolite minerals clinoptilolite and mordenite in alteration zones adjacent to the perlite deposits over several square miles. Because the zeolite occurrences are closely associated with perlite, these two commodities might be developed jointly. However, development of zeolite deposits in the study area is unlikely because many high-quality zeolite deposits are located closer to prospective markets.

The metalliferous black shale of the Bradshaw prospect contains relatively high concentrations of cadmium, chromium, copper, molybdenum, nickel, phosphorous, silver, vanadium, and zinc. About 800,000 tons of black shale containing inferred subeconomic resources of these metals occurs in the outcrop area. Resource estimates are based on data collected by Cominco American, Inc., which include geologic mapping, drill hole data, and results of sample analyses. A tonnage factor of 12 cubic feet per ton was used. This deposit has many characteristics that are similar to large syngenetic metal-rich black shale deposits elsewhere in the western United States (Desborough and Poole, 1983, p. 99-109; Ketner, 1982). Although considerable exploratory work was done at the prospect, the character and extent of the deposit still are uncertain.

Recovery of vanadium from black shales is technologically feasible (Brooks and Potter, 1974; Hyashi and others, 1985); however, to date the process is not economic (Kuck, 1985, p. 902). These black shales are fine grained, and metals in the shale are ionically bound to other elements making physical separation and extraction difficult (see Desborough and Poole, 1983, p. 100). Production of vanadium from black shales may become economic when combined with the recovery of other valuable metals (Kuck, 1985, p. 902).

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

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Geology

The Meadow Valley Range Wilderness Study Area is underlain by a sequence of folded and faulted sedimentary rocks of Cambrian through Triassic age. These rocks are overlain by an unconformable sequence of interlayered volcanic tuffs and flows of Miocene age, much of which originated just west of the study area in the Kane Springs Wash volcanic center (Noble, 1968; Novak, 1984; 1985).

The stratigraphy and structure of the study area are summarized by Tschanz and Pampeyan (1970) and Ekren and others (1977). A composite stratigraphic section of pre-Tertiary marine sedimentary rocks about 20,000 ft thick is present near the study area. No single location displays the full composite section because of faulting, folding, and erosion. The Cambrian through Permian part of the section is about 80 percent limestone and dolomite and about 20 percent clastic rocks, including shale, siltstone, and sandstone. The clastic rocks are most common in the Cambrian, Mississippian, and Permian parts of the section. About half of the Triassic rocks consist of sandy limestone; the other half consists of sandstone, siltstone, shale, and traces of siliceous conglomerate. Much of the Permian clastic rocks are red-bed deposits, some of which contain bedded deposits of gypsum. Locally the Mississippian rocks contain phosphatic shale beds that have been prospected for vanadium. The uppermost Devonian rocks in the southern one-third of the study area consist of white to light-gray limestone, the same unit that is mined 35 mi south at Arrowlime for high-calcium (98.05 percent calcium carbonate) limestone (Longwell and others, 1965, p. 156-157).

The pre-Tertiary strata of the study area are overlain by a sequence of volcanic rocks that consists mainly of welded ash-flow tuffs, but some rhyolitic and basaltic flows also are present locally. In addition, a few rhyolite dikes cut the tuffs and flows. The volcanic sequence can be divided into upper and lower parts, but this subdivision cannot be shown at the scale of figure 2. The lower part of the volcanic sequence consists of four dacitic to rhyolitic welded tuff formations and a basaltic flow breccia, part or all of which erupted from the Caliente cauldron north of the study area (Noble and McKee, 1972; Ekren and others, 1977). The upper part of the volcanic sequence consists largely of peralkaline rhyolitic welded tuffs and flows (Ekren and others, 1977; Novak, 1984; 1985), most of which erupted from the Kane Springs Wash volcanic center whose eastern margin impinges on the Meadow Valley Mountains (fig. 2). The rhyolitic flows are locally perlite-rich and some of the interlayered tuffs have been zeolitized. Deposits of lacustrine limestone and conglomerate are included with the volcanic rocks on figure 2. They rest unconformably on folded and faulted Paleozoic and Mesozoic strata and conformably underlie the volcanic sequence. The volcanic sequence, including the lacustrine limestone and conglomerate, is about 2,400 ft thick along the west edge of the study area near Grapevine Spring and thins to about 2,000 ft west of Vigo (E.F. Cook, unpub. data, 1955). The volcanic sequence is of Miocene age, the lower part 24 to 17 Ma and the upper part 15 to 11 Ma. Patches of welded tuff mostly assignable to the upper part of the volcanic sequence are present throughout the southern part of the study area, indicating that the volcanic rocks formerly extended over the entire area.

Carbonate-rich dikes that cut the younger welded tuffs 1.9 mi south of Grapevine Spring were described by Tieh and Cook (1971) who concluded that the carbonate in the dikes originated through the melting of limestone by a rhyolitic magma. Similar carbonate-rich rock is present in rhyolitic crystal tuffs 3.5 mi northeast of Grapevine Spring where the calcite appears to have replaced the groundmass leaving the crystals suspended in a calcite matrix. This "calcification" appears to have selectively affected certain layers of tuff, for the lateral extent of the bodies is significantly greater than the vertical extent. One mile northeast of Grapevine Spring a carbonate-rich rhyolite dike cuts an older welded tuff unit; this dike contains flow-banded rhyolite breccia cemented by color-banded coarse carbonate minerals. Neither the carbonate-rich dikes, calcified tuff, nor rhyolite dike showed signs of metallic mineralization. In the northernmost part of the study area a number of rhyolite dikes cut the volcanic rocks, several of which are aligned and form a discontinuous north-trending swarm 2.5 mi long.

At the south end of the study area a thick section of Miocene and Pliocene(?) lacustrine and alluvial deposits overlap and locally interfinger with the upper units of the volcanic sequence. Quaternary deposits of the study area consist of older and younger groups of unconsolidated to weakly consolidated sediments. The older sediments are mainly coarse, poorly sorted alluvial fan deposits and include a small percentage of stream and basin deposits. These deposits commonly are weakly cemented and sharply incised. In places on the east side of the study area some gravel layers are well cemented with caliche and form caps on vertical gravel cliffs and benches in drainage channels. The younger sediments consist of uncemented stream-channel, basin, and fan deposits and colluvium and talus that still are in the process of transport and accumulation.

