UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Mineral resources and mineral resource potential of the Saline Valley and Lower Saline Wilderness Study Areas Inyo County, California

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ILLUSTRATIONS

TABLES

STUDIES RELATED TO WILDERNESS

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 the Saline Valley Wilderness Study Area (BLM No. CDCA 117) and the Lower Saline Wilderness Study Area (BLM No. CDCA 117A), California Desert Conservation Area, Inyo County, California.

SUMMARY

The Saline Valley Wilderness Study Area and the Lower Saline Wilderness Study Area, located in eastern California between the Inyo Mountains and Death Valley, were studied in 1981-83 using geologic, geochemical, remote sensing, and geophysical surveys and the examination of mines and prospects to evaluate mineral resources and the potential for mineral resources. The Saline Valley Wilderness Study Area has a high potential for the occurrence of gold resources in two areas. One area, largely outside the study area, is in the vicinity of the Crater mine in the Last Chance Range, and it has potential for the occurrence of gold in a disseminated deposit in an epithermal environment. A small part of this area extends into the study area. The other area is in Marble Canyon in the western part of the study area, and it has high potential for the occurrence of gold placer deposits. Marble Canyon also has a moderate potential for gold in placer deposits downstream from the area of high potential. Seven areas, scattered from the Inyo Mountains to the Last Chance Range, have a low potential for the occurrence of gold in disseminated deposits, and one area that lies astride the border of Death Valley National Monument has a low potential for the occurrence of gold in vein deposits. An area of granitic rock near the southern end of the area was identified as having a low potential for the occurrence of copper and molybdenum resources in vein deposits surrounded by an area of low potential for the occurrence of lead, silver, and zinc resources. An area west of Jackass Flats near the western border of the study area has a low potential for the occurrence of lead, silver, and zinc resources in quartz veins. Part of the Last Chance Range peripheral to the area of high potential for the occurrence of gold resources has mercury prospects but only a low potential for the occurrence of mercury resources. The southern end of Eureka Valley has a low potential for the occurrence of lithium and uranium resources in buried sedimentary deposits beneath the valley floor. Demonstrated resources of native sulfur exist at the Crater mine but no resource potential was identified nearby in adjacent parts of the study area. A low potential for the occurrence of talc resources is present in the northwest end of the study area close to several talc mines that are north of the study area.

The Lower Saline Wilderness Study area has occurrences of copper, gold, silver, tungsten, and uranium but no recognized potential for additional resources of these commodities.

No potential for fossil fuels was identified in the Saline Valley or the Lower Saline Wilderness Study Areas.

INTRODUCTION

Field examinations were conducted by the U.S. Bureau of Mines in the fall of 1981 and the spring and fall of 1982 and by the U.S. Geological Survey in three spring field seasons in 1981-1983 to determine the mineral resources and mineral resource potential of the Saline Valley and Lower Saline Wilderness Study Areas. The Bureau of Mines searched mining records and examined mines, prospects, mineral claims, and mineralized areas and sampled them. The Geological Survey conducted geologic mapping, geochemical sampling, remote sensing studies, and geophysical surveys.

The Saline Valley Wilderness Study Area occupies 407,356 acres, and the Lower Saline Wilderness Study Area occupies an additional 2,241 acres in eastern California between the Inyo Mountains and Death Valley (fig. 1). The eastern edge of both study areas adjoins Death Valley National Monument. Big Pine, 17 mi west of the study areas, is the nearest town. Scottys Castle, about 10 mi from the study areas, is the nearest center of habitation to the east.

The principal access to the Saline Valley Wilderness study area is by paved road from Big Pine. This road passes along or close to the north border of the study area where it becomes a dirt road and extends into Death Valley. A gravel road down the west side of the study area provides access to several warm springs near the southwest margin of the area and to the Lower Saline Wilderness Study Area. Farther south this road connects with State Highway 190. Additional gravel roads are in Marble Canyon, along the east side of Eureka Valley to the sand dunes, and from Death Valley to the Jenny B mine (fig. 2). A jeep trail connects the sand dunes in Eureka Valley with the warm springs.

Most of the study area has an arid climate characterized by hot dry summers and cold to moderate winters. Only the western part of the area above an altitude of about 5,000 ft has a semi-arid climate. The arid part of the area has sparse vegetation consisting of creosote bushes and other low-growing shrubs and cactuses. The semi-arid part has sage, pinon pine, juniper, and mountain mahogany. Joshua trees grow in the higher parts of the Dry Mountain area.

Previous studies of mineral deposits and mineral resources

The only published information on the mines and mineral resources of the Saline Valley Wilderness Study Area is by McHugh and others (1984), but for the Lower Saline Wilderness Study Area information is available by Rumsey (1984) and McAllister (1955). Detailed descriptions and production data for mines in the region around the study areas are included in summary reports by Waring and Huguenin (1917), Tucker and Sampson (1938), and Norman and Stewart (1951) on the mines and mineral resources of Inyo County. A report on the Cerro Gordo mine in the Inyo Mountains was written by Merriam (1963). Bailey (1902), Gale (1914), and Ver Planck (1958) wrote about salt deposits in Saline Valley. Information on mines in the Ubehebe quadrangle is given by McAllister (1955), and a detailed investigation of the El Capitan mercury mine in the Last Chance Range was reported by Hill (1972). A report by Wrucke and others (1984) gives a summary of the mineral resources of the Little Sand Spring Wilderness Study Area, which is on the east side of Death Valley, immediately east of the Saline Valley Wilderness Study Area.

Physiography

The Saline Valley and Lower Saline Wilderness Study Areas are in the western part of the Basin and Range province and are as close as 20 mi to the Sierra Nevada. The study areas include the mountainous terrane east of the high northern parts of the Inyo Mountains, the Saline Range, the southern half of the Last Chance Range, and the range that extends north and south of Dry Mountain. Drainage is toward the three closed basins of Eureka, Saline, and Death Valleys, but there are no permanent streams. The highest and lowest points are Dry Mountain and the eastern side of Saline Valley, respectively 8,674 ft and about 1,200 ft above sea level. The bottom of Saline Valley just west of the study area is the lowest place in the northern Death Valley region. The general topographic trend of the mountains and valleys is approximately north-south, but significant local variations exist from this trend.

Mining history

Prospecting in the region of the Saline Valley and Lower Saline Wilderness Study Areas probably began in the late 1850s or early 1860s, as mineral discoveries were made in the Inyo Mountains as early as 1859 and the Lone Pine mining district was organized in 1866 (Chaflant, 1933). The rich silver-lead deposits at Cerro Gordo in the Inyo Mountains, southwest of the study areas, are reported to have been discovered in the interval 1861-1866 (Merriam, 1963). Several mines in the eastern foothills of the Inyo Mountains just outside the study areas were opened between 1879 and 1907 (Waring and Huguenin, 1917), including the Loretto (copper), Scheelite (tungsten and copper), Opal (lead and silver), Bedell (lead and silver), Waucoba (tungsten and copper), Bunker Hill (lead and silver), and Blue Monster (lead and silver) mines (fig. 2). Mineral production is recorded from these mines for the period 1899-1964; none is currently operating. The Victor Consolidated mine, located as a gold prospect in 1909, was patented in 1912 and was later operated as a talc mine. The Loretto mine, developed by an 1,800 ft-deep shaft during the period 1907-1915 (Waring and Huguenin, 1917), was patented in 1922 and was under exploration as recently as 1975. Silver- and lead-bearing quartz veins at the Lee, Del, August, Ruby Port, Emma, Hillside, and Morning Star prospects in the Whipporwill Flat - Jackass Flats area were prospected probably before 1900.

Placer gold was discovered in Marble Canyon before 1904 (Tucker and Sampson, 1938). Substantial development began in 1934 and at least three placer mines just west of the study area were active in 1982.

Silver-lead-zinc deposits in the Ubehebe district, which includes the Lower Saline Wilderness Study Area, were mined in the early 1900s. All of these mines are outside this study area. The first recorded production from the district was of silver from the Ubehebe mine (fig. 2) in 1908. The Lippincott mine was worked for lead and silver as early as 1908, and the Blue Jay mine, one-half mile east of the south end of the Saline Valley Wilderness Study Area, produced high-grade copper and silver ore in 1915 (McAllister, 1955). All were idle in 1982.

Salt deposits were discovered in the playa at the bottom of Saline Valley, outside the study areas, in 1864 (Bailey, 1902). An aerial tramway across the Inyo Mountains to Owens Valley was used to haul salt from the deposits between 1913 and 1930 (Ver Planck, 1958). Borax from surficial deposits was mined in Saline Valley west of the Lower Saline Wilderness Study Area from 1895 to 1907 (McAllister, 1955; Gale, 1914).

Talc deposits northwest of the Saline Valley Wilderness Study Area were known by the early 1900s and were worked as recently as 1970. Talc deposits in the Inyo Mountains west of Saline Valley have been active since 1941; small amounts of talc were mined through 1983.

Substantial deposits of sulfur were discovered at the Crater mine (fig. 2) in the Last Chance Range immediately north of the Saline Valley Wilderness Study Area in 1915 (Lynton, 1934). Peak activity was from 1928 to 1943. Intermittent production continued until 1972.

Mercury occurs at numerous mines and prospects in the Last Chance Range in the northeastern part of the Saline Valley Wilderness Study Area. Cinnabar was discovered in 1966 at the El Capitan mine 2 mi north of the Crater mine (fig. 2). Production from the El Capitan mine and exploration at mercury deposits inside the study area took place in the late 1960s when mercury prices were high ($536 per flask[1] in 1968) and ceased in 1971 when prices dropped to $292 per flask.

No mining was being conducted in the study areas in 1983.

GEOLOGY

Rocks ranging in age from Proterozoic to Cenozoic are widely exposed in the Saline Valley Wilderness Study Area (pl. 1). These rocks record a history of Proterozoic and Paleozoic marine sedimentation, Mesozoic plutonism, and Cenozoic volcanic and sedimentary deposition. Bedrock in the Lower Saline Wilderness Study Area consists of metamorphosed Mississippian, Pennsylvanian, and Permian strata and Jurassic granite.

Detailed geologic maps have been completed for the entire study area. Mapping was by Burchfiel (1969) in the Dry Mountain quadrangle, McAllister (1956) in the Ubehebe Peak quadrangle, McKee and Nelson (1967) in the Soldier Pass quadrangle, Nelson (1966, 1971) in the Waucoba Mountain and Waucoba Spring quadrangles, and Ross (1967b) in the Waucoba Wash quadrangle. Detailed mapping in the Last Chance quadrangle was done as part of this investigation. Ross (1967a) compiled a generalized geologic map of the Inyo Mountains region, which covers both study areas.

Upper Proterozoic and Paleozoic rocks

Strata of Upper Proterozoic age and from every period of the Paleozoic Era have been recognized in the Saline Valley Wilderness Study Area. The stratigraphic section formed by these rocks has an aggregate thickness on the order of 35,000 ft thick in the western part of the area and 16,000 ft thick in the eastern part of the area (Stewart and others, 1966). Rock types in the Proterozoic-Paleozoic section consist principally of quartzite, siltstone, shaly siltstone, limestone, and dolomite.

An important characteristic of the stratigraphy in the Saline Valley Wilderness Study Area is that the Proterozoic and Cambrian rocks in the western part have a different lithologic character than strata of the same age in the eastern part. This lithologic change takes place approximately across a narrow north-northeast-trending zone no more than about 5 to 10 mi wide that extends through the central part of the Saline Range, passes along Eureka Valley, and crosses the northern part of the Last Chance Range, north of the study area. In general the Proterozoic and Cambrian strata

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[1]A flask contains 76 lb of mercury

west of this zone contain more siltstone and limestone and less quartzite than equivalent strata east of the zone. These differences were first recognized by Stewart (1965) as occurring between rocks of equivalent age in the northern and southern parts of the Last Chance Range, but they apply as well to rocks across this zone elsewhere in the study area. Offset along a fault in the southern part of the Magruder Mountain quadrangle, which encompasses the northern end of the Last Chance Range, may account for the stratigraphic changes in that area (E. H. McKee, oral commun., 1984), but no structural feature has been found that might account for the stratigraphic changes in other parts of the Saline Valley area.

The facies changes in the Proterozoic and Cambrian rocks are indicated by the stratigraphic nomenclature, which is different for the formations of the Upper Proterozoic, Lower Cambrian, and the lower part of the Middle Cambrian on opposite sides of the zone (see pl. 1; Stewart, 1965, 1970). The stratigraphic differences between the western and eastern parts of the area are less marked in most of the Middle Cambrian and Upper Cambrian parts of the section. Some of the formations of Middle and Upper Cambrian age are found throughout the Saline Valley area.

Upper Proterozoic rocks in the western part of the Saline Valley Study Area have been divided into three formations and part of a fourth. The oldest rocks belong to the Wyman Formation, which consists mostly of argillite, quartzitic sandstone, and siltstone, and subordinate dolomite (Nelson, 1971). Strata of this formation exposed in the 15' quadrangles immediately west and northwest of the study area attain a thickness of 9,000 ft (Nelson, 1962), although the base is not exposed. Only the upper part of the formation is exposed in the study area. Above the Wyman Formation are dolomites and calcareous rocks of the Reed Dolomite, about 2,000 ft thick (Nelson, 1962, 1971,). Limestone, quartzite, sandstone, dolomite, and shale of the Deep Spring Formation, about 1,500 ft thick rest on the Reed Dolomite. The youngest Proterozoic rocks in the study area are in the lower half of the Campito Formation, which overlies the Deep Spring Formation. The Campito Formation is about 3,500 ft thick and is composed of sandstone, siltstone, and shale.

The Proterozoic-Cambrian boundary generally has been placed at the base of the lowest bed containing olenellid trilobites. In the Saline Valley Wilderness Study Area, this horizon is near the middle of the Campito Formation. Cloud and others (1966) preferred to place the boundary at the base of the Reed Dolomite. On the basis of fossils found near Gold Point in Esmeralda County, Nevada (fig. 1), Mount and others (1983) suggested that the boundary be placed near the top of the Reed Dolomite.

Using the definition of the Proterozoic-Cambrian boundary based on trilobites as followed by Nelson (1971, 1972), Ross (1967), and Stewart (1970) in reports and maps of the Inyo Mountain region, the Cambrian rocks in the Saline Valley area are about 11,000 ft thick. The Lower Cambrian strata in the western part of area are about 6,800 ft thick and consist principally of sandstone, siltstone, and quartzite, and subordinate amounts of limestone. Rocks above the lower part of the Campito Formation belong to the Poleta, Harkless, and Saline Valley Formations and the Mule Spring Limestone. The Mule Spring is the only Lower Cambrian formation that is dominantly calcareous. Middle and Upper Cambrian rocks total about 5,000 ft in thickness and are composed mostly of carbonate rocks. Formations in this part of the stratigraphic section, in ascending order, are the Monola Formation of Middle Cambrian age, the Bonanza King Dolomite of Middle and Late Cambrian age, and the Lead Gulch Formation of Late Cambrian age (Nelson, 1971; Ross, 1967). The Lead Gulch Formation is composed of hornfels (Nelson, 1971).

