CHAPTER III

GEOLOGY OF TAKUA PIT THONG AREA

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The Takua Pit Thong area is situated in a mountaineous terrain with an elevation of approximately 600 - 900 meters above mean sea level. The mountain belongs to the so-called Tennassarim mountain chain which is lying along the Thai-Burmese border.

The geology of the study area is illustrated in Figure 4. Apparently, the area is underlain for the most part by granitic rocks of presumably upper Cretaceous age (Beckinsale et al., 1979; Nakapadungrat et al., 1985). These granitic rocks intruded into a sequence of sedimentary rocks and subsequently thermally transformed them into marble intercalated with calcsilicate hornfels and metamorphosed sandstone. The cassiterite-sulfide orebodies are confined at or near the contact zone of these granitic rocks and the marble intercalated with calcsilicate hornfels (Figure 4).

3.1 <u>Igneous Rocks</u>

Igneous rocks exposed in the mining and nearby area are essentially granitic rocks ranging in their composition from granite to pegmatite and aplite with some quartz veins. Among these igneous phases, the granite is by far for the most abundance and covers more than three-fourth of the total exposure (Figure 4).

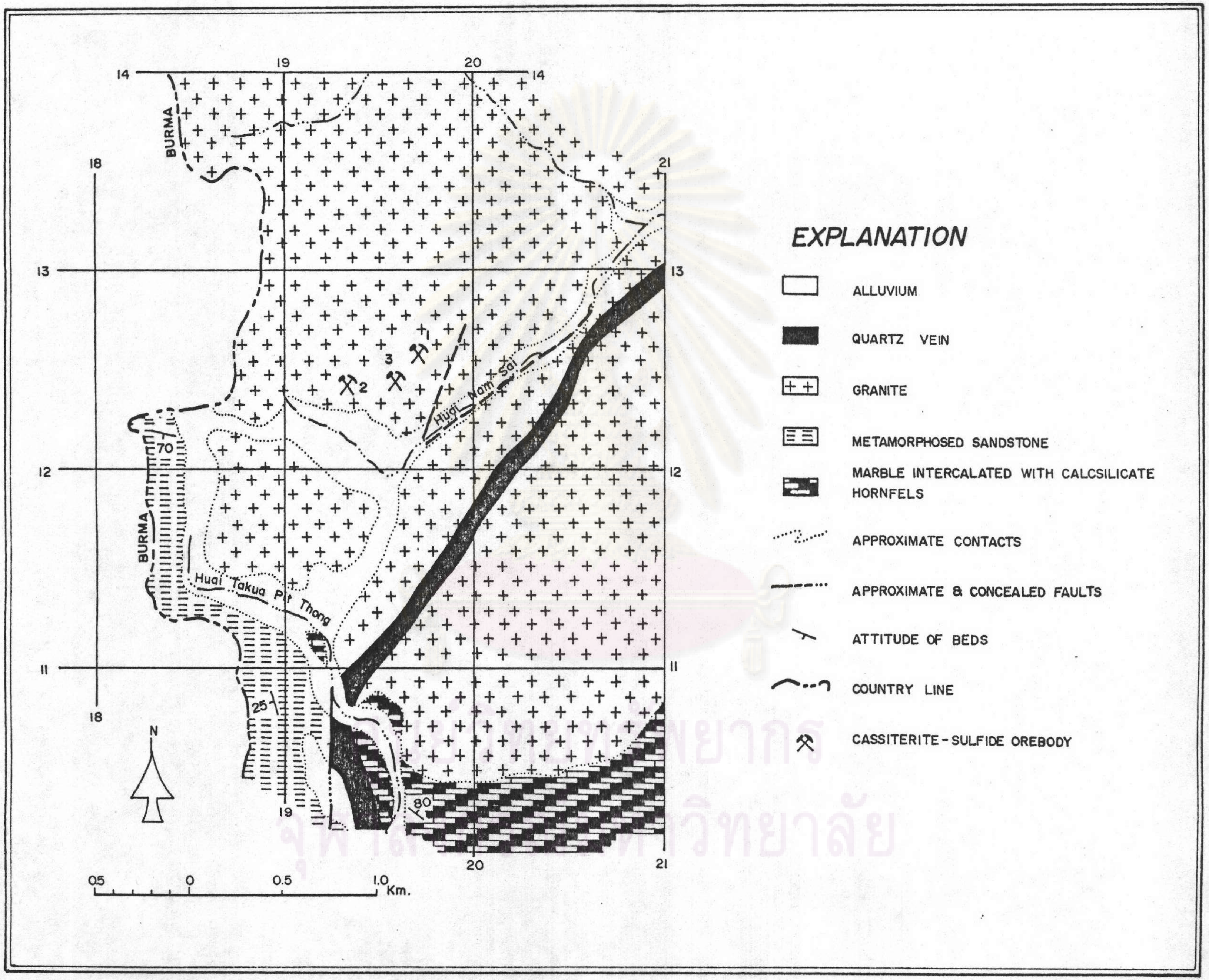

Figure 4 Geologic map of the Takua Pit Thong area (modified after Nutalaya, 1972 and Olanratmanee et al., 1983).

