Topographic base from U.S. Geological Survey
Chuckwalla Mts., Coxcomb Mts., Hayfield, Pinto Basin, 1963

SCALE 1:62 500

1 ½ 0 1 2 3 4 MILES

1 .5 0 1 2 3 4 KILOMETERS

NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology mapped by R. E. Powell 1973-1980, 1983-1984

Aeromagnetic surveys flown by Fairchild Aerial Surveys, Inc., 1954 and by QEB/High Life, Inc., in 1981

CORRELATION OF MAP UNITS

Qal — QUATERNARY — CENOZOIC
QTb — QUATERNARY AND (OR) TERTIARY — CENOZOIC
TJqp (felsic dikes) — TERTIARY, CRETACEOUS, AND (OR) JURASSIC — CENOZOIC AND (OR) MESOZOIC
KJg — CRETACEOUS AND (OR) JURASSIC — MESOZOIC
Jgbd — JURASSIC — MESOZOIC

San Gabriel terrane / Joshua Tree terrane (Age relations unknown)

Pz p€d, Pz p€g, Pz p€q — PALEOZOIC AND (OR) PRECAMBRIAN
p€smj, p€og, p€pg (San Gabriel terrane); p€gg (Joshua Tree terrane) — PRECAMBRIAN

DESCRIPTION OF MAP UNITS

Qal ALLUVIUM (QUATERNARY)--Sand and gravel in active stream channels and in older, incised deposits; locally, may include Pliocene alluvium

QTb BASALT (QUATERNARY AND (OR) TERTIARY)--Basalt flows and volcanic necks; in places overlies older alluvial deposits

TJqp QUARTZ PORPHYRY DIKES (TERTIARY, CRETACEOUS, AND (OR) JURASSIC)--Quartz latite; light to medium gray on fresh surfaces; phenocrysts of quartz, alkali feldspar, plagioclase, and rare garnet in a siliceous aphanitic groundmass that constitutes 80 to 85 percent of the rock. Shown separately only where wide enough to show on map; otherwise, included with felsic dikes

FELSIC DIKES (TERTIARY, CRETACEOUS, AND (OR) JURASSIC)--Consist of: (1) aphanitic or fine-grained, light-gray or white felsite; (2) light- to medium-gray quartz porphyry (unit TJqp: where outcrop width is too thin to distinguish on map); (3) gray, fine-grained latite and dacite with microphenocrysts of feldspar, biotite, and hornblende in varying proportions; rare quartz and garnet; (4) feldspar porphyry with cream-colored or pinkish-white alkali feldspar phenocrysts and smaller phenocrysts of hornblende, biotite, and rare quartz set in a dark-gray, aphanitic groundmass that makes up 75-80 percent of the rock

MAFIC AND INTERMEDIATE DIKES (TERTIARY, CRETACEOUS, AND (OR) JURASSIC)--Consist of two principal varieties: (1) fine-grained diorite, commonly propylitically altered to a greenish-gray rock characterized by actinolite, chlorite, and epidote; nonresistant to erosion; 0.5 to 4 m thick; locally dikes are pervasively foliated parallel to their contacts; (2) hornblende porphyry with phenocrysts of hornblende and rare biotite, feldspar, and quartz in a dark-gray aphanitic matrix

KJg GRANITIC ROCKS (CRETACEOUS AND (OR) JURASSIC)--Consists of subunits of (1) coarse-grained biotite monzogranite (youngest), typically containing 25 to 35 percent quartz, (2) coarse-grained porphyritic biotite monzogranite with abundant quartz and phenocrysts of pink alkali feldspar; (3) medium-grained sphene-biotite-hornblende granodiorite; (4) coarse-grained quartz-poor monzogranite that contains abundant lavender-tinted alkali feldspar; and (5) coarse-grained hornblende-biotite quartz-poor porphyritic monzogranite (oldest) characterized by phenocrysts of lavender-tinted alkali feldspar, and ubiquitous secondary chlorite, epidote, and carbonate that impart a greenish cast to the rock

