CHAPTER 3

PETROGRAPHY

3. 1 Granitic Rocks

3. 1. 1 Modal analysis data

25 modal analyses of the Mae Chedi granites were determined and presented in Table 3.1. The amount of the combined quartz and feldspars (felsic minerals) ranges approximately from 83 to 99 percent of the total mineral constituents. Except the GM-1 granitic rocks, the felsic minerals of the other GM- and the GR- granitic rocks collected in the study area, constitute well over 90 percent of the total mineral constituents. It is clearly seen that the average felsic mineral contents progressively increase both from the GM-1, the GM-2 to the GM-3 and from the GR-1, the GR-2 to the GR-3, i.e., from 85.82, 93.40 to 94.45 and from 92.21, 95.55 to 98.41, respectively. It should be noticed that in the GM- granitic series, the felsic mineral contents of the GM-2 are much greater than the GM-1 but just a little less than the GM-3. However, the difference of the felsic mineral contents, in sequential order, in the GR- granitic series are considerably the same. Another important contrasting feature of the felsic minerals between the GM- and the GR- granitic series is their feldspar content as illustrated in Table 3.1. In the GM- granitic series, plagioclase is the most abundant phase in the GM-1 and GM-2 then its quantity remarkably declines in the GM-3 whilst K-feldspar is the least abundant among the felsic constituents in the GM-1 then become numerous in the GM-2 and it is most widespread

Table 3.1 Modal analyses of the Mae Chedi granites (volume %)

Sample No. (Grid Reference)	Rock Type	Q	Kf	Pl	An-Content in Pl	Bi	ChBi	Mus	Op	Others	Staining Sample
(1) M1 - 13 (499145)	GM -1	27.34	18.27	37.73	An_{34} (An_{27}-An_{45})	13.80	1.43	N.D.	0.90	0.53	thin section
(2) S - 4B (499145)	GM -1	30.00	25.60	30.83	An_{33}	10.07	3.07	N.D.	0.30	0.13	thin section
(3) S - 3 (499145)	GM -1	30.30	28.07	31.23	An_{30}	5.37	3.73	0.10	1.07	0.13	thin section
(4) M1 - 12 (499144)	GM -1	29.90	18.20	35.37	An_{35}	14.97	1.00	N.D.	0.43	0.13	thin section
(5) M1-11-2 (499144)	GM -1	31.80	25.83	31.57	An_{31}	7.77	0.47	1.10	0.73	0.73	thin section
(6) S - 2 (499144)	GM -1	26.24	21.40	35.23	An_{38}	14.67	0.43	N.D.	1.00	1.03	thin section
(7) M1 - 18 (498145)	GM -2	33.87	23.20	34.30	An_{14}	2.63	2.90	2.33	0.53	0.23	thin section
(8) M1 - 11 (499144)	GM -2	28.87	30.97	34.19	An_{5}	1.97	3.23	0.03	0.67	0.07	thin section
(9) M1 - 15 (499144)	GM -2	28.50	32.23	32.87	An_{7}	0.80	4.34	0.13	0.60	0.53	thin section
(10) M1 - 9 (498144)	GM -2	26.57	38.27	30.50	An_{12}	1.66	1.93	0.43	0.37	0.27	thin section
(11) M1 - 7 (498143)	GM -2	27.37	28.70	36.10	An_{5}	0.56	5.20	0.63	1.17	0.27	thin section
(12) M1 - 4B (498143)	GM -2	28.53	29.87	35.47	An_{7}	N.D.	4.93	0.03	1.00	0.17	thin section
(13) M1 - 24 (498145)	GM -3	31.03	33.54	29.23	An_{2}	N.D.	1.73	3.50	0.80	0.17	thin section
(14) M1 - 23 (498144)	GM -3	26.90	41.23	26.17	An_{2}	N.D.	1.57	3.57	0.33	0.23	thin section
(15) M1 - 6 (498143)	GM -3	30.20	30.62	34.42	An_{1}	N.D.	1.68	1.88	0.98	0.22	thin section

Table 3.1 Continued

Sample No. (Grid Reference)	Rock Type	Q	Kf	Pl	An-Content in Pl	Bi	ChBi	Mus	Op	Others	Staining Sample
(16) MD 11 (480229)	GR -1	39.10	33.87	19.88	An_{28} (An_{23} - An_{33})	6.40	n/d	0.60	N.D.	0.15**	rock slab
(17) MD 10 (478210)	GR -1	31.18	39.93	20.82	An_{36}	8.07	n/d	N.D.	N.D.	N.D.	rock slab
(18) MD 6 (502209)	GR -1	33.48	39.78	19.70	An_{32} (An_{12} - An_{55})	6.62	n/d	0.42	N.D.	N.D.	rock slab
(19) MD 7 (497202)	GR -1	35.43	31.48	24.18	An_{34} (An_{13} - An_{55})	8.91	n/d	N.D.	N.D.	N.D.	rock slab
(20) MD 22 (504189)	GR 2	37.03	32.60	26.10	An_{13}	2.07	0.90	0.60	0.57*	0.13	thin section
(21) MD 24 (494171)	GR -2	33.53	40.31	21.53	An_{35}	3.98	n/d	0.13	N.D.	0.52**	rock slab
(22) MD 35 (514267)	GR -3	34.50	31.93	32.34	An_{14}	0.63	0.30	N.D.	0.30*	N.D.	thin section
(23) MD 16 (513232)	GR -3	36.03	31.90	31.66	An_{7}	N.D.	0.10	0.27	0.03*	N.D.	thin section
(24) MD 13 (498222)	GR -3	36.07	30.57	32.53	An_{10}	N.D.	0.10	0.30	0.43*	N.D.	thin section
(25) MD 21 (510193)	GR -3	38.63	26.27	31.20	An_{7}	N.D.	0.13	1.70	0.07*	2.00**	thin section

Abbreviations : Q = quartz, Kf = potassium feldspar, pl = plagioclase, Bi = biotite, ChBi = chloritized biotite, Mus = muscovite, Op = opaque minerals including iron oxides, pyrite, chalcopyrite and arsenopyrite, * iron oxides only, Others including apatite, zircon, sphene, chlorite, and tourmaline (plus scheelite in sample (15) M1-6), ** tourmaline only, N.D. = not detected, n/d = not determined.

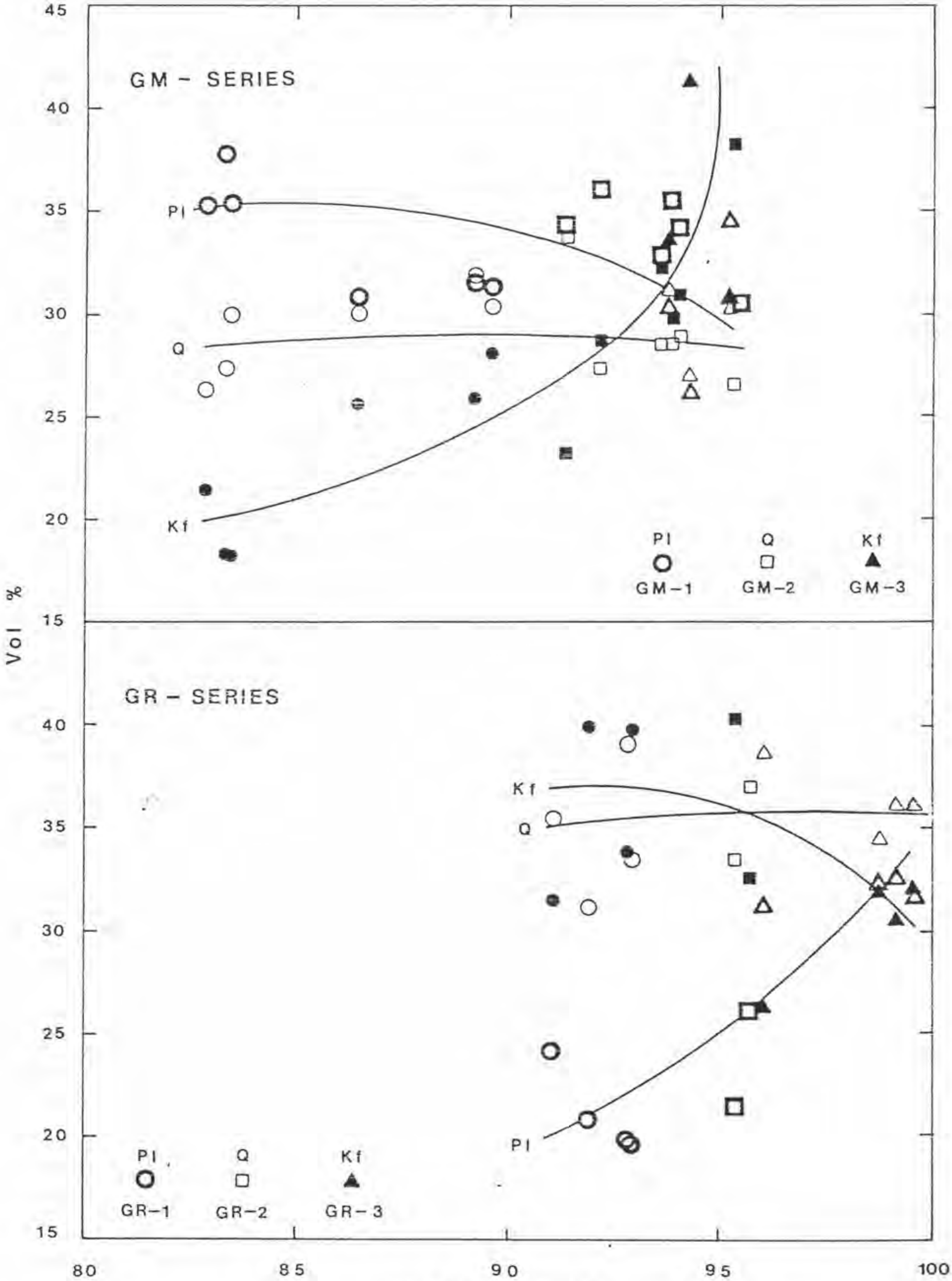


Figure 3.1 Variation of the modal abundance of plagioclase (Pl), quartz (Q), and K-feldspar (Kf) against felsic minerals (Q + Kf + Pl) for the Mae Chedi granites.

