DEPARMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

TO ACCOMPANY MAP MF-1201-D

MINERAL RESOURCE POTENTIAL OF THE MOKELUMNE WILDERNESS AND CONTIGUOUS ROADLESS AREAS, CENTRAL SIERRA NEVADA, CALIFORNIA

SUMMARY REPORT

By Edwin H. McKee[1], Maurice A. Chaffee[1], Francis E. Federspiel[2], Edward L. McHugh[2], Eric E. Cather[2], Douglas F. Scott[2], and Clayton M. Rumsey[2]

Studies Related to Wilderness

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Joint Conference Report on Senate Bill 4, 88th Congress, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Areas officially designated as "wilderness," "wild," or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of suitability studies. The act directs that the results of such surveys are to be made available to the public and be submitted to the President and the Congress. This report discusses the results of a mineral survey of the Mokelumne Wilderness, El Dorado National Forest, Amador, Calaveras and Alpine Counties, California and Caples Creek, Raymond Peak, and Tragedy-Elephants Back Roadless Areas, Alpine, Amador, Calaveras, and El Dorado Counties, California. The Mokelumne Wilderness was established by Public Law 88-577, September 3, 1964, the Roadless Areas were classified as further planning areas during the Second Roadless Area Review and Evaluation (RARE II) by the U.S. Forest Service, 1979.

SUMMARY

A combined geologic, geophysical, and geochemical investigation and a survey of the existing mines, prospects, and mineralized areas was conducted to determine the mineral resource potential of the Mokelumne Wilderness and contiguous roadless areas in the central Sierra Nevada, Calif. (fig. 1). The survey indicates that the study area contains mineral deposits that presently are not economically significant.

Mineral occurrences are concentrated in the northeastern part of the study area, around Woods Lake and along the upper part of Summit City Creek (see map and fig. 2). Veins at the Crockett (loc. 7) and Orphan Boy (loc. 13) prospects and at the head of Summit City Creek north of Upper Blue Lake are considered to have a moderate potential for gold and silver resources. Quartz veins at the Lost Cabin mine (loc. 8) may extend at depth into the study area. Some potential for molybdenum and uranium resources is indicated at two places in the Raymond Peak area (locs. 20, 21, map and fig. 2). Several parts of the wilderness and roadless areas are delineated by geologic and geochemical evidence as having anomalous amounts of a number of metallic minerals, but these anomalies are of generally low concentrations and the potential for mineral production is judged to be low.

No potential for petroleum, geothermal, or nonmetallic-mineral resources was identified in any part of the study area. No mineral production has been reported from the study area, and there is no current mining activity.

INTRODUCTION

The Mokelumne Wilderness and contiguous roadless areas lie near the crest of the Sierra Nevada, about 75 mi (121 km) east of Sacramento, Calif. (fig. 1). They include approximately 130,000 acres (52,800 ha) in western Alpine, eastern Amador, eastern El Dorado, and northeastern Calaveras Counties, Calif.

The area is dominated by deep rugged canyons that run from the Sierra Nevada crest westward to the Sacramento Valley. Elevations range from about 4,000 ft (1,200 m) in the bottom of Mokelumne Canyon to 10,380 ft (3,164 m) at Round Top along the north boundary of the Mokelumne Wilderness. Two State highways, 88 on the north and 4 on the south, provide access to the area; secondary roads and trails reach the study-area boundaries in a number of places, but access into individual areas is limited to a few trails. The nearest population center is South Lake Tahoe, Calif., about 20 mi (32 km) to the north; the smaller town of Markleeville, Calif., is about the same distance to the east.

Previous and present studies

The northwestern part of the area was studied in reconnaissance by Lindgren in 1896. Later, Strand and Koenig (1966) used Lindgren's map in a simplified form. The eastern part of the area that includes parts of the Tragedy-Elephants Back and Raymond Peak Roadless Areas was mapped in reconnaissance by Parker (1961). Geologic mapping and geochemical sampling for this study were done by the U.S. Geological Survey in 1979, and a geologic map has recently been published (McKee and Howe, 1981). The aeromagnetic survey (Plouff and McKee, 1981), was compiled from two reports by the U.S. Geological Survey (1979a, b). Chaffee and others (1981, 1982) published results of the geochemical survey.

Personnel of the U.S. Bureau of Mines searched the literature and county mining records and conducted field investigations during 1979 and 1980. A total of 117 lode samples from mines, prospects, and mineralized areas were analyzed by atomic-absorption,

[1]U.S. Geological Survey
[2]U.S. Bureau of Mines

chemical, and fire-assay methods; at least one sample from each site was analyzed by semiquantitative spectrography to determine the presence of unsuspected elements. Fifty-eight placer samples were taken from major drainages in the study area. These samples were panned in the field and further concentrated on a laboratory-size Wifley table; gold in the samples was then hand picked or recovered by amalgamation and weighed. Sample analyses are on file at the U.S. Bureau of Mines Western Field Operations Center, Spokane, Wash.

Geologic setting

Bedrock exposed in the Mokelumne Wilderness and contiguous roadless areas is composed mostly of Cretaceous plutons of the Sierra Nevada batholith. These granitic rocks have intruded and metamorphosed volcanic and sedimentary rocks of presumed Jurassic and Cretaceous age. Several large and numerous small bodies of metamorphic rock crop out as roof pendants within the granitic rocks. Many ridges and peaks in the area are capped by Tertiary volcanic and sedimentary rocks, and a few prominent peaks are deeply eroded volcanic necks or complex dike swarms.

The prevalent volcanic rock is andesite that includes lava flows and lahars. The sedimentary rocks contain a large amount of volcanic detritus and in places are almost entirely air-fall ash deposits. The wide variations in the thickness of deposits, the lenticularity of units, and the facies variations, ranging from coarse fan-type deposits to thinly laminated siltstone indicate that considerable topographic relief existed during the Tertiary, when these deposits accumulated. Deep erosion of the Tertiary deposits and underlying rocks reflects uplift of the Sierra Nevada and dissection by streams and glaciers. Mokelumne Canyon has the broad U-shaped cross section, hanging tributaries, and other features typical of glaciated river valleys throughout the higher parts of the Sierra Nevada.

