DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

TO ACCOMPANY MAP MF-1365-C

# MINERAL RESOURCE POTENTIAL OF THE EAST PART OF THE RAYMOND PEAK ROADLESS AREA, ALPINE COUNTY, CALIFORNIA

## SUMMARY REPORT

By

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## STUDIES RELATED TO WILDERNESS

Under the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and related acts, the U.S. Geological Survey and the U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive aras. 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 in the Wilderness System. The mineral surveys constitute one aspect of the 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 east part of the Raymond Peak Roadless Area, Toiyabe National Forest, Alpine County, California. The Raymond Peak Roadless Area was classified as a further planning area during the Second Roadless Area Review and Evalaution (RARE II) by the U.S. Forest Service, January 1979.

## SUMMARY

The east part of the Raymond Peak Roadless Area has mineral resource potential in base and precious metals and uranium. Three areas have been identified as having potential for undiscovered precious-metal and skarn-type tungsten deposits (fig 3). Area A in the southeastern part of the Roadless Area has geochemically anomalous elements, hydrothermal alteration, favorable rock types, and known mineralization in mines and prospects in the immediate area suggesting a high potential for undiscovered precious- and base-metal deposits. Area B, near Burnside Lake, has geochemically anomalous elements, favorable rock types, and mines and prospects in and near the area suggesting a moderate potential for undiscovered tungsten deposits. Area C, near Charity Valley, has geochemically anomalous elements suggesting a low potential for undiscovered molybdenum and tungsten deposits. Uranium mineralization is known in one prospect just south of the roadless area, but the potential for undiscovered uranium deposits is low.

An estimated 1,826,000 tons (1,657,000 t) of resources averaging from a trace to 0.04 oz gold per ton (1.37 g/t), and a trace to 23.5 oz silver per ton (805.7 g/t) occur within the roadless area on three properties (table 1 and fig. 2, nos. 3, 5, 9). About 1,500,000 tons (1,360,000 t) of inferred subeconomic resources are on the St. Helena prospect, and the California-Illinois property contains about 270,000 tons (245,000 t) of inferred subeconomic resources. At the Exchequer mine, an estimated 56,000 tons (50,800 t) of inferred marginal reserves averaging 0.04 oz gold per ton (1.37 g/t) and 23.5 oz silver per ton (805.7 g/t) occur in ore shoots. Other prospects adjacent to the southeastern boundary contain gold, silver, and uranium resources along structures which probably extend into the study area. Energy resource potential in the study area is low. A low geothermal potential exists near Grovers Hot Springs just east of the study area.

## INTRODUCTION

### LOCATION AND ACCESS

The Raymond Peak Roadless Area consists of two separate units. The west part (5985), about 12 mi (19 km) southwest of Markleeville in Stanislaus National Forest, has been studied separately as part of the Mokelumne Wilderness Area and vicinity (McKee and others, 1982) (fig. 1). The east part (4985) is the subject of this report (fig. 2).

The east part of the Raymond Peak Roadless Area (4985) encompasses about 57.8 $mi^2$ (153 $km^2$) along the crest and eastern slope of the Sierra Nevada, approximately 13 mi (21 km) south-southeast of Lake Tahoe. Markleeville, the county seat of Alpine County, lies about 1.5 mi (2 km) east of the area (fig. 2). The topography of the area is characterized by deeply incised canyons with glacially scoured canyon walls. Elevations range from 5,600 ft (1,700 m) near Markleeville to more than 10,000 ft (3,000 m) on Hawkins and Raymond Peaks.

Principal access is provided by California State Highways 89, 4, and 88, along the eastern and southern boundaries. Secondary roads from Highway 4 lead to the main mines in the southeastern part of the area, and a U.S. Forest Service road off of Highway 88 passes within 0.25 mi of the west side of the area.

### PRESENT STUDIES

The U.S. Geological Survey gathered data on the geology, geochemistry, and geophysics of the area. Geologic mapping, geochemical sampling, and geophysical surveys, including compilation of existing gravity data and an aeromagnetic survey, were conducted during 1979-80. Results of the geologic mapping are summarized in Armin and others (1982), a tabulation of the chemical analyses is given

in Sutley and others (1982), and results of the geophysical surveys are in Plouff (1983).

U.S. Bureau of Mines personnel gathered data concerning mines, prospects, and mineralized areas. They searched literature and courthouse records and conducted fieldwork to determine mineral resources and potential of the area. They collected 458 samples from mines, prospects, and mineralized areas and analyzed them by atomic absorption, chemical, and fire-assay methods. At least one sample from every prospect was analyzed by semiquantitative spectrographic methods to determine the presence of unsuspected elements. Complete sample analyses are on file at the U.S. Bureau of Mines, Western Field Operations Center, Spokane, Wash.

## GEOLOGY, GEOCHEMISTRY, AND GEOPHYSICS PERTAINING TO MINERAL RESOURCE ASSESSMENT

### GEOLOGY

The oldest rocks in the study area are metamorphic rocks of Triassic(?) and Jurassic(?) age, exposed near Burnside Lake in the northwest part of the area. These rocks consist mainly of calcareous siltstone and sandstone with minor amounts of volcanic rocks, and were regionally metamorphosed to amphibolite grade. Garnet-pyroxene skarns have formed locally along contacts with granitic rocks.

About half of the area is underlain by granitic rocks of the Sierra Nevada batholith. Thirteen plutons, probably emplaced during a relatively short span of time during the Late Cretaceous, are exposed in the area. The plutons are composed mostly of fine- to coarse-grained equigranular to porphyritic granite and granodiorite. Contacts between the plutons are sharp, and textures at contacts typically indicate the relative ages of plutons. The only mineralization known to be related to the granitic rocks is tungsten-gold skarn mineralization in metamorphic rocks along contacts with the Burnside Lake Adamellite of Parker (1961).

Volcanic rocks of early Miocene through early Pliocene age cover about half of the area. They range in composition from rhyolite to basalt, although andesitic compositions are more prevalent. The composite thickness of these volcanic rocks is as much as 7,000 ft (2,150 m) and decreases toward the northwest.

The oldest volcanic rocks exposed in the area are rhyolitic ash flow and air-fall tuffs of early Miocene age which are correlative with part of the Valley Springs Formation discussed by Slemmons (1966). These rhyolites are locally preserved where they fill paleochannels cut into deeply weathered granitic bedrock.

Unconformably overlying the rhyolitic tuffs and the granitic rocks is a thick sequence of andesitic flows, flow breccias, mudflows, and volcaniclastic sedimentary rocks of middle Miocene age which are probably correlative with the Relief Peak Formation (Slemmons, 1966). Most of these andesitic rocks are moderately to intensely propylitized. Uranium mineralization is locally present in the basal part of this andesitic sequence.

A thick sequence of andesitic mudflows and lava flows unconformably overlies the flat-lying to gently dipping older andesite sequence near Raymond and Reynolds Peaks. Curtis (1951) suggests that this younger sequence may represent part of the flank of a huge, deeply eroded composite volcano, the center of which lay to the southeast. These younger andesitic rocks are generally unaltered.

