UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

GEOLOGIC MAP OF CUYAMACA PEAK 7½' QUADRANGLE,

SAN DIEGO COUNTY, CALIFORNIA

By

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Open-file report

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This report is preliminary
and has not been edited or
reviewed for conformity with
Geological Survey standards
and nomenclature

Explanation for geologic map of Cuyamaca Peak 7½' quadrangle, San Diego County, California

Purpose of project:

Published maps indicate that rocks of the Peninsular Ranges batholith in southern San Diego County comprise a relatively unfaulted block but topographic maps and imagery at all scales reveal numerous prominent lineaments that cross the block in many directions. The purpose of this project, which began in 1974, is to evaluate the structural stability of the block, and in particular, to determine whether lineaments are related to faulting. Figure 1 shows the project area. The age, magnitude and direction of displacement of faults are being evaluated. The primary product of the project will be a number of geologic maps at a scale of 1:24,000. Mapping of the bedrock geology of the batholith became an important part of the project because the geologic maps that were available when the study began were not detailed enough for determination of fault displacements. The Cuyamaca Peak quadrangle is the first of this series.

Introduction:

The Cuyamaca Peak 7½' quadrangle lies within the mid-Cretaceous Peninsular Ranges batholith of southern California and Baja California (Fig. 1). Nine plutonic units have been differentiated within the project area and informal names have been assigned to avoid confusion with earlier nomenclature. Five of the units were not recognized previously and published names for rocks in the study area included one or more of these five units. The name Cuyamaca gabbro (Everhart, 1951) has been retained. A tenth bedrock unit consists of metasedimentary rocks of uncertain age which occur as roof pendants and septa in the batholith.

Previous usage has been followed in referring to the nine rock units as plutonic, even though all of the rocks in this part of the batholith have undergone dynamothermal metamorphism. The plutonic rocks are gneissic and their foliation consists chiefly of the planar orientation of recrystallized mineral grains and aggregates (Fig. 2). Gneissic textures include augen gneiss and mylonite gneiss. Petrographic study reveals igneous textures modified by strain at temperatures high enough for recrystallization to occur, indicating that the plutonic rocks have undergone solid-state flowage at elevated temperatures. Foliation is locally concordant with plutonic contacts, but commonly crosses contacts and, therefore, is in part younger than the intrusion of the igneous rocks. Where noted by earlier workers, foliation was considered to be a primary igneous structure or protoclastic structure. The foliations form a regional tectonite fabric which is concordant with that of the metasedimentary wall rocks. The metamorphism of the wall rocks was thought to pre-date emplacement of the batholith in this area (Everhart, 1951). Preliminary results of the present study indicate that in this part of the batholith plutons were emplaced during regional metamorphism and deformation and that deformation and recrystallization continued long after emplacement.

Nature of plutonic contacts:

A striking feature of the plutonic rocks in southern San Diego County is the prevalence of synplutonic contacts between plutons of different ages. Along some contacts between two plutons the true age relationship locally appears reversed, so that the older pluton has a chilled margin against the younger pluton, sends dikes into the younger pluton, and carries inclusions of it (Fig. 3). These contacts were deformed during the regional deformation, with the result that both "normal" dikes (younger pluton of an intrusive pair into older) and synplutonic dikes (older pluton into younger) have been stretched, intricately folded, and pulled apart so that they resemble inclusions. Whether they originated as stoped inclusions or dismembered dikes, blocks of one pluton in the other are increasingly rounded and assimilated away from the contact between the two plutons. The resulting contact relations may be extremely ambiguous, so that many outcrops had to be examined before consistent plutonic age relationships were worked out. The prevalence of synplutonic contacts indicates that the entire batholith remained mobile throughout emplacement. The presence of mutual chilled margins and quenched dikes suggests a continuing magmatic component of mobility, but rock textures and the relation between foliation and plutonic contacts imply solid-state flowage. Some combination of the two probably occurred.

Rock units:

Ten bedrock units are discussed below and their intrusive sequence is depicted in the map legend. Modal data for the plutonic units is given in Figure 4. Two of these units, Kcm and Klb, are not present within the Cuyamaca Peak quadrangle. The following discussion is based in part upon observations of rock units and contact relations in the surrounding quadrangles, which are shown in Figure 5. The bedrock units are overlain locally by unconsolidated Quaternary deposits.

Metasedimentary rocks:--Metasedimentary rocks (TRm) consist predominantly of fine-grained quartzo-feldspathic semischistose rock and micaceous, feldspathic quartzite. Andalusite-bearing schists are interbedded locally with these rocks, but pelitic schist is a minor rock in the Cuyamaca Peak quadrangle. The rocks are medium to dark gray and weather dark reddish-brown. They tend to form topographic highs. The quartzo-feldspathic semischistose rocks and feldspathic quartzites are thin-bedded (<1 foot) and probably were fine-grained, argillaceous sandstones and siltstones with calcareous cement. Fine-grained calc-silicate rock variably composed of epidote, garnet, plagioclase, pyroxene, quartz and hornblende is common in the vicinity of, and as inclusions in Kc and Klb plutons. Fine-grained black amphibolite (meta-basalt or meta-basaltic tuff?) is a minor component of the metasedimentary section, and metamorphosed calcareous pebble and small cobble conglomerate occurs locally. Cross-bedding and graded beds were observed locally but deformation has obliterated sedimentary structures in many places. Most mineral assemblages suggest amphibolite facies metamorphism but proximity to gabbros and pyroxene tonalite plutons locally has increased the grade of metamorphism, which indicates that the sedimentary rocks have undergone a complex combination of dynamothermal and thermal metamorphism. Foliation in the rocks is parallel to steep and near-vertical relict bedding, and axial planes of metamorphic folds are generally concordant with this foliation.

A stipple pattern superimposed on TRm means that the metasedimentary rock is interlayered intimately with Khc.

Cuyamaca Gabbro:--The name Cuyamaca Gabbro was applied by Everhart (1951) to the large mafic body in the Cuyamaca Mountains. He assumed that all of the large mafic bodies (Guatay Mountain, Viejas Mountain, Poser Mountain) in south-central San Diego County were coeval, and the present study agrees with this interpretation. These bodies, consisting of peridotite, olivine gabbro, hornblende gabbro, and norite were considered by Everhart to post-date the granitic plutons in the northern part of the Cuyamaca Peak quadrangle, but this study has found gabbro to be the oldest plutonic rock. Because the granitic intrusive bodies form sheets in gabbro, it is difficult to determine which rock is older from map relations in any one local area. However, relations over a large area show that the Kc bodies are screens surrounded by sheeted complexes of younger granitic rocks. Thus, the present outlines of gabbro bodies and their distribution probably do not accurately reflect either the original extent of gabbro or the original shapes of gabbro plutons.

The present study has found the Cuyamaca Gabbro unit to be deformed and recrystallized as are the younger granitic units. All gabbro observed in the Cuyamaca Peak and surrounding quadrangles is strongly foliated and in most cases apparent primary compositional layering is parallel or near parallel to the foliation of recrystallized mineral aggregates. In marginal parts of gabbro, foliation is concordant with regional foliation. It is more complex in the interior parts of the bodies where it may parallel regional foliation, but also shows swirling patterns. Foliation within the gabbro, and by inference, the so-called primary structures, appears to have formed by solid-state flowage.