Mining activity

No mineral production is recorded from deposits within the study area, although gold, silver, copper, lead, zinc, and tungsten were produced from nearby mines. About 240 mining claims have been staked within the wilderness and adjoining roadless areas; none of these claims are currently active, although uranium occurrences were explored in the Raymond Peak area during 1979.

GEOLOGY

Mesozoic

Metamorphic rocks

All the sedimentary and volcanic rocks intruded by the Sierra Nevada batholith in the Mokelumne area are thermally metamorphosed and show the effects of directed pressure. These rocks are mostly biotite-hornblende gneiss and schist, porphyroblastic granitoid rocks, and calc-silicate hornfels. Mineral assemblages suggest metamorphism to amphibolite facies or hornblende-hornfels contact facies. In most places, the metamorphic rocks are foliated and show a prevailing north-northwestward trend of lineations to the metamorphic fabric; bedding and other sedimentary structures have been completely obliterated. The principal minerals in most of the metamorphic rocks are potassium feldspar, plagioclase, quartz, biotite, hornblende, and muscovite; diopside, idocrase, cordierite, epidote, and garnet are present in some outcrops.

The largest body of metamorphic rock in the region is the Mokelumne Peak roof pendant, which crops out over an area of more than 15 mi^2 (39 km^2) in the vicinity of Mokelumne Peak north of the Mokelumne River canyon and Mount Reba, south of that canyon. Metamorphic rocks are exposed in the canyon in vertical profile for more than 5,000 ft (1,500 m), and aeromagnetic information suggests that they extend to depth an additional several thousand feet (Plouff and McKee, 1981). Various metamorphic-rock types were mapped in the pendant, most of which are quartz-feldspar-biotite granite gneiss and schist. The general pattern of outcrop reveals concentric zones of differing metamorphic-rock types around a core of highly folded and contorted gneiss. The outer zone is mostly porphyroblastic lineated granite that may have forcefully intruded and that imparted a pervasive metamorphic fabric to all the metamorphic rocks of the pendant. Emplacement of the surrounding granitic plutons of the Sierra Nevada batholith has created no metamorphic fabric but has thermally metamorphosed the pendants, reset the K-Ar age of the metamorphic rocks to that of the pluton, and, in places caused retrograde metamorphism.

A body of hornblende-biotite metadiorite and olivine metagabbro that is locally schistose occurs west of Woods Lake, and similar metamorphic rocks rich in mafic minerals form a cluster of northwest-trending elongate bodies on the ridge between Scout Carson and Summit Meadows Lakes. The metadiorite and gabbro range in texture from hypidiomorphic granular to strongly foliated and have a prevailing steep dip and north-northwestward trend. Small folds with elongate limbs parallel to the general trend of foliation are locally formed. Hornblende, biotite, pyroxene (now partially uralitized), and olivine are common accessory minerals.

Granitic rocks

At least three separately emplaced major plutons and several small bodies of alaskite and quartz diorite occur in the Mokelumne Wilderness and surrounding areas. The plutons are mostly quartz monzonite to granodiorite but include several textural and petrologic variations. The oldest pluton in the area, on the basis of crosscutting contact relation to the other plutons, is the Carson Pass Tonalite of Parker (1961). This body which crops out in the northeastern part of the study area, is distinctive because it is the most mafic pluton in the region; the rock is medium- to coarse-grained hypidiomorphic granular hornblende-biotite granodiorite. A second major pluton in the area is the granodiorite of Caples Lake, informally named for outcrops in the vicinity of Caples Lake. This pluton is the main rock body in the western part of the Mokelumne area enclosing the Mokelumne Peak and Woods Lake roof pendants. The rock is typically medium- to coarse grained porphyritic hornblende-biotite granodiorite. The granodiorite of Caples Lake is probably younger than the Carson Pass Tonalite of Parker (1961) and is older than the Ebbetts Pass Granodiorite of Wilshire (1957). K-Ar age determinations for this rock by Evernden and Kistler (1970, table 5) are: 91.7 m.y. and 94.3 m.y. on biotite, and 99.6 m.y. on hornblende.

The youngest pluton in the area, on the basis of its crosscutting contacts and on K-Ar age determinations, is the Ebbetts Pass Granodiorite of Wilshire (1957). This pluton extends into the Mokelumne Wilderness from the east, where it forms extensive outcrops along the Sierra Nevada crest. About a third of the total study area is underlain by the Ebbetts Pass pluton. The rock is typically fine- to medium grained biotite-hornblende granodiorite to quartz monzonite, although a wide variation in textures occurs, including coarse-grained porphyritic types. Like many other granitic bodies of the Sierra Nevada batholith, numerous dark hornblende-rich inclusions, quartzofeldspathic dikes, and small aplitic and pegmatite bodies occur throughout the pluton. K-Ar age determinations on biotite from two sites yield ages of 87.8±0.6 and 88.3±1.0 m.y.

An irregular body of aplite with a surface area of 0.5 mi^2 (1.25 km^2) crops out in Martell Flats on the north side of Mokelumne canyon. The rock is fine- to medium-grained allotriomorphic granular, composed of quartz, alkali feldspar, muscovite, and biotite. Large parts of this body are altered, and iron staining gives a distinctive red tint to the rock and surrounding soil.

Cenozoic

Volcanic and sedimentary rocks

Many peaks and ridges in the Mokelumne Wilderness and contiguous roadless areas are composed of late Tertiary volcanic and sedimentary rocks. No two sections of these rocks are alike because the paleotopographic surface on which they were deposited contained many deep valleys that filled with varying amounts of lava and sedimentary detritus. The volcanic rock is mostly andesitic, in the form of lava flows, mudflows, and pyroclastic deposits; andesitic and rhyolitic volcanic ash makes up a large part of the detritus in the sedimentary units. Numerous higher peaks, including Round Top and Thimble Peak, are volcanic necks that were are the sources of some of the flows and breccia in the area. Typically, the andesite contains phenocrysts of hornblende, plagioclase, and, in places, biotite in a fine-grained dark matrix.