The structural history of the study area includes two main episodes of deformation: (1) major faulting and folding in response to regional compressional forces, followed by erosion and volcanism, and (2) high-angle normal and low-angle extensional faulting, along with minor folding, that produced the present form of the Meadow Valley Mountains. Most of the western edge of the range is a northeast-trending fault zone that parallels a regional set of left-lateral strike-slip faults to the north, the Pahranagat shear system (Tschanz and Pampeyan, 1970, p. 84), but the southwest boundary is along more north-trending faults. In general, the range is an east-dipping block with the dips steepening eastward and reversing to form a major syncline and anticline in the Bunker Hills (fig. 2). The sedimentary strata locally are tightly folded and overturned, commonly near thrust faults. Numerous high-angle faults cut the sedimentary rocks, and near the center of the study area parts of the sedimentary section are absent, having been cut out along three thrust faults. Comparison of the stratigraphic section of the Meadow Valley Mountains with those of the nearby Delamar, Sheep, Arrow Canyon, and Mormon Ranges (fig. 1) suggests that the Meadow Valley Mountains may be part of an eastward-displaced thrust plate. The volcanic rocks overlying the sedimentary rocks have been cut by high-angle normal faults and deformed into broad minor folds.

Geochemical Studies

In June of 1983 the U.S. Geological Survey collected samples from sites in and adjacent to the study area. Nineteen rock samples were collected from bedrock outcrops. Stream-sediment samples were collected from 329 sites, and heavy-mineral concentrate samples were produced from a separate alluvial sample collected at 302 of these sites by hand panning followed by heavy-liquid immersion and electromagnetic separation (Hoffman and Day, 1984). Of the 329 sample sites, 181 were inside the study area. Analytical data and a description of the sampling and analytical techniques used are given in Hoffman and Day (1984).

The rock samples, stream-sediment samples, and nonmagnetic heavy-mineral concentrates were analyzed for 31 elements using a semiquantitative direct-current arc emission spectrographic method (Grimes and Marranzino, 1968). Spectrographic results were obtained by a visual comparison of spectra derived from the sample against spectra obtained from standards made from pure oxides and carbonates. Because of contamination during analysis, bismuth and copper were deleted from both stream-sediment and rock-data sets (Hoffman and Day, 1984, p. 5).

Trace elements present in nonmagnetic heavy-mineral concentrates in the volcanic terrane at the north end of the study area include beryllium (20-50 parts per million, ppm, at 19 sites), thorium (1,000-2,000 ppm at 18 sites), tin (more than or equal to 2,000 ppm at 17 sites), and yttrium (2,000 to more than 5,000 ppm at 16 sites) most likely are related to the Miocene volcanism. Beryllium, thorium, tin, and yttrium commonly are enriched in peralkaline rhyolitic rocks (Macdonald and Bailey, 1973) and may also occur in the form of accessory minerals such as thorite, uranothorite, and yttrialite (Hoffman and Day, 1984, p. 8). The minerals thorite, zircon, and topaz were identified at some of the sample sites but were not found in place. The high values of tin in heavy-mineral concentrates (more than or equal to 2,000 ppm) and in stream-sediment samples (less than 10 to 20 ppm at 9 sites) and presence of topaz and rhyolite dikes in the northernmost part of the volcanic terrane strongly suggest a correlation with the rhyolite-hosted tin model described by Reed and others (1986) where cassiterite occurs as disseminations and veins in tuffs and flows. No cassiterite was seen in any rock or stream samples, and 16 additional samples of rhyolite dike rock from the area of high tin anomalies all contained less than 10 ppm tin, 15 ppm beryllium, 150 ppm thorium, and 200 ppm yttrium. High values of thorium and beryllium may also occur in association with uranium mineralization in silicic volcanic rocks, but interpretation of data from an aerial gamma-ray survey of this region indicated no significant equivalent uranium or equivalent thorium anomalies in the study area.

Anomalous values of antimony (200 ppm at 2 sites), lead (1,500 ppm at 1 site), molybdenum (50-100 ppm at 3 sites), detectable amounts of tungsten (less than 100 ppm at 8 sites), and zinc (700-1,000 ppm at 15 sites) may indicate a carbonate-hosted silver-copper-lead-zinc replacement deposit or a tungsten skarn (Morris, 1986; Cox, 1986a).

Manganese oxides occur as thin coatings and fracture-filling veins as much as 0.5 in. wide in the volcanic terrane. One such exposure is found in a shallow prospect pit outside the west boundary 1.4 mi northeast of Grapevine Spring (fig. 2, No. 3), but no prospects for manganese were seen in the study area. Manganese is present in all of the geochemical samples but not in anomalous concentrations higher than values for volcanic and sedimentary rocks of this region. Barium and chromium are present in samples in and near the volcanic terrane but are not considered to be significant.

Near Grapevine Spring, west of the study area, six rock samples from the black phosphatic shale lens at the Bradshaw vanadium prospect had an average grade of 0.62 oz/ton (ounces per ton) silver, 0.27 percent vanadium, 4.8 percent P_2O_5 (phosphorous pentoxide), 0.01 percent molybdenum, 0.19 percent zinc, and 0.04 percent nickel (Heston, 1982, p. 88). Emission spectroscopic analysis of an additional grab sample of phosphorite and black shale from near Grapevine Spring contained 300 ppm cadmium, 1,200 ppm chromium, 130 ppm copper, 560 ppm nickel, 0.45 percent phosphorous, and 1,000 ppm vanadium; in this sample molybdenum, silver, and zinc were not determined because of interference. These elements commonly are present in chemically precipitated phosphorite and phosphatic shale deposits in Mississippian formations of northeast Nevada and northwest Utah correlative with the Chainman Shale (Ketner, 1982). The black phosphatic shale is a facies of the Mississippian Chainman Shale, a formation that extends to and beyond the south edge of the study area. The black shale lithology, however, only crops out for 1.5 mi north and south of Grapevine Spring and was not seen in the study area. Anomalous amounts of the elements listed above were not detected in samples in or near other outcrops of Chainman Shale.

