# CHAPTER IV

# GEOLOGY OF GRANITES



## 4.1 Introduction

The term "granites" or "granitic rocks" is freely used in the broad sense in genrral parts of the thesis, but is replaced by specific names (e.g., G-1, G-2, G-3, G-4, G-5) and names where specified definition from field observation are desirable.

Granitic rocks in the area studied occupy more than two-third of the total surface exposures (about 80 $km^2$). The specific term "Phuket Plutons" is applied to all granitic rocks which intrude in the wapped area and its vivinity. In general, the granite intrusions most commonly trend in the N-S and NNE-SSW directions. The Phuket Plutons are composite by different period of intrusions and by differences in their lithology. The overall shapes of the Phuket Plutons are more or less elongated. These distinct plutons are separated in the north-central side of the area by a wide screen of the (meta-) sedimentary rocks of the Phuket Group, with fault-contact on the west and an approximate contact on the east (Map 2). Approximate contact boundaries between granites or between gtanites and their country rocks are also rather common. Sharp contacts between two granites are rare whereas those with the country rocks are distinctively common.

## 4.2 Classification

The granitic rocks of the Phuket Plutons are classified following the recommendation of the IUGS (International Union of Geological Science) for the nomenclature of plutonic rocks (Streckeisen, 1973). The main classification is shown in Figure 3b. They are all considered to be granites, according to their modal percentages of quartz (Q), alkali feldspar (K) and plagioclase (P), which Q+K+P = 100 (Figure 3A). Detailed data of modal analyses are present in Appendix 1. It may be emphasized that most granites of the Phuket Plutons fall near the center of the QKP triangle which are nearly the same as the most widespread granites stated by Streckeisen (1973). According to this subcommission the granite is further subdivided into syenogranite (subfield A) and monzogranite (subfield B). The coarser-grained biotite granites (G-1 including G-2) are plotted on monzogranite whereas the finer-grained biotite-muscovite granites (G-3, G-4 and G-5) are predominantly located in the syenogranite subfield and subordinate in the monzogranite subfield. These modal compositions can be used to distinguish the coarser-grained types from the finer-grained types.

## 4.3 Geology of Phuket Plutons

The granites of the Phuket Plutons in the studied area have been collectively grouped on the basis of field observation. They are able to be grouped into, at least, five types, namely :

