STUDIES RELATED TO WILDERNESS

WILDERNESS AREAS

SHEEP MOUNTAIN STUDY AREA AND CUCAMONGA WILDERNESS AND ADDITIONS, CALIFORNIA

GEOLOGICAL SURVEY BULLETIN 1506-A-E

Mineral Resources of the Sheep Mountain Wilderness Study Area and the Cucamonga Wilderness and Additions, Los Angeles and San Bernardino Counties, California

By U.S. GEOLOGICAL SURVEY *and* U.S. BUREAU OF MINES

A. Geology of the Sheep Mountain Wilderness Study Area and the Cucamonga Wilderness and Additions, Los Angeles and San Bernardino Counties, California

By JAMES G. EVANS, U.S. GEOLOGICAL SURVEY

B. Aeromagnetic Studies of the Sheep Mountain Wilderness Study Area and the Cucamonga Wilderness and Additions, Los Angeles and San Bernardino Counties, California

By LEROY PANKRATZ, U.S. GEOLOGICAL SURVEY

C. Geologic and Geochemical Evaluation of Mineral Resources of the Sheep Mountain Wilderness Study Area and the Cucamonga Wilderness and Additions, Los Angeles and San Bernardino Counties, California

By JAMES G. EVANS, U.S. GEOLOGICAL SURVEY

D. Economic Appraisal of Mineral Resources of the Sheep Mountain Wilderness Study Area, Los Angeles and San Bernardino Counties, California

By JAMES RIDENOUR, STEVEN W. SCHMAUCH, *and* NICHOLAS T. ZILKA, U.S. BUREAU OF MINES

E. Economic Appraisal of Mineral Resources of the Cucamonga Wilderness and Additions, San Bernardino County, California

By NICHOLAS T. ZILKA *and* STEVEN W. SCHMAUCH, U.S. BUREAU OF MINES

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An evaluation of the mineral potential of the two areas

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STUDIES RELATED TO WILDERNESS

WILDERNESS AREAS

In accordance with 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 U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Studies and reports of all primitive areas have been completed. 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 currently 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 the suitability studies. This report discusses the results of a mineral survey of some national forest lands in the Sheep Mountain Wilderness study area and the Cucamonga Wilderness and additions that are being considered for wilderness designation.

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SUMMARY

The Sheep Mountain Wilderness study area and the Cucamonga Wilderness and additions together encompass some 66,500 acres (27,000 ha) of Los Angeles and San Bernardino National Forests in southern California; the two study areas are separated by San Antonio Canyon. The mineral-resource potential of these two areas has been evaluated through geologic, aeromagnetic, and geochemical studies by the U.S. Geological Survey, and through investigation of mines and prospects by the U.S. Bureau of Mines.

The Cucamonga Wilderness has little potential for the production of mineral resources, but the Sheep Mountain Wilderness study area includes the Mount Baldy mining district. The largest lode mine in the district, the inactive Big Horn mine, has produced 254 lb (115 kg) of gold and is estimated to contain approximately 1.2 million tons (1.1 million t) of submarginal mineral resources averaging 0.15 troy oz of gold per ton (5.1 g Au/t), on the basis of maps and assay data supplied by the owners. Tungsten is currently being produced from the Curtis claims in Cattle Canyon, which is estimated to contain 20 million yd^3 (15 million m^3) of scheelite-bearing gravel. Five other mines have demonstrated resources or potential for the discovery of ore shoots; four of these mines have already produced gold and silver. The study areas have no potential for fossil fuels, geothermal resources, or other energy-related commodities.

Igneous and metamorphic rocks, ranging in age from Precambrian to Miocene, underlie the study areas. Mylonitic rocks derived from Precambrian gneiss, Triassic gneissoid granodiorite, the Cretaceous or older Pelona Schist, Cretaceous quartz diorite, and Cretaceous or early Tertiary andesitic dikes overlie the Pelona Schist along the Vincent thrust. All these rocks are intruded by Miocene quartz monzonite, latite, and pegmatite. Uplift and probable high-angle strike-slip faulting dominate the late Tertiary to Holocene tectonism of the region; Holocene erosion has created the very large relief of the areas.

Geochemical studies indicate seven gold and two tungsten anomalies in the study areas (fig. 1); all these anomalies may have moderate potential for the discovery of

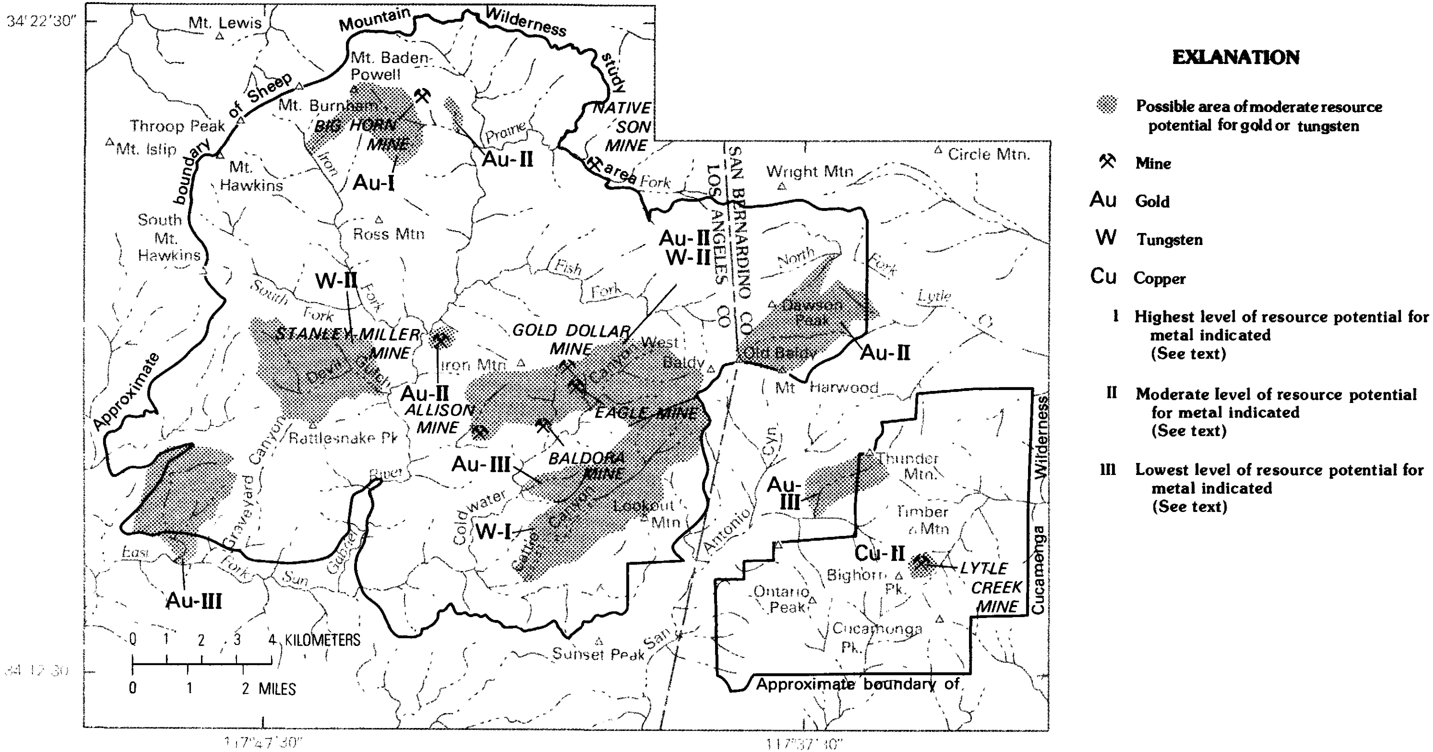

FIGURE 1.—Sheep Mountain Wilderness study area and Cucamonga Wilderness and additions, showing areas of mineral-resource potential. All mines have resources or potential for discovery of resources; demonstrated resources are submarginal.

lode deposits. Aeromagnetic studies do not indicate any buried intrusive bodies or other geologic features suggestive of mineralization in the study areas.

The principal mineral commodities of the Sheep Mountain Wilderness study area are gold and tungsten. The gold is associated with small amounts of sulfides and is found in quartz in fracture zones. Lode mines have produced about 5,364 troy oz (166,840 g) of gold, 2,879 troy oz (89,550 g) of silver, and small amounts of copper and lead; gold, however, accounts for about 99 percent of the total values produced. The Big Horn mine is estimated to hold 1.2 million tons (1.1 million t) of resources averaging 0.15 troy oz of gold per ton (5.1 g Au/t). Gold and silver have also been produced from the Eagle, Allison, Stanley-Miller, Gold Dollar, and Baldora (Widco) mines. The Eagle mine contains an estimated 36,000 tons (32,700 t) of resources that may include economically minable shoots. Resources of the Allison and Baldora (Widco) mines are estimated at 800 tons (730 t) averaging 0.26 troy oz of gold per ton (8.9 g Au/t) and 1,125 tons (1,020 t) averaging 0.15 troy oz of gold per ton (5.1 g Au/t), respectively. Assay data indicate that the Stanley-Miller and Gold Dollar mines have further potential for the discovery of mineral resources.

Scheelite deposits are abundant throughout a 2-mi^2 (5 km^2) area in Cattle Canyon; the scheelite occurs in fractures in the gneissoid country rock underlain and intruded by quartz diorite. Production has exceeded 2,500 lb (1,130 kg) of scheelite concentrate averaging 38.29 weight percent tungsten trioxide (WO_3). Cattle Canyon contains an estimated 20 million yd^3 (15 million m^3) of gravel, approximately 10 percent of which is minus 1/4 in. (0.6 cm), averaging 0.15 lb WO_3/yd^3 (89 g WO_3/m^3). Overall estimated minimum grade of the placer is 0.015 lb WO_3/yd^3 (8.9 g WO_3/m^3) valued at \$0.06/yd^3 (\$0.08/m^3).

Placers were mined in the late 1800's and early 1900's. Such deposits in the Sheep Mountain Wilderness study area probably yielded more gold than the 89 troy oz (2,800 g) recorded by the U.S. Bureau of Mines. The richest deposits were apparently along the East Fork of the San Gabriel River, from the San Gabriel Reservoir to below Heaton Flat, which is outside the study area. Gold has been produced near the Cucamonga Wilderness from remnants of ancient channel deposits in Lytle Creek, San Antonio Canyon, and Mount Baldy Notch, but no gold has come from within the study area. A small gold production originated from a copper deposit at the Lytle Creek mine in the Cucamonga Wilderness, and from small lead, zinc, silver, graphite, tungsten, and gem-stone deposits just outside the study area. An estimated 130 tons (118 t) of resources containing significant copper-silver values remains at the Lytle Creek mine.

Approximately 45 percent of the Sheep Mountain Wilderness study area and 22 percent of the Cucamonga Wilderness was included among lands withdrawn from mineral entry by Act of Congress in 1928; furthermore, 32 percent of the Sheep Mountain Wilderness study area and 25 percent of the Cucamonga Wilderness is subject to use restrictions during periods of high fire danger. Fire restrictions, lands withdrawn from mineral entry, exceedingly rugged topography, complex geology—all these factors have contributed to the decline of mining in the area.

On the basis of demonstrated resources, known occurrences, and rock and stream-sediment samples, the following classification of levels of mineral-resource (gold, tungsten, copper) potential is defined for the study areas:

Level I (highest) designates areas that contain demonstrated resources and (or) anomalous concentrations in rock, fine-stream-sediment (gold), and pan-concentrate (tungsten) samples.

Level II (moderate) designates areas that contain deposits of small tonnage and (or) anomalous concentrations in rock, fine-stream-sediment (gold), and pan-concentrate (tungsten) samples. One small copper deposit also occurs at this level.

Level III I (lowest) designates areas that contain occurrences of at least 1 ppm Au in pan-concentrate samples.

Level I gold potential occurs at the Big Horn mine and in the surrounding area. Level I tungsten potential was identified along the upper part of Cattle Canyon.

Level II gold potential was identified in the vicinity of the Allison, Baldora (Widco), Eagle, Gold Dollar, and Stanley-Miller mines—in the upper part of Allison Gulch, in the upper part of Coldwater Canyon, in the Mine Gulch area, on the southeast side of Dawson Peak, and on the north side of Mount Harwood, respectively. Level II tungsten potential was identified in Devil Gulch, and in Dry Gulch in the upper part of Coldwater Canyon, coincident with an area of Level II gold potential. Level II copper potential occurs at the Lytle Creek mine.

Level III gold potential was identified in Susanna, Fossil, and Cedar Canyons.

Additional areas of mineral-resource potential can be inferred from geologic models of the known mineral occurrences; such speculative resources, however, are not considered here.

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INTRODUCTION

The Sheep Mountain Wilderness study area and the Cucamonga Wilderness and additions cover 55,000 acres (22,300 ha) and 11,500 acres (4,700 ha), respectively, of the eastern San Gabriel Mountains, southern California (fig. 2). The Sheep Mountain Wilderness study area is in Los Angeles and San Bernardino Counties, about 27 mi (43 km) northeast of the Los Angeles Civic Center. The Cucamonga Wilderness and additions are in San Bernardino County, 1 to 2 mi (1.5-3 km) southeast of the Sheep Mountain Wilderness study area.

Drainage from the two study areas is to the south of the San Gabriel Mountains. The range divide, trending generally northwest, forms part of the north boundary of the Sheep Mountain Wilderness study area. Recent uplift of the range has resulted in the carving of deep canyons into the igneous and metamorphic rocks of the eastern San Gabriel Mountains. Relief in the Sheep Mountain Wilderness study area is 8,000 ft, from an elevation of 2,000 ft in the East Fork of the San Gabriel River to 10,000 ft at Mount Baldy summit. In the Cucamonga Wilderness the relief is 4,000 ft, from an elevation of 4,800 ft along the west and south borders of the Wilderness to 8,800 ft at Cucamonga Peak; many of the peaks and ridgetops are above 7,000 ft.

The climate in the eastern San Gabriel Mountains is semiarid at low elevations to subalpine at high elevations. Precipitation occurs chiefly during the winter months, commonly as snow on the high peaks and ridges. Large storms sometimes cause flooding, especially in years of severe fires in the mountains. During the summer months the study area is subject to thundershowers, with attendant fire hazards and flash flooding.

Most south-facing slopes are covered by thick, wiry, drought-resistant brush. On north-facing slopes and in the canyon bottoms are oak, alder, cedar, and big-cone Douglas-fir. The ridges and peaks above 6,000 ft have a pine-forest cover, except where steep slopes

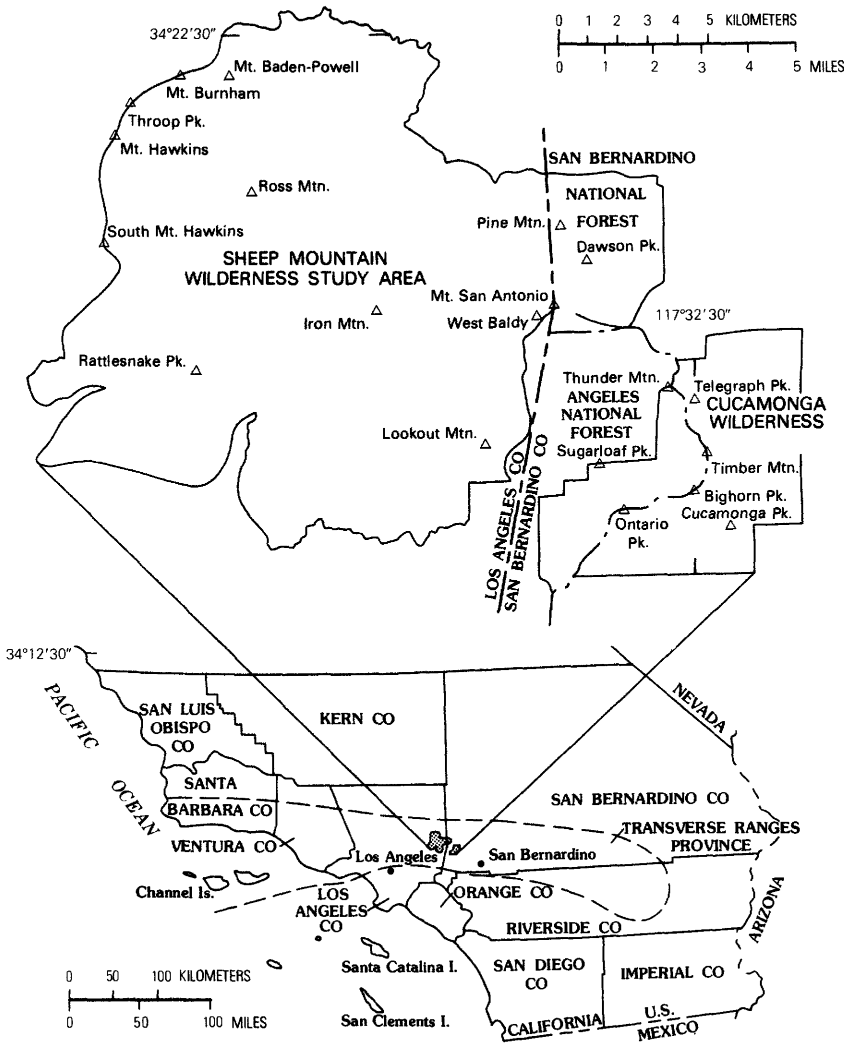

FIGURE 2.—Location of Sheep Mountain Wilderness study area and Cucamonga Wilderness and additions.

and microclimate deter tree growth. From these heights, spectacular vistas to the south and east of the San Bernardino and San Jacinto Mountains, the Los Angeles basin, and Catalina Island can be seen when haze and smog are absent or confined to lower elevations. An equally spectacular vista across the Mojave Desert, once visible from the northern peaks, has in recent years been nearly obliterated by dust and smog. Besides enjoying the mountain scenery, visitors to the Wilderness may occasionally glimpse deer, black bear, and Nelson bighorn sheep, or fish for trout that inhabit sections of the less frequented streams.

Several paved roads lead to and border on the Sheep Mountain Wilderness study area (pl. 1): East Fork Road (State Highway 39); the Angeles Crest Highway (State Highway 2), which is part of the north boundary of the study area; and Glendora Ridge Road, which is part of the south boundary. Blue Ridge Road (unpaved) also provides access to many places in the northern part of the Sheep Mountain Wilderness study area. Foot trails extend across the area from several points along these roads. San Antonio Canyon Road (paved) and a ski lift provide access by way of branching roads and trails to both the Sheep Mountain Wilderness study area and the Cucamonga Wilderness and additions. Middle Fork Road and Baldy Road (both unpaved) provide access to the Cucamonga Wilderness.

The study area is covered by 7.5-minute topographic maps at a scale of 1:24,000; the base for the geologic map (pl. 1) consists of mosaicked parts of eight 7.5-minute quadrangles (Glendora, Crystal Lake, Valyermo, Mescal Creek, Mount San Antonio, Mount Baldy, Telegraph Peak, and Cucamonga Peak) reduced to a scale of 1:48,000.

PREVIOUS GEOLOGIC STUDIES

Parts of the Sheep Mountain Wilderness study area and the Cucamonga Wilderness and additions have been mapped in previous studies. Noble (1954b) prepared a 1:125,000-scale reconnaissance geologic map of the San Andreas fault zone from Soledad Pass to Cajon Pass that included the generalized geology of the northern part of the Sheep Mountain Wilderness study area and the Cucamonga Wilderness. Baird (1956) mapped an area of San Antonio Canyon, including part of the southeast corner of the Cucamonga Wilderness. Ehlig (1958) mapped the geology of the Mount Baldy region, including the western part of the Cucamonga Wilderness and the eastern part of the Sheep Mountain Wilderness study area. Dibblee (1967), who surveyed the western Mojave Desert region, included parts of the two areas on his geologic maps. Rogers (1969) compiled the geology of the eastern San Gabriel Mountains. More recently, P. L. Ehlig (oral and written communs., 1974) mapped an area west of Mount Baldy within the Sheep Mountain Wilderness study area. D. M. Morton (unpub. data, 1974; Morton, 1975) mapped the eastern San Gabriel Mountains from Cajon Pass to Mount Baldy. Several summaries of the regional geology and tectonics of the Transverse Ranges, including the eastern San Gabriel Mountains, have been prepared (Bailey and Jahns, 1954; Dibblee, 1968; Baird and others, 1974; Ehlig, 1975; Morton, 1975). Ehlig (1973) summarized the tectonics of the San Gabriel fault, one branch of which passes through the southern part of the Sheep Mountain Wilderness study area. Radiometric dates on igneous and metamorphic rocks of the San Gabriel Mountains were reported by Hsu and others (1963), Silver (1971), and Miller and Morton (1974). A reconnaissance map of major landslides in the San Gabriel Mountains was prepared by Morton and Streitz (1969).

PRESENT STUDY

Geologic mapping of the two areas was undertaken to appraise their mineral resources. Fieldwork by the U.S. Geological Survey was done from mid-January to the end of February 1975 and during the last half of February 1976 by the author, and between the last week in July and the first week of September 1975 by the author assisted by John Olson. Foot traverses were made along most of the ridges, trails, and canyon bottoms. The geology was mapped at a scale of 1:24,000 and reduced to 1:48,000 (pl. 1). Photogeologic interpretations made before, during, and after field observations were generally inconclusive because the crystalline rocks of the study area are covered by thick regolith and brush and do not weather to give morphologic features that can be used to characterize geologic units. Some mapping by P. L. Ehlig (unpub. data, 1974) and D. M. Morton (unpub. data, 1974) has been incorporated into the geologic map (pl. 1). Terminology for the cataclastic rocks is from Higgins (1971).

Acknowledgments.—Thanks are due to D. M. Morton of the U.S. Geological Survey, P. L. Ehlig of the California State University, Los Angeles, and A. K. Baird of Pomona College, Claremont, Calif., for informative discussions on the geology of the San Gabriel Mountains. The cooperation of members of the U.S. Forest Service, Mount Baldy district, is also gratefully acknowledged.

GEOLOGY

The Sheep Mountain Wilderness study area and the Cucamonga Wilderness and additions are situated in the Transverse Ranges of southern California, between the Sierra Madre and Cucamonga faults to the south and the San Andreas fault to the north. The region is underlain by igneous and metamorphic rocks of Precambrian to Miocene age. Mylonitization of the gneissic rocks (Precambrian), gneissoid granodiorite (Triassic), quartz diorite (Cretaceous), and andesite dikes (Cretaceous or early Tertiary) occurred during Late Cretaceous or early Tertiary time. At that time and possibly later, the mylonitic rocks and their parent materials were thrust over the Pelona Schist. Quartz monzonite, latite, and pegmatite were emplaced during the Miocene. From late Tertiary through Holocene time the region has undergone strike-slip faulting and strong uplift; numerous landslide deposits and areas of elevated older alluvium reflect this Holocene tectonism.

ROCK UNITS

GNEISSIC ROCKS

Gneissic rocks occur in the western and southern parts of the Sheep Mountain Wilderness study area and in the west-central part of the Cucamonga Wilderness, where the rocks have been subdivided into gneiss, biotite gneiss, and gneiss and biotite schist (pl. 1). Quartzofeldspathic gneiss, the most abundant rock type in the gneiss, in the gneiss and biotite schist, and in the migmatite west of the San Antonio fault, is typically light gray to white, fine to medium grained, with well-developed planar or broadly undulating gneissic foliation.

The principal minerals of the gneissic rocks are plagioclase (An_{25-50}), quartz, potassium feldspar, and biotite; quartzofeldspathic gneiss constitutes about 90 percent of the rocks. The ratio of potassium feldspar to plagioclase varies widely; some gneiss is virtually free of potassium feldspar or contains only a few percent in thin veins that cut the foliation. In other gneiss, potassium feldspar is much more abundant, and the two feldspars occur in approximately equal amounts; minor epidote, sphene, and garnet are also present.

Three types of gneissic rocks occur in the Sheep Mountain Wilderness study area. Fine-grained biotite gneiss occurs within the dominantly quartzofeldspathic gneiss, of which it makes up less than 10 percent; biotite (15-40 percent), plagioclase (An_{25}, 30-45 percent), and quartz (5-35 percent) are the major components. Hornblende is locally abundant (max 60 percent); potassium feldspar, where present, is generally an accessory mineral, along with magnetite, muscovite, pyrite, and sphene. In places the gneiss grades into biotite schist. The foliation is defined by layering of the mafic minerals and preferred planar orientation of the biotite in the biotite gneiss. Local crosscutting of the foliation of the quartzofeldspathic gneiss suggests that the crosscutting bodies of biotite gneiss are metamorphosed dikes.

The gneiss and biotite schist consist chiefly of quartzofeldspathic gneiss, identical to that described above. The gneiss is interlayered with fine- to medium-grained biotite and hornblende schist, in zones 3 to 15 ft (1-5 m) thick, that constitute about a third of the unit. The principal minerals of the schist are hornblende and biotite (45 percent), plagioclase (An_{45}, 40 percent), and quartz (15 percent). Locally the schist grades into amphibolite; potassium feldspar and muscovite are accessory minerals.

The biotite gneiss in the northwest corner of the Sheep Mountain Wilderness study area is fine to medium grained and has an irregular anastomosing foliation with numerous minor folds. Biotite (15-60 percent), plagioclase (An_{30-50}, 15-40 percent), and quartz (max 35 percent) are the principal minerals. Garnet (max 20 percent), muscovite (max 15 percent), and sillimanite (max 15 percent) are locally important constituents; potassium feldspar and pyrite are accessory minerals. The relation between this biotite gneiss and the other gneissic rocks is unknown because the biotite gneiss is fault bounded.

Other minor rock types occur in gneissic rocks in the southern part of the Sheep Mountain Wilderness study area. A muscovite-quartzite zone, 500 ft (150 m) thick, containing scattered porphyroblasts of garnet, as large as 5 in. (2 cm), is present in the canyon of the East Fork of the San Gabriel River. Several boulders of dark-gray fine-grained marble occur in Susanna and Williams Canyons, but no outcrops of the marble were found.

Secondary epidote, sericite, and clay are widespread in the gneissic rocks as alteration products of the feldspars, chiefly the plagioclase. Biotite and hornblende are altered to chlorite; hematitic alteration of these mafic minerals and of pyrite is also common. Secondary alterations are especially pronounced near the major Tertiary and Quaternary fault zones, such as the San Gabriel fault zone. Orange-brown siderite-quartz veins are abundant both parallel to the foliation of the gneissic rocks and in fractures adjacent to faults. A few malachite veins, thinner than half an inch (1 cm), were found in the gneissic rocks.

The presence of intermediate plagioclase in apparent equilibrium with epidote, and of hornblende and sillimanite, indicate that the gneiss belongs to the amphibolite facies (Turner and Verhoogen, 1960, p. 544-553; Turner, 1968, p. 307-308).

