CHAPTER V

MINERALOGY AND PARAGENESIS

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The Takua Pit Thong cassiterite-sulfide deposit is situated near the crest of a granitic pluton as judging from the elevation and shape of the granitic body in the mining area (Figure 1). So far, four locations of cassiterite-sulfide (magnetite) occurrences have been found in the mining area. Of those, three of them, hereafter called No.1, 2 and 3 orebodies, are large and being mined for cassiterite ores. The location for each of them is referred to Figure 4. The other one, hereafter called No.4 occurrence, is a small occurrence and exposed nearby the Huai Nam Sai within the granitic rock on the southeast of the large three orebodies. In addition to those occurrences, many localities in the Takua Pit Thong area show sign of mineralization, i.e. green biotite occurring in the zone of open fractures.

Generally the Nos.1 and 2 orebodies appear as a rather massive orebody that are located at the contact zone between the granitic rocks and marble intercalated with calcsilicate hornfels unit. In contrast the No.3 orebody and the No.4 occurrence are confined within a fracture zone of granitic pluton. Because of the similarity in the nature and mineralogy between the Nos.1 and 2 orebodies, these two orebodies will be described together separated from the No.3 orebody and the No.4 occurrence which are somewhat different mineralogically.

5.1 The Nos.1 and 2 Orebodies

Among those three orebodies, the No.1 orebody is the largest and best exposed on one slope of a hill (Figure 28). The No.1 orebody is separated into lower and upper parts (Figures 29 and 30). The vertical separation between the two parts is about 20 meters. Field evidence seems to suggest that both the upper and the lower parts may have been previously interconnected. The dimension of the lower part of No.1 orebody is about 35 meters wide and 10 meters thick. No obvious zonation has been observed in the field due to the fact that majority of the ore has been blasted off (Figure 29). Nevertheless from a crude observation, it appears that cassiterite is richer toward the granitic body whereas fluorite is more abundant toward the marble and calcsilicate hornfels unit.

The upper part of the No.1 orebody is perhaps confined within a fracture zone inside the granitic rocks (Figure 30). The zone of the orebody is about 10 meters wide and 7 meters thick orientating in approximately north-south direction and dipping 65^{o} to the west. Field evidence and microscopic observation suggest that the granitic rocks have been sheared along the contact with the orebody.

The No.2 orebody as shown in Figure 31, is located about 350 meters south-west of the No.1 orebody lying approximately at the same elevation as the lower part of the No.1 orebody (around 750 meters above mean sea level). Similar to the No.1 orebody, the outcrop has been blasted off into pieces. Its dimension is around 15 meters wide and 5 meters thick. Field observation reveals that a series of north-south open joints filling with green biotite has been found on the

Figure 28 An overview of the Takua Pit Thong mine showing the locations of the No.1 orebody (upper part : No.1-U, lower part : No.1-L) and the No.3 orebody (No.3)

Figure 29 An exposure of the lower part of the No.1 orebody that has been blasted off into pieces and accumulated on the slope. Notes the outcrop of mable (Mb), granitic rocks (Gr) and orebody (Orb).

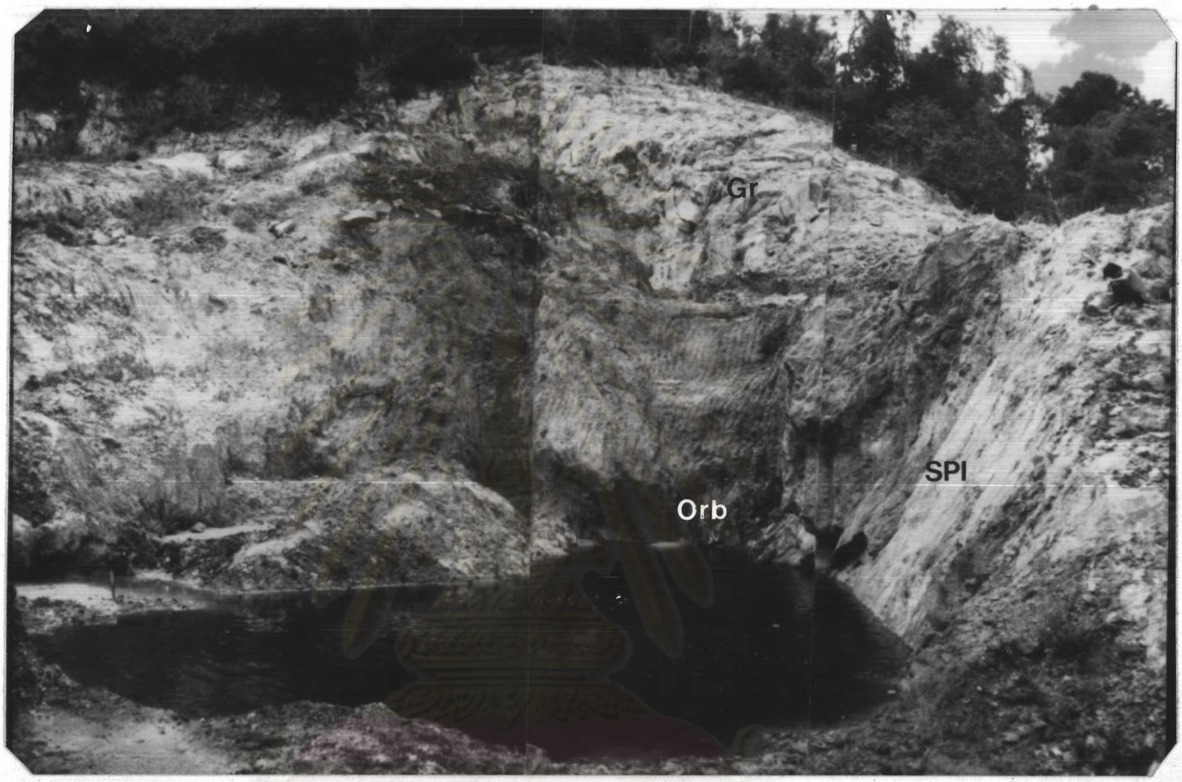


Figure 30 An exposure of the upper part of the No.1 orebody (almost completely mined out and filled with water). The orebody (Orb) is confined within a sheared zone of granitic body (Gr). One sheared plane (SP1) is on the middle right-hand side of the photograph.

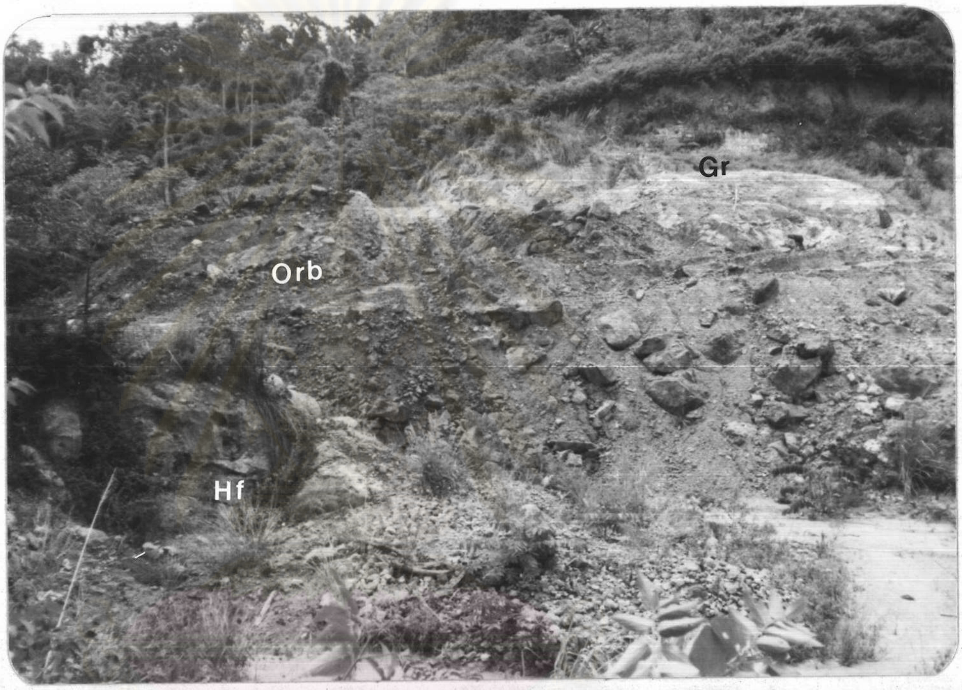


Figure 31 An overview of the No.2 orebody showing outcrop of calcsilicate hornfels (Hf), granitic rocks (Gr) and orebody (Orb).

side and probably underneath the No.2 orebody on the granite contact. This open joints might have probably been a feeder zone for the ore solution that will be discussed later.

5.1.1 Marble and Calcsilicate Hornfels Near the Nos.1 and 2 Orebodies

As stated earlier, the outcrops of the Nos.1 and 2 orebodies have been blasted off into pieces. Therefore, a systematic sampling of both marble and calcsilicate wallrocks to verify the zonation is not possible. However, some distinct characteristics of marble and calcsilicate rocks that diagnose the wallrock alteration are outlined.

On hand specimens, the marble near the Nos.1 and 2 orebodies is similar to those outside the orebodies in terms of their colors and sugarly textures. The noticeable difference is however marked by the appearance of dark patches or bands (Figure 32). Occasionally, these dark patches or bands are distorted (Figure 33). Microscopically, the marble is characteristically consisted of equigranular granoblastic calcite with subordinate phlogopite, brucite and sometimes tremolite-actinolite. Most of the marble in the vicinity of No.1 orebody are noticeably richer in phlogopite content as being compared to those outside the orebody. However, the mineralogical composition apparently varies from phlogopite-to brucite-rich marbles. The dark patches or bands are composed predominantly of phlogopite, occasionally with subordinate plagioclase and sphene or with sulfide minerals, namely pyrrhotite, pyrite and chalcopyrite. These phlogopite patches or bands are often sheared as evidenced from a preferred

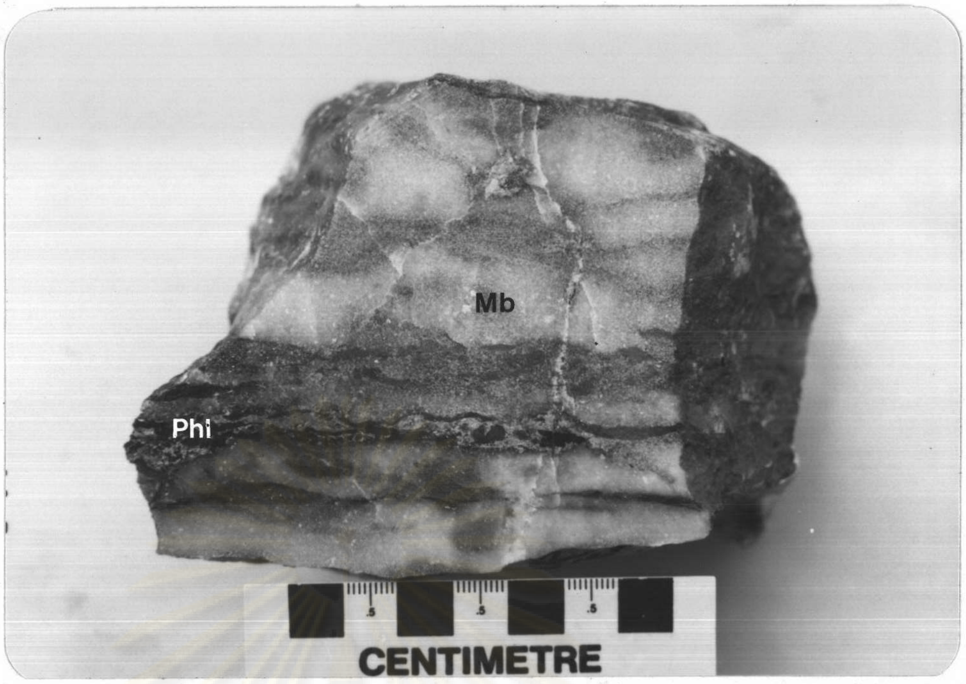


Figure 32 A hand specimen of marble (Mb) near the No.1 orebody. The rock contains dark bands (Phl) of mainly phlogopite and minor sulfide minerals.