One reason for ambiguity over the age of Cuyamaca Gabbro is that locally the unit has broad, fine-grained and porphyritic margins against younger granitic plutons. Thin sections of gabbro from these areas show relict chilled igneous textures modified by recrystallization. These rocks are commonly associated with zones of intrusion breccia between gabbro and granitic plutons consisting of variably rounded blocks of fine-grained and porphyritic gabbro in a matrix of chilled, contaminated granitic rock. In other places, contacts between gabbro and granitic plutons are sharp and the granitic plutons send dikes into gabbro.

Both types of contact may occur together in a given area. The intrusion breccia zones are deformed strongly parallel to the regional foliation. The intrusion breccia grades into highly contaminated granitic plutons which contain abundant, large, fine-grained gabbro inclusions. Although the intrusion breccia is younger than Kc, it is shown on the map by a block pattern superimposed on Kc because 1) fine-grained gabbro makes up most of the rock, 2) the zones of intrusion breccia grade into gabbro complexly and commonly cannot be mapped as separate zones, and 3) the granitic matrix may have as its source Kcp, Kpv, Kcm or Klb.

The origin of the chilled-appearing gabbro in this zone is still under investigation. Locally, gabbro intruded metasedimentary rocks to form a zone of intrusion breccia consisting of a matrix of fine-grained gabbro surrounding variably assimilated metasedimentary inclusions. Inclusions of metasedimentary rock occur in some intrusion breccia zones between Kc and granitic plutons, but there are places where no metasedimentary rocks appear to be involved and where gabbro grain size decreases systematically as contacts with granitic plutons are approached. These contacts may be synplutonic, i.e., both older and younger rocks were able to chill against one another. Fine-grained gabbro dikes emanating from Kc plutons cut the intrusion breccia zones surrounding several of the large gabbro bodies in the project area. Such dikes also cut units as young as Kem. This suggests that Kc contacts are in part synplutonic with younger plutons.

<u>Tonalite of Las Bancas</u>:--The tonalite of Las Bancas (Klb) does not crop out in the Cuyamaca Peak quadrangle but is a widespread unit in the project area.

The unit was formerly called Green Valley tonalite (Everhart, 1951). It is dark gray on fresh surfaces and weathers to a reddish or buff-gray color. Typically, the tonalite forms extensive, low, bouldery outcrops. The unit has few mafic inclusions in the Descanso quadrangle where it occupies a broad plateau at about 4,000 feet named Las Bancas. The unit is homogeneous and has sharp contacts with granitic units. Klb has complex contact relations with ₹m locally, marked by intrusion breccia, abundant partly assimilated metasedimentary inclusions in Klb, and contamination-assimilation reactions between the two units. Locally, injection migmatite occurs betwen Klb and ₹m. Klb has a fine-grained (chilled) margin against Cuyamaca Gabbro in a few places and it is intruded by Kcp, Kcr, Kcm and Kmd.

The tonalite of Las Bancas is a medium-grained gneissic rock, approximately equigranular, with lenticular recrystallized mafic aggregates. Locally it carries 1 cm poikilitic biotite grains. The rock has 15-20 percent quartz, traces of K-feldspar, relict zoned phenocrysts of calcic andesine to labradorite, with a color index ranging from 25-30 percent. The reaction sequence of the mafic assemblage is opx -> cpx -> olive-green hornblende-> yellowish-brown biotite. Most samples contain chiefly pyroxene and biotite, with the hornblende occurring as sparse, narrow rims on corroded pyroxene cores and both pyroxene and hornblende poikilitically enclosed by biotite. These igneous reaction textures have been modified by recrystallization.

Hybrid gneiss of Harper Creek:--The hybrid gneiss of Harper Creek (Khc) is a gray and yellow-weathering, cordierite- and sillimarite-bearing, quartz-biotite-plagioclase-K-feldspar/muscovite gneiss with a dynamothermal metamorphic texture. The unit, which is remarkably homogeneous over large areas, includes rocks that closely resemble Kcr in the field as well as rocks that are clearly metasedimentary in origin. Khc contains abundant metasedimentary inclusions, up to several meters in length, as well as evenly and closely spaced micaceous lenses, several cm long, which grade into partly assimilated metasedimentary inclusions. These inclusions, plus the high proportion of quartz and mica attest to the rock's partial sedimentary origin. Local relict igneous textures and gradation into Kcr indicate that the Khc unit originated by thorough mixing of Kcr and ₹m enhanced by deformation and metamorphic temperatures that existed for a considerable length of time both before and after emplacement of Kcr. In a few places, Khc has intruded younger plutons synplutonically which indicates that the rock was locally as mobile as the plutonic units.

The hybrid gneiss is not migmatite, although minor migmatite does occur at contacts with ₹m. These contacts may be sharp, or may be marked by large areas consisting of alternating layers of Khc and ₹m that are too small to be depicted at the map scale. A stipple pattern has been used in these areas to indicate that one of the two units contains up to 50 percent of the other. Contacts between Khc and Kcr may be gradational or sharp. Where they are gradational, a zone of fine-grained Kcr containing abundant partly assimilated inclusions of ₹m may occur between Khc and Kcr. These are interpreted as marginal parts of Kcr plutons.

Granodiorite and tonalite of Cuyamaca Reservoir:-- The area of outcrop of the granodiorite and tonalite of Cuyamaca Reservoir (Kcr) is small in the Cuyamaca Peak quadrangle, but the unit underlies large areas elsewhere within the project area. Because of this and the fact that Kcr is intruded by younger plutons, it is difficult to determine the original shapes of Kcr plutons solely from exposures in this quadrangle. Kcr is interlayered with younger units in sheeted complexes and may itself have been emplaced in a sheeted fashion into older plutons. The rock weathers to reddish and yellowish-tan and is light to dark gray on fresh surfaces depending upon its mafic content, which ranges from 14-29 percent. Locally, Kcr contains abundant fine-grained mafic inclusions that are flattened parallel to foliation. Although varying compositionally from tonalite to granodiorite, the unit is texturally homogeneous and the two compositional varieties seem to grade into one another. The rock's texture is fine to medium-grained, very strongly gneissic and, on the average, more strongly deformed than the other plutonic units. In thin section, Kcr shows some of the most strained and recrystallized igneous textures of all units.

All samples of Kcr contain some K-feldspar, the plagioclase is andesine, greatly modified by recrystallization, and pale reddish-brown biotite is the chief mafic mineral. Some samples contain no hornblende, others show a few hornblende relicts within biotite aggregates, but in most rocks intergrowths of actinolite and epidote have replaced hornblende. The chief accessory minerals are allanite and sphene. The mineralogical and textural differences between Kcr and other granitic units may be related to intimate mixing of the Kcr unit with metasedimentary rocks. The granodiorite and tonalite are especially gneissic, locally porphyroclastic and mylonitic, next to large bodies of metasedimentary rock. Here the unit contains abundant partly assimilated inclusions of ⊺Rm and is rich in mica. Fine-grained granodiorite and tonalite may grade into Khc which locally occurs as sheets between Kcr and ⊺Rm.

A noticeable decrease in Kcr grain size occurs 1 to 2 meters from contacts with Cuyamaca Gabbro (Kc) and tonalite of Las Bancas (Klb) suggesting that Kcr is younger. Many of these contacts are poorly exposed so these age relations must still be considered tentative and subject to re-interpretation with further mapping.

