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BASEMENT ROCK CLASTS IN THE TEMBLOR RANGE, CALIFORNIA--
SOME DESCRIPTIONS AND PROBLEMS

by

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INTRODUCTION

Conglomerates in the Santa Margarita Formation of Miocene age that contain enormous clasts of granitic rocks and smaller metamorphic fragments have long been recognized in the Temblor Range (fig. 1) (Arnold and Johnson, 1910; Simonsen and Krueger, 1942). I have measured granitic "clasts" whose maximum dimension is 7 m and there is one virtually monolithologic debris slab of granitic rock that outcrops over an area of about 1 x .25 km. In the past (Arnold and Johnson, 1910), some cliff exposures in this slab have been confused with basement outcrop; only close observation reveals the fragmental nature of the exposure. It is apparent from observing these conglomerates that they are near their source area and could not have been transported far. The clasts presumably were derived from the southwest but their source area has been "beheaded" by lateral movement on the San Andreas fault zone.

Huffman (1972) in a study of offsets along the San Andreas fault based on lateral displacements of Upper Miocene rocks, suggested that these coarse Miocene conglomerates in the Temblor Range most probably were derived from the basement rocks that presently crop out in the northern Gabilan Range. He based his correlation on comparisons of both granitic and metamorphic rock types. Huffman (1972, p. 2928) noted that hornfels with andalusite porphyroblasts was a rare but conspicuous constituent of the metamorphic debris in the Temblor Range. This immediately intrigued me, for I had seen no andalusite hornfels in the Gabilan Range. Thin sections of metamorphic clasts from the Temblor Range that I borrowed from Huffman revealed dark hornfels with large euhedral andalusite crystals and undoubted felsic metavolcanic rock with small phenocrysts of dusty plagioclase and biotite clots set in a dense hornfelsic groundmass. This latter lithology was also unknown to me from the Gabilan Range.

Huffman (1972, p. 2929) also noted that granitic clasts with abundant hornblende and biotite were much less voluminous than more felsic granitic rock types and that the clasts rich in mafic minerals appeared to have been selectively weathered away in surface outcrops. As the Temblor Range conglomerates are quite immature with local "house-size" boulders, I was surprised that dark granodiorite and tonalite were not preserved and a prominent part of the granitic debris if these conglomerates were derived from the northern Gabilan Range where these rock types are abundant.

The character of the basement clasts of conglomerates in the Santa Margarita Formation in the Temblor Range therefore appears to have some possibly significant differences from the basement of the Gabilan Range. With this in mind I have spent about 10 days re-examining and sampling the conglomerate units in the Temblor Range and have examined about 120 thin sections from clasts of metamorphic and granitic rocks. The following discussion is based on the basement clasts that I have collected and studied.

METAMORPHIC CLASTS

The metamorphic clasts of the Santa Margarita Formation in the Temblor Range are generally less abundant and smaller than the granitic clasts; they rarely exceed ½ m in largest dimension. Considerable lithologic variety exists but white to gray marble is widespread and locally abundant.

In sampling numerous conglomerate localities I became increasingly aware of the abundance of dense dark metamorphic clasts; these are perhaps best exposed near the join between the Fellows and Elkhorn Hills quadrangles. As thin section study proceeded it became apparent that an abundance of andalusite, tourmaline, and recognizable volcanic textures (figs. 2, 3, 4) characterized these rocks. Perhaps the most distinctive metamorphic rock has a coarse trachytoid texture and was seen at several localities.

The most common metavolcanic rock type is a gray dense hornfelsic rock sprinkled with small ghost-like to well-preserved plagioclase phenocrysts (to 3 mm) and small clots of biotite that in part pseudomorph dark mineral phenocrysts. Tiny bluish-green to greenish brown tourmaline crystals are common in these rocks.

The coarse trachytoid rock features well-alined crystals of twinned andesine as long as 2 cm set in a matrix of irregular clots and matrix fragments of brown biotite and green hornblende, as well as a hornfelsed mat of andesine--in some specimens the surprisingly fresh-appearing andesine crystals are partially hornfelsed to a sugary mat.

Dark silty, pelitic andalusite hornfels clasts with large euhedral andalusite (chiastolite) crystals in a micaceous groundmass are not common, but are widespread and distinctive.

Dark gray hornfels clasts with various amounts of biotite, muscovite, chlorite, quartz, and feldspar and generally small tourmaline crystals, in part preserve a silty texture. Some of these rocks appear to be tuffaceous and some may be crystal lithic tuffs. It is difficult to escape the conclusion that the source area of the Santa Margarita clasts in the Temblor Range contained significant metavolcanic material.

The undoubted metasedimentary rocks generally appear to be pelitic--rich in mica and in part andalusite-bearing. Impure quartzites are present, but relatively pure quartzite is absent. Also rare to absent are light colored quartzo-feldspathic schist, granofels, and gneiss.

