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The mineralogy, petrology, geochemistry and petrogenesis of the Mountain Poser gabbroic pluton, southern California.

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THE MINERALOGY, PETROLOGY, GEOCHEMISTRY AND PETROGENESIS OF THE MOUNT POSER GABBROIC PLUTON, SOUTHERN CALIFORNIA

by

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Dedicated to my parents, Mina and Norman, and to my wife, Patricia.

ABSTRACT

The Mount Poser pluton, southern California, is one of a series of layered gabbroic plutons that occupy the western margin of the dominantly granitoid Peninsular Ranges Batholith. There are four main lithologic units which can be divided into a plagioclase-olivine series and a plagioclase-pyroxene series. The mineralogy, petrography and geochemistry of the rocks of Mount Poser suggest that this pluton formed by crystal accumulation from a fractionating high alumina basalt-badaltic andesite parental magma of calc-alkaline affinity. Rayleigh fractionation models for the distribution of Sr, Rb, Ba and K indicate that 67% of the melt must have crystallized to produce the observed assemblages. This suggests that other gabbroic plutons within the batholith underwent similar differentiation, however tha vast quantities of granitic material observed within this batholith cannot be explained by further crystallization of this parental melt. The granitic rocks, therefore, owe their origin to some other process.

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The Mount Poser Complex is a layered gabbroic pluton, exposed on a hill of the same name, located in San Diego County, California. The hill lies approximately 50km east of San Diego, (Fig. 1). The pluton is approximately crescentic in shape, underlying $22km^2$ in area, and its long axis trends almost east-west. The exposed complex ranges in relief from 1036m above sea level at its base, to 1194m at the summit of the highest of its twin peaks, (Fig. 2, and Plate A #1).

Mount Poser is situated in the Cuyamaca Peak quadrangle, (Fig. 1). This quadrangle exhibits a variety of landforms including broad tablelands, above which both rugged steep-sided bouldery peaks and broad based cone shaped mountains, with gentle slopes, rise, (Plate A #2). Deep gorges and youthful canyons locally cut below the extensive upland surfaces, but in places the major streams flow through broad mature valleys. The three major streams and tributaries that drain the area flow south-west into the Pacific Ocean. The climate varies markedly according to elevation. The higher elevations have generally lower temperatures and greater precipitation than the low valley lands. Vegetation of the Cuyamaca Peak quadrangle includes a variety of conifers, deciduous trees, bushes, shrubs

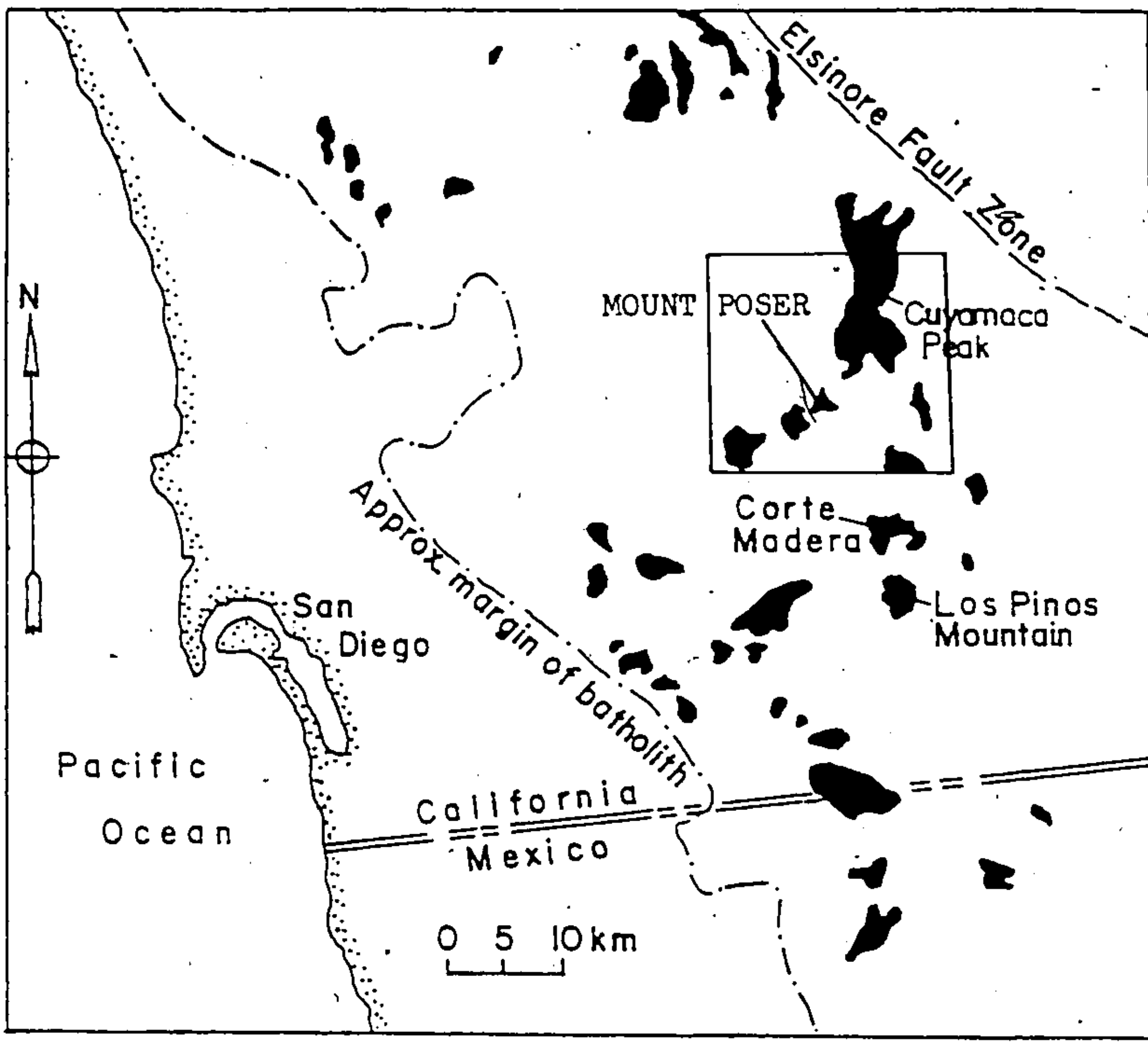

Figure 1. Location of the Mount Poser pluton within the Peninsular Ranges Batholith, southern California. Outlined area represents the Cuyamaca Peak Quadrangle.

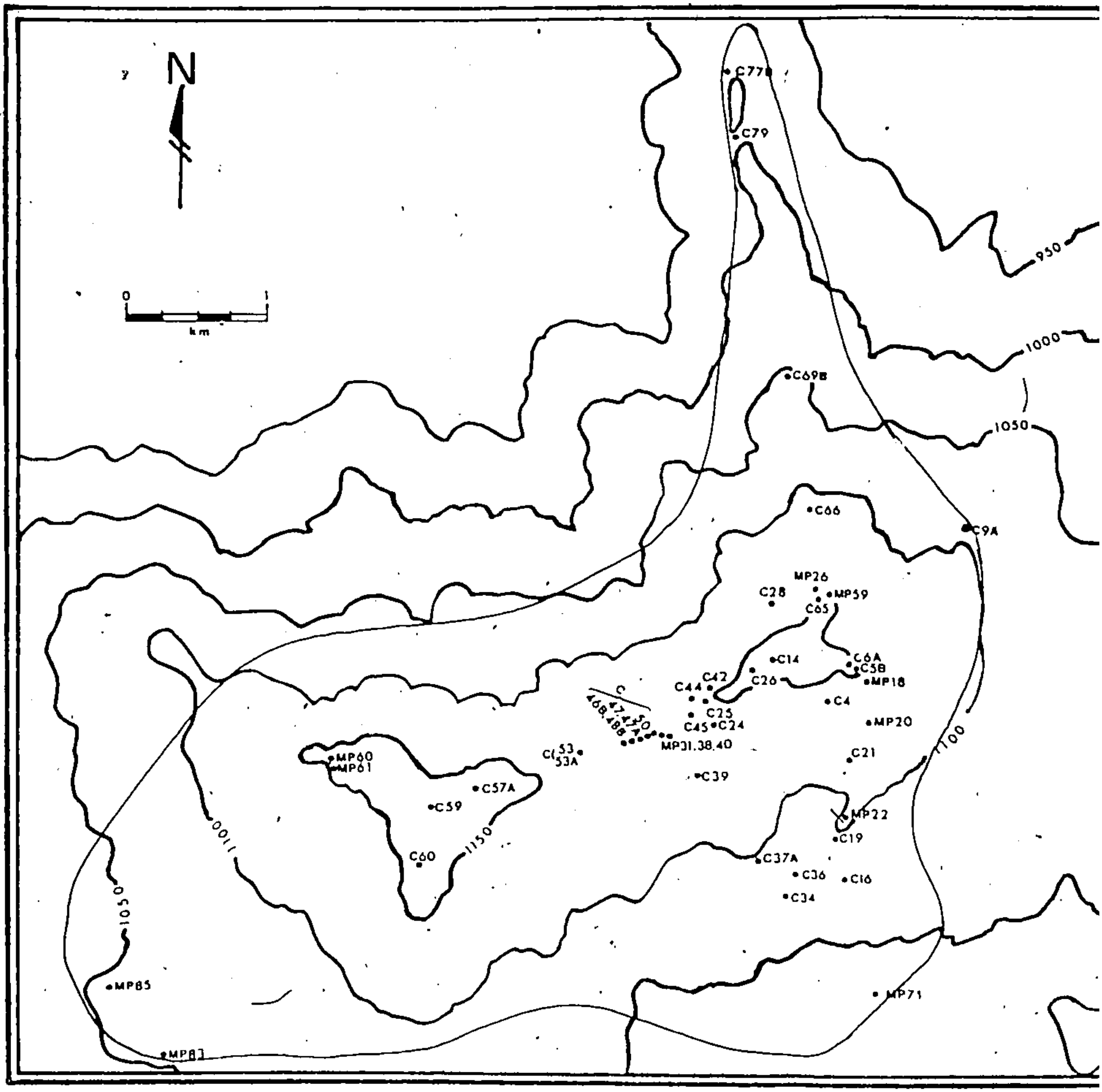

Figure 2. Location of samples used in petrographic thin section study and geochemical analysis. Outlined area represents the margin of the Mount Poser pluton.

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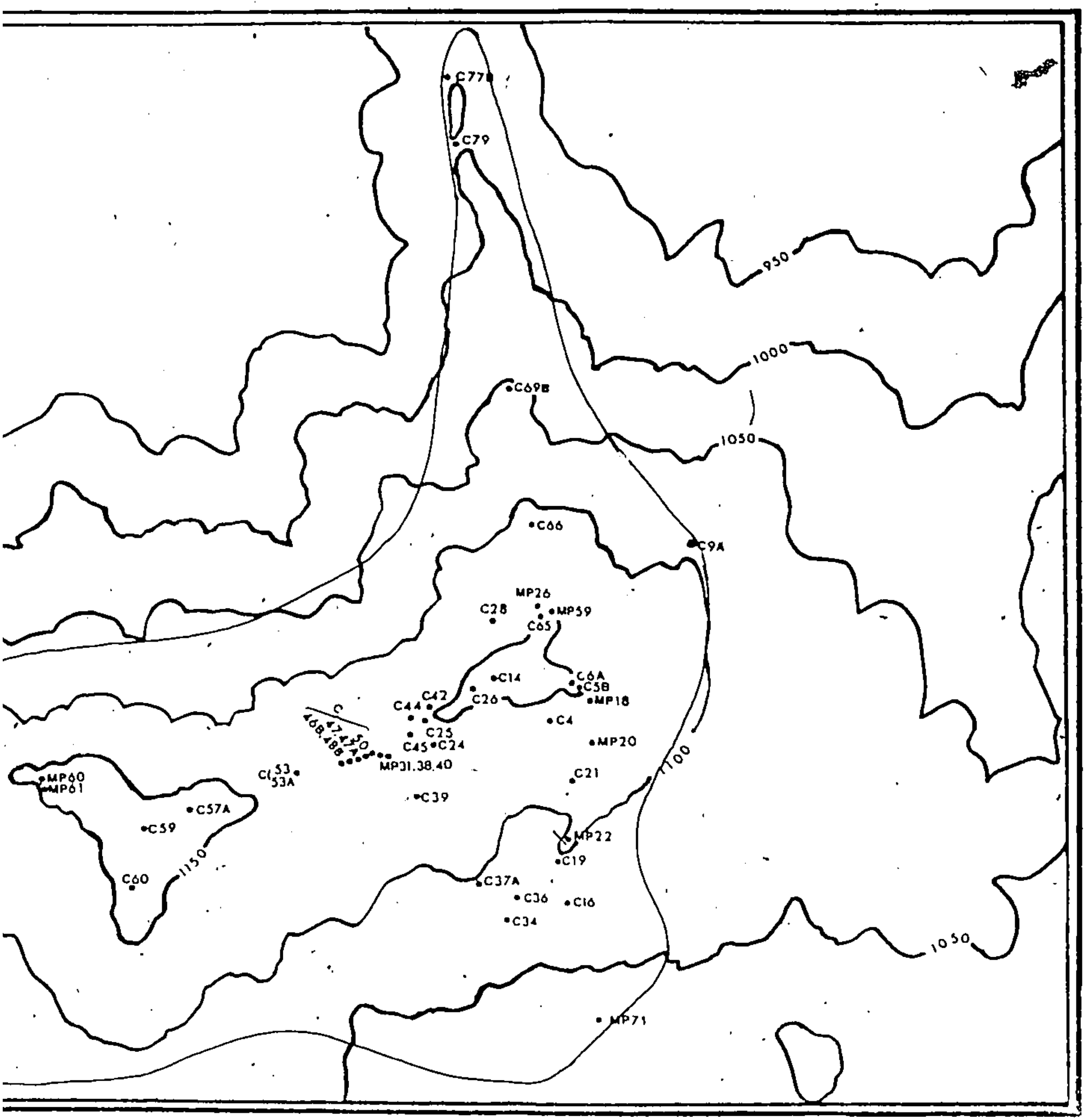

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and grasses. Mount Poser supports a variety of brush species, the most common of which are the manzanita and yucca plants, but sage and mesquite is also found.

Rock exposures on Mount Poser are poor near the base, and improve both in number and in size near the summit.

This pluton is part of a large geological province known as the Peninsular Ranges, (Fig. 3). The Peninsular Ranges extend from latitude 34°N in Alta California to latitude 28°N in Baja California. On the west, the Pacific border land defines the margin, while the eastern limit is the San Andreas fault system. The core of the province is occupied by the Peninsular Ranges Batholith, which is a complex sequence of igneous and metamorphic rocks extending the whole length of the range, 1000km, and has an average width of 100km. The igneous rocks of the batholith range from gabbro to granite, in composition, but tonalite and granodiorite are the most abundant rock types.

The Peninsular Ranges Batholith has been intruded into a series of volcanic and sedimentary rocks. Along the western margin of the batholith are upper Jurassic and Cretaceous volcanics and volcaniclastics which rest upon marine strata of late Triassic to late Jurassic age. The pre-batholithic rocks of the central area are Mesozoic and late Paleozoic clastic sedimentary

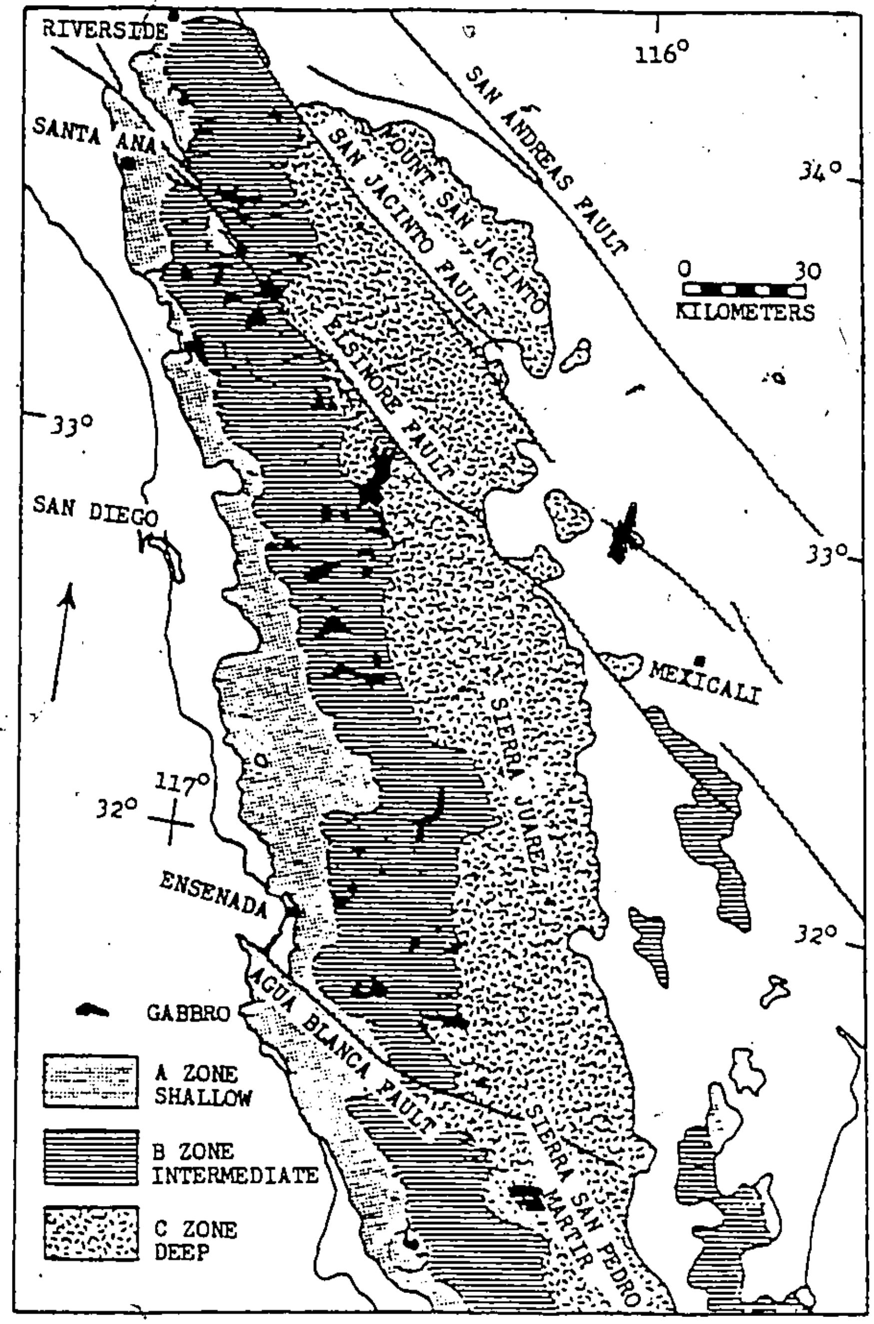

Figure 3. The plutonic sub-belts in the Peninsular Ranges batholith, southern California, and northern Baja California according to Gastil, (1975). The three sub-belts: Gabbroic sub-belt (A), Tonalite sub-belt (B), and Adamellite sub-belt (C).

rocks. The host rocks of the eastern section are calcareous Paleozoic and late Precambrian rocks that overlie Precambrian basement rocks.

Gastil, (1974), has described the metamorphism of the range. Regional metamorphism has altered these host rocks and there is some evidence of contact metamorphism in areas of low grade regional metamorphism, (Gastil et al, 1974). The pre-batholithic rocks of the southwestern and northeastern marginal areas are unmetamorphosed. The western section is characterized by fine grained hornfels, slates and phyllites in which most of the original textures have been preserved. Contact aureoles are common in this area but are narrow in extent. The central section contains schistose and plastically deformed host rocks that still contain relict structures and textures of pre-metamorphic origin. Coarse schists, gneisses and amphibolites characterize the host rocks of the eastern zone, where sillimanite is commonly found in the schists. Metamorphism has completely destoyed any original textures and structures.

Using the evidence presented above and the distribution of rock types, the batholith has been divided into three sub-belts by Gastil et al, (1974), (Fig. 3). The westernmost sub-belt, the gabbro sub-belt, has abundant gabbroic rocks which underlie approximately 20%

of this area. The gabbro plutons are commonly layered and vary in make-up from peridotite to anorthosite, but include norite, gabbronorite, troctolite and gabbro. Hornblende is a common mafic component of all of the plutons. The remaining rock types in this sub-belt are tonalite and minor granodiorite. Mount Poser is exposed in this sub-belt.

The central tonalite sub-belt contains plutons composed of mainly leucocratic hornblende-biotite-tonalite, grading into granodiorite on a local scale. Coarse sphene crystals, (0.5cm), are common in the tonalites. The largest plutons in this sub-belt reach 40km in diameter. Granite and gabbroic plutons are essentially lacking in this sub-belt.