<u>Quartz monzonite and granodiorite of Chiquito Peak</u>:--The quartz monzonite and granodiorite of Chiquito Peak (Kcp) is a medium-grained, strongly foliated, white-weathering rock with color index ranging from 5 - 12 percent. The plagioclase feldspar is oligoclase with relict euhedral zoning and the mafic minerals are chiefly dark greenish-brown biotite which appears to be derived from reaction of dark green to brown hornblende. Both biotite and hornblende have recrystallized but igneous relicts are present. Prominent accessory minerals are sphene and allanite. Although the unit forms at least one fairly large pluton (north of the town of Descanso), it typically was emplaced in a series of steeply-dipping interconnected sheets and lenses.

The quartz monzonite and granodiorite of Chiquito Peak intruded older plutons intimately, chilled against them, and locally show a high degree of contamination through assimilation of stoped inclusions. This is particularly true where quartz monzonite is in contact with metasedimentary rock, Kc, and Kem. The contamination and post-intrusive deformation have given rise to complex hybrid zones between these plutons. A contaminated quartz monzonite category has been used (dashed pattern) to designate parts of Kcp plutons which are particularly inclusion-rich and contaminated. These rocks are intimate mixtures of quartz monzonite, granodiorite, and tonalite representing both contaminated quartz monzonite and mafic inclusions which have been almost completely assimilated. Because of the close association of these zones with mafic plutons, there is little doubt that stoping of mafic plutons (both older and younger than Kcp) has given rise to the heterogeneous zones.

A textural variety of Kcp is a fine- to medium-grained, sub-porphyritic (1 cm relict euhedral white K-feldspar phenocrysts) rock locally contaminated by abundant mafic inclusions. This rock appears to be a chilled facies of average Kcp.

A quartz monzonite with color index ranging from 2 to 7 percent, locally no hornblende and slightly more quartz than the average Kcp grades into and intrudes the more mafic quartz monzonite and granodiorite. For example, the rock which underlies Stonewall Peak is leucoadamellite with abundant 1 to 2 cm relict euhedral K-feldspar grains. Some of the leucocratic Kcp is alaskite and aplite that resembles the leucocratic facies of the younger quartz monzonite and granodiorite of Pine Valley (Kpv).

The thin-sheeted style of intrusion, extensive stoping and chemical reactions with mafic rocks, finer grain size and mafic mineral suite of Kcp help to distinguish it from Kpv.

Quartz monzonite and granodiorite of Pine Valley:--In plan view the quartz monzonite and granodiorite of Pine Valley (Kpv) forms large (several km across), discrete plutons which are relatively inclusion-free and uncontaminated compared to Kcp. Mapping indicates that the unit has been emplaced in steeply-dipping sheets.

The rock is white-weathering and underlies highlands. It is chiefly coarse-grained quartz monzonite with color index ranging from 5 to 10 percent. Mafic minerals are dark yellowish-brown biotite and small, skeletal relicts of dark bluish-green hornblende. Many samples contain no hornblende. The plagioclase feldspar is oligoclase that occurs as relict, euhedrally zoned grains. Prominent accessory minerals are sphene, allanite, and epidote. In the Arroyo Seco area (Cuyamaca Peak quadrangle) and in the town of Pine Valley (Descanso quadrangle) the rock contains white, relict euhedral K-feldspar 2 cm long and approaches porphyritic texture. Everywhere, elongate, gray, 2 to 3 cm recrystallized quartz lenticles, probably relicts of large igneous grains, are characteristic of Kpv. The unit locally has chilled margins against, and sends dikes into, all units except Kem, which it locally intrudes synplutonically. The unit is strongly foliated.

Quartz monzonite and granodiorite of Corte Madera:--The quartz monzonite and granodiorite of Corte Madera (Kcm) appears to be a leucocratic variant of Kpv which crops out in the Descanso and Viejas Mountain quadrangles. Although Kpv and Kcm are not shown in contact on these two maps, small amounts of Kpv occur locally in Kcm plutons in a gradational relationship to Kcm. Both Kcm and Kpv are coarse-grained and have elongate gray quartz aggregates up to several cm long. Kcm has the same age relationship to other units as Kpv and typically occurs as sheets in older plutons. The chief difference between Kcm and Kpv are that Kcm has a lower average color index than Kpv. Most parts of the Kcm bodies are leucoadamellite, leucogranodiorite or leucogranite. Kcm and Kpv are probably closely related to one another because of the gradational relationship, textural and petrographic similarities and similar age relationship to other plutonic units. Kcm grades into pegmatite, alaskite and aplite which locally occur as dikes in the unit.

Pegmatite, alaskite and aplite:--Leucocratic dikes (Kl) of pegmatite, alaskite and aplite occur in all units. In some areas they can be traced into plutons of Kpv, Kcm or Kcp. Where no association with larger bodies was established, the dikes have been mapped separately. These dikes share the metamorphic fabric of the other plutonic rocks.

Tonalite, quartz diorite and gabbro of East Mesa:--The tonalite, quartz diorite and gabbro of East Mesa (Kem) is the most texturally and compositionally heterogeneous plutonic unit. In plan view the sizes and shapes of Kem bodies vary because the unit has intruded older plutons in multiple sheets which have moderate to steep dips. The sheets are interconnected and commonly are localized along older contacts.

Tonalite and quartz diorite form the major part of the unit. The rocks are typically dark gray, fine-to medium-grained, and locally sub-porphyritic with relict subhedral phenocrysts of plagioclase and hornblende. A common textural variety has a spotted appearance due to poikilocrysts of biotite in a fine-grained groundmass. Pale tan to green hornblende is either the dominant mafic mineral or is about equal in abundance to pale reddish-brown biotite. Color index decreases in a regular manner as modal quartz increases. Color indices of quartz diorite samples range from 35 to 50 percent, while those of tonalites range from 25 to 35 percent. In some samples, hornblende has been altered to actinolite, and biotite to chlorite. Relict phenocrysts of andesine show strong oscillatory zoning with calcic cores. Medium-grained Kem carries abundant, fine-grained mafic inclusions, less than one foot long, some of which are elongate parallel to foliation but many of which are angular or irregularly shaped blocks.

Dark gray quartz diorite locally grades into fine-grained black dikes, some with scattered plagioclase relict phenocrysts and others choked with relict euhedral plagioclase grains.

A more leucocratic, sub-porphyritic variety of the Kem unit in the southern part of the Descanso 7½'quadrangle intrudes dark gray to black Kem. Distinctive pale greenish-white aplite dikes cut this leucocratic variant and were seen only in this area.

Kem whose hornblendes enclose pyroxene cores (opx -> cpx) grades into the less abundant gabbro of the unit. The gabbro is generally fine- to medium-grained. The distribution of tonalite, quartz diorite and gabbroic rocks within the Kem plutons shows no regular pattern. Although these plutons were not studied in detail, internal contacts were seen locally and undoubtedly the history of the unit is complex.

The Kem unit sends dikes into and has chilled margins against all plutonic units except Klb and Kmd. Kem is locally continuous with, and also cut by, dikes of Kmd. Synplutonic dikes of some host rocks into Kem give rise locally to apparent reversals of age relations. This is especially true where Kem intrudes Kcr and Kcp. In the southeastern part of the Descanso quadrangle, these three units are intimately interlayered, their synplutonic contacts have been deformed, and granitic rocks and Kem have been contaminated by one another. A stippled map pattern for Kem indicates that it contains up to about 50 percent of granitic inclusions, chiefly quartz monzonite.

The Kem bodies are strongly foliated, especially near their margins. The Deer Park body in the eastern part of the Cuyamaca Peak quadrangle, for example, consists almost wholly of mylonite gneiss.