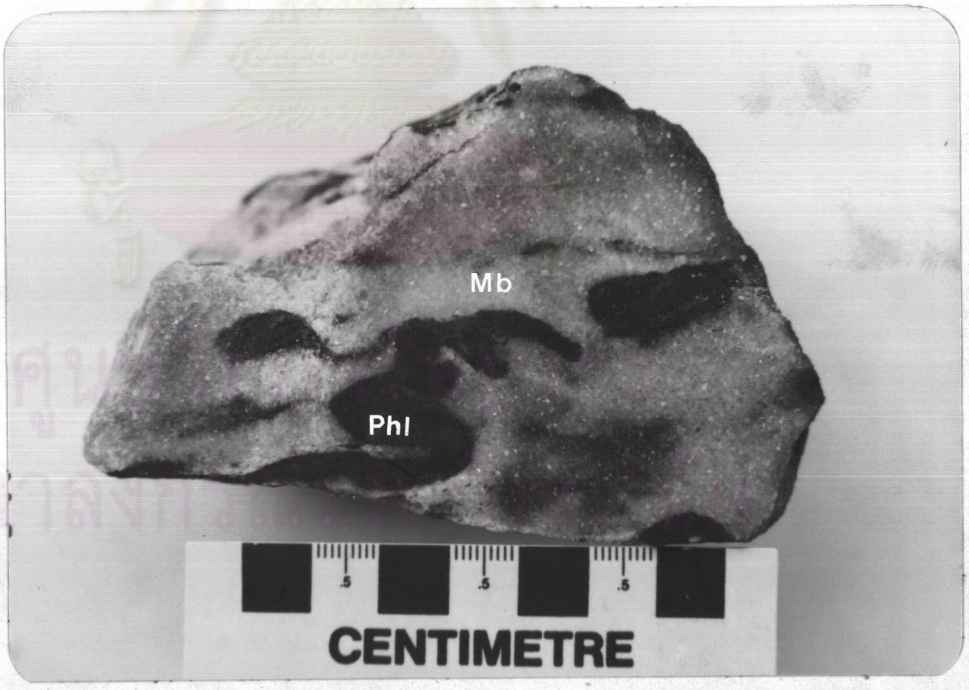


Figure 33 A marble sample showing the distorted patches (Phl) of predominantly phlogopite near the No.1 orebody at the Takua Pit Thong mine.

orientation of the phlogopite flakes. Calcite occasionally shows glide twinning and distorted crystals. Several generations of phlogopite probably occur in the marble. Their occurrences seemingly vary from small and short flakes intergranularly filling between calcite to somewhat small to large tabular aggregates or bands that often having been associated with plagioclase and sphene or sulfide minerals. The former might form earlier probably during the formation of marble whereas the later may have been introduced later in the paragenetic sequences. In other words, the dark patches or bands possibly are the result of late preferentially metasomatic infiltration of the foreign component along open fractures.

In the brucite marble, brucite normally forms as large tabular flakes that are locally altered to hydromagnesite (?) (Figure 34). Relicts of cubic outlines of original periclase already having been altered to brucite are occasionally found. On occasions, tremolite-actinolite has been developed in the marble especially at the contact zone with the orebody. The tremolite-actinolite is partially altered to talc.

Calcsilicate hornfels found at or near the No.1 and No.2 orebodies is characterized by the remarkable development of parallel, brownish bands of coarser-grained materials on the greenish and very fine-grained calcsilicate minerals (Figure 35). Under the microscope, the finer-grained material is similar to the calcsilicate hornfels exposed outside the orebody in terms of texture and mineralogy, i.e., fine-grained equigranular granoblastic texture of plagioclase, diopside, tremolite-actinolite, sphene, phlogopite, and quartz.

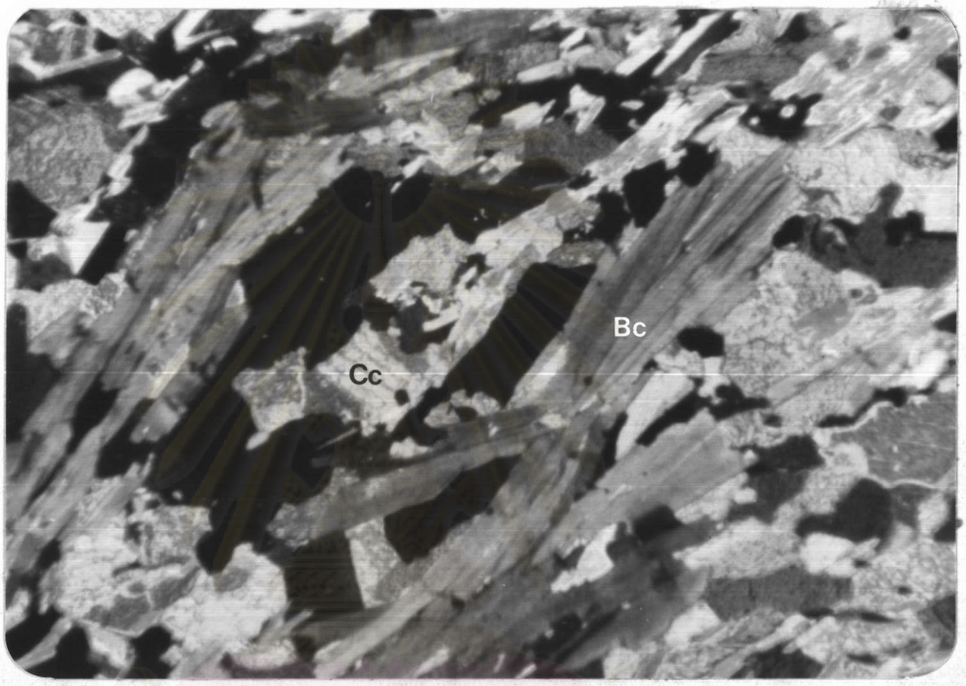


Figure 34 Photomicrograph of marble near the No.1 orebody showing the large tabular flakes of brucite (Bc) occurring among matrix of calcite (Cc). (Thin section, 90x, crossed nicols)

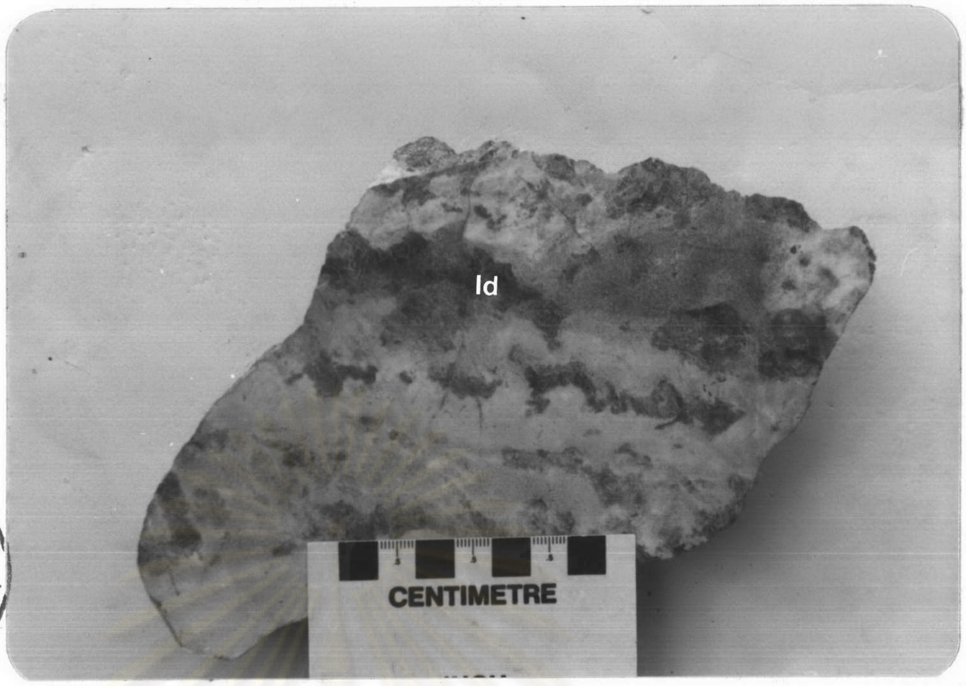


Figure 35 A sample of calcsilicate hornfels near the No.1 orebody showing the development coarse-grained brownish bands (Id) of mainly idocrase at the Takua Pit Thong mine.

