CHAPTER V

PETROGRAPHY

Introduction

In order to understand the petrological characteristics of individual granitic units, approximately 100 hand-specimen samples were collected. These samples were studied mesoscopically and microscopically. Location of samples collected from outcrops (and floats) is depicted in Appendix A. The Khanom gneissic complex rocks distributed in Khao Dat Fa, Khao Luang, Khao Pret, Khao Phlai Dam and Khao Yoi terrains are selected for thin section preparation. Location of rocks prepared for microscopically petrographic study is illustrated in Appendix C. Approximately 50 thin sections are systematically studied in detail. All thin sections were examined for mineral assemblages, compositional features, textures, microstructures and metamorphic grades. Most of them were determined by optical means. Detailed petrographic descriptions of the representative samples are presented below, and conclusion of individual granitic units is displayed in Appendix D.

Haad Nai Phlao Gneiss

The rock displays fine- to medium- grained equigranular (0.5-3.0 mm) with subidioblastic to xenoblastic granularities with small amount of porphyroblasts. Grain boundaries are typically curved, embayed and may be somtimes sutured. The porphyroblasts are subhedral orthoclase, commonly occurring as larger poikiloblasts (5x10 to 15x25 mm) and enclosing smaller mineral of micas, quartz and sillimanite. The Haad Nai Phlao Gneiss are composed averagely of K-feldspar (40%), quartz (27%), biotite (11%), plagioclase (8%), and muscovite (5%). Sillimanite and garnet

are minor minerals which are commonly seen. Other accessory minerals are zircon, apatite and opaque minerals.

Most alkali feldspars are orthoclase, and microcline are quite less abundant. These feldspar grains have either lenticular or tabular shapes, generally show simple twinning. They are generally formed as matrix ranging in size from 1x2 up to 3x8 mm.

Plagioclase occurs as subhedral oligoclase (An_{20} - An_{25}) lath commonly with albite twinning and deformed. It is partly altered to sericite. The grain size is about 1-4 mm.

Quartz crystals occur generally as larger grains with undulose extinctions. Some granulated margins of quartz as finer- grained, polygonal aggregates are also observed. The grain size is about 0.2-2.0 mm. It depicts subhedral to anhedral crystals with abundant cracks. Some samples contain myrmekitic quartz, suggesting the reaction between plagioclase and K-feldspar.

Most biotite tends to be enclosed in the grain boundaries between quartz and feldspar, and exhibits elongated tabular form showing greenish brown pleochroism. Laths of poikilitic biotite (up to 0.7 mm) are seen with inclusions of zircon and apatite.

Muscovite commonly coexists with biotite and seems to be a relict surviving from metamorphism. Size of grain is about 0.1-0.5 mm. Muscovite is prominent in the S_2 foliation.

Sillimanite (almost entively fibrolite) is present in several samples, and is generally in 1 percent amounts of the total. It occurs as fine-grained fibrous forms (Figure 5.1), aggregates of rods and needles (about 0.1-1.5 mm). It commonly occurs as inclusions in muscovite, biotite and quartz. Sillimanite is usually parallel to S_2 foliation, and some of which is associated with muscovite.