Anomalous values of arsenic (700-1,500 ppm at 10 sites) are aligned along the northeast-trending range-front faults in the southern part of the study area. Associated low values of antimony (200 ppm at 2 sites), cobalt (70-150 ppm at 9 sites), copper (70-100 ppm at 11 sites), molybdenum (30-50 ppm at 12 sites), lead (300-500 ppm at 4 sites), nickel (100-200 ppm at 10 sites), and zinc (less than 500 to 7,000 ppm at 5 sites) may represent leakage from gold-silver-lead-zinc vein deposits (Cox, 1986b) or carbonate-hosted lead-zinc replacement deposits (Briskey, 1986). The most favorable sedimentary host rocks for gold-silver and lead-zinc deposits in this region are presumed to underlie the area of this anomaly.

Anomalous values of cobalt (70-200 ppm at 10 sites), copper (70-300 at 19 sites), lead (300-1,000 ppm at 5 sites), molybdenum (50-100 ppm at 7 sites), nickel (100-200 at 15 sites), and zinc (less than 500 to 1,000 ppm at 9 sites) are present along the north-trending range-front faults in the study area and most likely represent leakage from a carbonate-hosted replacement copper-lead-zinc source (Briskey, 1986) at depth.

The D and D prospect (fig. 2, No. 7) is on the contact between limestone of the Guilmette Formation and Miocene rhyolitic welded tuff. The limestone is silicified locally and cut by veinlets of quartz. A 6-ft chip sample across the tuff and a grab sample of silicified limestone contained 0.01 and 0.02 oz/ton of silver, respectively, but no gold was detected. The geologic relations here are similar to those in the Viola mining district 30 mi to the northeast where Mississippian and younger limestone capped by Tertiary volcanic rocks is silicified and cut by veins that contain argentiferous lead-zinc-copper deposits (Tschanz and Pampeyan, 1970, p. 161-162)

The Fry and Jeffers claim (fig. 2, No. 8) at the south end of the study area is on a low-level occurrence of radioactivity in black limestone (U.S. Atomic Energy Commission, 1954; Garside, 1973, p. 36) of the Ely Springs(?) Dolomite. This occurrence was not associated with any veins or other geologic structures. Two samples taken from soils at the top and base of the range front were analyzed and found to contain 0.009 percent and 0.011 percent uranium oxide, respectively (U.S. Atomic Energy Commission, 1954). An aerial gamma-ray survey of this region detected no significant equivalent uranium or equivalent thorium anomalies within the study area.

Thirteen samples of devitrified glass from volcanic tuffs adjacent to perlite flows were analzyed for zeolite content by X-ray diffraction. Twelve of the samples contained 27 to 70 percent clinoptilolite and one sample 50 percent mordenite, all in a matrix composed largely of amorphous glass with trace amounts of cristobalite, feldspar, quartz, and montmorillonite (Campbell, 1987, table 3). The zeolitized tuff crops out over several square miles in close proximity to the perlitic rocks.

Mississippian carbonate rocks in a region that includes the Mormon, Muddy, and Meadow Valley Mountains, and the Las Vegas and Arrow Canyon Ranges have been classified as having medium potential for occurrence of oil and gas (cluster 8 of Sandberg, 1983), on the basis of Conodont Alteration Index (CAI) values of 2.5-3.5 and oil and gas shows in a well east of cluster 8. The CAI values indicate organic maturation close to the upper limit for oil generation but in the optimum range for gas generation. On the basis of regional structural, lithologic, and stratigraphic evidence and other interpretations of CAI, vitrinite reflectance, and proprietary data, however, the area is considered to have high potential for oil and gas (A.K. Chamberlain, oral commun., 1987). The favorable Mississippian strata were penetrated by the Texaco Federal No. 1 well, but no oil or gas shows were reported (Garside and others, 1977). The same strata are present in the study area, where they dip gently to steeply east, are cut by numerous faults, and may have good lithologic reservoir characteristics.

Geophysical Studies

Regional gravity and aeromagnetic maps of the Meadow Valley Mountains and vicinity provide an additional means of investigating the general geologic framework of the study area (figs. 3 and 4). The gravity map (fig. 3) was compiled using data from 441 gravity stations, mostly from files of the U.S. Defense Mapping Agency and obtained through the National Geophysical Data Center, NOAA, Code E/GC, 325 Broadway, Boulder, CO 80303. Observed gravity values at these stations were reduced to Bouguer anomaly values using a density of 2.67 g/cm^3 (grams per cubic centimeter), and corrected for terrain variations to a radius of 167 km (103.8 mi) (for example of procedures, see Cordell and others, 1982). The aeromagnetic map (fig. 4) was compiled from two regional aeromagnetic surveys: a constant-elevation (9,000 ft) survey north of lat 37° N., with flight traverses spaced 1 mi apart on north-south headings (U.S. Geological Survey, 1973) and a constant terrain-clearance (1,000 ft) survey south of lat 37° N., with flight traverses also spaced 1 mi apart but on east-west headings (U.S. Geological Survey, 1983). The International Geomagnetic Reference Field was subtracted from each of the two data sets, which were then merged and projected to a new datum of 12,500 ft above sea level.

The gravity map is dominated by a strong north-south gradient marking a drastic decrease of Bouguer anomaly levels north of about lat 37°05' N. This gradient coincides with a sharp northerly increase in the average regional elevation and is suppressed, though not eliminated, by use of isostatic rather than Bouguer anomalies. It was analyzed by Eaton and others (1978), who concluded that it mainly reflects a density contrast resulting from emplacement of large volumes of silicic intrusive material in late Mesozoic to Tertiary time beneath what is now the Great Basin province. The intrusive material, if near granitic in composition, should be much less dense than the Precambrian crystalline basement. Basement rocks are exposed in the Mormon Mountains and probably occur at depths of only a few miles on structural swells south and west of the mountains but at much greater depths north of the gravity gradient. The gradient also marks the southern limit of thick accumulations of Tertiary volcanic rocks. Tertiary rocks shown on figure 3 south of the gradient consist mainly of small outliers of welded tuff overlying carbonate rocks and of volcaniclastic and lacustrine rocks. Gravity lows that appear as perturbations of the regional gradient in Kane Springs Wash and upper Meadow Valley Wash reflect thick deposits of Cenozoic alluvium. Other lows are associated with Tertiary and Quaternary alluvial deposits in Delamar Valley, Coyote Spring Valley, Meadow Valley Wash, and Mormon Mesa.