1. Coarse-grained porphyritic biotite granites (G-1)
2. Medium-to fine - grained biotite granites (G-2)

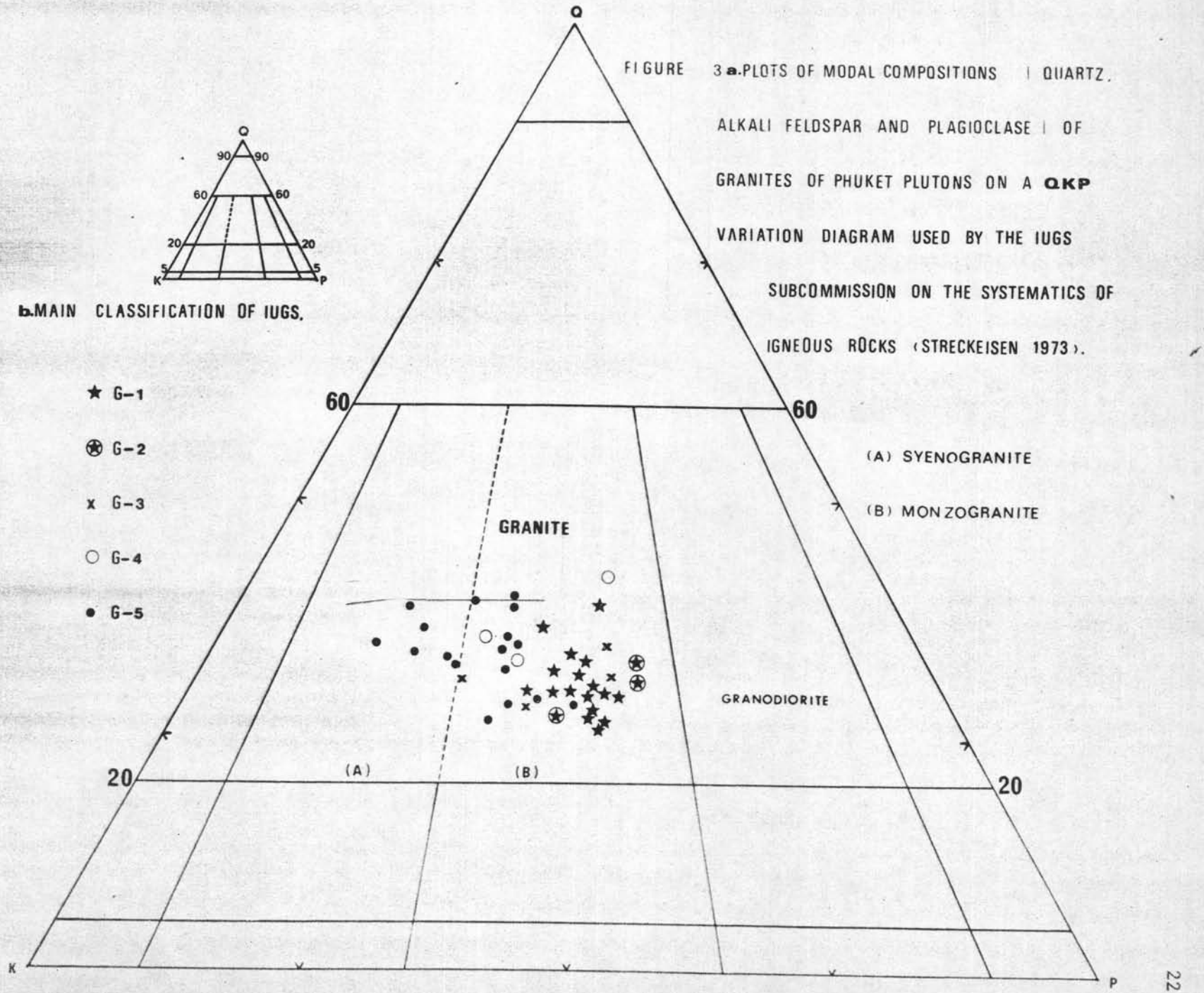



FIGURE 3 **a.** PLOTS OF MODAL COMPOSITIONS ( QUARTZ, ALKALI FELDSPAR AND PLAGIOCLASE ) OF GRANITES OF PHUKET PLUTONS ON A **QKP** VARIATION DIAGRAM USED BY THE IUGS SUBCOMMISSION ON THE SYSTEMATICS OF IGNEOUS ROCKS (STRECKEISEN 1973).

**b.** MAIN CLASSIFICATION OF IUGS.

3. Medium - to coarse - grained biotite - muscovite granites, slightly porphyritic (G-3)
4. Fine - to medium - grained biotite - muscovite granites, locally porphyritic (G-4)
5. Fine - grained biotite - muscovite - tourmaline granites

This classification of granites is based on traditional grain--size classification suggested by Compton (1962). The coarse-grained granites in this thesis are referred to those having average grain size over 5 mm whereas the medium- and fine - grained granites are those having average grain size about 1-5 mm and less than 1 mm, respectively.

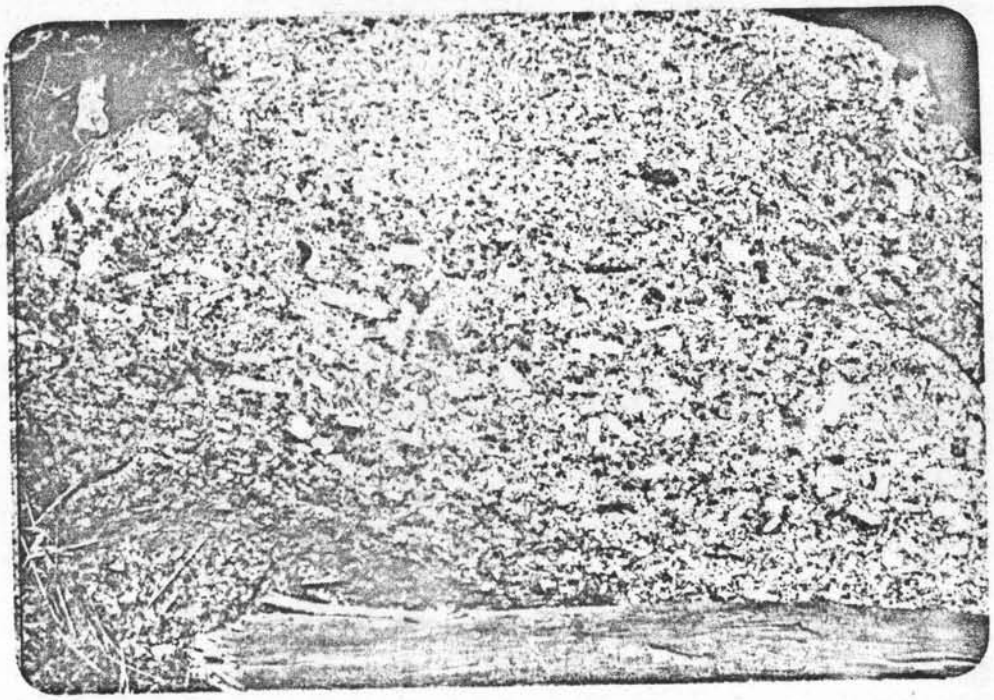
### 4.3.1 Coarse-grained Porphyritic Biotite Granites (G-1)

The granites of G-1 collectively occupy a total area not less than 35 $km^2$ which is about 45 percent of the surface area of the Phuket Plutons. It is the largest pluton of nearly elongate shape. The main mass of the pluton lies on the north-central part of the area (i.e., Khao Bang Nieo Dam and Khao Khek Nei) and is extending southward to central part of the area (Khao Kwan Wa). The minor pluton intrudes in the south-central part (wholly covering Khao Nakha). The granite terrain is invariably rugged which is characterized by steep-side valley with large accmulation of granite boulders and floats along the floor. There are several places, especially northwestern and southcentral parts, where the exposures are very good on the steep slopes. The granites are generally highly weathered due to wet and humid climate, dense vegetation and thick top-soil. The type areas for the rocks of G-1 are best shown at Chao Mine's quarry (3 km west trom Phuket Town), Kata's quarry (4 km southwest of Phuket