Cambrian strata in the eastern part of the area have been divided into five formations that have a total thickness of about 9,200 ft. The oldest of the Cambrian rocks are in the Wood Canyon Formation, which elsewhere in the Death Valley region contains Upper Proterozoic rocks. Only the Cambrian part of the Wood Canyon Formation is exposed in the study area (J. H. Stewart, oral commun., 1984). As exposed on the west side of the Last Chance Range, the Wood Canyon consists of quartzite, siltstone, and limestone and has strata that have been correlated with the Poleta Formation of Cambrian age and beds correlative with the upper part of the Campito Formation in the western part of the study area. Above the Wood Canyon Formation is the Zabriskie Quartzite of Lower Cambrian age, the Carrara Formation of Lower and Middle Cambrian age, the Bonanza King Dolomite of Middle and Late Cambrian age, and the Nopah Formation of Late Cambrian and Early Ordovician age (Burchfiel, 1969; Stewart and others, 1966). The Carrara is composed of limestone and siltstone, and the Bonanza King Dolomite and the Nopah Formation are mostly dolomite.

Rocks of Ordovician, Silurian, Devonian, and Mississippian age above the Nopah Formation have been assigned to formations that, unlike the Proterozoic and most of the Cambrian formations, are known throughout the study area. Approximately two-thirds of the Ordovician to Mississippian formations consist of carbonate rocks, and they have an aggregate thickness of about 7,000 ft. These stratigraphic units are the Pogonip Group, Eureka Quarzite, and Ely Springs Dolomite of Ordovician age, the Hidden Valley Dolomite of Silurian and Devonian age, the Lost Burro Formation of Devonian age, and the Tin Mountain Limestone, the Perdido Formation, and Rest Spring Shale of Mississippian age.

Pennsylvanian and Permian rocks are found in two formations exposed only in the southern part of the Saline Valley Wilderness Study Area and in the Lower Saline Wilderness Study Area (Burchfield, 1969; McAllister, 1956). They have a total thickness of about 4,500 ft. The lower unit, consisting mainly of limestone, is the Keeler Canyon Formation of Pennsylvanian and Permian age. The upper unit, composed of shale, siltstone, and limestone is the Owens Valley Formation of Permian age.

Mesozoic granitic rocks

Mesozoic granitic rocks are exposed in two plutons in the Saline Valley Wilderness Study Area. One pluton, located in the northwestern part of the study area, is elliptical in shape and 6 mi in longest dimension. It consists of two components, the diorite of Marble Canyon and the hornblende-augite quartz monzonite of Joshua Flat. The diorite occurs in irregular but generally elongate bodies that form a vaguely concentric pattern within the quartz monzonite of Joshua Flat. K-Ar age determinations ranging from 171 to 184 m.y. indicate that the quartz monzonite of Joshua Flat is Early to Middle Jurassic (McKee and Nash, 1967). A pluton in the southern part of the Saline Valley Wilderness Study Area and in the Lower Saline Wilderness Study Area is composed of the Hunter Mountain Quartz Monzonite. This rock is exposed in an area of several hundred square miles, mostly outside the study areas, and probably correlates with granitic rocks in the Inyo Mountains and ranges to the south. K-Ar ages range from 160 to 180 m.y. reported by Ross (1969) indicate an Early to Middle Jurassic age. Contact metamorphic effects ranging from schist and hornfels in silicic rocks to skarn in carbonate rocks can be found as much as 2 miles from the granitic contacts. Skarn is particularly evident at the southern tip of the Saline Valley Wilderness Study Area and in the Lower Saline Wilderness Study Area.

Cenozoic volcanic and sedimentary rocks

Tertiary rocks of the study areas crop out extensively in the Saline Range, at scattered localities in the Last Chance Range, and in the mountains north and south of Dry Mountain. The oldest Tertiary rocks are siltstone, sandstone, and limestone pebble and cobble conglomerate in the central part of the Last Chance Range and low on the eastern slopes of the mountains north of Dry Mountain. No datable materials have been found in these rocks. They are assumed to be Miocene or early Pliocene because they underlie basalt about 4.0 m.y. old. This basalt is a remnant of a volcanic field that extended from the eastern side of the Inyo Mountains easterly across the Saline Range to the Last Chance Range and the mountains around Dry Mountain. Basalt at the base of the volcanic section in the Saline Range, the Last Chance Range, and the mountains north of Dry Mountain has been dated by K-Ar methods at 3.7±0.2 to 4.2±0.3 m.y. (Elliott and others, 1984). Overlying this basalt in the Saline Range are air-fall and water-reworked tuffs, locally interlayered with basalt, which in turn are overlain by a thick latite flow dated at 3.4±0.2 m.y. (Elliott and others, 1984). The latite flowed from a plug dome near the east edge of the range. A small latite plug and latite flows interlayered with basalt in the northeastern part of the Last Chance Range are petrographically almost identical to the latite in the Saline Range and, therefore, may be of about the same age. Most of the extensive basaltic rock in the Saline Range is younger than the latite and is about 2 1/2 m.y. old (Ross, 1970; Elliott and others, 1984). On the basis of chemical analyses, Ross (1970) concluded that many of the flows that resemble basalt in the Saline Range are trachyandesites. Rhyolite tuff mapped by Nelson (1971) beneath basalt and trachyandesite in the Saline Range and intrusive rhyolite found in Paleozoic strata on the west side of the Last Chance Range during this study have not been dated. Also undated is a diatreme near the northeast corner of the Saline Valley Wilderness Study Area. Abundant quartz crystals in the diatreme are suggestive of rhyolitic affinities. The poorly consolidated gravels in uplifted fault-bounded masses along the Death Valley-Furnace Creek fault zone east of the Last Chance Range may be the youngest Tertiary deposits in the area studied, or they may be Quaternary.

Surficial deposits are exposed in the intermontane valleys and along stream channels in the mountains of the study area. The most extensive of these deposits are Pleistocene and Holocene fanglomerates that blanket the lower flanks of the mountains and slope to the valley bottoms. Active dunes and blankets of sands cover some of the fanglomerates and bedrock on the west and south sides of Eureka Valley, and playa deposits and a lofty field of active dune sand occupy the lowest parts of Eureka Valley. Alluvial gravels at the margin of Saline Valley grade into playa deposits at the west border of the Saline Valley and Lower Saline Wilderness Study Areas and then into brine deposits in the lowest parts of the valley outside the study areas.

Structural geology

The Proterozoic and Paleozoic strata in the Saline Valley Wilderness Study Area and the Paleozoic strata of the Lower Saline Wilderness Study Area were essentially flat lying and undeformed at the close of the Paleozoic Era. During the Mesozoic these rocks were telescoped by thrust faults and deformed by invading granitic bodies, and in the Cenozoic they were broken by basin and range faults. The rocks of the study areas, therefore, have been subjected to the principal tectonic events that affected the western part of the Basin and Range province.

The oldest deformation that disrupted the Proterozoic and Paleozoic rocks of the Saline Valley Wilderness Study Area resulted in the Last Chance thrust (Stewart and others, 1966). Exposures in widely spaced windows reveal that the thrust extends from the western part of the study area to the Nevada State line. The thrust may extend farther west than the study area because the rocks in the Inyo Mountains are structurally continuous with known upper-plate rocks. Throughout the region, Upper Proterozoic, Cambrian, and Ordovician strata at the sole of the upper plate rest on Mississippian rocks. The continuity of this relationship indicates that virtually all of the pre-Mesozoic rocks outside the windows and west of the Dry Mountain area are in the upper plate of the thrust, which is interpreted to have moved eastward for a distance of at least 20 miles (Stewart and others, 1966). The thrusting is considered to have taken place before emplacement of the Jurassic intrusives. Thrust faults in the Dry Mountain area are in the lower plate of the Last Chance thrust but probably are products of the same tectonic event.

Forceful emplacement of the Jurassic plutonic rocks in the study area pushed aside and folded the adjacent stratified rocks. Proterozoic and Cambrian strata were bowed into approximate parallelism with the contact of the invading monzonite of Joshua Flat. Effects of the shouldering action of the pluton are evident as much as 3 mi from the intrusive contact. Some strata adjacent to the Hunter Mountain pluton curve around the intrusive contact; other strata are cut at high angles, but the axes of folds in these rocks are deflected near the intrusion. The degree of contortion, like the effects of contact metamorphism, diminish away from the intrusive contacts of both plutons.

Basin and range faulting has been responsible for the present distribution of the mountain ranges and valleys in the study areas and for many of the faults in the mountains. The west side of the range in which Dry Mountain is located is the best example in the study areas of the topographic control of a mountain front by a basin and range fault. This nearly linear fault separates bedrock from the adjacent fan gravels. Topographic relief along the west side of the range is nearly 5,000 ft. The Last Chance Range and some of the other mountain areas also rise sharply in places from the down dropped valleys, but the faults that controlled the valleys and mountains are buried by alluvium.

The Saline Range, in marked contrast to the other mountain masses, is, in general aspect, a low broad dome whose surface is defined by Pliocene basaltic flows. The existence of this lava field and of the cinder cones alined along north-northeast-trending faults that break the field are suggestive that extensional processes responsible for basin and range structural features in the study areas were active at the time the basalt was erupting and probably provided the mechanism for tapping deep magma sources. Geophysical evidence discussed later, indicate that a valley connecting Saline and Eureka Valleys existed beneath the basalt in the northern part of the Saline Range and, therefore, that the crust at the site of the range has been the locus of crustal entension for at least 4 1/2 m.y. Remnants of basalt flows in the Last Chance Range 2,000 ft above flows in the Saline Range show that much of the present basin and range topography in the Saline Valley study area formed in the past 4 1/2 m.y. Faults in unconsolidated alluvium at numerous localities in Eureka and Saline Valleys and the deep valley west of Dry Mountain indicate that faulting is still active.

The Death Valley-Furnace Creek fault zone has offset upper Tertiary(?) and Pleistocene alluvial deposits near the northeast corner of the Saline Valley Wilderness Study Area. Displacement along this well known fault has been in a right-lateral sense and has resulted in cumulative offsets in Proterozoic and Paleozoic bedrock of many miles (Stewart, 1967). Holocene fanglomerates on the east side of Death Valley east of the study area are cut by faults that parallel the Death Valley-Furnace Creek fault.

GEOCHEMICAL STUDIES

A geochemical study of the Saline Valley and Lower Saline Wilderness Study Areas was conducted using three sample media—stream sediment, heavy-mineral concentrates, and rock. Stream sediment samples and heavy-mineral concentrates (2.6 specific gravity) were collected from 390 first- and second-order drainages at a sample density of approximately one sample site per square mile. Heavy-mineral concentrates provide enhanced geochemical anomaly patterns and information on mineral species such as oxides and ore forming sulfides. Information on background values and geochemical suites from mineralized areas were obtained from rock samples of outcrops, mines, prospect pits, and stream debris.

Stream-sediment samples were sieved to -80 mesh, pulverized, and analyzed for 29 elements by semiquantitative emission spectrographic methods (Grimes and Marranzino, 1968). Stream sediments also were analyzed for mercury and arsenic by wet chemical methods (Viets, 1978; Vaughn, and McCarthy, 1964). The heavy-mineral-concentrate samples were sieved to -30 mesh, and analyzed for 29 elements by the same methods as the stream sediment samples after removal of all magnetic and paramagnetic minerals. Rock samples were pulverized and analyzed for the same elements.

Anomaly thresholds were determined by using the break in slope of cumulative frequency plots or the 95th percentile value for most elements. For some elements, such as antimony, arsenic, gold, silver, tungsten, and zinc, a trace was considered anomalous for spectrographic data. High elemental concentrations from isolated samples were not considered as significant as were anomalies identified from many samples.

The geochemical data were interpreted and integrated with geologic, geophysical and remote sensing data to arrive at an assessment of the resource potential of the Saline Valley and Lower Saline Wilderness Study Areas.

REMOTE SENSING STUDIES

As a part of this study, limonitic materials were identified in LANDSAT images using a color-ratio-composite method (Rowan and others, 1974). This technique was used to map areas of hydrothermal alteration associated with limonitic materials and to help define potential mineralized systems. The term limonite is used, as defined by Blanchard (1968), as a general term for hydrous oxides but modified to include any material with the unique spectral reflectance properties of the ferric oxide minerals such as hematite and goethite as defined by Hunt (1980). Pyrite and (or) hematite are commonly associated with hydrothermal alteration that is potentially related to mineralization; these minerals weather to produce limonite, which is detected by this technique. Areas of hydrothermal alteration that lack limonitic materials are believed to be insignficant. All areas defined as limonitic from the satellite analysis were visited and sampled selectively to determine if the limonite was associated with hydrothermal alteration, and if so, with what type of alteration and (or) mineralization. The selected rock samples from limonitic areas were analyzed by a semiquantitative emission spectrographic method (Grimes and Marranzino, 1968) and a modified wet chemical method for selected elements (Viets, 1978) to determine trace mineralization in order to define the type and extent of any mineralizing process that could have produced the observed hydrothermal alteration. From these hydrothermal alteration studies, several mineralized areas were identified, and the extent, distribution, and type of alteration were mapped.

GEOPHYSICAL STUDIES

Aeromagnetic and gravity surveys were conducted as part of this mineral assessment study. Most of the aeromagnetic data were obtained from aircraft flown along east-west flightlines spaced 1 mi apart at 7,000 ft above sea level (U. S. Geological Survey, 1983). The extreme western part of the Saline Valley Wilderness Study Area was flown along east-west flight lines spaced 1 mi apart at 14,500 ft above sea level. New gravity data were added to data from the Department of Defense (DOD) gravity data set available through the National Oceanic and Atmospheric Administration (NOAA) Data Center (NOAA, National Geophysical and Solar-Terrestrial Data Center, Boulder, Colorado 80302). The gravity data were used to compute complete Bouguer and isostatic residual values (Simpson and others, 1983) for each datum. A total field magnetic map and an isostatic residual gravity map were produced from the data.

The most striking magnetic anomalies within the study areas occur over late Tertiary volcanic rocks of the Saline Range. Unmetamorphosed volcanic rocks, like those in the Saline Range, typically have high magnetic susceptibilities and high remnant magnetizations, for this reason many of the magnetic anomalies over the Saline Range are caused by topographic features. Several of the anomalies are negative, indicating that some of the volcanic rocks in the Saline Range formed during a time when the earth's magnetic field was reversed. A negative aeromagnetic anomaly over the southern end of the Last Chance Range and a positive anomaly 4 mi north of Dry Mountain probably are caused by similar volcanic rocks.

A magnetic depression about 4 mi across on the northeastern flank of the Saline Range cannot be explained by a reversely magnetized volcanic unit because the edges of the depression trend across the flows exposed in this area. This part of the Saline Range is thought to be underlain by a thick sequence of relatively nonmagnetic siliceous tuff similar to tuff exposed near the eastern part of the depression.

A major magnetic anomaly occurs over the Hunter Mountain Quartz Monzonite southeast of Upper Warm Spring. The shape of the anomaly indicates a steeply dipping contact of this plutonic rock with Paleozoic sedimentary rocks to the north and suggests a possible east-west structural boundary in this region. To the west, south, and east, however, the Hunter Mountain quartz monzonite extends at least several miles beyond its mapped extent. Hunter Mountain quartz monzonite probably underlies the entire Paleozoic sedimentary sequence in the southern tip of the Saline Valley Wilderness Study Area and in the Lower Saline Wilderness Study Area.

The pluton north of Marble Canyon in the northwest corner of the Saline Valley Wilderness Study Area also produces a significant magnetic anomaly. The anomaly indicates that this pluton does not extend appreciably to the east beyond its mapped boundary but that it may connect at relatively shallow depth with the pluton 4 miles north (and outside the Saline Valley Wilderness Study Area). Hence, the Cambrian sedimentary rocks in the northwest tip of the study area probably form a thin septum over these Jurassic plutonic rocks.