Volcanic activity concluded during the latest Miocene and early Pliocene with the intrusion of several small rhyolite plugs exposed near and mostly outside the southeast border of the area. Silver and gold mineralization in the Silver Mountain district, and the nearby Monitor district (Zaca mine, 1.5 mi east of the area) apparently is associated with this younger silicic volcanism. The numerous silicified (jasperoid) zones in andesitic rocks at the east end of the area also probably formed as a result of these intrusions.

The major fault system along the east margin of the Sierra Nevada passes through this area. The present topography is a result of uplift and westward tilting that is occurring along this fault system and Pleistocene glaciation that cut deep canyons and valleys.

### GEOCHEMISTRY

A total of 38 rock samples, 41 -60-mesh (0.25-mm) stream-sediment samples and 41 nonmagnetic heavy-mineral-concentrate samples were analyzed for the geochemical investigation of the Raymond Peak Roadless Area. All of the samples were analyzed for 31 elements (silver, arsenic, gold, boron, barium, beryllium, bismuth, calcium, cadmium, cobalt, chromium, copper, iron, lanthanum, magnesium, manganese, molybdenum, niobium, nickel, lead, antimony, scandium, tin, strontium, thorium, titanium, vanadium, tungsten, yttrium, zinc, and zirconium) by a six-step semiquantitative emission spectrographic method. All of the rock and stream-sediment samples were also analyzed for arsenic, bismuth, cadmium, antimony, and zinc by wet chemical methods. Two of the stream-sediment samples were also analyzed for gold by atomic-absorption spectrometry.

The rock samples were collected primarily to provide information on the normal, or background, chemical abundances of the rock units in the study area; consequently, only the stream-sediment and concentrate analyses are discussed here.

For the stream-sediment samples 11 elements (silver, arsenic, gold, bismuth, cadmium, copper, iron, molybdenum, lead, antimony, and zinc) were selected as possibly being related to mineralization; for the concentrate samples, 15 elements (silver, arsenic, boron, barium, bismuth, cobalt, cooper, iron, magnanese, molybdenum, lead, tin, strontium, tungsten, and zinc) were selected. Because of the small number of samples in the data set, the analyses for this study were compared to those of other study areas in the vicinity of the Raymond Peak Roadless Area, including the Freel-Dardanelles, Carson-Iceberg, and Leavitt Lake Roadless Area. On the basis of analytical distributions of elements in all of these areas, threshold values (highest background values) were selected for the Raymond Peak samples. The concentrations for the individual selected elements in each sample were then weighted using a technique called Scoresum (Chaffee, 1983), and the anomalies were than plotted on a geologic base map of the roadless area.

Selected elements in the concentrate samples have been divided into three separate suites. Suite 1 (silver, arsenic, copper, manganese, lead, and zinc) includes those elements most closely associated with base- and precious-metal deposits. Suite 2 (boron, bismuth, molybdenum, ting, and tungsten) includes those elements most closely associated with molybdenum and tungsten deposits, particularly skarn-type deposits. Suite 3 (barium, cobalt, iron, and strontium) includes those elements most closely associated with hydrothermal alteration but not necessarily with mineralization. This last suite helps to identify the minerals pyrite and barite and seems to indicate areas of pyritization, argillization, silicification, and bleaching, particularly in the Tertiary volcanic rock units.

#### Geochemical anomalies

Significant anomalies are present in three areas of the east part of the Raymond Peak Roadless Area (fig. 3) and are described below.

Area A.—This area is bounded roughly by the drainage divide between Raymond and Reynolds Peaks on the southwest, by Pleasant Valley Creek on the north, by the East Fork of the Carson River on the east, and by Silver Creek to the southeast. Geochemically the area is characterized by generally low level anomalies for silver, arsenic, gold, bismuth, cadmium, copper, iron, molybdenum, lead, antimony, and (or) zinc in stream-sediment samples. The strongest anomalies occurr in the drainage basins of IXL Canyon, Raymond Canyon Creek, and an unnamed north-flowing fork of Pleasant Valley Creek immediately west of Raymond Canyon Creek. Anomalies in the concentrate samples include most of the elements in suite 1 (base- and precious-metal suite) and suite 3 (hydrothermal-alteration suite). Anomalies for suite 3 are very strong throughout area A; anomalies for

suite 1 elements are strongest in the IXL Canyon, Raymond Canyon Creek, Indian Creek, and Poor Boy Creek drainage basins. Geologically, area A is characterized by locally intensely altered Tertiary andesitic rocks that are known to be favorable host rocks for base- and precious-metal deposits. Some, but probably not all, of the geochemical anomalies may have resulted from contamination from past mining activity. On the basis of the above information, area A is considered to have a high potential for precious- and base-metal deposits.

Areas B and C.--These areas include basins that represent (1) most of the tributaries flowing westward into the West Fork of the Carson River in Hope, Faith, and Charity Valleys; (2) the north-flowing tributaries that flow into this same river on the north side of the study area; and (3) the upper part of Hot Springs Creek. Areas B and C are represented by generally low anomalies for silver, arsenic, cadmium, copper, iron, molybdenum, and (or) zinc in stream-sediment samples and generally low to moderate anomalies for elements in suite 1 (base- and precious-metal suite) and suite 2 (molybdenum-tungsten suite) in the concentrate samples. The strongest anomalies from concentrates are in those basins draining the areas of the Burnside and Cal-Pine mines and in the basin draining upper Hot Springs Creek. Geologically, area B, with the stronger anomalies of these two areas for both kinds of samples, has outcrops of highly altered metasedimentary rocks known to contain contact metasomatic-type tungsten deposits. Some of the anomalies seem to be related to contamination from past mining activity. Area B is considered to have a moderate mineral potential for tungsten deposits that may also contain other base and precious metals. Other less significant anomalies in the roadless area generally contain low levels of one or more of the molybdenum-tungsten suite of elements. The geology of these areas, particularly area C in the Faith and Charity Valleys, suggests the possibility of molydenum-rich veins in the granitic plutons within these drainage basins. Area C is considered to have a relatively low potential for molybdenum and tungsten.

## GEOPHYSICS

Gravity and aeromagnetic surveys were used to aid geologic mapping and mineral appraisal in the east part of the Raymond Peak Roadless Area (Plouff, 1983). The regional gravity survey resulted in a gravity anomaly map that is dominated by closely spaced north-trending contours that reflect thickening of the crust beneath the Sierra Nevada (Oliver and others, 1982). The gravity gradient obscures anomalies that might be related to anomalous distributions of near-surface rocks in most of the area. A gravity low east of Hawkins Peak interrupts the otherwise continuous gradient along the eastern edge of the Sierra Nevada batholith. The central part of the gravity low to the east probably reflects a thick section of Tertiary volcanic rocks. A relative gravity high, 3 mi (4.8 km) in diameter, east of Poor Boy Creek at the eastern edge of the area may outline a relatively dense underlying pluton.