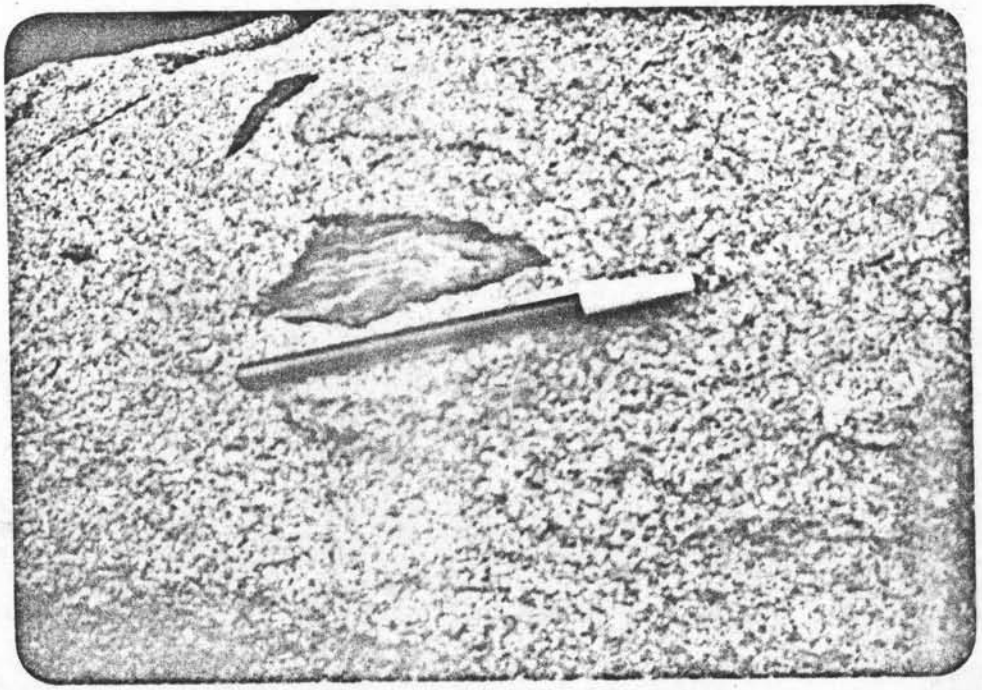
Town) and Kathu Fall (2 km northwest of Amphoe Kathu).

In general, most of the rocks are highly porphyritic and more or less foliated (Photograph 2). The foliation is defined by the arrangement of potash feldspar phenocryst and the mafic mineral of the groundmass (i.e., biotite). The foliation direction is about NNW-SSE. The biotite-rich mafic schlieren are locally abundant at Khao Nakha and Khao Khek Nei. Such schlierens and elongated inclusions are aligned parallel to the foliation direction. The contacts between the upper Paleozoic sediments and the granites are generally sharp. It is presumably a fault-contact which can be clearly defined from aerial photographic interpretation and field observation. Very good exposures of this contact are at the steep-side valley between Khao Bang Nieo Dam and Khao Chetra where fault-contact is located along the fall. Along the contact zone, the granite shows no marked reduction in grain size, little evidence of chilled margin, and minor assimilation of sedimentary material. On the contrary, the broken grains of K-feldspar phenocrysts and quartz should be rather good evidence that the fault occurred after the emplacement of the granite, such cases are also found at southeastern parts of Khao Khek Nei and along the ridge of Khao Nakha.

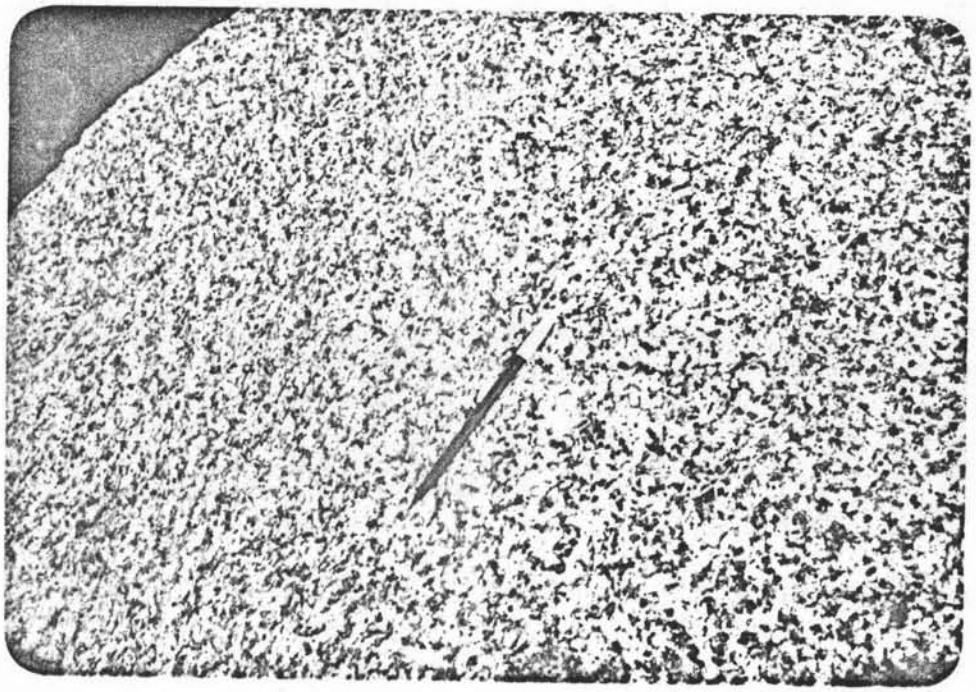
Inclusions in the G-1 granites are not abundant in this area, except at Khao Kwan Wa and the central part of Khao Khek Nei. They range in size from 20 cm length down to less than 1 cm. The inclusions are usually elongated in shape and aligned in the same foliation direction. The inclusions are tiny aggregates of glomeroporphyritic mafic minerals (mostly biotite) which are about 2 mm in diameter. Femic minerals,