GRANITIC CLASTS

The granitic clasts of the Santa Margarita Formation can be sorted into three rather distinctive rock types; 1) coarse-grained biotite granite[1/], 2) peppery textured biotite granodiorite with rare hornblende, and 3) hornblende-biotite granodiorite and tonalite. The latter type (3) appears to be restricted to some of the conglomerate outcrop areas on the west side of the range (fig. 5). The other two granitic types are found throughout the conglomerate outcrops; the coarse-grained granite is probably most abundant.

1/ The classification of granitic rocks in this report follows a recent recommendation of the IUGS Subcommission on the systematics of igneous rocks (see fig. 6). Rocks referred to as granite (IUGS) in this report were called quartz monzonite, and those referred to as tonalite (IUGS) were called quartz diorite in previous reports on the basement rocks of the Gabilan Range.

In addition some felsic granitic rocks (aplite-alaskite-pegmatite) are found in most outcrops.

The granite clasts (fig. 6) are notably coarse-grained and in part seriate. They contain a few percent of biotite and are otherwise composed of about equal parts of sodic plagioclase, K-feldspar, and quartz. This is a common granitic rock type that by itself has little correlative value.

The peppery granodiorite clasts (fig. 6) have a liberal sprinkling of small dark biotite crystals (and rare hornblende) set against a light-colored quartz and feldspar background. A scattering of somewhat larger biotite plates is also characteristic. Some clasts are weakly porphyritic. Somewhat zoned andesine generally is in a ratio of 2:1 to untwinned K-feldspar; quartz is abundant--a textbook example of granodiorite.

The hornblende-biotite granodiorite and tonalite clasts (fig. 6), though weathered and rare in some outcrops, are fresh and abundant along part of the west side of the Temblor Range. Both biotite (olive brown in thin section) and hornblende (grayish green in thin section) are conspicuous and common dark ingredients of most specimens. Quartz is abundant and K-feldspar is perhaps more abundant than one would expect in a granitic rock with an average of 22 percent dark minerals.

FACIES(?) IN THE TEMBLOR RANGE CONGLOMERATES

In my cursory examination and sampling of the conglomerates of the Santa Margarita Formation in the Temblor Range I observed two possibly distinctive conglomerate types (facies ?). The central part of the western conglomerate belt contains abundant boulders of relatively fresh hornblende-biotite granodiorite and tonalite (fig. 5). The clasts, particularly the cobbles and small boulders, are very well-rounded (in part "cannonballs"), some bedding was observed, and clasts of metamorphic rocks are sparse. In marked contrast the remainder of the conglomerate localities I examined in the western belt and those in the eastern belt contained virtually no hornblende-biotite granodiorite and tonalite clasts, the clasts are generally less well rounded, bedding is rare, and dark metamorphic debris, characterized by metavolcanic clasts and andalusite hornfels, is much more abundant.

From my brief observations the hornblende-bearing granodiorite-rich, dark metamorphic-poor clast localities look more "mature" than the localities with virtually no hornblende-bearing granodiorite and abundant dark metamorphic clasts. The former suggest well-worn clasts in a relatively well-bedded sandstone-conglomerate sequence, and the latter suggest a rapidly dumped "fanglomerate" pile. It is tempting to also suggest different source areas, but there are some dark clasts of metavolcanic rock and andalusite hornfels in the hornblende-bearing granodiorite-rich facies(?) and rare hints of hornblende-bearing granodiorite in the fanglomerate facies(?). Therefore though the proportions of the various rock types differ in the two possible facies, there are no lithologies exclusive to one or the other. The question of whether or not there are two facies and the significance of the real difference in proportions and distribution of the various rock types needs to be answered by a detailed sedimentologic study of these conglomerates.

It should also be noted here that Simonson and Krueger (1942, p. 1618) described three facies in the coarse detrital debris of the Santa Margarita Formation; 1) a "granitoid facies composed predominantly of granodiorite and quartz monzonite boulders," 2) a "facies made up almost entirely of schistose debris," and 3) "the most common facies of the Santa Margarita...composed predominantly of granitoid boulders with minor amounts of schistose material and volcanic rock, set in a coarse gray sand matrix." Their "granitoid facies" is the large monolithologic debris slab of peppery granodiorite near the north end of the west belt of conglomerate outcrop. The "schistose facies(?)" is in the same area and represents a concentration of dark metamorphic rock types. I suspect Simonson and Krueger's facies (1) and (2) represent relatively local (but very large) debris slides or flows that tapped specific lithologies in the source area, whereas in the remaining conglomerate outcrops there is more mixing, representing a larger source area, but of the same rock types.

SOURCE OF THE BASEMENT CLASTS

Arnold and Johnson (1910) were perplexed by the coarse conglomerate debris in close association with soft diatomaceous shale that presumably accumulated under very tranquil conditions. They reasoned that the conglomerate clasts could not have travelled far and that deposition must have been "on a very steep gradient and by torrential volumes of water, which dumped their loads unassorted at the first convenient place." They speculated that the "bowldery lenses" may have originated from the Mount Pinos Range some 40 km to the southeast. They even entertained the idea of a glacial moraine origin for the coarse clastic rocks, but noted that striae and other evidence of a glacial origin were absent. It is most interesting to note that in their report Arnold and Johnson (1910) discussed the rather newly discovered "San Andreas fault zone of intense displacement," but made no suggestion that it might have had some influence on these orphaned boulders--this being some 40 years before the days of Hill and Dibblee and heretical thoughts of large transcurrent fault movements.