The gneissic rocks resemble the layered quartzofeldspathic gneiss, amphibolite, quartzite, and rare calc-silicate layers in the western and central San Gabriel Mountains. Silver (1971) determined uranium-lead ages on zircons in these rocks west of the Sheep Mountain Wilderness study area and concluded that the rocks originated 1,680 to 1,750 m.y. ago. Therefore, on the basis of their gross similarity to the Precambrian gneiss studied by Silver, the gneissic rocks of the Sheep Mountain Wilderness study area are here assigned a Precambrian age.

PELONA SCHIST

The Pelona Schist, named by Hershey (1902) from its exposures in the Sierra Pelona and mapped by Noble (1954a, b) in the northeastern San Gabriel Mountains, is exposed in the northeastern part of the Sheep Mountain Wilderness study area and along the north edge of the Cucamonga Wilderness (pl. 1). The rock is typically fine-grained silvery-gray muscovite-chlorite schist. Its proportions of quartzofeldspathic and micaceous constituents vary widely: albite (30-75 percent), quartz (max 30 percent), muscovite (max 25 percent), and chlorite (max 10 percent). The albite occurs only as porphyroblasts, commonly $^{1}/_{32}$ in. (1 mm) long and black with graphite inclusions. The muscovite-chlorite schist grades into quartzofeldspathic schist and quartzite. The quartzofeldspathic schist and the quartzite, which are locally garnetiferous, contain less than 15 percent muscovite and chlorite; some samples contain potassium feldspar as an important primary constituent (max 25 percent). In places the schist encloses phyllite lenses, as long as 6 ft (2 m); calcite, hematite, leucoxene, and pyrite are minor constituents.

Layers of fine- to medium-grained green chlorite and chlorite-actinolite schist, as thick as 200 ft (60 m) and several hundred feet (meters) long, occur in the muscovite-chlorite schist. The principal minerals in the green schist are albite (20-30 percent), chlorite (max 30 percent), amphibole (principally actinolite: 30-50 percent), and epidote (max 15 percent). The albite and epidote form porphyroblasts, as large as $^{1}/_{4}$ in. (5 mm) in diameter, set in a matrix of much finer grained chlorite, epidote, and actinolite. Augen, composed of chlorite and actinolite grains, are less common than the white albite and green epidote porphyroblasts. Allanite, blue-green hornblende, calcite, garnet, hematite, muscovite, potassium feldspar, pyrite, quartz, sphene, and tremolite are minor constituents.

Distinctive dark-gray to black fine-grained quartzite layers, as thick as 15 ft (5 m), occur within the green chlorite and chlorite-actinolite schist. The quartzite consists of at least 90 percent quartz and small amounts of other minerals, such as actinolite, albite, garnet, muscovite, and piedmontite. Locally, malachite, barite, soda amphibole, and psilomelane laminae parallel the foliation of the quartzite. Calcareous quartzite layers, 1 to 6 in. (2-15 cm) thick, occur in the green chlorite and chlorite-actinolite schist. In addition to the major minerals (quartz and calcite), minor amounts of actinolite, chlorite, and stilpnomelane are present.

Rare coarse-grained green actinolite and actinolite-talc lenses, as much as 6 ft (2 m) long and 6 in. (15 cm) wide, including crystals of actinolite as long as 2 in. (5 cm), occur in the north-central part of the Sheep Mountain Wilderness study area. Boulders and pebbles of layered pink-and-white piedmontite and piedmontite-alurgite quartzite occur in the alluvium of the upper part of the East Fork and the Prairie Fork. Although these unusual rocks probably occur in the Pelona Schist in the northern part of the Sheep Mountain Wilderness study area, no outcrops of these quartzites were observed. Black fine- to medium-grained hornblende schist and black- and white-banded amphibolite occur on Blue Ridge. The plagioclase is oligoclase, and some of the rock contains abundant red garnets. Coarse-grained nodular white quartz and quartz-siderite veins, as much as a foot (0.3 m) thick and several feet (meters) long, parallel the schistosity of the schist; the grains of quartz and siderite are as long as 2 in. (5 cm). Veins are most common in the schist along the upper part of the East Fork and the Prairie Fork.

Occurrence of the mineral assemblage albite-quartz-muscovite-chlorite, characteristic of most of the Pelona Schist, indicates that the bulk of the schist was metamorphosed to greenschist facies (Turner and Verhoogen, 1960, p. 533-541; Turner, 1968, p. 268-270). In some schist, blue-green hornblende occurs with albite and epidote, an assemblage indicative of a transition to amphibolite facies (Turner and Verhoogen, 1960, p. 533, 539-541; Turner, 1968, p. 303-307). The mineral assemblage hornblende-oligoclase-garnet in the amphibolite on Blue Ridge is characteristic of amphibolite facies (Turner and Verhoogen, 1960, p. 544-553; Turner, 1968, p. 307-308). Thus, the Pelona Schist varies in metamorphic grade from green schist to amphibolite facies, although a clear progression from low to high grade was not found in the study area, probably because the isograds in the schist have been offset by Tertiary and Quaternary faulting.

The age of metamorphism of the Pelona Schist and of the sedimentary and volcanic protolith of the schist is not clearly known. The Pelona Schist has been considered Precambrian by some workers and Precambrian(?) by others (Hershey, 1902, p. 273; Hulin, 1925, p. 29-30; Simpson, 1934, p. 380-381; Clements, 1937, p. 231; Miller, 1946, p. 468; Wallace, 1949, p. 787; Dibblee, 1967, p. 9). Ehlig (1958, p. 33-40; 1968a) proposed that metamorphism of the Pelona Schist is Cretaceous and that deposition of the protolith of the schist may have been Mesozoic. Near the North Fork of Lytle Creek the Pelona Schist is intruded by quartz monzonite, 13.4 to 14.9 m.y. old (K-Ar method; Miller and Morton, 1977)—that is, Miocene—and so the metamorphism of the schist must be pre-Miocene. Muscovite-quartz-albite schist from the San Gabriel Mountains yielded a whole-rock potassium-argon age of 52.4±1.0 m.y. (Ehlig, 1975, p. 183; Ehlig and others, 1975)—that is, Eocene—which was interpreted as the cooling age after thermal metamorphism. Metachert from the Pelona Schist near the Vincent thrust yielded a whole-rock rubidium-strontium age of 59±1 m.y. (Gary Lass, written commun., 1977), that is, Paleocene. This date, however, could reflect an episode of recrystallization late in the formation of the schist, and so the metamorphic age of the Pelona away from the Vincent thrust could be older than Paleocene. In a preliminary report on the Sheep Mountain Wilderness study area (Evans and others, 1977), the Pelona Schist was assigned a Cretaceous or older age. In this report, the metamorphic age of the Pelona Schist is considered to be Cretaceous and (or) older.

GNEISSOID GRANDIORITE

Dikes of gneissoid granodiorite, containing distinctive large augen of pink potassium feldspar and black hornblende, intrude both the gneiss and biotite schist in the western part of the Sheep Mountain Wilderness study area (pl. 1). The granodiorite resembles the Mount Lowe Granodiorite of Miller (1934, p. 42-43). In the western part of the Sheep Mountain Wilderness study area the dikes are as thick as 6 ft (2 m) and cut the foliation of the gneiss and biotite schist. In the southeastern part of the area the dikes are thicker: the largest dike (pl. 1) is at least 3,200 ft (980 m) thick. Local grading of the gneiss host rock into gneissoid granodiorite suggests hybridism of the two rock types.

The gneissoid granodiorite consists principally of plagioclase (An_{40}, 55 percent), quartz (20 percent), potassium feldspar (15 percent), and hornblende (10 percent). Almost all the potassium feldspar in the rock occurs as subhedral to anhedral porphyroblasts, as long as $1\frac{1}{2}$ in. (3 cm); where these porphyroblasts are uncommon or absent, the bulk composition of the rock is dioritic. Two types of black augen occur: euhedral and subhedral porphyroblasts of hornblende, as long as half an inch (1 cm); and black aggregates of hornblende grains, $\frac{1}{32}$ to $\frac{1}{8}$ in. (1-3 mm) long, almost as large as the porphyroblasts. Biotite, epidote, garnet, hematite, and magnetite are also present.

The main body of gneissoid granodiorite to which this unit has been correlated is the Mount Lowe Granodiorite, west of the Sheep Mountain Wilderness study area, which yielded a uranium-lead radiometric age of 220 ± 10 m.y. (Silver, 1971), that is, Triassic. This age assignment is accepted here for the gneissoid granodiorite of the Sheep Mountain Wilderness study area.

MIGMATITE

Two bodies of migmatite are recognized in the eastern San Gabriel Mountains: the migmatite west of the San Antonio fault, in the Sheep Mountain Wilderness study area; and the migmatite east of the San Antonio fault, in the Cucamonga Wilderness (pl. 1).

The migmatite west of the San Antonio fault occurs within and to the south of the San Gabriel fault zone in the Sheep Mountain Wilderness study area. The unit is largely gneiss, identical to the Precambrian gneissic rocks described above. The gneiss is intruded by numerous dikes of quartz diorite, quartz monzonite, pegmatite, latite, and andesite, all of which are described below. In parts of the migmatite, quartz diorite, quartz monzonite, and pegmatite are more abundant than gneiss, and the interconnected dikes enclose angular blocks of the gneiss. Latite and andesite are less abundant in the migmatite than are the other intrusive rock types, and occur in dikes as thick as 50 ft (15 m); a few of these dikes can be traced for a mile ($1\frac{1}{2}$ km). The age of the gneiss fraction of the migmatite, like that of the gneiss to the north and west, is presumably Precambrian; the igneous fraction of the migmatite is Cretaceous to Oligocene and post-Miocene.

The migmatite east of the San Antonio fault, consisting largely of metasedimentary rocks named the "San Antonio Canyon Group" by Hsu (1955, p. 295), constitutes most of the south half of the Cucamonga Wilderness. The metasedimentary rocks of the migmatite consist of dolomite and calcite marble, argillite, carbonaceous and pyritiferous metasiltstone, graphite schist, quartzite, biotite gneiss, and layered calc-silicate rocks, with laminations of pink garnet, green pyroxene, and white calcic plagioclase. Uniform layers, as thick as 200 ft (60 m), can be traced for several hundred feet (meters); in many places the layering is contorted and intensively faulted. Calcic plagioclase (An_{50-65}, some in equilibrium with epidote), pyroxene, hornblende, and sillimanite indicate at least amphibolite facies metamorphism for the metasedimentary rocks (Turner and Verhoogen, 1960, p. 544-552; Turner, 1968, p. 307-308). These metamorphic rocks are intruded by numerous dikes of quartz diorite and quartz monzonite (described below), and, locally, by closely spaced potassium feldspar veins.

The metasedimentary rocks generally resemble the Placerita Formation described by Miller (1934) and Oakeshott (1937; 1958, p. 50-52) in the San Fernando quadrangle, 30 mi (48 km) west of the Cucamonga Wilderness. Graphite schist, an unusual rock type, occurs in both the migmatite and the Placerita Formation. Limestone in both the Placerita Formation and the metasedimentary rocks has been lithologically correlated with late Paleozoic limestone in the San Bernardino Mountains (Miller, 1946, p. 468; Baird, 1956; Ehlig, 1958; Oakeshott, 1958, p. 52; Woodford, 1960, p. 403-404; Stewart and Poole, 1975); a Precambrian age for these rocks, however, has not been ruled out. In this report the metasedimentary rocks are considered to be Paleozoic or older. The igneous rocks in the migmatite are considered to be Cretaceous (quartz diorite) and Oligocene and Miocene (quartz monzonite).

QUARTZ DIORITE

Quartz diorite, grading into granodiorite and diorite, intrudes the gneiss and migmatite in the study area. The quartz diorite is fine- to medium-grained, hypautomorphic granular, weakly gneissoid to massive, and, in places, cataclastic. The foliation is defined by the alinement of mafic minerals in millimeter-thick laminae and is locally warped around quartzofeldspathic augen or porphyroblasts. The principal minerals are plagioclase (An_{40-50}, 35-60 percent), quartz (10-30 percent), hornblende (max 30 percent), and biotite (max 30 percent). Potassium feldspar, generally a minor constituent (max 5 percent), is important in some rocks; it commonly fills thin veins, occurs along grain boundaries, or replaces plagioclase. Magnetite, pyrite, sphene, and zircon are accessory minerals. The quartz diorite is more fractured and intensely altered near large faults and near the pegmatite dikes, where the plagioclase is saussuritized, sericitized, and argillically altered, and where the mafic minerals are altered to chlorite and hematite. Orange-brown siderite-quartz veins are common in the fractured quartz diorite.

The quartz diorite engulfed the gneiss, amphibolite, coarse-grained hornblendite, and biotite-rich granodiorite. Xenoliths of these rock types in the quartz diorite and granodiorite are especially common in a quartz diorite block in the San Gabriel fault zone, in the vicinity of Allison Gulch. Most of the xenoliths are a few inches (centimeters) or feet (meters) long, occur in clusters, and are commonly arranged so as to define a crude layering in the rock; in places this layering is contorted. The largest xenoliths are as much as 1,000 ft (300 m) long and 500 ft (150 m) wide.

Quartz diorite of the Ontario Peak area, in the western part of the Cucamonga Wilderness, was dated at between 80 and 115 m.y. (K-Ar and Rb-Sr methods; Hsu and others, 1963, p. 510), which is interpreted to be Cretaceous. A similar age of 122 m.y. was obtained on the nearly identical quartz diorite of Mount Wilson, 12 mi (19 km) west of the Sheep Mountain Wilderness study area (U-Pb method; Larsen and others, 1958, p. 48). Therefore, the quartz diorite in the study area is here assigned a Cretaceous age.

MYLONITIC ROCKS

Mylonitic rocks occur in the San Gabriel fault zone, above the Vincent thrust, along the San Antonio fault, and in the north-central and northwestern parts of the Cucamonga Wilderness. These rocks have been subdivided into two units: mylonite and mylonite gneiss (pl. 1). Most of the mylonite occurs in a zone, 200 to 2,000 ft (60-600 m) thick, above the Vincent thrust. The rocks include protomylonite,

mylonite, ultramylonite, and blastomylonite but consist mostly of mylonite. The mylonite is characteristically fine grained to aphanitic, gray, green, violet, or white; the laminae are broadly undulating and anastomosing, and some laminae crosscut others at small angles. White porphyroclasts of plagioclase and potassium feldspar, commonly smaller than $^1/_8$ in. (3 mm), are abundant. The plagioclase is chiefly of intermediate composition (An_{20-35}); dark porphyroclasts of epidote and hornblende, partially altered to biotite, epidote, and chlorite, are less common. Porphyroblasts of epidote, sphene, and biotite are present in most of the mylonite; the fine-grained matrix of the mylonite is largely quartz and feldspar. White mica, epidote, chlorite, and biotite also occur in the matrix and are abundant in some of the mylonite. Potassium feldspar veins, pyrite (max 2 percent), and saussuritization and sericitization of the calcic plagioclase are nearly ubiquitous in the mylonite.

Phacoids of relatively unmylonitized gneiss, quartz diorite, and possibly also of the Pelona Schist occur in the mylonite above the Vincent thrust; most of those phacoids are no longer than 10 ft (3 m). Textural gradations of the gneiss and quartz diorite into mylonite, as well as unmylonitized fragments of these rocks in the mylonite, indicate that the mylonite was derived from the gneiss and quartz diorite. In addition, derivation of some mylonite from the Pelona Schist is suggested by its schistose appearance and by the presence in the mylonite of phacoids of medium- to coarse-grained muscovite schist resembling, but much coarser grained than, the ordinary Pelona Schist. Occurrence of lenses, as thick as 20 ft (6 m), of medium-grained white marble in the mylonite of Timber Mountain in the central part of the Cucamonga Wilderness suggests that this mylonite was derived from metasedimentary rocks of the migmatite east of the San Antonio fault.

Because the mylonite was partially derived from the quartz diorite, it must be Cretaceous or younger; the mylonite is intruded by an Oligocene and Miocene quartz monzonite and so must be pre-Oligocene. P. L. Ehlig (written commun., 1975) obtained a potassium-argon age of 52.7 m.y. on mylonite near The Narrows in East Fork Canyon, which he interpreted as the age of cooling. Conrad and Davis (1977) dated muscovite-albite-quartz schist, considered to be a sheared and recrystallized pegmatite, from the mylonitic rocks at 58.5$\pm$4 m.y. (Rb-Sr method), which is interpreted as Paleocene and Eocene. They considered this age to be the time of development of the mylonite and the time of thrusting. This dating, which falls within the Cretaceous-to-Miocene age limits deduced above for the mylonite, can be tentatively accepted.

Mylonite gneiss, at least 1,000 ft (300 m) thick, occurs between the mylonite above the Vincent thrust and below the gneiss in the western part of the Sheep Mountain Wilderness study area and in the northwestern part of the Cucamonga Wilderness. Other mylonite gneiss is present in the San Gabriel and San Antonio fault zones. The mylonite gneiss exhibits cataclastic textures reminiscent of the mylonite described above. Fragmented rotated augen-shaped to angular white porphyroclasts of feldspar, as long as 1 1/2 in. (3 cm) and mostly of plagioclase, are conspicuous in the mylonite gneiss. The foliation is defined by the alinement of porphyroclasts and by the laminar concentrations of micaceous minerals (biotite, chlorite, muscovite-sericite).

The principal minerals in the mylonitic rocks are plagioclase (An_{20-40}, 30-60 percent), quartz (20-40 percent), hornblende (max 35 percent), biotite (max 25 percent), and chlorite (max 25 percent). Potassium feldspar is an important constituent in some rocks and makes up the largest porphyroclasts. Epidote (max 20 percent) occurs as porphyroblasts and as an alteration product of plagioclase; hematite, leucoxene, magnetite, and pyrite are accessory minerals.

Textural gradations from the gneiss to the mylonite gneiss near the Vincent thrust occur across a zone no wider than 10 ft (3 m); these gradations suggest that the parent material of the mylonite gneiss was the gneiss. The relatively high mafic-mineral content (min 38 percent) of the mylonite gneiss further suggests that the parent material was biotite-rich gneiss. Large enclosed porphyroclasts of potassium feldspar were probably derived from gneissoid granodiorite that intruded the gneiss. The mylonite gneiss near the Vincent thrust forms a thick lens between the mylonite and the gneiss, and grades into mylonite over a zone from 0 to 15 ft (0-5 m) wide. The structural position of the mylonite gneiss and its transitional character between the gneiss and the mylonite suggest that the mylonite gneiss formed at the same time as the mylonite.

All the mylonitic rocks in the area of this report are considered to have formed during the Cretaceous or early Tertiary.

QUARTZ MONZONITIC DIKES

Three types of white to creamy-white dikes, all of quartz monzonitic composition, intrude the igneous and metamorphic rocks described above: equigranular and porphyritic quartz monzonite, aphanitic and porphyritic latite, and pegmatite. Although the quartz monzonite and the latite occur in both Wilderness areas, the pegmatite occurs only in the southern part of the Sheep Mountain Wilderness study area.

Quartz monzonitic dikes in the study area range from less than 1 to 2,000 ft (0.3-600 m) in thickness. The largest dikes shown on the geologic map (pl. 1) are in the western part of the Sheep Mountain Wilderness study area and in the northern part of the Cucamonga Wilderness; dikes as thick as 50 ft (15 m) are common throughout the two areas. The quartz monzonite, including porphyritic varieties that contain as much as 50 percent phenocrysts, consists largely of plagioclase (An_{15-30}, 30-45 percent), potassium feldspar (20-35 percent), and quartz (15-35 percent). Biotite (max 15 percent), partly intergrown with muscovite, is the principal mafic mineral. Hornblende is present in some of the quartz monzonite; apatite, epidote, garnet, leucoxene, magnetite, pyrite, and zircon are accessory minerals.

Most of the quartz monzonite is massive. Some, however, exhibits a weak foliation defined by alinement of the biotite; the foliation parallels or is at a small angle to the dike walls. These internal structural differences between the quartz monzonitic dikes could indicate two intrusive episodes, the first of which was followed by a minor deformation that resulted in alinement of the biotite. This hypothesis is difficult to substantiate on the basis of the evidence at hand, and in this report no such distinction between the quartz monzonitic dikes is made.

Latite dikes, as thick as 200 ft (60 m), are abundant and grade into quartz monzonite porphyry. The creamy-white latite is aphanitic to porphyritic and contains as much as 40 percent euhedral phenocrysts, as long as 1/4 in. (5 mm), of oligoclase, quartz, and biotite. The very fine grained groundmass, containing grains a few hundredths of an inch (centimeter) long, consists of plagioclase, potassium feldspar, quartz, and biotite. Intense saussuritization of the plagioclase and chloritization of the biotite are common. Some light-colored dikes contain no potassium feldspar and appear to have been silicified.

Pegmatite dikes, as thick as 50 ft (15 m), are common in the gneiss, quartz diorite, and quartz monzonite. The pegmatite contains pink subhedral grains of potassium feldspar (orthoclase and microcline), as large as 4 in. (10 cm) across; some of these grains are perthitic. The quartz and plagioclase (albite-oligoclase), which tend to be finer grained than the potassium feldspar, are also as large as several inches (centimeters) across. Biotite, chlorite, epidote, garnet, and muscovite are minor constituents. The dikes commonly are symmetrically zoned parallel to the dike walls. Some outer layers contain abundant biotite, concentrated in laminae parallel to the dike walls. The centers of the dikes consist of alternating zones, as thick as 1 ft (0.3 m), of coarse potassium-feldspar-rich and finer plagioclase-rich pegmatite, as well as millimeter-thick zones of tiny red garnets. Pegmatite veins and dikes in the quartz monzonite are so zoned and, in places, grade texturally into the quartz monzonite host rock. The compositional similarity of the pegmatite to its quartz monzonite host and the textural gradations from pegmatite to ordinary quartz monzonite suggest that the pegmatite is a late-stage differentiate of the quartz monzonite.

The quartz monzonite and latite intrude gneiss, metasedimentary rocks, quartz diorite, mylonitic rocks, and the Pelona Schist. The pegmatite intrudes gneiss, quartz diorite, and quartz monzonite and occurs only in the southern part of the Sheep Mountain Wilderness study area. The significance of this difference in distribution between the pegmatite and the quartz monzonite and latite is unclear. In general, the abundance of these three types of dikes decreases northeastward in the Sheep Mountain Wilderness study area, and so the center of intrustion of these dikes may lie in the southern part of the Wilderness. The pegmatite dikes may be more abundant near this center of intrusion; they do not occur in the Pelona Schist or in the mylonitic rocks, at least at the present erosional level.

Near the dikes the host rocks have been altered; some gneiss and quartz diorite are more resistant to weathering near than away from the dikes. Intense fracturing of the host rocks near some dikes could be due to postemplacement faulting parallel to the dike walls. Biotite and stilpnomelane are relatively abundant in the schist for several feet (meters) from the walls of some dikes. The largest metamorphic aureole in the schist occurs in the northern part of the Cucamonga Wilderness, where a quartz monzonite pluton intrudes the schist, and biotite is abundant in the schist for about 2,000 ft (600 m) from the intrusive contact.

Hsu and others (1963) dated quartz monzonite from the Telegraph Peak area in the Cucamonga Wilderness at 12 to 29 m.y. (K-Ar method), which is interpreted as Oligocene and Miocene. Miller and Morton (1977) dated granitic rocks in the quartz monzonite that intrudes the Pelona Schist in the northern part of the Cucamonga Wilderness at 13.4 to 14.9 m.y. (K-Ar method), and similar rocks from Telegraph Peak at 18.6$\pm$0.6 m.y. (K-Ar method); both these ages are interpreted as Miocene. In this report the quartz monzonitic dikes are assigned an Oligocene and Miocene age.

ANDESITE DIKES

Three types of gray andesite dikes cut the gneiss and quartz diorite and constitute less than 5 percent of the migmatite west of the San Antonio fault: (1) dark dikes ranging in composition from andesite to latite, (2) gray andesite dikes containing conspicuous black hornblende phenocrysts, and (3) dark-gray andesite dikes containing conspicuous white plagioclase phenocrysts. All these dikes contain little or no quartz and between 15 and 40 percent mafic minerals, chiefly hornblende, including pyroxene and biotite. Although these dikes are too thin to map, some dikes are hundreds of feet (meters) long and can be located as prominent lineaments on aerial photographs.

The fine- to medium-grained andesite dikes are steeply dipping and as thick as 25 ft (8 m). Some of the dikes are porphyritic and contain plagioclase phenocrysts, as long as 1/4 in. (5 mm), that make up as much as 25 percent of the rock. These plagioclase phenocrysts, of intermediate composition, are commonly lath shaped and poikilitic, and contain inclusions of chlorite, magnetite, and quartz. Potassium feldspar (max 25 percent) occurs principally in the groundmass. Hornblende, the principal mafic mineral, occurs with biotite, and together they make up 15 to 40 percent of the rock; leucoxene is a minor constituent. The plagioclase is saussuritized, the mafic minerals are much altered to chlorite and hematite, and the quartz occupies veins and vugs.

Gray hornblende porphyry, containing conspicuous abundant black acicular phenocrysts of hornblende as long as 1/4 in. (5 mm), occurs in dikes as thick as 50 ft (15 m). The groundmass consists of partially saussuritized plagioclase (max 60 percent), in lath-shaped and equant subhedral grains shorter than 1/32 in. (1 mm), and of hornblende, generally much chloritized; potassium feldspar and magnetite are minor constituents. In a few samples the potassium feldspar is abundant (max 30 percent) in the groundmass. Most of these dikes are of andesite, a few of latite. The andesitic hornblende porphyry is indistinguishable in the field from the gray latite containing hornblende phenocrysts.

Dark-gray andesite dikes, as wide as 20 ft (6 m), contain 20 to 25 percent conspicuous white plagioclase phenocrysts, 1/4 to 3/4 in. (5–15 mm) long. These euhedral poikilitic phenocrysts are both lath shaped and equant, and exhibit polysynthetic twinning and normal compositional zoning. The groundmass consists largely of plagioclase phenocrysts (max 60 percent), smaller than 1/64 in. (0.5 mm) across, and of the mafic minerals (max 20 percent) hornblende, pyroxene, and biotite; calcite (veins), magnetite, potassium feldspar, and pyrite are present in minor amounts. One unusual sample, in which the mafic minerals were completely replaced by hematite, contained 30 percent potassium feldspar. Dark-gray andesite of the Cucamonga Wilderness contains green aggregates of epidote, as large as 1/8 in. (3 mm) across. Argillic alteration and sericitization of the plagioclase and chloritization of the mafic minerals are common. The andesite dikes are Cretaceous or younger because they intrude the quartz diorite. The dikes also intrude the quartz monzonite, and so some must be Oligocene and post-Miocene.

