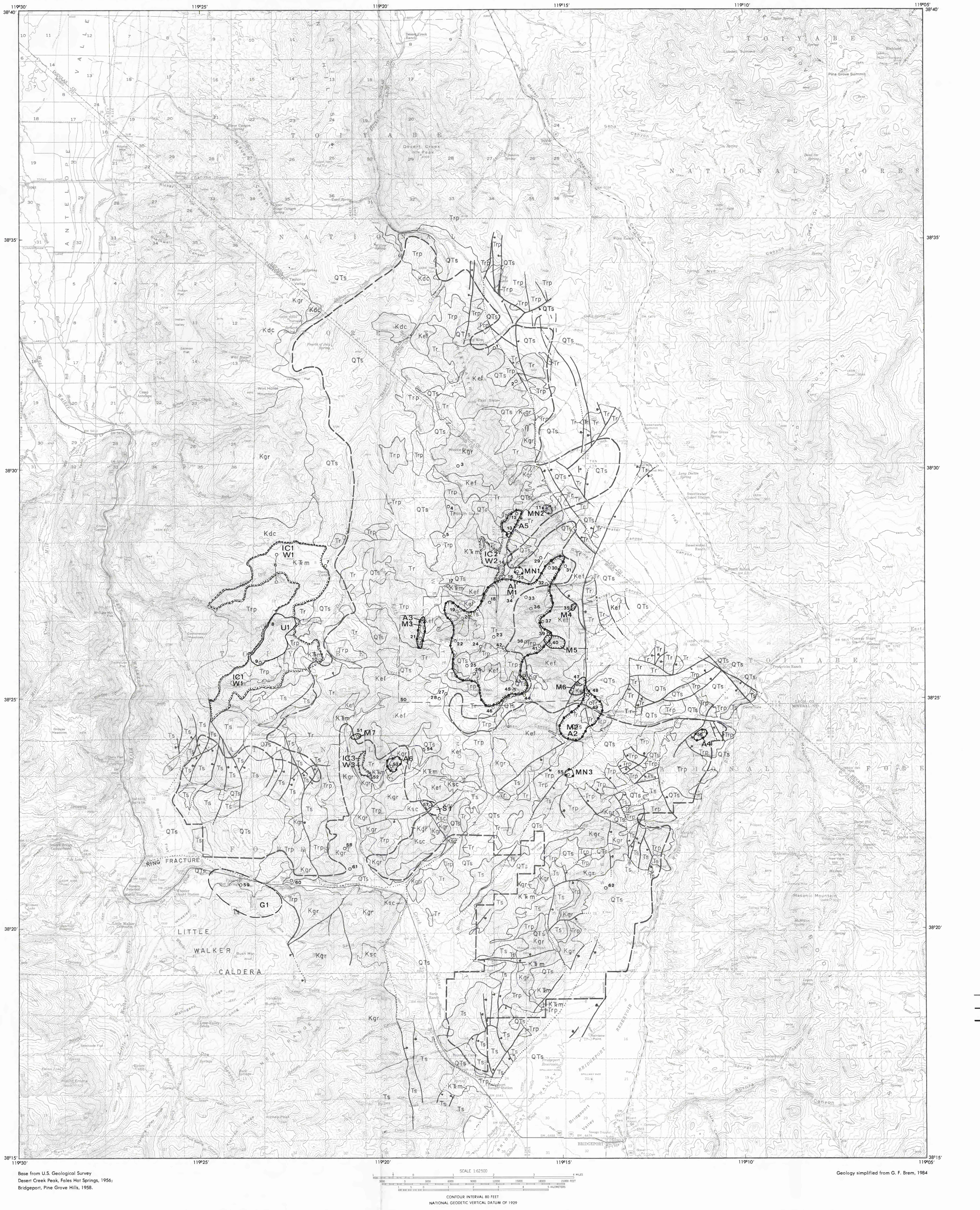
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

MISCELLANEOUS FIELD STUDIES
MAP MF-1535-A



Base from U.S. Geological Survey
Desert Creek Peak, Fales Hot Springs, 1956;
Bridgeport, Pine Grove Hills, 1958.

SCALE 1:62500

CONTOUR INTERVAL 80 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology simplified from G. F. Brem, 1984

MINERAL RESOURCE POTENTIAL MAP OF THE SWEETWATER ROADLESS AREA, MONO COUNTY, CALIFORNIA, AND LYON AND DOUGLAS COUNTIES, NEVADA

By
G. F. Brem, M. A. Chaffee, and Donald Plouff and R. H. Lambeth, H. W. Campbell, D. F. Scott, and J. M. Spear
U.S. Geological Survey U.S. Bureau of Mines

1983

EXPLANATION

AREA OF MINERAL RESOURCE POTENTIAL—Letters refer to metals, nonmetals, or metallic suites; numbers designate unique areas discussed in text. Line patterns are combined when more than one mineral occurs within a given area. Complete mineral resource assessment is tabulated in text

PRECIOUS METALS (GOLD AND SILVER)

A1	High
A2	High
A3	Moderate
A4	Low
A5	Low
A6	Low

MOLYBDENUM

M1	Moderate
M2	Low to moderate
M3	Low
M4	Low
M5	Low
M6	Low
M7	Low

IRON AND COPPER

IC1	Low
IC2	Moderate
IC3	Low

TUNGSTEN

W1	Low
W2	Low
W3	Low

URANIUM

U1	Low

MANGANESE

MN1	Low
MN2	Low
MN3	Low

SILICA

SI	Low

GEOTHERMAL ENERGY

G1	Low

MINE OR PROSPECT—Numbers refer to list of mines and prospects and table 1 of accompanying pamphlet.