An aeromagnetic survey was flown at about 1,000 ft (300 m) above the ground along northeast-trending flight lines spaced at 0.5-mi (0.8-km) intervals (U.S. Geol. Survey, 1981). The resulting magnetic intensity map is complex and mostly reflects the rugged topography. The surface rocks generally have normal magnetization, and consequently magnetic highs tend to occur over hilltops and ridges, while magnetic lows occur over valleys, where the observation level was higher above the ground.

Tertiary andesitic rocks have a relatively high magnetization (Plouff, 1983) and, hence, produce intense magnetic highs over steep hilltops such as Hawkins, Markleeville, and Raymond Peaks. Less intense magnetic highs occur over Tertiary rhyolitic rocks, which have moderate magnetization. The granitic and metamorphic rocks generally show low to moderate magnetization and produce magnetic lows and small magnetic highs. Broad complex magnetic lows generally overlie granitic rocks from Raymond Peak northwestward to Hope Valley. Superimposed local magnetic highs indicate that rocks at the surface are normally magnetized, but the larger negative anomalies may reveal underlying larger bodies of weakly magnetized or possibly reversely magnetized crystalline rocks.

The Burnside and Cal-Pine mines are located along the contact between metamorphic rocks and the Burnside Lake Adamellite. This contact appears to be parallel to fairly linear northwest-trending magnetic contours. These mines occur at the northeast edge of a 1-mi-diameter magnetic low that is located in the northern part of a broader low. This broad low is interrupted near Grovers Hot Springs by a magnetic high that is associated with relatively mafic granitic rocks. Northeast of this high, the granitic rocks underlying a magnetic low apparently have a relatively low magnetization, possibly caused by alteration associated with the hydrothermal system that feeds Grovers Hot Springs. Elsewhere the effects of topography and the variations in magnetization of the surrounding and deeper lying rocks tend to conceal possible aeromagnetic lows associated with occurrences of altered rocks.

## MINING DISTRICTS AND MINERALIZATION

### MINING HISTORY AND MINING DISTRICTS

Mining activity began in Alpine County in the 1850's, shortly after discovery of the Comstock lode in Nevada. Principal mining districts in the county including Monitor, Silver Mountain, Raymond, and Hope Valley, were established in the early 1860's. Most mineral production in the county estimated to be about $20 million since 1880 (Clark, 1977, p. 13) has been from the Leviathan (sulfur) and the Zaca mines (silver and gold); both are in the Monitor district, 1.5 to 5 mi (2-8 km) east of the Raymond Peak Roadless Area. These mines were initially developed in the 1860's and have yielded ore periodically since then.

Mining properties in and adjacent to the southeastern part of the roadless area are in the Silver Mountain district. Production records are incomplete, but Clark (1977, p. 28) reports district mines had an output of less than $300,000. Principal silver and gold deposits in this district are on the Exchequer, St. Helena, IXL, Acacia, Columbine, Bolin, and Pennsylvania properties (fig. 3 and table 1, nos. 9, 3, 13, 11, 23, 22, and 20, respectively). These deposits, excluding the Columbine, are in quartz veins in silicified shear zones in Tertiary andesite breccia; deposits at the Columbine claim (fig. 3, no. 23) are in shear zones in Cretaceous granitic rocks. These claims have been developed since the 1860's; currently small-scale prospecting is being done in IXL Canyon. The Cindy and Deer claims (fig. 3, No. 24), located in 1969, were explored for uranium by the Utah Construction and Mining Company (presently Pathfinder Mines, Inc.) until 1973.

The Raymond district, organized in the late 1860's along Raymond Canyon Creek, has been dissolved since the 1920's. Gold and silver deposits in this district were extensively developed at the California-Illinois prospect (fig. 3, No. 5), but only minor development was done on the Silver Cloud Claim (fig. 3, No. 4). These deposits are similar to those in the Silver Mountain district. The California-Illinois prospect probably yielded small quantities of ore before 1900, but production records are not available.

The Hope Valley and Summit City districts lie north and west, respectively, of the roadless area. Hope Valley district mines, including the Burnside, Brewer, and Cal-Pine mines (fig. 2), are in tungsten-bearing tactite deposits which were developed in the 1940's and 1950's; gold-bearing quartz veins were also mined at the Cal-Pine mine.

Prospecting in the Summit City district (west of the map area) commenced in the late 1860's with the discovery of gold-bearing quartz veins on the Nil Desperendum property. Numerous small veins in granitic and volcanic rocks were explored; no metal production was recorded for the district.

### Mining Claims

Since 1850, approximately 300 lode claims have been recorded in the roadless area; no placer claims were recorded. Some of the patented claims for the Exchequer

mine and Lady Franklin claim (fig. 3, nos. 9, 10) extend into the roadless area and are currently being developed by a small mining company.

No oil and gas, geothermal, or other mineral leases exist in the roadless area.

### Geologic factors related to deposits

Silver and gold deposits occur in hydrothermally altered shear zones which cut Miocene andesite breccia, mainly in the southeast part of the area. Limonite-stained silicified country rock has quartz veins and stringers with disseminated pyrite and pyrargyrite; galena and stibnite also occur locally in the quartz veins. Steeply dipping shear zones trend north to northeast and are 1 to 34 ft (0.3-10.4 m) thick, averaging about 5 ft (1.5 m) thick. They are segmented by east-west fracture systems and are difficult to trace along strike.

Uranium occurs in a podiform-type deposit in a buried Tertiary stream channel, along a contact between granitic and volcanic rocks.

## ASSESSMENT OF MINERAL RESOURCE POTENTIAL

The potential for resources of silver and gold is high in the east part of the Raymond Peak Roadless Area; the potential for tungsten resources is moderate to low; and the potential for uranium, lead, zinc, copper, molybdenum, and antimony resources is low. Most of the mineral potential is in andesite breccia and granitic rocks in the southeastern part of the area. These rocks have been broken by numerous northwest- and northeast-trending shear zones and faults and have been extensively altered.

The St. Helena, California-Illinois, and Exchequer properties contain approximately 1,826,000 tons (1,657,000 t) of silver and gold resources. These properties and others with mineral resources in similar geologic settings adjacent to the study area are shown on table 1. Resources are in north-trending steeply dipping shear zones that range from 1 to 34 ft (0.3-10.4 m) thick. Zones consist of limonite-stained and bleached andesite breccia with quartz and calcite veins and stringers. Pyrite is finely disseminated and is mostly confined to the quartz veins. Galena and lesser amounts of pyrargyrite and stibnite occur sporadically in the quartz.

Potential resources for gold and silver occur in structures on five properties, mainly near the southeast area boundary. Other properties, shown on figure 3 and summarized in table 1, have structures similar to those with resources in the study area; however, they are not sufficiently exposed to enable tonnage and grade estimates.