Mafic dikes:--The youngest plutonic unit is an ubiquitous system of mafic dikes (Kmd) which cut all other plutonic rocks. Few are large enough to be shown at 1:24,000 map scale. The dikes are dark gray to black, mostly fine-grained to very fine-grained, but some have fine- to medium-grained centers with chilled margins, while others are variably porphyritic. The dikes consist of plagioclase, hornblende, biotite, sphene and traces of quartz, and overlap Kem in modal composition. Their textures are dynamothermal metamorphic, and only the plagioclase phenocrysts in porphyritic dikes show relict euhedral outlines and oscillatory zoning. The dikes are abundant in the vicinity of bodies of Kem, and locally grade into these bodies. They also cut Kem, and locally crosscut one another.

Although in some places the mafic dikes crosscut regional foliation, for the most part the largest dikes were emplaced concordant to foliation. With few exceptions, foliation of the dikes' mineral grains is parallel to the surrounding regional foliation, regardless of the dikes' orientation.

The mafic dikes have a synplutonic relationship with their host rocks. Most of the dikes are highly deformed; many are pulled apart and resemble inclusions. They typically contain folded bodies of aplite that in some cases are continuous with the granitic host rock but mostly are not.

Surficial deposits:--Surficial deposits have been divided into alluvium, colluvium and landslide materials. Although most of the deposits have not been dated, they are probably Quaternary in age. Alluvium (Qal) consists of sand, silt, clay and gravel in stream valleys and meadows. The alluvium in stream valleys consists of older deposits which cover the valley floors and thin modern deposits in the beds of narrow channels that cut the older alluvium to depths of up to 6 meters. A preliminary C^{14} age of 920 ± 60 years has been obtained on charcoal from one of the lowest exposed beds in older alluvium in Pine Valley (Stephen W. Robinson, U.S. Geological Survey, Menlo Park). This data indicates only that the older alluvium is no older than 920 ± 60 years, because the charcoal may have been reworked from midden deposits of Indians living in Pine Valley. Considerable erosion of older alluvium has probably occurred in historic times, as suggested by the headward cutting of gullies 1 to 2 meters deep along wagon ruts in a few places. Since bedrock is exposed in most of the modern streambeds, the total thickness of older alluvium is probably about 6 m or less. Fine-grained sediments in the high meadows probably formed in situ by chemical weathering in addition to some stream deposition. These sediments are being stripped from the meadows by headward-cutting gullies and most meadows contain bedrock exposures.

Colluvial deposits, Qc, consist of poorly sorted sand, silt and gravel mixtures and formed by slopewash; they grade into bouldery deposits that fill small, steep valleys. The latter are probably debris flow deposits and locally, they form topographic ridges which are being eroded by modern gullies. Colluvial deposits have been mapped only where they are thick enough to completely obscure bedrock outcroppings over a large area. Thick colluvium deposits commonly are associated with fault-steepened topography. In general, their thickness is no more than a few meters, indeed, most slopes are bedrock which is essentially bare of colluvium or soil.

Landslide deposits (Qls) are of the slump and rockslide type and occur in terrain which has been oversteepened by faulting. The landslides are small (50-250 m wide) and are characterized by steep scarps, which are free of colluvium and vegetation, above the landslide deposits.

Structure of batholithic rocks:

The plutonic units occur as steeply dipping sheets and lenticular bodies which are separated locally by screens of metasedimentary rock. The sheets, lenticular bodies and screens range from a few meters to several kms in thickness and the larger ones continue for tens of kms along strike. In plan view, the preferred orientation of the long dimensions of plutonic sheets and lenticular bodies, of ₸Rm screens, and of foliation within plutonic and metamorphic rocks, imparts a structural grain to this part of the batholith. Only a small part of this structural grain can be seen in any one 7½' quadrangle. Successive intrusions parallel to this structural grain have resulted in stratiform complexes of 3 to 4 units. The structural grain varies greatly over the project area.

In the Cuyamaca Peak quadrangle, it is north-northwest to northwest and the dip is predominantly eastward, with the exception of the eastern margin of the Cuyamaca Mountains gabbro body whose walls dip inward. In the Descanso quadrangle, the structural grain is north-northwest in the eastern half of the quadrangle and northwest to east-west in the western half; the regional dip is strongly to the northeast. Locally, plutonic contacts and foliation describe large fold forms about steeply plunging axes. Several of these fold forms include metasedimentary screens which are folded concordantly with plutonic contacts and foliation. One such structure, involving Kc and Kcp, occurs just west of the center of the Cuyamaca Peak quadrangle. In the Descanso quadrangle, one involving TRm and Kcr occurs in the center of the map; a second, involving Kc, Kcp and TRm lies south of it. It is not clear at this time whether these structures are tectonic, i.e., systematic folds, or relicts of local deformation due to plutonic intrusion. Possibly, they are the result of a combination of the two processes.

Locally, the dips of plutonic contacts appear to be gentle to moderate, e.g., the contacts of the Rattlesnake Mountain pluton in the northeastern part of the Cuyamaca Peak quadrangle, and the Kc-Kcp contacts in the Buckman Mountain area, southeastern corner of the Descanso quadrangle. Here, foliation dips more steeply than plutonic contacts. The dips of plutonic contacts may appear less steep than they truly are because of a combination of the sheeted style of intrusion and poor exposure (dense vegetation). Apparently, magma moved upward utilizing steep planes of entry such as bedding in TRm and contacts and foliation in older plutonic rocks. Thus, TRm and older plutonic rocks tend to occur as screens which are underlain by and separated by younger plutonic rock. Where the present level of erosion is close to the highest level to which a younger magma intruded (and therefore to the keel-shaped bottoms of screens of TRm and older plutonic rocks), valleys expose chiefly the underlying, younger plutonic rocks. If exposure is limited, an approximate contact drawn between the younger plutonic rock and the host rocks may cut across many thin screens and thus appear flatter than it truly is.

If, as seems likely, the Cuyamaca Gabbro is the oldest plutonic unit, then the present Kc bodies are not individual plutons but are remnants of original plutons. The distribution of TRm remnants (probable wallrocks) in relation to Kc over the project area suggests that while some present Kc bodies coincide approximately with original plutons, others may not. The Cuyamaca Mountains body may be one of the former in which case it had a north-northwest-elongate shape originally. Younger granitic plutons apparently have divided the original gabbro plutons into a number of lobes--in the case of the Cuyamaca Mountains body, a northern lobe consisting of Middle Peak and North Peak, and a southern, Cuyamaca Peak lobe. The gabbro body north of Corte Madera Mountain in the Descanso quadrangle also shows partial division into lobes by granitic plutons. In the eastern part of this quadrangle there is a bead-like arrangement of Kc bodies in a linear array extending north-northwest from Buckman Mountain through Bear Valley to Guatay Mountain. This arrangement suggests boudinaging of gabbro in a granitic matrix which may have been more mobile under metamorphic conditions because of the presence of the empirically "weaker" minerals quartz and mica.

Faults and lineaments of the Cuyamaca Peak 7½' quadrangle:

Two fault zones are exposed in the Cuyamaca Peak quadrangle. One zone (Cuyamaca Mountains fault zone) extends in a north-northwest direction from the southwestern corner of the map to the west flank of Cuyamaca Peak where it passes into the Tule Springs 7½' quadrangle. The second zone is the en echelon, southern extension of the Chariot Canyon fault zone and is exposed in Oriflamme Canyon, in the northeast corner of the map.