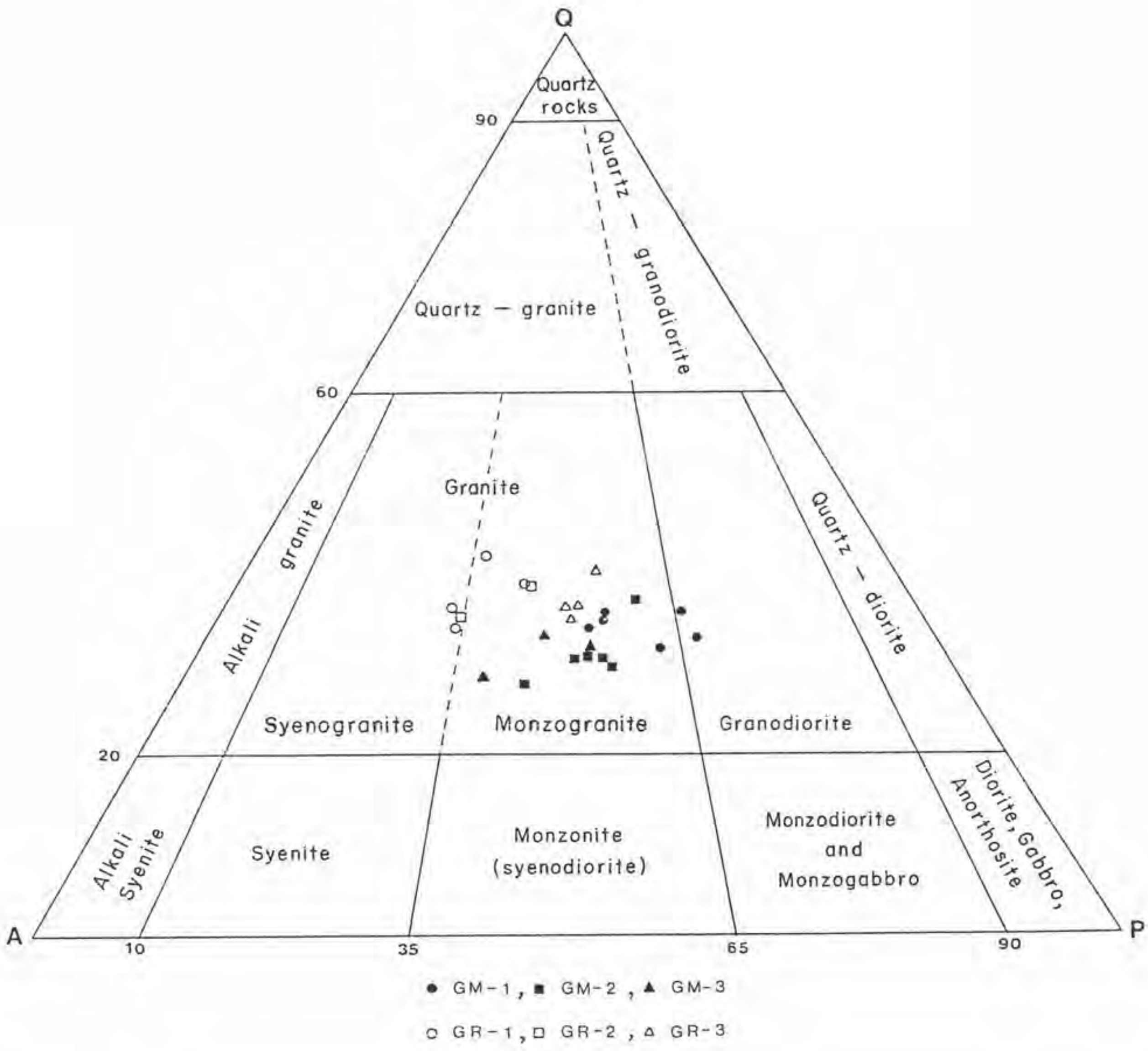


Figure 3.2 Modal quartz, alkali feldspar and plagioclase of the Mae Chedi granites plotted in the plutonic rock classification diagram after Streckeisen (1976).

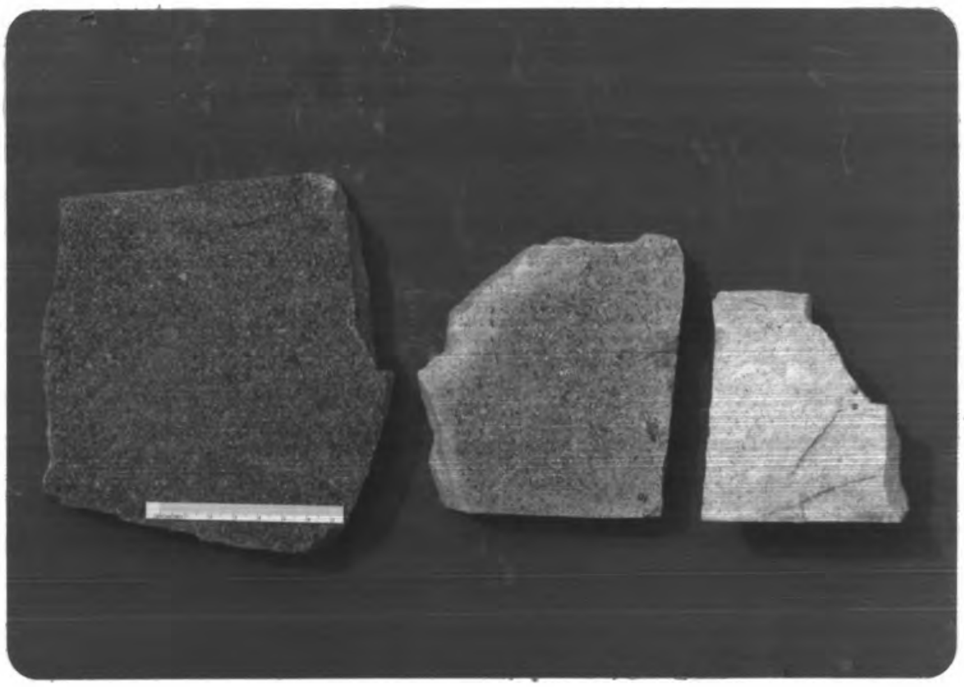
in the GM-3. In contrast, a comparative abundance of plagioclase and K-feldspar in the GR-granitic series is the reverse of the GM-granitic suites (Figure 3.1). It is worth noting that the content of quartz in both rock types is considerably unchanged.

The modal abundance of quartz, K-feldspar, and plagioclase, is recalculated to 100 percent, and plotted on a triangular diagram (Figure 3.2) for the classification of plutonic rocks proposed by Streckeisen (1976). The diagram shows that almost all of the Mae Chedi granites fall within the granite field boundary particularly monzogranite region except for two GM-1 samples, i.e.(1) M1-13 and (4) M1-12, which fall near the boundary line between granite and granodiorite fields. It is apparent that the evolution trend of the GM-granitic series is characterized by decreasing and increasing of the amounts of plagioclase and K-feldspar respectively. On the other hand, the evolution trend of the GR-granitic series is characterized by increasing of plagioclase and decreasing of K-feldspar. Thus, it can be concluded that the granite which may have given rise to Sn-W-mineralization, at the Mae Chedi area is characterized by high K-feldspar content. A similar conclusion was also obtained from the studies of granites in the vicinity of tin-tungsten mining area at Samoeng, northern Thailand (Punyaprasiddhi, 1980). In contrast, it is interesting to note that the Sn-W-bearing granite at Haad Som Pan, Ranong, southern Thailand is characterized by low K-feldspar content (Aranyakanon, 1961).

3. 1. 2 <u>Fine-grained biotite granite (GM-1)</u>

The rock is generally dark-grey colored, sub-

a)



b)

Figure 3.3 General texture of the GM-granitic series a), left: GM-1, middle: GM-2, right: GM-3, compared with the GR-granitic series b), left: GR-1, middle: GR-2, right: GR-3.

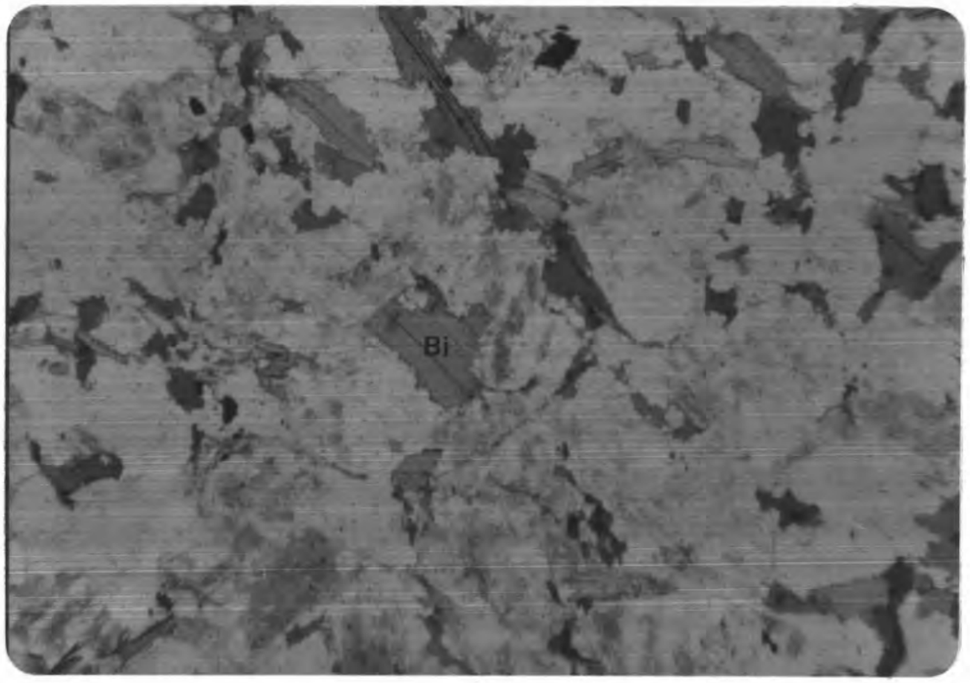
equigranular, and fine-grained with an average grain size of about 0.5 mm. Small amounts of large alkali feldspar crystals, as large as 4 by 7 mm, may give the rock a slightly porphyritic appearance (Figure 3.3).