Isostatic residual gravity anomalies indicate lateral variations in upper crustal density. Typically, thick sequences of Paleozoic and Proterozoic sedimentary rocks, such as in the Last Change Range, produce positive gravity anomalies whereas deep valleys filled with weakly consolidated Cenozoic deposits, such as Eureka Valley and Saline Valley, produce negative anomalies. The most striking gravity anomaly within the study area occurs over the Saline Range. Assuming our reduction density of 2.67 g/cm^3 is an appropriate density for the rocks of this volcanic field, we would not expect a substantial gravity anomaly. However, a pronounced gravitational depression is evident over the northeast part of the volcanic field. Apparently, the gravity minimum is caused by a thick sequence of air-fall and water lain tuffs and possibly alluvium in a pre-basalt graben connected on the north with Eureka Valley and on the south with Saline Valley and capped by the volcanic rocks of the Saline Range.

The gravity trough within Eureka Valley is interrupted at latitude 37°12' N. by a northeast-trending gravity ridge apparently caused by a rise in basement rocks beneath the alluvium. Consequently, the deepest parts of the gravel-bedrock interface beneath Eureka Valley are at northern and southern ends of the valley.

Audiomagnetotelluric (AMT) soundings were made in areas 8 and 9 (fig. 3) to assess the depth of alteration identified by remote sensing and geochemical studies. The AMT equipment used was designed and built by the U.S. Geological Survey. Details of the equipment and its application have been given by Hoover and others (1978). Soundings were made over a frequency range of 4.5 H_z to 27 KH_z, which provided data on resitivity variations from the surface to a depth of approximately 2 km.

In the vicinity of the Crater mine (fig. 2) three AMT traverses were run approximately east-west to identify low resistivity zones that might be associated with conduits responsible for the development of mineralized rocks and possibly related to epithermal gold deposition. The traverses were made using natural signal sources of 4.5, 7.5, 16.7, and 25 H_z, which provided an exploration depth of about 0.5 km in this area. AMT resistivities were made on one dipole of each line so resitivities along the traverse could be calculated.

MINERAL OCCURRENCES AND DEPOSITS

The Saline Valley Wilderness Study Area has a great variety of metallic and nonmetallic mineral commodities. Metallic commodities in the study area include copper, gold, lead, lithium, manganese, mercury, molybdenum, silver, tungsten, and uranium. Nonmetallic commodities identified consist of sand and gravel, sulfur, talc, and minerals of possible interest to collectors. The Lower Saline Wilderness Study Area has occurrences of copper, gold, and silver. Mines and prospects that were examined during this study are numbered on Figure 2 and briefly described in Table 1. Other mines in the vicinity and named on Figure 2 (not numbered), were not examined because mineralized structures do not extend into the study area. Some of these mines may have mineral resources; many have potential for resources of the commodities formerly produced.

Metallic commodities in the Saline Valley Wilderness Study Area

Copper and molybdenum

Occurrences of copper are found in and adjacent to the northwestern parts of the Saline Valley Wilderness Study Area in Paleozoic carbonate and fine-grained clastic rocks and in Mesozoic granitic plutons that have intruded these rocks. Occurrences of copper and molybdenum exist in a similar environment at the south end of the study area.

The largest copper deposit in the vicinity of the study area is at the Loretto mine, 2 mi north of the area boundary (fig. 2). Chalcopyrite, specular hematite, pyrite, and secondary copper minerals occur in quartz stringers and calcite veins in altered monzonite, which has been explored from a deep shaft at the mine (Waring and Huguenin, 1917). Skarn bodies in small hornfelsic roof pendants in diorite at the Black Rock prospect (fig. 2, no. 16), 8 mi south of the Loretto mine, contain malachite, chrysocolla, and small amounts of chalcopyrite. Skarn adjacent to the Hunter Mountain quartz monzonite in the southern part of the study area contains copper minerals and molybdenite. Chalcopyrite, specular hematite and molybdenite are scattered through garnet-rich tactite at the Blue Jay mine, 0.5 mi east of the Saline Valley Wilderness Study Area (fig. 2). Core from 3,807 ft of drilling in 11 holes near the Blue Jay mine in 1970 contained a maximum of 2.67 percent copper and 0.18 percent molybdenum in small erratically distributed pods (Rumsey, 1983). Small copper-bearing skarn pods exist in nearby parts of the study area at the Lucky Rich prospect (fig. 2, no. 44), and other prospects (fig. 2, nos. 46, 47).

Gold

Placer gold occurs in Marble Canyon (fig. 2), and lode gold is known at many localities in the Saline Valley and Lower Saline Wilderness Study Areas.

Gold-bearing gravels extend for a distance of nine miles along the bottom of Marble Canyon (fig. 2). Eighteen shafts and 3,000 ft of drifts have been dug in the gravels west of the Saline Valley Wilderness Study Area. All of the recently active workings are in this part of the canyon. Three shafts, partly or completely caved, are inside the study area. The source of the gold in the Inyo Mountains is not known. McKee and others (1983) speculated that the gold may have been derived from a pre-Tertiary stream system that originated north of Marble Canyon, possibly in the White Mountains. Production has been mostly unrecorded, but at least 329 oz gold and 22 oz silver were recovered from more than 7,300 cu yd of gravel between 1936 and 1960. Gravel mined during that period averaged $1-7 per cu yd at a gold price of $35 per oz. The largest single nugget had a value of $300 (Tucker and Sampson, 1938). Three placer mines just west of the study area were active in 1982.

Gold occurs in hydrothermally altered shear zones at the Jenny B. prospect located at the north end of the range that contains Dry Mountain (fig. 2, no. 38). The host rocks are limestone and intensely sheared quartzite at the sole of the Last Chance thrust. Samples of altered rock collected at the surface contain anomalous concentrations of boron, copper, lead, manganese, niobium, and silver. Chip samples from workings on the property contain from a trace to 0.19 oz gold per ton and a wide range of silver and copper concentrations (table 1).

The Leah-Venessa prospect (fig. 2, no. 37), 0.6 mi southwest of the Jenny B. prospect, has gold in veins in highly faulted calcareous shale and limestone of the Lost Burro Formation. Chip samples collected across one mineralized zone averaged 0.099 oz gold per ton (table 1). Geochemical samples collected at the surface have the same suite of elements as samples from rocks at the Jenny B. prospect.

Anomalous concentrations of gold were found in rock samples collected in the vicinity of the Crater mine, both inside and outside the study area (fig. 2). A sulfur deposit, a mercury mine, and numerous mercury prospects exist in the area around the Crater mine and are discussed later, but no properties have been worked for gold. However, stream-sediment samples and rock samples from prospects in this area have high concentrations of mercury, antimony, and arsenic, which are key elements in the well known geochemical suite characteristic of epithermal gold deposits (Erickson and others, 1966; White, 1981). Various combinations of these elements were found at mercury prospects southwest of the Crater mine (fig. 2, nos. 5-10, 12-14), and gold was detected at four of the prospects (table 1). The high detection limit for gold by the spectrographic technique used—10 ppm in stream-sediment samples and 20 ppm in heavy-mineral concentrates—is too high to assess adequately the gold potential in the Crater mine area. Jasperoid veins in the Crater mine area contain anomalous concentrations of antimony, arsenic, and mercury, and locally of manganese, silver, and zinc as well.

Anomalous amounts of antimony, arsenic, and mercury, or combinations of these elements, which are suggestive of epithermal gold mineraliztion (White, 1981), were detected in samples from several other areas (fig. 3, areas 3-7, 11, 14, 15). These areas contain Paleozoic carbonate and clastic rocks except area 3, which has Tertiary gravel composed of Paleozoic carbonate and siliceous clasts. No prospects were found in most of these areas, and gold has not been reported as occurring in them. However, antimony, arsenic, and mercury, or combinations of these elements which are suggestive of epithermal gold mineralization, were detected in samples from these areas.

Minor amounts of gold occur with base metals in skarns (fig. 2, nos. 16, 18) and in quartz veins (fig. 2, nos. 28, 29) in the western part of the study area.

Lead, silver, and zinc

Quartz veins in Proterozoic and Cambrian sedimentary rocks in the vicinity of Whippoorwill Flat and Jackass Flats (fig. 2) contain silver, lead, zinc, copper, and gold. Argentiferous galena and in places sphalerite, pyrite, and chalcopyrite occur in prospects along segments of veins as much as 3,600 ft long (fig. 2, nos. 26-31, 33). On average, the veins are 0.5-1.5 ft thick, strike northeast, and dip about 35° southeast. A vein 0.7 ft wide at the Ruby Port prospect (fig. 2, no. 28; table 1) has an inferred 8,200 tons of vein rock that averages 5.9 oz silver per ton, 0.63 percent lead, 0.24 percent copper, and 0.04 oz gold per ton. Exposed parts of other veins at prospects in the Whippoorwill Flat-Jackass Flats area (fig. 2, nos. 26, 27, 29, 30, 31, 33) generally are narrow and have spotty concentrations of metals. Sericitic lead-silver-zinc veins in the southern part of the study area (fig. 3, area 8) are thin; they contain small amounts of many metals and have few indications of having been prospected.

Lithium

Anomalous concentrations of lithium were detected in cuttings from a hole drilled in the Eureka Valley playa (fig. 2, no. 35) in 1978 (Morgan, 1979). The playa occupies 1,000 acres, but playa deposits may underlie much of the valley floor now covered by alluvium and dune sand. The hole was drilled to a depth of 340 ft. From depths of 20 to 220 ft, samples of mostly clay and mud taken at 5 ft intervals averaged 0.0479 percent lithium; three zones contained from 0.092-0.0945 percent lithium. Samples taken from below 220 ft were mainly sand and averaged less than 0.01 percent lithium.

Manganese and Tungsten

Hot spring deposits at the Black Diamond prospect (fig. 2, no. 43) near Upper Warm Spring consist of crumbly, porous layers of travertine alternating with tungsten-bearing manganese-oxide layers as much as 10 in thick. Tungsten also occurs with secondary copper minerals in veins and shear zones in granitic rock and metasedimentary rock near intrusive contacts at the Scheelite and Waucoba Tungsten mines west of the Saline Valley Wilderness Study Area; no similar occurrences are known inside the study area.

Mercury

Mercury is known at numerous localities in the northern part of the Last Chance Range and at one locality in the Saline Range. The largest mercury mine in the region is the El Capitan, located 2 mi north of the Crater mine (fig. 2). It produced 3,400 flasks of mercury during the period 1967-1970 from solution pipes developed by hot spring action in fault zones that cut Cambrian dolomite (Hill, 1972). Ore consisted of cinnabar and metacinnabar in a gangue of gypsum, sulfur, opalite, calcite, and dolomite. Mercury prospects along the study area boundary south of the El Capitan mine are along fault zones in Cambrian quartzite or between quartzite and other clastic rocks (fig. 2,nos. 6-10, 12, 13). Samples from the mercury veins at these prospects contained 0.002 to 10.2 lb mercury per ton (table 1). A few grab samples from a hopper had higher mercury values, but the average grade of the vein material is too low for the mercury to be classified as a resource. Cinnabar also occurs northeast of Upper Warm Spring (fig. 2, no. 42) as coatings on cobbles and fine fragments between clasts in the top 2 ft of alluvium on the valley floor and interstitially in beds of felsic lapilli tuff.

Uranium

One water sample collected during drilling of a well to search for lithium (discussed earlier) in the playa of Eureka Valley (fig. 2, no. 35) was found to have 0.047 mg uranium per liter (J. A. Crowley, 1979 written commun.). The uranium may have been derived from sandy layers penetrated during the drilling. Gamma logs from the hole show increased radioactivity below 200 ft. Uranium also occurs at the Lucky Strike prospect (fig. 2, no. 4) where torbernite and autunite are sparsely scattered along a fault.

Nonmetallic commodities in the Saline Valley Wilderness Study Area

Sand and gravel

A dune field about 700 ft high and as much as 4,000 ft wide and 3 mi long, consisting of at least 300 million tons of eolian sand, is a prominent physiographic feature at the lower end of Eureka Valley. The sand consists of approximately equal amounts of quartz and feldspar and has lesser amounts of mica, magnetite, hematite, calcite, amphibole, rutile, and lithic fragments. One sample was analyzed chemically and found to have minor but anomalous amounts of lead and silver. Sand and gravel for local road construction has been produced in Eureka Valley along the road at the north border of the study area and along the road leading to the sand dunes.

Sulfur

The largest deposit of native sulfur known in California until about 1953 (Vernon, 1951; Branner, 1959) is at the Crater mine in the northern part of the Last Chance Range immediately north of the Saline Valley Wilderness Study Area. The sulfur, along with gypsum and fine-grained quartz, extensively replaced Cambrian dolomite. It was mined by open-pit and underground methods (Tucker and Sampson, 1938) and used for the manufacture of sulfuric acid and as a soil conditioner. More than 3 million tons of demonstrated resources averaging 40 percent sulfur are estimated to remain at the Crater mine (McHugh and others, 1984). The only sulfur found in the study area occurs along bedding planes and faults at the Sally Joe prospect (fig. 2, no. 14) and is not considered a resource.

Talc

Talc occurs as irregular replacement bodies along faulted contacts between dolomite and quartzite or siltstone within and outside the northwest border of the Saline Valley Wilderness Study Area and west of the study area (fig. 2). Most of the deposits are near the Nikolaus-Eureka mine (fig. 2), which produced about 75,000 tons of talc during intermittent operation from 1945 to 1970 for use in cosmetics and pharmaceuticals (Chidester and others, 1964). This deposit contains both high-grade (steatite) talc and high-alumina, chloritic (clinochlore and chloritoid) talc. The Harlis and Broady mine (fig. 2, no. 3), immediately outside the study area, produced 31 tons of talc in 1957. No production is recorded from the Victor Consolidated talc deposit or from the Green Rock prospect (fig. 2, no. 2), the only talc occurrence inside the study area. The White Eagle and Eleanor deposits (fig. 2) west of the study area had a combined production of 50,000 tons of high-grade talc between 1941 and 1979.

Other commodities

The Saline Valley Wilderness Study Area and vicinity has a few localities of possible interest to mineral collections. Turquoise, apatite, and other calcium and magnesium phosphate minerals occur with chrysocolla along narrow discontinuous fissures in siltstone at the Mercury Knob claims in the Last Chance Range (fig. 2, no. 9). No gem quality turquoise was found. Torbernite occurs with autunite, malachite, and azurite in limonite- and gypsum-bearing veins at the Lucky Strike prospect just outside the study area north of the Mercury Knob claims (fig. 2, no. 4). Colorless to milky-white quartz crystals as much as 12 in. long occur in veins in the Hunter Mountain Quartz Monzonite southeast of Upper Warm Spring (fig. 2, no. 45). Hematite and caliche coatings and milky interiors detract from the appearance of the crystals.

