MINERAL RESOURCE POTENTIAL OF THE RAYWOOD FLAT ROADLESS AREAS, SAN BERNARDINO AND RIVERSIDE COUNTIES, CALIFORNIA

SUMMARY REPORT

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STUDIES RELATED TO WILDERNESS

Geologic, geochemical, and geophysical studies within the Raywood Flat Roadless Areas, together with an investigation of mines and prospects within the further planning area, resulted in (1) identification of nonmetallic mineral resources 1 at a marble mine in the further planning area and (2) recognition of a small area in the recommended wilderness that has moderate potential for base-metal resources. Except for these two areas of identified and suspected resources, we did not observe indications of resource potential elsewhere in the Raywood Flat Roadless Areas.

The area having nonmetallic mineral resources is in the vicinity of the Mill Creek mine near the northeastern boundary of the further planning area (B5-187); there, we identified marginal reserves of marble suitable for the production of lime and construction stone. The reserves are marginal because of their remote location and poor accessibility. Geologic mapping did not reveal any additional marble occurrences within the study area.

The area having moderate potential for base-metal resources forms a small zone in the eastern part of the recommended wilderness (A5-187). Within this zone, evidence provided by stream-sediment geochemistry suggests that crystalline bedrocks in several drainages contain concentrations of metallic elements. Because the terrain is inaccessible and covered with dense brush, most of the bedrock in the specific drainages containing the geochemical anomalies could not be examined. Thus, although we infer that mineral occurrences exist in the drainage basins, we have little data on which to base an estimate of their extent and quality. Locally, the crystalline rocks probably contain hydrothermal veins or disseminated occurrences where lead, copper, molybdenum, tin, cobalt, bismuth, and arsenic have been concentrated. However, the geochemical anomalies for these metals are small, and the stream drainages also are relatively small. Therefore, the inferred occurrences of metallic minerals probably are small scale, scattered, and low grade. There is only low probability that the inferred mineral occurrences are large scale.

INTRODUCTION

The Raywood Flat Roadless Areas consist of a further planning area and a recommended wilderness area that are located in the southeastern San Bernardino Mountains, about 35 mi east of San Bernardino and about 10 mi north of Banning, Calif. (fig. 1). The further planning area (B5-187) constitutes about 29 mi² (18,615 acres); the recommended wilderness area (A5-187) constitutes about 35 mi² (22,320 acres). The roadless areas are situated adjacent to the existing San Gorgonio Wilderness, and consist of rugged mountainous terrain that includes Allen Peak (7,747 ft), Little San Gorgonio Peak (9140 ft), Galena Peak (9,330 ft), and Kitche Peak (6,598 ft). The study area is drained by major streams that include Mill Creek, several tributaries of Oak Glen Creek, San Gorgonio River, and the North and South Forks of Whitewater River. Access to the roadless areas is gained from several entry points. In Mill Creek Canyon, a paved

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1The definition of resource follows established usage of the U.S. Bureau of Mines and U.S. Geological Survey (1980): "A concentration of naturally occurring solid, liquid, or gaseous material in or on the Earth's crust in such form and amount that economic extraction of a commodity from the concentration is currently or potentially feasible". Defined in this broad fashion, a resource can contain extractable material (reserves) that can be developed now, and (or) additional material (marginal reserves, subeconomic resources) that feasibly may be developed in the future under more favorable market conditions and (or) with more advanced technological capability.
road that branches from State Highway 38 affords access to much of the further planning area; southern parts of this area can be entered by dirt roads that lead from Oak Glen Road, a paved road that follows Oak Glen Creek. Access to the recommended wilderness is by dirt roads leading up Millard Canyon and its major tributaries, and by permit on a private dirt road that leads up San Gorgonio River and terminates at Raywood Flat.

Uses and limitations

This report summarizes the results of geologic, geochemical, and geophysical surveys conducted in the Raywood Flat Roadless Areas by the U.S. Geological Survey and an investigation of mines, prospects, and mineralized areas conducted by U.S. Bureau of Mines. The purpose of this study is to provide a mineral resource basis for land-use decisions regarding the study area and to target areas more suitable than other areas for additional mineral resource investigations. To achieve these goals, this study is designed to distinguish areas of lesser or greater resource potential based on differences in the type, scale, and degree of mineral concentration.

The techniques used in this investigation permit two types of reconnaissance evaluation: (1) where appropriate, we can estimate measured, indicated, or inferred resource potential for mines and prospects identified within the study area (mineral resource terminology follows the usage of U.S. Bureau of Mines and U.S. Geological Survey, 1980); (2) for geologic terranes that have no identified resources, we can judge whether high, moderate, or low potential exists for metallic, nonmetallic, or energy resources. The reconnaissance nature of this investigation limits our ability to make definitive statements about the geologic setting or resource content of either known or suspected mineral occurrences. We can identify areas that have potential for additional resource studies, and we can describe generalized geologic environments for particular minerals that are known or suspected to exist. In addition, for geologic terranes that have no identified resources, we can provide limited judgments about the most likely scale of occurrence for undiscovered minerals, based on what we know about the geologic setting and geochemical or geophysical signatures and based especially on analogy with known occurrences in similar geologic settings elsewhere in the region. However, for mineral occurrences newly identified by us or indicated indirectly by geochemical or geophysical data, we can not document the quality and quantity of resources contained in such occurrences. Followup studies in the Raywood Flat Roadless Areas—involving additional geologic mapping, more detailed geochemical surveys of bedrock and stream-sediments, and drilling—would be necessary to document the geologic setting, extent, and grade of metallic, nonmetallic, or energy resource potential that may be present. We can only judge whether high, moderate, or low potential we have assigned could be upgraded or downgraded based on new information or based on future changes in resource requirements.

