GEOSEA V Proceedings Vol. II, Geol. Soc. Malaysia, Bulletin 20, August 1986; pp. 473–485

Metamorphic mineral assemblages of gneisses along Doi-Inthanon Highway, Northern Thailand

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Abstract: The mineral assemblages of inferred Precambrian rocks of Chiang Mai -Tak gneiss belt along the Chomthong - Doi Inthanon Highway, were studied petrographically. These rocks are divided into mica-K-feldspar-sillimanite gneiss and biotite gneiss with intercalating marble and calc-silicate. These two units of gneiss are separated by biotite-granite intrusions.

The assemblages of the mica - K-feldspar - sillimanite gneiss is characterized by the coexistence of biotite, muscovite, K-feldspar, quartz and sillimanite. Fibrolitic sillimanite which is present in small amounts suggests the highest temperature conditions of the almandine - amphibolite facies. Textural evidence indicates generations of muscovite. The foliated small muscovite coexists with biotite appears to be formed during the earlier stage of metamorphism. Retrograde muscovite is found as non-foliated coarse flakes containing relict fibrolitic sillimanite, suggesting the reaction: sillimanite + K-feldspar + $H_2O \rightarrow$ muscovite + quartz, as the last metamorphic episode. Water needed for this reaction may have been derived from pegmatite or aplite veins which are widely distributed in the gneiss.

INTRODUCTION

Basement complexes in Thailand which are characterized by medium to high grade metamorphic rocks have long been recognized and considered to be Precambrian in age without definite field evidence or radiometric age data. Generally the exposures of these inferred Precambrian rocks are confined to the western mountain ranges of the country, forming a narrow discontinuous zone extending some 400 km. in a N-S direction from Mae Hong Sorn down to Uthai Thani (Figure 1). Metamorphic complexes crops out again as a narrow belt along the coastal line of Prachuab Khirikan. Recently, by using Rb - Sr Technique, Putthaphiban and Suensilpong (1978) indicates that Pranburi-Hua-Hin complex might have been derived from Triassic granite which developed foliation during Upper Tertiary.

In the south-eastern part of the country, another high - grade metamorphic belt called Chonburi massive is found. This belt is the subject of amphibolite facies metamorphism (Areesiri, 1982).

In spite of widespread occurrences, detailed petrological studies of these basement complexes have been few, especially in the northern part of Thailand which contains Chiang Saen Massif and Chiang Mai-Tak Gneiss belt. This report intends to provide a general petrographic data of the metamorphic rocks along the Chomthong - Doi Inthanon Highway from km 10 up to km 42. These rocks are part of the Chiang Mai-Tak Gneiss belt. However, because of the complexity of the basement and the rocks along the highway are highly weathered, it is impossible to get precise information on the changes of mineral assemblages