Under the microscope, the rock exhibits a hypidiomorphic granular texture. Poikilitic textures are common and characterized by small grains of biotite, plagioclase, and quartz enclosed in perthitic phenocrysts. Myrmekitic textures formed by subsolidus reaction along the grain boundaries between plagioclase and K-feldspar are uncommon.

Biotite (x = very pale yellowish brown, y = z = orangish brown to brown) is the first major mineral that has been crystallized from the melt after accessory zircon and apatite. It occurs as clusters of flakes and is partially altered to chlorite. It is the only essential mafic mineral which its quantity ranges from 8.24 to 15.97 with an average of 12.80 volume percent. This figure is considerably high as compared with those of other rock types (Figure 3.4). Apatite and zircon commonly occur as inclusions in biotites. As a result, pleochroic halos are normally observed.

Plagioclase (An_{30-38}) is the second major but the first felsic mineral to have been crystallized. It appears to be the most abundant constituent of the rock (30.83 to 37.73, average 33.66 volume percent). Usually, it either occurs as subhedral and tabular or equant form. Albite twins and to a lesser extent Carlsbad-albite twins are common. Pericline twins are occasionally observed. Normal zoning is also another common feature of plagioclase which is

a)



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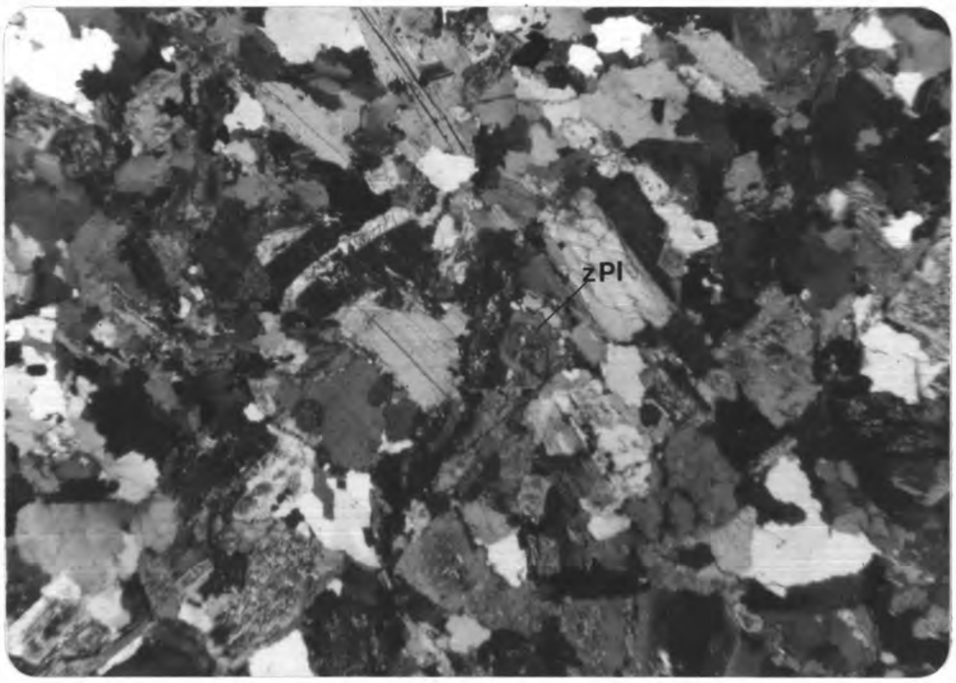


Figure 3.4 Photomicrographs of the GM-1 showing a): the abundance of biotite (Bi), and b): sericitized plagioclase (Pl) as well as zoned plagioclase (zPl) (Sample (4) M1-12, 2.5 x 2.5 x, a) Plane polarized light, b) X-nicols).

characterized by calcic andesine in the core and calcic oligoclase at the margins. Most of the plagioclase crystals appear to be intensely sericitized especially in the core. The plagioclase may include small flakes of biotite or chloritized biotite, minute needles of apatite, and oval-shaped zircon. Conversely, it is enclosed in later crystallized K-feldspar.

Quartz seems to be crystallized just before K-feldspar. It occurs both as large patches (up to 2 mm) and as aggregates of small grains (average 0.1 - 0.3 mm). It often scatters as small granular crystal enclosed in large K-feldspar phenocrysts. The modal volume percentage of quartz ranges from 26.24 to 31.80 with an average of 29.26.

K-feldspar (microcline, bi -, $2v = 68^\circ - 75^\circ$) appears to be the late and perhaps the last mineral to crystallize from the liquid. However, it forms large tabular poikilitic phenocrysts as well as small interstitially anhedral grains filling in the intergranular spaces between formerly crystallized mineral aggregates. K-feldspar phenocrysts often include totally or partially several preceding crystallized minerals, namely, biotite, plagioclase, and quartz (Figure 3.5). According to a modal analysis, K-feldspar ranges from 18.20 to 28.07 (average 22.90) percent in volume.

Accessory minerals : Muscovite is not common, though it has been observed in some specimens (Table 3.1). The close association of muscovite with the biotite (Figure 3.6) would probably suggest that the muscovite was formed as a product of the alteration of biotite (Schwartz, 1958; Haapala, 1978). Apatite occurs as

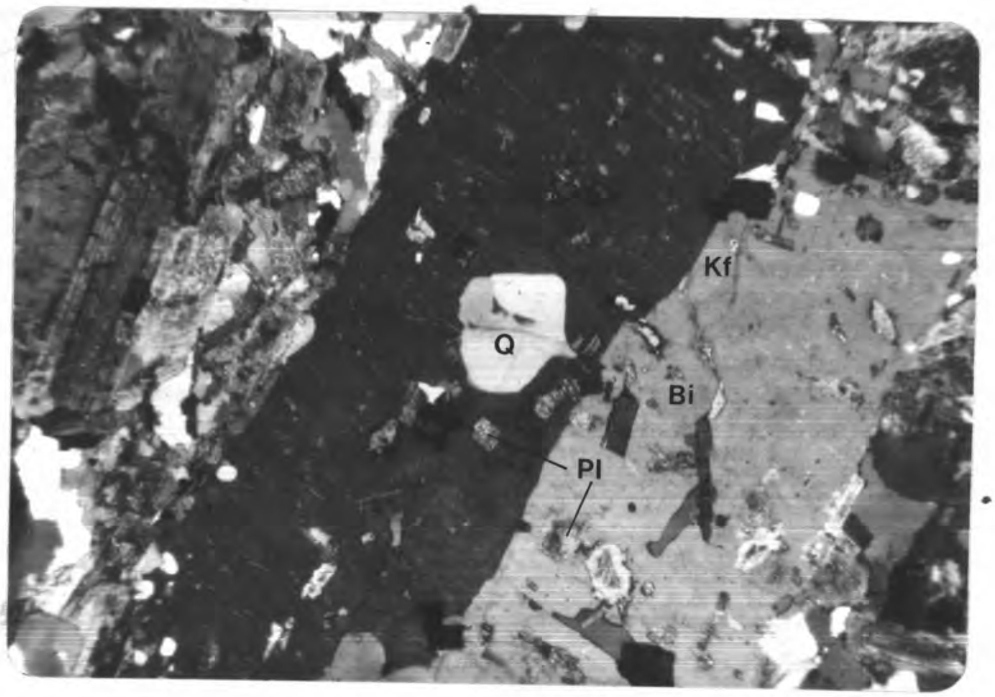


Figure 3.5 Photomicrograph of the GM-1 showing Carlsbad twin of a perthitic K-feldspar phenocryst (Kf) enclosing biotite (Bi), plagioclase (Pl), and quartz (Q). Most of plagioclase grains are intensely sericitized (Sample (6) S-2, X-nicols, 2.5 x 2.5 x).