3.1.1 Granite

Based on textural and field evidences, granites in the area can be distinguished into two catagories, namely, coarse-grained biotite-muscovite granite (Figure 5) and fine-to medium-grained biotite (± muscovite, tourmaline) granite (Figure 6). Owing to the fact that most of granitic rocks exposed in the area are highly weathered, these two types of granites, therefore, are mapped as only one rock unit as shown in Figure 4. From the field observation, however, the coarse-grained biotite-muscovite granite is predominantly outside the mining area and probably constitutes the main phase of the granitic pluton, as also reported by Dheeradilok (1981). Whereas the fine-grained biotite (± muscovite, tourmaline) granite is found mainly in the mining area.

3.1.1.1 Coarse-grained Biotite-Muscovite Granite

Megascopically, this rock is coarse-grained, light gray and slightly porphyritic. Microscopically, it is composed predominantly of K-feldspar, plagioclase and quartz with subordinate biotite and muscovite. Its principal accessory mineral is apatite. Texturally, K-feldspar mainly forms as subhedral to anhedral grains and occurs as microcline, microcline-perthite. However, perthitic feldspar phenocrysts are not uncommon. Plagioclase commonly occurs as subhedral tabular crystals. The composition of plagioclase is the characteristics of oligoclase ($An_{\sim 30}$). Poikilitic texture characterized by plagioclase, biotite, muscovite and quartz inclusions in K-feldspar is rather common. Most of plagioclase are partially altered to sericite while almost all the K-feldspar are still fresh.

Figure 5 Hand specimens of coarse-grained biotite-muscovite granite at the Takua Pit Thong mine.

Figure 6 Hand specimens of fine-to-medium-grained biotite (± muscovite, tourmaline) granite at the Takua Pit Thong mine.

Quartz commonly forms as anhedral crystals or crystal aggregates filling the interstitial spaces of other constituents and it frequently shows undulose extinction. *Biotite is reddish brown and partially altered to chlorite. Muscovite occurs predominantly as large flakes and occasionally shows kinked cleavages.

3.1.1.2 Fine-to Medium-grained Biotite (± Muscovite, Tourmaline) Granite

This rock is abundant in the mining area. Megascopically, the rock is fine-to-medium-grained, slightly porphyritic, light gray on fresh surface but becomes brownish on weathered surface. Small flakes of biotite are evenly distributed throughout the rocks. Occasionally, it contains muscovite and patches of tourmaline.

Microscopically, this rock is composed predominantly of K-feldspar, quartz, plagioclase with subordinate biotite and occasionally muscovite plus tourmaline. The accessory minerals are apatite, sphene and opaque minerals.

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* In the following sections, the name "biotite, muscovite, phlogopite and phengite" are assigned to the micas based solely on their optical properties, i.e., biotite = reddish-brown, brown, greenish-brown and green color, small 2V; muscovite = colorless, large 2V, changing relief; phlogopite = pale brown color, small 2V; phengite = colorless to pale green color, small 2V, changing relief.

Most of the K-feldspar occur predominantly as microcline and microcline-perthite of which the former is more common. Texturally it usually forms as tabular crystals with ragged edges. Poikilitic texture characterized by inclusions of quartz, plagioclase and biotite in the K-feldspar crystals is frequently observed (Figure 7). Incomplete grid twinning is rather common in the elongate tabular microcline crystals with remnant of carlsbad twinning.

Majority of quartz occurs as anhedral grains or crystal aggregates filling in the interstitial spaces of other constituents. They display moderately to strongly undulose extinction. Rounded quartz grains in the K-feldspar crystals showing poikilitic texture are rather common while myrmekitic quartz is less common.

Plagioclase usually forms as subhedral tabular crystals and its compositition is entirely albite / oligoclase ($An \sim 10$). It is frequently altered to sericite particularly in the core region. Deformation twins are also encountered in some plagioclase crystals.

Biotite, the prominent and characteristic ferromagnesian mineral, occurs commonly as tabular or elongate flakes having reddish brown color. It should be noted that green biotite is also found in the granite adjacent to the orebody, its characteristics and genetic implication will be mentioned in the later section. Bended or kinked biotite flakes are occasionally observed (Figure 8). Some biotite flakes show partial alteration to green chlorite.