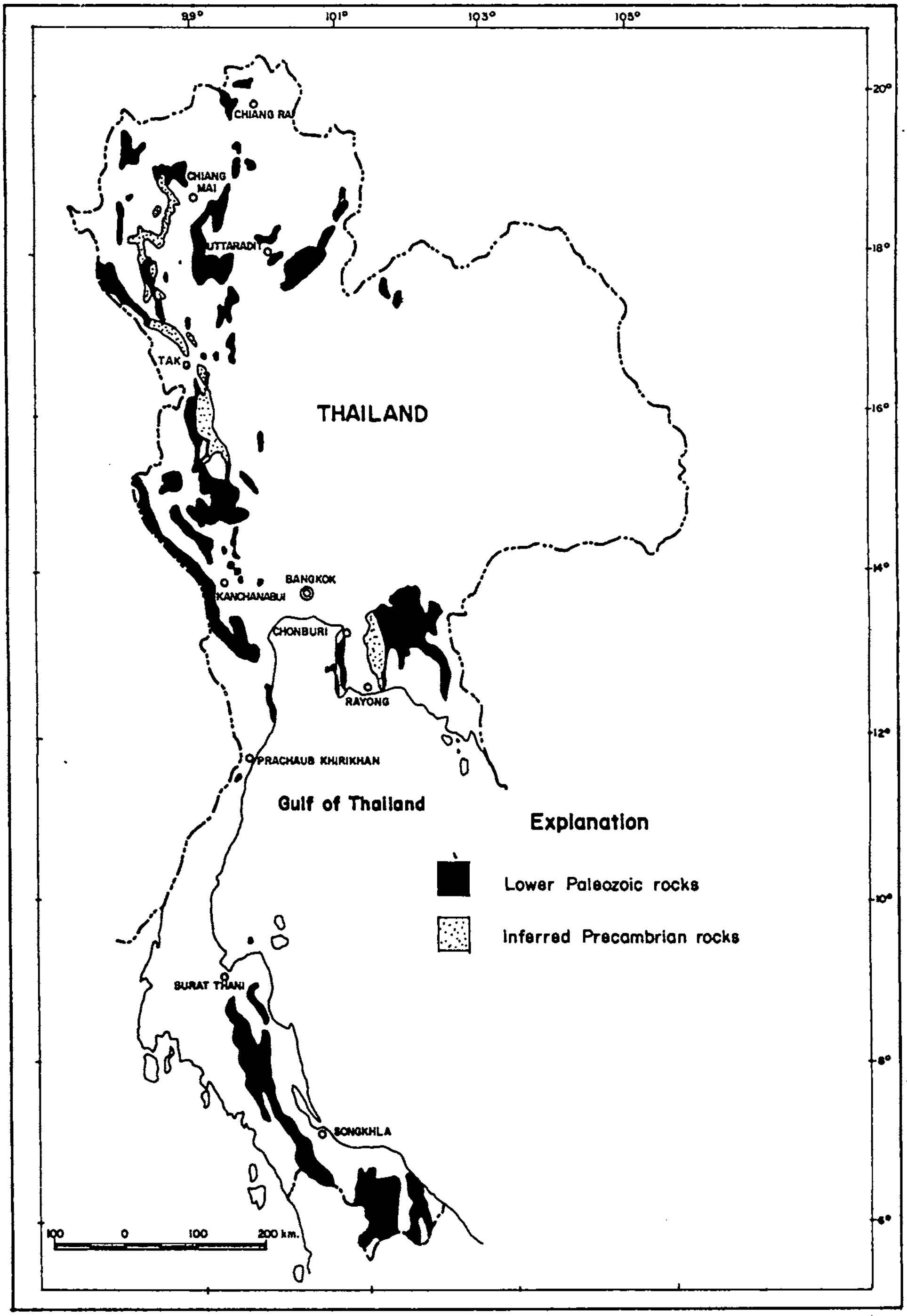

Fig. 1 Distribution of regional dynamothermal metamorphic rocks in Thailand. (after W. Pongsapich and others, 1983)

and chemistry as the bulk composition and metamorphic grade varies at this stage of the study. Therefore this is a preliminary effort which will lead to the further study on the details in the not too-distant future.

GEOLOGICAL SETTING

Pioneer work on Chiang Mai - Tak gneiss belt was carried out by Baum *et al.* (1970) who stated that the complex consists mainly of para-gneiss with minor marble, calc-silicate and biotite schist forming the core of a NS trending anticlinorium. The complex is regarded by these authors to be the subject of anatexis and granitization processes during a Lower Carboniferous orogeny. However according to radiometric age dating of granite in Thailand, it is found that there is no evidence of Carboniferous granite in Northern Thailand (van Braun, 1976).

The metamorphic rocks in this belt were studied in some petrographic detail in the area around Bhumiphol Dam, north of Tak, by Nutalaya (1973) who proposed four periods of metamorphism and two periods of deformation. Campbell (1973) described the Lan Sang Gneiss which occurs along the west of Tak as paragneiss for the most part with minor migmatite and younger orthogneiss. The paragneisses were described as having been metamorphosed to the andesine-epidote subfacies of the amphibolite facies.

Doi Inthanon, which is the highest peak in Thailand (about 2,565 m in elevation from sea level) is located around 60 km from Chiang Mai in the SW direction (Figure 2). On the basis of field investigation and petrographic data, two types of gneisses are recognized. In the eastern part of the study area up to km 22 (Figure 3), biotite gneiss crops out with intercalating thin to medium layers of calc - silicate and marble. This unit is presumably derived from sedimentary rocks. The foliation is in NE direction with gently dipping of about 50° towards the SE. The paragneiss grades into migmatite from east to west. The other unit is muscovite-K-feldspar-silimanite gneiss. They are exposed in the western part from km 30 up to the western end of the study area. Dip of the foliation in this unit is considerably high up to 80° in E direction with NW trending.

Two granitic intrusions of different age were emplaced into these gneisses. According to Tanomthin (1979) in investigation of landslides along Doi Inthanon Highway, he classified the slightly foliated granite as granite Type 1 which is fine-grained biotite granite (Figure 3). Although the age of the granite has not yet been dated with certainty, it is estimated to be Lower Carboniferous by German Mission (1970). The other granitic body or granite type, is also biotite granite of the Middle Triassic, showing compositional banding and more often intruded by aplite and pegmatite veins.

PETROGRAPHY (MINERAL ASSEMBLAGES)

Biotite Gneiss

Megascopically, the biotite gneiss exhibits thin alternating layers of fine and coarse-grained materials. Individual layer varies from 1 cm to more than 10 cm (Figure 4). Qualitatively, these are mineralogically comparable. The first migmatites are found when the paragneiss separated into distinct regular to semiregular leucocratic (light) and mesocratic (dark) layers which have been referred to as "leucosome" and 'mesosome" respectively