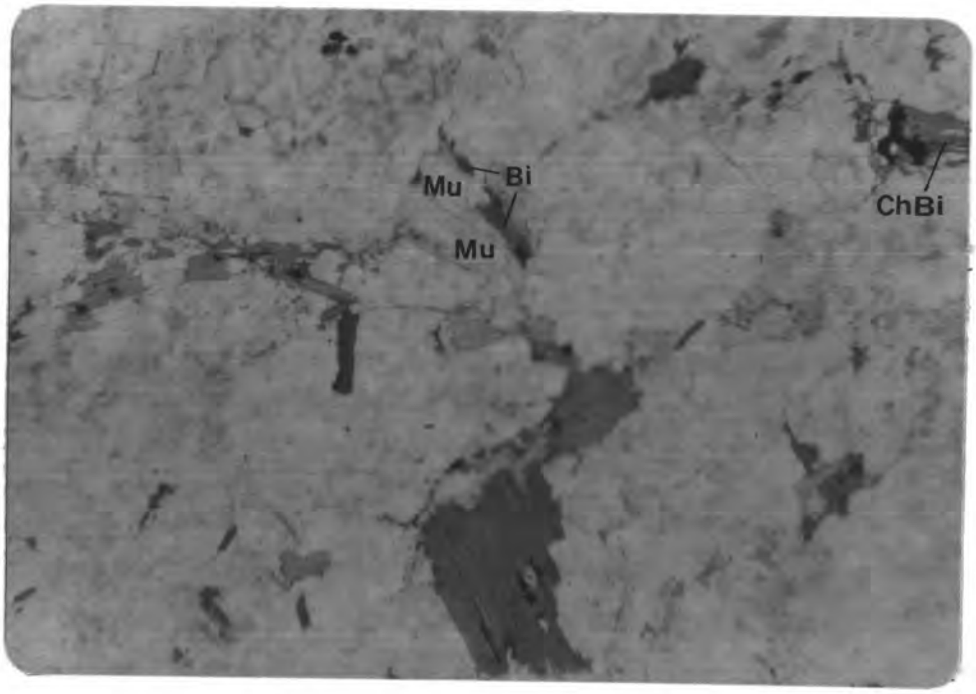


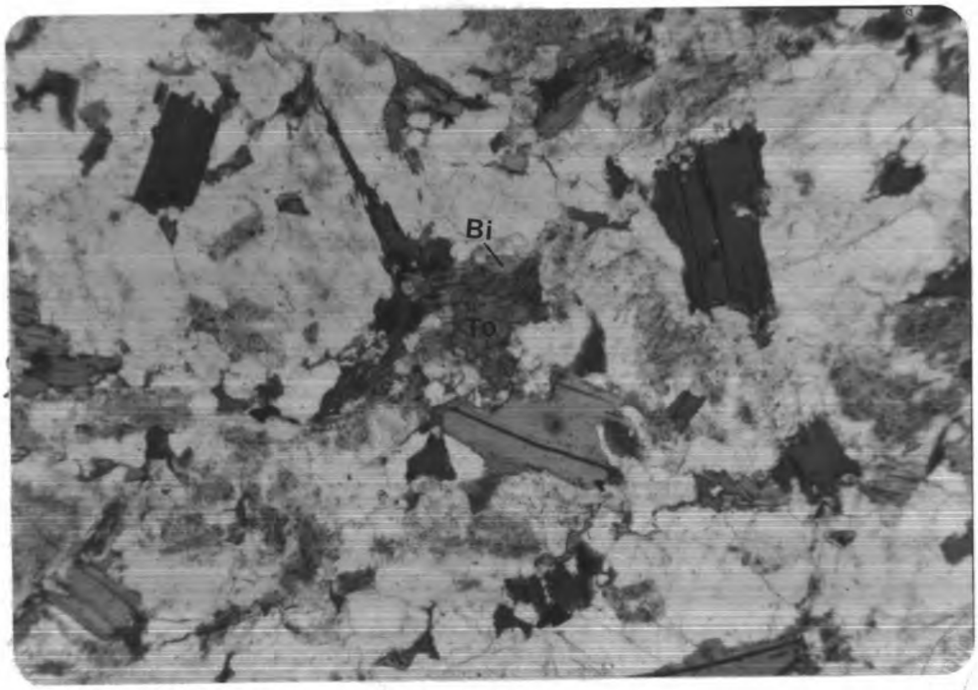
Figure 3.6 Photomicrograph of the GM-1 showing muscovite (Mu) in close association with biotite (Bi). Some of the biotite grains are altered to chloritized biotite (ChBi) (Sample (5) M1-11-2, Plane polarized light, 2.5 x 2.5 x).

inclusions (both euhedral and subhedral grains) in biotite, plagioclase, and K-feldspar. Zircon normally occurs as tiny inclusions in biotite. Sphene is considered to be secondary mineral, and usually forms anhedral grains. It almost always occurs in close association with chloritized biotite. Chlorite occurs as an alteration product and is a pseudomorph of biotite. Quite often, it is in close association with opaque minerals and sphene. Tourmaline is also present in close association with biotite. In places the former partially replaces the latter (Figure 3.7). Opaque minerals are mainly iron oxides, with occasionally pyrite, chalcopyrite, and, to a lesser extent, arsenopyrite. It should be noted that hornblende was not encountered in any of the thin sections examined.

3. 1. 3 Fine-grained muscovite-bearing biotite granite (GM-2)

This granitic rock is generally similar to the GM-1 with respect to its mineral constituents, sequence of crystallization, and, particular in, textures. Major differences between them are quantity of mineral components, i.e. average total felsic minerals and biotite. In the GM-2, the average total content of felsic minerals sharply increases and biotite decreases, as being compared with the GM-1. The increase in the average total felsic mineral is actually reflected by the addition of K-feldspar alone since the numbers of quartz and plagioclase remain relatively the same. Biotite (often chloritized) and minor muscovite are the main characteristic of this rock type and they make the rock light greenish grey in color (Figure 3.3).

a)



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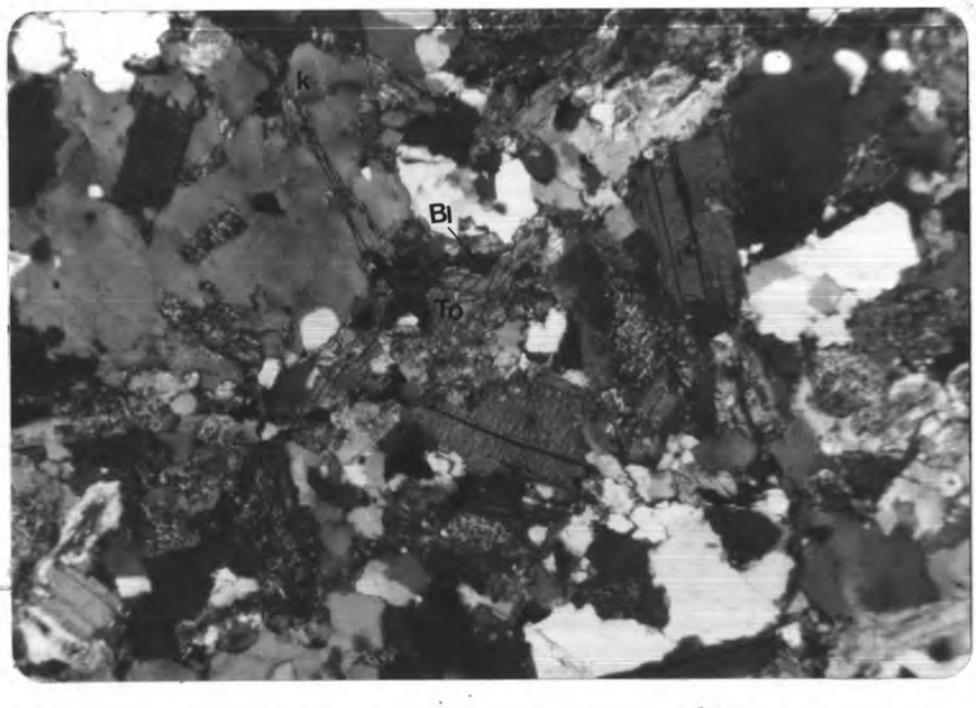

Figure 3.7 Photomicrographs of the GM-1 showing tourmaline (To) partially replaces biotite (Bi) (Sample (1) M1-13, 2.5 x 4 x, a) Plane polarized light, b) X-nicols).

Microscopically, the rock is hypidiomorphic to allotriomorphic granular texture. Poikilitic textures are common. Its alteration appears to be more extensive than that of the GM-1. It is characterized by K-feldspathization, chloritization, sericitization, muscovitization, tourmalinization, and albitization.

The first major mineral to crystallize from melt is biotite (x = very pale yellowish brown, y = z = orangish brown) which is generally similar to that of the GM-1 but remarkably lower quantity. It is mostly altered to chlorite and a small by-product of sphene (Figure 3.8). Its volume percentage ranges from 3.59 to 5.76 (average 5.03).

Plagioclase (An_{5-14}) is generally subhedral with tabular outline. Plagioclase inclusions in K-feldspar are not uncommon. Many plagioclase grains have undergone sericitization. Therefore, zoning texture is obscured by this intensive alteration. Modal percentage of plagioclase ranges from 30.50 to 36.10 (average 33.91).

Quartz forms both large anhedral grains (up to 2 mm) and small interstitial aggregates. This would probably suggest that though quartz has been crystallized before alkali feldspar, it has lasted till the final liquid. Small quartz grains enclosed in larger K-feldspar exhibit granophyric textures. Modal data shows that the rock contains quartz ranging in volume from 26.57 to 33.87 (average 28.95) percent which is nearly the same as that of the GM-1.

K-feldspar (microcline, bi -, $2v = 68^{\circ} - 73^{\circ}$) is usually perthitic. It forms large tabular poikilitic grains as well as

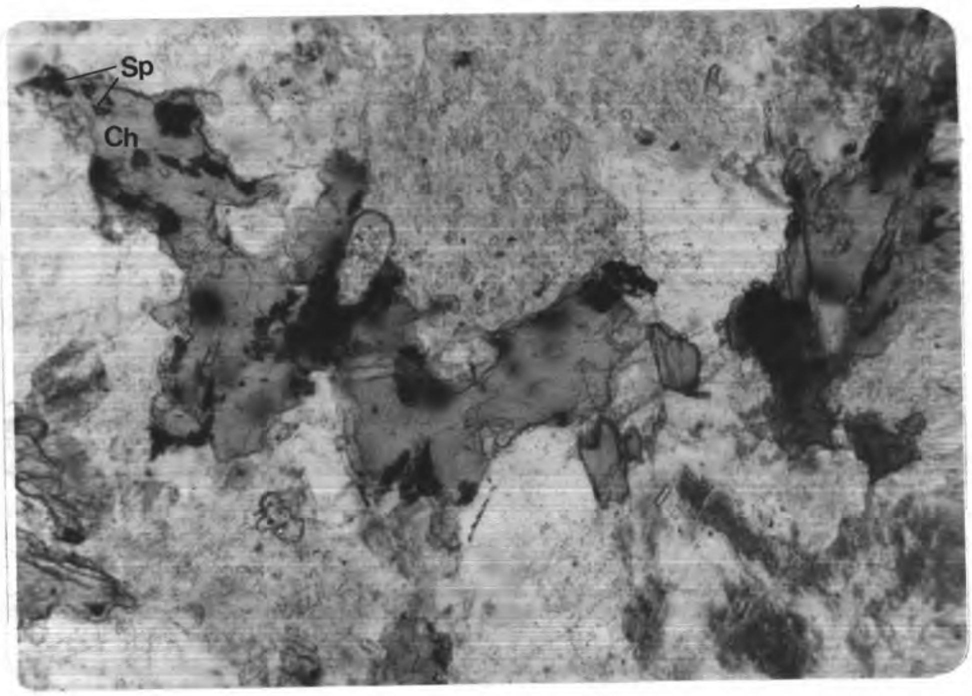

Figure 3.8 Photomicrograph of the GM-2 showing biotite grains are altered to chlorite (Ch) and a small by-product of sphene (Sp) (Sample (11) M1-7, Plane polarized light, 2.5 x 10 x)