Jgbd GABBRO AND DIORITE (JURASSIC)--Biotite-hornblende gabbro and diorite, and subordinate hornblendite and biotite-hornblende monzodiorite; color index ranges from about 50 to 95+. Clinopyroxene and olivine locally are poikilitically enclosed within hornblende locally in the more mafic rocks; small amounts of alkali feldspar and quartz are almost always present; sphene and secondary epidote and chlorite are ubiquitous. As mapped, unit may contain pre-Jurassic mafic intrusive rocks

San Gabriel terrane

p€smj SYENITE-MANGERITE-JOTUNITE (PRECAMBRIAN)--Medium-grained, rusty-brown-weathering syenitic, monzodioritic, and dioritic rocks characterized by mesoperthite and mafic clots with relict corona-textures in which orthopyroxene(?) has been replaced by amphibole; typically contains less than 5 percent quartz

p€og ORTHOGNEISS (PRECAMBRIAN)--Consists of two subunits: (1) a heterogeneous mixture of tonalitic to granitic gneiss that locally displays relict mesoperthite, antiperthite, and garnet and corona-textured replacement of pyroxene(?) by clots of uralite, biotite, and quartz, all of which indicate that at least parts of the unit were formed under granulite-facies conditions and then retrograded to amphibolite-grade, (2) granodioritic to monzogranitic orthogneiss that is characterized by eye-shaped or tabular megacrysts of pink or white alkali feldspar oriented in a foliated dark-colored feldspar-quartz-biotite matrix

p€pg PARAGNEISS (PRECAMBRIAN)--Biotitic and pelitic metasedimentary gneiss characterized by mineral assemblages containing prograde biotite + quartz + plagioclase + alkali feldspar ± sillimanite ± garnet with retrograde muscovite and chlorite

Joshua Tree terrane

Pz p€d DOLOMITE (PALEOZOIC AND (OR) PRECAMBRIAN)--Very coarse-grained, recrystallized dolomite marble with grains up to 1 cm across; white to light-gray on fresh surfaces, grayish orange to buff on weathered surfaces; thin- to thick-bedded to massive; scattered layers are rich in dark-brown weathering nodules, pods, and lenses that were probably derived from chert. Layers of very coarse-grained white calcite marble occur sporadically, as do ferriferous layers of hematite-dolomite

Pz p€g GRANOFELS AND SCHIST (PALEOZOIC AND (OR) PRECAMBRIAN)--Predominantly pelitic and ferriferous pelitic granofels where undeformed; schist near the Red Cloud thrust. Ferriferous rocks are varicolored, mottled in red, purple, lavender, blue, gray, and white; in places, the ferriferous granofels is exclusively quartz + hematite. At least one thin layer of calcite marble occurs within the unit

Pz p€q QUARTZITE (PALEOZOIC AND (OR) PRECAMBRIAN)--Consists of three subunits: (1) cross bedded quartzite: very coarse- to coarse-grained, vitreous, mottled gray and bluish gray; medium-bedded to massive with low-angle sets of tangential planar cross-laminations; compositionally mature (95+ percent quartz) with abundant white sillimanite and (or) andalusite, locally with abundant green viridine; (2) conglomerate: contains pebbles and cobbles of quartz and quartzite in layers and lenses up to 10 ft thick interbedded near the base of the cross-bedded quartzite; hematite imparts a characteristic rusty-brown stain to the rock; deformation has stretched the pebbles as much as 10:2:1; (3) vitreous white to light-gray quartzite: very coarse-grained, massive with bedding obscure or obliterated; compositionally supermature, commonly with 98-99+ percent quartz

p€gg GRANITE GNEISS (PRECAMBRIAN)--Granitic to monzogranitic; augen and rod gneiss, with both deformed megacrysts of alkali feldspar and spindle-shaped aggregates of feldspar and quartz; typically contains less than 10 percent biotite in recrystallized, lenticular aggregates. Where overlain by the quartzite unit, the granite gneiss is capped by aluminous schist (sillimanite and (or) andalusite + muscovite + quartz ± chloritoid) characterized by 2-5-mm augen of recrystallized-quartz aggregates; the schist is inferred to represent a metamorphosed paleosol. Near the schist layer, the granite gneiss is muscovitic

CONTACT--Dashed where approximately located

RED CLOUD THRUST FAULT--Dashed where approximately located, dotted where concealed; sawteeth on upper plate