MINES AND PROSPECTS

1. Rickey mine
2. Golden Rule prospect
3. Unnamed prospect
4. Unnamed prospect
5. Unnamed prospect
6. Iron King prospect
7. Unnamed prospect
8. C and B prospect
9. Unnamed prospect
10. Lobdell Lake prospect
11. Unnamed prospect
12. Apollo prospect
13. E. G. No. 1 prospect
14. Iron Cap prospect
15. Penrose (Lucky Joe) prospect
16. Unnamed prospect
17. Unnamed prospect
18. Unnamed prospect
19. Star and Great Western prospect
20. Angelo Mission mine
21. Montague mine
22. California Comstock prospect
23. Unnamed prospect
24. Unnamed prospect
25. Sweetwater Rose prospect
26. Unnamed prospect
27. Unnamed prospect
28. Unnamed prospect
29. Unnamed prospect
30. Silverado Extension No. 3 prospect
31. Unnamed prospect
32. Cottonwood Canyon prospect
33. Unnamed prospect
34. Red Dog prospect
35. Unnamed prospect
36. Silverado mine
37. Unnamed prospect
38. Kentuck mine
39. Tiger I mine
40. Tiger II mine
41. Unnamed prospect
42. Unnamed prospect
43. Frederick mine
44. Boulder Flat prospect
45. Wheeler Peak prospect
46. M and T prospect
47. Green Creek prospect
48. Thoroughbrace prospect
49. Monte Cristo mine
50. AMAX prospect
51. Pits prospect
52. Unnamed prospect
53. Longstreet mine
54. Unnamed prospect
55. Black Horse prospect
56. Sims prospect
57. Unnamed prospect
58. Quartz Hill No. 6 prospect
59. Fales Hot Springs
60. Red Gold prospect
61. Unnamed prospect
62. Unnamed prospect

CORRELATION OF MAP UNITS

SEDIMENTARY DEPOSITS

QTs — QUATERNARY AND TERTIARY(?)

Unconformity

VOLCANIC ROCKS

Ts
Unconformity
Tr — Miocene
Unconformity
Trp — Oligocene — TERTIARY

Unconformity

PLUTONIC ROCKS

Kgr
Kef
Kdc
Ksc — CRETACEOUS

Unconformity

METAMORPHIC ROCKS

K͞Rm — CRETACEOUS, JURASSIC, AND (OR) TRIASSIC

DESCRIPTION OF MAP UNITS

SEDIMENTARY DEPOSITS

QTs SURFICIAL DEPOSITS (QUATERNARY AND TERTIARY?)—Alluvium, landslide deposits, and glacial deposits

VOLCANIC ROCKS

Ts STANISLAUS GROUP (MIOCENE)—Latite lava flows and quartz latite ash-flow tuffs from Little Walker volcanic center

Tr RHYOLITE OF SWEETWATER MOUNTAINS (MIOCENE)—Rhyolite tuff breccia, domes, lava flows, dikes, and ash-flow tuff; intensely altered in central area of outcrop

Trp RELIEF PEAK AND VALLEY SPRINGS FORMATIONS, UNDIVIDED (MIOCENE AND OLIGOCENE) — Relief Peak Formation (Miocene) - andesite lahar, autobrecciated lava flow, lava flow, and domal rock. Valley Springs Formation (Miocene and Oligocene) - rhyolitic ash-flow tuff

PLUTONIC ROCKS

Kgr GRANITES OF DEVILS GATE-MACK CANYON, ROCK CREEK, TAYLOR VALLEY, MIDDLE SISTER, AND BELFORT, UNDIVIDED (CRETACEOUS)—Medium grained hypidiomorphic granular to porphyritic granite and granitic aplite; generally very fresh

Kef GRANITES OF EAST FORK AND GREEN CREEK, UNDIVIDED (CRETACEOUS)—Medium-grained hypidiomorphic porphyritic granite; thermally metamorphosed and locally altered

Kdc GRANITE OF DESERT CREEK (CRETACEOUS)—Medium-grained hypidiomorphic granular to porphyritic granite; thermally metamorphosed

Ksc MAFIC COMPLEX OF SWAUGER CREEK (CRETACEOUS)—Medium-grained layered gabbro-diorite-granodiorite complex; thermally metamorphosed