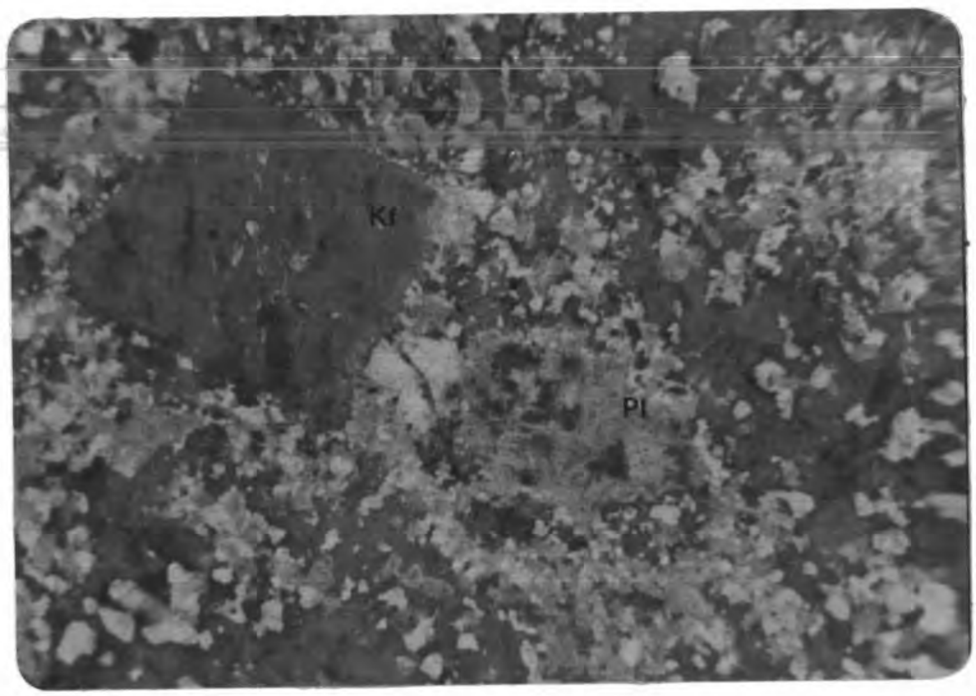

Figure 3.9 Photomicrograph of the GM-2 showing a tabular poikilitic grain of K-feldspar (Kf) as well as small anhedral patches replacing the host plagioclase (Pl) (Sample (12) M1-4B, stained thin-section, Plane polarized light, 2.5 x 4 x).

small anhedral patches replacing the host plagioclase (Figure 3.9). The modal analysis gives the volume percent of K-feldspar ranging from 23.20 to 38.27, averaging 30.54 percent. This figure is relatively higher than that of the GM-1 and moves the K-feldspar to be the second most abundant constituent.

Accessory minerals: Muscovite (0.03-2.33, average 0.60 in volume percent) occurs in all specimens of this rock type. It is believed to be of secondary origin and may be a result of the alteration of biotite (Schwartz, 1958; Haapala, 1978). Other accessory minerals include apatite, zircon, sphene, tourmaline, iron oxides, pyrite, chalcopyrite and arsenopyrite. Occurrences of the accessory minerals are similar to that of the GM-1, i.e., they are close associated with chloritized biotite.

3. 1. 4 Fine- to medium-grained leucocratic granite GM-3

The term "leucocratic granite" (including the GR-3) used herein is characterized by its white color due to the trace or small amounts of mafic minerals (Figure 3.3).

The GM-3 granite is mostly fine-grained, however, medium-grained varieties (grain size up to 2 mm) are also present, especially near the upper level of the pluton. Some K-feldspar crystals are as large as 4 by 6 mm, make the rock to be slightly porphyritic in appearance.

Microscopically, the rock usually shows an allotriomorphic, locally hypidiomorphic, granular texture. Poikilitic and granophyric textures are also present.

Biotite is the least abundant major mineral of the GM-granitic series. It makes up to 1.73 volume percent of the rock and represented by a small amount of relic chloritized biotite (Figure 3.10).

Plagioclase is relatively less abundant as being compared with that of other rock types in the GM- series. Almost all plagioclase grains show intensive sericitization. Only traces of polysynthetic twins can be observed in some grains. The composition of plagioclase, when it is ever possibly determined, is surprisingly almost pure albite (An_{1-2}). This compositional figure is much lower than the former rock types already described. This leads the author to conclude that the GM-3 is the ultimate albitization of the GM-granitic series. Modal volume percentage of plagioclase ranges from 26.17 to 34.42 (average 29.94).

Quartz content of the rock ranges from 26.90 to 31.03 (average 29.38) volume percentage. It occurs both as large anhedral patches and interstitially small aggregates. Most of them show strained effects. Granophyric intergrowth is not uncommon.

K-feldspar (microcline, bi -, 2v = 76°- 82°) is numerous, typically as late interstitially anhedral patches and replacing plagioclase. Its volume percentage ranges from 30.62 to 41.23 (average 35.13). Obviously, it is the most abundant constituent of the GM-3 granitic rock.

Accessory minerals : Muscovite is present in substantial amounts (up to 3.57 volume percent). It is believed that the GM-3 is the ultimate alteration product of the GM-1 resulting in a drastic

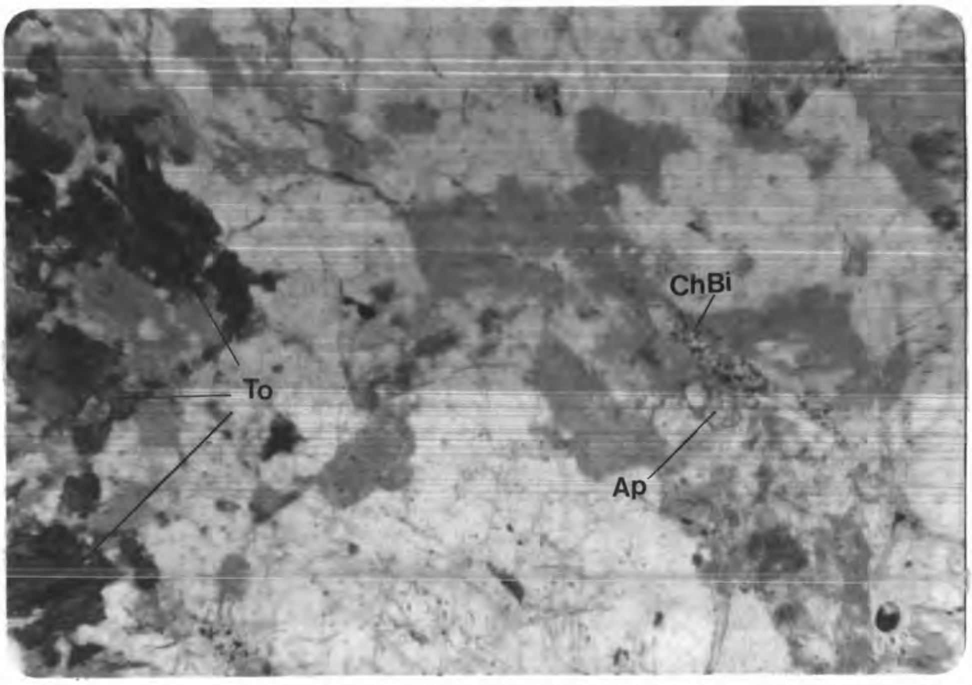

Figure 3.10 Photomicrograph of the GM-3 showing the relic of chloritized biotite (ChBi) in association with apatite (Ap). The dark colored grains, on the left hand side, are tourmaline (To) (Sample (13) M1-24 , Plane polarized light, 2.5 x 2.5 x).

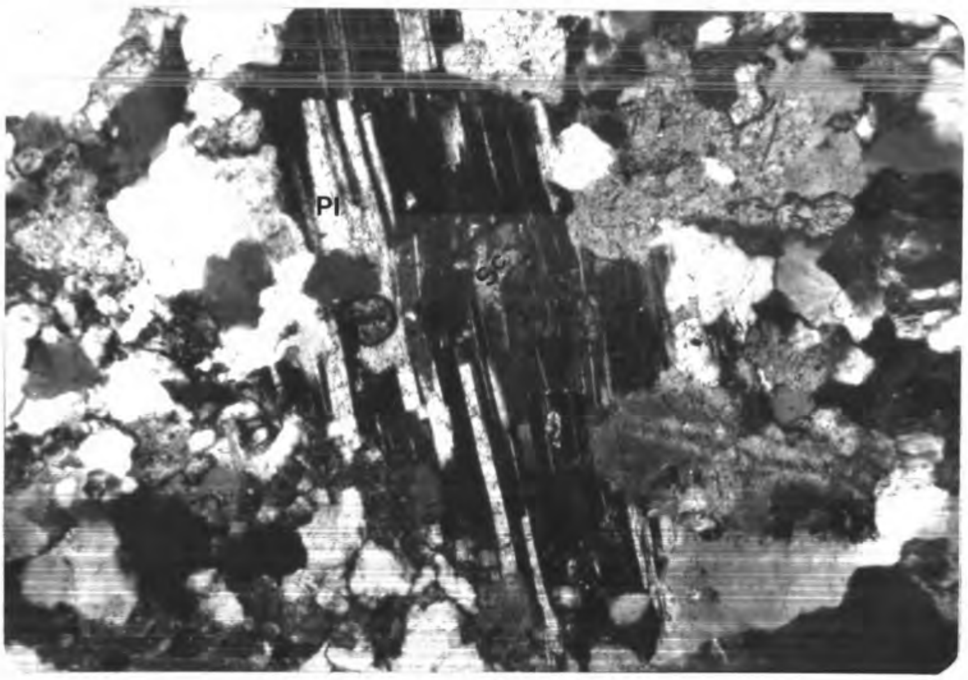

Figure 3.11 Photomicrograph of the GM-3 showing minute sheelite grains (Sc) are enclosed in plagioclase (Pl) (Sample (15) M1-6, Plane polarized light, 2.5 x 10 x).

increment of the muscovite content.

