CHAPTER 2

GEOLOGY

2. 1 Regional Geologic Setting

The Khuntan Mountain Range (Figure 1.2) is mainly occupied by the complex granitoids. The range elongates appoximately in the N-S direction extending southwards from northern Chiang Rai, through east of Ching Mai, to southwest of Lampang and forming a total distance of appoximately 250 km. The maximum width across this elongated granitic body is about 45 km. This granitic region was cited to be the Mae Chan-Khuntan tin field (Nutalaya et al., 1979). Moreover, a recent study incorporated with data compilation shows that this range includes significant tin-tungsten deposits along the eastern side and fluorite, manganese plus stibnite deposits along the western part of its general N-S trend (P. Vichit, pers. commun.).

Rocks of the Khuntan Mountain Range are generally medium-to coarse-grained porphyritic biotite granites and their derivatives,e.g. pegmatites, aplites, and hydrothermal quartz veins. In addition, minor amounts of quartz monzonite and diorite have been described by Suensilpong et al. (1977), Chuaviroj et al. (1978), and Udomratn et al. (1980).

The granitic rocks are Triassic in age (Teggin, 1975., Braun et al., 1976; Beckinsale, 1979; Nakapadungrat, 1982). They intrude rocks of paleozoic sequences ranging from Silurian to Carboniferous. It is evidenced by sharp contacts between the granites and the country rocks in many places (Vichit, 1971, 1973, 1976; Teggin, 1975;