Sedimentary rocks, ranging from coarse conglomerate to finely laminated siltstone, occur at various places in the stratigraphic sequence. The sandstone and siltstone deposits are well bedded and contain crossbedding and ripple marks. Fossil-plant material occurs in the fine-grained deposits. Andesite from four places in or near the wilderness has been dated by the K-Ar method, and ages of 7.3, 12, and 13.4 m.y. were reported by Morton and others (1977); one sample dated for this study indicated an age of about 4 m.y. for another flow. Volcanic activity of middle and late Miocene age has been documented at many other places in the central Sierra Nevada (Dalrymple, 1964).

AEROMAGNETIC INTERPRETATION

Aeromagnetic surveys flown over the Mokelumne Wilderness and adjacent lands have been compiled and interpreted by Plouff and McKee (1981), who discussed four magnetic anomalies that can be related to geologic features: (1) a magnetic minimum centered about 2 mi (3 km) south of Mokelumne Peak, caused by the large body of metamorphic rock that constitutes the Mokelumne Peak roof pendant, which has a low magnetization; (2) a magnetic maximum about 3 mi (5 km) west of Mokelumne Peak on the edge of the wilderness that extends to about 0.6 mi (1.0 km) below the surface, caused by rocks of relatively high magnetization; (3) a magnetic maximum about 3 mi (5 km) southeast of Silver Lake, caused by the presence of magnetite-rich hornblende-biotite gneiss forming a series of tabular elongate northwest-trending bodies that extend as much as 3,000 ft (1,000 m) beneath the surface; and (4) a conspicuous magnetic maximum centered over the north edge of Round Top.

The large positive anomaly on Round Top is probably caused by a combination of the 3,000-ft (1,000 m) relief and the magnetite-bearing andesite forming the peak and extending beneath it. Geologic mapping indicates that Round Top is a deeply dissected volcano or volcanic neck which includes several of lava flows near its top and flanks and intrusive rock beneath the peak. The size and shape of the magnetic anomaly suggest that the roots of the Round Top volcano extend a considerable depth into the crust.

GEOCHEMICAL STUDIES

A total of 86 rock, 115 minus-60-mesh stream sediment, and 115 nonmagnetic heavy-mineral concentrate samples were collected in the Mokelumne Wilderness and contiguous roadless areas. Analyses of the rock samples from unaltered outcrops indicate the chemical abundances in typical rock material; analyses of the stream-sediment and nonmagnetic-heavy-mineral concentrate samples indicate the overall chemistry of the minerals present in eroded rock material from the entire drainage basin upstream from the sample sites. The higher concentrations measured in the nonmagnetic-heavy-metal samples permit determination of some elements that are not commonly detected in stream-sediment samples. All samples were analyzed for 31 elements by six-step semiquantitative emission spectrography, and most of the rock and stream-sediment samples were also analyzed for five additional elements (Zn, Cd, As, Sb, and Bi) by atomic absorption spectroscopy or colorimetry. The results of these analyses are listed in Chaffee and others (1981).

The drainage basins from which the eroded material containing anomalous values originated were evaluated by assigning a numerical score dictated by the number of anomalous metals and their actual concentrations (Chaffee and others, 1982). The final step in the geochemical analyses was to evaluate these anomalies with respect to the geologic features present in the various drainage basins. Most anomalies relate to a given rock unit or rock type, and areas with observed alteration correspond closely to the detected anomalies. The most noteworthy drainage basins showing metal anomalies are west of Woods Lake including the area around the Lost Cabin mine (loc. 8, map and fig. 2) and the upper part of Summit City Creek. The only gold value detected in the study area, in the lower part of Summit City Creek, may have originated at the upper end of that drainage. Basins of secondary interest cluster around these two basins and some isolated basins occur west of Silver Lake and south of Ladeux Meadow.

MINING DISTRICTS AND MINERALIZED AREAS

Mining activity in the region began soon after the discovery of gold at Sutter's Mill in 1848. Substantial production of gold from mines in the East Belt district, about 20 mi (30 km) west of the study area, took place during the 1850's. After the rush caused by discovery of the Comstock Lode near Virginia City, Nev., in 1857, gold and silver were discovered in several mining districts east of the study area. The Monitor-Mogul, Silver Mountain, Silver King, and Hope Valley mining districts, 1 to 10 mi (2-16 km) east of the study area, yielded gold and silver worth \$3 to 5 million (Clark, 1977). Gold and silver production were about equal in value; copper, tungsten, lead, and zinc were produced in relatively smaller amounts. Tungsten and molybdenum were mined at Garnet Hill, about 6 mi (10 km) west of the study area, between 1953 and 1957 (Clark and Lydon, 1962, p. 123).

The earliest reported activity in the study area centered around the Summit City district (locs. 11, 14-19 map and fig. 2; table 1), where veins carrying silver minerals were prospected during the early 1860's and gravel along the head of Summit City Creek was worked for placer gold. The rush was short lived, however, and left no record of production. The Lost Cabin mine, 2 mi (3 km) northwest of Summit City Creek outside the study area (loc. 8), was also first active during the 1860's. Renewed activity in the region during the 1940's and 1950's, first for tungsten and then for uranium, resulted in the location of several claims in and near the study area.

Mokelumne Wilderness

Sixty-five mining claims have been located within the Mokelumne Wilderness; all but one are lode claims. These claims were concentrated in two areas: along the upper part of Summit City Creek and in the vicinity of Mokelumne Peak.

More than 30 mining claims have been staked in the Summit City Creek area since 1872. Andesite and the underlying granitic rocks in this area are sheared and altered near their contact on the south side of Round Top. Small amounts of pyrite and molybdenite occur in the north- to northwest-trending shear zones. The only significant workings in the Mokelumne Wilderness are at the Orphan Boy prospect (loc. 13, map and fig. 2), south of Fourth of July Lake. Two short adits at the prospect follow a limonite-stained quartz-bearing shear zone in granodiorite. Most samples from the zone contained trace amounts of gold and silver; one sample assayed 0.17 troy oz of gold per ton (5.8 g/t) and 0.5 troy oz of silver per ton (17 g/t).

Thirty lode claims were staked on Mokelumne Peak between 1929 and 1934. No workings were found. Mokelumne Peak consists of metamorphic rocks in a roof pendant. Gneiss and aplite on the east side contain abundant pyrite and sparse arsenopyrite, chalcopyrite, and bornite. Samples contained as much as 0.01 troy oz of gold and 0.2 troy oz of silver per ton (0.3 and 7 g/t) and minor amounts of base metals.