Simonson and Krueger (1941) noted that the rock types in their granitoid and schistose facies "correspond rather closely in composition with the Sur Series and Santa Lucia "granite" as defined...by Trask" (1926), but made no further attempt at specific correlations. Fletcher (1967) suggested that "the clast content of...conglomerates in the Pinnacles area (southern Gabilan Range) is similar in every way to those in the Santa Margarita section mapped in the (southern) Temblor Range."

Huffman (1972) made the first real attempt to correlate the Temblor clasts with specific rock types in a potential source terrane. He concluded that the northern Gabilan Range was the probable source terrane, and was the only basement area of the correct composition that was exposed at the time of clast deposition (late Miocene). He noted the striking similarity between the clasts of coarse-grained granite and those of light gray, medium-grained biotite granodiorite to basement rock types in the northern Gabilan Range (the quartz monzonite of Fremont Peak and granodiorite of Natividad of Ross, 1972). He further noted the rarity or absence of clasts of hornblende-bearing granodiorite and tonalite; a rock type that is widespread in the Gabilan Range. He attributed this rarity to preferential disintegration by weathering of these darker granitic types. The local abundance of quite fresh hornblende-bearing granodiorite in the "more mature facies" makes this argument for the absence of the hornblende-bearing rocks in the seemingly less reworked fanglomerate-like facies suspect. It is also possible that drainage from only areas of coarse granite and light gray granodiorite supplied most of the Temblor clasts, but this seems unlikely based on the present distribution of rock types in the Gabilan Range (dark granodiorite-tonalite is abundant). Also Huffman (1972, p. 2923) estimated the clastic sheet of the Santa Margarita to represent the erosion of 165 km^3 (40 mi^3) of basement rock. It would seem difficult to derive such a bulk from the Gabilan Range and not have dark granodiorite-tonalite represented in most conglomerate lenses. However, though it requires some special pleading, it is physically possible for the granitic clasts of the Santa Margarita Formation of the Temblor Range to be derived from the Gabilan Range.

It is much more difficult to attribute the metamorphic clasts to a Gabilan Range source. The rather widespread clasts of dark dense metamorphic rocks with obvious volcanic textures (fig. 4), the trachytoid rocks, and the dark andalusite hornfels (fig. 2) have no known counterparts in the present basement exposures of the Gabilan Range, or for that matter anywhere within the Salinian block.[2] It seems unlikely that all such metamorphic rocks are selectively buried by younger deposits, but of course this is a possibility. Even discounting the andalusite-bearing and metavolcanic lithologies, the overall appearance of the metamorphic clasts makes a poor match with the presently exposed metamorphic terrane in the Gabilan Range. The abundance of marble clasts is compatible with a Gabilan Range source--or any other terrane with abundant marble, but the relative paucity of clasts of light quartzo-feldspathic hornfels and impure quartzite relative to dark dense rocks suggests a different terrane than the presently exposed metamorphic rocks of the Gabilan Range. Admittedly this conclusion is very subjective and needs to be confirmed or condemned by a more quantitative study of clast populations.

A source terrane for the basement rock clasts of the Temblor Range should contain intermediate to felsic porphyritic metavolcanic rocks, andalusite hornfels, marble, peppery granodiorite, and coarse-grained biotite granite. Other lithologies should be present, but the above five types should be widespread and common--their association, with no other rock type dominant, would make the best combination for a correlative source terrane.

Against the south side of the Garlock fault and extending nearly 60 km from the San Andreas fault is just such a terrane. The metamorphic rocks of Bean Canyon Formation (Dibblee, 1967; Dunne and others, 1975) contain marble, dark dense hornfels, porphyritic metavolcanic rocks, and andalusite hornfels. These rocks are intruded by peppery granodiorite and coarse-grained biotite granite that are very similar to the two main granitic clast types of the Temblor Range and to the granodiorite of Natividad and the quartz monzonite of Fremont Peak in the Gabilan Range (Ross, 1972). The idea of dragging a

[2] David John (oral commun., 1979) has identified andalusite in coarsely crystalline sillimanite-bearing contact metamorphic rocks near Fremont Peak in the northern Gabilan Range. These rocks, however, are quite unlike the dark andalusite (chiastolite) hornfels of the Temblor Range clasts.

block from the Bean Canyon terrane north along the San Andreas fault, eroding it to produce the Santa Margarita Formation clasts, and then have the remainder of the block buried under younger deposits or "sailing" northwest, and out to sea by further San Andreas fault movement is rather difficult to swallow--and probably is not a viable answer to the problem! Still the similarity of the Bean Canyon terrane to the Temblor clasts seems too close to be merely coincidental, and suggests a similar environment for a source terrane.