BRECCIA OF THE PUNCHBOWL FAULT ZONE

The Punchbowl fault zone, 200 to 4,000 ft (60-1,200 m) wide, contains fault breccia and blocks of several rock types: gneiss, the Pelona Schist, quartz diorite, green mylonitic rocks similar to those overlying the Vincent thrust, red arkose, and red arkosic boulder conglomerate. The sedimentary rocks are probably derived from the Punchbowl Formation of late Miocene age. Red beds of the Punchbowl Formation are conspicuous at Vincent Gap but diminish in frequency eastward toward Cabin Flat. Mylonitic rocks are abundant in the fault zone from Cabin Flat eastward for about a mile ($1^1/_2$ km). Gneiss predominates elsewhere in the fault zone.

The breccia of the fault zone is post-late Miocene inasmuch as it includes fragments of the Punchbowl Formation. The Punchbowl fault zone was active probably during late Pliocene or Pleistocene time (Dibblee, 1968, p. 264) and possibly into Holocene time (Noble, 1954a). Therefore, the breccia is here considered to be late Pliocene(?), Pleistocene(?) and Holocene(?).

SURFICIAL DEPOSITS

Surficial deposits in the study area include landslide deposits, older alluvium, and younger alluvium (pl. 1). The largest landslide deposits, from 0.25 to 0.5 mi^2 (0.6-1.3 km^2) in area, occur on the flanks of the higher peaks and on steep slopes, especially those underlain by the Pelona Schist. Angular fragments in these unsorted deposits vary widely in size, from sand and pebbles to boulders 50 ft (15 m) across. The surfaces of the deposits generally consist of unstable debris; many of the landslide deposits are covered with thick brush and trees that have partially stabilized the surface material. Minor scarps and closed depressions are common near the headwall. The basal contacts of the deposits with bedrock are commonly irregular; where the glide surface of the landslide cuts through bedrock, as at the base of the Airplane Flat Slide in East Fork Canyon, the base of the deposit consists of brecciated rock and resembles a fault zone.

One small deposit of older alluvium occurs in the Sheep Mountain Wilderness study area on a low ridge between Cow Canyon and Cattle Canyon. This deposit consists of bedded sand and gravel and contains rounded cobbles of gneiss, as large as 6 in. (15 cm) across. The deposit is 460 ft (140 m) above the younger alluvium in Cow Canyon and 320 ft (100 m) above the younger alluvium in Cattle Canyon. Uplift of the older alluvium probably occurred during the Pleistocene or Holocene.

Younger alluvium in the deeply incised canyons consists of cobble and boulder gravel that includes clasts of crystalline rock, as large as 15 ft (5 m) across. These deposits may be thicker than 100 ft (30 m) in some of the wide canyons, such as Cattle Canyon and East Fork Canyon. The alluvium is commonly very coarse in the uppermost parts of the deposit because the finer fractions of the bedload (sand, silt, and clay) have been transported downstream or washed into spaces between the larger clasts. Active-stream-channel gravel lies as much as 12 ft (4 m) below the general surface of alluvium in the canyons and is commonly cemented by caliche; in places, this caliche-cemented alluvium is 20 ft (6 m) thick. Minor stream-terrace deposits are here included in the younger alluvium; these nearly flat lying terrace deposits, generally thinner than 10 ft (3 m), consist of sand, silt, and clay.

STRUCTURE

The oldest structures in the study area are the foliations in the gneissic rocks, in the metasedimentary rocks of the migmatite east of the San Antonio fault, and in the Pelona Schist. The foliation of the Precambrian gneissic rocks is older than that of the Triassic gneissoid granodiorite because dikes of gneissoid grandiorite cut the foliation of the gneiss. Both rocks, however, may have been deformed during Triassic or later time. The foliations of the metasedimentary rocks and the Pelona Schist tend to parallel their gross compositional layering (although the internal structure of these two rock units is complex), and so quite likely this general parallelism resulted from transposition of the original bedding. The relative ages of the foliations in the Precambrian gneiss, in the Paleozoic or older metasedimentary rocks, and in the Cretaceous or older Pelona Schist are not clearly known. The Cretaceous or early Tertiary mylonitic rocks above the Vincent thrust have well-developed foliations that clearly postdate the gneiss, from which they were principally derived; the mylonite foliations are probably younger than the metasedimentary rocks. The foliation in the Pelona Schist near the mylonite may be penecontemporaneous with the mylonite.

The foliations in the metamorphic rocks are the directions of relative weakness along which later dikes intruded. Many of the large Cretaceous quartz diorite dikes are in part subparallel to the foliations of the gneiss and of the metasedimentary rocks of the migmatite east of the San Antonio fault (cross secs. *A-A'*, *C-C'*, *D-D'*, pl. 1).

Oligocene and Miocene quartz monzonite and latite sills also intrude the metamorphic rocks but are less common than dikes; only a few pegmatite sills were observed.

The gneissic rocks, gneissoid granodiorite, quartz diorite, and possibly also part of the Pelona Schist were all mylonitized in a zone, 200 to 2,000 ft (60-600 m) thick, during the Cretaceous or early Tertiary. The mylonite zone, which is cut by Tertiary faults and dikes, extends across the Sheep Mountain Wilderness study area from Mount Baden-Powell on the northwest to Mount Baldy on the east and is present in the northern part of the Cucamonga Wilderness (fig. 3). Probably contemporaneously with the mylonitization, a zone of mylonite gneiss, as thick as 1,000 ft (300 m), was formed between the mylonite zone and the undeformed gneiss. The main belt of this mylonite gneiss occurs in the western part of the Sheep Mountain Wilderness study area and in the northern part of the Cucamonga Wilder ness. The base of the mylonite zone, called the "Vincent thrust," marks a sharp break between the Pelona Schist (lower plate) and the mylonite (upper plate). In some places the thrust itself is a zone of silvery-gray-green chlorite and chlorite-talc phyllonite, from 0 to 5 ft

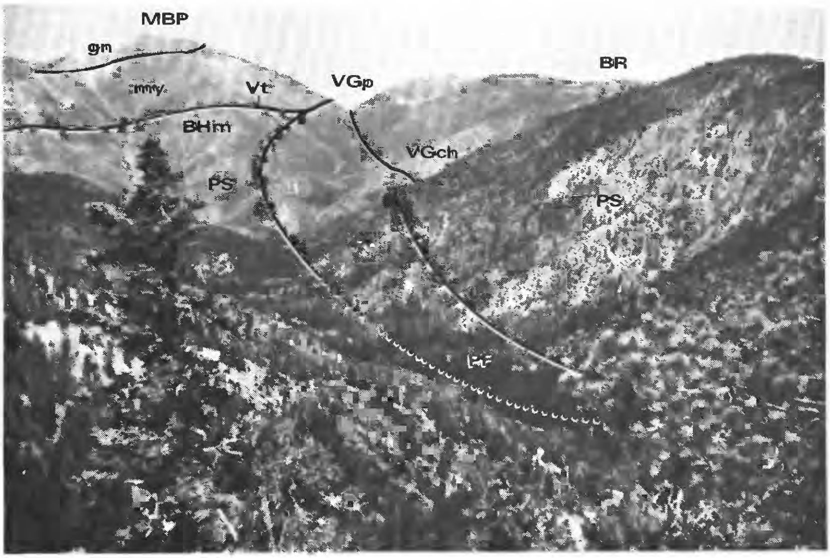

FIGURE 3.—Punchbowl fault zone, northern part of Sheep Mountain Wilderness study area. MBP, Mount Baden-Powell; VGp, Vincent Gap; BR, Blue Ridge; VGch, Vincent Gulch; PF, Prairie Fork; BHm, Big Horn mine; gn, gneiss; my, mylonite; PS, Pelona Schist; VT, Vincent thrust; pb, breccia of Punchbowl fault zone. Distance from foreground to top of MBP is 3 mi (5 km). View northwestward.

(0-1.5 m) thick. As shown on the geologic map (cross sec. *C-C'*, pl. 1), much of the Sheep Mountain Wilderness study area, as far south as the San Gabriel fault zone, is underlain by the Vincent thrust.

Mylonitized Miocene quartz monzonite dikes along the Middle Fork of Lytle Creek, and small unmapped blocks of mylonite in the San Gabriel fault zone, are probably related to late Tertiary faulting in the range. The San Gabriel and Punchbowl fault zones, both considered to be splays of the San Andreas fault system, occur in the northern and southern parts of the Sheep Mountain Wilderness study area. The San Gabriel fault bifurcates in the western San Gabriel Mountains; its northern branch extends into the Sheep Mountain Wilderness study area, where the fault zone, 1,200 to 8,000 ft (400-2,400 m) wide, is truncated by the San Antonio fault. The steep faults along Icehouse Canyon (fig. 4), which join steep faults along the Middle Fork of Lytle Creek, may be extensions of the northern branch of the San Gabriel fault eastward of the San Antonio fault (Dibblee, 1968, p. 266). Activity on the San Gabriel fault may have begun during the late Oligocene or early Miocene (Crowell, 1954, p. 52). The fault was intermittently active during late Miocene to middle Pleistocene time (Eaton, 1939, p. 522; Crowell, 1950, p. 1644) and may have moved during the late Pliocene and Quaternary (Oakeshott, 1958, p. 92). A right-lateral slip of 15 to 25 mi (24-40 km) was proposed for the San Gabriel fault in the northwestern San Gabriel Mountains (Crowell, 1952, p. 2034), and of 13 mi (21 km) in the central San Gabriel Mountains (Ehlig, 1968a).

The San Antonio and Weber faults offset segments of the San Gabriel fault. Left-lateral separation of the Vincent thrust from associated mylonite along these two steep faults suggests a left-lateral component of slip of about 3 to 4 mi (5-6 km). These faults were probably active during late Tertiary or Quaternary time. The Weber fault is truncated by a splay of the Punchbowl fault zone in the Sheep Mountain Wilderness study area.

The Punchbowl fault zone, 200 to 4,000 ft (60-1,000 m) wide, was active during late Pliocene or Pleistocene time (Dibblee, 1968, p. 264). In the Valyermo quadrangle, Noble (1954b) mapped strands of the Punchbowl fault cutting Pleistocene and Holocene alluvium. However, no well-defined scarps or other topographic features associated with active faulting have been observed along the Punchbowl fault (Morton, 1975, p. 175).

The San Gabriel Mountains have been a positive topographic area since the Miocene. Rugged mountains on the present site of the San Gabriel Mountains shed debris contributing to the Miocene conglomerate of the San Jose and Puente Hills, 2 to 20 mi (3-30 km) south of the present front of the eastern San Gabriel Mountains (Woodford and others, 1946). Holocene tectonism in the study area is primarily expressed by uplift of the crystalline rocks. This uplift is shown by the extreme relief within the study area and by the deposits of fluvial

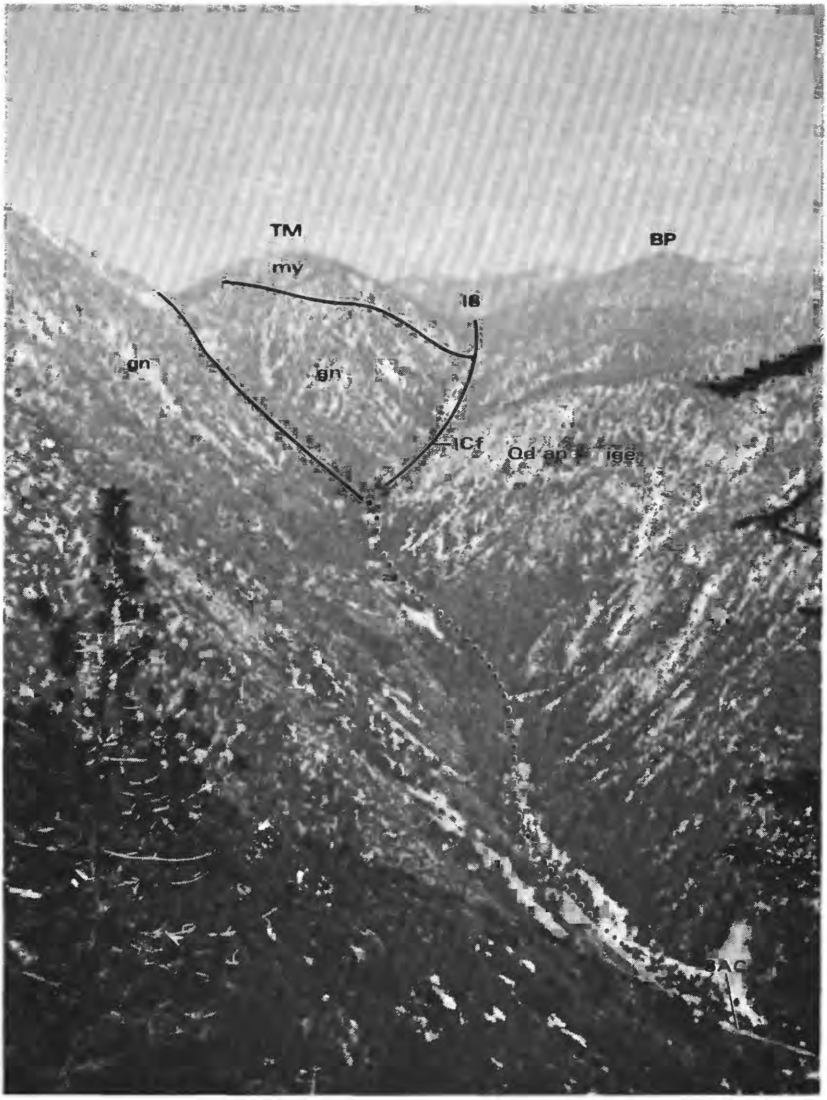

FIGURE 4.—Icehouse Canyon, Cucamonga Wilderness. IS, Icehouse Saddle. BP, Bighorn Peak; TM, Timber Mountain; SAC, San Antonio Canyon; ICf, Icehouse Canyon fault; gn, gneiss; my, mylonite; qd, quartz diorite; mige, migmatite east of San Antonio fault. Distance from San Antonio Canyon to head of Icehouse Canyon is 2 1/2 mi (4 km). View eastward.

gravel that now lie more than 300 ft (90 m) above the east-west-trending segment of the East Fork of the San Gabriel River, south of the Sheep Mountain Wilderness study area. The eastern San Gabriel Mountains, including the study area, lie on the south flank of a presently active uplift recently discovered in the western Mojave Desert (Castle and others, 1976).

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Aeromagnetic Studies of the Sheep Mountain Wilderness Study Area and the Cucamonga Wilderness and Additions, Los Angeles and San Bernardino Counties, California

By LEROY PANKRATZ, U.S. GEOLOGICAL SURVEY

MINERAL RESOURCES OF THE SHEEP MOUNTAIN WILDERNESS STUDY AREA AND THE CUCAMONGA WILDERNESS AND ADDITIONS, LOS ANGELES AND SAN BERNARDINO COUNTIES, CALIFORNIA

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By LEROY PANKRATZ, U.S. GEOLOGICAL SURVEY

An aeromagnetic survey of the Sheep Mountain Wilderness study area and the Cucamonga Wilderness and additions was flown in 1975 along north-south flightlines spaced approximately 1 mi ($1\frac{1}{2}$ km) apart, at a barometric elevation of 1.8 mi (2.9 km) above sea level. The survey area was between lat 34°10'-34°24.5' N. and long 117°30'-117°49' W. From the observed total magnetic field, a regional trend of 5.62γ/km N. and 2.33γ/km E. was removed by using International Geomagnetic Reference Field (IGRF) data updated to July 1975. The resulting residual anomalies were computer contoured at an interval of 10γ on a scale of 1:62,500. Subtraction of a datum base of 50,437γ at the southwest corner of the survey area gave the negative values.

The residual magnetic map (pl. 1) extends several miles (kilometers) beyond the boundaries of the two areas, except for the extreme west tip of the Sheep Mountain Wilderness study area. After the aeromagnetic flight, the boundaries of the Sheep Mountain Wilderness study area were modified, and so an absence of aeromagnetic data for this tip is evident on the map. However, earlier flight data by Hanna and others (1972) indicated a continuing inert trend in this small area.

Hanna and others detected two major positive magnetic anomalies: (1) a major northwest-trending high over the San Andreas fault, directly north of the Sheep Mountain Wilderness study area; and (2) a major high near the southeast corner of the Cucamonga Wilderness. Both anomalies are somewhat better defined in our survey because of a closer spacing of flightlines. The first anomaly has a generally similar configuration in both surveys, but Hanna and others contoured the second anomaly as more equidimensional and of lower amplitude than is shown on our map (pl. 1).

Magnetic lineaments generally trend northwest along the San Andreas fault and the associated Punchbowl fault several miles (kilometers) to the south. The juncture of the Punchbowl and San Antonio faults outlines a triangular feature of broad lows that extends off the map (pl. 1) to the west and southwest. Both the elevation and magnetization of the rocks are lower within this feature. The San Antonio fault seems to cut off the high occurring southeast of Cucamonga Peak.

Intrusive rocks of the southeastern part of the area, chiefly quartz diorite and quartz monzonite, are moderately magnetic. Local magnetic benches are caused by the magnetic effects of Cucamonga and Ontario Peaks, but the main magnetic high over the intrusive bodies occurs well south of the topographic crest. If these dioritic and monzonitic rocks are the cause of the main high in the Cucamonga Wilderness, they must be substantially more magnetic beneath the south slopes of the mountains than elsewhere in the study area. Gabbroic or mafic rocks occurring at shallow depth beneath the surficial quartz diorite may cause the large 400γ high. However, the elongate shape of this high suggests that the quartz diorite, whose southernmost extent coincides with the south slope of the high and whose northernmost extent coincides with the table on the north side, may be the cause of the anomaly. The quartz diorite of the Cucamonga Peak area is apparently much less magnetic than that to the south. Geologic cross sections extending into the northern part of the anomaly (pl. 1) and slightly to the west (Hsu, 1955) indicate a northerly dip of the fault planes and reveal that the southernmost diorite may be structurally distinct from other rocks of this area.

Additional surface rocks as far south as the Cucamonga fault zone include granodiorite, mylonite, and Precambrian igneous and metamorphic rocks (Rogers, 1969). A model of this structure (fig. 5) seems to fit the observed data well except for the north side, which requires further adjustment.

Within the Sheep Mountain Wilderness study area, underlain by the weakly magnetic Pelona Schist and mylonitic rocks, are four magnetic anomalies, three of which are of inconsequential magnitude. The fourth high (H-523, pl. 1), which occurs on the east-central edge of this area, most certainly correlates in part with the complex of quartz diorite and gneissic rocks, whereas the magnetic gradient extending to the west reflects the contrast in magnetization of these rocks with that of the weakly magnetic Pelona Schist.

This model adequately explains the observed magnetic anomalies of these two areas as the result of extensions of the exposed rocks to several miles (kilometers) depth. Consequently, the aeromagnetic data do not favor further investigation of the mineral-resource potential of the study area.

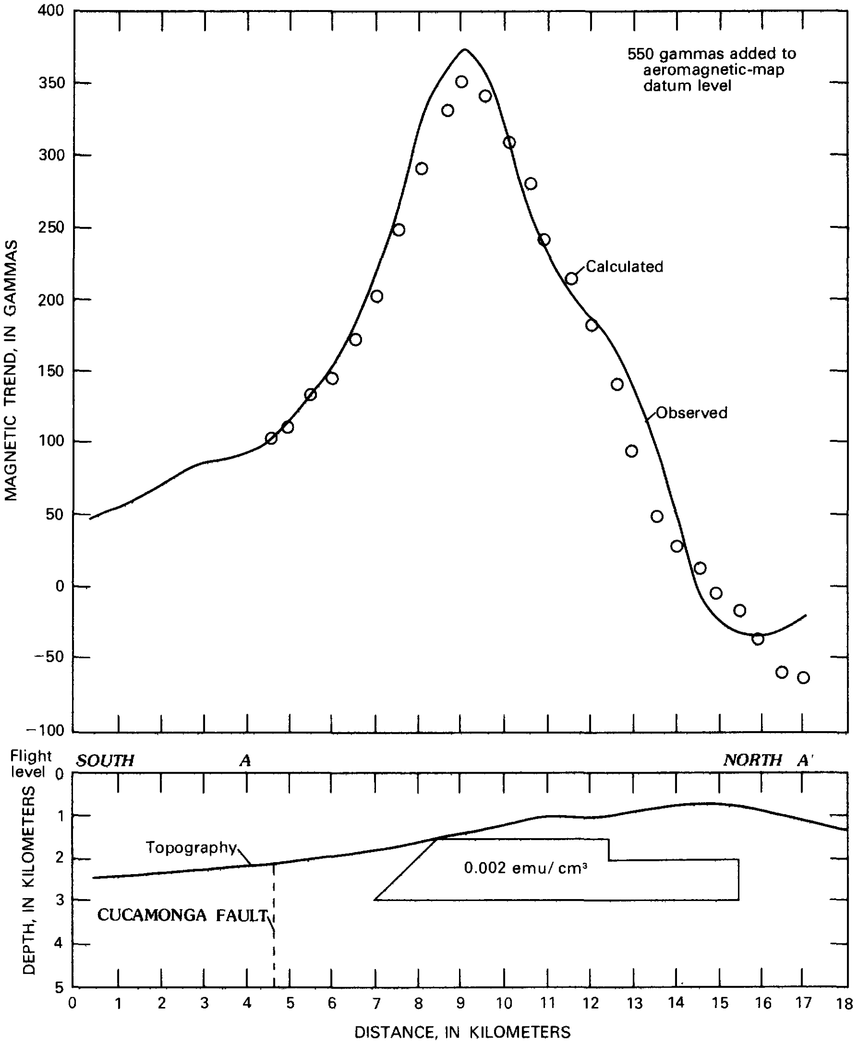

FIGURE 5.—Magnetic profile of Cucamonga Wilderness along cross section *A-A'* (pl. 1). Profile south of *A* is inferred from south corners of map and from mapping by Hanna and others (1972).

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Geologic and Geochemical Evaluation of Mineral Resources of the Sheep Mountain Wilderness Study Area and the Cucamonga Wilderness and Additions, Los Angeles and San Bernardino Counties, California

By JAMES G. EVANS, U.S. GEOLOGICAL SURVEY

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By JAMES G. EVANS, U.S. GEOLOGICAL SURVEY

INTRODUCTION

The mineral-resource potential of the Sheep Mountain Wilderness study area and the Cucamonga Wilderness and additions has been evaluated by examination of the rocks, by investigation of the geologic features that control the occurrence of metals, and by geochemical sampling. Rocks and stream sediment in the study areas were sampled during the geologic field studies described in the first chapter of this volume.

A total of 297 samples were collected for chemical analysis (see pl. 2 for localities): 8 of stream pebbles, 163 of stream sediment (135 fine stream sediments and 28 pan concentrates), and 126 of outcrops. Rock samples included fresh and unaltered rocks, altered rocks, veins, and fault breccia. Outcrops were inspected for sulfide minerals (pyrite, chalcopyrite, and galena), malachite, iron stains, and other signs of mineralization. The 1 to 2-lb (0.5-1 kg) samples of fine stream sediment included, where possible, significant amounts of clay and silt. Rock fragments in gravel bars were examined, and fragments showing staining, alteration, or veining were sampled. Pan concentrates were prepared from 5- to 10-lb (2.5-5 kg) samples of fine to coarse sand and gravel collected from localities throughout the study areas—where possible, from gravel bars. Large pebbles and cobbles were removed after washing the fine material from the sample into the pan.

Rock and stream-sediment data were stored on magnetic tape and are available through the U.S. Department of Agriculture, National Technical Information Service (McDanal and others, 1977).

Fine-stream-sediment samples were taken from the mouths of most tributaries to the main streams (East Fork, Iron Fork, Prairie Fork, Vincent Gulch, Cattle Canyon, Coldwater Canyon, and Cow Canyon) in the Sheep Mountain Wilderness study area. The main canyons have a large bedload, the channels are very broad (greater than 20 ft [7 m]), and in many places the fine-sediment fraction has been washed between large boulders. The large canyons themselves were not sampled because it was believed that the large bedload would mask any anomalous concentrations of elements and minerals entering the main canyons. Many tributaries to the Fish Fork were not sampled because of the numerous cliffs and waterfalls in the middle and upper parts of the canyon. Tributaries to the major streams in the easternmost San Gabriel Mountains were sampled (San Antonio Canyon, Cucamonga Canyon, Deer Canyon, Day Canyon, and the three forks of Lytle Creek); the upper part of Cucamonga Canyon was not sampled in detail because of its inaccessibility.

All analytical values for gold, tungsten, silver, arsenic, and zinc are listed (tables 1-4) without statistical analysis because few samples contained any detectable quantities of these elements. However, samples containing barium, copper, lead, and mercury were more numerous, and these analytical results were treated by standard statistical methods to determine background and threshold levels (Lepeltier, 1969). The sample data were evaluated by comparing the analytical results for the elements in each sample with geometric-mean values (background) for the elements in all samples of the same rock type; sufficiently high values were classified as anomalous (greater than or equal to the threshold value). Determination of an anomalous value depends on the rock type and the kind of sample, as well as on the analytical results. In this study the analytical differences among the major rock types (gneiss, quartz diorite, the Pelona Schist, and mylonitic rocks) were small. Consequently, the background and threshold levels for many elements in these rocks, including barium, copper, lead, and mercury, do not differ appreciably, and so minor variations in analytical values from one rock type to another can be ignored here.

Acknowledgments.—All fine-stream-sediment, pan-concentrate, and rock samples were sent to the U.S. Geological Survey laboratory in Denver, Colo., for spectrographic analyses of 30 elements by H. G. Neiman, M. J. Malcolm, and N. M. Conklin; and for atomic-absorption analysis of gold by Jim Crock, A. W. Haubert, P. Guest, and L. Lee. The rock and fine-stream-sediment samples were analyzed by mercury detector by J. D. Hoffman and by wet oxidation and

atomic absorption by J. A. Thomas and J. Gardner. In addition, 60 samples (16 of rock and 44 of fine stream sediment) were tested for lithium by atomic absorption by T. Lee, J. D. Hoffman, L. Lee, and P. Guest. Also, 23 selected samples were analyzed for uranium and thorium by neutron activation by H. T. Millard, Jr., R. J. Knight, A. J. Bartel, J. P. Hemming, R. J. White, R. J. Vinnola, and E. L. Brandt. Bromoform was used to separate the heavy minerals from pan concentrates, which were then analyzed by spectrographic and atomic-absorption methods.