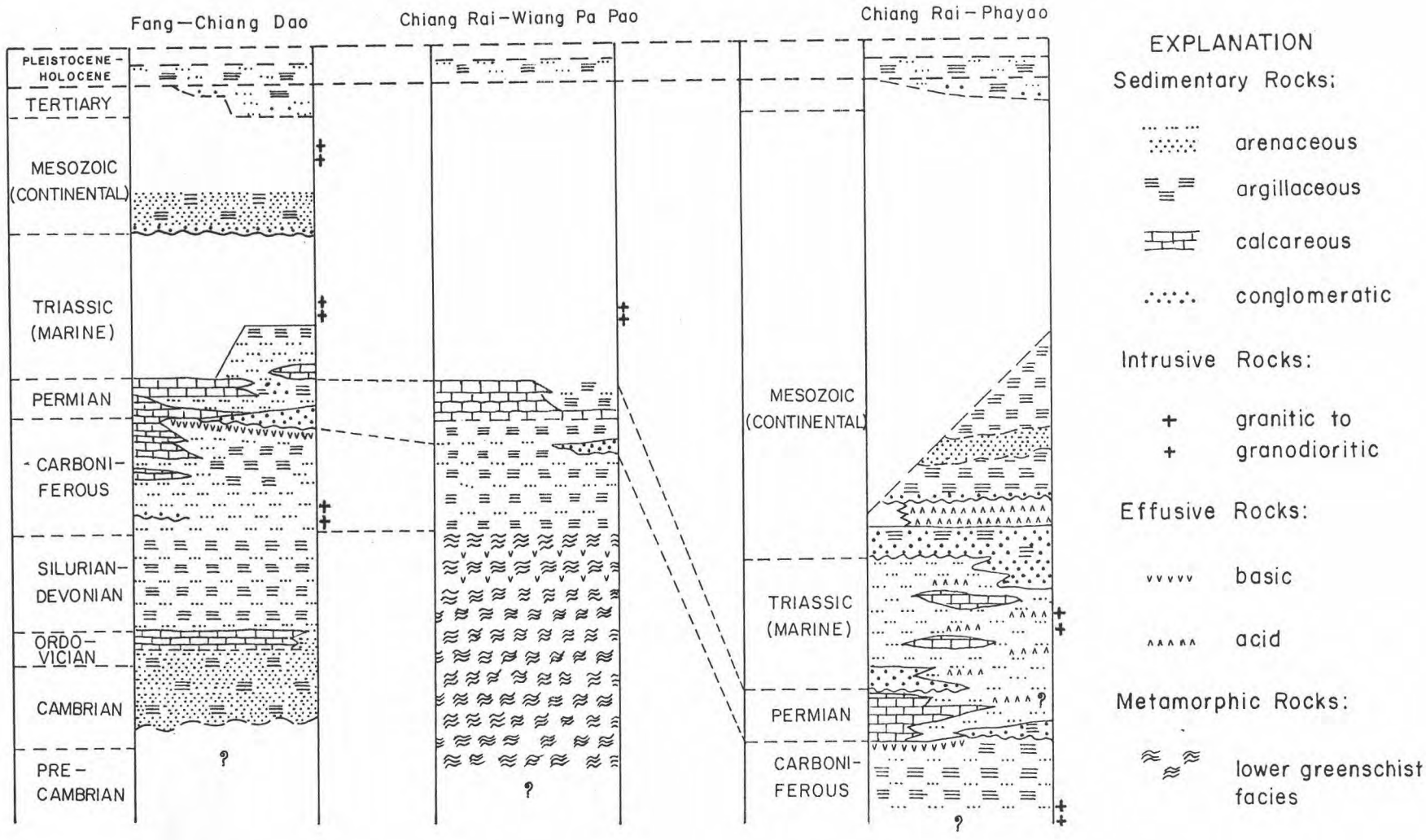


Figure 2.1 Generalized stratigraphic columns of Chiang Rai – Wiang Pa Pao and adjacent regions.
(Compiled after German Geological Mission, 1972; Charoenprawat et al., 1980)

Braun et al., 1976; Baum and Hahn, 1977; Suensilpong et al., 1977; Chuaviroj et al., 1978; Gebert et al., 1980; Udomratn et al., 1980).

The following description of the metamorphic and sedimentary rocks of the regional geologic setting is summarized from Charoenprawat et al. (1980) and Gebert et al. (1980) unless otherwise specified. The stratigraphic succession and correlation within the study area and its vicinity is shown in Figure 2.1.

The Silurian-Devonian rocks are exposed on both flanks of the Khuntan Mountain Range. They consist predominantly of schist, phyllite, quartzite, and metamorphosed volcanic rocks of mafic composition. The thickness of the succession is estimated to be in the order of 500-1,000 m near Wiang Pa Pao (Chuaviroj et al., 1978). This metamorphic unit is overlain by nonmetamorphosed rocks of Permo-Carboniferous unit.

Rocks of the Permo-Carboniferous age crop out at the south of Mae Chan and the west-southwest of Chiang Rai. They consist of alternating layers of reddish shale, sandstone, conglomerate, tuffaceous shale and sandstone and agglomerates. In the upper section, conglomerate beds are characteristically made of large white quartz pebbles and interbedded with fine-grained sandstone

The Permian limestone of the Ratburi group is located in the northwest-southwest of Chiang Rai. The limestone has been determined as Middle Permian based on the identification of Callowayinella meitienensis CHEN and Palaeofusulina sinensis SHENG (Kemper, 1969, cited in Baum et al., 1970). The thickness of the limestone formation exceeds 100 m.

Felsic volcanic rocks suggested to be Permo-Triassic age (Udomratn et al., 1980) are found at the northwestern Mae Chan area. Diabase dikes, found along Nam Mae Ko, northeast of Wiang Pa Pao, intrude the Silurian-Devonian metamorphic complex in the NE direction. The rocks were suggested to be of Tertiary age (Chuaviroj et al., 1978).

Quaternary sediments are found in the north and the southwest of Chiang Rai and in the Nam Mae Lao Valley. The unconsolidated clastic sediments consist mainly of gravel, sand, and clay of Pleistocene age (Baum, et al., 1970).

2. 2 General Geology of the Mae Chedi Area

Geologic map of the Mae Chedi area is illustrated in Figure 2.2. The area studied is situated on the east-central part of the Khuntan Mountain Range. It is covered predominently by intrusive rocks of granitic compositions.