The only detectable magnetic-field disturbances at the altitude chosen for the aeromagnetic map of figure 4 arise from magnetic sources of considerable thickness; contributions from thin sources such as sheets of lava quickly decrease in amplitude with increasing distance upward to the level of observation. A circular positive anomaly of about 250 nanoteslas (nT) amplitude centered over the western part of the Mormon Mountains represents the combined effects of a domoform uplift of the strongly magnetic crystalline basement and a possible granitic intrusion of Tertiary age (Shawe and others, 1988). Anomalies over the Delamar and Clover Mountains are probably due exclusively to Tertiary volcanic rocks and related intrusive bodies that are inferred to floor the eruptive centers. The broad, east-west-elongated positive anomaly centered over the southern part of the Delamar Mountains coincides in part with syenitic intrusives mapped in the Kane Springs Wash volcanic center (Noble, 1968; Novak, 1984), but the anomaly source apparently extends to the east beyond Kane Springs Wash into the northern part of the Meadow Valley Mountains. Geologic mapping to date has revealed only minor hydrothermal alteration and geochemical anomalies that might be attributed to a shallow heat source in the northern part of the Meadow Valley Mountains. Curvature of contours at the extreme east end of the anomaly suggests either left-lateral offset of the source body for several miles along faults of the Pahranagat shear system in Kane Springs Wash or structural control of the source by an arcuate fracture.

In addition to the aeromagnetic and gravity data discussed above, limited aerial gamma-ray spectrometer data (3-mi spacing) were obtained for the region in conjunction with the National Uranium Resource Evaluation program (Western Geophysical Company of America, 1979; Geodata International, Inc., 1980). Examination of these data by J.S. Duval of the U.S. Geological Survey (written commun., 1985) shows that rocks of the southern part of the Meadow Valley Mountains have generally low radioactivity (0-1.5 percent potassium (K), 0-3.0 ppm equivalent uranium (eU), and 0-11 ppm equivalent thorium (eTh)), and rocks of the northern volcanic part have moderate values (1.5-2.5 percent K, 3.0-4.0 ppm eU, and 11-16 ppm eTh). There are no significant gamma-ray anomalies within the study area or the immediate vicinity. A local occurrence of low-level radioactivity at the Fry and Jeffers claim (fig. 2, No. 8; table 1) in black limestone of the Ely Springs(?) Dolomite was not considered to be significant (U.S. Atomic Energy Commission, 1954; Garside, 1973, p. 36).

CONCLUSIONS

Geologic information, the distribution of metallic elements occurring in anomalous concentrations (based on data from rock, stream-sediment, and nonmagnetic heavy-mineral concentrate samples), information on nearby mining districts, and compilations of ore deposit models (for example, Boyle, 1974; Rose and others, 1979; Ericksen, 1982; and Cox and Singer, 1986) were used to determine the mineral resource potential shown in figure 2.

Geologic and geophysical studies, geochemical sampling (Hoffman and Day, 1984), examination of prospects (Campbell, 1987), and review of ore deposits from surrounding districts (Tschanz and Pampeyan, 1970) indicate that the Meadow Valley Mountains lie at the edge of a province characterized by hydrothermal deposits in the form of bedded replacement bodies in carbonate rocks (Mississippi Valley type) containing zinc, lead, silver, and manganese and fissure veins and related silicified breccias in siliceous rocks containing gold and silver (Tschanz and Pampeyan, 1970). Examples of bedded replacement deposits are found in the Groom mining district, 62 mi to the northwest, and the Comet and Pioche districts, about 60 mi to the north, where ore bodies occur in limestone beds of the Cambrian Pioche Shale. Veins and silicified bodies are present in the Delamar and Pennsylvania districts, about 15 mi northwest and 11 mi northeast, respectively, in the Lower Cambrian Prospect Mountain Quartzite. About 10 mi east in the Viola mining district, small replacement bodies and veins containing copper, fluorspar, lead, mercury, silver, and zinc occur in Mississippian and Pennsylvanian limestones directly beneath overlying Tertiary volcanic rocks, a geologic setting that is not common in this province. No active mines are in or immediately adjacent to the study area; the rocks that host gold-silver and lead-zinc deposits in nearby mining districts do not crop out in the study area. Although the Pioche Shale and underlying Prospect Mountain Quartzite are not exposed in or immediately adjacent to the study area they are assumed to underlie faulted and folded Cambrian rocks that are present along the west edge of the study area about 5 mi north of the Lincoln-Clark County line. The south half of the study area, which is underlain by faulted pre-Tertiary carbonate rocks and is locally capped by patches of Tertiary volcanic rocks and gravels, has a geologic setting that is favorable for carbonate-hosted gold-silver and lead-zinc-copper deposits.

Deposits of perlite exist in and adjacent to the northeast side of the study area in the area underlain by tuffs and flows. These deposits, referred to as the Johnston and Fitchett prospect, were examined in 1947-1948 by K.L. Cochran (written commun., 1951). The perlite occurs as flows and as lenses in the flow units that crop out discontinuously at the base of the volcanic slopes, but in some cases it can be traced continuously over several square miles. The perlite flows range in thickness from a few feet to tens of feet. Preliminary laboratory tests on samples of perlite from this area show that the perlite is within the range of commercial deposits (Campbell, 1987, table 2), but these tests need to be confirmed by full-scale tests by the carload at a commercial expander along with further laboratory testing for specialized filter or aggregate uses. The north end of the study area has a high potential, certainty level D, for additional perlite resources.