Area A.—A high potential exists for additional undiscovered resources of gold and silver in area A (fig. 3). This area contains older andesitic rocks and younger silicic intrusive rocks that are similar both in age and composition to rocks in the nearby Monitor mining district, which contains large silver deposits. Extensive hydrothermal alteration (propylitization and silicification), similiar to alteration in the Monitor district is present throughout area A. Area A has anomalous concentrations of elements in the base- and precious-metal and the hydrothermal-alteration suites. It also contains most of the mines and prospects described above and summarized in table 2. The geologic and geochemical features suggest that there is a high probability for the occurrence of additional gold and silver deposits of this type in this area. Copper resources, similiar to mineralization in the Monitor district (Clark, 1977), may also be associated with precious-metal resources in this area.

Area B.—A moderate potential exists for undiscovered tungsten resources in area B near Burnside Lake. This area includes the southern end of a pendant of metamorphic rocks, consisting largely of calcareous sedimentary rocks, which includes two tungsten-skarn deposits (Burnside and Cal-Pine mines) outside of the roadless area. The pendant which may also be covered in part by Tertiary volcanic rocks, was intruded on the west by the Burnside Lake Adamellite, which was apparently the source of metal-bearing fluids that formed all the tungsten deposits in the Hope Valley district. Area B contains anomalous concentrations of tungsten and four other elements that probably are not the result of contamination from the mines. These data suggest the possibility of undiscovered tungsten skarn resources in area B.

Area C.—A low potential exists for molybdenum- and tungsten-bearing quartz vein or pegmatite deposits in area C. There are anomalous concentrations of molybdenum and tungsten, but no alteration or extensive veining was observed in any of the four granitic plutons here.

Uranium.—A low potential exists for undiscovered uranium resources in area A. Uranium mineralization is locally present in the lower part of the Relief Peak Formation at the Cindy and Deer claims (No. 24) on the southern edge of the area and about 20 mi (32 km) farther south near Sonora Pass at the Juniper mine (Rapp and Short, 1980). In a detailed study of the Sonora Pass area, Rapp and Short (1980) concluded that uranium mineralization resulted from reduction of uranium-bearing groundwater by carbonaceous matter in the Relief Peak Formation. They also concluded that high permeability in the Relief Peak Formation was an important factor in groundwater circulation and mineralization, and that the uranium was probably leached from rocks in the overlying Stanislaus Group. In the east part of the Raymond Peak Roadless Area most of the andesitic rocks correlated with the Relief Peak Formation are strongly propylitized and may have low permeabilities. Furthermore, the Stanislaus Group probably never extended as far north as this area. The lack of suitable host rocks, the lack of known uranium mineralization (except at the Cindy and Deer claims) and the lack of a uranium source suggest a low potential for undiscovered uranium resources in area A.

Placer resources.—Alluvial deposits consisting of silt and sand and gravel occur along all drainages in the study area. Nine samples were collected from various creeks; no gold was detected, but two pan concentrates from Pleasant Valley Creek had 0.016 percent $e^{U}{}_{3}{}^{O}{}_{8}$ (uranium oxide equivalent).

Energy resources.—A small potential for geothermal energy is present near Grovers Hot Springs near the eastern part of the area. The reservoir is estimated to have a volume of 3.3+0.9 $km^3$ and a mean temperature of $126^{o}\pm6^{o}C$ (Muffler, 1979, p. 64), not hot enough for steam-fire power generation. There is no oil or gas potential in the roadless area.

## REFERENCES CITED


Armin, R. A., John, D. A., and Moore, W. J., 1982, Geologic map of the east part of the Raymond Peak Roadless Area, Alpine County, California, with Quaternary geology by J. C. Dohrenwend: U.S. Geological Survey Miscellaneous Field Studies Map MF-1365-A, scale 1:62,500.

Chaffee, M. A., 1983, Scoresum—A technique for displaying and evaluating multi-element geochemical information, with examples of its use in regional mineral assessment programs: Journal of Geochemical Exploration (in press).

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

Curtis, G. H., 1951, Geology of the Topaz Lake quadrangle and the eastern half of the Ebbetts Pass quadrangle: Berkeley, University of California, Ph. D. thesis, 310 p.

McKee, E. H., Chaffee, M. A., Federspiel, F. E., McHugh, E. L., Cather, E. E., Scott, D. F., and Rumsey, C. M., 1982, Mineral resource potential of the Mokelumne Wilderness and contiguous roadless areas, central Sierra Nevada, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1201-D, scale 1:62,500.

Mining and Scientific Press, 1873, Mining summary: v. 26, no. 8, p. 116.

Muffler, L. J. P., 1979, Assessment of geothermal resources of the United States 1978: U.S. Geological Survey Circular 790, 163 p.

Oliver, H. W., Plouff, Donald, and Robbins, S. L., 1982, Bouguer gravity map of California: Walker Lake Sheet, scale 1:250,000

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, p. 1789-1805.

Plouff, Donald, 1983, Aeromagntic and gravity maps of the east part of the Raymond Peak Roadless Area, Alpine County, California: U.S. Geological Survey Miscellaneous Field Studies Map MF-1365-B, scale 1:62,500.

Rapp, J. S., and Short, W. O., 1980, Geology and uranium favorability of the Sonora Pass region, Alpine and Tuolumne Counties, California: U.S. Department of Energy, National Uranium Resource Evaluation, GJBX-132 (81), 145 p.

Raymond, R. W., 1874, Statistics of mines and mining in the states and territories west of the Rocky Mountains: House of Representatives Executive Document No. 141, 43rd Congress, 1st Session, p. 48-59.

Slemmons, D. B., 1966, Cenozoic volcanism of the central Sierra Nevada, California, in Bailey, E. G., ed., Geology of Northern California: California Division of Mines and Geology Bulletin 190, p. 199-208.

Sutley, S. J., Chaffee, M. A., Fey, D. L., and Hill, R. H., 1982, Chemical analyses and statistical summaries for samples of rock, minus-60 mesh (0.25 mm) stream sediment, and non-magnetic heavy-mineral concentrates, Raymond Peak Roadless Area, Alpine County, California: U.S. Geological Survey Open-File Report 82-1050.

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

U.S. Geological Survey, 1981, Aeromagnetic map of the Dardanelles area, California: U.S. Geological Survey Open-File Report 81-431, scale 1:62,500.