HIGH-ANGLE FAULT OR FRACTURE--Dashed where approximately located, dotted where concealed; arrows indicate relative movement

MAGNETIC CONTOURS--Showing residual total intensity magnetic field of the Earth in gammas. Regional magnetic field removed as described in aeromagnetic survey index map. Hachures indicate closed magnetic lows. Contour interval 10 gammas. Letters mark anomalies referred to in discussion

BOUNDARY OF AEROMAGNETIC SURVEY--See aeromagnetic survey index map

APPROXIMATE BOUNDARY OF WILDERNESS STUDY AREA

STUDIES RELATED TO WILDERNESS

Bureau of Land Management Wilderness Study Areas

The Federal Land Policy and Management Act (Public Law 94-579, October 21, 1976) requires the U. S. Geological Survey and the U. S. Bureau of Mines to conduct mineral surveys on certain areas to determine the mineral values, if any, that may be present. Results must be made available to the public and be submitted to the President and the Congress. This report presents the results of a geophysical study of the Eagle Mountains Wilderness Study Area (CDCA-334), California Desert Conservation Area, Riverside County, California.

INTRODUCTION

This report describes the interpretation of aeromagnetic surveys of the Eagle Mountains area, concentrating on the Eagle Mountains Wilderness Study Area (WSA). The interpretations are based on correlations with mapped surface geology by R. E. Powell, reproduced here from Powell and others (1984), as a base for the aeromagnetic data.

The Eagle Mountains Wilderness Study Area consists of about 49,723 acres in the southeastern and east-central part of the Eagle Mountains, Riverside County, California, just north of Interstate 10 about 170 mi east-southeast of Los Angeles. The western boundary of the WSA abuts Joshua Tree National Monument, the northern boundary skirts the Eagle Mountains mining district, and parts of the southern and eastern boundaries follow the Colorado River aqueduct. Principal access to the interior of the WSA is provided by jeep trails in Big Wash and an unnamed, major north-draining wash in the western part of the study area.

GEOLOGY

Crystalline rocks of the Eagle Mountains Wilderness Study Area constitute parts of a Mesozoic batholith and Precambrian and Precambrian and (or) Paleozoic country rock into which the batholith has intruded. In the Eagle Mountains and several nearby mountain ranges, prebatholithic rocks comprise two lithologically distinct terranes: the Joshua Tree and San Gabriel terranes of Powell (1981, 1982). The two terranes are superposed along a prebatholithic low-angle fault system of regional extent, the Red Cloud thrust.

The structurally lower Joshua Tree terrane consists of Precambrian granite capped by a metamorphosed paleosol and overlain nonconformably by orthoquartzite that interfingers with pelitic and feldspathic granofels units. Dolomite occurs locally in the section. The rocks of the Joshua Tree terrane were metamorphosed under amphibolite-grade conditions and, near the Red Cloud thrust, were pervasively deformed to granite gneiss, lineated quartzite, and schist.

Precambrian units of the San Gabriel terrane comprise a three-part deep-crustal section. At the highest level, metasedimentary gneiss of uppermost amphibolite-grade is intruded by granodioritic augen gneiss. Both of these units are intruded by retrograded granulite gneiss at an intermediate level, and the granulitic rocks are in turn intruded by syenite-mangerite-jotunite at the lowest level exposed.

Mesozoic plutonic rocks comprise two batholithic suites, both of which intrude the Joshua Tree and San Gabriel terranes and the Red Cloud thrust system. West-northwest-, north-northwest-, and northeast-trending swarms of felsic, intermediate, and mafic dikes crosscut plutons of both batholithic suites in the Eagle Mountains. The orientations of the dikes are parallel to the orientations of fractures that crosscut batholithic and prebatholithic rocks throughout the Eagle Mountains and nearby ranges.

The principal mineral occurrences in the Eagle Mountains are iron deposits in the Eagle Mountain mine area in the northern part of the range. The iron deposits have usually been interpreted as skarns developed by metasomatic replacement of dolomite where it is intruded by plutonic rocks of the older batholithic suite (Harder, 1912; Hadley, 1945; Dubois and Brummett, 1968). Gold, scheelite, and copper minerals occur in quartz veins and bleached and limonite-stained rock associated spatially with propylitically altered mafic dikes and relatively unaltered hornblende porphyry dikes in the Eagle Mountains, although no associated mineral occurrences have been recognized in the WSA.