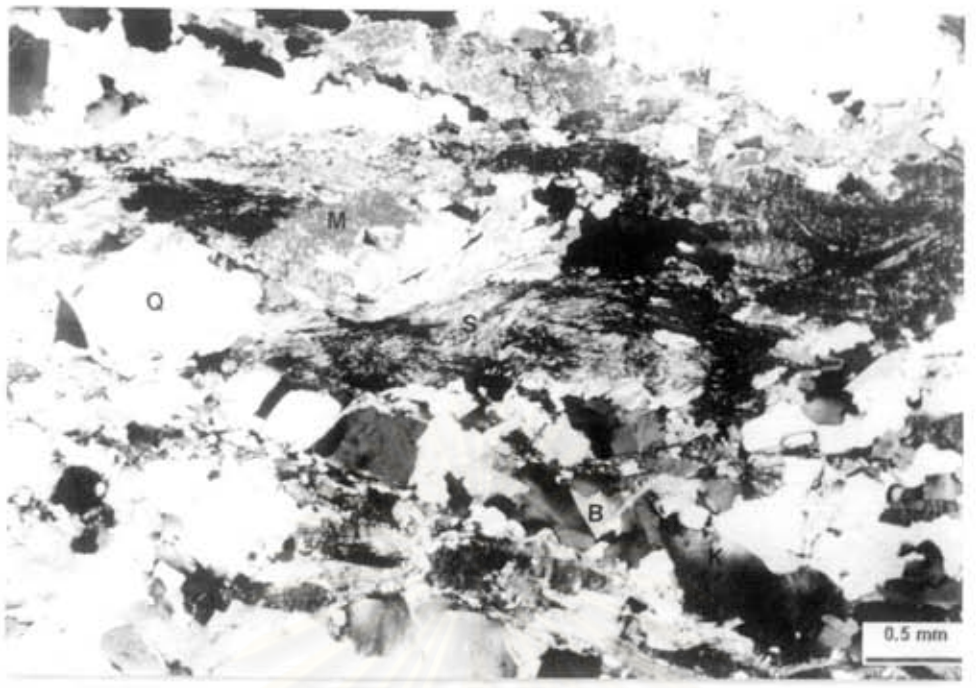

Figure 5.1. Photomicrograph of the Haad Nai Phlao - type biotite-sillimanite gneiss (sample KN1-2), sillimanite (S) showing muscovite (M) around its margin and core. other minerals are biotite (B), K-feldspar (K) and quartz (Q). S_2 foliation is shown parallel the long-axis of the photo. Transmitted light crossed nicols.

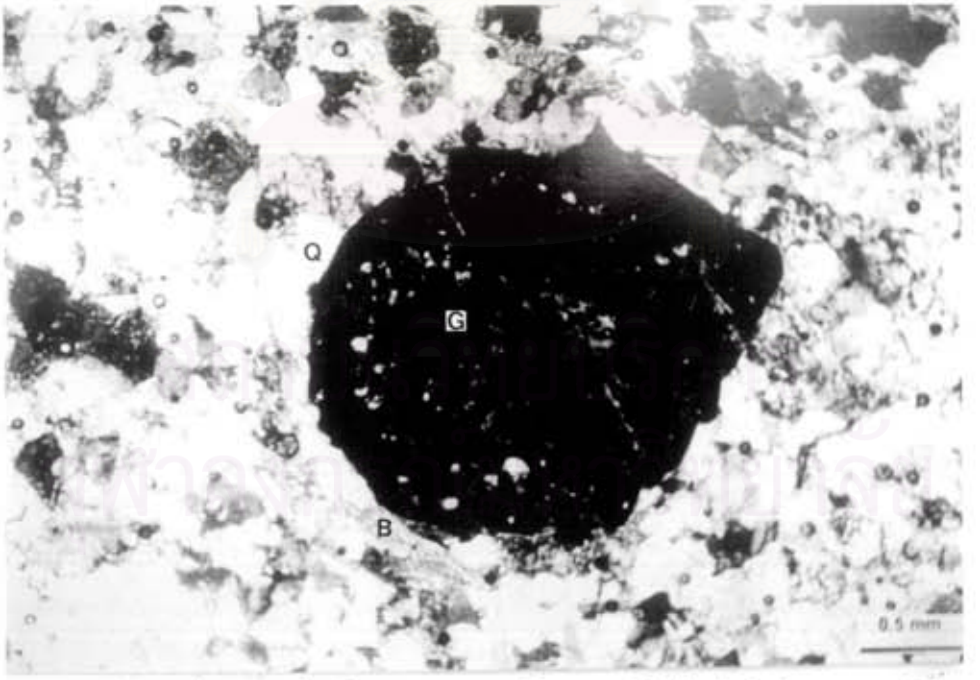

Figure 5.2. Photomicrograph of occurrence of quartz (Q) include in garnet (G) porphyroblast and along fractures in the Haad Nai Phlao Gneiss (sample KN36). Foliation defined by biotite (B), partially draped around the megablast. With crossed nicols.

Garnet is commonly present and always marks the S_1 foliation with pressure shadow. It occurs mostly as subidioblastic megacrysts (0.3x0.5 to 3x4 mm), with poikiloblastic texture. Inclusions within garnet include quartz and biotite. Garnet grains with inclusion-rich cores and inclusion-poor rims possibly indicate that two metamorphic reactions were involved in their growth (Augustithis, 1973). Syntectonic garnet which exhibits rotational textures and cracks are common.