The western side of Cuyamaca Peak is marked by a series of northward-trending benches, graben-like valleys and vegetation lineaments which are essentially parallel to the strike of rock foliation. Mylonite, gouge and/or breccia are exposed along a number of these linear features, and minor hydrothermal alteration, landslides, gullying, thick colluvial deposits and possibly offset lithologic contacts are associated with some lineaments. Where no direct evidence of faulting (i.e., crush zone) was seen, in some cases because of obscuring brush or colluvium, lineaments have been short-dashed and queried. Apparently, movement was distributed along numerous short breaks which trend from north-south to north-northwest. The maximum thickness of crushed rock exposed in the zone is about 4 m of gouge in Kc; most crushed zones are considerably thinner.

Lithologic contacts do not show clearcut lateral displacement although the brushy terrain and abundant gabbro colluvium shed from Cuyamaca Peak might disguise small displacements. The character of the faulting (many short, discontinuous breaks) and the elevation of Cuyamaca Peak (at 6512 feet, the highest point in San Diego County) relative to the valley to the west suggest predominantly vertical displacement. Steep north-northeast- and north-northwest-trending faults (1-2" gouge) exposed in a roadcut of Boulder Creek Road (Tule Springs quadrangle) show as much as 10-15 feet offset with the hanging walls down to the west. The relative youthfulness of the faulted topography suggests that the faults are probably Quaternary in age. Some vegetation lineaments appear to cross colluvium but this may be a reflection of bedrock control. Other lineaments juxtapose bedrock having 1-2 m colluvial cover against bedrock with no colluvium at all. The thick brush and inaccessibility of some of these lineaments make it difficult to evaluate these relations.

The faults in Oriflamme Canyon are the en echelon extension of the Chariot Canyon fault zone (Julian 7½' quadrangle). The crush zone exposed in the ephemeral streambed in Oriflamme Canyon is locally 50-100 m wide and is overlain locally by alluvium which is probably young. At least one spring lies along this crush zone. Oriflamme Canyon and part of flat-topped Oriflamme Mountain to the east appear to be a northward-tilted graben. Both the canyon and fault zone strike parallel to regional foliation and contacts, making lateral displacement of contacts difficult to assess. However, the same lithologies are present on both sides of the zone, as is true in Chariot Canyon to the north, where slickensides on fault planes typically plunge steeply (approximately 75°) to the northeast. The Oriflamme Canyon fault system gives way to a prominent, brushy scarp immediately to the north (Julian 7½' quadrangle). The topography of Oriflamme Canyon implies erosion along a fault zone in contrast to the more youthful topographic expression of the zone west of Cuyamaca Peak.

The Oriflamme Canyon fault zone may be surrounded by an envelope of broken rock that extends north-south through the eastern one-third of the

Cuyamaca Peak quadrangle and continues southward into the Descanso quadrangle. Many of these faults are too small to be mapped at 1:24,000, and those that are shown were discovered fortuitously because they cross a rocky canyon or roadcut that provided exposures in the class A brush which covers much of the quadrangle. (Class A brush is about 2 m or more tall, and rate of progress is roughly one ridge per 2 hours.) These faults typically do not have strong topographic expression. A group of comparable small faults can be seen in a roadcut of Sunrise Highway immediately north of the entrance road to the Lucky 5 Ranch in Rattlesnake Valley. These faults show a large variation in orientation and movement direction and have crushed zones up to 2 m. Scattered, similar crush zones which parallel rock foliation occur south of Rattlesnake Valley, suggesting that the linear, north-south valley may be in part fault-controlled. Prominent north-trending lineaments can be picked out on aerial photographs of the East Mesa area and of the meadows surrounding Cuyamaca Reservoir, but no crushed rock was seen along them and they are probably controlled by foliation. A group of northeast-trending, normal and reverse faults with up to 3-5 m offset was seen in a roadcut along East Mesa Fire Road, a little less than one-half mile east of Highway 79.

The faults in the upper Pine Creek drainage (southeastern part of map) have crush zones ranging from about 1 m of mylonite, to anastomosing thin mylonite zones up to 5 inches thick, to gouge zones typically less than 2 m. One fault had 5 m of gouge. The contacts of the linear Kem body in this area tend to be faulted, possibly because the unit here is mylonite gneiss.

The major lineament in the Cuyamaca Peak quadrangle is the Sweetwater River-Green Valley lineament. Although this is a prominent lineament on high-altitude imagery, no crushed rock was seen in the streambeds of Green Valley or the Sweetwater River; the mapped fault in the east wall of upper Green Valley has a 2-m-gouge zone and was found only because a road follows it. Several faults marked by breccia and loose gouge were found in the eastern bank of the Sweetwater River north of the town of Descanso (Descanso 7½' quadrangle), and two of these extend a short distance northward into the southwestern corner of the Cuyamaca Peak quadrangle. There is a suggestion of about 600 m right-lateral offset of geologic contacts just north of Camp Cuyamaca (Cuyamaca Rancho State Park Headquarters) where they cross Green Valley, but this offset is ambiguous because the units involved are interfingering. Two right-lateral flexures of contacts occur across the Sweetwater River in the southwestern quarter of the map, but in general, all contacts cross the lineament with no large-scale offset.

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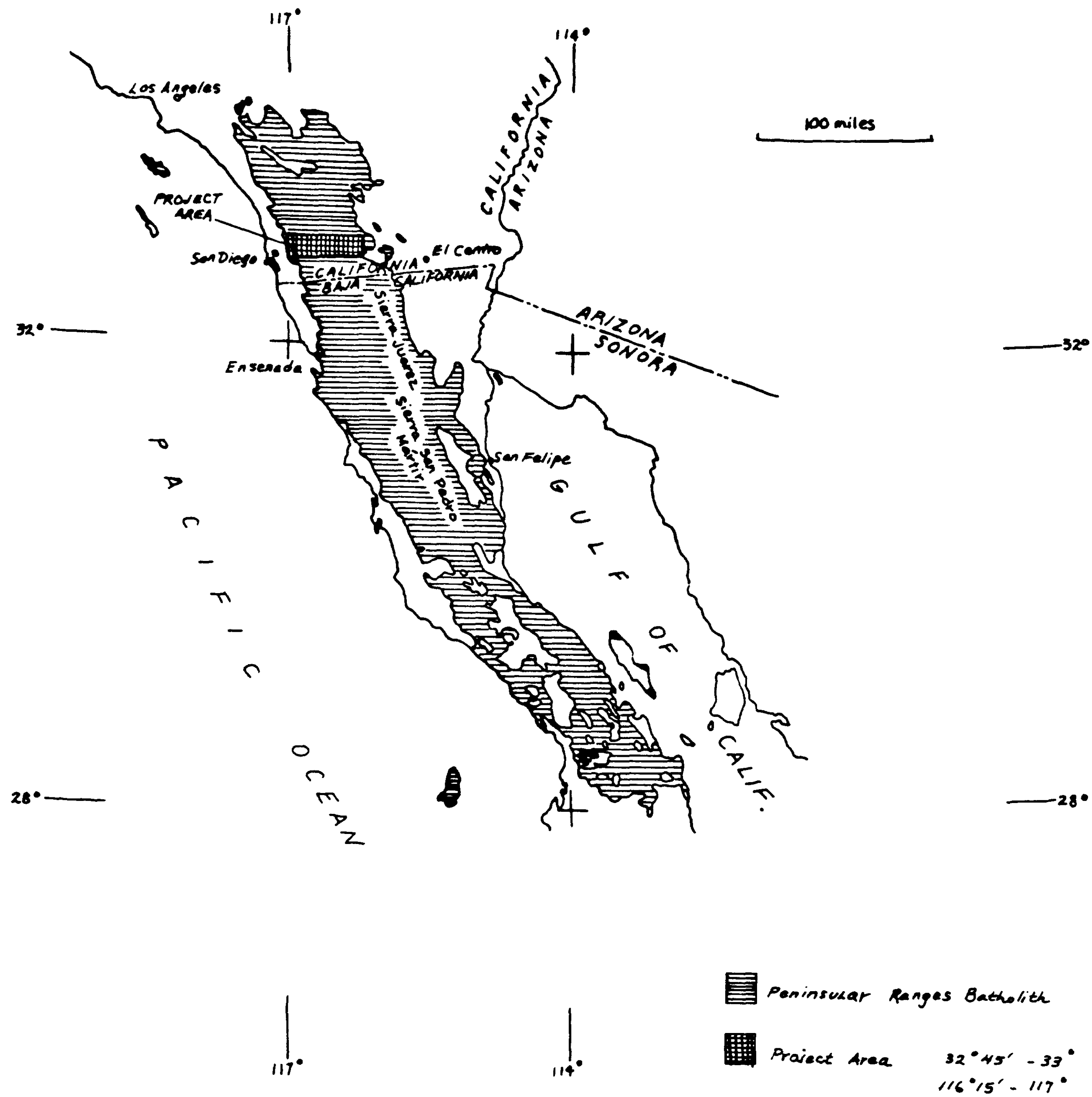