GEOCHEMICAL DATA

GOLD

Gold has been the main target of prospecting and mining activity in the Sheep Mountain Wilderness study area. Most gold production in the area came from placer mining along the East Fork of the San Gabriel River (see next chapter in this volume). No gold is mined in the area today, but many visitors to the area pan for gold. Presumably, much of the gold recovered from placer deposits in the East Fork was derived from gold-bearing veins in the schist and mylonite.

Almost a third of the samples contain detectable amounts of gold (lower limit of detection, 0.05 ppm). Because the ordinarly crustal abundance of gold is estimated at 0.003 to 0.004 ppm (Jones, 1968, p. 3; Tan and Chi-lung, 1970, p. 782), any amount of gold detected in the rock and fine-stream-sediment samples is considered anomalous.

Gold concentrations in the rock samples, even in the most altered rock and vein material, are generally low (table 1), and the localities of these samples are widely scattered (fig. 6). Nearly all gold concentrations of at least 1 ppm in rock are at gold mines. Although most of the mines in the area are in mylonite and the Pelona Schist, only five rock samples containing gold are of these two rock types. Gold in detectable amounts occurs in samples of altered rock and quartz veins in the vicinity of the Allison (0.36 ppm), Baldora (max 0.13 ppm), Big Horn (max 21.3 ppm), Eagle (3.23 ppm), and Native Son (max 3.03 ppm) mines. Approximately a third of the rock samples containing gold are from veins and dikes in gneiss, diorite, and migmatite above the mylonite zone of the Vincent thrust. Analyses of samples of breccia from the Native Son mine in the Punchbowl fault zone indicate a gold potential for part of the fault zone outside the Sheep Mountain Wilderness study area. Gold in low concentrations (max 0.23 ppm) was detected in rock samples along part of the San Gabriel fault zone.

Gold was detected at low concentrations in about 7 percent of the fine-stream-sediment samples. In parts of the Mine Gulch and Vincent Gulch areas, gold in fine stream sediment may be derived mainly from mining in the Big Horn mine area. However, although the main

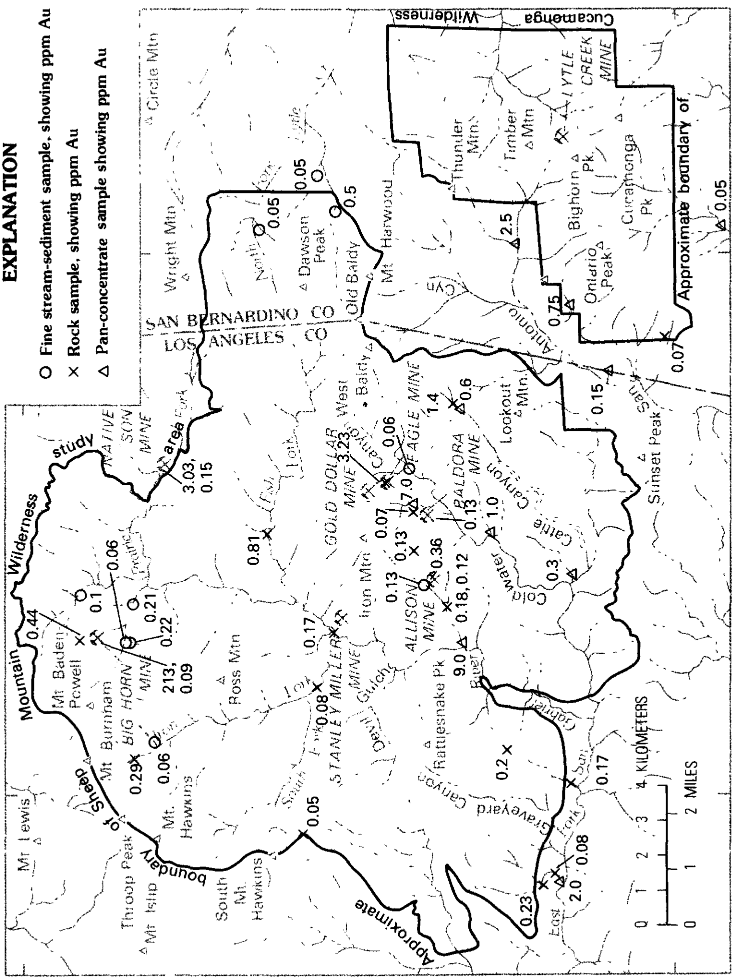

FIGURE 6.—Localities of samples containing at least 0.05 ppm Au.

branch of Mine Gulch and one of its tributaries contain gold, they have not been contaminated by mine debris; these drainages, as well as an adjoining tributary to the Iron Fork, constitute one gold target. The source of the gold may be an extension of the mineralized zone along the Vincent thrust southward and westward of the Big Horn mine. In Allison Gulch, gold in fine stream sediment occurs above the Allison mine and indicates gold-bearing veins in the mylonite. Gold is present in fine stream sediment in the headwaters of Coldwater Canyon and in three streams on the east side of Dawson Peak; no mining from these drainages is known. In the upper part of Coldwater Canyon, the most likely host for gold is the breccia zone along the Weber fault. At Dawson Peak, gold occurs in the Pelona Schist; the fine-stream-sediment sample containing the highest gold concentration (0.5 ppm) came from one of the streams draining the east side of Dawson Peak.

Detectable amounts of gold were found in 32 percent of the pan-concentrate samples, but no gold was visible in the concentrates under microscopic examination. In the eastern San Gabriel Mountains, pan-concentrate samples seem to be more sensitive indicators

TABLE 1.—*Summary of gold analyses and types of rocks containing gold*

Sample type	Number of samples containing at least 0.05 ppm Au	Maximum value of Au (ppm)	Value of Au in rock sample (ppm)
Fine stream sediment	10	0.5	--
Pan concentrate	10	9.0	--
Rock	23	21.3	--
Breccia	3	--	0.05
		--	.08
		--	.15
Quartz-siderite vein	3	--	.08
		--	.17
		--	.23
Muscovite-chlorite schist with hematitic alteration (Pelona Schist)	2	--	.17
		--	.17
Quartzite (Pelona Schist) with hematitic veins	1	--	.81
Mylonite with hematitic alteration	2	--	.13
		--	.36
Malachite vein	1	--	1.4
Quartz vein	7	--	.13
		--	.18
		--	.2
		--	3.23
		--	.13
		--	.07
		--	3.03
Pegmatite dike	1	--	.07
Fractured latite with hematite veins	3	--	21.3
		--	.09
		--	.44

of gold than are fine-stream-sediment samples. However, the time consumed in obtaining numerous pan-concentrate samples is great, and gold concentrations that are so small as to be detectable only in pan-concentrate samples may represent concentrations near the crustal abundance. In this study the occurrence of at least 1 ppm Au in pan concentrates from basins where there are no mines is considered high enough to indicate possibly anomalous amounts of gold upstream from the sample sites. The relatively high values of gold in the pan concentrates from Dry gulch (7 ppm) and Allison Gulch (9 ppm) are probably due to mining upstream. At least 1 Au also occurs in pan concentrates from canyons in which no mining is known: Susanna Canyon (2 ppm), Fossil Canyon (1 ppm), and Cedar Canyon (2.5 ppm); these drainages are designated as gold targets. A small part of the Susanna Canyon target and two-thirds of the Cedar Canyon target lie outside the boundary of the study area. The gold in the pan concentrate from Susanna Canyon may be from gold-bearing veinlets in fractured rock of the San Gabriel fault zone.

Because fine-stream-sediment samples are more representative of the average rock composition of drainage basins than are pan concentrates, those gold targets designated on the basis of detectable amounts of gold in fine stream sediment are considered to be the most important. Therefore, there may be a moderate mineral-resource potential for gold in the Wilderness, chiefly in the Sheep Mountain Wilderness study area.

TUNGSTEN

Scheelite has been mined from veins in quartz diorite and from alluvium in the upper part of Cattle Canyon in the southern part of the Sheep Mountain Wilderness study area. The 17 samples containing detectable amounts of tungsten (lower limit of detection by spectrographic methods, 50 ppm) are also from the Sheep Mountain Wilderness study area, where the element is widely scattered (fig. 7). Although the tungsten typically occurs in fractured or hematitically altered rocks, many samples of similar rock do not contain detectable amounts (table 2). Tungsten is found at the Big Horn and Allison mines; two rock samples containing tungsten from the Allison Gulch-Iron Mountain area also contain gold.

Tungsten was not detected in fine stream sediment, although the element is sparsely distributed in pan concentrates in the Sheep Mountain Wilderness study area. The tungsten in the pan concentrate from Dry Gulch may be derived from mining upstream from the sample site. Tungsten is associated with gold in pan concentrates from the upper parts of Coldwater and Cattle Canyons. The highest tungsten concentrations are in pan concentrates from the upper part of Cattle

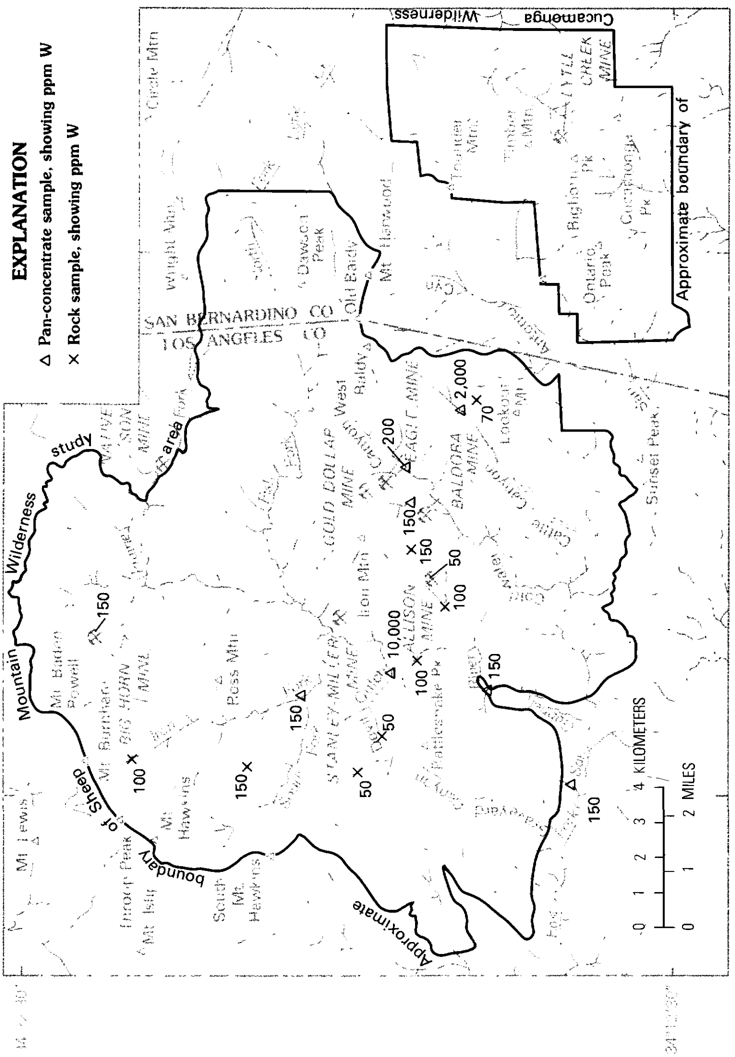

FIGURE 7.—Localities of samples containing at least 50 ppm W.

TABLE 2.—*Summary of tungsten analyses and types of rocks containing tungsten*

Sample type	Number of samples containing at least 50 ppm W	Maximum value of W (ppm)	Value of W in sample (ppm)
Pan concentrate	7	10,000	--
Rock	10	200	--
Muscovite-chlorite schist with hematitic alteration (Pelona Schist)	1	--	100
Gneiss with hematitic alteration	3	--	50
		--	50
		--	150
Fractured mylonite	2	--	50
		--	150
Fractured latite	1	--	50
Quartz vein	2	--	70
		--	100
Siderite vein	1	--	100

Canyon (2,000 ppm) at the Curtis claims, and from the mouth of Devil Gulch (10,000 ppm). Scheelite was identified in these and in other tungsten-bearing pan concentrates; several scheelite occurrences in Cattle Canyon are described in the next chapter of this volume. The amount of scheelite in the pan concentrate from Devil Gulch indicates a large or nearby source in the gulch; minor amounts of tungsten occur in rocks of the gulch, but no clear indications of large deposits of tungsten ore were found in this investigation. A potential for tungsten in the lode deposits in Cattle Canyon is suggested by the occurrence of scheelite in alluvium and in talus cones, and in Devil Gulch by the high concentration of tungsten in the pan concentrate from the mouth of the gulch.

SILVER

Silver has been produced from gold mines in the Sheep Mountain Wilderness study area. In this study, silver was found in detectable amounts in five rock and five pan-concentrate samples (lower limit of detection by spectrographic methods, 0.5 ppm). Because the crustal abundance of silver is estimated at 0.07 ppm (Vinogradov, 1962), any detectable amounts of silver are considered to be anomalous.

Silver occurs in association with arsenic and lead in two quartz veins, one of which is in the Pelona Schist at the Eagle mine (fig. 8). A rock sample containing the highest silver concentration (table 3) was obtained from a quartz vein on a ridge south of Rattlesnake Peak. No silver was detected in fine-stream-sediment samples. Pan concentrates containing silver in association with gold were obtained from

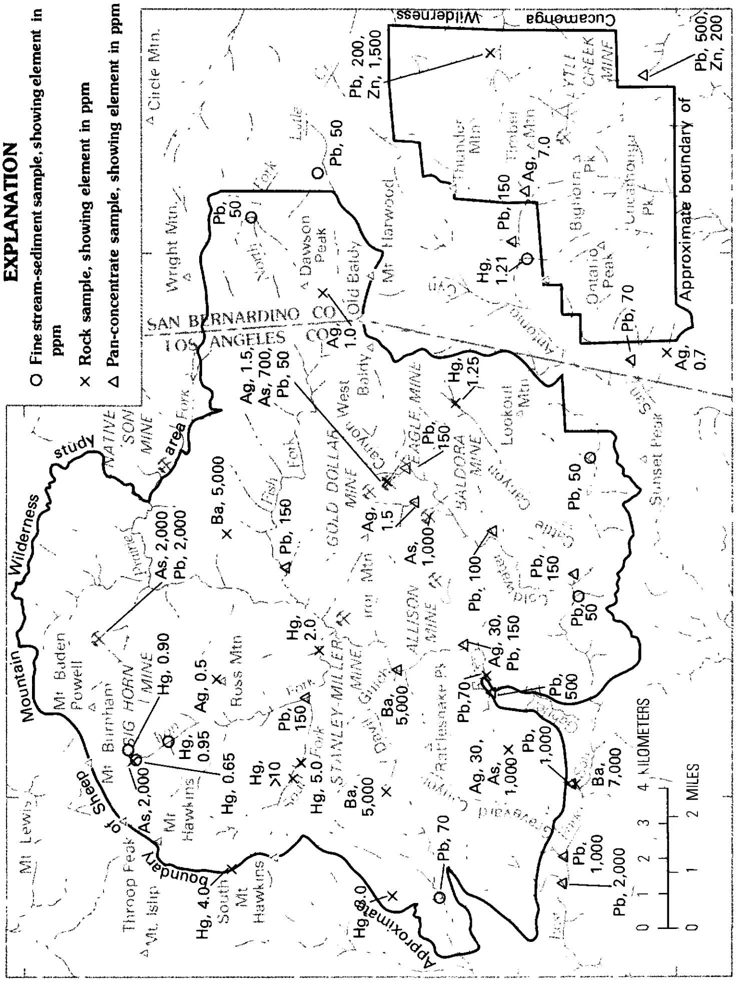

FIGURE 8.— Localities of samples containing arsenic (As), silver (Ag), zinc (Zn), and anomalous amounts of barium (Ba), lead (Pb), and mercury (Hg).

TABLE 3.—*Summary of silver analyses and types of rocks containing silver*

Sample type	Number of samples containing at least 0.5 ppm Ag	Maximum value of Ag (ppm)	Value of Ag in sample (ppm)
Pan concentrate	5	30	--
Rock	5	30	--
Latite	1	--	1
Monzonite porphyry with hematitic alteration	1	--	.5
Quartz vein	3	--	.7
		--	1.5
		--	30

Allison Gulch and Dry Gulch; both elements may have been introduced into these drainages by mining upstream from the sample sites. Silver occurs in association with lead and zinc in pan concentrate from the upper part of Day Canyon in the southeastern part of the Cucamonga Wilderness.

No potentially economic deposits in which silver is the chief commodity are known in the study area, and none are indicated by the sample data.

COPPER

Copper occurs in small amounts in most rock and stream-sediment samples. Background copper values for the major rock types (gneiss, quartz diorite, the Pelona Schist, and mylonitic rocks) are low, ranging from 7 ppm in gneiss and quartz diorite to 20 ppm in the Pelona Schist. Most quartz, hematite, and siderite veins are low in copper (background, 15 ppm); quartz monzonite, latite, and pegmatite dike rocks are very low in copper (background, 2 ppm); and metasedimentary rocks in the migmatite of the southern part of the Cucamonga Wilderness are relatively high in copper (most samples contain at least 50 ppm) in comparison with other rocks.

Because the background level for copper in all the rock samples is low and does not vary significantly, the samples were grouped to determine a threshold level for anomalous copper concentrations. Similarly, the fine-stream-sediment samples were not subdivided into groups defined by the rock types underlying the drainages sampled because the range of background values in the major rock types is small and copper concentration are low. The background level for copper in rock samples (10 ppm) is slightly lower than that in fine-stream-sediment samples (20 ppm); threshold levels of anomalous copper concentrations are the same (70 ppm) for both types of sample. Pan concentrates are somewhat enriched in copper (background, 50 ppm; threshold, 100 ppm).

Anomalous copper concentrations are widely distributed within and near the two areas (fig. 9). Analytical data on rock samples from the Allison and Dry Gulch areas suggest that the copper occurs in proximity to gold deposits. Two veins of quartz and quartz-malachite are high in copper (1,000 to 2,000 ppm, respectively) and also contain gold but are not close to mines. Some rock samples (table 4) containing silver and tungsten also contain at least 70 ppm Cu. Three samples of metasedimentary rocks from the southwestern part of the Cucamonga Wilderness, containing from 70 to 200 ppm Cu, may not be anomalous in the element because most of this type of rock contains at least 70 ppm Cu and the precise distribution of copper in the rocks is not clearly known. Quartz and quartz-malachite veins contain at least 1,000 ppm Cu in scattered isolated discontinuous zones, thinner than 3 ft (1 m).

Fine stream sediment containing at least 70 ppm Cu is sparsely scattered in the Sheep Mountain Wilderness study area but does not

TABLE 4.—*Summary of copper analyses and types of rocks containing copper*

Sample type	Number of samples containing at least 70 ppm Cu	Maximum value of Cu (ppm)	Value of Cu in sample (ppm)
Fine stream sediment	7	100	--
Pan concentrate	11	200	--
Rock	22	5,000	--
Quartz-malachite or quartz vein	6	--	70
		--	1,000
		--	1,500
		--	2,000
		--	3,000
		--	5,000
Breccia	2	--	150
		--	500
Siderite vein	1	--	100
Chlorite schist	2	--	70
		--	150
Pelona Schist with hematitic alteration	1	--	300
Gneiss with hematitic alteration	3	--	70
		--	150
		--	200
Metasedimentary rock	3	--	70
		--	150
		--	200
Hematite vein	2	--	150
		--	200
Pegmatite	1	--	100

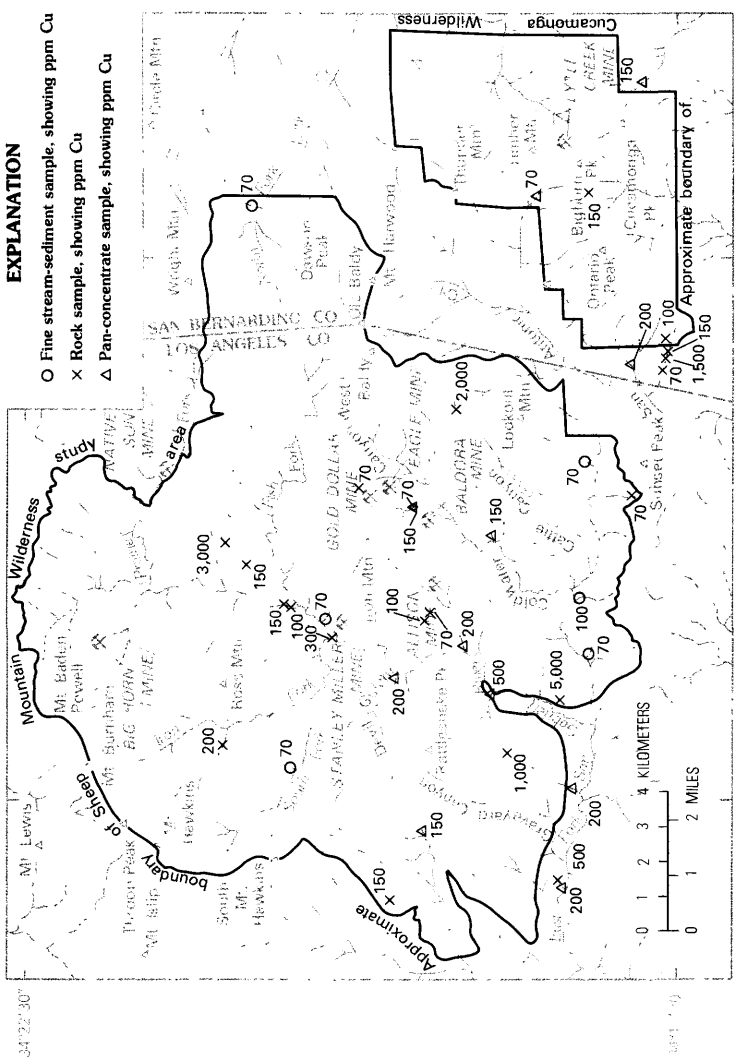

FIGURE 9.—Localities of samples containing anomalous amounts of copper.

outline areas that appear to be especially rich in copper (max 100 ppm). For example, anomalous amounts of copper were not detected in stream-sediment samples from the area of the Lytle Creek copper mine in the central part of the Cucamonga Wilderness.

Pan concentrates, though richer in copper than other sample types, do not contain noteworthy amounts of copper (max 200 ppm). The distribution of pan concentrates containing 100 ppm Cu reinforces the association of copper with gold because four of the pan concentrates containing anomalous amounts of copper also contain gold. In the Allison and Dry Creek areas the copper may have been introduced from mining upstream.

The sample data generally show weakly anomalous copper concentrations scattered broadly across the study area; a few veins relatively rich in copper do not appear to indicate large copper deposits in the area. Conceivably, minor amounts of copper could be recovered from gold mining, as has been done in the past, but there appears to be no potential in the study area for deposits in which copper is the chief target.

BARIUM

A few anomalous concentrations of barium are scattered throughout the Sheep Mountain Wilderness study area. All the samples studied (fig. 8) contain barium at above the lower limit of detection by spectrographic methods (20 ppm). The background level of barium for each of the major rock types (gneiss, quartz diorite, the Pelona Schist, mylonitic rocks, and granitoid rocks) is 1,000 ppm. The background level of barium for quartz, hematite, and siderite veins is lower (300 ppm), although the highest barium concentration measured (7,000 ppm) occurs in a quartz-siderite vein. The threshold value for anomalous concentrations of barium in rock is 5,000 ppm. Stream-sediment samples generally contain amounts of barium equal to or greater than the background for rock (fine-stream-sediment background, 700 ppm; pan-concentrate background, 300 ppm). Barite, which was identified in some of the pan concentrates, is the most likely source of the barium. One pan concentrate has a barium concentration of 5,000 ppm, which is probably anomalous.

At least 5,000 ppm Ba is associated: (1) with gold in a quartz-siderite vein in Williams Canyon, (2) with anomalous amounts of copper in quartzite of the Pelona Schist, and (3) with tungsten in the pan concentrate from Devil Gulch. Anomalous concentrations of barium also occur in gneiss of the Devil Gulch area and in andesite of the east boundary of the Sheep Mountains Wilderness study area. No large barium anomaly is indicated by the sample data.

LEAD

Lead-bearing minerals occur (fig. 8) at the Big Horn mine (galena) and at the Blew Jordam prospect, southeast of the Cucamonga Wilderness. Lead occurs in detectable amounts in nearly all the stream-sediment samples and in 101 of the rock samples (lower limit of detection by spectrographic methods, 5 ppm). The background levels for the major rock types are similar (gneiss, quartz diorite, and the Pelona Schist, 15 ppm; mylonitic rocks, 10 ppm). Veins have lower (7 ppm), and granitoid rocks higher (20 ppm), background levels. In all rock types the range of lead concentrations is small. On an average, rocks have a background level of 15 ppm and a threshold level of 50 ppm; fine stream sediments have identical background and threshold concentrations; and pan concentrates are somewhat richer in lead (background, 50 ppm; threshold, 70 ppm).

Lead in anomalous amounts is uncommon in rock samples from the study area. At least 50 ppm Pb is associated: (1) with arsenic and silver in a quartz vein at the Eagle mine, (2) with arsenic and tungsten in a latite dike at the Big Horn mine, and (3) with zinc in oxidized metasedimentary rocks in the Middle Fork of Lytle Creek. The highest concentration of lead in rock (2,000 ppm) is in a latite dike at the Big Horn mine.

At least 50 ppm Pb in fine-stream-sediment samples and at least 70 ppm Pb in pan-concentrate samples are variously associated with copper, gold, silver, and zinc. Four pan concentrates contain at least 500 ppm Pb: from Shoemaker Canyon (500 ppm), Susanna Canyon (2,000 ppm), Graveyard Canyon (1,000 ppm), and Williams Canyon (1,000 ppm). Slivers of metallic lead, probably from bullets, were identified in the sample from Susanna Canyon. All these canyons are or have been readily accessible from the main paved road along the East Fork and were much frequented by shooters. It seems likely that the high lead concentration in these pan-concentrate samples are due to human activity and not to naturally occurring lead-bearing minerals in the area. Fifty parts per million lead occurs in the fine-stream-sediment sample from a tributary to Bichota Canyon road, which is a much-used shooting range. The broad, weak lead anomaly outlined by stream sediment in the southeastern part of the Sheep Mountain Wilderness study area may also reflect human activity because that is one of the most accessible parts of the study area for visitors to the mountains.

ARSENIC

Four rock samples from the Sheep Mountain Wilderness study area contain detectable amounts of arsenic (lower limit of detection by spectrographic methods, 200 ppm). Three of the samples, from two quartz veins and a latite dike rock in the Big Horn, Baldora (Widco), and Eagle mines, contain 700 to 2,000 ppm As (fig. 8); two of these samples also contain anomalous amounts of lead. The arsenic-bearing quartz vein south of Rattlesnake Mountain contains gold, silver, and anomalous amounts of copper as well. Arsenic, therefore, is a minor element associated with mineralization in the study area but does not by itself form significant deposits, although its presence in gold ore may increase the cost of gold extraction.