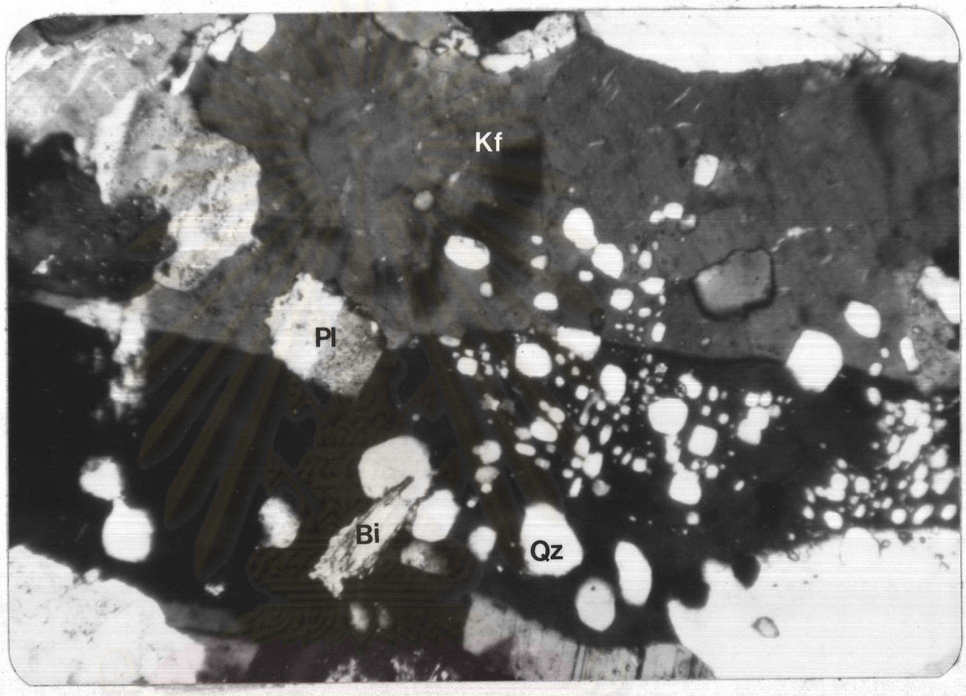

Figure 7 Photomicrograph of fine-to-medium-grained biotite (± muscovite, tourmaline) granite showing poikilitic texture of quartz (Qz), biotite (Bi) and plagioclase (Pl) inclusions in K-feldspar (Kf) at the Takua Pit Thong mine. (Thin section, 45x, crossed nicols)

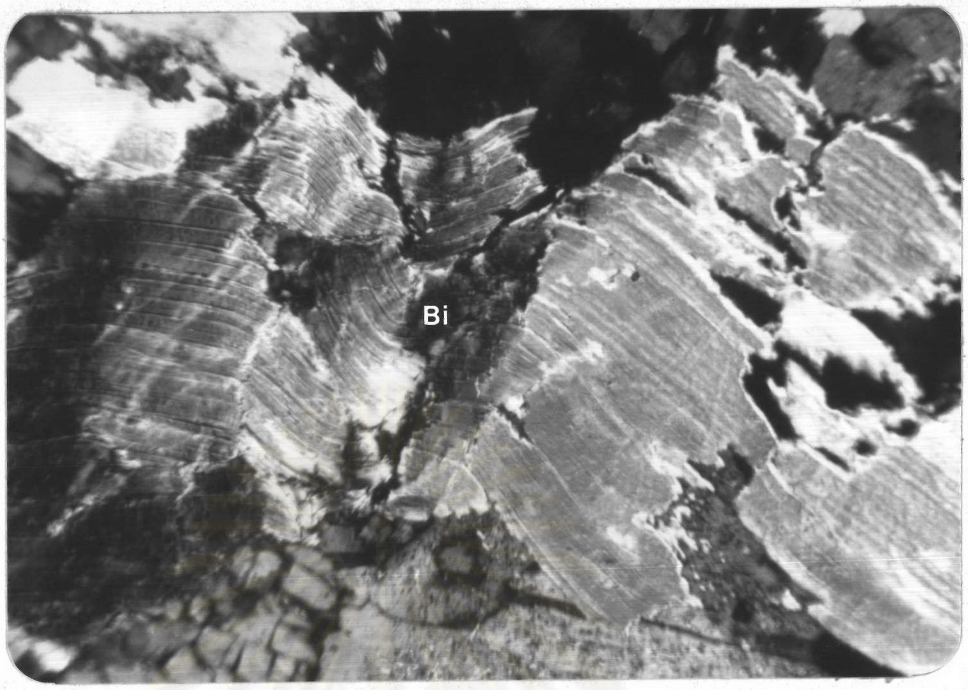

Figure 8 Photomicrograph of fine-to-medium-grained biotite (± muscovite, tourmaline) granite showing bended or kinked biotite (Bi) at the Takau Pit Thong mine. (Thin section, 100x, crossed nicols)