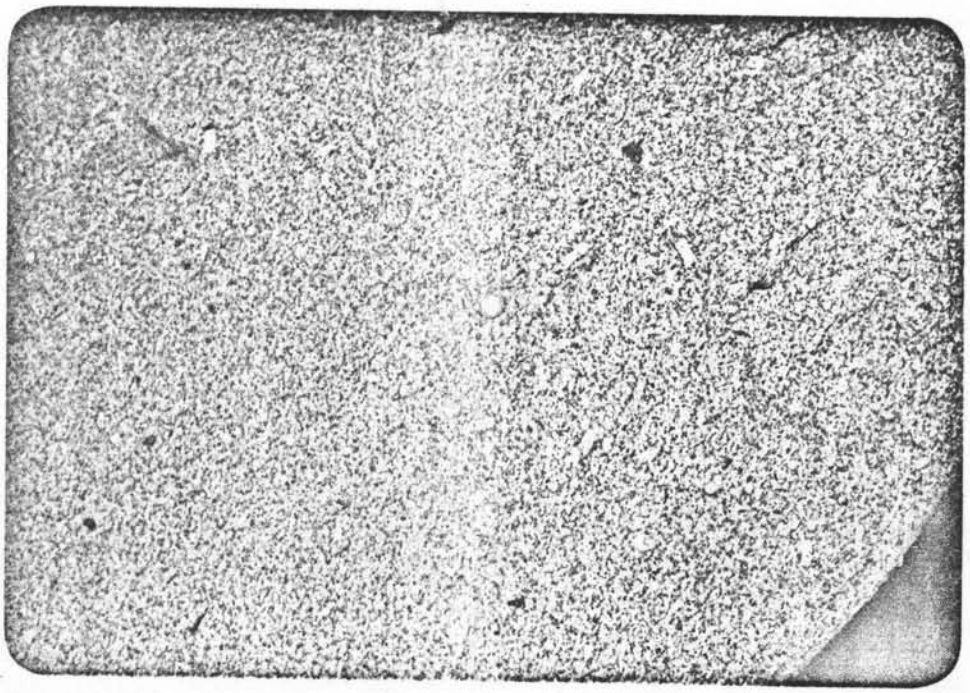
Photograph 2. Feldspar phenocryst alignment in coarse-grained porphyritic biotite granite (G-1) at top of Khao Kwan Wa.



Photograph 3. Xenolith (9 x 4 $cm^2$) showing alternate bands of dark and light colors of probably sedimentary origin in fine-grained biotite-muscovite granite (G-4) at Khao Nai Grang.

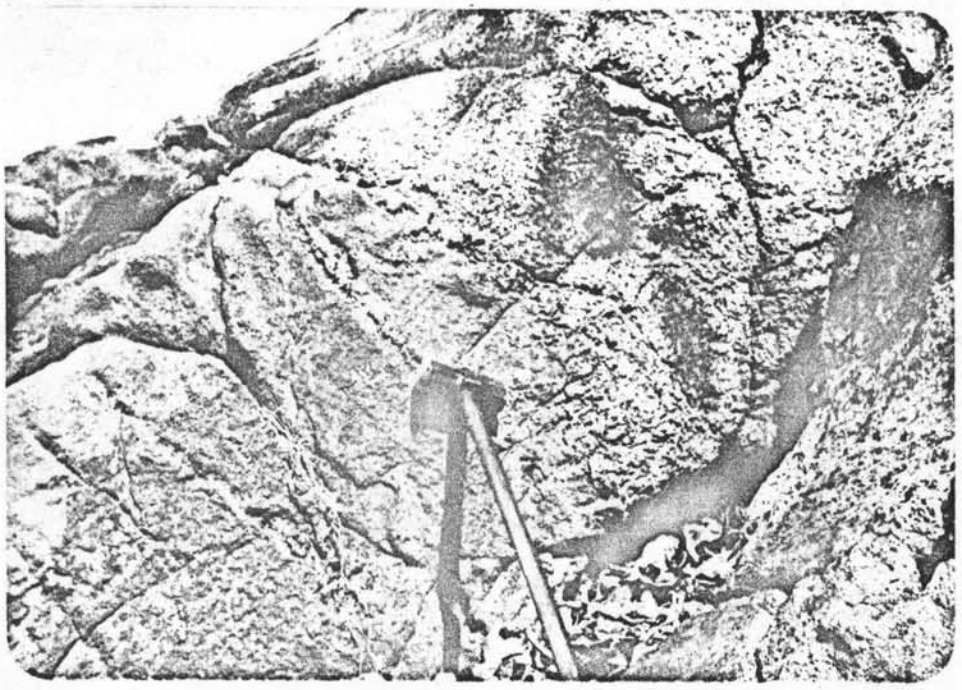


Photograph 4. Medium-grained biotite granite (G-2) showing locally faint foliation approximately along the pen (at Ko Maprao)



Photograph 5. Fine-grained leucocratic biotite-muscovite granite (G-4) at Khao Nai Grang.

Photograph 6. Coarse-grained porphyritic biotite granite (G-1) cut by younger fine-grained biotite-muscovite granite (G-4) at Khao Nai Grang.



Photograph 7. The same coarse-grained biotite granite (G-1) as in Photograph 6 occuring as an autolith in younger fine grained biotite-muscovite granite (G-4) at Khao Nai Grang.

quartz and feldspar, are extensively rare. At some exposures, the granites are so crowded with inclusions that it is not representative, consequently chemical and modal analyses are not practical and cannot be made.

The G-1 granites, a major phase of the Phuket Plutons, are believed to intrude in this area before other granites As shown in Map 3, this type of granites is also marked by the small amount of pegmatite and aplites cropping out in the area.

4.3.2 Fine - to Medium - grained Biotite Granites (G-2)

The granites of this type expose as several small separated intrusions in the eastern part of the area. They form oval shapes and crop out only at Ko Maprao and at Khao Pan Thu Rat. They are exposed over an area of about 4 $km^2$ or about 5 percent of the Phuket Plutons. Mostly, the G-2 granites contact with or are intruded by the G-4 and G-5 granites (Map 2). On the other hand, it is believed that the G-2 type was formed at the same period as the G-1 type, but the exact relationship between these two granite types is still not clear due to the fact that the actual contact between these granites has not been found. The sediment/granite contacts are found at two places, i.e., at the top of Khao Pan Thu Rat and northern part of Ko Maprao. Such contacts are not sharply defined and can be traced only for short distance.

The granites also contains abundant even-grained inclusions ranging in size from 1 cm to 60 cm. The maximum size of the elongated inclusion is about 20 x 60 cm . These inclusions are concentrated only at Ko Maprao whereas at Khao Pan Thu Rat, they are absent. The inclusions are composed mainly of the mafic mineral aggregates (glomeroporphyritic)

with sparsely distributed felsic mineral as feldspar. The mafic schlieren are locally abundant also at Ko Maprao. Minor intrusions are normally rare.