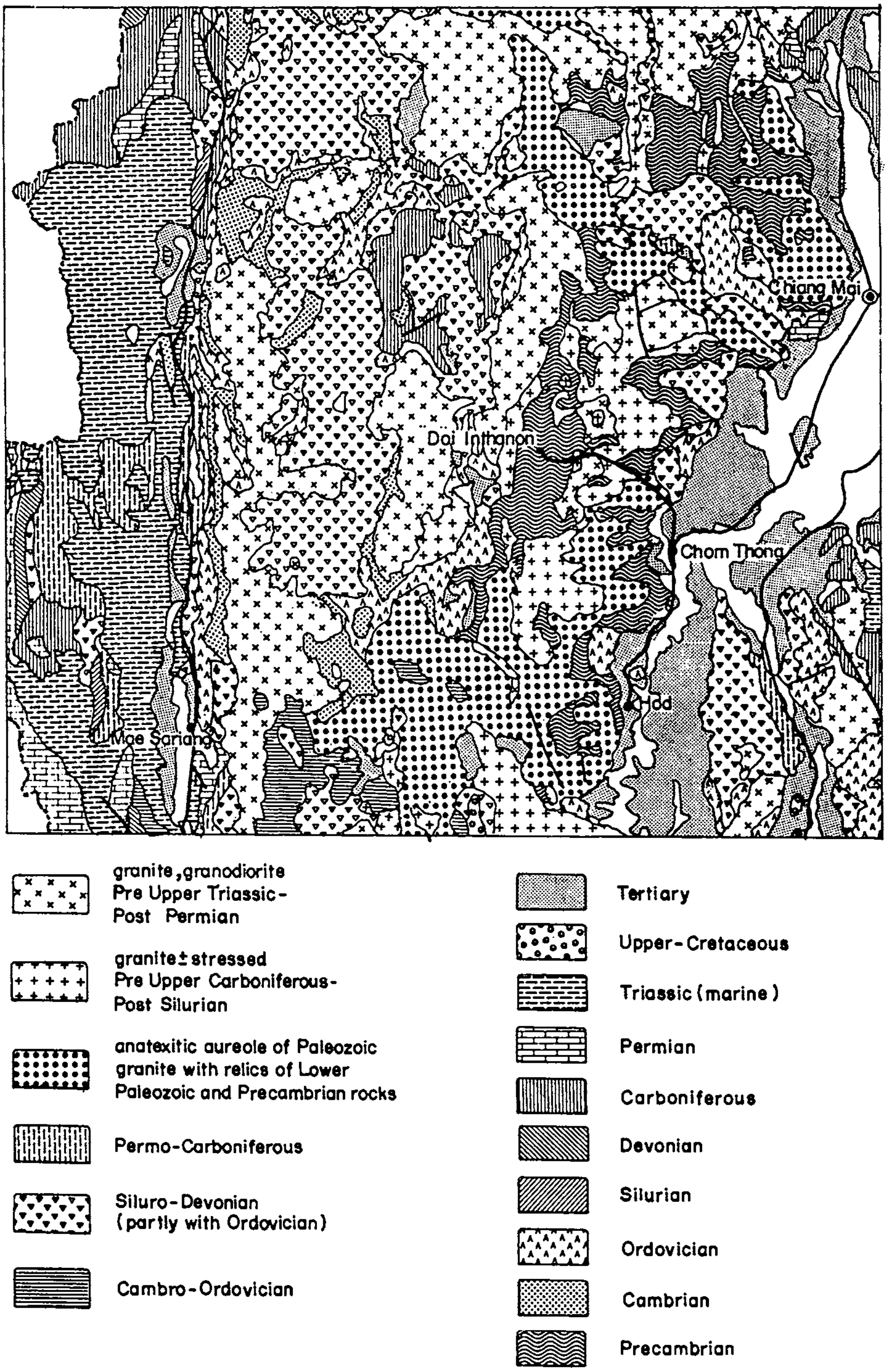

Fig. 2 Geological map of Northern Thailand (German Geological Mission, 1970)