The eastern adamellite sub-belt is characterized by tonalites and granodiorites which make up about one-half of the area. The remainder of this sub-belt consists of adamellite and granite. Rocks of gabbroic composition are absent in this sub-belt.

Krummenacher et al, (1975), have determined a large number of radiometric ages on the rocks of the Peninsular Ranges Batholith, using Rb/Sr, U/Pb and K/Ar methods. These ages show, that in common with other Circum-Pacific batholith complexes, there is a systematic decrease in age from west to east, in the rocks of the Peninsular Ranges Batholith. An average age of approximately 145 m.y. has been determined for the plutons for the western gabbroic sub-belt, while the eastern adamellite sub-belt average is about 80 m.y. The ages agree with the statigraphic limits that were discussed previously regarding the host rocks. The K/Ar ages determined from hornblende and biotite contained in the Peninsular Ranges Batholith rocks are systematically lower than the ages determined by the other two methods. Krummenacher and Gastil, (1975), also found that the K/Ar ages for hornblende are 5 m.y. older, on average, than those for biotite, (four ages from hornblende range from 93 to 99 m.y., while six biotite ages range from 90 to 96 m.y.). This difference in age indicates the length of time required to cool the rock from 475°C to 275°C, at which temperatures hornblende and biotite respectively, are closed to argon diffusion. Krummenacher et al, (1975), suggest that the K/Ar ages do not indicate the time when the batholith was emplaced, but record the times at which uplift and erosion of the batholith occurred. This uplift and erosion is the quickest way to cool the rocks. And it is suggested, (Gastil, 1975), that this process occurred 5 to 20 m.y. after emplacement.

The same explanation has been offered for the Coast Range Complex in British Columbia by Hutchison, (1967). However, Symons, (1974, 1977a, 1977b), found, in paleomagnetic studies, that the remanence polarity pattern and directions of selected plutons within the complex, were incompatible with the uplift hypotheses. And further, (Symons, 1977a), that the remanence directions predate regional folding of the plutons and must record their initial cooling.

Previous field work in the Cuyamaca Peak and adjacent quadrangles dates back to early Annual Reports of the State Mineralogist, (1890). However, more detailed work has been completed by Hudson, (1922), Miller, (1935, 1946), and more recently by Larsen, (1948), Everhart, (1951), Nishimóri, (1976), Walawender, (1976), and Walawender, Hoppler, Smith and Riddle, (1979). Their conclusions based on field relations suggest the following order of events, deposition of sediments followed by metamorphism to schists, gneisses and quartzites. Emplacement of igneous rocks followed next with gabbros emplaced first, followed by tonalite and lastly granodiorite. In some localities within the Peninsular Ranges Batholith, volcanism has accompanied the emplacement of the plutonic igneous rocks.

Several workers have proposed contrasting theories regarding the origin of the magma and magma types which formed the Peninsular Ranges Batholith. Gastil, (1975), has proposed that due to a subducting oceanic plate under the continental plate of Southern California magma generation has produced the Peninsular Ranges Batholith. The differences in the rock compositions emplaced within the batholith results from the differences in the crustal materials available for contribution to the magmas. "In the outer continental borderland... only melt newly derived from either the mantle or the subducted oceanic crust," (p.363), could have contributed to the batholith's rocks found here. "In the inner continental borderland, there may be some contribution from the fusion of older oceanic crust, but no fusion of older sialic rocks is involved. In the western Peninsular Ranges, fusion of both older oceanic crust and the clastic wedge that rests on it may be involved", (p.363). Gastil suggests that processes like those described above would produce the zoned batholith as described earlier in this section.

This type of multiple origin corresponds with models which have been largely developed on the basis of experimental evidence. T. Green and A.E. Ringwood, (1966, 1967 and 1968), undertook a detailed experimental investigation aimed at discovering how magmas might form when lithosphere was subducted into the mantle. It was demonstrated that andesitic-dacitic magmas could be formed by partial melting of the mafic oceanic crust along the subduction zone when lithosphere was subducted into the mantle. However, the tholeiitic magmas associated with andesites and dacites were believed to have formed not from the subducted oceanic crust, but by partial melting of pyrolite in the wedge overlying the subduction zone. Alternatively, water liberated by dehydration of subducted oceanic crust might have entered the overlying wedge, causing partial melting and producing hydrous basaltic magmas which fractionated by amphibole separation to form a range of orogenic magmas associated with hydrous high alumina basalts.

Summarizing Green and Ringwood's results it appears that the orogenic magmas are derived from partial melting under high water pressures from two principal sources: (1) subducted mafic oceanic crust and (2) the pyrolite wedge overlying the subduction zone.

The primary magmas produced near the subduction zone at depths of 80 to 100km consist of hydrous tholeiitic basalts, close to silica saturation. They are not andesitic. These magmas undergo fractionation as they rise principally by olivine separation, and are reponsible for the tholeiitic stage of development of island arcs. Magmas produced at depths greater than 100km rise and fractionate to produce andesites, dacites and rhyolites possessing the calcalkaline petrochemical trends which are characteristic of mature island arc systems.

Green, (1979), has suggested that "mature" sedimentary material is invoved in melting at depth and the generation of volcanic and plutonic magmas in evolved island arc or continental marginal environments.

Ringwood, (1977), states that the basalt-andesite-dacite-rhyolite series together with their plutonic equvalents are the dominant constituents of island arcs.

These experimental results of Green and Ringwood contrast very much with the views of Larsen, (1948), Nishimori, (1976), Albarede, (1977) and Erikson, (1977), who all believe that the gabbros and granitoids have a common source.

Larsen, (1948), suggested that the whole series of rock types of the Peninsular Ranges Batholith were derived from one single deep seated gabbroic parental magma that differentiated at depths and the differentiates were systematically emplaced into the upper crust. This hypothesis has received support in recent studies, (Nishimori, (1976), of the gabbros of the Peninsular Ranges Batholith, and Erikson, (1977), of the Mount Stuart Batholith of Washington State).

Albarede, (1977), suggests that a tonalite parental magma differentiated to form all the rock types of the batholith, and that the gabbros were cumulative in origin and the granodiorite was derived from a residual magma.

Several workers, Walawender, (1976), Walawender, Hoppler, Smith and Riddle, (1977, 1979) and Wilson, (1978), have suggested that the gabbroic rocks are not cogenetic with the granitoid rocks of the Peninsular Ranges Batholith.

Walawender et al, (1979), try to show the differences between the origin of the gabbros and granitoids and that quartz diorites present in a few plutons may result from contamination.

This study continues the work of Walawender et al, (1979), uses the petrography and geochemistry of the Mount Poser pluton to identify the parent magma of the gabbros, to recognize the conditions under which they formed and the fractionation processes which they undergo. This study then tests the possibilities of fractionation of the parent melt to produce a basaltic andesite or andesite and also the possibilities of producing tonalite, granodiorite and ultimately granite having compositions determined by Larsen, (1948) and Nockolds, (1953).

FIELD GEOLOGICAL OBSERVATIONS:

The Mount Poser gabbroic pluton is surrounded by the Bonsall Tonalite on the west and the Green Valley Tonalite on the east, (Fig. 4). Locally dykes of Woodson Mountain Granodiorite cut both the tonalite units and the gabbro. The gabbro to tonalite complex has been intruded into a metamorphosed assemblage of pelitic rocks known locally as the Julian Schist, (Hudson, 1922). Remnants of this sequence of metasedimentary rocks are found throughout the Peninsular Ranges Batholith, (Larsen, 1948, Gastil, 1975).

The pluton is a heterogeneous body composed of several rock types. The four main rock types include layered and foliated leucocratic-amphibole-troctolite*, (LAT), exposed at the eastern end of the complex, coarse grained amphibole-olivine-norite, (AOlN), and medium grained orthopyroxene-amphibole-olivine-gabbro, (OAOlG), in the central region, and amphibole-gabbronorite, (AGN), which is partly foliated, at the western end.

Near the base of the pluton, on the south-west slope, an area of LAT occurs. This patch of LAT possesses the same characteristics as the main mass of LAT on the eastern side of the pluton, (Fig. 4). The contacts between the gabbroic rock types shown on the map

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*All rock names are after Streckeisen, (1973).

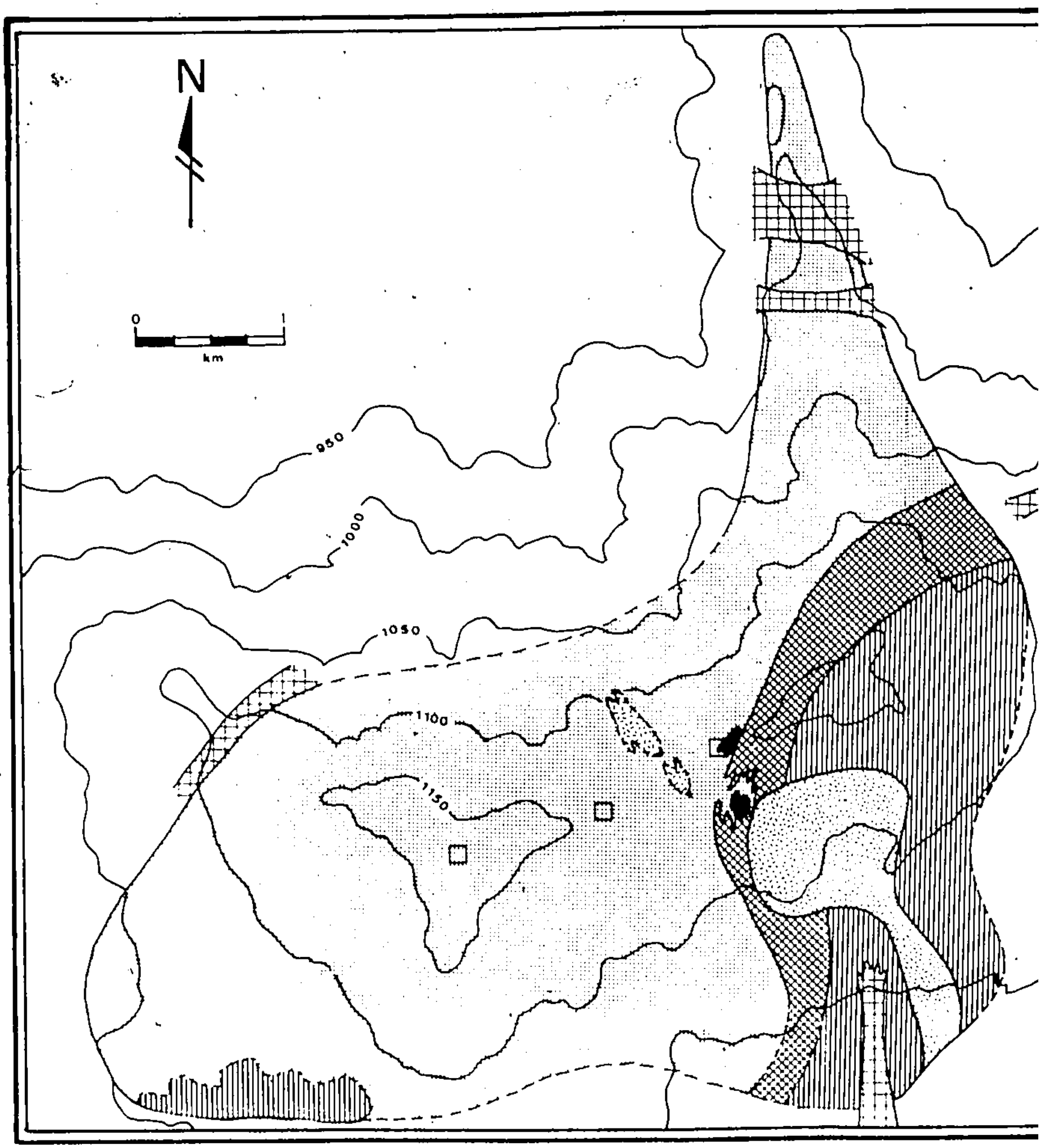
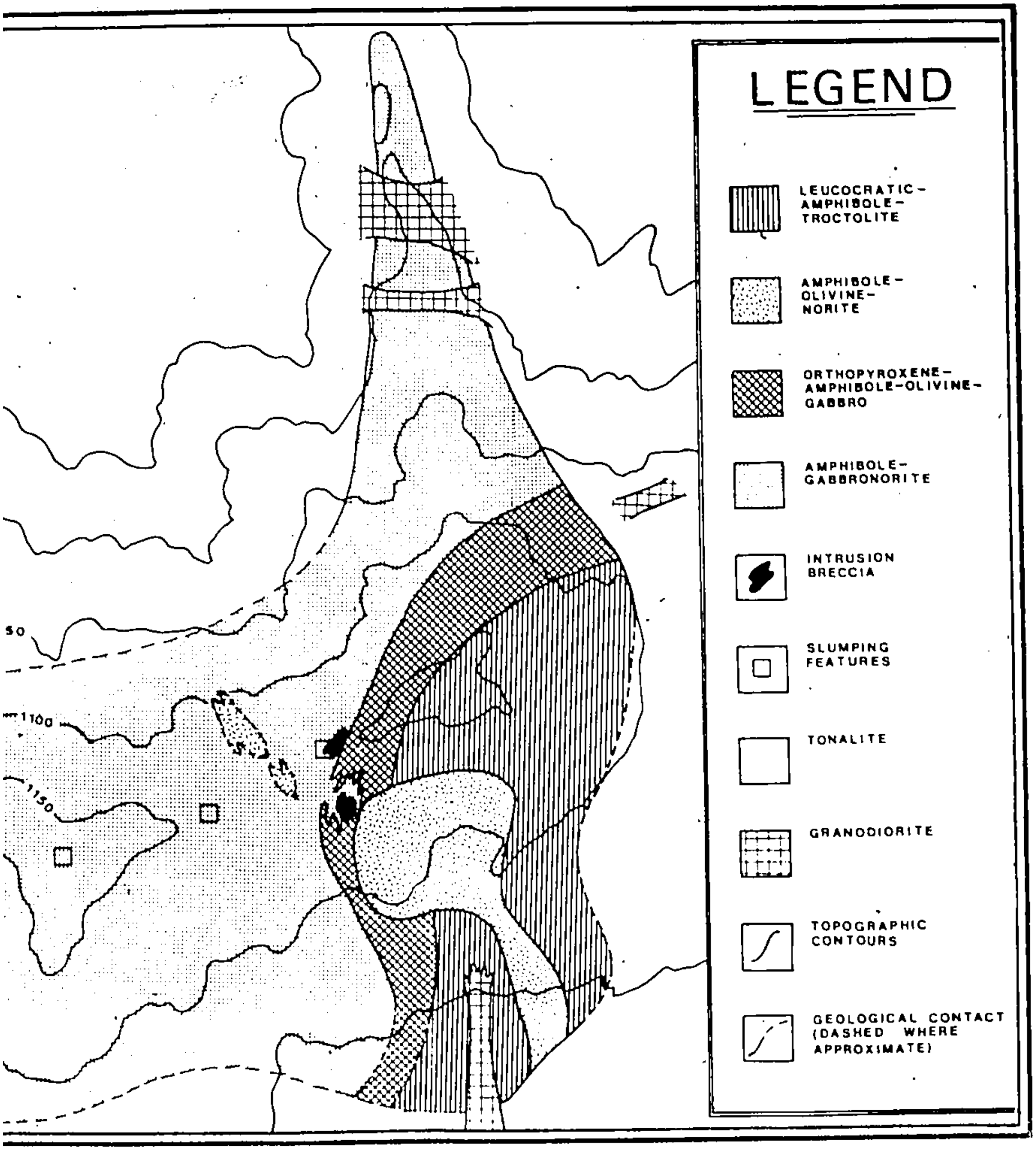


Figure 4. Geologic map showing the lithologic units within the Mount Poser pluton.



the lithologic units
r pluton.

are approximate and delineate areas of one recognizable rock type to another.

The boundaries between the complex and the surrounding country rock, and the boundaries between each different rock unit of the pluton, are not generally exposed. But at a few localities relationships can be deduced with reasonable certainty.

A sharp contact between the A01N and the OA01G, trending N70°E occurs through the centre of the complex, (Fig. 4). On the south-eastern side a transitional boundary occurs between the LAT and A01N. This change takes place over a distance of 1m and is marked by an increase in grain size and mafic content. Angular inclusions of the LAT are found in the A01N a short distance from the boundary. The LAT/OA01G boundary occurs in the northeast. Although the contact is not exposed, the two rock types outcrop within a few metres of each other. In the central region of the pluton the boundary of the LAT and the OA01G is marked by bodies of LAT included within the OA01G. However, in one locality OA01G is seen to abut mutually against LAT and A01N.

Boundaries between the AGN and the other rock units are not exposed. Exposures of A01N within the AGN are interpreted as large inclusions. Veins of AGN occur within the OA01G and also apparently brecciate it.

The contact between the small patch of LAT on the south-west slope and the main AGN mass is never distinct, but probably parallels the margin of the pluton.

Large, dark green poikilitic amphiboles, reaching 2 or 3cm are found in all of these rock units, as well as fibrous amphiboles which have developed along joint planes, (Plate B, #1 and #2).

Two suites of dykes occur within this complex, a dark grey foliated suite, (Plate C, #1), (amphibole-gabbro, AG), and a lighter grey non-foliated suite, (amphibole-olivine-gabbro, AOlG). There are abundant examples of both suites of dykes cutting AGN, but the LAT is penetrated only by the dark foliated dykes. No fine-grained dykes have been found penetrating either the AOlN or the OAOlG. A few of the dark foliated dykes contain inclusions of LAT. Numerous exposures of AG near the AGN/OAOlG contact are pulled apart and form inclusions of dyke material within the AGN. Stringers of AGN occur sporadically in the AOlG dykes, (Plate C, #2).

Both types of dykes commonly occur in close proximity within the AGN and at one locality a dark grey foliated dyke cross-cuts and displaces a light grey, non-foliated dyke.

An intrusion breccia occurs near the contact of the AGN and the OAOlG. This rock has the appearence of rounded to sub-angular inclusions of OAOlG within a groundmass of AGN. These inclusions average 8 to 10cm by 15 to 20cm, (Plate D, #1 and #2). The groundmass exhibits flow banding around the inclusions. Subsequent thin section study has shown that these inclusions do not possess the mineralogy of the OA01G rock unit, but rather a mineralogy and texture of typical hornfels.

Although individual rock units show some heterogeneity, each rock unit occupies a distinct area within the pluton, (Fig. 4). In the east, the LAT outcrops in an elliptical area of approximately 5km^2, or 25% of the exposed pluton. The coarser grained A01N is exposed in the southeast and underlies an area of less than 20% or approximately 3km^2. In the northeast and centre of the pluton, the OA01G occupies approximately 3km^2, or less than 20%. Almost 50%, or 11km^2 of the pluton is occupied by the AGN, from the western end to the central area of the complex.

Summarizing the field relationships a transitional boundary exists between the LAT and A01N. Bodies of LAT penetrate the OA01G, which in turn buts against the A01N, while dykes of AGN occur within the OA01G. These observations lead to contradictory interpretations of the order of events. This, taken with the patchy distribution of very similar rock types, i.e. LAT at several different localities, leads to the suggestion that the complex was formed by multiple intrusion.

Batches of magma of very similar composition, which crystallized to form the same rock types, were intruded at several different times at different localities.

Dykes penetrating the AGN unit, which in turn veins the dykes are relationships produced as a result of multiple intrusion and also minor movement of the main body after dyking. This may be the result of tectonic instability or of a later nearby intrusive event.

Two series of rocks can be recognized- plagioclase+ olivine rocks with a transition from LAT to A01N- and the plagioclase+pyroxene rocks of the AGN series.

The OA01G unit contains olivine and thus belongs in the plagioclase+olivine rock series.

The relative dyke ages are certain. A01G dykes pre-date AG dykes and both sets of dykes post-date the emplacement of the other rock units of the complex.

Details of the appearance of these rocks in the field are now given.

ORTHOPYROXENE-AMPHIBOLE-OLIVINE-GABBRO

This rock is fine grained, (less than 2mm), and of reddish colour, (Plate E, #1). It is the finest grained major rock unit in the complex, and has the most uniform texture. Only the dyke rocks are finer grained. There is no foliation or lineation in this rock unit.

The mineralogy consists of subhedral plagioclase, up to 55 to 60%, rounded olivine, up to 15%, and subhedral pyroxene, up to 15%. Interstitial amphibole is present but not abundant, (less than 15%). Table 1 presents the modal mineralogy of this and the other rock units.

On exposed surfaces the olivine and pyroxene weather a reddish colour.