Thirteen samples of devitrified glass adjacent to the perlite flows and volcanic tuffs were analyzed by X-ray diffraction and chemical methods for zeolite content and cation exchange capacity (Campbell, 1987, table 3). The sampling was of a reconnaissance nature but indicates that one zeolitized tuff unit that underlies the perlite flows is more than 50 ft thick and crops out over several square miles in the northeastern part of the study area (Campbell, 1987, p. 20). The mineral resource potential for zeolites in the northern part of the study area is moderate with a certainty level C. Agate, marekanite (Apache tears), and opaline rock, materials of

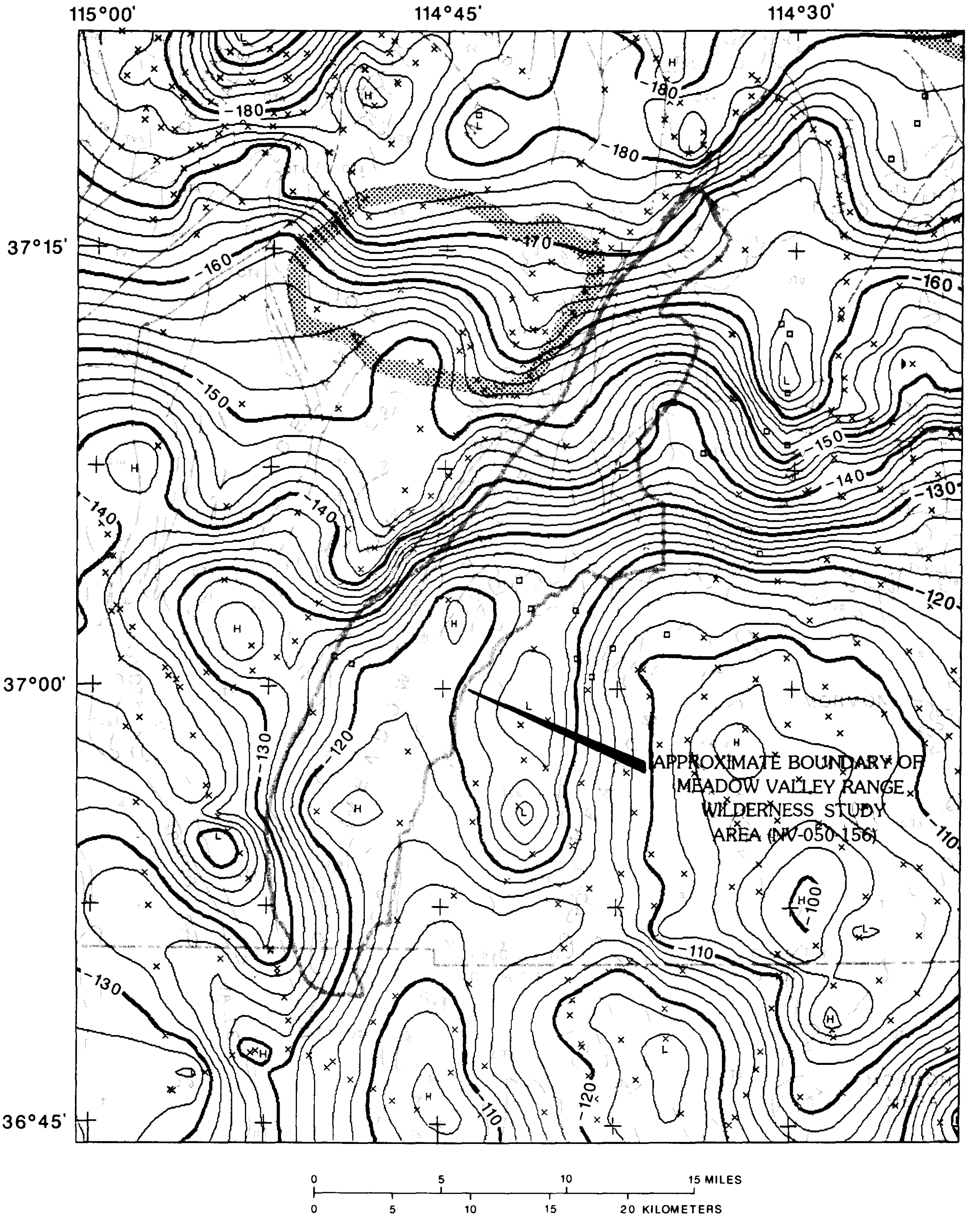


Figure 3. Complete Bouguer gravity anomaly map of the Meadow Valley Range Wilderness Study Area and vicinity, Lincoln and Clark Counties, Nevada. Contour interval, 2 and 5 mGals; reduction density, 2.67 g/cm³; H, gravity high; L, gravity low. Geology generalized from Tschanz and Pampeyan (1970), Longwell and others (1965), and Ekren and others (1977).

interest to mineral collectors, are associated with the perlite and zeolites, and the northern part of the study area has a moderate resource potential, certainty level C, for those minerals.

At the north end of the study area, where rocks of the Kane Springs Wash volcanic center predominate, anomalous amounts of beryllium, thorium, tin, and yttrium are present in nonmagnetic heavy-mineral concentrates (areas M1 and M2 of Hoffman and Day, 1984). The beryllium, thorium, and yttrium are confined to the northernmost part of the study area, which is underlain by volcanic tuffs, flows, and dikes and possibly also by hypabyssal granitic intrusive rocks (see Geophysics section). The tin anomalies occur in two areas of volcanic rock (one of which overlaps the areas of high beryllium-thorium-yttrium values). Peralkaline volcanic rocks (Macdonald and Bailey, 1977), similar to rocks present in the north half of the study area, are commonly enriched in these elements. The presence of thorite in stream-sediment samples suggests that the thorium and yttrium occur in accessory minerals in the peralkaline volcanic rocks. Aerial gamma-ray surveys show moderate values of potassium, equivalent uranium, and equivalent thorium in the study area, but not in sufficient amounts to be considered anomalous. A piece of rhyolite float containing topaz and hematite, and some topaz crystals, were found in the stream sediment within the northernmost area of tin anomalies; the rhyolite strongly resembled a metaluminous topaz-bearing rhyolite described by Novak (1984; 1985) 13 mi west in the Kane Spring Wash volcanic center. The positive magnetic anomaly centered over the volcanic center extends eastward into the northern part of the study area (fig. 4) and may reflect a continuation of an intrusive body under the eruptive center. No rhyolite domes or plugs were seen in the study area, but rhyolite flows resembling the topaz-hematite-bearing rhyolite float are present, and a swarm of rhyolite dikes cuts the rhyolitic rocks near the northern tin anomaly. The northern tin anomaly and topaz-bearing rhyolite float probably originate from the area of the rhyolite dike swarm, as the dike rock has characteristics that fit the rhyolite-hosted tin model described by Reed and others (1986). A rhyolite dike cuts the lower part of the volcanic sequence at the west end of the southern tin anomaly and other dikes may be present elsewhere in the anomalous area. Trace amounts of tungsten occur in non-magnetic heavy-mineral samples from the same area where topaz was found, and according to Boyle (1974) topaz is a common mineral in igneous rocks containing tin, tungsten, molybdenum, and beryllium. It is possible that the tin anomaly represents a halo from a tin skarn (Reed and Cox, 1986), but, if so, the requisite leucogranitic and carbonate rocks lie at substantial depth beneath the anomaly, and, according to Boyle (1974, p. 35), few skarn deposits are commercial sources of tin. In summary, the geochemical, geological, and geophysical interpretations suggest that there is moderate potential, certainty level C, in the northernmost part of the study area and low potential, certainty level B, in the north-central part of the study area for tin resources in rhyolite-hosted deposits.