Calc-silicate rock is commonly layered and posses relatively medium-grained granoblastic and hypidoblastic granularity. It has interlayers of fine- and medium-grained minerals ranging averagely from 0.1 to 0.5 mm. Mineralogically, the calc-silicate gradually passes into quartzo- feldsparthite. The layers are generally caused by contrasting in mineral composition. Diopside (50%), quartz (35%), plagioclase (15%), calcite (5%), sphene (1%) and actinolite-tremolite (1%), are major constituent. One layer is characterized by the abundance of diopside and the other by plagioclase and quartz (Figure 5.3).

Diopside which is subhedral to anhedral rounded grains (up to 0.8 mm) and plagioclase lath (up to 1.0 mm) (observed compositional range An_{40} to An_{70}) forms abundantly in the alternating layers and are major constituent occurring in most assemblages.

Quartz which mostly occurs associated with plagioclase is common additional phases in these assemblages, which is rounded and dipyramid forms. The grain size is about 0.1-0.8 mm.

Khao Yoi Schist

Microscopic studies of the Khao Yoi Schist show that these rocks display varieties of mineral assemblages passing form muscovite-quartz schist into quartz-muscovite schist and muscovite-feldspar quartzite. These gradations may represent the

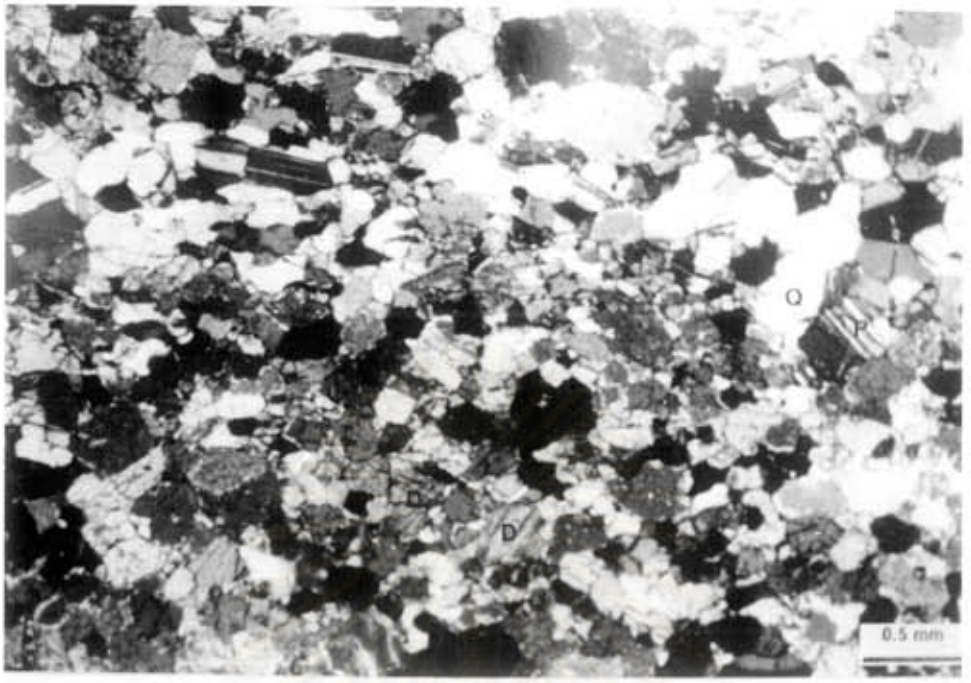

Figure 5.3. Photomicrograph of metamorphic banding or layering containing diopside (D) - rich band, and plagioclase (P) and quartz (Q) - rich band in calc-silicate lenses in the Haad Nai Phlao Gneiss. With crossed nicols.