LEUCOCRATIC-AMPHIBOLE-TROCTOLITE

This unit is medium to coarse grained, (2 to 5mm). A foliation is defined by alignment of mafic lenses, described below, which strike nearly east-west with sub-vertical dips.

The mineralogy of this rock unit consists of subhedral to euhedral plagioclase, up to 60 to 65%, rounded olivine, up to 10 to 15%, and amphibole, up to 10%, (Table 1). Each olivine grain, which weathers a reddish colour, is surrounded by a green rim of amphibole. This mafic assemblage is found as distinct blebs or as coalesced lenses reaching a maximum of 5mm by 5cm.

The LAT is banded in part, due to variations in the proportions of the mafics and felsics. This banding is pronounced at the base of the complex near the tonalite/pluton boundary. The strike of the banding is sub-parallel to the tonalite/pluton boundary, with near vertical dips. The mafic bands reach a maximum thickness of 1m and contain a maximum of 80% mafics. Leucocratic bands average less than 1m thick and contain a maximum

	LAT		AOlN		AOlG			OAOlG		AGN		AG	INCLUSIONS	
	C-36	MP-18	MP-22	C-16	MP-31	C-44	C-9-A	C-34	MP-59	C-53	C-48-B	C-57	C-39	C-45
Plagioclase	62	65	46	22	43	44	52	53	61	60	63	36	60	61
Olivine	9	17	38	42	3	8	14	12	18	-	-	-	-	-
Spinel	2	1	2	10	-	-	1	-	2	-	-	-	-	-
Reaction Corona	8	12	7	-	-	-	-	-	-	-	-	-	-	-
Orthopyroxene	1	1	1	6	-	-	-	2	4	12	14	-	-	-
Clinopyroxene	-	-	-	-	10	15	16	26	1	10	8	-	27	28
Amphibole	9	3	6	20	31	18	16	6	13	12	7	46	3	2
Opaques	9	1	-	-	13	15	1	1	1	6	8	18	10	9

Table 1. Modal mineralogy of the Mount Poser pluton. Abbreviations as per text.

of 30% mafics, (Plate E, #2). These leucocratic bands display a uniform texture with larger, (5mm), plagioclase crystals than those found in the mafic bands. At the top of a few of the leucocratic bands, adjacent to a mafic band, a smaller, (less than 2cm), band of anorthosite has formed. In the anorthosite bands the plagioclase displays subhedral to euhedral shapes. These average 5mm in size. A few pegmatitic patches, (grain size greater than 5mm), occur.

Each variety of mineralogical banding exhibits its own characteristic weathered appearance. The mafic bands show a sponge-like texture due to the weathering out of plagioclase, (Plate F, #1). The remaining mafics are green on exposed surfaces. In contrast, the leucocratic bands show cores of reddish mafics with green rims in a light grey-white matrix of plagioclase.

Towards the eastern summit of the hill, banding within the LAT is gradually replaced by a uniform texture and finally by a foliated structure, (as defined earlier).

AMPHIBOLE-OLIVINE-NORITE

The AOlN unit is characterized by having the coarsest grain size of all of Mount Poser's rock units. Grain sizes average 4 to 8mm. Subhedral to euhedral plagioclase, which may reach a maximum of 1cm in size, makes up 35 to 40% of the rock unit. Olivine accounts for 35 to 40% and has a rounded crystal shape. Amphibole grains are fibrous and make up, up to 15% of the rock. Subhedral spinel reaches a maximum content of 10%, (Table 1). Partial to total replacement of olivine is characterized by the presence of yellow-green iddingsite. There is no defined foliation or lineation within this rock unit.

On weathered surfaces, the plagioclase appears as dull white to grey grains and the olivine as reddish grains.

Within the unit there is an east to west increase in the percentage of mafic minerals and in the average grain size. Maximum variations are: in the east the average grain size is 4mm and the plagioclase content up to 70%, with olivine accounting for up to 20% and amphibole up to 10%. In the west the average grain size is 6 to 8mm with a plagioclase content of up to 20%, olivine, 35 to 40% and amphibole, 40 to 45%.

In addition to variations in grain size and content of mafic minerals, a difference between the eastern and western A01N is seen on the weathered surface. In general, the further west, in the rock unit, the more friable and darker coloured is the hand sample.

Locally, pegmatitic patches, (grain size in excess of 1½cm), occur, (Plate F, #2). In these patches, which average 2 X 8 cm in size, euhedral zoned plagioclase crystals exist. These plagioclase crystals show greyish cores and white rims. The cores enclose small, (1 to 2 mm), olivine crystals with amphibole rims.

Mafic and leucocratic crescentic shaped pods also occur throughout this unit. (Plate G #1 and #2). The mafic pods reach 7 X 40 cm proportions and consist of almost 100% badly weathered, reddish olivine grains. These mafic pods usually have a rim of euhedral plagioclase crystals with an average size of 1 cm. The leucocratic pods are smaller and consist of plagioclase, 80 to 90%, and olivine/amphibole aggregates, 10 to 20%.

AMPHIBOLE GABBRONORITE

Rocks in this unit are characterized by euhedral plagioclase, 60 to 65%, rounded grains of pyroxene, up to 25%, amphibole, up to 10%, and opaque grains, up to 5%, (Table 1). The plagioclase averages 5 mm in size, and is aligned to define a weak foliation. The strike of this foliation trends NE-SW with an average dip of 75° to the SE. The amphibole and pyroxene grains average less than 2 mm in diameter.

Weathering of the mafic minerals, pyroxene and amphibole, causes two distinct surface appearances of the same unit. In the east, amphibole exceeds pyroxene in abundance, 25 to 30% and up to 10% respectively, leading to an overall black and white appearance. In the west, the reverse is true. Pyroxene accounts for 15 to 25% and amphibole for up to 15%. This variety appears red and white on the weathered surface.

Within this unit, several outcrops, (Figure 4), showing thin folded laminations of alternating leucocratic and melanocratic compositions occur, (Pate H, #1 and #2). These laminations average less than 5mm in thickness, but reach a maximum of 2cm. The mineralogy of these laminations, consists of subhedral amphibole, olivine and plagioclase, (less than 2mm), with larger, (up to 1cm), poikilitic hornblende. Assymetrical relations exist between one set of melanocratic/leucocratic laminations and the next set. Each lamination has a sharp boundary at its base. A lower very mafic lamination composed of olivine and amphibole is found to grade upwards into progressively more leucocratic bands, (Plate H, #1 and #2). Amphibole in these bands is resistant to weathering, and stands out in high relief. These features resemble slumping structures as described by Wager and Brown, (1967), for the Rhum Complex.

DYKE ROCK UNITS

In addition to those features already described in the introduction, the dyke units possess the following characteristics.

The lighter grey, non-foliated, (A01G), dykes average 6 to 10 cm in width. One location shows a 25 cm wide dyke.

Strikes vary from outcrop to outcrop, usually NW-SE, with 70 to 75^0 dips. Mineralogy of these dykes consists of plagioclase, 43 to 52%, olivine, 3 to 8%, clinopyroxene, 10 to 16%, amphibole, 16 to 31% and opaques up to 15%, (Table 1).

The darker grey, foliated, (AG), unit also averages 6 to 10 cm in width. At one location a 1 m wide dyke occurs. Strikes are variable, NE-SW to NW-SE, yet most dykes have 70 to 75^0 dips. These dykes are composed of strongly aligned, elongated amphibole crystals, up to 46%, plagioclase, up to 36% and opaque grains, up to 18%, (Table 1).

INTRUSION BRECCIA

An intrusion breccia has developed in a few locations near the OA01G/AGN boundaries.

This unit is characterized by fine grained, rounded inclusions, (reaching maximum dimensions of 15 X 40 cm), resembling the OA01G unit, embedded in a groundmass of AGN. The groundmass exhibits a flow texture around the inclusions.

The inclusions are characterized by fine grained, (less than 1 mm) textures. The mineralogy consists of anhedral grains of plagioclase, up to 60%, clinopyroxene , up to 28% and opaque grains, up to 10%. Amphibole accounts for approximately 2% and is interstial, (Table 1).

MINERALOGY AND PETROLOGY

Introduction

Mineralogical and petrological descriptions of Mount Poser's rock units follow. A total of 40 thin sections have been studied. Modes for the different rock units of Mount Poser are listed in Table 1, and normative mineralogy can be found in Tables 2 through 7.

ORTHOPHROXENE-AMPHIBOLE-OLIVINE-GABBRO

This unit consists of well shaped crystals of plagioclase, olivine, and clinopyroxene. Very minor spinel and opaque grains are also present. Reaction coronas between olivine and plagioclase have developed. Plate I shows typical OAOlG textures and mineralogy.

Unzoned plagioclase, ranging in composition from An_{80} to An_{93}*, forms a fine grained, (less than 2 mm), interlocking network of anhedral to subhedral grains. A very few plagioclase crystals show spotty alteration to chlorite and calcite. These alteration spots are less than 0.5 mm in size.

Olivine is also less than 2 mm in size, and usually anhedral to subhedral. (Plate I, #3 and #4). It is characteristically altered to iddingsite and magnetite along internal fractures.

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* Determined on flat stage using Michel-Levy method or Albite-Carlsbad, (Tobi, 1963). Paul Cheung (person. comm.) reports a similar range of plagioclase composition by XRD.

	LEUCOCRATIC-AMPHIBOLE-TROCTOLITE								
	MP-18	C-36	C-4	C-5-B	C-6-A	C-14	C-42	MP-20	MP-83
Or	0.16	0.17	0.18	0.11	0.25	0.31	0.12	0.59	0.18
Ab	4.17	0.65	1.86	2.18	4.46	6.27	4.13	3.24	6.36
An	65.08	50.56	56.74	58.19	64.44	62.57	60.06	44.45	56.38
Lc	---	---	---	---	---	---	---	---	---
Ne	1.19	2.91	1.75	1.53	0.38	---	2.19	1.28	0.73
Di	8.00	5.22	4.84	3.99	10.31	9.50	11.07	18.48	7.08
Hb	2.56	1.43	1.39	1.22	3.31	2.79	3.67	4.61	2.44
En	---	---	---	---	---	1.67	---	---	---
Fs	---	---	---	---	---	0.56	---	---	---
Fo	12.11	26.81	22.42	21.66	10.75	10.55	11.81	18.81	16.87
Fa	4.91	9.26	8.15	8.41	4.36	3.92	4.94	5.94	7.34
Cs	---	---	---	---	---	---	---	---	---
Mt	1.70	2.81	2.50	2.54	1.64	1.60	1.84	2.27	2.39
Il	0.09	0.17	0.16	0.14	0.09	0.24	0.13	0.31	0.21
Ap	0.02	0.02	0.02	0.02	0.03	0.02	0.01	0.02	0.02

Table 2. Normative mineralogy of the Leucocratic-Amphibole-Troctolite unit of the Mount Poser pluton.

	AMPHIBOLE-OLIVINE-NORITE								
	C-16	C-19	MP-22	C-50	C-37-A	C-21	MP-71	MP-40	MP-38
Or	0.24	0.13	0.12	0.34	0.36	0.18	---	---	0.18
Ab	3.65	3.90	3.31	4.45	3.79	3.55	---	---	5.40
An	33.76	48.30	44.68	51.61	42.51	50.81	30.83	36.03	50.40
Lc	---	---	---	---	---	---	0.14	0.18	---
Ne	---	---	---	0.48	0.15	0.33	1.38	1.52	0.61
Di	1.92	4.74	2.04	5.30	2.14	5.42	2.26	2.87	5.75
Hb	0.55	2.17	0.79	1.31	0.38	1.61	0.57	0.74	2.12
En	1.41	7.47	6.84	---	---	---	---	---	---
Fs	0.46	3.92	3.02	---	---	---	---	---	---
Fo	39.35	16.15	23.50	25.67	39.06	25.55	45.71	41.11	21.95
Fa	14.26	9.34	11.43	8.05	8.65	9.57	14.48	13.37	10.22
Cs	---	---	---	---	---	---	0.25	0.12	---
Mt	4.22	3.76	3.99	2.48	2.55	2.90	4.19	3.89	3.17
Il	0.14	0.08	0.06	0.30	0.39	0.06	0.18	0.15	0.19
Ap	0.05	0.03	0.03	0.01	0.02	0.02	0.02	0.02	0.02

Table 3. Normative mineralogy of the Amphibole-Olivine-Norite unit of the Mount Poser pluton.

	ORTHOPYROXENE-AMPHIBOLE-OLIVINE-GABBRO								
	MP-26	C-26	C-28	C-34	C-65	MP-59	C-59	C-24	C-25
Or	0.18	0.12	0.18	0.18	0.18	0.18	0.18	0.18	0.18
Ab	6.19	4.66	4.86	4.04	4.75	5.68	5.19	5.85	6.59
An	49.12	52.43	48.78	46.51	50.31	51.41	56.21	52.30	52.29
Lc	—	—	—	—	—	—	—	—	—
Ne	—	0.63	0.44	0.61	—	—	0.93	—	—
Di	18.28	7.95	20.60	18.96	21.46	5.12	9.35	3.77	4.88
Hb	5.62	2.58	6.00	5.43	6.00	2.18	3.28	1.49	1.90
En	9.39	—	—	—	0.95	1.26	—	13.83	0.56
Fs	3.31	—	—	—	0.30	0.62	—	6.26	0.25
Fo	3.96	20.42	12.19	15.76	10.17	19.37	16.07	8.79	19.65
Fa	1.54	8.37	4.49	5.71	3.59	10.42	7.12	4.38	9.68
Cs	—	—	—	—	—	—	—	—	—
Mt	1.88	2.68	2.03	2.32	1.85	3.40	2.44	2.83	3.78
Il	0.50	0.12	0.40	0.45	0.42	0.35	0.23	0.31	0.22
Ap	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.02	0.02

Table 4. Normative mineralogy of the Orthopyroxene-Amphibole-Olivine-Gabbro unit of the Mount Poser pluton.

	AMPHIBOLE-OLIVINE-GABBRO			AMPHIBOLE-GABBRO				
	C-44	C-9-A	MP-31	C-69-B	C-77-B	C-57-A	MP-61	C-47-A
Or	0.29	—	—	0.70	—	—	—	—
Ab	3.37	—	—	9.04	—	—	—	—
An	47.19	38.56	46.39	41.96	41.98	36.76	39.51	39.77
Lc	—	0.17	0.33	—	0.69	0.62	0.72	0.53
Ne	3.05	2.39	3.09	0.37	5.81	5.76	4.42	5.02
Di	13.00	5.02	9.51	14.22	14.14	12.98	12.23	13.90
Hb	5.92	1.23	1.82	7.85	8.08	5.76	6.18	5.89
En	—	—	—	—	—	—	—	—
Fs	—	—	—	—	—	—	—	—
Fo	13.41	32.83	16.07	11.21	12.85	18.31	16.92	18.32
Fa	7.72	10.22	10.30	7.82	9.27	10.27	10.80	9.82
Cs	—	6.16	3.50	—	0.42	2.17	1.57	0.54
Mt	3.36	3.13	3.92	3.70	4.10	4.24	4.45	3.97
Il	2.67	0.21	1.99	3.09	2.44	3.11	3.15	2.24
Ap	0.02	0.03	0.08	0.05	0.22	0.03	0.03	0.03

Table 5. Normative mineralogy of the Amphibole-Olivine-Gabbro unit and the Amphibole-Gabbro unit of the Mount Poser pluton.

AMPHIBOLE-GABBRONORITE

	C-79	C-53	C-60	C-66	C-45	C-53-A	MP-60	C-47	MP-85	C-48-B
Or	0.67	0.37	0.43	0.43	0.43	0.43	0.79	0.42	0.62	0.48
Ab	11.37	6.53	17.13	7.54	16.79	20.69	6.70	6.87	14.45	6.16
An	44.90	45.94	44.77	46.60	43.29	43.28	41.73	40.91	46.44	52.03
Lc	—	—	—	—	—	—	—	—	—	—
Ne	—	—	—	—	—	—	—	—	2.48	3.51
Di	6.89	8.47	7.82	9.22	8.13	7.88	8.74	15.20	8.15	10.48
Hb	3.28	2.84	4.96	2.76	4.21	4.67	3.19	5.50	3.76	5.78
En	11.38	13.74	8.68	19.76	11.27	7.58	18.62	14.36	—	—
Fs	6.21	5.28	6.31	6.79	6.69	5.15	7.78	5.96	—	—
Fo	7.02	9.61	2.66	3.08	2.94	3.31	5.91	4.60	12.79	13.05
Fa	4.22	4.07	2.14	1.17	1.92	2.48	2.72	2.10	7.46	9.10
Cs	—	—	—	—	—	—	—	—	—	—
Mt	3.05	2.70	2.93	2.19	2.77	2.69	2.96	2.77	2.79	3.64
Il	0.87	0.44	2.03	0.43	1.54	1.82	0.84	1.29	1.01	1.76
Ap	0.14	0.02	0.15	0.03	0.02	0.02	0.02	0.02	0.06	0.03

Table 6. Normative mineralogy of the Amphibole-Gabbronorite unit of the Mount Poser pluton.

	INCLUSIONS		
	C-39	C-45	C-46-B
Or	1.06	0.56	0.78
Ab	23.92	20.35	14.14
An	35.12	35.95	42.10
Lc	—	—	—
Ne	2.19	2.70	3.12
Di	10.19	12.04	8.42
Hb	7.38	7.08	7.07
En	—	—	—
Fs	—	—	—
Fo	7.63	9.31	8.28
Fa	6.99	6.92	8.79
Cs	—	—	—
Mt	3.23	3.16	3.86
Il	1.81	1.71	2.56
Ap	0.48	0.22	0.87

Table 7. Normative mineralogy of the Inclusions of the Intrusion Breccia of the Mount Poser pluton.

Clinopyroxene exhibits a "sieved" appearance and a general anhedral to subhedral shape. (Plate I, #1 and #3). Average size of the clinopyroxene grains is less than 2 mm. Individual grains are not common. Rather, the grains aggregate together with other clinopyroxene grains forming clots reaching a maximum 4 mm in any one dimension. The blebs which occupy the "holes" within the main body of the clinopyroxene grains exhibit characteristic amphibole properties, (colour in plane polarized and crossed polarized light, and pleochroism), but are generally too small for accurate determination.

Very minor amounts, (less than 2%), of subhedral spinel occur in this unit. This mineral is found associated with interstial opaque grains. These opaque grains are found at olivine to olivine grain boundaries. Distinct subhedral opaque grains also occur, though not necessarily near olivine grains. Total opaque content is less than 2%.

In a few samples, amphibole, (hornblende), poikilitically encloses all other minerals. An average poikilitic hornblende grain is 6 to 8 mm. Single grains may exhibit patchy pleochroism in brown/green shades. A few grains show spotty alteration to a fibrous tremolitic form. This intercumulus hornblende accounts for a maximum 13% of the total rock.

Reaction coronas develop at the olivine/plagioclase interfaces. This marked by embayment of the olivine grains. The corona assemblage consists of olivine $\pm$ (amphibole + spinel) + plagioclase. The orthopyroxene occurs as thin rims, (less than 0.5 mm), immediately adjacent to the olivine but is not always present within the corona assemblage. However, when present, orthopyroxene exhibits moderate pleochroism from pale pink to pale green, suggesting hypersthene.

The next mineral in the corona, which is immediately adjacent to the orthopyroxene, or to the olivine if orthopyroxene is absent, is amphibole. This amphibole is characterized by pale blue/green to green pleochrosim suggesting an edenitic composition. If orthopyroxene is missing in the corona, the portion of the edenite immediately adjacent to the olivine is marked by a thin bleached zone showing no colour or pleochroism.

Amphibole, possibly edenite, occurs intergrown with spinel in a fibrous manner. This assemblage occurs immediately adjacent to the plagioclase, within the reaction corona. This fibrous mass is not alwasy present.

LEUCOCRATIC-AMPHIBOLE-TROCTOLITE

The well shaped minerals of this rock unit are plagioclase, olivine and spinel. Interstitial minerals are orthopyroxene and amphibole. Reaction coronas between olivine and plagioclase occur. Plates J and K shows typical LAT textures and mineralogy.

Plagioclase, ranging in composition from An_{83} to An_{94}*, which is unzoned, occurs as a series of subhedral to euhedral interlocking crystals. These crystals average 2 mm in diameter.

Olivine crystals average 1 to 2 mm in diameter and reach a maximum of 3 mm. These crystals are subhedral to anhedral and show extensive embayment due to resorption. (Plate J, #1 to #4). Alteration to iddingsite and magnetite has occurred along cracks in the crystals. Aggregates of olivine crystals occur in a few samples, (those from the foliated LAT zone as described in Chapter 2). These aggregates reach a maximum of 5 mm X 5 cm. The olivine to olivine boundaries, within these aggregates, show alteration to iddingsite and magnetite.