The oldest rocks in the area studied consist of various metasediments, namely, schist phyllite, and quartzite, and meta-mafic volcanics which are here defined as "metabasites", of probable Silurian-Devonian age (Charoenprawat et al., 1980; Gebert et al., 1980). These rocks have been intruded by the N-S elongated body of the presumably Triassic granites throughout the area.

2. 2. 1 Silurian-Devonian metamorphic rocks

Metamorphic rocks of the Silurian-Devonian age are exposed in southeast and southwest of the area. They are generally grouped as being metamorphic rocks of the greenschist facies. Phyllite and schist are more abundant than quartzite (Gebert et al.,

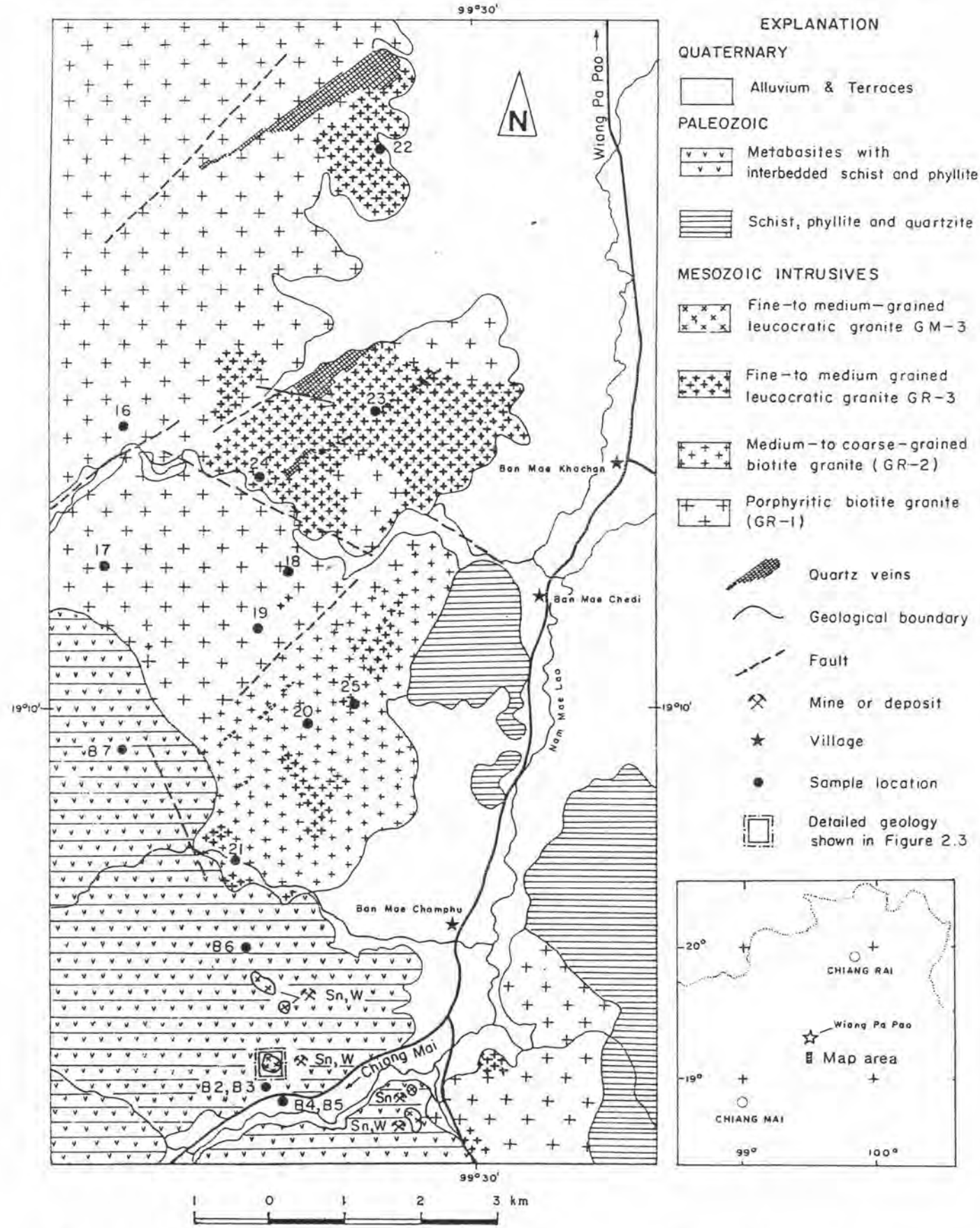


Figure 2.2 Geologic map of the Mae Chedi area, Wiang Pa Pao, Chiang Rai.
(modified after Gebert et al., 1980)

1980). These metasediments have been folded with the fold-axes lie in the N-S to NE-SW directions (Charoenprawat et al., 1980).

The metabasites are previously called "basic volcanic rocks" (Baum and Hahn, 1977; Charoenprawat et al., 1980; Gebert et al., 1980) and "ophiolite" (Baum et al., 1970) for field description purpose. According to German Geological Mission (1972), they are mainly andesites and pyroxenites of Late Carboniferous age. They are interpreted to be a result of volcanic activity in a geosynclinal environment (Gebert et al., 1980). Based on their silica contents, the rocks range in composition from ultramafic to mafic (tholeiitic basalt) which might have been formed in an island-arc environment of Late Carboniferous age (Macdonald and Bar, 1978). They cropped out in the southwestern part of the study area. Their brief petrography and geochemistry are described in Chapters 3 and 4 respectively.

2. 2. 2 Quaternary deposits

Unconsolidated clastic sediments forming terraces and Recent flood plains are mainly composed of gravel, sand, silt and clay. They are commonly found in an elongated extensive plains along the Nam Mae Lao Valley occupying the eastern part of the area studied.

2. 2. 3 Granitic rocks

Granites are the most abundant rocks occupied throughout the area studied. On the basis of field observation, they can be classified into six types, namely:

