INTRODUCTION
Scope and procedure

This report summarizes the results of geologic and geochemical surveys carried out by the U.S. Geological Survey (R. E. Powell and others, 1981, unpublished map, U.S. Geological Survey, Menlo Park, Calif; Obi and others, 1983b, and an investigation of mines, prospects, and mineralized areas conducted by the U.S. Bureau of Mines (Gabby, 1982). These surveys were designed to provide mineral-resource data for land-use decisions regarding the study area and, if compatible with such decisions, to provide a basis from which to plan followup mineral resources investigations. Our objectives in this summary document are (1) to assess known resources in the study area and (2) to evaluate potential for additional resources.

To accomplish the first objective, we have examined known mineral occurrences and reviewed production history of mines and prospects in and around the roadless area, and we have estimated the quantity and quality of known resources where appropriate. To accomplish the second objective, we have sought evidence for mineral concentrations by direct observation (geologic mapping) and by a remote technique (stream-sediment geochemical survey). From this evidence and the results of the mining survey, we have identified geologic environments in the study area that are favorable for the concentration of mineral resources and have judged the likelihood (potential) for the presence of undiscovered mineral resources. On the basis of the strength of the available evidence for mineralization, the potential is expressed as low, moderate, or high. Where a specific model can be inferred for the mode of occurrence of known mineral concentrations in the vicinity of the study area, the approximate form and amount of resource (see footnote 1) most likely to be present in any undiscovered mineral deposit is evaluated by appropriate analogy with known deposits.

Geographic setting

Situated in the southwestern San Gabriel Mountains in Los Angeles County, Calif., the Arroyo Seco Roadless Area encompasses about 8 mi² (3000 acres) within the Angeles National Forest (fig. 1). The roadless area includes Bear and Little Bear Canyons and most of upper Arroyo Seco between Red Box Gap and Oakwilde Picnic Area. The area is approximately bounded to the north by the Angeles Crest Highway (State Highway 2) and to the south by CCC Ridge and the crest of a ridge that includes the summits of Brown Mountain, Mount Lowe, and Mount Markham. Topographic elevations within the roadless area range from 1800 ft in Arroyo Seco near Oakwilde Picnic Area to nearly 6000 ft atop Mount Disappointment.

The area is readily accessible from the west and north along the Angeles Crest Highway. Access from the east can...
be gained from the Mount Wilson-Red Box Road via a paved road that leads to the summit of Mount Disappointment and via a dirt road that leads west along the north flank of the Mount Markham-Mount Lowe ridge and then turns south into Millard Canyon. Entry to the latter two roads is controlled by the U.S. Forest Service. A hiking trail maintained by the U.S. Forest Service (USFS trail 12W07) traverses the area from Switzer Station (USFS) to Oakwilde Picnic Area. From the ridge between Brown Mountain and Mount Lowe, an undesignated trail runs down Bear Canyon to Arroyo Seco.

Geologic setting

The Arroyo Seco Roadless Area includes part of a terrane of crystalline rocks that is situated between the San Gabriel fault and the Sierra Madre fault, two major strands of the Cenozoic right-lateral San Andreas fault system (fig. 2). Crystalline-rock units within the area are distributed in lithologic belts that generally trend northwest. The geologic summary presented here is based on field work conducted in 1981 by Powell, Cox, and Matti, who mapped a study area that extends beyond the boundary of the roadless area. Previous geologic mapping within the study area includes that of Miller (1934), Soul (1976), and Smith (1977).

In this study, three lithologic varieties (gneissic subunits) are mapped together as a single Precambrian gneiss unit. The oldest of these subunits is Precambrian metasedimentary biotite-quartz-feldspar gneiss that commonly contains garnet, sillimanite, and possibly stauroilite. This metasedimentary gneiss is interlayered in places with deformed Mesozoic mafic rocks that have undergone Precambrian biotite-quartz-feldspar metaplutonic augen gneiss, the protolith of which intruded the metasedimentary gneiss as porphyritic granodiorite and monzogranite (igneous-protolith age) and is also cut by dikes of fine-grained hornblendite; hornblende gabbro and diorite; biotite-hornblende gneiss, radiometrically dated in several localities at about 1425 m.y. (Silver, 1971). The gneissic unit is intruded by the Mount Lowe Granodiorite, hornblende-biotite monzogranite, and granodiorite. All of these lithologic units are younger than the Echo Granite of Miller (1930).