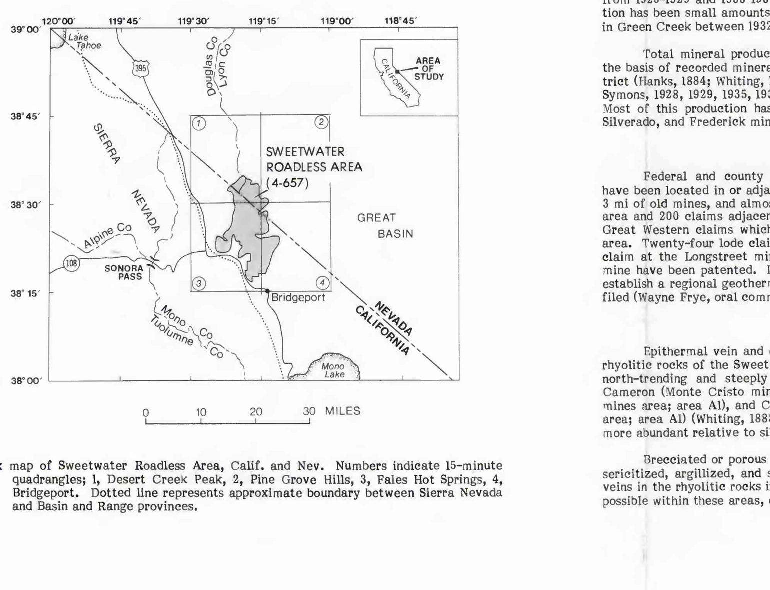
METAMORPHIC ROCKS

K͞Rm METASEDIMENTARY AND METAVOLCANIC ROCKS (CRETACEOUS, JURASSIC, AND (OR) TRIASSIC)—Thermally metamorphosed calcareous tuffaceous mudstone and sandstone, and intermediate to felsic volcanic rocks.

CONTACT

FAULT—Dotted where inferred; bar and ball on downthrown side

APPROXIMATE BOUNDARY OF SWEETWATER ROADLESS AREA



Index map of Sweetwater Roadless Area, Calif. and Nev. Numbers indicate 15-minute quadrangles; 1, Desert Creek Peak, 2, Pine Grove Hills, 3, Fales Hot Springs, 4, Bridgeport. Dotted line represents approximate boundary between Sierra Nevada and Basin and Range provinces.

STUDIES RELATED TO WILDERNESS

The Wilderness Act (Public Law 88-577, September 3, 1964) and related acts require the U.S. Geological Survey and the U.S. Bureau of Mines to survey certain areas on Federal Lands to determine their mineral resource potential. 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 resource potential survey of the Sweetwater Roadless Area in the Toiyabe National Forest, Mono County, California, and Lyon and Douglas Counties, Nevada. The Sweetwater Roadless Area (4-657) was classified as a further planning area during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, January 1979.

SUMMARY

A 9-mi² intensely altered area underlain by rhyolite of the middle Miocene Sweetwater volcanic center along the east side of the study area and two smaller areas within and east of the roadless area have a high mineral resource potential for epithermal vein or disseminated silver and gold (precious metals) deposits. Precious-metal-bearing veins occur along north-trending shear zones in the intensely altered areas, and there is a potential for disseminated precious-metal deposits, especially near vein deposits with previous mineral production. Since 1882, mines mostly east of the roadless area have produced minerals with a value of $3,000,000, primarily in precious metals. Within the roadless area, extensive mineralization is indicated by numerous vein, dump, and rock samples with significant assay values. The podiform nature of vein deposits, inaccessibility of underground workings, and scarcity of mineralized outcrops generally preclude estimation of mineral resources.

An area coincident with the zone of Tertiary rock alteration and precious-metal enrichment has a low to moderate resource potential for a disseminated molybdenum deposit. Anomalous concentrations of molybdenum occur in shear zones, intensely altered rock, and veins in Tertiary rhyolite of the Sweetwater volcanic center within the same area as precious-metal mineralization. Lithologic characteristics, alteration, geochemical anomalies, and geophysical anomalies in Tertiary rhyolitic rocks are consistent with a disseminated-molybdenum system. Molybdenum in quartz-molybdenite veinlets also occurs in granitic rocks just east of the roadless area and is related to a Late Cretaceous event. The mineral resource potential for molybdenum in granitic rocks is low.

In three areas within and immediately adjacent to the roadless area,calcareous facies of thermally metamorphosed sedimentary rocks are favorable host rocks for iron, copper, tungsten, gold, or uranium contact-metasomatic mineral deposits. The mineral resource potential for these types of deposits is generally low with only one area having a moderate potential for iron. Manganese of hot-spring origin occurs in three areas and has a low resource potential. Silica and geothermal energy each occur in one area and have a low resource potential.

INTRODUCTION

The Sweetwater Roadless Area covers approximately 72,240 acres in the Sweetwater Mountains north of Bridgeport, Calif., in Toiyabe National Forest in east-central California and adjacent Nevada. The roadless area encompasses most of the higher parts of the Sweetwater Mountains between the north-flowing East Walker River on the southeast and Desert Creek on the northwest. Elevations range from 6,160 ft along the East Walker River to 11,673 ft on Mount Patterson.

GEOLOGY

A Mesozoic basement complex of dominantly silicic plutonic rocks with minor septa and roof pendants of metavolcanic and metasedimentary rocks is overlain by extensive Tertiary volcanic and hypabyssal intrusive rocks and upper Tertiary(?) and Quaternary surficial deposits (Brem, 1983). Mineralized areas are associated with thermally metamorphosed and metasomatized Mesozoic sedimentary and volcanic rocks, and with hydrothermally altered Cretaceous granite and Tertiary rhyolite.

Metamorphic rocks crop out over less than 5 percent of the roadless area. One small pendant crops out in Sweetwater Canyon; other metamorphic rock bodies are exposed just outside, but probably extend into, the roadless area beneath a thin volcanic cover. The metamorphic rocks are favorable hosts for iron, copper, and tungsten deposits primarily in calcareous metasomatic skarn bodies and for gold and uranium deposits in silicified shear zones and skarn bodies.

Plutonic rocks are exposed over about 20 percent of the study area and are predominately Late Cretaceous in age (Brem, 1983). Just east of the roadless area, the East Fork and Green Creek plutons have been locally altered and mineralized with pyrite and molybdenite during Late Cretaceous mineralization events possibly related to the complex intrusive history of the East Fork pluton. Two pegmatitic quartz bodies occur within the roadless area and are probably late-stage products of the Devils Gate-Mack Canyon pluton.