** GEOLOGIC SETTING **

The San Bernardino Mountains consist of a high elongate block that has been uplifted to its present elevation during the last few million years (Sadler, 1982). Crystalline bedrock within this block records a complex sequence of geologic events. Early events that occurred in Mesozoic time include granitic plutonism, metamorphism of pre-plutonic sedimentary and igneous rocks, and folding, faulting, and penetrative shearing of both the plutonic and pre-plutonic units. These early events provided a geologic setting within which mineralization processes could have produced mineral deposits. The most recent geologic events have occurred during Tertiary and Quaternary time, when rocks that may have been mineralized during earlier events were redistributed within the mountain range and within the region by movements along faults. These events include (1) lateral movements on strike-slip faults of the San Andreas system that occur along the south margin of the range and (2) vertical and lateral movements on major thrust faults that flank the north margin of the range. Mineralization most likely did not occur during these latest geologic events.

Rocks within the Raywood Flat Roadless Areas record many elements of this geologic history. The study area is underlain mainly by crystalline bedrock that consists of granitoid plutonic rocks, gneissic plutonic rocks, and common bodies of metasedimentary rock (fig. 2). Valley and upland areas locally contain Quaternary deposits of gravel and sand (Raywood Flat itself is an intermontane upland valley that contains dissected deposits of older gravel). Lateral and small landslides down the hillsides of these slope-failure deposits appear to be most common and most extensive in areas where active vertical uplift may be occurring, or where seismic ground shaking due to earthquake activity on nearby faults may provide a triggering mechanism. Three strands of the San Andreas fault system occur in the vicinity of the Raywood Flat Roadless Areas—the Mission Creek fault, the Mill Creek fault, and the south branch of the San Andreas fault. The south branch presently is the active strand of the San Andreas system. Although the Mill Creek and Mission Creek faults both appear to be strands that have been abandoned by the San Andreas system, many tens of miles of right-lateral displacement on these two faults have carried rocks northwestward into the Raywood Flat area from their original location in the Salton trough area.

**Crystalline rocks**

Crystalline rocks in the Raywood Flat Roadless Areas are divided into three suites according to their origin and structural setting: (1) rocks north of the Mill Creek fault; (2) rocks between the Mission Creek and Mill Creek faults; and (3) rocks south of the Mission Creek fault. The two crystalline suites separated by the Mill Creek and Mission Creek faults have been subdivided into three distinct suites of gneiss that are known or suspected to exist. Any potential that may be present in these gneiss terranes has been intruded by plutonic rocks north of the Mill Creek fault; (2) rocks between the Mission Creek and Mill Creek faults; and (3) rocks south of the Mission Creek fault. These two crystalline suites separated by the Mill Creek and Mission Creek faults have several unique features not found in the other two suites. Similarities and differences among the three suites provide evidence for approximate and relative amounts of right-lateral displacement along the Mission Creek and Mill Creek faults of the San Andreas fault system.

Rocks north of the Mill Creek fault

Rocks north of the Mill Creek fault (fig. 2) have been described by Morton and others (1980) and by Cox and others (1983a) during their geologic investigations of the San Gorgonio Wilderness. The crystalline rocks consist of two distinct suites of gneissic rock that have been intruded by several varieties of plutonic rock. In this area, the southern gneiss terrane consists of biotite-rich, compositionally layered Precambrian gneiss. A younger gneiss terrane includes a heterogeneous assemblage of foliated to gneissic granitoid rocks whose plutonic rocks are mainly Mesozoic in age. These two gneiss terranes have been intruded by lithologically distinct varieties of Mesozoic granitoid rock that form plutons of moderate size. The plutonic rocks include leucocratic muscovite-biotite monzogranite (termed quartz monzonite by Morton and others, 1980), biotite granodiorite, hornblende-biotite granodiorite, and porphyritic hornblende quartz monzodiorite containing distinctive phenocrysts of potassium feldspar (rock nomenclature follows Streckeisen, 1973). The elongate arcuate extension of the Raywood Flat further planning area (55187) that is situated north of the Mill Creek fault is underlain mainly by the phenocryst-bearing quartz monzodiorite and by the biotite-rich gneiss unit. At its east end, this area is underlain by monzogranite and by gneissic plutonic rocks of the heterogeneous crystalline complex.

Rocks between the Mill Creek and Mission Creek faults

Crystalline rocks between the Mill Creek and Mission Creek faults (fig. 2) generally are similar to foliated and gneissic rocks north of the Mill Creek fault. Near the western end of the further planning area, this assemblage includes foliated biotite granodiorite that forms a discrete pluton of moderate size. However, in most areas the crystalline rocks are represented by biotite-bearing granitoid rocks that exhibit...
it diffuse to conspicuous gneissic layering and that have compositions ranging from monzogranite to tonalite. Locally, pods of biotite-sillimanite-garnet schist, metaquartzite, and marble occur as inclusions within the foliated and gneissic plutonic rocks. As with the terrane of heterogeneous gneissic granitoid rocks north of the Mill Creek fault, this terrane between the Mill Creek and Mission Creek faults probably formed during Mesozoic time as a result of intense thermal and tectonic activity. These events involved partial melting of pre-existing continental crust, along with plutonism, migmatization, and deformation by ductile shearing. These processes probably occurred at intermediate or deep levels in the Earth’s crust, and produced fabrics and structures that impart a metamorphic rather than plutonic appearance to the rocks.