LITHIUM

The 60 samples analyzed for lithium contain concentrations that are generally less than or equal to the normal crustal abundance (20 ppm for the upper crust; Heier and Billings, 1969). The greatest concentration of lithium measured was 63 ppm, in a quartz vein. No mineral-resource potential for lithium in the study area is suggested by the sample data.

MERCURY

Mercury was detected in anomalous amounts (0.6 ppm in fine stream sediment, 1 ppm in rock) in a few widely scattered samples, most of which are from the Sheep Mountain Wilderness study area (fig. 8). Most of the rocks anomalous in mercury are hematitically altered; one sample contains malachite, and some fine-stream-sediment samples anomalous in mercury also contain anomalous amounts of copper. In general, however, the broad mercury anomaly outlined in the Iron and South Forks is spatially unrelated to anomalous concentrations of other elements in that area. No indication of a potential mercury deposit is inferred from the geochemical data.

ZINC

Two samples containing detectable amounts of zinc (lower limit of detection by spectrographic methods, 200 ppm) are from the Cucamonga Wilderness: oxidized quartzite in the Middle Fork of Lytle Creek (1,500 ppm), and pan concentrate from the upper part of Day Canyon (200 ppm) (fig. 8). Each sample also contains 200 ppm Pb; the pan concentrate contains a small amount of silver as well. In the study area, zinc is a minor element of no economic importance.

URANIUM AND THORIUM

A total of 13 rock and 10 fine-stream-sediment samples were analyzed for uranium and thorium by neutron activation, after lanthanum, niobium, scandium, and yttrium were detected during the spectrographic analyses. These elements are commonly associated with uranium and thorium in heavy minerals from igneous and metamorphic terranes, and so those samples exceptionally rich in these elements were further analyzed for uranium and thorium. Of the 13 rock samples, 3 are pegmatite from dikes, 3 are mylonite, 4 are metasedimentary rocks from the southern part of the Cucamonga Wilderness, 2 are gneiss, and 1 is the Pelona Schist.

The uranium content of the rock samples ranges from 0.78 to 22.73 ppm; the highest value occurs in a pegmatite sample. In all, 11 samples contain less than 4 ppm U, which is equivalent to the crustal abundance (2-4 ppm U; Finch and others, 1973, p. 465). The uranium content of the 10 fine-stream-sediment samples ranges from 0.83 to 5.35 ppm; 7 of these samples contain less than 3 ppm U, which apparently reflects the uranium content of the rocks. The highest uranium value obtained is still below the average uranium content of the Chattanooga Shale of eastern Tennessee (35 ppm U; Finch and others, 1973, p. 462), a large but submarginal uranium resource. Therefore, on the basis of the sample data, no potential for a uranium deposit is indicated in the study area.

The thorium content of the rock samples ranges from 4.31 to 30.29 ppm; the quartzite from metasedimentary rocks is richest. In all, 11 samples contain less than 20 ppm Th, which is equivalent to the crustal abundance (6-13 ppm Th; Staatz and Olson, 1973, p. 471). The fine-stream-sediment samples contain from 7.81 to 18.76 ppm Th, which seems to reflect the concentration of thorium in the rocks. These amounts of thorium are small in comparison with the average grade of the Conway Granite of New Hampshire (56 ppm U; Adams and others, 1962, p. 1902), a submarginal thorium resource. No potential for a thorium deposit in the study area is indicated by the sample data.

OTHER COMMODITIES

MONAZITE

Monazite, a possible source of thorium and the rare earths cerium, lanthanum, and yttrium, is present in all pan concentrates. All but one of the samples contain 35 volume percent or less monazite, which could have been derived from the low concentrations of monazite ordinarily disseminated in igneous and metamorphic rocks. The high concentration of monazite (70 volume percent) in the pan concentrate from Dry Gulch may be due to mining upstream from the sample site; the monazite could be related to mineralization in that area. The bedrock source of the monazite has not been identified; latite dikes, certain quartz veins, mylonite, or the Pelona Schist could be the host. However, small deposits or concentrations of monazite may be associated with scattered dikes and quartz veins, or with mylonite and the Pelona Schist. It is unlikely that small or low-grade deposits of monazite, as inferred for the Dry Gulch area, would be economically competitive with the larger and richer monazite sources outside the study area (Staatz and Olson, 1973).

GRAPHITE

Small bodies of graphite schist occur in migmatite near the southwest corner of the Cucamonga Wilderness. Although locally the graphite constitutes as much as 35 percent of the schist, graphite schist makes up less than 1 percent of the metasedimentary rocks. Much larger deposits occur in migmatite immediately west of the Wilderness boundary, and in the Placerita Formation of Miller (1934) in the San Fernando quadrangle, 30 mi (48 km) west of the Cucamonga Wilderness, where the graphite has been mined (Oakeshott, 1958, p. 112). There appears to be no mineral-resource potential for graphite in the study area.

STONE

Deposits of high-quality ornamental stone were not found in the study area; most of the rocks are thoroughly fractured and faulted and thus unsuitable for building stone. Parts of the Pelona Schist could be used for flagstone, but this rock can be obtained from the schist outside the Wilderness areas. Vein quartz, for possible use as a source of silica or as decorative rock, occurs in small scattered veins of no economic importance. Lenses of fractured highly impure calcite and dolomite marble occur in the migmatite of the southern part of the Cucamonga Wilderness. The sparsity of the marble, its fractures and impurity, and its location in extremely rugged terrain eliminate it from consideration for use in construction or industry.

SAND AND GRAVEL

Deposits of sand and gravel occur in all the major canyons in the study area. However, much larger and more accessible deposits are present farther down the San Gabriel River and outside both the areas.

FOSSIL FUELS

No fossil fuels were found in either of the areas. Ordinarily, such deposits do not occur in such crystalline terrane as that which underlies the two areas. However, a small amount of oil was produced from fractured crystalline rocks in and near the San Gabriel fault zone in the Placerita oilfield, San Fernando quadrangle (Oakeshott, 1958, p. 121): the oil probably migrated into the crystalline rock from nearby

Tertiary strata. Petroliferous Tertiary strata do not occur near the study area, and the Tertiary and Quaternary faults, including the San Gabriel fault in the southern part of the Sheep Mountain Wilderness study area, do not have oil seeps. Therefore, there is no potential for oil or other fossil fuels in the study area.

GEOTHERMAL RESOURCES

No hot springs, geysers, or other surface indications of a concentration of geothermal energy beneath either of the areas were found. Most geothermal areas in the world are associated with Pleistocene or Holocene volcanism and commonly are rhyolitic in composition. In the study area, however, the youngest rocks are Oligocene and post-Miocene andesite dikes. The geology of the area, therefore, suggests no potential for geothermal resources.

CONCLUSIONS

The Sheep Mountain Wilderness study area and the Cucamonga Wilderness and additions may have a moderate potential for the discovery of lode gold and tungsten (scheelite) deposits. Silver, copper, and lead may be produced with the gold but, by themselves, do not appear to form significant deposits. Barium and mercury are nearly ubiquitous in small amounts, but no indications of large deposits were found. Arsenic and zinc are minor elements in the area. No potential was found for graphite, monazite, or marble. Sand, gravel, and flagstone are available in more accessible deposits outside the study area. No ornamental or building stone occurs, nor is any potential for fossil or nuclear fuels or for geothermal resources indicated.

GOLD

Seven lode-gold targets occur in the study areas: the southwestern part of the Mine Gulch area, the upper part of Allison Gulch, the upper part of Coldwater Canyon, the eastern part of the Dawson Peak area, Susanna Canyon, Fossil Canyon, and Cedar Canyon. The first four targets are based on the occurrence of detectable amounts of gold in fine stream sediment, and the last three on the occurrence of 1 ppm Au in pan concentrates. All targets may have potential for the discovery of new deposits (see "Summary" to this volume for definition of levels of potential).

TUNGSTEN

Two tungsten (scheelite) targets occur in the Sheep Mountain Wilderness study area: the upper part of Cattle Canyon, and Devil Gulch. Both targets may have potential for lode deposits.

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Economic Appraisal of Mineral Resources of the Sheep Mountain Wilderness Study Area, Los Angeles and San Bernardino Counties, California

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NICHOLAS T. ZILKA, U.S. BUREAU OF MINES

MINERAL RESOURCES OF THE SHEEP MOUNTAIN WILDERNESS STUDY AREA AND THE CUCAMONGA WILDERNESS AND ADDITIONS, LOS ANGELES AND SAN BERNARDINO COUNTIES, CALIFORNIA

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By JAMES RIDENOUR, STEVEN W. SCHMAUCH, and NICHOLAS T. ZILKA
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ECONOMIC APPRAISAL

Identified resources of gold and tungsten occur in the Sheep Mountain Wilderness study area in fault and shear zones and in placer deposits derived from these zones. The Big Horn mine contains an estimated 1.2 million tons (1.1 million t) of gold-, silver-, copper-, and lead-bearing quartz; it is the only mine in the study area that has been systematically sampled by the owners. The mineralized zone lies in the Vincent thrust and is the largest lode in the study area. The Stanley-Miller, Baldora (Widco), Gold Dollar, Allison, and Eagle mines have demonstrated resources or potential for the discovery of resources. These occurrences are associated with intense shearing and, generally, with porphyritic granodiorite intrusive rocks. Gold occurs in pockets or shoots in quartz-cemented and -filled shear zones. Systematic exploration and development of these properties have not been conducted, apparently because of the random distribution of ore shoots throughout these bodies. High-grade pockets were evidently mined out after initial discovery, and the mines were abandoned.

Placer gold deposits are too small and of too low a grade to be minable at current prices. Gold has been found in both recent and older alluvium; older alluvium, the remnant of ancestral streams, once contained the metal in relative abundance. Some gold may remain in a few deposits, but those of higher grade have probably been mined out.

Tungsten-bearing rock is currently being recovered in Cattle Canyon from talus cones and alluvium. Four scheelite-bearing fracture zones observed near the head of the canyon, as well as scheelite in talus cones apparently derived from similar occurrences, indicate a potential for the discovery of tungsten lode deposits. Approximately 20 million yd^3 (15 million m^3) of placer gravel is in the canyon; it has not been tested at depth.

SETTING

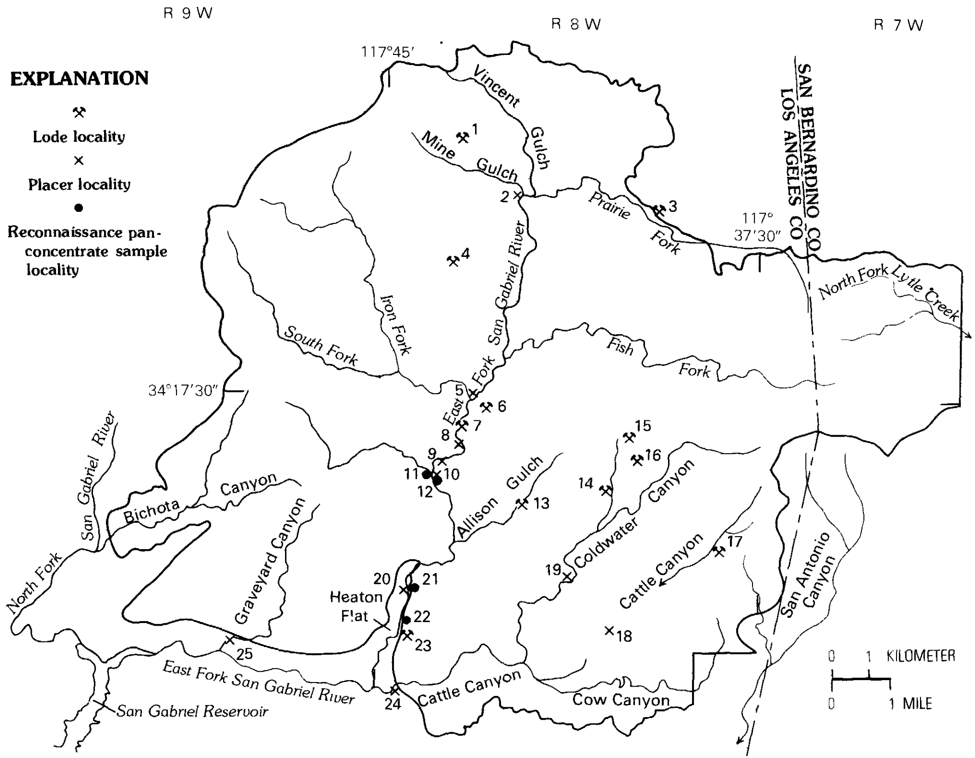
The Sheep Mountain Wilderness study area includes most of the East Fork of the San Gabriel River and small parts of the North Fork Lytle Creek and North Fork San Gabriel River drainages in Los Angeles and San Bernardino Counties. Mines, prospects, and mineralized areas within the boundary constitute the Mount Baldy mining district (fig. 10).

Mining activity began in the 1840's (Clark, 1970) and has continued intermittently. By 1874 more than $2 million in gold had been produced from placer deposits along the San Gabriel River and its tributaries, the most productive deposits occurring along the east-west reach of the river from the San Gabriel Reservoir to below Heaton Flat (Clark, 1970). Gold was found in recent streambeds and in remnants of perched ancient channels.

The search for sources of the placer gold in the late 1800's led to discovery of the Big Horn mine (A. P. Rogers, unpub. data, 1906), which was principally worked during the early 1900's. Other discoveries followed, notably the Allison, Gold Dollar, Baldora (Widco), and Stanley-Miller mines. The historical value of ore from these mines totals nearly $150,000 in gold (table 5). By the early 1900's, 2 placer claims, 15 lode claims, and 2 millsites were patented within the study area, and 4 placer claims were surveyed but not patented. Substantially more gold may have been recovered from these and other deposits before the 1930's, although the claims were worked by small-scale methods. Disastrous flooding in 1938 obliterated nearly all traces of placer-mining activity in the study area.

Recent activity includes a renewed interest in the Big Horn mine—a response to the rapid increase in the price of gold on the world market—and production of scheelite from Cattle Canyon beginning in 1975. Tungsten occurrences are known on lands withdrawn from mineral entry near the head of Cattle Canyon.

The study area is exceedingly rugged and difficult to traverse. Roads into the area have deteriorated and would require reconditioning to support any further mining ventures. Cattle Canyon and Coldwater Canyon roads are the only routes into the interior of the study area accessible by vehicle; trails to most mines are passable only on foot.



Localities
1. Big Horn mine
2. Jumbo-channel placers
3. Native Son mine
4. Blue Jay [No.] 1 and 2 mines
5. Next Best placer
6. Stanley-Miller mine
7. Prospect
8. Chicken Finlay placer
9. Horse Shoe Consolidated placer
10. San Gabriel Mining Co.
11. Reconnaissance placer sample
12. Reconnaissance placer sample
13. Allison mine
14. Baldora (Widco) mine
15. Gold Dollar mine
16. Eagle mine
17. Curtis claims
18. Curtis claims
19. Coldwater Canyon prospect
20. Holly (Dot) placer
21. Reconnaissance placer sample
22. Reconnaissance placer sample
23. Queenie mine
24. Dime Canyon prospect
25. Glen-Marie placer

FIGURE 10.—Mines and prospects in Sheep Mountain Wilderness study area.

TABLE 5.—*Recorded mineral production from lode deposits in the Sheep Mountain Wilderness study area*

[From U.S. Bureau of Mines statistical files. Copper production was 707 lb (321 kg) in 1934 and 650 lb (295 kg) in 1935; lead production was 1,296 lb (588 kg) in 1934]

Year	Mine	Ore		Gold		Silver	
		tons	(t)	troy oz	(g)	troy oz	(g)
1896	Big Horn	?	---	16	(500)	---	---
1903	-do	500	(450)	121	(3,760)	---	---
1904	-do	4,171	(3,784)	597	(18,600)	126	(3,920)
1905	-do	5,028	(4,561)	528	(16,400)	131	(4,070)
1906	-do	6,692	(6,071)	793	(24,700)	147	(4,570)
1907	-do	3,000	(2,700)	485	(15,100)	1,191	(37,040)
1908	-do	5	(4)	3	(90)	---	---
1921	Gold Dollar	90	(82)	20	(620)	3	(90)
1923	-do	25	(23)	11	(340)	3	(90)
1924	-do	50	(45)	26	(810)	4	(120)
1928	-do	50	(45)	10	(310)	2	(60)
1933	-do	50	(45)	6	(190)	1	(30)
	Stanley-Miller	50	(45)	13	(400)	5	(160)
1934	Allison	800	(725)	97	(3,020)	29	(900)
	Big Horn	255	(230)	226	(7,030)	381	(11,850)
	Gold Dollar	200	(180)	19	(590)	4	(120)
	Stanley-Miller	210	(190)	38	(1,180)	10	(310)
1935	Allison	2,013	(1,826)	200	(6,220)	55	(1,710)
	Baldora (Widco)	509	(462)	92	(2,860)	22	(680)
	Big Horn	11,200	(10,160)	777	(24,200)	395	(12,300)
	Gold Dollar	215	(195)	36	(1,120)	6	(190)
1936	Allison	2,835	(2,570)	331	(10,300)	88	(2,740)
	Baldora (Widco)	203	(184)	18	(560)	5	(160)
	Big Horn	200	(180)	155	(4,820)	59	(1,840)
	Gold Dollar	215	(195)	36	(1,120)	6	(190)
1937	Allison	2,066	(1,874)	275	(8,550)	83	(2,580)
	Gold Dollar	300	(270)	35	(1,090)	7	(220)
	Stanley-Miller	359	(326)	6	(190)	5	(160)
1938	Allison	175	(160)	14	(440)	4	(120)
	Gold Dollar	20	(18)	3	(90)	1	(30)
	Stanley-Miller	37	(34)	2	(60)	1	(30)
1939	Baldora (Widco)	500	(450)	55	(1,710)	14	(440)
1940	Allison	1,480	(1,340)	171	(5,320)	44	(1,370)
	Baldora (Widco)	110	(100)	17	(530)	5	(160)
1941	Allison	684	(621)	56	(1,740)	17	(530)
1942	-do	317	(288)	20	(620)	7	(220)
1943	-do	120	(110)	2	(60)	3	(90)
	Total	44,734	(40,582)	5,310	(165,200)	2,864	(89,080)

PREVIOUS STUDIES

Reports on investigations of mineral properties by the California Division of Mines and Geology (Sampson, 1937; Gay and Hoffman, 1954; Clark, 1970) as well as individual company data were used to supplement data collected during the present study.

In 1928 certain lands in Angeles National Forest were withdrawn from mineral entry "***to conserve water resources and to encourage reforestation of the watershed of Los Angeles County" (Public Law 578, 70th Congress). Withdrawn lands within the Sheep Mountain Wilderness study area (fig. 11) total approximately 25,000 acres (10,000 ha), or more than 45 percent of the area. Existing mines were not directly affected, but land withdrawal has probably discouraged further exploration. Lode mining continued during the 1930's, and mineral production was last recorded in 1949 (Gay and Hoffman, 1954). A small amount of placer gold was extracted by vacationers subsequent to the land withdrawal.

Approximately 16,600 acres (6,700 ha), or 32 percent of the study area (fig. 11), is restricted during periods of high fire danger. Special use permits are required at such times for any activity on restricted lands.

METHODS OF EVALUATION

The locations of claims and mineral deposits were determined from mining property files of the Mount Baldy and Valyermo district offices, Angeles National Forest. Lack of time prohibited a search of the voluminous records of the Los Angeles County courthouse to determine the locations of claims within the study area. Owners of mineral properties were contacted, and data concerning the history of their

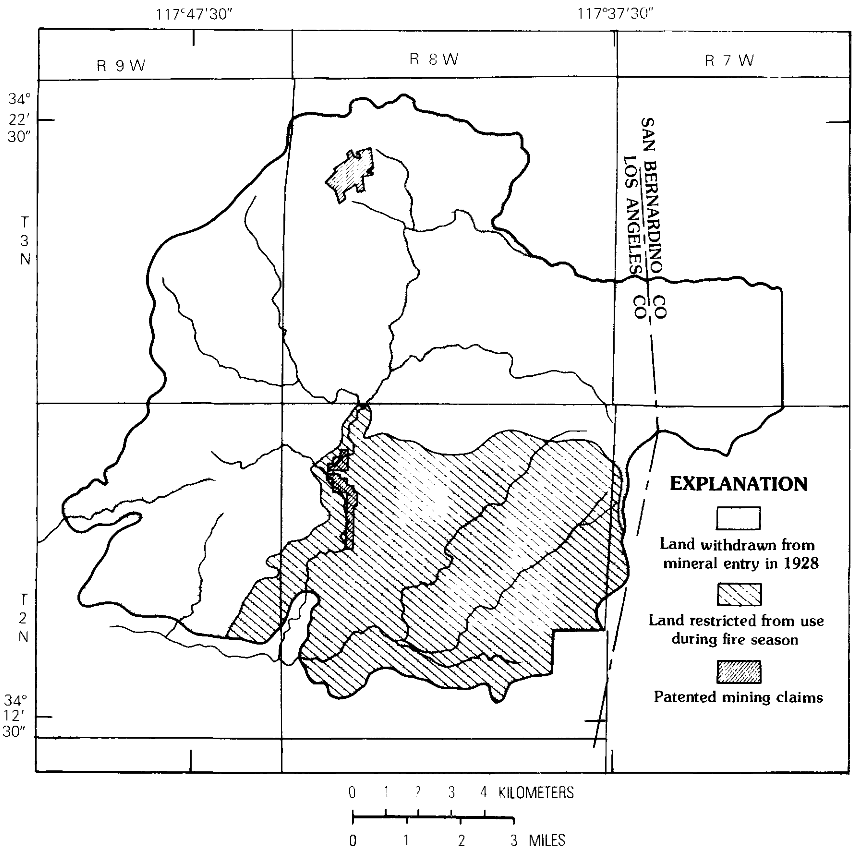


FIGURE 11.—Restricted lands of Sheep Mountain Wilderness study area.

property, production records, and unpublished reports were obtained if available.

Attempts were made to examine all known mines, prospects, and claims. Lode properties were examined and mapped, and samples were taken from all workings, whether mineralized material was apparent or not. Most placer claims were examined by sampling near-surface gravel. Channel samples were taken of some gravel deposits.

A total of 175 lode and 57 placer samples were analyzed. Most lode samples ranged from 5 to 10 lb (2-5 kg) in size and were taken by chipping across veins, mineralized zones, and altered zones. Selected material was taken from stockpiles or dumps of carved workings if no structure was visible. It was assumed that stockpiled material is the richest available at these sites, and that a prospect has little potential for development if stockpile assay values are low. All samples were checked for the presence of radioactive and fluorescent minerals, and most were fire assayed to determine gold and silver content. Metallic values of visible minerals were determined by atomic absorption, colorimetry, or X-ray fluorescence methods. At least one sample from each type of mineralized structure or zone at a property was analyzed by semiquantitative spectrographic methods. If anomalous amounts of elements of economic significance were indicated, the sample was analyzed further by more acurate methods. A selected number of specimens were also examined petrographically.

Samples of gravel assumed to contain gold were collected and partially processed in a 14-in. (36 cm) gold pan; pan concentrates were further processed on a laboratory-sized Wilfley table. Table concentrates were treated with acid, base washed, and amalgamated to determine recoverable gold. Residual material was fire assayed for gold content.

Gravel sampled for scheelite content was screened on site to minus 1 1/2 in. (3 cm); bulk samples constituted 0.4 ft^3 (0.01 m^3) in volume. In the laboratory, these samples were sieved through Tyler screens ranging in size from minus 12 to plus 200 mesh; table concentrate from selected fractions was then analyzed for tungsten trioxide (WO_3).

ECONOMIC CONSIDERATIONS

The following generalizations are intended to familiarize the reader with some of the factors relevant to mining. Production costs have a wide range and may differ by twofold or threefold for various deposits of the same mineral commodity. Relative mining costs are generally highest when the deposit is at great depth or in unstable ground. Where large, thick ore bodies are found near the surface, unit mining costs are lowest. The location of a given deposit has a significant effect on such costs as access, transportation to market, environmental considerations, and development. For example, transportation charges from a mine to a distant mill or smelter can reduce even a relatively high-grade deposit to uneconomic status. The metallurgy of a deposit is also a significant factor, and can make the difference between a subeconomic and an economic deposit. Commodities can, in combination (for example, silver in association with gold, copper and lead with gold, and so forth), increase the total value of a deposit. However, the presence of certain elements and minerals, such as arsenic and pyrite (containing gold), can raise the costs of extractive metallurgy.

The two significant factors affecting the economics of placer mining are the size of a deposit (of a given grade) and the water requirement. The source, amount, and delivered cost of water will often determine the kind of equipment or the mining method to be used. The range in water requirements is large; rockers require only 4 to 5 gal/min (15-20 L/min), but bucket-line dredges may require a fresh input of more than 2,000 gal/min (8,000 L/min) (Wells, 1969).

MINERAL COMMODITIES

The principal mineral resources of the Sheep Mountain wilderness study area are gold and tungsten, although silver, lead, and copper have been produced as byproducts of gold mining. Data for the following section are from the most recent compilations (Metals Week, 1981; U.S. Bureau of Mines, 1981).

GOLD

The United States produced an estimated 0.93 million troy oz (28.9 million g) of gold in 1980 while apparently consuming an estimated 3.90 million troy oz (121 million g); most imports came from Canada, Switzerland, and the U.S.S.R. Major uses are in jewelry and the arts, for industrial needs, and in dental work. Gold prices averaged $562.70/troy oz ($18.09/g) during the week ending January 16, 1981, although the unrefined metal used in jewelry and as specimens is usually sold for much higher prices. Although commercial demand for gold in 1980 decreased 36 percent from the 1979 level, it is expected to increase by 2.2 percent annually through 1990.

U.S. Bureau of Mines research continues on gold extractive technology. Research results suggest that ores containing as little as 0.05 troy oz of gold per ton (1.7 g Au/t) can be treated by heap leaching, provided only a minimum amount of cyanicides (soluble sulfides, sulfates, and arsenates) is present. Gold production was nearly 99 percent of the total value of all minerals produced from within the study area.

TUNGSTEN

The United States produced an estimated 7.0 million lb (3.2 million kg) of tungsten in 1980, approximately 30 percent of the 1980 apparent domestic consumption; the major foreign supplier was Canada. Principal uses are in metal working and construction machinery, transportation, and lighting and electrical equipment. The demand for tungsten is projected to increase by about 5 percent annually through 1990. The average price per short ton unit (20 lb [9.1 kg]) of contained tungsten trioxide (WO_3) was $127.91 during the week ending January 16, 1981.