In view of many studies of offset of Miocene and other Tertiary deposits and correlations across the San Andreas fault (Grantz and Dickinson, 1968, p. 118; Nilsen and Clarke, 1975) it looks unlikely for the basement clasts embedded in a Miocene clastic section to have been derived from a totally foreign basement block that has now been displaced beyond the present land area of California. The most "comfortable" explanation with the present data is that "Bean Canyon type" metamorphic rocks intruded by "Gabilan Range type" granitic rocks lie buried somewhere in the Salinian block.

It would be the height of arrogance for me to suggest that all of the Tertiary correlations are equivocal and that the Salinian block is a true exotic block, just because I don't feel the basement rocks match as presumed Tertiary correlations say they should. Yet I am haunted by the dilemma of having seen no metavolcanic textures or dark andalusite hornfels in the Salinian block, for surely these rock types were widespread in the source terrane of the conglomerates, and both are so readily noticeable in exposures --it is not likely their exposed presence would have been missed. It is still tempting to speculate on an "exotic terrane" for the Temblor metamorphic clasts, for here is one more instance where the Salinian block does not seem to be able to produce the right rock types to fulfill expected correlations (Ross, 1977, 1978).

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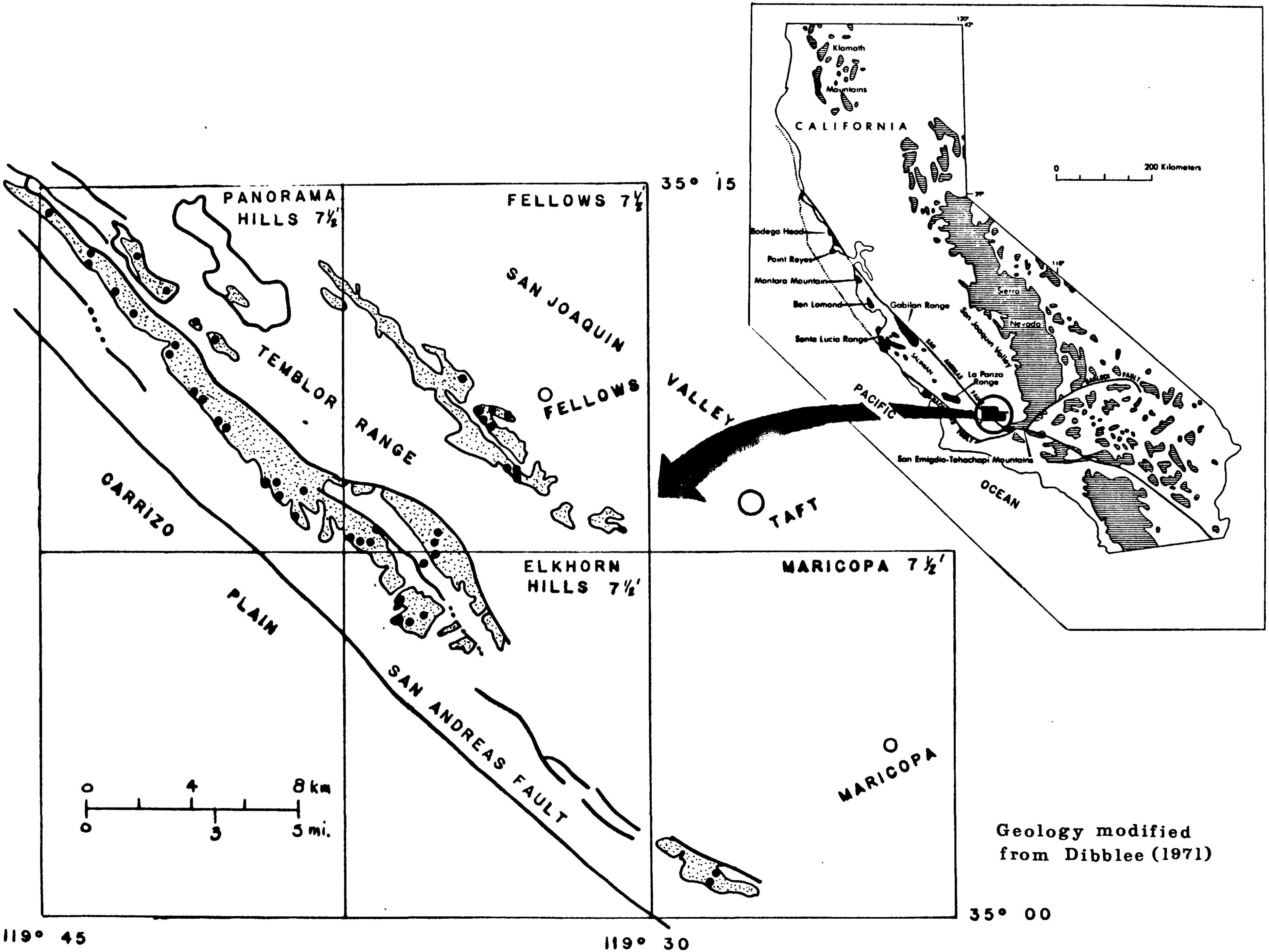

Figure 1. Generalized outcrop area of Santa Margarita Formation in the Temblor Range. Larger black dots indicate conglomerate localities sampled in this study.