Cenozoic east-west trending left-lateral strike-slip faults bound the Eagle Mountains to the north and south and transect the range.

SURVEY DATA

Total-intensity aeromagnetic data for the map were obtained from surveys flown in 1954 by Fairchild Aerial Surveys, Inc., for a division of U.S. Steel, and in 1981 by QEB/High Life (U. S. Geological Survey, 1983). The 1954 U.S. Steel surveys were flown at one time with an average spacing of 0.25 mi but in a piecemeal fashion; the four pieces that cover the study area and vicinity were flown at different barometric elevations and different flight-line orientations. Only a very small portion of the 1981 QEB/High Life survey covers the WSA on the south; this survey was flown east-west at 0.5-mile spacing 1,000 feet above ground. The aeromagnetic survey index map displays the survey specifications in more detail.

The U.S. Steel surveys were analytically draped to 1,000 feet above ground so that they could be merged with the QEB/High Life survey into one larger, coherent data set. When using draped data, magnetic anomalies caused by sources on mountaintops will tend to look similar to those in valleys (if the sources are similar), whereas in level surveys, the plane flies closer to the tops of mountains than to the bottom of valleys so that small magnetic sources on mountaintops are enhanced over those in valleys. Draped data deepen the lows caused by valleys when compared to level data (Grauch and Campbell, 1984).

The merged U.S Steel survey data were taken from Grauch (1984), from which the geomagnetic reference field established by the Goddard Space Flight Center (GSFC 12/66; Cain and others, 1967), calculated on the draped surface, had been removed. The merged grids were then combined with the QEB/High Life data, from which the standard geomagnetic reference field (IGRF 1975; IAGA Div. I Study Group on Geomagnetic Reference Fields, 1976), updated to the time of the survey, had been removed. The final grid has a 0.2-km grid spacing and was contoured using the program of Dynamic Graphics (1976).

DISCUSSION

The high relief of the WSA lends itself to identification of geologic units magnetically. High-relief topography composed of uniformly magnetized rocks causes positive anomalies that, although shifted due to the polarity of the Earth's field, approximately mirror the topographic shapes (considering induced magnetization only). Therefore, coherent magnetic units are indicated where there is a correspondence between topographic and aeromagnetic highs. Rocks that lack magnetization, because of primary composition or later destruction of magnetization by alteration, can be identified by general lack of aeromagnetic character over rugged areas or by aeromagnetic lows that correspond to topographic highs.

Of the geologic units mapped in the area, Jurassic gabbroic and dioritic intrusive rocks (Jgbd) show the strongest magnetic signature, owing to their mafic composition and their occurrence in relatively large bodies. Large positive aeromagnetic anomalies (A) over several individual outcrops within and just outside the northwestern boundary of the WSA show that these outcrops are part of one large coherent body. A major aeromagnetic high (B) that is located north of Hayfield Lake corresponds to the exposed gabbro and diorite (Jgbd) but also extends out into the valley, suggesting the presence of a large stock of gabbro under the alluvium in the valley. Another large aeromagnetic anomaly (C) near the northeastern boundary of the WSA suggests that the gabbro and diorite (Jgbd) mapped there is only a small piece of a much larger subsurface intrusion.