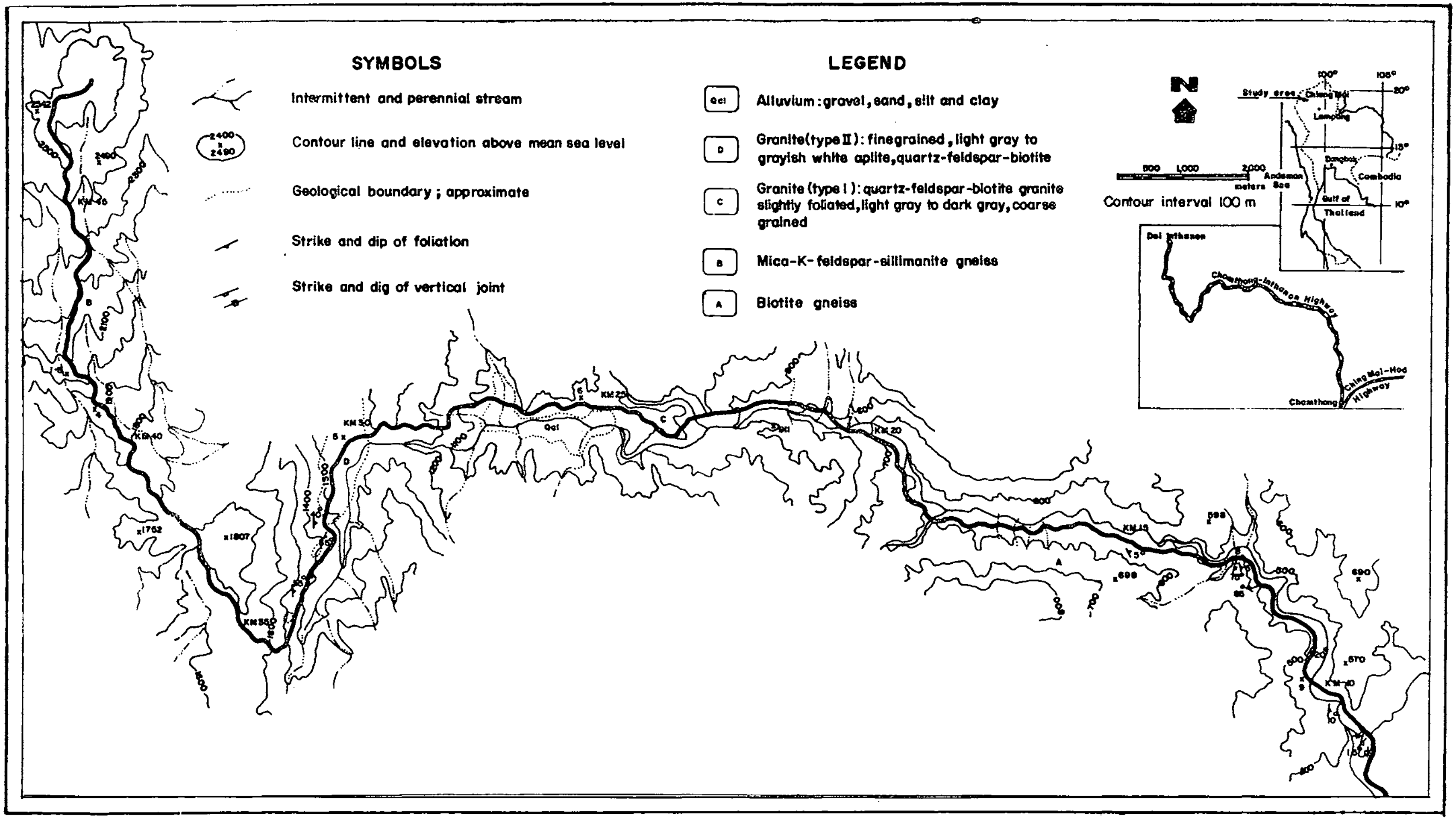

Fig. 3 Geologic map along the Chom Thong - Dai Inthanon Highway. (modified after Tanomtin, 1979)

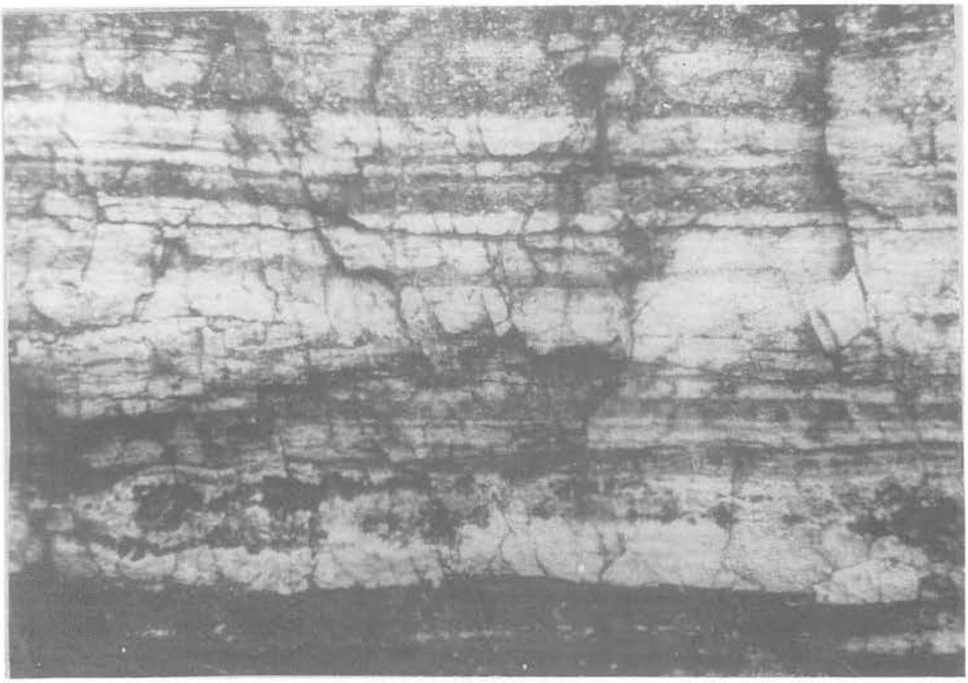

Fig. 4 Field photograph of alternating layers of biotite gneiss.

Fig. 5 Field photograph of migmatite showing leucosome (light) and mesosome (dark) layers.

(Figure 5). This process is interpreted to be due to recrystallization of the felsic minerals through partial melting and to the separation of biotite.