4.3.3 Medium - to Coarse - grained Biotite - muscovite Granites (G-3)

This type of granites crops out over an area of about 13 $km^2$ or about 15 percent of the Phuket Plutons. It has previously been included in the G-1 granite (Hummel & Pawandon, 1967 and Garson,et al.,1975). From this field observation, it is noteworthy that it is mineralogically and texturally different from the G-1 granites. The G-3 granite forms as two separated stocks which locate distanctly apart. These two stocks occupy approximately the same area of 6 $km^2$. One is found at Khao Pak Bang and the other at Khao Mai Tao Sip Song. Small intrusions of the G-3 granites are also exposed locally at Khao Trai Trang and Pin Yok Mine. The general physiographical feature of the granite is quite similar to that of G-1. The best representative rocks of the G-3 granites are at Pin Yok Mine and those expose along the beach of Khao Pak Bang. In general, the coarse-grained type is characterized by the foliation resulting from alignment of phenocrysts whereas in the finer-grained varieties, the foliation is less distinct due to a rather obscure porphyritic texture. The former is found at Khao Pak Bang and the latter is at Khao Mai Tao Sip Song. Most of these granites are in contact with the fine-grained biotite-muscovite granites (G-4) either at gradational or faulting. The contact between G-3 and sedimentary rocks is sharp in several places, particularly at the eastern slope of Khao Mai Tao Sip

Song. Minor intrusives are more common than those found in G-1 and G-2

4.3.4 Fine-to Medium-grained Biotite-muscovite Granites (G-4)

The G-4 granites comprise several small separate intrusive stocks which occupy a total area of about 26 $km^2$ (or about 30% of the Phuket Plutons). The granitic intrusions are generally elongate in shape, they can be found at Khao Sapam, Khao Rang, Khao To Sae, Khao Pan Thu Rat, Khao Kaw and Khao Na Kha Lae. The typical G-4 granites are found at the quarries of Khao Rang and Khao To Sae. Frequently the G-2 granites intrude into the Upper Paleozoic sediments of the Phuket Group and also into the coarser-grained biotite granites of G-1. The sharp contacts between G-4 and the country rocks are commonly found in many places, i.e., at eastern slopes of Khao Sampan and Khao To Sae, whereas the contacts with the G-1 granites are rare. The G-4 type appears to be of later-stage intrusion of Phuket Plutons as indicated by its cross--cutting the feldspar phenocrysts of G-1 (Photograph 6). Moreover, some G-1 xenoliths are found in this G-4 (Photograph 7). As shown in Map 2, G-4 intrudes in G-2 and G-3 at Khao Pan Thu Rat and at Khao Pak Bang, and Khao Mai Tao Sip Song, respectively.

From the mentioned evidence, this type of granites (G-4) is consequently, the latest major phase of the acid igneous activities. In general, the physiographic features of the granites are marked by low relief, gentle slope due to violent effect of erosion and denudation Such interaction of surface processes is probably the reflection of the main mineral composition of the granites such as feldspar minerals. These features seem to be quite different from the granites that Pitakpaiwan (1969) mentioned in his studies on tin-bearing and tin-barren granites.

In addition, there is also minor type of granites which should be grouped into this type (G-4). This minor type of granites is referred to also in some sections of the thesis as greisen or greisenized granites (named after Janecka & Stemprok, 1967). Greisen is a characteristic of this type of granite, particularly where the granite is mineralized (Khao Sapam) or where the granite intrudes into the country rocks (Khao To Sae). It is manifested by the decomposition of feldspar and biotite and by the formation of quartz, mica and some ore minerals (i.e. fluorite) in the rocks. These granites have undergone such alteration that chemical analyses of major elements are no longer representative. The greisens as suggested by Hosking (1967, 1969) and Sheraton & Labonne (1978) were probably formed by pneumatolytic alteration of granites in the roof zone of the intrusion during the final stage of the magma crystallization. Cassiterite is also present in G-4 in trace amount at Khao Sapam. It occurs as brownish black crystals which may be as large as 0.5 cm. The granite is believed to be tin-bearing not only from the precence of cassiterite but also from the data of geochemistry.

Inclusions locally concentrate particularly at Khao Nakhalae and Khao Tritrang. They are clusters of biotite-muscovite inclusions or biotite accumulates, some are probably laminated hornfelses. The metasedimentary xenoliths with the maximum size 10 x 15 cm are elongated and aligned in the same direction of foliation of G-4 at Khao Nakha Lae where slightly porphyritic texture is present.

4.3.5 Fine-grained Biotite-muscovite-tourmaline Granites (G-5)

This type of granites occurs in a relatively very small amount comparing to those of the other types. It crops out at least in four

parts of the area, i.e. Ko Maprao, Khao Nai Grag-Traitrang, Patong Beach, and along the road from Kathu to Patong. Most of the granites are generally associated with the finer-grained varieties. It forms a lens-like bodies mainly along the fracture zones or along the intrusive contacts. Garson and other (1975) stated that the age of tourmaline-rich granites is probably the same as that of pegmatites and other minor intrusives.

4.3.6 Other Granitic Rocks

Garson and others (1975) noted the other type of granitic rocks of Phuket Plutons cropping out nearby the studied area, one at Khao Prathiu of the north and the other at small hills of Karon in the southern part. They generally form elongated intrusions. According to their studies, the rocks vary in compositions from hornblende-biotite granites to hornblende granites and granodiorite. The granitic rocks have allotriomorphic granular to hypidiomorphic granular/porphyritic texture. Felsic minerals comprise quartz, alkali feldspar and plagioclase. Quartz occurs in a small amount. Alkali feldspar includes both orthoclase and microcline. The latter usually forms poikilitic phenocryst and is perthitic. Plagioclase of a composition of mostly oligoclase/andesine is over alkaline feldspar. Biotite is the prominent ferromagnesian mineral, and there is also a variable but small amount of hornblende and clino pyroxene. Sphene, allanite, rutile, zircon, pyrite and ilmenite are common accessories. These granites which were described by Garson and others (1975) are probably the equivalent of the older granites of Brown and others (1951). Similar rocks also occur in the westcentral part of Malaysia, where the main rock-types have been studied and named

as the Benom Igneous Complex by Ahmad (1979) and also in the northern part of Thailand as Tak Granites by Pongsapich & Mahawat (1977).