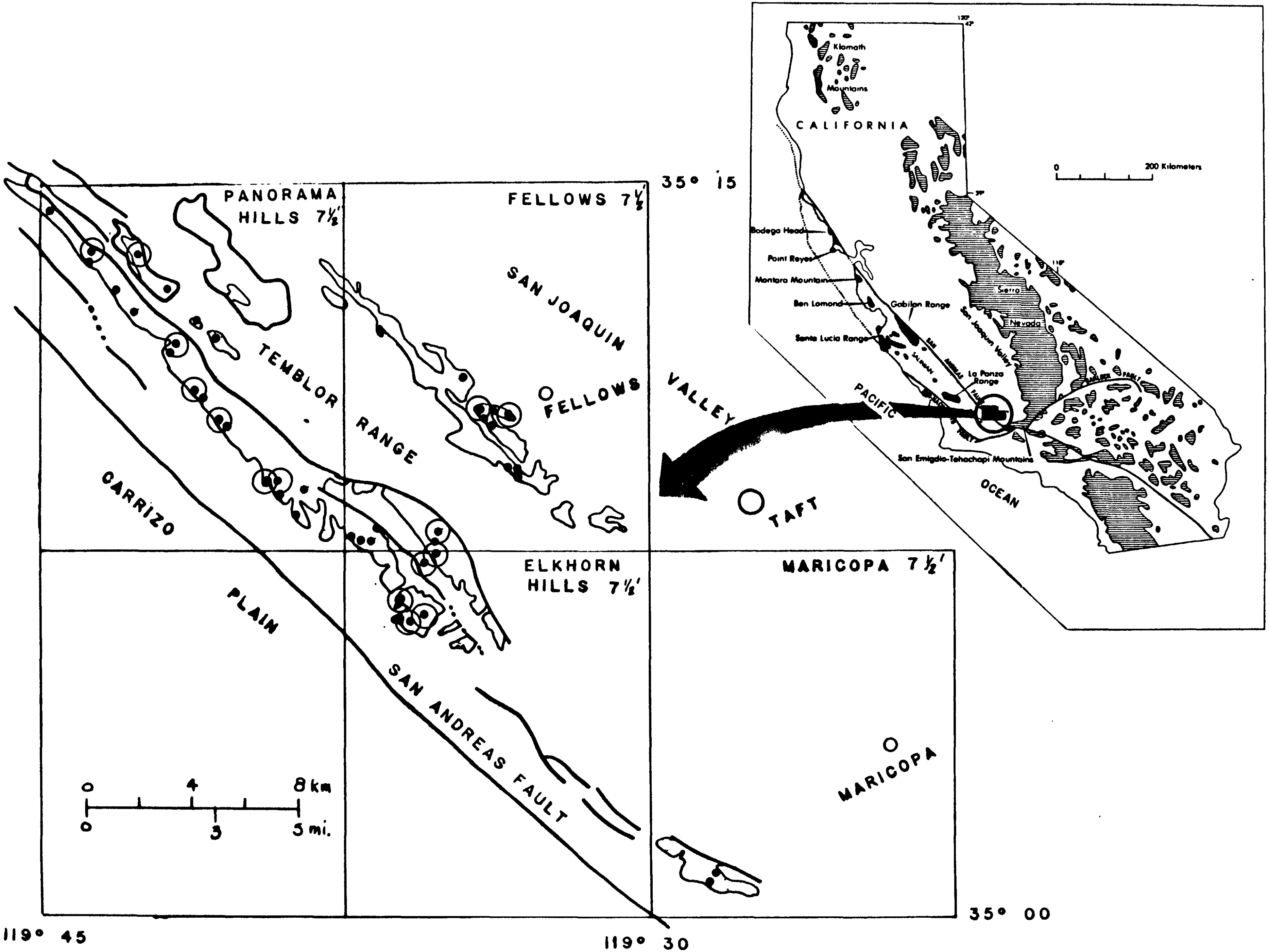

Figure 2. Location of andalusite-bearing metamorphic clasts ○

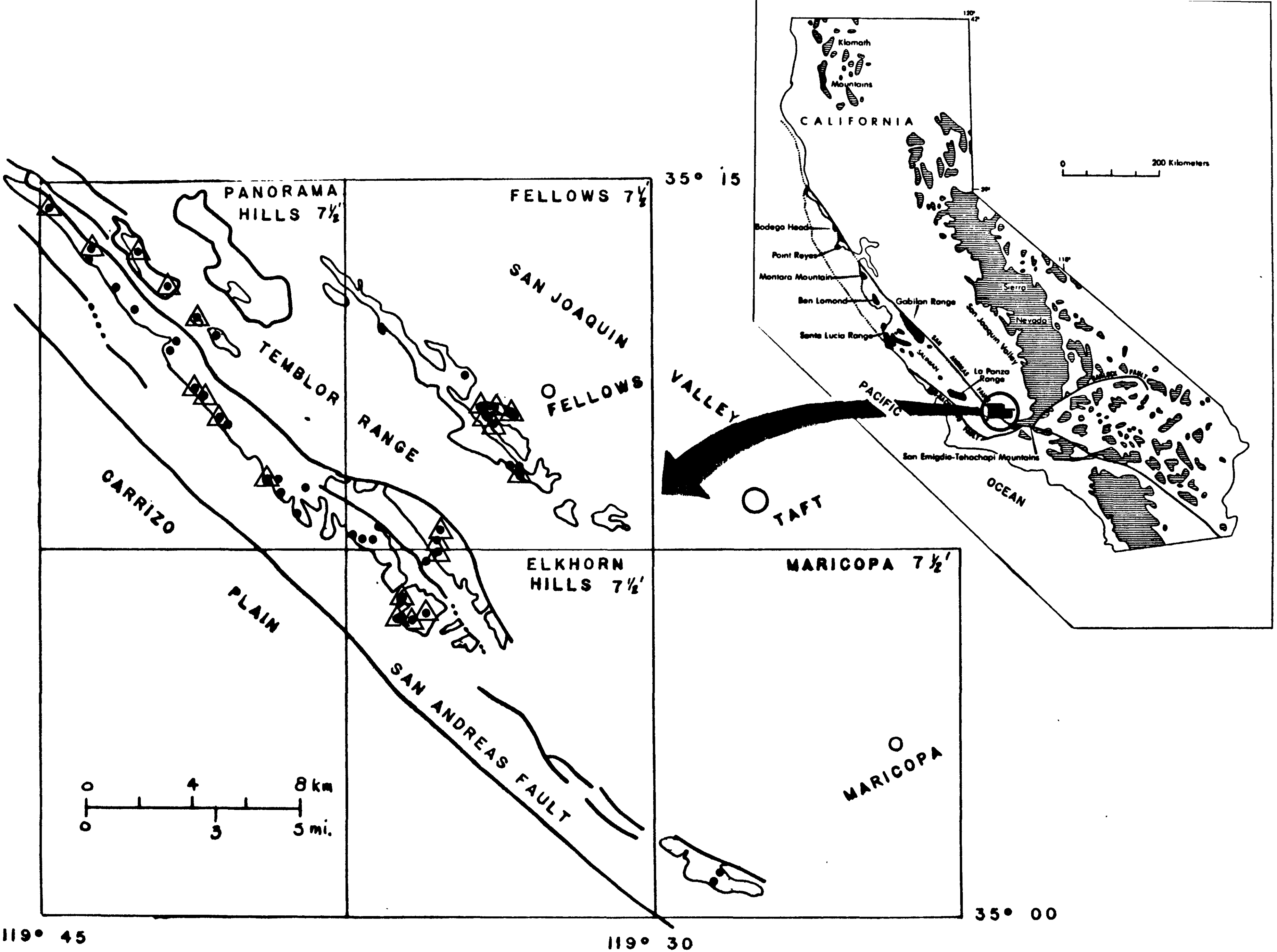