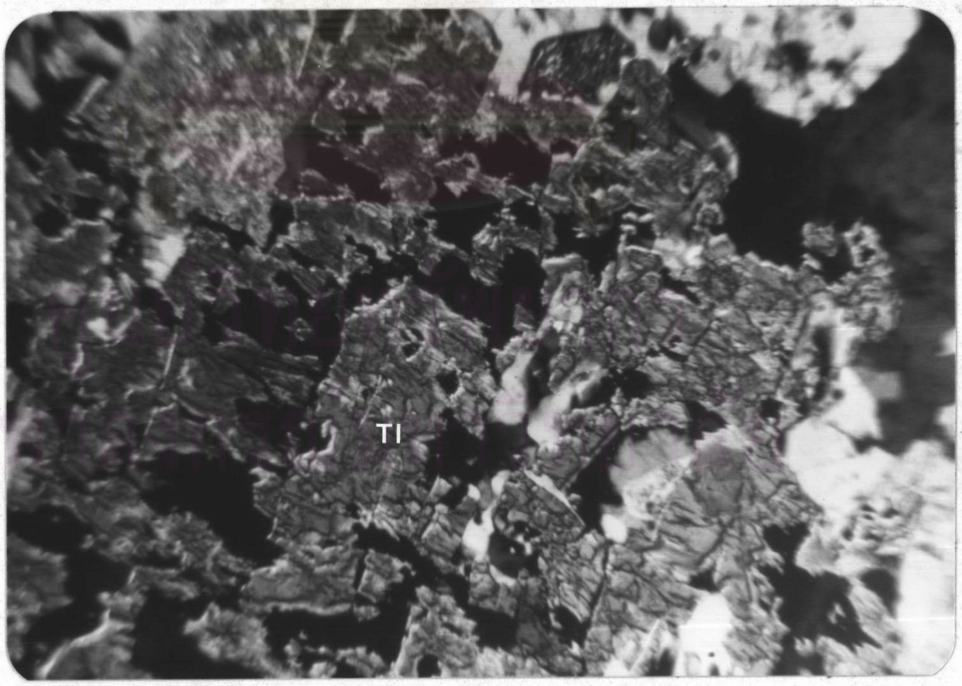

Figure 9 Photomicrograph of fine-to-medium-grained biotite (± muscovite, tourmaline) granite showing patches of tourmaline (Tl) at the Takua Pit Thong mine (Thin section, 50x, crossed nicols)

Muscovite commonly forms as large flakes in places or as poikilitic inclusions in plagioclase crystals. It also occurs along grain boundaries between feldspar and quartz or other minerals. This textural evidence seems to suggest that a large portion of muscovite is probable the alteration products of plagioclase and probably K-feldspar. In addition, for the sample that contains essential muscovite as the only mica mineral, faint brownish color was observed on some muscovite flakes. This evidence further suggests that at least some muscovite flakes may have been transformed originally from biotite.

Tourmaline occurs commonly as a patches scattered in the granite (Figure 9).

Apatite and sphene, the common accessory minerals, occur as euhedral to subhedral crystals.

3.1.2 Pegmatitic and Aplitic Veins

Pegmatitic and aplitic veins occur throughout the mining area crosscutting the granite. The size of those veins varies from a few meters to a few centimeters wide. The veins are mostly aligned in approximately NE-SW and N-S directions.

The pegmatitic rock in the area is characteristically very coarse-grained, and composed predominantly of microcline, microcline-perthite and quartz, with minor plagioclase, muscovite, tourmaline and garnet. Of those mineralogical compositions, the K-feldspar and quartz constitute more than 90% of the whole rock. Generally, plagioclase forms subhedral tabular crystals and is albite in composition

(An content approximately 9). Texturally, graphic quartz and K-feldspar is not uncommon. Tourmaline generally occurs as large prismatic crystals and is occasionally altered to chlorite.

Aplitic rock in the area is characteristically fine-grained and slightly porphyritic. Microscopically, the groundmass displays the spectrum of grain size ranging from very fine to fine interlocking grains or aggregate of crystals. In many instances, the large crystals or crystal aggregates appear to be corroded and embedded in a finer grained matrix. Mineralogically, the aplitic rock is composed essentially of K-feldspar, plagioclase, quartz with subordinate muscovite, tourmaline and garnet. The K-feldspar is commonly microcline with occasionally microcline-perthite and usually forms anhedral crystals, whereas the plagioclase is albite (An content of 8) and frequently shows undulose extinction. Muscovite also displays a large variation in their grain size varying from a small, long thin flake to a large somewhat corroded flake surrounded by finer-grained groundmass. Moreover, aggregates of radiating, needle-like flakes of muscovite are frequently observed. Tourmaline generally forms as a large prismatic crystal associated with other large crystals of quartz and K-feldspar or embedded in finer-grained matrix. Garnet commonly occurs as euhedral crystals or crystal aggregates. Inclusions of quartz in the garnet grains showing poikilitic texture is occasionally observed.

It should be further noted that no cassiterite or sulfide minerals occurs contemporaneously with both pegmatitic and aplitic minerals.

3.1.3 Quartz Veins

Quartz veins are another type of rock that are widely distributed in the mining area. They are probably of the late phase crosscutting granitic rocks, country rocks and cassiterite-sulfide orebodies. In general, these quartz veins orient roughly in three directions, notably, N-S, NE-SW and E-W as shown in the contour diagram in Figure 10. Their sizes vary from less than 1 cm up to 2 m wide. From the crosscutting relationship, it appears that the N-S quartz vein is the oldest whereas the NE-SW and the E-W ones are the younger and youngest, respectively. The NE-SW and E-W quartz veins also cut through the sulfide orebody. It should particularly be noted that the largest NE-SW quartz vein which is approximately 40 m wide and 4 km long crosscuts the granitic rocks on the eastern side of the mining area, and it bends somewhat to the north-south direction in the southern part of the area (Figure 4). These quartz veins are composed essentially of quartz without any noticeable mineralization.