## 4.4 Minor Intrusives

Many kinds of pegmatites occur throughout the mapped area especially in the western and central parts where a great amount of granite varieties and their country rocks are exposed (Map 3). Some of them contain considerable amount of tin whereas the others are tin-barren. Many tin mines in the area have been operated along the pegmatite zones for long times. The pegmatites form dykes and sills of lenticular, sheet-like bodies, and irregular pods. The thickness ranges from less than 0.25 m up to more than 20 m. Its length can be traced over a distance of 1 km. Large pegmatites frequently associate with aplites and quartz veins as seen at Tor Soong and Pin Yok mines.

Previous classification of pegmatites in the area and its vicinity was primarily done by Hummel & Pawandon (1967). They divided pegmatites on the basis of textural criteria, coarse-grained and fine-grained types. Garson and others (1975) grouped pegmatites into 2 kinds based upon mineral composition, namely mica-tourmaline pegmatite and lepidolite-rich pegmatites. Bleackley and others (1965) have examined the heavy minerals obtained from pegmatites of 2 mines in the Kathu Valley. They found that the heavy minerals are mainly garnet, ilmenite, topaz and cassiterite accompanied by smaller amount of zircon, ilmenorutile and pyrite. Beside these, Gocht & Pluhar (1979) recently studied tin-bearing

pegmatites in the area around Kathu Valley. They suggested a classification of such pegmatites by combining the geochemical and mineralogical criteria as Sn-Mo-Ta mica free pegmatite, Sn-W-Ta-Nb-REE muscovite pegmatite and Sn-Li-F-W-Ft-Nb-REE lepidolite pegmatite. In addition, they also mentioned that the composite texture of pegmatites, especially tin-bearing ones are mainly due to multistage alteration including albitization and kaolinization. The present classification of pegmatites is based upon the mineralogical criteria and amount of accessories present but in a greater field-details than the previous classifications. The pegmatites can be divided into 6 types :

(1) Muscovite-biotite pegmatites.

(2) Tourmaline-muscovite pegmatites.

(3) Lepidolite-rich pegmatites.

(4) Tourmaline-rich pegmatites.

(5) Quartz-feldspar pegmatites.

(6) Miscellaneous types.

(1) Muscovite-biotite pegmatites.

This type of pegmatites occurs in several places. All of them associate only with granites. The largest mica-rich pegmatite in G-1 granites, about 6 m thick and trending NE direction is along the Kathu--Patong Road. Here, biotite is more abundant than muscovite. Another big one (about 5 m thick) is at Kathu-Kamala Valley, where it cuts across the G-4 granite in NW direction and contains a high amount of muscovite. However, several small pegmatites (about 2 m thick) of this type are also found at Khao Kaw, Khao To Sae and NE of Chao Fa Mine. In general,

the rock is composed mainly of quartz, feldspar, large plates of muscovite (up to 2 cm), and flakes of biotite of about 5 mm in size. Accessories are zircon, ilmenite, magnetite.

(2) Tourmaline-muscovite pegmatites.

Among the pegmatites in the area, tourmaline-muscovite pegmatites seem to be mostly abundant and they are found in both granites and sedimentary rocks. At least 30 localities of such pegmatites are of mappable sizes and 9 localities will be mentioned in this paper. Their thickness varies in sizes from 20 cm up to 30 m. Generally, the pegmatites are coarse-grained to very coarse-grained and highly leucocratic. They contain major phase quartz and feldspar (up to 5 cm length) and are characterized by the presence of tourmaline in association with muscovite as a common accessory. The other accessory minerals are cassiterite, i ilmenite, wolframite, garnet, zircon, rutile, arsenopyrite and a trace of monazite was recorded by Gocht & Pluhar (1979). Tourmaline forms long euhedral crystals (average about 1-2 cm. in length) with prominent parting. Its color may vary from black to blueish black. The long prismatic, blueish black tourmaline with the maximum size about 2.5 x 10 cm occurs at Khao Nakha Lae. Muscovite forms a large plate up to 3 cm across. Biotite is rare and may be locally present as small flakes such as at Khao Pak Bang. The largest pegmatite observed is that of Tanitkovit mine cutting across sedimentary rocks of Phuket Group. Its thickness is not less than 30 m and its body can be traced at least as far as 250 m along the excavated trench. Tantikovit pegmatite is a tin-bearing type, highly kaolinized and trending NNE. The other kaolinized pegmatites of this

type are at Pune Thawee, Kiet Sa-nguan, and Pad Roi mines. All pegmatitic dykes are thicker than 5 m. Most of the tin-bearing pegmatites extend in the NNE/SSW direction (see details in Chapter v). In addition to these highly kaolinized pegmatites, there is another variety in this group, tourmaline-muscovite-garnet pegmatite. It crops out particularly at eastern slope of Khao Mai Tao Sip Song near the contact zone between G-3 and the country rocks. This pegmatite, (2 m thick) trending WSW and cutting into laminated protoquartzite contains large muscovite plates, long black tourmaline crystals and a considerable amount of reddish brown euhedral crystals of garnet (5 mm diameter).

(3) Lepidolite-rich pegmatites.