The only current mineral interest within the wilderness is at the Monte Wolf property on the Mokelumne River above the mouth of Summit City Creek. It and several other scattered claims are undeveloped; they show little potential for the discovery of resources.

Caples Creek Roadless Area (5-027)

At least 20 mining claims were located in the area, mainly for uranium, during the 1950's. Interest focused on pegmatite dikes that emitted radiation counts above background levels. None of these occurrences is of high enough grade to be economically important.

A few claims were staked between 1900 and 1920 on discontinuous quartz veins and stringers. Samples of these structures contained no significant amounts of metals.

Tragedy-Elephants Back Roadless Area (4-984)

No claims were identified within the Tragedy-Elephants Back Roadless Area. A limonite-stained silicified shear zone in andesite is exposed in five prospect pits; the zone is nearly vertical, strikes N. 25° W., and is at least 9 ft (2.7 m) thick. Samples from the zone contained as much as 0.1 oz troy silver per ton (3 g/t) and traces of gold.

Tragedy-Elephants Back Roadless Area (5-984)

At least 67 claims have been located within the Tragedy-Elephant Back Roadless Area (5-984) since 1877, most in the eastern part of the area near Woods Lake. On the Crockett Prospect just outside the study area (loc. 7, map and fig. 2), a steeply dipping shear zone cuts andesite and granodiorite; this zone strikes N. 25° W. and can be traced intermittently for about 0.5 mi (0.8 km) toward the roadless area. Galena, pyrite, and chalcopyrite are sporadically distributed in quartz veins along the zone. Samples contained as much as 0.01 troy oz gold per ton (0.3 g/t), 0.6 troy oz of silver per ton (21 g/t), 0.43 weight percent Pb, and 0.1 weight percent Cu.

The Lost Cabin mine lies within 100 ft (30 m) of the roadless area near Woods Lake (loc. 8, map and fig. 2). U.S. Bureau of Mines records show that nearly 200 tons (180 t) of ore and concentrates containing 132 troy oz (4,110 g) of gold, 375 troy oz (11,660 g) of silver, 917 lb (416 kg) of copper, and 3,832 lb (1,738 kg) of lead was shipped from the mine between 1932 and 1939; production came from at least two west-trending quartz veins. None of the underground workings were accessible in 1979, but surface and dump samples contained as much as 0.07 troy oz of gold and 1.7 troy oz of silver per ton (2.4 and 58 g/t, respectively).

Raymond Peak Roadless Area (5-985)

County records indicate that about 60 gold and silver claims and 28 uranium claims have been located in the Raymond Peak Roadless Area. Most gold-silver claims were at the head of Summit City Creek (locs. 14-19, map and fig. 2) and were recorded during the 1860's and early 1900's. Prospecting was along northwest-trending silicified shear zones in granodiorite and andesite. Vein quartz in these zones contains sporadically distributed sulfide minerals, mainly pyrite; the zones average 2 ft (0.6 m) thick where exposed in surface workings. Samples contained as much as 0.03 troy oz of gold and 0.9 troy oz of silver per ton (1.0 and 31 g/t, respectively); most samples contain detectable gold and silver.

The Critical Molly claim (loc. 20 map and fig. 2) is on three molybdenite-bearing quartz stringers in granodiorite. A select sample across the stringers contained 1.4 weight percent molybdenum disulfide (MoS_2).

Recent activity in this area has been on the Shirley claims Nos. 1 through 28 (loc. 21 map and fig. 2) where the Lucky McUranium Corp. (now Pathfinder Mines) conducted a drilling project between 1971 and 1979. The drilling revealed as much as 0.056 equivalent-weight percent equivalent U_3O_8 in thin horizons within a sequence of andesitic flows and sedimentary rocks that overlie granitic rock. The uranium showed some affinity for beds containing organic debris, although a bog-type zone encountered in one hole contained no anomolous radioactivity. The property has subsequently been abandoned Analyses of samples taken during examination of the property by U.S. Bureau of Mines personnel reveal as much as 0.009 equivalent-weight percent U_3O_8 in an ancient stream channel in andesite. No resource potential was identified.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

In general, average grades are low and metal distribution erratic in the exposed mineralized quartz veins and shear zones that surround Round Top. The complex sulfide ores mined from altered Tertiary volcanic rocks in the Monitor-Mogul and Silver

Mountain mining districts do not occur in similar rocks within the study area. Tactite bodies in pre-Cretaceous rocks in the Hope Valley mining district and at Garnet Hill contain scheelite and metallic sulfide ores, but roof pendants within the Mokelumne Wilderness and adjacent roadless areas are less highly mineralized.

Samples from mineralized zones at the Orphan Boy prospect (loc. 13, map and fig. 2) in the Mokelumne Wilderness suggest a moderate potential for gold and silver resources in quartz-filled shear zones near intrusive contacts. Production of gold, silver, copper, and lead at the Lost Cabin mine north of Round Top (loc. 8, near but outside of the Tragedy-Elephants Back Roadless Area 5984) indicates a moderate potential for the discovery of additional resources. Mineralized quartz veins at the mine may extend at depth into the roadless area; access to underground workings or drilling would be necessary to evaluate this possibility. Sulfide-bearing quartz veins along shear zones at the Crockett prospect may also extend into the study area. Similar quartz veins and shear zones near the head of Summit City Creek (Tragedy-Elephants Back Roadless Area 4984 and Raymond Peak Roadless Area 5985) indicate a moderate resource potential for gold and silver, although poor exposures preclude any estimation of resources.

Also in the Raymond Peak area, company drilling data from the Shirley claims (loc. 21, map and fig 2) and samples taken in 1979 indicate a low uranium resource potential. Molybdenite blebs in quartz stringers at the Critical Molly claim (loc. 20, map and fig. 2) indicate the presence of a small amount of molybdenum. No significant mineralized areas are known in the Caples Creek Roadless Area (5027), and no mineral resource potential is evident.