Subhedral to euhedral spinel occurs in this rock unit. It is less than 1 mm in diameter and less than 3% of the total rock. It is generally found within a reaction corona between olivine and plagioclase, but a few isolated grains do occur.

Orthopyroxene and amphibole are present as interstitial phases. The orthopyroxene does not poikilitically enclose any other crystals. Amphibole, as an interstitial phase, shows brown/green to green pleochroism and patchy colour zoning. This suggests hornblende. It poikilitically

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* Paul Cheung (person. comm.) reports a similar range of plagioclase composition determined by XRD.

encloses plagioclase and/or olivine in some samples. An average poikilitic amphibole reaches 8 mm in size. Some samples show minor alteration of the amphibole to a fibrous tremolitic form. This interstitial mineral, (hornblende), accounts for less than 10% of the total rock.

The plagioclase/olivine contact is characterized by a reaction corona of olivine $\pm$ orthopyroxene amphibole $\pm$ (amphibole +spinel)+ plagioclase, (Plate J and K). This reaction corona displays similar characteristics as the corona assemblage found in the OA01G.

The amphibole within this assemblage is optically continuous with the poikilitic interstitial amphibole. Minor alteration of the corona amphibole to a fibrous tremolitic form occurs in a few samples.

AMPHIBOLE-OLIVINE-NORITE

Plagioclase, olivine and spinel occurs as euhedral/ subhedral minerals in this rock unit. Interstitial phases include orthopyroxene and amphibole. A reaction corona has developed between olivine and plagioclase. Plate L, #1 and #2 shows typical A01N textures and mineralogy. Plagioclase, of composition An_{86}*, averages 3 mm in diameter but a few samples show crystals reaching a maximum diameter of 6mm. It is subhedral to euhedral in shape and shows no compositional zoning.

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* Paul Cheung (person. comm.) reports a similar value of plagioclase composition determined by XRD.

Olivine is subhedral to euhedral and averages 2 to 3 mm in size. (Plate L, #1). Clumps of olivine crystals are the usual mode of occurrence rather than distinct crystals. These clumps are irregular in shape, and reach a maximum diameter of 1 cm. Extensive alteration along cracks to iddingsite and magnetite has occurred.

Anhedral crystals of spinel make up a maximum of 10% of the total rock. (Plate L, #2). These crystals reach a maximum diameter of 1 mm and are found enclosed in poikilitic amphibole or within the corona assemblage between olivine and plagioclase.

Orthopyroxene, as an interstitial phase, makes up less than 6% of the total rock. An average size of these grains is 3 mm. One slide, however, shows an orthopyroxene grain included in amphibole. It has an irregular shape which seems to have been originally prismatic.

Interstitial amphibole makes up a maximum of 20% and poikilitically encloses olivine and plagioclase crystals. Olivine grains within a poikilitic amphibole show sharp grain boundaries. Plagioclase grains within a poikilitic amphibole, show embayment along the boundaries

This interstitial amphibole exhibits brown/green to green pleochroism, (suggesting amphibole), patchy colour zoning and some samples show spotty alteration to a fibrous tremolitic form.

The reaction corona between olivine and plagioclase exhibits much the same characteristics as the corona found in the LAT. The assemblage in the A01N consists of olivine ± amphibole + (amphibole+spinel) + plagioclase.

AMPHIBOLE-GABBRONORITE

The well shaped crystals of this unit consist of plagioclase, orthopyroxene, and opaques. Interstitial phase include amphibole and opaques. Plate L, #3 and # 4 shows typical AGN textures and mineralogy.

Plagioclase, of composition An_{53} to An_{90}*, forms subhedral unzoned crystals. It has a maximum grain size of 5 mm.

This unit is the only rock unit of Mount Poser which possesses prismatic orthopyroxene. Distinct subhedral grains of this mineral average 3 to 4 mm in diameter. (Plate L, #3 and #4). Aggregates of orthopyroxene crystals reach a maximum dimension of 1.5 cm. The aggregates are amoeboid in shape, showing no preferred orientation. This orthopyroxene exhibits stronger pleochroism than orthopyroxene found in the other units. The pleochroism ranges from pink to light green, suggesting hypersthene.

Anhedral clinopyroxene crystals, showing a "sieved" appearance, reach a maximum of 3 mm in diameter. Aggregates of these grains do occur in a few samples. These clots reach 1 cm in diameter, and occur in those samples near the A01N/AGN and AGN/OA01G boundaries in the central region.

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* XRD determination by Paul Cheung (person. comm.)

Small, (less than 1 mm), opaque grains make up an average 7% of the total rock. These grains are anhedral in shape and are found associated with poikilitic amphiboles.

In one section a very small subhedral crystal of spinel was found. Otherwise this mineral is absent from this rock unit.

Interstitial amphibole exhibits dark brown/green to light brown/green pleochroism. A few samples show this amphibole as poikilitic grains enclosing plagioclase and orthopyroxene. Such poikilitic grains reach a maximum of 1 cm in dimension. The amphibole shows colour zoning.

Two samples show extensive secondary alteration of the amphibole to a fibrous tremolitic form. In these samples the amphibole content is 40 to 50% of the total rock. Other mafic minerals are absent from these samples, and this explains the field appearance of black, (mainly amphibole bearing), and red, (pyroxene bearing), weathered AGN, as described in an earlier section.

DYKE ROCKS

Two sets of dykes are present on Mount Poser. A lighter grey, non-foliated set and a dark grey, foliated set. (See Chapter 2). Plate M shows typical light dyke and dark dyke textures and mineralogy.

The lighter grey, non-foliated set, (Amphibole-Olivine-Gabbro, AOlG), consist of two sub-groups. One group contains plagioclase, 45 to 50%, olivine, up to 8%, and clinopyroxene, up to 15%. Very minor spinel, less than 2%, and minor opaques, less than 2%, are also present. The other group differs from the first by having abundant opaques, 15%, and no spinel. Both groups have interstitial, sometimes poikilitic amphibole, 16 to 30%, and a reaction corona between olivine and plagioclase. The average grain size is 1 to 2 mm.

Plagioclase, in both groups of light grey dykes, has a composition of An_{75} to An_{80}*, is anhedral to subhedral and unzoned. Very minor replacement by chlorite and calcite occurs in a few crystals of plagioclase.

Rounded subhedral olivine is characterized by being partially altered to iddingsite and magnetite along fractures.

Clinopyroxene is present in both groups of lighter grey dykes as anhedral to subhedral grains. It displays the "sieved" appearance as described previously.

The spinel present in one group of light grey dykes is anhedral to subhedral and found either closely associated with olivine crystals or as an interstitial phase.

Opaques in both sets of light grey dykes, are anhedral to subhedral.

Interstitial, poikilitic amphibole, possesses a

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* Paul Cheung (person. comm.) reports a similar range of plagioclase composition determined by XRD.

moderate pleochroism of brown to light brown. This variety of amphibole is probably hornblende. The amphibole encloses small subhedral grains of clinopyroxene and magnetite.

At the olivine/plagioclase interface a reaction corona has developed. This assemblage consists of olivine $\pm$ orthopyroxene + amphibole + plagioclase. The fibrous amphibole + spinel assemblage present in coronas of other earlier described rock units is missing.

The dark grey, foliated set of dykes, (Amphibole-Gabbro), consists of plagioclase, 36%, amphibole, 46%, and opaques, 18%. This dyke is equigranular and a strong alignment of amphibole, (hornblende), and plagioclase is recognized. (Plate M, #3 and #4).

Plagioclase, ranges in composition from An_{76} to An_{85}*. It is anhedral to subhedral and unzoned. Twinning in these plagioclase crystals if predominantly of the Carlsbad/Albite rather than Albite type, which is so common in the other rock units.

The amphibole, (hornblende), is strongly pleochroic from brown/green to lighter green. It is subhedral and is commonly simply twinned.

Opaque grains are generally smaller, (less than 1 mm), than plagioclase or amphibole, and anhedral to subhedral in shape.

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* Paul Cheung (person. comm.) reports a similar of plagioclase composition determined by XRD.

INCLUSIONS FROM THE INTRUSION BRECCIA

Plate N shows typical inclusion textures and mineralogy. The fine grained inclusions were chosen for microscopic study to confirm their affinity to the OA01G unit. However, study has revealed that these inclusions differ in mineralogy and texture from the OA01G unit.

These rocks are fine grained, 1 mm or less, and consist of plagioclase, up to 60%, clinopyroxene, up to 28%, and opaques, up to 10%. Amphibole, 2% is present as an interstitial phase. In thin section triple point grain boundaries are plentiful. This and its overall equigranular nature suggest a hornfelsic texture for the inclusions.

Plagioclase, has a range of composition of An_{72} to An_{86}*, is anhedral in shape and shows ragged cores. Finer inclusions of opaques and clinopyroxene, within the plagioclase, occur in a few samples.

Clinopyroxene shows a strong pleochroism of pinkish tan to light green. The crystals are anhedral.

Opaques, as anhedral grains, are found filling intersticies between the clinopyroxene and plagioclase and as small inclusions within the clinopyroxene.

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* Determined by XRD by Paul Cheung (person. comm.)

PARAGENESIS

Introduction

Many major layered intrusions, (ex. Skaergaard, Rhum and Bushveld), show mineralogical and petrological textures which classify the rocks as cumulates. Plutons already studied within the Peninsular Ranges Batholith also possess similar textures and have also been classified as having cumulate rocks, (ex. Los Pinos, Target Range, and Corte Madera). The criteria for recognizing cumulate rocks follows.

Bowen, (1928), proposed the term "accumulate" to describe rocks which he believed, formed as the result of crystal settling due to gravity. Bowen's terminology was modified in 1960 by Wager, Brown and Wadsworth. These workers shortened Bowen's term to "cumulates", and proposed several prefixes to give a new nomenclature for igneous rocks formed by crystal settling and accumulation. The term "cumulus crystal" has been proposed to replace the term "primary precipitate crystal". Cumulus crystals are individual units of the pile of crystals as originally precipitated by the magma before any modification by later crystallization. The liquid in the intersticies between the cumulus crystals may be called intercumulus liquid and the crystalline material occupying this position, whether or not it has the same composition as the original liquid, may be called intercumulus material. The classification into types of cumulates has proven useful in leading to clearer thinking about the details of the solidification processes involved.

"Adcumulus growth" has been proposed for the extension of the original cumulus crystals by material of the same composition, to give unzoned crystals. This process, which gradually reduces the intercumulus liquid by mechanically pushing it out, may sometimes reduce the amount of intercumulus liquid to vanishing point. A rock produced in this way, with less than 5% of pore material is called an "adcumulate". A "mesocumulate" is a cumulate rock showing small amounts of intercumulus material. An "orthocumulate" is a cumulate consisting essentially of one or more cumulus minerals together with the products of crystallization of the intercumulus liquid, which necessarily has the composition of the contemporary liquid. Adcumulus growth is not conspicuous, however the slow crystallization of the intercumulus liquid will form successive lower temperature zones round the cumulus crystals and new mineral phases, (such as zoned, poikilitic intercumulus crystals).

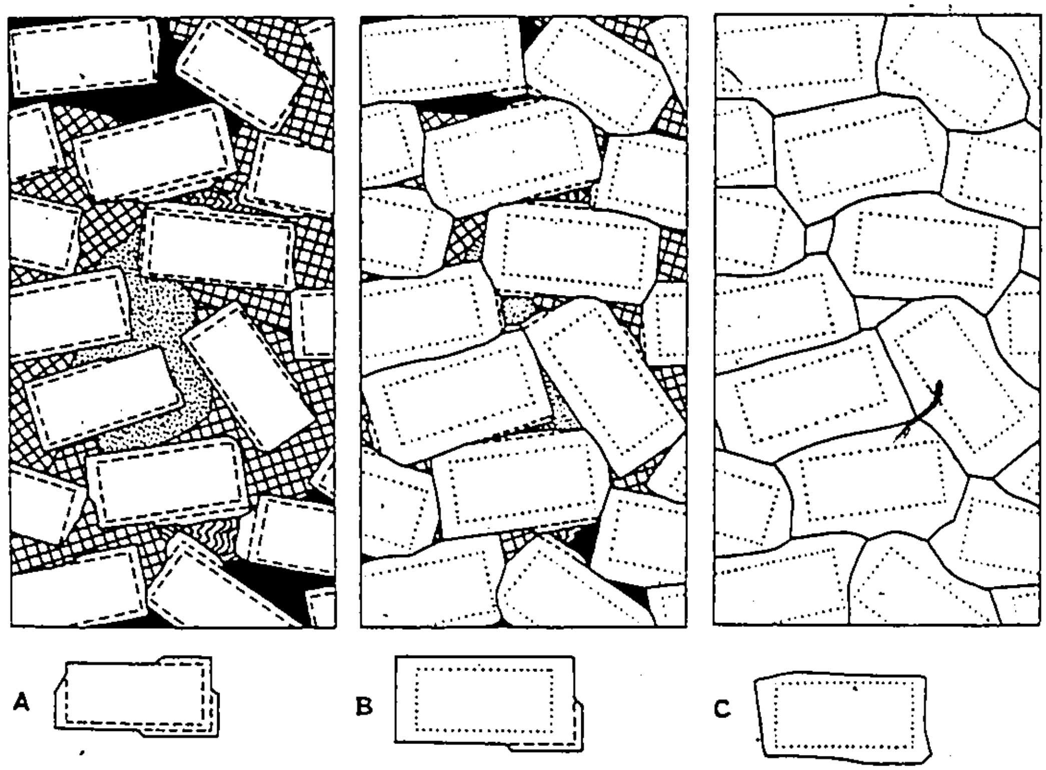
The formation of orthocumulates will be favoured by fast bottom accumulation of crystals. Adcumulus growth must be favoured by relatively slow accumulation of the bottom precipitate.

It has proven useful to have a name for the extreme type of cumulate such as orthocumulate and adcumulate. It is likely, however, that the pure types will be rare.

In the layered series of Rhum certain olivine rich rocks have been interpreted as the result of upward growth of cumulus crystals of olivine as they lay at the bottom of the magma, forming the temporary floor. These rocks are referred to as having a harristic structure, that is, upstanding elongated olivines often exhibiting parallel growth and with scarcely zoned plagioclase and augite crystals in poikilitic patches between them.

Occasionally unzoned poikilitic crystals which have the same composition as cumulus crystals in adjacent layers, completely enclose many unzoned cumulus crystals. This type of cumulate is referred to as a "heteradcumulate". Such a rock type is seen in the higher olivine cumulates on Askival and Hallival in Rhum. The diffusion mechanism suggested here results in the continued growth of both cumulus and poikilitic crystals at constant temperature until little or no pore liquid remains. A heteradcumulate may have the same composition as an adcumulate with the appropriate variety of cumulus crystal phases and thus a name linking this cumulate type to the adcumulate is appropriate. Figures 5 and 6 show diagramatic representation of the different types of cumulates.

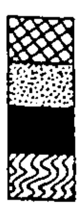
The rocks of Mount Poser are cumulates. Field observations and petrological characteristics support



PLAGIOCLASE: Boundary of the cumulus crystals (labradorite) diagrammatically shown by the innermost rectangle. The limits of medium and low temperature zones, where developed, shown outside the cumulus crystal boundaries.

PLAGIOCLASE: Boundary of the cumulus crystals (labradorite) shown by the dotted line. Outside is adcumulate growth of plagioclase of similar composition. In places beyond the broken lines, lower temperature zones are shown.

PLAGIOCLASE: The cumulus part of the crystal is shown within the dotted line. This has been enlarged by growth of more plagioclase of the same composition, which fills the crystal interstices.



Pyroxene, Olivine, Iron ore } Poikilitic crystals. Zoned, but this not shown.

Quartz and orthoclase; locally the final residuum.

Figure 5.
Diagrammatic representation of plagioclase cumulates formed from a gabbroic magma. A, extreme plagioclase orthocumulate; B, plagioclase mesocumulate; C, extreme plagioclase adcumulate.

Source: Wager et al, (1960).

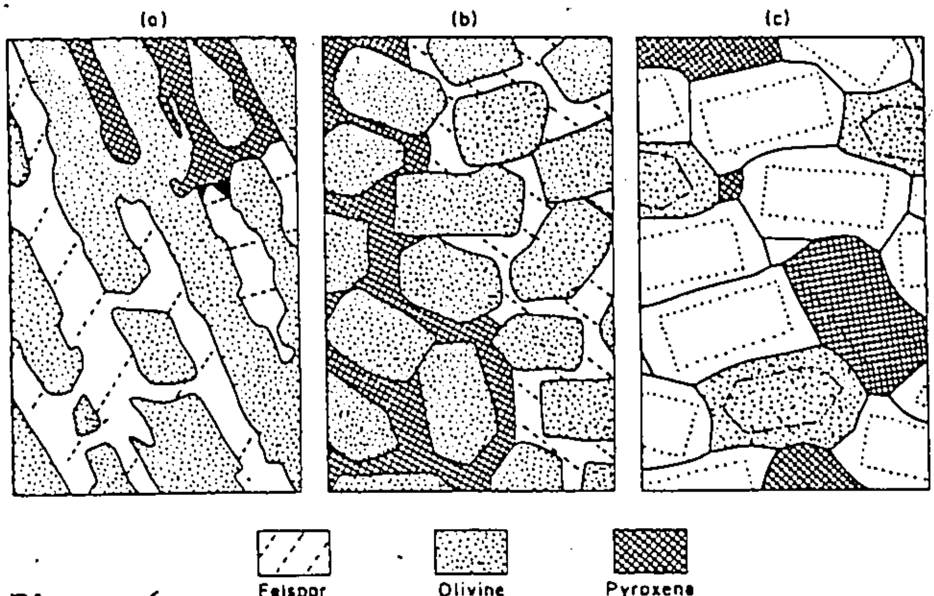


Figure 6.

Diagrammatic representation of a crescumulate, heteradcumulate, and adcumulate formed from gabbroic magma. Plagioclase, white; olivine, stippled; pyroxene, cross-hatched. It is assumed that there was no trapped liquid.

a. Olivine crescumulate. All olivine shown has the same orientation and is essentially unzoned. The surrounding plagioclase and pyroxene are also essentially unzoned and are considered to have been formed in the same way as in heteradcumulates.

b. Olivine heteradcumulate. Large poikilitic augite and plagioclase crystals, essentially unzoned, are shown surrounding cumulus olivines. In this diagram, unlike 14c, no distinction is made between the cumulus and adcumulus olivines.

c. Plagioclase-olivine-augite adcumulate in which the three types of cumulus crystals are shown as enlarged by adcumulus growth until all the intercumulus liquid has been eliminated (Fig. 13C). The boundaries of the cumulus crystals of plagioclase, olivine, and pyroxene are indicated diagrammatically by dotted lines. The material inside and outside the dotted lines has the same composition.

Source: Wager et al, (1960).

this statement. In the field mineralogical banding due to differences in the content of mafic and felsic components, is observed. Igneous lamination due to alignment of mafic clots can also be recognized in the field. Thin section study reveals the following. The general shape of Mount Poser's primary minerals, (subhedral), is suggestive of a cumulate origin. The minerals show no compositional zoning, which is typical of minerals that are in equilibrium with a fractionated parental melt. Minerals in a non-cumulate igneous rock will show compositional zoning as cooling progresses. Mafic minerals tend to be clumped together, suggesting early fractionation and subsequent gravity settling.

As described earlier in this section, cumulate rocks may be further sub-divided on the basis of cumulate and intercumulate mineral characteristics.

The average LAT and A01N show unzoned cumulus crystals and approximately 5% intercumulus material. Such characteristics are typical of adcumulate rocks.

The average OA01G also shows unzoned cumulus crystals and 5% or less intercumulus material. This rock would be classified as an adcumulate.

The average AGN shows unzoned cumulus crystals, but greater than 5% intercumulus material. Such a rock type would be classified as a mesocumulate.

In determining the mineralogical paragenesis of the rocks of Mount Poser, it is easiest to summarize the mineralogies of each unit in tabular form.

ROCK UNIT	CUMULUS OR PRIMARY PHASE	INTERSTITIAL PHASE
LAT AO1N	Pl+Ol+Sp (Larger grain size & mafic content increases)	Opx+Amph Opx+Amph
OAO1G	Pl+Ol+Sp	Opx+(Minor)Opaq+Amph
	Pl+Ol+(Minor)Sp+Cpx	Opaq+Amph
AO1G	Pl+Ol+Sp+Cpx	Opaq+Amph (I)
		(II)
AGN	Pl+Opx+Cpx	Opaq+Amph
AG	Pl+Amph+Opaq	Opaq

The table suggests several points:

1) Plagioclase and olivine are the first minerals to crystallize.

2) Cpx is earlier than Opx as a cumulus mineral

3) As opaques become abundant spinel disappears, i.e. spinel is earlier than the opaques.