3.2 Country Rocks

3.2.1 Marble and Calcsilicate Hornfels

The marble intercalated with calcsilicate hornfels are exposed at the southern part of the study area (Figure 4). Generally, these rocks are well bedded to massive (Figure 11). In several locations they show distorted bedding and dragfolds. However, their general bedding attitude is approximately NW-SE and dipping 70^{o} to 80^{o} to the northeast. Their overall appearance as shown in

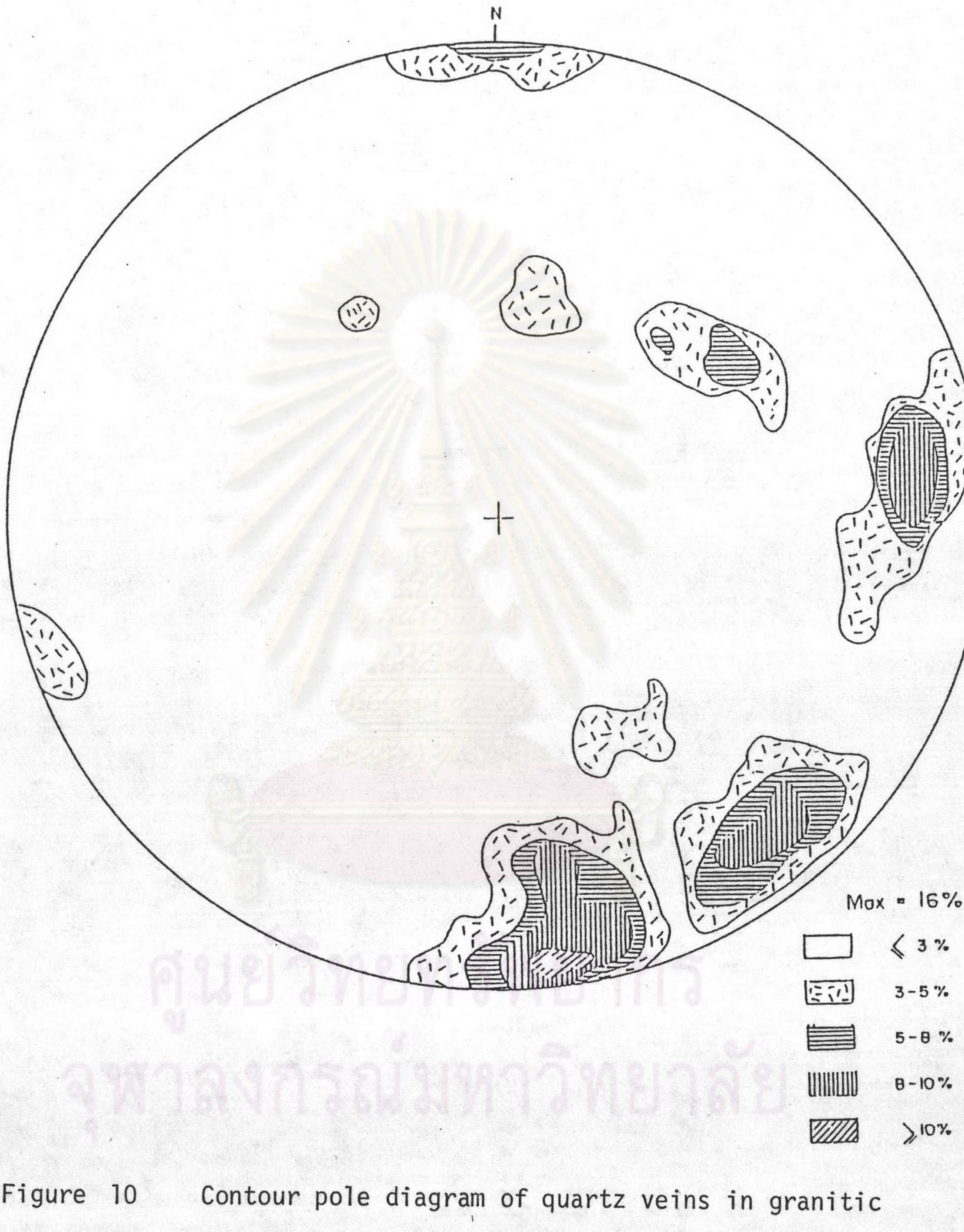

Figure 10 Contour pole diagram of quartz veins in granitic rocks at the Takua Pit Thong mine.

Figure 12 and 13 is light to dark gray and sugarly texture in which the marble layers show less resistant to weathering as being compared to the calcsilicate bands. Typically, the thickness of marble and calcsilicate hornfels varies from a few millimeter to a few meter thick.

Microscopically, the marble is composed essentially of fine-to-medium-grained-equigranular granoblastic calcite with subordinate intergranular phlogopite. This mineralogical composition of marble seems to suggest that the original carbonate rock was probably dolomitic in composition. Locally in the zone that is closer to the band of calcsilicate hornfels, grains or aggregates of phlogopite, diopside, tremolite-actinolite, clinozoisite and sphene are developed intergranularly.