Figure 1.--Peninsular Ranges batholith in southern California and Baja California and project area (after Jahns, 1954).

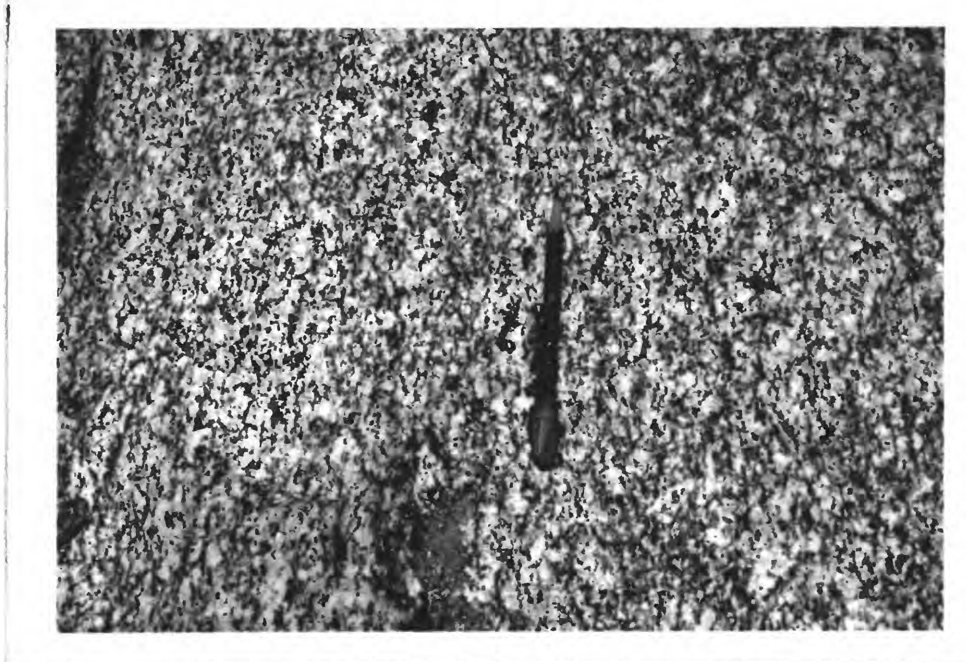

Figure 2a.--Kpv outcrop, trace of foliation parallel to pencil. Color index appears higher than 5-10 percent because mafic minerals have broken down and recrystallized into fine-grained aggregates.

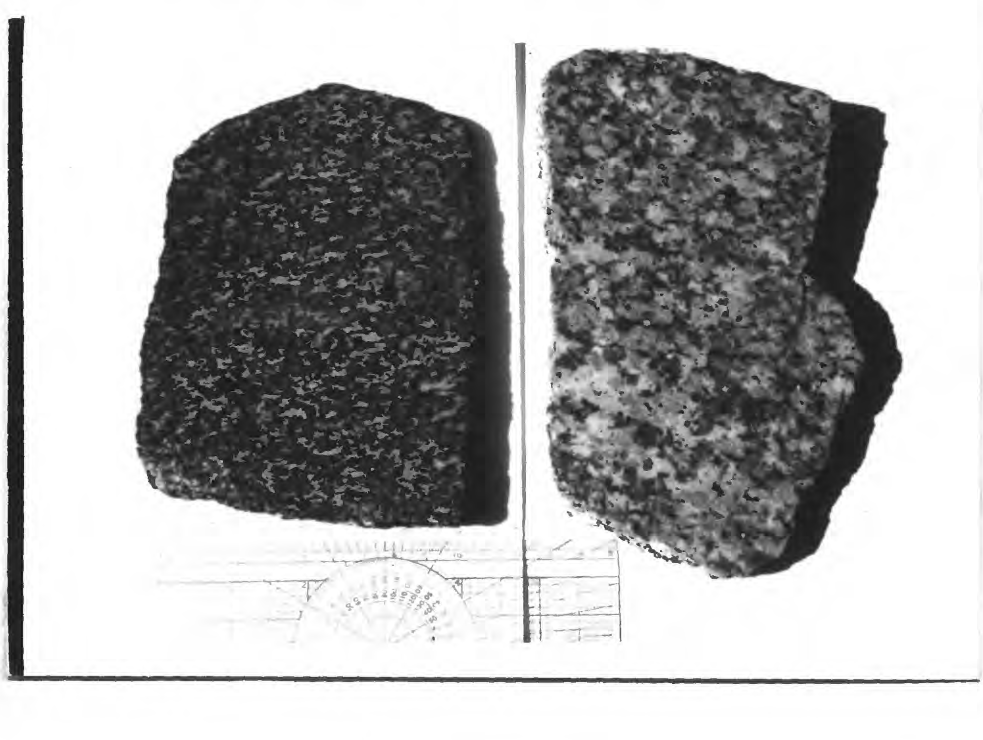

Figure 2b.--Slabs cut at right angles to foliation. Left, Kcp granodiorite; right, Kpv quartz monzonite. Stained for K-feldspar and plagioclase; 6-inch scale.