A suite of trace elements (antimony, lead, molybdenum, tungsten, and zinc) is present in several samples from Hackberry Canyon and vicinity, about 6 mi west of Vigo siding (fig. 2), near where the volcanic rocks are eroded to expose underlying Permian carbonate rock (area M3 of Hoffman and Day, 1984). No mineralized rock was seen in this area. The antimony, lead, and zinc may represent a carbonate-hosted silver-lead-zinc-copper replacement deposit (Morris, 1986), or the molybdenum, tungsten, and zinc may represent a tungsten skarn deposit (Cox, 1986a). Because of the absence of leucogranitic rocks and low level of tungsten, the trace elements more likely represent leakage from carbonate-hosted replacement silver-lead-zinc-copper mineralization. The area around Hackberry Canyon has a low mineral resource potential, certainty level B, for silver, copper, lead, and zinc resources.

EXPLANATION

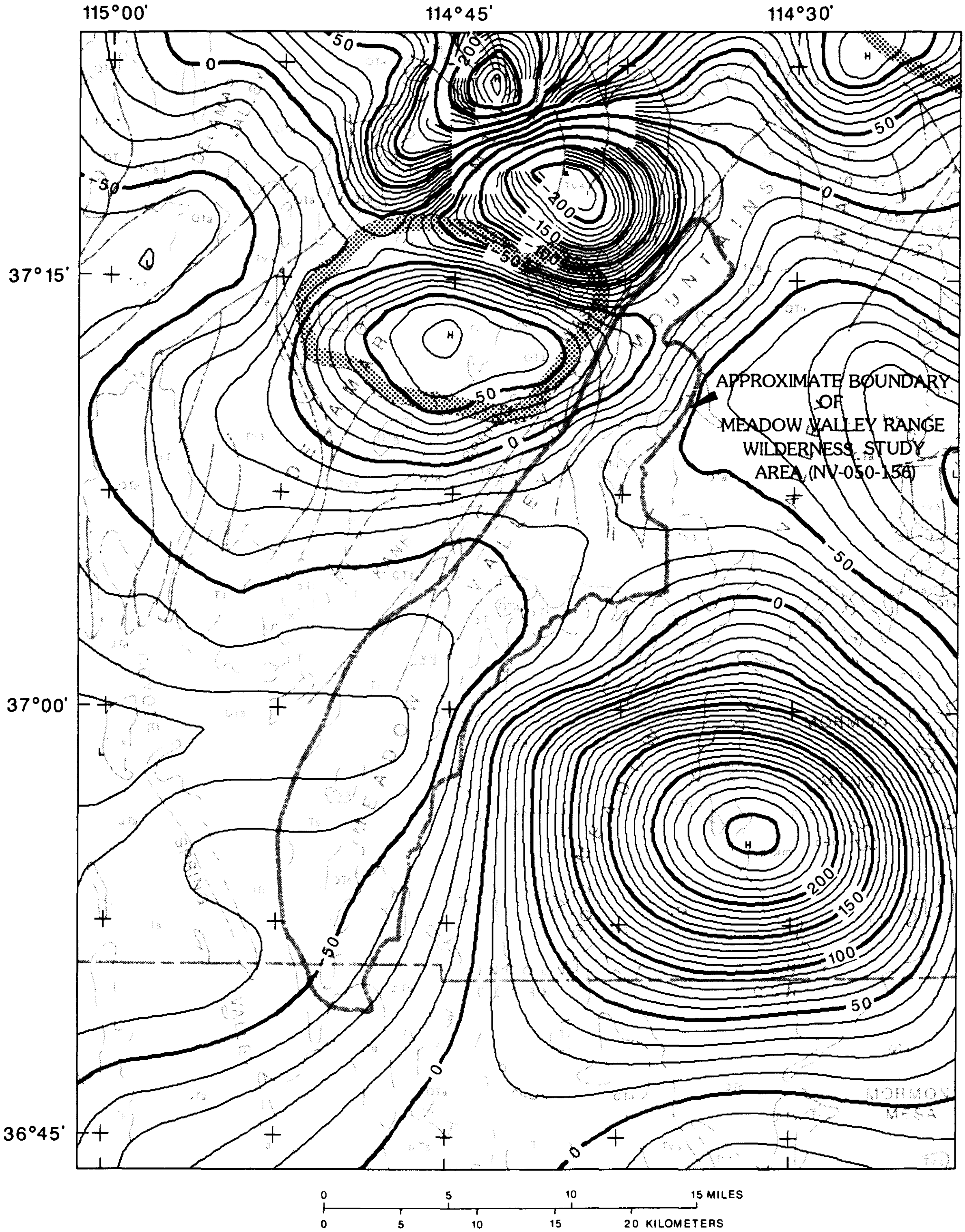
—-100— Bouguer gravity contour
QTa Alluvial deposits (Quaternary and Tertiary)
Ti Intrusive rocks (Tertiary)
Tvs Volcanic and sedimentary rocks (Tertiary)
pTs Sedimentary rocks (pre-Tertiary)
p€im Igneous and metamorphic rocks (Precambrian)

Contact
Fault—Dashed where inferred
Edge of collapse caldera—After Ekren and others (1977)
□ × Gravity station

Correlation of map units

QTa — QUATERNARY
Ti, Tvs — TERTIARY
pTs — MESOZOIC AND PALEOZOIC
p€im — PRECAMBRIAN

Figure 3. Continued.