The calcsilicate hornfels forms as the intercalating bands with marble. Microscopically, the rock is characteristically composed predominantly of very fine-grained equigranular granoblastic plagioclase and quartz with subordinate diopsidic pyroxene, tremolite-actinolite, sphene, phlogopite, minor clinozoisite and opaque minerals. Diopsidic pyroxene commonly forms as granular crystal or crystal aggregates. Tremolite-actinolite generally occurs as long prismatic crystals and also as typical rhombic cross section. Often enough, diopsidic pyroxene is closely associated with tremolite-actinolite. Sphene occurs frequently as subhedral crystals closely associated with diopsidic pyroxene. Phlogopite forms locally as small flake associated with feldspar groundmass. Patches of opaque minerals are observed. Locally thin and somewhat parallel layers of coarser-

Figure 11 An exposure of marble intercalated with calcsilicate hornfels unit outside the orebody at the Takua Pit Thong mine.

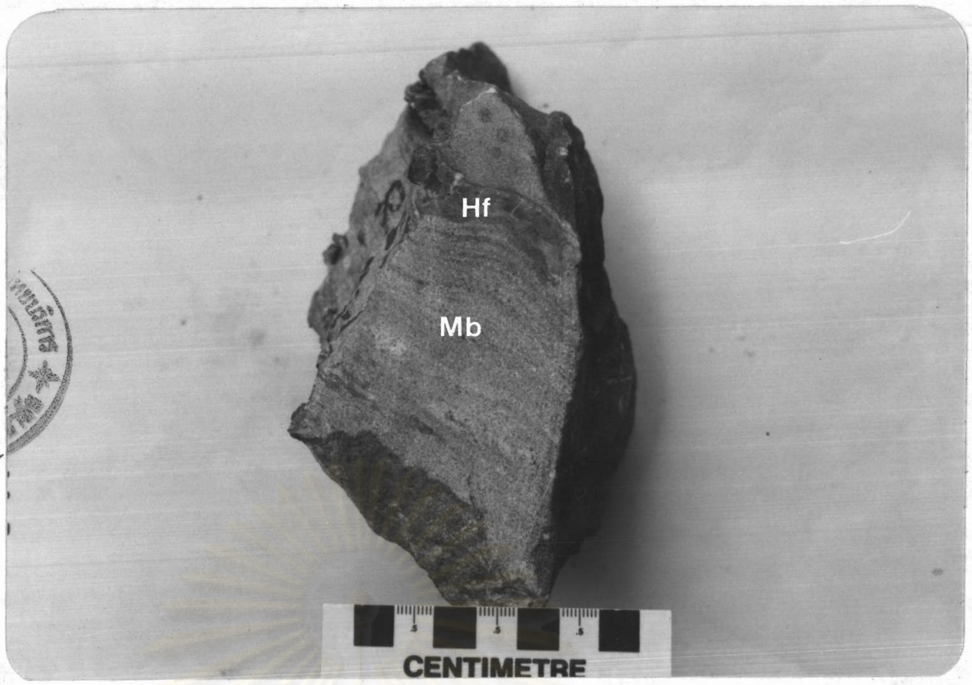

Figure 12 Hand specimen of marble (Mb) intercalated with layers of calcsilicate hornfels (Hf) at the Takua Pit Thong mine.

Figure 13 Hand specimen of calcsilicate hornfels at the Takua Pit Thong mine showing bands of original bedding.

grained mixture of feldspar, quartz and diopsidic pyroxene are occasionally noticeable on the microscopic scale. These thin layers are often border both sides by diopsidic pyroxene. The diopsidic pyroxene is locally altered to clinozoisite. This textural evidence suggests that the small scale layering of coarse-to-fine-grained materials is likely to represent the relict of the bedding in the original rocks. The mineralogical composition of the rock also suggest that this calcsilicate hornfels is probably transformed from a finely laminated calcareous siltstone. It should be further noted that calcsilicate minerals was later crosscut by microveinlets of massive aggregate of talc suggesting the low temperature remobilization of magnesium rich solution.

3.2.2 Metamorphosed Sandstone

The metamorphosed sandstone is located at the southwestern corner along the Thai-Burmese border, occupying about 10% of the study area (Figure 4). Megascopically, the rock is represented by a weathered, slightly metamorphosed, and poorly bedded sandstone. In hand specimens, its color varies from yellowish-brown to reddish-brown on the weathered surface. The attitude of bedding plane is about S $15^{o}E/25^{o}$ SW. The contact between the metamorphosed sandstone and granitic rocks is approximately along Huai Takua Pit Thong and has been offsetted by a fault to the south of the area (Figure 4). Field observations seem to suggest that the metamorphosed sandstone is probably underlain by marble intercalated with calcsilicate hornfels.

Microscopically, the rock is well sorted, and composed predominantly of very fine grained quartz and minor feldspar showing granular texture containing ferruginous cement. The rock appears to be subjected to thermal metamorphism as evidenced from a granoblastic polygonal grain boundaries.