The metamorphic and plutonic rock assemblages in the roadless area are comparable to assemblages found in much of the Sierra Nevada and adjacent parts of the Basin and Range province. All of these assemblages may be related to a Mesozoic Andean-type arc along the west edge of North America (Dickinson, 1976). Mineral deposits within these rocks, as well as comparable ones within the roadless area, commonly include disseminated molybdenum or contact-metasomatic-derived tungsten, iron, copper, molybdenum, or gold.

Upper Oligocene to upper Miocene volcanic rocks crop out over nearly 50 percent of the roadless area. The volcanic rocks and related mineralization events here and in adjacent parts of the Sierra Nevada and Great Basin are generally similar because the entire region is part of the same Tertiary magmatic arc.

The oldest volcanic rocks in the roadless area are the upper Oligocene and lower Miocene Valley Springs Formation which consists of a few scattered outcrops of silicic tuff. The unconformably overlying middle Miocene Relief Peak Formation crops out discontinuously throughout the roadless area and consists of andesite lahar with less abundant flow or domal rocks. The andesite is generally weakly to strongly propylitized but is more intensely altered where locally affected by mineralization associated with rhyolitic volcanism.

Rhyolitic rocks, which are generally younger than the andesite, crop out throughout the roadless area and are derived from the Sweetwater volcanic center. The rocks, consisting of a series of north-trending dikes, hypabyssal intrusive rocks, and overlying pyroclastic and lava flow rocks, are concentrated primarily in the central part of the range (Brem, 1982). The rhyolite and underlying rocks are intensely altered and mineralized with silver, gold, and geochemically related metals in the central part of the volcanic center. Anomalous concentrations of molybdenum in the same rocks in combination with the anomalous silver and geologic setting suggest the possibility of an underlying disseminated-molybdenum system.

Younger latite rocks of the upper Miocene Stanislaus Group from the Little Walker volcanic center (Brem, 1977; Priest, 1974, 1979; Noble and others, 1969) unconformably overlie andesite and rhyolite along much of the southeastern and southwestern parts of the roadless area. The latite sequence postdates alteration and mineralization of the rhyolite and does not contain any recognized alteration or mineralization. Although Fales Hot Springs is located along the ring-fracture system of the Little Walker volcanic center, the current hot spring activity is possibly related to more recent tectonic activity rather than Little Walker center volcanic activity.

The late Tertiary and Quaternary history of the area reflects one of volcanic quiescence, but moderate to intense tectonic activity. Upper Tertiary(?) gravel in the northern and southern parts of the Sweetwater Mountains suggest early uplift of the Sierra Nevada. Quaternary uplift of the Sweetwater Mountains and westward rotation of the entire range are indicated by changes in drainage directions and by fanglomerates and normal faults along the east side of the range.

GEOCHEMISTRY

The geochemical investigation of the Sweetwater Roadless Area was based on the analysis of 127 rock, 59 minus-60-mesh stream-sediment, and 59 nonmagnetic heavy-mineral-concentrate samples (Sutley and others, 1983). Some rock samples were collected in order to provide information on the normal or background chemical abundances of the rock units present in the study area. Mineralized and (or) hydrothermally altered outcrops and selected mine dumps were also sampled to provide information about chemical abundances in potentially anomalous areas and to identify ore-related elements that might not be identified visually.

For rock samples, 14 elements (Ag, As, Au, Ba, Be, Bi, Cd, Cu, Mo, Pb, Sb, Sn, W, and Zn) were selected as having anomalous concentrations that might be related to mineralization; in a similar manner, 13 elements (Ag, As, Au, Be, Bi, Cd, Cu, Mn, Mo, Pb, Sb, Sn, and Zn) were selected in stream-sediment samples. Similarly, 13 elements (Ag, As, Au, Be, Bi, Cd, Cu, Mo, Pb, Sb, Sn, W, and Zn) were selected for concentrate samples. In addition, four elements (Ba, Co, Fe, and Sr) were selected as possibly being indicative of hydrothermal alteration, but not necessarily mineralization. The elements related to mineralization in concentrate samples were further divided into two groups—a base- and precious-metal suite (Ag, As, Au, Cd, Cu, Pb, Sb, and Zn) and a molybdenum-tungsten suite (Be, Bi, Mo, Sn, and W).

GEOPHYSICS

Isostatic residual gravity and aeromagnetic maps were compiled to aid in the mineral resource assessment. The isostatic residual gravity map (Donald Plouff, unpub. data, 1983) was derived from a compilation of published gravity data (Plouff, 1982a). Gravity values were contoured at a 2-mGal interval for 175 stations. The only prominent gravity low in the region is associated with the caldera of the Little Walker volcanic center, southwest of the roadless area. A three-dimensional gravity model suggests that tuffaceous rocks in the caldera probably exceed 4,000 ft in thickness (Plouff, 1982b). The rim of the caldera, on which Fales Hot Springs is sited, coincides with a steep gravity gradient and abrupt lithologic changes.

Several small-scale gravity anomalies are present. A gravity low between Wheeler Peak and Mount Patterson may reflect the reduced density of underlying intensely altered rocks and (or) the local accumulation of volcanic rocks of lower density than surrounding plutonic rocks. Small gravity highs west of the roadless area and Mount Patterson, east of the roadless area near Sweetwater Creek, and at the south end of the roadless area northwest of Bridgeport probably reflect higher density of underlying metamorphic rocks compared to surrounding plutonic and Tertiary volcanic rocks. Gravity coverage north of Mount Patterson is too sparse to determine the origin of a gravity high over South Sister.