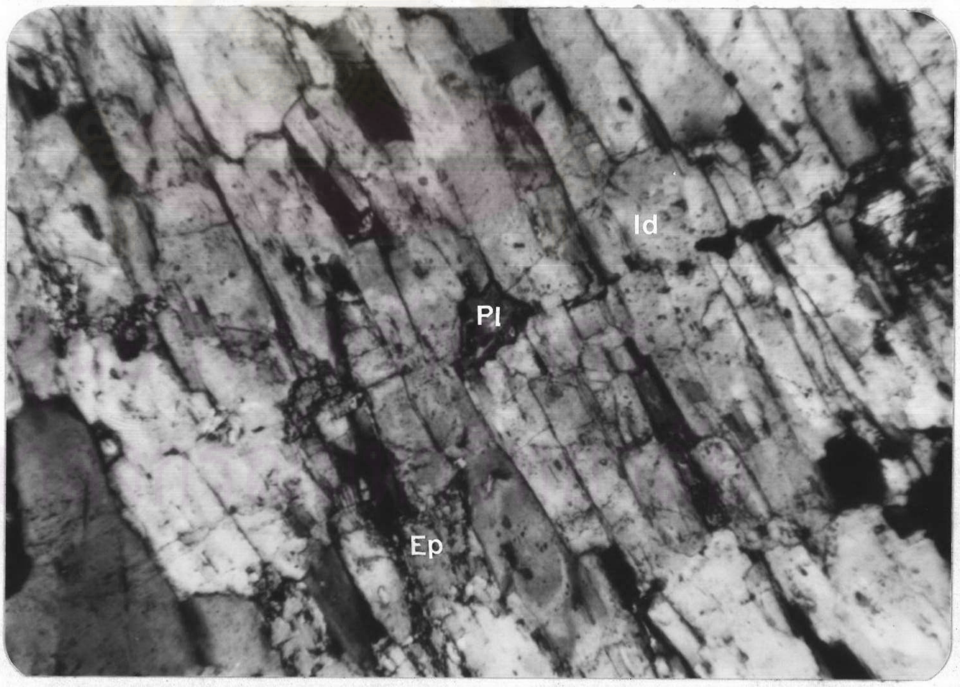


Figure 36 Photomicrograph showing coarse-grained idocrase (Id) including the crystals of epidote (Ep) and plagioclase (Pl) in the brownish band of calcsilicate hornfels at the Takua Pit Thong mine. (Thin section, 45x, crossed nicols)

Some noticeable differences are however depicted by the fact that it contains considerably higher amounts of phlogopite and sulfide minerals. Most of plagioclase are oscillatory zone with andesine in composition (An content $\sim$ 37). The sulfide minerals mostly are pyrrhotite and minor chalcopyrite filling in vugs or forming patches closely associated with large prismatic crystals of tremolite-actinolite and clinozoisite together with sphene. Phlogopite usually occurs as short tabular flakes filled intergranularly. Stringers of calcite are frequently observed whereas those of tremolite-actinolite plus sphene are less common. Microveinlets of essentially talc aggregate occasionally crosscut it.

The coarser-grained bands are composed dominantly of idocrase with occasionally some wollastonite, scapolite, plagioclase, fluorite, calcite and epidote. Idocrase normally forms a large crystal or radiating crystal aggregates frequently incorporating inclusions of diopsidic pyroxene, plagioclase, phlogopite and epidote (Figure 36). A few bodies of original calcite still remain in the large idocrase crystals. Formation of incipient idocrase at the contact zone between calcite and calcsilicate minerals is clearly observed. This evidence suggests that the idocrase has been formed at the expense of calcite and other calcsilicate minerals. The inclusions of those calcsilicate minerals as well as the calcite bodies within the idocrase crystals are therefore the unconsumed portions of the original minerals. Wollastonite locally occurs nearby the No.1 orebody as multiple-twinned-elongate crystals or a radial fibrous aggregates closely associated with idocrase. Scapolite and fluorite are found nearby the No.2 orebody intimately intergrown with idocrase plus plagioclase (An content up to 58) within the coarse-grained bands. This fluorite is probably an early-formed and hereafter called stage I. At the contact of calcsilicate hornfels and orebody, idocrase as well as other calcsilicate minerals are partially replaced by phlogopite and becoming phlogopite rich band. This evidence suggests that phlogopite occurred both during and after the formation of calcsilicate minerals and being richer toward the orebody.

Moreover, this metamorphic stage is essentially barren of cassiterite whereas the sulfide minerals were likely to introduce late in time.

5.1.2 Granitic Rocks Near the No.1 and 2 Orebodies

The granitic rocks adjacent to the Nos.1 and 2 orebodies are fine-to-medium-grained biotite (± muscovite, tourmaline) granite, pegmatite and aplite. On approaching the orebody, they appear as greenish gray color due to the presence of green biotite.

Microscopically, all varieties of the granitic rocks near the Nos.1 and 2 orebodies are characteristically modified by the development of foreign minerals metasomatically infilling along the grain boundaries or cracks of the pre-existing coarser-grained granitic minerals. Mineralogically, the infilling minerals are fine-grained equigranular granoblastic aggregates of predominantly plagioclase and K-feldspar with subordinate quartz, biotite, hornblende, calcite, sphene, apatite and fluorite (Figure 37).

Plagioclase occurs as subhedral crystals of oligoclase in composition. Oscillatory zonation is common in plagioclase crystals.

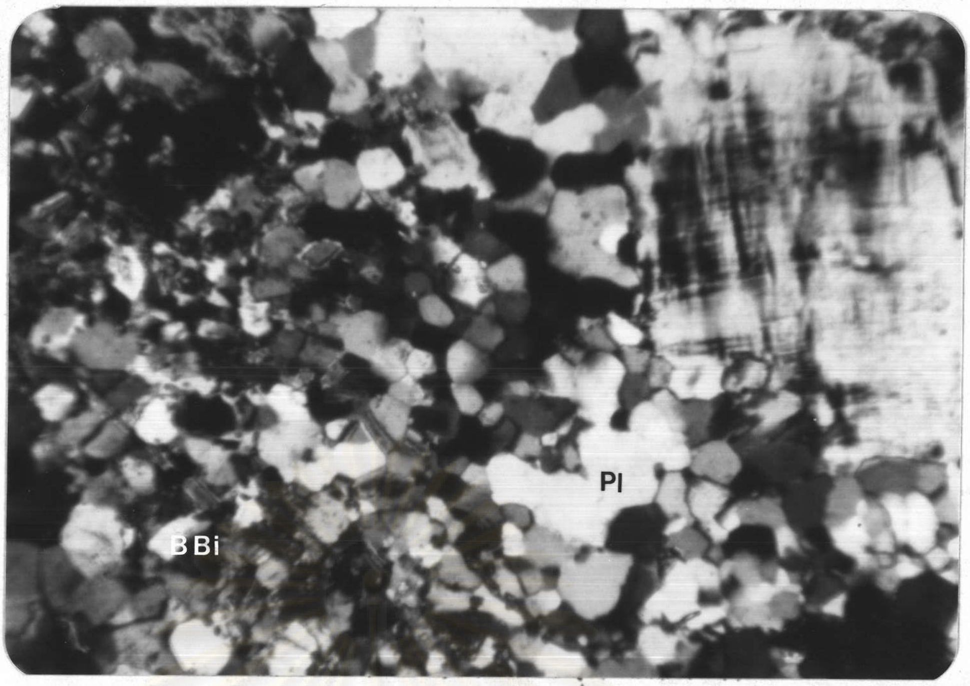


Figure 37 Photomicrograph showing fine-grained metasomatic infilling minerals of predominantly plagioclase (Pl) and brown biotite (BBi) in original granitic rock near the No.1 orebody. (Thin section, 45x, crossed nicols)

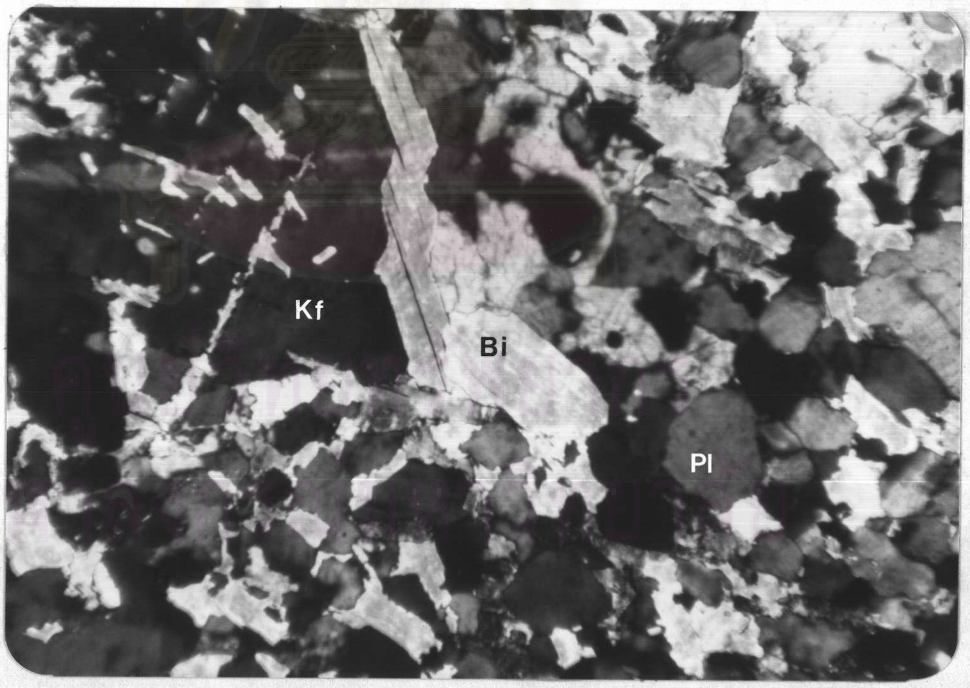


Figure 38 Photomicrograph of granitic rock near the No.1 orebody showing the pre-existing minerals as K-feldspar (Kf), biotite (Bi) occurring as coarser-grain islands among the infilling minerals of mainly plagioclase (Pl). (Thin section, 90x, crossed nicols)

K-feldspar is mainly microcline or microcline-perthite. Subhedral to anhedral quartz occurs intergranularly among the feldspar crystals. Poikilitic of quartz in feldspar is fairly common.