All the rocks studied consist predominantly of quartz, biotite, plagioclase and K-feldspar with strong biotite foliation. Accessary minerals are zircon and apatite. In the western end of the unit veinlets and stringers of chlorite are common (Figure 6), these are interpreted as having been introduced into the rocks during the last episode of metamorphism, causing retrograde metamorphism by changing biotite into chlorite. Feldspars are also sericitised. Light green actinolite is sporadically present as a minor constituent in this area. Rocks in the unit are locally sheared. Quartz is ubiguitous in the assemblages, forming slightly elongate grains and interstitial recrystallized grains showing sutured grain boundaries or locally occuring as sheared structure warping around the augens of K-feldspar.

Most of the plagioclase have an An content in a range between An_{25} to An_{30} (oligoclase). It is found as augens with or without oscillatory zoning (Figure 7).

K-feldspar is orthoclase which is remarkably porphyroblastic forming large augens set in fine-grained groundmass. The quantity of K-feldspar is less than plagioclase. Myrmekitic texture is common and found in most of the rocks studied.

Certainly biotite is an important mineral in the assemblage, typically lying in the plane of the principal foliation of the rocks. In places, biotite is altered to chlorite.

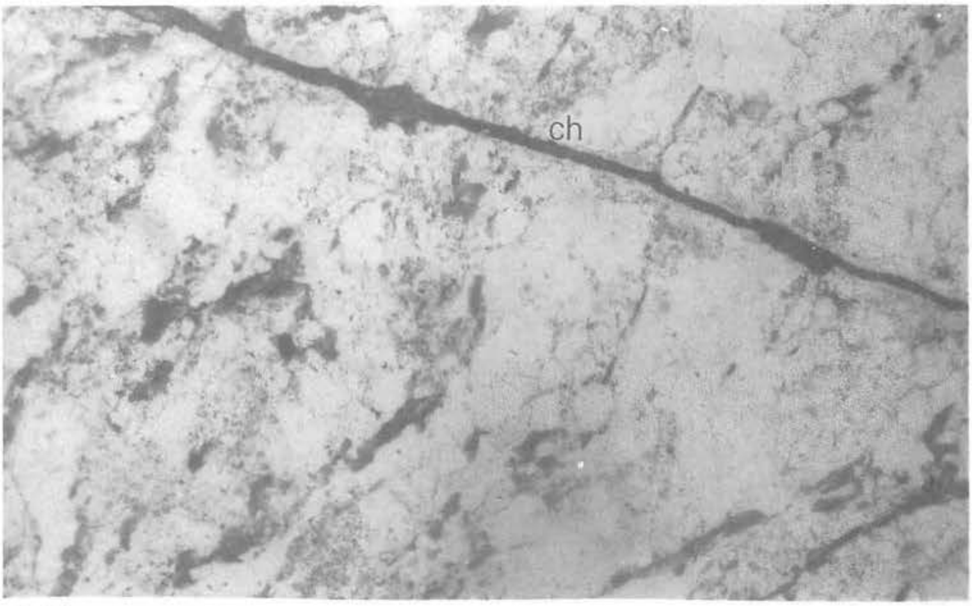

Fig. 6 Photomicrograph of veinlet of chlorite (ch) in biotite gneiss. Dark minerals are replacing chlorite after biotite.

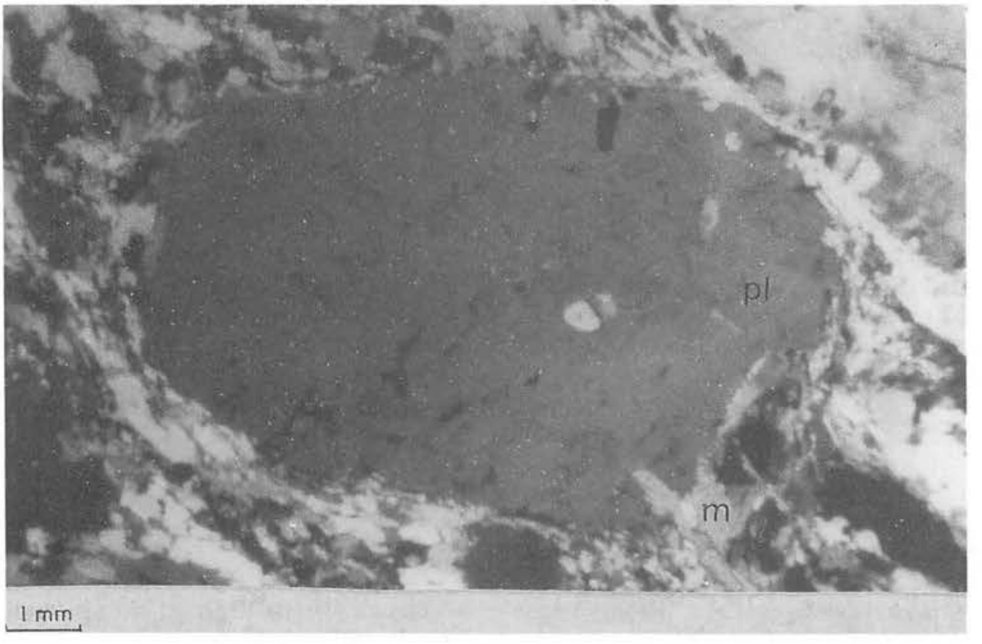

Fig. 7 Photomicrograph showing augen of plagioclase (pl) wrapped around by foliated fine-grained muscovite and quartz.