Rocks south of the Mission Creek fault

South of the Mission Creek fault, the rocks consist of two distinct terranes separated by a steeply dipping thrust fault that is part of the region-wide Vincent-Oroopia thrust system (Ehlig, 1981, p. 266-277). Rocks in the lower plate of this thrust crop out in a restricted area in the headwaters of San Gorgonio River. There, the rocks consist mainly of albite-actinolite-chlorite-epidote greenstone that has been metamorphosed to greenschist facies. Subordinate lithologies include metatuff, metatuffstone, and minor carbonate rocks. These rocks are similar to the Pelona Schist of the San Gabriel Mountains 45 mi west of the study area.

Rocks in the upper plate of the Vincent-Oroopia thrust consist of a lithologically monotonous assemblage that includes foliated granitoid rocks, gneissic granitoid rocks, compositionally layered gneiss, and pegmatite. Abundant epidote characterizes many of these rocks. The granitoid rocks and their gneissic equivalents have a range of compositions that includes leucocratic biotite granodiorite, mesocratic biotite-biotite-chorrit quartz diorite and tonalite, granodioritic orthogneiss, and distinctive hornblende- and potassium-feldspar-bearing porphyritic granodiorite that is lithologically similar to the Triassic Mount Lowe Granodiorite of the San Gabriel Mountains (Miller, 1920, introduced the name Mount Lowe Granodiorite; Ehlig, 1981, p. 262-263, discussed the petrology and regional correlation of the unit). Farley (1979) mapped the distribution of the Mount Lowe lithologies in the Raywood Flat area and discussed their affinity with similar rocks in the San Gabriel Mountains. Most of the plutonic rocks and most of the plutonic protoliths for the layered gneisses probably are Mesozoic in age, although bodies of Precambrian orthogneiss may be present. This crystalline terrane has been affected by one or more regional deformations that have crushed and sheared the rocks and have produced pervasive planar fabrics that include textural foliation, cataclastic and mylonitic foliation, and gneissic compositional layering. Mylonitic fabrics are especially well developed structurally low in the terrane, near the Vincent-Oroopia thrust in the headwaters of San Gorgonio River. Following the latest episode of deformation, the crystalline rocks were intruded by dikes of hypabyssal dacite porphyry and porphyritic basalt.

Faults

The two most conspicuous faults in the Raywood Flat Roadless Areas are the Mill Creek and Mission Creek faults. The Mill Creek fault is exposed best in the headwaters of Mill Creek, where the fault consists of a south-dipping zone of crushed and sheared rock that is about 700 ft wide. The shear planes do not disturb Quaternary older-gravel deposits that overlie the fault zone.

The Mission Creek fault is a complicated zone that traverses the South Fork of Whitewater River and splays into southern and northern strands in the vicinity of Raywood Flat. Both of these strands pass westward into the headwaters of San Gorgonio River, where the northern strand is truncated by the southern strand. The southern strand then curves southwestward and eventually is truncated by the south branch of the San Andreas fault. West of Raywood Flat, the two strands of the Mission Creek fault bound a small window of Pelona Schist that is overthrust by sheared and cataclasized upper-plunge rock of the Vincent-Oroopia thrust. Here, both the upper-plunge and lower-plunge rocks differ significantly from their counterparts south of the southern strand, a relationship which suggests that the two strands of the Mission Creek fault have had distinct and separate geologic histories. We believe that the northern strand is an older strand that was active early in the history of the Mission Creek fault zone. Following an initial period of displacements on the northern strand, the southern strand became the principal deformation zone until the older strand probably had greater displacements as evidenced by its wider shear zone. Neither fault appears to have been active since the deposition of Quaternary older-gravel deposits. The older gravels in the vicinity of Raywood Flat are disturbed by a fault that breaks the deposits to the east (Ehlig, 1977) and forms a topographic scarp in the deposits to the west, but we do not attribute this fault to Quaternary right-lateral activity within the Mission Creek fault zone. Instead, we believe this Quaternary deformation has been produced by a fault whose trace coincides with the Mission Creek fault system in the vicinity of Raywood Flat, but departs from it in the headwaters of San Gorgonio River.

The Mill Creek and Mission Creek fault zones both are right-lateral faults that once were major strands of the San Andreas fault system, but were abandoned by that system during late Quaternary time. Right-lateral displacements along both zones have resulted in lithologic differences across the faults. However, Holocene or late Pleistocene activity appears to have been minimal as evidenced by the fact that the faults have not broken Quaternary gravel deposits that developed unconfinedly overlie the terrane. Lithologic contrasts across the Mill Creek fault system are greater than contrasts across the Mission Creek fault system, a relationship which suggests that right-lateral displacement on the Mission Creek fault zone has been greater than that on the Mill Creek fault zone (see Ehlig, 1977; Farley, 1979).

GEOLGY, GEOCHEMISTRY, AND GEOPHYSICS PERTAINING TO MINERAL RESOURCE ASSESSMENT

Geology

Metallic mineralization

Although geologic environments that commonly are favorable for the development of mineral deposits occur in the Raywood Flat Roadless Areas, we did not observe evidence for significant occurrences of precious and base metals, nonmetallic minerals, or energy minerals. Favorable sites for mineralization in the study area might be expected in the following generalized geologic settings: (1) metasedimentary rocks that could contain contact-zone metasomatic replacement deposits; (2) injection pegmatites and pegmatitic metamorphic segregations that could contain deposits of metallic or radioactive elements; (3) foliated and gneissic granitoid rocks that could contain disseminated deposits of metals, radioactive elements, or rare-earth elements; (4) quartz veins or other vein-type deposits that result from hydrothermal mineralizing systems; (5) layered greenstone units of Pelona Schist that could contain massive-sulfide deposits; and (6) Quaternary sand and gravel deposits that could contain placer accumulations of precious metals, radioactive minerals, or rare-earth elements. Our examination of rocks within the Raywood Flat Roadless Areas suggests that, although small-scale mineral occurrences may exist locally, these generalized geologic environments probably have not been the sites of large-scale mineralization.