Metallic commodities in the Lower Saline Wilderness Study Area

Copper, gold, silver, tungsten, and uranium

Only one area in the Lower Saline Valley Wilderness Study Area shows evidence of mineralization. The Bonanza prospect (fig. 2, no. 49), located at the south end of the study area, has minor amounts of copper, gold, silver, tungsten, and uranium. Host rocks of the prospect are marble and skarn formed from Paleozoic carbonate rocks that lie in a septum about 2,000 ft wide in the Hunter Mountain Quartz Monzonite. The marble is bleached light gray to nearly white and contains masses of wollastonite, irregular pods of coarse-grained diopside, and narrow elongate zones of garnet-rich skarn. Idocrase and the manganese-bearing zoisite, thulite, occur locally in the skarn. The rocks are fractured and sheared along a broad, poorly defined zone that extends along the southwest contact of the septum and can be traced nearly 2 mi to the Lippincott mine area inside Death Valley National Monument (fig. 2). Malachite, chrysocolla, and minor azurite occur sporadically as fracture coatings and as disseminations in tactite and quartz-bearing shear zones at the Bonanza prospect and are particularly evident in a shear zone exposed in the open pit at the prospect. McAllister (1955) reported disseminated chalcopyrite at the prospect.

Table 1.--Mines and prospects in and adjacent to the Saline Valley and Lower Saline Wilderness Study Areas

[Asterisk (*) indicates outside study area; placer gold values at $400 per troy oz]

No. on Fig. 2	Name	Commodity	Workings and facilities	Summary
1	Uncle Adolf prospect	Unknown	Several open cuts and bulldozer trenches as deep as 15 ft.	Interbedded Cambrian siltstone and quartzite, locally hematite stained. No significant mineral values were found.
2	Green Rock prospect	Talc	One bulldozer trench and one small pit.	Talc, chlorite, and secondary copper minerals along sheared zones within limestone, siltstone, and quartzite near contacts with aplite intrusions. A sample of talc with minor chlorite had 5.6 percent alumina (Al_2O_3), 5.7 percent iron oxide (Fe_2O_3), 30.6 percent magnesia (MgO), and 55 percent silica (SiO_2).
3	*Harlis and Broady (D and D) mine	Talc	One adit with 281 ft of workings, one 10-ft-long adit and a 50-ft-long open cut.	Talc and chlorite in pods along sheared zones in limestone and quartzite near intrusive contacts. Numerous faults trend north to northeasterly. Six samples from talc zones that averaged 3.4 ft thick, contained 11.2 percent Al_2O_3, 3.6 percent Fe_2O_3, 22.5 percent MgO, and 44.8 percent SiO_2. No substantial talc bodies are exposed; 31 tons of talc were produced in 1957.
4	*Lucky Strike (UO Extension Nos. 1-6) prospect	Unknown	Two adits, 30 and 120 ft long and a pit.	Tobernite, autunite, malachite, chrysocolla, and azurite with limonite and gypsum fill fissures in quartzite along a segment of the Last Chance thrust. Of eight samples, six contained from 0.001 to 0.093 percent uranium oxide (U_3O_8) and seven contained 0.01 to 0.11 percent copper. Scintilometer surveys indicated that radioactive minerals are present only locally.
5	Lucky 13 prospect	Mercury	About 5,600 ft of bulldozer cuts and trails; furnace and collapsed cabin.	A branch fault of the Last Chance thrust that separates interlayered siltstone and quartzite from underlying shale contains stringers of quartz, gypsum, calcite, and small amounts of cinnabar (mercury sulfide). Four of 15 samples contained 0.0012 to 0.06 lb mercury per ton.

6	Aloha prospect	Mercury	Eight bulldozer trenches as much as 50 ft long and 10 ft deep.	Calcareous hot spring deposits with gypsum, sulfur, limonite, and minor cinnabar in fractured quartzite and shale. One of seven samples contained 0.0214 lb mercury per ton.
7	*Rebecca prospect	Mercury, gold	Three open cuts and several hundred ft of bulldozer cuts; a cabin and a retort are near the main cut.	Cinnabar fills fissures in highly fractured quartzite and is concentrated along shear zones. One sample from a 5.1-ft-thick shear zone contained 47.6 lb mercury per ton. One sample of fractured quartzite contained 0.8 lb mercury per ton; 35 other samples ranged from 0.002 to 0.2 lb mercury per ton; one contained 0.006 oz gold per ton.
8	Up and Down (James No. 1) Prospect	Mercury, gold, silver	Two adits 38 and 55 ft long, several levels of bulldozer cuts; a cabin, mercury retort, crusher, hopper, and rotary furnace.	Branch fault zones of the Last Chance thrust in siltstone, argillite, and quartzite are intensely altered to alunite and hematite, and contain concentrations of mercury; gold and silver are rarely present. Twelve of 34 chip samples across the zones contained 0.2 to 10.2 lb mercury per ton; two grab samples from a hopper contained 120.8 and 168 lb mercury per ton, of which one had 0.26 oz gold per ton; one grab sample of stockpile contained 0.6 oz silver per ton.
9	Mercury Knob prospect	Mercury, Copper, turquoise	Three small pits and a 120-ft-long, 50-ft-wide, & 30-ft-deep open cut; ore bin and grizzly below main pit; collapsed cabin.	Intensely fractured siltstone and conglomerate contain turquoise, apatite, and other phosphates in fissures along a shear zone. Of 12 samples, five contained between 0.011 and 0.086 lb mercury per ton and five had between 0.01 and 0.08 percent copper.
10	Eureka (Bear Cat) prospect	Mercury	A 55-ft-long adit, open cuts on four levels and several bulldozer cuts.	Cinnabar fills fissures and shear zones in intensely fractured quartzite in an area about 35 ft wide and 670 ft long. Of 12 chip samples one contained 6 lb mercury per ton; two samples contained 0.006 and 0.008 oz gold per ton.
11	*Sulfur Queen prospect	Sulfur	An 80-ft-long, 30-ft-wide open cut, two pits, several bulldozer trenches and at least four drill holes.	Sulfur and gypsum are along a fault zone in limestone. Four samples contained between 2.20 and 13.41 percent sulfur and averaged 6.4 percent.

12	April Fool prospect	Mercury	A trench 340 ft long, as much as 30 ft wide, and 17 ft deep; numerous bulldozer cuts, and a small pit; a jaw crusher and storage bins are nearby.	A branch of the Last Chance thrust separates quartzite from underlying cherty siltstone. Small amounts of cinnabar are in the fault zone. Six of 20 samples contained 0.2 to 2.4 lb mercury per ton.
13	Storm Cloud prospect	Mercury, gold	More than 3,000 ft of bulldozer cuts and trenches.	Highly-fractured quartzite contains hematite and minor cinnabar along fissures. Five out of ten samples contained from 0.0006 to 0.076 lb mercury per ton, one sample contained 0.046 oz gold per ton.
14	Sally Joe (Eureka Sulfur) prospect	Sulfur, mercury	Four pits and two bulldozer trenches.	Narrow seams of sulfur and manganese oxides in calcareous hot spring deposits rest on fanglomerate, gypsum, and limestone. Of six samples taken, one sample contained 58 percent sulfur, the remainder less than 1 percent; two samples had 0.2 lb mercury per ton.
15	Reo prospect	Uncertain	None.	Placer claims staked for rare earth minerals in 1958. Dark gray limestone is overlain by basalt. Limestone is brecciatd along a fault that strikes N. 41° E. and dips 80° NW. Six panned concentrate samples contained no significant mineral values.
16	Black Rock prospect	Copper, gold, silver	Three adits, each less than 10 feet long, and three small pits.	Small isolated roof pendants of hornfels and marble in a diorite body. Skarn zones in the pendants contain chrysocolla, malachite, hematite, and sparse chalcopyrite. Six samples averaged 1.6 percent copper, three contained 0.3 to 2.4 oz silver per ton, and two contained 0.016 and 0.020 oz gold per ton.
17	Alluvial prospect	Gold	None	Placer claims located in 1981. The prospect is mostly covered by Recent alluvium; Precambrian siltstone and Jurassic monzonite crop out at the mouth of Marble Canyon. No samples were taken.
18	*Coyote (Mystery, Rainbow)	Gold, copper	Several small pits and bulldozer cuts.	Skarn zones adjacent to the Joshua Flat pluton consist of marble with diopside, epidote, wollastonite, garnet, and zoisite, and locally contain chrysocolla and

	prospect			malachite. Two of five samples contained gold, 0.006 and 0.192 oz gold per ton; one contained 0.56 percent copper.
19	*Easy Pickings prospect	Gold	One shaft 21 ft deep and one 32 ft deep with 125 ft of drifts.	Placer gold in alluvium on bedrock. Three samples contained from a trace to 0.000452 oz gold per cu yd (0.009 to 18 cents per cu yd).
20	Krater-Van Norman prospect	Gold	"Inclined shaft, 115 ft deep to bedrock, with a drift north, 150 ft" (Tucker and Sampson, 1938, p. 410). Incline caved at 102 ft deep.	Gold-bearing gravel on the canyon floor and in older terrace gravel along canyon walls. One sample from botton of shaft contained 0.000265 oz gold per cu yd (10.6 cents per cu yd). Five samples from channel and terrace gravels north of the shaft contained 0.00000103 to 0.000638 oz gold per cu yd (0.04 to 25.5 cents per cu yd.). Tucker and Sampson (1938, p. 410) reported that no pay gravel was encountered here.
21	Tam prospect	Gold	None.	Lode claim located in 1976. Bedrock is shale, siltstone, quartzite, and limestone of Cambrian age. No indications of significant mineral values were found; no samples were taken.
22	Montezuma prospect	Gold	None.	Lode claim located in 1981. Bedrock is Cambrian siltstone, limestone, and shale. No indications of significant mineral values were found.
23	Opportunity prospect	Gold?	Two adits, 25 and 60 ft long.	A shear zone with some quartz veins trends northeasterly in argillaceous limestone. Three samples contained no significant mineral values.
24	Fuller prospect	Gold?	One 21-ft-long adit.	A quartz vein in silicified limestone contains some pyrite. Three samples contained no significant mineral values.
25	Gingerbell "Apex" prospect	Unknown	None.	Quartz veins follow bedding in argillite, quartzite, and limestone. No samples were taken.
26	Lee prospect	Copper lead, silver,	Two adits 87 and 88 ft long, two inclines 95 and 150 ft long	A quartz vein along bedding in quartzite strikes N. 12° to 21° E. and dips 30° to 50° E. The vein contains galena, chalcopyrite, and sphalerite. Of 16 chip samples

		zinc	with 60 ft of drifts, and several pits.	taken, seven contained 0.4 to 5.1 oz silver per ton; 16 contained 0.02 to 2.65 percent lead; 14 contained 0.01 to 1.95 percent zinc; and 11 contained 0.01 to 0.37 percent copper. Chip samples averaged 0.9 oz silver per ton, 0.45 percent lead, 0.47 percent zinc, and 0.045 percent copper. Six of seven select samples contained 1.3 to 23.0 oz silver per ton. The vein system extends for 3,600 ft along strike and averages 0.6 ft thick.
27	August prospect	Copper, lead, silver, zinc	One adit 78 ft long, one incline 27 ft long, and one pit.	A quartz vein in dolomite contains argentiferous galena, chalcopyrite, sphalerite, and tennantite(?). Of four chip samples, three across the quartz vein averaged 4.5 oz silver per ton, 0.70 percent zinc, 0.71 percent lead and 0.32 percent copper. Two select samples of stockpiles averaged 12.9 oz silver per ton, 2.2 percent zinc, 1.68 prcent lead and 0.88 percent copper. Vein is exposed for 1,000 ft, averages 0.6 ft thick.
28	Ruby Port (Ram Horn Del No. 3) prospect	Copper, lead, silver	A 37-ft-long inclined shaft, at least three open cuts, and a pit. A cabin is about 1,100 ft northwest of the shaft.	A quartz vein in dolomite contains pods of galena with chalcopyrite, chrysocolla, malachite, hematite, and limonite. Exposed for 530 ft along strike and averages 0.7 ft thick. One select sample of dump debris contained 41.5 oz silver per ton, 2.18 percent copper, and 1.86 percent lead. Seven chip samples delineated 8,200 tons of an inferred occurrence averaging 0.04 oz gold per ton, 5.9 oz silver per ton, 0.63 percent lead, and 0.024 percent copper.
29	Del No. 1 (Bonnie, Newcastle) prospect	Copper gold, lead silver, zinc	One shaft 8 ft deep, a 6-ft-long adit, and six small pits. One cabin.	Quartz veins with lenses of argentiferous galena, pyrite, sphalerite, chalcopyrite, and secondary copper minerals along bedding in limestone and sandstone. One vein crops out in three sections, offset by faults, for about 1,700 ft and averages 3.8 ft thick. Two of ten chip samples from this vein contained silver (0.6 and 2.9 oz per ton) and lead (1.01 and 5.00 percent); four grab samples averaged 3.23 oz silver per ton, 2.4 percent lead and 0.13 percent copper. Two chip samples from a limonitic fault zone contained 0.026 and 0.042 oz gold per ton. Two samples from other short veins contained 0.6 and 1.7 oz silver per ton, 0.09 and 0.39 percent copper, and 0.14 and 0.32 percent lead.

30	Hillside prospect	Lead silver	One 55-ft-long adit.	A 5-in.-thick quartz vein in dolomite contains pods of argentiferous galena. Two chip samples contained 0.8 and 2.0 oz silver per ton, and 1.97 and 6.80 percent lead.
31	Emma prospect	Lead, silver	Two adits, 25 and 30 ft long.	A 0.7-ft-thick quartz vein along a sheared contact between limestone and quartzite contains argentiferous galena and pyrite in pods. Chip samples averaged 3.2 oz silver per ton and 4.25 percent lead. One grab sample of a stockpile had 0.6 oz silver per ton and 1.68 percent lead.
32	*Premier (Gold) prospect	Silver	One 30-ft-long adit and several bulldozer trails and cuts.	A northeast-trending shear zone in thinly-bedded quartzite. A grab sample of limestone debris contained 0.3 oz silver per ton and one chip sample across a shear zone had no significant mineral values.
33	*Morning Star (Pine Tree) mine	Lead, silver	One 30-ft-long adit, one shallow shaft, at least 16 prospect pits, and numerous bulldozer scrapings; one cabin.	Seven mineralized shear zones in siltstone and quartzite contain quartz veins and pods with argentiferous galena, pyrite, and limonite. Seventeen tons of ore containing 13.5 percent lead and 4 to 5 oz silver per ton were mined in 1968 (S. L. Blair, oral commun., 1981). Of 19 chip samples, values in 16 ranged from 0.2 to 3.0 oz silver per ton and from 0.47 to 7.0 percent lead. A 600-ft-long 1.9-ft-wide vein at the south end of the property averaged 0.9 oz silver per ton and 2.2 percent lead; three, 0.9- to 16-ft-thick zones on the north part of the property averaged 1.1 oz silver per ton and 2.37 percent lead; two grab samples of stockpile averaged 6.3 oz silver per ton and 8.5 percent lead.
34	Desert View prospect	Copper	None.	Reported copper occurrence (unpublished BLM file). One chip sample across a limonitic shear zone in siltstone contained 0.01 percent copper.
35	Lithium occurrence	Lithium, uranium	One drill hole 335 ft deep.	Mud and clay zones from 20 to 200 ft beneath the surface of the Eureka Valley playa contain anomalous concentra-ions of lithium. Lithium content averaged 0.0479 per-cent, and three zones contained 0.092 to 0.0945 percent percent lithium; one water sample contained 0.047 mg uranium per liter (Morgan, 1979). Two samples of water

				contained 0.020 and 0.070 mg/liter lithium and amounts of sodium, potassium, sulfate, chloride, and fluoride at least an order of magnitude lower than those found in commercial grade brines (Smith, 1979).
36	Titan (Eureka Dunes) prospect	Quartz sand	None.	Eighteen placer claims located in 1962. Deposit consists of dune sand with approximately equal amounts of quartz and feldspar and small amounts of other minerals and lithic fragments. Nine samples averaged 66.6 percent SiO_2, 12.9 percent Al_2O_3, 4.0 percent CaO, 1.1 percent MgO and 2.3 percent Fe_2O_3. More than 300 million tons of sand are present.
37	Leah-Venessa prospect	Gold	Two inclines 15 and 25 ft deep and five prospect pits.	A mineralized 3.5-ft-thick bedding plane fault between calcareous shale and limestone strikes from N.50° E. to N.80° E. and dips 35° NW. The fault zone contains quartz stringers, limonite, and secondary copper minerals. Gold in four chip samples across the zone averaged 0.099 oz per ton and one had as much as 0.624 oz per ton. A select sample of quartz-rich gossan from dump contained 0.312 oz gold per ton. Three other chip samples across a shear zone to the southwest had no significant mineral values.
38	Jenny B. prospect	Gold, copper, silver	Four adits 12, 47, 100, and 590 ft long, a 25-ft-long inclined shaft, and several pits and trenches; the 590-ft-long adit is a crosscut with 210 ft of additional workings and a raise to the surface.	Sheared contacts of limestone with overlying quartzite contain quartz, limonite, hematite, chlorite, and malachite. Of 34 samples, three chip samples across a 5.6-ft-thick, 100-ft-long limestone-quartz breccia contact averaged 0.132 oz gold per ton, 0.14 oz silver per ton, and 4.29 percent copper. Five chip samples from other veins contained a trace to 0.05 oz gold per ton. A select sample of vein quartz contained 0.488 oz gold per ton, 0.2 oz silver per ton, and 4.9 percent copper. One of 14 chip samples from the crosscut, had 0.018 oz gold per ton.
39	Independence prospect	Gold	None	Located as a lode claim in 1974. The area is covered mainly by alluvium with isolated outcrops of Cambrian dolomite and Tertiary volcanic rocks. No significant mineralized zones were found, and no samples were taken.