Biotite is noteworthyly richer than those of the granitic rocks far from the orebody. Biotite apparently develops both as small flakes and large or elongate flakes. The former is more abundant and occurs during and after the metasomatic infiltration of feldspars and others whereas the latter is less abundant and probably the pre-existing biotite in the original biotite granite as evidenced from its close association with the remaining islands of coarse-grained granitic minerals (Figure 38). Closer to the orebody contact, the small biotite flakes are so intensely developed in places of original granitic minerals as well as infilling minerals that they nearly obliterated the original granitic and infill textures. As a result the rock contains almost exclusively of biotite. It often shows preferred orientation. Furthermore, the color of biotite apparently varies from original reddish brown color in the biotite granite to normal brown color in the infill and pervasive biotite alteration. Occasionally it may change into greenish brown or green color (see section 5.1.3 for further details on color of biotite). In the No.2 orebody, veinlets of greenish brown to green biotite, closely associated but predating sulfide minerals of mainly pyrite and minor chalcopyrite and pyrrhotite, are ubiquitous and crosscutting in granitic and infilling materials in particular on approaching the orebody contact (Figures 39 and 40). These veinlets are oriented approximately north-south direction and apparently change the granitic

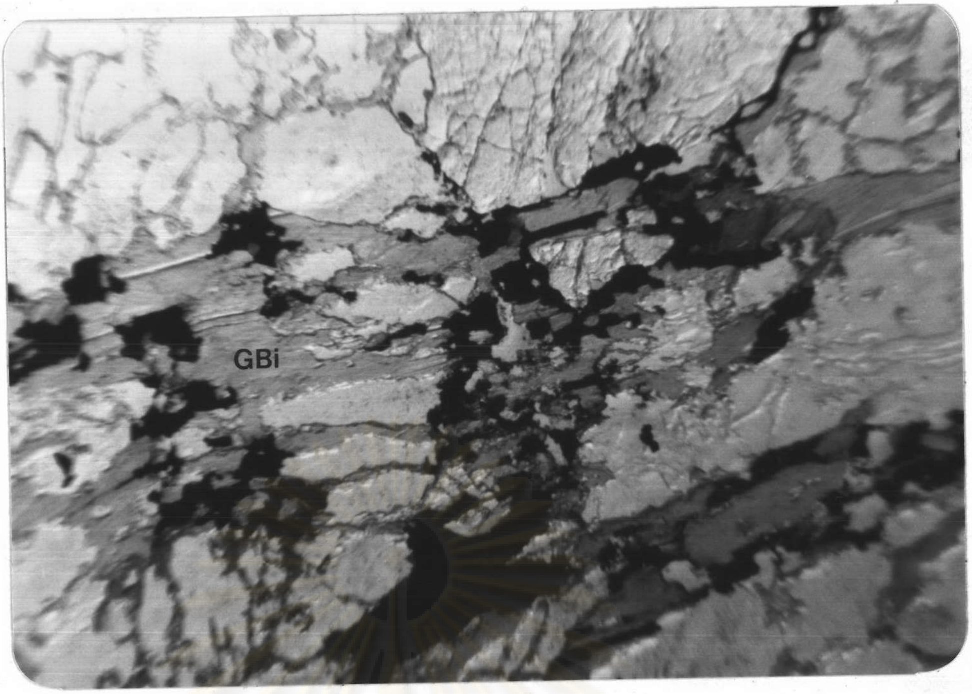


Figure 39 Photomicrograph showing veinlets of greenish brown to green biotite (GBi) associated with sulfide minerals (dark) crosscutting in granitic rock near the No.2 orebody. (Thin section, 50x, uncrossed nicols)

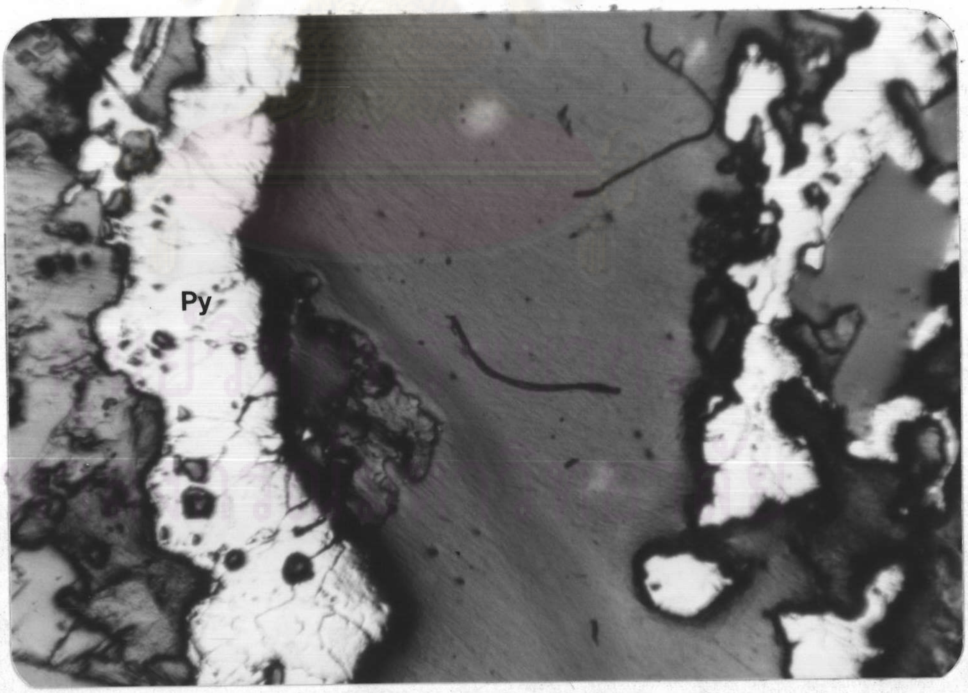


Figure 40 Photomicrograph of sulfide minerals mainly pyrite (Py) occurring as veinlets in granitic rock at the No.2 orebody. (Polished section, 45x, crossed nicols)

rocks into green biotite rock depending on the degree of alteration. Frequently, brown or green biotite had been altered to chlorite plus opaque minerals.

Green hornblende found near No.1 orebody occurs as large prismatic crystals commonly associated with greenish-brown biotite, sphene, calcite and apatite (Figure 41). Sphene forms as subhedral to anhedral crystals or aggregates. It is usually but not always associated with brown biotite that is somewhat changed to greenish color, or with infilling minerals. Apatite, which is probably the early-formed mineral in the biotite granite, still remains as euhedral to subhedral crystals. Occasionally fluorite is found closely associated with both feldspar of the infilling materials, and with plagioclase in the biotite granite. It is probably the early-formed stage I fluorite.

In addition to the metasomatic infiltration, the granitic rocks near the Nos.1 and 2 orebodies also show some evidences of intensively pervasive greisen alteration (i.e., marked enrichment of muscovite $\pm$ tourmaline) and tectonic deformation (in the north-south direction). In some cases, the development of muscovite almost obliterates the original granitic texture (Figure 42). The original reddish-brown biotite has been altered to chlorite during greisen alteration. The granitic rocks collected from the sheared plane display a beautiful motar texture with post-tectonic chlorite pseudomorph after pretectonic biotite The greisen found at the sheared plane contains kinked muscovite, broken prismatic tourmaline crystals and recrystallized, plastically mobilized quartz. This textural evidences suggest that the tectonic deformation postdated the pervasive greisen alteration and metasomatic infiltration.

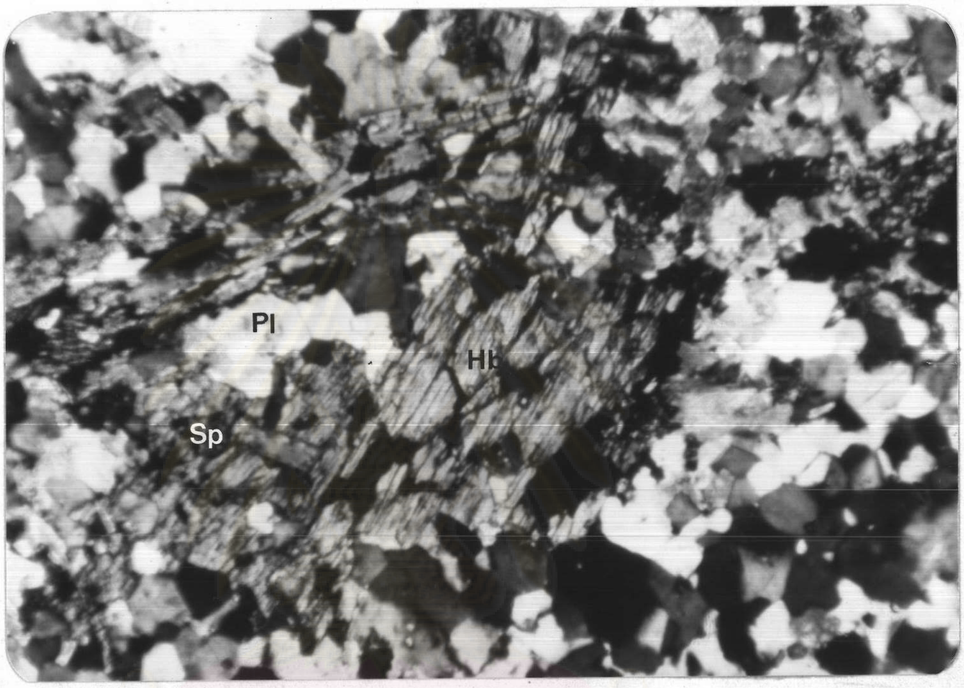


Figure 41 Photomicrograph of granitic rock near the No.1 orebody showing large prismatic crystals of green hornblende (Hb) and sphene (Sp) associated with infilling minerals mainly plagioclase (Pl). (Thin section, 45x, crossed nicols)

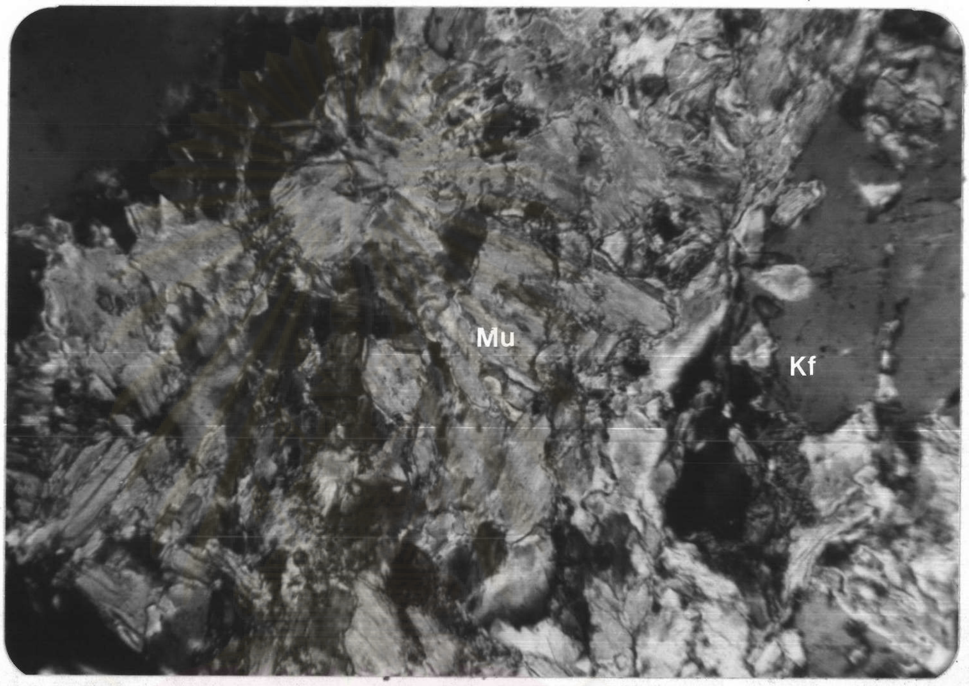


Figure 42 Photomicrograph of pervasive greisen alteration in granitic rock near the No.1 orebody showing development of fine-grained muscovite (Mu) almost obliterates the original granitic texture. Note the remaining K-feldspar (Kf). (Thin section, 100x, crossed nicols)

It should be noted that no cassiterite or sulfide mineralization has taken place during this period.