3.3 Structure

Aerial photograph and field observation reveal that there are at least two major fault zones in the mining area (Figure 4). The first one aligns in the N-S direction approximately locating at the contact between marble intercalated with calcsilicate hornfels unit and metamorphosed sandstone in the southern part of the area (Figure 4). The other probably lies along the Huai Nam Sai in approximately NE-SW direction within the granitic body (Figure 4). The temporal relationship between these two fault systems is not ascertained.

Eventhough the cassiterite-sulfide orebodies appear, on the large scale, to confine at or near the contact zone between the granitic rocks and the marble intercalated with calcsilicate hornfels unit, a closer examination on the orebodies itself reveals that a number of ore minerals, i.e. chlorite, green biotite, appears to fill in small open fractures within the granitic rocks underneath and nearby the orebody. Attempts therefore have been made to quantify the attitudes of these open fractures because they certainly bear some genetic implication of the Takua Pit Thong ore deposit. A total of 50 measurements have been made and plotted in contour pole diagram as shown in Figure 14. It is rather obvious from the Figure 14 that the open fractures filled with ore and gangue minerals are confined to the system of approximately N-S direction. Furthermore, a sheared plane aligned in approximately N-S direction is recognized at the No.1 orebody. The significance of this open fracture system and sheared plane will be discussed in later sections.

Furthermore, a number of joint system without any infills are also observed within the granitic and country rocks. A total of 99 values of the attitude of these joints mostly from the granitic rocks within the area have been measured and plotted in a contour pole diagram in Figure 15. From the diagram, it reveals that there are four main directions of joint systems, namely N-S, NE-SW, NW-SE and E-W directions.

Numerous minor dragfolds can also be observed in the marble interbedded with calcsilicate hornfels unit (Figure 16). The axis of minor folds lies approximately NE-SW direction and plunging 55° N.