Most of the lepidolite-rich pegmatites intruded parallel to the Phangnga Fault and Klong Marui Fault (Garson and Mitchell, 1970). They occur at two places at the Kathu Valley at Ban Nguan Mine as large dykes, and at Tantikovit Mine as irregular pods. The rock is rather medium-grained, pale purplish pink-coloured, and locally kaolinized. The large pegmatite at Ban Nguan Mine trends NE and dip about 45° SE, forming lenticular sheet-like body associated with muscovite pegmatite and small quartz veins. It can be traced far more than 100 m along the strike and has the thickness as much as 6 m. The pegmatite seems to contain an appreciable quantities of cassiterite. Garson, et al (1975) reported that lepidolite pegmatite at Reung Kiet Mine, Phangnga contains up to 3% $Li_2O$ and as high as 300 ppm Sn. Hummel and Phawandon (1967) described layered structures consisting of fine-to coarse-grained felsic bands with a variation of brown and black tourmaline, white mica, pale

garnet and small amount of cassiterite and wolframite. Unfortunately, during the field investigation, many important data were not available because of flooding caused by heavy rainfall. Tantitamsophon (1980, pers. comm.) believes that the lepidolite-muscovite pegmatite should extend far more than 5-6 km from Chao Fa Mine northwards to the richer in lepidolite at Ban Nguan Mine.

(4) Tourmaline-rich pegmatites.

Tourmaline pegmatite is another type of pegmatite found. Mostly it occurs in the southern part of the area, Khao Nai Grang and Khao Tri Trang. All the pegmatites align in the NNE direction, are rather small bodies and the thickness never exceeds 8 m (averaging about 2 m). It is always found in the G-3 and G-4 granites. Tourmaline forms euhedral prismatic crystals and is not as large as that found in tourmaline-muscovite pegmatite. However it occurs in a notable amount throughout the body. Feldspar and quartz are still the major constituents, muscovite is rare, forming very tiny flakes.

(5) Quartz-feldspar pegmatites.

This type of pegmatite occurs only at Tor Soong Mine. It forms many sets of dykes sharply cross-cutting micaceous shales, mudstone/graywacke, and arkosic sandstone of the Phuket Group. The most important pegmatites form two sets extending in two directions, one, tin-bearing, trends about NNE and dips steeply to the SE, the other tin-barren, trends at approximately 330° to 340° (NNW) and dips moderately to the NNE. The NNE-trending pegmatite (about 200m in length) clearly cuts the NNW one

The tin-bearing pegmatite, forms large 3 sheet dykes (about 5 m thick), is highly kaolinized, and always associated with quartz veins and aplitic dykes. The tin-barren pegmatites never exceed 3 m in thickness and are less weathered than the tin-bearing ones due to the fact that they contain a higher amount of quartz than feldspar minerals. Nevertheless, both of the pegmatite varieties have the same major mineral assemblage comprising coarse-grained quartz, orthoclase, and albite with very small amount of acicular tourmaline crystals and some tiny flakes of muscovite. The very interesting thing about muscovite is that it is richer and darker in tin-barren pegmatites than it is in the tin-bearing ones. Accessories present in the tin-bearing are cassiterite, wolframite, almandine, zircon, sphene, rutile and apatite (?). Columbite was recorded by Garson and others (1975) whereas tantalite and monazite traces were noted by Gocht & Pluhar (1979). According to Garson and others (1975), a small amount of scheelite ($CaWO_4$), occurs as pale yellow, rounded grains in one drainage ditch of Tor Soong Mine.

(6) Miscellaneous types.

There are also 2 types of pegmatites which occur as thin sheet and are always associated with other pegmatites. Muscovite pegmatite (1 m thick) occurs at Pin Yok Mine associated with tourmaline muscovite pegmatite. The rock is highly kaolinized and composed mainly of quartz, feldspar, large plates of muscovite with small amount of tiny tourmaline aciculars. A smaller one (0.25 m thick) occurs at Khao Kaw. Another type is biotite pegmatite ( 1 m thick) occurring at Khao Nai Grang,

cross-cutting the G-3 granite. The rock comprises quartz, feldspar, and large plates (2-4 mm) of bluish black biotite as major component with traces of muscovite and tourmaline grains.

Mostly the pegmatites intrude along the NE-trending fractures (Map 3). Such NE-trending fractures are more or less parallel to the late Mesozoic large-scale faulting, i.e. Klong Marui Fault and Ranong Fault. As shown in Table 1, Garson and others (1975) reported that 2 samples of pegmatites in Phuket and Phangnga areas are dated at Tertiary Ages. This, consequently, show the close structural and age relation to these two regional fractures.

4.4.2 Quartz Veins and Aplitic Dykes

Quartz veins and aplitic dykes are not as common as pegmatites, however, they occur sometimes associated with pegmatites. Large quartz veins are abundant in Kathu area and intrude the metasedimentary rocks of the Phuket Group. The rocks are white to fawn, composed mainly of quartz with minor amounts of pyrite, arsenopyrite, and tourmaline. Aplitic dykes are less common than quartz veins. Large aplitic veins associated with pegmatite are found at Sahakit Mine. The rock contains quartz, feldspar, muscovite, and sometimes tourmaline. Cassiterite and wolframite occur as a trace amount both in quartz veins and in aplitic dykes. All veins from sharp contacts to their host rocks and generally strike NE-SW with rather steep dips. Some veins are as wide as 5 m and can be traced for more than a half kilometer long particularly at Pan Thu Rat (Map 3).