Contact metasomatic environments—Metasedimentary rocks that are scattered throughout gneissic plutonic rocks of the study area provide potential sites for metallic mineralization contact metasomatism. Elsewhere in the eastern San Bernardino Mountains, in areas such as the Tip Top Mountain, Holcomb Valley, and Bear Valley districts about 20 mi north of the study area, gold and tungsten have been discovered in Paleozoic quartzite, metatexture, and marble that have been intruded by late Mesozoic plutons. Adjacent to the Raywood Flat roadless areas, small-scale
metallic mineralization resulting from contact metamorphism has been inferred by Cox and others (1983a) for parts of the San Gorgonio Wilderness that contain small bodies of marble. In the study area, north of the Mill Creek fault and between the Mill Creek and Mission Creek faults, small bodies of metasedimentary rock are scattered sparsely throughout that are related and genetically distinct. The metasedimentary rock consists mainly of biotite–sillimanite–garnet schist that do not show obvious signs of mineralization. Except for several small marble lenses that occur in the vicinity of the Mill Creek mine (fig. 2, loc. 3), marble and metasedimentary rocks are rare in the study area. In the marble bodies at the Mill Creek mine we observed scattered small-scale tectite zones containing the tungsten mineral scheelite. This was the only evidence of mineralization related to contact-zone metamorphism that we observed in the roadless area.

Legends and veins of pegmatite that occur locally within the study area provide potential sites for occurrences of metallic, rare-earth, or radioactive elements. A known example of such mineralization is the abandoned workings near Alger Creek in the further planning area (the St. Patrick mine, fig. 2, site 2); here, a low-grade occurrence of the uranium-bearing mineral uranothorite has been reported by Hewett and Stone (1957). The uranothorite is disseminated in pegmatitic lenses that occur in granite gneiss near Mill Creek. Nearby, pegmatitic segregations also occur within biotite-rich compositionally layered Precambrian gneiss. In their study of the adjacent San Gorgonio Wilderness, Cox and others (1983a) cited evidence from geochemical and aeroradiometric surveys (Pitkin and Bliss, 1981) that the presence of uranium in the pegmatitic lenses that we examined.

Porphyry occurrences in granitoid environments.—Fertilized and gneissic granitoid rocks within the study area provide potential sites for disseminated occurrences of metallic elements. However, the petrology and intrusive setting of these plutonic rocks differs from plutonic rocks elsewhere that have produced disseminated–mineral deposits (for example, copper–molybdenum–porphyry deposits); occurrence and extent for dissemination in the study area are discussed by Cox, 1982, Ludington, 1982, and Theodore, 1982). In the Raywood Flat Roadless Areas, we did not observe textural and petrologic features that characterize porphyry–metal deposit types; we also did not observe evidence indicating that disseminated metals might be present (extensive zones of alteration or oxidation, or zones of rock containing disseminated native metals or metallic sulphides). Vein and replacement environments.—Fertilized and gneissic granitoid rocks within the study area are potential sites for hydrothermal veins or replacement bodies containing metallic mineral occurrences. However, in the rocks we examined, we did not observe direct evidence for these types of mineralizing systems (for example, surficial evidence such as extensive quartz–vein networks, iron– or copper–stained rock or gossans, alteration zones, concentrations of metallic ore minerals in veins). Stream–sediment geochemistry suggests that some drainages in the eastern part of the study area have been sites where base metals have been concentrated. Moreover, the greenstones possibly originated as submarine basaltic tuff, an idea favored by Ehlig (1968; 1981, p. 270). Under these conditions the rocks probably would not have been hot for periods sufficient to permit significant migration of precious metals, radioactive minerals, or minerals containing rare–earth elements. We obtained numerous geochemical samples of fresh sediment deposited by active streams; however, none of these samples provides geochemical evidence that undiscovered occurrences of radioactive elements or rare–earth elements within pegmatitic segregations or veins in these rocks are likely to be small-scale and insignificant. This conclusion is applicable not only to the San Gorgonio Wilderness, but also to adjacent parts of the recommended wilderness.

Nonmetallic mineral resources

Sand and gravel deposits and granitoid rocks that occur in the Raywood Flat Roadless Areas provide possible sources of sand and gravel deposits for industrial uses. These deposits are similar to the older sedimentary deposits, including younger alluvial deposits as well as dissected older deposits. The older deposits contain larger placer deposits. We did not sample the older gravel units and thus have evaluated these gravels as a potential placer resource; however, panned concentrates forplacer-type mineral occurrences. Bodies of sand and gravel within the study area most likely are not sites for placer-type mineral occurrences.

Geochemistry

A reconnaissance geochemical survey of stream sediments in the Raywood Flat Roadless Areas was conducted for 33 major, minor, and trace elements to identify any spatial variations in the concentration of platinum-group elements. The results of the geochemical survey are discussed by Matti and Cox (1983).