It is worth noting that all of the accessory minerals that have been recognized in the GM-1 and the GM-2 are also commonly present in the GM-3. In general, they have a close association with chlorite, tourmaline, and muscovite. Occasionally, small anhedral scheelite grains (up to 1 mm), in sample (15) M1-6, have been spatially associated with albitic plagioclase. In addition, minute scheelite grains are enclosed in plagioclase (Figure 3.11).

From the petrographical evidences of the GM-granitic series, it would seem reasonable to conclude that they have a tendency to be tin-bearing granites (Aranyakanon, 1961, 1969, 1971; Hosking, 1967, 1979; Aranyakanon and Vichit, 1979; Pitakpaivan, 1969; Suensilpong, 1977; Tischendorf, 1977; Asnachinda, 1978; Taylor, 1979; Vichit, 1981).

3. 1. 5 Porphyritic biotite granite (GR-1)

This granite is the most abundant type and largely distributed throughout the study area. The rock is generally light grey to gray colored, porphyritic, medium-grained groundmass (1-5 mm) with phenocrysts of K-feldspar ranging in size from 1 by 2 cm to 3 by 6 cm (usually 1 by 2 to 1 by 3 cm) (Figure 3.3). Mineral constituents of the groundmass are quartz, K-feldspar, plagioclase, biotite, and minor accessories.

Microscopic study shows that the groundmass is hypidiomorphic granular texture. Poikilitic textures in K-feldspar phenocrysts are quite common. Myrmekitic textures formed by subsolidus reaction along the contacts of plagioclase and K-feldspar are not common, only few grains have been observed.

Biotite (x = very pale yellowish brown, y = z = orangish brown to reddish brown) ranges modally from 6.40 to 8.91 (average 7.50) volume percent. It has been crystallized before other major mineral constituents and occurs as clusters of flakes as well as individual grains. It is partially altered to chlorite. The important inclusions in biotite are apatite and zircon. Pleochroic halos are very common feature.

Plagioclase (An_{28-36}) is the second in order of major crystallization sequence and generally shows subhedral grain of varying sizes ranging from 2 to 5 mm. Fine-grained minerals, apatite, zircon, and biotite, are occasionally found as inclusions in it. Myrmekitic intergrowths are locally developed along in contacts of K-feldspar. Normal zoning in plagioclase is common (Figure 3.12). When its composition is determined, the core is calcic andesine or sodic labradorite whereas the rim is sodic to intermediate oligoclase (see Table 3.1). Its modal ranges from 19.70 to 24.18 (average 21.15) percent in volume.

Quartz ranges in modal percent from 31.18 to 39.10 with an average of 34.80. Its volume percent is notably higher than that of plagioclase but relatively lower than that of K-feldspar. Quartz is mostly interstitially anhedral of late crystal aggregates. It is of various sizes ranging from 1-10 mm (usually 2-5 mm) in diameter. Strained quartz with undulose extinction is commonly observed.

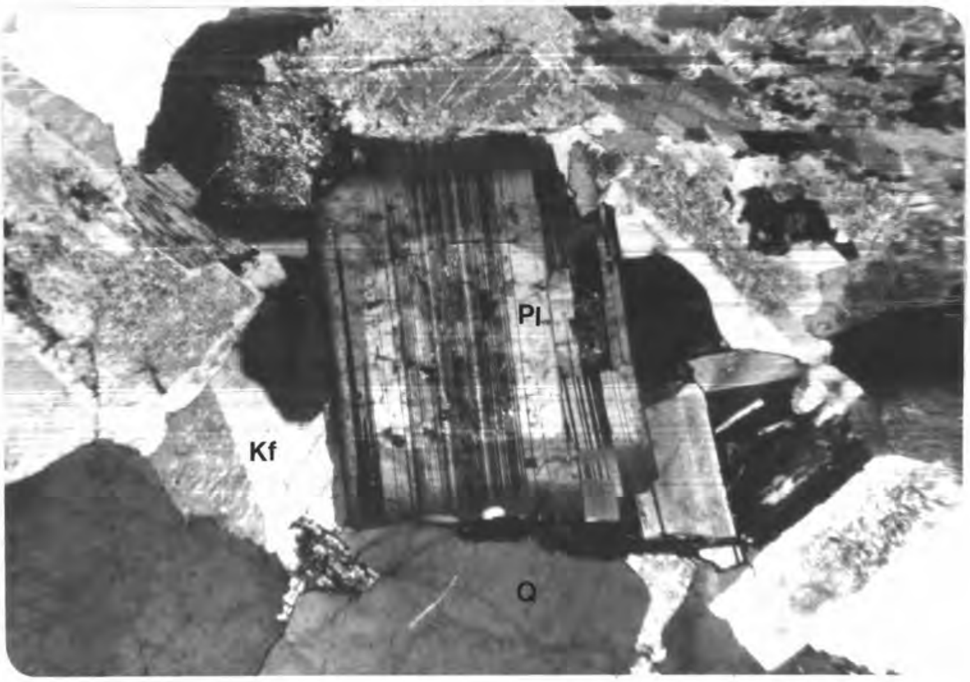

Figure 3.12 Photomicrograph of the GR-1 showing normal zoned plagioclase (Pl) in association with K-feldspar (Kf), biotite (Bi) and quartz (Q). Some of plagioclase grains are altered to sericite (Sample (18) MD6, X-nicols, 2.5 x 2.5 x).

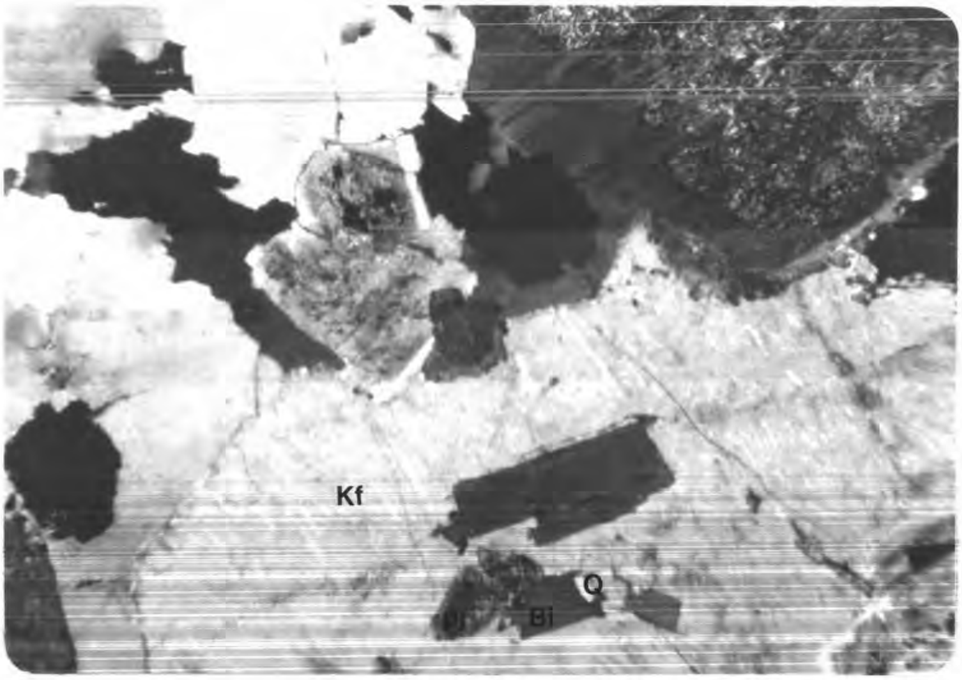

Figure 3.13 Photomicrograph of the GR-1 showing anhedral twinned and weakly zoned plagioclase (Pl) as well as biotite (Bi) and quartz (Q) enclosed by anhedral patches of perthitic K-feldspar (Kf) (Sample (19) MD7, X-nicols, 2.5 x 2.5 x).

K-feldspar (microcline, bi -, 2v = 64°- 68°) appears to be the most abundant mineral of the rock with an average modal volume percent of 36.27. It is the only phenocrysts with subhedral shape. K-feldspar also occur as anhedral grains in the groundmass. The phenocrysts usually show poikilitic texture containing biotite, plagioclase, and occasionally, apatite. Carlsbad twin is frequently found especially in the phenocrysts, many of which show perthitic textures (Figure 1.13). The modal percentage of K-feldspar determined varies from 31.48 to 39.93.

Accessory minerals : Muscovite is scarce. It has seldomly been found with a trace amount (up to 0.60 volume percent) in some specimens. It is considered to be a secondary mineral which occurs as small flakes (up to 2 mm) in association with chloritized biotite. Apatite generally occurs as minute euhedral prismatic crystals enclosed in biotite, and, to a lesser extent, in plagioclase, K-feldspar, and quartz. Zircon occurs either as round or oval-shaped inclusions in biotite. Sphene and chlorite are considered to be secondary minerals. Both of them occur in closed association with chloritized biotite and iron oxides. Secondary calcite, forming veinlets are also observed in sample (17) MD 10. Tourmaline is not common, though present in sample (16) MD 11 up to 0.15 volume percent.

3. 1. 6 Medium-to coarse-grained biotite granite (GR-2)

The GR-2 is generally similar to the GR-1, particularly in mineralogy, except for its slightly porphyritic texture and considerably less biotite contents (Table 3.1). The rock is normally light gray colored. Its grain size varies from 1 to 10 mm (usually 2 to 5 mm), as shown in Figure 3.3. It has minor K-feldspar phenocrysts, having grain size up to 1 by 2 cm.