5.1.3 Mineralogy and Mineral Paragenesis at the Nos.1 and 2 Orebodies

The Nos.1 and 2 orebodies are characteristically composed principally of pyrrhotite with subordinate cassiterite and chalcopyrite, minor pyrite and magnetite, and trace sphalerite and arsenopyrite. The major gangue minerals are biotite, phlogopite and phengite, subordinate fluorite and quartz, and minor sphene and garnet. The paragenetic sequence of ore and gangue minerals in the Nos.1 and 2 orebodies is summarized in Figure 43.

Among the gangue minerals, biotite is by far the most abundant mineral in the orebody and commonly forms as massive body associated with the ore minerals. Because of the significance of biotite in terms of its color variation in relation to the ore minerals and its ubiquity in the orebody, detailed observation of biotite formation might greatly help understanding the ore genesis.

As mentioned earlier, the brown biotite is intensely pervasive enriched toward the orebody on the granite side while the phlogopite is abundant on the marble and calcsilicate hornfels side. Within the orebody itself, biotite as well as phlogopite usually form as massive aggregates of fine to coarse crystals. They tend to develop larger crystals toward the open spaces. The brown color of biotite seemingly changes to greenish brown or green color. Often

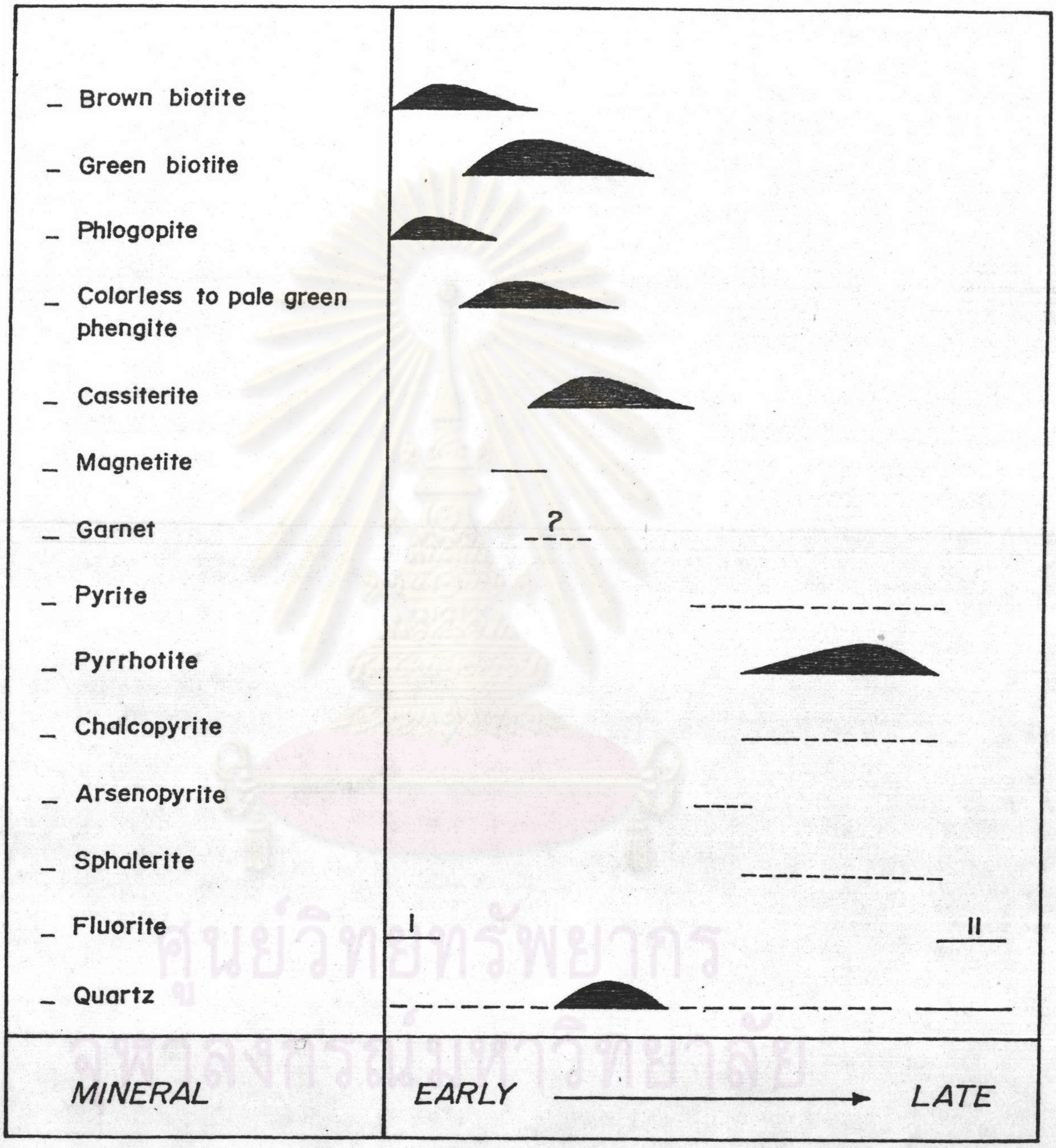


Figure 43 Mineral paragenesis at the Nos.1 and 2 orebodies. Thick, thin and dash horizontal line represent the relative amount of each mineral varying from the most to the least abundance, respectively.

enough, some biotite flakes exhibit brownish core and greenish rim suggesting a progressive green coloration inward. Relatively more intense greenish color toward an open vug is occasionally observed. Furthermore, the brown biotite or pale brown phlogopite also progressively convert to very pale or colorless to pallid green phengite (i.e., still retains very small 2V but show changing relief). The brownish-core and colorless-to-pale-green rim phengite is often observed. As a whole, therefore, the orebodies, especially the No.2, seem to contain more green biotite or colorless to pale green phengite than the brown biotite and phlogopite. The majority of green biotite might probably be converted from the brown biotite. Nevertheless a number of green biotite might have formed as a late stage open vug filling prior to the precipitation of cassiterite and sulfides. This color variation of biotite and phlogopite as well as phengite is certainly related to the difference in iron, titanium and magnesium contents (Hayama, 1959).

Occasionally fragments of granite surrounding by coarse crystalline aggregate of green biotite are found in the orebody. Almost all the feldspar in granite fragments have been transformed into sericite. Fragments of green biotite aggregate imbedded in pyrrhotite are also common in the No. 2 orebody.

Cassiterite is the most important and early- formed ore mineral. It usually occurs as coarse subhedral to anhedral crystals or aggregates. Cassiterite crystals frequently are so large that they could be visually observed on hand specimen (Figure 44). They frequently fill in open spaces or replace massive

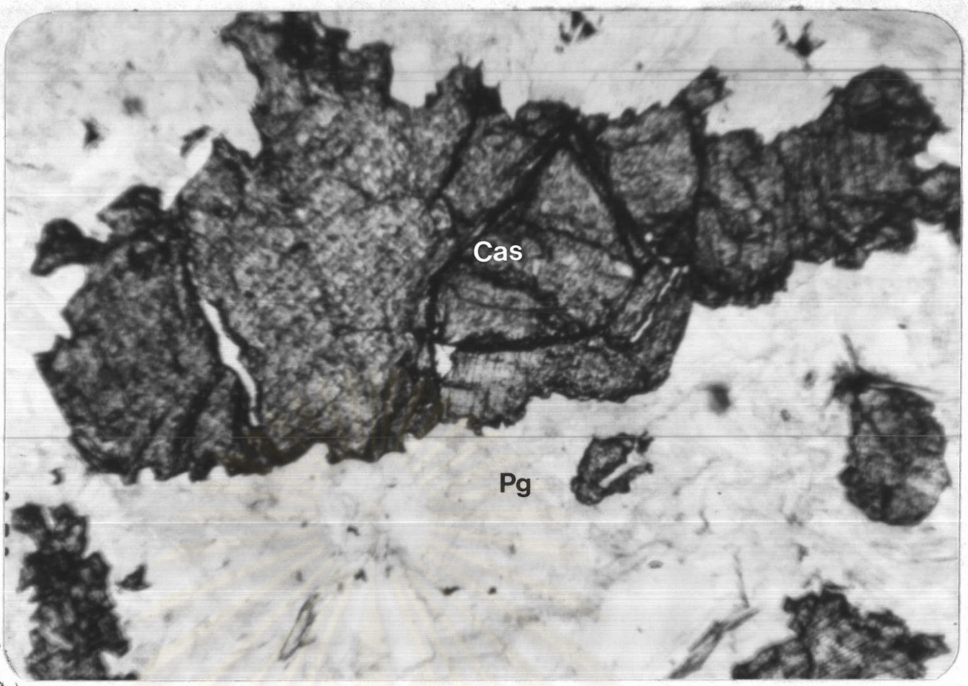
Figure 44 Photograph showing cassiterite occurring as the large crystals (Cas) associated with predominantly phengite in the No.1 orebody at the Takua Pit Thong mine (see photomicrograph of this sample in the next Figure).

green to greenish brown biotite as well as colorless to pale green phengite (Figure 45). But they are rarely found associated with brown biotite or phlogopite. Cassiterite occasionally displays growth zoning of varying color with slight pleochroism. Often, it incorporates inclusions of green biotite or colorless phengite in their crystals. It also forms intergrowth with coarse euhedral quartz crystals in open fractures. This mineral assemblage was later infilled by pyrrhotite and chalcopyrite.

Pyrrhotite is by far the most common sulfide mineral in the orebodies. It usually forms as an infill or crosscutting veinlets in cassiterite and euhedral quartz assemblage (Figure 46). Frequently it shows an intergrowth with chalcopyrite and minority of pyrite (Figure 47).

Chalcopyrite is the second most common sulfide mineral in the orebody. Similar to pyrrhotite, it usually forms as an infill in vugs or fractures in cassiterite, quartz and massive mica aggregates. Chalcopyrite also forms mutual boundary with trace sphalerite.