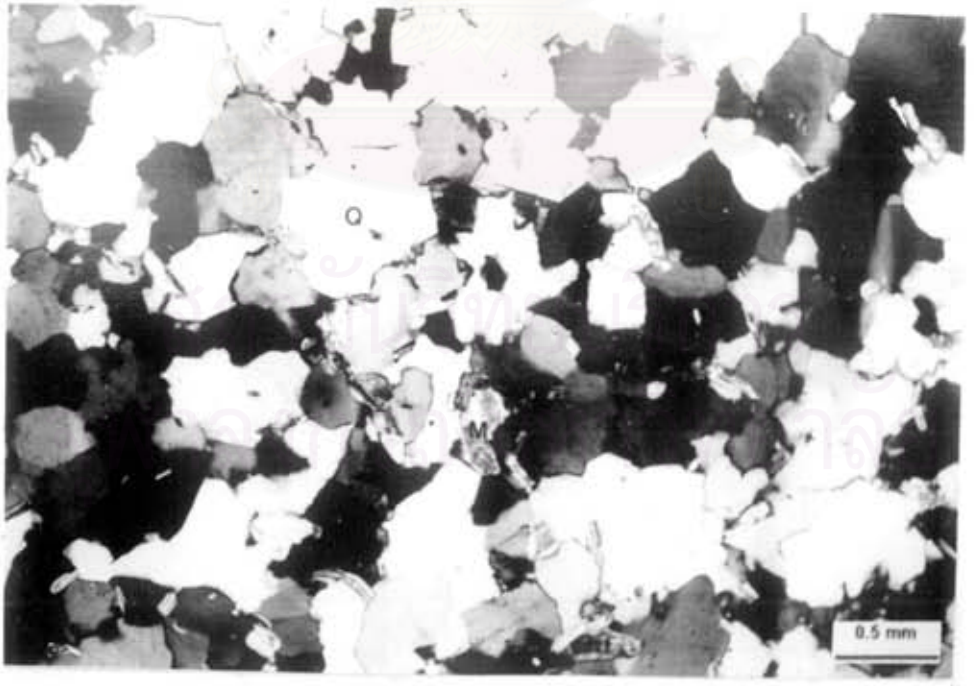

Figure 5.4. Photomicrograph of quartzitic pebble consisting of interlocking quartz (Q) and contain muscovite (M) laths in the Khao Yoi Schist. With crossed nicols.

lithological transition from original shale to sandstone and have undergone rather high-grade regional metamorphism. The schistose texture of the schists (S_r-foliation) is indicated by relatively finer grained, well defined foliated mineral constituents. The quartzite is composed almost entirely of quartz with minor amounts of fine-grained mica and opaques, the quartz is slightly stretched and shows moderately well preferred orientation.

The schists are commonly fine-grained and consist chiefly of quartz (50%) and relatively evenly arranged grains of muscovite (30%) and granoblastic orthoclase (15%). Biotite (5%), garnet (1%) and iron ores (1%) are accessory minerals. Muscovite occurs both as foliated (bent form) and non-foliated, flaky mineral. Elongate aggregates of muscovite commonly mark an impersistent foliation. Quartz grains (0.2-1.0 mm) are usually stretched parallel to the schistosity, and have finely sutured grain boundaries. Quartz invariably shows strained, undulatory extinction and interlocking boundaries, indicating shearing event.

Garnet varies considerably from 5x8 to 15x20 mm and is widely distributed throughout this gneissic unit. The garnet always occurs as porphyroblasts and is sometimes flattened. It also occurs as subidioblastic to xenoblastic grains.

Petrographic study of cal-silicate lens reveals that it is a fine grained (0.2 - 0.5 mm), mosaic and granoblastic texture. Diopside (45%), quartz (40%) and plagioclase (10%) are major mineral assemblage. The minor constituents are actinolite, tremolite, calcite, iron oxide and epidote.

Laem Thong Yang Gneiss

Petrographic studies reveal that the rocks of this unit are characterized by very coarse-grained, inequigranular, principally blastoporphyritic textures with slight to moderate foliation. In term of modal volume, this gneiss consists largely of orthoclase

(35%), quartz (30%), microcline (10%), plagioclase (9%), biotite (7%) and muscovite (6%). Zircon is ubiquitous accessory mineral.

Potassium feldspar is markedly blastoporphyritic, and the grains have either lenticular or tabular shapes, generally show simple twinning in orthoclase. Microcline displays cross-hatched twinning pattern. The porphyroblasts which range in size from 3x5 to 15x30 mm, are mostly orthoclase, microcline, perthite and small amount of plagioclase. It normally shows poikiloblastic texture containing inclusions of quartz, muscovite and biotite (Figure 5.5).

Plagioclase, whose compositional range is from An_{20} to An_{25}, forms albite twinning and partly altered to sericite. Typically it is lath-shaped with the slightly to moderate preferred orientation parallel to the main foliation. The oligoclase plagioclase is generally fine- to medium-grained (1-5 mm).