4) In group (II), with the disappearance of pyroxene as primary phases, amphibole and opaques become abundant.

5) We have two main mineralogical groups, based on cumulus minerals present, (I) Plagioclase - Olivine and (II) Plagioclase - Pyroxene. The recognition of two different mineralogical groups supports the theory of multiple intrusions.

6) In group (I) the light dykes, (A01G), match with other rock units of this group, specifically with OA01G rocks. These A01G dykes are possibly residual melts of the OA01G phase.

In group (II) the dark dykes (AG) represent the residual melt of the AGN phase. In this rock unit amphibole and opaques have become important cumulus phases, replacing the pyroxenes which were important in the AGN phase.

7) A transition from LAT to A01N.

8) Paragenesis of group (I):Pl-Ol-Sp-Cpx-Opx-Opaq-Amph.

9) Paragenesis of group (II):Pl-Cpx-Opx-Opaq-Amph.

The mineralogies of the different rock units of Mount Poser are presented in Figure 7. The two mineralogical groups, i.e. a Plagioclase - Olivine series and a Plagioclase - Pyroxene group, can be recognized.

The plagioclase and olivine bearing rocks of Mount Poser have developed a reaction corona at the plagioclase/olivine interface. This corona is similar in composition to the coronas developed in the Los Pinos pluton as described by Walawender, (1976). The development of such coronas has been studied by many workers. A partial list includes Shand, (1945), Herz, (1951), Gjelsvik, (1952), Murthy, (1958), Frodesen, (1968), and Sapountzis, (1975). In most cases the reaction is considered as subsolidus, occurring at high pressures and appears to be characteristic of gabbroids emplaced in high grade,

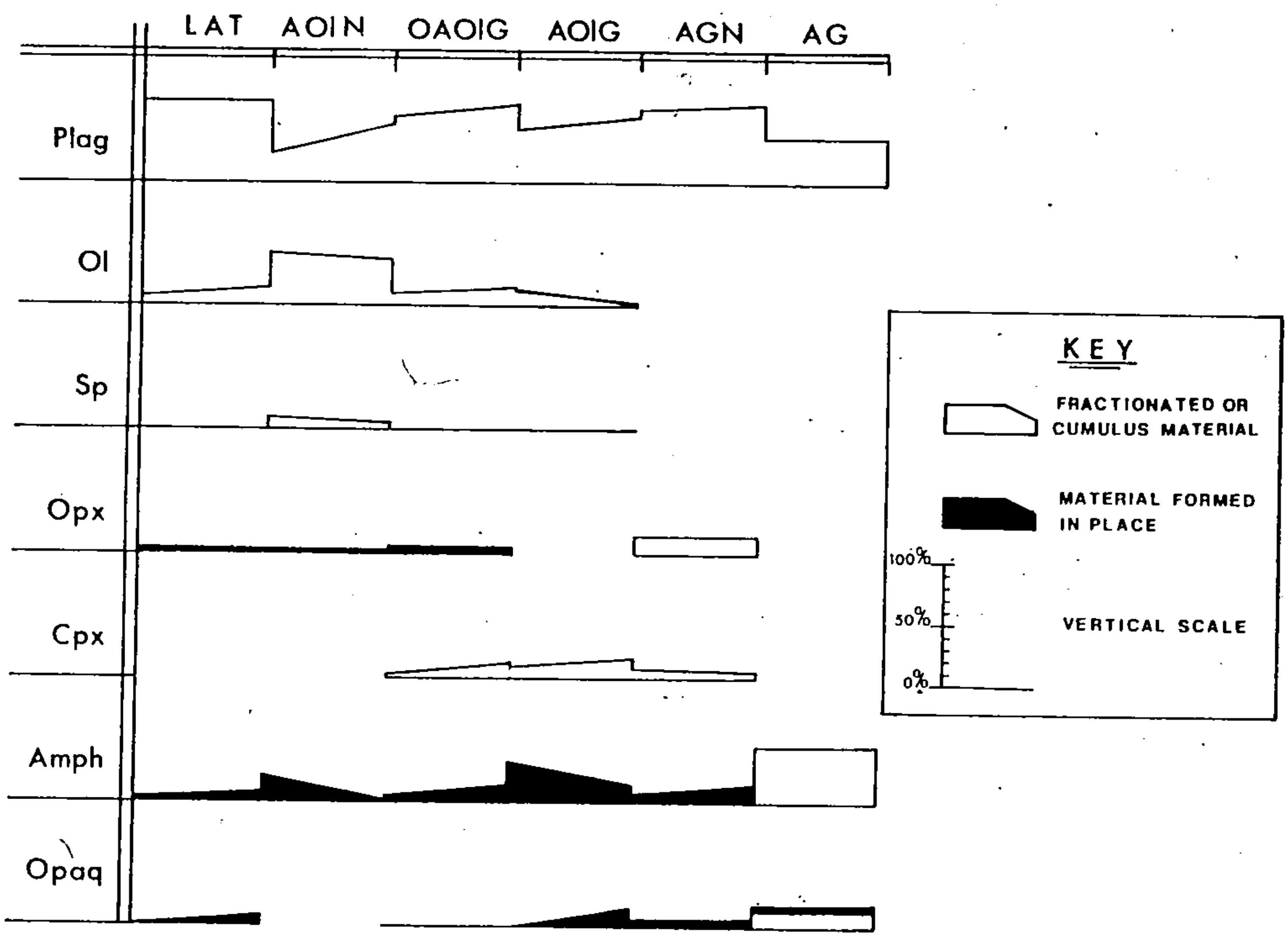


Figure 7. Mineralogical distribution per rock unit of the Mount Poser pluton.

(upper amphibolite to granulite), metamorphic terrains, unlike the gabbro of the Peninsular Ranges Batholith. Walawender, (1976), has shown that the development of a reaction corona can occur at lower pressure regimes (as low as 2kbar).

The coronas at Mount Poser consist of the following assemblages, olivine ± orthopyroxene + amphibole ± (amphibole + spinel) + plagioclase, and can be seen in Plates I,J and K. (Each combination and in which units they occur, has been discussed earlier).
The orthopyroxene does not occur in the coronas of the A01N unit, however, minor orthopyroxene is present within the coronas of the OA01G and abundantly found in those of the LAT unit. Independant anhedral spinel crystals averaging less than 2 mm, occur within the coronas. These spinel crystals are most abundant and the largest, (up to 2.5 mm), in the A01N unit. The amphibole + spinel assemblage does not occur in abundance in the coronas of the AON unit.

GEOCHEMISTRY

The major and trace element chemistry of the Mount Poser pluton is highly variable and systematic trends of variation are difficult to discern. The petrology of these rocks indicates that they have formed by mineral accumulation and do not represent a series of liquids formed by fractionation. This accounts for the difficulty in discerning any systematic trends.

Wager et al, (1967), recognized a chilled facies in his study of the Skaergaard Intrusion. It was proposed, in that study, that the chemistry of this chilled margin representd the composition of the original parent melt from which the intrusion crystallized.

Cawthorn, (1978), in his study of the Tilting Harbour igneous complex of Newfoundland, recognized fine grained dykes which he assumed represented liquid compositions.

No chilled margin has been recognized on the Mount Poser pluton, and the dyke rocks are not regarded as the quenched product of liquid magmas. It is very difficult, therefore, to obtain a clear idea of the original composition of the magma from which the pluton crystallized.

Analytical Methods

A total of 48 samples of the rocks exposed within the Mount Poser pluton were analysed for 10 major elements and 10 trace elements. (Sample localities are shown in Fig. 2). The trace elements analysed include V, Cr, Co, Ni, Zn, Rb, Sr, Y, Nb, Ba. The analyses were performed on a Philips PW1410 Universal Vaccuum X-Ray Spectrometer, using rock powder pellets. (Appendix A gives the preparation technique for the rock powder pellets as well as a discussion regarding their use). Compton scatter peaks were measured for each sample, for U.S.G.S. standard rock powders W-1, AGV, GSP, BCR, G-2 and for pure quartz on Ag, Mo, Cr, and W target tubes. From these data, mass absorption values were determined for each sample. The values derived from the measurements using the Ag target tube were used to correct for mass absorption effects the analyses of Nb and Y. Those values derived from the Mo target tube were used to correct for mass absorption effects for the analyses of Rb, Sr and Ni. Using the Cr target tube, values were obtained to correct for mass absorption effects the analyses of Co, Zn and Ba, while the analyses of V and Cr were corrected for mass absorption effects using data obtained from the use of the W target tube. The theoretical precision values for Rb, Sr, Ba, Zn, Y, Nb, V and Ni analyses is $\pm$ 5%, while Cr and Co should be within $\pm$ 20%. The values obtained for the trace element analyses of the 48 samples fall within the ranges discussed.

The major elements were all analysed using the Cr target tube except for Mn where the W target tube was used. The values obtained from the analyses were then mass absorption corrected using a computer program. The precision of those analyses, (Fe_2O_3, CaO, SiO_2), involving a count rate of one million counts is ± 0.3% at the 99% confidence level. At lower count rates, on other major element analyses, the precision is: ± 0.49% for 400,000 counts, (MgO, Al_2O_3), ± 0.70% for 200,000 counts, (TiO_2, K_2O), ± 0.95% for 100,000 counts, (MnO), ± 1.30% for 50,000 counts, (Na_2O), ± 2.10% for 20,000 counts, (P_2O_5). The major element determinations for the 48 samples fall within the ranges discussed. (Complete analytical conditions for the major and trace elements are presented in Tables 8 and 9).

Major and Trace Element Geochemistry

Listings of the major and trace element values can be found in Tables 10 through 16. Total iron is reported as Fe_2O_3. Differences in major and trace element concentrations between the individual rock units are emphasized in Table 10, wherein the range and mean value for each element are given for all units.

The pluton, in general is characterized by high Al_2O_3, low total alkalies, low SiO_2 and low K_2O.

Chemical characteristics of the individual rock units will now be discussed.

OXIDE	TUBE	kV	mA	CRYSTAL	COLLIMATOR	LL	W	ATT'N	PEAK	COUNTS or TIME	BKGD	TIME	COUNTER/ HELIPOT SETTING
SiO_2	Cr	45	20	TLAP	Fine	140	220	2	32.06	$1x10^6$	—	—	FC500
Al_2O_3	Cr	50	40	TLAP	Coarse	150	170	2	37.68	$1x10^6$	—	—	FC490
TiO_2	Cr	50	40	LiF200	Fine	150	200	3	86.12	$1x10^6$	—	—	FC500
Fe_2O_3	Cr	50	40	LiF200	Fine	210	140	3	57.53	$1x10^6$	—	—	FC480
MnO	W	50	40	LiF200	Coarse	150	120	3	62.88	40s	61.50 64.21	20s	FC280
MgO	Cr	50	40	ADP	Coarse	190	300	3	136.7	100s	135.6 139.0	40s	FC540
CaO	Cr	50	40	LiF200	Fine	250	230	3	113.1	$1x10^6$	—	—	FC520
Na_2O	Cr	50	40	TLAP	Coarse	170	240	3	54.98	100s	53.00 56.20	40s	FC540
K_2O	Cr	50	40	TLAP	Fine	200	140	2	16.61	40s	17.61	20s	FC500
P_2O_5	Cr	50	40	Germ	Coarse	250	250	2	141.0	100s	143.0	40s	FC492

Table 8. Analytical conditions for determination of major elements.

ELEMENT	TUBE	kV	mA	CRYSTAL	COLLIMATOR	LL	W	ATT'N	PEAK	TIME	BKGD	TIME	COUNTER/ HELIPOT SETTING
V	W	50	40	LiF220	Fine	250	400	3	123.3	100s	122.0 126.0	40s	FC520
Cr	W	50	40	LiF200	Coarse	250	200	3	69.0	100s	68.25 70.25	40s	FC500
Co	Cr	50	40	LiF200	Coarse	300	240	3	52.80	100s	50.74	40s	FC500
Ni	Mo	50	40	LiF220	Coarse	400	250	3	71.45	100s	70.20 72.20	40s	FC500
Zn	Cr	50	40	LiF220	Fine	210	330	3	60.64	100s	60.00 61.50	40s	SC280
Rb	Mo	80	20	LiF220	Coarse	300	320	3	38.10	100s	30.30 34.80	40s	SC270
Sr	Mo	80	20	LiF220	Coarse	300	320	3	35.95	100s	36.80 41.00	40s	SC270
Y	Ag	50	40	LiF220	Fine	160	340	3	32.16	100s	31.20 33.20	40s	SC240
Nb	Ag	100	20	LiF220	Fine	170	200	3	30.50	100s	30.11 34.80	40s	SC240
Ba	Cr	60	30	LiF200	Fine	220	200	3	87.17	100s	85.27 90.50	40s	FC500

Table 9. Analytical conditions for determination of trace elements.

ELEMENT(%)	LAT	AO1N	AO1G	OAO1G
SiO_2	41.30-45.02(43.39)	39.25-43.10(41.48)	40.05-42.16(40.80)	42.40-47.66(44.60)
Al_2O_3	17.46-25.09(22.32)	11.79-19.98(16.63)	14.97-19.05(17.37)	18.05-21.08(19.75)
TiO_2	0.05- 0.16(0.09)	0.03- 0.21(0.09)	0.11- 1.40(0.85)	0.06- 0.26(0.18)
ΣFe_2O_3	5.63- 9.90(7.54)	8.72-14.83(12.17)	11.00-13.75(12.18)	6.51-11.94(8.83)
MnO	0.07- 0.13(0.10)	0.13- 0.20(0.16)	0.15- 0.21(0.19)	0.10- 0.16(0.13)
MgO	8.07-16.29(11.34)	13.10-26.52(19.02)	10.08-19.69(13.56)	9.43-13.15(11.48)
CaO	11.85-16.40(14.45)	7.08-12.11(9.92)	13.33-15.15(14.23)	11.84-17.04(14.31)
Na_2O	0.59- 0.97(0.73)	0.30- 0.63(0.48)	0.52- 1.06(0.75)	0.56- 0.82(0.69)
K_2O	0.02- 0.10(0.04)	0.02- 0.06(0.03)	0.04- 0.07(0.05)	0.02- 0.03(0.03)
P_2O_5	0.004- 0.01(0.01)	0.004- 0.02(0.01)	0.01- 0.04(0.02)	0.004- 0.01(0.01)
ELEMENT(ppm)				
V	9- 90(30)	6-125(31)	77-356(268)	26-133(83)
Cr	16-146(58)	14-121(40)	25- 71(41)	45-119(85)
Co	14- 28(20)	25- 43(34)	32- 35(34)	17- 33(23)
Ni	34-110(62)	89-321(182)	8- 35(19)	14-126(70)
Zn	19- 44(30)	51- 79(65)	62- 83(74)	23- 64(41)
Rb	1- 2(1)	1- 5(2)	N/D- 1(1)	3- 4(4)
Sr	261-398(345)	161-333(253)	281-308(297)	242-353(300)
Y	N/D- 2(1)	N/D (N/D)	4- 23(9)	N/D- 5(2)
Nb	1- 3(2)	3- 12(8)	N/D- 2(1)	N/D- 9(5)
Ba	8- 21(11)	5- 20(10)	N/D- 61(26)	4- 15(10)

Table 10. Range and mean value (in parenthesis) for the analysed elements in the rock units of the Mount Poser pluton.

ELEMENT(%)	AGN	AG	INCLUSIONS
SiO_2	41.05-48.75(46.84)	39.87-43.77(41.09)	43.74-47.56(46.08)
Al_2O_3	16.37-20.76(18.85)	15.61-17.54(16.63)	18.12-19.34(18.63)
TiO_2	0.23- 1.07(0.63)	1.17- 1.65(1.47)	0.90- 1.34(1.06)
ΣFe_2O_3	7.70-12.78(10.01)	13.05-15.61(14.36)	11.09-13.55(12.00)
MnO	0.16- 0.24(0.18)	0.17- 0.21(0.19)	0.20- 0.22(0.21)
MgO	6.39-12.57(9.62)	9.07-13.02(11.36)	6.28- 7.54(6.69)
CaO	11.38-14.46(12.35)	13.25-14.27(13.61)	11.61-12.69(12.11)
Na_2O	0.77- 2.44(1.41)	0.96- 1.26(1.14)	2.34- 3.29(2.87)
K_2O	0.07- 0.66(0.14)	0.11- 0.16(0.13)	0.10- 0.18(0.14)
P_2O_5	0.01- 0.06(0.02)	0.01- 0.09(0.03)	0.09- 0.37(0.22)
ELEMENT(ppm)			
V	61-372(208)	390-597(490)	259-293(274)
Cr	19- 68(32)	25- 34(28)	18- 28(24)
Co	21- 31(26)	34- 43(39)	23- 31(27)
Ni	5- 41(20)	4- 16(12)	12- 18(15)
Zn	37-101(72)	81-108(91)	88-109(99)
Rb	1- 7(4)	1- 6(3)	1- 2(2)
Sr	277-486(372)	284-340(310)	351-359(354)
Y	N/D- 12(5)	14- 29(23)	10- 53(34)
Nb	N/D- 9(3)	1- 5(2)	1- 3(2)
Ba	3- 63(22)	N/D- 96(65)	74-150(115)

Table 10. Continued.

ELEMENT(%)	MP-23	C-36	C-4	C-5-B	C-6-A	C-14	C-42	MP-20	MP-83
	LEUCOCRATIC-AMPHIBOLE-TROCTOLITE								
SiO_2	43.84	41.30	41.90	41.81	44.36	45.02	44.16	44.55	43.55
Al_2O_3	25.09	19.69	21.77	22.28	24.64	24.18	23.60	17.46	22.16
TiO_2	0.05	0.09	0.08	0.07	0.05	0.13	0.07	0.16	0.11
ΣFe_2O_3	5.99	9.90	8.78	8.95	5.76	5.63	6.49	7.98	8.42
MnO	0.08	0.13	0.11	0.12	0.07	0.08	0.09	0.12	0.12
MgO	8.41	16.29	13.72	13.12	8.07	8.47	8.81	14.19	10.96
CaO	15.76	11.85	12.99	13.03	16.40	15.70	15.79	14.78	13.74
Na_2O	0.75	0.71	0.60	0.59	0.61	0.74	0.97	0.66	0.91
K_2O	0.03	0.03	0.03	0.02	0.04	0.05	0.02	0.10	0.03
P_2O_5	0.01	0.01	0.01	0.01	0.01	0.01	0.004	0.01	0.01
ELEMENT(ppm)									
V	15	31	23	22	9	31	26	90	25
Cr	52	78	76	66	22	35	35	146	16
Co	16	28	24	25	14	14	17	21	22
Ni	34	83	110	61	41	49	38	59	86
Zn	24	44	40	41	15	20	19	33	36
Rb	1	1	1	1	1	2	1	2	1
Sr	371	294	340	319	382	398	364	261	376
Y	N/D	N/D	N/D	N/D	N/D	1	N/D	2	N/D
Nb	2	2	2	2	2	2	2	1	3
Ba	11	8	11	8	9	21	8	13	13

Table 11. Major and trace element chemistry of the Leucocratic-Amphibole-Troctolite unit of the Mount Poser pluton.

	AMPHIBOLE-OLIVINE-NORITE								
ELEMENT(%)	C-16	C-19	MP-22	C-50	C-37-A	C-21	MP-71	MP-40	MP-38
SiO_2	40.51	43.10	42.00	42.61	41.79	42.07	39.25	39.68	42.35
Al_2O_3	13.08	18.43	17.06	19.98	16.41	19.42	11.79	13.75	19.73
TiO_2	0.07	0.04	0.03	0.16	0.21	0.03	0.10	0.08	0.10
ΣFe_2O_3	14.83	13.23	14.03	8.72	8.96	10.21	14.73	13.67	11.14
MnO	0.20	0.17	0.18	0.13	0.15	0.13	0.19	0.18	0.15
MgO	23.39	13.10	16.54	15.66	22.73	15.61	26.52	24.02	13.61
CaO	7.43	11.44	9.74	12.06	9.20	11.99	7.08	8.24	12.11
Na_2O	0.43	0.46	0.39	0.63	0.48	0.49	0.30	0.33	0.77
K_2O	0.04	0.02	0.02	0.06	0.06	0.03	0.03	0.04	0.03
P_2O_5	0.02	0.01	0.01	0.004	0.01	0.01	0.01	0.01	0.01
ELEMENT(ppm)									
V	16	9	7	32	125	6	35	23	23
Cr	23	40	24	14	121	22	71	31	14
Co	41	32	36	25	30	27	43	39	30
Ni	294	143	182	89	99	113	321	293	102
Zn	78	51	62	52	72	51	79	78	61
Rb	1	1	1	2	2	1	1	4	5
Sr	195	256	217	333	294	300	161	214	304
Y	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D	N/D
Nb	6	8	8	12	4	3	10	10	9
Ba	12	7	6	20	12	12	5	3	12

Table 12. Major and trace element chemistry of the Amphibole-Olivine-Norite unit of the Mount Poser pluton.