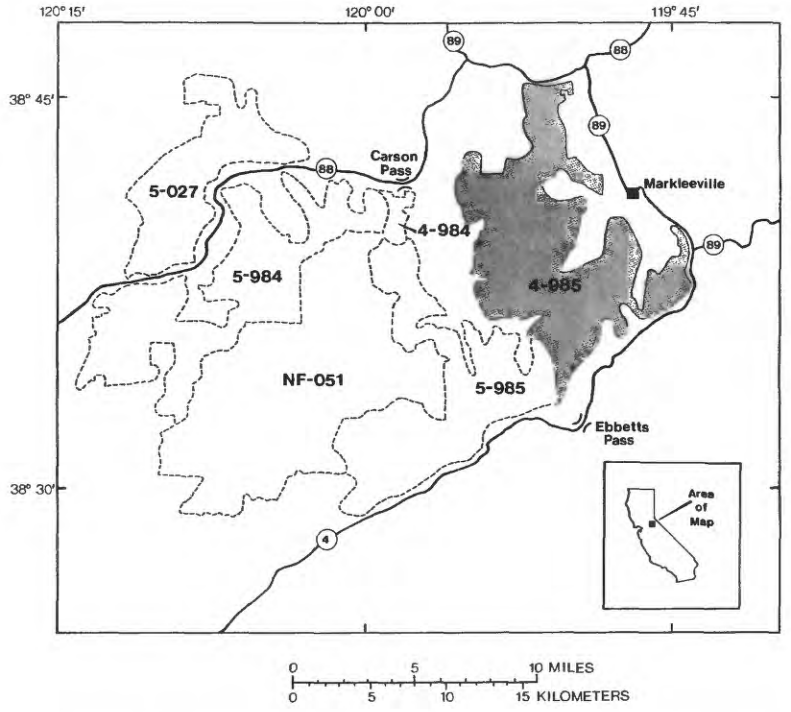


Figure 1.--Index of wilderness and roadless areas in the vicinity of the east part of the Raymond Peak Roadless Area.

4-985 East part of the Raymond Peak Roadless Area

NF-051 Mokelumne Wilderness

5-027 Caples Creek Roadless Area

4-984 Tragedy-Elephants Back Roadless Area; part in Toiyabe National Forest

5-984 Tragedy-Elephants Back Roadless Area; part in El Dorado National Forest

5-985 Raymond Peak Roadless Area

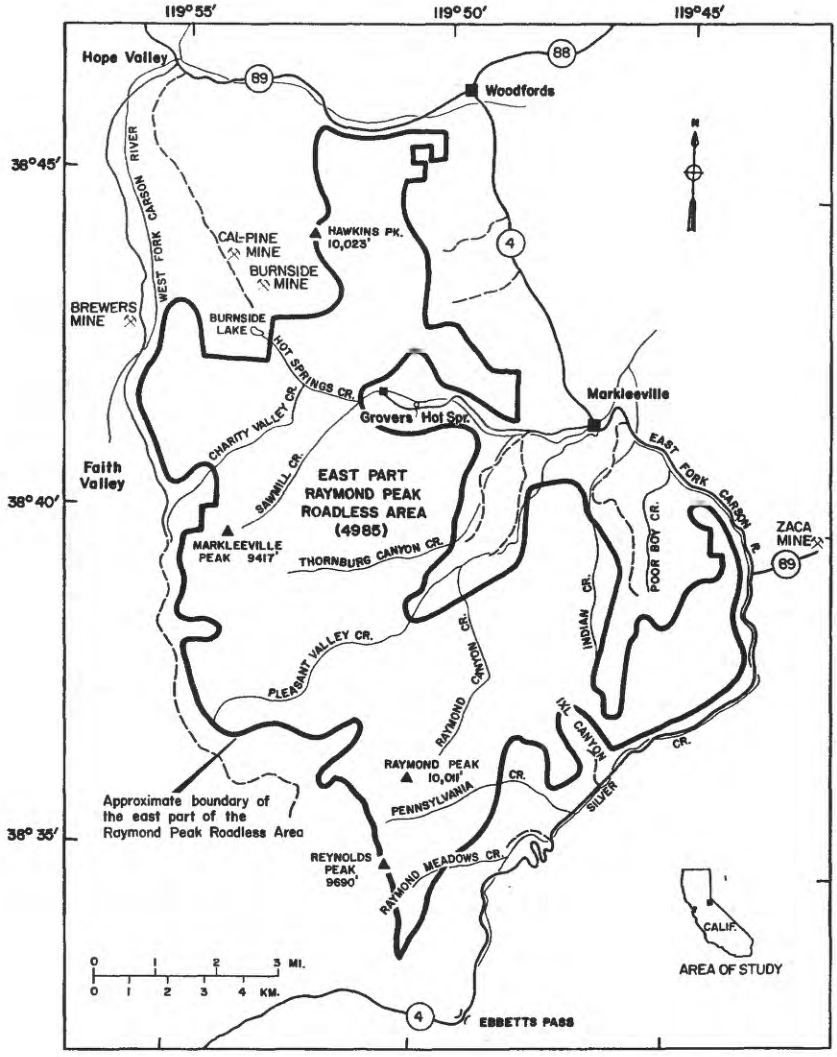


Figure 2.--Index map of the east part of the Raymond Peak Roadless Area and vicinity, Alpine County, California.

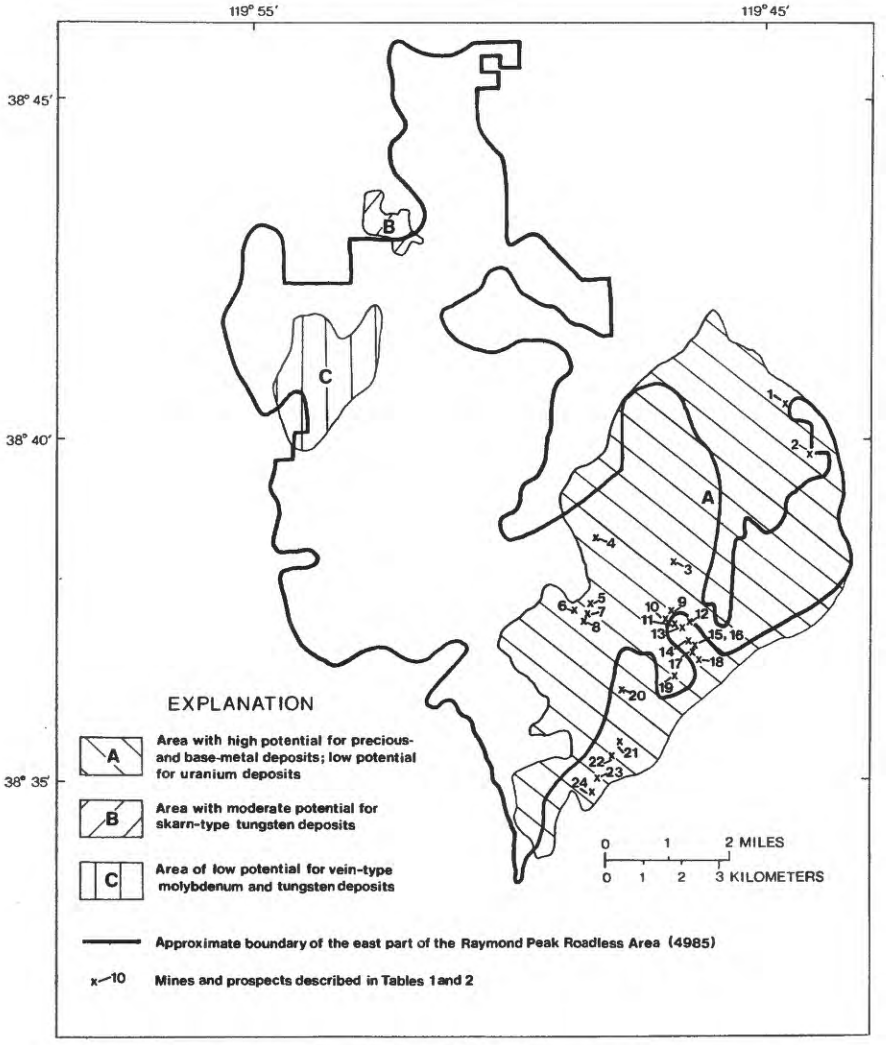


Figure 3.--East part of the Raymond Peak Roadless Area showing areas of mineral resource potential and mines and prospects described in tables 1 and 2.