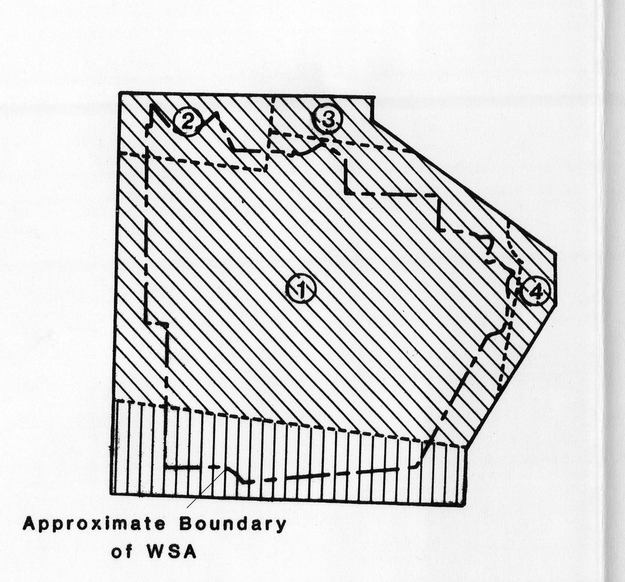
The gabbro and diorite unexpectedly lacks aeromagnetic signature in a few places because (1) the subsurface and (or) surface extent of the intrusion is too small, and (or) (2) the magnetization of part or all of the rock has been destroyed by alteration. Alteration is the more likely explanation for the lack of signature over the massive outcrop of gabbro and diorite in the north-central part of the WSA (D). Alteration may also be the partial cause of the broad aeromagnetic low partially covering syenite-mangerite-jotunite (p€smj) of the Precambrian San Gabriel terrane and gabbro and diorite just south of Big Wash (E). The steep gradients of the low probably result from the additional effect of draping that exaggerates the magnitude of the low in the valley.

The granite gneiss (p€jgg) of the Joshua Tree terrane is exposed extensively in the Eagle mountains. Correspondence of its aeromagnetic signature to topography in places suggests that the gneiss is somewhat magnetic. The large aeromagnetic high near the center of the western boundary of the WSA (F) generally correlates with a mountain made up of the granite gneiss. However, northeastward from the peak, in the valley where Jurrasic and(or) Cretaceous granodiorite (KJg) crops out, the high over the valley ceases the correlation, suggesting that this anomaly is actually the superposition of two anomalies: one caused by the granite gneiss and one caused by the granodiorite.

There are also large areas of broad aeromagnetic lows over high-relief topography of the granite gneiss (KJg), indicative of loss of magnetization or a primary compositional difference in the granite gneiss itself. A primary compositional difference is unlikely because of general homogeneity observed in the mapped unit. These lows flank the major aeromagnetic high (F) discussed in the previous paragraph on the north and south (G, H). On the north, the low (G) crosses a ridge in the vicinity of altered mafic dikes and (or) hornblende porphyry dikes and continues down into the valleys on either side of the ridge. Aeromagnetic lows in the valleys are to be expected even with magnetic rocks, so that a lack of magnetization cannot be conclusively attributed to the valley rocks. The southern low (H) covers a broad area that extends across the northwestern side of the large positive anomaly attributed to gabbro and diorite (Jgbd) earlier in this section. It extends eastward into Big Wash, where it is again indistinguishable from normal valley effects, but may also extend further east, joining the unexpected low (E) over the gabbro and diorite and San Gabriel terrane discussed earlier. Part of anomaly H may be caused by the polarization effects of anomaly B.

A linear aeromagnetic low (I) along the west side of anomaly F follows a mapped fault. This low may result from alteration along the fault, valley effects, or both.

A strong northwest-southeast trend is prominent in the aeromagnetic data across the northern half of the WSA and follows the general strike of geologic units in the north. On the south and west the general trend of anomalies is more north-south, as is the general geologic strike. The roughly north-south and east-west strikes of the dike swarms in the northeastern half of the area are not very evident in aeromagnetic trends.



AEROMAGNETIC SURVEY INDEX MAP

U.S. Steel surveys, flown in 1954 with 1/4-mile average spacing at level barometric elevation then analytically draped 1000 feet above ground. Arbitrary datums removed. Earth's field removed (see text).

(1) ESE-WNW flight lines. Originally flown at 3750 feet above sea level.

(2) ESE-WNW flight lines. Originally flown at 3000 feet above sea level.

(3) NNE-SSW flight lines. Originally flown at 3400 feet above sea level.

(4) NNE-SSW flight lines. Originally flown at 1500 feet above sea level.

QEB/High Life survey, flown in 1981 with 1/2-mile flight-line spacing and E-W lines at 1000 feet above ground. Earth's field removed (see text).