The patterns of chemical composition determined by the stream–sediment geochemical survey of the Raywood Flat Roadless Area do not indicate significant large-scale min-
eralization within the study area. Few elemental values are anomalous with respect to the average geochemical background for the roadless areas; most of the anomalies fall within ranges that are reasonable for nonmineralized crystalline rocks and derivative stream sediments. Geochemical evidence thus is compatible with geologic evidence: both reconnaissance techniques suggest that significant occurrences of metal-nonmetallic minerals probably do not occur in the Raywood Flat Roadless Areas.

Radioactive and rare-earth elements and transition metals

Anomalous and elevated values for uranium, thorium, lanthanum, niobium, yttrium, and zirconium occur in stream-sediment samples throughout the Raywood Flat Roadless Areas, although most commonly in the further planning area (B5-187) north of the Mission Creek and Mill Creek fault zones. For example, uranium was detected in higher-than-average amounts in several bulk-sediment samples north of the Mission Creek fault zone and especially north of the Mill Creek fault zone, but south of the Mission Creek fault zone. Elevated values for uranium occur only in isolated samples. The distribution of these elements seems to be related to (1) the overall composition of foliated and gneissic plutonic rocks and (2) the distribution of pegmatitic veins and segregations. Foliated and gneissic biotite-bearing plutonic rocks north of the Mission Creek fault zone generally are more ioeuocratic and more enriched in potassium than biotite-bearing foliated and gneissic plutonic rocks south of this fault zone. Moreover, pegmatite dikes and metamorphic segregations are common throughout the crystalline rocks north of the Mission Creek fault zone, but are only abundant locally south of this fault zone. We believe these geochemical contrasts give rise to the geochemical contrasts for radioactive and rare-earth elements that exist in the Raywood Flat Roadless Areas.

Elevated or anomalous values for radioactive and rare-earth elements and transition metals probably reflect higher-than-average background levels for these elements rather than local concentrations of ore minerals. These elements probably occur in common non-ore rock-forming minerals such as plagioclase, biotite, amphibole, and epidote that we have observed in thin sections of the crystalline rock units. The abundance and chemical composition of these non-ore minerals vary in different rock types from place to place within the study area; these variations probably account for higher-than-average values of rare-earth elements, radioactive elements, and transition metals that occur in some drainages.

Metallic elements

In some panned-concentrates, metallic elements were detected in amounts that exceed background values; these elevated values indicate that local mineral concentrations may exist in the study area. The origin of the geochemical anomalies is unknown. However, their geologic sources probably are limited in size and distribution because the anomalies are not large and because they generally do not show systematic geographic patterns or clustering. The anomalies probably are not related to significant mineral occurrences; instead, they probably represent local geologic sources such as quartz veins, injection pegmatites and pegmatitic segregations in the layered gneiss, or various kinds of igneous dikes.

One example of metallic anomalies that we have attributed to isolated geologic point sources include higher-than-average values for chromium, cobalt, nickel, and copper that occur in panned-concentrates samples and to a lesser degree in bulk-sediment samples from several streams that drain the further planning area (B5-187) north of Mill Creek. A particularly anomalous sample collected from Skinner Creek (fig. 2, site SG-08) contains 700 ppm (parts per million) chromium, 50 ppm cobalt, and 500 ppm nickel in the bulk-sediment fraction. These conspicuous anomalies suggest a mafic or ultramafic igneous source. Numerous dikes of fine-grained mafic rock are well exposed in roadcuts along Highway 38, and some of them crop out upstream from the sample site on Skinner Creek. We did not study the dikes in detail, but it is possible that they contain disseminated chromite and sulfide minerals and thus are responsible for the chromium-cobalt-nickel anomalies on Skinner Creek as well as for small copper anomalies that occur in two adjacent drainages.

Stream-sediment samples from the east end of the recommended wilderness (A5-187) contain geochemical anomalies which indicate that mineralizing processes have taken place within in the crystalline rocks of the adjacent stream drainages. Geographic clustering of these anomalies suggests that the area drained by the streams forms a distinct zone where metal-concentrating processes not only have occurred but have been sufficiently intense to be detected consistently by the reconnaissance geochemical method. Anomalous or higher-than-background values for several metals occur in panned concentrates from the following stream-sediment localities (fig. 2): RW-31 (1,500 ppm lead); RW-36 (700 ppm arsenic); RW-38 (1,500 ppm lead, 10,000 ppm barium, 500 ppm copper); RW-40 (500 ppm lead, 100 ppm tin); RW-41 (700 ppm lead, 100 ppm molybdenum, 20 ppm bismuth, 70 ppm cobalt); and RW-42 (700 ppm lead, 150 ppm molybdenum). Steep brush-covered topography prevented our examination of much of the bedrock in the drainages sampled by RW-31, -36, -38, -39, -40, -41, and -42. Consequently, we have no direct evidence for the type or scale of mineralization that may have occurred in this vicinity and can only infer that mineral occurrences exist here. Metallic mineralization here may reflect occurrences of minerals in disseminated concentrations (porphyry mineralization). However, the lead-barium-bismuth-copper-molybdenum suite from sample RW-38, together with tin, molybdenum, lead, and arsenic in the other samples, is a suite of elements commonly found in vein and replacement deposits of hydrothermal origin. The barium anomaly in RW-38 probably is derived from barite, a common gangue mineral in lead-bearing hydrothermal veins. Thus, we suspect that this part of the recommended wilderness contains small-scale hydrothermal quartz-barite veins containing base metals.