Anomalous amounts of 15 metallic elements (Ag, As, Au, B, Ba, Bi, Cd, Cu, Fe, Mo, Pb, Sb, Sn, W, and Zn) were identified by geochemical sampling in the Mokleumne Wilderness and contiguous roadless areas. Concentrations of four of these elements (B, Mo, Sn, and W) probably represent only their expected normal enrichment in granitic rocks. Anomalies of four other element (As, Cd, Sb, and Zn), though widely scattered, do not seem to represent minerals or mineral groups that by themselves indicate enrichment or mineralization. The remaining seven elements (Ag, Au, Ba, Bi, Cu, Fe, and Pb) are commonly associated with many types of sulfide-rich hydrothermal mineral deposits. Enrichment of these elements, shown as anomalies in the rock, stream-sediment, and nonmagnetic-heavy-mineral-concentrate samples, indicates some degree of hydrothermal alteration and mineralization and the possibility for mineral deposits. The clustering of those drainage basins that contain anomalies of these metals, the proximity of these anomalies to old mines and prospects, and the presence of disseminated pyrite in the country rock in these areas all point to a zone of sulfide-bearing hydrothermal mineralization in the vicinity of Round Top (map, fig. 2).

Round Top, the highest mountain in the study area, is part of a deeply dissected andesitic volcano of Miocene age. The upper parts of the mountain are extrusive rocks, mostly lava flows, and some mudflows. Deep erosion of the mountain, afforded by Summit City canyon on the south side of Round Top exposes nearly 3,000 vertical ft (1,000 m) of intrusive rock in the neck of the volcano. Interpretation of the large positive aeromagnetic anomaly at Round Top indicates that this volcanic neck extends a considerable depth below the basal outcrops in Summit City canyon. The two drainage areas with the highest number of anomalous elements and the highest concentrations of those elements associated with hydrothermal activity are the upper part of Summit City canyon and the Woods Lake basin on the south and north flanks of Round Top, respectively; other drainages with similar but smaller anomalies cluster around these drainages or around Round Top. It seems likely that hydrothermal activity, commonly associated with subvolcanic hypabyssal systems, was the source of the mineralization around Round Top. Most of the alteration affected rocks adjacent to the volcano or its deeper parts; the two areas designated on the accompanying map and in figure 2 reflect this interpretation. Close to the volcano is a zone, including the Lost Cabin mine and the upper part of Summit City canyon that was designated most likely to have anomalous amounts of hydrothermally formed sufide mineralization; a second belt surrounding this zone also probably contains some mineralization. Although there is good geologic, geophysical, and geochemical evidence to indicate that the Round Top volcano caused some hydrothermal alteration and mineralization, the concentrations of metals are relatively low in comparison with those normally detected in or near exposed mineral deposits. On the basis of present information, the existence of deeply buried mineral deposits at Round Top can be neither confirmed nor denied.

REFERENCES

Chaffee, M. A., McKee, E. H., Hill, R. H., Speckman, W. S., and Sutley, S. J., 1981, Chemical analyses of samples of rock, minus-0.25-mm stream sediment and nonmagnetic heavy-mineral concentrate, Mokelumne Wilderness and adjacent RARE II further planning areas, California: U.S. Geological Survey Open-File Report 81-670, 36 p.

Chaffee, M. A., Hill, R. H., and Sutley, S. J., 1982, Geochemical map showing anomalous concentrations and drainage basins of the Mokelumne Wilderness and contiguous Roadless Areas, central Sierra Nevada, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1201-C, scale 1:62,500.

Clark, W. B., 1977, Mines and mineral resources of Alpine County, California: California Division of Mines and Geology County Report 8, 48 p.

Clark, W. B., and Lydon, P. A., 1962, Mines and mineral resources of Calaveras County, California: California Division of Mines and Geology County Report 2, 217 p.

Dalrymple, G. B., 1964, Cenozoic chronology of the Sierra Nevada: University of California Publications in Geological Sciences, v. 47, 41 p.

Evernden, J. R., and Kistler, R. W., 1970, Chronology of emplacement of Mesozoic batholithic complexes in California and western Nevada: U.S. Geological Survey Professisonal Paper 623, 41 p.

Lindgren, Waldemar, 1896, Pyramid Peak (quadrangle) California, folio 31 of Geologic atlas of the United States: Washington, U.S. Geological Survey.

McKee, E. H., and Howe, R. A., 1981, Geologic map of the Mokelumne Wilderness and contiguous RARE II further planning areas, central Sierra Nevada, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1201-A, scale 1:62,500.

Morton, J. L., Silberman, M. L., Bonham, H. F., Jr., and Garside, L. J., 1977, K-Ar ages of volcanic rocks, plutonic rocks, and ore deposits in Nevada and eastern California--determinations run under the USGS-NBMG cooperative program: Isochron/West, no. 20, p. 19-29.

Parker, R. B., 1961, Petrology and structural geometry of pre-granitic rocks in the Sierra Nevada, Alpine County, California: Geological Society of America Bulletin, v. 72, no. 12, p. 1789-1806.

Plouff, Donald, and McKee, E. H., 1981, Aeromagnetic map of the Mokelumne Wilderness and contiguous RARE II further planning areas, central Sierra Nevada, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1201-B, scale 1:62,500.

Strand, R. G., and Koenig, J. B., compilers, 1966, Sacramento sheet of Geologic map of California: California Division of Mines and Geology, scale 1:250,000.

U.S. Geological Survey, 1979a, Aeromagnetic map of the Hoover-Walker Lake area, California: U.S. Geological Survey Open-File Report 79-1194, scale 1:250,000.

_____1979b, Aeromagnetic map of the Mokelumne area, California: U.S. Geological Survey Open-File Report 79-1233, scale 1:62,500.

Wilshire, H. G., 1957, Propylitization of Tertiary volcanic rocks near Ebbetts Pass, Alpine County, Calfornia: University of California Publications in Geological Sciences, v. 32, no. 4, p. 243-271.