Thin, fine-grained, generally foliated and propylitically altered mafic dikes crosscut the Echo Granite, the Mount Lowe Granodiorite, and probably the Precambrian gneiss unit. The dikes are most abundant in the Mount Lowe Granodiorite near the Angeles Crest Highway between Georges Gap and the junction between the Angeles Crest and Angeles Forest Highways and in the Mount Lowe Granodiorite from Bear Canyon southward across Mount Lowe into Millard Canyon. Some or all of the mafic dikes appear to be related to the Precambrian units in that the Precambrian biotite-quartz-feldspar metaplutonic rocks have been intruded by various units of fine- to medium-grained, locally porphyritic, foliated biotite and hornblende-biotite monzogranite and monzogranite.

Surficial Quaternary deposits of sand, pebbly sand, and gravel are largely confined to narrow, deeply incised active stream beds, although a few small terraces are covered with dissected alluvial deposits in the northern part of the study area.

The segment of the San Gabriel fault adjacent to the study area has a demonstrated net right-lateral displacement of 14 m (Elgh, 1966). Apparently unbroken Quaternary (?) terrace deposits lap over the fault, although dense chapparal may obscure small displacements. Right-lateral displacement of about 24 m has been proposed by Pritchard (1968); 14 m is the southwest margin of the study area. Contrast in rock units across the fault within the mapped area allows, but does not require, the proposed displacement.

GEOLOGY AND GEOCHEMISTRY PERTAINING TO MINERAL RESOURCE ASSESSMENT

Geology

The study area includes rocks that were formed and deformed in geologic environments having potential for concentration and deposition of ore minerals by magmatic and hydrothermal processes. However, we did not observe mineral concentrations along any of the faults or intrusive contacts or within any of the rock units in the roadless area; nor did we observe conspicuous veining or extensive alteration. A gold-silver-copper bearing quartz vein occurs south of the roadless area at the Dawn mine (fig. 2), where the host rock is the Echo Granite. Although the Echo Granite extends to the south boundary of the roadless area at Brown Mountain, very little of the granite is exposed within the roadless area, and we observed no mineral occurrences in the part of the Echo Granite that crops out within the roadless...
area. Because the Echo Granite is not exposed in the deeply incised Arroyo Seco north of Brown Mountain, it is unlikely that the high 137Cs present beneath much of the roadless area. Thin, fine-grained mafic dikes crosscut the Echo Granite at the Dawn mine. Although gold, silver, copper, tungsten, molybdenum, bismuth, and lead concentrations are spatially associated with similar-looking mafic dikes that intrude the Mount Lowe Granodiorite and the Pennsylvania gneiss unit elsewhere in the San Gabriel Mountains and in the Transverse Ranges east of the San Andreas fault (R. E. Powell and others, 1983, unpublished maps, U.S. Geological Survey, Menlo Park, Calif.), no evidence was found for significant mineralization near dikes in the vicinity of the roadless area other than at the Dawn mine. At those localities in the region where metallic mineral deposits are found associated with mafic dikes, thick quartz veins—commonly exposed for lengths of several hundred feet—and evidence for hydrothermally altered rock are also present. Only scattered small quartz veins and veinlets were observed associated with mafic dikes in the vicinity of the study area. One such locality is at the Dawn mine and another is in roadcuts through the Mount Lowe Granodiorite along the Angeles Crest Highway between Georges Gap and the junction between the Angeles Crest and Angeles Forest Highways.