Table 1.—Properties with mineral resource potential in the east part of the Raymond Peak (4985) Roadless Area and vicinity. (Underlined properties contain identified mineral resources)

| Map no. | Name (commodity) | Summary | Workings and production | Assessment of resources or potential |
|---|---|---|---|---|
| 1 | Good Hope prospect (gold, silver) | Rhyolite and andesite breccia underlie the prospect; no mineralized structure is exposed. Raymond (1874) reports a 3- to 10-ft (0.9-3 m)-thick quartz vein striking northerly and dipping 40° W. was developed for 400 ft (120 m) in presently caved portions of the prospect adit. | An adit is reported to be 600 ft (183 m) long; only 100 ft (30 m) are accessible. | Ten samples of dump material and county rock assayed trace gold and 0.1 oz silver per ton (3.4 g/t). Mill tests of vein material in 1874 (Raymond) reportedly averaged $4.05/t per ton gold. Based on previous reports, this prospect has a high potential for gold and silver resources. |
| 2 | Easy Nos. 1-9 claims (Highland Mary) (gold, silver) | Rhyolite flows, tuffs, and breccia underlie most claims; andesite breccia occurs locally. Rhyolite is highly stained by iron and manganese oxides and in places is highly silicified. Prominent fracture systems trend northwest and dip steeply northeast. | One small, sloughed pit | Seventeen chip samples, mainly of silicified rhyolite, contained no more than trace gold and 0.2 oz silver per ton (6.9 g/t). These claims have a moderate potential for the discovery of gold and silver resources. |
| 3 | St. Helena prospect (silver, gold) | A 2- to 4-ft (0.6-1.2 m)-thick shear zone strikes north to N. 41°E. and dips 55° W. to vertical in Pliocene andesite breccia. The zone contains silicified and kaolinized breccia and quartz stringers as much as 2 ft (0.6 m) thick with disseminated pyrite, galena, and pyrargyrite. A stibnite vein 3 in. (8 cm) thick occurs locally along the shear zone. Segments of the shear zone are exposed intermittently along strike for about 3,600 ft (1,098 m) | Clark (1977, p. 46) reports 100 ft (30 m) of development on shear zone. | Approximately 1,500,000 tons (1,360,000 t) of inferred subeconomic resources averaging 0.014 oz gold per ton (0.479 g/t) and 2.5 oz silver per ton (85.7 g/t) are in shear zones on the prospect. |
| 4 | Silver Cloud claim (gold, silver) | A north-trending shear zone in andesite breccia is exposed intermittently along strike for about 1,200 ft (366 m). The zone ranges from 1.5 to 4.5 ft (0.5 to 1.4 m) thick and contains limonite-stained andesite and quartz stringers with about 1 percent finely disseminated pyrite. | Historical field survey notes indicate a 157-ft (48 m) long adit, and shaft developed a 2- to 4-ft (0.6 to 1.2 m) thick shear zone containing quartz with disseminated sulfides. | Nine samples across the zone contained much as trace gold and 0.3 oz silver per ton (10.39 g/t). A grab sample assayed 0.4 oz silver per ton (13.7 g/t). The claim has moderate gold-silver resource potential. |
| 5 | California-Illinois prospect (gold, silver) | Andesite breccia contains numerous northwest-trending, steeply dipping shear zones. These zones are 3 to 34 ft (1 to 10 m) thick and contain silicified, bleached andesite breccia and quartz stringers as much as 2 ft (0.6 m) thick with disseminated pyrite. | Seven caved adits totaling an estimated 1,900 ft (580 m) of underground workings and 13 prospect pits and trenches are on the prospect. | Approximately 270,000 tons (245,000 t) of inferred subeconomic resources averaging 0.03 oz gold per ton (1.039 g/t) and 0.1 oz silver per ton (3.4 g/t) are in shear zones on the prospect. |
| 6 | Unnamed prospect (gold, silver) | Two shear zones 2 ft (0.6 m) thick strike N. 10° - 25° W. and dip 80° NE. to 80° SW. in greenish gray andesite. They contain bleached and silicified andesite and limonite-stained quartz stringers. | One prospect pit, 12 ft (3.7 m) long, 8 ft (2.4 m) wide, and 3 ft (0.9 m) deep | One chip sample from each zone; one sample contained 0.12 oz gold per ton (4.11 g/t) and 0.4 oz silver per ton (13.7 g/t). The other sample assayed 0.01 oz gold per ton (0.34 g/t) and no silver. This property has moderate gold-silver resource potential in the shear zones. |
| 7 | Unnamed prospect (gold, silver) | Discontinuous segments of subparallel shear zones strike N. 5°-35° W. and dip 70°-80° SW. in andesite breccia. Zones are 2 to 50 ft (0.6-15 m) thick and consist mainly of bleached andesite with a few quartz veins and stringers; they are not traceable more than 100 ft (30 m) along strike. Quartz contains 1-3 percent disseminated pyrite. | Two small prospect pits | Four chip samples and one grab sample were taken. Two samples across the 50-ft (15-m) zone contained 0.56 and 0.1 oz gold per ton (19.20 g/t and 3.4 g/t) and 0.9 and 0.2 oz silver per ton (30.9 g/t and 6.9 g/t). Samples of other zones had as much as 0.1 oz gold per ton (3.4 g/t) and 1.0 oz silver per ton (34.36 g/t). A moderate potential for the discovery of gold-silver resources is in the shear zones. |
| 8 | Unnamed prospect (gold, silver) | Quartz and calcite are along fractures that strike N. 35°-55° W. and dip nearly vertical in andesite breccia. The quartz and calcite have 1 to 2 percent disseminated pyrite and numerous pseudomorphs after sulfides. | One prospect pit, 30 ft (9 m) long, 10 ft (3 m) wide, and 5 ft (1.5 m) deep | Four chip samples ranged from trace to 0.35 oz gold per ton (11.99 g/t) and trace to 0.3 oz silver per ton (10.3 g/t). Zones at the prospect have a moderate potential for gold-silver resources. |
| 9 | Exchequer mine (gold, silver) | A shear zone in andesite breccia strikes N. 21° W. and dips 67° E. The zone is 1 to 15 ft (0.3-4.5 m) thick and contains limonite-stained, silicified and kaolinized country rock and quartz veins and stringers with disseminated pyrite and pyrargyrite. This zone is exposed for about 200 ft (61 m) at the surface and is segmented by east-west fracture systems. | Raymond (1874) reported an adit 811 ft (247 m) long and a shaft in excess of 300 ft (91 m) deep. The adit is accessible for 52 ft (16 m) but the shaft is completed caved. | An estimated 56,000 tons (50,800 t) of inferred marginal reserves containing 0.04 oz gold per ton (1.37 g/t) and 23.5 oz silver per ton (805.7 g/t) are in ore shoots along the shear zones. |
| 10 | Lady Franklin claim (gold, silver) | A 3-ft (0.9-m) zone strikes N. 20° E. and dips from 80° SE. to vertical in andesite breccia. The zone contains limonite-stained, silicified, and kaolinized andesite breccia and quartz veins with disseminated sulfides, mainly pyrite and pyrargyrite. | One adit with 135 ft (41 m) of workings | Eight samples across sulfide-bearing quartz stringers assayed as much as 0.339 oz gold per ton (11.623 g/t) and 57.0 oz silver per ton (1954.6 g/t). Three samples of shear zone material contained 0.01 to 0.03 oz gold per ton (0.34-1.03 g/t) and 0.2 to 3.1 oz silver per ton (6.9-105.3 g/t). The shear zones have a high potential for the discovery of gold and silver resources. |