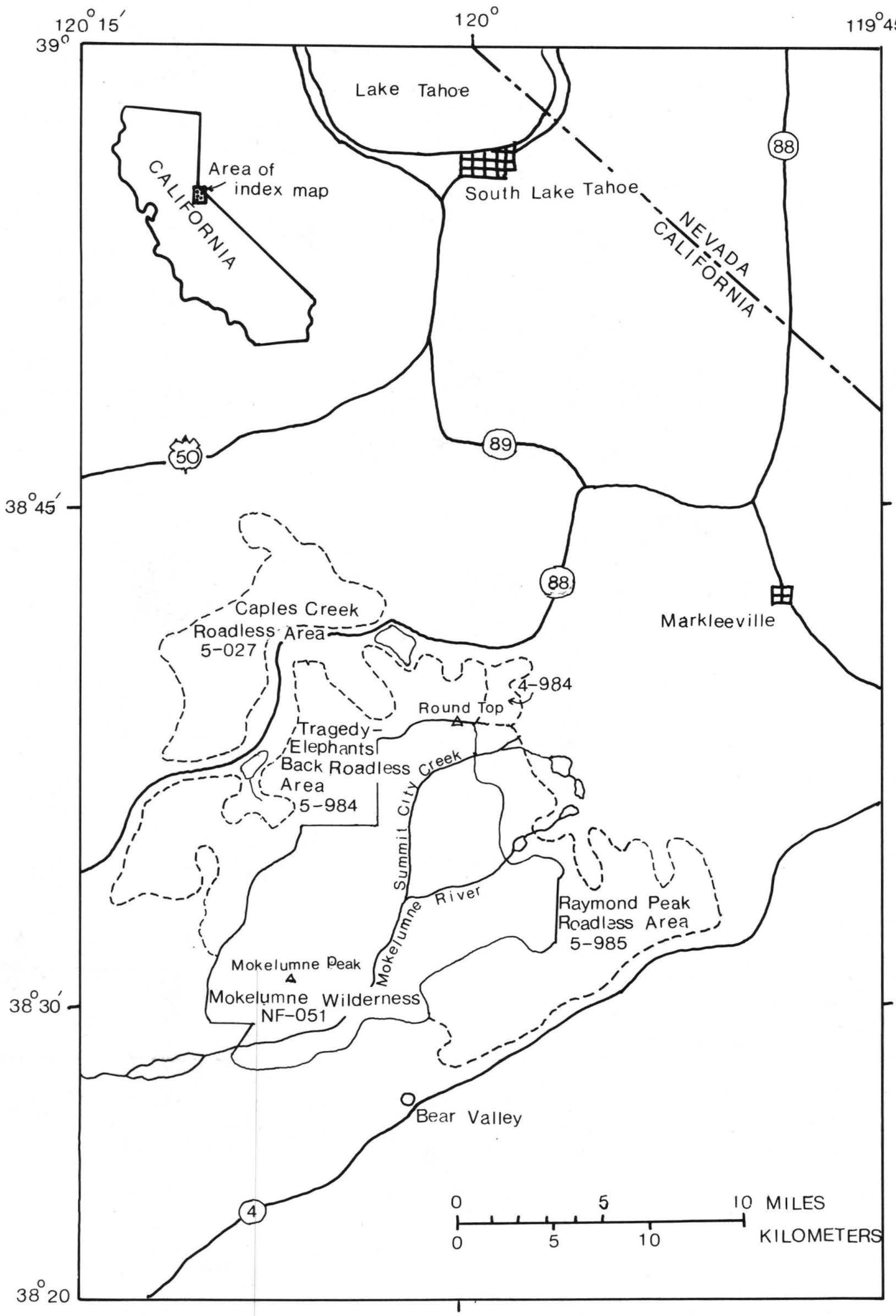

Figure 1. Index map showing location of study area.

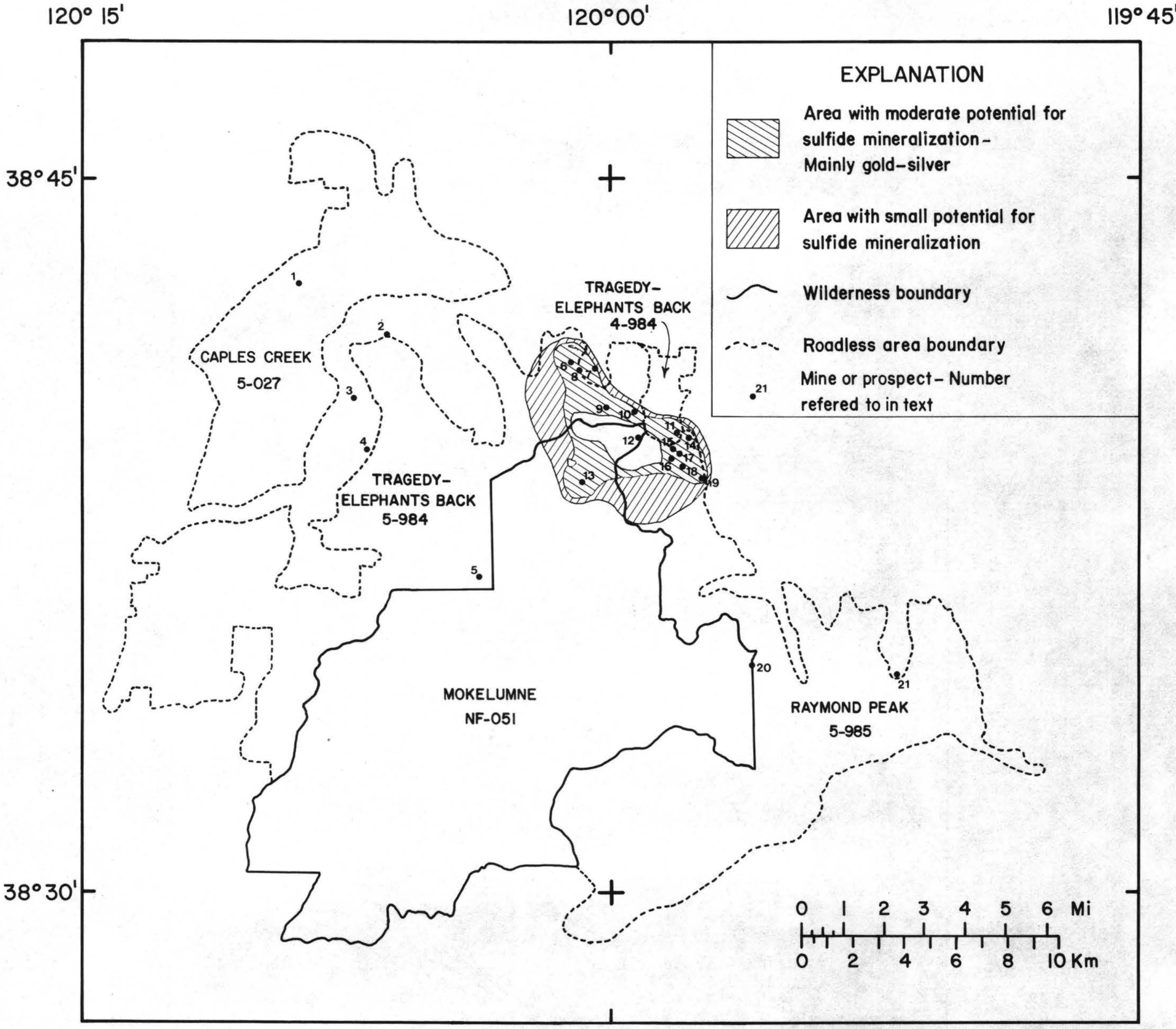

Figure 2. Map showing mineral resource potential and mines and prospects in the Mokelumne Wilderness and contiguous roadless areas.