40	Cerro Albino prospect	Mercury	Two shallow pits.	Rhyolitic tuff beds rest on limestone and are overlain by basaltic flows. Three samples contained trace amounts of mercury.
41	Dry Mountain prospect	Gold	One 34-ft-long adit in alluvium, one 7-ft-deep shaft to bedrock, and two bulldozer trenches.	Alluvium in a dry stream channel consists mainly of limestone clasts. A sample of the limestone and three placer samples from the workings contained no significant mineral values.
42	Coffee Stop prospect	Mercury	At least six prospect pits are in alluvium, tuff beds, and bedrock. A cabin, retort, and dry washer are nearby.	Cinnabar occurs interstitially and as thin coatings in Ouaternary alluvium and in felsic lapilli tuff beds. Of 35 samples, 27 contained no significant mineral values. Eight samples of screened alluvium contained from 0.1 to 1.4 lb mercury per ton.
43	Black Diamond prospect	Manganese, silver, tungsten	Seven pits and bull-dozer trenches; one 4 in. diameter drill hole. Depth unknown.	Crumbly, porous deposits of alternating travertine and manganese oxides occur around mineral springs. Of 14 samples, four chip samples across banded manganese oxides and calcite contained between 1.00 and 1.80 percent manganese, and 0.05 to 0.09 percent tungsten trioxide (WO_3); one chip across tufa with pyrolusite had 2.4 oz silver per ton. Norman and Stewart (1951, p. 192) reported 20-30 percent manganese and 0.24-0.63 percent WO_3 in samples from the prospect.
44	Lucky Rich prospect	Copper, molybdenum	Two prospect pits.	At least three pods of garnet skarn occur over a distance of 1,000 ft along contacts of Hunter Mountain Quartz Monzonite with limestone of the Pogonip Group . Of six skarn samples, three contained traces of silver, two had 0.01 and 0.08 percent copper, and one had 0.01 percent zinc. Spectrographic analysis indicates the presence of small amounts of molybdenum.
45	Unnamed prospect	Silver	Several small pits	Steeply dipping quartz veins roughly follow joints in quartz monzonite. Quartz is massive to very coarsely crystalline. Veins contain sparse blebs and cubes of pyrite. Three of six samples contained 0.1 to 0.2 oz silver per ton.

46	Indian prospect	Lead, silver, tungsten	One prospect pit.	A 10-ft-thick skarn zone is exposed for 100 ft along a limestone-monzonite contact. A sample contained 0.2 oz per ton silver, 0.01 percent lead, 0.50 percent zinc, and 0.07 percent WO_3.
47	Mary V. prospect	Copper	One prospect pit.	Limonitic epidotized shear zones in limestone contain sulfur, malachite, wollastonite, and chrysocolla. Ten samples contained trace amounts of silver, of these three samples had 0.01 to 0.12 percent copper.
48	*Blue Jay (Jarosite) mine	Copper, molybdenum	One adit nearly 100 ft long with a shallow winze, several short adits, and at least 14 drill holes (to as deep as 544 ft) that aggregate 3,800 ft.	Twenty tons of ore mined in 1915 yielded 4,000 lb copper and 1,199 oz silver. Garnet skarn along a contact of quartz monzonite with Devonian carbonate rocks contains molybdenite, chalcopyrite, and secondary copper minerals. The skarn body extends for at least 1,100 ft along its northerly strike; it is 70 to 260 ft wide and reaches a depth of 450 ft in places. Samples from holes drilled in 1971 by M.S. and W. Resources Inc. (records on file with National Park Service, Death Valley National Monument) suggest a 29-ft-thick, 590-ft-long mineralized zone that averages 1.05 percent copper and 0.12 percent molybdenum.
49	Bonanza prospect	Copper, gold, silver	One open pit 50 ft long, 30 ft wide, and 40 ft deep. A 65 ft long adit and 35 ft deep shaft were destroyed by excavation of the pit. Ten smaller pits and trenches are within 300 ft north and south of the main pit.	A narrow septum of Paleozoic carbonate rocks in quartz monzonite consists of marble and calcium-silicate minerals. The skarn zones and a quartz-bearing shear zone in the pit contain malachite, chrysocolla, minor azurite, and limonite. Of 23 chip samples from shear zones and skarn bodies, each contained silver (0.00292 - 1.140 oz per ton), 15 contained gold (0.000583 - 0.134 oz per ton), 13 contained copper (0.0340 - 11.0 percent), 5 contained tungsten (0.0005 to 0.0021 percent WO_3), and 4 contained uranium (0.0013 - 0.0057 percent U_3O_8).

ASSESSMENT OF MINERAL RESOURCES

As a result of this study, 17 areas in the Saline Valley Wilderness Study Area were found to have resource potential. The Saline Valley Wilderness Study Area has resource potential for gold, copper, lead, lithium, mercury, molybdenum, silver, and zinc. No resource potential was found in the Lower Saline Wilderness Study Area. Areas having resource potential are shown in Figure 3 and Plate 1.

The resource potential of mineralized areas in and adjacent to the Saline Valley and Lower Saline Wilderness Study Areas is ranked in the following scheme:

Low mineral resource potential is assigned to areas in which geologic, geochemical, or geophysical characterisitics define a geologic environment permissive for resource occurrence but where there is little evidence of the existence of a mineral resource. This broad category embraces areas of dispersed mineralized rock as well as areas that have few indications of having been mineralized.

Moderate mineral resource potential is assigned to areas in which geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a reasonable chance for resource accumulation, and where an application of genetic or descriptive models indicates favorable ground.

High resource potential is assigned to areas in which geologic, geochemical, and geophysical characteristics indicate a geologic environment favorable for resource occurrence, where interpretations of data indicate a high degree of likelihood for resource accumulation, where data support genetic or descriptive models indicating the presence of resources, and where evidence indicates that mineral concentration has taken place.

Identified resources are those whose location, grade, quality, and quantity are known or estimated from specific geologic evidence (U.S. Bureau of Mines and U.S. Geological Survey, 1980).

The procedure used for determining mineral resource potential in this investigation was described by Shawe (1981). It involves recognition of the presence in the study area of geologic environments known to be favorable for the occurrence of particular types of mineral deposits elsewhere in the world. Attempts are made to compare and match the geologic, geochemical, and geophysical features found in the mineralized areas in the study area with the geologic, geochemical, and geophysical features that have been demonstrated to be characteristic of, or criteria for, the occurrence of different types of known mineral deposits. The absence of key criteria is important in establishing the degree of favorability for resource potential and may be as significant as the recognition of positive criteria. The resource potential that best classifies an area is a measure of the probability of the existence of a resource, which is defined as a concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's surface in such form or amount that economic extraction of a commodity from the concentration is currently or potentially feasable (U.S. Geological Survey and U.S. Bureau of Mines, 1980).

Metallic commodities in the Saline Valley Wilderness Study Area

Gold

Evidence of gold mineralization has been found in eleven areas of the Saline Valley Wilderness Study Area (fig. 3, nos. 1, 3-7, 11-15). Eight of these areas are interpreted to have potential for the occurrence of gold in disseminated deposits formed in an epithermal environment related to hot spring systems. Most of these areas do not appear to have been prospected. Two of the eleven areas have placer gold or potential for placer gold, and one area has vein gold of mesothermal or epithermal origin.

Epithermal Gold.— Disseminated epithermal gold deposits commonly are of large size and low grade. They form in near-surface parts of hot spring systems or in hydrothermal cells where meteoric waters have merged with rising fluids in zones of high heat flow (Berger and Eimon, 1983; Silberman, 1982). Shallow intrusions, commonly of felsic composition provide the heat necessary to drive the hydrothermal systems. Silicification and evidence of hydrothermal brecciation may be extensive and may be accompanied by argillic alteration. High-grade disseminated deposits commonly have undergone multiple episodes of brecciation and mineralization (Berger and Eimon, 1983). A characteristic feature of epithermal gold deposits is the presence of anomalous concentrations of arsenic, antimony, and mercury introduced during mineralization. This suite of elements, and in some cases high concentrations of thallium, silver, and other metals, are found in the ore zone of disseminated gold deposits and near the surface in epithermal precious metal systems (Erickson and others, 1966; Radtke and others, 1980; White, 1981). Disseminated gold deposits occur in faulted volcanic or sedimentary rocks. The Carlin deposit, developed in fractured thin-bedded Silurian and Devonian carbonate rocks in north-central Nevada, is perhaps the best-known example of this type of deposit in carbonate rocks.

Area 1 in the northern part of the Last Chance Range (fig. 3) has features suggestive of a buried disseminated gold deposit. The characteristic geochemical suite of arsenic, antimony, and mercury occurs in highly anomalous concentrations in stream-sediment samples from streams draining the area and in rock samples from mercury prospects. Moreover, gold was found in rock samples from four mercury properties in and adjacent to area 1 (table 1, nos. 7, 8, 10, 13). Other characteristics favorable for epithermal gold deposits are faulted carbonate host rocks and extensive alteration common in a hot spring environment.

Alteration in area 1 consists of abundant native sulfur, gypsum, and quartz replacement bodies in the carbonate rocks and provides evidence that a hydrothermal system vented in the area. This type of alteration results from the oxidation of rising sulfur-rich fluids as they reach near-surface waters enriched in atmospheric oxygen and are converted to sulfate solutions. This process takes place above the boiling zone and results in replacement of the carbonate rocks with gypsum. The sulfate ions lower the pH, which, along with declining temperatures, cause the precipitaion of quartz, native sulfur, and any mercury sulfide along with gypsum. Gold may precipitate as a result of chemical changes that take place accompanying boiling (Berger and Eimon, 1983). In area 1, boiling would have taken place below the sulfur-quartz-gypsum alteration zone. Therefore, deeper parts of the fault zones and fractures that served as channels for the boiling mineralizing fluids could be likely sites of disseminated gold in the area.

The sulfur-gypsum-quartz zone in area 1 should be examined for evidence of multiple episodes of sealing and brecciation. Intermittent sealing and breaking would be expected in an area of prolonged hydrothermal activity involving boiling and alteration (Berger and Eimon, 1983; Silberman, 1982).

Audiomagnetotelluric (AMT) traverse data obtained at the Crater mine indicate the existence of a north-northeast-trending low resistivity zone associated with the mineralized rocks and extending to depth. This low resistivity zone probably represents the region where hydrothermal activity was concentrated, producing localized brecciation and alteration. Another low resistivity zone was identified 0.75 mi northwest of the mineralized rocks at the mine. The zone also trends north-northeast but has no evidence of mineralized rock at the surface. An extremely large 400 µm self potential anomaly also is associated with this zone. These data imply the existence in this area of a buried fossil hydrothermal system that may have potential for epithermal gold.

The source of the heat for the hot spring activity at the Crater mine is not well known but could have been the undated intrusive silicic volcanic rock found in a shaft at the Crater mine (Lynton, 1938) or the intrusive latite thought to be about 4 m.y. old and found a few miles from the mine during this study. This latite and volcanic rocks dated at 2.5 m.y. (Elliott and others, 1984) in nearby parts of the Saline Valley Wilderness Study Area lend credence to the possibility that the hydrothermal system in area 1 may be relatively young. Hill (1972) concluded that the El Capitan mercury deposit (fig. 2), which may have formed in the same hot spring system as at the Crater mine, developed within a few hundred feet of the surface.

The abundant altered rock along fault zones in carbonate rocks and the favorable geochemical data, including the existence of gold at a number of localities, are strong indications that area 1 has a high potential for the occurrence of a gold resource in a disseminated deposit.

In addition to area 1, seven other areas in the Saline Valley Wilderness Study Area (fig. 3, nos. 3-4, 6-7, 11, 14-15) have geologic and geochemical characteristics that identify them as areas of resource potential for the occurrence of epithermal gold deposits. Five characteristics were used to identify these areas, 1) a hot spring geologic environment generally near young faults, 2) bleached Paleozoic limestones, with poorly formed iron oxides, 3) the occurrence of calcite or quartz veins and (or) jasperoid, 4) anomalous concentrations of chemical elements in the epithermal precious metal geochemical suite (arsenic, antimony, and mercury), often with silver, manganese, and zinc, and 5) the occurrence of minor amounts of kaolinite and (or) sericite. Table 2 gives the concentration used in defining anomalous geochemical values for chemical elements found in these areas.

Table 2. Definition of Anomalous Geochemical Values

Wet Chemical Analyses, Anomalous Values in Parts Per Million (ppm)
As $\geq$ 30, Au $\geq$ 0.05, Bi $\geq$ 5, Cd $\geq$ 1, Hg $\geq$ .1, Sb $\geq$ 4, Zn $\geq$ 100
Semiquantitative Spectographic Analyses, Anomalous Values in Parts Per Million (ppm)
Ag $\geq$ 0.5, As $\geq$ 200, B $\geq$ 100, Ba $\geq$ 2000, Bi $\geq$ 10, Cu $\geq$ 100, Mn $\geq$ 2000, Mo $\geq$ 10, Nb $\geq$ 20, Pb $\geq$ 70, Sb $\geq$ 100, Sn $\geq$ 50, W $\geq$ 50, Zn $\geq$ 100

Areas 3 and 4 are on the east flank of the Last Chance Range. Both areas were identified from remote sensing data as having iron oxides of possible hydrothermal origin, and kaolinite was observed in area 4. The iron oxides were found to be poorly ordered types similar to ferrihydrite, which resembles a common iron oxide found in spring deposits (Carlson and Schwertmann, 1980, Henmi and others, 1980). Area 3 consists of gravel that is composed of abundant clasts of Paleozoic carbonate rocks in a matrix rich in iron oxides. Anomalous concentrations of arsenic and mercury were found in samples from the matrix of the gravel. Area 4 exposes brecciated and locally bleached and iron-stained Paleozoic carbonate rocks. Narrow quartz-calcite veins and thin films of jasperoid in fractures are anomalous in arsenic, antimony, mercury, manganese, and zinc. No indications of prospecting were found in either area. Based on this study, areas 3 and 4 have a low potential for the occurrence of gold resources of the disseminated type.