A magnetic map (Donald Plouff, unpub. data, 1983) was prepared from two aeromagnetic surveys (U.S. Geological Survey 1979, 1982). Prominent irregularly shaped magnetic highs indicate relatively thick accumulations of volcanic rocks occurring at the north edge of the roadless area, the southernmost part of the roadless area west of Bridgeport Reservoir, and at the southwest edge of the roadless area. Two magnetic lows, approximately 2 mi in diameter, are located northeast of Wheeler Peak and north of the Monte Cristo mine in Fryingpan Canyon. Both are probably related to intensely altered Tertiary volcanic rocks.

Several magnetic anomalies may be related to plutonic rocks. A complex magnetic high extends about 7 mi northward along the crest of the Sweetwater Mountains from Mount Patterson. The northern part of the magnetic high reflects the relatively higher magnetization of an extensive body of granite underlying Middle Sister. Farther south along this magnetic high, similar plutonic or possibly metamorphic rocks are presumed to underlie the magnetic high, although only small exposures of the granite of East Fork and metamorphic rocks crop out within an extensive area of Tertiary volcanic rocks. The granite of East Fork may not be the source of the magnetic high, as this pluton has only a low to moderate magnetization in other parts of the roadless area. Other magnetic anomalies are generally attributed to variations in plutonic rock compositions. Relative magnetic lows are associated with the weakly magnetic granites of Desert Creek and Devils Gate-Mack Canyon and a strong, but irregular magnetic high is associated with the mafic complex of Swauger Creek.

Metamorphic rocks generally have a moderate to high magnetization, as evidenced by magnetic highs located outside the roadless area east of Sweetwater Creek, west of Bridgeport Ranger Station, and west of Mount Patterson. Though concealed beneath alluvium near the southeast edge of the roadless area, a circular-shaped magnetic high near the north end of Bridgeport Reservoir may reflect an underlying body of metamorphic rocks, as such rocks crop out within an apparent northeastward extension of the circular-shaped anomaly. The existence of an underlying mafic pluton, however, is not precluded. A magnetic low in upper Sweetwater Creek is associated with metamorphic rocks containing magnetite in skarn deposits which suggests that some metamorphic rocks are reversely magnetized.

MINING DISTRICTS AND MINERAL DEPOSITS

History and production

The Patterson mining district includes all of the California part of the Sweetwater Mountains and the Sweetwater Roadless Area. Prospecting began within the district in the 1850's at the same time mineral discoveries were being made in nearby districts such as Bodie and Masonic. The Patterson district was organized in 1880. By 1882, many of the epithermal silver- and gold-bearing areas were being developed and the Kentuck mine (No. 38) in Ferris Canyon was opened. Until its close in 1885 because of litigation, the Kentuck mine produced approximately $450,000 (400,000 oz) in silver. From 1882 until 1888, other mines and prospects in the area produced approximately $50,000 (45,000 oz) in silver (Whiting, 1888).

Mining activity from 1888 until 1925 was sporadic. The Silverado mine (No. 36) just east of the roadless area, was one of the most active, but produced an unknown amount of silver, the Monte Cristo mine (No. 49) in Fryingpan Creek produced 650 oz of silver and 90 oz of gold, and other mines and prospects may have produced small amounts of metals for which there is no record. In 1910 and 1911, approximately 24,000 oz of silver and 156 oz of gold were recovered by reworking of the Kentuck mill tailings at Clinton. From 1925 until the present, the Silverado mine has been the most active, having produced an estimated 3,000,000 oz of silver, 3,000 oz of gold, and 35,000 lb of copper from 1925-1929 and 1933-1939 (Lambeth and others, 1983). The only other known production has been small amounts of molybdenite in granite that was produced from prospects in Green Creek between 1932 and 1935.

Total mineral production for the district is estimated to be about $3,000,000 on the basis of recorded mineral production and estimates by people who worked in the district (Hanks, 1884; Whiting, 1888; Eakle and McLaughlin, 1917; Tucker, 1927; Bradley, 1927; Symons, 1928, 1929, 1935, 1936, 1937, 1938, 1939; Hunter, 1976; Lambeth and others, 1983). Most of this production has been in Ferris and Silverado Canyons from the Kentuck, Silverado, and Frederick mines.

Mining claims

Federal and county mining-claim records indicate approximately 2,500 claims have been located in or adjacent to the study area. The majority of these are within 2 or 3 mi of old mines, and almost all are lode claims. Approximately 200 claims in the study area and 200 claims adjacent to the study area were maintained in 1982. The Star and Great Western claims which contain 39.36 acres, are patented and lie within the study area. Twenty-four lode claims incorporating the Silverado-Kentuck mine areas, one lode claim at the Longstreet mine, and one lode claim and a mill site at the Monte Cristo mine have been patented. During 1981, several holes were drilled near the study area to establish a regional geothermal gradient, but no geothermal lease applications have been filed (Wayne Frye, oral commun., 1983).

Geology of deposits

Epithermal vein and disseminated silver and gold deposits occur in highly altered rhyolitic rocks of the Sweetwater volcanic center (areas A1, A2, and A3). The generally north-trending and steeply dipping veins are grouped from east to west into the Cameron (Monte Cristo mine area; area A2), the Clinton (Silverado-Kentuck-Frederick mines area; area A1), and Comstock belts (California Comstock-Star and Great Western area; area A1) (Whiting, 1888). The belts are generally similar, although gold is slightly more abundant relative to silver in the Cameron belt.