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

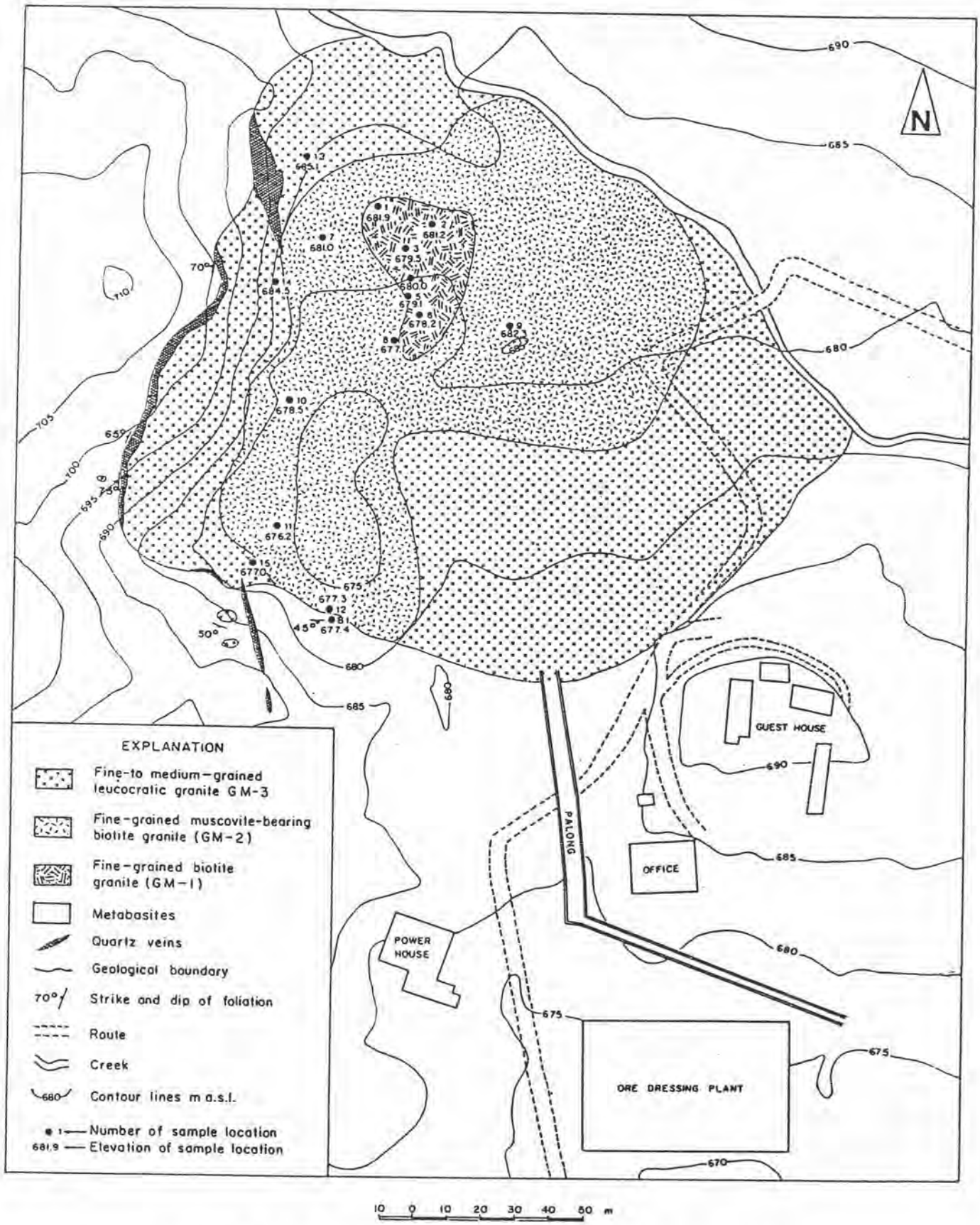


Figure 2.3 Geologic map of the Mae Chedi Sn-W Mine, Wiang Pa Pao, Chiang Rai

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

4. Porphyritic biotite granite (GR-1)

5. Medium-to coarse-grained biotite granite (GR-2)

6. Fine-to medium-grained leucocratic granite GR-3

The rock types mentioned above are able to be grouped into two series. The GM-series were collected from the immediate Mae Chedi Mine (GM-1 to GM-3), in which tin-tungsten minalization is associated. The GR-series were collected from out side of the Mae Chedi Mine (GR-1 to GR-3). To the author's knowledge the latter series are normally tin-tungsten barren. Distributions and sample locations of the GM-and the GR-series are shown in Figures 2.2 and 2.3. Detailed petrography and geochemistry of these rocks are described in Chaper 3 and Chapter 4 respectively.

2. 2. 4 Geochronology of granitic rocks

Up to date, there is no radiometric age determination for the granites within the area studied has been recorded. However, some radiometric datings of the main-range porphyritic biotite granite, which is believed to have been crystallized and emplaced about the same period as that of the pluton concerned, have been reported, for example, Braun et al. (1976). On the basis of the Rb-Sr whole-rock isochron and K-Ar biotite, they showed that the age of Fang-Mae Suai granite is 232 $\pm$ 31 Ma with the initial $^{87}Sr/^{66}Sr$ ratio of 0.7280 $\pm$ 0.0033 and 209 Ma, respectively. Subsequently Beckinsale (1979) has recalculated the age of the granite concerned and shown that it is 240 $\pm$ 64 Ma with the initial $^{87}Sr/^{86}Sr$ ratio of 0.7280 $\pm$ 0.0066. Teggin (1975) reported that the Rb-Sr whole-rock isochron age, K-Ar biotite mean age and muscovite mean age of