Areas 6 and 7, located on the west side of the mountains that culminate in Dry Mountain, consist of Paleozoic carbonate rocks. Both areas occur along a north-northeast-trending fault zone that offsets alluvial fan deposits, and both were identified from remote sensing studies as having iron oxides of possible hydrothermal origin. Area 6 is conspicuously red from iron oxides. The fault zone has silicified and sericitized gouge and numerous steeply dipping veins parallel to one another that contain calcite and wad (manganese oxide). These veins have anomalous concentrations of arsenic, antimony, and manganese, a mineral and geochemical association suggestive of epithermal mineralization. The fault zone in area 7 has hematite as well as poorly ordered iron oxides. Calcite veins in a system of anastomosing veins in the fault zone are as much as 3 ft wide, and some of them have limonite pseudomorphs after pyrite. Anomalous concentrations of arsenic, antimony, molybdenum, and silver were found in samples from the fault zone. Carbonate bedrock is bleached in an interval several hundred feet wide adjacent to the fault zone. The potential for gold resources in disseminated deposits in areas 6 and 7 is low.

Area 11 in the Inyo Mountains at the west border of the area (fig. 3) contains faulted Proterozoic rocks, including carbonate rocks, some of which are orange, possibly from alteration, and some are bleached white. Weak concentrations of iron oxides in the area were detected in remote sensing studies. Northerly trending fault zones have weak concentrations of montmorillonite and iron oxides similar to ferrihydrite. Minor narrow quartz veins were found to have anomalous amounts of arsenic, antimony, mercury, and zinc suggestive of the suite of elements associated with epithermal gold mineralization. The proximity of the area to a Mesozoic pluton rather than to areas close to Tertiary igneous activity is suggestive that any mineralization that affected the area may have a different origin than rocks that have potential for gold resources farther east. The area is recognized as having been weakly mineralized and in having a low potential for the occurrence of gold resources.

Areas 14 and 15 are located near the north end of the Saline Range (fig. 3). Evidence of mineralized rock in these areas was first identified from remote sensing data. The areas have perceptible but weak concentrations of iron oxides. Area 14 lies in Paleozoic carbonate rock adjacent to the west margin of the volcanic field that is extensively exposed in the Saline Range. The carbonate bedrock is broken by a north-northeast-trending fault zone that contains breccia fragments encased in quartz. Anomalous concentrations of arsenic found in this silicified breccia are the only hints of the geochemical suite commonly associated with gold mineralization. Area 15 has carbonate and clastic Paleozoic rocks that are offset along numerous north- and northeasterly trending faults and by the Last Chance thrust, which is exposed at a small window in the thrust near the middle of the area. Scattered thin quartz-calcite veins and thin films of jasperoid on fracture planes have anomalous amounts of arsenic, antimony, mercury, manganese, and zinc. Kaolinite was found on a few joint planes. Information gathered during our study indicates that areas 14 and 15 have a low potential for disseminated -type gold deposits.

The low potential for the occurrence of gold resources in areas 3, 4, 6, 7, 11, 14, and 15, discussed above, is based on the relatively weak hydrothermal alteration and low geochemical values found. Areas of known epithermal gold deposits generally give a highly anomalous expression of the epithermal precious metal gold suite, values that are variable but usually considerably higher above background than those found in this survey. Epithermal gold deposits also commonly exhibit evidence of several stages of silicification, brecciation, and stockwork veining. Such repetitive hydrothermal activity is not in evidence in these areas.

Placer Gold.— Areas 12 and 13 outline alluvial gravels in Marble Canyon in the western part of the study area. Area 12 contains the gravels that extend into the study area from the west and can be followed a distance of about 1.5 mi down the canyon from the west border of the area. Because these gravels contain mines at several localities along a considerable portion of area 12 inside as well as outside the study area, the area is assesssed as having a high potential for resources of placer gold at localities that have not been explored by mine workings. Bedrock is exposed along the bottom of Marble Canyon downstream from the east end of area 12 to the west end of area 13. Gravel is again exposed in area 13 to the lower end of the canyon, and these gravels could be expected to have placer gold that was transported downstream beyond area 12. Significant concentrations of placer gold, if present in area 13, reasonably would be at and near the bottom of the alluvium as they are in area 12. Area 13 has a moderate potential for the occurrence of gold resources in placer deposits.

Vein gold.— Area 5 is in the northern part of the mountains that contain Dry Mountain and has the Jenny B. prospect at its northeast end and the Leah-Venessa prospect at its southwest end. Evidence of iron oxides of hydrothermal origin in the area were detected in remote sensing data. Anomalous concentrations of boron, copper, lead, manganese, niobium, and silver, mentioned earlier as having been found at both prospects, is permissive of an origin by mesothermal mineralization. Despite the modest values of precious metals identified at the prospects, the area appears to be weakly mineralized and is assigned a low potential for the occurrence of gold resources.

Copper and Molybdenum

Copper and molybdenum occur in skarn deposits developed in calcsilicate rocks formed from Paleozoic carbonate rocks adjacent to the Hunter Mountain pluton near the southern end of the study area and in small skarn bodies enclosed in the Hunter Mountain pluton in nearby parts of Death Valley National Monument. The amounts of copper, molybdenum, and various other metals are low in these deposits, and the areas containing the skarns are interpreted as having no recognized potential for resources of these metals. Copper and precious metals occur in skarn developed in a marble inclusion in the diorite of Marble Canyon near the north end of the study area (Black Rock prospect, fig. 2, no. 16). Despite modest metal values at the prospect, the small size of this and similar marble inclusions indicate that no recognized resource potential exists for copper or other metals in the area containing the inclusions. Copper without associated molybdenum has been explored in workings of the Loretto mine (fig. 2), but because mineralized rock at this property does not extend into the study area the resource potential for copper in the mine area was not determined.

Concentrations of metals (as much as 1,500 ppm arsenic, 1,000 ppm copper, 0.8 ppm gold, 200 ppm lead, 1,000 ppm molybdenum, 15 ppm silver, and 500 ppm zinc) in veins containing iron oxides and quartz were found in area 9 (fig. 3) in Burchfiel's (1969) border phase of the Hunter Mountain pluton. Tungsten, boron, and niobium also were found in selected samples. These veins, the pervasive sericitic alteration between the veins, and a local stockwork of fine-grained quartz veins in the granite are indicative of a hydrothermal system probably related to the cooling of the Hunter Mountain pluton. An audiomagnetotelluric survey in the area indicated that the alteration extends $\frac{1}{2}$ to 1 km in depth. Copper and molybdenum in skarn deposits adjacent to the pluton is additional evidence that the mineralization is related to emplacement of the Hunter

Mountain Quartz Monzonite. Abundant roof pendant rock in the vicinity of the mineralized veins indicate that the veins occur high in the pluton. These observations suggest the possibility that a concealed porphyry copper or porphyry molybdenum system is present in the area. However, the geochemical signature is weak, and porphyritic or aplitic rocks suggestive of igneous venting to the surface were not found in the pluton.

Based on geochemical data and mineralogy, the veins in area 9 may have a multiphase history for which no single ore-deposit model applies. High concentrations of boron, niobium, and some tungsten in the veins suggest a high temperature phase of mineralization when volatiles were released during consolidation of the granite. Arsenic lead, mercury, silver, and zinc in the veins suggest a mesothermal phase of mineralization. Abundant iron oxide and siliceous gossan were observed, and although no sulfide minerals or pyrite were found in the veins precursor sulfides are assumed. The observed sericitic alteration may have resulted from mixing of magmatic and meteoric waters as the granite cooled. The large size of the vein quartz crystals (commonly 3 in. or more in length) associated with iron oxides, the well developed crystal faces including pyramidal terminations, the symmetrical distribution of the crystals inward from the vein walls, and the abundant open spaces between crystals are indications of deposition under epithermal conditions, and the areas of finer-grained quartz are indications of possible venting to the surface and boiling. A reasonable interpretation of the origin of the veins is that they formed in a regime of declining temperatures, possibly from hypothermal to epithermal conditions.

Area 9 is considered to be a favorable environment for the occurrence of metallic mineral resources because of the abundance of high metal values and numerous quartz-iron oxide veins in sericitized rock. However, because of the lack of pervasive strong hydrothermal alteration of the country rock and the absence of clear evidence of abundant sulfide mineralization in the veins, the resource potential for copper, molybdenum, and silver in area 9 is assessed as low.

Lead, silver, and zinc

Area 8 (fig. 3) represents a broad zone of high lead, silver, and zinc geochemical concentrations in Proterozoic and Paleozoic carbonate rocks and shale around the copper-molybdenum center in the Hunter Mountain Quartz Monzonite of area 9. The sericitic alteration of area 9 grades outward to propylitic alteration in area 8. This geochemical and alteration zonation is suggestive of a porphyry-type model, although the geochemical signature is weak and no porphyry rocks were found. In panned concentrates lead values ranged from 20-500 ppm, silver values ranged from not detected to 1.5 ppm, and zinc values ranged from not detected to 500 ppm. Anomalous concentrations of lead, silver, or zinc occur in many of the numerous quartz-sericite-epidote veins in the area. On the basis of the tentative model proposed above, the potential for the occurrence of lead, silver, and zinc resources in area 8 is low.

Area 10 has numerous lead-silver-zinc occurrences from Jackass Flats on the east to Whippoorwill Flat on the west. The area is dominated by carbonate rocks and quartzite that are cut by numerous quartz veins containing argentiferous galena. Lead-silver-zinc anomalies found in stream sediment and panned concentrate samples taken in the area are probably related to argentiferous galena occurrences in the numerous mines and prospects. During this study eight prospects within area 10 were visited and sampled. All of them contained sulfide bearing quartz veins in sedimentary rocks. The vein systems generally strike north-northeast, are discontinuous, average 1-2 feet thick, and were traced from 500 to 3600 feet along strike. The sulfide minerals occur as pods of galena and are associated with sparse sphalerite, chalcopyrite and secondary copper, lead, and zinc minerals.

The origin of these minerals is uncertain. Many mines east, west, and south of the Saline Valley Wilderness Study Area produced lead and silver, the most prominent being the Cerro Gordo mine in the Inyo Mountains, 1/2 mi northwest of Cerro Gordo Peak (fig. 1). Three prominent rock types are common to all of the mine areas: 1) the Hunter Mountain Quartz Monzonite, 2) Proterozoic-Paleozoic carbonate rocks, and 3) Carboniferous shale. The juxtaposition of these three rock types helps outline favorable ground and is believed to be an important characteristic of a tentative model proposed here for the lead, silver, and zinc occurrences. Although the main phase of the Hunter Mountain pluton appears to be relatively poor as a metal source, it may have provided sufficient heat to mobilize and transport metallic elements from carboniferous black shale and redeposit them as sulfides in quartz veins in the carbonate host rocks. Fluids from the quartz monzonite also could have played a part in the transport of metals. In most areas the veins are small and weakly mineralized. The larger mineralized bodies occur in areas having large amounts of carboniferous black shale, as at Cerro Gordo. Further studies are needed to establish the validity of this model.

The closest large intrusive to area 10 is the quartz monzonite of Joshua Flat, about 3 miles north. The sedimentary rocks in area 10 consist of Proterozoic and early Paleozoic limestones, siltstones, and quartzites that were thrust over Mississippian rocks along the Last Chance thrust prior to emplacement of the Joshua Flat pluton. Metals in the underlying Mississippian black shales may have been mobilized by the intrusive event, transported into the overlying Proterozoic and Paleozoic sediments, and deposited in sulfide bearing quartz veins. The absence of widespread hydrothermal alteration in the area and the absence of Tertiary volcanism, with the exception of basaltic cover, seems to preclude a more recent hydrothermal origin. Although numerous veins occur in the area, some having small identified resources, the potential for the occurrence of lead, silver, and zinc resources in area 10 is low.

Lithium

The lower part of Eureka Valley (fig. 3, area 16) contains lithium, based on reported analyses of clay samples obtained by drilling in the playa in the lower part of the valley (fig. 2, no. 35) (Morgan, 1979). The distribution of the lithium-bearing sediments is unknown, but these materials reasonably could underlie much of the southern part of the valley. Pliocene silicic volcanic tuffs, possible source rock for the lithium, occur immediately south in the northern part of the Saline Range. Ground water leaching of the tuffs, and concentration of the lithium in clays during evaporation of surface waters in the enclosed basin of Eureka Valley are likely methods of transportation and deposition, based on a model for lithium deposited in clays (Asher-Bolinder, 1982). The gravity low in Eureka Valley north of latitude 37° 12' may be the site of thick detrital accumulations that also could contain lithium-bearing playa deposits.

In 1981 lithium production in the United States was from pegmatite dikes in North Carolina and subsurface brines in Nevada (Ferrell and Searls, 1982). Although no lithium is currently produced from sediments, developing markets and advances in extraction technology may make mining of sediments containing 0.1 percent lithium economically feasible. Based on the above criteria, the lithium potential for area 16 is considered as low.

Manganese and tungsten

Manganese and tungsten occur in travertine at the Black Diamond prospect (fig. 2, no. 43) near Upper Warm Spring. A similar occurrence of manganese and tungsten deposited by hot spring activity exists at the Golconda Hot Spring in northern Nevada and was mined for tungsten in World War II (Marsh and Erickson, 1975). Although these occurrences are too small to be considered resources, additional occurrences of these metals are possible in the Quaternary gravels near Upper Warm Spring. The area of hydrothermal alteration at these occurrences was studied using an airborne spectrometer system to determine the distribution of important alteration minerals such as carbonate and clay minerals and sericite. The advantage of the airborne spectrometer system is the capacity to make very high spectral resolution measurements in the 1.6 to 2.5 micrometer (μm) region of reflectance radiation wavelengths. Important hydrothermal alteration minerals were identified in this area using this technique. As a result of this study, no resource potential for manganese or tungsten was identified in the Upper Warm Spring area.

Mercury

The mercury prospects and the El Capitan mercury mine in the northern part of the Last Chance Range are located peripheral to an area of sulfur deposits, which, as discussed earlier, is considered to have potential for a disseminated gold deposit (fig. 3, area 1). The mercury occurrences, sulfur deposits, and the area of gold potential are thought to be genetically related to a hot spring hydrothermal system.

The principal features of mercury deposits that have originated in hot springs systems have been outlined in an ore deposit model (Rytuba, 1983) that is based on the Sulfur Bank mercury deposit in northern California (White and Roberson, 1982). According to this model, mercury deposits of hot spring origin form in areas that have undergone extensional faulting and have been the sites of mafic to intermediate volcanism. Cinnabar, the principal ore mineral is deposited beneath the water table as disseminations and as coatings on fractures. At Sulfur Bank, abundant sulfur was deposited above the water table but decreased in abundance downward as cinnabar became abundant. Characteristic suites of alteration minerals originated above and below the water table, and opal was deposited at the water table.