In contrast to our observations in the study area, at those localities in the Transverse Ranges east of the San Andreas fault where metallic mineral concentrations are also associated with quartz veins and mafic dikes in rocks related to those of the Arroyo Seco area, the mafic dikes are observed to crosscut all Mesozoic plutonic units (R. E. Powell, 1983, unpublished maps, U.S. Geological Survey, Menlo Park, Calif.). Despite ambiguity as to the number of generations of mafic dikes that have served as conduits for later mineralization, the regional spatial association between mafic dikes and mineral concentrations forms a basis for evaluating metallic mineral resource potential.

Geochemistry

A reconnaissance geochemical survey in the Arroyo Seco Roadless Area and vicinity was conducted to determine spatial variations in stream-sediment chemistry that might reflect local concentrations of ore minerals. Each of 13 stream-sediment samples (fig. 2) was analyzed for 32 elements (Obi and others, 1983b). A bulk-sediment and two heavy-mineral fractions of each sample were analyzed using a semiquantitative emission spectrographic method (Crimes and Marranzino, 1968). The rationale for this survey is that elements indicative of ore minerals will show up in anomalously high concentrations in drainages that contain deposits of those minerals, which might not contrast normal background concentrations in drainages that do not contain deposits. However, because less than 1% of any element is not necessarily reflected in economic mineral concentrations, the results of a stream-sediment survey should be evaluated within the context of geologic data, and conclusions tested with further geochemical studies.

Eight elements (Au, Bi, Cd, Mo, Nb, Sn, W, Zn) were not detected in either the bulk-sediment or heavy-mineral fractions of any sample. Because the lower detection limit of gold (Au) using the emission spectrographic method is 2,000 times greater than its estimated average elemental abundance for rock-types exposed within the study area, significant gold concentrations in stream sediments derive from gold deposits could remain undetected.

In the bulk-sediment fraction, most elements (Fe, Mg, Ca, Ti, Mn, Ba, Be, Co, Cr, Cu, La, Nb, Ni, Pb, Sc, Sr, V, Y, Zr) were detected in concentrations within a factor of three of their respective ranges of estimated average elemental abundances for rock-types exposed within the study area, significant gold concentrations in stream sediments derive from gold deposits could remain undetected. In the bulk-sediment fraction, most elements (Fe, Mg, Ca, Ti, Mn, B, Ba, Be, Co, Cr, Cu, La, Nb, Ni, Pb, Sc, Sr, V, Y, Zr) were detected in concentrations within a factor of three of their respective ranges of estimated average elemental abundances for rock-types exposed within the study area, significant gold concentrations in stream sediments derive from gold deposits could remain undetected. On the basis of the chemistry correspondence between stream-sediment and source rock-types, we conclude that none of these elements and many anomalous in the bulk-sediment fraction and that each detected element probably occurs in common non-ore minerals or sparsely disseminated ore minerals, rather than in material derived from mineral deposits. The distribution of suites of elements in the two heavy-mineral fractions is generally compatible with typical inferences of chemical compositions of non-ore heavy minerals that we have observed in the rocks of the study area. For instance, higher concentrations of iron (Fe), magnesium (Mg), manganese (Mn), chromium (Cr), scandium (Sc), and vanadium (V) in the total heavy-mineral fraction as compared to the non-ore concentration fraction is consistent with incorporation of these elements in paramagnetic non-ore silicate and oxide minerals, such as hornblende, garnet, and possibly ilmenite, that occur in the rocks of every drainage basin in the study area. Cobalt (Co), copper (Cu), and nickel (Ni) also tend to result from iron in paramagnetic minerals rather than to reside in nonmagnetic minerals. This tendency is consistent with a non-ore association for these elements in observed ferromagnesian silicates and oxides rather than in potential sulfide ore minerals, most of which contain little or no iron. Concentrations of lead (Pb) in the non-ore heavy-mineral fraction of several samples (200 ppm, AS-2; 150 ppm, AS-7; 12; 100 ppm, AS-1; 70 ppm, AS-9; 11) are slightly elevated with respect to concentrations in the remainder of the samples (30 ppm, AS-4; 20 ppm, AS-3; 5, 8, 13; less than 20 ppm, AS-5). The slightly elevated values could indicate either the presence of a rare ore mineral such as galena or because all the slightly elevated concentrations of lead are only found in samples derived from drainage basins through which the Angeles Crest Highway passes and because target shooting and littering have contaminated the roadside—the presentation of minor contamination.