Brecciated or porous rhyolite rocks around vein deposits have also been intensely sericitized, argillized, and silicified, and probably mineralized at the same time as the veins in the rhyolitic rocks in areas A1 and A2. Disseminated precious-metal deposits are possible within these areas, especially around veins with mineral production.

Gold and silver also have been found in silicified shear zones in andesite of the Relief Peak Formation near the East Walker River (area A4), and in sheared and silicified metamorphic rock in Sweetwater Canyon (area A5) and East Fork of Swauger Creek (area A6).

Although hypogene molybdenum minerals were not observed, geochemical analyses of veins, altered rock, and weakly altered shear zones indicate that molybdenum in background to 0.11 percent concentrations is associated with the epithermal silver and gold in rhyolitic and underlying rocks (areas M1, M2, and M3; Sutley and others, 1983; Lambeth and others, 1983). The widespread occurrence of molybdenum, the intensive alteration of the complex series of extrusive and intrusive rhyolites of the Sweetwater volcanic center, occurrence of huebnerite and fluorite, indirectly the extensive silver mineralization and epithermal alterations, and magnetic and gravity lows may indicate a disseminated-molybdenum system of the Climax-type at depth.

Four areas, M4, M5, M6, and M7 just outside of the roadless area, contain molybdenum of known or probable Late Cretaceous age in the East Fork and Green Creek granitic plutons. Quartz-molybdenite veinlets or quartz-sericite altered rock in each area contain coarse-grained molybdenite in fractures or altered areas of a few hundred to a thousand square feet.

Contact-metamorphic deposits of iron, copper, tungsten, gold, and uranium occur near contact zones between granitic plutonic rocks and metamorphic rocks with carbonate lenses. Iron and copper deposits such as those in areas IC1 and IC2 along the east and west sides of the roadless area and possibly near Swauger Creek (area IC3) consist of replacement bodies of disseminated to massive magnetite, traces of copper-bearing sulfides, and serpentine in carbonate lenses. Typically, the deposits have maximum lengths of less than 100 ft although the deposit in Sweetwater Canyon can be traced for about 1,000 ft. Silicified shear zones or veins in metamorphic rocks are typically more copper rich (area A5 within area IC2), contain gold and (or) silver (area A5 and IC3), or have small amounts of uranium (area U1). Calc-silicate skarn mineral assemblages typically associated with tungsten are probable within the same metamorphic bodies as the iron deposits, although tungsten has only been found near Swauger Creek (area W3).

Manganese occurs in brecciated volcanic rocks where it may be of hot-spring origin in area MN1 in Sweetwater Canyon, in manganiferous quartz veins in Sweetwater Creek (area MN2), and as breccia cement south of Fryingpan Canyon (areas MN2 and MN3).

Silica occurs within the mafic complex of Swauger Creek in two circular-shaped bodies measuring about 300 ft in diameter (area S1). The bodies consist of massive quartz surrounded by a thin shell of very coarse-grained feldspar. The bodies appear to be pegmatites and are most likely derived from the nearby granite of Devils Gate-Mack Canyon.

A potential for geothermal resources occurs at one area near Fales Hot Springs (area G1). The hot springs are located on the ring-fracture system of the Little Walker volcanic center and the most favorable volcanic rock reservoir would be to the south of the hot springs. The current hot-spring activity may be related to more recent tectonic activity because the youngest igneous rocks in the Little Walker volcanic center are late Miocene.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

The mineral resource potential of the Sweetwater Roadless Area has been evaluated on the basis of: 1) host-rock composition, structure, and alteration; 2) known mineral occurrences; 3) geochemical anomalies in rock, stream-sediment and nonmagnetic heavy-mineral-concentrate samples; 4) aeromagnetic and gravity anomalies; and 5) mining activity. Map areas that are assigned a high to moderate mineral resource potential have favorable characteristics in at least three of these criteria; areas assigned a low to moderate potential have fewer favorable characteristics.

In general, epithermal silver and gold deposits have the highest potential; disseminated molybdenum has a low to moderate potential; manganese, silica, and geothermal energy has a low potential; and iron, gold, copper, uranium, and tungsten in contact-metasomatic deposits have a low potential except for one occurrence of iron which has a moderate potential.

Precious metals

The mineral resource potential for epithermal vein and disseminated silver and gold in rhyolitic rocks is considered to be high in the central alteration zone (area A1), high around the Monte Cristo mine between Fryingpan Creek and Ferris Canyon (area A2), and moderate around the Montague mine at the head of Desert Creek (area A3). Favorable host-rock characteristics include numerous intrusive bodies and widespread deposits of porous tuff, abundant shearing and brecciation, and intensive epithermal alteration including silicification. In the past, the areas A1 and A2 are both known mineral producers with about $3,000,000 in silver and gold having been produced primarily from mines just east of the roadless area. Geochemical anomalies in all three areas indicate a broad spectrum of ore-related elements in stream-sediment and heavy-mineral-concentrate samples and numerous dump, vein, or altered-rock samples indicate widespread precious-metal mineralization. Gravity and magnetic lows in both areas (A1 and A2) suggest large bodies of relatively low-density rocks with weak magnetization.