Khuntan granite are 206 ± 4 Ma, 199 ± 4 Ma and 202 ± 5 Ma, respectively. These figures were subseguently corrected to be 212 ± 12 Ma with the initial $^{87}Sr/^{86}Sr$ ratio of 0.7244 ± 0.0020 by Beckinsale (1979). Recently Nakapadungrat (1982) indicated that the Rb-Sr whole-rock isochron age of the Doi Saket-Wiang Pa Pao granite is 215 ± 3 Ma with the initial $^{87}Sr/^{86}Sr$ ratio of 0.7295 ± 0.0007

Accordingly, it is possible to conclude that the porphyritic biotite granites of the Mae Chedi area (GR-1) are of Triassic age.

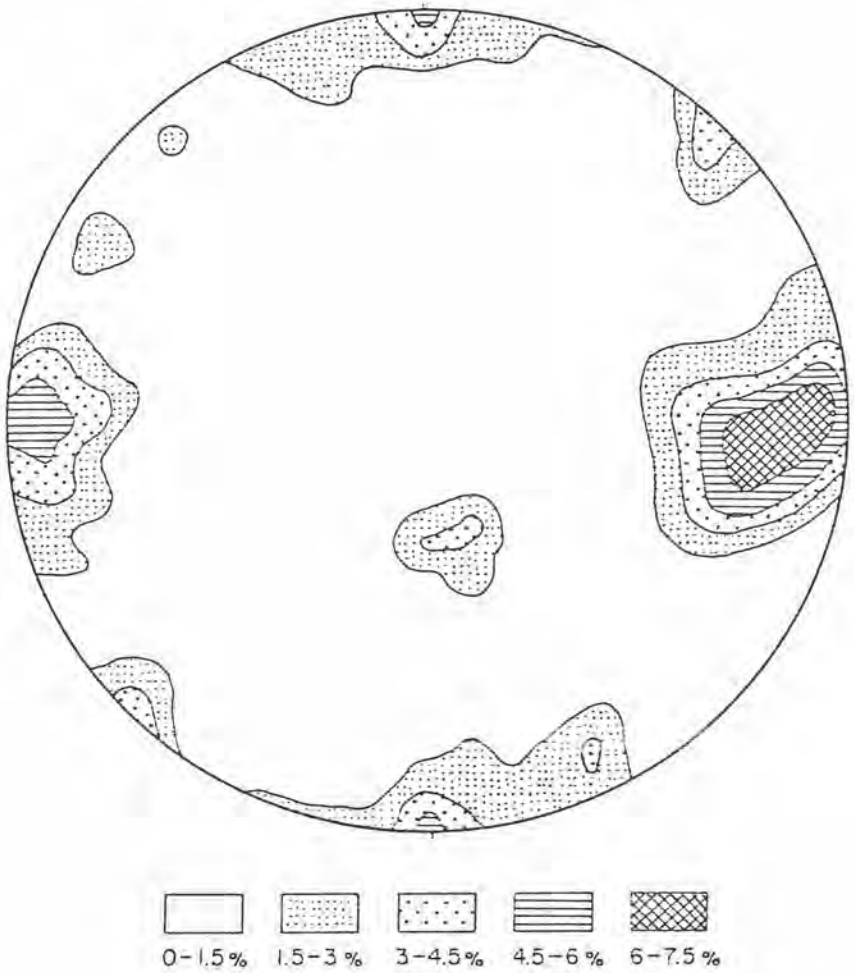
2. 2. 5 Tectonic features

There are two major fault sets recorded in this area (Figure 2.2). One of them lying in NE-SW direction while the other lies in NW-SE direction. According to Gebert et al. (1980), another major NS-trending fault developed in the Nam Mae Lao Valley along the eastern margin of the plutonic belt.