SILVER

Approximately 24 percent of an estimated 135 million troy oz (4.2 billion g) of silver consumed domestically in 1980 was produced in the United States; major foreign sources are Canada, Mexico, and Peru. Primary uses are for photographic materials, silverware, and electrical equipment. The average price of silver during the week ending January 16, 1981, was $14.98/troy oz ($0.482/g). The demand for silver is expected to increase at an annual rate of approximately 3.1 percent through 1990.

Silver has been produced as a byproduct from lode gold mines within the study area. Total production is more than 50 percent of the gold produced but accounts for only about 1 percent of the total mineral value.

COPPER AND LEAD

Reported domestic consumption of refined copper was estimated at 2.06 million tons (1.87 million t) in 1980; U.S. mine production was 1.30 million tons (1.18 million t). Imports between 1973 and 1976 were mainly from Canada, Chile, and Peru. Major uses include electrical, construction, industrial machinery, and transportation. The average price of copper during the week ending January 16, 1981, was $0.85/lb ($1.87/kg). Demand for copper is expected to increase at an annual rate of 3 percent through 1985 (U.S. Bureau of Mines, 1979, p. 43).

An estimated 1.15 million tons (1.04 million t) of lead was apparently consumed by the United States in 1980, in comparison with domestic mine production of about 634,000 tons (575,000 t). The main consuming industries are transportation, construction, paints, ammunition and electrical. Canada, Peru, Mexico, and Australia accounted for most of the imports (1973-76). Domestic demand for lead is expected to increase through 1990 at an annual rate of 1.3 percent. The price of lead as of January 16, 1981, was $0.34/lb ($0.75/kg).

Approximately 1,350 lb (610 kg) of copper and 1,300 lb (590 kg) of lead have been produced as byproducts from the Big Horn mine. The presence of copper and lead is not expected to affect the economics of gold mining significantly.

DEFINITION OF RESERVES AND RESOURCES

Categories of resources used in this study follow those agreed upon by the U.S. Bureau of Mines and the U.S. Geological Survey (U.S. Bureau of Mines and U.S. Geological Survey, 1976):

Resources are concentrations of naturally occurring material from which mineral commodities may be extracted, either currently or in the future.

Reserves are a part of total resources and refer to mineralized material (ore) that can be mined and marketed under prevailing economic conditions.

Measured resources are those computed on the basis of sample analyses and measurements from closely spaced sample sites.

Indicated resources are those computed partly from sample analyses and measurements and partly from reasonable projections.

Inferred resources are estimated based on relatively few sample sites and measurements and on geologic evidence and projection.

Paramarginal resources (a) border on being of economic grade or (b) are not exploitable because of legal or political circumstances.

Submarginal resources require an increase in market value of more than 1.5 times the current price, or a major cost-reducing advance in mining and extractive technology, to become economical.

Undiscovered resources include *hypothetical resources* in known mining districts and *speculative resources* in undiscovered districts.

MINES, PROSPECTS, AND MINERALIZED AREAS

Gold deposits in the Wilderness study area are mainly confined to occurrences in quartz-filled fractures, faults, and shears and in placers derived from them; shear zones at various mines seem related to recognizable regional faults, such as the Weber fault or the Vincent thrust. The gold appears to lie in shoots or pockets rather than to be distributed evenly throughout any given zone and is commonly associated with pyrite and arsenopyrite, which rarely exceed 2 or 3 percent of the mineralized rock.

Tungsten-bearing deposits also occur in shear zones and in placers; in brecciated shear zones, scheelite, quartz, and calcite cement the rocks. Scheelite was reported to occur from near Mount Baldy Notch, east of the study area, to the East Fork of the San Gabriel River (Ronald Curtis, oral commun., 1975), but only the Cattle Canyon area contains this mineral in relative abundance. Observed occurrences indicate that exploration targets are most favorable near biotite gneiss/quartz diorite contacts toward the head of the canyon, and in gravel deposits derived from these rocks.

The mines, prospects, and mineralized areas described below are important because of past production and (or) potential for the discovery of mineral resources.

CURTIS CLAIMS

Scheelite ($CaWO_4$) was discovered in Cattle Canyon in the 1950's, when the Curtis group of lode and placer claims (localities 17, 18, fig. 10) were established; the property has been worked intermittently since its discovery. Small amounts of ore are produced by handpicking high-grade pieces of rock from the canyon floor and from talus cones along the canyon walls. To date, the property has produced more than 2,500 lb (1,100 kg) of scheelite concentrate averaging 38.29 weight percent WO_3. At the time of our investigation, the Curtis Mining Co. was examining scheelite-bearing fracture zones and conducting mill tests to establish recovery rates.

Gneiss, augen gneiss, and minor schist are the predominant rock types in the claims area. A quartz diorite mass underlies and has intruded the gneiss near the head of the canyon. Quartz monzonite and andesite dikes, ranging from a few inches (centimeters) to more than 6 ft (2 m) in thickness, crosscut all rock types; porphyry dikes and sills, and hornblendite lenses in gneiss, are also present.

General strike of the gneiss and schist is N. 36°-40° W., with a 41°-43° SW. dip. Several stages of faulting are indicated by slickenslides and by displacements of the dikes exposed in the canyon walls. Scheelite was deposited in fracture zones, probably as a result of intrusion of the quartz diorite mass. These fracture zones strike from N. 70° E. to east-west and dip steeply north; their average width is commonly less than 2 ft (0.6 m), and observed zones were not traceable for more than 39 ft (12 m). Scheelite occurs as veinlets, pods, and fine disseminations in and along fracture planes; veinlets as thick as 1 in. (2.5 cm) are common. Locally the scheelite is associated with quartz, calcite, and limonite.

Samples were taken from 11 separate fracture zones, 8 of which were near the headwaters of Cattle Canyon (fig. 12). In one locality, a mineralized fracture zone 39 ft (12 m) long was observed. Four samples (locs. R-104, R-127, R-128, R-130, fig. 12) averaging 0.66 weight percent WO_3 were taken from across the zone, which is estimated to hold at least 127 tons (115 t) of mineralized rock. This zone and others observed are not uniformly mineralized, but high-grade scheelite can be obtained by hand cobbing.

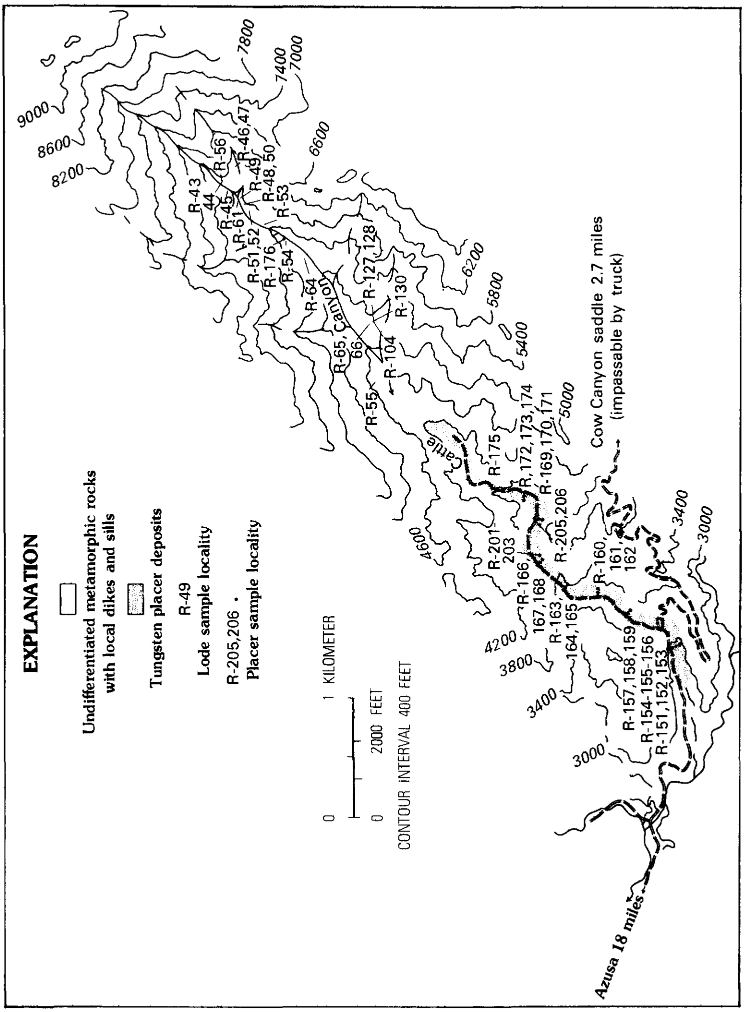


FIGURE 12.—Sample localities in Cattle Canyon.

High-grade tungsten-bearing rock fragments were found in alluvium on the canyon floor and in talus cones. In one sample locality (below loc. R-104, fig. 12), about 800 lb (360 kg) of material from a talus cone averaged about 3 weight percent WO_3 before milling and from 6 to 6.5 weight percent WO_3 after concentration (Ronald Curtis, oral commun., 1975). In another locality, scheelite-bearing rock could be handpicked from talus to yield an ore grade of more than 30 weight percent WO_3. The talus cones commonly measure no more than 150 to 200 ft (50-60 m) from apex to toe.

Data for lode samples shown in figure 12

[<, less than shown. Metric conversion factor: Feet x 0.3048=meters]

Sample	Type	Length (feet)	Description	WO_3 (percent)
R-43	Chip	1.4	Across scheelite-bearing fracture	0.34
R-44	—do—	4.0	Across country rock and scheelite-bearing fracture at R-43	.01
R-45	—do—	4.0	Across country rock and scheelite-bearing fracture	.24
R-46	—do—	1.0	Across scheelite-bearing fracture	<.01
R-47	—do—	4.3	Across country rock and scheelite bearing fracture at R-46	<.01
R-48	—do—	.6	Across scheelite-bearing fracture	1.59
R-49	—do—	4.5	Across country rock and scheelite-bearing fracture	<.01
R-50	—do—	4.0	Across country rock and scheelite-bearing fracture at R-48	.10
R-51	—do—	4.0	Across country rock and scheelite-bearing fracture	<.01
R-52	—do—	4.0	—do—	.02
R-53	—do—	4.0	—do—	<.01
R-54	—do—	4.0	—do—	<.01
R-55	—do—	1.5	Across scheelite-bearing fracture	<.01
R-56	—do—	4.7	Across mafic dike	<.01
R-61	—do—	4.0	Across country rock and scheelite-bearing fracture	<.01
R-64	—do—	1.0	Across scheelite-bearing fracture	<.01
R-65	—do—	.5	Across contact between gneiss and mafic dike	<.01
R-66	Chip	5.0	Across mafic dike	<.01
R-104[1]	—do—	4.0	Across scheelite-bearing fracture	1.28
R-127[1]	—do—	1.7	—do—	.10
R-128[1]	—do—	.9	—do—	.05
R-130[1]	—do—	1.5	—do—	<.01

[1]Samples used in tonnage and grade calculations.

FIGURE 12.—Sample localities in Cattle Canyon.—Continued

Tungsten placer deposits, consisting of scheelite-bearing alluvium, extend about 3 mi (5 km) through a relief of more than 2,600 ft (800 m) (fig. 12). The upper 5,000 ft (1,500 m) averages about 275 ft (85 m) in width and may be as shallow as 46 ft (14 m). The lower 10,000

Data for placer samples shown in figure 12

[Analyses by size fraction. Metric conversion factors: inches × 2.54=centimeters; cubic feet × 0.0283=cubic meters. Mesh sizes: 12 mesh = 0.0661 in.=1.68 mm; 40 mesh=0.0165 in.=0.420 mm; 100 mesh=0.0059 in.=0.149 mm; 200 mesh=0.0029 in.=0.074 mm]

		+12 mesh [1]		−12 to +40 mesh		−40 to +100 mesh		−100 to +200 mesh		−200 mesh	
Sample	Volume (ft^3)	WO_3 (percent)	Percent of sample by weight	WO_3 (percent)	Percent of sample by weight	WO_3 (percent)	Percent of sample by weight	WO_3 (percent)	Percent of sample by weight	WO_3 (percent)	Percent of sample by weight
					Surface alluvium						
R-151	0.5	<0.01	46.8	<0.01	22.5	<0.01	23.9	0.01	4.1	0.03	2.7
R-152	.5	<.01	50.8	<.01	24.7	<.01	20.0	.03	2.6	.04	1.9
R-153	.5	<.01	35.5	<.01	30.0	<.01	29.3	.03	4.2	.04	1.0
R-154	.5	<.01	56.6	<.01	26.2	<.01	15.3	.02	1.2	.03	.7
R-155	.5	<.01	27.7	<.01	38.9	<.01	28.6	.02	2.9	.06	1.9
R-156	.5	<.01	45.3	<.01	37.5	<.01	15.9	.07	.8	.03	.5
R-157	.5	<.01	58.6	<.01	28.8	<.01	10.9	.04	1.0	.01	.7
R-158	.5	<.01	45.9	<.01	29.7	<.01	18.7	.02	3.8	.03	1.9
R-159	.5	<.01	40.5	<.01	38.9	<.01	17.4	.04	1.8	.03	1.4
R-160	.5	<.01	45.5	<.01	34.4	<.01	15.2	.01	3.0	.01	1.9
R-161	.5	<.01	44.3	<.01	39.2	<.01	12.3	.02	3.5	.02	.7
R-162	.5	<.01	45.3	<.01	36.3	<.01	13.1	.01	2.6	.03	2.7
R-163	.5	<.01	53.5	<.01	33.0	<.01	10.6	.04	1.9	.03	1.0
R-164	.5	<.01	41.1	<.01	41.6	<.01	13.0	.01	2.8	.02	1.5
R-165	.5	<.01	33.3	<.01	37.9	<.01	22.9	.02	2.5	.02	3.4
R-166	.5	<.01	32.2	<.01	40.6	<.01	21.6	.04	2.1	.04	3.5
R-167	.5	<.01	44.0	<.01	38.6	<.01	14.5	.02	2.0	.05	.9
R-168	.5	<.01	42.4	<.01	41.5	<.01	12.6	.04	2.0	.03	1.5
R-169	.5	<.01	24.0	<.01	39.0	<.01	28.1	.03	5.8	.18	3.1
R-170	.5	<.01	44.8	<.01	35.2	<.01	14.1	.05	4.2	.05	1.7
R-171	.5	<.01	29.3	<.01	35.7	<.01	25.7	.02	5.9	.06	3.4
R-172	.5	<.01	27.1	<.01	43.7	<.01	20.7	.02	5.6	.09	2.9
R-173	.5	<.01	30.6	<.01	33.8	<.01	26.7	.06	6.4	.10	2.5
R-174	.5	<.01	33.6	<.01	47.8	<.01	12.8	.05	3.5	.08	2.3
R-175	.5	<.01	47.2	<.01	37.0	<.01	12.5	.06	2.0	.10	1.3

		−¼ inch [1]
Sample	Volume (ft^3)	WO_3 (percent)
	Subsurface alluvium	
R-176	0.5	0.07
R-201	1.5	No data
R-202	1.8	.05
R-203	2.0	.04
R-205	1.5	.04
R-206	2.0	.06

FIGURE 12.—Sample localities in Cattle Canyon.—Continued

ft (3,000 m) averages more than 500 ft (150 m) in width and may be at least 100 feet (30 m) deep. The average stream gradient is 1,200 ft/mi (230 m/km). Average thickness was estimated by constructing geologic cross sections of the canyon at four locations and projecting canyon slopes to a point below the surface.

The alluvium consists of subrounded boulders, cobbles, and sand and is proportionately representative of the rock types in the canyon area. Boulders 6 ft (2 m) in diameter are common in the upper part of the deposit and in places constitute as much as 50 percent by volume; the lower part contains as much as 15 volume percent boulders. The minus-6-in. (15 cm) fraction ranges from 40 to 60 volume percent. The minus-1-in. (2.5 cm) fraction ranges from 25 to 50 volume percent but is noticeably less abundant where the canyon narrows. The minus-$^1/_4$-in. (0.5 cm) fraction is estimated to make up from 10 to 15 volume percent of the deposit. The gravel is loosely compacted and contains little or no clay.

The gravel was deposited in roughly stratified sheets or layers by spring runoff and freshets. Sporadic, rather than continual, reworking of alluvium by the streamflow has resulted in less pronounced chemical-mechanical disintegration of the scheelite particles.

A total of 25 surface samples and 6 vertical-channel (subsurface) samples were collected from the alluvium in Cattle Canyon. At most sample sites, a 1.5 ft^3 (0.03 m^3) loose volume yielded 0.5 ft^3 (0.01 m^3) of minus-$^1/_4$-in. (0.5 cm) material. Surface samples were screened into five fractions and weighed. The rough concentrates were further processed in a laboratory and assayed for tungsten trioxide (WO_3) (fig. 12); each sample was then analyzed for tungsten to determine concentration by particle size. The minus-100- to plus-200-mesh and the minus-200-mesh sands contained the highest concentrations; most other fractions contained traces of scheelite, although assays were not sensitive enough to determine the WO_3 contents precisely.

Sample radioactivity was not above anticipated levels typical of alluvium. Two surface samples contained traces of free gold. Heavy detrital black sand, mostly magnetite and ilmenite, averages 21.6 lb/yd^3 (12.8 kg/m^3).

The deposit is estimated to contain 20 million yd^3 (15 million m^3) of alluvium. Only the minus-$^1/_4$-inch (0.5 cm) fraction, constituting an estimated 10 volume percent of the alluvium, has been sampled. The average scheelite grade for this particle size is 2.4 troy oz/yd^3 (89 g/m^3), determined from the minus-$^1/_4$-inch (0.5 cm) fraction. This figure is conservative because it excludes undetermined values in the remaining 90 volume percent of the placer.

A mining operation would process scheelite-bearing talus cones in conjunction with the alluvium; in addition, it could easily separate and stockpile black sand during the recovery of scheelite.

The deposit, as tested, represents a submarginal mineral resource. Statistically valid sampling of the plus-1/4-inch (0.5 cm) fraction would require bulk sampling beyond the scope of this study. The relative abundance of scheelite observed in lode occurrences and in gravel on the canyon floor indicates a possible higher grade of tungsten trioxide at depth in the placers.

BIG HORN MINE

The Big Horn mine (loc. 1, fig. 10) has been the major mineral producer in the study area. U.S. Bureau of Mines production records indicate that approximately 31,000 tons (28,000 t) of ore was extracted, containing 3,701 troy oz (115 kg) of copper and 1,296 lb (588 kg) of lead (table 5). The workings were inaccessible at the time of this investigation. The following descriptions and resource estimates are based on previous examination reports furnished by the Siskon Corp.

The Big Horn vein was discovered in 1891, and underground exploration was initiated in 1893. The property was idle during the late 1890's, but exploration was renewed in 1901, when it was purchased by the Lowell and California Mining Co. Encouraged by early exploratory results, the company located additional claims; the claim group consists of 15 patented lodes and 2 patented millsites. Development work continued between 1914 and 1917, and ore was probably stockpiled and treated during a brief period in the 1930's. The property was acquired by principals of the Siskon Corp. of Reno, Nev., in 1939; it has been idle since 1936. In 1974, the Siskon Corp. applied to the U.S. Forest Service for a permit to upgrade the access road, the purpose of which was to transport equipment to the mine in order to reevaluate the mine's worth.

The country rock consists of gray medium-grained muscovite schist containing layers of chlorite schist and carbonaceous schist (all of the Pelona Schist), overlain by mylonite; a quartz monzonite porphyry sill intrudes the schist below the Vincent thrust. The foliation of the schist strikes approximately N. 60° E. and dips 20°-40° NW. The deposit occurs mainly on the footwall of the mineralized shear zone, in carbonaceous schist that is fractured over a thickness ranging from 20 to 60 ft (6-18 m) and cemented with quartz and calcite. The mineralized zone is well marked on both walls by 2 to 6 in. (5-15 cm) of gouge and generally dips 17°-20°NW., steepening to 30° NW. near the head of Mine Gulch; it also appears to occur in the Vincent thrust zone.

Gold occurs in two shoots along the hanging wall and footwall of the zone, but the middle part of the zone is more or less barren. Metallurgic tests indicate that about 65 percent of the gold is in the free state and that the remaining 35 percent is associated with pyrite and arsenopyrite. The total sulfide mineral content of the zone is about 2 percent. Silver-, copper-, and lead-bearing minerals are present. The higher grade shoot, along the hanging wall of the zone, averages 30 ft (9 m) in thickness but varies in thickness and tenor. The average grade of the ore ranges from 0.12 to 0.30 troy oz of gold per ton (4.1-10.3 g Au/t).

A total extent exceeding 6,100 feet (1,860 m) of crosscuts, drifts, raises, and stopes has been excavated in 10 adits (fig. 13); several small cuts and additional short adits are also on the property. Milling equipment consisted of a 50-ton (45 t) ore bin, a jaw crusher, a rod

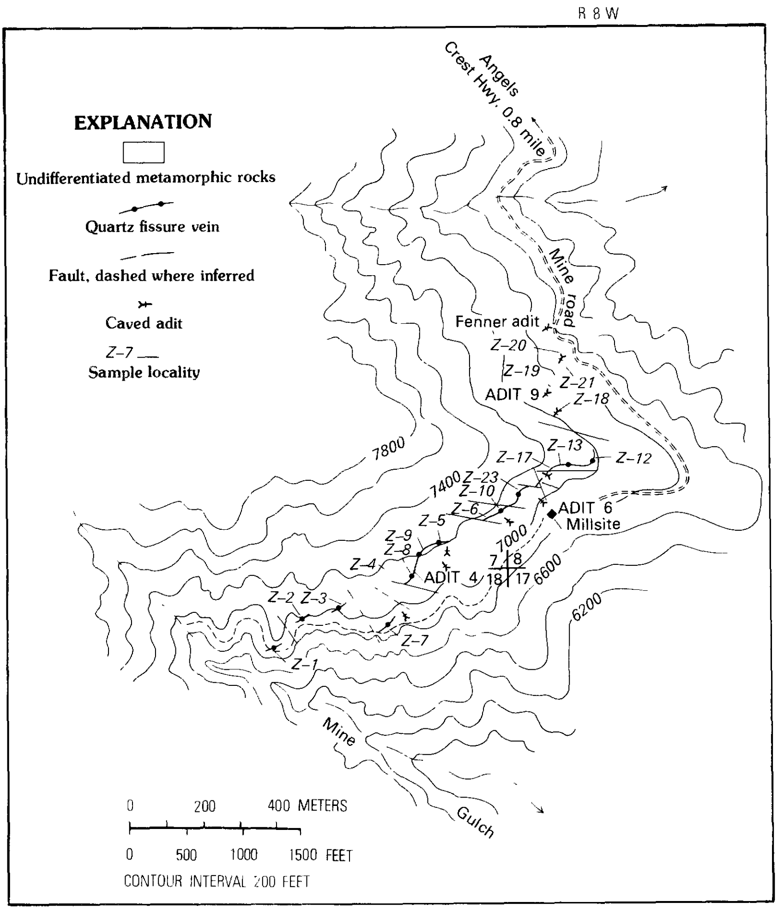


FIGURE 13.—Big Horn patented claim group (surface workings).

mill, a classifier, flotation cells, and a Wilfley table, most of which have been removed or destroyed.

Ore was produced mainly from adit 6, adjacent to the millsite, and from stopes in adit 9; developed ore lies mostly in the oxidized zone. Occurrence of primary sulfides at the face of the Fenner adit (6,600 level) indicates that the probable zone of secondary enrichment is downdip from the 6,900 level, where the major stoping was accomplished. At least 400,000 tons (360,000 t) of indicated resources, above the 6,900 level in adits 6 and 9, is estimated from company data compiled in 1918. This estimate assumes a strike length of 270 ft (80 m), a dip length of 600 ft (180 m), and a thickness of 30 ft (9 m). An additional 340,000 tons (310,000 t) of resources are inferred between adits 4 and 5, on the basis of a strike length of 630 ft (190 m), a dip length of 215 ft (70 m), and a thickness of 30 ft (9 m). These

Data for samples shown in figure 13

[Tr, trace; N, none detected. Metric conversion factors: Feet x 0.3048=meters, Troy ounces per ton x 34.285=grams per tonne]

Sample	Type	Length[1] (feet)	Description	Gold (tr oz per ton)	Silver (tr oz per ton)
Z-1	Chip	11.0	Across quartz fissure vein	N	N
Z-2	—do—	20.0	—do—	N	N
Z-3	—do—	12.0	—do—	N	N
Z-4	—do—	8.0	Across quartz fissure vein and altered rock	N	N
Z-5	—do—	15.0	Across quartz fissure vein	N	N
Z-6	—do—	22.0	—do—	N	Tr
Z-7	—do—	12.0	—do—	N	N
Z-8	—do—	16.0	—do—	N	N
Z-9	—do—	12.0	—do—	N	N
Z-10	—do—	10.0	—do—	N	N
Z-11	—do—	14.0	—do—	N	0.1
Z-12	Grab	—	Quartz float	0.14	.1
Z-13	Chip	8.0	Across quartz fissure vein	N	.1
Z-17	Grab	—	Altered rock near dike	.03	N
Z-18	—do—	—	Quartz in dump	.09	.1
Z-19	Chip	3.0	Across altered augen schist	Tr	N
Z-20	—do—	2.8	Across siliceous dike	Tr	.1
Z-21	—do—	4.0	—do—	.1	.1
Z-23	—do—	10.0	Across quartz fissure vein	Tr	N
Z-24	Grab	—	Quartz from ore bin at stamp mill	.01	N

FIGURE 13.—Big Horn patented claim group (surface workings).—Continued

resources lie in the oxidized zone, above the zone of secondary enrichment, and do not include near-surface material. Below the 6,900 level, between the Fenner adit and adit 6 lies an additional 460,000 tons (420,000 t) of inferred resources, on the basis of a length of 770 ft (230 m), a depth of 240 ft (70 m), and a thickness of 30 ft (9 m). All calculations were made using a tonnage factor of 12 ft^3 per ton (0.37 m^3/t).

On the basis of data obtained from the owners, the total resources of the Big Horn mine are estimated at 1.2 million tons (1.1 million t) containing a weighted average of 0.15 troy oz of gold per ton (5.1 g Au/t).

ALLISON MINE

The Allison mine (loc. 13, fig. 10) accounted for 22 percent of the total reported gold production from the study area. Statistical files of the U.S. Bureau of Mines indicate that 1,166 troy oz (36,270 g) of gold and 330 troy oz (10,260 g) of silver were extracted from 10,489 tons (9,515 t) of mineralized rock.