	ORTHOPYROXENE-AMPHIBOLE-OLIVINE-GABBRO								
ELEMENT(%)	MP-26	C-26	C-28	C-34	C-65	MP-59	C-59	C-24	C-25
SiO_2	47.66	42.97	45.52	44.73	45.97	42.40	43.86	45.61	42.65
Al_2O_3	19.21	20.33	18.98	18.05	19.37	19.93	21.08	20.29	20.52
TiO_2	0.26	0.06	0.21	0.24	0.22	0.19	0.12	0.17	0.12
ΣFe_2O_3	6.62	9.43	7.15	8.16	6.51	11.94	8.62	9.94	11.07
MnO	0.14	0.13	0.11	0.12	0.10	0.16	0.12	0.15	0.14
MgO	9.43	13.15	10.80	12.54	10.19	12.52	10.99	11.26	12.42
CaO	15.90	13.19	16.51	15.50	17.04	12.16	14.36	11.84	12.27
Na_2O	0.73	0.69	0.67	0.61	0.56	0.67	0.82	0.69	0.78
K_2O	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03
P_2O_5	0.01	0.01	0.01	0.01	0.01	0.004	0.004	0.01	0.01
ELEMENT(ppm)									
V	133	26	97	106	109	90	47	87	52
Cr	90	61	128	119	116	65	45	78	59
Co	18	25	18	21	17	33	22	27	29
Ni	28	113	32	37	14	119	46	115	126
Zn	29	41	24	35	23	62	35	57	64
Rb	4	4	3	4	4	4	3	4	4
Sr	279	339	264	242	261	326	328	309	353
Y	3	N/D	3	2	5	1	N/D	N/D	N/D
Nb	4	7	N/D	9	4	1	3	8	7
Ba	8	4	13	10	15	13	5	11	14

Table 13. Major and trace element chemistry of the Orthopyroxene-Amphibole-Olivine-Gabbro unit of the Mount Poser pluton.

ELEMENT(%)	AMPHIBOLE-OLIVINE-GABBRO C-44	C-9-A	MP-31	AMPHIBOLE-GABBRO C-69-B	C-77-B	C-57-A	MP-61	C-47-A
SiO_2	42.16	40.19	40.05	43.77	40.88	40.05	39.87	40.87
Al_2O_3	19.05	14.97	18.09	17.41	17.54	15.61	16.15	16.42
TiO_2	1.40	0.11	1.04	1.63	1.28	1.63	1.65	1.17
ΣFe_2O_3	11.80	11.00	13.75	13.05	14.38	14.87	15.61	13.88
MnO	0.20	0.15	0.21	0.19	0.21	0.17	0.18	0.18
MgO	10.08	19.69	10.92	9.07	9.94	12.34	11.91	13.02
CaO	14.20	13.33	15.15	13.59	14.27	13.43	13.50	13.25
Na_2O	1.06	0.52	0.67	1.15	1.26	1.25	0.96	1.09
K_2O	0.05	0.04	0.07	0.12	0.15	0.13	0.16	0.11
P_2O_5	0.01	0.01	0.04	0.02	0.09	0.01	0.01	0.01
ELEMENT(ppm)								
V	356	77	371	390	438	597	578	445
Cr	26	71	25	34	28	27	25	27
Co	32	35	35	34	37	41	43	38
Ni	8	35	15	4	13	13	13	16
Zn	83	62	78	86	95	86	81	108
Rb	N/D	1	1	6	1	2	2	2
Sr	301	281	308	324	303	234	301	340
Y	N/D	4	23	22	29	22	27	14
Nb	2	N/D	1	5	2	1	1	1
Ba	N/D	17	61	N/D	80	96	90	61

Table 14. Major and trace element chemistry of the Amphibole-Olivine-Gabbro unit and the Amphibole-Gabbro unit of the Mount Poser pluton.

	AMPHIBOLE-GABBRONORITE									
ELEMENT(%)	C-79	C-53	C-60	C-66	C-45	C-53-A	MP-60	C-47	MP-85	C-48-B
SiO_2	46.83	46.48	47.86	48.55	48.58	48.75	47.44	47.56	45.28	41.05
Al_2O_3	18.75	18.14	19.78	18.59	19.17	19.92	16.70	16.37	20.76	20.35
TiO_2	0.46	0.23	1.07	0.23	0.81	0.96	0.44	0.68	0.53	0.92
ΣFe_2O_3	10.74	9.48	10.29	7.70	9.74	9.47	10.42	9.73	9.79	12.78
MnO	0.24	0.18	0.17	0.17	0.17	0.17	0.22	0.16	0.16	0.20
MgO	9.85	12.57	6.45	11.40	7.71	6.39	12.46	11.21	8.81	9.38
CaO	11.63	12.08	12.23	12.40	11.77	11.81	11.38	13.41	12.31	14.46
Na_2O	1.34	0.77	2.02	0.89	1.98	2.44	0.79	0.81	2.24	0.78
K_2O	0.11	0.66	0.07	0.07	0.07	0.07	0.13	0.07	0.11	0.08
P_2O_5	0.06	0.01	0.06	0.01	0.01	0.01	0.01	0.01	0.02	0.01
ELEMENT(ppm)										
V	147	91	285	100	335	249	61	229	209	372
Cr	19	35	28	56	22	25	25	68	21	21
Co	28	27	28	21	26	25	28	26	21	31
Ni	37	41	9	18	7	5	26	24	14	21
Zn	101	53	76	37	64	87	76	63	66	94
Rb	3	5	4	5	4	4	7	5	2	1
Sr	341	348	411	296	472	486	277	286	414	389
Y	12	5	3	N/D	3	3	10	10	3	5
Nb	1	3	9	4	3	3	4	5	N/D	1
Ba	32	17	3	17	8	8	10	5	63	52

Table 15. Major and trace element chemistry of the Amphibole-Gabbronorite unit of the Mount Poser pluton.

ELEMENT(%)	INCLUSIONS C-39	C-45	C-46-B
SiO_2	47.56	46.93	43.74
Al_2O_3	18.42	18.12	19.34
TiO_2	0.95	0.90	1.34
ΣFe_2O_3	11.35	11.09	13.55
MnO	0.22	0.22	0.20
MgO	6.24	7.54	6.28
CaO	11.61	12.03	12.69
Na_2O	3.29	2.98	2.34
K_2O	0.18	0.10	0.13
P_2O_5	0.21	0.09	0.37
ELEMENT(ppm)			
V	259	271	293
Cr	28	26	18
Co	26	23	31
Ni	18	12	15
Zn	101	88	109
Rb	2	1	2
Sr	351	359	352
Y	39	10	53
Nb	2	1	3
Ba	150	74	122

Table 16. Major and trace element chemistry of the Inclusions of the Intrussion Breccia of the Mount Poser pluton.

The LAT unit is characterized by the highest alumina content of all the rock units. CaO and Sr is also high in concentration. Since this unit has been shown to have the highest plagioclase content of all the rock units, the above chemical trends are not surprising. In this unit plagioclase separation from the magma controls the chemistry. Cr content is high in this unit where it enters spinel.

The A01N unit is characterized by the highest content of MgO of all the units. This, together with the highest Ni content of Mount Poser's rocks, signify olivine separation from the melt as the controlling factor of the chemistry.

The A01G unit is characterized by high TiO_2, high Fe_2O_3, V, Co and Zn. These elements probably occur in the abundant opaques in this unit. CaO is also high in this unit and is contained in the clinopyroxene.

The OA01G unit contains a high concentration of CaO, where it has entered plagioclase and/or clinopyroxene. Cr content is also high in these rocks where it has entered the clinopyroxene.

The AGN is characterized by the highest Sr content of Mount Poser's rock units. This, together with high CaO and Al_2O_3 and a high concentration of plagioclase, shows that the chemistry of this rock unit was contolled by plagioclase separation. In addition, orthopyroxene and amphibole separation may account for other chemical characteristics, (i.e. CaO content and Ba content respectively).

The AG unit contains the highest Fe_2O_3, Co and V content of all the rock units. Zn is also high in concentration. All four elements would be concentrated in the opaque minerals, (which have the highest concentration in this unit).

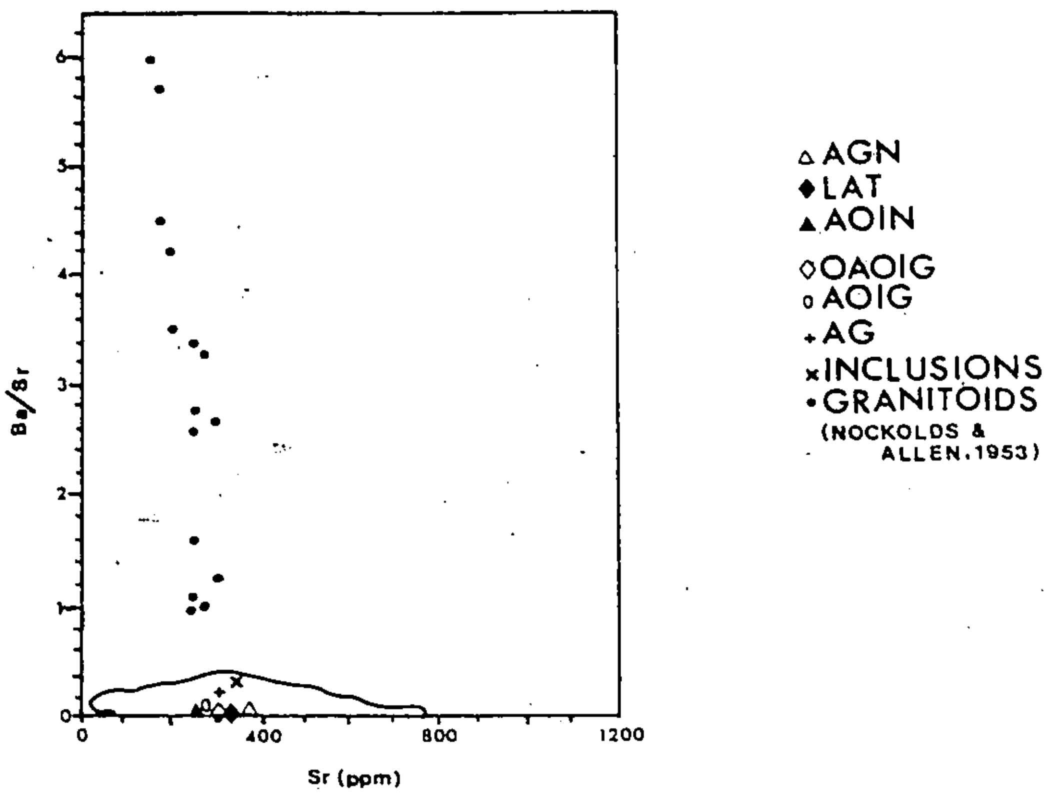
The inclusions contain the highest Ba content of all the rocks of Mount Poser. Ba, along with Sr, (which is also high in these rocks), would be concentrated in the plagioclase.

The significance of the dyke units in the pluton is difficult to ascertain. Aside from certain field relations, (i.e. the darker foliated dykes post-date the emplacement of the lighter non-foliated dykes, and both sets of dykes post-date the emplacement of the other rock units of the pluton), and previously mentioned chemical trends, one other point may be made concerning these dykes. Chemically they possess too low of a SiO_2 content to be considered as chilled liquids of the cumulate rocks.

An initial estimate of the water content of the melt which differentiated to form the cumulates of Mount Poser can be made. The Mount Poser pluton was emplaced into a deformed sequence of meta-sedimentary rocks. The lack of metamorphic features in Mount Poser indicates that the emplacement of the gabbro post-dates the main metamorphic episode. The metamorphism of the country rocks is due to the same thermal event that produced the Jurassic and Mesozoic plutons of the Peninsular Ranges Batholith, (Gastil, 1975). This implies that the Mount Poser gabbro was emplaced at a shallow (2 to 3kbar) crustal level. Berggreen and Walawender, (1977), suggest that the metamorphic paragenesis of the nearby Morina Reservoir roof pendant occurred at 2 to 2.5kbar and 600°C. Using the data of Hamilton et al, (1964), a basaltic melt at 3kbars will be saturated with about 6 wt% water. The presence of olivine and plagioclase on the liquidus indicates the magma is not water saturated. As an approximation, therefore, the initial basaltic melt must have contained less than 6 wt% water, but more than the minimum 2.8 wt% water necessary for the formation of amphibole, (Burnham, 1972). This presence of hornblende is important since most basaltic melts are dry, (less than 1 wt% water). The occurrence of hornblende and the implication that can be drawn from this presence has been discussed by other authors, (Bailey, 1958 and Joplin, 1958). Both authors agree that the presence of hornblende implies the presence of abundant water in the magma.

Figures 8 through 11 show the elemental variation

Figure 8. Plot of Ba/Sr against Sr (ppm) for the lithologic units of the Mount Poser pluton and the granitoids from the Peninsular Ranges Batholith.



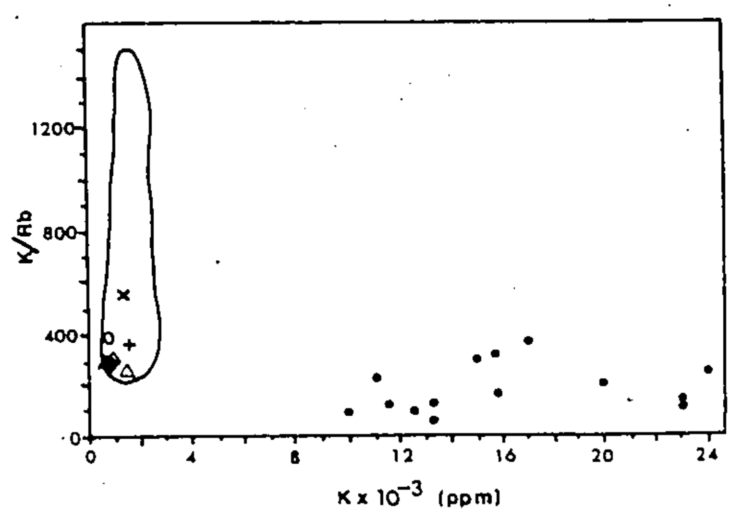


Figure 9. Plot of K/Rb against $Kx10^{-3}$ (ppm) for the lithologic units of the Mount Poser pluton and the granitoids from the Peninsular Ranges Batholith. Symbols as per Fig. 8.

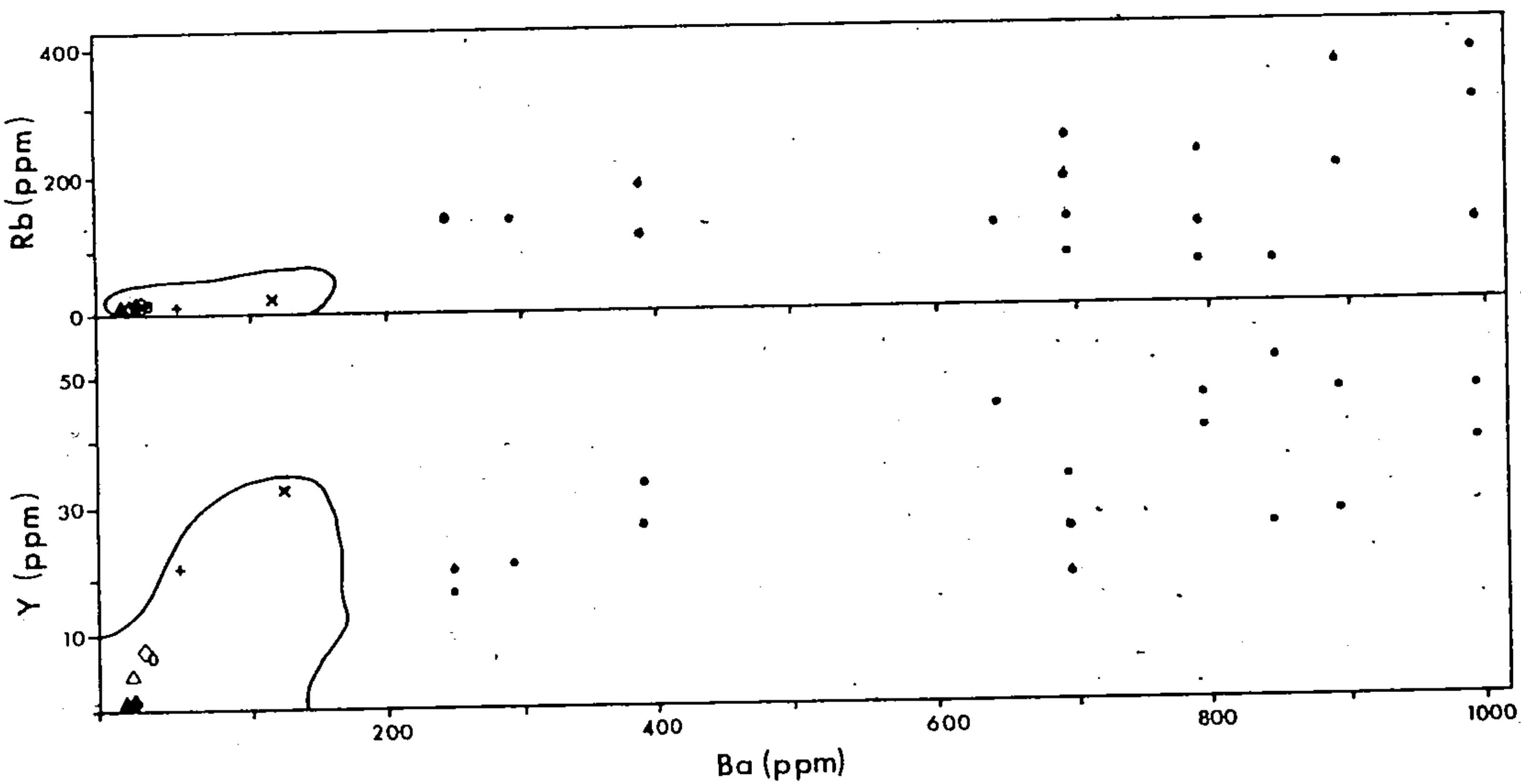


Figure 10. Plots of Rb (ppm) and Y (ppm) against Ba (ppm) for the lithologic units of the Mount Poser pluton and the granitoids from the Peninsular Ranges Batholith. Symbols as per Fig. 8.

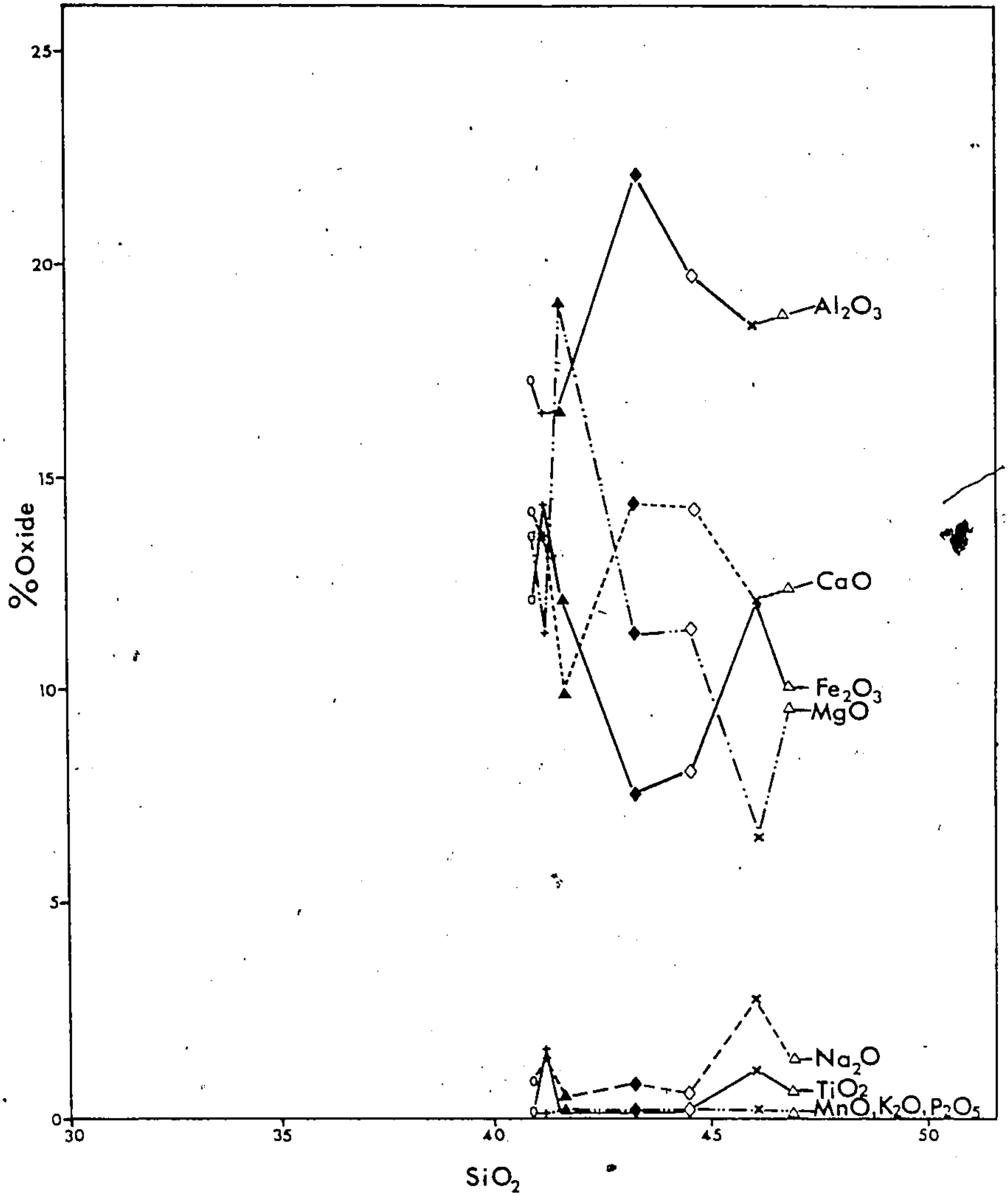


Figure 11. The variation of the major element chemistry of the rock units of the Mount Poser pluton. Symbols as per Fig. 8.

within the rock units of Mount Poser. In addition, the field of trace element variation for eight gabbro plutons, (Walawender and others unpublished data), and the data of Nockolds and Allen, (1953), for the granitic components of the batholith are shown. These plots help to emphasize the trace element differences between gabbroic and granitic rocks of the batholith, as well as the differences between rock units of Mount Poser.