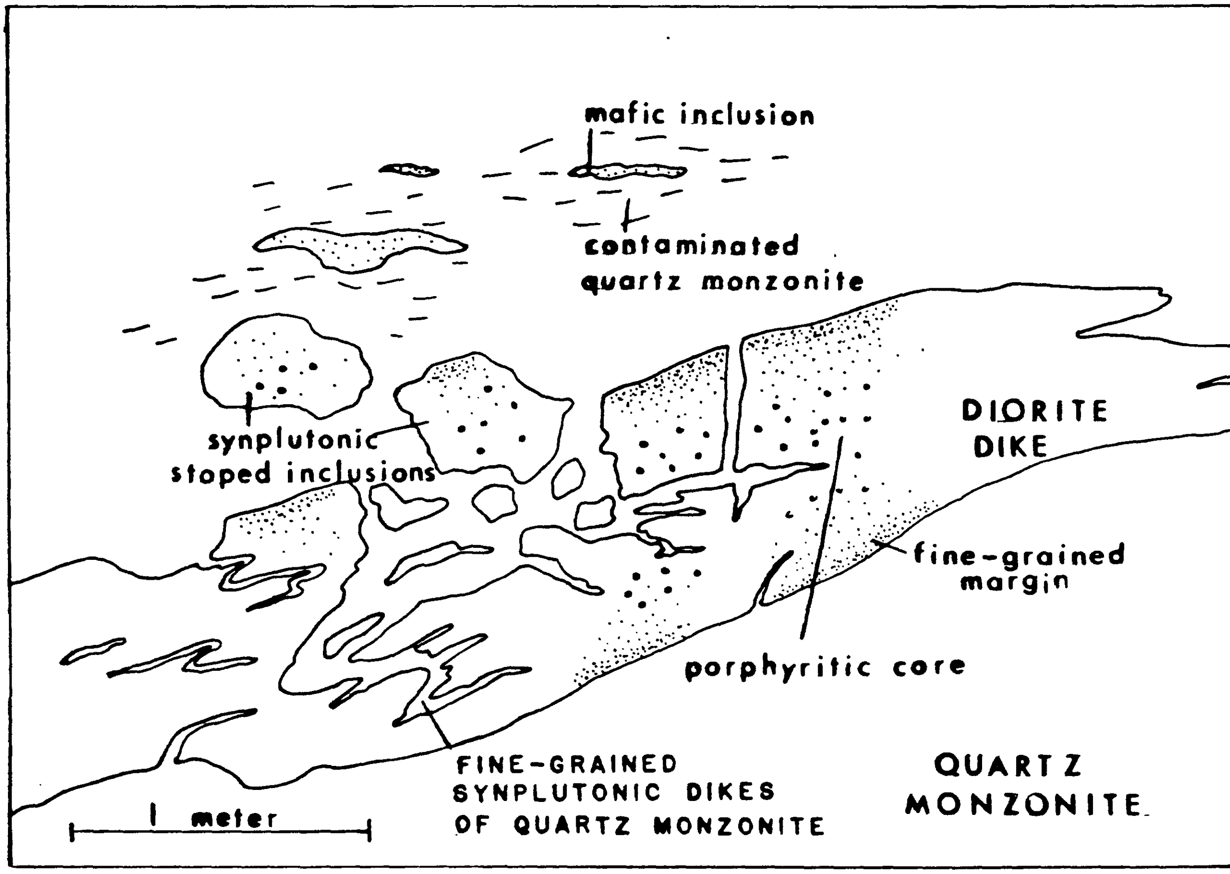

Figure 3.--Sketch diagram of synplutonic relation between Kem dike and Kep host rock.

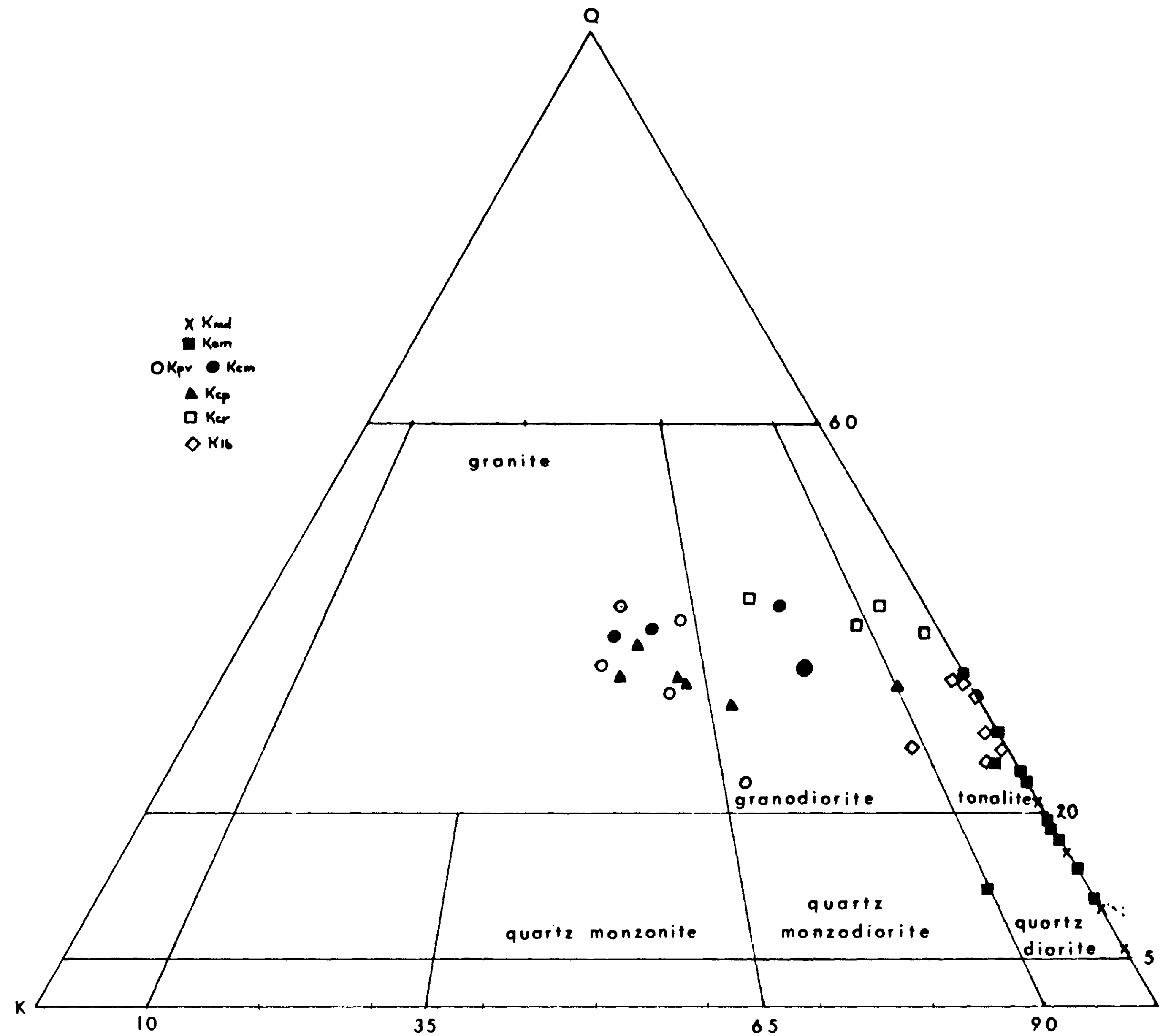

Figure 4a.--Modal data for granitic rocks from Cuyamaca Peak 15' quadrangle (classification according to Streckeisen, 1973).