Pyrite occurs in minor amount. Two forms of pyrite are recognized, a rhythmical or colloform pyrite and normal pyrite. The rhythmical or colloform pyrite is among the earliest sulfide mineral to precipitate in vugs probably after cassiterite and euhedral quartz (Figure 48). This kind of pyrite is generally found in the outer zone of orebody especially in the fracture zone near the contact with igneous and country rocks. It commonly forms as rounded to oval shape (Figure 49) occasionally surrounded by pyrrhotite or graded into normal pyrite. The normal pyrite apparently precipitated somewhat



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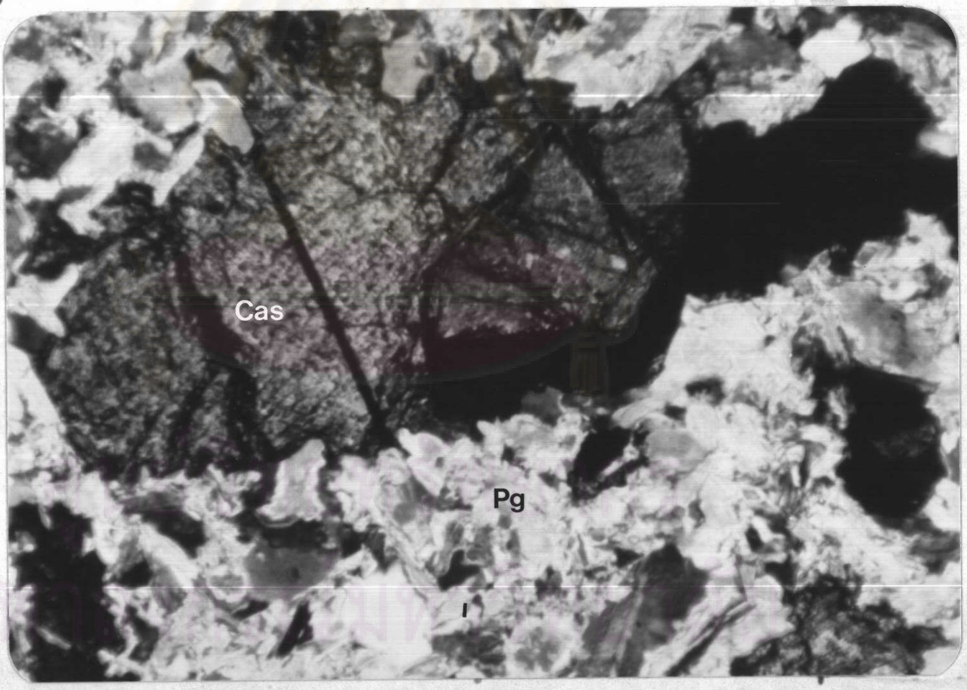

B

Figure 45 Photomicrographs of anhedral crystals of cassiterite (Cas) replacing massive pale green phengite (Pg) in the No.1 orebody. Note thin section, 45x. A) uncrossed nicols, B) crossed nicols.

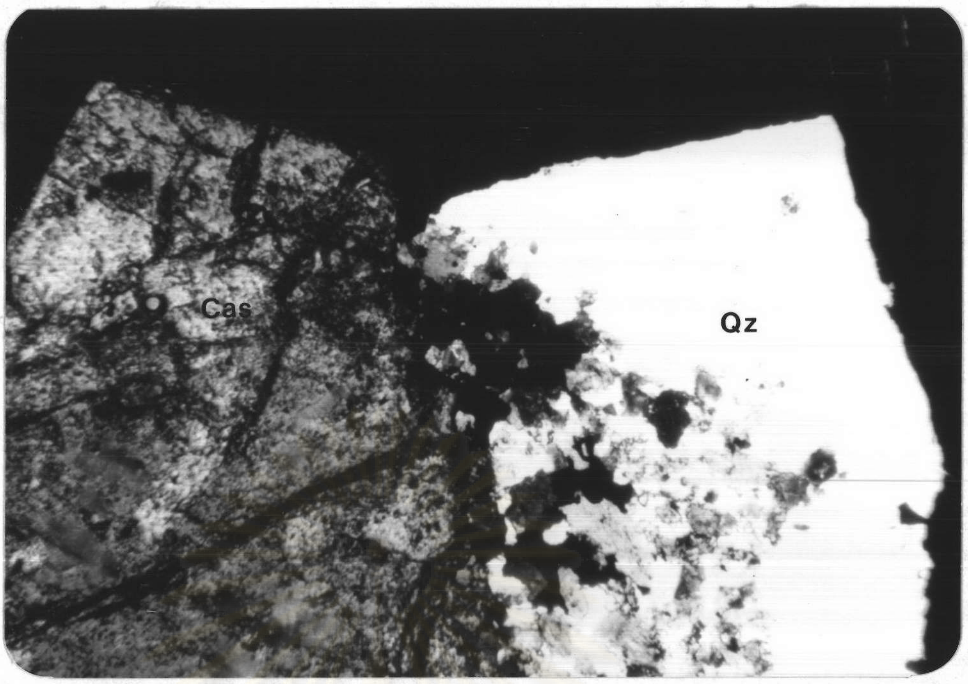

Figure 46 Photomicrograph of euhedral intergrowth between cassiterite (Cas) and quartz (Qz) with sulfide minerals (dark) of mainly pyrrhotite infilling or crosscutting along small veinlets (Thin section, 45x, crossed nicols)

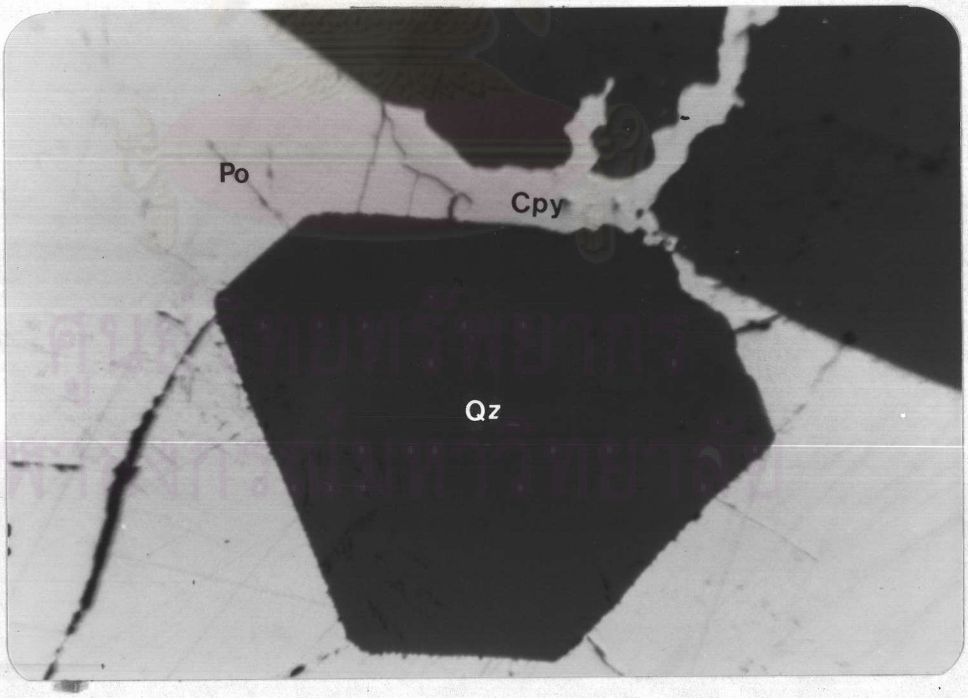

Figure 47 Photomicrograph showing pyrrhotite (Po) and chalcopyrite (Cpy) surrounding euhedral quartz crystal (Qz) or as veinlets crosscutting quartz in the No.1 orebody (Polished section, 45x, uncrossed nicols)

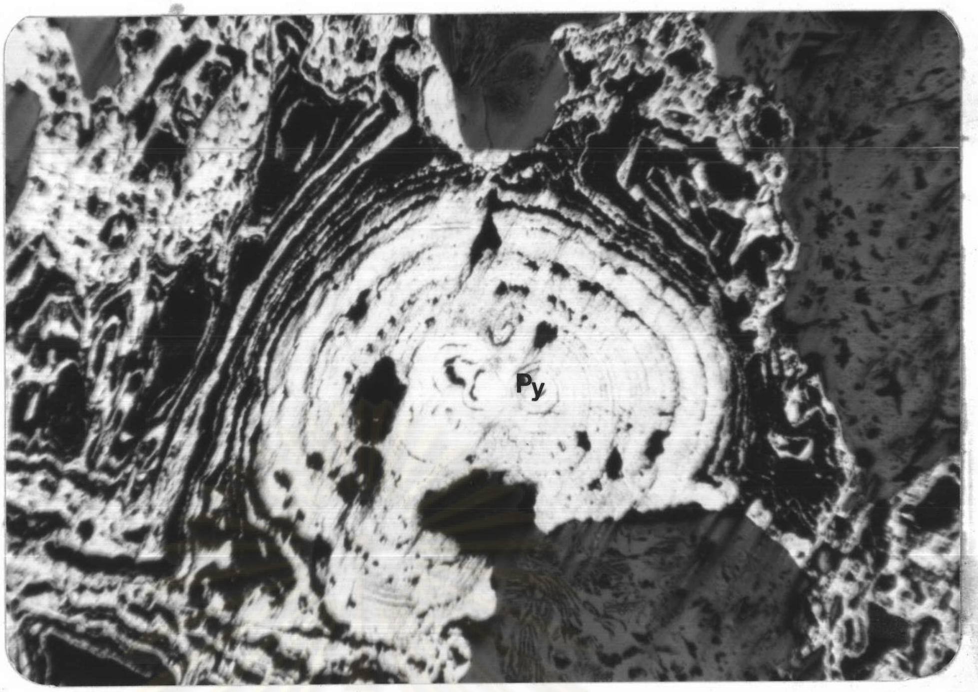

Figure 48 Photomicrograph showing rhythmical or colloform pyrite (Py) occurring in vugs at the No.1 orebody. (Polished section, 45x, uncrossed nicols)

Figure 49 Photomicrograph showing oval shape of pyrite (Py) surrounded by pyrrhotite (Po) filling vugs of marble near the No.1 orebody. (Polished section, 45x, uncrossed nicols)

after the colloform pyrite in vug or crack but were contemporaneous with pyrrhotite and chalcopyrite as judging from their mutual boundaries. This pyrite frequently exhibits slight anisotropic and occasionally forms cubic outline.

Magnetite occurs in minor amount slightly preceding and/or contemporaneous with cassiterite. It usually forms as euhedral (octahedral, dodecahedral) crystals frequently surrounded by cassiterite. Parts of magnetite were altered to hematite along small cracks or by forming fine lamellae along crystallographic direction.

Arsenopyrite is found as euhedral rhomb crystals in matrix of pyrrhotite.

At least two generations of fluorite can be recognized in this investigation. The early-formed stage I fluorite, as previous mentioned, occurs in minor amount closely related to the infilling feldspar and plagioclase of granitic rocks nearby the orebody. The stage I fluorite also occurs as an intergrowth with idocrase, scapolite and feldspar in the calcsilicate hornfels. In addition, fragments of fluorite cementing by pyrrhotite are found in No.2 orebody. This fluorite is probable belonging to the stage I.