The property is developed at several levels with numerous stopes and interconnecting raises (fig. 14); more than 1,100 ft (340 m) of workings is accessible. Crushed ore was stored in a bin near the main workings and transported by pipe a short distance downslope to a mill; the millsite contains remnants of a ball mill, a rake classifier, and a shaking table.

The country rock consists of thinly laminated mylonite that strikes N. 65°-77° W. and dips 20°-28° NE. Porphyritic granodiorite cuts the mylonite in the vicinity of the workings.

The gold-bearing zones are composed of intensely sheared mylonite; the shear zones are discontinuous and range from 0.7 to 3.0 ft (0.2-0.9 m) in thickness. Some shear boundaries are poorly defined and consist of friable limonite-stained mylonite; other shears are well defined and contain green siliceous mylonite, commonly in association with quartz veins containing as much as 2 percent disseminated pyrite. The shear zones do not show any preferred orientation.

The shear zone in the stope level has an indicated resource of 800 tons (730 t), averaging 0.26 troy oz of gold per ton (8.9 g Au/t), through a 3.0-ft (0.9 m) average width, a length of 80 ft (24 m), and a depth of 40 ft (12 m). Two samples from other mine structures contained significant gold-silver values that indicate a potential for undiscovered resources.

STANLEY-MILLER MINE

The Stanley-Miller mine (loc. 6, fig. 10) produced 59 troy oz (1,830 g) of gold and 21 troy oz (650 g) of silver between 1933 and 1938. The surface plant consisted of a jaw crusher, a ball mill, a rake classifier, and several Wilfley tables. Fire has destroyed the buildings, and little machinery is left. Floods have eroded most of the road constructed to within 1 mi ($1^1/_2$ km) of the property.

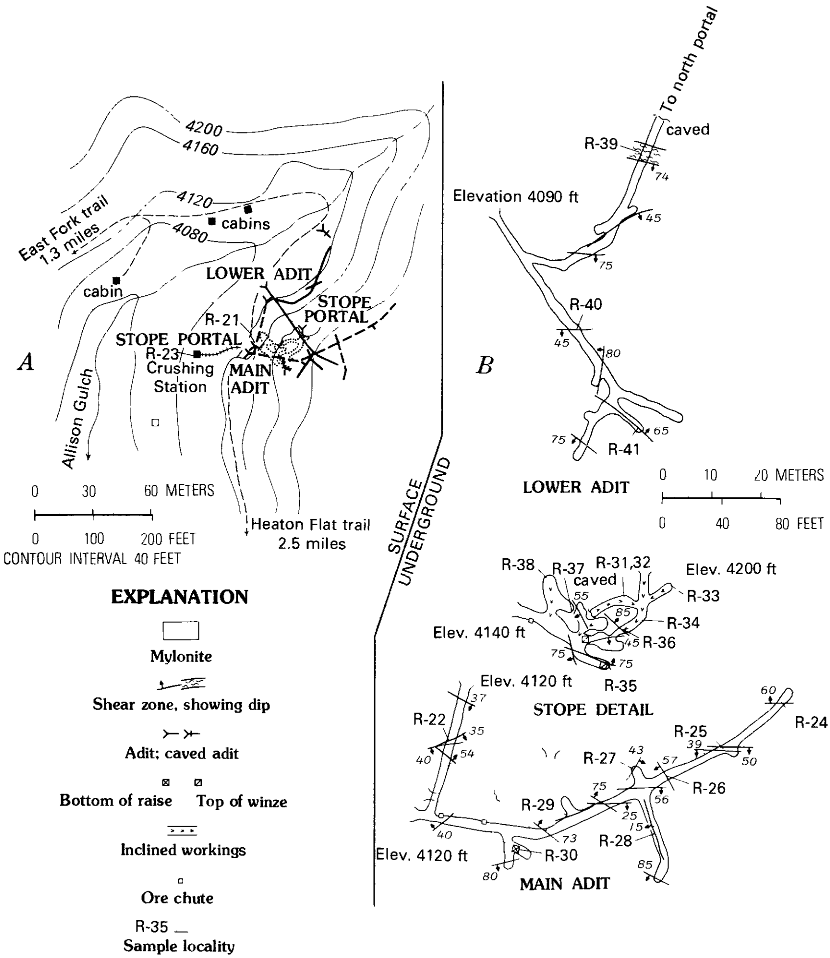


FIGURE 14.—Allison mine. *A*, Surface workings. *B*, Underground workings.

The country rock consists of thinly laminated micaceous chloritic schist; the rock is contorted and highly fractured. The foliation strikes N. 45°-67° W., and the dip ranges from 20° to 62° SW. (fig. 15). A total of 1,126 ft (343 m) of workings, including 267 ft (81 m) of stopes, are accessible in three adits (fig. 16); the north adit and two small adits above the main adit are caved.

Data for samples shown in figure 14

[Tr, trace; N, none detected. Metric conversion factors: Feet x 0.3048=meters, Troy ounces per ton x 34.285=grams per tonne]

Sample	Type	Length (feet)	Description	Gold (tr oz per ton)	Silver (tr oz per ton)
R-21	Chip	11.0	Across limonite-stained breccia zone striking N. 65° E., dipping 38° SE.	N	N
R-22	—do—	1.7	Across limonite-stained shear zone	Tr	N
R-23	Grab	—	Crushed rock from ore bin	Tr	0.3
R-24	Chip	0.7	Across gouge-filled shear zone	Tr	.2
R-25	—do—	5.0	Across fractured silicified green mylonite bounded by 6-inch (15 cm)-thick shears	Tr	N
R-26	—do—	3.0	Across green mylonite wallrock and small shear zone	Tr	.1
R-27	—do—	3.0	—do—	Tr	.2
R-28	—do—	3.0	—do—	Tr	N
R-29	—do—	5.0	—do—	Tr	.1
R-30	—do—	3.0	Across highly fractured mylonite wallrock in raise	0.15	.4
R-31	—do—	5.0	Across green mylonite wallrock with half-inch-thick gouge-filled shears	Tr	.1
R-32	—do—	0.9	Across green highly-fractured micaceous mylonite	N	N
R-33	—do—	1.9	Across highly fractured siliceous mylonite	.14	N
R-34	—do—	3.1	Across quartz-cemented mylonite with about 1 percent medium- to fine-grained disseminated pyrite	N	N
R-35	—do—	2.9	Across fractured siliceous mylonite	Tr	.3
R-36	—do—	3.0	Across prominent shear zone	N	Tr
R-37	—do—	3.4	Across highly fractured siliceous mylonite	.18	N
R-38	—do—	3.0	—do—	.69	N
R-39	Chip	12.0	Across limonite-stained zone of brecciated mylonite and gouge	N	N
R-40	—do—	1.5	Across shear zone of brecciated mylonite	N	.2
R-41	—do—	1.7	—do—	.07	N

[1]Samples used in resource calculations

FIGURE 14.—Allison mine. *A*, Surface workings. *B*, Underground workings.—Continued

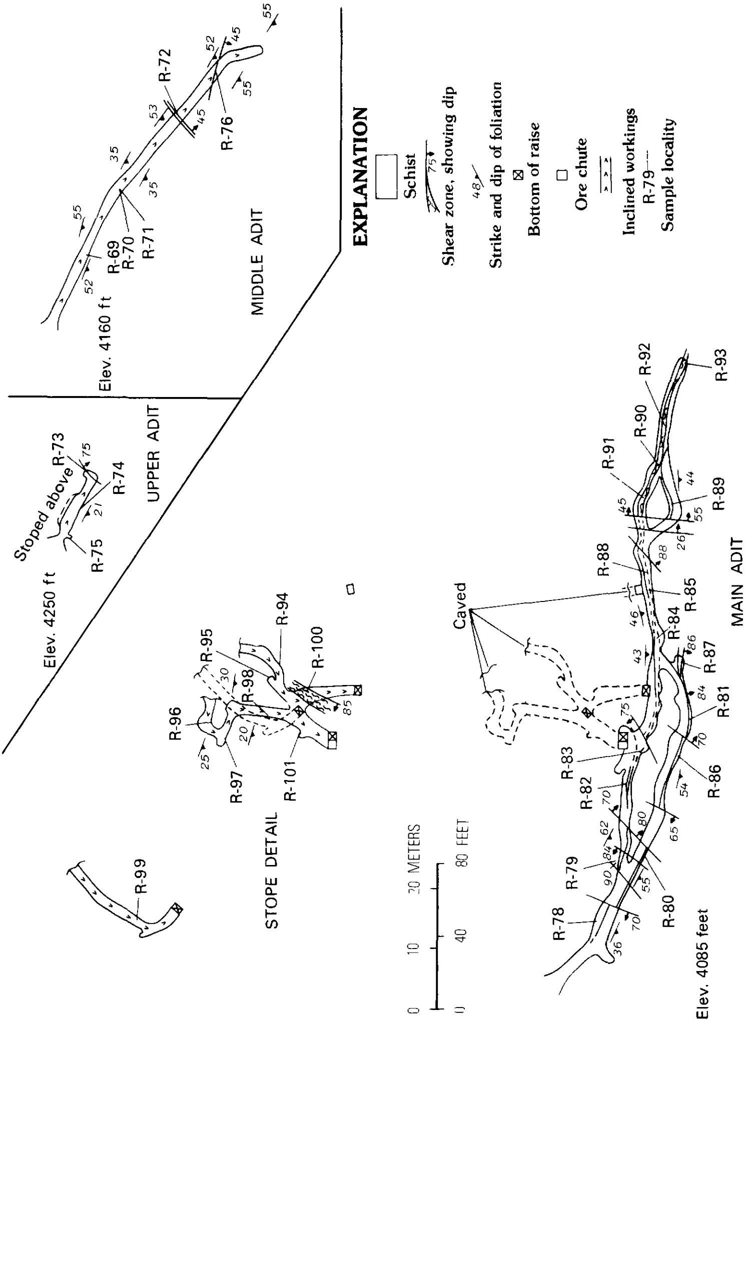


FIGURE 15.—Stanley-Miller mine (underground workings).

In the main adit, quartz veins and veinlets occur in an altered shear zone that is locally concordant with foliations in the host rock. The zone, which is composed of friable schist and fractured sinuous quartz veins mostly thinner than 2 in. (5 cm), is moderately stained with limonite and about 3.5 ft (1.1 m) thick in the stoped areas. The zone is not readily traceable throughout the adit because of displacement

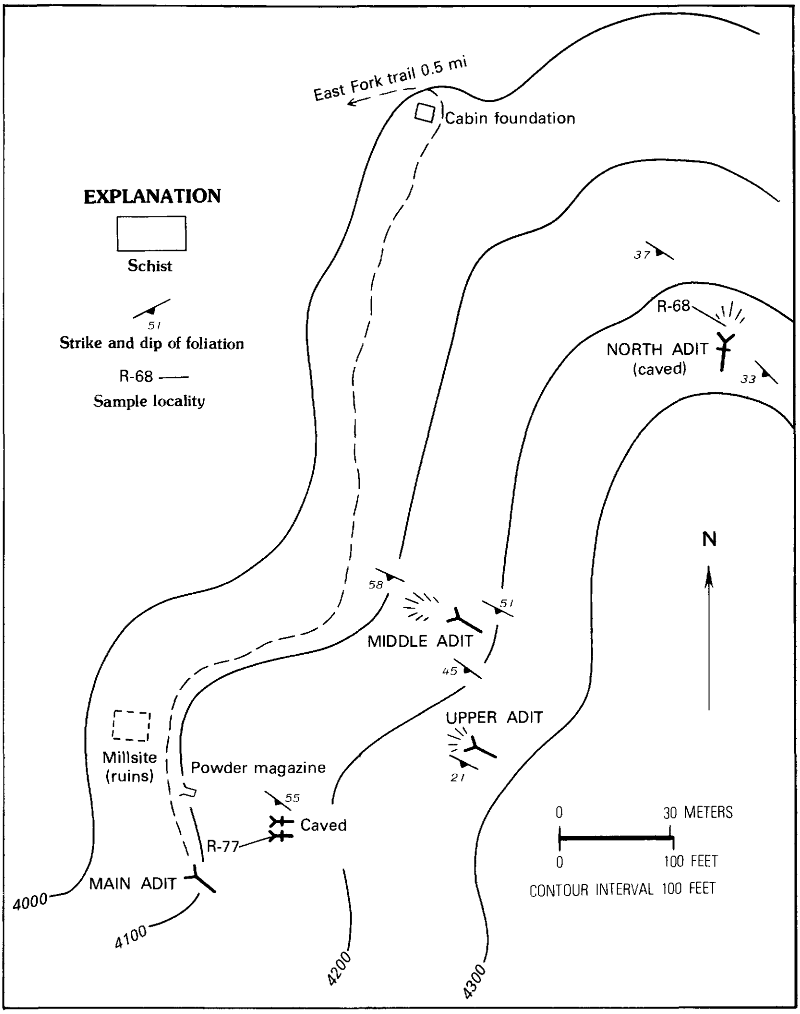


FIGURE 16.—Stanley-Miller mine (surface workings).

Data for samples shown in figures 15 and 16

[Tr, trace; N, none detected. Metric conversion factors:
Feet x 0.3048=meters, Troy ounces per ton x 34.285=grams per tonne]

Sample	Type	Length[1] (feet)	Description	Gold (tr oz per ton)	Silver (tr oz per ton)
R-68	Grab	—	Quartz veinlets in phyllitic schist	N	Tr
R-69	Chip	1.5	Shear zone containing gouge	0.03	0.1
R-70	—do—	1.3	—do—	N	Tr
R-71	—do—	.5	—do—	.16	.2
R-72	—do—	2.6	Small quartz vein in shear zone	.15	.1
R-73	—do—	2.3	Limonite-stained shear zone	N	Tr
R-74	—do—	3.2	—do—	.11	.1
R-75	—do—	3.0	—do—	.07	.1
R-76	—do—	2.3	Altered schist in shear zone	.02	.1
R-77	—do—	.9	—do—	N	.2
R-78	—do—	4.0	Black micaceous schist	.03	.1
R-79	—do—	1.7	Altered schist in shear zone	Tr	Tr
R-80	—do—	2.2	Black, limonite-stained schist	Tr	N
R-81	—do—	2.7	—do—	Tr	.1
R-82	—do—	2.8	Shear zone	.02	N
R-83	—do—	3.7	—do—	.03	N
R-84	—do—	3.0	Shear zone with quartz veinlet	.02	.1
R-85	—do—	2.0	—do—	.05	.2
R-86	—do—	3.0	Shear zone in black altered schist	Tr	.1
R-87	—do—	3.3	Across shear zone	.01	.1
R-88	—do—	4.0	—do—	.01	.1
R-89	—do—	1.5	Iron-stained altered schist	.01	.1
R-90	—do—	2.5	Altered schist in shear zone	.01	N
R-91	Chip	3.8	Iron-stained quartz	0.01	0.1
R-92	—do—	1.6	Iron-stained shear zone	.04	.2
R-93	—do—	4.2	Shear zone	Tr	.1
R-94	—do—	4.0	Quartz blebs and stringers in fractured schist	.02	.1
R-95	—do—	3.5	—do—	.03	.1
R-96	—do—	3.0	—do—	.03	.2
R-97	—do—	3.5	Bedding-plane shear zone	.03	N
R-98	—do—	3.8	—do—	.04	.1
R-99	—do—	1.8	—do—	.02	N
R-100	—do—	8.6	Shear zone	.03	N
R-101	—do—	3.8	Bedding-plane shear zone	.02	N

FIGURE 16.—Stanley-Miller mine (surface workings).—Continued

by normal faults. The middle adit is characterized by a quartz-limonite-filled shear zone ranging from 1 to 2 ft (0.3-0.6 m) in thickness; the zone strikes parallel to the foliation of the host rock but ranges in dip from flat lying to 60° SW. The upper adit exposes a concordant 3.2-ft (1.0 m)-thick shear zone, similar to the one exposed in the stoped areas of the main adit. The shear zones exposed by the three open adits are apparently separate structures. Assays indicate a potential for the discovery of low-grade gold resources that would probably contain high-grade pockets or shoots.

BALDORA (WIDCO) MINE

The Baldora (Widco) (loc. 14, fig. 10) was the last mine in the study area to produce gold; approximately 40 tons (36 t) of ore was processed in 1949, yielding $100 in gold (Gay and Hoffman, 1954). The property was most active during the years 1935 to 1940; U.S. Bureau of Mines production data show that 182 troy oz (5,660 g) of gold and 46 troy oz (1,430 g) of silver was extracted from 1,322 tons (1,199 t) of ore. Since 1949, the mill machinery has been removed, and the property has been idle.

Development of the property consists of a 17-ft (5 m)-diameter shaft, 30 ft (9 m) deep, and 11 adits. Structures include two small mills and several cabins (fig. 17); the upper mill contains remnants of a jaw crusher, sizing screens, a cone crusher, and a shaking table. Only an ore bin and foundations are left at the lower millsite.

The country rock consists of green micaceous schist containing massive irregular dikes and sills of granodiorite porphyry, ranging from a few inches (centimeters) to more than 10 ft (3 m) in thickness. Stringers and veinlets of quartz are concordant with the schistosity and generally thinner than 2 in. (5 cm).

The workings expose dike-schist contacts and irregular shear zones within the schist; the shear zones consist of fractured slightly altered limonite-stained schist containing discontinuous quartz veins and blebs. Dike and schist contacts are sharp and well defined. No alteration or mineralization adjacent to the contacts was observed.

Nine samples contained measurable amounts of gold, four of which were taken from the quartz fissure filling exposed in adits 2 and 3. This structure contains about 1,125 tons (1,020 t) of inferred resources averaging 0.15 troy oz of gold per ton (5.1 g Au/t); resource estimates are based on a strike length of 100 ft (30 m), a depth of 50 ft (15 m), and an average thickness of 2.7 ft (0.8 m). Although the quartz veins are narrow in places, systematic investigation may lead to the discovery of veins containing minable shoots, particularly in the vicinity of the northern group of workings.

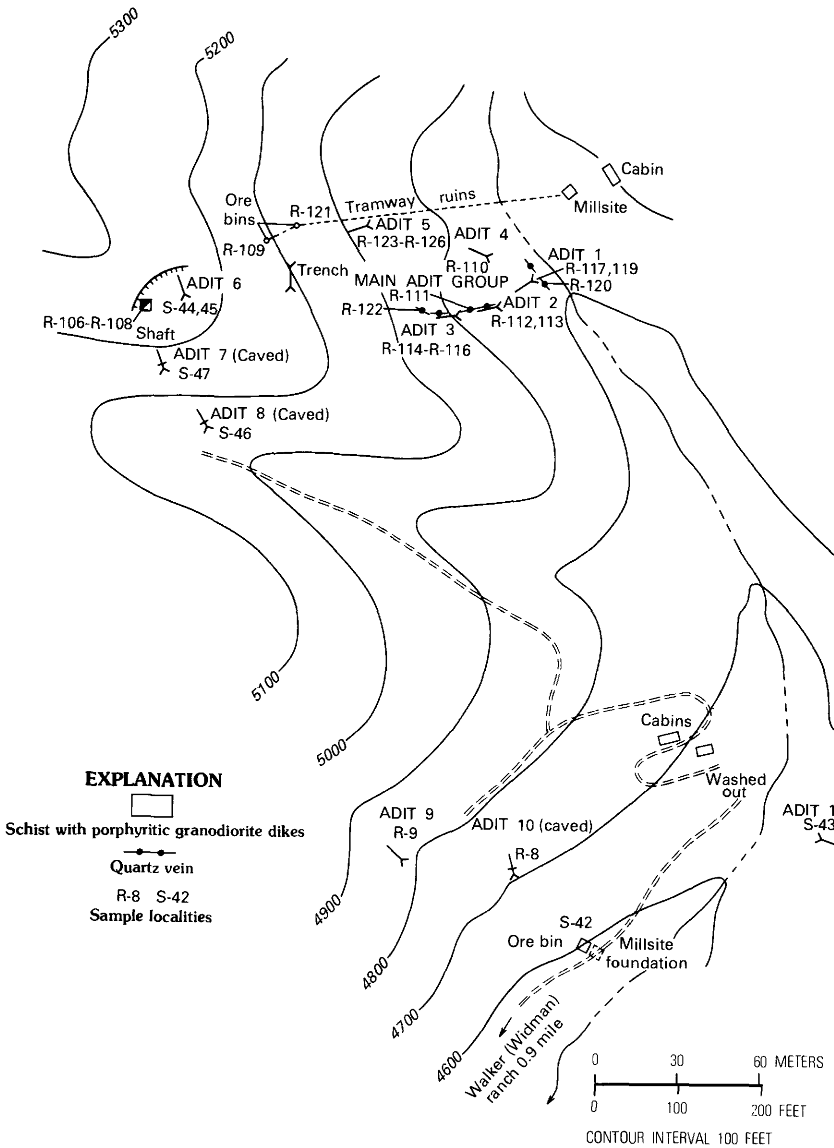


FIGURE 17.—Baldora (Widco) mine (surface workings).

EAGLE MINE

More than 450 ft (140 m) of underground workings have been excavated at the Eagle mine (loc. 16, fig. 10), which was served by a

Data for samples shown in figure 17

[Tr, trace; N, none detected. Metric conversion factors: Feet x 0.3048=meters, Troy ounces per ton x 34.285=grams per tonne]

Sample	Type	Length (feet)	Description	Gold (tr oz per ton)	Silver (tr oz per ton)
R-8	Chip	6.0	Above caved portal, across fracture zone containing stringers of quartz	Tr	0.2
R-9	—do—	4.0	Across schist containing quartz stringers, below contact with porphyritic granodiorite dike	N	.2
R-106	—do—	9.5	Across quartz stringers striking N. 65° E., dipping 30° to 40° SE., in fractured schist	0.29	Tr
R-107	—do—	2.4	Across small quartz veins at collar of shaft on hanging wall above dike	.10	Tr
R-108	—do—	2.4	Kaolinized porphyritic granodiorite at bottom of shaft	N	N
R-109	Grab	—	Quartz vein material from ore bin	.02	Tr
R-110	Chip	2.3	Across small quartz vein in fractured schist in adit 4	.01	.2
R-111	—do—	3.3	Across quartz fissure filling on surface	N	.2
R-112	—do—	3.3	Across quartz and schist at face of adit 2	.05	.3
R-113	—do—	1.5	Across quartz fissure filling 30 feet from portal in adit 2	Tr	Tr
R-114	—do—	1.0	Across shear zone near face in adit 3	Tr	Tr
R-115	—do—	2.7	Across quartz fissure filling 15 feet from portal in adit 3	N	N
R-116	—do—	1.9	Across quartz fissure filling 30 feet from portal in adit 3	.65	Tr
R-117	—do—	1.0	Across quartz fissure filling 30 feet from portal in adit 1	Tr	N
R-119	Chip	4.0	Across silicified schist (normal to foliation) containing stringers of quartz; near face of adit 1	Tr	N
R-120	—do—	3.6	Across quartz fissure filling	Tr	N
R-121	Grab	—	Quartz vein material in schist from ore bin	.05	N
R-122	Chip	3.3	Across quartz fissure filling	.29	N
R-123	—do—	1.5	Across quartz fissure filled shear zone in siliceous schist, 75 feet from portal in adit 5	Tr	N
R-124	—do—	1.0	Across quartz fissure filled shear zone in siliceous schist, 105 feet from portal in adit 5	Tr	N
R-125	—do—	1.8	Across quartz fissure filled shear zone in siliceous schist, at face of adit 5	Tr	N
R-126	—do—	1.2	Across shear zone 160 feet from portal in adit 5	Tr	N
S-42	Grab	—	Siliceous schist and quartz from ore bin	N	N
S-43	Chip	1.5	Shear zone in porphyritic granodiorite in adit 11	N	N
S-44	—do—	0.6	Across quartz vein	N	N
S-45	—do—	4.0	Across schist, normal to foliation, in adit	N	N
S-46	Grab	—	Quartz blebs in schist from dump of adit	N	N
S-47	—do—	—	Across porphyritic dike in portal of adit	N	N

[1]Samples used in resource calculation

FIGURE 17.—Baldora (Widco) mine (surface workings).—Continued

small mill; an aerial tramway was used to transport ore from the main adit (fig. 18) to the millsite. The miners stayed at a cabin at the foot of the trail in Coldwater Canyon. All the structures are in ruins. No production from the property is listed, although some ore was probably mined from a currently inaccessible level above the main adit and milled at the Gold Dollar mine to the west. The Eagle mine has apparently been idle for many years.

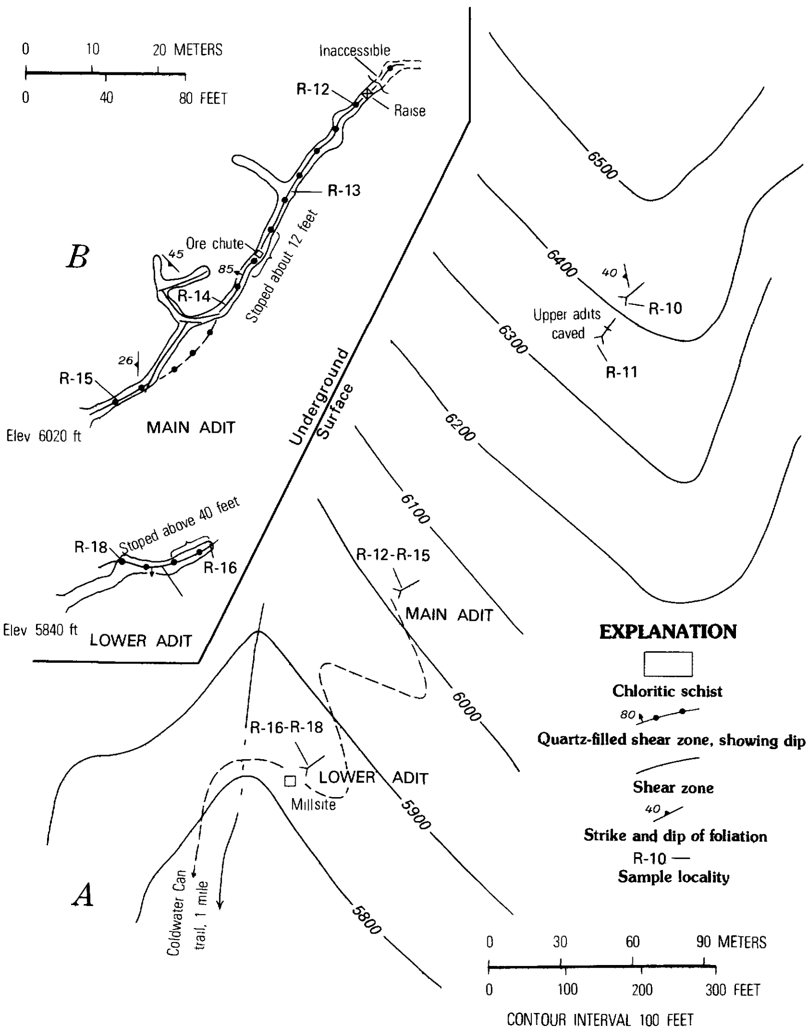


FIGURE 18.—Eagle mine. *A*, Surface workings. *B*, Underground workings.