The El Capitan deposit has many features of this model and is reasonably typical of hot spring type mercury deposits. Hill (1972) demonstrated that the El Capitan deposit is localized along steeply dipping north-northeast-trending faults at intersections with north-trending faults. The mercury ore consisted of cinnabar and minor amounts of metacinnabar associated with gypsum, native sulfur, opaline silica, and quartz. Ore was deposited in irregular, funnel-shaped and carrot-like, vertically oriented bodies that were near-surface conduits in a hot spring system. Open pipe-like and funnel-shaped channel ways that must have served as conduits for rising fluids could be seen at the mine in 1983.

Veins containing cinnabar, native sulfur, quartz, and gypsum occur at the El Capitan mine outside the main ore bodies, and various combinations of these same minerals are found at mercury occurrences inside the Saline Valley Wilderness Study Area. Alunite also commonly is present. Bedrock adjacent to the mercury occurrences in the study area commonly is bleached and silicified, and carbonate host rock locally is replaced by gypsum. At the Aloha, Rebecca, and Eureka propects (fig. 2, nos. 6, 7, 10), cinnabar fills fissures in highly fractured quartzite. Based on the presence of the cinnabar veins at the El Capitan mine, the mercury veins in the study area probably also originated in a hot springs environment even though obvious channel ways for hot spring waters have not been found.

The age of the mercury mineralization is probably late Pliocene or younger, as many of the mercury occurrences and the El Capitan deposit are localized along faults that are part of a fault system which has offset volcanic rocks as young as about 4 m.y. old (Elliott and others, 1984). Intrusive latite shown on Plate 1 as a few miles east of the Crater mine may be about this age, because latite flows nearby are interlayered with Pliocene basalt. Intrusive silicic volcanic rock found in a shaft at the Crater mine (Lynton, 1938) and the volcanic material in the diatreme to the northeast (fig. 3) have not been dated but are assumed to be Pliocene or younger. Any of these intrusive rocks at or near the Crater mine could have been the source of heat and possibly hydrothermal fluids for the hot spring system that deposited the mercury.

Based on the sparseness of mercury occurrences and the low average grade of the mercury prospects, area 2 and adjacent parts of area 1 have a low potential for the occurrence of mercury resources. If present, the mercury deposits reasonably could have high-grade zones.

Cinnabar also was found in alluvium and tuff beds in the area of hydrothermal alteration near Upper Warm Spring (fig. 2, no. 42). The concentration of mercury is low and is not considered indicative of a potential for mercury resources in that area.

Talc

A zone of talc deposits and occurrences extends southwesterly from the Victor Consolidated mine outside the Saline Valley Wilderness Study Area to the Green Rock prospect just inside the north end of the study area (fig. 3, area 17). Only a small part of this zone lies in the study area, and all of the properties in this belt that have had production are outside the study area. The zone of talc deposits at the Eleanor and White Eagle mines (fig. 2), 25 miles south of the Nikolaus-Eureka mine, is not known to extend into the study area. Wright (1966) stated that most talc deposits in the Inyo Mountains region have been nearly mined out and that other deposits are certain to exist but discovering them will be difficult and expensive. This statement probably is applicable to the study area. The study area is considered to have a low potential for the occurrence of talc resources.

Uranium

Although a small quantity of uranium found in a water sample taken from a well in Eureka Valley (fig. 2, no. 35), and although uranium minerals occur at the Lucky Strike prospect (fig. 2, no. 4), the study area is not considered to have significant potential for the occurrence of uranium. The uranium in both areas probably was derived by leaching from igneous sources—respectively, latite tuffs in the Saline Range and intrusive latite in the Last Chance Range. Latite is not known to be a favorable source rock for uranium.

Nonmetallic commodities in the Saline Valley Wilderness Study Area

Sand and gravel

Sand in the large dune field in Eureka Valley has a high percentage of impurities and cannot be classified as high-silica sand for specialty uses. High-silica specialty sands for the manufacture of clear glass are composed almost entirely of SiO_2, and sands for many other uses must be of moderately high purity (Ketner, 1973). The impurities and great distances from centers of population preclude assigning any resource potential to the sand in Eureka Valley.

Sand and gravel sufficient for local use as road metal or other uses as an aggregate are available in fanglomerates and other alluvial deposits in the wilderness study area, but these materials have little promise for use elsewhere.

Sulfur

Although numerous occurrences of sulfur are known in the vicinity of the Crater mine in the Last Chance Range (fig. 2), only one occurrence is known in the Saline Valley Wilderness Study Area. Additional small occurrences may be found near the north border of the study area, but the potential for a sulfur resource is nil.

Metallic commodities in the Lower Saline Wilderness Study Area

Copper, gold, silver, tungsten, and uranium

Marble and skarn at the Bonanza prospect (fig. 3, no. 49) near the south end of the Lower Saline Wilderness Study Area contain concentrations of copper minerals and small amounts of gold, silver, tungsten, and uranium (table 1). No indications of these metals were found in the study area outside the immediate vicinity of the workings, and no record of mineral production has been found for the prospect. Similar small occurrences of copper and other metals are found in skarn bodies along the contact of the Hunter Mountain pluton at scattered localities to the north and northeast in the southern part of the Saline Valley Wilderness Study Area and nearby parts of Death Valley National Monument. All of these occurrences are considered to have formed from mineralizing solutions generated during emplacement of the Hunter Mountain Quartz Monzonite. Based on the small size of the mineralized area and the low concentrations of metals at the Bonanza prospect, the Lower Saline Wilderness Study Area is considered to have no indentified potential for the occurrence of copper, gold, silver, tungsten, and uranium resources.

REFERENCES CITED

Asher-Bolinder, Sigrid, 1982, Lithium-rich clays, in Characteristics of mineral deposit occurrences: U. S. Geological Survey Open-File Report 82-795, p. 225-229.

Bailey, G. E., 1902, The saline deposits of California: California Division of Mines Bulletin 24, 216 p.

Berger, B. R., and Eimon, P. I., 1983, Conceptual models of epithermal precious metal deposits, in Shanks, W. C., ed., Proceedings of the Cameron Symposium on Unconventional Resources: Society of Economic Geologist, p. 191-205.

Blanchard, Roland, 1968, Interpretation of leached outcrops: Nevada Bureau of Mines Bulletin 66, 196 p.

Branner, G. C., 1959, Sulfur in California and Nevada: U. S. Bureau of Mines Information Circular IC 7898, 50 p.

Burchfiel, B. C., 1969, Geology of the Dry Mountain quadrangle, Inyo County, California: California Division of Mines and Geology Special Report 99, 19 p.

Chalfant, W. A., 1933, The story of Inyo: Chalfant Press, 437 p.

Chidester, A. H., Engel, A. E. J., and Wright, L. A., 1964, Talc resources of the United States: U. S. Geological Survey Bulletin 1167, 61 p.

Cloud, P. E., and Nelson, C. A., 1966, Phanerozoic-cryptozoic and related transitions: new evidence: Science, v. 154, p. 766-770.

Carlson, L., and Schwertmann, V., 1980, Natural occurrence of feroxyhite: Clays and Clay Materials, v. 28, p. 272-280.

Elliott, G. S., Wrucke, C. T., and Nedell, S. S., 1984, K-Ar ages of Late Cenozoic volcanic rocks from the northern Death Valley region: Isochron/West, no. 40, p. 3-7.

Erickson, R. L., Van Sickle, G. H., Nakagawa, H. M., McCarthy, J. H., Jr., and Leong, K. W., 1966, Gold geochemical anomaly in the Cortez district, Nevada: U. S. Geological Survey Circular 534, 9 p.

Ferrell, J. E. and Searls, J.P. 1982, Lithium, in Minerals Yearbook: U. S. Bureau of Mines, v. 1, p. 551-556.

Gale, H. S., 1914, Salt, borax, and potash in Saline Valley, Inyo County, California: U. S. Geological Survey Bulletin 540, p. 416-421.

Grimes, D. J., and Marranzino, A. P., 1968, Direct-current arc and alternating-current spark emission spectrographic field methods for the semiquantitative analysis of geologic materials: U. S. Geological Survey Circular 591, 6 p.

Henmi, T., Wells, N., Childs, C. W., and Parfett, R. W., 1980, Poorly ordered iron-rich precipitates from springs and streams on andesitic volcanoes: Geochimica et Cosmochimica Acta, v. 44, p. 365-372.

Hill, R. L., 1972, Geology and geochemistry of El Capitan mercury mine, Last Chance Range, Inyo County, California: Los Angeles, University of California M.S. thesis, 144 p.

Hoover, D.B., Frischknecht, F.C., and Tippens, C.L., 1976, Audiomagnetotelluric sounding as a reconnaissance exploration technique in Long Valley, California: Journal of Geophysical Research, v. 81, p. 801-809.

Hunt, G. R., 1980, Electromagnetic radiation: the communication link in remote sensing, in Siegal, B. S., and Gillespie, A. R., Remote sensing in geology: New York, John Wiley and Sons, p. 5-45.

Ketner, K. B., 1973, Silica sand, in Brobst, D. A., and Pratt, W. P., United States mineral resources: U. S. Geological Survey Professional Paper 820, p. 577-580.

Lynton, E. D., 1938, Sulphur deposits in Inyo County, California: California Journal of Mines and Geology, v. 34, p. 563-590.

Marsh, S. P., and Erickson, R. L., 1975, Integrated geologic and geochemical studies, Edna Mountains, Nevada, in Elliot, I. L., and Fletcher, W. K., eds., Geochemical exploration 1974: Developments in Economic Geology, No. 1, p. 239-250.

McAllister, J. F., 1955, Geology of mineral deposits in the Ubehebe Peak quadrangle, Inyo County, California: California Division of Mines Special Report 42, 63 p.

____, 1956, Geology of the Ubehebe Peak quadrangle, California: U. S. Geological Survey Geologic Quadrangle Map GQ-95, scale 1:62,500.

McKee, E. H., and Nash, T. B., Potassium-argon ages of granitic rocks in the Inyo batholith, east-central California: Geological Society of America Bulletin, v. 78, no. 5, p. 669-680.

McKee, E. H., and Nelson, C. A., 1967, Geologic map of the Soldier Pass quadrangle, California and Nevada: U. S. Geological Survey Geologic Quadrangle Map GQ-654, scale 1:62,500.

McHugh, E. L., Gaps, R. S., Causey, J. D., and Rumsey, C. M., 1984, Mineral resources of the Saline Valley Wilderness Study Area (BLM no. CDCA-117), Inyo County, California: U.S. Bureau of Mines Mineral Land Assessment MLA 16-84, 41 p.

Merriam, C. W., 1963, Geology of the Cerro Gordo mining district, Inyo County, California: U. S. Geological survey professional paper 408, 83 p.

Morgan, J. D., 1979, Lithologic log, lithium content, and mineralogy of sediments penetrated in test boring drilled in Eureka Valley, Inyo County, California: U. S. Geological Survey Open-File Report 79-1089, 13 p.

Mount, J. F., Gevirtzman, D. A., and Signor, P. W. III, 1983, Precambrian-Cambrian transition problem in western North America: Part I. Tommotian fauna in the southwestern Great Basin and its implications for the base of the Cambrian System: Geology, v. 11, no. 4, p. 224-226.

Nelson, C. A., 1962, Lower Cambrian-Precambrian succession, White-Inyo Mountains, California: Geological Society of America Bulletin, v. 73, no. 1, p. 139-144.

____, 1966, Geologic map of the Waucoba Mountain quadrangle, Inyo County, California: U. S. Geological Survey Geologic Quadrangle Map GQ-528, scale 1:62,500.

____, 1971, Geologic map of the Waucoba Spring quadrangle, Inyo County, California: U. S. Geological Survey Geologic Quadrangle Map GQ-921, scale 1:62,500.

Norman, L. A., Jr., and Stewart, R. M., 1951, Mines and mineral resources of Inyo County: California Journal of Mines and Geology, v. 47, no. 1 p. 17-223.

Radtke, A. S., Rye, R. O., and Dickson, F. W., 1980, Geology and stable isotope studies of the Carlin gold deposit, Nevada: Economic geology, v. 75, p. 641-672.

Ross, D. C., 1967a, Generalized geologic map of the Inyo Mountains region, California: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-506, scale 1:125,000.

____, 1967b, Geologic map of the Waucoba Wash quadrangle, Inyo County, California: U. S. Geological Survey Geologic Quadrangle Map GQ-612, scale 1:62,500.

____, 1969, Descriptive petrography of three large granitic bodies in the Inyo Mountains, California: U. S. Geological Survey Professional Paper 601, 47 p.

____, 1970, Pegmatitic trachyandesite plugs and associated volcanic rocks in the Saline Range-Inyo Mountains region, California: U. S. Geological Survey Professional Paper 614-D, p. D1-D29.

Rowan, L. C., Wetlaufer, P. H., Goetz, A. F. H., Billingsley, F. C., and Stewart, J. H., 1974, Discrimination of rock types and detection of hydrothermally altered areas in south-central Nevada by use of computer-enhanced ERTS images: U. S. Geological Survey Professional Paper 883, 35 p.

Rumsey, C. M., Mineral investigations of the Lower Saline Wilderness Study Area (BLM no. CDCA-117A), Inyo County, California: U. S. Bureau of Mines Mineral Land Assessment MLA 1-84, 10 p.

Rytuba, J., 1983, Hot spring Hg, in Cox, D. P., ed., U. S. Geological Survey-Ingeominas mineral resource assessment of Colombia: Ore deposit models: U. S. Geological Survey Open-File Report 83-423, p. 45.

Shawe, D. R., 1981, U. S. Geological Survey workshop on nonfuel mineral-resource appraisal of wilderness and CUSMAP areas: U. S. Geological Survey Circular 845, 18 p.

Silberman, M. L., 1982, Hot-spring type, large tonnage, low-grade gold deposits, in Characteristics of mineral deposit occurrences: U. S. Geological Survey Open-File Report 82-795, p. 131-143.

Simpson, R. W., Jachens, R. C., and Blakely, R. J., 1983, AIRYROOT: A Fortran program for calculating the gravitational attraction of an Airy isostatic root out to 166.7 km: U. S. Geological Survey Open-File Report 83-883, 66 p.

Smith, G. I., 1979, Subsurface stratigraphy and geochemistry of late quaternary evaporites, Searles Lake, California: U. S. Geological Survey Professional Paper 1043, 130 p.

Stewart, J. H., 1965, Precambrian and Lower Cambrian formations in the Last Chance Range area, Inyo County, California, in Cohee, G. V., and West, W. S., Changes in stratigraphic nomenclature by the U. S. Geological Survey, 1964: U. S. Geological Survey Bulletin 1224-A, p. A60-A70.

____, 1967, Possible large right-lateral displacement along fault and shear zones in the Death Valley-Las Vegas area, California and Nevada: Geological Society of America Bulletin, v. 78, p. 131-142.

____, 1970, Upper Precambrian and Lower Cambrian strata in the southern Great Basin, California and Nevada: U. S. Geological Survey Professional paper 620, 206 p.

Stewart, J. H., Ross, D. C., Nelson, C. A., and Burchfiel, B. C., 1966, Last Chance thrust—a major fault in the eastern part of Inyo County, California, in Geological Survey Research, 1966: U. S. Geological Survey Professional Paper 550-D, p. D23-D34.

Tucker, W. B., and Sampson, R. J., 1938, Mineral resources of Inyo County: California Journal of Mines and Geology, v. 34, no. 4, p. 368-500.