Quartz is typically strained, with strong undulatory extinction. It has interlocking boundaries which is probably due to shear stress. Not only are the grains fractured but also within the same grains several distinct individuals can be differentiated, visible only between crossed polars. This fracture implies intense dynamic effects. Myrmekitic intergrowth around quartz and feldspar is observed in some places and is thought to have formed immediately postdating the dynamic stress. Quartz occurs as both matrix (0.2-0.4 mm) and porphyroblasts (2.0-3.5 mm).

Biotite (0.5-1 mm) tends to be enclosed in the grain boundaries between quartz and feldspar, exhibits elongated tabular form and shows greenish brown pleochroism and greenish in the chloritized ones. Biotite is predominantly oriented parallel to the major foliation. Poikilitic biotite invariably contains inclusions of zircon and apatite. Pleochroic haloes of zircon in biotite are very common, implying high quantity of radioactive elements and being in a good agreement with airborne geophysical data.

Muscovite is overgrown on the biotite and feldspar crystals, and sometimes presents as secondary mineral. The grain size is about 0.2-0.8 mm.

Khao Dat Fa Granite

This rock is generally characterized by fine- to medium- grained, equigranular, biotite granite with well defined orientation of flaky minerals showing lepidoblastic texture. In thin section, it is found as hypidiomorphic to allotriomorphic granular textures.

The typical mineral composition of this granite includes orthoclase (40%), quartz (20%), microcline (5%), perthite (4%), plagioclase (11%), biotite (10%) and muscovite (8%). Garnet and tourmaline are ubiquitous minor minerals. Accessory minerals are apatite and sphene.

The average grain-sizes are in a range of 0.5-3.5 mm. This rock unit is locally altered to finer-grained aggregates of anhedral sericitized feldspar and chloritized biotite.

Potassium feldspar (0.2x0.5 to 2.5x3.5 mm) is generally orthoclase and occurs as subhedral to anhedral crystals. Microcline is present in several samples. The presence of microcline indicates that the cooling rate was very slow (Wunapeera, 1992). Perthitic intergrowth and carlsbad twin have been observed in some cases. Inclusions of dipyramid quartz and muscovite occur in some perthite.

Plagioclase (0.2x0.4 to 0.8x1.5 mm) has An-content varying from 5 to 15% ; the plagioclase phases commonly have euhedral to subhedral outlines and oscillatory zonal pattern. Myrmekitic intergrowth between quartz and plagioclase is normally existent, particularly where the K-feldspar is in contact with plagioclase.

Figure 5.5. Photomicrography of K-feldspar (K) megacryst of the Laem Thong Yang Gneiss (sample KN70-1), showing neocrystallized quartz (Q) and muscovite (M) filling fractures. Pleochroic haloes of zircon (Z) inclusion in biotite (B), cross nicols.

Figure 5.6. Photomicrograph of deformed garnet (G) in sample KS153 of the Khao Dat Fa Granite, showing recrystallized quartz (Q) and biotite (B) along fractures. Other minerals are muscovite (M) and K-feldspar (K). With crossed nicols.

Quartz (0.3-3.0 mm) in this rock type is of particular interest since it exists both as primary and secondary mineral phases. The primary quartz is anhedral in nature and often displays consertal relationship. It occurs as large irregular patches and as aggregates of small grains interstitial to feldspar. In contrast, the secondary quartz exhibits subhedral to euhedral outlines and lack in consertal texture. It is present as irregularly fine-grained aggregates and inclusions.

Biotite is normally present as small clusters of flakes in the foliation. It is characteristically subhedral outline with green and yellowish brown pleochroism. The grain size is about 0.2-1.3 mm.

Muscovite (0.2-0.5 mm), which is relatively less abundant than biotite, appears to pseudomorph after biotite and is entirely retrograde.

Garnet (0..5x1.0 to 1x1.5 mm) is commonly present and may be abundant in this units. It occurs mostly as subidiomorphic megacrysts, which may be poikiloblastic or skeletal, and rarely as fine-grained idiomorphic grains. Inclusions within garnet include quartz and biotite. Some garnet grains appear initially to have grown at first idiomorphically and later by partial infiltration along quartz grain boundaries producing skeletal texture.

Tourmaline is pale green in color and is present as tabular grains (up to 2 mm) with subhedral outlines and as small discrete grains. Tourmaline is highly pleochroic from brownish olive colour to a very faint greenish brown colour. Tectonically fractured tourmaline invaded and replaced by plastically mobilized quartz (showing undulating extinction).