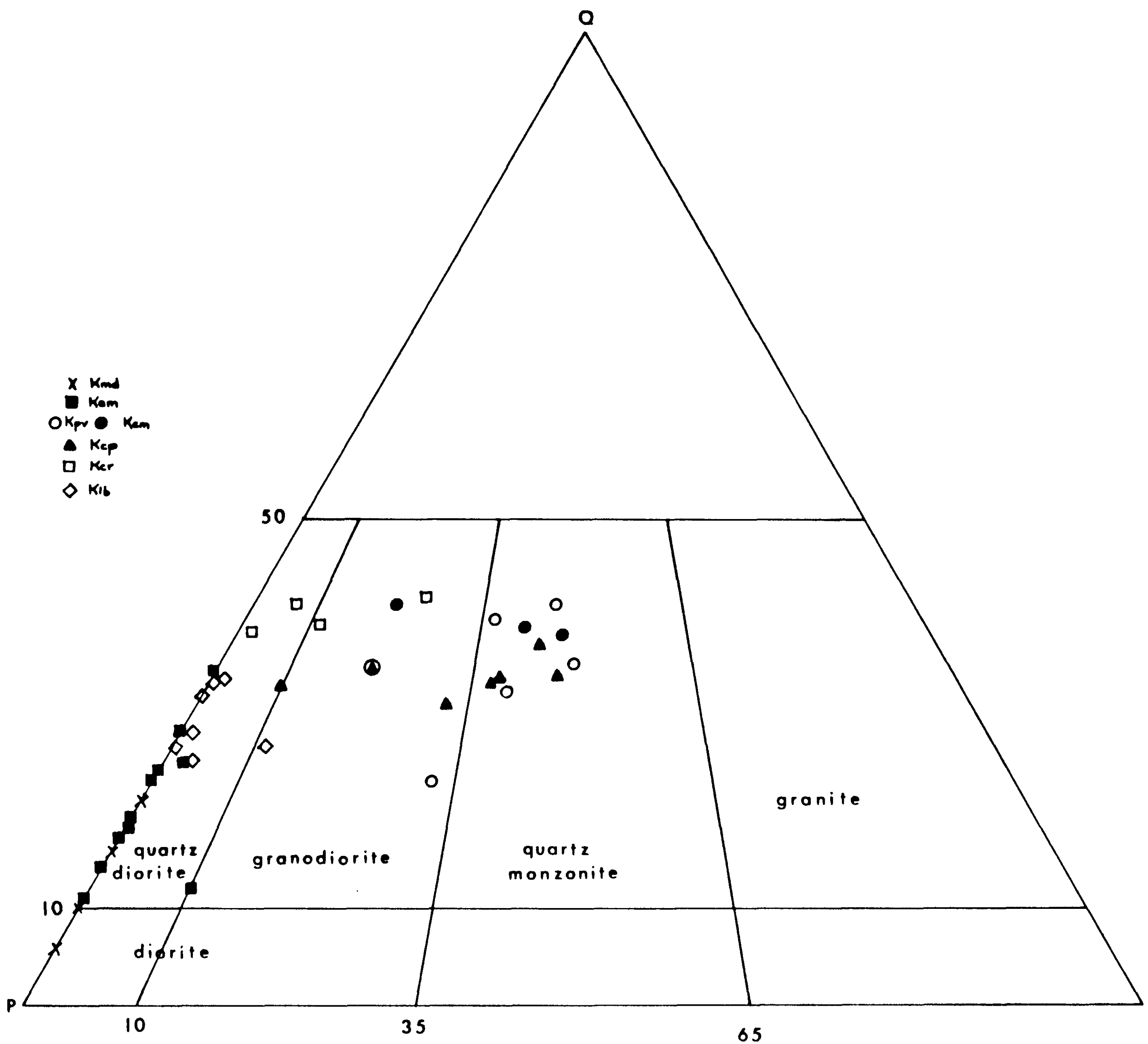

Figure 4b.--Modal data for granitic rocks from Cuyamaca Peak 15' quadrangle (classification according to Williams and others, 1954).

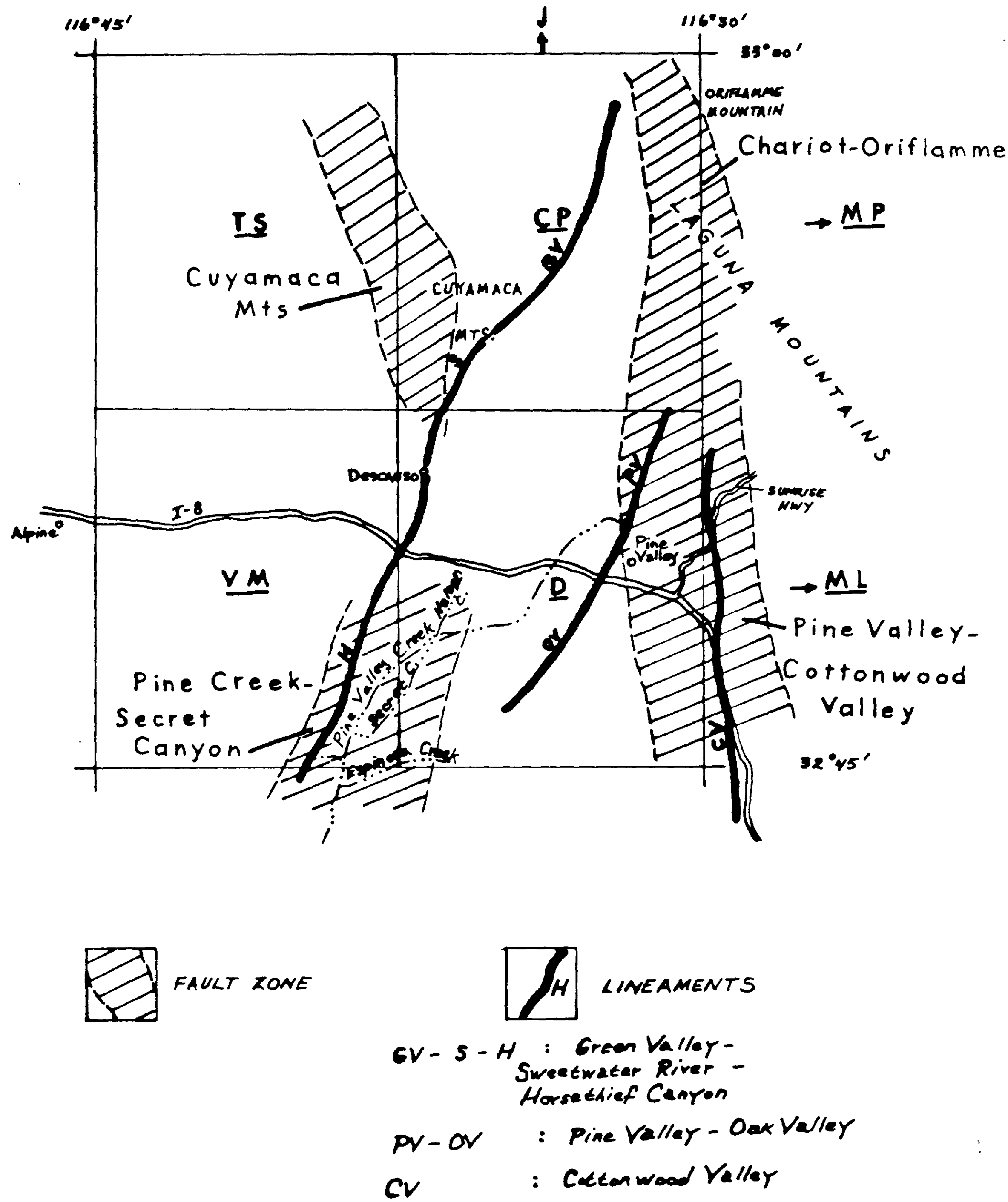

Figure 5.--Index map showing lineaments, fault zones, and geographic features in and around Cuyamaca Peak and Descanso quadrangles. (7½' quadrangles: TS - Tule Springs, CP - Cuyamaca Peak, VM - Viejas Mountain, D - Descanso, MP - Monument Peak, ML - Mount Laguna, J - Julian)