The stage II fluorite is the lastest and comparatively more abundant in the orebody especially toward the marble and calcsilicate contact. The stage II fluorite occurs mainly as infill in open space in the sulfides ores or massive micas. The stage II fluorite tends to associate, but not always, with colorless to pale green phengite rather than green biotite.

Minor amount of quartz occurs as large euhedral crystal closely intergrown with cassiterite or as small veinlets crosscutting in massive biotite. Inclusions of green biotite in quartz euhedral crystal are occasionally encountered.

Finally, garnet forms as large euhedral crystal intergrown with cassiterite in vugs or fractures.

5.2 The No.3 Orebody and the No.4 Occurrence

The No.3 orebody is situated about 150 meters south-southwest of the No.1 (see an overview in Figure 28). Its elevation is some 10 - 15 meters below the lower part of the No.1 orebody. The orebody is approximately 8 meter wide, and confined within the fracture zone of granitic rocks (Figure 50). The mineralization has been taken place in forms of parallel green stringers along the fractures in the north-south direction with steeply dipping (Figure 51). Large pink garnet crystals are frequently observed as inclusion in the ore zone.

The No.4 occurrence is exposed as an outcrop of 2 x 2 meters in size within the granitic body nearby the Huai Nam Sai, some 40 meters below the lower part of the No.1 orebody to the southeast direction. The ore zone is characterized by a body of dark green rock (mostly green biotite) and a series of north-south open fractures filled with green biotite (Figure 52).

5.2.1 Granitic Rocks Near the No.3 Orebody and the No.4 Occurrence

The characteristic of granitic rocks near the No.3 orebody and the No.4 occurrence is generally similar to those at the Nos.1

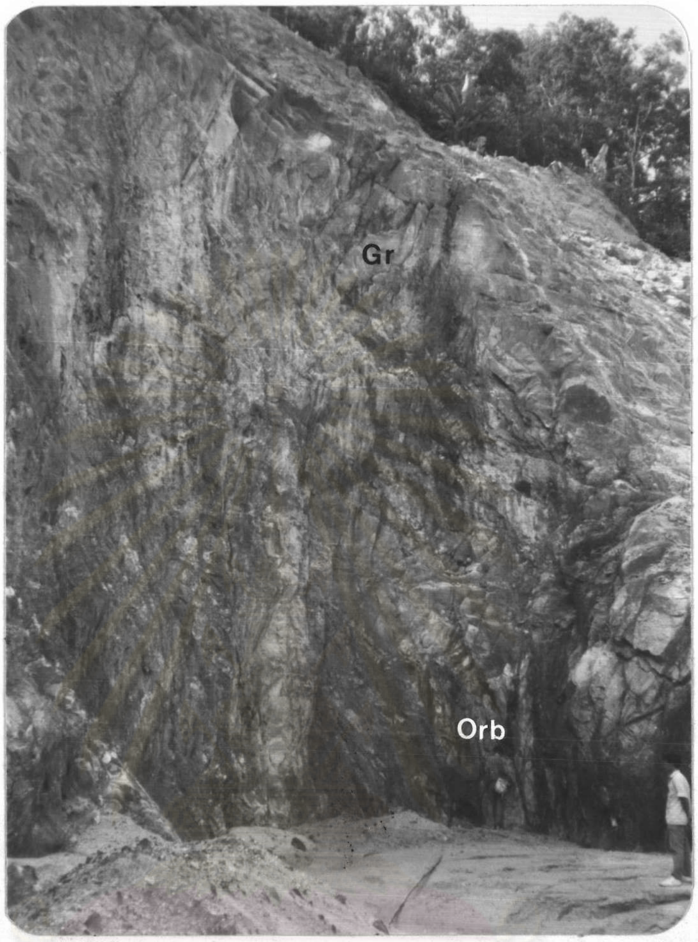

Figure 50 An exposure of the No.3 orebody showing the mineralization in forms of parallel-vertical-green stringers (Orb) confined within the fracture zone of granitic pluton (Gr).

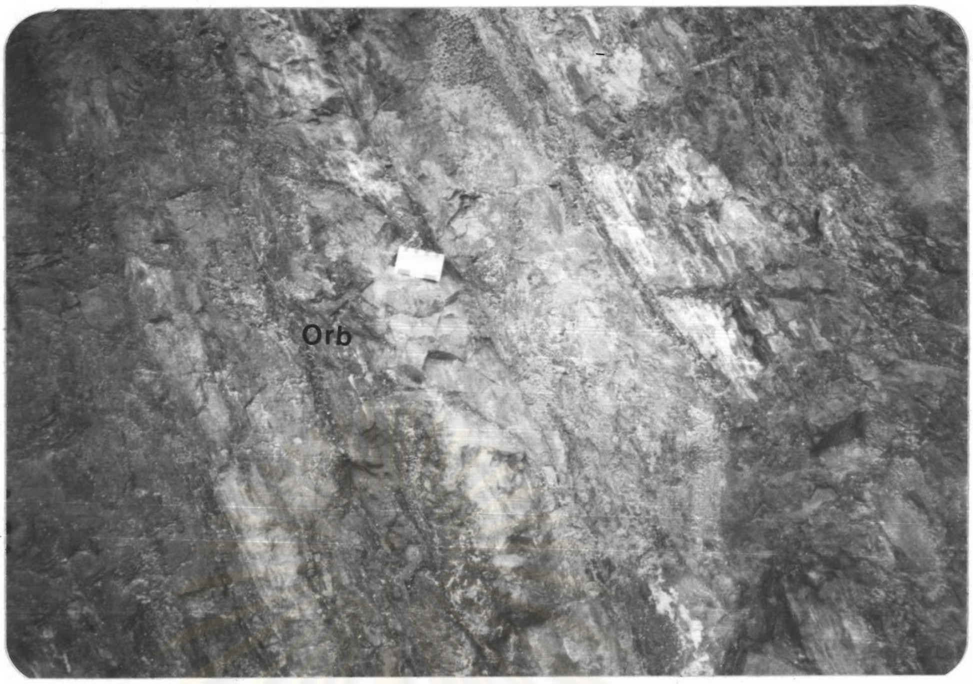

Figure 51 Stringers of mainly green biotite (Orb) with cassiterite and magnetite at the No.3 orebody.

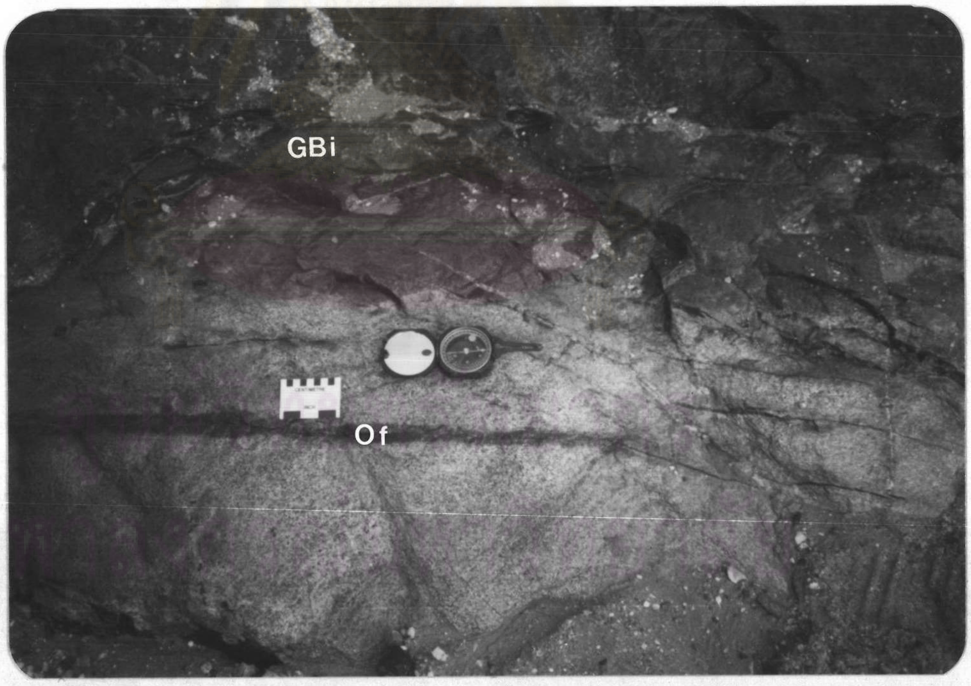

Figure 52 The outcrop of the No.4 occurrence showing the open fractures (Of) filled with predominantly green biotite. Notes the massive green biotite (GBi) on the upper part of the photograph.

and NO.2 orebodies. That is they have been metasomatically infilled by an equigranular granoblastic aggregates of plagioclase, K-feldspar, reddish-brown to green biotite and quartz along the grain boundaries. These have been subsequently sheared and crosscutted as well as replaced by numerous veinlets of green biotite plus sphene. Sphene is closely associated with green biotite. The intensity of green biotite replacement has increased toward the fractures until the granitic and infilling textures have been entirely obliterated and turned into a green biotite rock.

5.2.2 Mineralogy and Mineral Paragenesis at the No.3 Orebody and the No.4 Occurrence

The No.3 orebody as well as the No.4 occurrence differ from the previous orebodies both in terms of mineralogy and quantity of mineralization. The No.3 orebody (equally applied to the No.4 occurrence) consists of cassiterite and magnetite as the major ore minerals but contains only trace amounts of sulfide minerals, namely pyrite, chalcopyrite and pyrrhotite. The major gangue mineral is green biotite with minor amounts of garnet, epidote and fluorite. The paragenetic sequence of these ore and gangue minerals is summarized in Figure 53.

The No.3 orebody and the No.4 occurrence contain almost exclusively of the green variety of biotite. The intensity of green coloration of biotite is somewhat deeper than those in the No.1 and No. 2 orebodies. Nevertheless, some brownish green or brownish-core-and-greenish-rim varieties could be observed on some flakes of biotite. The green biotite in the No.4 occurrence has been highly altered to chlorite.