Silver (Ag) is detected only in one heavy-mineral fraction of one sample (300 ppm, AS-7) from the Arroyo Seco. Because silver is not detected in the nonmagnetic heavy-mineral fraction and because traces of silver in an iron-bearing non-ore or ore mineral are unlikely to result in such a high concentration, the detected silver probably resides either in a trace amount of silver ore, which could have a source either inside or outside the study area, or in a contaminant. The latter interpretation is possible because of the proximity of the sampling site to a major highway and heavily used campgrounds and picnic areas.

In the nonmagnetic heavy-mineral fractions of nine samples (AS-1, 2, 6, 7, 9, 10, 12, 13), tin (Sn) is detected in concentrations of 100 ppm or less. Tin occurs in every sample collected from a drainage basin through which the Angeles Crest Highway passes and in only one sample (AS-6) from a drainage basin that does not contain part of the highway. The one exception was collected from the Arroyo Seco. Although the tin could be present as a trace constituent in a non-ore mineral, such as zircon, or in trace amounts of an ore mineral, such as cassiterite, it also could be a contaminant derived from litter, such as tin-plated cans.

Thorium (Th) is detected in the nonmagnetic heavy-mineral fraction of one sample (1,000 ppm) and in a lower concentration in two other samples (200 ppm, AS-4, -11). Although the three drainage basins from which these samples were collected do not share a common rock unit that was not also sampled in other drainages, the anomalous samples are all from streams that drain Mesozoic monzogranite. Thorium may be present either as a trace constituent in non-ore minerals, such as allanite or zircon, or in the ore mineral monazite, any of which could be derived from the monzogranite. Monazite, which is the principal ore mineral of thorium, is commonly recovered from cassiterite. Even if the detected thorium is present in monazite, the small volume of alluvial deposits within the study area provides no place for the accumulation of large placer deposits, and the low concentrations of thorium in the stream sediments do not suggest high-grade placer deposits.

In areas of the Transverse Ranges known to have mineral deposits, relatively high concentrations have been detected in the nonmagnetic heavy-mineral fraction of stream-sediment samples for associated suites of elements that include gold and silver (up to 200 ppm), silver (up to 30 ppm), galena (Mo, up to 200 ppm; Pb, up to 200 ppm), lead (up to 50,000 ppm), bismuth (Bi, up to 2,000 ppm), tin (up to 2,000 ppm), and thorium (up to 5,000 ppm) (for references, see Obi and others, 1983b). In the context of these elevated values for elements typically associated with...
MINES, PROSPECTS, AND MINING AREAS

Methods and previous studies

The U.S. Bureau of Mines personnel conducted a literature search and examined mines and prospects in the Arroyo Seco Roadless Area (fig. 2) (Gabby, 1982). Twenty-one lode samples from the Dawn mine were analyzed by fire assay, atomic absorption, and semiquantitative spectrographic methods. Four placer samples taken from streams draining the study area were gravity concentrated to determine gold and heavy mineral content. Mineral deposits and occurrences in the region were previously summarized by Gay and Hoffman (1954).

Mining and prospecting history

The entire study area was withdrawn from mineral entry by the Act of May 29, 1928 (Public Law 70-578). There are no producing or developing mines, active or patented mining claims, or mineral leases in the study area. A prospect that was reported to be located approximately on the northwestern boundary of the roadless area and to contain molybdenite and copper-bearing minerals (Gay and Hoffman, 1954) was not found during this study. The Dawn mine just south of the roadless area produced gold between 1895 and 1950 (Gay and Hoffman, 1954). About 6 mi north of the study area the Monte Cristo, Tejunga, Last Hope, Loomis, Alice Keng, and Black Cargo mines produced gold intermittently between 1895 and 1955, according to USGS records.