EXPLANATION

—150— Aromagnetic contour

Edge of collapse caldera—After Ekren and others (1977)

Figure 4. Residual and total-intensity aeromagnetic map of the Meadow Valley Range Wilderness Study Area and vicinity, Lincoln and Clark Counties, Nevada. Contour interval, 10 and 50 nT; level of observation, 12,500 ft above sea level; H, magnetic high; L, magnetic low. See figure 3 for explanation of geologic units.

Outside the study area at Grapevine Spring, the Upper Mississippian Chainman Shale contains a lens of metalliferous black shale that has been prospected for vanadium (Heston, 1982; written commun., 1982). Geochemical samples from sites within the study area on or downslope from the Chainman Shale outcrop, however, showed no anomalous concentrations of vanadium, cadmium, chromium, copper, molybdenum, nickel, phosphorous, silver, or zinc. As noted previously, the metalliferous shale lens has an average thickness of 12 ft and eastward dip of about 25° over a discontinuous outcrop length of about 3 mi (Heston, 1982). It is estimated that about 800,000 tons of inferred subeconomic resources of metalliferous black phosphatic shale exist along the outcrop adjacent to the study area, assuming a down-dip extension of 50 ft. The metalliferous shale lens may extend down-dip into the study area, but disruption by faulting, folding, and facies changes most likely have affected its continuity, for it is not present within the study area where the total Chainman Shale is only about one-fifth as thick as at the Bradshaw prospect. The metalliferous shale has a high potential for resources of vanadium, certainty level D, adjacent to the study area but unknown potential, certainty level A, within the study area immediately east of the outcrop. The metalliferous shale lens crops out from 600 to more than 3,000 ft west of the study area, so to verify its down-dip existance and composition within the area will require sampling the appropriate stratigraphic interval at depths of 250 to more than 2,000 ft beneath the surface. Although vanadium was the commodity of principal interest, anomalous amounts of cadmium, chromium, copper, molybdenum, nickel, silver, and zinc are present, elements commonly present in phosphatic shales and phosphorites of northeastern Nevada and adjacent states (Ketner, 1982; Desborough and Poole, 1983). These elements all are ionically bound, making physical separation and extraction difficult and, at the present time, uneconomic (Kuck, 1985). The pelletal phosphorite, occurring as 1- to 2-in.-thick beds in the black phosphatic shale outcrop at the Bradshaw prospect, is present in sufficient amounts to be of scientific interest but does not constitute an identified resource or suggest resource potential of phosphorous.

In the southwestern part of the study area anomalous values of arsenic are present along the southwest-trending range front in Cambrian and Ordovician carbonate rocks. These rocks are cut by numerous faults, but the arsenic is restricted to a narrow band along a zone of range-front faults. Scattered anomalies of antimony, cobalt, copper, molybdenum, lead, nickel, and zinc also are present in this zone, elements which commonly accompany carbonate-hosted gold-silver and lead-zinc deposits. No mineralized rock or alteration was seen in the area. Gold occurs in epithermal fissure vein and silicified breccia deposits in the Cambrian Prospect Mountain Quartzite at Delamar, the Pennsylvania mine, and other major districts of the region, but the stratigraphic position of that formation is on the order of 2,000 ft lower than the lowest Cambrian rocks exposed along the range front. Gold also occurs with lead and zinc in veins in the region but quantitatively in much smaller amounts. Silver is present in carbonate-hosted bedded replacement lead-zinc deposits of the Pioche mining district, and arsenopyrite (FeAsS) was present in some of those deposits (Westgate and Knopf, 1932, p. 47). The most favorable carbonate host for replacement deposits in this region, the Pioche Shale, directly overlies the Prospect Mountain Quartzite. The geologic and geochemical evidence suggests a low potential, certainty level B, for resources of gold, silver, lead, and zinc in the southwestern part of the study area.

In the southernmost part of the study area, in an area underlain by Ordovician to Mississippian carbonate rocks, copper, lead, and zinc along with cobalt, molybdenum, and nickel are present in anomalous amounts. The principal anomalous values lie close to a zone of north-trending range-front faults and other northeast-trending faults showing evidence of large displacement. A likely source for these elements would be a carbonate-hosted irregular-replacement copper-lead-zinc deposit (Briskey, 1986) similar to that at the Bristol mining district northwest of Pioche, where veinlike or pipelike replacement deposits occur along fissures in the Cambrian Highland Peak Formation (Tschanz and Pampeyan, 1970, p. 134). Geologic and geochemical evidence suggest that the potential for resources of copper, lead, and zinc is low with a level of certainty B, in the southernmost part of the study area. No mineralized or altered rock was seen in this area.

At the D and D prospect, in the southernmost part of the study area (fig. 2, No. 7), two samples from the contact between Devonian limestone and overlying Miocene welded tuff contain low concentrations of silver. The size of the exposure and the geologic setting indicate that this occurrence has no mineral resource potential for silver, with a certainty level of D. Similarly, geologic, geochemical, and geophysical evidence indicates that an area of low-level radioactivity at the Fry and Jeffers claim (fig. 2, No. 8) has no mineral resource potential for uranium or thorium, with a certainty level of D.

Ornamental stone under the name "Nevada Wonder Rock" has been quarried outside the west edge of the study area, about 1.5 mi southwest of Grapevine Spring (fig. 2, No. 5), but, judging from the size of the quarry, production was small. Nevada Wonder Rock is a predominantly yellowish to very light gray, well-sorted, fine-grained siltstone in the lower part of the Chainman Shale (Wonderstone of Duley, 1957, p. 85-86). Yellow, orange, red, and purple color banding and mottling, caused by oxidation and weathering along fractures, create colorful and interesting patterns in the siltstone. This color-banded siltstone was not seen in the Chainman Shale inside the study area and, therefore, has no resource potential, with a certainty level of D. The quarried outcrop was bulldozed out of existence in 1987.