Khao Pret Granite

The Khao Pret Granite can be petrographically distinguished as medium-grained phaneritic biotite granite and granodiorite with locally porphyritic texture.

In thin section, biotite granite is observed as holocrystalline, medium-grained (0.4-1.5 mm) equigranular hypidiomorphic to allotriomorphic granular texture. Orthoclase (0.5-3.5 mm) and microcline (1.0-2.0 mm) (up to 50%) form anhedral to subhedral grains with embayed texture. Plagioclase (0.6-1.5 mm) (about 15%) (Figure 5.7) shows typically albite twin and always contain minute inclusions of biotite, muscovite and quartz. Perthitic intergrowth has been observed somewhere. Myrmekitic texture is also very common. Quartz (0.3-3.0 mm) (about 20%) occurs as granulated feature. The most abundant ferromagnesian mineral is the greenish yellow pleochroic biotite (0.4-1.5 mm) (about 10%). Inclusions in biotite include zircon and apatite. Muscovite occurs as intergrowth with biotite and small amount of its flakes. Accessory minerals are anhedral magnetite and small crystal grains of zircon, apatite and occasionally sphene and monazite.

Minor phase, granodiorite is generally equigranular and fine-grained. It is holocrystalline and posses a hypidiomorphic to allotriomorphic granular texture. Mymerkitic texture is quite common. The alkali feldspar is mostly orthoclase (30%). Plagioclase (50%) have common albite twinning and less albite-carlsbad twin. Quartz (15%) is anhedral form. Biotite (5%) is generally exhibits subhedral, shows brownish green pleochroism, and is always altered to chlorite. Green pleochroitic hornblende occurs as well but in small amount. Zircon and apatite are accessory minerals and occur as inclusions in the biotite. Other mineral is mostly opaque minerals.

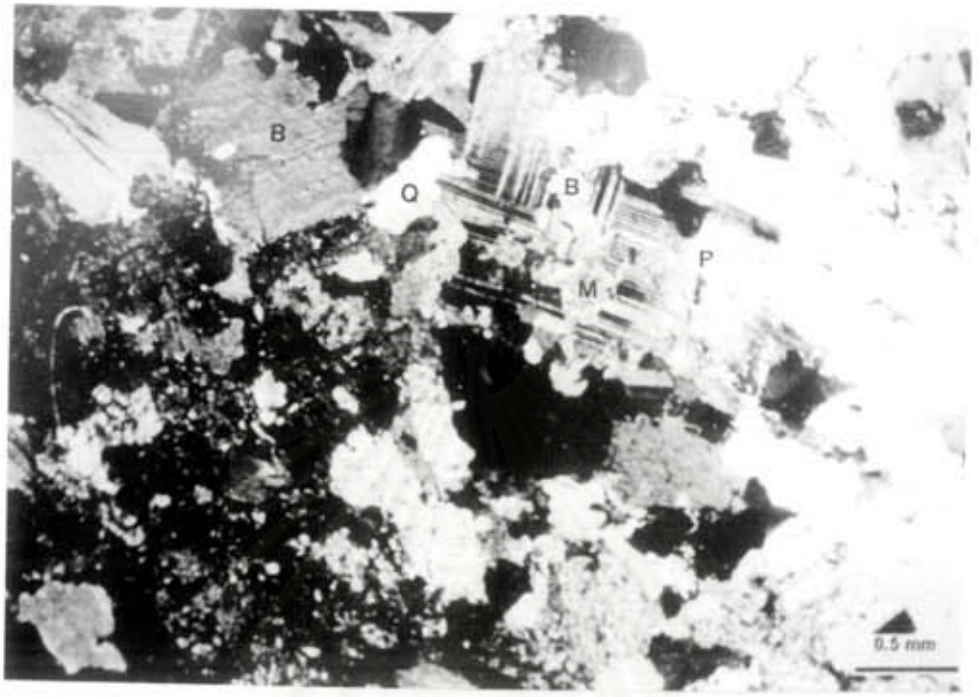

Figure 5.7. Photomicrograph of plagioclase (P) of the Khao Pret Granite (sample KN21-6), showing inclusions of quartz (Q), muscovite (M) and biotite (B). With crossed nicols.