Gold

The Dawn mine is located in the SW1/4, sec. 27, T. 2 N., R. 12 W. on Millard Creek, about 0.6 mi south of the roadless area. At the Dawn mine, a gold-bearing vein as much as 5 ft thick contains white quartz, altered (silicified) granite, fractured granite, granite gouge, limonite, pyrite stringers, and copper minerals. The host rock is medium- to coarse-grained leuocratic syenogranite (Echo Granite). Workings consisted of about 900 ft of drifts and about 100 ft of raises and winzes (Gay and Hoffman, 1954, p. 619). However, only three adits, 50, 175, and 360 ft long, were accessible for mapping and sampling in 1981.

Seventeen chip samples of the vein and altered (silicified) granite were taken. Six had 0.03 to 0.78 oz gold per ton; four contained 0.3 to 1.9 oz silver per ton; and five had 0.02 to 0.06 weight percent copper.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Gold

No previously unknown gold occurrence was found during this study and no gold resources are identified in the Arroyo Seco Roadless Area, although there are about 1,000 tons of subeconomic gold-bearing rock that averages 0.046 oz gold per ton at the Dawn mine south of the roadless area. The host rock for the gold-bearing quartz vein at the Dawn mine is a distinctive granite (Echo Granite of Miller, 1930) that extends only to the south boundary of the roadless area at Brown Mountain. We did not find gold associated with any other lithologic unit in the study area. Because very little of the Echo Granite is exposed within the roadless area, because it is unlikely that much of the unit is present in the subsurface, and because gold was not found to be associated with any other unit, we conclude that, if the Echo Granite is the principal gold-bearing rock unit in the area, no evidence of a potential for gold resources was found in most of the roadless area. Where the Echo Granite is exposed along the south margin of the roadless area in the vicinity of Brown Mountain, there is a low potential for small, low-grade gold deposits.

REFERENCES CITED

Carter, Bruce, 1982, Field petrology and structural development of the San Gabriel anorthosite-syenite body, Los Angeles County, California: in Cooper, J.


——1975, Basement rocks of the San Gabriel Mountains, southern California; California Division of Mines and Geology Special Report 118, p. 177-186.


Miller, W. J., 1926, Crystalline rocks of the middle-southern San Gabriel Mountains, California (abs.); Geological Society of America Bulletin, v. 37, p. 149.


Saul, R. B., 1976, Geology of the west central part of the Mt. Wilson 7-1/2' quadrangle, Los Angeles County, California: California Division of Mines and Geology Map Sheet 28, scale 1:24,000, 15 p.


Smith, D. P., 1977, Geology of the north half of the Pasadena 7-1/2' quadrangle, Los Angeles County, California: California Division of Mines and Geology, Los Angeles, preliminary map, scale 1:24,000.


Figure 1.—Index map showing location of the Arroyo Seco Roadless Area (05012), San Gabriel Mountains, Los Angeles County, Calif.
GEOLOGIC UNITS

- Surficial deposits (Quaternary)
- Monzogranite (Mesozoic)
- Monzodiorite (Mesozoic)
- Diorite, quartz diorite, gabbro (Mesozoic)
- Hornblendite (Mesozoic)
- Mylonite (Mesozoic)
- Granite (Mesozoic)
- Gneiss (Precambrian)

EXPLANATION

- Area of low potential for low-grade gold resources in minor deposits
- Dawn mine
- Prospect
- Stream-sediment sample locality
- Contact
- Fault--Dotted where concealed. Arrows indicate relative movement
- Approximate boundary of roadless area

Figure 2.--Arroyo Seco Roadless Area showing zone with mineral resource potential, Dawn mine, and prospect reported by Gay and Hoffman (1954). Geology simplified from accompanying mineral resource potential map.