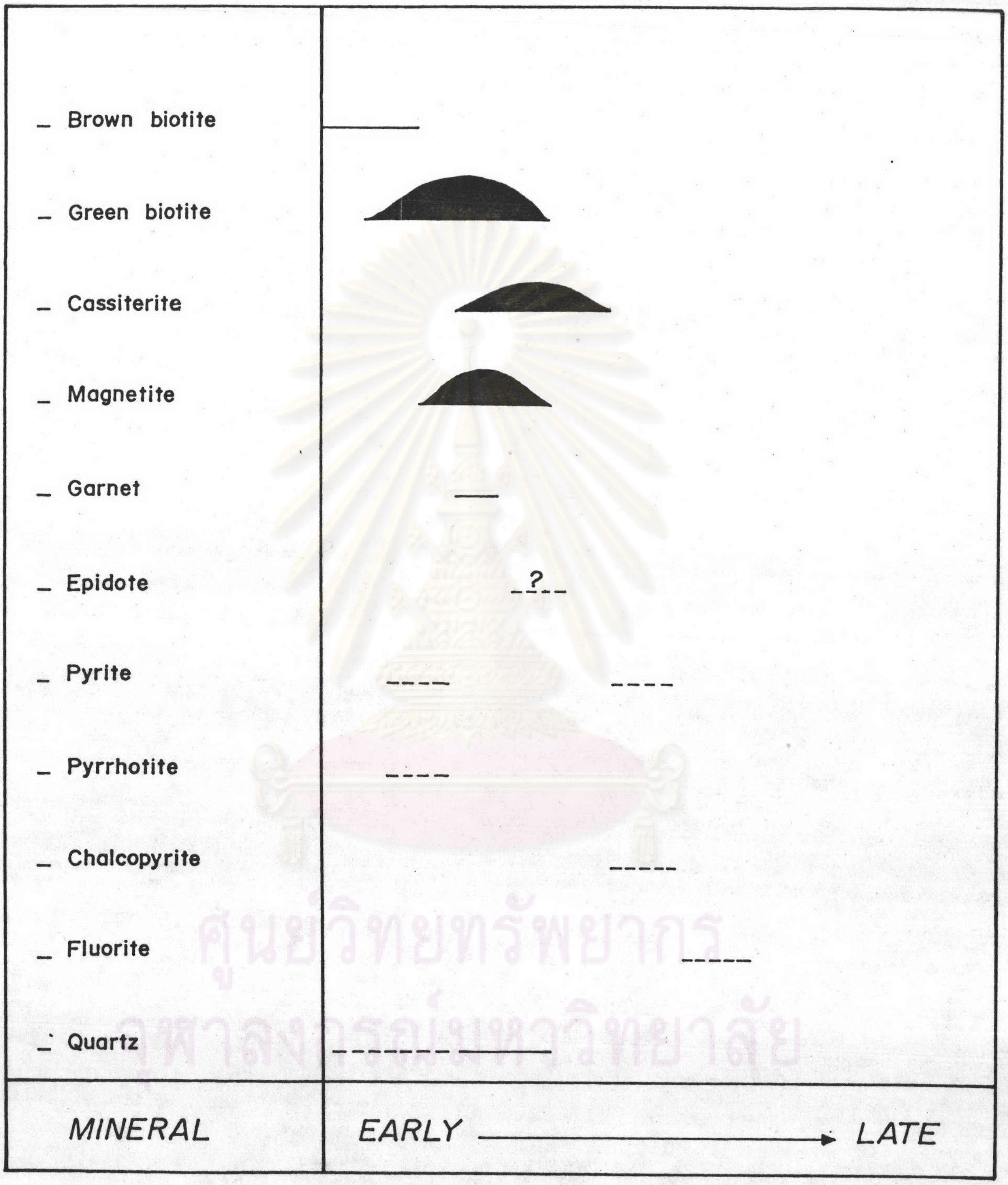

Figure 53 Mineral paragenesis at the No.3 orebody. Thick, thin and dash horizontal line represent the relative amount of each mineral varying from the most to the least abundant, respectively.

Cassiterite invariably occurs as large euhedral to subhedral crystals in the open fracture or replacing massive green biotite (Figure 54). It is intimately intergrown with magnetite as well as surrounding magnetite crystals. Magnetite in turn commonly forms as euhedral crystals or massive aggregate closely associated with late infilled deep green biotite (Figure 55). On occasions, magnetite has been slightly altered to hematite along the microcracks and crystallographic directions. Garnet occurs as large euhedral crystal in vug closely associated with cassiterite. Pyrite and chalcopyrite have commonly filled open spaces or formed as microveinlets crosscutting in garnet and magnetite crystals. Pyrite as well as pyrrhotite also occur as small blebs in magnetite crystals suggesting a slight predating and/or simultaneity of their precipitation. Epidote commonly forms as tabular crystals filling in between magnetite crystals. In the vicinity of epidote occurrence, green biotite was altered to chlorite. Most of quartz is contemporaneous with cassiterite and magnetite. Minor fluorite is the latest infilling mineral.

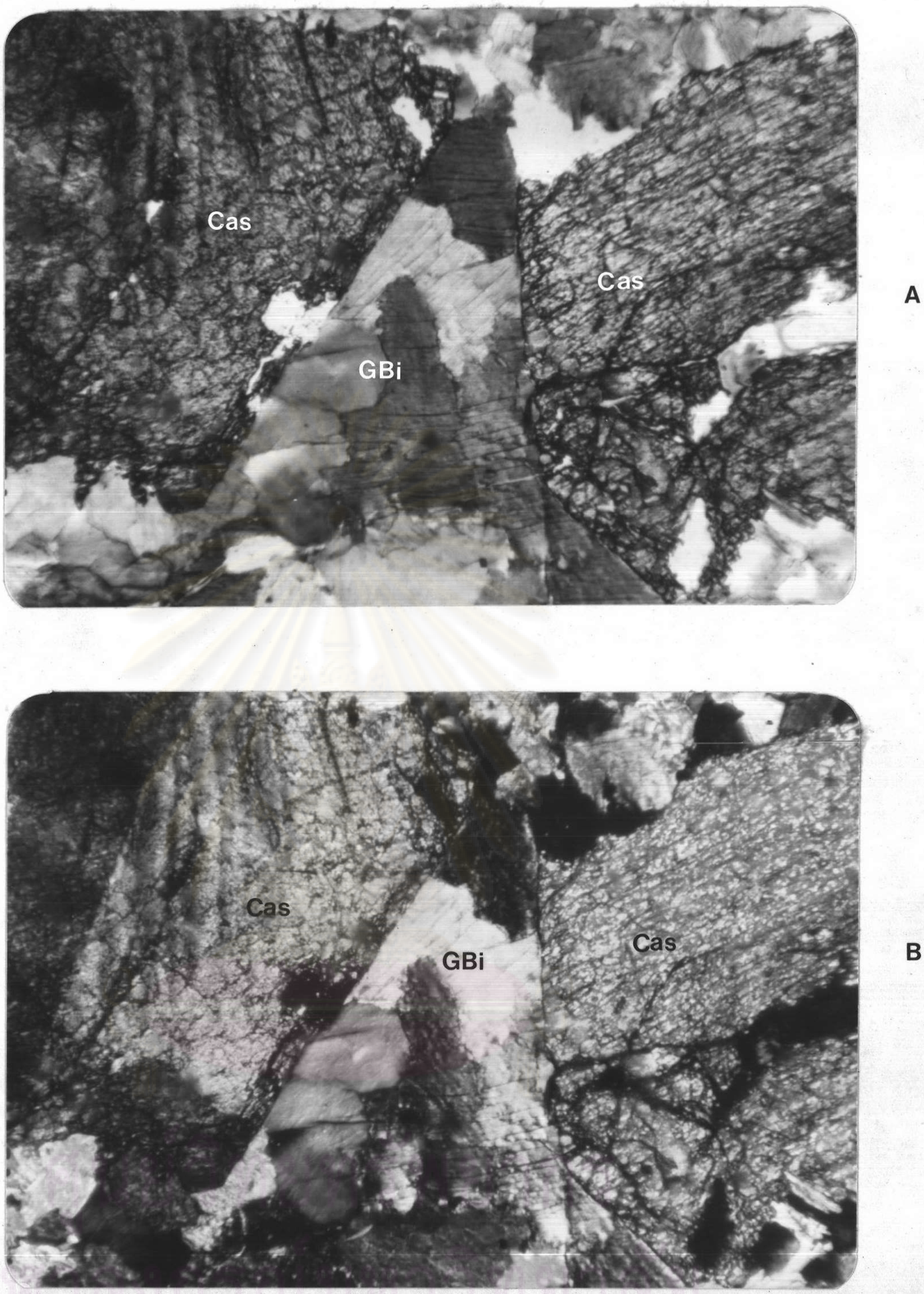

Figure 54 Photomicrographs showing euhedral cassiterite (Cas) occurring in the open spaces and intimately intergrown with late infilling deep green biotite (GBi) at the No.3 orebody. Note thin section, 45x. A) uncrossed nicols, B) crossed nicols.

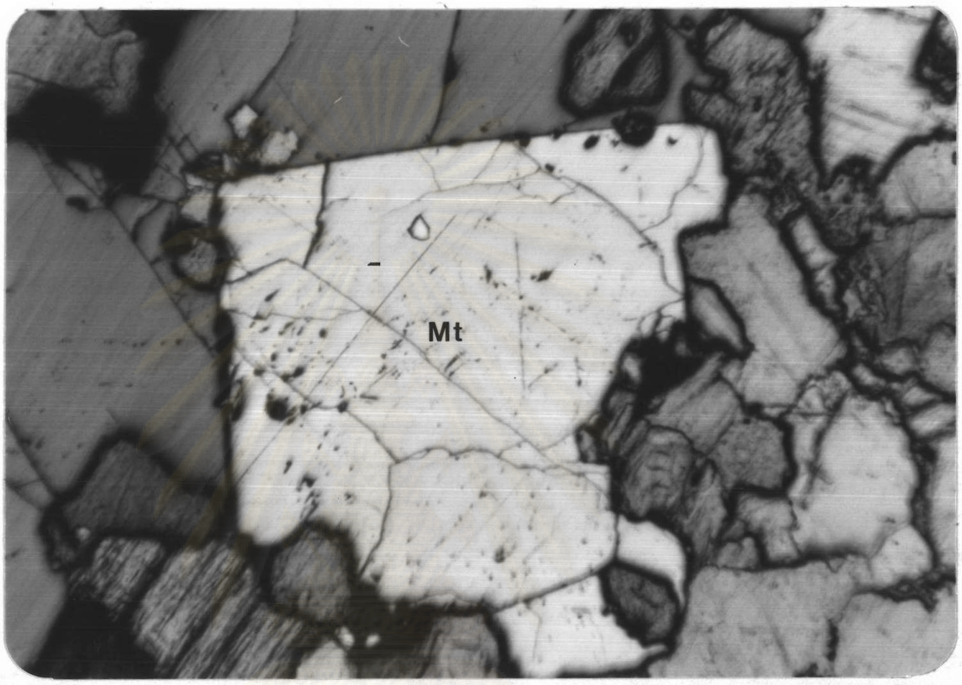

Figure 55 Photomicrograph of magnetite (Mt) commonly showing as euhedral crystals at the No.3 orebody. (Polished section, 45x, uncrossed nicols)