A number of measurements of joint pattern in the Mae Chedi area have been conducted by Sukvattananunt et al., (1980, cited in charoenprawat et al., 1980). It is clearly illustrated that four major sets of joints are in existence. The predominant sets develop in the 40° - 70° and 300° - 330° directions while other sets are in the 340° to 360° and 80° to 90° directions (Charoenprawat et al., 1980).

Gebert et al. (1980) noted that joints develop strongly in both the Paleozoic sedimentary strata and the Triassic biotite granite. He also mentioned that the initial fracture pattern developed in the NW direction has been superimposed by fractures of the NE direction.

(a)



(b)

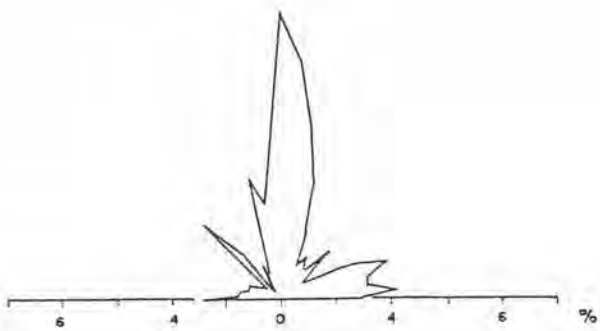


Figure 2.4 Patterns of fracture distribution in granite stock of the Mae Chedi Sn-W Mine.

(a) Distribution illustrated in an equal-area stereographic net plot of 318 poles of fractures (joints and faults)

(b) Distribution of strike of 318 fractures illustrated by a rose diagram.

The total 318 of fractures in granite stock within the mine area were measured in order to study the orientation of joint system. The stereographic projection of poles perpendicular to fracture planes were plotted on the equal area net followed by using Kalsbeek's counting method (Figure 2.4). The plots display two well defined point maxima that are elongated in N - S and nearly E - W directions. The minor fracture planes are concentrated in NE - SW and NW - SE diriction. The major mineralized zones appear to follow fracture zones of generally the N - S direction. Fractures are usually infilled with quartz, tourmaline, cassiterite and tungsten minerals, etc., with a zone of wall-rock alteration on both sides. Field and petrographic evidences indicate that the mining area has been affected by intense tectonic activities.

2. 3 Geology of Sn-W Deposits of the Mae Chedi Mine

Sn-W deposits of the Mae Chedi Mine are located near the southern end of the mapped area (Figure 2.2). The primary tin-tungsten mineralizations are found where a small granitic pluton intruded metabasites. The granitic pluton appears to be a small cupola covering an area of approximately 0.5 km^2. The granitic rock is in sharp contact with metabasites and possesses internal vertical and lateral zonations. It is fine-grained biotite granite (GM-1) in the core area and transitionally grades outwards into fine-grained muscovite-bearing biotite granite (GM-2) and finally to fine-to medium-grained leucocratic granite (GM-3) in the marginal zone. (Figure 2.3).

The ore bodies commonly occur in quartz veins cutting through the granites and less commonly in metabasites. The widths of ore bearing veins vary from a few mm up to 50 cm. They are entirely fracture-controlled. The major ore-bearing veins systems are predominant in N - S direction. The stereogram plot and rose diagram of 318 measurements of fractures recorded in this granitic pluton are shown in Figure 2.4.

Mineral constituents of ore-bearing veins are very variable. The major ore minerals are scheelite and cassiterite. However, wolframite freguently rimmed by scheelite have been found in quartz veins cutting through the GM-1 granitic rock. Gangue minerals comprise predominantly of quartz, tourmaline, chlorite, pyrite, chalcopyrite and to a minor extent of arsenopyrite. Occurrences of disseminated ores are also observed. They are generally restricted to the wall rocks adjacent to ore-bearing veins.

It is interesting to note that there is an apparent zonation of metallization in the deposit from the present field observation. Occurrences of cassiterite are chiefly associated with the GM-3 granitic rock, especially in the apical zone of the cupola, whereas scheelite is commonly abundant towards the lower level particularly in the GM-2 granitic type.