U. S. Bureau of Mines and U. S. Geological Survey, 1980, Principles of a reserve/resource classification: U. S. Geological Survey Circular 831, 5 p.

U. S. Geological Survey, 1983, Aeromagnetic survey of the Eureka and Saline Valley areas, California and Nevada: U. S. Geological Survey Open-file Report 83-653, scale 1:250,000.

Vaughn, W. W., and McCarthy, J. H., Jr., 1964, An instrumental technique for the determination of submicron concentrations of mercury in soils, rocks, and gas, in Geological Survey Research 1964: U. S. Geological Survey Professional Paper 501-D, p. D123-D127.

Vernon, J. W., 1951, California sources of sulfur and sulfuric acid, in Minerals useful to California agriculture: California Division of Mines Bulletin 155, p. 129-130.

Ver Plank, W. E., 1958, Salt in California: California Division of Mines Bulletin 175, 168 p.

Viets, J. G., 1978, Determination of silver, bismuth, cadmuim, copper, lead, and zinc in geologic materials by atomic absorption spectrometry with tricaprylyl methyl ammonium chloride: Analytic Chemistry, v. 50, p. 1097-1101.

Waring, C. A., and Huguenin, Emile, 1917, Inyo County: California State Mining Bureau Report 15, p. 29-134.

White, D. E., 1981, Active geothermal systems and hydrothermal ore deposits, in Skinner, B. J., ed., Seventy-fifth anniversary volume: Economic Geology, p. 392-423.

White, D. E., and Roberson, C. E., 1962, Sulphur Bank, California, a major hot spring quicksilver deposit, in Petrologic studies: Geological Society of America Buddington volume, p. 397-428

Wright, L. E., 1966, Talc and soapstone, in Mineral resources of California: California Division of Mines and Geology Bulletin 191, p. 414-420.

Wrucke, C. T., Werschky, R. S., Raines, G. L., Blakely, R. J., Hoover, D. B., and Miller, M. S., 1984, Mineral resource potential of the Little Sand Spring Wilderness Study Area, Inyo County, California: U. S. Geological Survey Open-File Report 84-557, 20 p.

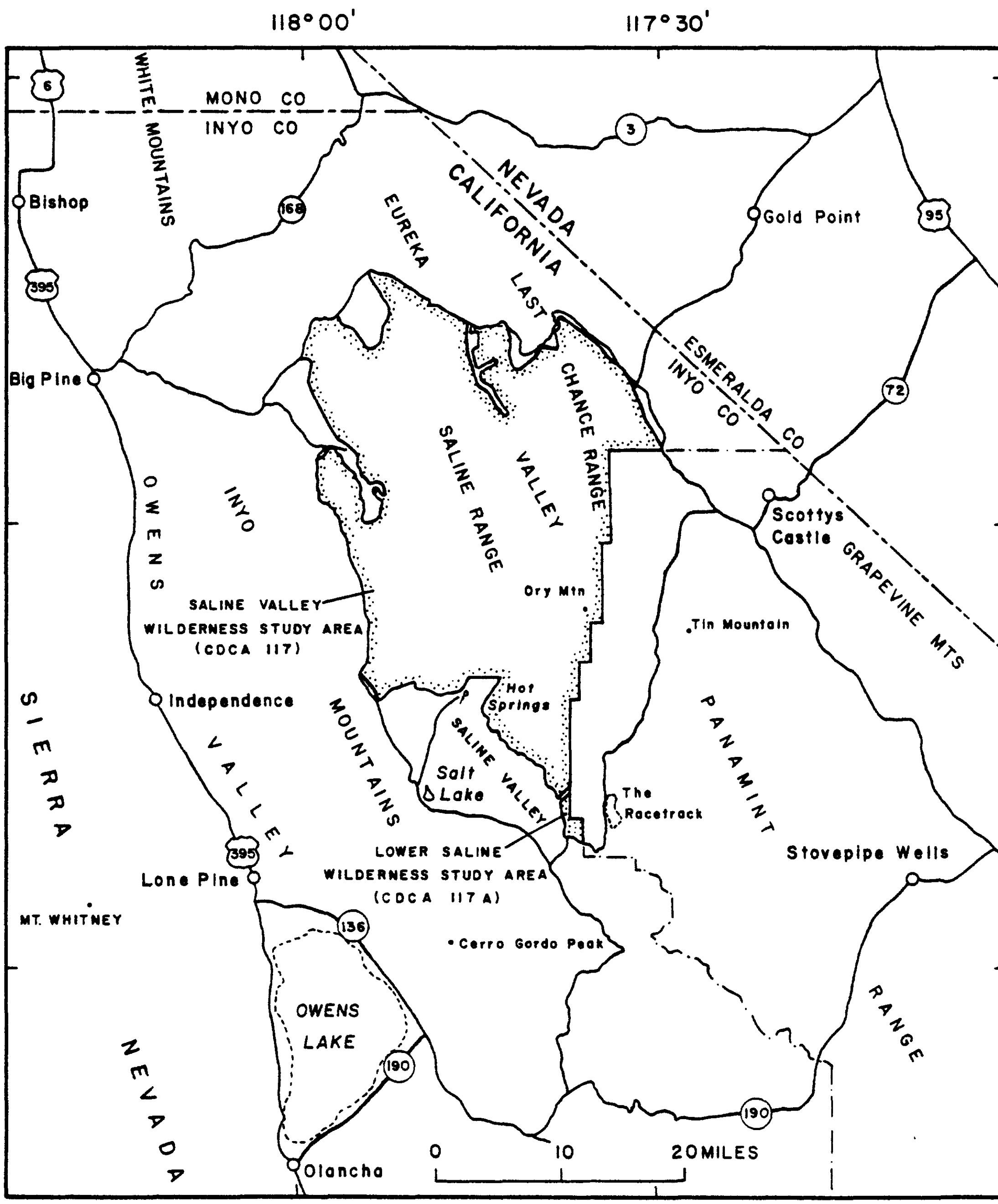

Fig. I-- Map showing location of Saline Valley and Lower Saline Wilderness Study Areas, California.

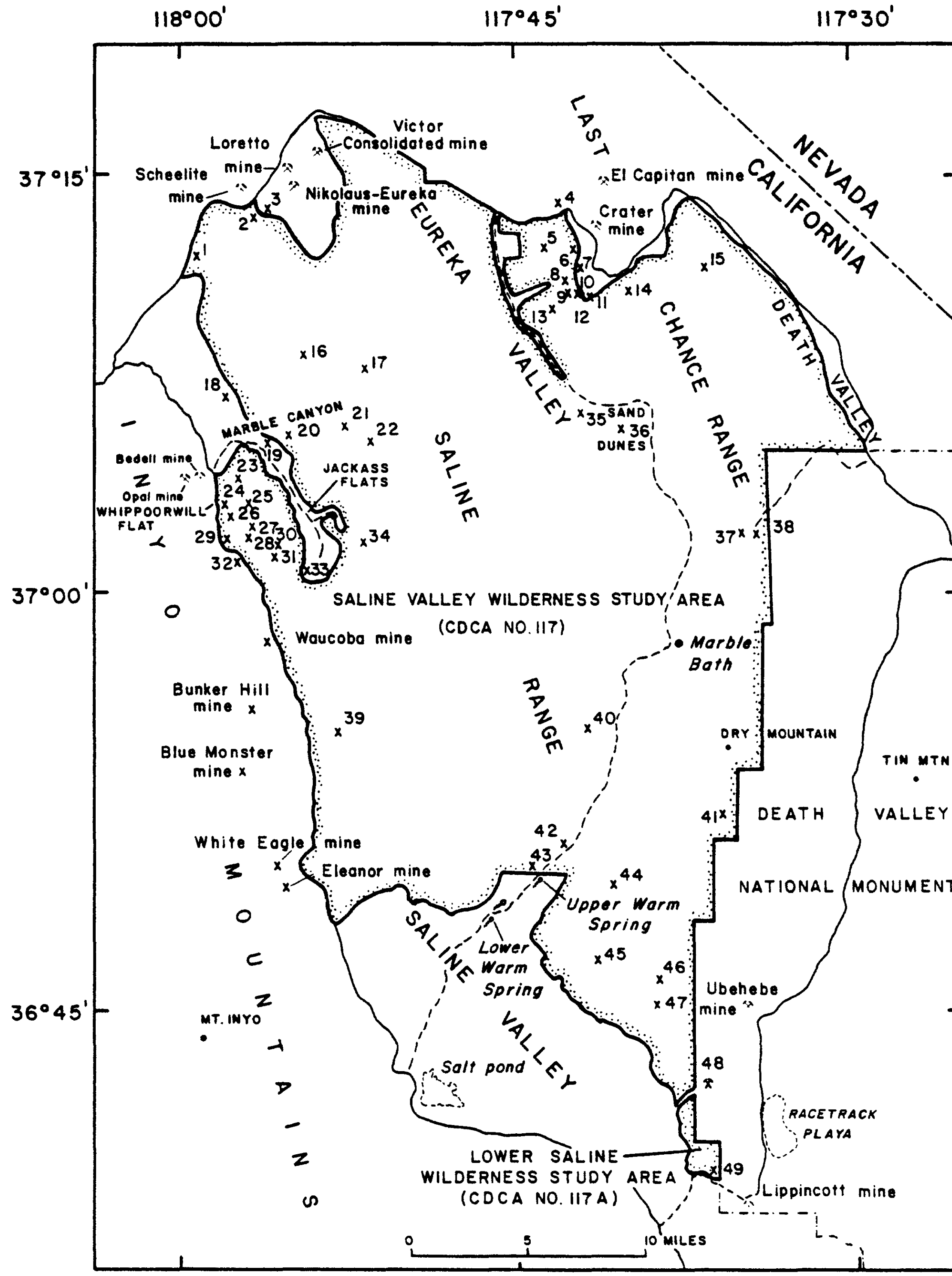

Figure 2--Map showing mines and prospects in the Saline Valley and Lower Saline Wilderness Study areas.

EXPLANATION FOR FIGURE 2

⚒ MINE

x PROSPECT

List of mines and prospects

1. Uncle Adolf prospect
2. Green Rock prospect
3. Harlis and Broady mine
4. Lucky Strike prospect
5. Lucky 13 prospect
6. Aloha prospect
7. Rebecca prospect
8. Up and Down prospect
9. Mercury Knob prospect
10. Eureka prospect
11. Sulfur Queen prospect
12. April Fool prospect
13. Storm Cloud prospect
14. Sally Joe prospect
15. Reo prospect
16. Black Rock prospect
17. Alluvial prospect
18. Coyote prospect
19. Easy Pickings prospect
20. Krater-Van Norman prospect
21. Tam prospect
22. Montezuma prospect
23. Opportunity prospect
24. Fuller prospect
25. Gingerbell prospect
26. Lee prospect
27. August prospect
28. Ruby Port prospect
29. Del No. 1 prospect
30. Hillside prospect
31. Emma prospect
32. Premier prospect
33. Morning Star mine
34. Desert View prospect
35. Unnamed lithium occurrence
36. Titan prospect
37. Leah-Vanessa prospect
38. Jenny B. prospect
39. Independence prospect
40. Cerro Albino prospect
41. Dry Mountain prospect
42. Coffee Stop prospect
43. Black Diamond prospect
44. Lucky Rich prospect
45. Unnamed prospect
46. Indian prospect
47. Mary V. prospect
48. Blue Jay prospect
49. Bonanza prospect

—— ROAD

-- JEEP TRAIL

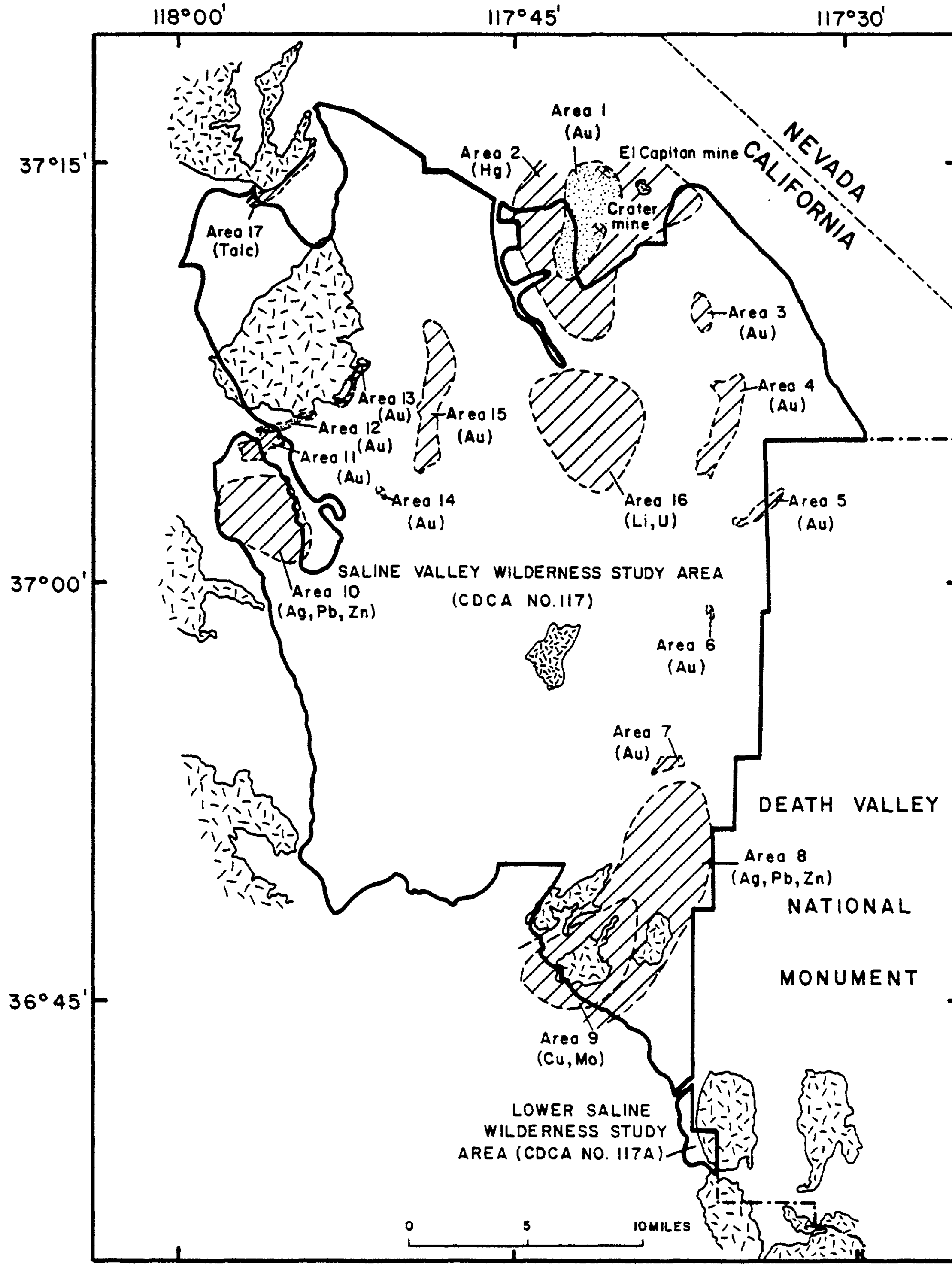

Figure 3-- Map showing areas of mineral resource potential in the Saline Valley and Lower Saline Wilderness Study Areas. See following page for explanation. See text for description of numbered areas.