## 4.5 Geochronology

The age relations of the Phuket Plutons, in some cases, could be established from field observation especially in places where contacts are clear and distinct. Where the sharp contact are absent, however, a transitional zone may be developed. In the first case, at Khao Nai Grang, the granites form well-defined contact. As shown in Photograph 6 and 7, the G-1 granites are intruded by the G-4 granites shown by the crosscut feldspar phenocryst and the xenolith of the former by the latter. However, from the present study, it is apparent that transitional zones between the various granite phases are quite common. For example, at the western slopes of Khao Mai Tao Sip Song, the G-3 granites grade into the G-4 granites, and at the northern part of Khao Pan Thu Rat where G-2 is transitional to G-4. It is suggested from the field evidence and datings (Table 1) that the coarse-grained highly porphyritic granites (i.e. G-1) seem to be the oldest prominent phase in the area studied (of Phuket Plutons). This coarse-grained type at Khao Nai Grang can be correlated with the pluton of Khao Khek Nei which has been dated by Rb/Sr method at about 114±7 Ma (Garson et al., 1975).

Data on isotopic-age determination on granites are not well established in mapped area. The radiometric datings of igneous rocks in the vicinity area on Phuket Island was firstly executed on the mica granite by Dr. J. Aldrich, Carnegies Institution of Washington, D.C. (Pitakpaiwan, 1969). The Rb/Sr and K/Ar methods of datings of this granite reveal the Late Cretaceous (85±5 Ma) and Early Tertiary (60±5 Ma),

Many papers on granite dating such as those of Snelling and others (1970), of Bignell (1972), of Garson and others (1975), of Suensilpong & Putthapiban (1979), and of Beckinsale and others (1979) summerized that the coarse-grained porphyritic biotite granites (G-1 of Phuket Plutons) and hornblende adamellite have an average age of Early ? Cretaceous (124 4 Ma). According to Garson and others (1975), the important episodes of emplacement of coarse-grained porphyritic biotite granites and adamellites in Phuket Island and nearby areas should be at an age of 115±7 Ma (Early Cretaceous) by using the Rb/Sr method. On the contrary fine-grained two mica granite from Khao To Sae yields a significantly younger whole-rock age of 56±2 Ma (Early Tertiary) by using the same method. Beckinsale and others (1979) has dated the fine-grained mica granite from Phuket Island using the Rb/Sr whole rock method and concluded that the granite consolidated at an age of Middle Cretaceous.

From these available data, the possible sequence of granite explacement from the older to the younger could be as follows :

(1) coarse-grained porphyritic biotite granites (G-1) accompanied by fine-to medium-grained biotite granites (G-2).

(2) medium-to coarse-grained slightly porphyritic biotite-muscovite granites (G-3).

(3) fine-to medium-grained biotite-muscovite granites, locally porphyritic and highly greissenized (G-4).

(4) fine-grained biotite-muscovite-tourmaline granites (G-5) and minor intrusives.

Table 1 Compilation of Radiometric Age Determination on Granite Rocks in the Studied and Adjacent Areas.

| No. | Sample Location | Rock Type | Rb/Sr Age Ma (whole rock) | K/Ar Age Ma (minerals) | Source |
|---|---|---|---|---|---|
| 1 | Boulder on main road, 55 km. N of Phuket, Takua Pa | biotite granite | 222 | - | Bignell (1972) |
| 2 | Khao Khek Nei, Phuket Island | porphyritic biotite granite | 114 ± 7 | B 54 + | Garson et al. (1975) |
| 3 | Khao Prathiu, Phuket Island | hornblende biotite adamellite | 109 + 40 | B 54 + 2 | - ditto - |
| 4 | Khao Khanim, S of Takua Pa, Phangnga | porphyritic biotite granite | 107 + 5 | M 65 + 2 | - ditto - |
| 5 | Khao Kuan Kha, SW of Phangnga | porphyritic biotite granite | 120 + 5 | - | - ditto - |
| 6 | Beach on west coast, N of Phuket Island, Takua Pa | coarse grained biotite granite | 119 | - | Bignell (1972) |

| No. | Sample location | Rock Type | Rb/Sr Age Ma (whole rock) | K/Ar Age Ma (minerals) | Source |
|---|---|---|---|---|---|
| 7 | Beach, Mad Surin, NE of Khao Khek Nei, Phuket Island | porphyritic hornblende biotite granite | 209 | - | Bignell (1972) |
| 8 | Khao Pathiu, Phuket Island | hornblende biotite granite | 109 | B 53.7 ± 1.8 | - ditto - |
| 9*1 | Phuket Island, unclarified location | biotite granite (I-type) | 124 ± 4 | - | Snelling (1970) |
| 10 | Quarry near Phuket Town, (Khao Fa Mine ?) | biotite granite | 140 | - | Bignell (1972) |
| 11 | Quarry 5 km. N of Phuket Town, Khao Tang | biotite muscovite granite | 75 | M 56 ± 1.5 | Bignell (1972)<br>Suensilpong & Putthapiban (1979) |
| 12*2 | Phuket Island, unclarified location | biotite muscovite granite (S-type) | 108 ± 5 | - | Beckinsale (1979) |

| No. | Sample Location | Rock Type | Rb/Sr Age Ma (whole rock) | K/Ar Age Ma (Minerals) | Source |
|---|---|---|---|---|---|
| 13 | Khao Fo See, Phuket Island | biotite muscovite granite | 56 ± 2 | - | Garson et al.,(1975) |
| 14 | Khao Mai Khao, Phuket Island | muscovite granite | ? | M 60 ± 5<br>M 85 ± 5 | Pitakpaivan (1969) |
| 15 | Phuket Island, northern end | biotite muscovite granite | 139 | - | Bignell (1972) |
| 16 | Lang I Tum Mine, Phangnga | lepidolite pegmatite | - | L 52.1 ± 1.5 | Bignell (1972) |
| 17 | Road from Phuket Town to Patong, Phuket Island | tourmaline muscovite pegmatite | - | M 56.6 ± 1.7 | Bignell (1972) |

M = Muscovite B = Biotite L = Lepidolite

*1 $Sr^{87}/Sr^{86} = 0.7073 \pm 13$

*2 $Sr^{87}/Sr^{86} = 0.7293 \pm 5$