In thin sections, the rock shows a holocrystalline hypidiomorphic granular texture. Plagioclase, biotite, and quartz are poikilitically enclosed in K-feldspar. Perthitic and myrmekitic intergrowths are also common.

Biotite (x = very pale yellowish brown, y = z = orangish brown to reddish brown) occurs as small discrete flakes (up to 2 mm), many of which are intensively chloritized. Apatite and zircon usually occur as inclusions in biotite, but appear to be less common than that of the GR-1. In addition, the biotite constituents (up to 3.98 volume percent) are also remakably lower than that of the GR-1.

Plagioclase (An_{13-35}) usually occurs as subhedral tabular crystals, many of which are intensively sericitized espectally at their cores. Zoning in plagioclase is weakly developed. Its common inclusions are biotite and apatite. Some small plagioclase crystals are poikilitically enclosed in K-feldspar. Myrmekitic textures are very common (Figure 3.14). According to a modal analysis, plagioclase content ranges from 21.53-26.10 (average 23.82) volume percent.

Quartz occurs both as large anhedral patches and interstitial grains. Its modal volume percent ranges from 33.53 to 37.07 (average 35.28).

K-feldspar (microcline, bi -, $2v = 66^{\circ} - 69^{\circ}$) occurs as large subhedral phenocrysts and as anhedral aggregates of smaller grains in the groundmass. The small discrete crystals of biotite and

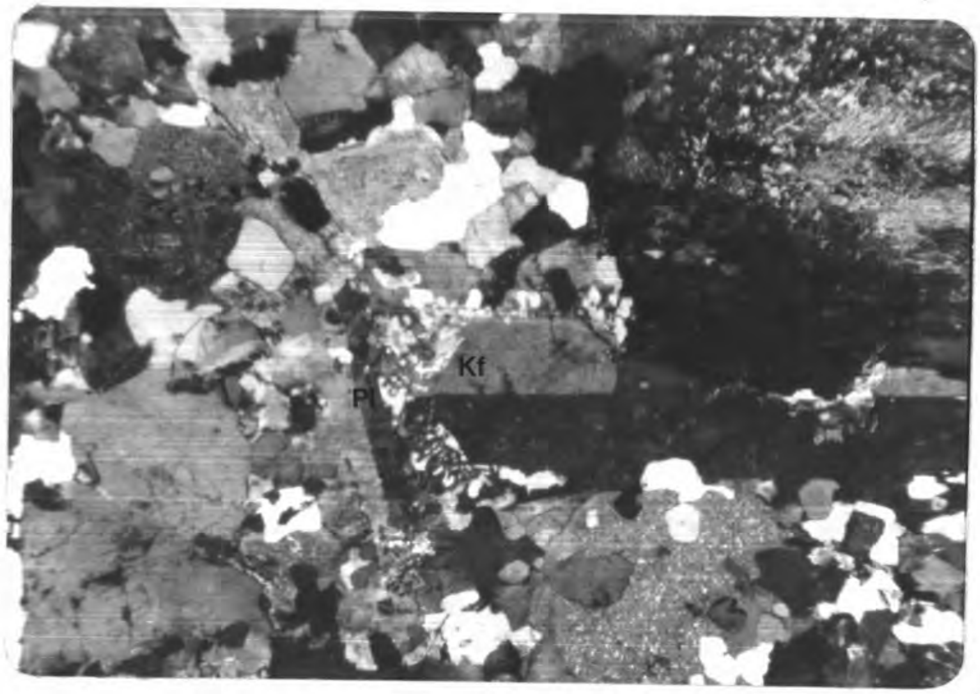

Figure 3.14 Photomicrograph of the GR-2 showing K-feldspar (Kf) in contact with plagioclase (Pl) and myrmekitized margin (Sample (20) MD 22, X-nicols, 2.5 x 2.5 x).

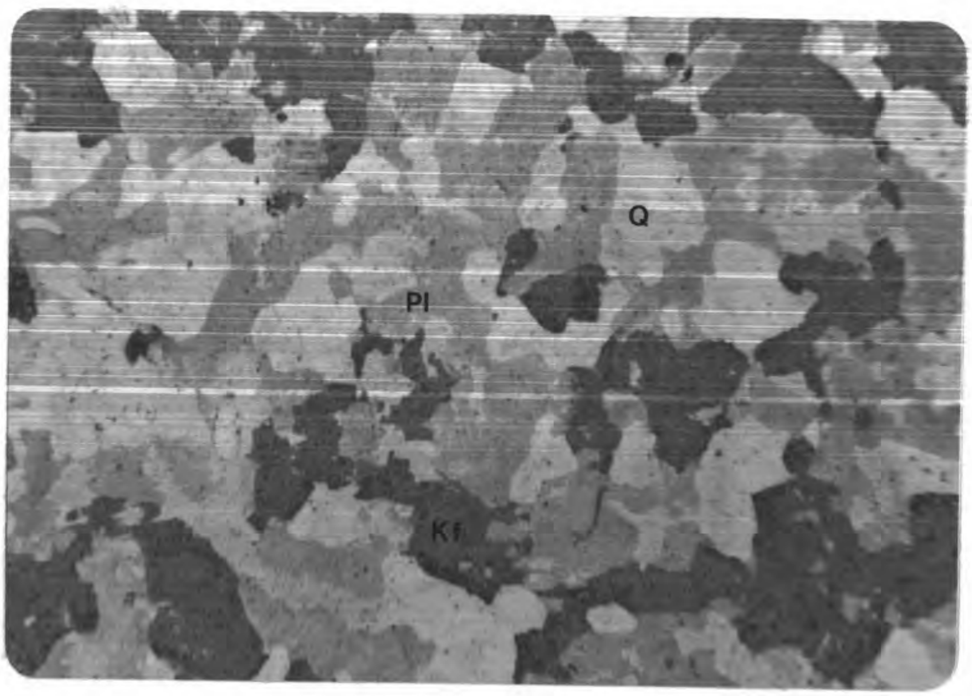

Figure 3.15 Photomicrograph of the GR-3 showing anhedral grains with interlocking boundaries of plagioclase (Pl), quartz (Q), and K-feldspar (Kf) (Sample (23) MD 16, stained thin-section, Plane polarized light, 2.5 x 2.5 x).

plagioclase are usually poikilitically enclosed in K-feldspar. The volume percentage of K-feldspar ranges from 32.60-40.31 (average 36.46).

Accessory minerals : muscovite, in a trace amount up to 0.60 volume percent, occurs as small discrete flakes with varying grain-size up to 2 mm. Muscovite is always in close association with the chloritized biotite. Other accessory minerals are generally similar to those of the GR-1 but notably less abundant. They are apatite, zircon, sphene, chlorite, iron oxides, and tourmaline. All of them are in close association with biotite or chloritized biotite.

3. 1. 7 Fine-to medium-grained leucocratic granite GR-3

The general appearance of the GR-3 grainitic rock is similar to that of the GM-3 (Figure 3.3). It is white or light greenish white, mostly fine-grained with locally medium-grained, and slightly porphyritic due to scattered occurrences of K-feldspar phenocrysts (up to 3 by 6 mm).

Microscopic study indicates that the rock has a holocrystalline allotriomorphic granular texture. Perthitic and poikilitic textures are also common. The difference between the amount of K-feldspar and plagioclase is insignificant. By comparing the GR-3 with the GM-3, the former is notably higher quartz and plagioclase but lower K-feldspar than that of the latter.

Biotite (x = very pale yellowish brown, y = z = orangish brown to reddish brown) occurs only in trace amounts except for the sample of (22) MD 35 which contains up to 0.93 volume percent. In general, alomost all of the biotite grains of this rock type are affected by the process of chloritization.

Plagioclase (An_{7-14}) occurs as subhedral crystals and generally lacks zoning. It is intensively sericitized and its amount ranges from 31.20 to 32.53 (average 31.93) volume percent.

Quartz (34.50-38.63, average 36.31 volume percent) forms as a late crystallized aggregate, of small anhedral grains and as interstitially grains among the formerly crystallized minerals. It commonly shows undulated extinction.

K-feldspar (microcline, bi -, $2v = 68^{\circ} - 73^{\circ}$) content ranges from 26.27-31.93, average 30.17 volume percent. It forms anhedral crystals and show interlocking boundaries with quartz and plagioclase (Figure 3.15). Perthitic textures are also not uncommon.

Accessory minerals : Muscovite is generally present in trace amounts (except for sample (25) MD 21 which reach content up to 1.70 volume percent). It occurs as small patches with a maximum size of 2 mm. Muscovite is found to be in association with chloritized biotite and opaque minerals. It shoud be noted that the accessory minerals, i.e. apatite, zircon, sphene and tourmaline are rare in the GR-3. Only one specimen, (25) MD 21, contains an appreciable amount of tourmaline (Table 3.1).

3. 2 Metabasites

The rock is greenish black to black, fine-grained, foliated, and durable (Figure 3.16). When weathered, it is yellowish brown in color. The rock locally shows blastoporphyritic texture with containing porphyroblasts of amphibole ranging up to a maximum size

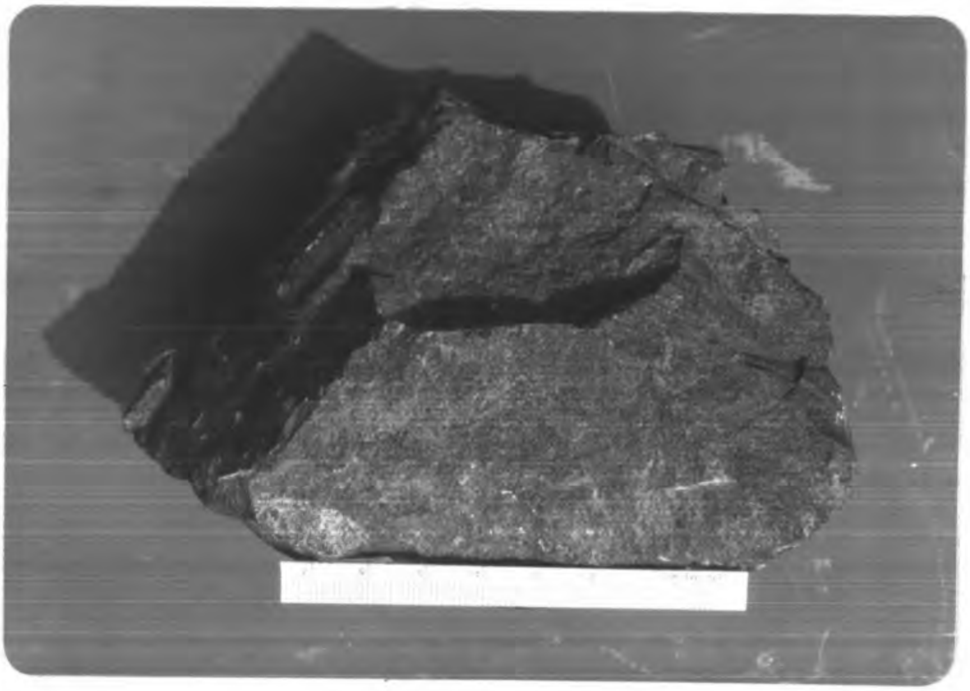

Figure 3.16 General texture of metabasites of the Mae Chedi area, Wiang Pa Pao, Chiang Rai (Sample B 6).