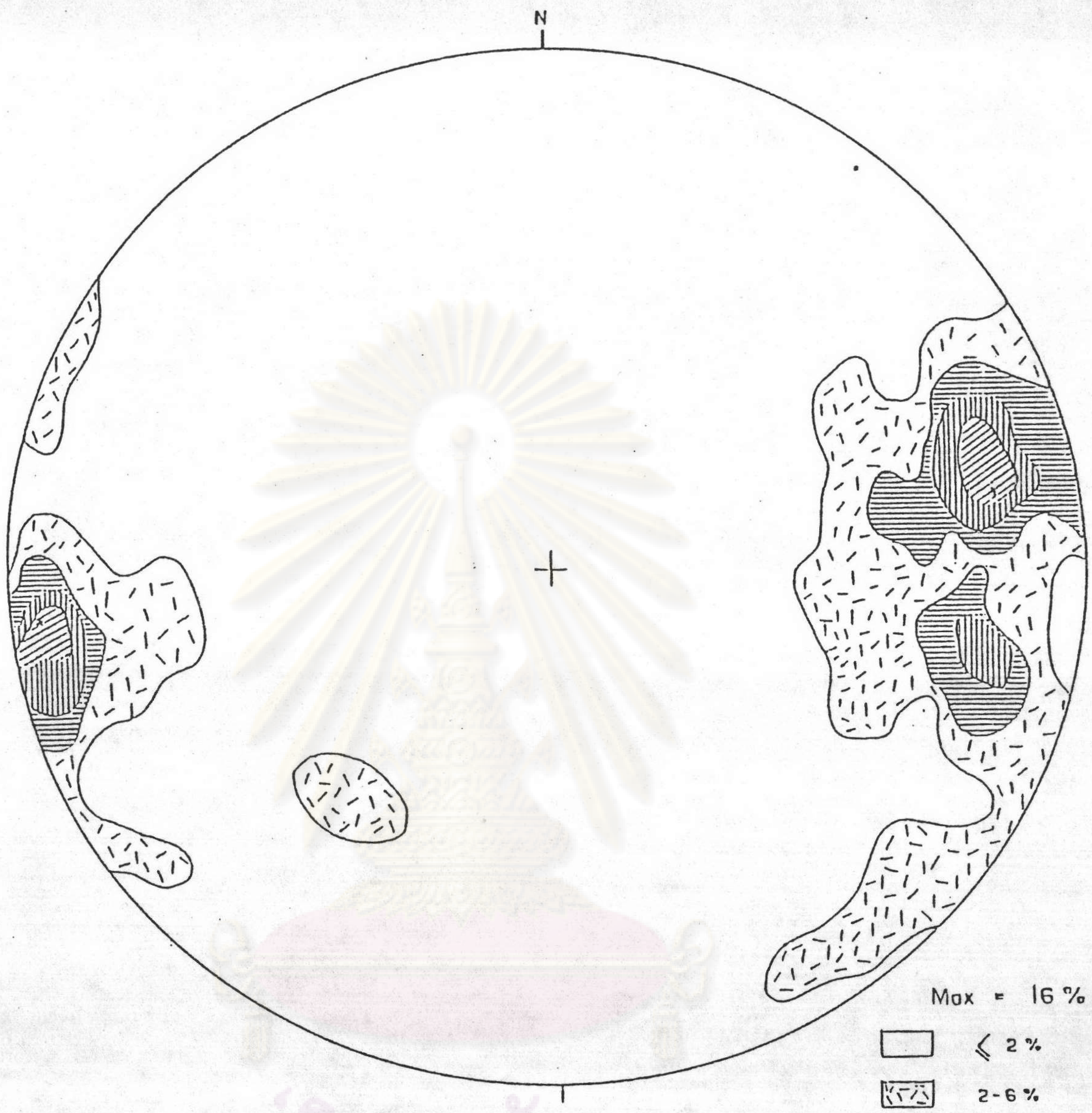

Figure 14 Contour pole diagram of the open fractures filled with green biotite in granitic rocks nearby the cassiterite-sulfide orebodies at the Takua Pit Thong mine.

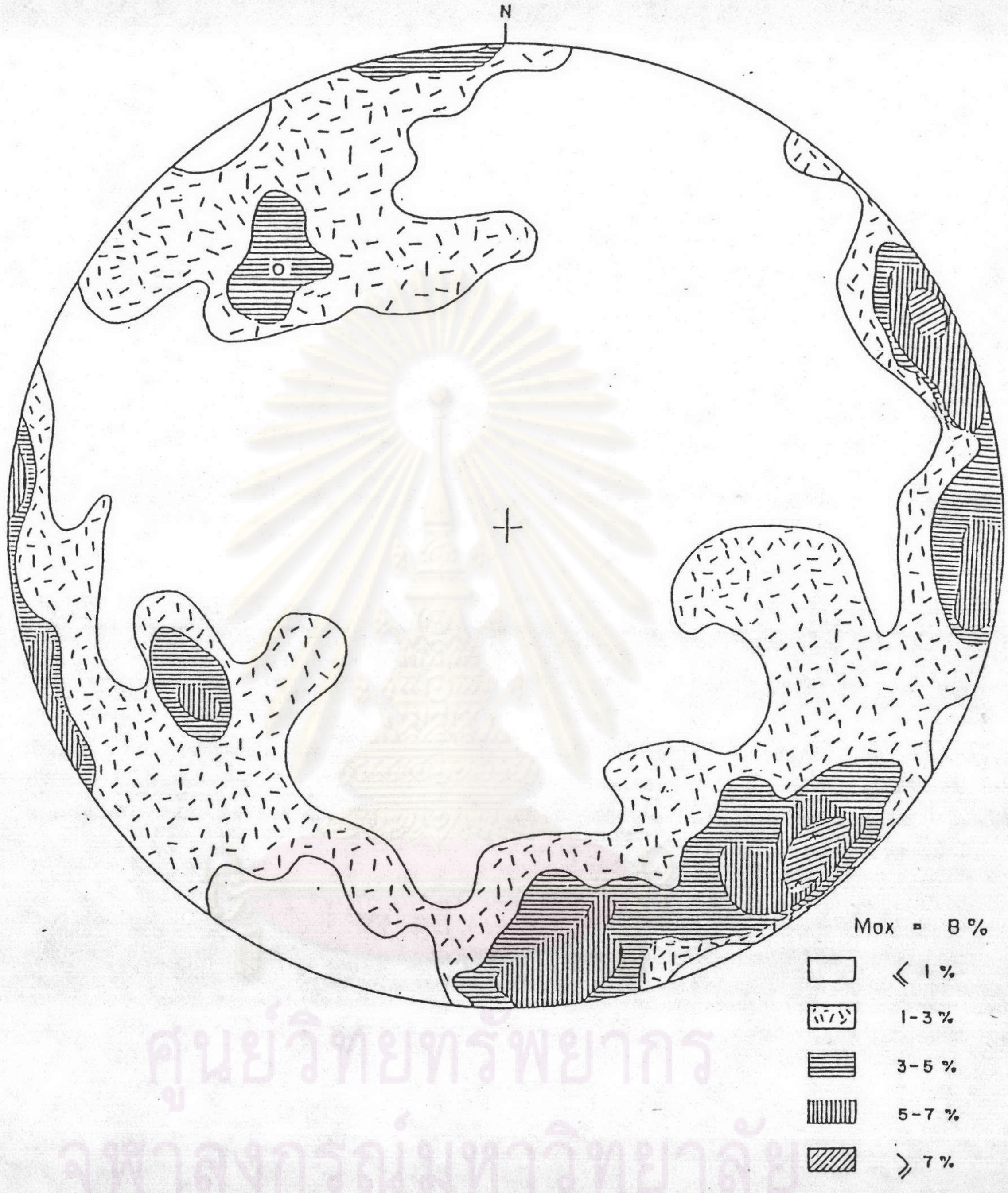

Figure 15 Contour pole diagram of the joints in granitic rocks at the Takua Pit Thong mine.

Figure 16 An exposure of marble intercalated with calcsilicate hornfels showing numerous minor dragfolds at the Takua Pit Thong mine.