Past mineral production in these areas has been from vein deposits and the mineral resource potential is high for additional deposits of this type. Vein systems have the highest potential, especially around existing mines such as the Monte Cristo (area A2), and the Silverado-Kentuck-Frederick group (indicated or inferred resources of 120,000 tons with 11 oz of silver per ton in the Silverado mine in the eastern part of area A1), although an occurrence of 4,500 tons with 7.8 oz silver and 0.06 oz gold per ton is recognized in the Star and Great Western-California Comstock system at the head of Sweetwater Canyon (Lambeth and others, 1983). Disseminated precious-metal deposits in areas A1 and A2 also have a high resource potential, especially in the vicinity of veins with known production.

The mineral resource potential for precious metals in andesite along the East Walker River (area A4) and in metamorphic rocks (areas A5 and A6) is low. In general, the host rocks are not strongly favorable; shear zones and stream-sediment and heavy-mineral-concentrate samples and numerous dump, vein, or altered-rock samples indicate widespread precious-metal mineralization. Gravity and magnetic lows in both areas (A1 and A2) suggest large bodies of relatively low-density rocks with weak magnetization.

Molybdenum

The mineral resource potential for disseminated molybdenum associated with Tertiary rhyolite rocks is low to moderate in areas M1 and M2 (corresponding to areas A1 and A2) and low in M3 (corresponding to area A3). A number of criteria are favorable for a disseminated deposit. These include multiple and complex igneous activity is comparable to that in Climax-type deposits. The intense and widespread alteration including pyritization, silver mineralization, and the presence of fluorite and huebnerite are also features commonly observed in the upper parts of disseminated-molybdenum systems. Geochemical analyses of stream-sediment and heavy-mineral-concentrate samples indicate widespread anomalous molybdenum concentrations as well as other ore-mineral related elements in shear zones, veins, and altered rocks. Gravity and magnetic lows in the areas suggest large bodies of low-density, altered (for example, weakly magnetic) rock that might be a suitable host rock for such a deposit. From available surface and geophysical data, it is not possible to determine whether the Tertiary mineralization event had a net effect of dispersing or concentrating molybdenum beneath the volcanic center.

The mineral resource potential for molybdenum in granitic rocks in areas M4 through M7 on the east and south sides of the roadless area is low. Although there is a suggestion of multiple intrusive episodes in rocks of the East Fork pluton, the textural features are not suggestive of very fine grained rocks commonly associated with the uppermost parts of disseminated-molybdenum systems. The upper portions of these granitic bodies, where molybdenum may have been more likely to occur, have probably been lost due to erosion, and the only molybdenum occurrence is coarse-grained flakes in quartz veins or quartz-sericite replacements of plutonic rocks. Additionally, the generally small mineralized zones are not accompanied by extensive alteration, mineralization, or strong geochemical anomalies (except for molybdenum), and gravity and magnetic data are not suggestive of large bodies of rock that would be a suitable host for a molybdenum deposit.

Iron and copper

The mineral resource potential for contact-metasomatic iron and copper deposits is low on the west side of the roadless area in area IC1, low for iron and copper and on the south side of the roadless area in area IC3, and moderate for iron only in area IC2 in Sweetwater Canyon. In area IC2, an occurrence of 1,000,000 tons of iron ore (52 percent average iron content) have been located in one prospect and a silicified shear zone (area A5 within area IC2) contains copper with iron and gold. The carbonate lenses within the metamorphic rock sequence are favorable for contact-metasomatic replacement by iron- and (or) copper-bearing minerals; however, the carbonate lenses tend to be less than 100 ft long except for the Sweetwater Canyon occurrence. Gravity and magnetic data suggest that inferred metamorphic rock bodies at depth roughly correspond with surface outcrop areas and that with the exception of the unexplained magnetic high extending 7 mi north of Mount Patterson, buried strongly magnetic bodies are not likely.

Tungsten

The mineral resource potential for tungsten is low in three areas (W1, W2, and W3) that correspond to areas of iron and copper resource potential. In this type of geologic setting, carbonate-bearing host rocks with calc-silicate skarn mineral assemblages occur primarily near Swauger Creek (area W3) and along the west side of the roadless area (area W1); however, tungsten has been detected in very small amounts only in the Swauger Creek area. Geochemical anomalies in stream-sediment and heavy-mineral-concentrate samples in general are weak and are not supportive of widespread or intensive tungsten mineralization.

Uranium

The mineral resource potential for uranium is low in area U1 west of the roadless area. The occurrence of uranium in silicified shear zones in metamorphic rocks, small controlling structures, and absence of extensive alteration zones are not suggestive of widespread uranium mineralization.

Manganese

The mineral resource potential for manganese in the three areas MN1, MN2, and MN3 on the east and south sides of the roadless area is low. Area MN1 has a low manganese resource potential because the occurrence appears to be a hot-spring deposit only 15-20 ft thick and 150-200 ft in diameter. Areas MN2 and MN3 also have a low potential because the manganiferous deposits are restricted to small breccia zones or quartz veins.

Silica

The resource potential for silica in area S1 is low. Although of moderately high purity, the quartz-bearing bodies are of small size and the geologic environment is not favorable for additional or larger bodies.

Geothermal energy

The resource potential for geothermal energy in area G1 is low. The reservoir has an estimated volume of only 0.8 mi^3 and a temperature of 241°F (Muffler, 1979).