Figure 3. Location of tourmaline-bearing metamorphic clasts △

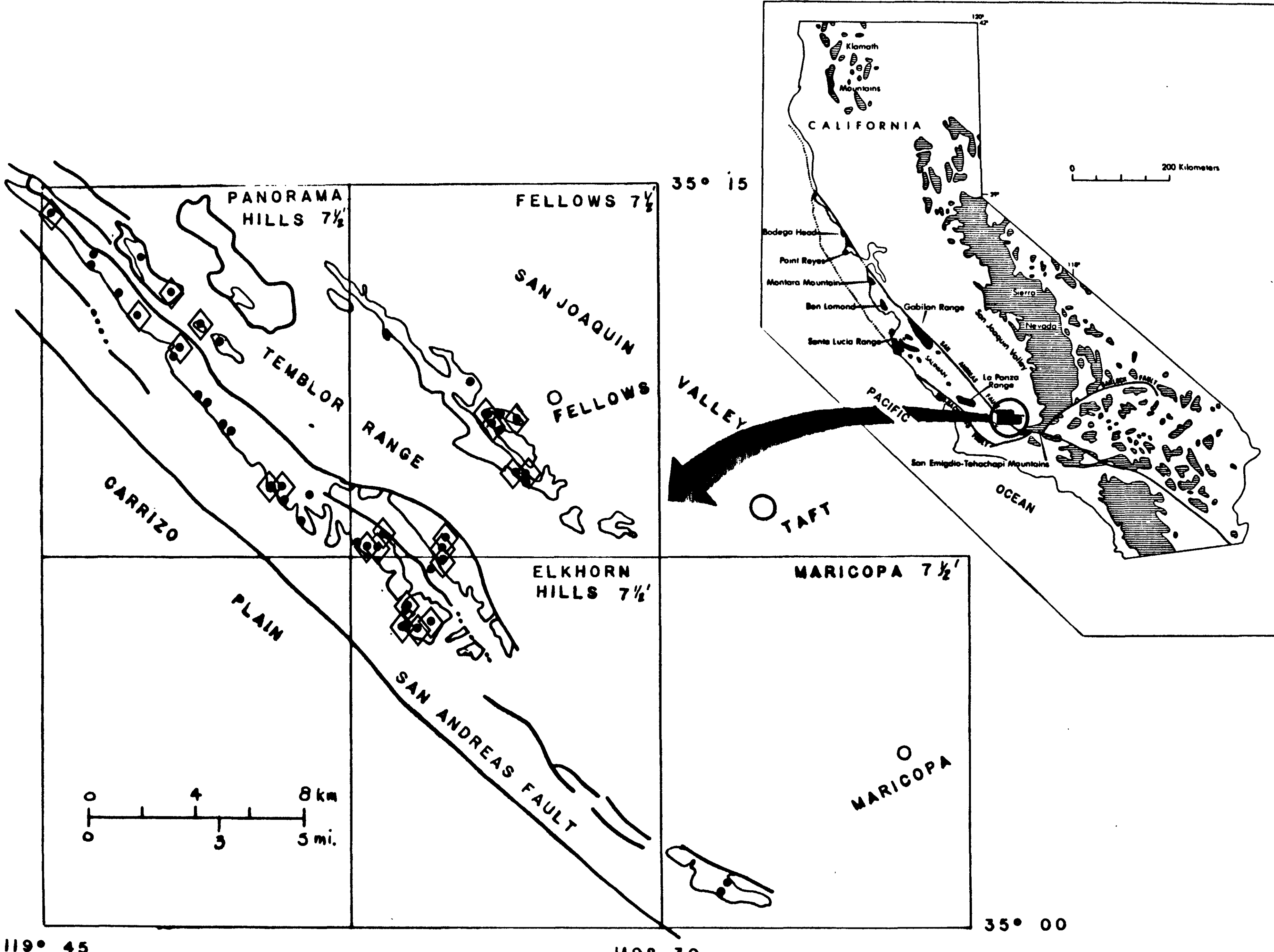

Figure 4. Location of metamorphic