Sedimentary evaporite deposits of gypsum are widely distributed in the Permian rocks of southeastern Lincoln County (Tschanz and Pampeyan, 1970, p. 124). One of the better deposits, though not of commercial quality, is near the top of the Permian red-bed section 2.5 mi west of Vigo siding (fig. 2, No. 6), outside of the study area boundary near the southeast corner of the volcanic terrane. Jones and Stone (1920, p. 158) report that this deposit is about 3,600 ft long and 1,000 ft wide with individual gypsum beds ranging in thickness from a few inches to 20 ft. The gypsum deposits in this region were extensively prospected between 1955 and 1957, but none was brought into production. No gypsum bed more than several inches thick was seen, and the exposed gypsum-bearing beds appear to represent a small isolated depositional basin in the red-bed section that does not extend into the study area. The study area has no resource potential for gypsum, with a level of certainty D.

Lime, in the form of limestone and dolomite, and silica, in the form of quartzite, are present in the south half of the study area. Limestone makes up a considerable part of the pre-Tertiary sedimentary sequence here, but the purity of the limestone is unknown. At Arrowlime in Clark County, 35 mi south of the study area, high-purity limestone is mined from the Crystal Pass Member of the Upper Devonian Sultan Limestone (Longwell and others, 1965, p. 156). This same white to light-gray limestone, less than 200 ft thick, which is assigned to the upper part of the Guilmette Formation in the area of this report, has an outcrop length of more than nine miles in the southern one-third of the study area, but its purity here is unknown. The southern part of the study area underlain by pre-Tertiary sedimentary rocks (fig. 2) has high resource potential, certainty level C, for high-purity limestone. Dolomite is present in large quantities in the study area but is too impure to be of commercial value. Quartzite of the Eureka Quartzite is clean but is only 12 to 15 ft thick along the west side of the study area and thins to less than 5 ft on the east side. The Eureka Quartzite has been quarried 12 mi south of the study area, in the Arrow Canyon Range of Clark County, where it is 100 ft thick. The extreme hardness and abrasiveness of the rock made that operation economically unfeasible (Longwell and others, 1965, p. 163). Quartzite beds are present in the Devonian Simonson Dolomite and Guilmette Formation, Pennsylvanian and Permian Bird Spring Formation, and Triassic Shinarump Member of the Chinle Formation, but none of these beds are of suitable quality for a source of silica. The quartzite has no resource potential, certainty level D.

Sand and gravel exist in significant quantities throughout the the study area and consist of alluvial deposits (QTa on fig. 2) eroded from adjacent bedrock slopes. There is high potential for sand and gravel beneath known deposits, certainty level D, for industrial minerals, but there are other suitable deposits closer to prospective markets.

An exploratory well was drilled by Texaco, Inc., in 1972 to test the petroleum potential of Mississippian rocks in an anticline in the Bunker Hills, about 2 mi east of the study area boundary and about 4 mi west of Rox (fig. 2). No oil or gas shows were reported (Garside and others, 1977), and the well was plugged and abandoned. The rocks penetrated in this well are present in the study area where they locally may have good reservoir characteristics. Other regional structural, lithologic, and stratigraphic evidence and interpretations of CAI, vitrinite reflectance, and proprietary data (Sandberg, 1983; A.K. Chamberlain, oral commun., 1987), however, suggest the study area has a moderate potential for resources of oil and gas, certainty level B.

Thermal springs are present near Moapa and at Ash Springs, 7 mi south and 35 mi northwest, respectively, of the study area (fig. 1). No thermal springs are known to exist in the Meadow Valley Mountains, and no evidence of recent, currently active geothermal activity was seen. In the northern one-fourth of the study area some of the volcanic rocks show minor hydrothermal alteration and geochemical anomalies that might be attributed to a shallow heat source related to the Kane Springs Wash volcanic center (fig. 2), but detailed studies will be required before such a correlation can be made. There is no potential for geothermal resources in the study area, with a certainty level of D.

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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.

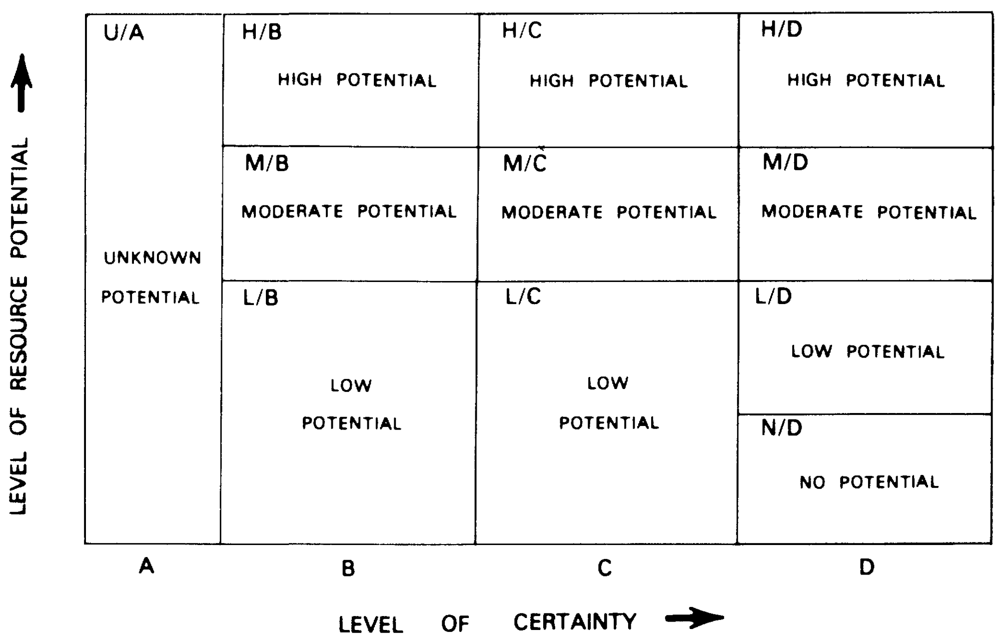
MODERATE mineral resource potential is assigned to areas where geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate reasonable likelihood of resource accumulation, and (or) where an application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

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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.

GPO 585-045/78047

U. S. DEPARTMENT OF THE INTERIOR
March 3, 1849