Geophysical surveys

Two aerial magnetic surveys of the southern San Bernardino Mountains were flown in 1978 and 1979 as part of mineral resource investigations for the San Gorgonio Wilderness and Raywood Flat Roadless Areas (J. A. Pitkin, J. S. Duvall, and H. W. Oliver, U.S. Geological Survey, unpub. data, 1978; U.S. Geological Survey, 1979). The magnetic data have been analyzed by H. W. Oliver (in Cox and others, 1983; unpub. data, 1983). Rocks within the Raywood Flat study area are overlapped by both aerial surveys.

These surveys measured variations in the total intensity of the Earth’s magnetic field over the Raywood Flat Roadless Areas and vicinity. Slight variations in magnetic intensity are caused by uneven distribution of iron-rich minerals in rocks at or near the Earth’s surface. Therefore, a magnetic survey can help identify concentrations of iron-rich minerals or other minerals that may be associated with deposits of iron ore. The magnetic patterns and anomalies within the study area are not unexpected for the kinds of crystalline rocks exposed here, and there is no aeromagnetic evidence for mineralization within the Raywood Flat Roadless Areas.

Gravity measurements in the Raywood Flat Roadless Areas were made in 1981 to complete a larger gravity survey of the San Bernardino 1° by 2° quadrangle (Yang and Ponce, 1982; Bishler and others, 1983). The gravity data provide no evidence for mineralization within the study area.

MINING DISTRICTS AND MINERALIZATION

Personnel from the U.S. Bureau of Mines studied mineral resources of the Raywood Flat further planning area (B5-187) in 1982. County mining records were examined to determine claim locations. Library research was done to provide historical, geologic, and mineral resource data. Field studies included examining and sampling mines and
prospects. A total of eight lode samples were taken from mineralized structures; five placer samples were taken from gravel deposits.

Previous studies include an unpublished investigation in 1954 by the Defense Minerals Exploration Administration (DMEA) of marble deposits at the Mill Creek mine. This investigation was in response to a request by Robert Burns and others, claimants of the Mill Creek mine, for DMEA assistance to explore tungsten occurrences at the mine. A geologic investigation of the St. Patrick uranium-thorium mine was conducted by Hewett and Stone (1957). A mineral resource study of the adjacent San Gorgonio Wilderness included an examination of the St. Patrick and Mill Creek mines (Zilka, in Cox and others, 1983).

History and production

The Mill Creek mining district covers Mill Creek Canyon and the northern half of the further planning area. The mineral commodities produced from this district consist of ground marble (possibly used for manufacture of lime) from the Mill Creek mine, uranium-thorium ore from the St. Patrick mine, and construction stone from the Cable mine a few miles west of the study area. The Bear Valley mining district, 9 miles north of the study area, yielded placer gold and limestone.

The first mining in the Mill Creek district occurred in 1888 when H. G. Cable quarried dimension stone from a sandstone formation (the Potato Sandstone of Vaughan, 1923) on Mill Creek about 4 mi west of the study area. This stone was used in the construction of buildings in Redlands (about 10 mi west of the study area) and Los Angeles. In 1897, Mill Creek Canyon was prospected for gold, but no deposits were found (Redlands Daily, October 8 and 16, 1897). In May 1907, the Mill Creek marble deposit was claimed by George Burris. It was relocated several times, and by 1942 it had been acquired by the Mill Creek Limestone Company. That company operated the mine in 1942 and 1943 (Logan, 1947, p. 292). The marble was trucked to a 15-ton-per-hour grinding plant 8 mi east of Redlands on Highway 38. It is not known how the ground marble was used. A uranium-thorium occurrence on the north side of Mill Creek, the St. Patrick mine, was located in 1953 by Earl Gilliam, Jr. and others; numerous uranium claims were located in this vicinity during the 1950s. Peat has been dug from deposits in the Burro Flats area, 1 mi south of the study area. Intermittent peat production has occurred since 1956, yielding 1,000 yd³ per month in 1960 (California Division of Mines, 1960, unpub. data).

Mining claims

Since 1893, about 70 placer claims and 160 lode claims have been filed within the Raywood Flat further planning area, and 80 placer claims and 170 lode claims have been located near the area. There are no active claims, patented claims, or mineral leases in the further planning area.

Mines and prospects

Mines and prospects examined in the Raywood Flat further planning area are described in table 1. The Mill Creek mine.—Marble has been quarried at the Mill Creek mine on the north wall of Mill Creek Canyon (fig. 2, site 1). The workings are located in the largest and easternmost of three lenticular marble bodies enclosed by granitic gneiss and intruded by monzogranite. The marble is white and crystalline, and locally hosts yellow, discontinuous garnet-epidote-talcite pods which contain minor scheelite and pyrite. Uranium and thorium-bearing pegmatite bodies that occur in granitic gneiss are exposed in bulldozer cuts at the St. Patrick mine (fig. 2, site 2). The pegmatite lenses probably formed as metamorphic segregations within the granitic gneiss. They consist of reddish-brown microcline and quartz, with small amounts of uranothorite. The lenticular bodies are en echelon, and their northwest strike and southeast dip are conformable with foliation of the granitic gneiss. The dikes measure a maximum of 3.5 ft thick and 48 ft long. Similar pegmatite dikes and lenses occur in the unit of biotite-rich Precambrian gneiss, and also in the units of monzogranite and quartz monzodiorite. The Mountain Home prospect (fig. 2, site 1) is developed in pegmatites that cut the foliated quartz monzodiorite unit. Only the pegmatites at the St. Patrick mine are known to contain radioactive minerals.