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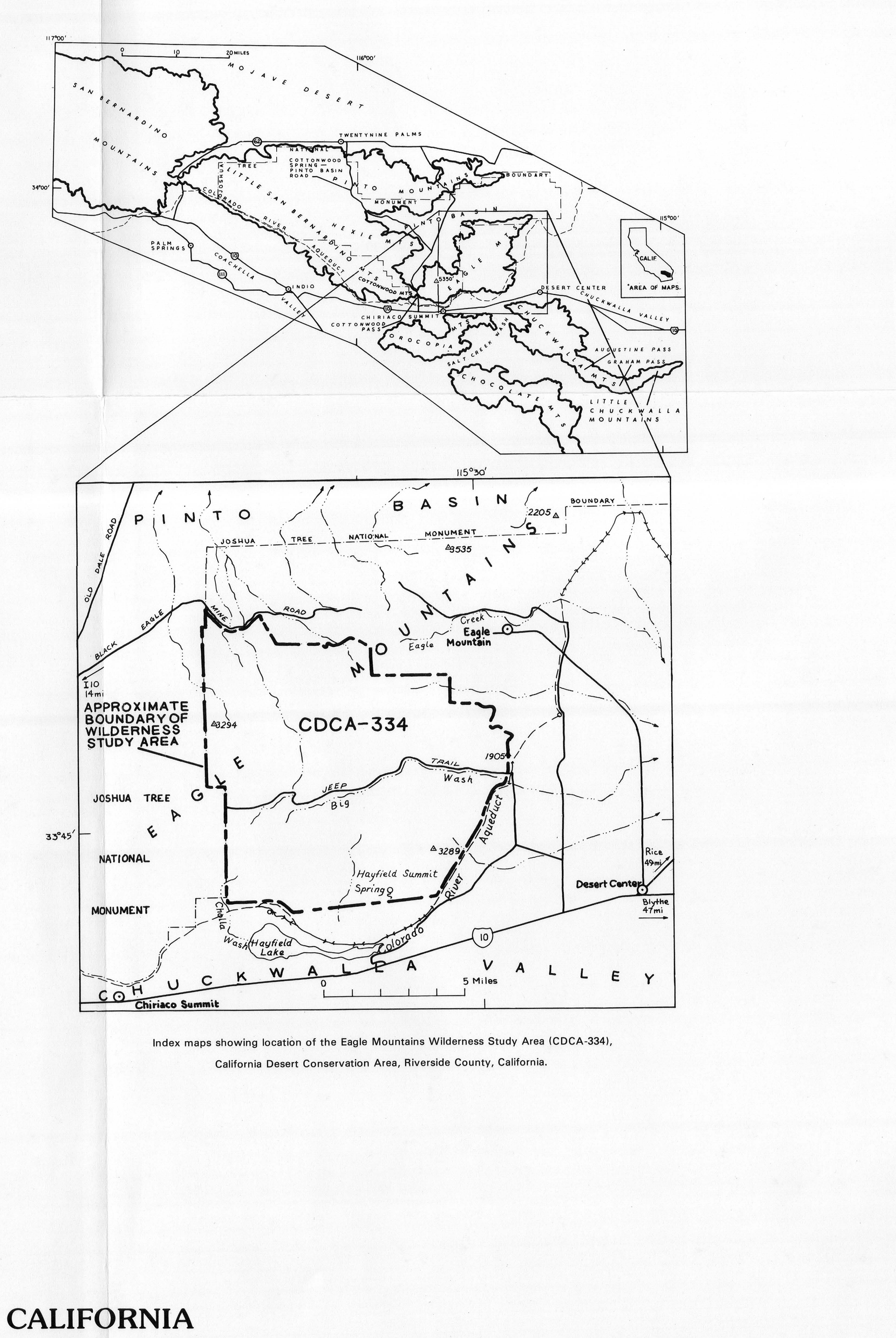

Index maps showing location of the Eagle Mountains Wilderness Study Area (CDCA-334), California Desert Conservation Area, Riverside County, California.

INTERPRETIVE AEROMAGNETIC MAP OF THE EAGLE MOUNTAINS WILDERNESS STUDY AREA, RIVERSIDE COUNTY, CALIFORNIA

By
V.J.S. Grauch

1988

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1988

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