Table 1.--Mines, prospects, and mineralized areas, Mokelumne Wilderness and adjacent Roadless Areas, California
[Underlined entries indicate properties with moderate mineral resource potential]

Map number	Name (commodity)	Summary	Workings and production	Sample data and resource assessment
		Caples Creek Roadless Area 5027		
1	Unnamed prospect (silver)	A limonite-stained quartz veins strikes N. 40°-45° W. and dips 70°-80° NE. in granodiorite. The vein is as much as 2.5-ft (0.8-m) thick and can be traced intermittently for 40 ft (12 m).	None	One sample contained 0.1 oz silver/ton (3 g/t). Low mineral resource potential.
		Tragedy-Elephants Back Roadless Area 5984		
2	Unnamed prospect (gold-silver)	Dump material is light-gray porhyritic andesite and tuff. No structure is exposed.	One sloughed pit, 6 ft (1.8 m) in diameter. No recorded production.	One grab sample contained no anomalous metals. Low mineral resource potential.
3	Unnamed prospect (gold-silver)	Rhyolite tuff and quartz monzonite is on the dump. Both rock types are lightly limonite stained, and have 10 to 35 percent anhedral quartz.	One caved shaft, about 20 ft (6 m) deep. No recorded production.	One sample of each rock type assayed trace gold and 0.1 oz silver/ton (3 g/t). Low mineral resource potential.
4	Weasel Claims (gold-silver-uranium)	Medium-grained quartz diorite that is cut by a narrow northeast-trending shear zone. About 100 lbs (45 kg) of intensely limonite stained quartz diorite is stockpiled.	One 10-ft- (3-m-) deep flooded shaft. No production.	One chip and one grab sample had as much as 0.1 oz silver/ton (3 g/t), and 0.002 percent U_3O_8. Low mineral resource potential.
5	Unnamed prospect (gold-silver)	Highly limonite stained aplite that is broken by a fracture system striking predominantly N. 60°-80° E. and dipping 60°-80° NW. Pyrite and pyrrhotite are finely disseminated locally in the aplite.	None	Six chip samples assayed trace gold and 0.1 oz silver/ton (3 g/t). No mineral resource potential.
6	Unnamed prospect (gold-silver)	A 5-ft- (1.5 m-) thick shear zone strikes N. 28° W. and dips 85° SW in granodiorite. The zone is limonite stained and kaolinized.	One trench, 15 ft (4.6 m) long and 10 ft (3-m) wide. No recorded production.	One chip sample across the shear zone had trace gold. Low mineral resource potential.
7	<u>Crockett prospect</u> (gold-silver)	Quartz veins up to 6 in. (15 cm) thick occur sporadically in a steeply dipping shear zone that strikes N. 25° W. in granodiorite. The zone is traceable intermittently for almost 0.5 mi (0.8 km). The quartz is locally brecciated, vuggy, and contains sporadic pyrite, galena, and chalcopyrite. Wallrock is sheared, limonite stained, kaolinized, and contain sparse pyrite.	Two 40-ft- (12-m-) long trenches; 6 pits as much as 10 ft (3 m) in diameter. All sloughed. No recorded production.	Seven samples were collected. Three samples at the northwest end of the zone which contained quartz assayed from trace to 0.01 oz gold/ton (0.3 g/t) and 0.2 to 0.6 oz silver/ton (7-21 g/t). A select sample of quartz contained 0.43 percent lead and 0.10 percent copper. A sample of wallrock is barren. The structure has a moderate potential for gold-silver resources.
8	Lost Cabin mine (gold-silver)	Three west-trending quartz veins and a northeast-striking steeply dipping fault in granitic rocks. Quartz veins are 1 to 2 ft (0.3-0.6 m) thick, limonite stained, and contain pyrite locally. Brecciated material along the fault is limonite stained; no sulfides were observed.	One flooded shaft, one caved adit with reported 950 ft (290 m) of workings, two 10-ft- (3-m-) wide, 30-ft- (9.1-m-) long trenches, and a pit 6 ft (1.8 m) in diameter. U.S. Bureau of Mines records show 132 oz (4,110 g) gold, 375 oz (11,660 g) silver, 917 lb (516 kg) copper, and 3,832 lb (1,738 kg) lead was produced from 192 tons (174 t) of ore and 4 tons (3.6 t) of concentrates between 1932 and 1939.	Nine lode samples collected. Five chip samples contained as much as 0.07 oz gold and 1.7 oz silver/ton (2.4 and 58.3 g/t). Four dump samples contained as much as 0.05 oz gold and 0.5 oz silver/ton (1.7 and 17.1 g/t). Only minor amounts of copper and lead were detected in samples. Based on past production and select sample analyses, the property has moderate potential for the discovery of mineral resources.
9	Unnamed prospect (gold, silver)	A 2-ft- (0.6-m-) thick shear zone striking N. 50° W. and dipping 82° SW is in andesite. Sheared andesite in the zone is bleached, limonite stained, locally silicified, and contains sporadic pyrite.	One 10-ft- (3-m-) wide by 15-ft- (4.6-m-) long cut. No recorded production.	One chip sample across the shear zone contained no gold and 0.2 oz silver/ton (7 g/t). Low mineral resource potential.
10	Unnamed prospect (gold, silver)	A limonite-stained zone in porphyritic granodiorite crops out about 5 ft (1.5 m) east of a fine-grained dioritic dike.	One 3-ft- (0.9-m-) diameter pit. No recorded production.	One random chip sample contained a trace of gold and 0.1 oz silver/ton (3 g/t). Low mineral resource potential.