ASSESSMENT OF MINERAL RESOURCE POTENTIAL

Geologic, geochemical, and geophysical studies within the Raywood Flat Roadless Areas, together with an investigation of mines and prospects within the further planning area, resulted in our identification of nonmetallic mineral resources at a marble mine in the further planning area, and in our recognition of a small area in the recommended wilderness that has moderate potential for base-metal resources. Except for these two areas of identified and suspected resources, we did not observe indications of resource potential elsewhere in the Raywood Flat Roadless Areas. These mineral resource assessments are based on the following considerations:

(1) Geologic mapping within the study area revealed several geologic environments potentially favorable for metallic and nonmetallic mineralization. However, we did not observe evidence of significant mineral occurrences that might have formed in these environments.

(2) Chemical analyses from 56 bulk-sediment and panned-concentrate samples indicate that elemental abundances generally fall within background ranges expected for nonmineralized rocks. In the recommended wilderness (A5-187), a small area having geochemical anomalies is an exception to this generalization.

(3) Aeromagnetic patterns and gravity data do not indicate concentrations of magnetic minerals or minerals having high or low density.

(4) Prospecting activities have been limited and short lived, production has been restricted to small amounts of marble and low-grade uranium ore from abandoned workings in the further planning area (BS-187), and no large deposits of metallic, nonmetallic, or radioactive minerals have been discovered. In view of extensive prospecting conducted in the San Bernardino Mountains for mineral deposits similar to those of the Holcomb Valley and Bear Valley districts, the absence of significant historical workings in the vicinity of the Raywood Flat Roadless Areas reflects the generally low mineral resource potential of rocks in this area.

Discussion of base-metal potential

Geochemical anomalies for base metals were detected in several small streams that drain an area in the eastern part of the recommended wilderness (fig. 5, A5-187). Anomalies for lead, molybdenum, copper, tin, bismuth, cobalt, barium, and arsenic occur in the panned-concentrate fractions of stream-sediment samples from several drainages that occur in this part of the study area. Because the terrain is inaccessible and covered with dense brush, we could not examine all the bedrock in these drainages; hence, the origin of the metallic anomalies is unknown. Thus, although we infer that mineral occurrences exist in the drainages, we have little data on which to base an estimate of their extent and quality. The mineral occurrences probably are in hydrothermal quartz-barite veins or in small-scale disseminated concentrations.

The geochronologic evidence suggests that there is a high probability that mineral occurrences of some kind exist in the drainage basins. However, there is only low probability that the occurrences are large scale; more likely, they are small scale or scattered. This interpretation is based on three arguments:

(1) Geologic setting.—Although we were not able to examine all the rocks in this area, those that we did examine are similar to other foliated and gneissic granitoid rocks in this part of the recommended wilderness. These rocks occur in the upper plate of the Vincent-Orologia thrust. Here and elsewhere in the upper plate, we did not observe extensive quartz-vein networks or large areas of stained or altered rock that would provide surficial evidence for large-scale base-
metal mineralization in hydrothermal veins or disseminated concentrations.

(2) Geochmical evidence.—The stream drainages that yielded anomalous metallic values are fairly small, and the geochmical anomalies themselves are not large. Therefore, any mineral occurrences containing base metals also are likely to be small and scattered.

The probable scale of mineral occurrence in the area of geochmical anomalies can be estimated crudely by analogy with what is known about metallic mineral occurrences in similar geologic terranes elsewhere in southern California. Rocks similar to those in the recommended wilderness occur in the eastern San Gabriel Mountains, 45 mi west of the Raywood Flat Roadless Areas. A comparison between the two areas is valid not only because rocks in the upper plate of the Vincent-Orocopia thrust are similar in both areas, but because this geologic terrane probably once was continuous between the southeastern San Bernardino Mountains and the eastern San Gabriel Mountains and subsequently was dismembered and offset by strike-slip displacements on various fault systems in this part of southern California. In the eastern San Gabriel Mountains, large-scale mineral deposits containing lead, copper, molybdenum, and tin have not been discovered, although isolated small-scale occurrences of base metals have been identified and interpreted as accessory metals associated with tungsten and gold. Tungsten and gold occurrences in quartz and carbonate veins have been the targets of mineral exploration in the San Gabriel Mountains and have produced small amounts of ore, but base-metal occurrences have not produced any major deposits (Gey and others, 1954; Ridenour and others, 1983; Zilka and Sehmaueh, 1982). Gold and tungsten were not detected in the Raywood Flat stream-sediment samples that contain base metals. Using previous experience in the eastern San Gabriel Mountains as a guide, it is unlikely that large-scale mineral occurrences containing base metals exist in rocks underlying the Raywood Flat Recommended Wilderness.

Based on these three arguments, we conclude that bedrock in the area of geochmical anomalies has moderate potential for base metals in hydrothermal veins or in disseminated occurrences. The potential is moderate because two parameters are satisfied by our studies: (1) geologic and geochemical data provide suggestive evidence that mineral-concentrating processes have taken place; and (2) we recognize some conditions of an occurrence model for the type of metallic mineralization (hydrothermal quartz-barite veins), even though evidence for these conditions is fragmentary or ambiguous. Although we assign moderate resource potential to this area (fig. 2), any undiscovered mineral occurrences that might exist in this area probably are not important mineral deposits. Moreover, the delineated zone having moderate resource potential probably is much greater in size than the area actually containing mineral occurrences, as the boundaries are arbitrary and were drawn to enclose all drainage basins that contain stream-sediment geochemical anomalies.