Fig. 8 Photomicrograph showing K-feldspar porphyroblast with perthitic texture.

Muscovite - Sillimanite - K-feldspar Gneiss

This unit is commonly coarse grained consisting of quartz, orthoclase, plagioclase, muscovite, sillimanite and small amount of biotite with apatite and zircon as accessory minerals. K-feldspar is remarkably porphyroblastic showing perthitic texture (Figure 8), a few of them appear as blurred plaid or grid twinned grain of microcline. The quantity of K-feldspar in this unit is much higher than plagioclase which occurs as groundmass crystals or occasionally as porphyroblasts. Plagioclase consists of oligoclase.

Petrographic study shows that two generations of muscovite are present in this unit. They can be distinguished texturally. Primary muscovite occurs as flakes oriented within the foliation and may have intergrown stably with biotite (Figure 9). The second generation of muscovite is characterized by large porphyroblast containing sillimanite inclusions (Figure 10). These muscovites exhibit various orientations.

Sillimanite occurs as fibrolite mats, as small colourless needles and as bundles of fibrous forms. It is found as trails of inclusions in large muscovite porphyroblast (Figure 11). The orientations of the fibrolitic inclusions are varied. They are unrelated to the crystallographic orientation of the host mineral. The trails of inclusions can be traced across many adjacent or separated, diversely oriented grains of muscovite. This microstructural relationship gives the impression that the fibrolitic sillimanite grains were in position before the final positioning of the new muscovite grain or can be interpreted that these coarse muscovite flakes are the retrograde products of the sillimanite. The paragenesis of retrograde muscovite may result from the reverse hydrated reaction.

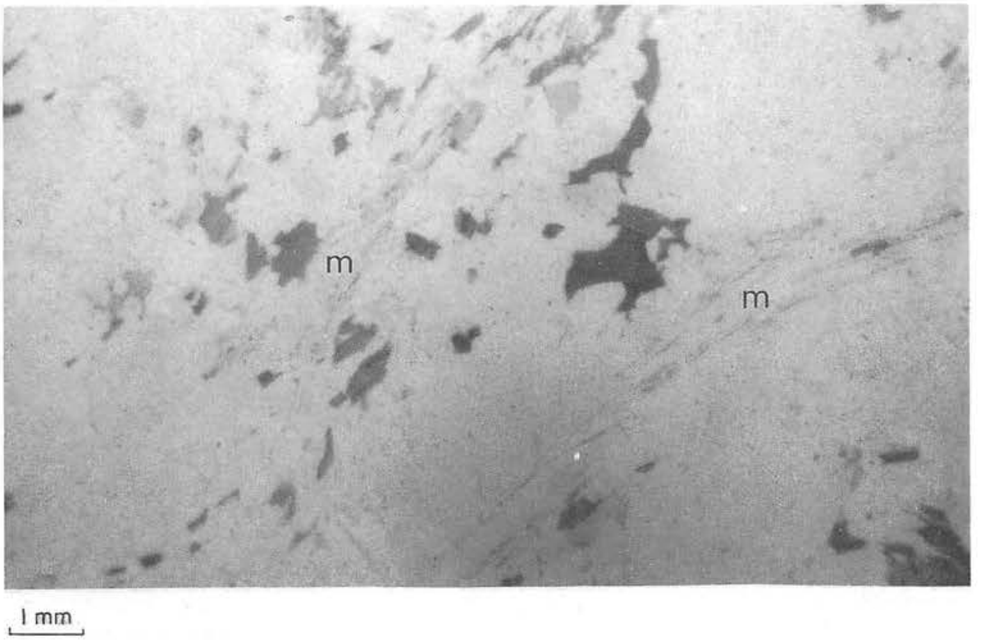

Fig. 9 Photomicrograph showing foliated primary muscovite (m) with biotite intergrowth (black).