REFERENCES CITED

Bradley, W. W., 1927, Silver, in California mineral production for 1926: California Division of Mines and Mining Bulletin 100, p. 59–61.
Brem, G. F., 1977, Petrogenesis of late Tertiary potassic volcanic rocks in the central Sierra Nevada and western Great Basin: Riverside, Calif., University of California, Ph. D. thesis, 361 p.
—— 1982, Sweetwater rhyolite center, Sweetwater Mountains, Mono County, California, and Lyon County, Nevada abs.: Geological Society of America Abstracts with Programs, v. 14, no. 4, p. 152.
—— 1984, Geologic map of the Sweetwater Roadless Area, Mono County, California, and Lyon and Douglas Counties, Nevada: U.S. Geological Survey Miscellaneous Field Studies Map MF-1535-B.
Dickinson, W. R., 1976, Sedimentary basins developed during evolution of Mesozoic-Cenozoic arc-trench systems in western North America: Canadian Journal of Earth Science, v. 13, p. 1268–1287.
Eakle, A. S., and McLaughlin, R. P., 1917, Patterson district, in Mono County: California State Mining Bureau Report XV of the State Mineralogist, v. 15, p. 160–167.
Hanks, H. G., 1884, Mono County: California State Mining Bureau Fourth Annual Report of the State Mineralogist, v. 4, p. 363–364.
Hunter, R. D., 1976, Volcanic stratigraphy and structural control of mineralization in the northeastern portion of the Patterson mining district, Mono County, California: Riverside, Calif., University of California, M.A. thesis, 135 p.
Lambeth, R. H., Campbell, H. W., Scott, D. F., and Spear, J. M., 1983, Mineral investigation of the Sweetwater RARE II Area (4-657), Mono County, California, and Douglas and Lyon Counties, Nevada: U.S. Bureau of Mines Open File Report MLA-59-83.
Muffler, L. J. P., 1979, Assessment of geothermal resources of the United States - 1978: U.S. Geological Survey Circular 790, 163p.
Noble, D. C., Dickinson, W. R., and Clark, M. M., 1969, Collapse caldera in the Little Walker area, Mono County, California: in Abstracts for 1968: Geological Society of America Special Paper 121, p. 536–537.
Plouff, Donald, 1982a, Gravity observations in the Walker Lake 1°x2° quadrangle, California-Nevada: U.S. Geological Survey Open-File Report 82-405, 105 p.
—— 1982b, Map showing gravity and magnetic surveys of the Hoover Wilderness and adjacent study area, Mono and Tuolumne Counties, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1101-C, scale 1:62,500, 2 sheets.
Priest, G. R., 1974, Eruptive history and geochemistry of the Little Walker center, east-central California: Reno, Nev., University of Nevada, M.A. thesis, 99 p.
—— 1979, Geology and geochemistry of the Little Walker center, Mono County, California: Corvallis, Ore., Oregon State University, Ph. D. thesis, 311 p.
Schweickert, R. A., 1972, Shallow level plutonic intrusions in the eastern Sierra Nevada, California: Stanford, Calif., Stanford University, Ph. D. thesis, 85 p.
—— 1976, Shallow level plutonic complexes in the eastern Sierra Nevada, California and their tectonic implications: Geological Society of America Special Paper 176, 58 p.
Sutley, S. J., Chaffee, M. A., Brem, G. F., Fey, D. L., and Hill, R. H., 1983, Chemical analyses and statistical summaries for samples of rock, minus-60-mesh (0.25 mm) stream sediment, and nonmagnetic heavy-mineral concentrate, Sweetwater Roadless Area, Mono County, California, and Lyon and Douglas Counties, Nevada: U.S. Geological Survey Open-File Report 83-647, 44 p., 1 plate.
Symons, H. H., 1928, Silver, in California mineral production for 1927: California Division of Mines and Mining Bulletin 101, p. 58–60.
—— 1929, Silver, in California mineral production for 1928: California Division of Mines and Mining Bulletin 102, p. 60–62.
—— 1935, Silver, in California mineral production and directory of mineral producers for 1934: California Division of Mines and Mining Bulletin 111, p. 59–61.
—— 1936, Silver, in California mineral production and directory of mineral producers for 1935: California Division of Mines and Mining Bulletin 112, p. 48–49.
—— 1937, Silver, in California mineral production and directory of mineral producers for 1936: California Division of Mines and Mining Bulletin 114, p. 46–48.
—— 1938, Silver, in California mineral production and directory of mineral producers for 1937: California Division of Mines and Mining Bulletin 116, p. 46–47.
—— 1939, Silver, in California mineral production and directory of mineral producers for 1938: California Division of Mines and Mining Bulletin 117, p. 49–52.
Tucker, W. B., 1927, Lead, silver, and zinc, in Mono County: California Division of Mines and Mining Report XXIII of the State Mineralogist, v. 23, p. 374–406.
U.S. Geological Survey, 1979, Aeromagnetic map of the Hoover-Walker Lake area, California: U.S. Geological Survey Open-File Report 79-1194, scale 1:250,000.
—— 1982, Aeromagnetic map of the Sweetwater area, California and Nevada: U.S. Geological Survey Open-File Report 82-66, scale 1:62,500.
Whiting, H. M., 1888, Patterson mining district, in Mono County: California State Mining Bureau Eighth Annual Report of the State Mineralogist, v. 8, p. 357–363.

Explanatory pamphlet accompanies map

Interior—Geological Survey, Reston, Va.—1983
For sale by Branch of Distribution, U.S. Geological Survey, Box 25286, Federal Center, Denver, CO 80225