Discussion of nonmetallic and energy resources

The Mill Creek mine has about 5.5 million tons of demonstrated marginal reserves of marble suitable for lime, chemicals, cement, and construction material; however, nearly all the marble reserves are outside the further planning area (BS-187). Although marble has been produced from this deposit and possibly used for lime, we have classified the reserves as marginal because of their remote location and poor accessibility. Similar or better deposits elsewhere are closer to major markets, are more accessible, and therefore incur lower transportation costs. Granitic rock and deposits of sand and gravel in the study area are suitable for construction uses, but similar or better deposits elsewhere are closer to major markets. Consequently, those in the study area are subject to higher transportation costs.

Pegmatite and uranium totalling less than 10 tons was shipped from the St. Patrick mine in 1954 (Hewett and Stone, 1957), at about the same time that other small uranium deposits, including the Thum Bum claim near Big Bear Lake (Troxel and others, 1957, p. 671), were being developed elsewhere in the eastern San Bernardino Mountains. Samples of the pegmatite that we analyzed contained 0.019 and 0.002 percent uranium oxide ($U_3O_8$) and 0.159 and 0.35 percent thorium. By comparison with most commercial uranium deposits being mined today that contain at least 0.1 percent $U_3O_8$, the uraninite-bearing occurrences at the St. Patrick mine are small and low grade. The absence of significant radioactive-mineral resources at the St. Patrick mine is corroborated by an airborne radiometric survey (Pitkin and Duval, 1981), which did not detect abnormal levels of gamma radiation in this vicinity.

Recommendations for future studies

If additional mineral resource studies are conducted in the Raywood Flat Roadless Areas, we recommend that the area having moderate potential for base-metal resources be examined more thoroughly to determine the extent and quality of mineral occurrences that might exist there. Detailed mapping and followup geochemical studies of bedrock and stream sediments in accessible areas are necessary to confirm the presence or absence of mineral occurrences and to locate the areas that are the sources for the metallic anomalies.

REFERENCES


Figure 1.—Index map showing location of the Raywood Flat Roadless Areas (further planning area B5-187 and recommended wilderness area A5-187), San Bernardino and Riverside Counties, Calif.
Figure 2.--Raywood Flat Roadless Areas, showing zone with mineral resource potential, mines and prospects, and selected stream-sediment geochemistry sites. Geology simplified from accompanying mineral resource potential map. s, surficial sedimentary deposits, including younger alluvium, older gravel deposits, and glacial deposits; sc, sandstone and conglomerate; gr, granitoid rocks; ps, Pelona Schist; gg, granitic gneiss and gneissic granite south of the Mission Creek fault zone; gg, granitic gneiss and gneissic granite north of the Mission Creek fault zone; ms, metasedimentary rock; gs, gneiss and schist.
Table 1.—Mines and prospects in the Raywood Flats further planning area B5-187

<table>
<thead>
<tr>
<th>Location No.</th>
<th>Name</th>
<th>Summary</th>
<th>Production and workings</th>
<th>Sample data and resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mountain Home</td>
<td>A pegmatite dike in porphyritic quartz monzodiorite is 2.7 ft thick, strikes N. 63° E., dips vertically, and is composed of 80 to 90 percent pink and white feldspar, 10 percent quartz, and minor biotite.</td>
<td>Prospect out</td>
<td>One sample across dike assayed no appreciable metals.</td>
</tr>
<tr>
<td>2</td>
<td>St. Patrick mine</td>
<td>Uranothorite occurs in three reddish-brown, microcline- and quartz-rich pegmatite dikes conformable with foliation in gneiss. The lenticular dikes are en echelon, strike from N. 66° to 76° E., dip 28° to 34° SE., and measure a maximum of 3.5 ft thick and 48 ft long. A 1.7-ft-thick zone in the 48-ft dike is radioactive.</td>
<td>Less than 10 tons of mineralized material has been removed (Hewitt and Stone, 1957, p. 104). Workings include two bulldozer cuts and one prospect pit.</td>
<td>Two samples across the 1.7-ft-thick radioactive zone in the dike assayed 0.019 and 0.002 percent U₃O₈ and 0.159 and 0.35 percent thorium. Three samples representing the three lenses taken by Zilka (in Cox and others, 1983) averaged 0.02 percent U₃O₈.</td>
</tr>
<tr>
<td>3</td>
<td>Mill Creek mine</td>
<td>Three lenses of marble occur within gneissic rocks intruded by monzogranite. The lenses parallel foliation, striking north-northeast and dipping from 32° to 50° NW. A tactite zone averaging 0.5 ft thick occurs in the marble. From east to west, the marble lenses are 64, 48, and 27 ft thick and 1,800, 1,100, and 500 ft long (Zilka, in Cox and others, 1983). At depth the marble may be contaminated and completely assimilated by monzogranite.</td>
<td>13,600 tons of marble have been quarried (Zilka, in Cox and others, 1983). Workings include three large open cuts and an adit 18 ft long.</td>
<td>A random chip sample from the marble contained 82.1 percent CaCO₃, 1.2 percent SiO₂, 1.46 percent Al₂O₃, 0.06 percent Fe₂O₃, 0.35 percent MgO, 0.83 percent K₂O, and 0.02 percent Na₂O. Of three samples across tactite, two assayed 0.26 and 0.07 percent WO₃. There are about 5.5 million tons of marginal marble reserves. Nearly all of the marble reserves lie outside the study area.</td>
</tr>
<tr>
<td>4</td>
<td>Fallsvale claim</td>
<td>A zone of black muscovite gabbro is intruded into gneiss.</td>
<td>None</td>
<td>A random chip sample from gabbro assayed no appreciable metals.</td>
</tr>
</tbody>
</table>