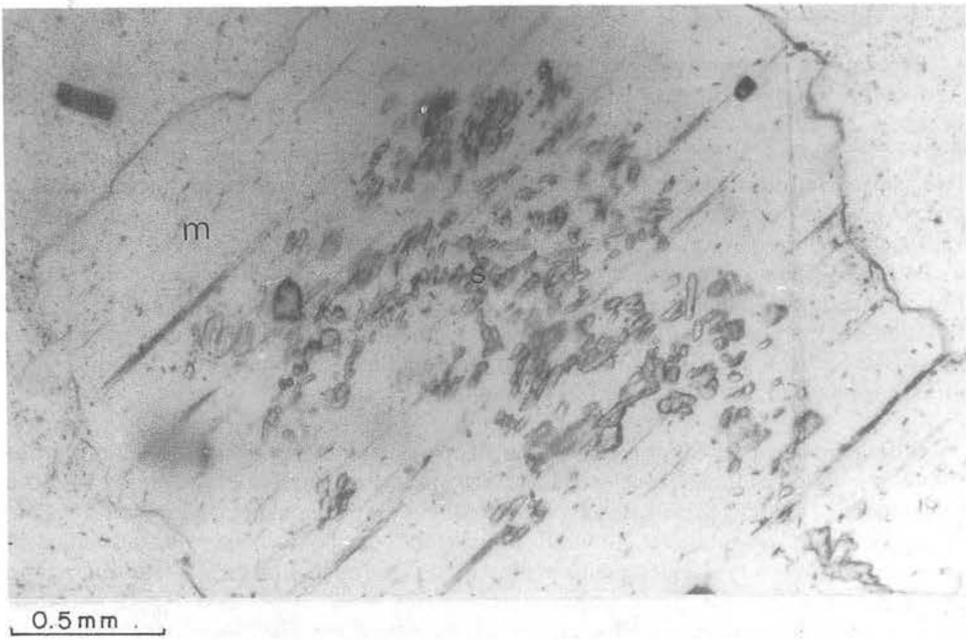

Fig. 10 Photomicrograph showing secondary muscovite (m) with sillimanite (s) inclusions.

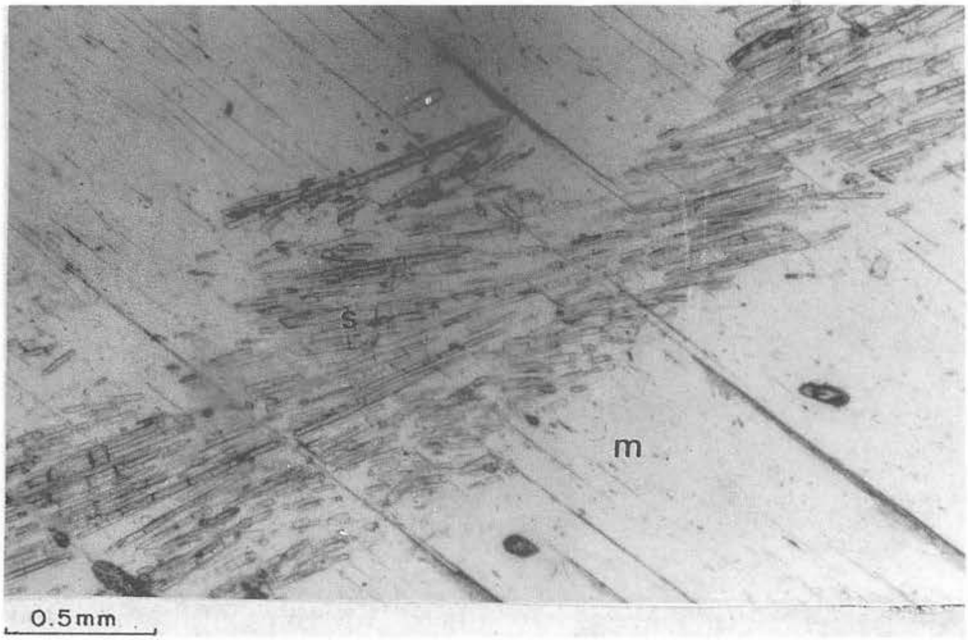

Fig. 11 Photomicrograph showing trails of prismatic sillimanites inclusions which can be traced across many adjacent, diversely oriented grains of secondary muscovite (m).

$$\text{Sillimanite} + \text{K-feldspar} + H_2O \Leftrightarrow \text{muscovite} + \text{quartz}$$

This is the last metamorphic reaction episode of the gneiss.

Water needed for this reaction may have been derived from pegmatite or aplite veins which are widely distributed in the gneiss. The other sources of water may be introduced into the rocks along the sheared zones.

In a number of occurrences thin layers of mica schist commonly occur within the mica-sillimanite - K-feldspar gneiss. Two periods of deformation are recorded in these mica-schists. D_1 deformation is the foliation of fine-mica flake. The second deformation is characterized by open folding (Figure 12). As the metamorphism became intense, these mica schists became coarser and developed gneissic structure.

CONDITIONS OF METAMORPHISM

Although it is very difficult to make the quantitative estimation of temperature and pressure values of metamorphism of the Doi Inthanon Gneisses at this stage of the study, helpful estimates of approximate value can be made on the basis of existing experimental data. The metamorphic mineral assemblages belonging to the sillimanite - K-feldspar - muscovite gneiss are indicative of the highest temperature conditions of the amphibolite facies. The coexisting sillimanite and orthoclase may be formed by the breakdown of muscovite in which:

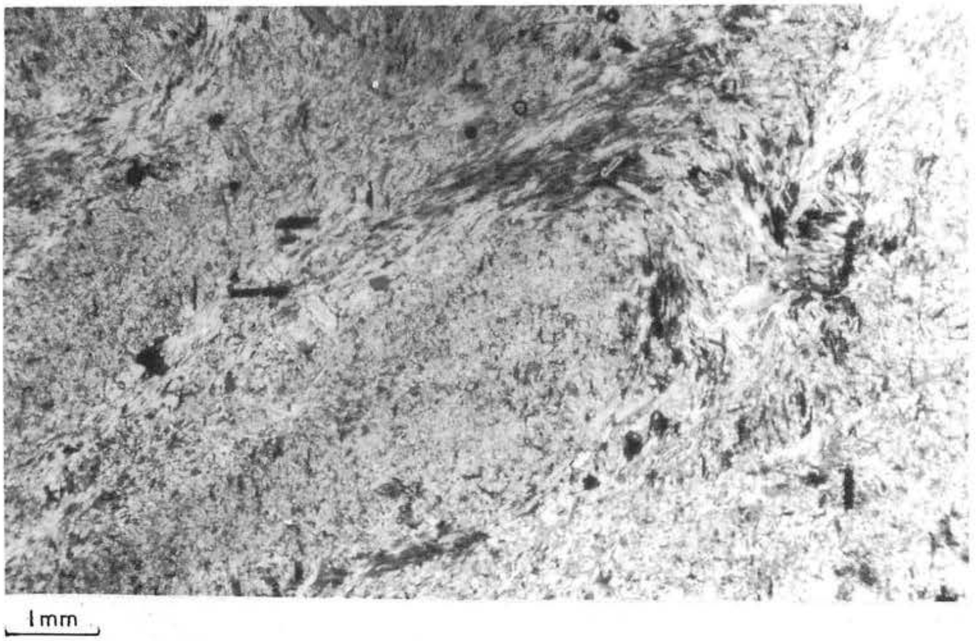

Fig. 12 Photomicrograph of mica schist showing open folding of D_2.

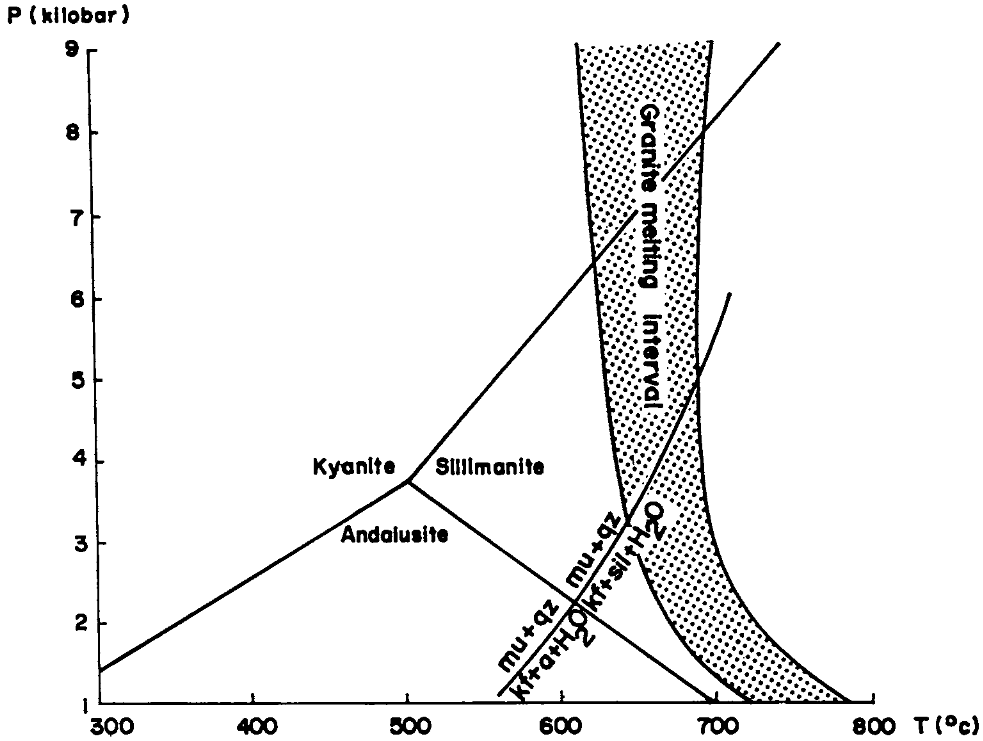

Fig. 13 Schematic P-T diagram showing some model reactions pertaining to the study area. Al_2SiO_5 triple point (Holdaway, 1971); breakdown of muscovite (Chatterjee and Johannes, 1974); melting interval of muscovite granite with excess H_2O (Wyllie, 1977).

muscovite + quartz→ orthoclase + sillimanite + H_2O

The migmatitic appearance of the gneiss at some localities, suggests that some *in-situ* melting of the gneiss may have occurred. Using the Al_2SiO_5 triple point of Holdaway (1971), break down of muscovite curve (Chatterjee and Johannes, 1974), and the melting interval of muscovite granite with excess H_2O (Wyllie, 1977), the estimated metamorphic temperature and pressure in the gneiss should be more than 650°C and 3.4 kilobars respectively, at which the breakdown of muscovite + quartz and the melting occur as shown in Figure 13.

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Manuscript received 25th January 1985