Table 1.--Mines, prospects, and mineralized areas, Mokelumne Wilderness and adjacent Roadless Areas, California--Continued
[Underlined entries indicate properties with moderate mineral resource potential]

Map number	Name (commodity)	Summary	Workings and production	Sample data and resource assessment
		Tragedy-Elephants Back Roadless Area 4984		
11	Unnamed prospect (gold-silver)	A limonite-stained silicified shear zone in andesite strikes N. 25° W., dips nearly vertical, and is at least 9 ft (2.7 m) thick.	Five small pits. No recorded production.	Four grab samples from dumps and one chip sample contained trace gold and as much as 0.1 oz silver/ton (3 g/t). Low mineral resource potential.
		Mokelumne Wilderness		
12	Jimmie No. 1 Claim	A quartz vein in altered chloritized andesite contains pyrite and sparse chalcopyrite. Strike is N. 32° W., dip is 81° NE. The vein is exposed for 250 ft (76 m) along strike and is as much as 6 ft (1.8 m) thick.	Three shallow partly sloughed pits. No recorded production.	Three samples of quartz vein material contained as much as 0.01 oz gold/ton (0.3 g/t), 0.1 oz silver/ton (3 g/t), and 0.013 percent copper. Low mineral resource potential.
13	<u>Orphan Boy Prospect</u> (gold, silver)	A quartz-bearing shear zone is granodiorite strikes about N. 20° W. and dips 50° SW. the zone is as thick as 3 ft (0.9 m) and can be traced about 200 ft (60 m).	Two adits 44-ft and 50- 13.4- and 15/2-m) long. No recorded production.	Seven of nine chip samples from the shear zone contained gold and silver, as much as 0.17 oz gold/ton (5.8 g/t) and 0.5 oz silver/ton (17 g/t). Select samples from the dump contained as much as 0.16 (5.5 g/t) oz gold/ton. Moderate gold-silver resource potential.
		Raymond Peak Roadless Area 5985		
14	Unnamed prospect (gold, silver)	A shear zone striking N. 10° E., dipping nearly vertical is in andesite. The zone contains limonite-stained slightly brecciated and siliceous andesite and although not well exposed, appears to be 2 ft (0.6 m) thick.	One shallow pit, 6 ft (1.8 m) in diameter. production.	One grab sample had trace gold and silver. Low mineral resource potential.
15	<u>Unnamed</u> (gold, silver)	A 2-ft- (0.6-m-) thick shear zone striking N. 37° W., dipping 75° SW is along a granodiorite-andesite contact. The zone contains milky quartz and clay minerals.	One cut, 6 ft wide (1.8 m) wide and 10 ft long. No recorded production.	Two chip samples were collected. One chip across the zone assayed 0.02 oz gold/ton (0.7 g/t), one chip across the andesite hanging wall had trace gold. Both samples contained 0.1 oz silver/ton (3 g/t). Moderate gold-silver resource potential.
16	Unnamed prospect (gold-silver)	A limonite-stained silicified shear zone containing sporadic pyrite cuts hornblende biotite monzonite.	One short caved adit. No recorded production.	Ore dump sample assayed trace gold and 0.1 oz silver/ton (3 g/t). Low mineral resource potential.
17	Unnamed prospect (gold-silver)	A northerly trending breccia zone containing pyrite up to 0.25 in. across in silicified kaolinized andesite. Acicular tourmaline occurs interstitial to the andesite fragments.	One small sloughed pit. No recorded production.	One dump sample contained no gold and 0.1 oz silver/ton (3/4 g/t). Moderate gold-silver resource potential.
18	Unnamed prospect (gold-silver)	A quartz-filled fissure vein is in granodiorite and overlying andesite. The vein strikes N. 50° W. and dips nearly vertical. Vein exposures average 2 ft (0.6 m) thick and are traceable for about 2,600 ft (790 m) along strike. Quartz is vuggy, locally brecciated, coarsely crystalline, and contains as much as 5 percent pyrite locally. The granodiorite is sheared, kaolinized, silicified, and has about 1 percent pyrite.	Three trenches, up to 40 ft (12 m) long and 20 ft (6 m) wide; one 6-ft- (1.8-m-) diameter pit. No recorded production.	Five samples were collected. Four samples of vein quartz assayed trace to 0.03 oz gold/ton (1.0 g/t) and trace to 0.9 oz silver/ton (31 g/t). Most of these samples have less than 0.3 oz silver per ton (7 g/t). One samples of granodiorite wallrock contained 0.06 oz gold/ton (2.1 g/t) and trace silver. Moderate gold-silver resource potential.
19	<u>Nil Desperandum</u> (gold, silver)	Propylitized and partly silicified andesite on dump contains approximately 2 percent pyrite as much as 0.25 in. (0.6 cm) in diameter.	Two caved adits, estimated to have 150 ft of workings. No recorded production.	Four dump grab samles contained trace gold, and no other anomalous metals. Moderate gold-silver resource potential.
20	Critical Molly Claim (molybdenum)	Three parallel quartz stringers contain molybdenite blebs. Stringers are 1 to 3 in. (3-7 cm) thick and have randomly distributed molybdenite blebs up to 1 in. (3 cm) in diameter. The stringers strike N. 60° W., dip vertically, and are exposed along strike for 210 ft (64 m). Country rock is granodiorite with narrow pegmatite and aplite dikes.	One prospect pit, 5 ft (1.5 m) long, 3 ft (0.9 m) wide, and 3 ft (0.9 m) deep. No recorded production.	Three chip samples collected; two of the quartz stringers contained 0.11 and 1.6 percent MoS_2 (molybdenum sulfide). Low mineral resource potential.
21	Shirley Claims (uranium)	A 10- to 23-ft- (3-7-m-) thick zone containing carbonaceous debris occurs in a buried stream channel near a granodiorite-volcanic flow contact.	Twenty-eight drill holes. Several covered trenches. No recorded production.	Six sample from the surface contained from 0.003 to 0.009 percent eU_3O_8. Low mineral resource potential.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1982—361-614/121