PETROGENESIS

The spatial, geochemical and petrographic characteristics of the rocks of the Mount Poser pluton indicate that it is part of the system of gabbroic plutons that occupy the western margin of the Peninsular Ranges Batholith.

In deciding on a parental melt from which the rocks of Mount Poser formed, it must be noted that, since these gabbros are of cumulate origin, the bulk chemical composition cannot therefore represent the composition of the liquids from which they crystallize. Mineralogical evidence must therefore be used to help decide on a parental melt.

Several workers, (Walawender, 1976, Walawender et al, 1977 and 1979., and Wilson, 1978), in studies of similar neighboring plutons have suggested high-alumina basalt as the parent magma from which these plutons formed.

Other workers studying plutons showing similar mineralogy, textures, chemistry and rock types, in other areas of the world, (Mullen and Bussell, 1977, on intrusions in Mexico and Peru, Mertzman, 1978, on a study from the Southern Cascades, California; Price and Sinton, 1978, on a suite of granitoids and gabbros from Southland New Zealand), have also suggested high-alumina basalt differentiates from a calc-alkaline magma series.

Lewis, (1969), studied cognate gabbro blocks occurring in calc-alkaline basalts and andesites from the Soufriere volcano, St. Vincent, West Indies. These blocks have similar mineralogies and textures to the rocks of Mount Poser, and represent cumulates crystallizing under high water vapour pressures from fractionating basalt magma. They are often adcumulates with poikilitic amphiboles enclosing other mineral phases.

The blocks contain interstitial scoria, which Lewis maintains, represents the parental magma from which the blocks originated. His arguments supporting the above are now presented.

> "There are several lines of evidence indicating that the interstitial scoria, in most cases, represents the residual liquid and not material injected into the blocks, either at depths or during the passage of the blocks to the surface. Firstly, the interstitial scoria is regularly distributed filling large and small cavities, and the crystals have the appearance of being suspended in the scoria, thus giving no indication that liquid has been forced into the rocks. Secondly, if the scoria represents material that has been injected into the blocks, it must have occurred under conditions of perfect equilibrium with the mineral phases present, otherwise pronounced resorption or reaction would have occurred. The majority of the blocks with and without interstitial scoria show no signs of resorption or reaction.
> The suggestion that the interstitial scoria, particularly the thin film separating the minerals, represents a melt which resulted from solution of the minerals on release of pressure when the blocks were ejected, or simply melting due to increase of temperature at depth, can also be largely discounted. If this were the case it would be difficult to account for the larger patches of scoria which are found together with the thin film separating the minerals. It would be expected that the film would be wider at the junctions between minerals of a different type where the eutectic temperature would be lower, than between minerals of the same type.

> The composition of the interstitial scoria is that of a basalt, and the compositions of the crystals are those of unzoned high-temperature minerals. If it may be assumed the composition of the interstitial scoria represents the composition of the almost gas-free equivalent of the magma which was in equilibrium with the crystals separating from it at depth, then in some way crystallization has taken place under constant conditions, so that the residual magma among the crystals has remained constant in composition. It is considered that this has taken place through diffusion of components from the interstitial liquid in the crystal mush to the main overlying magma body and vise versa. (Lewis, 1973, pp.95-97).

Lewis has further shown that the chemistry of the interstitial scoria closely resembles a high-alumina basalt and maintains that these blocks indicate fractionation of high-alumina basaltic melt to yield other calc-alkaline rocks. However, only basalt and andesite are represented at Soufriere, dacite is not present.

The mineralogy present in these blocks is a high temperature assemblage, (approx. 1000°C). Tschermakitic amphibole is present. The presence of abundant, very calcic, (greater than An_{90}), plagioclase and the absence of garnet indicates crystallization at less than 10kbars, (Lewis, 1973). Although the metamorphic rocks of the Peninsular Ranges Batholith are generally considered to have formed at lower pressure regimes than St. Vincent's blocks, (approx. 2 to 2.5kbars, Berggreen and Walawender, 1977), Helz, (1973) has measured compositions of phases, olivine, augite, tschermakite and pargasite, crystallizing from a basalt magma with falling temperatures, (down to 680°C), at P_{H_2O}=3kbars.

Other studies by Longshore, (1966), on the Virgin Islands Batholith, and by Nishimori, (1976), on the Peninsular Ranges Batholith, further support the choice of high-alumina basalt as a parent magma for the repective batholiths.

A comparison of Mount Poser's mineralogy with mineralogies typical of high-alumina basalts, now follows.

The anorthite content of plagioclase in Mount Poser's rock units may be the key to magma parentage. Plagioclase ranges in composition from An_{53} to An_{96}, (these values are for the plagioclase occurring in the four main rock units, LAT, A01N, OA01G, AGN). Plagioclase with an anorthite content of greater than An_{90} is confined, with rare exception, to three major associations; 1) phenocrysts and crystal ejecta in basalts and rarely in andesites, from calc-alkaline suites, 2) basic and ultrabasic rocks mainly occurring in calc-alkaline suites, and 3) metamorphosed calcareous sediments, (Lewis, 1969). Aside from the last occurrence, which clearly does not apply to Mount Poser, the presence of plagioclase with an anorthite content greater than An_{90} implies a calc-alkaline parentage.

The presence of primary amphibole in the rocks of Mount Poser implies the presence of H_2O in the magma, but it does not imply that the magma was water saturated.

Yoder, (1969), has shown, from synthetic systems, that calcic plagioclase in calc-alkaline rock suites may crystallize from a basalt or andesite magma under conditions of elevated water pressure, (P_{H_2O}=1 to 2kbars, at 1000° to 1300°C).

To further support the choice of calc-alkaline parentage, Kuno, (1950, 1966), has shown that the pigeonitic clinopyroxene series is an indicator of tholeiitic parentage, while hypersthenic orthopyroxene series is an indicator of calc-alkaline parentage.

Smith, (person. comm.), has shown that the orthopyroxene present in neighboring plutons is hypersthene and bronzite.

Other workers, (Nishimori, 1976, Smith, person. comm.), in studies of similar neighboring plutons, (Cuyamaca, Guatay, Los Pinos, Target Range and Corte Madera), have shown that the amphibole present is of hornblende to tschermakitic pargasite composition. If the amphibole found at Mount Poser is of this compositional range, (as it seems from optical observations), it would be an indicator of calc-alkaline rock series affinity, (Jakes and White, 1972, Allen, 1975, Nishimori, 1976). The clinopyroxene compositions in these similar plutons in the area of Mount Poser range in composition from diopsidic- augite to salite, (Smith, person. comm.). Mount Poser's clinopyroxene should show similar compositional ranges. Although salitic clinopyroxene is particularly characteristic of hypabyssal rocks derived from alkali basalt magmas, (Deer et al, 1963), salite also occurs in calc-alkaline volcanic rocks, (Lewis, 1971), and in cognate gabbro blocks from the Soufriere calc-alkaline suite, (Lewis, 1973).

It has been shown that olivine was one of the earliest minerals to crystallize in the rocks of Mount Poser. Olivine, while not being a common liquidus mineral in calc-alkaline andesite, is a common liquidus phase in basalts and basaltic-andesites.

The parental magma chosen in consideration of the above constraints is high-alumina basalt-basaltic andesite differentiates from a calc-alkaline magma series.

DISCUSSION

The various theories regarding the petrogenesis of the Peninsular Ranges Batholith, will now be tested.

Larsen, (1948), has suggested that differentiation from a gabbroic melt produced the range of rock types found within the Peninsular Ranges Batholith. Wilson, (1978), has shown that this may be true for rocks varying in composition from pyroxenite to quartz diorite in the Corte Madera pluton, but it is questionable that the granitic rocks within the batholith could have been produced by further differentiation. Figures 8 through 11 show a large compositional gap between the tonalites reported by Nockolds et al, (1954), and the gabbroic rocks in relation to trace element content.

To further test this theory, the Rayleigh Fractionation Law (Rayleigh, 1896), will be used to derive the amount of melt that must crystallize to explain the different trace element patterns within this pluton. The Rayleigh Fractionation Law has been used since the elements chosen to test the theory are Rb, Ba, K and Sr. These elements, which Ringwood has called incompatible elements, are not readily accomodated by any crystalline phase, rather, they preferentially enter the coexisting liquids.

Several assumptions must first be made. The parental melt can be represented by a high alumina basalt, (as supported by Lewis' interstitial scoria), while a residual melt can be represented by a tonalite.

Table 17 lists values used in the following calculations.

The Rayleigh Fractionation Law is represented by:

$$\frac{C_e^1}{C_e^o} = F^{(K_e^{s/m}-1)}; \quad \text{where}$$

C_e^1=concentration of element e in the residual melt.

C_e^o=concentration of element e in the parental melt.

F= weight fraction of liquid remaining.

$K_e^{s/m}$=distribution coefficient of element e for a single phase crystallizing from a melt.

Textural evidence shows that plagioclase was on the liquidus but near liquidus phases of olivine, orthopyroxene and clinopyroxene were present. The tonalite is enriched in Ba, Rb and K while Sr is depleted between parental and residual melts. The element with the largest distribution coefficient for the observed liquidus or near liquidus phases is Sr. This suggests that the depletion in Sr is due to the separation of one of the observed liquidus or near liquidus phases. Korringa and Noble, (1971), state that the composition of plagioclase controls the partition coefficient value for Sr between the plagioclase and the melt. The plagioclase

Table 17. Values used in the Rayleigh Fractionation Law. (Values reported are in ppm).

	High Alumina[1] Basalt	Andesite[2]	"Average"[3] Tonalite
Rb	9.6	10.0	140.0
Ba	115.0	110.0	660.0
K	3300.0	13300.0	20000.0
Sr	330.0	385.0	215.0

Source of data:

1) and 2) Taylor, S.R. 1969.

3) Nockolds, S.R. et al 1953. Average of tonalites numbers 7, 10, 11, 14, 19, 20, 22.

in the gabbro units of Mount Poser have a maximum anorthite content of An_{96}, and the corresponding value of K_{Sr} is 1.2, (Korringa and Noble, 1971). Using this value in the Rayleigh Fractionation Law, the separation of only plagioclase from the melt will not alone account for the distribution of Sr, Ba, K and Rb between parental and residual melts. This implies that at least one other phase has separated out with the plagioclase. Textural evidence shows that olivine disappears followed by clinopyroxene , then orthopyroxene, all have similar distributions coefficients. Olivine has the lowest reported distribution coefficients among the liquidus or near liquidus phases for each of the above elements, (Philpotts and Schnetzler, 1972), and will be used as a representative of the other phase. The Rayleigh Fractionation Law changes when two phases separate from a parental melt, and takes the following form, (after Gast, 1968):

$$\frac{C_e^1}{C_e^o} = F^{(K_e^{pl/m}(Z) + K_e^{ol/m}(1-Z))-1}$$, where

$K_e^{pl/m}$ =the distribution coefficient of element e between plagioclase and the melt.

$K_e^{ol/m}$ =the distribution coefficient of element e between olivine and the melt.

Z =the weight fraction of plagioclase separated from the melt.

1-Z =the weight fraction of olivine separated from the melt.

To account for the differences between the parental and residual melt by crystallization differentiation, the above relationship in terms of plagioclase and olivine separation should generate a solution that is consistent and realistic for each of the four elements examined. This solution can be obtained graphically by letting Z vary from 0 to 1 for each element and then calculating F. The weight percent plagioclase and olivine separated is equal to 100(1-F)(1-Z) and 100(1-F)Z respectively, and is plotted graphically for each element, (Fig. 12). The intersections of Ba, K, Rb and the X and Y axes yields the minimum proportions of plagioclase, (An_{93}), and olivine separated that will account for the observed trace element patterns of a differentiating high alumina basalt whose residual phase is a tonalite. These separations of plagioclase and olivine range from 83 to 93% and 85 to 95% respectively, depending on the element considered. Plots of plagioclase against orthopyroxene or clinopyroxene would closely resemble Figure 12 because their partition coefficients are very similar to olivine's for each element. The weight percent of orthopyroxene and clinopyroxene separation was calculated and the values show the same ranges as derived for plagioclase and olivine. This suggests that orthopyroxene or clinopyroxene can replace olivine as the second phase and therefore they

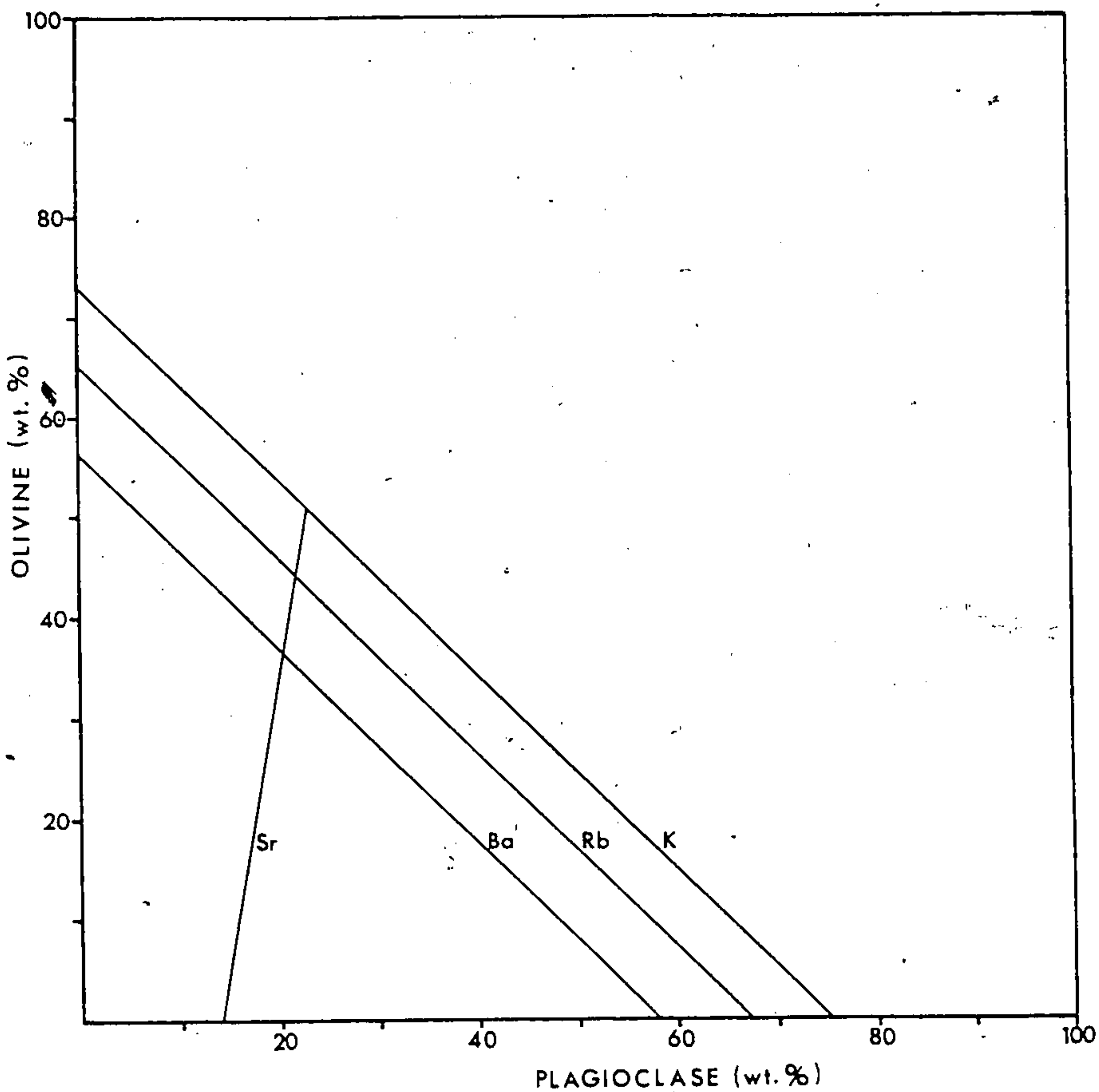


Figure 12. Phase separation curves for Sr, Ba, Rb and K.

can be used to explain the trace element differences in rocks lacking olivine. Assuming that 88% of the melt must crystallize to explain the trace elemnt differences between the two units, then this crystalline mass mould be composed of 4% plagioclase and 84% olivine, (orthopyroxene or clinopyroxene). This calculated crystallization differentiation of 4% plagioclase and 84% olivine, (orthopyroxene or clinopyroxene), is not supported by modal mineralogy of the rocks at Mount Poser. It appears highly unlikely that crystallization of the remaining parental melt, (12%), could explain the trace element concentration between these two units, (tonalites and gabbros). Also, crystallization of the remaining melt could not have produced the vast quantity of tonalite, (50%), and granodiorite (34%), (Larsen, 1948), found within this geologic province. These values imply a vast mafic residue should be present beneath the granitoids which is not supported by geophysical evidence. Therefore Larsen's proposal to explain the variation in the rock types within the Peninsular Ranges Batholith is invalid because of the evidence presented.

Albarede, (1977) in his study suggests that a tonalite parental magma differentiated to form the batholith in which the gabbro was a cumulative phase and the granodirite was dervied from a residual magma. The liquidus minerals at pressures less than 5 kbars for a tonalite melt are, plagioclase, hornblende and biotite, (Piwinskii and Wyllie, 1968). This suggests that the gabbros of the Peninsular Ranges Batholith which are cumulates composed of plagioclase pyroxene and olivine, could not be cumulate phases of a tonalite magma. However, the tonalite magma could differentiate to produce the associated granodiorite bodies.

Further, Walawender, (1976), in his study of a neighboring pluton, Los Pinos, has identified dyke rocks which represent quenched liquids. These dyke rocks are of gabbroic composition. A tonalite could not possibly fractionate from such a parental liquid. Therefore Albarede's proposal to explain the variation in the rock types within the Peninsular Ranges Batholith is invalid because of the evidence presented.

Several workers, (Walawender, 1976, Walawender, Hoppler, Smith and Riddle, 1979 and Wilson, 1978), have suggested that the gabbroic rocks of the Peninsular Ranges Batholith are not cogenetic with the granitoid rocks. In order to test this theory, similar calculations using the modified Rayleigh Fractionation Law (after Gast, 1968) will be used with a high alumina basalt as the parental melt, while a residual melt, (following the differentiation path), could possibly be an andesite, (Table 17), as suggested by Lewis, (1973). In this case 67% of the magma must crystallize to explain the trace element differences between andesite and high alumina basalt. This crystall-ine mass would be composed of 22% plagioclase and 45% olivine, (orthopyroxene or clinopyroxene).

Although some gabbroic plutons within the Peninsular Ranges Batholith show sub-volcanic features, (ex. comb layering at Los Pinos), it is proposed that an andesitic residual melt is never fully attained in the peninsular Ranges Batholith.