Table 1.—Properties with mineral resource potential in east part of the the Raymond Peak (4985) Roadless Area and vicinity—Continued

| Map no. | Name (commodity) | Summary | Workings and production | Assessment of resources or potential |
|---|---|---|---|---|
| 11 | **Acacia claim (gold, silver)** | Andesite breccia underlies the claim. A 0.5- to 5-ft (0.15-1.5-m)-thick shear zone strikes from N. 22° W. to due north and dips steeply to the east and west. The zone has limonite-stained silicified andesite breccia with quartz and calcite veins containing disseminated pyrite and pyrargyrite. | Development consists of a 430-ft (131-m) adit with 165 ft (50 m) of crosscuts and drifts. | Thirty-two samples: 30 samples across shear zones assayed from trace to 0.02 oz gold per ton (0.69 g/t) and trace to 0.9 oz silver per ton (30.9 g/t); two samples of mineralized quartz veins averaged 0.03 oz gold per ton (1.03 g/t) and 8.55 oz silver per ton (293.14 g/t). The shear zones have high potential for gold-silver resources. |
| 12 | **Adolphus Canyon prospect (gold, silver)** | Shear zones in andesite breccia range from 3 to 7 ft (0.9 to 2 m) thick, strike N. 30° W. and dip from 70° W. to vertical. These zones contain silicified, andesite breccia and quartz stringers with about 1 percent finely disseminated sulfides. | None | Seven chip samples across the shear zones contained from trace to 0.02 oz gold per ton (0.69 g/t) and trace to 1.6 oz (54.9 g/t) silver per ton. The shear zones have high gold-silver resource potential. |
| 13 | **IXL mine (gold, silver)** | Numerous shear zones strike from N. 16° E. to N. 35° W. and dip steeply to the northwest and northeast in Miocene andesite breccia. The zones range in thickness from 1 to 7 ft (0.3 to 2 m) and contain limonite-strained silicified andesite breccia and quartz veins with disseminated pyrite and pyrargyrite. | Raymond (1874) reported the lower adit was 990 ft (302 m) long with an additional 1,040 ft (317 m) of crosscuts and drifts. In 1979 only 530 ft (162 m) of this adit and 300 ft (91 m) of crosscuts and drifts were open. Other mine workings include a caved upper adit of unknown length and two caved shafts, one of which was more than 200 ft (61 m) deep. | There are approximately 150,000 tons (136,000 t) of inferred subeconomic resources containing 0.01 oz gold per ton (0.34 g/t) and 0.93 oz silver per ton (31.89 g/t) along shear zones. Ore shoots within these zones contain an estimated 15,000 tons (13,600 t) of marginal reserves averaging 0.56 oz gold per ton (19.2 g/t) and 48.47 oz silver per ton (1,661.8 g/t). |
| 14 | **Pine Tree prospect (gold, silver)** | Shear zones in andesite breccia range from 3 to 5.5 ft (0.9-1.7 m) thick, strikes N. 6°-14° W. and dips 74° NE. to vertical. These zones contain silicified, andesite breccia and quartz stringers with about 1 percent finely disseminated sulfides. | One prospect pit | Four chip samples across the shear zone contained trace gold and as much as 0.2 oz silver per ton (6.9 g/t). This prospect has a moderate potential for discovery of gold-silver resources in shear zones. |
| 15 | **Big Sandy prospect (gold, silver)** | A shear zone in andesite breccia ranges from 3 to 10 ft (0.9 to 3 m) thick, strikes N. 31° W., and dips 70° NE. The zone contains silicified, andesite breccia and quartz veins with about 1 percent finely disseminated sulfides. | One prospect pit | Two chip samples across a shear zone contained as much as 0.01 oz gold per ton (0.34 g/t) and 4.3 oz silver per ton (147.4 g/t). A moderate potential for gold-silver resources is in shear zones at the prospect. |
| 16 | **Little Sandy prospect (gold, silver)** | A shear zone in andesite breccia averages 1 ft (0.34 m) thick, strikes N. 42° W., and dips 64° NE. The zone contains silicified andesite breccia and quartz veins with about 1 percent disseminated sulfides. | None | One chip sample cross the shear zone contained 0.01 oz gold per ton (0.34 g/t) and no silver. A moderate potential for discovering gold-silver resources in shear zones on the prospect is based on values from samples in nearby zones. |
| 17 | **Pittsburgh prospect (gold, silver)** | Shear zones in andesite breccia range from N. 21°W. to N. 20° E. and dip 80° E. to vertical. These zone segments are 0.5 to 5.0 ft (0.15-1.5 m) thick and contain silicified country rock and quartz stringers. | Carl Munck (oral comm., 1979) reported the caved adit to be 800 ft (244 m) in length. A prospect pit is northwest of the caved working. | Six chip samples across a shear zone contained from trace to 0.02 oz gold per ton (0.69 g/t) and trace to 0.3 oz silver per ton (10.3 g/t). Two select grab samples contained from trace to 0.01 oz gold per ton (0.34 g/t) and trace to 0.1 oz silver per ton (3.4 g/t). This prospect has moderate potential for the discovery of gold-silver resources. |
| 18 | **Gould and Curry prospect (gold, silver)** | A shear zone 2 ft (0.6 m) thick in andesite breccia strikes due north and dips 55° E. in the adit. Surface exposures of shear zones in andesite breccia range from 1 to 17 ft (0.3-5 m) thick, strike from N. 42° W. to N. 20° W., and dip 80° NE to vertical. The zones contain silicified andesite breccia and quartz veins with finely disseminated sulfides. | An adit is inaccessible 75 ft (23 m) from the portal because of a flooded winze. One caved shaft and a prospect pit are northwest of the adit. | Ten chip samples across the shear zones contained from trace to 0.06 oz gold per ton (2.06 g/t) and from trace to 1.0 oz silver per ton (34.3 g/t). Three chip samples from the adit contained as much as 0.01 oz gold per ton (0.34 g/t) and 0.5 oz silver per ton (17.1 g/t) and 0.1 oz silver per ton (3.4 g/t). The prospect has a moderate gold-silver resource potential. |