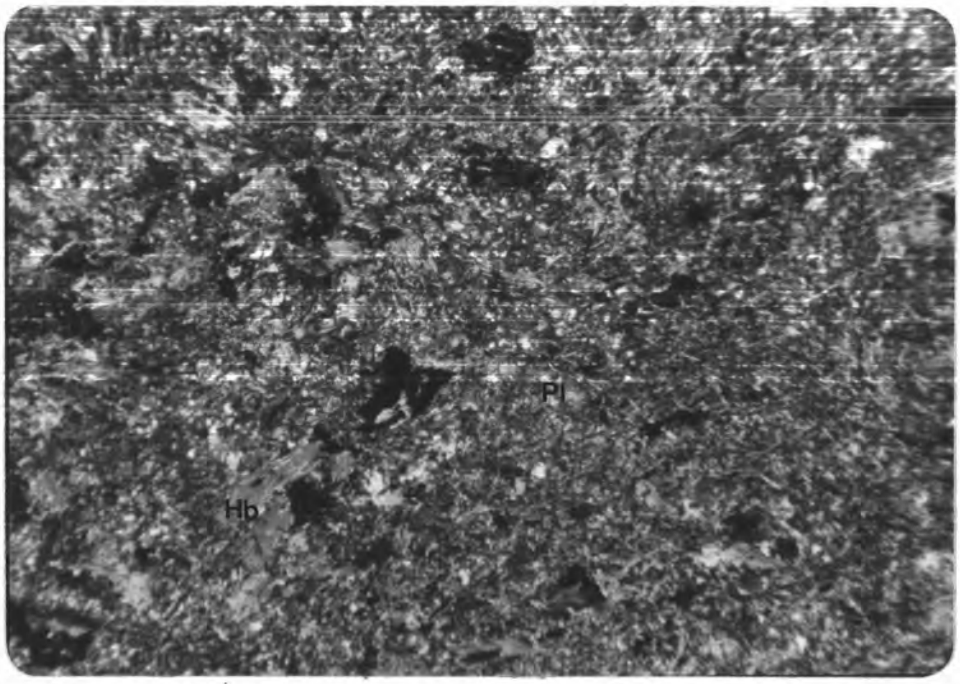

Figure 3.17 Photomicrograph of metabasites showing sub-parallel preferred oreintation of hornblende (Hb) and plagioclase (Pl) (Sample B 2, X-nicols, 2.5 x 2.5 x).

of 5 by 10 mm.

In thin sections,the rock is holocrystalline, hypidiomorphic granular texture (except for blastoporphyritic of sample B 3). It shows a more or less distinct foliation due to the sub-parallel preferred orientation of the amphiboles and plagioclase (Figure 3.17).

The major mineral constituents of the rock (B 1 - B 6, except B 3) are hornblende and plagioclase (andesene-labradorite). Common accessory minerals are sphene, chlorite, pyrite and iron oxide presumably magnetite. Plagioclase is generally in equant form and locally shows intensive sericitization. Diopside may also be common in certain specimens (e.g.,sample B 4). The sample B 3 is fine-grained and blastoporphyritic rock. It contains abundant idioblastic hornblende porphyroblasts, usually 2 by 3 to 3 by 5 mm in size. Quite often, the porphyroblasts, believed to be the relics of phenocrysts in the original mafic volcanic rock, show twinning. They are embedded in a foliated matrix of minute grains of prismatic hornblende (normally less than 0.1 mm in length) and subordinate iron oxide (presumably magnetite) (Figure 3.18). Small amounts of lens-shaped aggregates (up to 0.4 by 2.5 mm) of biotite and chlorite have been observed lying parallel to foliation. Sphene is scarce. Plagioclase, forming veinlets crossing porphyrobalsts and foliated matrix, usually contain sphene, pyrite, and epidote. Secondary calcite, forming veinlets are also present.

The sample B 7 is fine-grained, essentially composed of actinolite and chlorite. Minute aggregates of sphene and iron oxide (presumably magnetite) are not uncommon (Figure 3.19).

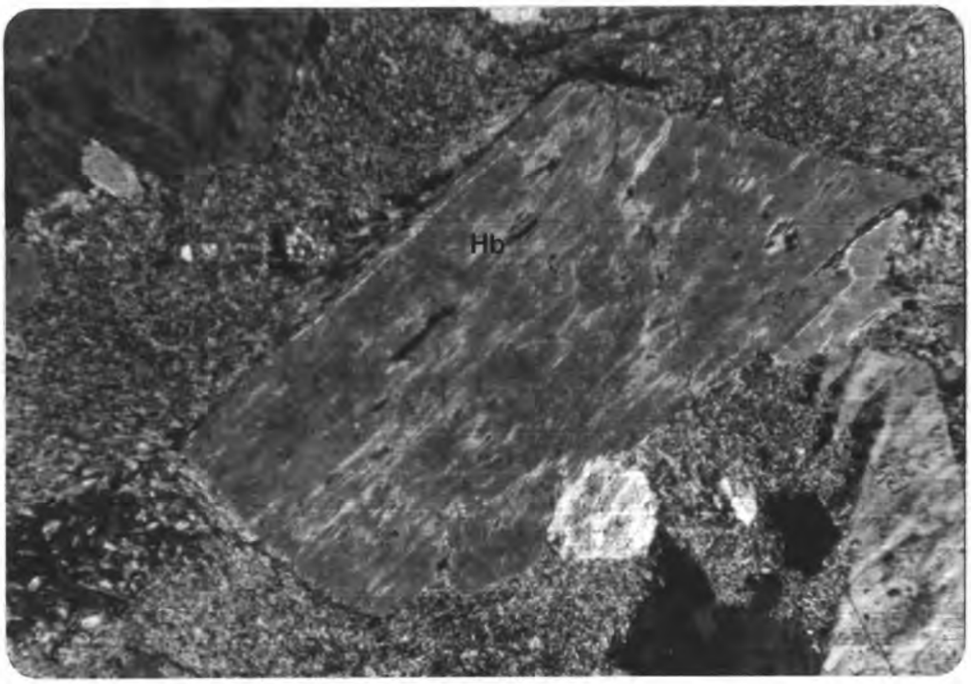

Figure 3.18 Photomicrograph of metabasites showing idioblastic hornblende porphyroblasts (Hb) are embedded in a foliated matrix of minute grains of prismatic hornblende and subordinate iron oxide (Sample B 3, X-nicols, 2.5 x 2.5 x).

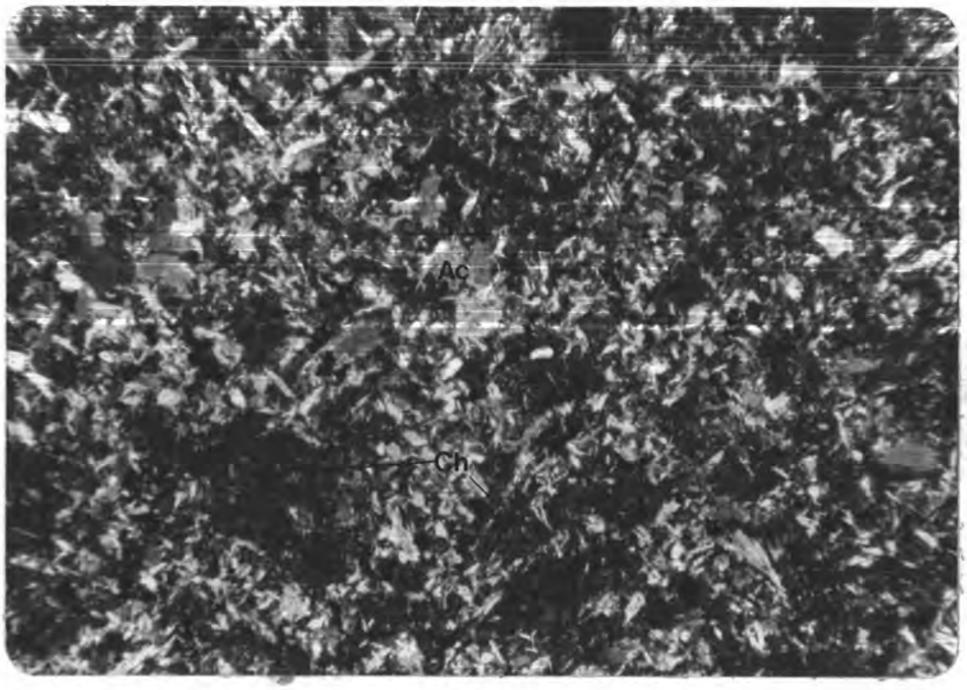

Figure 3.19 Photomicrograph of the sample B 7 showing fine-grained prismatic actinolite (Ac) in association with chlorite (Ch) (X-nicols, 2.5 x 2.5 x).