CONCLUSIONS

1) The Mount Poser pluton has formed from multiple intrusions.

2) The mineralogical and petrological characteristics suggest the rock units have formed by crystal settling of an earlier cumulate phase followed by later crystallization of the residual interstitial melt.

3) The mineralogy and chemistry suggest a parental melt of high alumina basalt - basaltic andesite. This parental melt is of calc - alkaline affinity. It appears that other such bodies within the Peninsular Ranges Batholith described by Larsen and others owe their origin to the same process.

4) The trace element chemistry suggests that the genesis of tonalites and granodiorites within this batholith is not related to the parental high alumina basalt - basaltic andesite melt, but formed by some other process, possibly a later melt of granitic composition.

APPENDIX A

The rock powder pellets are 32 mm in size and were prepared in the following manner:

1) Weigh out approximately 2.5 grams of -200 mesh rock powder in a plastic vial, add 4 drops of 2% polyvinyl alcohol and mix thoroughly.
2) Assemble 32 mm die with aluminium sleeve. Place the rock powder in the die and form a disk by counterrotation of the perspex plunger and alumium sleeve.
3) Remove the plunger and sleeve and add about 4 grams of boric acid backing.
4) Assemble the rest of the die and press for 15 sec. at 9 tons.
5) Disassemble die and place pellets out to dry.

The use of rock powder pellets in major element determination causes slight errors due to grain size and mineralogical effects. The grain size effects occur in samples with an uneven grain size distribution which results in fewer larger grains at the surface of the pellet. The larger grains are usually the harder minerals while the finer grains are the softer minerals. This decrease in large grains means that some harder minerals will be absent and therefore a true representative analysis of the sample will not be obtained. Grain size effects can be considered minimal in these samples due to the care taken during the grinding process.

The mineralogical effect is also known as the biotite effect. The large platy minerals such as biotite when pressed will be aligned in a horizontal position and therefore occupy a larger surface area than non-platy minerals. The larger surface area causes larger intensities of radiation to be emitted for certain major elements resulting in higher concentration values of these elements. The mineralogical effects can be disregarded in this analysis because the Mount Poser Pluton rocks do not contain any biotite.

PHOTOGRAPHIC PLATES

Plate A

Photo 1 - View of South slope of Mount Poser, looking East.

Photo 2 - View of North slope of Mount Poser looking West. Note the numerous land slips.

1

A

1

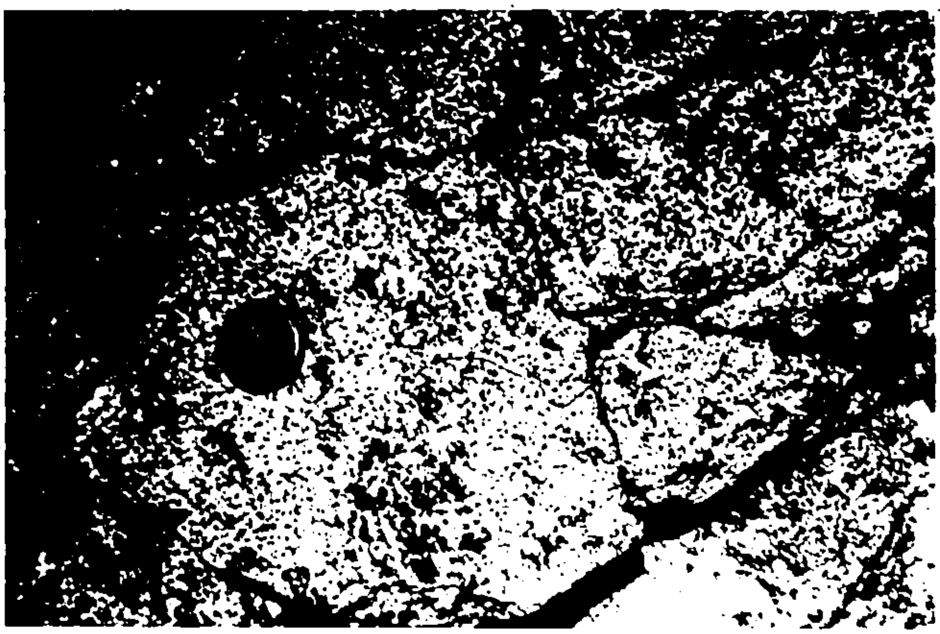
2

Plate B

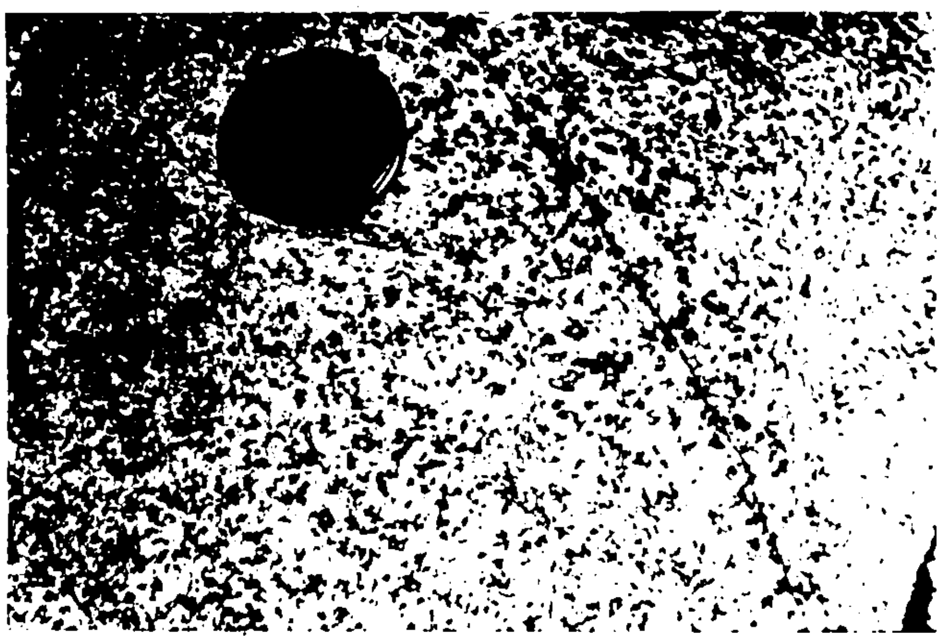
Photo 1 - LAT unit with large (1-3 cm) poikilitic hornblende. Unit consists of red, weathered olivine and light coloured plagioclase.

Photo 2 - LAT unit with late stage fibrous amphibole which have developed along joint planes. Note the bimineralic mafic assemblage of olivine with amphibole rims.

B



1



2

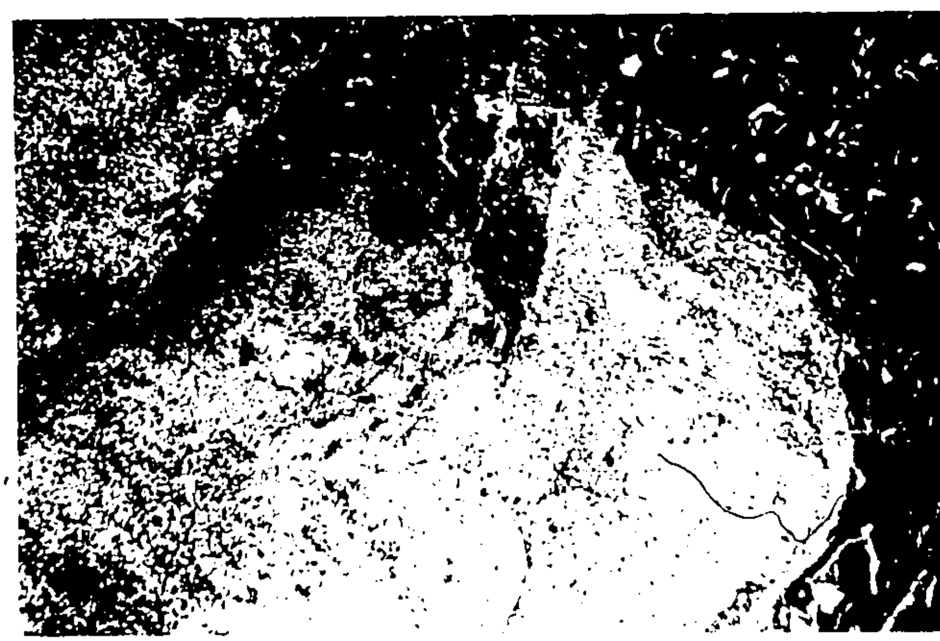
Plate C

Photo 1 - AG dykes in AGN. Note rectilinear pattern of dykes.

Photo 2 - A01G dyke penetrated by stringers of AGN.

C

1



2

Plate D

Photo 1 - Intrusion breccia. Inclusions of fine grained plagioclase, clinopyroxene, opaques and amphibole in a ground mass of AGN.

Photo 2 - Close up of inclusion in the Intrusion breccia.

D

1

2

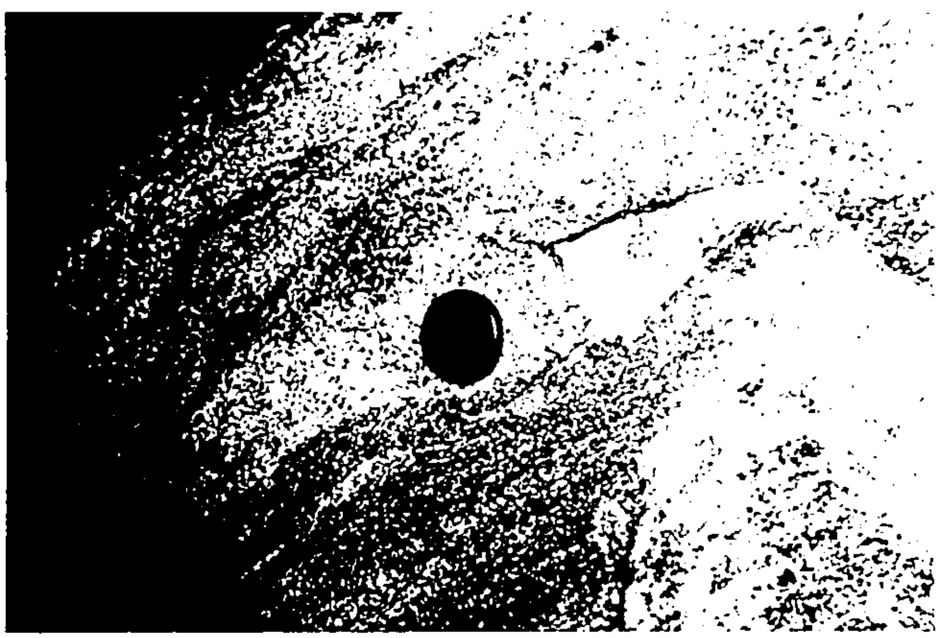
Plate E

Photo 1 - Typical OAOlG. Unit consists mainly of plagioclase and olivine, with minor amounts of clinopyroxene, amphibole and opaques.

Photo 2 - Large scale mineralogical banding in a mafic member of the LAT.

E

1



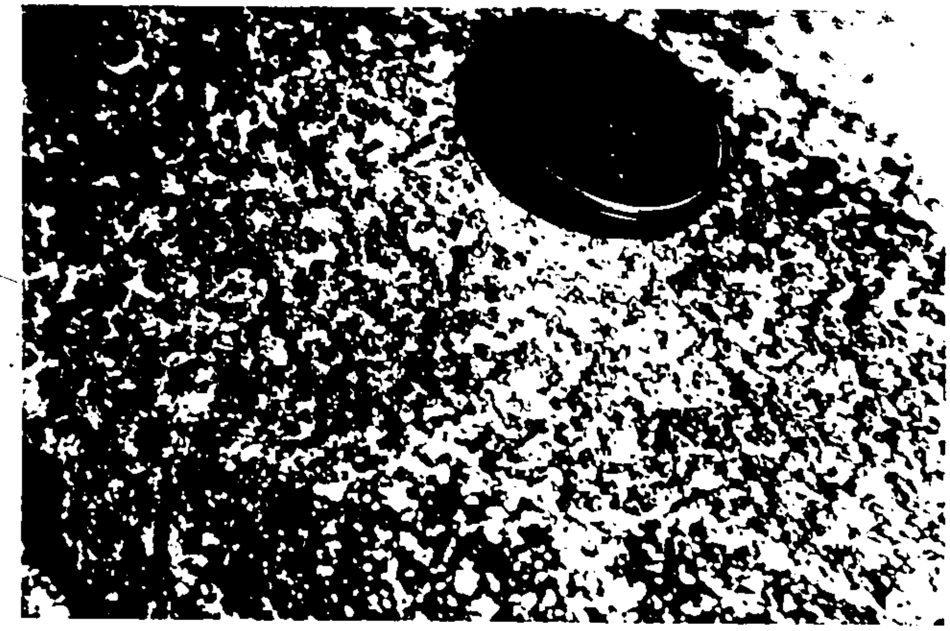
2

Plate F

Photo 1 - Weathering of plagioclase from the LAT unit leaving a sponge - like texture. Dark mafic clots consist of olivine and amphibole.

Photo 2 - Pegmatitic patch of amphibole and plagioclase in AO1N.

F



1

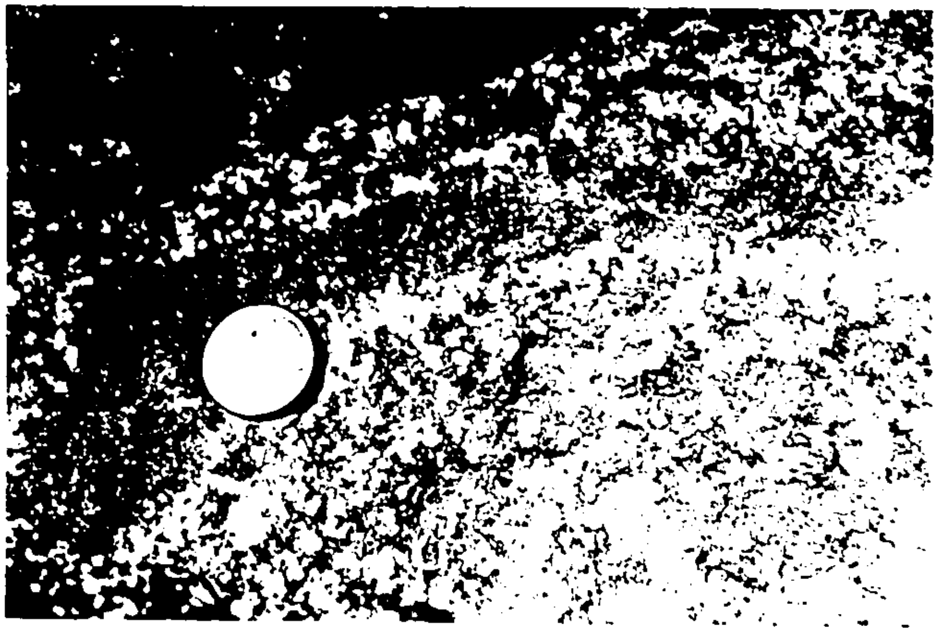
2

Plate G

Photo 1 - Mafic lens in A01N. Note rim of plagioclase immediately adjacent to lens.

Photo 2 - Leucocratic lens in A01N.

G



1

2

Plate H

Photo 1 - Slumping feature in AGN composed of a mafic band of olivine and amphibole followed by progressively more lencocratic bands.

Photo 2 - Slumping feature in AGN.

H

1

2

Plate I

Photo 1 - Plane polarized light. OA01G unit. Olivine with amphibole rim in centre with a "Sieved" clinpyroxene to the right of centre. Plagioclase making up the remainder. Magnification X 50. Sample #C-34.

Photo 2 - Crossed polarized light. Same photograph as #1.

Photo 3 - Plane polarized light. OA01G unit. Olivine and plagioclase grains. Poikilitic amphibole in upper left. Magnification X 50. Sample #MP-59.

Photo 4 - Crossed polarized light. Same photograph as #3.

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Plate J

Photo 1 - Plane polarized light. LAT unit. Embayed olivine grains, showing reaction corona between olivine and adjacent plagioclase. Corona assemblage consists of olivine + amphibole + (spinel + amphibole) + plagioclase. Magnification X 50. Sample #MP-18.

Photo 2 - Crossed polarized light. Same photograph as #1.

Photo 3 - Plane polarized light. LAT unit. Similar photo to #1. Magnification X 50. Sample #MP-18.

Photo 4 - Crossed polarized light. Same photograph as #3.

J

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3

4

Plate K

Photo 1 - Plane polarized light. LAT unit. Olivine with reaction corona between itself and adjacent plagioclase. Corona assemblage consists of olivine + orthopyroxene + amphibole + (spinel + amphibole) + plagioclase. Magnification X 50. Sample #MP-18.

Photo 2 - Crossed polarized light. LAT unit. View of reaction Corona between olivine and adjacent plagioclase. Corona assemblage consists of olivine + orthopyroxene + plagioclase. Magnification X 150. Sample #C-36.

Photo 3 & 4 - Plane polarized light. LAT unit. Similar photographs to #1. Magnification X 150. Sample #MP-18.

K

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3

4

Plate L

Photo 1 - Crossed polarized light. A01N unit. Olivine with interstitial amphibole. Magnification X 50. Sample #MP-22.

Photo 2 - Plane polarized light. A01N unit. Olivine, interstitial amphibole and large grain of spinel (dark grey). Magnification X 50. Sample #C-16.

Photo 3 - Plane polarized light. AGN unit. Orthopyroxene crystals in the centre, with opaques and plagioclase. Magnification X 50. Sample #C-48-B.

Photo 4 - Crossed polarized light. Same photograph as #3.


1


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3


4


Plate M

Photo 1 - Plane polarized light. AO1G unit. Olivine, light grey, amphibole dark grey, opaques and plagioclase, white. Magnification X 50, Sample #C-44.

Photo 2 - Crossed polarized light. Same photograph as #1.

Photo 3 - Plane polarized light. AG unit. Amphibole, opaques and plagioclase. Magnification X 50. Sample #C-57-A.

Photo 4 - Crossed polarized light. Same photograph as #3.

M

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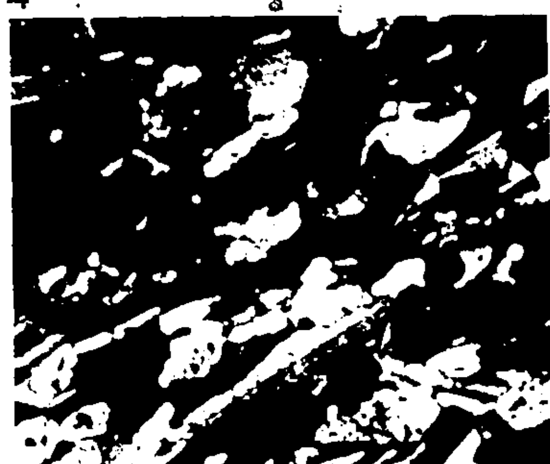
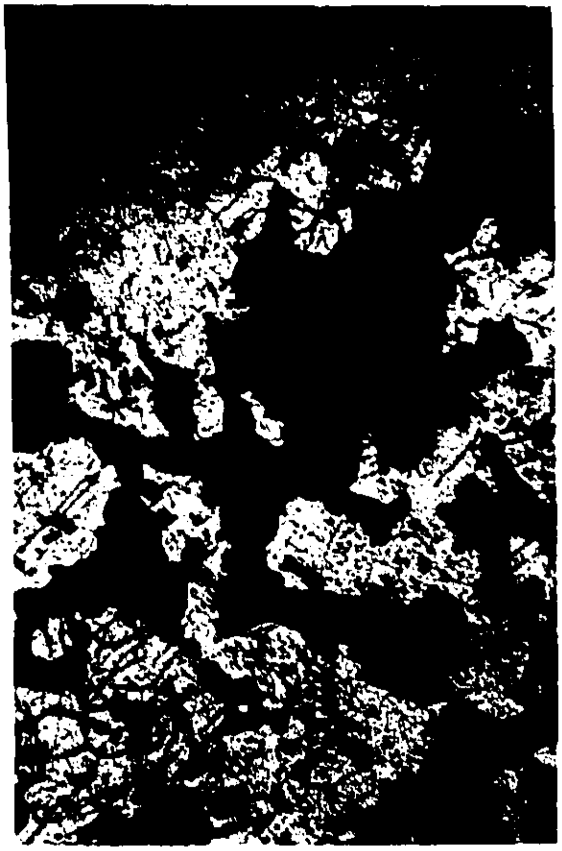


Plate N

Photo 1 - Plane polarized light. Inclusions from intrusion breccia. Clinopyroxene, opaques and plagioclase. Magnification X 50. Sample #C-39.

Photo 2 - Crossed polarized light. Same photograph as #1.

N



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2

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