Table 1.—Properties with mineral resource potential in the east part of the Raymond Peak (4985) Roadless Area and vicinity—Continued

| Map no. | Name (commodity) | Summary | Workings and production | Assessment of resources or potential |
|---|---|---|---|---|
| 19 | Knox prospect (gold, silver) | A shear zone in andesite breccia is 3 ft (0.9 m) thick, strikes N. 40° E., and dips 65° SE. The zone contains silicified andesite breccia and quartz veins with about 1 percent disseminated sulfides | One caved shaft | Two chip samples across the shear zone contained as much as 0.01 oz gold per ton (0.34 g/t) and 0.1 oz silver per ton (3.4 g/t). This prospect has a moderate gold-silver resource potential. |
| 20 | Pennsylvania claim (gold, silver) | A shear zone 2 to 8 ft (0.6–2 m) thick segmented strikes from N. 20° W. to N. 5° E. and dips from 73° to 84° E. in andesite breccia. The zone is segmented but continuous for about 700 ft (213 m) and contains limonite-stained silicified country rock and a quartz vein 2 ft (0.6 m) thick with about 1 percent disseminated sulfides, mainly pyrite | Three adits are on the prospect. The longest adit was reported to be 918 ft (280 m) long (Mining and Scientific Press, 1873), but access is restricted to 200 ft (61 m) because of a lack of ventilation. One adit was reported 300 ft (91 m) in length (field notes of a survey of the Pennsylvania Gold and Silver Mines in 1874), but is caved. The remaining adit 52 ft (16 m) in length. | Five samples from the zone assayed as much as trace gold and 0.08 oz silver per ton (2.74 g/t). Four select dump grab samples contained as much as trace gold and 2.3 oz silver per ton (78.9 g/t). A moderate gold-silver resource potential is in shear zones on the claim. |
| 21 | Sa Sha prospect (gold, silver) | Several shear zones trend from N. 18°–80° W. and dip from 75°–80° SW. in granodiorite. These zones are 1.5 to 10 ft (0.56 to 3 m) thick and contain silicified granodiorite and massive, limonite-stained quartz. | None | Three chip samples across the shear zones contained as much as 0.072 oz gold per ton (2.469 g/t) and 0.4 oz silver per ton (13.7 g/t). On the basis of sample values, the shear zones have a moderate potential for gold-silver resources |
| 22 | Bolin claims (gold, silver) | Granodiorite capped by andesite breccia underlies the claims. Segments of a shear zone strike N. 5°–10° W. and dip 79° NE. Zone exposures are 1 to 6 ft (0.3 to 2 m) thick and contain limonite-stained, silicified andesite breccia and quartz stringers with disseminated sulfides. | None | Twelve chip samples across the shear zones contained from 0 to 0.028 oz gold per ton (0.960 g/t) and 0 to 5.6 oz silver per ton (192.0 g/t). A moderate potential for gold-silver resources is in shear zones at the claims. |
| 23 | Columbine claim (gold, silver) | A principal shear zone strikes N. 20°–56° W. and dips 40°–61° SW. in granodiorite. The zone ranges from 3 to 20 ft (0.9 to 6 m) thick and contains silicified and brecciated granodiorite with quartz veins as much as 2 ft (0.6 m) thick containing disseminated sulfides. | One 85-ft (26-m) adit, two prospect trenches about 20 ft (6 m) long, 8 ft (2 m) wide, and 10 ft (3 m) deep; and several small pits | An estimated 94,000 tons (85,300 t) of inferred subeconomic resources averaging 0.05 oz gold per ton (01.7 g/t) and 0.4 oz silver per ton (13.7 g/t) are in shear zones at the prospect. |
| 24 | Cindy and Deer claims (uranium) | Cretaceous granodiorite capped by Miocene volcanic rocks underlie the claims. Small amounts of uranium oxide are in a buried stream channel along the granodiorite-volcanic rocks contact. This podiform-type deposit contains granodiorite and andesite cobbles, sand and gravel, and woody carbonaceous debris. | There is an adit 12 ft (4 m) long and 12 ft (4 m) wide and several trenches as much as 50 ft (15 m) long. Eighteen holes totalling 2,100 ft (640 m) were drilled by Utah Construction and Mining Company (now Pathfinder Mines) Reno, Nev. | Approximately 8,000 tons (7,300 t) of inferred subeconomic resources containing 0.05 percent $_eU_3O_8$[1] are in carbonaceous material in a buried stream channel. Samples across the shear zones assayed as much as trace gold and 0.3 oz silver per ton (10.3 g/t). |

[1]Equivalent percent uranium oxide assuming uranium is in equilibrium with daughter products which emit gamma radiation.

Table 2.--Estimated mineral resources in the east part of the Raymond Peak Roadless Area and vicinity
(Underlined numbers refer to properties with mineralized structures which probably extend into the study area)

| Map number | Property | Type | Tonnage[1] (tons) | Resource[2] classification | Product | Grade |
|---|---|---|---|---|---|---|
| 3 | St. Helena | Shear zone | 1,500,000 | Inferred subeconomic | Gold<br>Silver | 0.01 oz/ton<br>2.5 oz/ton |
| 5 | California-Illinois | Shear zone | 270,000 | Inferred subeconomic | Gold<br>Silver | 0.03 oz/ton |
| 9 | Exchequer | Shear zone | 56,000 (in shoots) | Inferred marginal reserve | Gold<br>Silver | 0.04 oz/ton<br>23.5 oz/ton |
| 13 | IXL | Shear zone | 150,000 | Inferred subeconomic | Gold<br>Silver | 0.01 oz/ton<br>0.93 oz/ton |
| | | | 15,000 (in shoots) | Marginal reserve | Gold<br>Silver | 0.56 oz/ton<br>48.47 oz/ton |
| 23 | Columbine (Sawmill) | Shear zone | 94,000 | Inferred subeconomic | Gold<br>Silver | 0.005 oz/ton<br>0.5 oz/ton |
| 24 | Cindy and Deer | Stream channel | 8,000 | Inferred subeconomic | Uranium | 0.05% $_{e}U_3O_8$[3] |

[1]Metric conversions: tons x 0.9072 = metric tons ( t); oz per ton x 34.285 = grams per metric ton ( t).

[2]Resource classification terminology from U.S. Bureau of Mines and U.S. Geological Survey (1980).

[3]Equivalent percent uranium oxide assuming uranium is in equilibrium with daughter products which emit gamma radiation.