clasts with volcanic textures ◇

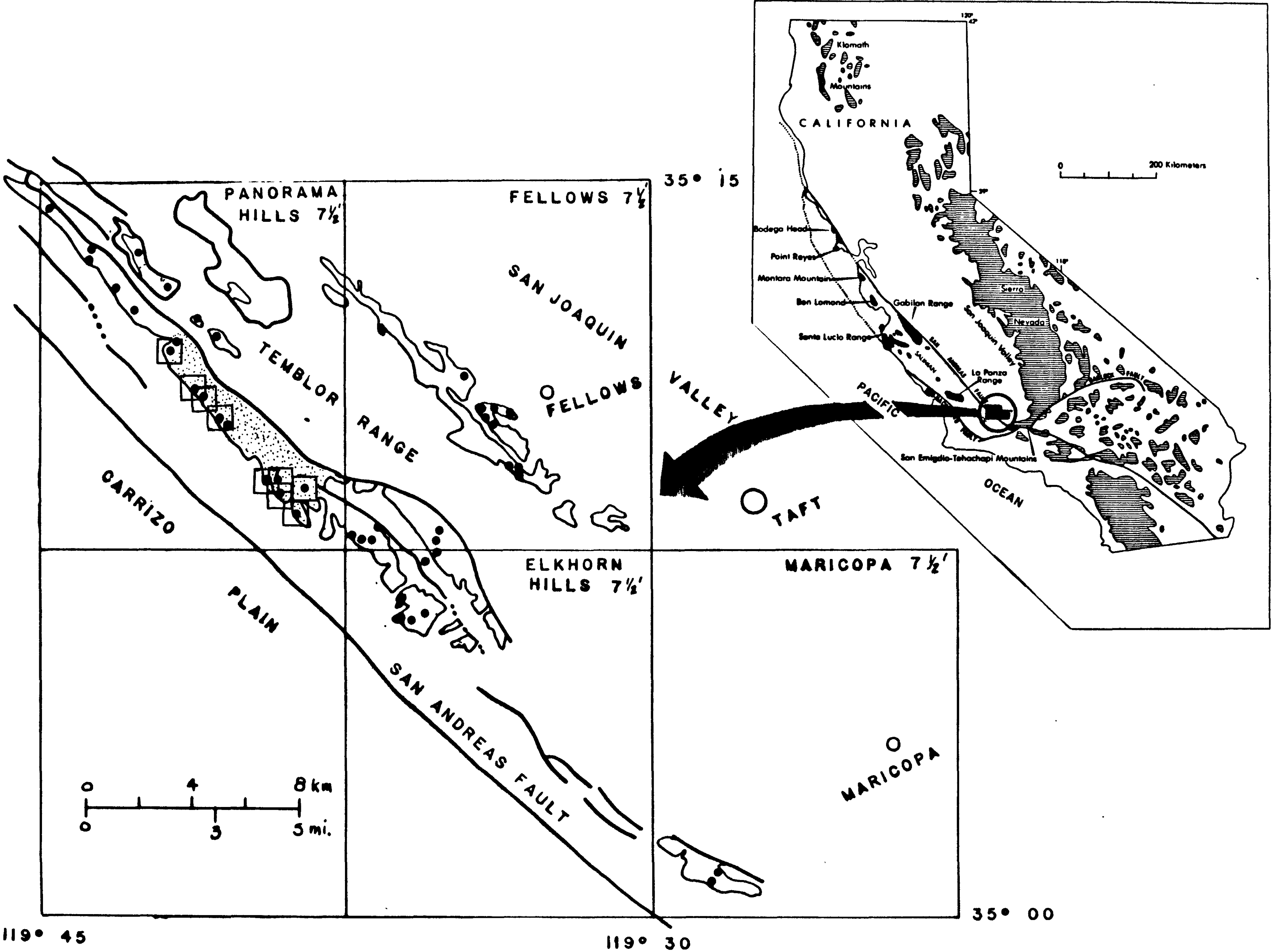

Figure 5. Location of abundant clasts of hornblende-biotite granodiorite □