One of the upper adits, 10 ft (3 m) long, was partly open but unsafe to enter. The main and lower adits are in fairly good condition, but the main adit is inaccessible beyond the raise.

The country rock is chloritic schist, but outcrops are scarce because a thin regolith mantles the bedrock. The foliation ranges in strike from N. 45° W. to north-south, and in dip from 26° to 40° W. A porphyritic granodiorite dike and sill that intrude the schist several hundred feet (meters) west of the upper workings were not observed near the main workings.

Gold occurs in a shear zone containing gouge, brecciated country rock, and quartz. The zone has been cemented with quartz and refractured; it strikes N. 30°-60° E., dips 80° NW. to vertical, and is 2.1 to 3.5 ft (0.6-1.1 m) thick in the main adit and 1.2 to 2.7 ft (0.4-0.8 m) thick in the lower adit. Quartz veins and quartz-filled shear zones contain as much as 0.16 troy oz of gold per ton (5.5 g Au/t) as well as 5 percent limonite and hematite. No sulfides were observed, but the gold may be associated with pyrite.

Continuity of the zone between the lower and upper workings, which is questionable, has been offset at least twice in the main adit and appears offset between the lower and main adits. However, about 18,000 tons (16,000 t) of indicated resources are estimated between the main and lower adits, and an additional 18,000 tons (16,000 t)

Data for samples shown in figure 18

[Tr, trace; N, none detected. Metric conversion factors: Feet x 0.3048=meters, Troy ounces per ton x 34.285=grams per tonne]

Sample	Type	Length (feet)	Description	Gold (tr oz per ton)	Silver (tr oz per ton)
R-10	Grab	—	Lightly limonite stained quartz from dump	0.01	N
R-11	Chip	0.9	Across quartz-filled shear zone in block of schist on adit dump	N	N
R-12	—do—	2.5	Across quartz-filled shear zone	N	N
R-13	—do—	3.5	—do—	Tr	Tr
R-14	—do—	3.4	—do—	Tr	0.1
R-15	—do—	1.4	—do—	.16	.4
R-16	—do—	1.8	—do—	.12	.2
R-17	—do—	2.7	—do—	N	N
R-18	—do—	1.2	—do—	.09	.1

FIGURE 18.—Eagle mine. *A*, Surface workings. *B*, Underground workings.—Continued

are inferred (half of the tonnage above and below the adits). These resources are based on a strike length of 500 ft (150 m), a depth of 180 ft (55 m), and a thickness of 2.4 ft(0.7 m); average grade is 0.04 troy oz of gold per ton (1.4 g Au/t). Gold values are erratic in the zone; assay results, however, indicate a potential for the discovery of high-grade ore shoots.

GOLD DOLLAR MINE

U.S. Bureau of Mines statistical records list 1,235 tons (1,120 t) of ore produced at the Gold Dollar mine (loc. 15, fig. 10) intermittently from 1921 through 1938; yield was 202 troy oz (6,280 g) of gold and 37 troy oz (1,150 g) of silver. The ore was treated on site at a mill consisting of a jaw crusher, a ball mill, a rake classifier, and Wilfley tables. An aerial tramway brought ore 1,000 ft (300 m) from the main adit to the mill. The mill and bunkhouse are in ruins, and the main adit has been blasted shut at the portal. Two other sites of possible adits or surface cuts are badly sloughed. Total length of the workings is not known.

The chloritic schist country rock strikes roughly north-south and dips about 30° or less to the west; the rock is intruded by porphyritic diorite, which locally exhibits the characteristics of both a dike and a sill. Near the hanging-wall side of this intrusive mass are numerous quartz veins that can be traced by flat and sparse outcrops for about 700 ft (200 m) uphill from the main adit. One outcrop near the adit consists of quartz veins, as thick as 6 in. (15 cm), and bands of chloritic schist. The vein-bearing zone, approximately 10 ft (3 m) thick, is exposed for 30 ft (9 m) along a north-southward strike; the quartz contains light to moderate limonite staining. No other exposures of this magnitude were observed, and it is assumed that ore was mined from this zone in the main adit.

Four samples of quartz contained as much as a trace of gold and 0.4 troy oz of silver per ton (14 g Ag/t). Ore in the vein that was mined was probably localized in pockets or shoots. Geologic conditions indicate a potential for the discovery of resources along the schist-diorite contact.

MISCELLANEOUS PROPERTIES

Several prospects were examined that have little or no economic potential or are insufficiently exposed to permit economic evaluation (table 6). Some of these prospects were on placer deposits, but, in a few cases, adits were also driven on shear zones of various types of host rock; several sites are outside the study area.

TABLE 6.—*Miscellaneous properties in the Sheep Mountain Wilderness study area*

Prospect	Locality (fig. 10)	Description	Number and type of workings	Sample data	Remarks
Native Son mine	3	Gold associated with pyrite in quartz stringers in mica schist and gneiss (Sampson, 1937, p. 188; Gay and Hofmann, 1954, p. 627).	Six caved adits ranging in length from 100 to 750 ft (30-230 m).	One grab sample contained no gold and 0.2 troy oz of silver per ton (7 g Ag/t).	Mine produced 54 troy oz (1,680 g) of gold and 15 troy oz (470 g) of silver from 105 tons (95 t) of ore during 1905-7 (U.S. Bureau of Mines statistical files).
Queenie	23	Shear zones, striking N. 47°-53° N., dipping 75°-90° SE., near contact between mylonitic gneiss and granodiorite. Dacite porphyry dike was emplaced between granodiorite and mylonitic gneiss.	Adit, 150 ft (46 m) long	Three samples contained 0-0.1 troy oz of gold per ton (0-0.3 g Au/t) and 0-3.8 troy oz of silver per ton (0-130 g Ag/t); copper values range from 25 to 80 ppm.	Prospect is in San Gabriel fault zone.
Blue Jay Nos. 1 and 2	4	Quartz pods and narrow veins in schist and along contacts with felsite dikes and country rock. Locally heavy limonite staining near dike-schist contacts. No visible sulfides.	Pit and short adit caved at portal	Three samples contained 0-0.02 troy oz of gold per ton (0-0.7 g Au/t) and 0-0.2 troy oz of silver per ton (0-7 g Ag/t).	Claims located in 1935.
Horse Shoe Consolidated (placer)	9	Adit, driven 240 ft (73 m) through siliceous schist, penetrated older stream gravel covered by landslide deposits. At least 370 yd^3 (280 m^3) of gravel was removed from adit.	Adit	One placer sample contained no recoverable gold; one of three hardrock samples contained 0.1 troy oz of silver per ton (3 g Ag/t).	Patented placer claim. Current owner reports that 2,000 troy oz (62,000 g) of gold were produced from drifts, now inaccessible. Deeded land totals 60 acres (24 ha).
San Gabriel Mining Co.	10	Claim includes both recent placer and older stream deposits. Floods have obliterated all workings in streambed gravel, but a few small pits were found in older stream gravel.	Several sloughed pits	Four of six vertical-channel samples contained gold. Highest value came from older gravel and is equivalent to \$0.39/yd^3 (\$0.30/m^3).	Patented placer claim. Deeded land totals 160 acres (65 ha).
Holly (Dot) (placer)[1]	20	Two drift mines and a pit explore older stream gravel exposed by an intermittent tributary. Gravel is compacted and well stratified.	Pit and two drift mines, totaling 125 ft (38 m) in length.	One of three placer samples contained 0.62 mg of gold per cubic foot (22 mg Au/m^3), equivalent to \$0.075/yd^3 (\$0.057/m^3).	Gay and Hoffman (1954, p. 624).
Jumbo-Channel (placers)	2	Drift mine along bedrock-gravel contact. Pit exposes 8 ft (2.5 m) of gravel.	Pit and drift mine, 110 ft (34 m) long.	Two of five placer samples from drift mine contained less than 0.01 mg Au.	Surveyed for patent in 1937 (MS 6211)
Glen-Marie (placer)	25	Small deposit of coarse angular gravel and boulders moderately cemented with clay.	Sloughed pit(?)	One placer sample contained no gold	...

Coldwater Canyon (placer)	19	Moderately sorted subrounded gravel occurs as a streambed remnant occupying a small preexisting topographic low.	Trench, 40 by 80 ft (12 by 24 m)	-do	Remnants of a screen and galvanized sluiceways. Small piles of boulders. Reported adit not found.
Dime Canyon (placer)	24	Loosely consolidated gravel and sand intermixed with Cattle Canyon alluvium.	None	One placer sample contained no gold. Trace of scheelite observed in pan concentrate.	...
Chicken Finlay (placer)	8	Strike of country rock parallels stream locally and provides a natural sluiceway. Roughly stratified flood deposits dissected by a tributary to East Fork of San Gabriel River.	None	One of two placer samples contained 0.01 mg Au.	U.S. Forest Service campground
Next Best (placer)	5	Pit exposes more than 100 ft (30 m) of discordant limonite-stained shear zone in schist. Small pockets of well-sorted sand occur behind large boulders near confluence of Iron Fork and East Fork of San Gabriel River.	Pit	One placer sample contained no gold. No gold or silver detected in one hardrock sample.	Patented claim (MS 5409)
------------------	7	Adit exposes small iron-stained quartz stringers. Schist country rock strikes N. 75° E. and dips 47° SE.	Adit, 10 ft (3 m) long	No gold or silver detected in one sample.	...
Reconnaissance placer samples	11, 12, 21, 22	Older and recent streambed gravel deposits were sampled along East Fork of San Gabriel River. Highest value was from lower part of an older deposit.	None	Three of five samples contained gold values as much as \$0.16/yd^3 (\$0.12/m^3).	...

[1]Outside boundary of study area.

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onomic Appraisal of ineral Resources of the icamonga Wilderness and Additions, n Bernardino County, ifornia

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ERAL RESOURCES OF THE SHEEP MOUNTAIN WILDERNESS
DY AREA AND THE CUCAMONGA WILDERNESS AND ADDITIONS,
ANGELES AND SAN BERNARDINO COUNTIES, CALIFORNIA

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By NICHOLAS T. ZILKA and STEVEN W. SCHMAUCH
U.S. BUREAU OF MINES

ECONOMIC APPRAISAL

Minor copper production has come from the Lytle Creek mine in the central part of the Cucamonga Wilderness (loc. 6, fig. 19); an estimated 130 tons (120 t) of mineralized rock containing copper-silver values remains. Small deposits of lead, zinc, silver, graphite, tungsten, and gem stones occur at the boundary of, or just outside, the study area.

SETTING

The Cucamonga Wilderness and its proposed additions (fig. 19), which encompass approximately 13,000 acres (5,300 ha) of Angeles and San Bernardino National Forests, are 8 mi (13 km) north of Upland, Calif., and are separated from the Sheep Mountain Wilderness study area by San Antonio Canyon. Roads reach all sides of the two areas, but rugged topography makes the territory difficult to traverse except by trail. The aridity of the area and numerous fires have created an impenetrable growth of brush and yucca on many slopes; water occurs year round only in the lower valleys.

Mining activity in the region began in the 1840's and has continued intermittently to the present. Most activity has involved recovery of placer gold from both recent streambed and older, perched-stream-channel deposits.

Lytle Creek, named for Andrew Lytle, who settled in San Bernardino, Calif., in 1851, was the site of several mining operations (Clark, 1970). Placer mining by both hydraulic and hand methods, which reached a peak in the 1890's, extended from near the mouth of the canyon to near its headwaters. Gold was found mainly in elevated

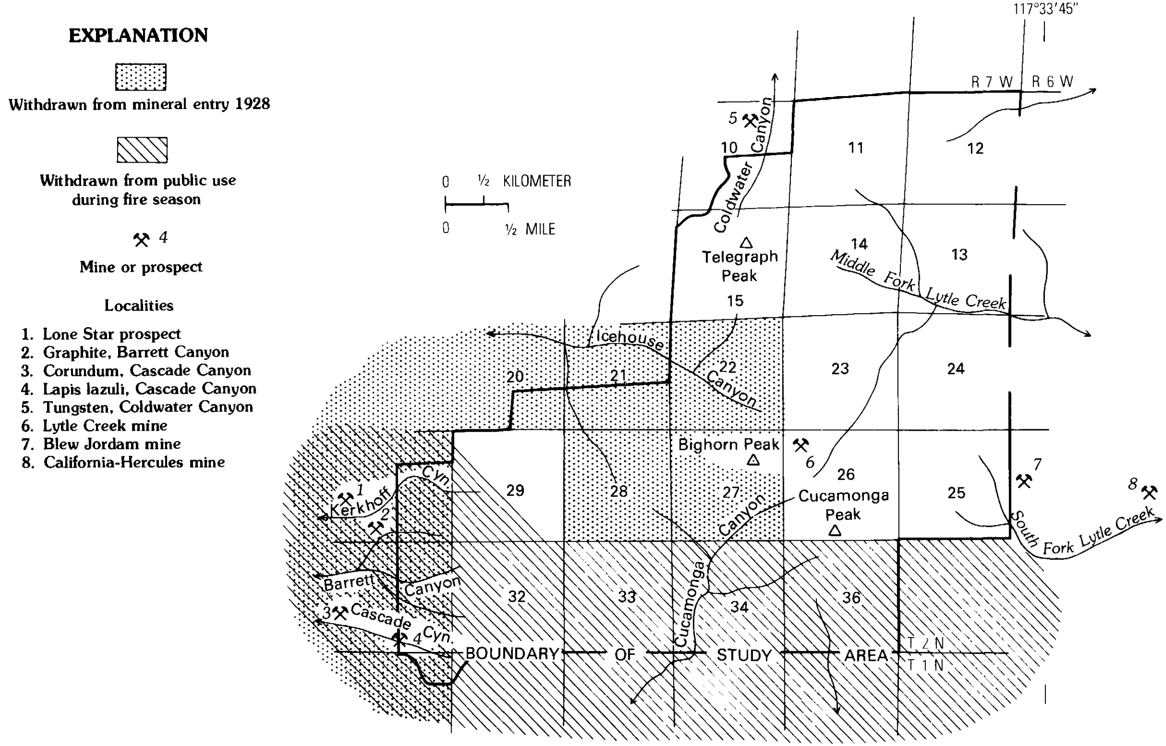

FIGURE 19.—Cucamonga Wilderness and proposed additions, showing mines, prospects, and lands with restricted entry.

high-river terraces in the lower part of Lytle Creek; by the turn of the century, much of the ore had been removed, and water consumption by nearby agricultural developments hampered operations. Total gold production from the canyon is not recorded but was estimated at more than $80,000 (Cloudman and others, 1919).

An auriferous gravel deposit was discovered in 1882 in Mount Baldy Notch, now the site of a ski area, just northwest of the study area. This channel deposit, which was 200 to 250 feet (60-75 m) wide and trended northwest (Cloudman and others, 1919), was hydraulicked, and the gold was recovered in a series of sluiceboxes. Water came from reservoirs supplied by snowmelt and Hocamac Spring. Mining activity ceased near the turn of the century, when the deposit was nearly mined out and when muddy debris-filled water from the operation interfered with agricultural and power developments in the lower part of San Antonio Canyon. Total gold production is unknown, but daily yield was stated to have had a value of $48 (Cloudman and others, 1919).

In 1889 a company constructed a dam, a tunnel, and a sequence of sluiceboxes to work gold-bearing gravel in San Antonio Canyon (Cloudman and others, 1919). Details of the operation are unavailable, and flooding in 1938 obliterated the remnants of such operations in most of the area's major canyons.

As placer production decreased, prospectors began to search for the source of gold. Most efforts were unsuccessful because the gold apparently came from numerous small low-grade veins throughout the area and not from a few large deposits.

The Lytle Creek mine (loc. 6, fig. 19) was worked for copper since about 1888 (Aubury, 1908, p. 335). In the mid-1900's, lead-zinc-silver deposits were mined at the Blew Jordam and California-Hercules mines, just outside the Cucamonga Wilderness area (locs. 7, 8, fig. 19); mineral production from these properties was apparently small.

Lands in Angeles National Forest were withdrawn from mineral entry in 1928 "*** to conserve the water resources and to encourage reforestation of the watersheds" (Public Law No. 578, S. 4135—70th Congress); withdrawn lands within the Wilderness study area, mainly on the west side, constitute about 4.5 mi^2 (12 km^2) (fig. 19). The law does not prohibit prospecting and allows entry to proven ore deposits but effectively discourages complex exploration methods. Exploration is also discouraged in the southern part of the study area by fire-hazard closure (fig. 19); the lands are closed to public use from July 1 until the first autumn rain.

PREVIOUS STUDIES

Wright and others (1953) briefly described the mines and mineral deposits of San Bernardino County. Prospects in or near the study area were reported by De Groot (1890), Aubury (1908), Cloudman and others (1919), Tucker and Sampson (1931, 1943), Eric (1948), and Clark (1970). The study area was mapped by T. W. Dibblee, Jr., and P. L. Ehlig, and their data were incorporated into the geologic map of San Bernardino County compiled by Rogers (1969) for the California Division of Mines and Geology.

PRESENT INVESTIGATIONS

Studies by the U.S. Bureau of Mines, consisting of an investigation of mines, prospects, and mineralized areas, were made during 1975 by the authors assisted by M. C. McCarthy, G. D. Clarke, and S. D. Brown. Analytical work was directed by H. H. Heady of the U.S. Bureau of Mines, Reno, Nev.; records of mineral sites were obtained from U.S. Forest Service files.

Acknowledgments.—The cooperation of claim holders and local residents in the area is appreciated. We are especially grateful for assistance from personnel of the U.S. Forest Service.

MINERAL COMMODITIES AND ECONOMIC CONSIDERATIONS

Mineral commodities found in or adjacent to the Cucamonga Wilderness include gold, silver, copper, tungsten, zinc, lead, graphite, and gem stones. However, only copper occurs in significant amounts.

Most U.S. production of copper is from large disseminated low-grade deposits and not from vein deposits, such as are found in the study area. Dependence on domestic resources will likely increase as foreign sources become less available. The average price of domestic copper was $0.89/lb ($1.96/kg) in December 1980 (Engineering and Mining Journal, 1981).

METHODS OF EVALUATION

Locations of prospects were obtained from U.S. Forest Service records, various publications, and from local residents. All prospects in and near the study area were mapped and sampled; samples were also taken of mineralized material occurring outside claim boundaries.

A total of 54 lode samples, averaging about 5 lb (2.5 kg) each, were collected. All samples were pulverized, analyzed for radioactive or fluorescent minerals, and fire assayed for gold and silver; other metallic elements were determined by atomic-absorption, colorimetry, or X-ray fluorescence methods. Selected samples were analyzed by a semiquantitative spectrographic method.

MINING CLAIMS

U.S. Forest Service records and the available literature indicate that about 53 claims have been located within or adjacent to the study area; some were relocations of previous claims. The Blew Jordam mine and millsite on the east side of the area were patented in 1944.

MINERALIZED AREAS

A single mineral deposit, the Lytle Creek mine, lies within the Cucamonga Wilderness. Several other deposits are on the boundary of, or just outside, the study area.

LYTLE CREEK MINE

The Lytle Creek mine is situated on the east side of Bighorn Peak at approximately 7,600 ft elevation (loc. 6, fig. 19); the site is accessible by foot trail from Icehouse Canyon. A small hillside excavation and more than 200 ft (60 m) of underground workings in four adits expose copper-bearing pods, shear zones, and joint systems (fig. 20).

The country rock is composed of quartz diorite. Randomly distributed sulfide and quartz-sulfide pods in the rock range from several inches (centimeters) to more than 2 ft (0.6 m) in diameter. Chalcopyrite, tetrahedrite, and sphalerite are contained in these pods. Malachite staining, found along fractures and in some small shear zones, has been traced to pods in the workings.

Eight samples from the two largest pods, from a shear zone, and from a joint system contained significant copper-silver values; zinc concentrations averaged less than 0.05 weight percent. An estimated total resource of 130 tons (120 t) averages 0.67 weight percent Cu and 0.67 troy oz of silver per ton (23.0 g Ag/t).

Most mineral resources are contained in the sulfide pods; further exploration may disclose additional deposits. The average grade of the pods is as much as 2.18 weight percent Cu and 4.06 troy oz of silver per ton (139 g Ag/t), but the measured tonnage makes the occurrence submarginal.

MISCELLANEOUS DEPOSITS

Thirteen trenches, seven pits, and a 13-ft (4 m)-deep shaft at the Blew Jordam mine, east of the boundary of the Cucamonga Wilderness (loc. 7, fig. 19), intermittently expose garnet-epidote tactite along a quartz diorite/limestone contact; lead-zinc sulfides are found locally in the contact zone. Samples reportedly contain as much as

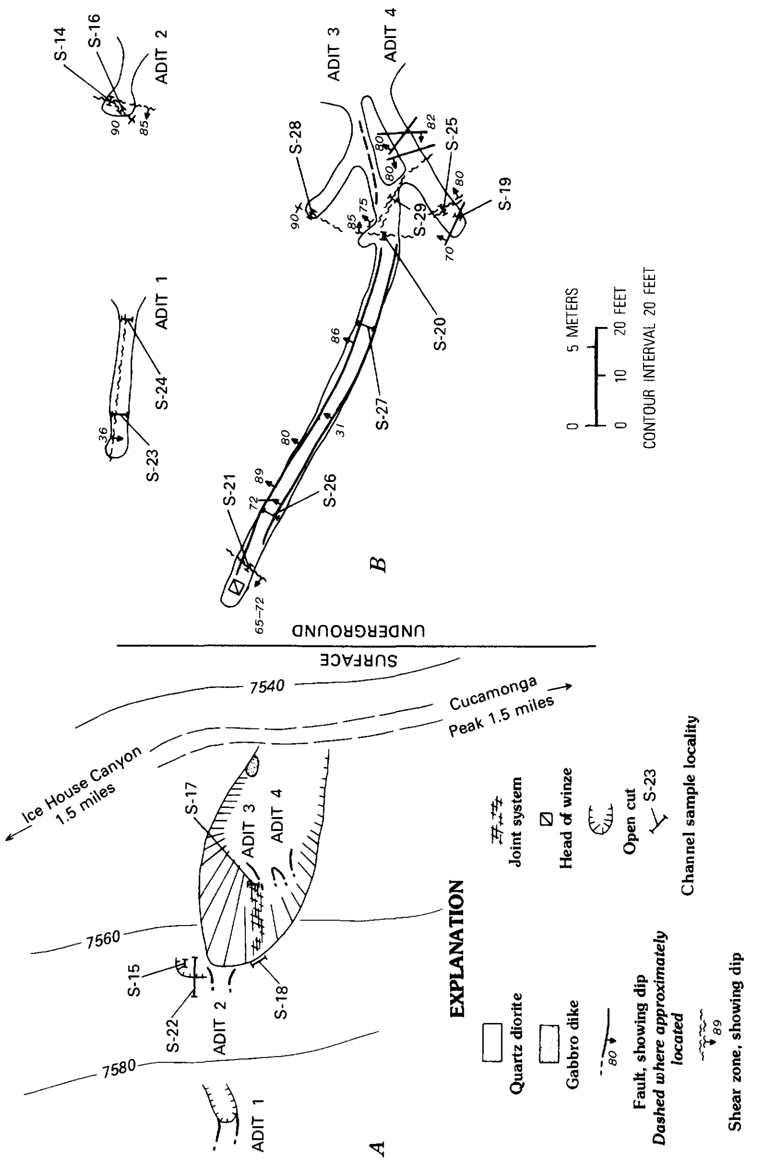

FIGURE 20.—Lytle Creek mine (surface and underground workings).

13.1 weight percent Zn, 3.6 weight percent Pb, and 6.65 troy oz of silver per ton (228 g/t). The 20- to 30-ft (6-9 m)-thick zone is traceable for more than 1,000 ft (300 m) but does not appear to extend into the study area.

The California-Hercules mine (loc. 8, fig. 19) lies outside the study area on the South Fork of Lytle Creek; lead-zinc sulfides occur locally along quartz diorite/limestone contacts. All workings are caved, and the mine road has been washed out.

Crystals of ruby corundum in migmatite occur just outside the study area (loc. 3, fig. 19), and veinlets of lapis lazuli are found at the wilderness boundary in Cascade Canyon (loc. 4, fig. 19). Graphite is present at the boundary in the North Fork of Barrett Canyon (loc. 2, fig. 19). The quality and size of these occurrences make them economically valuable only for mineral specimens.

A 103-ft (31 m)-long adit driven into highly sheared migmatite lies outside the study area, north of the mouth of Kerkhoff Canyon (loc. 1, fig. 19); samples from the adit contained no economic mineral values.

Data for samples shown in figure 20

[Tr, trace; N, non detected. Metric conversions: Feet x 0.3048=meters, Troy ounces per ton x 34.285=grams per tonne]

Sample	Type	Length (feet)	Description	Gold (tr oz per ton)	Silver (tr oz per ton)	Copper (percent)
S-14	Chip	1.0	Across shear zone	N	N	0.83
S-15	—do—	2.5	Across sulfide pod	Tr	15.9	7.7
S-16	—do—	1.0	Across shear zone	Tr	1.4	.95
S-17	—do—	3.0	—do—	N	.2	1.4
S-18	—do—	2.4	—do—	N	.2	.90
S-19	—do—	1.0	—do—	Tr	.3	Tr
S-20	—do—	1.2	—do—	Tr	.1	Tr
S-21	—do—	1.0	—do—	Tr	.1	Tr
S-22	—do—	10.0	—do—	Tr	1.1	.80
S-23	—do—	4.0	—do—	N	N	.09
S-24	—do—	1.9	Across sulfide pod	Tr	3.9	1.4
S-25	—do—	2.1	Across shear zone	Tr	.2	Tr
S-26	—do—	2.5	—do—	N	.2	Tr
S-27	—do—	2.5	—do—	N	.1	Tr
S-28	—do—	0.8	—do—	Tr	.1	.03
S-29	—do—	1.5	—do—	Tr	.1	Tr

FIGURE 20.—Lytle Creek mine (surface and underground workings).—Continued

Several cuts in sec. 10, T. 2 N., R. 7 W., expose scheelite-bearing veinlets in mylonite gneiss (loc. 5, fig. 19). Selected samples from across the four mineralized outcrops contained as much as 3.13 weight percent tungsten trioxide (WO_3). The foliation trends north-south, but both sampling and an ultraviolet-lamp survey indicate no potential for the discovery of placer deposits in the study area.

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