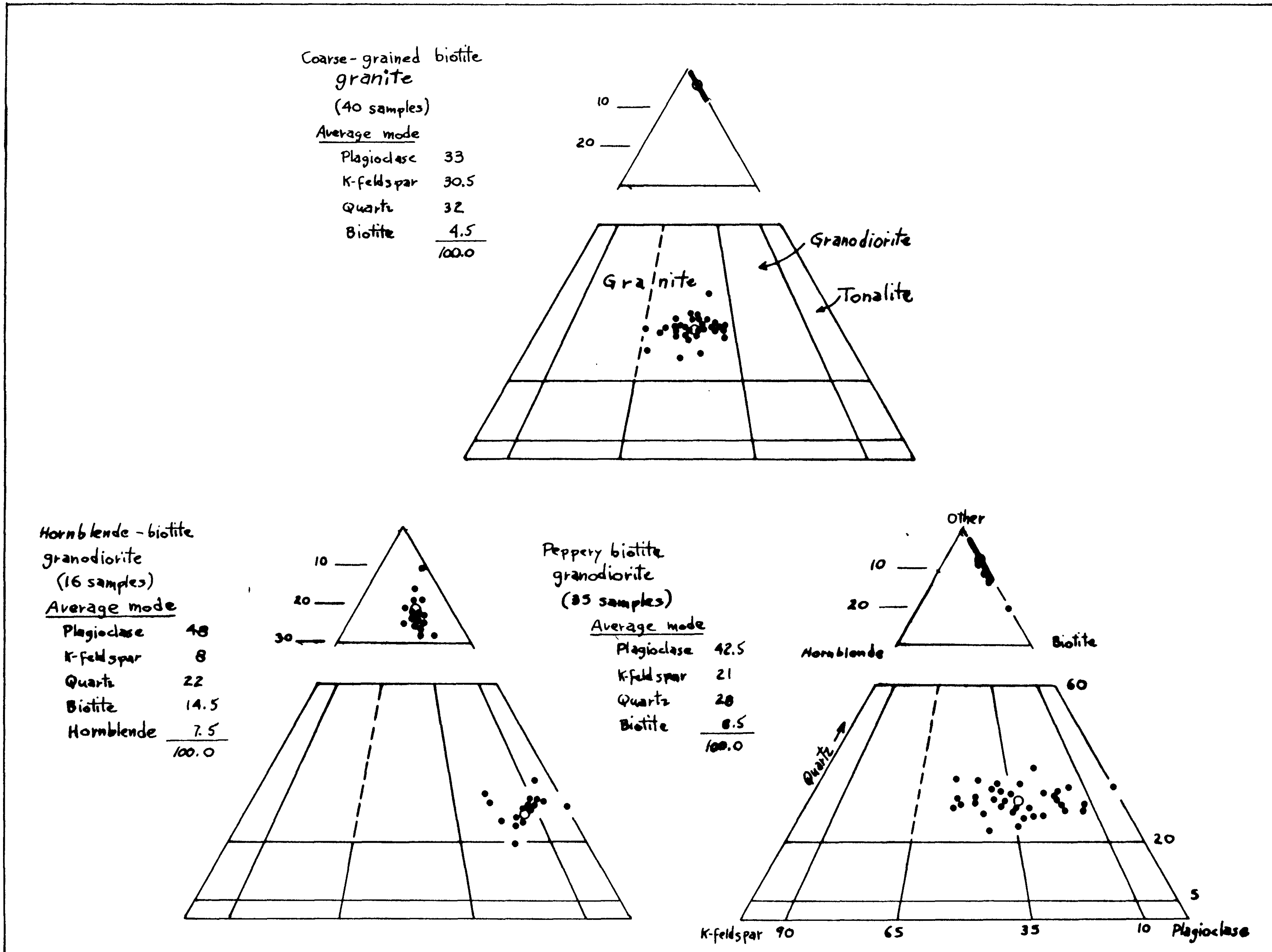

Figure 6. Modal character of the three main granitic rock types occurring as clasts